タ判定部と、タップ係数演算部とを備え、タップ係数演算部ではタップ係数更新アルゴリズムに従い等化フィルタ部のタップ係数を更新する判定帰還形適応等化器部と、タップ付き遅延回路を有する等化フィルタ部と、データ判定部と、タップ係数演算部を備え、タップ係数演算部ではタップ係数更新アルゴリズムに従い等化フィルタ部のタップ係数を更新する線形適応等化器部と、上記判定帰還形適応等化器部の等化誤差より定める値と、上記線形適応等化器部の等化誤差より定める値を比較する比較回路と、上記比較回路の結果に基づいて、上記判定帰還形適応等化器部の等化出力または、上記線形適応等化器部の等化出力のいずれかを選択し、最終的な等化出力とする手段を備え、上記判定帰還形適応等化器部と線形適応等化器部の等化特性の差を比較し、等化特性の良い方の出力を最終的な等化出力とするようにしたものである。

【００３６】上記の目的を達成するために、請求項２に係わる発明の適応等化器は、フィードフォワード部（ＦＦ部）とフィードバック部（ＦＢ部）にタップ付き遅延回路を有する等化フィルタ部と、データ判定部と、タップ係数演算部とを備え、タップ係数演算部ではタップ係数更新アルゴリズムに従い等化フィルタ部のタップ係数を更新し、また、外部制御信号により動作を停止する判定帰還形適応等化器部と、タップ付き遅延回路を有する等化フィルタ部と、データ判定部と、タップ係数演算部を備え、タップ係数演算部ではタップ係数更新アルゴリズムに従い等化フィルタ部のタップ係数を更新し、また、外部制御信号により動作を停止する線形適応等化器部と、上記判定帰還形適応等化器部の等化誤差より定める値と、上記線形適応等化器部の等化誤差より定める値を比較する比較回路と、上記比較回路の結果に基づいて、上記判定帰還形適応等化器部の等化出力または、上記線形適応等化器の等化出力のいずれかを選択し、最終的な等化出力とするとともに、上記判定帰還形適応等化器部または、上記線形適応等化器部の動作を停止する手段を備え、上記判定帰還形適応等化器部と線形適応等化器部の等化特性の差を比較し、等化特性の良い方の出力を最終的な等化出力とするとともに、等化特性が悪い方の適応等化器部の動作を停止するようにしたものである。

【００３７】上記の目的を達成するために、請求項３に係わる発明の適応等化器は、フィードフォワード部（ＦＦ部）とフィードバック部（ＦＢ部）にタップ付き遅延回路を有する等化フィルタ部と、データ判定部と、タップ係数演算部とを備え、タップ係数演算部ではタップ係数更新アルゴリズムに従い等化フィルタ部のタップ係数を更新し、また、外部制御信号により動作を停止および再開する判定帰還形適応等化器部と、タップ付き遅延回路を有する等化フィルタ部と、データ判定部と、タップ係数演算部を備え、タップ係数演算部ではタップ係数更新アルゴリズムに従い等化フィルタ部のタップ係数を更新する線形適応等化器部と、上記判定帰還形適応等化器部にて、既知信号系列に対応する受信信号を等化する際の等化誤差からしきい値を定めるしきい値設定回路と、上記線形適応等化器部にて、ランダム信号系列に対応する受信信号を等化する際の等化誤差より定まる値と上記しきい値を比較する第一の比較回路と、上記線形適応等化器部より定まる値が上記しきい値より少なくとも小さい場合には、線形適応等化器部の等化出力を最終的な等化出力とするとともに、判定帰還形適応等化器部のランダム信号系列に対する等化を停止する手段と、上記線形適応等化器部より定まる値が上記しきい値より少なくとも大きい場合には、判定帰還形適応等化器部にて、既知信号系列以外に対する受信信号の等化を行なう手段と、上記線形適応等化器部より定まる値が上記しきい値より少なくとも大きい場合には、上記判定帰還形適応等化器部による既知信号系列以外に対する受信信号の等化誤差より定めた値と、上記線形適応等化器部より定まる値を比較する第二の比較回路と、上記線形適応等化器部より定まる値が上記しきい値より少なくとも大きい場合には、上記第二の比較回路の結果に基づいて、上記判定帰還形適応等化器部の等化出力または、上記線形適応等化器部の等化出力のいずれかを選択し、最終的な等化出力とする手段を備え、上記判定帰還形適応等化器部によるランダムデータの等化を行なわなくても良い場合は、判定帰還形適応等化器部の動作を停止し、判定帰還形適応等化器部によるランダムデータの等化を行なった場合でも、判定帰還形適応等化器部と上記線形適応等化器部の等化特性の差を比較し、等化特性の良い方の出力を最終的な等化出力とするようにしたものである。

【００３８】上記の目的を達成するために、請求項４に係わる発明の適応等化器は、フィードフォワード部（ＦＦ部）とフィードバック部（ＦＢ部）にタップ付き遅延回路を有する等化フィルタ部と、データ判定部と、タップ係数演算部とを備え、タップ係数演算部ではタップ係数更新アルゴリズムに従い等化フィルタ部のタップ係数を更新し、また、外部制御信号により動作を停止および再開する判定帰還形適応等化器部と、タップ付き遅延回路を有する等化フィルタ部と、データ判定部と、タップ係数演算部を備え、タップ係数演算部ではタップ係数更新アルゴリズムに従い等化フィルタ部のタップ係数を更新し、また、外部制御信号により動作を停止および再開する線形適応等化器部と、上記判定帰還形適応等化器部と上記線形適応等化器部の等化処理を任意のデータで一旦打ち切り、両等化器のタップ係数をリセット、再トレーニングを行なった後に再び等化処理を行なう手段と、等化処理を一旦打ち切るまでの上記判定帰還形適応等化器部の等化誤差より定める値と、上記線形適応等化器部の等化誤差より定める値を比較する比較回路と、上記比較回路の結果に基づいて、上記判定帰還形適応等化器部

の等化出力または、上記線形適応等化器部の等化出力のいずれかを選択し、最終的な等化出力とする手段と、上記比較回路の結果に基づいて、上記判定帰還形適応等化器部の等化出力または、上記線形適応等化器部の等化出力のいずれかを上記再トレーニング時に参照信号とする手段を備え、上記判定帰還形適応等化器部と線形適応等化器部の等化特性の差を任意のデータシンボル数毎に比較し、等化特性の良い方の出力をそのデータシンボルに対する最終的な等化出力とするとともに、等化特性の良い方の等化出力結果を用いて両適応等化器部の再トレーニングするようにしたものである。

【００３９】上記の目的を達成するために、請求項５に係わる発明の適応等化器は、フィードフォワード部（ＦＦ部）とフィードバック部（ＦＢ部）にタップ付き遅延回路を有する等化フィルタ部と、データ判定部と、タップ係数演算部とを備え、タップ係数演算部ではタップ係数更新アルゴリズムに従い等化フィルタ部のタップ係数を更新する判定帰還形適応等化器部と、タップ付き遅延回路を有する等化フィルタ部と、データ判定部と、タップ係数演算部を備え、タップ係数演算部ではタップ係数更新アルゴリズムに従い等化フィルタ部のタップ係数を更新する線形適応等化器部と、伝送路の多重路伝搬特性を検出する遅延測定回路と、上記遅延測定回路の測定結果に基づいて、上記判定帰還形適応等化器部または、上記線形適応等化器部のいずれかを動作させ、等化出力とする手段を備え、上記遅延測定回路にて測定した多重路伝搬特性に対して等化特性が良いと思われる方の適応等化器部の出力を等化出力とするようにしたものである。

【００４０】上記の目的を達成するために、請求項６に係わる発明の適応ダイバーシチ等化器は、複数のアンテナと、複数のアンテナにより受信した複数の受信波を検波する複数の検波回路と、検波後の各信号をそれぞれの入力とする、フィードフォワード部（ＦＦ部）とフィードバック部（ＦＢ部）にタップ付き遅延回路を有する等化フィルタ部と、データ判定部と、タップ係数演算部とを備え、タップ係数演算部ではタップ係数更新アルゴリズムに従い等化フィルタ部のタップ係数を更新する複数の判定帰還形適応等化器部と、上記検波後の各信号をそれぞれの入力とする、タップ付き遅延回路を有する等化フィルタ部と、データ判定部と、タップ係数演算部を備え、タップ係数演算部ではタップ係数更新アルゴリズムに従い等化フィルタ部のタップ係数を更新する複数の線形適応等化器部と、上記各適応等化器部の等化誤差より定める値を比較する比較回路と、上記比較回路の結果に基づいて、上記複数の判定帰還形適応等化器部の等化出力または、上記複数の線形適応等化器部の等化出力のうちの一つを選択し、最終的な等化出力とする手段を備え、上記複数の判定帰還形適応等化器部および複数の線形適応等化器部の等化特性を比較し、等化特性が一番良い適応等化器部の出力を最終的な等化出力とするようにしたものである。

【００４１】上記の目的を達成するために、請求項７に係わる発明の適応ダイバーシチ等化器は、複数のアンテナと、複数のアンテナにより受信した複数の受信波を検波する複数の検波回路と、検波後の各信号をそれぞれの入力とする、フィードフォワード部（ＦＦ部）とフィードバック部（ＦＢ部）にタップ付き遅延回路を有する等化フィルタ部と、データ判定部と、タップ係数演算部とを備え、タップ係数演算部ではタップ係数更新アルゴリズムに従い等化フィルタ部のタップ係数を更新し、また、外部制御信号により動作を停止する複数の判定帰還形適応等化器部と、上記検波部の各信号をそれぞれの入力とする、タップ付き遅延回路を有する等化フィルタ部と、データ判定部と、タップ係数演算部を備え、タップ係数演算部ではタップ係数更新アルゴリズムに従い等化フィルタ部のタップ係数を更新し、また、外部制御信号により動作を停止する複数の線形適応等化器部と、上記各適応等化器部の等化誤差より定める値を比較する比較回路と、上記比較回路の結果に基づいて、上記複数の判定帰還形適応等化器部の等化出力または、上記複数の線形適応等化器部の等化出力のうちの一つを選択し、最終的な等化出力とするとともに、選択されなかった判定帰還形適応等化器部または、線形適応等化器部の動作を停止する手段を備え、上記複数の判定帰還形適応等化器部および複数の線形適応等化器部の等化特性を比較し、等化特性が一番良い適応等化器部の出力を最終的な等化出力とするとともに他の適応等化器部の動作を停止するようしたものである。

【００４２】上記の目的を達成するために、請求項８に係わる発明の適応ダイバーシチ等化器は、複数のアンテナと、複数のアンテナにより受信した複数の受信波を検波する複数の検波回路と、検波後の各信号をそれぞれの入力とする、フィードフォワード部（ＦＦ部）とフィードバック部（ＦＢ部）にタップ付き遅延回路を有する等化フィルタ部と、データ判定部と、タップ係数演算部とを備え、タップ係数演算部ではタップ係数更新アルゴリズムに従い等化フィルタ部のタップ係数を更新し、また、外部制御信号により動作を停止および再開する複数の判定帰還形適応等化器部と、上記検波後の各信号をそれぞれの入力とする、タップ付き遅延回路を有する等化フィルタ部と、データ判定部と、タップ係数演算部を備え、タップ係数演算部ではタップ係数更新アルゴリズムに従い等化フィルタ部のタップ係数を更新する複数の線形適応等化器部と、上記複数の判定帰還形適応等化器部にて、既知信号系列に対応する受信信号を等化する際の等化誤差からしきい値を定めるしきい値設定回路と、上記複数の線形適応等化器部にて、ランダム信号系列に対応する受信信号を等化する際の等化誤差より定まる値と上記しきい値を比較する第一の比較回路と、上記複数の線形適応等化器部より定まる値が上記しきい値より少な

くとも小さい場合には、複数の線形適応等化器部の等化出力の中の一つを選択し、最終的な等化出力とするとともに、複数の判定帰還形適応等化器部のランダム信号系列に対する等化を停止する手段と、上記線形適応等化器部より定まる値が上記しきい値より少なくとも大きい場合には、複数の判定帰還形適応等化器部にて、複数の受信信号における既知信号系列以外に対する等化を行なう手段と、上記線形適応等化器部より定まる値が上記しきい値より少なくとも大きい場合には、上記複数の判定帰還形適応等化器部による既知信号系列以外に対する受信信号の等化誤差より定めた値と、上記複数の線形適応等化器部より定まる値を比較する第二の比較回路と、上記線形適応等化器部より定まる値が上記しきい値より少なくとも大きい場合には、上記第二の比較回路の結果に基づいて、上記複数の判定帰還形適応等化器部の等化出力および上記複数の線形適応等化器部の等化出力の中の一つを選択し、最終的な等化出力とする手段を備え、上記複数の判定帰還形適応等化器部によるランダムデータの等化を行なわなくても良い場合は、複数の判定帰還形適応等化器部の動作を停止し、複数の判定帰還形適応等化器部によるランダムデータの等化を行なった場合でも、複数の判定帰還形適応等化器部および複数の線形適応等化器部の等化特性を比較し、等化特性が一番良い適応等化器部の出力を最終的な等化出力とするようにしたものである。

【００４３】上記の目的を達成するために、請求項９に係わる発明の適応等化器は、複数のアンテナと、複数のアンテナにより受信した複数の受信波を検波する複数の検波回路と、検波後の各信号をそれぞれの入力とする、フィードフォワード部（ＦＦ部）とフィードバック部（ＦＢ部）にタップ付き遅延回路を有する等化フィルタ部と、データ判定部と、タップ係数演算部とを備え、タップ係数演算部ではタップ係数更新アルゴリズムに従い等化フィルタ部のタップ係数を更新し、また、外部制御信号により動作を停止および再開する複数の判定帰還形適応等化器部と、タップ付き遅延回路を有する等化フィルタ部と、データ判定部と、タップ係数演算部を備え、タップ係数演算部ではタップ係数更新アルゴリズムに従い等化フィルタ部のタップ係数を更新し、また、外部制御信号により動作を停止および再開する複数の線形適応等化器部と、上記複数の判定帰還形適応等化器部と上記複数の線形適応等化器部の等化処理を任意のデータで一旦打ち切り、全ての等化器のタップ係数をリセット、再トレーニングを行なった後に再び等化処理を行なう手段と、等化処理を一旦打ち切るまでの上記複数の判定帰還形適応等化器部の等化誤差より定める値と、上記複数の線形適応等化器部の等化誤差より定める値を比較する比較回路と、上記比較回路の結果に基づいて、上記複数の判定帰還形適応等化器部の等化出力または、上記複数の線形適応等化器部の等化出力の中の一つを選択し、最終的な等化出力とする手段と、上記比較回路の結果に基づいて、上記判定帰還形適応等化器部の等化出力または、上記線形適応等化器部の等化出力の中から上記選択された等化出力を上記再トレーニング時に参照信号とする手段を備え、上記複数の判定帰還形適応等化器部および複数の線形適応等化器部の等化特性の差を任意のデータシンボル数毎に比較し、等化特性が一番良い適応等化器部の出力をそのデータシンボルに対する最終的な等化出力とするとともに、等化特性が一番良い適応等化器部の等化出力結果を用いて全ての適応等化器部の再トレーニングするようにしたものである。

【００４４】上記の目的を達成するために、請求項１０に係わる発明の適応ダイバーシチ等化器は、複数のアンテナと、複数のアンテナにより受信した複数の受信波を検波する複数の検波回路と、検波後の各信号をそれぞれの入力とする、フィードフォワード部（ＦＦ部）とフィードバック部（ＦＢ部）にタップ付き遅延回路を有する等化フィルタ部と、データ判定部と、タップ係数演算部とを備え、タップ係数演算部ではタップ係数更新アルゴリズムに従い等化フィルタ部のタップ係数を更新する複数の判定帰還形適応等化器部と、上記検波後の各信号をそれぞれの入力とする、タップ付き遅延回路を有する等化フィルタ部と、データ判定部と、タップ係数演算部を備え、タップ係数演算部ではタップ係数更新アルゴリズムに従い等化フィルタ部のタップ係数を更新する複数の線形適応等化器部と、検波後の各信号をそれぞれの入力とする伝送路の多重路伝搬特性を検出する複数の遅延測定回路の測定結果から、上記判定帰還形適応等化器部の等化出力または、上記複数の線形適応等化器部の等化出力のうちの一つを選択し、最終的な等化出力とする手段を備え、上記各遅延測定回路にて測定した多重路伝搬特性に対して等化特性が良いと思われる方の適応等化器部を各ブランチ毎に動作させ、そのブランチの等化出力とした後、各ブランチの等化出力の特性を比較し、等化特性が一番良い適応等化器部の出力を最終的な等化出力とするようにしたものである。

【００４５】

【作用】以上のように構成された請求項１に係わる発明の適応等化器では、遅延波の遅延時間が大きい周波数選択性フェージング下において等化特性が良い判定帰還形適応等化器部と、遅延波の遅延時間が小さい周波数選択性フェージング下および遅延波がないフェージング下において等化特性が良い線形適応等化器部を用いて等化を行い、等化特性の良い方の出力結果を最終的な等化出力とするために、フェージング下において遅延波の有無、また遅延波の遅延時間の大小にかかわらず良好な等化特性がえらえる。

【００４６】以上のように構成された請求項２に係わる発明の適応等化器では、遅延波の遅延時間が大きい周波数選択性フェージング下において等化特性が良い判定帰

還形適応等化器部と、遅延波の遅延時間が小さい周波数選択性フェージング下および遅延波がないフェージング下において等化特性が良い線形適応等化器部を用いて等化を行い、等化特性の良い方の出力結果を最終的な等化出力とするために、フェージング下において遅延波の有無、また遅延波の遅延時間の大小にかかわらず良好な等化特性がえられるとともに、等化特性の比較をバースト途中までのデータに対して行い、等化特性が悪いほうの等化器の演算を停止することによって、適応等化器全体の演算量を低減することができる。

【００４７】以上のように構成された請求項３に係わる発明の適応等化器では、判定帰還形適応等化器部にて、まず、既知信号系列に対する受信信号のみの等化を行い、等化誤差からしきい値を定め、次に線形適応等化器部を用いて１バースト分の受信信号に対して等化を行いその時の等化誤差より定まる値としきい値を比較する。そして、線形適応等化器部の等化誤差より定まる値がしきい値より低い場合には、線形適応等化器部の出力を最終的な等化出力とし、また、線形適応等化器部の等化誤差より定まる値がしきい値より少なくとも大きい場合には、判定帰還形適応等化器部にて既知信号系列以降の受信信号の等化を行いその等化誤差より定まる値と、先に求めた線形適応等化器部の等化誤差より定まる値を比較し、等化特性の良い方の出力結果を最終的な等化出力とする。このために、フェージング下において遅延波の有無、また遅延波の遅延時間の大小にかかわらず良好な等化特性がえられるとともに、判定帰還形適応等化器部の特性を既知信号の部分で判断し線形適応等化器部と比較して、等化特性が良いと思われるときのみ既知信号以降のデータにたいして等化を行うために適応等化器全体の演算量を低減することができる。

【００４８】以上のように構成された請求項４に係わる発明の適応等化器では、１バースト中の信号に対して等化処理を打ち切り、判定帰還形適応等化器部と線形等化器部とのタップ係数をリセットし、それまでの判定帰還形適応等化器部の等化誤差より定める値と線形適応等化器部の等化誤差より定める値を比較し、等化誤差より定める値が小さい方の適応等化器部のメモリ出力を選択し、それまでの等化出力とするとともに、等化誤差より定める値が小さい方の等化出力の、等化処理を打ち切る前の数シンボルの値を次の等化処理の既知参照信号として判定帰還形適応等化器部と線形適応等化器部を再トレーニングするので、伝送路特性の変動に対する追従性が改善さえるとともにフェージング下において遅延波の有無、また遅延波の遅延時間の大小にかかわらず良好な等化特性が得られる。

【００４９】以上のように構成された請求項５に係わる発明の適応等化器では、遅延測定回路により、伝送路の状態を測定し、遅延波の遅延時間が大きい場合には、周波数選択性フェージング下において等化特性が良い判定帰還形適応等化器部を用いて等化を行い、遅延波の遅延時間が小さい場合には、遅延波の遅延時間が小さい周波数選択性フェージング下および遅延波がないフェージング下において等化特性が良い線形適応等化器部を用いて等化を行うために、フェージング下において遅延波の有無、また遅延波の遅延時間の大小にかかわらず良好な等化特性がえられる。

【００５０】以上のように構成された請求項６の係わる発明の適応ダイバーシチ等化器では、複数のアンテナおよび検波器の出力信号それぞれに対して遅延波の遅延時間が大きい周波数選択性フェージング下において等化特性が良い判定帰還形適応等化器部と、遅延波の遅延時間が小さい周波数選択性フェージング下および遅延波がないフェージング下において等化特性が良い線形適応等化器部を用いて等化を行い、等化特性が一番良い適応等化器部の出力結果を最終的な等化出力とするために、フェージング下において、ダイバーシチ効果により受信特性が向上するとともに、遅延波の有無、また遅延波の遅延時間の大小にかかわらず良好な特性がえられる。

【００５１】以上のように構成された請求項７に係わる発明の適応ダイバーシチ等化器では、複数のアンテナおよび検波器の出力信号それぞれに対して遅延波の遅延時間が大きい周波数選択性フェージング下において等化特性が良い判定帰還形適応等化器部と、遅延波の遅延時間が小さい周波数選択性フェージング下および遅延波がないフェージング下において等化特性が良い線形適応等化器部を用いて等化を行い、等化特性が一番良い適応等化器部の出力結果を最終的な等化出力とするために、フェージング下において、ダイバーシチ効果により受信特性が向上するとともに遅延波の有無、また遅延波の遅延時間の大小にかかわらず良好な等化特性がえられ、また、等化特性の比較をバースト途中までのデータに対して行い、等化特性が一番良い適応等化器部以外の適応等化器部の演算を停止することによって、適応ダイバーシチ等化器全体の演算量を低減することができる。

【００５２】以上のように構成された請求項８に係わる発明の適応ダイバーシチ等化器では、複数のアンテナおよび検波器の出力信号それぞれに対して、判定帰還形適応等化器部にて、まず、既知信号系列に対する受信信号のみの等化を行い、その等化誤差からしきい値を定め、次に同じく複数のアンテナおよび検波器の出力信号それぞれに対して線形適応等化器部にて１バースト分の受信信号に対して等化を行い、等化誤差より定める値と上記しきい値を比較する。そして、線形適応等化器部の等化誤差より定める値がしきい値より低いものがある場合には、その中で等化誤差より定める値が一番小さい線形適応等化器部の出力を最終的な等化出力とし、また、全ての線形適応等化器部の等化誤差より定める値が上記しきい値より大きい場合には、複数のアンテナおよび検波器の出力信号それぞれに対して、判定帰還形適応等化器部

にて既知信号系列以降の受信信号の等化を行いその等化誤差より定める値と、先に求めた複数の線形適応等化器部の等化誤差より定める値と比較し等化特性が一番良い出力結果を最終的な等化出力とする。このため、フェージング下においてダイバーシチ効果により受信特性が向上するとともに、遅延波の有無、また遅延波の遅延時間の大小にかかわらず良好な等化特性がえられるとともに、複数のアンテナおよび検波器の出力信号に対する判定帰還形適応等化器部の特性を既知信号の部分で判断し、複数のアンテナおよび検波器の出力信号に対する線形適応等化器部の特性と比較して、等化特性が良いと思われるときのみ判定帰還形適応等化器部にて既知信号以降のデータにたいして等化を行うために適応ダイバーシチ等化器全体の演算量を低減することができる。

【００５３】以上のように構成された請求項９に係わる発明の適応ダイバーシチ等化器では１バースト中の信号に対して等化処理を打ち切り、すべての判定帰還形適応等化器部と線形適応等化器部とのタップ係数をリセットし、それまでの複数のアンテナおよび検波器の出力信号それぞれに対する判定帰還形適応等化器部の等化誤差より定める値と線形適応等化器部の等化誤差より定める値を比較し、等化誤差より定める値が一番小さい適応等化器部のメモリ出力を選択し、それまでの等化出力とするとともに、等化誤差より定める値が、一番小さい等化出力の等化処理を打ち切る前の数シンボルの値を次の等化処理の既知参照信号として全ての判定帰還形適応等化器部と線形適応等化器部を再トレーニングするので、伝送路特性の変動に対する追従性が改善され、また、フェージング下においてダイバーシチ効果により受信特性が向上するとともに、遅延波の有無、また遅延波の遅延時間の大小にかかわらず良好な等化特性がえられる。

【００５４】以上のように構成された請求項１０に係わる発明の適応ダイバーシチ等化器では、複数のアンテナおよび検波器の出力信号それぞれに対して、遅延測定回路により伝送路の状態を測定し、各ブランチにおいて遅延波の遅延時間が大きい場合には、遅延波の遅延時間が大きい周波数選択性フェージング下において等化特性が良い判定帰還形適応等化器部を動作させ、また、各ブランチにおいて遅延波の遅延時間が小さい場合、または遅延波がない場合には、遅延波の遅延時間が小さい周波数選択性フェージング下および遅延波がないフェージング下において等化特性が良い線形適応等化器部を動作させ、次に、各ブランチ間で等化特性が一番良い適応等化器部の出力結果を最終的な等化出力とするために、フェージング下において、ダイバーシチ効果により受信特性が向上するとともに、遅延波の有無、また遅延波の遅延時間の大小にかかわらず良好な特性がえられる。

【００５５】

【実施例】実施例１．以下、請求項１に係わる発明の実施例１について説明する。図１はこの発明の適応等化器の実施例１を示す構成ブロック図である。図中、従来例と同一部分には同一符号を付し説明を省く。図１において、４０は１バースト分の受信信号を蓄える受信信号メモリ、４１は受信信号メモリ４０より受信信号を読み出し等化を行う判定帰還形適応等化器、４２は受信信号メモリ４０より受信信号を読み出し等化を行う線形適応等化器である。なお、ここで、線形適応等化器とは、判定帰還形適応等化器において、フィードバック部（ＦＢ部）がないものを意味している。また、４３は判定帰還形適応等化器４１の等化出力を記憶する等化出力メモリａ、４４は線形適応等化器４２の等化出力を記憶する等化出力メモリｂ、４５は判定帰還形適応等化器４１の等化２乗誤差を積算する等化２乗誤差積算回路ａ、４６は線形適応等化器４２の等化２乗誤差を積算する等化２乗誤差積算回路ｂ、４７は等化２乗誤差積算回路ａ４５の出力と等化２乗誤差積算回路ｂ４６の出力の大小を比較しその結果を出力制御信号として出力する比較回路、４８は比較回路４７の出力制御信号にしたがって等化出力メモリａ４３と等化出力メモリｂ４４の出力を切り替える出力選択スイッチである。

【００５６】図１の適応等化器の動作について説明する。受信信号メモリ４０は受信信号を蓄える。判定帰還形適応等化器４１では、受信信号メモリ４０よりデータを読み出し、図１５に示す等化器の動作の項で示したようにＵＷ１１を用いて伝送路の特性を推定しタップ係数を収束させる。次いでランダムデータ部１２について等化を行なう。そして、ランダムデータ部１２の等化時には、式４で示す誤差値を等化２乗誤差積算回路ａ４５に出力する。また、等化出力メモリａ４３にランダムデータ部１２の等化結果を出力する。線形適応等化器４２では、受信信号メモリ４０よりデータを読み出し、図１５に示す等化器の動作の項で示したように、ＵＷ１１を用いて伝送路の特性を推定しタップ係数を収束させる。次いで、ランダムデータ部１２について等化を行なう。そして、ランダムデータ部１２の等化時には、式４で示す誤差信号を等化２乗誤差積算回路ｂ４６に出力する。また、等化出力メモリｂ４４にランダムデータ部１２の等化結果を出力する。

【００５７】等化２乗誤差積算回路ａ４５では、判定帰還形適応等化器４１のランダムデータ部１２の等化部に出力された誤差値を２乗しその１バースト分の和を求め、その結果を比較回路４７に出力する。等化２乗誤差積算回路ｂ４６では、線形適応等化器４２のランダムデータ部１２の等化時に出力された誤差値を２乗しその１バースト分の和を求め、その結果を比較回路４７に出力する。

【００５８】比較回路４７では等化２乗誤差積算回路ａ４５の出力結果と、等化２乗誤差積算回路ｂ４６の出力結果を比較し、等化２乗誤差積算回路ａ４５の等化２乗誤差の和の方が小さい場合、すなわち、そのバーストに

対して判定帰還形適応等化器４１の等化特性の方が、線形適応等化器４２の等化特性より良い場合には、出力選択スイッチ４８に等化出力メモリａ４３と接続する制御信号を出力する。等化２乗誤差積算回路ｂ４６の等化２乗誤差の和の方が小さい場合、すなわち、そのバーストに対して線形適応等化器４２の等化特性の方が、判定帰還形適応等化器４１の等化特性より良い場合には、出力選択スイッチ４８に等化出力メモリｂ４４と接続する制御信号を出力する。等化出力メモリａ４３または、等化出力メモリｂ４４は、出力選択スイッチ４８と接続した後、比較回路４７からの制御信号によって、最終的な等化出力としてそのメモリ内の等化結果を出力する。

【００５９】図２は、本実施例１による等化特性の改善効果を示す一例である。図２は、周波数選択性フェージング下において、ドップラー周波数及び受信信号の１ビット当たりの平均信号電力対雑音比（Ｅｂ／Ｎｏ）が一定で、遅延波の正規化遅延時間τを可変としたときの、ＦＦ部のタップ数４（分数間隔数Ｔ／２：Ｔは１シンボル）およびＦＢ部のタップ数１の判定帰還形適応等化器単体の誤り率特性例、タップ数を２（分数間隔数Ｔ／２：Ｔは１シンボル）とした線形適応等化器単体の誤り率特性例、本実施例１の適応等化器の誤り率特性例を示す図である。図２で示すように判定帰還形適応等化器４１単体では、発明が解決しようとしている課題の項で述べたように遅延波の正規化遅延時間τが１より小さくなるにつれて誤り率特性は劣化する。線形適応等化器４２では、タップ数が少なく、また、判定帰還でないため、τ＝０（一波レイリー）での特性が一番良く、τが大きくなるにつれて特性が急激に劣化する。それに対して本実施例１で示す適応等化器では、２つの適応等化器の等化特性をバースト単位で比較し等化特性の良いほうの出力を選択し最終的な等化出力とするので、τ＝０およびτが小さい場合には、線形適応等化器４２の等化出力を選択し、τが大きい場合には判定帰還形適応等化器４１の等化出力を選択するためにτの大きさにかかわらずτ≦１においてほぼ一定の誤り率特性を示す。

【００６０】なお、本実施例１では、１バースト分のランダムデータの等化２乗誤差の和に従って、出力選択スイッチ４８を判定帰還形適応等化器４１の出力と線形適応等化器４２の出力とに切り替えたが、１バースト分のランダムデータをｎ分割し（ｎ：整数）、分割されたデータ毎に判定帰還形適応等化器４１の等化２乗誤差の和および線形適応等化器４２の等化２乗誤差の和を求め比較し、出力の選択をその分割されたデータ毎に行っても良い。

【００６１】また、本実施例１では、１バースト分のランダムデータの等化２乗誤差の和に従って、出力選択スイッチ４８を判定帰還形適応等化器４１の出力と線形適応等化器４２の出力とに切り替えたが、任意の数バースト分のランダムデータの判定帰還形適応等化器４１の等化２乗誤差の和および線形適応等化器４２の等化２乗誤差の和を求め比較し、メモリ出力の選択をその数バースト毎に行っても良い。

【００６２】実施例２．以下、請求項２に係わる発明の実施例２について説明する。図３はこの発明の適応等化器の実施例２を示す構成ブロック図である。図中、従来例および実施例１と同一部分には同一符号を付し説明を省く。図３において、４９は受信信号メモリ４０より受信信号を読み出し等化を行うとともに外部からの制御信号によって動作を停止する判定帰還形適応等化器、５０は受信信号メモリ４０より受信信号を読み出し、等化を行なうとともに外部からの制御信号によって動作を停止する線形適応等化器、５１は判定帰還形適応等化器４９の等化出力を記憶する等化出力メモリａ、５２は線形適応等化器５０の等化出力を記憶する等化出力メモリｂ、５３は判定帰還形適応等化器４９の等化２乗誤差を積算する等化２乗誤差積算回路ａ、５４は線形適応等化器５０の等化２乗誤差を積算する等化２乗誤差積算回路ｂ、５５は等化２乗誤差積算回路ａ５３の出力と等化２乗誤差積算回路ｂ５４の出力の大小を比較しその結果を用いて出力制御信号を出力選択スイッチ４８、判定帰還形適応等化器４９、線形適応等化器５０に出力する比較回路である。

【００６３】図３の適応等化器の動作について説明する。判定帰還形適応等化器４９では、受信信号メモリ４０よりデータを読み出し、図１５に示す等化器の動作の項で示したようにＵＷ１１を用いて伝送路の特性を推定し、タップ係数を収束させる。次いでランダムデータ部１２について等化を行なう。そして、ランダムデータ部１２の等化時には、式４で示す誤差値を等化２乗誤差積算回路ａ５３に１シンボル毎に出力する。また、等化出力メモリａ５１にランダムデータ部１２の等化結果を１シンボル毎に出力する。線形適応等化器５０では、受信信号メモリ４０よりデータを読み出し、図１５に示す等化器の動作の項で示したように、ＵＷ１１を用いて伝送路の特性を推定し、タップ係数を収束させる。次いで、ランダムデータ部１２について等化を行なう。そして、ランダムデータ部１２の等化時には、誤差値を１シンボル毎に等化２乗誤差積算回路ｂ５４に出力する。また、等化出力メモリｂ５２にランダムデータ部１２の等化結果を１シンボル毎に出力する。

【００６４】等化２乗誤差積算回路ａ５３では、判定帰還形適応等化器４９のランダムデータ部１２の等化時に出力される誤差値を２乗し、そのランダムデータｍシンボル分（ｍは整数）の和を求め、その結果を比較回路５５に出力する。等化２乗誤差積算回路ｂ５４では、線形適応等化器５０のランダムデータ部１２の等化時に出力された誤差値を２乗し、そのランダムデータｍシンボル分（ｍは整数）の和を求め、その結果を比較回路５５に出力する。

【００６５】比較回路５５では等化２乗誤差積算回路ａ５３の出力結果と、等化２乗誤差積算回路ｂ５４の出力結果を比較し、等化２乗誤差積算回路ａ５３の出力の方が小さい場合、すなわち、そのバーストに対して判定帰還形適応等化器４９の等化特性の方が、線形適応等化器５０の等化特性より良いと予想される場合には、出力選択スイッチ４８に等化出力メモリａ５１と接続する制御信号を出力するとともに線形適応等化器５０に停止信号を出力する。線形適応等化器５０は、この制御信号により同バーストの残りのランダムデータに対する等化を中止する。また、等化２乗誤差積算回路ｂ５４の出力の方が小さい場合は、出力選択スイッチ４８に、等化出力メモリｂ５２と接続する制御信号を出力するとともに、判定帰還形適応等化器４９に停止信号を出力する。判定帰還形適応等化器４９は、この制御信号により同バーストの残りのランダムデータに対する等化を中止する。

【００６６】等化出力メモリａ５１、または等化出力メモリｂ５２では、出力選択スイッチ４８が接続した後に、比較回路５５からの制御信号によって、最終的な等化出力としてそのメモリ内の等化結果を出力する。

【００６７】なお、本実施例２では、１バースト毎に１回、等化２乗誤差の和の比較、演算停止を行っているが、受信バーストの間隔が短く伝送路の変動がゆっくりしている場合には、等化２乗誤差の和の比較および演算停止をｍバースト（ｍ＝２，３，４…）毎に１回行っても良い。

【００６８】実施例３．以下、請求項３に係わる発明の実施例３について説明する。図４はこの発明の適応等化器の実施例３を示す構成ブロック図である。図中、従来例および実施例１，２と同一部分には同一符号を付し説明を省く。図４において、５６は受信信号メモリ４０より受信信号を読み出しＵＷ１１の等化を行い、その後、外部からの制御信号によりランダムデータ部１２の等化を行なう判定帰還形適応等化器、５７は受信信号メモリ４０より受信信号を読み出し等化を行なう線形適応等化器、５８はＵＷ１１の等化後のタップ係数、ＵＷ１１に対応する受信信号よりしきい値を定めるしきい値設定回路、５９は線形適応等化器５７の等化２乗誤差を積算する等化２乗誤差積算回路ｂ、６０は等化２乗誤差積算回路ｂの出力を積算シンボル数で平均をとる等化２乗誤差積算回路、６１は等化２乗誤差積算回路６０の出力である等化２乗誤差平均値と、しきい値設定回路５８の出力を比較し、等化２乗誤差平均値がしきい値より小さい場合には、線形適応等化器選択信号を出力し、そうでない場合には選択保留信号を出力する比較回路ａ、６２は判定帰還形適応等化器５６の等化出力を記憶する等化出力メモリａ、６３は線形適応等化器５７の等化出力を記憶する等化出力メモリｂ、６４は判定帰還形適応等化器５６の等化２乗誤差を積算する等化２乗誤差積算回路ａ、６５は等化２乗誤差積算回路ａ６４の出力と等化２乗誤差積算回路ｂ５９の出力の大小を比較しその結果を用いて出力制御信号を出力選択スイッチ４８、等化出力メモリａ６２、等化出力メモリｂ６３に出力する比較回路ｂである。

【００６９】図４の適応等化器の動作について説明する。図５は図４に示す適応等化器の動作を説明するフローチャートである。Ｓ１において、判定帰還形適応等化器５６では、図１５に示す等化器の動作の項で示したようにＵＷ１１を用いて伝送路の特性を推定しタップ係数を収束させる。次にそのタップ係数を固定としたまま、再びＵＷ１１に対応する受信入力データおよび参照信号を入力信号とし、１シンボル毎に積和演算を行いその結果と参照信号の差をとり１シンボル毎の誤差を求める。そして、固定したタップ係数値と１シンボル毎の誤差を、しきい値設定回路５８に出力する。

【００７０】しきい値設定回路５８は、上記固定したＦＦ部のタップ係数の絶対値の和を求める積算回路ａ、ＦＢ部のタップ係数の絶対値の和を求める積算回路ｂ、ＦＦ部のタップ係数の絶対値の和とＦＢ部のタップ係数の絶対値の和の比ＦＦＲを求める除算回路、上記１シンボル毎の誤差を２乗して和をとる２乗誤差積算回路、この２乗誤差の和を平均しＭＳＥ１を定める平均回路、さらに、ＭＳＥ１にＦＦＲと適当な定数αを乗じ、ＭＳＥ１１を定める乗算器によって構成される。

【００７１】Ｓ２において、しきい値設定回路５８では、まず、積算回路ａ、積算回路ｂにて、ＦＦ部のタップ係数値の絶対値の和ＳＦＦ、ＦＢ部のタップ係数値の絶対値の和ＳＦＢを定める。次に、除算回路で、この比ＦＦＲを求める。

【００７２】

【数５】

$$SFF=|C_1(n)|+|C_2(n)|+\cdots+|C_L(n)| \tag{13}$$

$$SFB=|C_{L+1}(n)|+|C_{L+2}(n)|+\cdots+|C_M(n)| \tag{14}$$

$$FFR=SFF/SFB \tag{15}$$

【００７３】次に、上記２乗誤差積算回路と、平均回路にて２乗誤差平均値ＭＳＥ１を定める。さらに上記乗算回路にて、ＦＦＲ、定数αを乗じＭＳＥ１１を定め、比較回路ａ６１に出力する。

【００７４】

$$MSE11=MSE1*FFR*\alpha \quad (16)$$

【００７５】ここで、ＦＦＲを求めるのは、伝送路における先行波と、遅延波の大きさの比の簡易推定を行なうもので、例えば、遅延波の大きさが小さい場合には、遅延波の影響を打ち消すＦＢ部のタップ係数の絶対値も小さくなり、ＦＦＲは大きくなる。そして、ＭＳＥ１１も大きくなる。また、逆に遅延波の大きさが大きい場合には、ＦＢ部のタップ係数の絶対値も大きくなり、ＦＦＲは小さくなる。そして、ＭＳＥ１１も小さくなる。これは、遅延波の大きさが小さい場合には、線形適応等化器５７の等化出力を選択する確率を高くし、遅延波の大きさが大きい場合には、判定帰還形適応等化器５６の等化出力を選択する確率を高くしている。

【００７６】Ｓ３において、線形適応等化器５７では、図１５に示す等化器の動作の項で示したようにＵＷ１１を用いて伝送路の特性を推定しタップ係数を収束させる。次いでランダムデータ部１２について等化を行なう。そして、ランダムデータ部１２の等化時には、式４で示す誤差信号を等化２乗誤差積算回路ｂ５９に出力する。また、等化出力メモリｂ６３にランダムデータ部１２の等化結果を出力する。等化２乗誤差積算回路ｂ５９では、線形適応等化器５７のランダムデータ部１２の等化時に出力された誤差値を２乗し、その１バースト分の和ＳＥ２を求め、その結果を等化２乗誤差平均回路６０と比較回路ｂ６５に出力する。等化２乗誤差平均回路６０では、ＳＥ２をランダムデータ部１２のシンボル数で除算し、平均値ＭＳＥ２を求め、比較回路ａ６１に出力する。この平均値ＭＳＥ２もＳ２において求められるＭＳＥ１と同様に、伝送路の信号対雑音比が小さいと大きくなる。

【００７７】Ｓ４において、比較回路ａ６１では、しきい値ＭＳＥ１１と平均値ＭＳＥ２を比較し、ＭＳＥ２＜ＭＳＥ１１の場合には、線形適応等化器選択信号を比較回路ｂ６５に出力し、そうでない場合には選択保留信号を比較回路ｂ６５と判定帰還形適応等化器５６に出力する。

【００７８】ＭＳＥ２＜ＭＳＥ１１の場合には、Ｓ５において、比較回路ｂ６５では出力選択スイッチ４８に等化出力メモリｂ６３と接続する制御信号を出力する。また、等化出力メモリｂ６３では、出力選択スイッチ４８が接続した後に、比較回路ｂ６５からの制御信号によって、最終的な等化出力としてそのメモリ内の等化結果を出力する。

【００７９】ＭＳＥ２≧ＭＳＥ１１の場合には、Ｓ６にて、判定帰還形適応等化器５６は、比較回路ａ６１より出力された選択保留信号を受けて、ランダムデータ部１２について等化を行なう。そして、ランダムデータ部１２の等化時には、誤差値を等化２乗誤差積算回路ａ６４に出力する。また、等化出力メモリａ６２にランダムデータ部１２の等化結果を出力する。等化２乗誤差積算回路ａ６４では、判定帰還形適応等化器５６のランダムデータ部１２の等化時に出力された式４で示される誤差信号を２乗しその１バースト分の和ＳＥ３を求め比較回路ｂ６５に出力する。

【００８０】Ｓ７において、比較回路ｂ６５では、等化２乗誤差積算回路ａ６４の出力結果ＳＥ３と、先に入力されているＳＥ２の大きさを比較する。ＳＥ２＜ＳＥ３の場合には、そのバーストに対して線形適応等化器５７の等化特性の方が、判定帰還形適応等化器５６の等化特性より良いと考えられるので、出力選択スイッチ４８に等化出力メモリｂ６３と接続するスイッチ制御信号を出力する。また、等化出力メモリｂ６３では、出力選択スイッチ４８に接続した後、比較回路ｂ６５からの制御信号によって、最終的な等化出力としてそのメモリ内の等化結果を出力する。

【００８１】Ｓ８において、比較回路ｂ６５で、ＳＥ２≧ＳＥ３の場合には、そのバーストに対して判定帰還形適応等化器５６の等化特性の方が、線形適応等化器５７の等化特性より良いと考えられるので、比較回路ｂ６５では出力選択スイッチ４８に等化出力メモリａ６２と接続する制御信号を出力する。また、等化出力メモリａ６２では、出力選択スイッチ４８が接続した後に、比較回路ｂ６５からの制御信号によって、最終的な等化出力としてそのメモリ内の等化結果を出力する。

【００８２】なお、本実施例３では、しきい値設定回路５８で、判定帰還形適応等化器５６から出力されたタップ係数値に対して、ＦＦ部のタップ係数の絶対値の和とＦＢ部のタップ係数の絶対値の和の比ＦＦＲを求めているが、これはＦＦ部のタップ係数の２乗値の和とＦＢ部のタップ係数の２乗値の和の比としてかまわない。

【００８３】また、本実施例３では、しきい値設定回路５８で、判定帰還形適応等化器５６から出力されたタップ係数値に対して、ＦＦ部のタップ係数の絶対値の和とＦＢ部のタップ係数の絶対値の和の比ＦＦＲを求めているが、この計算を行わず、ＦＦＲ＝１としてもかまわない。

【００８４】実施例４．以下、請求項４に係わる発明の実施例４について説明する。図６はこの発明の適応等化器の実施例４を示す構成ブロック図である。図中、従来例と同一部分には同一符号を付し説明を省く。図６において、６６は受信信号メモリ４０より受信信号を読み出しＵＷ１１の等化を行い、その後、外部からの制御信号により、タップ係数のリセット、ランダムデータ部１２の等化を行なう判定帰還形適応等化器、６７は受信信号メモリ４０より受信信号を読み出しＵＷ１１の等化を行い、その後、外部からの制御信号によりタップ係数のリセット、ランダムデータ部１２の等化を行なう線形適応

等化器、６８は判定帰還形適応等化器６６より出力される等化２乗誤差を積算する等化２乗誤差積算回路ａ、６９は線形適応等化器６７より出力される等化２乗誤差を積算する等化２乗誤差積算回路ｂ、７０は判定帰還形適応等化器６６より出力される等化出力を記憶する等化出力メモリａ、７１は線形適応等化器６７より出力される等化出力を記憶する等化出力メモリｂ、７２は等化２乗誤差積算回路ａ６８の出力と等化２乗誤差積算回路ｂ６９の出力の大小を比較しその結果を等化出力メモリａ７０、等化出力メモリｂ７１、制御部７４に出力する比較回路、７３は等化出力メモリａ７０、等化出力メモリｂ７１から出力されるデータを１バースト分蓄えた後に出力する等化出力メモリｃ、７４は判定帰還形適応等化器６６、線形適応等化器６７の動作を制御する制御部である。

【００８５】図６の適応等化器の動作について説明する。図７は図６に示す適応等化器の動作を説明するフローチャートである。また、図８は、図６に示す適応等化器の動作を説明する図である。Ｓ１において、判定帰還形適応等化器６６では、受信信号メモリ４０よりデータを読み出し、ＵＷ１１を用いて伝送路の特性を推定しタップ係数を収束させる。次いでランダムデータ部１２について一定のシンボル数（ｍ１）等化を行なう。そして、ランダムデータ部１２の等化時には、式４で示す誤差値を等化２乗誤差積算回路ａ６８に出力する。また、等化出力メモリａ７０にランダムデータｍ１の等化結果を出力する。また、線形適応等化器６７においても、受信信号メモリ４０よりデータを読み出し、ＵＷ１１を用いて伝送路の特性を推定しタップ係数を収束させる。次いでランダムデータ部１２について一定のシンボル数（ｍ１）等化を行なう。そして、ランダムデータ部１２の等化時には、式４で示す誤差値を等化２乗誤差積算回路ｂ６９に出力する。また、等化出力メモリｂ７１にランダムデータｍ１個の等化結果を出力する。

【００８６】Ｓ２において、等化２乗誤差積算回路ａ６８では、判定帰還形適応等化器６６におけるランダムデータの等化時に出力されたｍ１個の誤差値をそれぞれ２乗した後に、その和ＳＥ１１を求め、その結果を比較回路７２に出力する。等化２乗誤差積算回路ｂ６９では、線形適応等化器６７におけるランダムデータの等化時に出力されたｍ１個の誤差値をそれぞれ２乗した後に、その和ＳＥ２１を求め、その結果を比較回路７２に出力する。

【００８７】Ｓ３において、比較回路７２では、ＳＥ１１とＳＥ２１を比較する。

【００８８】ＳＥ１１≦ＳＥ２１の場合、Ｓ４ａにおいて、比較回路７２では、選択信号１を判定帰還形適応等化器６６、線形適応等化器６７、等化出力メモリａ７０、等化出力メモリｂ７１に出力する。また、制御部７４に選択終了信号を出力する。等化出力メモリａ７０は、選択信号１を受けた場合には、ｍ１シンボルの等化出力を等化出力メモリｃ７３に書き込む。

【００８９】ＳＥ１１＞ＳＥ２１の場合、Ｓ４ｂにおいて、比較回路７２では、選択信号２を判定帰還形適応等化器６６、線形適応等化器６７、等化出力メモリａ７０、等化出力メモリｂ７１に出力する。また、制御部７４に選択終了信号を出力する。等化出力メモリｂ７１は、選択信号２を受けた場合にはｍ１シンボルの等化出力を等化出力メモリｃ７３に書き込む。

【００９０】Ｓ５において、制御部７４では選択終了信号を受けた後、判定帰還形適応等化器６６、線形適応等化器６７のタップ係数、およびタップ係数更新アルゴリズムを初期化する。

【００９１】Ｓ６ａにおいて、判定帰還形適応等化器６６では、上記初期化の後、選択信号１を受けた場合には等化出力メモリａ７０よりｍ１個のデータ系列の後半部ｍ２個（ｍ１＞ｍ２）の等化出力を読み込む。次に、この値を参照信号として伝送路の特性を推定しタップ係数を収束させる。次いでｍ１シンボル以降のランダムデータについて一定のシンボル数（ｍ３）等化を行なう。線形適応等化器６７でも、上記初期化の後、選択信号１を受けた場合には等化出力メモリａ７０よりｍ１個のデータ系列の後半部２個（ｍ１＞ｍ２）の等化出力を読み込む。次に、この値を参照信号として伝送路の特性を推定しタップ係数を収束させる。次いでｍ１シンボル以降のランダムデータについて一定のシンボル数（ｍ３）等化を行なう。Ｓ６ｂにおいて、判定帰還形適応等化器６６では、上記初期化の後、選択信号２を受けた場合には等化出力メモリｂ７１よりｍ１個のデータ系列の後半部ｍ２個（ｍ１＞ｍ２）の等化出力を読み込む。次に、この値を参照信号として伝送路の特性を推定しタップ係数を収束させる。次いでｍ１シンボル以降のランダムデータについて一定のシンボル数（ｍ３）等化を行なう。線形適応等化器６７でも、上記初期化の後、選択信号２を受けた場合には等化出力メモリｂ７１よりｍ１個のデータ系列の後半部ｍ２個（ｍ１＞ｍ２）の等化出力を読み込む。次に、この値を参照信号として伝送路の特性を推定しタップ係数を収束させる。次いでｍ１シンボル以降のランダムデータについて一定のシンボル数（ｍ３）等化を行なう。

【００９２】Ｓ７において、等化２乗誤差積算回路ａ６８では、Ｓ６における判定帰還形適応等化器６６のランダムデータ等化時に出力されたｍ３個の誤差値をそれぞれ２乗した後に、その和ＳＥ１２を求め、その結果を比較回路７２に出力する。等化２乗誤差積算回路ｂ６９でも同じくＳ６における線形適応等化器６７のランダムデータ等化時に出力されたｍ３個の誤差値をそれぞれ２乗した後に、その和ＳＥ２２を求め、その結果を比較回路７２に出力する。

【００９３】Ｓ８において、比較回路７２では、ＳＥ１

２とＳＥ２２を比較する。

【００９４】ＳＥ１２≦ＳＥ２２の場合、Ｓ９ａにおいて、比較回路７２では、選択信号１を判定帰還形適応等化器６６、線形適応等化器６７、等化出力メモリａ７０、等化出力メモリｂ７１に出力する。等化出力メモリａ７０は、選択信号１を受けた場合にはｍ３シンボルの等化出力を等化出力メモリｃ７３に書き込む。ＳＥ１２＞ＳＥ２２の場合、Ｓ９ｂにおいて、比較回路７２では、選択信号２を判定帰還形適応等化器６６、線形適応等化器６７、等化出力メモリａ７０、等化出力メモリｂ７１に出力する。等化出力メモリｂ７１は、選択信号２を受けた場合にはｍ３シンボルの等化出力を等化出力メモリｃ７３に書き込む。制御部７４に比較終了信号を出力する。

【００９５】１バースト分のデータの等化が終了していない場合には、Ｓ５からＳ９の動作を繰り返し、１バースト分の等化が終了した後に、等化出力メモリｃ７３より最終的な等化出力を出力する。

【００９６】実施例５．以下、請求項５に係わる発明の実施例５について説明する。図９はこの発明の適応等化器の実施例５を示す構成ブロック図である。図中、従来例と同一部分には同一符号を付し説明を省く。図９において、４０は１バースト分の受信信号を蓄える受信信号メモリ、７５は受信信号メモリ４０より受信信号を読み出し、伝送路における多重路伝搬特性を測定し、制御信号を出力する遅延測定回路、７６は遅延測定回路７５の制御信号により、受信信号メモリ４０より受信信号を読み出し等化を行なう判定帰還形適応等化器、７７は遅延測定回路７５の制御信号により、受信信号メモリ４０より受信信号を読み出し等化を行なう線形適応等化器、７８は判定帰還形適応等化器７６の等化出力または線形適応等化器７７の等化出力を記憶する等化出力メモリである。

【００９７】図９の適応等化器の動作について説明する。受信信号メモリ４０は受信信号を蓄える。遅延測定回路７５は、ＵＷと入力信号の相関値を出力する相関器とこの相関器の出力結果から、判定帰還形適応等化器７６、線形適応等化器７７に制御信号を出力する制御信号出力回路から構成される。遅延測定回路７５は、受信信号メモリ４０よりＵＷ１１に対応する受信データを読み出し、相関器で、ＵＷと入力信号の相関をとる。相関器の出力は、入力信号の主波と遅延波の部分で相関値が大きくなる。この相関値から制御信号出力回路では、相関器の主波と遅延波に対する相関値の比、最大遅延時間に応じて、判定帰還形適応等化器７６と線形適応等化器７７のどちらかをそのバーストに対して動作させるか決定する。この判断の基準としては、例えば、図２に示したビット誤り率の結果を用いて、遅延波の最大遅延時間が０．３５シンボル以下ならば線形適応等化器７７を動作させ、０．３５シンボル以上ならば判定帰還形適応等化器７６を動作させるというような方法がある。動作させる適応等化器を決定した後、遅延測定回路７５は判定帰還形適応等化器７６を動作させる場合には、判定帰還形適応等化器７６に制御信号を、線形適応等化器７７を動作させる場合には、線形適応等化器７７に制御信号を出力する。

【００９８】判定帰還形適応等化器７６では、遅延測定回路７５より制御信号を受けた場合には受信信号メモリ４０よりデータを読み出し、図１５に示す等化器の動作の項で示したようにＵＷ１１を用いて伝送路の特性を推定しタップ係数を収束させる。次いで、ランダムデータ部１２について等化を行なう。また、等化出力メモリ７８にランダムデータ部１２の等化結果を出力する。線形適応等化器７７では、遅延測定回路７５より制御信号を受けた場合には受信信号メモリ４０よりデータを読み出し、図１５に示す等化器の動作の項で示したようにＵＷ１１を用いて伝送路の特性を推定しタップ係数を収束させる。次いで、ランダムデータ部１２について等化を行なう。また、等化出力メモリ７８にランダムデータ部１２の等化結果を出力する。等化出力メモリ７８では最終的な等化出力としてメモリ内の等化結果を出力する。

【００９９】実施例６．以下、請求項６に係わる発明の実施例６について説明する。図１０はこの発明の実施例６を示す構成ブロック図である。図中、従来例と同一部分には同一符号を付し説明を省く。図１０において、１１０はアンテナａ１０１より受信され検波回路ａ１０３によってベースバンド信号に変換された受信信号を１バースト分蓄える受信信号メモリａ、１１１は受信信号メモリａ１１０より受信信号を読み出し等化を行なう判定帰還形適応等化器ａ、１１２は判定帰還形適応等化器ａ１１１の等化２乗誤差を積算する等化２乗誤差積算回路ａ、１１３は判定帰還形適応等化器ａ１１１の等化出力を記憶する等化出力メモリａ、１１４は受信信号メモリａ１１０より受信信号を読み出し等化を行なう線形適応等化器ａ、１１５は線形適応等化器ａ１１４の等化２乗誤差を積算する等化２乗誤差積算回路ｂ、１１６は線形適応等化器ａ１１４の等化出力を記憶する等化出力メモリｂ、１１７はアンテナｂ１０２より受信され検波回路ｂ１０４によってベースバンド信号に変換された受信信号を１バースト分蓄える受信信号メモリｂ、１１８は受信信号メモリｂ１１７より受信信号を読み出し等化を行なう判定帰還形適応等化器ｂ、１１９は判定帰還形適応等化器ｂ１１８の等化２乗誤差を積算する等化２乗誤差積算回路ｃ、１２０は判定帰還形適応等化器ｂ１１８の等化出力を記憶する等化出力メモリｃ、１２１は受信信号メモリｂ１１７より受信信号を読み出し等化を行なう線形適応等化器ｂ、１２２は線形適応等化器ｂ１２１の等化２乗誤差を積算する等化２乗誤差積算回路ｄ、１２３は線形適応等化器ｂ１２１の等化出力を記憶する等化出力メモリｄ、１２４は等化２乗誤差積算回路ａ１１

２、等化２乗誤差積算回路ｂ１１５、等化２乗誤差積算回路ｃ１１９、等化２乗誤差積算回路ｄ１２２のそれぞれの出力を比較し、その結果を出力制御信号として出力する比較回路、１２５は比較回路１２４の出力制御信号に従って等化出力メモリａ１１３、等化出力メモリｂ１１６、等化出力メモリｃ１２０、等化出力メモリｄ１２３より出力される等化出力を選択する選択回路、１２６は等化出力端子である。

【０１００】図１０の適応ダイバーシチ等化器の動作について説明する。受信信号メモリａ１１０はアンテナａ１０１より受信され検波回路ａ１０３によってベースバンド信号に変換された受信信号を１バースト分蓄える。判定帰還形適応等化器ａ１１１では、受信信号メモリａ１１０よりデータを読み出し、図１５に示す等化器の動作の項で示したようにＵＷ１１を用いて伝送路の特性を推定しタップ係数を収束させる。次いでランダムデータ部１２について等化を行なう。そして、ランダムデータ部１２の等化時には、式４で示す誤差値を等化２乗誤差積算回路ａ１１２に出力する。また、等化出力メモリａ１１２にランダムデータ部１２の等化結果を出力する。線形適応等化器ａ１１４では、受信信号メモリａ１１０よりデータを読み出し、図１５に示す等化器の動作の項で示したようにＵＷ１１を用いて伝送路の特性を推定しタップ係数を収束させる。次いでランダムデータ部１２について等化を行なう。そして、ランダムデータ部１２の等化時には、式４で示す誤差信号を等化２乗誤差積算回路ｂ１１５に出力する。また、等化出力メモリｂ１１６にランダムデータ部１２の等化結果を出力する。受信信号メモリｂ１１７はアンテナｂ１０２より受信され検波回路ｂ１０４によってベースバンド信号に変換された受信信号を１バースト分蓄える。判定帰還形適応等化器ｂ１１８では、受信信号メモリｂ１１７よりデータを読み出し、図１５に示す等化器の動作の項で示したようにＵＷ１１を用いて伝送路の特性を推定しタップ係数を収束させる。次いでランダムデータ部１２について等化を行なう。そして、ランダムデータ部１２の等化時には、式４で示す誤差値を等化２乗誤差積算回路ｃ１１９に出力する。また、等化出力メモリｃ１２０にランダムデータ部１２の等化結果を出力する。線形適応等化器ｂ１２１では、受信信号メモリｂ１１７よりデータを読み出し、図１５に示す等化器の動作の項で示したようにＵＷ１１を用いて伝送路の特性を推定しタップ係数を収束させる。次いでランダムデータ部１２について等化を行なう。そして、ランダムデータ部１２の等化時には、式４で示す誤差信号を等化２乗誤差積算回路ｄ１２２に出力する。また、等化出力メモリｄ１２３にランダムデータ部１２の等化結果を出力する。

【０１０１】等化２乗誤差積算回路ａ１１２では、判定帰還形適応等化器ａ１１１のランダムデータ部１２の等化時に出力された誤差値を２乗し、その１バースト分の和を求め、その結果を比較回路１２４に出力する。等化２乗誤差積算回路ｂ１１５では、線形適応等化器ａ１１４のランダムデータ部１２の等化時に出力された誤差値を２乗し、その１バースト分の和を求め、その結果を比較回路１２４に出力する。等化２乗誤差積算回路ｃ１１９では、判定帰還形適応等化器ｂ１１８のランダムデータ部１２の等化時に出力された誤差値を２乗し、その１バースト分の和を求め、その結果を比較回路１２４に出力する。等化２乗誤差積算回路ｄ１２２では、線形適応等化器ｂ１２１のランダムデータ部１２の等化時に出力された誤差値を２乗し、その１バースト分の和を求め、その結果を比較回路１２４に出力する。

【０１０２】比較回路１２４では等化２乗誤差積算回路ａ１１２、等化２乗誤差積算回路ｂ１１５、等化２乗誤差積算回路ｃ１１９、等化２乗誤差積算回路ｄ１２２それぞれの出力結果を比較し、等化２乗誤差の和が最も小さい、すなわち、そのバーストに対して最も等化特性の良いと思われる適応等化器を選択し、その結果を選択回路１２５に出力する。選択回路１２５では、比較回路１２４の出力結果に従い、等化出力メモリａ１１３、等化出力メモリｂ１１６、等化出力メモリｃ１２０、等化出力メモリｄ１２３に蓄積された等化出力の中から最終的な等化出力を選択し等化出力端子１２６より出力する。

【０１０３】なお、本実施例６では、１バースト分のランダムデータの等化２乗誤差の和に従って、選択回路１２５にて各メモリの出力を選択したが、１バースト分のランダムデータをｎ分割し（ｎ：整数）、分割されたデータ毎に判定帰還形適応等化器ａ１１１、線形適応等化器ａ１１４、判定帰還形適応等化器ｂ１１８、線形適応等化器ｂ１２１それぞれの等化２乗誤差の和、を求め比較し、選択回路１２５における等化出力の選択をその分割されたデータ毎に行っても良い。

【０１０４】また、本実施例６では、１バースト分のランダムデータの等化２乗誤差の和に従って、選択回路１２５にて各メモリの出力を選択したが、任意のバースト分のランダムデータに対して判定帰還形適応等化器ａ１１１、線形適応等化器ａ１１４、判定帰還形適応等化器ｂ１１８、線形適応等化器ｂ１２１の等化２乗誤差の和を求め比較し、選択回路１２５における等化出力の選択をその数バースト毎に行っても良い。

【０１０５】実施例７．以下、請求項７に係わる発明の実施例７について説明する。図１１はこの発明の適応ダイバーシチ等化器の実施例７を示す構成ブロック図である。図中、従来例および実施例６と同一部分には同一符号を付し説明を省く。図１１において、１２７は受信信号メモリａ１１０より受信信号を読み出し等化を行なうとともに外部からの制御信号によって動作を停止する判定帰還形適応等化器ａ、１２８は判定帰還形適応等化器ａ１２７の等化２乗誤差を積算する等化２乗誤差積算回路ａ、１２９は判定帰還形適応等化器ａ１２７の等化出

力を記憶する等化出力メモリａ、１３０は受信信号メモリａ１１０より受信信号を読み出し等化を行なうとともに外部からの制御信号によって動作を停止する線形適応等化器ａ、１３１は線形適応等化器ａ１３０の等化２乗誤差を積算する等化２乗誤差積算回路ｂ、１３２は線形適応等化器ａ１３０の等化出力を記憶する等化出力メモリｂ、１３３は受信信号メモリｂ１１７より受信信号を読み出し等化を行なうとともに外部からの制御信号によって動作を停止する判定帰還形適応等化器ｂ、１３４は判定帰還形適応等化器ｂ１３３の等化２乗誤差を積算する等化２乗誤差積算回路ｃ、１３５は判定帰還形適応等化器ｂ１３３の等化出力を記憶する等化出力メモリｃ、１３６は受信信号メモリｂ１１７より受信信号を読み出し等化を行なうとともに外部からの制御信号によって動作を停止する線形適応等化器ｂ、１３７は線形適応等化器ｂ１３６の等化２乗誤差を積算する等化２乗誤差積算回路ｄ、１３８は線形適応等化器ｂ１３６の等化出力を記憶する等化出力メモリｄ、１３９は等化２乗誤差積算回路ａ１２８、等化２乗誤差積算回路ｂ１３１、等化２乗誤差積算回路ｃ１３４、等化２乗誤差積算回路ｄ１３７のそれぞれの出力を比較し、その結果を出力制御信号として出力する比較回路、１４０は比較回路１３９の出力制御信号に従って等化出力メモリａ１２９、等化出力メモリｂ１３２、等化出力メモリｃ１３５、等化出力メモリｄ１３８より出力される等化出力を選択する選択回路である。

【０１０６】図１１の適応ダイバーシチ等化器の動作について説明する。受信信号メモリａ１１０はアンテナａ１０１より受信され検波回路ａ１０３によってベースバンド信号に変換された受信信号を１バースト分蓄える。判定帰還形適応等化器ａ１２７では、受信信号メモリａ１１０よりデータを読み出し、図１５に示す等化器の動作の項で示したようにＵＷ１１を用いて伝送路の特性を推定しタップ係数を収束させる。次いでランダムデータ部１２について等化を行なう。そして、ランダムデータ部１２の等化時には、式４で示す誤差値を等化２乗誤差積算回路ａ１２８に１シンボル毎に出力する。また、等化出力メモリａ１２９にランダムデータ部１２の等化結果を１シンボル毎出力する。線形適応等化器ａ１３０では、受信信号メモリａ１１０よりデータを読み出し、図１５に示す等化器の動作の項で示したようにＵＷ１１を用いて伝送路の特性を推定しタップ係数を収束させる。次いでランダムデータ部１２について等化を行なう。そして、ランダムデータ部１２の等化時には、式４で示す誤差値を１シンボル毎に等化２乗誤差積算回路ｂ１３１に出力する。また、等化出力メモリｂ１３２にランダムデータ部１２の等化結果を１シンボル毎に出力する。受信信号メモリｂ１１７はアンテナｂ１０２より受信され検波回路ｂ１０４によってベースバンド信号に変換された受信信号を１バースト分蓄える。判定帰還形適応等化器ｂ１３３では、受信信号メモリｂ１１７よりデータを読み出し、図１５に示す等化器の動作の項で示したようにＵＷ１１を用いて伝送路の特性を推定しタップ係数を収束させる。次いでランダムデータ部１２について等化を行なう。そして、ランダムデータ部１２の等化時には、式４で示す誤差値を等化２乗誤差積算回路ｃ１３４に１シンボル毎に出力する。また、等化出力メモリｃ１３５にランダムデータ部１２の等化結果を１シンボル毎に出力する。線形適応等化器ｂ１３６では、受信信号メモリｂ１１７よりデータを読み出し、図１５に示す等化器の動作の項で示したようにＵＷ１１を用いて伝送路の特性を推定しタップ係数を収束させる。次いでランダムデータ部１２について等化を行なう。そして、ランダムデータ部１２の等化時には、式４で示す誤差値を等化２乗誤差積算回路ｄ１３７に１シンボル毎に出力する。また、等化出力メモリｄ１３８にランダムデータ部１２の等化結果を１シンボル毎に出力する。

【０１０７】等化２乗誤差積算回路ａ１２８では、判定帰還形適応等化器ａ１２７のランダムデータ部１２の等化時に出力された誤差値を２乗し、そのランダムデータｍシンボル分（ｍは整数）の和を求め、その結果を比較回路１３９に出力する。等化２乗誤差積算回路ｂ１３１では、線形適応等化器ａ１３０のランダムデータ部１２の等化時に出力された誤差値を２乗し、そのランダムデータｍシンボル分（ｍは整数）の和を求め、その結果を比較回路１３９に出力する。等化２乗誤差積算回路ｃ１３４では、判定帰還形適応等化器ｂ１３３のランダムデータ部１２の等化時に出力された誤差値を２乗し、そのランダムデータｍシンボル分（ｍは整数）の和を求め、その結果を比較回路１３９に出力する。等化２乗誤差積算回路ｄ１３７では、線形適応等化器ｂ１３６のランダムデータ部１２の等化時に出力された誤差値を２乗し、そのランダムデータｍシンボル分（ｍは整数）の和を求め、その結果を比較回路１３９に出力する。

【０１０８】比較回路１３９では等化２乗誤差積算回路ａ１２８、等化２乗誤差積算回路ｂ１３１、等化２乗誤差積算回路ｃ１３４、等化２乗誤差積算回路ｄ１３７それぞれの出力結果を比較し、等化２乗誤差の和が最も小さい、すなわち、そのバーストに対して最も等化特性の良いと予想される適応等化器を選択し、その結果を選択回路１４０に出力するとともに選択されなかった残り３つの適応等化器に停止信号を出力する。これらの適応等化器は、この制御信号により同バーストの残りのランダムデータに対する等化を中止する。選択回路１４０では、比較回路１３９の出力結果に従い、等化出力メモリａ１２９、等化出力メモリｂ１３２、等化出力メモリｃ１３５、等化出力メモリｄ１３８に蓄積された等化出力の中から最終的な等化出力を選択し等化出力端子１２６より出力する。

【０１０９】なお、本実施例７では、１バースト毎に１

回、等化２乗誤差の和の比較、演算停止を行っているが、受信バーストの間隔が短く、伝送路の変動がゆっくりしている場合には、等化２乗誤差の和の比較をｍバースト（ｍ＝２，３，４…）毎に行っても良い。

【０１１０】実施例８．以下、請求項８に係わる発明の実施例８について説明する。図１２はこの発明の適応等化器の実施例８を示す構成ブロック図である。図中、従来例および実施例６，７と同一部分には同一符号を付し説明を省く。図１２において、１４１は受信信号メモリａ１１０より受信信号を読み出しＵＷ１１の等化を行ない、その後、外部からの制御信号によりランダムデータ部１２の等化を行なう判定帰還形適応等化器ａ、１４２は判定帰還形適応等化器ａ１４１の等化２乗誤差を積算する等化２乗誤差積算回路ａ、１４３は判定帰還形適応等化器ａ１４１のＵＷ１１の等化後のタップ係数とＵＷに対応する受信信号よりしきい値を求めるしきい値設定回路ａ、１４４は判定帰還形適応等化器ａ１４１の等化出力を記憶する等化出力メモリａ、１４５は受信信号メモリａ１１０より受信信号を読み出し等化を行なう線形適応等化器ａ、１４６は線形適応等化器ａ１４５の等化２乗誤差を積算する等化２乗誤差積算回路ｂ、１４７は等化２乗誤差積算回路ｂ１４６の出力を積算シンボル数で平均をとる等化２乗誤差平均回路ａ、１４８は線形適応等化器ａ１４５の等化出力を記憶する等化出力メモリｂ、１４９は受信信号メモリｂ１１７より受信信号を読み出しＵＷ１１の等化を行ない、その後、外部からの制御信号によりランダムデータ部１２の等化を行なう判定帰還形適応等化器ｂ、１５０は判定帰還形適応等化器ｂ１４９の等化２乗誤差を積算する等化２乗誤差積算回路ｃ、１５１は判定帰還形適応等化器ｂ１４９の等化後のタップ係数とＵＷ１１に対応する受信信号よりしきい値を定めるしきい値設定回路ｂ、１５２は判定帰還形適応等化器ｂ１４９の等化出力を記憶する等化出力メモリｃ、１５３は受信信号メモリｂ１１７より受信信号を読み出し等化を行なう線形適応等化器ｂ、１５４は線形適応等化器ｂ１５３の等化２乗誤差を積算する等化２乗誤差積算回路ｄ、１５５は等化２乗誤差積算回路ｄ１５４の出力を積算シンボル数で平均をとる等化２乗誤差平均回路ｂ、１５６は線形適応等化器ｂ１５３の等化出力を記憶する等化出力メモリｄ、１５７は等化２乗誤差積算回路ａ１４７の出力、等化２乗誤差平均回路ｂ１５５の出力、しきい値設定回路ａ１４３の出力、しきい値設定回路ｂ１５１の出力を比較する比較回路ａ、１５８は等化２乗誤差積算回路ａ１４２、等化２乗誤差積算回路ｂ１４６、等化２乗誤差積算回路ｃ１５０、等化２乗誤差積算回路ｄ１５４の大小を比較する比較回路ｂである。

【０１１１】図１２の適応等化器の動作について説明する。判定帰還形適応等化器ａ１４１では、図１５に示す等化器の動作の項で示したようにＵＷ１１を用いて伝送路の特性を推定しタップ係数を収束させる。次にそのタップ係数を固定としたまま、再びＵＷ１１に対応する受信入力データおよび参照信号を入力信号とし、１シンボル毎に積和演算を行いその結果と参照信号の差をとり１シンボル毎の誤差を求める。そして、固定したタップ係数値と１シンボル毎の誤差を、しきい値設定回路ａ１４３に出力する。

【０１１２】しきい値設定回路ａ１４３は、上記固定したＦＦ部のタップ係数の絶対値の和を求める積算回路ａ、ＦＢ部のタップ係数の絶対値の和を求める積算回路ｂ、ＦＦ部のタップ係数の絶対値の和とＦＢ部のタップ係数の絶対値の和の比ＦＦＲａを求める除算回路、上記１シンボル毎の誤差を２乗して和をとる２乗誤差積算回路、この２乗誤差の和を平均しＭＳＥ１ａを定める平均回路、さらに、ＭＳＥ１ａにＦＦＲａと適当な定数αを乗じ、ＭＳＥ１１ａを定める乗算器によって構成される。

【０１１３】しきい値設定回路ａ１４３では、まず、積算回路ａ、積算回路ｂにて、ＦＦ部のタップ係数値の絶対値の和ＳＦＦａ、ＦＢ部のタップ係数値の絶対値の和ＳＦＢａを定める。次に、除算回路で、この比ＦＦＲａを求める。

【０１１４】

【数７】

$$SFFa=|C_{1a}(n)|+|C_{2a}(n)|+\cdots+|C_{La}(n)| \quad (17)$$

$$SFBa=|C_{(L+1)a}(n)|+|C_{(L+2)a}(n)|+\cdots+|C_{Ma}(n)| \quad (18)$$

$$FFRa=SFFa/SFBa \quad (19)$$

$C_{ia}(n)$ i=1,2,…M：判定帰還形適応等化器ａ141 のタップ係数

【０１１５】次に、上記２乗誤差積算回路と、平均回路にて２乗誤差平均値ＭＳＥ１ａを定める。さらに上記乗算回路にて、ＦＦＲａ、定数αを乗じＭＳＥ１１ａを定め、比較回路ａ１５７に出力する。

【０１１６】

【数８】

$$MSE11a = MSE1a * FFRa * \alpha \quad (20)$$

【０１１７】ここで、ＦＦＲを求めるのは、伝送路における先行波と、遅延波の大きさの比の簡易推定を行なうもので、例えば、遅延波の大きさが小さい場合には、遅延波の影響を打ち消すＦＢ部のタップ係数の絶対値も小さくなり、ＦＦＲａは大きくなる。そして、ＭＳＥ１１ａも大きくなる。また、逆に遅延波の大きさが大きい場合には、ＦＢ部のタップ係数の絶対値も大きくなり、ＦＦＲａは小さくなる。そして、ＭＳＥ１１ａも小さくなる。これは、遅延波の大きさが小さい場合には、線形適応等化器ａ１４５、または線形適応等化器ｂ１５３の等化出力を選択する確率を高くし、遅延波の大きさが大きい場合には、判定帰還形適応等化器ａ１４１または判定帰還形適応等化器ｂ１４９の等化出力を選択する確率を高くしている。

【０１１８】線形適応等化器ａ１４５では、図１５に示す等化器の動作の項で示したようにＵＷ１１を用いて伝送路の特性を推定しタップ係数を収束させる。次いでランダムデータ部１２について等化を行なう。そして、ランダムデータ部１２の等化時には、式４で示す誤差値を等化２乗誤差積算回路ｂ１４６に出力する。また、等化出力メモリｂ１４８にランダムデータ部１２の等化結果を出力する。等化２乗誤差積算回路ｂ１４６では、線形適応等化器ａ１４５のランダムデータ部１２の等化時に出力された誤差値を２乗し、その１バースト分の和ＳＥ２ａを求め、その結果を等化２乗誤差平均回路ａ１４７と比較回路ｂ１５８に出力する。等化２乗誤差平均回路ａ１４７では、ＳＥ２ａをランダムデータ部１２のシンボル数で除算し、平均値ＭＳＥ２ａを求め、比較回路ａ１５７に出力する。この平均値ＭＳＥ２ａもＭＳＥ１ａと同様に、受信信号の信号対雑音電力比が小さいと大きくなる。

【０１１９】判定帰還形適応等化器ｂ１４９では、図１５に示す等化器の動作の項で示したようにＵＷ１１を用いて伝送路の特性を推定し、タップ係数を収束させる。次にそのタップ係数を固定としたまま、再びＵＷ１１に対応する受信入力データおよび参照信号を入力信号とし、１シンボル毎に積和演算を行い、その結果と参照信号の差をとり１シンボル毎の誤差を求める。そして、固定したタップ係数値と１シンボル毎の誤差を、しきい値設定回路ｂ１５１に出力する。

【０１２０】しきい値設定回路ｂ１５１は、上記固定したＦＦ部のタップ係数の絶対値の和を求める積算回路ａ、ＦＢ部のタップ係数の絶対値の和を求める積算回路ｂ、ＦＦ部のタップ係数の絶対値の和とＦＢ部のタップ係数の絶対値の和の比ＦＦＲｂを求める除算回路、上記１シンボル毎の誤差を２乗して和をとる２乗誤差積算回路、この２乗誤差の和を平均しＭＳＥ１ｂを定める平均回路、さらに、ＭＳＥ１ｂにＦＦＲｂと適当な定数αを乗じ、ＭＳＥ１１ｂを定める乗算器によって構成される。

【０１２１】しきい値設定回路ｂ１５１では、まず、積算回路ａ、積算回路ｂにて、ＦＦ部のタップ係数値の絶対値の和ＳＦＦｂ、ＦＢ部のタップ係数値の絶対値の和ＳＦＢｂを定める。次に、除算回路で、この比ＦＦＲｂを求める。

【０１２２】

【数９】

$$SFFb = |C_{1b}(n)| + |C_{2b}(n)| + \cdots + |C_{Lb}(n)| \quad (21)$$

$$SFBb = |C_{(L+1)b}(n)| + |C_{(L+2)b}(n)| + \cdots + |C_{Mb}(n)| \quad (22)$$

$$FFRb = SFFb / SFBb \quad (23)$$

$C_{ib}(n)$ i=1, 2, …M：判定帰還形適応等化器ｂ149 のタップ係数

【０１２３】次に、上記２乗誤差積算回路と、平均回路にて２乗誤差平均値ＭＳＥ１ｂを定める。さらに上記乗算回路にて、ＦＦＲｂ、定数αを乗じＭＳＥ１１ｂを定め、比較回路ａ１５７に出力する。

【０１２４】

【数１０】

$$MSE11b = MSE1b * FFRb * \alpha \quad (24)$$

【０１２５】線形適応等化器ｂ１５３では、図１５に示す等化器の動作の項で示したようにＵＷ１１を用いて伝送路の特性を推定しタップ係数を収束させる。次いでランダムデータ部１２について等化を行なう。そして、ランダムデータ部１２の等化時には、式４で示す誤差値を等化２乗誤差積算回路ｄ１５４に出力する。また、等化出力メモリｄ１５６にランダムデータ部１２の等化結果を出力する。等化２乗誤差積算回路ｄ１５４では、線形適応等化器ｂ１５３のランダムデータ部１２の等化時に出力された誤差値を２乗し、その１バースト分の和ＳＥ２ｂを求め、その結果を等化２乗誤差平均回路ｂ１５５と比較回路ｂ１５８に出力する。等化２乗誤差平均回路

ｂ１５５では、ＳＥ２ｂをランダムデータ部１２のシンボル数で除算し、平均値ＭＳＥ２ｂを求め、比較回路ａ１５７に出力する。この平均値ＭＳＥ２ｂもＭＳＥ１ｂと同様に、受信信号の信号対雑音電力比が小さいと大きくなる。

【０１２６】比較回路ａ１５７では、しきい値ＭＳＥ１１ａ、しきい値ＭＳＥ１１ｂ、平均値ＭＳＥ２ａ、平均値ＭＳＥ２ｂを比較し、ＭＳＥ２ａが一番小さい場合には、線形適応等化器ａ選択信号を比較回路ｂ１５８に出力し、また、ＭＳＥ２ｂが一番小さい場合には、線形適応等化器ｂ選択信号を比較回路ｂ１５８に出力する。それ以外の場合には選択保留信号を比較回路ｂ１５８と判定帰還形適応等化器ａ１４１および判定帰還形適応等化器ｂ１４９に出力する。

【０１２７】比較回路ｂ１５８では、比較回路ａ１５７より線形適応等化器ａ選択信号または、線形適応等化器ｂ選択信号が出力された場合には、選択回路１４０に線形適応等化器ａ選択信号、または線形適応等化器ｂ選択信号を出力する。選択回路１４０では、比較回路ｂ１５８の選択信号に従い、等化出力メモリｂ１４８、または、等化出力メモリｄ１５６に蓄積された等化出力の中から最終的な等化出力を選択し、等化出力端子１２６より出力し、このバーストに対する処理を終了する。

【０１２８】比較回路ａ１５７における、しきい値ＭＳＥ１１ａ、しきい値ＭＳＥ１１ｂ、平均値ＭＳＥ２ａ、平均値ＭＳＥ２ｂの比較において、しきい値ＭＳＥ１１ａまたは、しきい値ＭＳＥ１１ｂが一番小さい場合には、判定帰還形適応等化器ａ１４１は、比較回路ａ１５７より出力された選択保留信号を受けて、ランダムデータ部１２について等化を行なう。そして、ランダムデータ部１２の等化時には、誤差値を等化２乗誤差積算回路ａ１４２に出力する。また、等化出力メモリａ１４４にランダムデータ部１２の等化結果を出力する。同様に、しきい値ＭＳＥ１１ａまたは、しきい値ＭＳＥ１１ｂが一番小さい場合には、判定帰還形適応等化器ｂ１４９は、比較回路ａ１５７より出力された選択保留信号を受けて、ランダムデータ部１２について等化を行なう。そして、ランダムデータ部１２の等化時には、誤差値を等化２乗誤差積算回路ｃ１５０に出力する。また、等化出力メモリｃ１５２にランダムデータ部１２の等化結果を出力する。等化２乗誤差積算回路ａ１４２では、判定帰還形適応等化器ａ１４１のランダムデータ部１２の等化時に出力された式４で示される誤差値を２乗しその１バースト分の和ＳＥ３ａを求め比較回路ｂ１５８に出力する。等化２乗誤差積算回路ｃ１５０では、判定帰還形適応等化器ｂ１４９のランダムデータ部１２の等化時に出力された式４で示される誤差値を２乗しその１バースト分の和ＳＥ３ｂを求め比較回路ｂ１５８に出力する。

【０１２９】比較回路ｂ１５８では、等化２乗誤差積算回路ａ１４２の出力結果ＳＥ３ａと、等化２乗誤差積算回路ｃ１５０の出力結果ＳＥ３ｂと、先に入力されているＳＥ２ａとＳＥ２ｂの大きさを比較し、一番値が小さいものを選択し、結果を選択回路１４０へ出力する。選択回路１４０では、比較回路ｂ１５８の出力結果に従い、等化出力メモリａ１４４、等化出力メモリｂ１４８、等化出力メモリｃ１５２、等化出力メモリｄ１５６に蓄積された等化出力の中から最終的な等化出力を選択し等化出力端子１２６より出力する。

【０１３０】なお、本実施例８では、しきい値設定回路ａ１４３および、しきい値設定回路ｂ１５１で、判定帰還形適応等化器ａ１４１および、判定帰還形適応等化器ｂ１４９から出力されたタップ係数値に対して、ＦＦ部のタップ係数の絶対値の和とＦＢ部のタップ係数の絶対値の和の比ＦＦＲａおよび、ＦＦＲｂを求めているが、これはＦＦ部のタップ係数の２乗値の和とＦＢ部のタップ係数の２乗値の和の比としてかまわない。

【０１３１】また、本実施例８では、しきい値設定回路ａ１４３および、しきい値設定回路ｂ１５１で、判定帰還形適応等化器ａ１４１または、判定帰還形適応等化器ｂ１４９から出力されたタップ係数値に対して、ＦＦ部のタップ係数の絶対値の和とＦＢ部のタップ係数の絶対値の和の比ＦＦＲａ、ＦＦＲｂを求めているが、この計算を行わず、ＦＦＲａ＝１、ＦＦＲｂ＝１、としてもかまわない。

【０１３２】実施例９．以下、請求項９に係わる発明の実施例９について説明する。図１３はこの発明の適応ダイバーシチ等化器の実施例９を示す構成ブロック図である。図中、従来例と同一部分には同一符号を付し説明を省く。図１３において、１５９は受信信号メモリａ１１０より受信信号を読み出しＵＷ１１の等化を行ない、その後、外部からの制御信号により、タップ係数のリセット、ランダムデータ部１２の等化を行なう判定帰還形適応等化器ａ、１６０は判定帰還形適応等化器ａ１５９より出力される等化２乗誤差を積算する等化２乗誤差積算回路ａ、１６１は判定帰還形適応等化器ａ１５９より出力される等化出力を記憶する等化出力メモリａ、１６２は受信信号メモリａ１１０より受信信号を読み出しＵＷ１１の等化を行ない、その後、外部からの制御信号によりタップ係数のリセット、ランダムデータ部１２の等化を行なう線形適応等化器ａ、１６３は線形適応等化器ａ１６２より出力される等化２乗誤差を積算する等化２乗誤差積算回路ｂ、１６４は線形適応等化器ａ１６２より出力される等化出力を記憶する等化出力メモリｂ、１６５は受信信号メモリｂ１１７より受信信号を読み出しＵＷ１１の等化を行ない、その後、外部からの制御信号により、タップ係数のリセット、ランダムデータ部１２の等化を行なう判定帰還形適応等化器ｂ、１６６は判定帰還形適応等化器ｂ１６５より出力される等化２乗誤差を積算する等化２乗誤差積算回路ｃ、１６７は判定帰還形適応等化器ｂ１６５より出力される等化出力を記憶する

等化出力メモリＣ、１６８は受信信号メモリｂ１１７より受信信号を読み出しＵＷ１１等化を行い、その後、外部からの制御信号によりタップ係数のリセット、ランダムデータ部１２の等化を行なう線形適応等化器ｂ、１６９は線形適応等化器ｂ１６８より出力される等化２乗誤差を積算する等化２乗誤差積算回路ｄ、１７０は線形適応等化器ｂ１６８より出力される等化出力を記憶する等化出力メモリｄ、１７１は判定帰還形適応等化器ａ１５９、判定帰還形適応等化器ｂ１６５、線形適応等化器ａ１６２、線形適応等化器ｂ１６８の動作を制御する制御部、１７２は等化２乗誤差積算回路ａ１６０、等化２乗誤差積算回路ｂ１６３、等化２乗誤差積算回路ｃ１６６、等化２乗誤差積算回路ｄ１６９の出力の大小を比較しその結果を等化出力メモリａ１６１、等化出力メモリｂ１６４、等化出力メモリｃ１６７、等化出力メモリｄ１７０、制御部１７１に出力する比較回路、１７３は等化出力メモリａ１６１、等化出力メモリｂ１６４、等化出力メモリｃ１６７、等化出力メモリｄ１７０から出力されるデータを１バースト分蓄えた後に出力する等化出力メモリｅである。

【０１３３】図１３の適応ダイバーシチ等化器の動作について説明する。判定帰還形適応等化器ａ１５９では、受信信号メモリａ１１０よりデータを読み出し、ＵＷ１１を用いて伝送路の特性を推定しタップ係数を収束させる。次いでランダムデータ部１２について一定のシンボル数（ｍ１）等化を行なう。そして、ランダムデータ部１２の等化時には、式４で示す誤差値を等化２乗誤差積算回路ａ１６０に出力する。また、等化出力メモリａ１６１にランダムデータｍ１の等化結果を出力する。また、線形適応等化器ａ１６２においても、受信信号メモリａ１１０よりデータを読み出し、ＵＷ１１を用いて伝送路の特性を推定しタップ係数を収束させる。次いでランダムデータ部１２について一定のシンボル数（ｍ１）等化を行なう。そして、ランダムデータ部１２の等化時には、式４で示す誤差値を等化２乗誤差積算回路ｂ１６３に出力する。また、等化出力メモリｂ１６４にランダムデータｍ１個の等化結果を出力する。

【０１３４】判定帰還形適応等化器ｂ１６５では、受信信号メモリｂ１１７よりデータを読み出し、ＵＷ１１を用いて伝送路の特性を推定しタップ係数を収束させる。次いでランダムデータ部１２について一定のシンボル数（ｍ１）等化を行なう。そして、ランダムデータ部１２の等化時には、式４で示す誤差値を等化２乗誤差積算回路ｃ１６６に出力する。また、等化出力メモリｃ１６７にランダムデータｍ１の等化結果を出力する。また、線形適応等化器ｂ１６８においても、受信信号メモリｂ１１７よりデータを読み出し、ＵＷ１１を用いて伝送路の特性を推定しタップ係数を収束させる。次いでランダムデータ部１２について一定のシンボル数（ｍ１）等化を行なう。そして、ランダムデータ部１２の等化時には、式４で示す誤差値を等化２乗誤差積算回路ｄ１６９に出力する。また、等化出力メモリｄ１７０にランダムデータｍ１個の等化結果を出力する。

【０１３５】等化２乗誤差積算回路ａ１６０では、判定帰還形適応等化器ａ１５９におけるランダムデータの等化時に出力されたｍ１個の誤差値をそれぞれ２乗した後に、その和ＳＥ１１を求め、その結果を比較回路１７２に出力する。等化２乗誤差積算回路ｂ１６３では線形適応等化器ａ１６２におけるランダムデータの等化時に出力されたｍ１個の誤差値をそれぞれ２乗した後に、その和ＳＥ２１を求め、その結果を比較回路１７２に出力する。等化２乗誤差積算回路ｃ１６６では、判定帰還形適応等化器ｂ１６５におけるランダムデータの等化時に出力されたｍ１個の誤差値をそれぞれ２乗した後に、その和ＳＥ３１を求め、その結果を比較回路１７２に出力する。等化２乗誤差積算回路ｄ１６９では線形適応等化器ｂ１６８におけるランダムデータの等化時に出力されたｍ１個の誤差値をそれぞれ２乗した後に、その和ＳＥ４１を求め、その結果を比較回路１７２に出力する。

【０１３６】比較回路１７２では、ＳＥ１１、ＳＥ２１、ＳＥ３１、ＳＥ４１を比較する。そして、ＳＥ１１が一番小さい場合には選択信号１、ＳＥ２１が一番小さい場合には選択信号２、ＳＥ３１が一番小さい場合には選択信号３、ＳＥ４１が一番小さい場合には選択信号４を、判定帰還形適応等化器ａ１５９、線形適応等化器ａ１６２、判定帰還形適応等化器ｂ１６５、線形適応等化器ｂ１６８、等化出力メモリａ１６１、等化出力メモリｂ１６４、等化出力メモリｃ１６７、等化出力メモリｄ１７０に出力する。また、制御部１７１に選択終了信号を出力する。等化出力メモリａ１６１は、選択信号１を受けた場合のみ、ｍ１シンボルの等化出力を等化出力メモリｅ１７３に書き込む。また、等化出力メモリｂ１６４は、選択信号２を受けた場合のみ、ｍ１シンボルの等化出力を等化出力メモリｅ１７３に書き込む。また、等化出力メモリｃ１６７は、選択信号３を受けた場合のみ、ｍ１シンボルの等化出力を等化出力メモリｅ１７３に書き込む。等化出力メモリｄ１７０は、選択信号４を受けた場合には、ｍ１シンボルの等化出力を等化出力メモリｅ１７３に書き込む。

【０１３７】制御部１７１では選択終了信号を受けた後、判定帰還形適応等化器ａ１５９、線形適応等化器ａ１６２、判定帰還形適応等化器ｂ１６５、線形適応等化器ｂ１６８のタップ係数、およびタップ係数更新アルゴリズムを初期化する。

【０１３８】判定帰還形適応等化器ａ１５９、線形適応等化器ａ１６２、判定帰還形適応等化器ｂ１６５、線形適応等化器ｂ１６８では、上記初期化の後、選択信号１を受けた場合には等化出力メモリａ１６１より、選択信号２を受けた場合には等化出力メモリｂ１６４より、選択信号３を受けた場合には等化出力メモリｃ１６７よ

り、選択信号４を受けた場合には等化出力メモリｄ１７０より、それぞれｍ１個のデータ系列の後半部ｍ２個（ｍ１＞ｍ２）の等化出力を読み込む。次に、判定帰還形適応等化器ａ１５９、線形適応等化器ａ１６２、判定帰還形適応等化器ｂ１６５、線形適応等化器ｂ１６８では、この値を参照信号として伝送路の特性を推定しタップ係数を収束させる。次いでｍ１シンボル以降のランダムデータについて一定のシンボル数（ｍ３）等化を行なう。

【０１３９】等化２乗誤差積算回路ａ１６０では、判定帰還形適応等化器ａ１５９の上記ｍ３個のランダムデータ等化時に出力されたｍ３個の誤差値をそれぞれ２乗した後に、その和ＳＥ１２を求め、その結果を比較回路１７２に出力する。等化２乗誤差積算回路ｂ１６３では線形適応等化器ａ１６２の上記ｍ３個のランダムデータ等化時に出力されたｍ３個の誤差値をそれぞれ２乗した後に、その和ＳＥ２２を求め、その結果を比較回路１７２に出力する。等化２乗誤差積算回路ｃ１６６では、判定帰還形適応等化器ｂ１６５の上記ｍ３個のランダムデータ等化時に出力されたｍ３個の誤差値をそれぞれ２乗した後に、その和ＳＥ３２を求め、その結果を比較回路１７２に出力する。等化２乗誤差積算回路ｄ１６９では線形適応等化器ｂ１６８の上記ｍ３個のランダムデータ等化時に出力されたｍ３個の誤差値をそれぞれ２乗した後に、その和ＳＥ４２を求め、その結果を比較回路１７２に出力する。

【０１４０】比較回路１７２では、ＳＥ１２、ＳＥ２２、ＳＥ３２、ＳＥ４２を比較する。そして、ＳＥ１２が一番小さい場合には選択信号１、ＳＥ２２が一番小さい場合には選択信号２、ＳＥ３２が一番小さい場合には選択信号３、ＳＥ４２が一番小さい場合には選択信号４を、判定帰還形適応等化器ａ１５９、線形適応等化器ａ１６２、判定帰還形適応等化器ｂ１６５、線形適応等化器ｂ１６８、等化出力メモリａ１６１、等化出力メモリｂ１６４、等化出力メモリｃ１６７、等化出力メモリｄ１７０に出力する。また、制御部１７１に選択終了信号を出力する。等化出力メモリａ１６１は、選択信号１を受けた場合のみ、ｍ３シンボルの等化出力を等化出力メモリｅ１７３に書き込む。また、等化出力メモリｂ１６４は、選択信号２を受けた場合のみ、ｍ３シンボルの等化出力を等化出力メモリｅ１７３に書き込む。また、等化出力メモリｃ１６７は、選択信号３を受けた場合のみ、ｍ３シンボルの等化出力を等化出力メモリｅ１７３に書き込む。等化出力メモリｄ１７０は、選択信号４を受けた場合には、ｍ３シンボルの等化出力を等化出力メモリｅ１７３に書き込む。

【０１４１】１バースト分のデータの等化が終了していない場合には、制御部１７１では選択終了信号を受けた後、判定帰還形適応等化器ａ１５９、線形適応等化器ａ１６２、判定帰還形適応等化器ｂ１６５、線形適応等化器ｂ１６８のタップ係数、およびタップ係数更新アルゴリズムの初期化から、選択された等化出力の等化出力メモリｅ１７３への書き込みまで、上記と同じ動作を繰り返し、１バースト分の等化が終了した後に、等化出力メモリｅ１７３より最終的な等化出力を出力する。

【０１４２】実施例１０．以下、請求項１０に係わる発明の実施例１０について説明する。図１４はこの発明の適応等化器の実施例１０を示す構成ブロック図である。図中、従来例と同一部分には同一符号を付し説明を省く。図１４において、１７４は受信信号メモリａ１１０より受信信号を読み出し、伝送路における多重路伝搬特性を測定し、制御信号を出力する遅延測定回路ａ、１７５は遅延測定回路ａ１７４の制御信号により、受信信号メモリａ１１０より受信信号を読み出し等化を行なう判定帰還形適応等化器ａ、１７６は遅延測定回路ａ１７４の制御信号により、受信信号メモリａ１１０より受信信号を読み出し等化を行なう線形適応等化器ａ、１７７は判定帰還形適応等化器ａ１７５または線形適応等化器ａ１７６の等化２乗誤差を積算する等化２乗誤差積算回路ａ、１７８は判定帰還形適応等化器ａ１７５の等化出力または線形適応等化器ａ１７６の等化出力を記憶する等化出力メモリａ、１７９は受信信号メモリｂ１１７より受信信号を読み出し、伝送路における多重伝搬特性を測定し、制御信号を出力する遅延測定回路ｂ、１８０は遅延測定回路ｂ１７９の制御信号により、受信信号メモリｂ１１７より受信信号を読み出し等化を行なう判定帰還形適応等化器ｂ、１８１は遅延測定回路ｂ１７９の制御信号により、受信信号メモリｂ１１７より受信信号を読み出し等化を行なう線形適応等化器ｂ、１８２は判定帰還形適応等化器ｂ１８０または線形適応等化器ｂ１８１の等化２乗誤差を積算する等化２乗誤差積算回路ｂ、１８３は判定帰還形適応等化器ｂ１８０の等化出力または線形適応等化器ｂ１８１の等化出力を記憶する等化出力メモリｂ、１８４は等化２乗誤差積算回路ａ１７７の出力と等化２乗誤差積算回路ｂ１８２の出力の大小を比較しその結果を出力制御信号として出力する比較回路、１８５は比較回路１８４の出力制御信号に従って等化出力メモリａ１７８と等化出力メモリｂ１８３の出力を切り替える選択回路である。

【０１４３】図１４の適応ダイバーシチ等化器の動作について説明する。受信信号メモリａ１１０は、アンテナａ１０１で受信され、検波回路ａ１０３でベースバンド信号に変換された受信信号を蓄える。遅延測定回路ａ１７４は、ＵＷと入力信号の相関値を出力する相関器とこの相関器の出力結果から、判定帰還形適応等化器ａ１７５、線形適応等化器ａ１７６に制御信号を出力する制御信号出力回路から構成される。遅延測定回路ａ１７４は、受信信号メモリａ１１０よりＵＷ１１に対応する受信データを読み出し、相関器で、ＵＷと入力信号の相関をとる。相関器の出力は、入力信号の主波と遅延波の部

分で相関値が大きくなる。この相関値から制御信号出力回路では、相関器の主波と遅延波に対する相関値の比、最大遅延時間に応じて、判定帰還形適応等化器ａ１７５と線形適応等化器ａ１７６のどちらかをそのバーストに対して動作させるか決定する。この判断の基準としては、例えば、図２に示したビット誤り率特性の結果を用いて、遅延波の最大遅延時間が０．３５シンボル以下ならば線形適応等化器ａ１７６を動作させ、０．３５シンボル以上ならば判定帰還形適応等化器ａ１７５を動作させるというような方法がある。動作させる適応等化器を決定した後、遅延測定回路ａ１７４は判定帰還形適応等化器ａ１７５を動作させる場合には、判定帰還形適応等化器ａ１７５に制御信号を、線形適応等化器ａ１７６を動作させる場合には、線形適応等化器ａ１７６に制御信号を出力する。

【０１４４】判定帰還形適応等化器ａ１７５では、遅延測定回路ａ１７４より制御信号を受けた場合には受信信号メモリａ１１０よりデータを読み出し、図１５に示す等化器の動作の項で示したようにＵＷ１１を用いて伝送路の特性を推定しタップ係数を収束させる。次いで、ランダムデータ部１２について等化を行なう。ランダムデータ部１２の等化時には、式４で示す誤差値を等化２乗誤差積算回路ａ１７７に出力する。また、等化出力メモリａ１７８にランダムデータ部１２の等化結果を出力する。線形適応等化器ａ１７６では、遅延測定回路ａ１７４より制御信号を受けた場合には受信信号メモリａ１１０よりデータを読み出し、図１５に示す等化器の動作の項で示したようにＵＷ１１を用いて伝送路の特性を推定しタップ係数を収束させる。次いで、ランダムデータ部１２について等化を行なう。ランダムデータ部１２の等化時には、式４で示す誤差値を等化２乗誤差積算回路ａ１７７に出力する。また、等化出力メモリａ１７８にランダムデータ部１２の等化結果を出力する。

【０１４５】受信信号メモリｂ１１７は、アンテナｂ１０２で受信され、検波回路ｂ１０４でベースバンド信号に変換された受信信号を蓄える。遅延測定回路ｂ１７９は、ＵＷと入力信号の相関値を出力する相関器とこの相関器の出力結果から、判定帰還形適応等化器ｂ１８０、線形適応等化器ｂ１８１に制御信号を出力する制御信号出力回路から構成される。遅延測定回路ｂ１７９は、受信信号メモリｂ１１７よりＵＷ１１に対応する受信データを読み出し、相関器で、ＵＷと入力信号の相関をとる。相関器の出力は、入力信号の主波と遅延波の部分で相関値が大きくなる。この相関値から制御信号出力回路では、相関器の主波と遅延波に対する相関値の比、最大遅延時間に応じて、判定帰還形適応等化器ｂ１８０と線形適応等化器ｂ１８１のどちらかをそのバーストに対して動作させるか決定する。この判断の基準としては、例えば、図２に示したビット誤り率の結果を用いて、遅延波の最大遅延時間が０．３５シンボル以下ならば線形適応等化器ｂ１８１を動作させ、０．３５シンボル以上ならば判定帰還形適応等化器ｂ１８０を動作させるというような方法がある。動作させる適応等化器を決定した後、遅延測定回路ｂ１７９は判定帰還形適応等化器ｂ１８０を動作させる場合には、判定帰還形適応等化器ｂ１８０に制御信号を、線形適応等化器ｂ１８１を動作させる場合には、線形適応等化器ｂ１８１に制御信号を出力する。

【０１４６】判定帰還形適応等化器ｂ１８０では、遅延測定回路ｂ１７９より制御信号を受けた場合には受信信号メモリｂ１１７よりデータを読み出し、図１５に示す等化器の動作の項で示したようにＵＷ１１を用いて伝送路の特性を推定しタップ係数を収束させる。次いで、ランダムデータ部１２について等化を行なう。ランダムデータ部１２の等化時には、式４で示す誤差値を等化２乗誤差積算回路ｂ１８２に出力する。また、等化出力メモリｂ１８３にランダムデータ部１２の等化結果を出力する。線形適応等化器ｂ１８１では、遅延測定回路ｂ１７９より制御信号を受けた場合には受信信号メモリｂ１１７よりデータを読み出し、図１５に示す等化器の動作の項で示したようにＵＷ１１を用いて伝送路の特性を推定しタップ係数を収束させる。次いで、ランダムデータ部１２について等化を行なう。ランダムデータ部１２の等化時には、式４で示す誤差値を等化２乗誤差積算回路ｂ１８２に出力する。また、等化出力メモリｂ１８３にランダムデータ部１２の等化結果を出力する。

【０１４７】等化２乗誤差積算回路ａ１７７では、判定帰還形適応等化器ａ１７５または、線形適応等化器ａ１７６のランダムデータ部１２の等化時に出力された誤差値を２乗しその１バースト分の和を求め、その結果を比較回路１８４に出力する。等化２乗誤差積算回路ｂ１８２では、判定帰還形適応等化器ｂ１８０または、線形適応等化器ａ１８１のランダムデータ部１２の等化時に出力された誤差値を２乗しその１バースト分の和を求め、その結果を比較回路１８４に出力する。

【０１４８】比較回路１８４では等化２乗誤差積算回路ａ１７７の出力結果と、等化２乗誤差積算回路ｂ１８２の出力結果を比較し、等化２乗誤差積算回路ａ１７７の等化２乗誤差の和の方が小さい場合、すなわち、そのバーストに対して判定帰還形適応等化器ａ１７５または線形適応等化器ａ１７６の等化特性の方が、判定帰還形適応等化器ｂ１８０または線形適応等化器ｂ１８１の等化特性より良い場合には、選択回路１８５に等化出力メモリａ１７８と接続する制御信号を出力する。また、等化２乗誤差積算回路ｂ１８２の等化２乗誤差の和の方が等化２乗誤差積算回路ａ１７７の等化２乗誤差の和より小さい場合、すなわち、そのバーストに対して判定帰還形適応等化器ｂ１８０または線形適応等化器ｂ１８１の等化特性の方が、判定帰還形適応等化器ａ１７５または線形適応等化器ａ１７６の等化特性より良い場合には、選

択回路１８５に等化出力メモリｂ１８３と接続する制御信号を出力する。選択回路１８５では、比較回路１８４の出力結果に従い、等化出力メモリａ１７８、等化出力メモリｂ１８３に蓄積された等化出力の中から最終的な等化出力を選択し等化出力端子１２６より出力する。

【０１４９】

【発明の効果】以上のように請求項１に係わる発明によれば、遅延波の遅延時間が大きい周波数選択性フェージング下において等化特性が良い判定帰還形適応等化器と、遅延波の遅延時間が小さい周波数フェージング下および遅延波がないフェージング下において等化特性が良い線形適応等化器を用いて等化を行い、等化特性の良い方の出力結果を最終的な等化出力とするために、フェージング下において、遅延波の有無、また遅延波の遅延時間の大小にかかわらず良好な等化特性がえられる。また、移動体通信に用いられる適応等化器のタップ係数更新アルゴリズムの演算量は一般にタップ数の２乗に比例して増加するが、遅延波の正規化遅延時間が１シンボル以内での特性改善を考える場合には、線形適応等化器のタップ数は１、または２ですむので、判定帰還形適応等化器単体時に比べて、演算量がそれほど増加せずに、等化特性が改善される適応等化器を得ることができる。

【０１５０】以上のように請求項２に係わる発明によれば、遅延波の遅延時間が大きい周波数選択性フェージング下において等化特性が良い判定帰還形適応等化器と、遅延波の遅延時間が小さい周波数フェージング下および遅延波がないフェージング下において等化特性が良い線形適応等化器を用いて、受信信号の一部分に対して等化を行い、等化特性を判断し、特性の良くない方の適応等化器の動作を停止するために、伝送路特性の変動が比較的緩やかな場合には、遅延波の有無、また遅延波の遅延時間の大小にかかわらず良好な等化特性がえられ、また、全体の演算量が低減する適応等化器を得ることができる。

【０１５１】以上のように請求項３に係わる発明によれば、既知信号系列部分の受信信号に対する判定帰還形適応等化器の特性と、線形適応等化器の１バースト分の受信信号に対する等化特性を比較して、線形適応等化器の特性が判定帰還形適応等化器の特性に比べて悪いと予想されるときのみ、判定帰還形適応等化器にて、既知信号系列以降の受信信号の等化を行なう。そのために、遅延波が存在しない時、また、遅延波の遅延時間が小さいときは、判定帰還形適応等化器は、既知信号系列部分の受信信号以外に対して、等化を行なう必要がなくなるために、全体の演算量が低減する適応等化器を得ることができる。また、判定帰還形適応等化器にて、既知信号系列以降の受信信号の等化を行った場合でも、等化特性の良い方の出力結果を最終的な等化出力とするために、フェージング下において遅延波の有無、また遅延波の遅延時間の大小にかかわらず良好な等化特性を持つ適応等化器が得られる。

【０１５２】以上のように請求項４に係わる発明によれば、１バースト中の信号に対して等化処理を打ち切り、判定帰還形適応等化器と線形適応等化器とのタップ係数をリセットし、それまでの特性が良い方の適応等化器の出力を選択するとともに、等化特性の良い方の出力データを次の等化処理の既知参照信号として判定帰還形適応等化器と線形適応等化器を再トレーニングするので、伝送路特性の変動に対する追従性が改善されるとともにフェージング下において遅延波の有無、また遅延波の遅延時間の大小にかかわらず良好な等化特性を持つ適応等化器が得られる。

【０１５３】以上のように請求項５に係わる発明によれば、遅延測定回路により、伝送路の状態を測定し、遅延波の遅延時間が大きい場合には、遅延波の遅延時間が大きい周波数選択性フェージング下において等化特性が良い判定帰還形適応等化器にて等化を行い、また、遅延波の遅延時間が小さい場合には、遅延波の遅延時間が小さい周波数フェージング下および遅延波がないフェージング下において等化特性が良い線形適応等化器部を用いて等化を行うために、フェージング下において、遅延波の有無、また遅延波の遅延時間の大小にかかわらず良好な等化特性がえられる。また、判定帰還形適応等化器と線形適応等化器のどちらか一方の演算を行わないことによって、演算量が削減された適応等化器を得ることができる。

【０１５４】以上のように請求項６に係わる発明によれば、複数のアンテナおよび検波器の出力信号それぞれに対して、遅延波の遅延時間が大きい周波数選択性フェージング下において等化特性が良い判定帰還形適応等化器と、遅延波の遅延時間が小さい周波数フェージング下および遅延波がないフェージング下において等化特性が良い線形適応等化器を用いて等化を行い、等化特性が一番良い適応等化器の出力結果を最終的な等化出力とするために、フェージング下において、ダイバーシチ効果により受信特性が向上するとともに、遅延波の有無、また遅延波の遅延時間の大小にかかわらず良好な特性がえられる。また、移動体通信に用いられる適応等化器のタップ係数更新アルゴリズムの演算量は一般にタップ数の２乗に比例して増加するが、遅延波の正規化遅延時間が１シンボル以内での特性改善を考える場合には、線形適応等化器のタップ数は１、または２ですむので、複数のアンテナおよび検波器の出力信号それぞれに対して判定帰還形適応等化器のみを備えた場合に比べて、演算量がそれほど増加せずに、等化特性が改善される適応ダイバーシチ等化器を得ることができる。

【０１５５】以上のように請求項７に係わる発明によれば、複数のアンテナおよび検波器の出力信号それぞれに対して、遅延波の遅延時間が大きい周波数選択性フェージング下において等化特性が良い判定帰還形適応等化器

と、遅延波の遅延時間が小さい周波数選択性フェージング下および遅延波がないフェージング下において等化特性が良い線形適応等化器を用いて、受信信号の一部分に対して等化を行い、等化特性を判断し、特性の良くない適応等化器の動作を停止するために、フェージング下において、ダイバーシチ効果により受信特性が向上するとともに、伝送路特性の変動が比較的緩やかな場合には、遅延波の有無、また遅延波の遅延時間の大小にかかわらず良好な等化特性がえられ、また、全体の演算量が低減する適応ダイバーシチ等化器を得ることができる。

【０１５６】以上のように請求項８に係わる発明では、複数のアンテナおよび検波器の出力信号それぞれに対して、既知信号系列部分の受信信号に対する各判定帰還形適応等化器の特性と、線形適応等化器の１バースト分の受信信号に対する等化特性を比較して、一番等化特性が良いのが判定帰還形適応等化器と予想されるときのみ、各判定帰還形適応等化器は、既知信号系列以降の受信信号の等化を行う。そのために、遅延波が存在しない時、また、遅延波の遅延時間が小さいときは、各判定帰還形適応等化器は、既知信号系列部分の受信信号以外に対して、等化を行なう必要がなくなるために、全体の演算量が低減する適応ダイバーシチ等化器を得ることができる。また、判定帰還形適応等化器にて、既知信号系列以降の受信信号の等化を行った場合でも、等化特性が一番良い出力結果を最終的な等化出力とするために、フェージング下において、ダイバーシチ効果により受信特性が向上するとともに遅延波の有無、また遅延波の遅延時間の大小にかかわらず良好な等化特性を持つ適応ダイバーシチ等化器が得られる。

【０１５７】以上のように請求項９に係わる発明によれば、複数のアンテナおよび検波器のそれぞれの出力信号に対する等化処理を１バースト中で打ち切り、各判定帰還形適応等化器と各線形適応等化器とのタップ係数をリセットし、それまでの特性が一番良い適応等化器の出力を選択するとともに、等化特性が一番良い出力データを次の等化処理の既知参照信号として各判定帰還形適応等化器と各線形適応等化器を再トレーニングするので、伝送路特性の変動に対する追従性が改善されるとともに、フェージング下において、ダイバーシチ効果により受信特性が向上する。また、遅延波の有無、および遅延波の遅延時間の大小にかかわらず良好な等化特性を持つ適応ダイバーシチ等化器が得られる。

【０１５８】以上のように請求項１０に係わる発明によれば、複数のアンテナおよび検波器の出力信号それぞれに対して、遅延測定回路により、伝送路の状態を測定し、遅延波の遅延時間が大きい場合には、遅延波の遅延時間が大きい周波数選択性フェージング下において等化特性が良い判定帰還形適応等化器にて等化を行い、また、遅延波の遅延時間が小さい場合には、遅延波の遅延時間が小さい周波数選択性フェージング下および遅延波がないフェージング下において等化特性が良い線形適応等化器を用いて等化を行い、各ブランチ毎に等化出力を定めた後に、等化特性が一番良いブランチの出力結果を最終的な等化出力とするために、フェージング下において、ダイバーシチ効果により受信特性が向上するとともに、遅延波の有無、また遅延波の遅延時間の大小にかかわらず良好な特性がえられる。また、各ブランチにおいては、判定帰還形適応等化器と線形適応等化器のどちらか一方の演算を行わないことによって、演算量が削減された適応ダイバーシチ等化器を得ることができる。

【図面の簡単な説明】

【図１】この発明の適応等化器の実施例１を示す構成ブロック図である。

【図２】この発明の適応等化器の実施例１による等化特性の改善効果の一例を示す特性図である。

【図３】この発明の適応等化器の実施例２を示す構成ブロック図である。

【図４】この発明の適応等化器の実施例３を示す構成ブロック図である。

【図５】図４に示す適応等化器の動作を示すフローチャートである。

【図６】この発明の適応等化器の実施例４を示す構成ブロック図である。

【図７】図６に示す適応等化器の動作を示すフローチャートである。

【図８】図６に示す適応等化器の動作を説明する図である。

【図９】この発明の適応等化器の実施例５を示す構成ブロック図である。

【図１０】この発明の適応等化器の実施例６を示す構成ブロック図である。

【図１１】この発明の適応等化器の実施例７を示す構成ブロック図である。

【図１２】この発明の適応等化器の実施例８を示す構成ブロック図である。

【図１３】この発明の適応等化器の実施例９を示す構成ブロック図である。

【図１４】この発明の適応等化器の実施例１０を示す構成ブロック図である。

【図１５】従来の適応等化器を示す構成ブロック図である。

【図１６】移動体通信に用いられるバーストフォーマットの一例を示す図である。

【図１７】従来の適応等化器を示す構成ブロック図である。

【図１８】従来の適応等化器を示す構成ブロック図である。

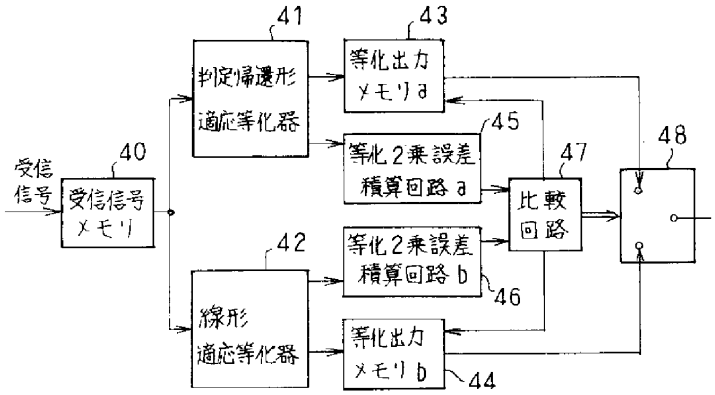
【図１９】従来の適応等化器を動作を説明する図である。

【図２０】従来の等化器を含むディジタル通信制御装置

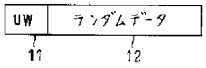
を示す構成ブロック図である。
【図２１】従来の適応ダイバーシチ等化器を示す構成ブロック図である。
【図２２】従来の等化器の遅延波の正規化遅延時間に対する特性の一例を示す図である。
【図２３】従来の等化器の遅延波の正規化遅延時間に対する特性の一例を示す図である。
【図２４】従来の等化器の特性の一例を示す図である。
【符号の説明】
１　フィードフォワード部のトランスバーサルフィルタ（ＦＦ部）
２　フィードバック部のトランスバーサルフィルタ（ＦＢ部）
３　加算器
４　判定器
５　加算器
６　タップ係数更新回路
７　スイッチ回路
８　受信信号入力端子
９　参照信号系列入力端子
１０　出力信号端子
１１　ユニークワード（ＵＷ）
１２　ランダムデータ部
１３　シンボル間隔自動等化器
１４　分数間隔自動等化器
１５　出力選択スイッチ
１６　スイッチ制御部
１７　受信信号メモリ
１８　等化処理部
１９　等化出力メモリ
２０　制御部
２１　入力信号分配器
２２　遅延器
２３　適応自動等化器
２４　切り換えスイッチＳＷａ
２５　遅延検波器
２６　遅延器
２７　符号誤り率測定器
２８　第１の復調器
２９　第２の復調器
３０　スイッチＳＷｂ
４０　受信信号メモリ
４１　判定帰還形適応等化器
４２　線形適応等化器
４３　等化出力メモリａ
４４　等化出力メモリｂ
４５　等化２乗誤差積算回路ａ
４６　等化２乗誤差積算回路ｂ
４７　比較回路
４８　出力選択スイッチ
４９　判定帰還形適応等化器
５０　線形適応等化器
５１　等化出力メモリａ
５２　等化出力メモリｂ
５３　等化２乗誤差積算回路ａ
５４　等化２乗誤差積算回路ｂ
５５　比較回路
５６　判定帰還形適応等化器
５７　線形適応等化器
５８　しきい値設定回路
５９　等化２乗誤差積算回路ｂ
６０　等化２乗誤差積算回路
６１　比較回路ａ
６２　等化出力メモリａ
６３　等化出力メモリｂ
６４　等化２乗誤差積算回路ａ
６５　比較回路ｂ
６６　判定帰還形適応等化器
６７　線形適応等化器
６８　等化２乗誤差積算回路ａ
６９　等化２乗誤差積算回路ｂ
７０　等化出力メモリａ
７１　等化出力メモリｂ
７２　比較回路
７３　等化出力メモリｃ
７４　制御部
７５　遅延測定回路
７６　判定帰還形適応等化器
７７　線形適応等化器
７８　等化出力メモリ
１０１　アンテナａ
１０２　アンテナｂ
１０３　検波回路ａ
１０４　検波回路ｂ
１０５　判定帰還形適応等化器ａ
１０６　判定帰還形適応等化器ｂ
１０７　比較回路
１０８　選択回路
１０９　等化出力端子
１１０　受信信号メモリａ
１１１　判定帰還形適応等化器ａ
１１２　等化２乗誤差積算回路ａ
１１３　等化出力メモリａ
１１４　線形適応等化器ａ
１１５　等化２乗誤差積算回路ｂ
１１６　等化出力メモリｂ
１１７　受信信号メモリｂ
１１８　判定帰還形適応等化器ｂ
１１９　等化２乗誤差積算回路ｃ
１２０　等化出力メモリｃ

１２１　線形適応等化器ｂ
１２２　等化２乗誤差積算回路ｄ
１２３　等化出力メモリｄ
１２４　比較回路
１２５　選択回路
１２６　等化出力端子
１２７　判定帰還形適応等化器ａ
１２８　等化２乗誤差積算回路ａ
１２９　等化出力メモリａ
１３０　線形適応等化器ａ
１３１　等化２乗誤差積算回路ｂ
１３２　等化出力メモリｂ
１３３　判定帰還形適応等化器ｂ
１３４　等化２乗誤差積算回路ｃ
１３５　等化出力メモリｃ
１３６　線形適応等化器ｂ
１３７　等化２乗誤差積算回路ｄ
１３８　等化出力メモリｄ
１３９　比較回路
１４０　選択回路
１４１　判定帰還形適応等化器ａ
１４２　等化２乗誤差積算回路ａ
１４３　しきい値設定回路ａ
１４４　等化出力メモリａ
１４５　線形適応等化器ａ
１４６　等化２乗誤差積算回路ｂ
１４７　等化２乗誤差積算回路ａ
１４８　等化出力メモリｂ
１４９　判定帰還形適応等化器ｂ
１５０　等化２乗誤差積算回路ｃ
１５１　しきい値設定回路ｂ
１５２　等化出力メモリｃ
１５３　線形適応等化器ｂ
１５４　等化２乗誤差積算回路ｄ
１５５　等化２乗誤差平均回路ｂ
１５６　等化出力メモリｄ
１５７　比較回路ａ
１５８　比較回路ｂ
１５９　判定帰還形適応等化器ａ
１６０　等化２乗誤差積算回路ａ
１６１　等化出力メモリａ
１６２　線形適応等化器ａ
１６３　等化２乗誤差積算回路ｂ
１６４　等化出力メモリｂ
１６５　判定帰還形適応等化器ｂ
１６６　等化２乗誤差積算回路ｃ
１６７　等化出力メモリｃ
１６８　線形適応等化器ｂ
１６９　等化２乗誤差積算回路ｄ
１７０　等化出力メモリｄ
１７１　制御部
１７２　比較回路
１７３　等化出力メモリｅ
１７４　遅延測定回路ａ
１７５　判定帰還形適応等化器ａ
１７６　線形適応等化器ａ
１７７　等化２乗誤差積算回路ａ
１７８　等化出力メモリａ
１７９　遅延測定回路ｂ
１８０　判定帰還形適応等化器ｂ
１８１　線形適応等化器ｂ
１８２　等化２乗誤差積算回路ｂ
１８３　等化出力メモリｂ
１８４　比較回路
１８５　選択回路

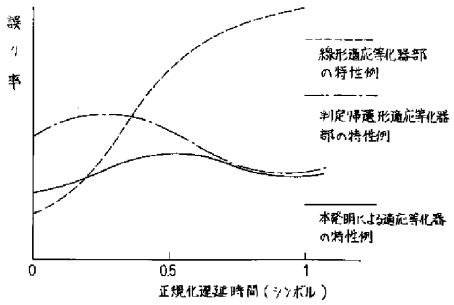
【図１】



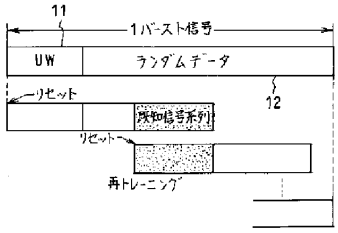
【図１６】



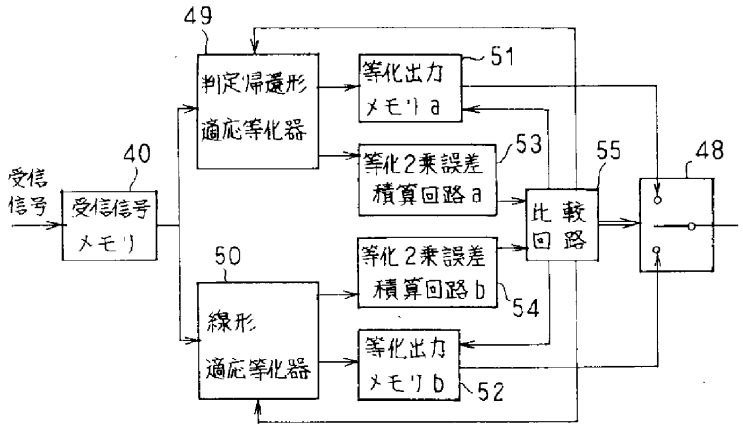
【図2】


誤り率
線形適応等化器部の特性例
判定帰還形適応等化器部の特性例
本発明による適応等化器の特性例
0
0.5
1
正規化遅延時間（シンボル）

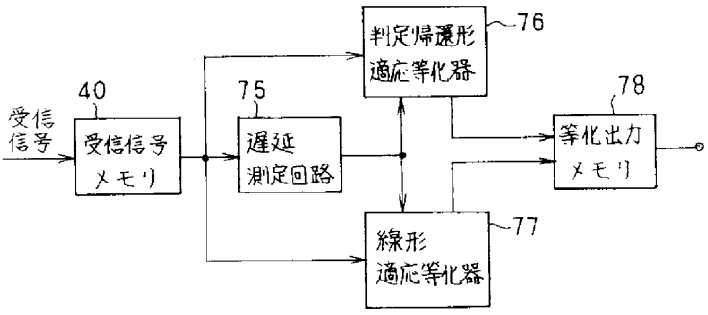
【図19】


11
1バースト信号
UW
ランダムデータ
12
リセット
既知信号系列
リセット
再トレーニング

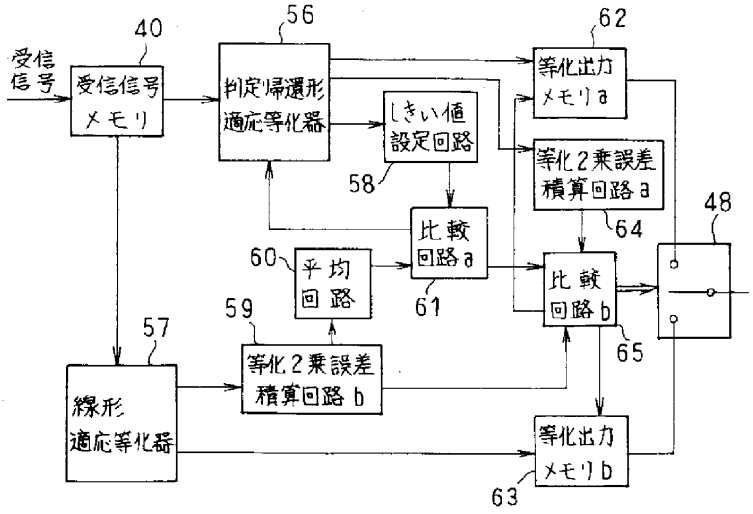
【図3】


49
判定帰還形適応等化器
等化出力メモリa
51
40
受信信号
受信信号メモリ
等化2乗誤差積算回路a
53
55
48
比較回路
50
線形適応等化器
等化2乗誤差積算回路b
54
等化出力メモリb
52

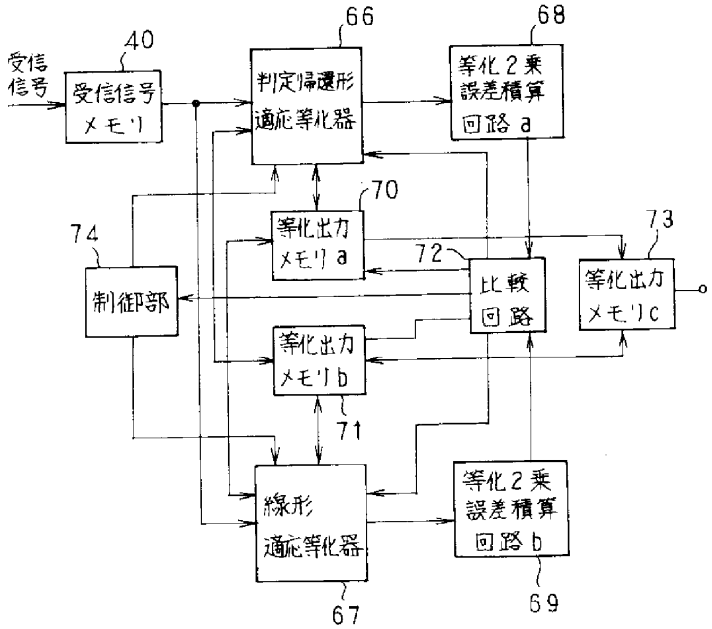
【図9】


判定帰還形適応等化器
76
40
受信信号
受信信号メモリ
75
遅延測定回路
78
等化出力メモリ
線形適応等化器
77

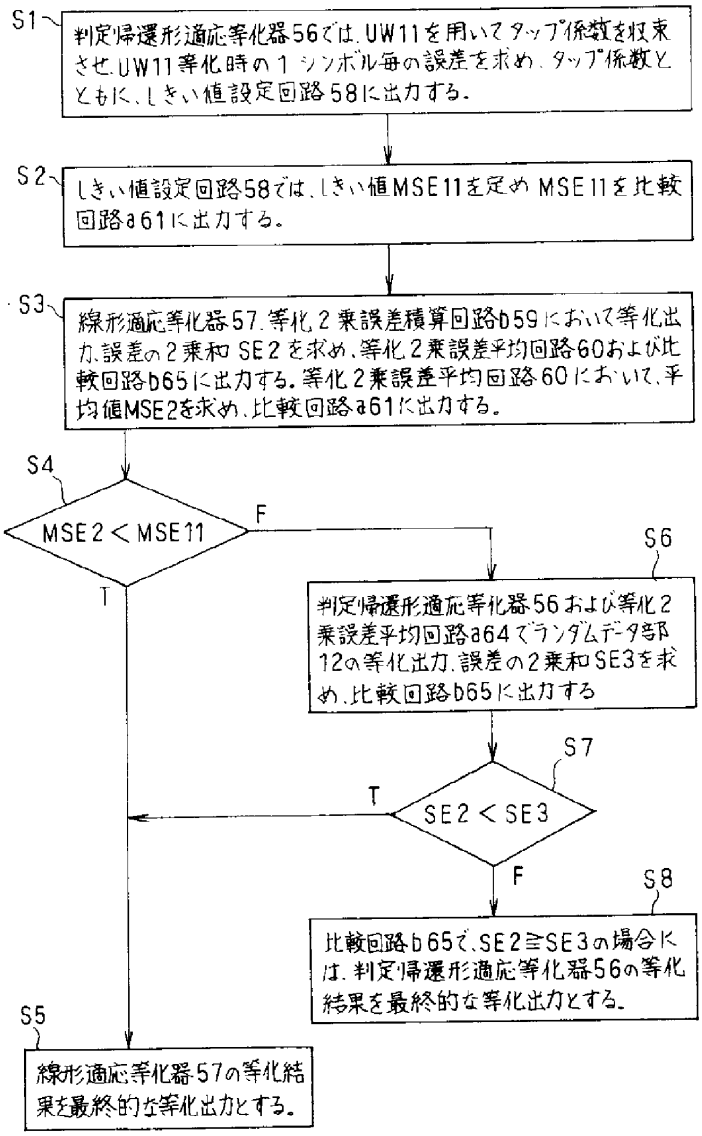
【図4】


受信信号
40
受信信号メモリ
56
判定帰還形適応等化器
しきい値設定回路
58
62
等化出力メモリa
等化2乗誤差積算回路a
64
48
比較回路a
60
平均回路
61
比較回路b
65
59
57
等化2乗誤差積算回路b
線形適応等化器
等化出力メモリb
63

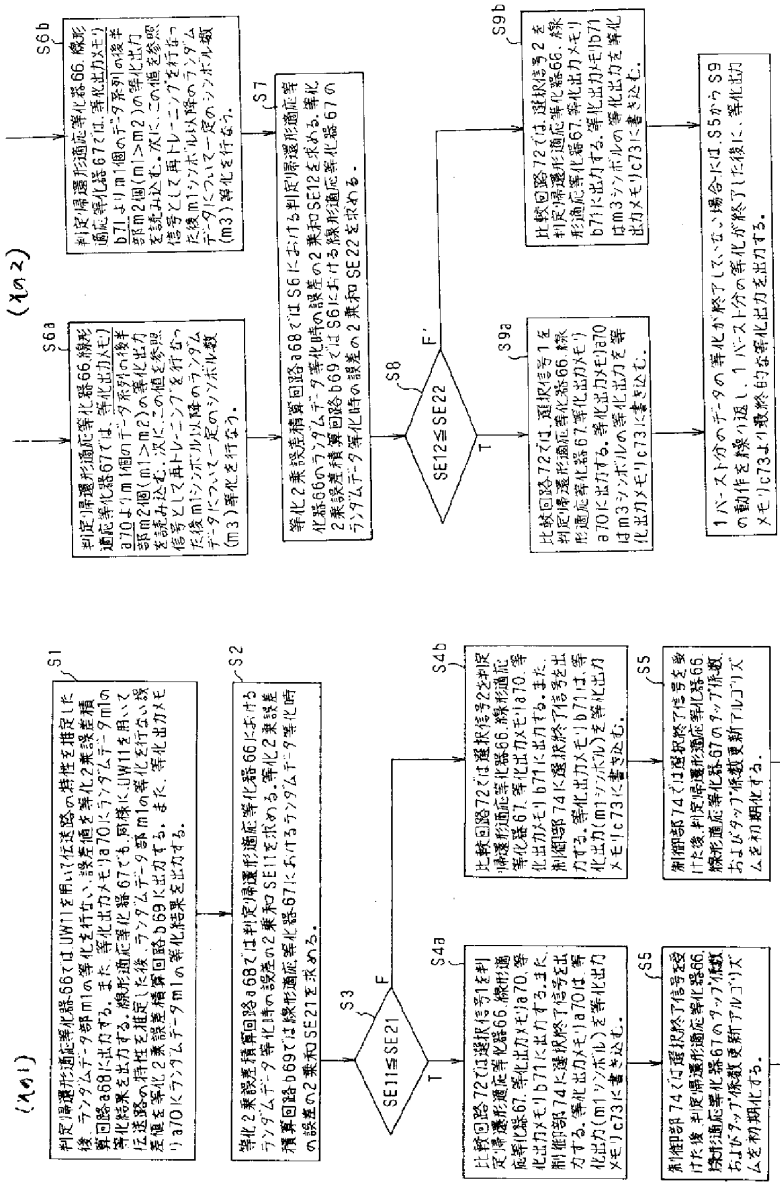
【図6】


受信信号
40
受信信号メモリ
66
判定帰還形適応等化器
68
等化2乗誤差積算回路a
70
等化出力メモリa
74
制御部
72
比較回路
73
等化出力メモリc
等化出力メモリb
71
線形適応等化器
67
等化2乗誤差積算回路b
69

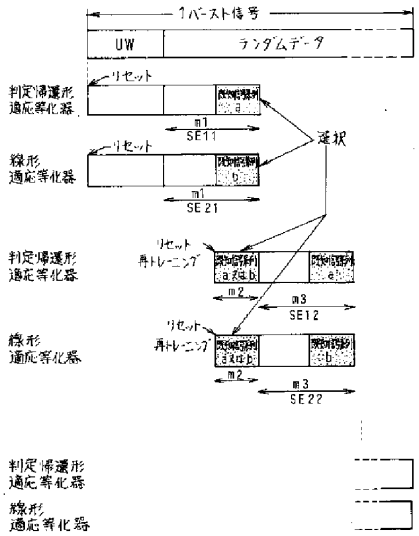
【図5】


S1
判定帰還形適応等化器56では、UW11を用いてタップ係数を収束させ、UW11等化時の1シンボル毎の誤差を求め、タップ係数とともに、しきい値設定回路58に出力する。
S2
しきい値設定回路58では、しきい値MSE11を定めMSE11を比較回路a61に出力する。
S3
線形適応等化器57、等化2乗誤差積算回路b59において等化出力、誤差の2乗和SE2を求め、等化2乗誤差平均回路60および比較回路b65に出力する。等化2乗誤差平均回路60において、平均値MSE2を求め、比較回路a61に出力する。
S4
MSE2＜MSE11
F
T
S6
判定帰還形適応等化器56および等化2乗誤差平均回路a64でランダムデータ部12の等化出力、誤差の2乗和SE3を求め、比較回路b65に出力する
S7
SE2＜SE3
T
F
S8
比較回路b65で、SE2≧SE3の場合には、判定帰還形適応等化器56の等化結果を最終的な等化出力とする。
S5
線形適応等化器57の等化結果を最終的な等化出力とする。

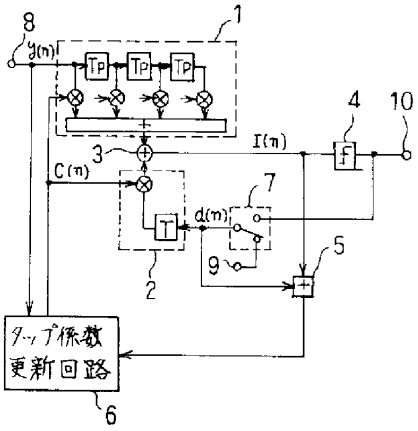
【図7】


(その1)
S1
判定帰還形適応等化器66では UW11を用いて伝送路の特性を推定した後 ランダムデータ部m1の等化を行ない、誤差値を等化2乗誤差積算回路a68に出力する。また、等化出力メモリa70にランダムデータ部m1の等化結果を出力する。線形適応等化器67では、同様にUW11を用いて伝送路の特性を推定した後 ランダムデータ部m1の等化を行ない誤差値を等化2乗誤差積算回路b69に出力する。また、等化出力メモリa70にランダムデータ部m1の等化結果を出力する。
S2
等化2乗誤差積算回路a68では判定帰還形適応等化器66におけるランダムデータ等化時の誤差の2乗和SE11を求める。等化2乗誤差積算回路b69では線形適応等化器67におけるランダムデータ等化時の誤差の2乗和SE21を求める。
S3
SE11≦SE21
F
T
S4a
比較回路72では選択信号Sを判定帰還形適応等化器66、線形適応等化器67、等化出力メモリa70、等化出力メモリb71に出力する。また、制御部74に選択終了信号Eを出力する。等化出力メモリa70は等化出力(m1シンボル)をメモリc73に書き込む。
S5
制御部74では選択終了信号Eを受けた後 判定帰還形適応等化器66、線形適応等化器67のタップ係数およびタップ係数更新アルゴリズムを初期化する。
S4b
比較回路72では選択信号Sを判定帰還形適応等化器66、線形適応等化器67、等化出力メモリa70、等化出力メモリb71に出力する。また、制御部74に選択終了信号Eを出力する。等化出力メモリa70は等化出力(m1シンボル)をメモリc73に書き込む。
S5
制御部74では選択終了信号Eを受けた後 判定帰還形適応等化器66、線形適応等化器67のタップ係数およびタップ係数更新アルゴリズムを初期化する。
(その2)
S6a
判定帰還形適応等化器66、線形適応等化器67では、等化出力メモリb71より m1個のデータ系列の後半部m2個(m1>m2)の等化出力を読み込む。次に、この値を参照信号として再トレーニングを行なった後 m1シンボル以降のランダムデータについて一定のシンボル数(m3)等化を行なう。
S6b
判定帰還形適応等化器66、線形適応等化器67では、等化出力メモリb71より m1個のデータ系列の後半部m2個(m1>m2)の等化出力を読み込む。次に、この値を参照信号として再トレーニングを行なった後 m1シンボル以降のランダムデータについて一定のシンボル数(m3)等化を行なう。
S7
等化2乗誤差積算回路a68では S6における判定帰還形適応等化器66のランダムデータ等化時の誤差の2乗和SE12を求める。等化2乗誤差積算回路b69では S6における線形適応等化器67のランダムデータ等化時の誤差の2乗和 SE22を求める。
S8
SE12≦SE22
F'
T
S9a
比較回路72では、選択信号 1を判定帰還形適応等化器66、線形適応等化器67、等化出力メモリb71に出力する。等化出力メモリa70は m3シンボルの等化出力を等化出力メモリc73に書き込む。
S9b
比較回路72では、選択信号 2を判定帰還形適応等化器66、線形適応等化器67、等化出力メモリb71に出力する。等化出力メモリa70は m3シンボルの等化出力を等化出力メモリc73に書き込む。
1バースト分のデータの等化が終了していない場合には S5から S9の動作を繰り返し、1バースト分の等化が終了した後に、等化出力メモリc73より最終的な等化出力を出力する。

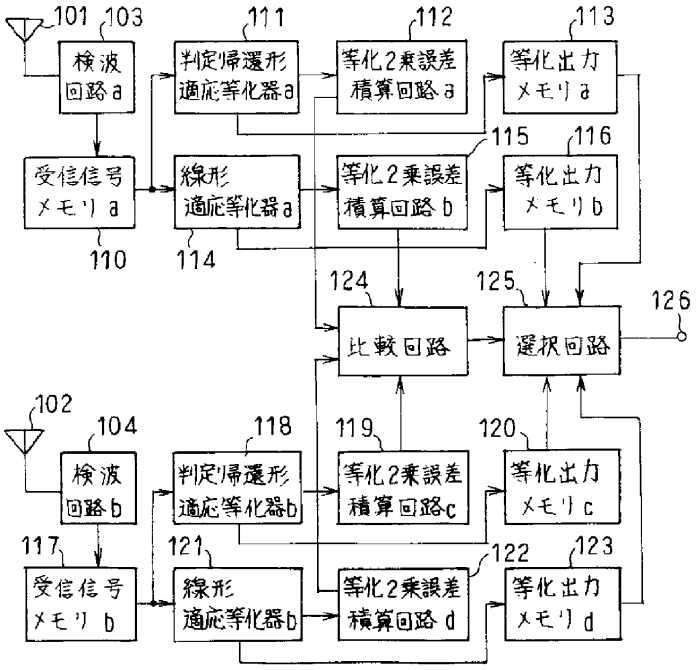
【図8】


1バースト信号
UW
ランダムデータ
リセット
判定帰還形適応等化器
m1
SE11
選択
線形適応等化器
SE21
再トレーニング
m2
m3
SE12
SE22

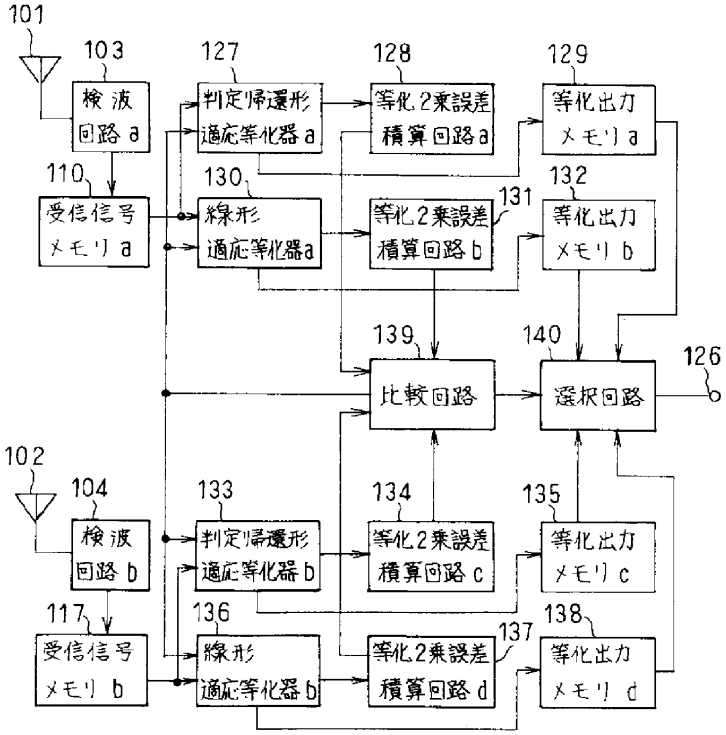
【図15】


8
y(n)
1
Tp
4
10
I(n)
3
C(n)
7
T
d(n)
2
9
5
タップ係数更新回路
6

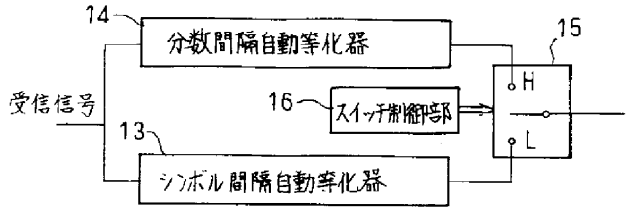
【図10】


101
103
検波回路a
111
判定帰還形適応等化器a
112
等化2乗誤差積算回路a
113
等化出力メモリa
115
116
受信信号メモリa
線形適応等化器a
等化2乗誤差積算回路b
等化出力メモリb
110
114
124
125
126
比較回路
選択回路
102
104
118
119
120
検波回路b
判定帰還形適応等化器b
等化2乗誤差積算回路c
等化出力メモリc
117
121
122
123
受信信号メモリb
線形適応等化器b
等化2乗誤差積算回路d
等化出力メモリd

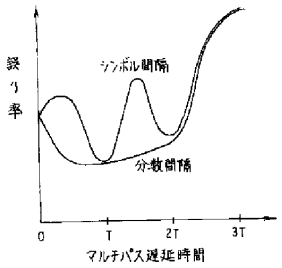
【図11】


101
103
検波回路a
127
判定帰還形適応等化器a
128
等化2乗誤差積算回路a
129
等化出力メモリa
110
受信信号メモリa
130
線形適応等化器a
131
等化2乗誤差積算回路b
132
等化出力メモリb
139
比較回路
140
選択回路
126
102
104
検波回路b
133
判定帰還形適応等化器b
134
等化2乗誤差積算回路c
135
等化出力メモリc
117
受信信号メモリb
136
線形適応等化器b
137
等化2乗誤差積算回路d
138
等化出力メモリd

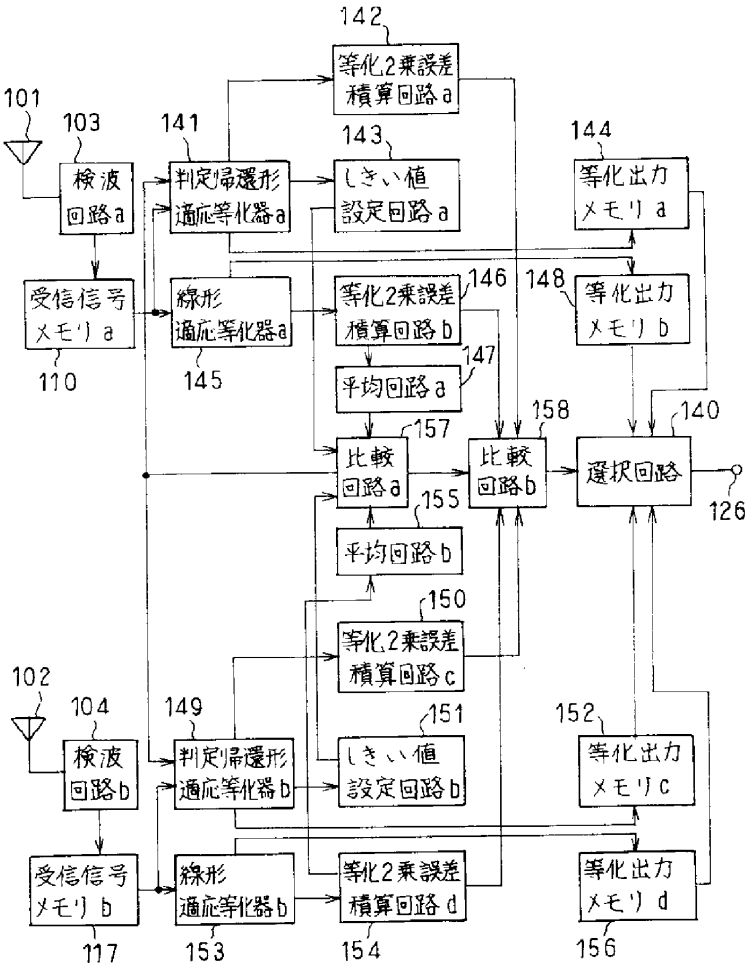
【図17】


14
分数間隔自動等化器
15
受信信号
16
スイッチ制御部
H
L
13
シンボル間隔自動等化器

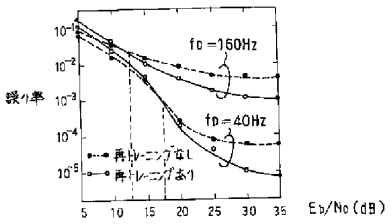
【図22】


誤り率
シンボル間隔
分数間隔
0
T
2T
3T
マルチパス遅延時間

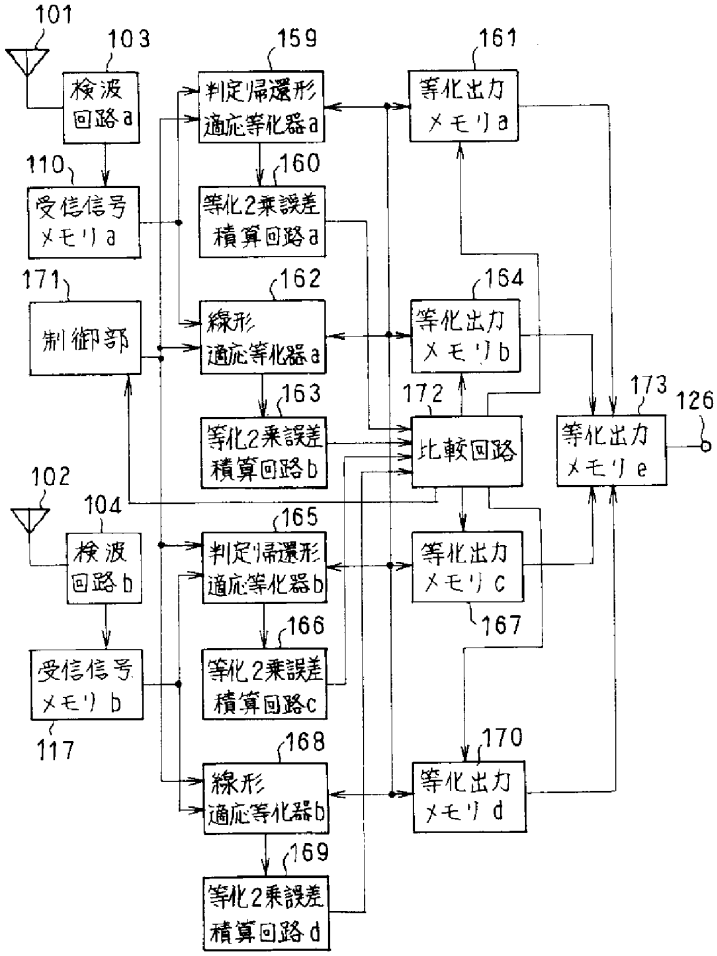
【図12】


142
等化2乗誤差積算回路a
101
103
141
143
144
検波回路a
判定帰還形適応等化器a
しきい値設定回路a
等化出力メモリa
受信信号メモリa
線形適応等化器a
等化2乗誤差積算回路b
146
148
等化出力メモリb
147
平均回路a
158
140
157
比較回路a
比較回路b
選択回路
126
155
平均回路b
150
等化2乗誤差積算回路c
102
104
149
151
152
検波回路b
判定帰還形適応等化器b
しきい値設定回路b
等化出力メモリc
受信信号メモリb
線形適応等化器b
等化2乗誤差積算回路d
等化出力メモリd
110
145
117
153
154
156

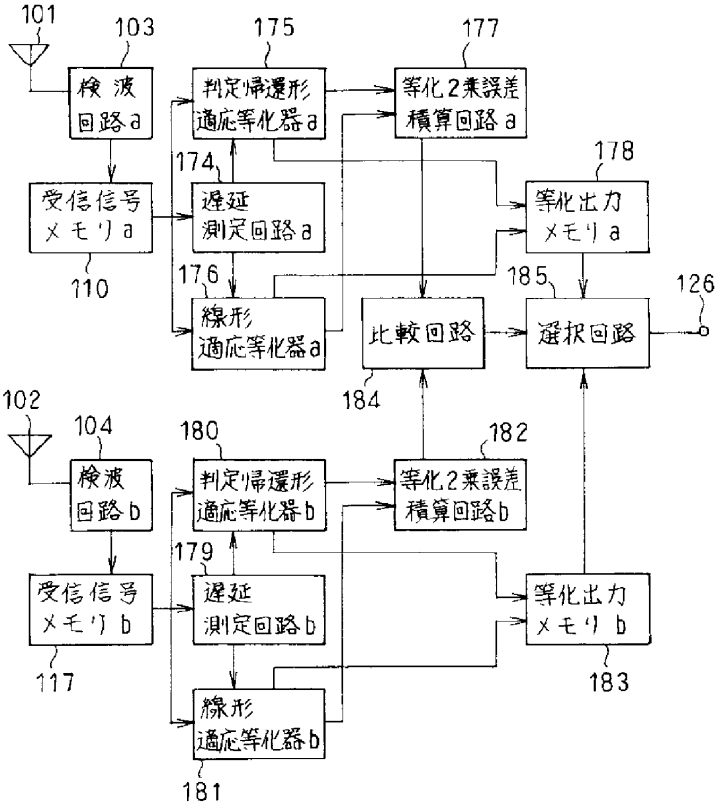
【図24】


fD=160Hz
fD=40Hz
誤り率
Eb/No(dB)

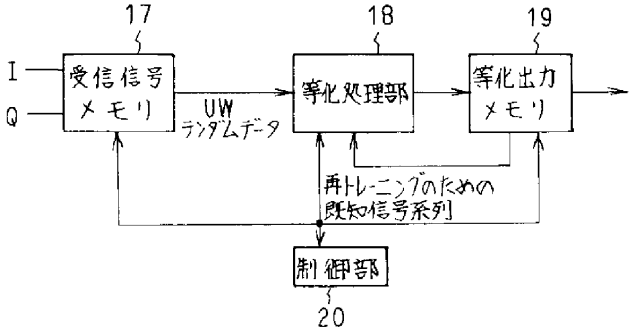
【図13】


101
103
検波回路a
159
判定帰還形適応等化器a
161
等化出力メモリa
110
受信信号メモリa
160
等化2乗誤差積算回路a
171
制御部
162
線形適応等化器a
164
等化出力メモリb
163
等化2乗誤差積算回路b
172
比較回路
173
126
等化出力メモリe
102
104
検波回路b
165
判定帰還形適応等化器b
等化出力メモリc
167
166
等化2乗誤差積算回路c
受信信号メモリb
117
168
線形適応等化器b
170
等化出力メモリd
169
等化2乗誤差積算回路d

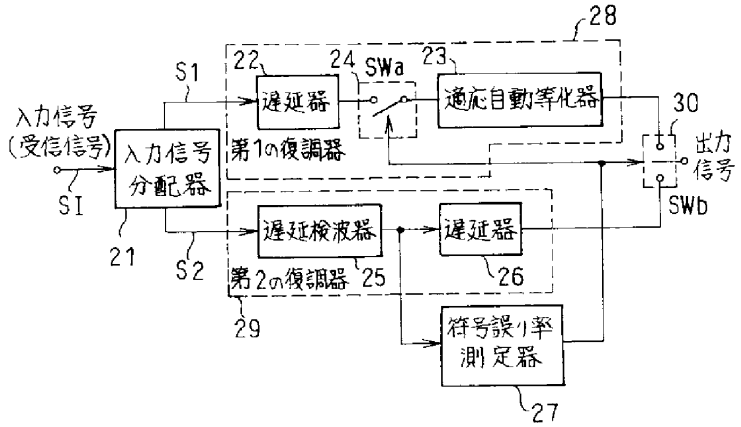
【図14】


101
103
175
177
検波回路a
判定帰還形適応等化器a
等化2乗誤差積算回路a
178
174
遅延測定回路a
等化出力メモリa
受信信号メモリa
110
176
185
126
線形適応等化器a
比較回路
選択回路
184
102
104
180
182
検波回路b
判定帰還形適応等化器b
等化2乗誤差積算回路b
179
遅延測定回路b
等化出力メモリb
受信信号メモリb
117
183
線形適応等化器b
181

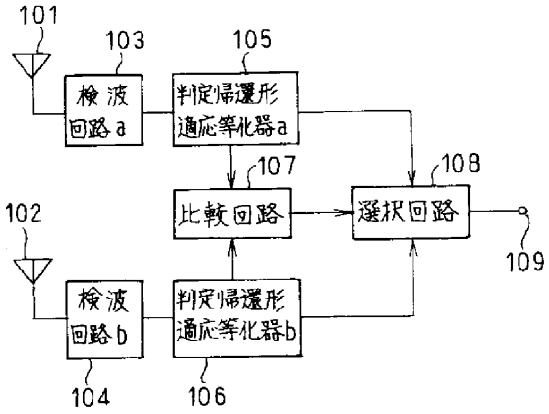
【図18】


17
18
19
I
Q
受信信号メモリ
UW
ランダムデータ
等化処理部
等化出力メモリ
再トレーニングのための既知信号系列
制御部
20

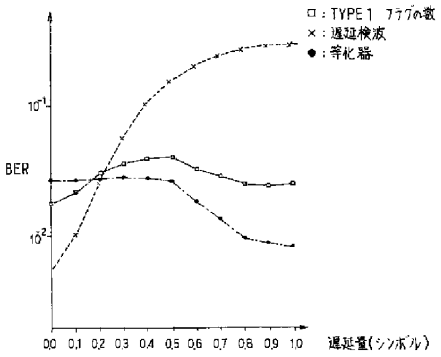
【図20】


28
22
24
SWa
23
S1
遅延器
適応自動等化器
30
入力信号
(受信信号)
入力信号
分配器
第1の復調器
出力
信号
SI
SWb
遅延検波器
遅延器
21
S2
第2の復調器
25
26
29
符号誤り率
測定器
27

【図21】


101
103
105
検波
回路a
判定帰還形
適応等化器a
107
108
比較回路
選択回路
102
109
検波
回路b
判定帰還形
適応等化器b
104
106

【図２３】


□：TYPE１　ﾌﾗｸﾞの数
×：遅延検波
●：等化器
BER
10^{-1}
10^{-2}
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
遅延量(ｼﾝﾎﾞﾙ)

PATENT ABSTRACTS OF JAPAN

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(43)Date of publication of application : 21.10.1997

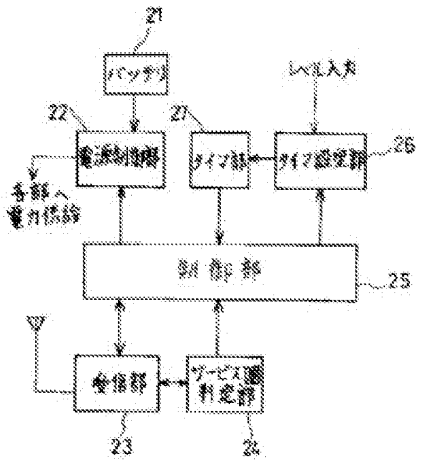
(51)Int.Cl. H04Q 7/38
H04B 7/26

(21)Application number : 08-082666
(22)Date of filing : 04.04.1996

(71)Applicant : SHARP CORP
(72)Inventor : YAMAGUCHI HIROAKI

(54) MOBILE TERMINAL EQUIPMENT IN MOBILE COMMUNICATION SYSTEM

(57)Abstract:
PROBLEM TO BE SOLVED: To realize the battery saving in response to an operating state of a mobile terminal equipment at the outside of a service zone.
SOLUTION: The terminal equipment is provided with a timer section 27 whose time is set variably, power supply to a reception section 23 is interrupted during count of the timer section 27, and at the end of the count operation, the power supply to the reception section 23 is restarted to conduct intermittent reception processing of control information at the outside of a service zone. The reception operation stop time for the intermittent reception processing is revised optionally for the setting by the operation of the timer setting section 26 by the user.



(19)日本国特許庁（ＪＰ）　(12) **公開特許公報（Ａ）**　(11)特許出願公開番号

特開平9－275587

(43)公開日　平成９年(1997)10月21日

(51)Int.Cl.[6]	識別記号	庁内整理番号	ＦＩ		技術表示箇所
Ｈ０４Ｑ　7/38			Ｈ０４Ｂ　7/26	１０９Ｈ	
Ｈ０４Ｂ　7/26				Ｘ	

審査請求　未請求　請求項の数２　ＯＬ　（全 13 頁）

(21)出願番号　特願平8－82666

(22)出願日　平成８年(1996)４月４日

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シャープ株式会社
大阪府大阪市阿倍野区長池町22番22号

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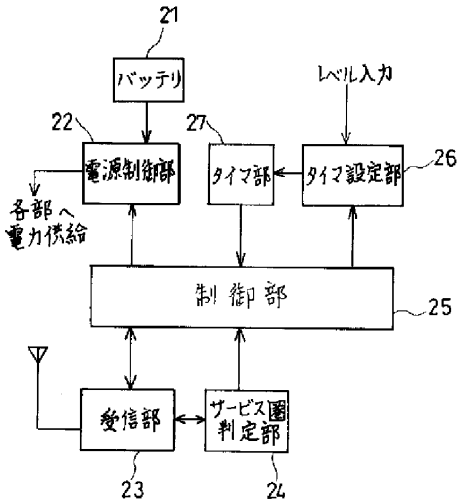
(74)代理人　弁理士　原　謙三

(54)【発明の名称】　移動通信システムの移動端末機

(57)【要約】

【課題】　サービス圏外において、移動端末機の使用状況に応じたバッテリセービングを実現する。

【解決手段】　移動端末機は、可変に時間設定の可能なタイマ部２７を備え、タイマ部２７の計時動作中は受信部２３への電力供給を中断し、当該計時動作の終了後に受信部２３への電力供給を再開することによって、サービス圏外において制御情報の間欠受信処理を行う。この間欠受信処理の受信動作停止時間は、使用者によるタイマ設定部２６の操作により、その設定を任意に変更することができる。



【特許請求の範囲】
【請求項１】移動通信システムのサービス圏を構成する基地局から送信される制御情報の受信状態に基づいてサービス圏内か否かを判定するサービス圏判定手段を備え、サービス圏外と判定された場合に制御情報の間欠受信処理によって圏内復帰を試みる移動通信システムの移動端末機において、
上記間欠受信処理の受信動作停止時間を可変設定入力するための入力操作部と、
上記入力操作部により設定された受信動作停止時間に応じたサービス圏外判定後の間欠受信処理が行われるように受信手段を制御し、当該間欠受信処理時の受信動作停止中は、受信手段への電力供給を中断または受信手段への電力供給量を通常時より低減する電力消費抑制手段とを備えていることを特徴とする移動通信システムの移動端末機。
【請求項２】移動通信システムのサービス圏を構成する基地局から送信される制御情報の受信状態に基づいてサービス圏内か否かを判定するサービス圏判定手段を備え、サービス圏外と判定された場合に制御情報の間欠受信処理によって圏内復帰を試みる移動通信システムの移動端末機において、
上記サービス圏判定手段が連続して圏外判定した回数が多いほど、上記間欠受信処理の受信動作停止時間を延長設定する受信周期延長手段と、
上記間欠受信周期可変手段によって延長設定される受信動作停止時間の上限を可変設定入力するための上限入力操作部と、
上記受信周期可変手段により上記の上限範囲内で延長設定された受信動作停止時間に応じたサービス圏外判定後の間欠受信処理が行われるように受信手段を制御し、当該間欠受信処理時の受信動作停止中は、受信手段への電力供給を中断または受信手段への電力供給量を通常時より低減する電力消費抑制手段とを備えていることを特徴とする移動通信システムの移動端末機。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、移動通信システムの移動端末機に関し、特に、バッテリセービング機能を有する移動端末機に関するものである。
【０００２】
【従来の技術】携帯電話機等の移動端末機は、複数の基地局によって構成される通信可能なサービス圏内を移動して通信を行う。そのため、バッテリに蓄えられた有限の電源容量で、移動端末機を長時間使用可能な状態に保持することが必要とされる。したがって、移動端末機の消費電流を低減することは、その移動端末機の性能を決定する重要な要素の一つとなっている。従来より、消費電流低減へ向けた回路設計は当然行われているが、更に待ち受け状態においても、実働回路以外の回路については、低消費電力状態にしたり、あるいは電源供給を停止したりする方法が実施されている。
【０００３】ここで、使用時における実働回路以外の回路への電源供給を停止する方法について、デジタル方式自動車電話システムを例に挙げて説明する。
【０００４】デジタル方式自動車電話システムに係る携帯電話機は、電源投入後、事業者固有の周波数を一通り受信し、閾値レベルを越えるチャネルがあるかどうかを調べる（いわゆる止まり木チャネルスキャン）。閾値レベルは、基地局から送信されるチャネル内の制御情報を常時確実に捕捉するのに必要な受信レベルに基づいて、予め定められているものである。
【０００５】該当するチャネルがあれば、そのチャネルに同期し、そのチャネル内の制御情報の受信の可否により、自機が当該基地局のサービス圏内に位置するかどうかを判定する。制御情報を受信できたときは、自機が基地局のサービス圏内に位置していると判断して、自機の位置情報を当該基地局へ送信（位置登録）し、受信した制御情報（基地局の識別情報等）を記憶しておく。これによって、移動端末は当該基地局を介して無線回線に接続され、待ち受け状態となる。いったん待ち受け状態に移行すると、携帯電話機は、基地局から一定の周期で送られてくる信号のうち、自機が指定されたタイミングのスロットのみを間欠受信することにより着信を可能とする。そのため、受信時以外のときには、動作不要な回路に対して、低消費電力状態への移行、又は、電力供給の停止を行うことにより、消費電流を削減することが従来より行われている。
【０００６】一方、閾値レベルを越えるチャネルを捕捉できない場合や、捕捉できても、そのチャネル内の制御情報を受信できないときは、自機がサービス圏外に位置していると判断して、以降、自機が、基地局のサービス圏内に移行し制御情報を受信できるまで、止まり木チャネルスキャンから、自機がサービス圏内とサービス圏外とのいずれに位置しているのかを判断するまでの一連の動作（制御情報捕捉動作）を繰り返す。
【０００７】すなわち、従来の携帯電話システムに係る携帯電話機には、使用者が無線基地局のサービス圏外にいる場合、又は、エリアとしてはサービス圏内ではあるが電波の届かない所（例えば地下構内、鉄筋構造のビル内など）にいるためにサービス圏外となる場合は、上記制御情報捕捉動作を繰り返すことになるため、受信回路その他周辺回路が常時動作していなければならい。そのため、長期間サービス圏外にいるときなどは、その間待ち受け状態に移行する可能性がないのに、受信回路及びその周辺回路を無駄に動作させることになり、バッテリの電力を浪費してしまうという問題点がある。
【０００８】そこで、例えば、サービス圏外にいるか高速移動中であるときに、無線基地局から間欠送信される制御情報の周期よりも大幅に長い時間を電力供給停止時

間として、受信部に対する電力の間欠供給を行うような携帯電話機が知られている（特開平７－８７０１０号公報）。

【０００９】

【発明が解決しようとする課題】ところが、特開平７－８７０１０号公報に記載された携帯電話機では、サービス圏外において電力の間欠供給を行うか否かを使用者がモード選択することは可能であるが、当該電力間欠供給モードを選択した場合のサービス圏外における上記電力供給停止時間が固定であり、使用者にとっては次のような不都合が生じる。

【００１０】すなわち、サービス圏外における上記電力供給停止時間を長く設定すればするほど電力消費量の低減化効果は大きくなるが、その分、移動端末機がサービス圏外からサービス圏内に戻ったときの圏内復帰が遅延する可能性も高くなる。したがって、ある使用者にとっては、固定された電力供給停止時間が長すぎる場合があり、回線の復帰の遅れを考えると電力間欠供給モードを選択できない場合もある。また逆に、電力消費量の低減化を重要視する使用者にとっては、固定された電力供給停止時間が短か過ぎる場合もある。このように、当該電力供給停止時間は各使用者の移動端末機の使用状況によって異なるものである。

【００１１】本発明は、上記に鑑みてなされたものであり、その目的は、サービス圏外において、使用状況に応じたバッテリセービングを実現することができる移動通信システムの移動端末機を提供することにある。

【００１２】

【課題を解決するための手段】請求項１の発明に係る移動通信システムの移動端末機は、移動通信システムのサービス圏を構成する基地局から送信される制御情報の受信状態に基づいてサービス圏内か否かを判定するサービス圏判定手段を備え、サービス圏外と判定された場合に制御情報の間欠受信処理によって圏内復帰を試みるものであって、上記の課題を解決するために、以下の手段が講じられていることを特徴としている。

【００１３】すなわち、上記間欠受信処理の受信動作停止時間を可変設定入力するための入力操作部と、上記入力操作部により設定された受信動作停止時間に応じたサービス圏外判定後の間欠受信処理が行われるように受信手段を制御し、当該間欠受信処理時の受信動作停止中は、受信手段への電力供給を中断または受信手段への電力供給量を通常時より低減する電力消費抑制手段とを備えている。

【００１４】上記の構成によれば、サービス圏外判定後の圏内復帰のための制御情報の間欠受信処理の受信動作停止時間を、入力操作部の操作により使用者自らが任意に設定変更することが可能となっている。この間欠受信処理の受信動作停止中は、電力消費抑制手段によって受信手段への電力供給が中断されるか低電力消費になるのでバッテリセービング効果が得られる。

【００１５】そして、上記のような使用者自らの設定による受信動作停止時間の可変機能を用いて、例えば、電力消費量の低減化を重要視する使用者は受信動作停止時間を長く設定し、サービス圏外から圏内への復帰遅延を少なくしたバッテリセービングを望む使用者は、受信動作停止時間をそれよりも短く設定するといったような設定変更を行うことによって、各使用者の移動端末機の使用状況に応じたバッテリセービングを実現することができる。

【００１６】請求項２の発明に係る移動通信システムの移動端末機は、移動通信システムのサービス圏を構成する基地局から送信される制御情報の受信状態に基づいてサービス圏内か否かを判定するサービス圏判定手段を備え、サービス圏外と判定された場合に制御情報の間欠受信処理によって圏内復帰を試みるものであって、上記の課題を解決するために、以下の手段が講じられていることを特徴としている。

【００１７】すなわち、上記サービス圏判定手段が連続して圏外判定した回数が多いほど、上記間欠受信処理の受信動作停止時間を延長設定する受信周期延長手段と、上記間欠受信周期可変手段によって延長設定される受信動作停止時間の上限を可変設定入力するための上限入力操作部と、上記受信周期可変手段により上記の上限範囲内で延長設定された受信動作停止時間に応じたサービス圏外判定後の間欠受信処理が行われるように受信手段を制御し、当該間欠受信処理時の受信動作停止中は、受信手段への電力供給を中断または受信手段への電力供給量を通常時より低減する電力消費抑制手段とを備えている。

【００１８】上記の構成によれば、連続してサービス圏外判定された回数が多いほど、すなわちサービス圏外に滞在する時間が長くなるほど、サービス圏外判定後の圏内復帰のための制御情報の間欠受信処理の受信動作停止時間が延長設定されるので、移動端末機がサービス圏外に滞在する時間が短ければ、短い時間間隔で制御情報の間欠受信が行われて圏内復帰が大きく遅延することはない一方、移動端末機がサービス圏外に滞在する時間が長ければ消費電力の削減効果が大きくなる。したがって、サービス圏外に滞在する時間に応じた適切な間欠受信処理が可能である。

【００１９】そして、上記のように自動的に延長設定される受信動作停止時間の上限を、入力操作部の操作により使用者自らが任意に設定変更することが可能となっている。したがって、サービス圏外に滞在する時間が長くなった場合には、上限設定された受信動作停止時間に落ち着き、各使用者の移動端末機の使用状況に応じたバッテリセービングを実現することができる。

【００２０】

【発明の実施の形態】

〔実施の形態１〕発明の実施の一形態について図１ないし図３に基づいて説明すれば、以下の通りである。

【００２１】本発明の実施の一形態に係る移動通信システムとしての携帯電話機システムは、無線回線のサービス圏を形成する少なくとも１つ（通常は複数）の基地局と、当該基地局と無線通信を行う携帯電話機（移動端末機）とからなる。

【００２２】上記携帯電話機が有するバッテリセービング回路及びその周辺回路の構成を図１に基づいて説明する。

【００２３】バッテリセービング回路及びその周辺回路は、電力を蓄えているバッテリ２１と、該バッテリ２１から供給される電圧を基にして携帯電話機の各部へ電源電圧を供給する電源制御部２２と、基地局より送信される電波（高周波信号）を受信する受信部（受信手段）２３と、携帯電話機がサービス圏内と圏外の何れに位置しているのかを判定するサービス圏判定部（サービス圏判定手段）２４と、携帯電話機全体の制御を行う制御部２５と、タイマ設定部（入力操作部）２６と、タイマ部２７とを備えている。

【００２４】電源制御部２２は、制御部２５からの制御信号に基づいて、携帯電話機各部への電力供給を制御する。具体的には、電源制御部２２は、受信部２３が機能する必要があるときには、受信部２３へ電力を供給するように制御し、受信部２３が機能する必要がないときには、受信部２３を含む動作不要な回路に対して、電力供給の停止や、電力供給の停止が困難な回路については低消費電力状態への移行を行うよう制御する。尚、本実施形態では、電源制御部２２および制御部２５によって電力消費抑制手段が構成されている。

【００２５】サービス圏判定部２４は、自機がサービス圏内と圏外との何れに位置するかを判定する。具体的には、受信部２３によって基地局から送信される決められた数（事業者固有）の周波数（チャネル）のスキャンが行われたとき、受信部２３が一通り受信したチャネルの受信レベルを測定し、閾値レベルを越えるチャネルがあるかどうかを調べる（いわゆる止まり木チャネルスキャン）。閾値レベルは、基地局から送信されるチャネル内の制御情報を常時確実に捕捉するのに必要な受信レベルに基づいて、予め定められているものである。該当する周波数チャネルがあれば、再度当該周波数チャネル内のＢＣＣＨ（Broadcast Control Channel）を受信するよう受信部２３を制御する。そして、受信されたＢＣＣＨを解析する（同期ワードの検索を行う）ことによって、基地局との同期を確立し、ＢＣＣＨ中にある制御情報を正常に受信できるか否かで圏内か圏外かの判定を行う。

【００２６】上記タイマ設定部２６は、自機がサービス圏外にいるとき、基地局に対するチャネル受信動作中断時間を使用者自らが任意に設定するための入力操作部である。この設定時間としては、サービス圏内か圏外かの判定に要する時間に対して十分な時間幅を持つものが予め何段階か準備されている。本実施の形態では、上記タイマ設定部２６の設定レベル（バッテリセービングレベル）ＬＶとして、ＬＶ＝１～３の３段階のレベルがあり、各設定レベルＬＶに応じたタイマ時間ＴＩＭ１、ＴＩＭ２及びＴＩＭ３（ＴＩＭ１＜ＴＩＭ２＜ＴＩＭ３）が用意されているものとする。使用者はタイマ設定部２６を用いて所望のレベルＬＶを入力操作することにより、サービス圏外におけるチャネル受信動作中断時間（すなわち、間欠受信周期）を段階的に任意に設定変更することができる。また、タイマ設定部２６は、使用者により設定されたレベルＬＶに対応する時間ＴＩＭ１、ＴＩＭ２又はＴＩＭ３をタイマ部２７に設定する。

【００２７】タイマ部２７は、サービス圏外におけるチャネル受信動作中断時間をカウントする機能を有し、上記タイマ設定部２６により設定された時間をカウントしたのち、制御部２５へ対して割り込み信号を送出する。尚、タイマ部２７には、常時電力が供給されている。

【００２８】上記の構成において、携帯電話機の動作について以下に説明する。

【００２９】サービス圏を構成する各基地局からは、制御チャネル上において制御情報がフレーム周期ＴＦで周期的に携帯電話機に送信されている。図３に、下り制御チャネルフォーマットの一例を示す。当該制御チャネルのフレーム構成は、報知チャネルＢＣＣＨ（Broadcast Control Channel）と、一斉呼出しチャネルＰＣＨ（Paging Channel）１～ＰＣＨ４と、個別セル用シグナリングチャネルＳＣＣＨ（Signalling Control Channel）の３つの機能チャネルからなる。

【００３０】ＢＣＣＨは、基地局から携帯電話機に対して、制御情報やチャネル構造に関する情報等を報知するための下り片方向チャネルである。ＰＣＨ１～ＰＣＨ４は、基地局から携帯電話機に対して、同一の情報を一斉に転送する下り片方向チャネルであり、携帯電話機をグループ分けして、グループ毎に着信情報を転送する。本実施の形態において、ＰＣＨのグループの数は４つ設けられている。個別セル用シグナリングチャネルＳＣＣＨは、基地局と携帯電話機の間で呼接続に必要な情報を転送する双方向チャネルである。

【００３１】携帯電話機は、電源投入時等に、制御チャネル上の制御情報の捕捉を試みる。その手順として、先ず、受信部２３にて当該携帯電話機システムの提供する制御情報を含んだ各周波数チャネルのスキャンを行う。そして、受信部２３が一通り受信したチャネルの受信レベルを測定し、閾値レベルを越えるチャネルがあるかどうかを調べる。なお、閾値レベルを越えるチャネルが複数存在する場合には、該複数のチャネルを、受信レベルの高いものから順位付けし、最も高いものから順に、再度チャネルスキャンを行い、ＢＣＣＨ内の同期ワードを検索する。もし当該検索が不可能な場合は、次に受信レ

ベルの高いチャネルに対して同様の検索処理を行う。

【００３２】携帯電話機は、ＢＣＣＨ内同期ワードの検出に成功することによって基地局との同期を確立し、予めチャネル構造がわかっている当該ＢＣＣＨ内にある制御情報を抽出し、携帯電話機システムの提供するサービスを受けるための処理を行う。その後、携帯電話機は、制御情報により自機が指定されたグループのＰＣＨｋ（ｋは１～４）のみを受信すれば、着信が可能であるので、ＰＣＨｋ（ｋは１～４）の受信時以外は、受信部２３への電源供給を停止する。すなわち、携帯電話機は、待ち受け時、ＰＣＨｋ（ｋは１～４）の受信に要する時間をＴ１とすれば、ＯＮ時間Ｔ１、ＯＦＦ時間（ＴＦ－Ｔ１）で受信部２３への電力供給のＯＮ／ＯＦＦの制御を周期的に行うことになる（サービス圏内での待ち受け時の間欠受信動作によるバッテリセービング）。

【００３３】以上の動作は、携帯電話機がサービス圏内で正常に制御情報を捕捉できた場合の動作であるが、次に、サービス圏外（地下構内等を含む）に位置しているために制御情報を正常に捕捉できなかった場合のバッテリセービング動作について説明する。

【００３４】図２のフローチャートに示すように、上述のようにしてＢＣＣＨ内の制御情報の捕捉（Ｓ１）を試みたが、正常に捕捉できなかった場合（Ｓ２でＮＯ）、サービス圏判定部２４にてサービス圏外にあると判断され、次に、使用者がタイマ設定部２６に設定しているレベルＬＶ（１～３）に応じた時間ＴＩＭ１、ＴＩＭ２又はＴＩＭ３がタイマ部２７に設定される（Ｓ３～Ｓ６）。

【００３５】その後、制御部２５は、受信部２３を含む動作不要回路に対して動作を中断させる制御を行う（Ｓ７）。すなわち、制御部２５は、スタンバイモードへの設定又は実働回路以外へ供給される電力を中断させるように、電源制御部２２に対して制御を行う。その後、制御部２５は、タイマ部２７より設定時間が経過したことを通知する割り込み信号が入力されるまで待機しておく。

【００３６】タイマ設定時間が経過し（Ｓ８）割り込み信号が入力されると、制御部２５は、受信部２３を含む受信に関わる回路へ対して通常モードの電力供給が行われるように電源制御部２２に対して制御を行った上で、再度Ｓ１の制御情報の捕捉を行うための制御を行う。

【００３７】以降は、制御情報を正確に捕捉できるまで上記のＳ１～Ｓ８の動作を繰り返し、サービス圏外での間欠受信動作によるバッテリセービングを実現する。

【００３８】本実施の形態では、可変に時間設定の可能なタイマ部２７を用いた制御情報の間欠受信処理を行うものであり、使用者が上記タイマ設定部２６の設定レベルＬＶを変更すれば、サービス圏外での間欠受信周期が変化し、各使用者の携帯電話機の使用状況に応じたバッテリセービングを実現することができる。具体的には、電力消費量の低減化を重要視する使用者は、間欠受信周期が長くなるように例えばレベルＬＶ＝３に設定し、サービス圏外から圏内への復帰遅延を少なくしたバッテリセービングを望む使用者は、レベルＬＶ＝１又はＬＶ＝２に設定することによってそれが可能となる。

【００３９】〔実施の形態２〕本発明のその他の実施の一形態について、図４ないし図８に基づいて説明すれば、以下の通りである。尚、説明の便宜上、前記実施の形態１の図面に示した部材と同一の構成・機能を有する部材には同一の符号を付記し、その説明を省略する。

【００４０】本実施形態に係る携帯電話機は、サービス圏外における受信動作停止時間の設定（すなわちＶＬの設定）を自動で行う自動設定モードを具備しており、当該自動設定モードが選択されている場合には、サービス圏判定部２４が連続して圏外判定した回数に応じて受信動作停止時間を自動的に延長する機能を備えている。

【００４１】この携帯電話機のバッテリセービング回路及びその周辺回路の構成を図４に基づいて説明する。

【００４２】本実施形態の携帯電話機は、制御部３５およびタイマ設定部３６の構成が実施の形態１のものと異なる以外の構成は、実施の形態１と同様である。

【００４３】本実施形態において、受信周期延長手段としての制御部３５は、情報捕捉失敗カウンタＦＣを有する。該カウンタＦＣは、制御情報の捕捉に失敗したときに、その連続失敗回数を記録している。制御部３５は、このカウンタＦＣの値に応じたコントロール信号を、タイマ設定部３６へ出力する。

【００４４】上記タイマ設定部３６は、制御部３５から入力されるコントロール信号に基づいて、カウンタＦＣの値に応じた時間ＴＩＭ１、ＴＩＭ２又はＴＩＭ３をタイマ部２７へ設定する。

【００４５】上記の構成において、携帯電話機のサービス圏外におけるバッテリセービング動作を、図５のフローチャートを参照して以下に説明する。

【００４６】携帯電話機への電源投入後、使用者によって受信動作停止時間の自動設定モードが選択される（或いは電源投入前から自動設定モードが選択されている）と（Ｓ２１）、制御部３５に設けられている捕捉失敗カウンタＦＣの値を初期値０に設定し（Ｓ２２）、制御情報の捕捉を試みる（Ｓ２３）。

【００４７】このとき、サービス圏判定部２４は、上述したようにチャネルスキャンを行った後、閾値を越える周波数チャネルがあれば、同期ワードを検索して制御情報の抽出を試み、その可否に基づいて自機がサービス圏内と圏外との何れに位置するのか判定する。制御情報を捕捉できれば（Ｓ２４でＹＥＳ）、自機がサービス圏内に位置していると判定され、位置登録等の必要な処理を行った後に上述した待ち受け状態に移行する。この場合、捕捉失敗カウンタＦＣの値をクリアする（Ｓ２５）。

【００４８】一方、チャネルスキャンにより閾値を越えるチャネルを受信できなかった場合や、受信できても制御情報の捕捉ができなければ（Ｓ２４でＮＯ）、サービス圏外に位置していると判定される。この場合には、受信部２３への電力供給停止時間を選択するためのステップ群（Ｓ２６・Ｓ２７）に移行する。

【００４９】Ｓ２６・Ｓ２７では、制御情報捕捉の連続失敗回数が何回であるかを判定する。当該失敗回数が１回であれば（ＦＣ＝０）、Ｓ２８に進む。このＳ２８では、先ず、制御部３５が、捕捉失敗カウンタＦＣの値が０であることを示すコントロール信号をタイマ設定部３６に送ると共に、捕捉失敗カウンタＦＣの値を１にする。このとき、タイマ設定部３６は、制御部３５より入力されたコントロール信号に基づいてタイマ時間ＴＩＭ１を設定してタイマ部２７を起動する。

【００５０】この後、制御部３５は、受信部２３への電力供給を停止する命令を電源制御部２２に対して行う（Ｓ３１）。この電力供給を停止は、上記で設定されたタイマ時間が経過するまで継続される。

【００５１】この後、時間ＴＩＭ１が経過すれば（Ｓ３２でＹＥＳ）、タイマ部２７が制御部３５にカウント終了を知らせる割り込み信号を出力する。制御部３５は、その割り込み信号を認識後、電源制御部２２に対して、受信部２３の電源をＯＮにする命令を行った上で、再度、制御情報の捕捉（Ｓ２３）を行うための制御を行う。

【００５２】また、制御情報捕捉の失敗回数が２回であれば、すなわち捕捉失敗カウンタＦＣの値が１であれば（Ｓ２６でＮＯ、且つＳ２７でＹＥＳ）、制御部３５が、捕捉失敗カウンタＦＣの値が１であることを示すコントロール信号をタイマ設定部３６に送ると共に、捕捉失敗カウンタＦＣの値を２にする（Ｓ２９）。このとき、タイマ設定部３６は、入力されたコントロール信号に基づいて、ＴＩＭ１よりも長いＴＩＭ２を設定してタイマ部２７を起動する（Ｓ２９）。その後はＳ３１に移行し、時間ＴＩＭ２の経過までは受信部２３への電力供給が中断され、その後に受信部２３への電力供給が行われて、再度、制御情報の捕捉（Ｓ２３）が試行される。

【００５３】また、制御情報捕捉の失敗回数が３回以上であれば、すなわちＦＣの値が２であれば（Ｓ２６およびＳ２７でＮＯ）、上記した動作と同様の動作により、時間ＴＩＭ２よりも長い時間ＴＩＭ３がタイマ部２７に設定され、時間ＴＩＭ３の経過までは受信部２３への電力供給が中断され、その後に受信部２３への電力供給が行われて、再度、制御情報の捕捉（Ｓ２３）が試行される。

【００５４】以降、携帯電話機のサービス圏外における受信動作は、制御情報の捕捉に成功するまで、時間ＴＩＭ３の受信動作の中断をともなって間欠的に行われる。制御情報の捕捉に成功すれば（Ｓ２４でＹＥＳ）、捕捉失敗カウンタＦＣの値をクリアして（Ｓ２５）このサービス圏外におけるバッテリセービング動作のルーチンから抜け出し、待ち受け状態に移行する。

【００５５】上記のサービス圏外におけるバッテリセービング動作による受信動作タイミングを図６に示している。同図中の時間Ｔ４は、受信部２３の電源をＯＮにした後、チャネルスキャンを行ってサービス圏内であるかどうかの判断へ至るまでに要する時間である。制御情報の捕捉に失敗してサービス圏外判定が行われる回数が増加するに連れて、間欠受信周期が（Ｔ４＋ＴＩＭ１）から（Ｔ４＋ＴＩＭ２）へ、さらに（Ｔ４＋ＴＩＭ３）へと自動的に延長される。

【００５６】以上のように、連続して制御情報の捕捉に失敗した回数をカウントし、そのカウント値（ＦＣの値）に応じて、受信部２３への電源供給の停止期間を延長制御しつつ、制御情報の捕捉動作と電源停止状態を交互に行うことにより、携帯電話機がサービス圏外に滞在する時間が長くなる程、受信部２３への電力供給が停止される時間が長くなるので、消費電力の削減を図ることができる。さらに、携帯電話機がサービス圏外に滞在する時間が短ければ、短い時間間隔で制御情報捕捉動作が開始されるので、圏内復帰が大きく遅延することはない。

【００５７】次に、上述のようなサービス圏外における間欠受信周期の自動延長モードを具備している携帯電話機に、さらに間欠受信周期の上限を使用者自らが可変設定入力することができる機能を付加した構成について説明する。

【００５８】使用者は、上限入力操作部としてのタイマ設定部３６が有する図示しない入力部を操作して、ＬＶ１～ＬＶ３の何れかのレベルを選択することができるようになっている。この携帯電話機のサービス圏外におけるバッテリセービング動作を、図７のフローチャートを参照して以下に説明する。

【００５９】携帯電話機への電源投入後、使用者によって手動設定モードの選択（Ｓ４１）およびレベルＬＶの設定（Ｓ４２）が行われ、その後は図５のフローチャートと同様に、捕捉失敗カウンタＦＣの値がクリアされ（Ｓ４３）、制御情報の捕捉が試行される（Ｓ４４）。

【００６０】ここで、報知チャネルＢＣＣＨ内の制御情報の捕捉に失敗し（Ｓ４５でＮＯ）、サービス圏外の判定が行われた場合、制御情報捕捉の連続失敗回数の判定が行われ（Ｓ４６・Ｓ４７）、続いて上限として設定されたレベルＬＶの判定が行われる（Ｓ４８～Ｓ５０）。

【００６１】上限としてレベルＬＶ＝１が設定されている場合、制御情報捕捉の連続失敗回数に関わらずＳ４８でＹＥＳの判定が行われ、時間ＴＩＭ１がタイマ部２７に設定される（Ｓ５１）。その後の受信部２３の電源ＯＦＦ（Ｓ５４）、タイマ設定時間の経過（Ｓ５５）後の受信処理（Ｓ４４）は、上記と同様である。

【００６２】また、上限としてレベルＬＶ＝２が設定されている場合、制御情報捕捉の連続失敗回数が１回のときはＳ４６およびＳ４８を介して時間ＴＩＭ１がタイマ部２７に設定され（Ｓ５１）、当該連続失敗回数が２回以上のときはＳ４９でＹＥＳの判定が行われ、時間ＴＩＭ２がタイマ部２７に設定される（Ｓ５２）。

【００６３】また、上限としてレベルＬＶ＝３が設定されている場合、制御情報捕捉の連続失敗回数が１回のときはＳ４６およびＳ４８を介して時間ＴＩＭ１がタイマ部２７に設定され（Ｓ５１）、当該連続失敗回数が２回のときは、Ｓ４７およびＳ４９を介して時間ＴＩＭ２がタイマ部２７に設定され（Ｓ５２）、当該連続失敗回数が３回以上のときはＳ５０でＹＥＳの判定が行われ、時間ＴＩＭ３がタイマ部２７に設定される（Ｓ５３）。

【００６４】以降、携帯電話機のサービス圏外における受信動作は、制御情報の捕捉に成功するまで、タイマ部２７に設定された時間の受信動作の中断をともなって間欠的に行われ、制御情報の捕捉に成功すれば（Ｓ４５でＹＥＳ）、捕捉失敗カウンタＦＣの値をクリアして（Ｓ５６）このサービス圏外におけるバッテリセービング動作のルーチンから抜け出し、待ち受け状態に移行する。

【００６５】上記のように、間欠受信周期の自動延長モードを具備している携帯電話機に、さらに間欠受信周期の上限を使用者自らが可変設定入力することができる機能を付加したので、消費電力の削減と短時間圏内復帰との両効果が効率的に得られるという間欠受信周期の自動延長の利点を生かしたまま、各使用者の携帯電話機の使用状況に応じたバッテリセービングを実現することができる。

【００６６】尚、上記では、携帯電話機の電源投入直後の制御情報の捕捉に失敗した場合について説明したが、制御情報の捕捉に成功してＰＣＨに受信タイミングを合わせた待ち受け状態に遷移してから後にサービス圏から外れた場合にも、上記と同様のサービス圏外におけるバッテリセービング動作に移行する。このときの動作を図８のフローチャートを参照して以下に説明する。

【００６７】待ち受け状態に遷移した場合、先ず、一斉呼び出しチャネルＰＣＨ受信失敗カウンタ（図示せず）の値ｎをクリアする（Ｓ６１）。この後、指定された受信タイミングでＰＣＨの間欠受信を行うが、当該受信タイミングでＰＣＨを正常に受信できなかった場合（Ｓ６２でＮＯ）、ＰＣＨ受信失敗カウンタの値ｎを１だけカウントアップし（Ｓ６３）、続いて当該カウンタ値ｎが予め定められた値Ｎ以上か否かを判断する（Ｓ６４）。ここでカウンタ値ｎがＮよりも小さければ、再度、指定された受信タイミングでＰＣＨの受信を試みる。

【００６８】もし、連続してＰＣＨの受信に失敗してＰＣＨ受信失敗カウンタの値ｎがＮ以上であると判定された場合（Ｓ６４でＹＥＳ）、待ち受け状態時のルーチンから抜け出す。その後は、先述の受信動作停止時間の設定モードが自動であるなら図５のＳ２３へ、受信動作停止時間の上限設定が手動モードで行われている場合は図７のＳ４４へと移行する。

【００６９】尚、上記の各実施の形態においては、制御情報捕捉停止時間ＴＭｎの可変段階を３と仮定しているが、これに限定されるものではなく、２段階または４段階以上であってもよい。

【００７０】

【発明の効果】請求項１の発明に係る移動通信システムの移動端末機は、以上のように、サービス圏外判定後の圏内復帰のための間欠受信処理の受信動作停止時間を可変設定入力するための入力操作部と、上記入力操作部により設定された受信動作停止時間に応じたサービス圏外判定後の間欠受信処理が行われるように受信手段を制御し、当該間欠受信処理時の受信動作停止中は、受信手段への電力供給を中断または受信手段への電力供給量を通常時より低減する電力消費抑制手段とを備えている構成である。

【００７１】それゆえ、例えば、電力消費量の低減化を重要視する使用者は受信動作停止時間を長く設定し、サービス圏外から圏内への復帰遅延を少なくしたバッテリセービングを望む使用者は、受信動作停止時間をそれよりも短く設定するといったような設定変更が可能であり、各使用者の移動端末機の使用状況に応じたバッテリセービングを実現することができるという効果を奏する。

【００７２】請求項２の発明に係る移動通信システムの移動端末機は、以上のように、サービス圏判定手段が連続して圏外判定した回数が多いほど、サービス圏外判定後の圏内復帰のための間欠受信処理の受信動作停止時間を延長設定する受信周期延長手段と、上記間欠受信周期可変手段によって延長設定される受信動作停止時間の上限を可変設定入力するための上限入力操作部と、上記受信周期可変手段により上記の上限範囲内で延長設定された受信動作停止時間に応じたサービス圏外判定後の間欠受信処理が行われるように受信手段を制御し、当該間欠受信処理時の受信動作停止中は、受信手段への電力供給を中断または受信手段への電力供給量を通常時より低減する電力消費抑制手段とを備えている構成である。

【００７３】それゆえ、サービス圏外に滞在する時間に応じた適切な間欠受信処理が行われると共に、サービス圏外に滞在する時間が長くなった場合には、上限設定された受信動作停止時間に落ち着き、各使用者の移動端末機の使用状況に応じたバッテリセービングを実現することができるという効果を奏する。

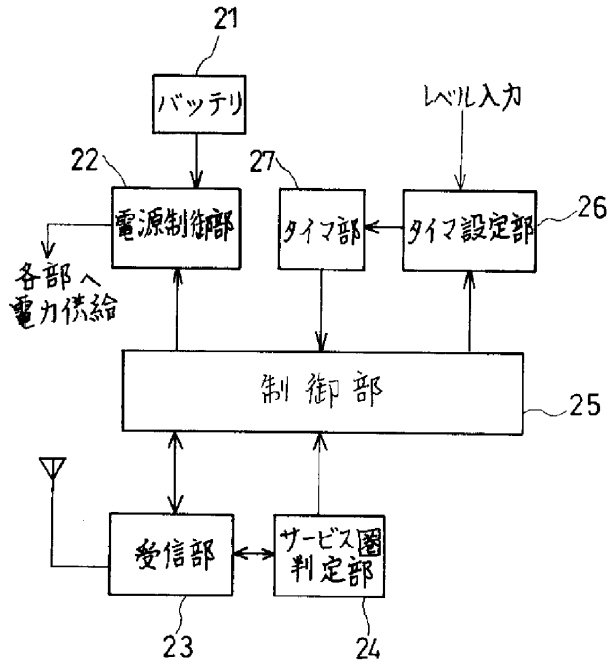
【図面の簡単な説明】

【図１】本発明の実施の一形態を示すものであり、携帯電話機の要部の構成を示すブロック図である。

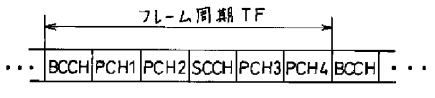
【図２】図１の携帯電話機のサービス圏外におけるバッテリセービング動作を示すフローチャートである。

【図３】下り制御チャネルフォーマットの一例を示す説明図である。
【図４】本発明のその他の実施の一形態を示すものであり、携帯電話機の要部の構成を示すブロック図である。
【図５】図４の携帯電話機のサービス圏外におけるバッテリセービング動作を示すフローチャートである。
【図６】図５のバッテリセービング動作による受信動作タイミングを示すタイミングチャートである。
【図７】図４の携帯電話機において、手動による受信動作停止時間の上限設定を可能にした場合のバッテリセービング動作を示すフローチャートである。
【図８】待ち受け状態からサービス圏外でのバッテリセービング状態へ遷移するときの動作を示すフローチャートである。
【符号の説明】
２２　電源制御部（電力消費抑制手段）
２３　受信部（受信手段）
２４　サービス圏判定部（サービス圏判定手段）
２５　制御部（電力消費抑制手段）
２６　タイマ設定部（入力操作部）
２７　タイマ部
３５　制御部（受信周期延長手段、電力消費抑制手段）
３６　タイマ設定部（上限入力操作部）

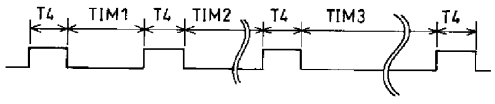
【図１】



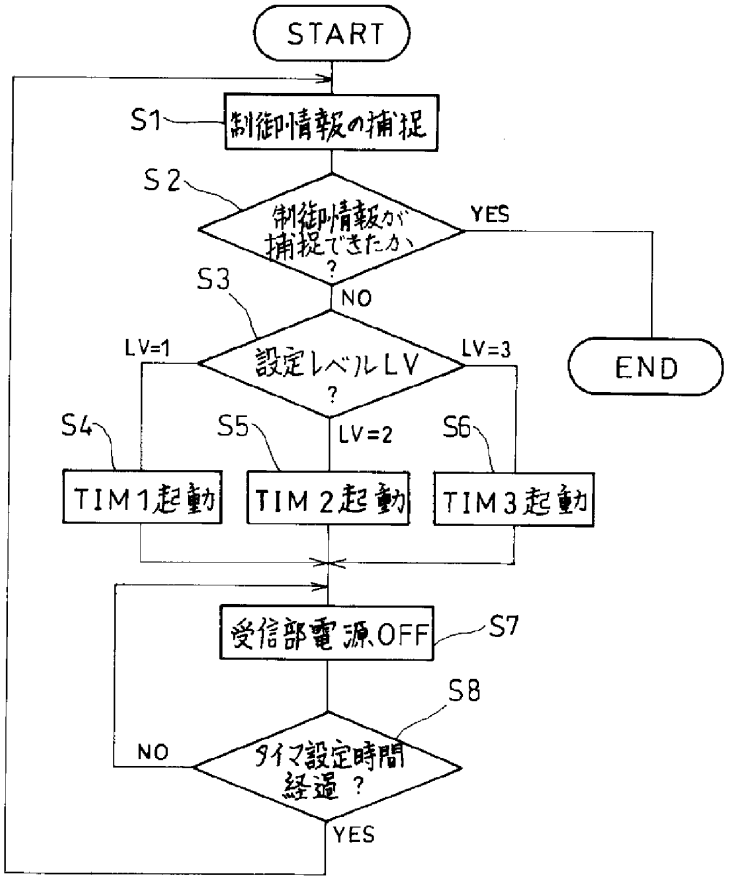
【図３】



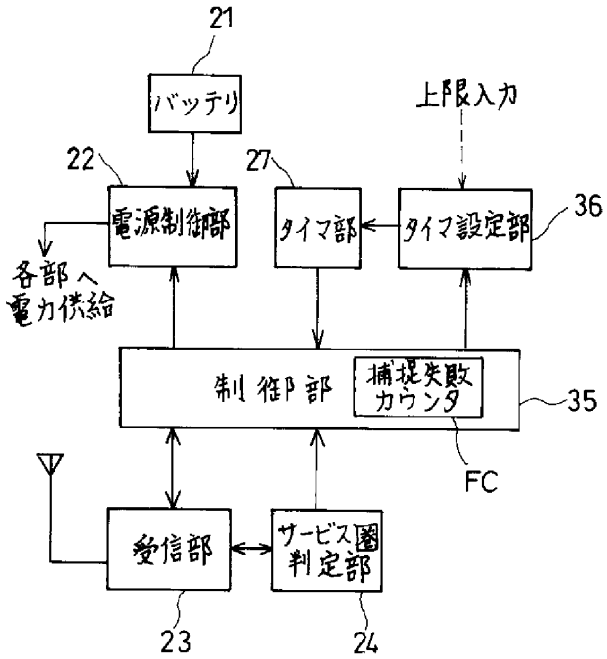
【図６】



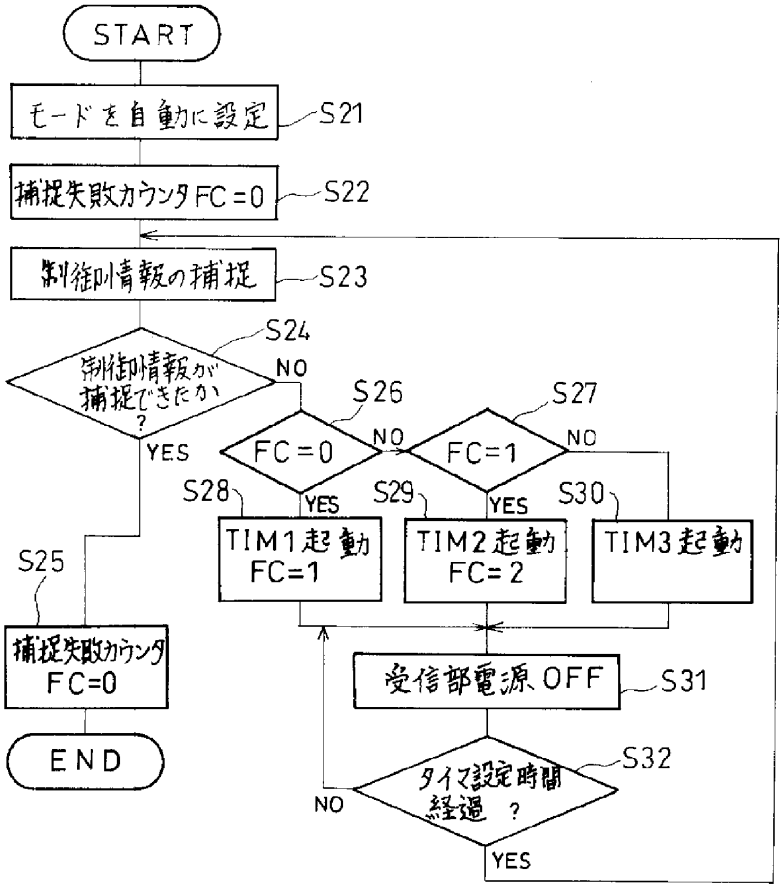
【図2】


START
S1
制御情報の捕捉
S2
制御情報が捕捉できたか？
YES
NO
S3
設定レベルLV？
LV=1
LV=2
LV=3
END
S4
S5
S6
TIM1起動
TIM2起動
TIM3起動
受信部電源OFF
S7
S8
タイマ設定時間経過？
NO
YES

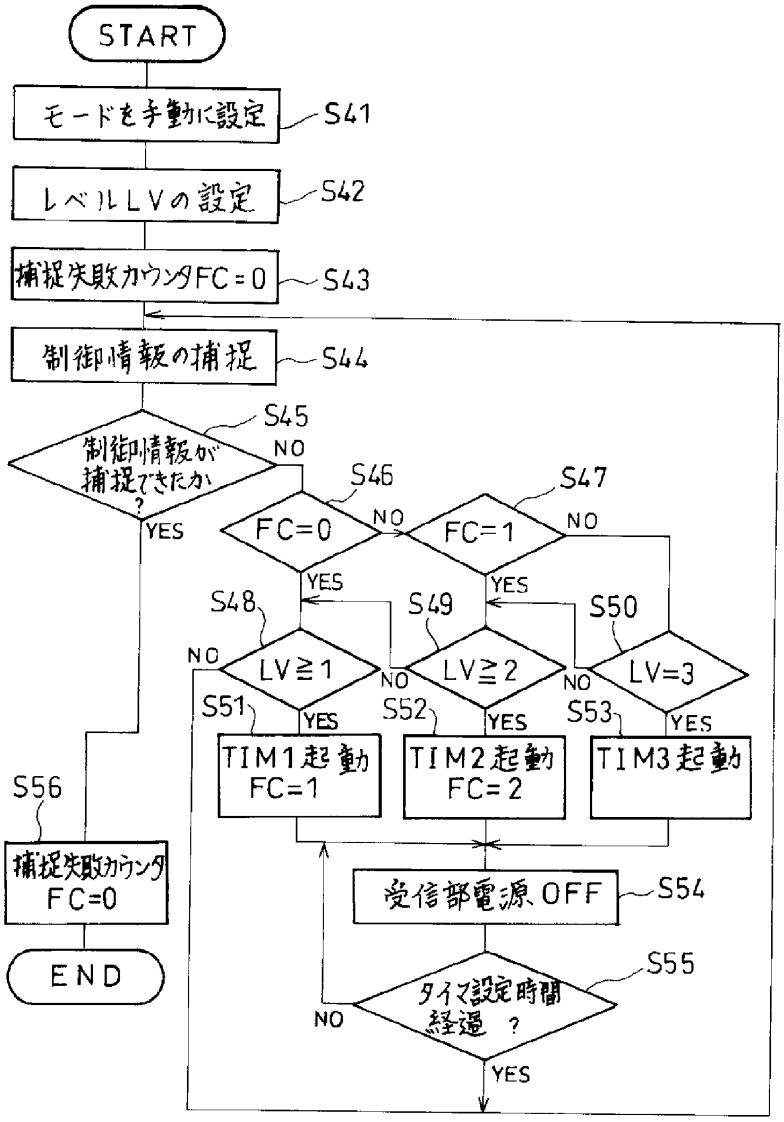
【図４】


21
バッテリ
上限入力
22
27
電源制御部
タイマ部
タイマ設定部
36
各部へ
電力供給
制御部
捕捉失敗
カウンタ
35
FC
受信部
サービス圏
判定部
23
24

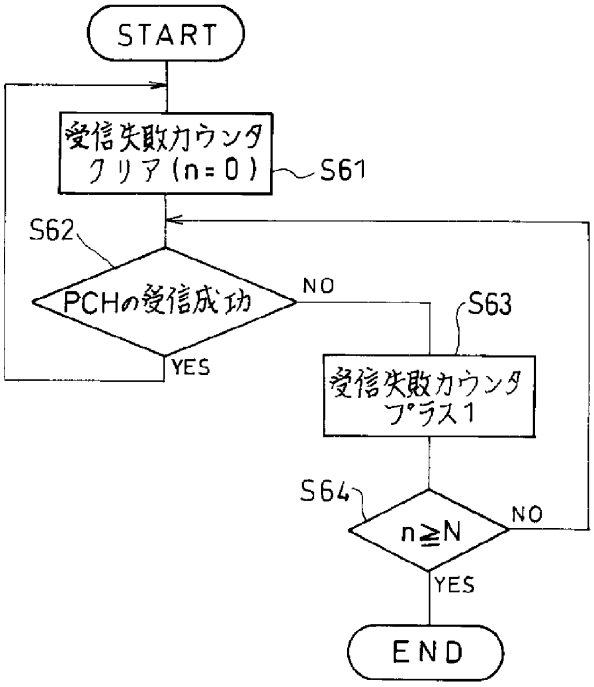
【図5】


START
モードを自動に設定
S21
捕捉失敗カウンタFC=0
S22
制御情報の捕捉
S23
S24
制御情報が捕捉できたか？
NO
YES
S26
FC=0
NO
S27
FC=1
NO
S28
YES
S29
YES
S30
TIM1起動 FC=1
TIM2起動 FC=2
TIM3起動
S25
捕捉失敗カウンタ FC=0
受信部電源OFF
S31
END
S32
タイマ設定時間経過？
NO
YES

【図7】


START
モードを手動に設定
S41
レベルLVの設定
S42
捕捉失敗カウンタFC=0
S43
制御情報の捕捉
S44
S45
制御情報が捕捉できたか？
NO
YES
S46
FC=0
NO
YES
S47
FC=1
NO
YES
S48
LV≧1
NO
YES
S49
LV≧2
NO
YES
S50
LV=3
NO
YES
S51
TIM1起動 FC=1
S52
TIM2起動 FC=2
S53
TIM3起動
受信部電源OFF
S54
S55
タイマ設定時間経過？
NO
YES
S56
捕捉失敗カウンタ FC=0
END

【図８】


START
受信失敗カウンタ
クリア(n=0)
S61
S62
PCHの受信成功
NO
YES
S63
受信失敗カウンタ
プラス1
S64
n≧N
NO
YES
END

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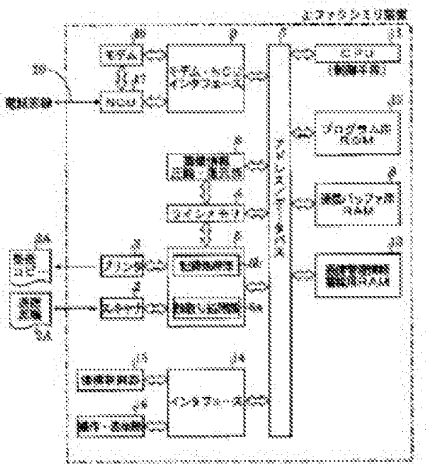
(54) FACSIMILE EQUIPMENT AND FACSIMILE COMMUNICATION CONTROL METHOD

(57)Abstract:
PROBLEM TO BE SOLVED: To prevent channel interruption processing by a MODEM and repetition of redialing.
SOLUTION: Training is made without control of a CPU 11 between a MO DEM of its own station and a MODEM of a called station according to a function stipulated by the ITU-T recommendations V.34 to execute a unique negotiation for deciding a data rate. In the case that the negotiation is not established and channel interruption processing is conducted due to a communication error, a communication management information storage RAM 13 stores communication management information. Then in the case of executing redial processing, the CPU 11 excludes the negotiation unique to the MODEM by the ITU-T recommendations V.34. Then the CPU 11 executes the negotiation to control the MODEM and the CPU 11 selects a transmission mode according to a communication capability by the ITU-T recommendations V.17, V.29, V27ter or the like by its own discrimination.



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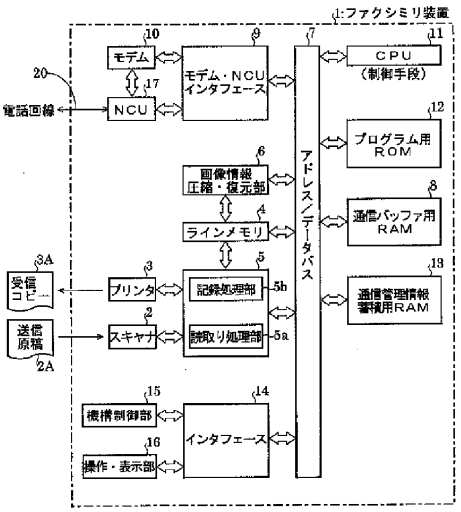
(54)【発明の名称】　ファクシミリ装置とファクシミリの通信制御方法

(57)【要約】

【解決手段】ＩＴＵ－Ｔ勧告Ｖ．３４で規定された機能によれば、モデムと被呼局のモデムとの間でＣＰＵ１１の制御無しにトレーニングを行って、データレート決定のための独自のネゴシエーションを実行する。そのネゴシエーションが成立しないで通信エラーによる回線切断処理が行われたとき、通信管理情報蓄積用ＲＡＭがその通信管理情報を格納して保存する。その後リダイヤル処理を実行するとき、ＣＰＵ１１は、ＩＴＵ－Ｔ勧告Ｖ．３４によるモデム独自のネゴシエーションを排除する。そして、ＣＰＵ１１がモデムを制御するネゴシエーションを実行し、ＣＰＵ１１の判断によって、ＩＴＵ－Ｔ勧告Ｖ．１７、Ｖ．２９、Ｖ．２７ｔｅｒといった通信能力による伝送モードを選択する。

【効果】モデムによる回線切断処理とリダイヤルの繰り返しが防止できる。



具体例１のファクシミリ装置のブロック図

【特許請求の範囲】
【請求項１】　回線と接続されて通信を行うモデムと、このモデムの動作と画像情報の送受信を制御する制御手段と、通信管理情報を格納する通信管理情報蓄積手段とを備え、
回線接続後、前記モデムと被呼局のモデムとの間で前記制御手段の制御無しにトレーニングを行って、データレート決定のための独自のネゴシエーションを実行し、そのネゴシエーションが成立しないで通信エラーによる回線切断処理が行われたとき、
前記通信管理情報蓄積手段がその通信管理情報を格納して保存し、
前記制御手段は、
前記通信管理情報蓄積手段に保存された通信管理情報を参照して、前記通信エラーに基づくリダイヤル処理を実行するとき、前記モデムによる独自のネゴシエーションを排除して、制御手段が前記モデムを制御するネゴシエーションを実行し、このネゴシエーションの結果通信可能なデータレートの伝送モードを選択することを特徴とするファクシミリ装置。
【請求項２】　回線と接続されて通信を行うモデムと、このモデムの動作と画像情報の送受信を制御する制御手段と、通信管理情報を格納する通信管理情報蓄積手段とを備え、
回線接続後、前記モデムと被呼局のモデムとの間で前記制御手段の制御無しにトレーニングを行って、独自のネゴシエーションを実行し、そのネゴシエーションの結果決定したデータレートの伝送モードで通信を開始し、その後、通信エラーで回線切断処理が行われたとき、前記通信管理情報蓄積手段がその通信管理情報を格納して保存し、
前記制御手段は、
前記通信管理情報蓄積手段に保存された通信管理情報を参照して、前記通信エラーに基づくリダイヤル処理を実行するとき、前記モデムによる独自のネゴシエーションを排除して、制御手段が前記モデムを制御するネゴシエーションを実行し、このネゴシエーションの結果通信可能なデータレートの伝送モードを選択することを特徴とするファクシミリ装置。
【請求項３】　請求項１または２に記載のファクシミリ装置において、
送信すべき画像情報を予め蓄積しておく画像メモリを備え、
制御手段は、
通信エラーが発生したとき前記画像メモリの内容を保存し、リダイヤル処理後、新たな伝送モードが選択されて通信が開始されたとき、前記画像メモリの内容を読み出して送信することを特徴とするファクシミリ装置。
【請求項４】　回線と接続されて通信を行うモデムと、このモデムの動作と画像情報の送受信を制御する制御手段と、通信管理情報を格納する通信管理情報蓄積手段とを備え、
前記制御手段は、
前記通信管理情報蓄積手段に保存された通信管理情報を参照して、通信エラーの原因に応じたリダイヤル制御を行うことを特徴とするファクシミリ装置。
【請求項５】　請求項４に記載のファクシミリ装置において、
送信すべき画像情報を予め蓄積しておく画像メモリを備え、
制御手段は、
通信エラーが発生したとき、その通信エラーの原因を示す通信管理情報を収集して、
リダイヤル処理により再接続が可能と判断したときは、前記画像メモリの内容を保存し、リダイヤル処理後、新たな伝送モードが選択されて通信が開始されたときには、前記画像メモリの内容を読み出して送信することを特徴とするファクシミリ装置。
【請求項６】　請求項５に記載のファクシミリ装置において、
制御手段は、
リダイヤルをしても、被呼局の機能上通信ができないと判断したときは、画像メモリの内容を保存しないで、リダイヤルを中止することを特徴とするファクシミリ装置。
【請求項７】　請求項５に記載のファクシミリ装置において、
制御手段は、
強制的な回線の切断により通信エラーが生じたときは、画像メモリの内容を保存しないで、リダイヤルを中止することを特徴とするファクシミリ装置。
【請求項８】　請求項５に記載のファクシミリ装置において、
制御手段は、
リダイヤル処理をしても繰り返し通信エラーが発生するときは、画像メモリの内容を保存しないで、リダイヤルを中止することを特徴とするファクシミリ装置。
【請求項９】　請求項４に記載のファクシミリ装置において、
制御手段は、
発生した通信エラーの原因に応じて、リダイヤル処理を実行するまでの待機時間を設定することを特徴とするファクシミリ装置。
【請求項１０】　請求項４に記載のファクシミリ装置において、
制御手段は、
発生した通信エラーの原因に応じて、リダイヤル処理を繰り返す制限回数を設定することを特徴とするファクシミリ装置。
【請求項１１】　請求項９または１０に記載のファクシ

ミリ装置において
通信エラーに基づくリダイヤル制御を完了するまでは、通信エラーの原因を表示する情報を通信管理情報蓄積手段に保持しておき、これを制御手段が参照することを特徴とするファクシミリ装置。
【請求項１２】　回線が接続されると、発呼局と被呼局のモデムが、制御手段を介在させずに独自にトレーニングを行って、適切なデータレートの伝送モードを設定するためのネゴシエーションを実行し、ネゴシエーションが成立するまでリトレーニングを繰り返す第１の通信制御機能と、制御手段が前記モデムを制御して被呼局とネゴシエーションを行い、それぞれデータレートの異なる複数の伝送モードの中から適切な伝送モードを選択する第２の通信制御機能とを持ち、
前記第１の通信制御機能によりネゴシエーションが成立せず通信エラーとなって回線切断処理がされたとき、
リダイヤル処理によって再び回線が接続されると、前記第１の通信制御機能を排除して、前記第２の通信制御機能によりネゴシエーションを開始することを特徴とするファクシミリの通信制御方法。
【請求項１３】　回線が接続されると、発呼局と被呼局のモデムが、制御手段を介在させずに独自にトレーニングを行って、適切なデータレートの伝送モードを設定するためのネゴシエーションを実行し、ネゴシエーションが成立するまでリトレーニングを繰り返す第１の通信制御機能と、制御手段が前記モデムを制御して被呼局とネゴシエーションを行い、それぞれデータレートの異なる複数の伝送モードの中から適切な伝送モードを選択する第２の通信制御機能とを持ち、
前記第１の通信制御機能によりネゴシエーションが成立して、通信が開始された後に通信エラーとなって回線切断処理がされたとき、
リダイヤル処理によって再び回線が接続されると、前記第１の通信制御機能を排除して、前記第２の通信制御機能によりネゴシエーションを開始することを特徴とするファクシミリの通信制御方法。
【請求項１４】　請求項１２または１３に記載のファクシミリの通信制御方法において、
第１の通信制御機能は、ＩＴＵ－Ｔ勧告Ｖ．３４で規定された機能で、第２の通信機能は、ＩＴＵ－Ｔ勧告Ｖ．３４で規定された機能以外の通信能力であって、それぞれデータレートの異なる２種以上の通信能力のうちから、発呼局と被呼局の双方が備えたものを選択する機能であることを特徴とするファクシミリの通信制御方法。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、ファクシミリ装置とファクシミリの通信制御方法に関する。
【０００２】
【従来の技術】ファクシミリ装置においては、１９９４年にＩＴＵ－Ｔ（International Telecommunications Union-Tele-communications Standarization Sector）Ｖ．３４が勧告された。このＩＴＵ－Ｔ勧告Ｖ．３４（以下Ｖ．３４とする）はモデムの通信方法の勧告である。この勧告Ｖ．３４では、回線の特性を測定し、これに照らし合わせて送信するためのパラメータを微妙に調整することで、28,800ｂｐｓまでのデータレートを実現するモデムの通信方法を規定する。なお、勧告Ｖ．３４の正式な題名は、「電話網もしくは１対１の２線式専用線のために使われる、データレートが28,800ｂｉｔ／ｓまでのモデムの動作」である。
【０００３】また、この勧告Ｖ．３４を採用したファクシミリ装置は、伝送制御手順をＩＴＵ－Ｔ勧告Ｔ．３０「一般電話交換網における文書ファクシミリ伝送用手順」の「バイナリ制御手順」に従っている。この「バイナリ制御手順」は、複雑な運用手順を発呼局側と被呼局側とで相互に確認するために、データ伝送用に開発されたハイレベルデータリンク制御（ＨＤＬＣ）のフレーム構成を用いる。
【０００４】なお、上記勧告Ｖ．３４を採用したファクシミリ装置は、ＩＴＵ－Ｔ勧告Ｖ．８（以下、Ｖ．８とする）の機能を備えている。この勧告Ｖ．８は、モデムの接続シーケンスを規定する。即ち、通信する相互のモデム同士が、どの勧告（モード）に沿った通信方法で通信するかを決める方法である。勧告Ｖ．３４の前手順として勧告Ｖ．８の方法を必ず行うので、勧告Ｖ．３４を採用するモデムでは勧告Ｖ．８の機能を有している。
【０００５】以下に、勧告Ｖ．８及びＶ．３４（以下単にＶ．８、Ｖ．３４と表現する）の機能を備えたモデムを採用しているファクシミリ装置について説明する。
【０００６】Ｖ．８及びＶ．３４の機能を備えたモデムを採用したファクシミリ装置においては、発呼局から被呼局に情報を送信する場合、回線接続後、ＩＴＵ－Ｔ勧告Ｔ．３０Fax Handshakingの手順を行う前に、所定のシーケンスを行う。このシーケンスでは、発呼局のモデムと被呼局のモデムとが、ＣＰＵ（中央処理装置）を介さずにモデム自身でネゴシエーション（伝送モードを決めるまでの発呼局と被呼局とのやり取り）を行う。この発呼局のモデムと被呼局のモデムとがネゴシエーションを行うシーケンスが、以下に示すＶ．３４フェーズ２である。
【０００７】Ｖ．８及びＶ．３４の機能を備えたモデムは、Ｖ．８フェーズ１と、Ｖ．３４フェーズ２からフェーズ４までの合わせて４つのフェーズ処理を行う。この４つのフェーズの中で回線特性の補正や変調パラメータの決定が行われる。この各フェーズで行われることがＶ．３４の主な動作になる。
【０００８】次にＶ．３４フェーズ２について説明する。Ｖ．３４フェーズ２では、ラインプロービングとモデムの持っている変調オプションを交換することで、

Ｖ．３４の基本的設定を行う。まず、Ｖ．８フェーズ１で、発呼局モデムと被呼局モデムの接続が開始される。そしてその後、Ｖ．３４フェーズ２が開始される。このＶ．３４フェーズ２では、Ｖ．８によりＶ．３４で通信することが確定した後、すぐに発呼局と被呼局双方のモデムが持っている変調オプションを交換し合う。その後で原稿の送信側がラインプローブ信号を送信し、ラインプローブ信号によって測定された回線特性とＩＮＦＯデータの内容によって、シンボルレート、プリエンファシスの有無、使用可能なデータレート、キャリア周波数、各送信機の送出レベルを交換する。そして次のＶ．３４フェーズ３に移る。

【０００９】このＶ．３４フェーズ２においては、モデム自身でネゴシエーションを行うので、ネゴシエーションが不可能であった場合には、リトレーニングをモデムが自動的に行う。回線が細く信号が通り難かったり、ノイズが発生しやすい回線であって回線状況が悪いと、モデムのネゴシエーションが不可能となる。そのような場合には、ネゴシエーションが成立するまで半永久的にモデムはリトレーニングを繰り返す。

【００１０】ファクシミリ装置に内蔵されたＣＰＵは、モデムのネゴシエーションに介在することが不可能なため、モデムが半永久的にリトレーニングを繰り返す恐れがある。これを防止するために、Ｖ．３４フェーズ２内にタイマを使用している。そして、所定時間内にＶ．３４フェーズ２を抜けることができない場合には、ＣＰＵが回線切断処理を行い、通信エラーとするように設定されている。

【００１１】

【発明が解決しようとする課題】上記ファクシミリ装置においては、Ｖ．３４フェーズ２において、回線状況が悪く、発呼局のモデムと被呼局のモデムとでネゴシエーションができずに通信エラーとなった場合、その後リダイヤル（再送信）で再度Ｖ．３４通信を行ったとしても、回線状況が悪いままの状態では通信エラーとなってしまう場合があった。

【００１２】

【課題を解決するための手段】本発明は以上の点を解決するため次の構成を採用する。

〈構成１〉回線と接続されて通信を行うモデムと、このモデムの動作と画像情報の送受信を制御する制御手段と、通信管理情報を格納する通信管理情報蓄積手段とを備え、回線接続後、上記モデムと被呼局のモデムとの間で上記制御手段の制御無しにトレーニングを行って、データレート決定のための独自のネゴシエーションを実行し、そのネゴシエーションが成立しないで通信エラーによる回線切断処理が行われたとき、上記通信管理情報蓄積手段がその通信管理情報を格納して保存し、上記制御手段は、上記通信管理情報蓄積手段に保存された通信管理情報を参照して、上記通信エラーに基づくリダイヤル処理を実行するとき、上記モデムによる独自のネゴシエーションを排除して、制御手段が上記モデムを制御するネゴシエーションを実行し、このネゴシエーションの結果通信可能なデータレートの伝送モードを選択することを特徴とするファクシミリ装置。

【００１３】〈構成２〉回線と接続されて通信を行うモデムと、このモデムの動作と画像情報の送受信を制御する制御手段と、通信管理情報を格納する通信管理情報蓄積手段とを備え、回線接続後、上記モデムと被呼局のモデムとの間で上記制御手段の制御無しにトレーニングを行って、独自のネゴシエーションを実行し、そのネゴシエーションの結果決定したデータレートの伝送モードで通信を開始し、その後、通信エラーで回線切断処理が行われたとき、上記通信管理情報蓄積手段がその通信管理情報を格納して保存し、上記制御手段は、上記通信管理情報蓄積手段に保存された通信管理情報を参照して、上記通信エラーに基づくリダイヤル処理を実行するとき、上記モデムによる独自のネゴシエーションを排除して、制御手段が上記モデムを制御するネゴシエーションを実行し、このネゴシエーションの結果通信可能なデータレートの伝送モードを選択することを特徴とするファクシミリ装置。

【００１４】〈構成３〉構成１または２に記載のファクシミリ装置において、送信すべき画像情報を予め蓄積しておく画像メモリを備え、制御手段は、通信エラーが発生したとき上記画像メモリの内容を保存し、リダイヤル処理後、新たな伝送モードが選択されて通信が開始されたとき、上記画像メモリの内容を読み出して送信することを特徴とするファクシミリ装置。

【００１５】〈構成４〉回線と接続されて通信を行うモデムと、このモデムの動作と画像情報の送受信を制御する制御手段と、通信管理情報を格納する通信管理情報蓄積手段とを備え、上記制御手段は、上記通信管理情報蓄積手段に保存された通信管理情報を参照して、通信エラーの原因に応じたリダイヤル制御を行うことを特徴とするファクシミリ装置。

【００１６】〈構成５〉構成４に記載のファクシミリ装置において、送信すべき画像情報を予め蓄積しておく画像メモリを備え、制御手段は、通信エラーが発生したとき、その通信エラーの原因を示す通信管理情報を収集して、リダイヤル処理により再接続が可能と判断したときは、上記画像メモリの内容を保存し、リダイヤル処理後、新たな伝送モードが選択されて通信が開始されたときには、上記画像メモリの内容を読み出して送信することを特徴とするファクシミリ装置。

【００１７】〈構成６〉構成５に記載のファクシミリ装置において、制御手段は、リダイヤルをしても、被呼局の機能上通信ができないと判断したときは、画像メモリの内容を保存しないで、リダイヤルを中止することを特徴とするファクシミリ装置。

【００１８】〈構成７〉構成５に記載のファクシミリ装置において、制御手段は、強制的な回線の切断により通信エラーが生じたときは、画像メモリの内容を保存しないで、リダイヤルを中止することを特徴とするファクシミリ装置。

【００１９】〈構成８〉構成５に記載のファクシミリ装置において、制御手段は、リダイヤル処理をしても繰り返し通信エラーが発生するときは、画像メモリの内容を保存しないで、リダイヤルを中止することを特徴とするファクシミリ装置。

【００２０】〈構成９〉構成４に記載のファクシミリ装置において、制御手段は、発生した通信エラーの原因に応じて、リダイヤル処理を実行するまでの待機時間を設定することを特徴とするファクシミリ装置。

【００２１】〈構成１０〉構成４に記載のファクシミリ装置において、制御手段は、発生した通信エラーの原因に応じて、リダイヤル処理を繰り返す制限回数を設定することを特徴とするファクシミリ装置。

【００２２】〈構成１１〉構成９または１０に記載のファクシミリ装置において通信エラーに基づくリダイヤル制御を完了するまでは、通信エラーの原因を表示する情報を通信管理情報蓄積手段に保持しておき、これを制御手段が参照することを特徴とするファクシミリ装置。

【００２３】〈構成１２〉回線が接続されると、発呼局と被呼局のモデムが、制御手段を介在させずに独自にトレーニングを行って、適切なデータレートの伝送モードを設定するためのネゴシエーションを実行し、ネゴシエーションが成立するまでリトレーニングを繰り返す第１の通信制御機能と、制御手段が上記モデムを制御して被呼局とネゴシエーションを行い、それぞれデータレートの異なる複数の伝送モードの中から適切な伝送モードを選択する第２の通信制御機能とを持ち、上記第１の通信制御機能によりネゴシエーションが成立せず通信エラーとなって回線切断処理がされたとき、リダイヤル処理によって再び回線が接続されると、上記第１の通信制御機能を排除して、上記第２の通信制御機能によりネゴシエーションを開始することを特徴とするファクシミリの通信制御方法。

【００２４】〈構成１３〉回線が接続されると、発呼局と被呼局のモデムが、制御手段を介在させずに独自にトレーニングを行って、適切なデータレートの伝送モードを設定するためのネゴシエーションを実行し、ネゴシエーションが成立するまでリトレーニングを繰り返す第１の通信制御機能と、制御手段が上記モデムを制御して被呼局とネゴシエーションを行い、それぞれデータレートの異なる複数の伝送モードの中から適切な伝送モードを選択する第２の通信制御機能とを持ち、上記第１の通信制御機能によりネゴシエーションが成立して、通信が開始された後に通信エラーとなって回線切断処理がされたとき、リダイヤル処理によって再び回線が接続されると、上記第１の通信制御機能を排除して、上記第２の通信制御機能によりネゴシエーションを開始することを特徴とするファクシミリの通信制御方法。

【００２５】〈構成１４〉構成１２または１３に記載のファクシミリの通信制御方法において、第１の通信制御機能は、ＩＴＵ－Ｔ勧告Ｖ．３４で規定された機能で、第２の通信機能は、ＩＴＵ－Ｔ勧告Ｖ．３４で規定された機能以外の通信能力であって、それぞれデータレートの異なる２種以上の通信能力のうちから、発呼局と被呼局の双方が備えたものを選択する機能であることを特徴とするファクシミリの通信制御方法。

【００２６】

【発明の実施の形態】本発明の実施の形態について図面を参照しながら説明する。なお、具体例毎に、各図面に共通な要素には同一の符号を付す。本実施の形態に示す発呼局側のファクシミリ装置（以下発呼局とする）及び被呼局側のファクシミリ装置（以下被呼局とする）は、Ｖ．８及びＶ．３４の機能を備えたモデムを採用している。また、伝送制御手順をＩＴＵ－Ｔ勧告Ｔ．３０「一般電話交換網における文書ファクシミリ伝送用手順」の「バイナリ制御手順」に従って行うものとする。

【００２７】なお、モデムの通信プロトコルを定める規定には、Ｖ．３４以外にも、ＩＴＵ－Ｔ勧告Ｖ．１７、ＩＴＵ－Ｔ勧告Ｖ．２９、ＩＴＵ－Ｔ勧告Ｖ．２７ｔｅｒ（以下それぞれＶ．１７、Ｖ．２９、Ｖ．２７ｔｅｒとする）等がある。Ｖ．３４は、発呼局と被呼局とが回線接続後、ＩＴＵ－Ｔ勧告Ｔ．３０Fax Handshakingの手順を行う前に、発呼局のモデムと被呼局のモデムとが、ＣＰＵを介さずにモデム自身でネゴシエーションを行う。一方、Ｖ．１７、Ｖ．２９、Ｖ．２７ｔｅｒは、回線接続後、直ちに勧告Ｔ．３０Fax Handshakingの手順へと移り、この手順の中でＣＰＵの指示を受けて、発呼局のモデムと被呼局のモデムとがネゴシエーションを行う。

【００２８】Ｖ．３４はモデム同士のみでネゴシエーションを行うので、データレートを他のモデムよりも高速化することができるという利点がある。一方、Ｖ．３４以外では、ＣＰＵを介してモデム同士のネゴシエーションを行い、データレートがＶ．３４よりもＶ．１７、Ｖ．２９、Ｖ．２７ｔｅｒの順序で低下するから、回線状況が悪くても通信を行うことができる利点がある。なお、Ｖ．１７、Ｖ．２９、Ｖ．２７ｔｅｒの最高データレートは、それぞれ14,400ｂｐｓ、9,600ｂｐｓ、4,800ｂｐｓとなっている。

【００２９】〈具体例１〉以下、ファクシミリ装置の構造について説明する。図１は、具体例１のファクシミリ装置のブロック図である。

【００３０】図１において、一点鎖線で示す発呼局側のファクシミリ装置１（以下発呼局とする）には、送信原稿２Ａ上の情報を読み取るスキャナ２と、被呼局から受

信した情報を受信コピー３Ａ上に記録するプリンタ３と、スキャナ２で読み取った情報を処理し、画像情報としてラインメモリ４へと送信する読取り処理部５ａと、ラインメモリ４から受信した印刷すべき画像情報を処理し、プリンタ３へと送信する記録処理部５ｂとが設けられている。なお、読取り処理部５ａと記録処理部５ｂとで読取・記録処理部５が構成されている。

【００３１】発呼局１にはまた、被呼局に送信すべき画像情報を、データ圧縮モードに応じてラインメモリ４から読み出しを行いながら画信号に圧縮すると共に、被呼局から受信し、処理された画信号を復元する画像情報圧縮・復元部６と、画像情報圧縮・復元部６で圧縮された画信号がアドレス／データバス７を介して送信され、送信バッファとなって画信号を記録する通信バッファ用ＲＡＭ（ランダムアクセスメモリ）８と、通信バッファ用ＲＡＭ８に記録された画信号をモデム・ＮＣＵ（ネットワークコントロールユニット）インタフェース９を介して送信し、該送信すべき画信号及び制御信号を変調すると共に、被呼局から画信号及び応答信号を受信すると、該画信号及び応答信号を復調するモデム１０と、ＮＣＵ１７とが設けられている。

【００３２】なお、上記通信バッファ用ＲＡＭ８は、被呼局からの受信時には、受信バッファとなり、モデム１０で復調された画信号及び応答信号を格納する。該格納された画信号及び応答信号は、アドレス／データバス７を介して画像情報圧縮・復元部６へと送信される。また、モデム１０は、Ｖ．８及びＶ．３４の機能を備えたモデムである。

【００３３】発呼局１には更に、発呼局１全体のシステム制御及び各信号の流れの管理、通信制御、網制御の総括コントロール等を行うＣＰＵ（制御手段）１１と、ＣＰＵ１１のプログラムデータを格納するプログラム用ＲＯＭ（リードオンリメモリ）１２と、後述する通信エラーフラグビットや、発呼する電話番号を格納する通信管理情報蓄積用ＲＡＭ１３と、インタフェース１４を介してアドレス／データバス７と接続された機構制御部１５及び操作・表示部１６が設けられている。

【００３４】なお、機構制御部１５はドライバや媒体検知センサ等の制御をＣＰＵ１１からの指示に従って行う。また操作・表示部１６はマンマシンインタフェース機能を持ち、ファクシミリ通信に伴う主な機器の操作内容（動作指示）をＣＰＵ１１に伝え、また機器の状態表示内容をＣＰＵ１１から受信し、図示せぬパネルに表示する。

【００３５】次に発呼局１と被呼局との送受信手順の方法について説明する。図１に示す発呼局１から被呼局へ制御信号を送信する場合には、制御信号がＣＰＵ１１からアドレス／データバス７、モデム・ＮＣＵインタフェース９を介してモデム１０に送信される。そして、モデム１０で変調されＮＣＵ１７を介して電話回線に送り出され、被呼局へと送信される。

【００３６】一方、被呼局から電話回線を介して制御信号を受信した場合には、制御信号は、ＮＣＵ１７を介してモデム１０に受信され、モデム１０で復調され、モデム・ＮＣＵインタフェース９及びアドレス／データバス７を介してＣＰＵ１１で受信される。

【００３７】なお、発呼局が被呼局と回線接続された後、データを送信するためのＩＴＵ－Ｔ勧告Ｔ．３０Fax Handshakingの手順を行う前に、Ｖ．８及びＶ．３４の機能を備えたモデム１０は、Ｖ．８フェーズ１と、Ｖ．３４フェーズ２からフェーズ４までの合わせて４つのフェーズ処理を行う。この４つのフェーズの中で回路特性の補正や変調パラメータの決定が行われる。

【００３８】以下、４つのフェーズのうち、Ｖ．８フェーズ１と従来の技術に詳説したＶ．３４フェーズ２における、被呼局と送受信動作を行うときの発呼局１の動作について図１に示す図面を参照し、図２、図３、図４に示すフローチャートに従って説明する。図２、図３、図４は実施の形態の発呼局の処理手順を示すフローチャートである。

【００３９】まず、オペレータが被呼局の電話番号を操作・表示部１６から入力する。すると、入力された電話番号が、インタフェース１４、アドレス／データバス７を介してＣＰＵ１１に送信される。

【００４０】ステップＳ１でＣＰＵ１１は、通信管理情報蓄積用ＲＡＭ１３内のリダイヤル電話番号格納エリアに発呼する電話番号を格納する。

【００４１】ステップＳ２でＣＰＵ１１は発呼処理を行う。ステップＳ３でＣＰＵ１１はＣＮＧ信号（発呼トーン）を送信する。ＣＮＧ信号は電話回線を介して被呼局へ送信される。ステップＳ４でＣＰＵ１１は、被呼局からＡＮＳａｍ（Answer Tone）信号を持つ。このＡＮＳａｍを受信すると、被呼局のモデムがＶ．８通信が可能なモデムであると判断してステップＳ５に進み、「否」ならば、ステップＳ１８に進む。

【００４２】ステップＳ５でＣＰＵ１１は、自分の持っている変調モードを知らせるＣＭ（Call Menu Signal）信号を被呼局へ送信する。すると、被呼局は共通する変調モードのみを有効にして、ＣＭ信号と同じフォーマットでＪＭ（Joint Menu Signal）信号として発呼局に返す。ステップＳ６でＣＰＵ１１はＪＭ信号を検出し、これにより有効な変調モードを確認することができる。ステップＳ７でＣＰＵ１１は、ＪＭ信号から、被呼局がＶ．３４全二重モードであるか否かを判断する。この例に示すファクシミリ装置はＶ．３４半二重モードであるので、Ｖ．３４全二重モードである場合には、ステップＳ１７に進み、回線切断処理を行い、処理を終了する。一方、「否」の場合は、ステップＳ８に進み、ＪＭ信号を受けたことを示す、すべて「０」であるシングルオクテットの信号、即ちＣＪ（Call Joint Signal）信号を

被呼局に送信する。

【００４３】以上ステップＳ３からステップＳ８までがＶ．８フェーズ１である。そして、７５ｍｓｅｃ（millisecond）の後、モデム１０はＶ．３４フェーズ２に入る。ステップＳ９で、ＣＰＵ１１はＶ．３４フェーズ２のタイマをスタートし、フェーズ２が開始される。

【００４４】ステップＳ１０で、ＣＰＵ１１はＶ．３４フェーズ２が終了すれば、ステップＳ１１に進み、Ｖ．３４フェーズ３へと進み、Ｖ．３４通信制御をそのまま継続する。

【００４５】Ｖ．３４フェーズ２は、ステップＳ１２でＶ．３４フェーズ２がタイムアウトとなるまで継続されるが、Ｖ．３４フェーズ２がタイムアウトとなってもまだＶ．３４フェーズ２が終了しないのならば、ステップＳ１３に進む。ステップＳ１３でＣＰＵ１１は、通信管理情報蓄積用ＲＡＭ１３内に格納されている、Ｖ．３４通信エラーフラグビットを「１」にして、再び通信管理情報蓄積用ＲＡＭ１３内に格納する。

【００４６】なお、ステップＳ１２で、Ｖ．３４フェーズ２がタイムアウトとなっても、Ｖ．３４フェーズ２が終了とならないのは、回線状況が悪いためであると考えられる。

【００４７】ステップＳ１４でＣＰＵ１１は回線切断処理を行い、ステップＳ１５で通信エラー処理を行う。そして、ステップＳ１６でリダイヤル送信制御を行うための準備をし、リダイヤル送信制御へと移る。

【００４８】なお、上記ステップＳ４からステップＳ１８に進んだ場合、ステップＳ１８で、ＣＰＵ１１は被呼局からＮＳＦ（非標準機能）信号、ＣＳＩ（被呼端末識別）信号、ＤＩＳ（ディジタル識別）信号を受信したことを検出したならば、ステップＳ１９に進み、「否」ならばステップＳ２８に進む。なお、上記ＣＳＩ信号は、オプショナル信号であるので、必ずしも送信されてくるとは限らない。

【００４９】ステップＳ１８からステップＳ２８に進むと、予め設定されたＴ１がタイムアウトとなるまで、ＣＰＵ１１は、上記ステップＳ３、ステップＳ４、ステップＳ１８、ステップＳ２８の処理を繰り返し、被呼局からの信号を待つ。

【００５０】ステップＳ２８で、Ｔ１がタイムアウトとなっても被呼局から信号を受信しなければ、ステップＳ２９に進み、ＣＰＵ１１は回線切断処理を行い、ステップＳ１６へと進む。なお、ステップＳ２８からステップＳ２９に進むのは、被呼局が「話中」の場合である。

【００５１】一方、ステップＳ１８で、ＣＰＵ１１が被呼局からＮＳＦ信号、ＣＳＩ信号、ＤＩＳ信号を受信したことを検出すると、ＣＰＵ１１はＮＳＦ信号、ＣＳＩ信号、ＤＩＳ信号を解析し、被呼局のモデムの能力、即ち通信能力を調べる。そして、ステップＳ１９でＶ．３４の通信能力があるモデムであった場合には、ステップＳ２０に進み、被呼局にＣＩ（Call Indicator Signal）信号を送出し、ステップＳ４に戻る。一方、ステップＳ１９で「否」の場合には、ステップＳ２１に進む。ステップＳ２１で、Ｖ．１７の通信能力があるモデムであった場合には、ステップＳ２２に進み、Ｖ．１７の送信制御へ移行する。一方、ステップＳ２１で「否」の場合には、ステップＳ２３に進む。ステップＳ２３で、Ｖ．２９の通信能力があるモデムであった場合には、ステップＳ２４に進み、Ｖ．２９の送信制御へ移行する。一方、ステップＳ２３で「否」の場合は、ステップＳ２５に進む。ステップＳ２５で、Ｖ．２７ｔｅｒの通信能力があるモデムであった場合には、ステップＳ２６に進み、Ｖ．２７ｔｅｒの送信制御へ移行する。一方、ステップＳ２５で「否」の場合は、ステップＳ２７に進み、ＣＰＵ１１は回線切断処理を行い、処理を終了とする。

【００５２】次に、上記フローチャートにおいて、ステップＳ１６でリダイヤル送信制御へと進んだ場合の処理について、図５～図７に示すフローチャートに従って説明する。図５、図６、図７は、この具体例１によるのリダイヤル時の発呼局の処理手順を示すフローチャートである。

【００５３】まず、ステップＳ４１でＣＰＵ１１は、通信管理情報蓄積用ＲＡＭ１３内のリダイヤル電話番号格納エリアから、発呼先の電話番号を読み込む。ステップＳ４２でＣＰＵ１１はリダイヤル発呼処理を行う。ステップＳ４３でＣＰＵ１１はＣＮＧ信号（発呼トーン）を送信する。ＣＮＧ信号は電話回線を介して被呼局へ送信される。

【００５４】すると、ステップＳ４４でＣＰＵ１１は、被呼局からＡＮＳａｍ信号を待つ。このＡＮＳａｍを受信すると、被呼局がＶ．８通信が可能なモデムであるとしてステップＳ４５に進み、「否」ならば、ステップＳ６０に進む。

【００５５】ステップＳ４５でＣＰＵ１１は、通信管理情報蓄積用ＲＡＭ１３からＶ．３４通信エラーフラグビットを読み込む。ステップＳ４６でＣＰＵ１１は、Ｖ．３４通信エラーフラグビットが「１」であるか否か判断し、「１」であればステップＳ６０に進み、「否」ならばステップＳ４７に進む。

【００５６】ステップＳ４７からステップＳ５９までは、図２に示すフローチャートのステップＳ５からステップＳ１７までの処理と同様であるので、重複する説明は省略する。

【００５７】なお、ステップＳ４６からステップＳ４７に進む場合は、被呼局へＶ．８，Ｖ．３４通信が可能である。このケースは、第１回目に発呼処理したときに被呼局が「話中」であり、リダイヤル発呼処理になって、「話中」が解除された場合である。

【００５８】一方、ステップＳ４４からステップＳ６０に進んだ場合、ステップＳ６０で、ＣＰＵ１１は被呼局

からＮＳＦ信号、ＣＳＩ信号、ＤＩＳ信号を受信したならば、ステップＳ６１に進み、「否」ならばステップＳ７３に進む。また、ステップＳ４６で、Ｖ．３４通信エラーフラグビットが「１」であり、ステップＳ６０に進んだ場合には、被呼局から自動的にＮＳＦ信号、ＣＳＩ信号、ＤＩＳ信号が送信されてくるように予め設定されている。

【００５９】ステップＳ６０で、ＣＰＵ１１は被呼局からＮＳＦ信号、ＣＳＩ信号、ＤＩＳ信号を受信したことを検出すると、ステップＳ６１に進む。

【００６０】一方、上記ステップＳ６０からステップＳ７３に進むと、予め設定されたＴ１がタイムアウトとなるまで、ＣＰＵ１１は、上記ステップＳ４３、ステップＳ４４、ステップＳ６０、ステップＳ７３を繰り返し、被呼局からの信号を待つ。

【００６１】ステップＳ７３で、Ｔ１がタイムアウトとなっても、被呼局から信号を受信しなければ、ステップＳ７４に進み、回線切断処理を行い、そして、ステップＳ５８に進み、リダイヤル送信制御を行うための準備をし、ステップＳ４１に戻る。なお、ステップＳ７３からステップＳ７４に進むのは、被呼局が「話中」の場合等である。

【００６２】ステップＳ６０で、ＣＰＵ１１がＮＳＦ信号、ＣＳＩ信号、ＤＩＳ信号を受信したことを検出すると、各信号を解析し、被呼局のモデムの能力、即ち通信能力を調べる。そして、ステップＳ６１で、被呼局にＶ．３４の通信能力があり、且つＶ．３４通信エラーフラグビットが「０」である場合には、ステップＳ６２に進み、被呼局にＣＩ信号を送出し、ステップＳ４４に戻る。一方、ステップＳ６１で「否」の場合にはステップＳ６３に進む。ステップＳ６３で、被呼局にＶ．１７の通信能力がある場合には、ステップＳ６４に進み、Ｖ．３４通信エラーフラグビットを「０」にクリアし、通信管理情報蓄積用ＲＡＭ１３に格納する。そして、ステップＳ６５に進み、Ｖ．１７の送信制御へ移行する。（モデム１０の伝送モードをＶ．１７の送信制御用に変更し通信を行う。）

【００６３】一方、ステップＳ６３で「否」の場合は、ステップＳ６６に進む。ステップＳ６６で、被呼局にＶ．２９の通信能力がある場合には、ステップＳ６７に進み、Ｖ．３４通信エラーフラグビットを「０」にクリアし、通信管理情報蓄積用ＲＡＭ１３に格納する。そして、ステップＳ６８に進み、Ｖ．２９の送信制御へ移行する。

【００６４】一方、ステップＳ６６で「否」の場合は、ステップＳ６９に進む。ステップＳ６９で、被呼局にＶ．２７ｔｅｒの通信能力がある場合には、ステップＳ７０に進み、Ｖ．３４通信エラーフラグビットを「０」にクリアし、通信管理情報蓄積用ＲＡＭ１３に格納する。そして、ステップＳ７１に進み、Ｖ．２７ｔｅｒの送信制御へ移行する。

【００６５】一方、ステップＳ６９で「否」の場合は、ステップＳ７２に進み、Ｖ．３４通信エラーフラグビットを「０」にクリアし、通信管理情報蓄積用ＲＡＭ１３に格納する。そして、ステップＳ５９に進み、ＣＰＵ１１は回線切断処理を行い、処理を終了する。

【００６６】なお、図４に示すステップＳ２１、ステップＳ２３、ステップＳ２５、図６に示すステップＳ６３、ステップＳ６６、ステップＳ６９に示す順序で、被呼局のモデムの通信能力が順に低下していく。それ故、可能な限り高速に送信することができるように、処理の順序を決めている。また、図３のステップＳ１６でリダイヤル送信制御となった場合、自動的に図５に示すフローチャートの処理が開始され、リダイヤル発呼処理が始まる。

【００６７】このときの送信方法は、フィーダー送信の場合であってもメモリ送信の場合であっても変わらない。即ち、フィーダー送信の場合であっても、まだ原稿を読み込む前であればリダイヤルを実行し、自動的に装置にセットされた原稿を読み込み、１ページ目の送信から処理を開始することができる。また、メモリ送信であれば問題なくリダイヤル処理後に全ての原稿の送信を自動的に開始できる。

【００６８】〈具体例１の効果〉ＩＴＵ－Ｔ勧告Ｖ．３４で規定された機能によれば、発呼局のモデムと被呼局のモデムとの間で制御手段の制御無しにトレーニングを行って、データレート決定のための独自のネゴシエーションを実行する。そのネゴシエーションが成立しないで通信エラーによる回線切断処理が行われたとき、通信管理情報蓄積手段がその通信管理情報を格納して保存する。通信エラーの原因を明らかにして、リダイヤル処理後の制御方法を決定するためである。このような場合に、その後リダイヤル処理を実行するとき、制御手段は、ＩＴＵ－Ｔ勧告Ｖ．３４によるモデム独自のネゴシエーションを排除する。そして、制御手段がモデムを制御するネゴシエーションを実行し、制御手段の判断によって、ＩＴＵ－Ｔ勧告Ｖ．１７、Ｖ．２９、Ｖ．２７ｔｅｒといった通信能力による伝送モードを選択する。

【００６９】以上の構成によれば、リダイヤル処理後再度モデム独自のネゴシエーションを行って通信エラーを繰り返すといった動作を未然に防止できる。また、リダイヤル後、Ｖ．３４通信が不可能な回線状況であっても、他の伝送モードを用いて確実に通信を行うことが可能になる。

【００７０】以上のようにして、被呼局がＶ．３４通信を行うことが可能なモデムを備えている場合に、回線状況が悪くて通信エラーになると、自動的にリダイヤル発呼処理を行い、Ｖ．３４で失敗したという履歴表示（フラグ）を残しておく。リダイヤル時には被呼局のモデムの能力に合わせて、Ｖ．３４以外のモデムの伝送モード

で送信制御を行うことにしたので、Ｖ．３４通信が不可能な回線状況であっても、確実に発呼局と被呼局との通信を行うことが可能となる。

【００７１】また、モデムの能力の変更は回線状況に合わせて選択可能となっている、即ち可能な限り高速で送信できるようにモデムの伝送モードが選択されるので、そのときの回線状況で最高の伝送モードでの通信が可能となる。

【００７２】〈具体例２〉具体例１では、モデムが主としてラインプロービングを行って通信エラーを生じた場合について、そのリダイヤル時の動作モードの最適化を図るようにした。しかしながら、実際に正常に通信が開始された後も、同様の問題が生じ得る。即ち、モデムが、独自のネゴシエーションを行ってそのネゴシエーションが成立し、通信が開始された後、通信エラーで回線切断処理が行われることがある。このような場合も、ネゴシエーションが成立しなかった場合に準じて、具体例１と同様の制御を行えば、通信エラーを繰り返すのを防止できる。

【００７３】図８に、ファクシミリ装置の通信シーケンスチャートを示す。ファクシミリ装置は、この図の左上から右下に向かって一定の通信手順を実行し、原稿のイメージを送信する。この手順については、既に従来技術の部分で詳細に説明をしたので、ここでは簡単に触れ、具体例２の要点を説明する。

【００７４】まず、発呼処理を行うと、フェーズ１のネットワーク（回線）への接続が行われる。そして、フェーズ２で、既に説明したラインプロービングが行われ、フェーズ３では、プライマリチャネルでのトレーニングが行われる。そして、フェーズ４では、変調パラメータの交換が行われる。次に、Ｔ．３０のファックスハンドシェーキング（Fax Handshaking）が行われる。ここで手順信号データの交換が終わると、１ページ分のデータ送信に移る。

【００７５】第１ページのデータ送信は、プライマリチャネルにおいて行われる。また、ファクシミリ送信の場合、１ページ分のデータ送信が終わると、再びＴ．３０ FaxHandshakingが行われる。この部分をコントロールチャネルと呼ぶ。このコントロールチャネルは、複数枚の送信を行うときは、１ページ送信毎に設けられる。

【００７６】コントロールチャネルにおけるＴ．３０Fax Handshakingは、2,400ｂｐｓあるいは1,200ｂｐｓの通信速度で行われる。従って、手順信号データの交換を３００ｂｐｓで行う他の伝送モード、例えばＶ．１７，Ｖ．２９等に較べて信頼性が低い。また、このコントロールチャネルでもモデム自身がＣＰＵ１１の制御によらず独自のネゴシエーションを行う。そして、ネゴシエーションができない場合には、リトレーニングを行うが、これが成立しないと通信エラーとなる。従って、具体例１の場合と同様の問題が生じる。

【００７７】なお、通信開始後にリダイヤルを行う場合には、自動的に全ての送信原稿のイメージを再送することが必要になる。従って、予め全ての原稿の画像情報を画像メモリに予め蓄積しておくいわゆるメモリ送信を行うことが好ましい。この画像情報は、図１に示した通信バッファ用ＲＡＭ８に格納される。即ち、図１に示したスキャナ２で読み取られた画像情報は、読取り処理部５ａを経て、一旦ラインメモリ４に記憶される。

【００７８】その後、画像情報圧縮・復元部６のデータ圧縮モードに応じて、ラインメモリ４から画像情報が読み出され、圧縮処理される。このデータは、アドレス／データバス７を通じて通信バッファ用ＲＡＭ８に蓄積される。こうして、全ての送信原稿について、画像情報を通信バッファ用ＲＡＭ８に蓄積した後、その画像情報を順次読み出して送信する。その他の部分についての装置構成は具体例１と変わるところはなく、重複する説明を省略する。

【００７９】次に、具体例２についての動作を説明する。図９と図１０には、具体例２の発呼局の処理手順を示すフローチャート（その１）、（その２）を示す。なお、具体例２は、その処理が新たにステップＳ１より開始しており、これらのステップ表示は具体例１のフローチャートとは対応していない。即ち、具体例２独自のステップを示している。

【００８０】まず初めに、オペレータが電話番号を操作・表示部１６に入力すると、ＣＰＵ１１はその情報をインタフェース１４を経て認識する。続いて、ステップＳ１で、ＣＰＵ１１は、通信管理情報蓄積用ＲＡＭ１３のリダイヤル電話番号格納エリアにリダイヤルの際発呼する電話番号を格納する。その後、ステップＳ２で、ＣＰＵ１１は、送信原稿２Ａをスキャナ２を用いて読み取る。読み取られた画像情報は、読取り処理部５ａ、ラインメモリ４、画像情報圧縮・復元部６を経て、通信バッファ用ＲＡＭ８に格納される。

【００８１】次に、ステップＳ３で、ＣＰＵ１１は、発呼処理を行う。更に、ＣＰＵ１１は、ステップＳ４で、ＣＮＧ信号を送出し、ステップＳ５で、ＡＮＳａｍ信号を待つ。このＡＮＳａｍ信号を受信すると、被呼局のモデムがＶ．８通信の可能なモデムであると判断する。この場合には、ステップＳ６に進む。一方、被呼局のモデムがＶ．８通信の不可能なモデムと判断すると、ステップＳ１１に進む。

【００８２】ステップＳ６で、ＣＰＵ１１は、自分の持っている変調モードを知らせるＣＭ信号を被呼局へ送信する。被呼局は、発呼局の変調モードに対してどれが有効かを提示するＪＭ信号を発呼局に送出する。ステップＳ７で、ＣＰＵ１１は、このＪＭ信号を検出する。その後、ステップＳ８で、ＣＪ信号を送出する。更に、ステップＳ９に進み、モデム１０は、Ｖ．３４フェーズ２の処理に進む。

【００８３】Ｖ．３４フェーズ２の処理では、発呼側と着呼側のモデムが変調オプションを交換し合い、ラインプロービング信号により回線特性を測定し、シンボルレート、プリエンファシスの有無、使用可能なデータレート、キャリア周波数、各送信機の送出レベルに関する情報を交換する。その後、次のステップＳ１０に移る。

【００８４】ステップＳ１０では、モデム１０が、Ｖ．３４フェーズ３を実行する。Ｖ．３４フェーズ３では、シンボルレートとキャリア周波数から、イコライザとエコーキャンセラのトレーニングを行う。こうして、図１０に示すステップＳ１４に進む。

【００８５】このステップＳ１４で、モデム１０は、コントロールチャネルの動作に移る。コントロールチャネルの先頭部分では、実質的に通信に使用される変調パラメータを交換し、トレーニングを行う。これによって、通信できるデータレートを決定する。ステップＳ１４で、ＣＰＵ１１は、コントロールチャネル用タイマをスタートさせる。そして、ステップＳ１５で、ＣＰＵ１１は、モデム１０が変調パラメータの交換とトレーニングを終了してデータモードに進んだかどうかをチェックする。データモードに進むと、次はステップＳ１６を実行する。

【００８６】ステップＳ１６で、ＣＰＵ１１は、ＩＴＵ－ＴのＴ．３０に従って手順信号を被呼局との間で送受信する。そして、その手続が完了すると、ステップＳ１７に進む。ここで、未送信の画像情報が１ページ以上メモリ内に存在するかどうかを判断する。メモリに送信用画像データが蓄積されていればステップＳ１８に進む。そして、ステップＳ１８では、この画像情報をプライマリチャネルデータとして、１ページ分被呼局に送信する。

【００８７】送信が終了すると、ステップＳ１４に戻り、ステップＳ１４～ステップＳ１８までの処理を繰り返し、全てのページについての送信を実行する。全てのページの送信が終了すると、ステップＳ１７からステップＳ１９に進み、回線の切断処理を行ってファクシミリ送信を終了する。

【００８８】各ページが送信される度に、コントロールチャネルが実行されるが、コントロールチャネルが開始される度にコントロールチャネル用タイマがスタートする（ステップＳ１４）。そして、コントロールチャネル用タイマがタイムアウトになっても、ステップＳ１５において、コントロールチャネルのデータモードに移行しない場合やステップＳ１６において、コントロールチャネルのデータ送受信が完了しないような場合には、何らかの障害が発生したものとしてステップＳ２１に進む。

【００８９】そして、ステップＳ２１において、通信管理情報蓄積用ＲＡＭ１３内のＶ．３４通信エラーフラグビットを“1”にして格納する。このエラーフラグビットは、モデムがコントロールチャネルにおいて、独自のネゴシエーションを行い、通信エラーが生じたことを表すフラグである。このような通信エラーが生じるのは、例えば通信開始後、回線状況が悪化した場合が考えられる。ステップＳ２２では、回線切断処理が行われ、ステップＳ２３で、通信エラー処理を行い、更にステップＳ２４のリダイヤル送信制御へ進む。

【００９０】なお、図９のステップＳ５において、ＡＮＳａｍ信号を受信しない場合には、ステップＳ１１に進む。これ以降の処理は、既に図２を用いて説明したものと同様である。図９のステップＳ１１は、図２のステップＳ１８に対応し、図９のステップＳ１２は、図２のステップＳ２８に対応する。また、図９のステップＳ１３は、図２のステップＳ２９に対応する。更に、ステップＳ１１でイエスと判断された場合には、図４に示した処理が実行される。そして、図４のステップＳ２０の処理を終了すると、図９のステップＳ５に戻る。その他の処理は、図４で示した通りとなる。

【００９１】一方、リダイヤル送信制御が実行される場合は、実質的に具体例１で説明した図５～図７までの処理と同一となる。即ち、図１に示した通信管理情報蓄積用ＲＡＭ１３のリダイヤル電話番号格納エリアから発呼元の電話番号を読み込んでリダイヤル処理が実行される。そして、通信エラーフラグビットを読み込む。これが“１”の場合には、図６に示したステップＳ６３以降の処理によってモデム独自のネゴシエーションを排除し、ＣＰＵ１１が介在するネゴシエーションが実行される。

【００９２】こうして、伝送モードが決定されると、図１に示した通信バッファ用ＲＡＭ８に格納した送信原稿についての画像情報を読み出し、全ての画像情報の送信を実行する。この送信手順等は、Ｖ．１７、Ｖ．２９、Ｖ．２７ｔｅｒに規定された通りの手順で実行される。

【００９３】〈具体例２の効果〉上記のように通信が開始された後、コントロールチャネルにおいて、モデムが独自のネゴシエーションを行って通信エラーが生じたとき、具体例１と同様の制御を行えば、回線状況が悪化しているとしても、通信エラーを繰り返すのを防止できる。なお、通信が開始された後に通信エラーが生じて、自動的にリダイヤル処理を実行する場合には、送信原稿の画像情報が既にメモリに格納されていることが好ましい。これで、通信再開後もオペレータの介在無しに必要な全ての通信を自動継続できるという効果がある。

【００９４】〈具体例３〉通信エラーの発生原因によっては、リダイヤル処理をしても再接続が不可能な場合がある。その場合には、リダイヤル処理を止めたり、画像メモリの内容を保存しないでおけば、無駄なリダイヤル処理を防止して、画像メモリを有効に利用できる。被呼局の機能上通信ができないきは、再接続できないからこれに該当する。繰り返し通信エラーが発生するときも同様である。オペレータによる強制的な回線切断は、再接

続できない特別の理由によることが多い。

【００９５】更に、通信エラーの原因に応じて、すぐにリダイヤル処理を実行すれば再接続可能な場合と、しばらく待機してからリダイヤル処理を実行したほうがよい場合がある。これを判断して待機時間を設定すれば、無駄なリダイヤル処理と通信エラーの繰り返しを防止できる。

【００９６】通信エラーの原因によっては、リダイヤル処理を繰り返せば再接続可能な場合と、リダイヤル処理を繰り返しても再接続が不可能な場合とがある。これを判断して、リダイヤル処理を繰り返す制限回数を設定すれば、無駄なリダイヤル処理と通信エラーの繰り返しを防止できる。

【００９７】こうした通信エラーに基づくリダイヤル制御を完了するまでは、通信エラーの原因を表示する情報を通信管理情報蓄積手段に保持しておき、これをいつでもＣＰＵ１１が参照できるようにしておくことが好ましい。通信エラーに基づくリダイヤル制御を完了するのは、リダイヤル処理により再接続されてその通信が完了するか、リダイヤル処理が中止されたときである。

【００９８】以上のような観点にもとづいてなされた具体例３の発明の説明をする。図１１は、具体例３のパラメータ説明図である。具体例３を実施するにあたっては、図１に示した通信管理情報蓄積用ＲＡＭ１３に、この図に示すような各種のパラメータを記憶する。この図に示すように、通信管理情報蓄積用ＲＡＭ１３には、エラーコード記憶部２１、リダイヤル回数格納部２２、リダイヤル間隔格納部２３、リダイヤル有無表示部２４及び通信結果格納部２５が設けられる。

【００９９】エラーコード記憶部２１には、後で説明するような内容のエラーコードが記憶される。エラーの種類を表示するためである。リダイヤル回数格納部２２には、通信エラーが生じた後、何回リダイヤルをするかという回数が格納される。ここには、製品出荷時に適当なデフォルト値が記憶される。また、オペレータによって入力された任意の数値が記憶される。この具体例では、通信結果の如何によって自動的にＣＰＵ１１がこの回数を決定する。

【０１００】リダイヤル間隔格納部２３には、「話中」等によってリダイヤルを失敗した場合に、何分おきにリダイヤルを実行するかといった指示を格納する。これもＣＰＵ１１によって通信結果に応じて設定される。リダイヤル有無表示部２４は、リダイヤルをすべきかどうか、例えばリダイヤルをしても無駄な場合にはリダイヤルをしないといった表示データを格納する部分である。

【０１０１】通信結果格納部２５には、正常終了の場合には正常終了、通信エラーの場合にはどういった原因でエラーが生じたかといった情報が格納される。この情報には、さらに、例えば相手方ファックス番号、送信の線密度、圧縮方式、誤り訂正機能の有無、伝送時のデータレート、その他各種の情報が付加される。これらの情報によって、通信エラーがどういった原因で発生し、その通信エラーが発生した場合には、リダイヤル回数を何回にし、リダイヤル間隔を何分にすればよいかといった判断を行うことが可能になる。

【０１０２】図１１中の破線に示した矢印は、通信管理情報蓄積用ＲＡＭ１３に記憶された各種のパラメータを利用して、ＣＰＵ１１が所定の処理を行う際の手順を示す。即ち、Ｘは、通信結果格納部２５に格納された内容に基づいてエラーコードを生成する処理である。その生成した結果得られたエラーコードがエラーコード記憶部２１に記憶される。

【０１０３】また、Ｙは、エラーコード記憶部２１に記憶されたエラーコードに基づいてＣＰＵ１１がリダイヤル回数、リダイヤル間隔、リダイヤルの有無等を決定し、これらをリダイヤル回数格納部２２、リダイヤル間隔格納部２３及びリダイヤル有無表示部２４に格納するためのリダイヤル判定処理を示している。

【０１０４】図１２には、エラーコード生成処理とリダイヤル判定処理の説明図を示す。この図の最も左の欄には、通信が成立しない状態の種類を示す。また、その右側の欄には、判断要素を示す。そして、その更に右側には、エラーコードの例を示す。ＣＰＵ１１は、判断要素に従って、図の左側に示すような状態であることを認識し、その右側に示すようなエラーコードを生成する。そして、そのエラーコードに基づいて、リダイヤルの有無やリダイヤル間隔、リダイヤル回数等が決定される。

【０１０５】例えば、受信側が通話中でビジートーンが検出された場合には、エラーコードを“１１１１”とする。この場合、リダイヤル有りとする情報をリダイヤル有無表示部２４に格納すると共に、リダイヤル間隔やリダイヤル回数を、例えばオペレータの設定したままあるいはデフォルトの状態にしておく。次に、エラーが頻発して通信が切断された場合を考える。これは、例えば回線不良が原因と考えればよい。このときには、ＣＰＵ１１がエラー原因を調べるポストコマンドを発するとＲＴＮが受信される。このような場合には、エラーコードを“３２１０”とする。この場合、リダイヤルを行うとするものの、回線不良が回復する時間を考慮すると、リダイヤルの間隔をあまり短くするのは好ましくない。

【０１０６】そこで、例えばリダイヤル間隔を５分とする。更に、数回リダイヤルを行っても状況が変わらない場合には、回線が直ちに復旧する見込みがないと判断してよい。そこで、リダイヤル回数は３回程度に設定する。

【０１０７】次に、トレーニング中のエラーによって、2,400ｂｐｓといった最低の通信速度でも通信エラーになった場合を考える。この場合には、これ以上ＦＴＴフォールバックができない。回線状態が悪くなければ、そのまますぐに再接続が可能とも予想できる。このとき

は、エラーコードを、例えば“２３４５”とする。そして、必要最小限の時間だけ間隔を空けてリダイヤルを実行する。従って、リダイヤル間隔を３分とする。また、この場合には、通信が成立するまでリダイヤルを繰り返せばよいから、例えばリダイヤル回数を５回に設定する。

【０１０８】今度は、例えば受信側が、受信中に紙詰まりや紙無しで受信続行不能になった場合を考える。あるいは受信側が受信中に停電によってパワーオフになった場合を考える。これは、ポストコマンドに対して３回とも無応答であるといった状態で判断できる。このときは、エラーコードを“３１１１”とする。こうした場合、受信側で受信用紙をセットする時間やあるいは停電が回復するまでの時間を考慮すると、短時間でリダイヤルをしても無駄となる。そこで、リダイヤルの間隔を１５分というように長い時間に設定する。

【０１０９】また、それだけ間隔を空けてリダイヤルを行っても、更に接続が不可能な場合には、他の原因により容易に回復できないことも考えられる。そこで、無駄なリダイヤルを防止するために、リダイヤル回数を２回と限定する。

【０１１０】次に、送信中に送信側が停電した場合を考える。この場合は、エラーコードを“３５００”にする。リダイヤルは停電が回復すればすぐに実行すればよい。リダイヤル回数は自由に設定すればよい。

【０１１１】次に、受信機がパワーオフのため呼び出しに応じない、あるいは受信側が電話機のため音声が返ってきたというような場合、呼接続待ちタイムアウトという状況でこの状態が判断できる。このときは、エラーコードを“１２ＡＡ”とし、リダイヤルをしないと決定する。即ち、リダイヤルをしても必ずしも受信側で正しい応答が行われないと判断されるからである。

【０１１２】また、発呼中に発呼側のオペレータが停止スイッチを押し下げて送信をキャンセルした場合、あるいは送信中に送信を停止するスイッチを押し下げて通信が中断されたりキャンセルされたりした場合を考える。これらは、ストップキーを押し下げたことを検出することにより判断できる。このとき、エラーコードは“１００１”あるいは“３Ａ００”とする。こうした場合、オペレータの側に特別の事情があると考えられるから、自動的にリダイヤル処理をするのは不適切である。従って、リダイヤルをしないという設定を行う。

【０１１３】また、親展送信を行った場合に、受信側にその機能がないことがある。相手方に親展受信機能がないかどうかは、ＮＳＦ信号等の検出ビットを利用して判断することができる。また、中継依頼送信等を要求した場合、受信側にその機能がないことがある。これも同様の方法で検出が可能である。こうした場合、エラーコードを“５６７８”あるいは“５６７９”と設定する。これもリダイヤルをする意味がないからリダイヤルをしないと設定する。

【０１１４】以上のようなエラーコードの形式は、番号や記号等を組み合わせた任意の形態でよい。送信側や受信側から見たときに、それぞれ数多くのエラー形態があるため、分類可能な判別しやすい桁数で表現するとよい。例えば、図の例のように３～４桁程度の１６進数の英数字を用いると表現がしやすい。更に、先頭の数字が、例えば“１”で始まれば受信側につながる前のエラーであるとか、“２”で始まれば手順上のフェーズＢでのエラーであるといった分類をしておくと判断がしやすくなる。なお、リダイヤルの間隔や回数等については、エラーコードを見て、オペレータが手動で設定するようにしても構わない。

【０１１５】図１３には、具体例３の動作フローチャートを示す。この図により、上記のような具体例３のファクシミリ装置の動作を説明する。なお、このフローチャートに示す動作に移行する前に、ファクシミリ装置は既に、発呼、ネゴシエーション等を経て、原稿の一部を送信し始めている。

【０１１６】まず、ステップＳ１で、通信エラーが発生すると、ステップＳ２で、送信原稿の画像情報を保存したままにする。即ち、図１に示した通信バッファ用ＲＡＭ８に対し、メモリ送信用として予め読み込んだ全ての原稿の画像情報を、消去させないように保存しておく。通常は、回線を切断すると自動的にメモリ中の画像情報が消去されてしまうからである。次のステップＳ３において、通信エラーが発生したそのときの状態を通信結果格納部２５（図１１）に記憶する。そして、ＣＰＵ１１は、この通信結果に基づいて、既に説明した要領でエラーコードを生成して、図１１に示したエラーコード記憶部２１に記憶する。

【０１１７】更に、ＣＰＵ１１は、そのエラーコードに基づき、図１１に示すリダイヤル有無表示部２４にリダイヤルの有無、即ちリダイヤルをすべきかどうかの情報を記憶する（ステップＳ５）。次のステップＳ６では、この情報を参照してリダイヤルが必要かどうかを判断する。リダイヤルが必要であればステップＳ７に進み、リダイヤル回数とリダイヤル間隔とを決定し、図１１に示すリダイヤル回数格納部２２とリダイヤル間隔格納部２３に記憶する。

【０１１８】次のステップＳ８で、リダイヤルのためのタイマをセットする。そして、ステップＳ９で、時間待ちを行う。タイムアップした場合には、ステップＳ１０に進み、リダイヤルを実行する。その後通信が正常に終了するかどうかを監視する。なお、このとき、既に具体例１や具体例２を用いて説明した要領で、ＣＰＵ１１の制御によるネゴシエーションが実行され、所定のデータレートでの通信が実行される。

【０１１９】ここで、通信が正常終了すれば処理を終わる。また、通信エラーが生じた場合には、ステップＳ１

１からステップＳ１２に進み、その通信のエラーコードを生成する。次にステップＳ１３で、記憶されている前回のエラーコードと今回のエラーコードとを比較する。前回のエラーコードと今回のエラーコードとが等しい場合には、ステップＳ１４で、リダイヤル回数のデクリメントを行って、その結果をリダイヤル回数格納部２２に格納する。ステップＳ１５でこのリダイヤル回数がゼロより大きいか判断する。リダイヤル回数がゼロより大きければステップＳ８にもどり、再び、リダイヤルを繰り返す。リダイヤル回数がゼロならば、これ以上のリダイヤルをしないで、ステップＳ１６へ進み、通信エラー表示処理を行う。

【０１２０】ステップＳ１６において、画像情報の保存を解除するのは、メモリ送信用に保存していた画像情報を開放し、他の通信に利用できるようにするためである。リダイヤルをしないと判断された場合には、それ以上画像情報を保存しておくと、他の処理の効率を低下させ、メモリ資源が無駄になるからである。ステップＳ１７において、通信エラー表示を行うのは、これ以上リダイヤルをしない旨をオペレータに通知して、通信エラーに対する後処理をオペレータに要求するためである。この通信エラー表示は、ファクシミリ装置の操作・表示部１６（図１）に表示する。

【０１２１】一方、ステップＳ１３で前回のエラーコードと今回のエラーコードとが異なると判断されたときは、ステップＳ２に戻って、新たな通信エラーが発生した場合の処理を実行する。なお、通信エラーが多発する回線では、上記ステップＳ１３で、前回のエラーコードと今回のエラーコードとが異なると判断されたときに、ステップＳ２に戻って、リダイヤル回数やリダイヤル間隔を新たに設定するようにした場合、いつまでもリダイヤルが終了しないことが考えられる。

【０１２２】そこで、前回のエラーコードと今回のエラーコードとが異なると判断されたとき、そのままステップＳ１６に進んで、通信エラー表示処理を行うようにしてもよい。また、エラーコードの内容にかかわりなく、リダイヤル回数に上限を設けて、合計リダイヤル回数が上限をこえた場合には、無条件にステップＳ１６に進んで、通信エラー表示処理を行うようにしてもよい。

【０１２３】〈具体例３の効果〉以上説明したように、通信エラーが発生したとき、その通信エラーの原因を示す通信管理情報を収集して、リダイヤル処理により再接続が可能と判断した場合には画像メモリの内容を保存し、リダイヤル処理の後、新たな伝送モードが選択されて通信が再開されたとき、その画像メモリの内容を読み出して送信するようにすれば、自動的なリダイヤル処理が可能になる。また、再接続が不能な場合にリダイヤル処理を繰り返すという無駄も防止できる。

【０１２４】また、通信エラーの原因に応じてリダイヤル処理を実行するまでの待機時間やリダイヤル処理を繰り返す制限回数を設定することによって、無駄なリダイヤルを数多く繰り返す無駄を防止することができる。こうして、リダイヤル制御を完了するまで、通信エラーの原因を表示する情報を通信管理情報蓄積手段に保持しておき、これを制御手段が参照することによって、常に最適なリダイヤル制御が可能となる。

【図面の簡単な説明】

【図１】具体例１のファクシミリ装置のブロック図である。

【図２】具体例１の発呼局の処理手順を示すフローチャート（その１）である。

【図３】具体例１の発呼局の処理手順を示すフローチャート（その２）である。

【図４】具体例１の発呼局の処理手順を示すフローチャート（その３）である。

【図５】具体例１のリダイヤル時の処理手順を示すフローチャート（その１）である。

【図６】具体例１のリダイヤル時の処理手順を示すフローチャート（その２）である。

【図７】具体例１のリダイヤル時の処理手順を示すフローチャート（その３）である。

【図８】ファクシミリ装置の通信シーケンスチャートである。

【図９】具体例２の発呼局の処理手順を示すフローチャート（その１）である。

【図１０】具体例２の発呼局の処理手順を示すフローチャート（その２）である。

【図１１】具体例３のパラメータ説明図である。

【図１２】エラーコード生成処理とリダイヤル判定処理の説明図である。

【図１３】具体例３の動作フローチャートである。

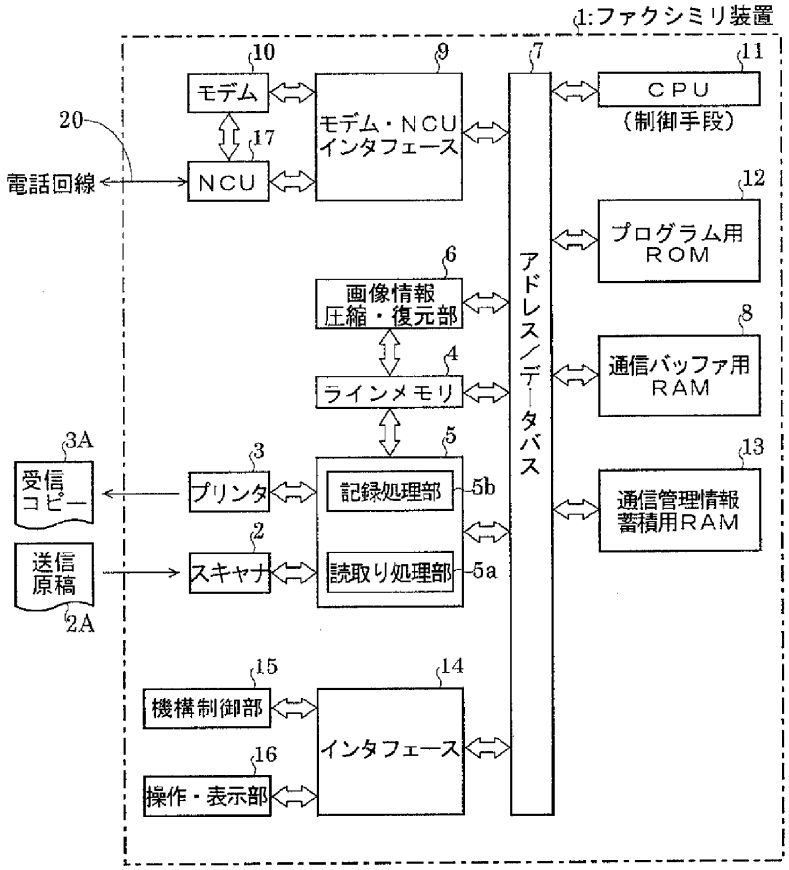
【符号の説明】

１　ファクシミリ装置

１０　モデム

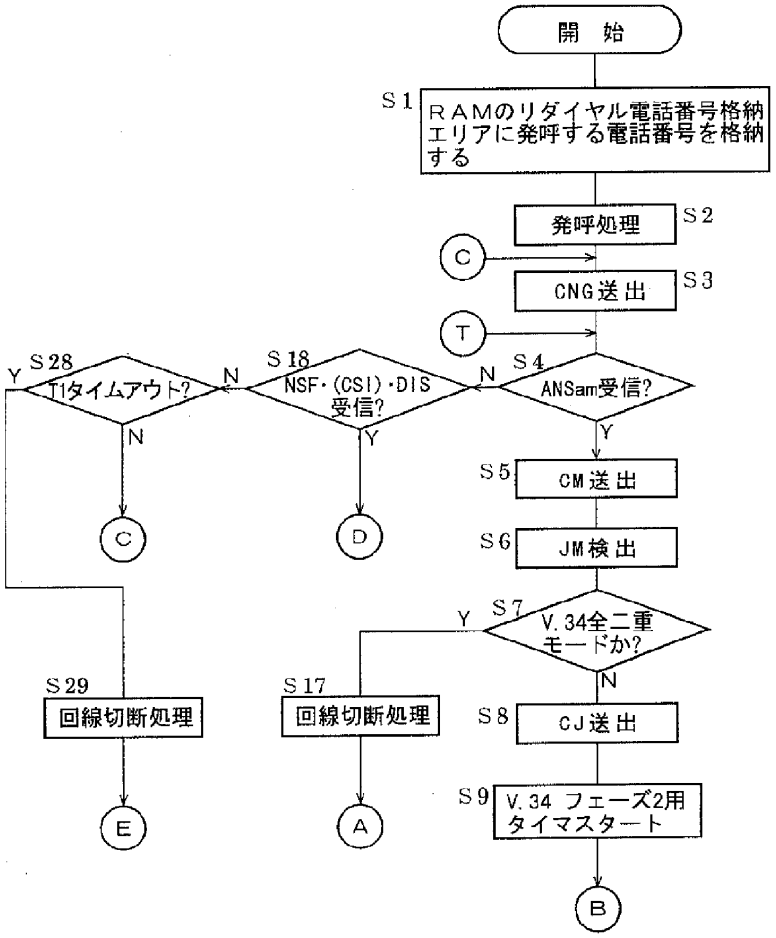
１１　ＣＰＵ（制御手段）

【図１】



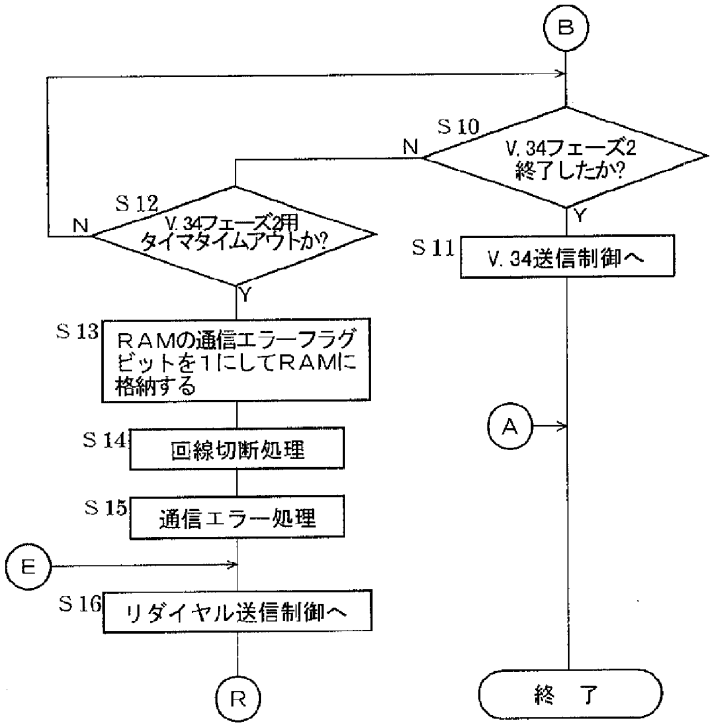
具体例１のファクシミリ装置のブロック図

【図2】



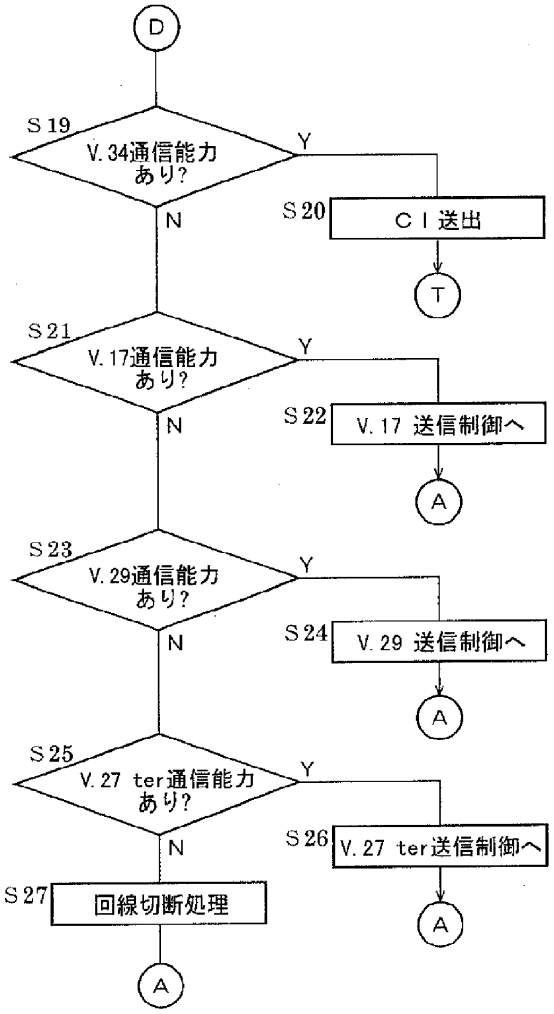
具体例１の発呼局の処理手順を示すフローチャート（その１）

【図3】



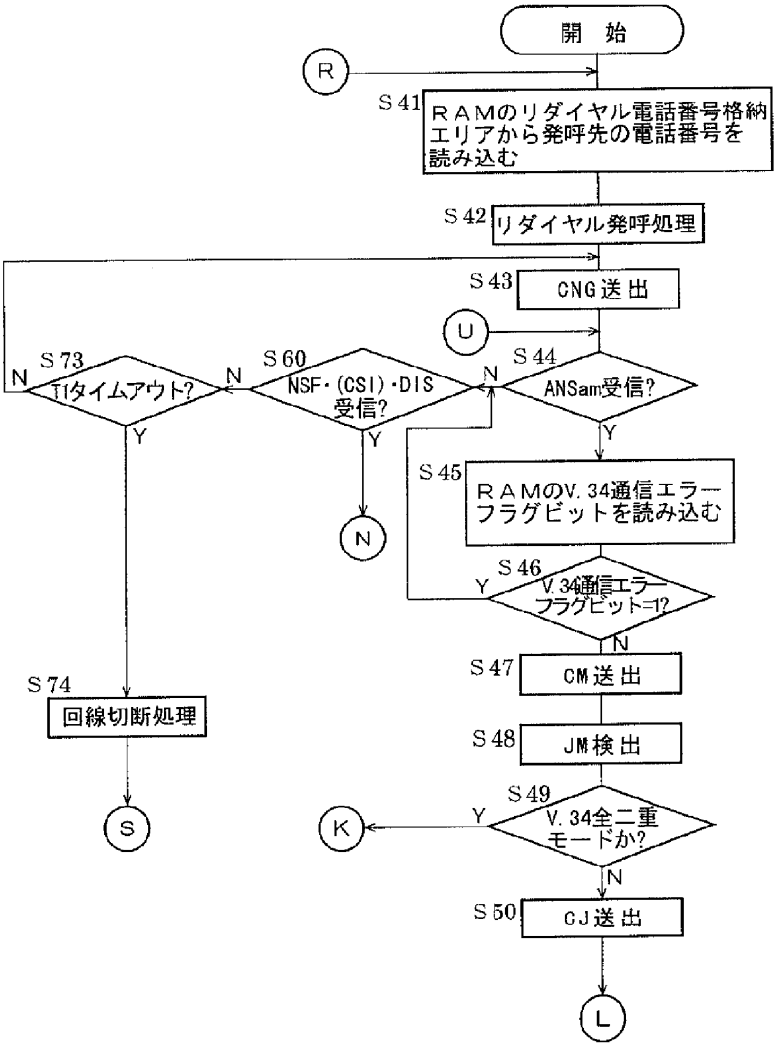
具体例1の発呼局の処理手順を示すフローチャート（その2）

【図４】



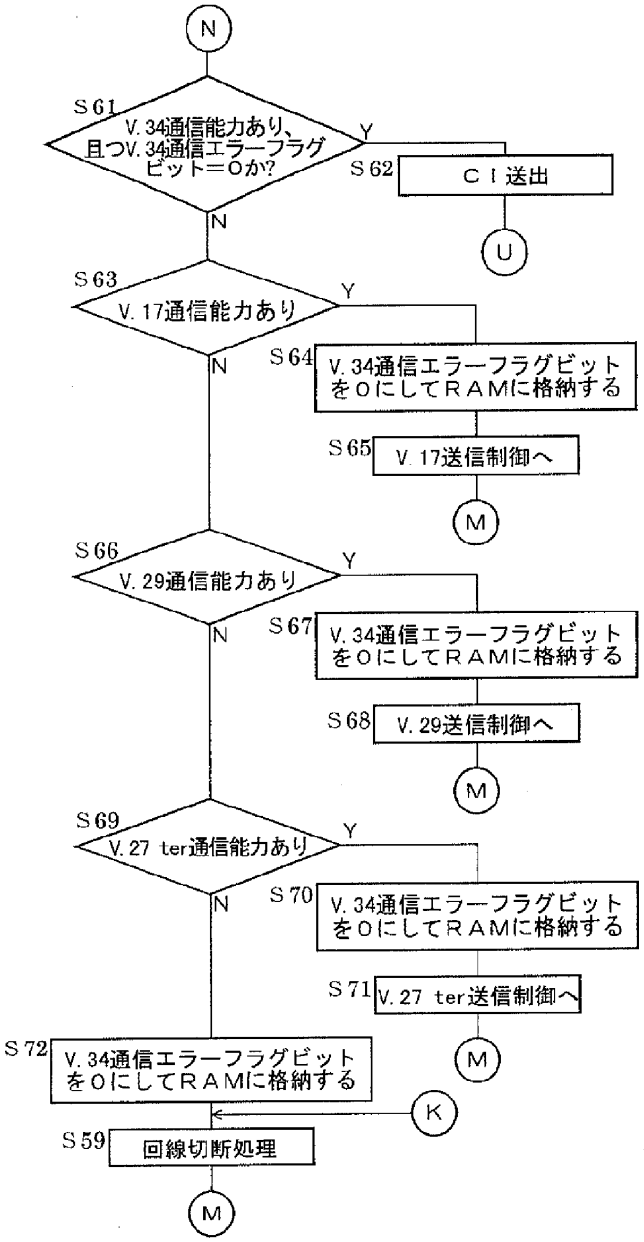
具体例１の発呼局の処理手順を示すフローチャート（その３）

【図5】



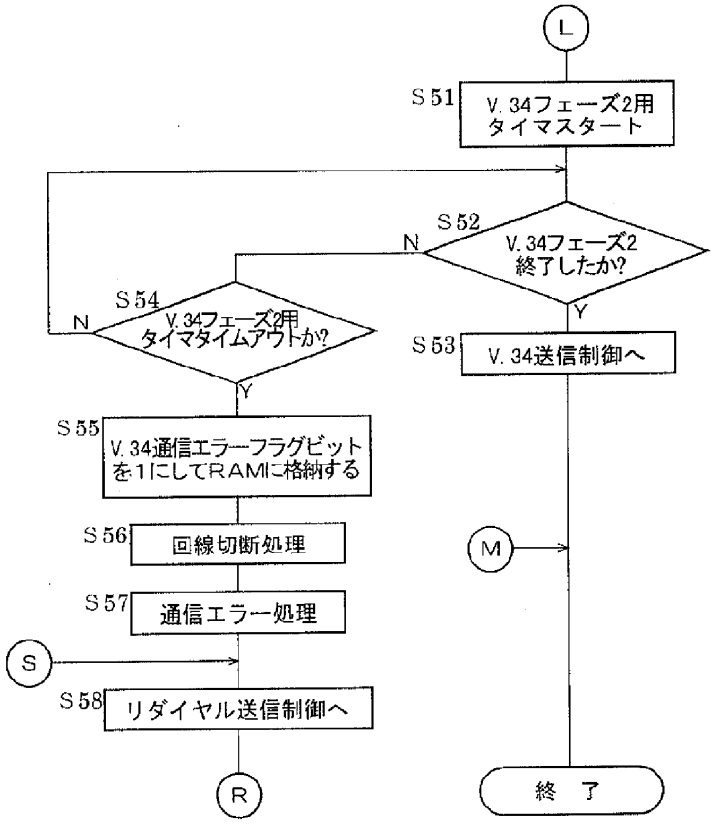
具体例１のリダイヤル時の処理手順を示すフローチャート（その１）

【図6】



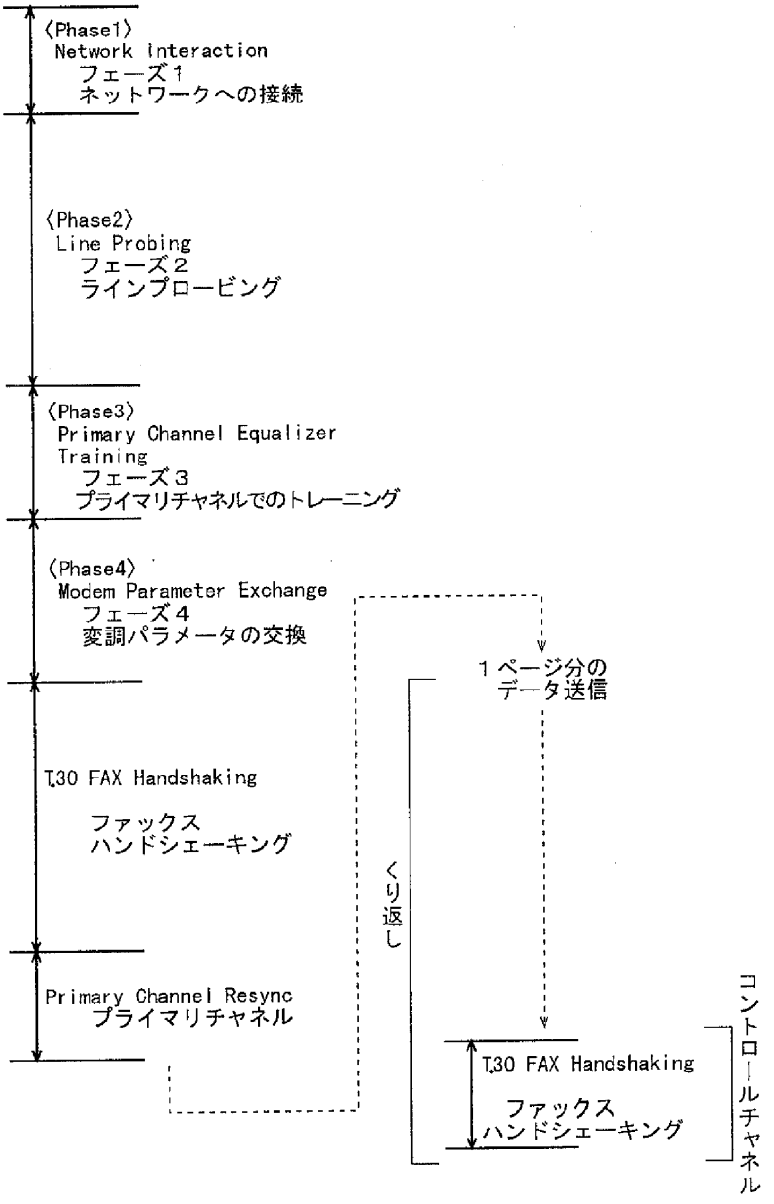
具体例1のリダイヤル時の処理手順を示すフローチャート（その2）

【図７】



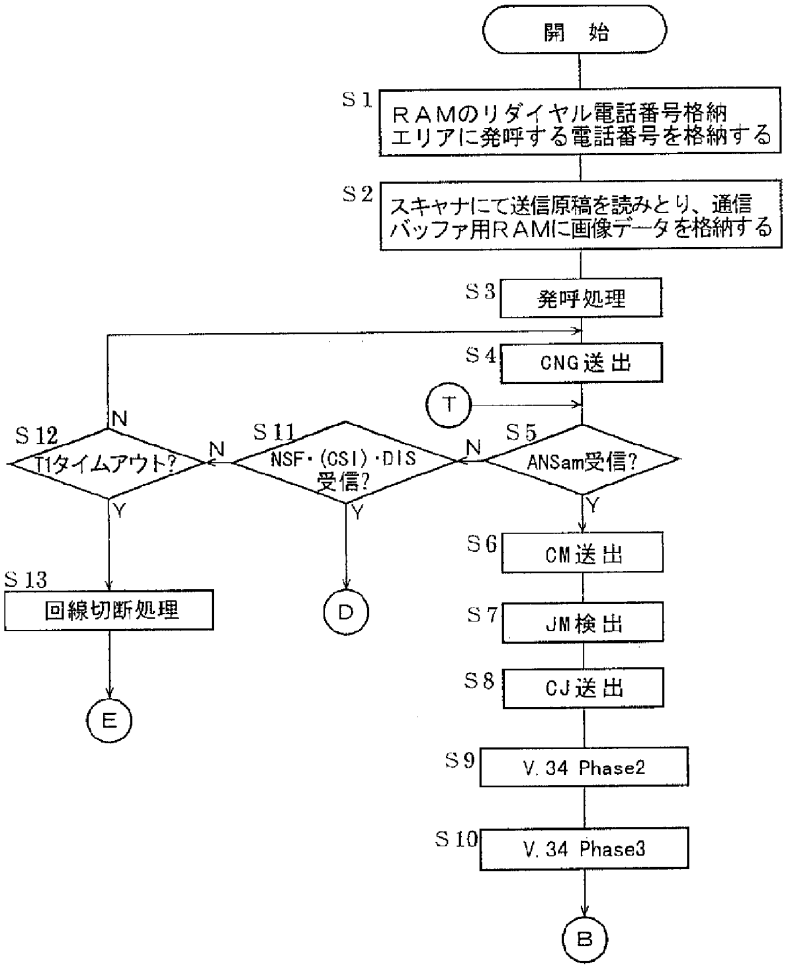
具体例１の発呼局の処理手順を示すフローチャート（その３）

【図8】



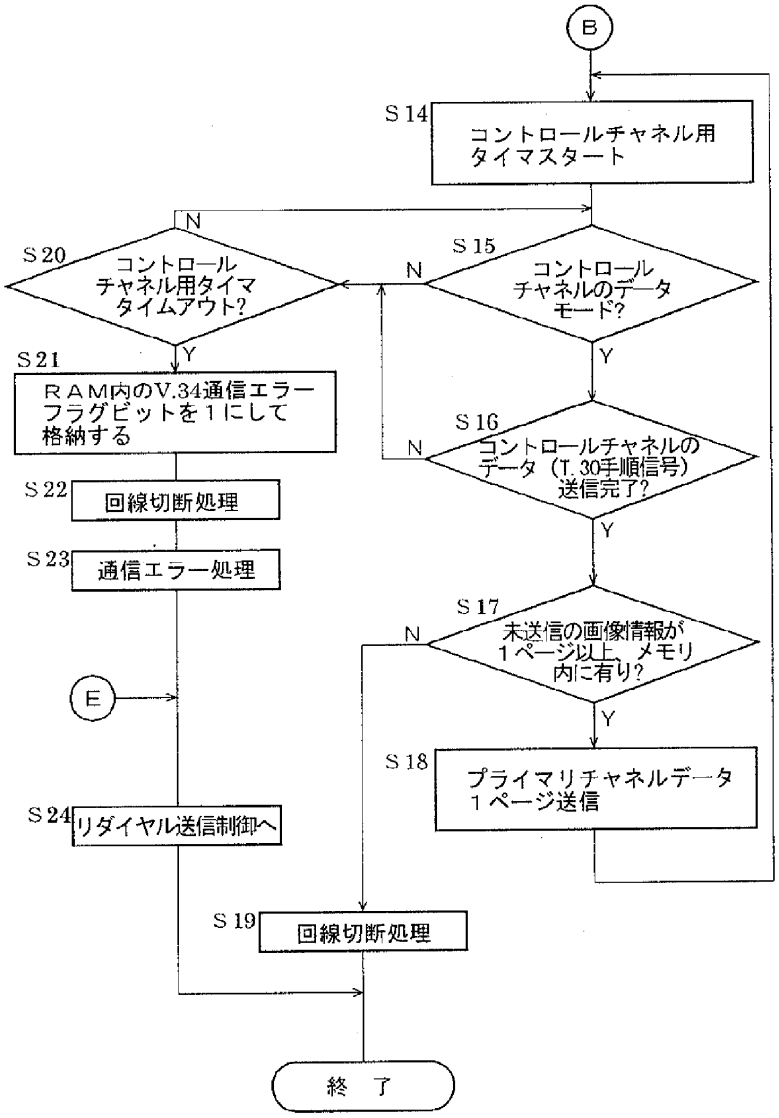
ファクシミリ装置の通信シーケンスチャート

【図９】



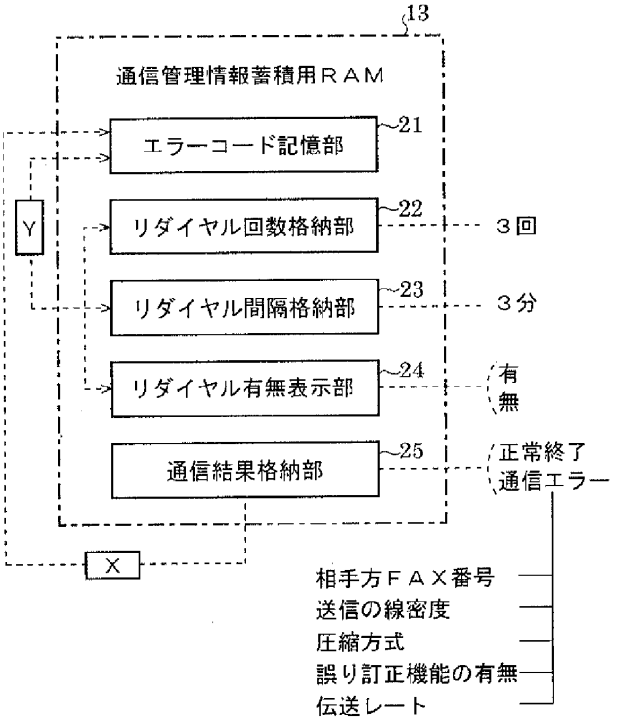
具体例２の発呼局の処理手順を示すフローチャート（その１）

【図１０】



具体例２の発呼局の処理手順を示すフローチャート（その２）

【図１１】



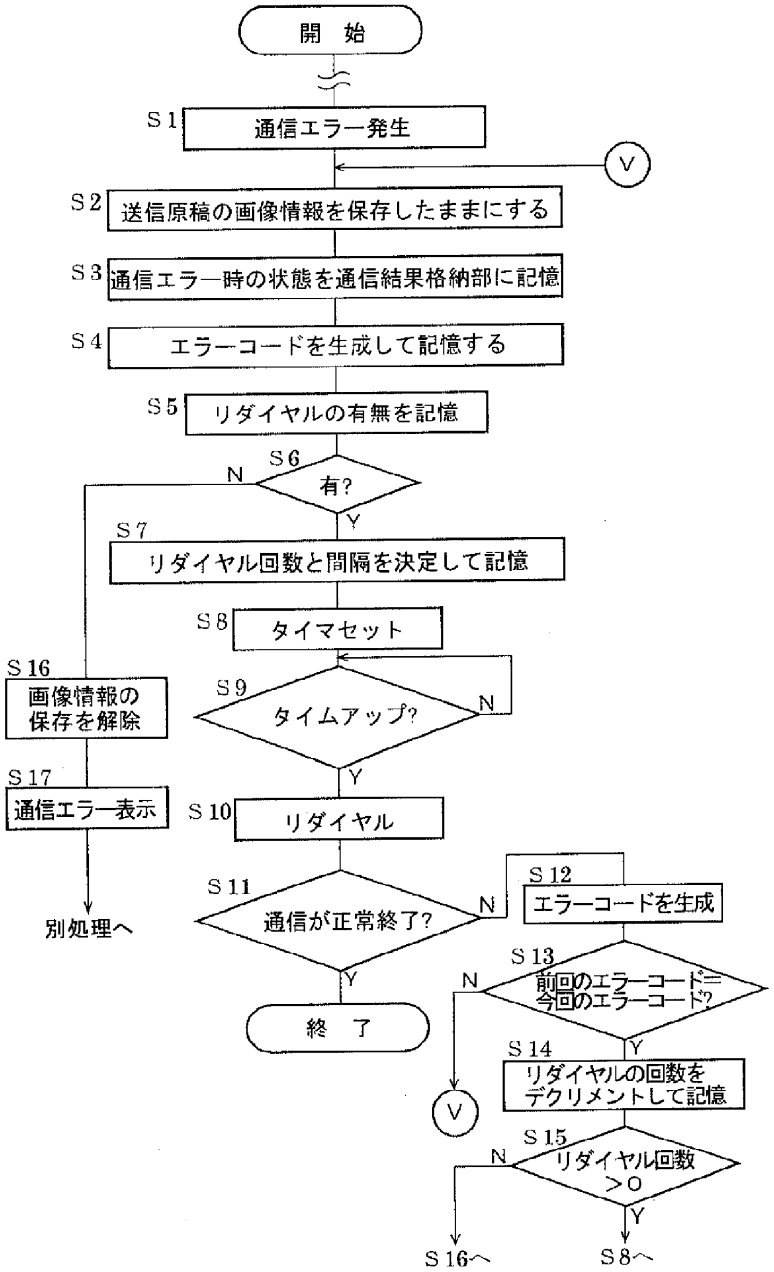
具体例３のパラメータ説明図

【図12】

通信が成立しない状態（エラー形態）	判断要素	エラーコード（例）	リダイヤルの有無、間隔、回数
受信側が通話中	ビジートーン検出	1111	する、自由、自由
画エラーが頻発して通信断（回線不良）	ポストコマンドに対してRTNを受信	3210	する、５分、３回
トレーニング中のエラーにより2400bpsでもNG	FTTフォールバック不可	2345	する、３分、５回
＊受信側が受信中に紙詰まり、紙無しで受信続行不可 ＊受信側が受信中に停電によりPOWOFF	ポストコマンドに対して３回とも無応答	3111	する、１５分、２回
送信中に送信側が停電	停電	3500	する、即時、随時
＊受信機がPOWOFFのため呼出しに応じない ＊受信側が電話器のため音声が返ってきた	呼接続待ちタイムアウト	12AA	しない
発呼中の停止SW押下によるキャンセル	発呼中にSTOPキー押下	1001	しない
停止SW押下による通信中断／キャンセル	送信中のSTOPキー押下	3A00	しない
＊親展送信で受信側にその機能がない ＊中継依頼送信で受信側にその機能がない	＊NSF信号などの検出ビットを用い親展指定送信で相手機に親展受信機能無しを検出 ＊中継依頼送信で相手機に中継機能無しを検出	5678 5679	しない しない

エラーコード生成処理とリダイヤル判定処理

【図13】



具体例３の動作フローチャート

KOREAN PATENT ABSTRACTS(KR)

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Application No. 1996-39605 Application Date. November 12, 1996
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Applicant:
Samsung Electronics Corp.
Inventor:
Yim, Jeong Gyu

Title of Invention
CONTROL DEVICE CAPABE OF PERFORMING POWER MANAGEMENT AND REMOTE CONTROL MANAGEMENT

Abstract:

PURPOSE: According to conventional technology of power management, a control device needs both a micom to perform power management for protecting data at a power saving mode or a power breakdown, and a micom to perform remote control management for receiving data from a remote control device, so that cost thereof increases and its operation is complicated.

The present device, therefore, solves aforementioned problems associated with conventional devices by providing a control device capable of performing both power management and remote control management, in which an integrated micom is used in not only the power management that protects processing data at a power saving mode for reducing power consumption of an idle computer system or at a power breakdown, but also the remote control management that receives data from a remote control device.

CONSTITUTION: A control device capable of performing power management and remote control management comprising: a power supply to supply power to a computer system; a wireless input unit to wirelessly receive data from a remote control device; a controlling unit to control the power supply according to operations of the computer system, output a signal for protecting processing data to the corresponding device, and receive the data from the remote control device through the wireless input unit; and a system controller to sense an operating state of the computer system, output a signal to the controlling unit for switching power being supplied to the computer system on the basis of the operating state, store the processing data in response to the signal output from the controlling unit, and process a signal received from the remote controller through the controlling unit.

EFFECT: One micom is capable of performing both the power management to protect data at the power saving mode or at the power breakdown and the remote control management to receive data from the remote control device, so that system logic is simplified, thereby reducing a production cost thereof and stabilizing its operation.

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심사청구 : 없음

(54) 전원 관리기능과 리모콘 관리기능이 가능한 제어장치

요약

시스템에 전원을 공급하기 위한 전원공급수단과;

무선으로 데이터를 입력하는 무선입력수단과;

시스템의 동작 상태에 따라 상기 전원공급수단의 동작 상태를 제어하며 작업중인 데이터를 보호하기 위한 신호를 출력하고, 상기 무선입력수단에서 송신되는 신호를 입력받아 출력하는 제어수단과;

시스템의 동작 상태를 감지하여 상기 제어수단으로 시스템을 절전모드로 전환하기 위한 신호를 출력하고, 상기 제어수단에서 입력되는 신호에 의해 작업중인 데이터를 저장하는 시스템 컨트롤러를 포함하여 이루어지는 데이터 백업기능과 리모콘 수신기능이 가능한 제어장치는 하나의 마이컴으로 데이터 백업기능과 리모콘 수신기능이 가능하므로 시스템 로직이 단순화되어 비용을 절감할 수 있으며, 동작을 안정화시킬 수 있다.

대표도

도1

명세서

도면의 간단한 설명

도1은 이 고안의 실시예에 따른 전원 관리기능과 리모콘 관리기능이 가능한 제어장치의 블록 구성도.

도2는 종래의 전원 관리와 리모콘 관리를 위한 제어장치의 블록 구성도이다.

고안의 상세한 설명

고안의 목적

고안이 속하는 기술분야 및 그 분야의 종래기술

이 고안은 전원 관리기능과 리모콘 관리기능이 가능한 제어장치에 관한 것으로, 더욱 상세하게는 컴퓨터 시스템이 일정한 시간동안 동작하지 않을 때 전력 소비를 줄이기 위해 수행되는 절전기능 수행시와 정전시에 작업중인 데이터를 보호하기 위한 전원 관리기능과, 리모콘에서 송신되는 데이터를 수신하기 위한 리모콘 관리기능을 모두 수행할 수 있는 전원 관리기능과 리모콘 관리기능이 가능한 제어장치에 관한 것이다.

이하, 첨부된 도면을 참고로 하여 종래의 전원관리와 리모콘 관리를 위한 제어장치에 대하여 설명하면 다음과 같다.

도2는 종래의 전원관리와 리모콘관리를 위한 제어장치의 블록 구성도이다.

도2에 도시되어 있듯이, 종래의 전원 관리와 리모콘 관리를 위한 제어장치의 구성은,

컴퓨터 시스템에 전원을 공급하는 전원공급부(1)와;

컴퓨터 시스템의 동작상태에 따라 작업중인 데이터를 보호하기 위해 상기 전원공급부(1)의 동작 상태를 제어하는 전원관리 마이콤(2)과;

리모콘(3)으로부터 무선으로 입력되는 데이터를 수신하여 해당장치로 출력하는 리모콘 수신부(4)와;

상기 리모콘 수신부(4)로 입력되는 데이터를 해당장치로 출력하는 리모콘관리 마이컴(5)과;

컴퓨터 시스템의 동작 상태를 감지하여 상기 전원관리 마이컴(2)으로 컴퓨터 시스템을 절전모드로 전환하기 위한 신호를 출력하고, 상기 전원관리 마이컴(2)에서 입력되는 신호에 의해 작업중인 데이터를 저장하고, 상기 리모콘관리 마이컴(5)을 출력되는 데이터를 입력받아 리모콘(3)에서 송신되는 데이터를 처리하는 시스템 컨트롤러(6)로 이루어진다.

상기 구성에 의한 종래의 전원관리와 리모콘관리를 위한 제어장치의 동작은 다음과 같다.

첫 번째로 절전기능과 정전시에 데이터를 보호하기 위한 전원 관리기능의 수행 과정에 대하여 설명하면 다음과 같다.

먼저, 절전기능시 데이터 보호를 위한 전원 관리기능에 대하여 설명하면 다음과 같다.

상기 시스템 컨트롤러(6)는 전원이 공급되는 상태에서 임의로 지정된 시간이 경과하도록 사용자가 컴퓨터 시스템을 사용하지 않으면, 상기 전원관리 마이컴(2)으로 컴퓨터 시스템을 절전모드로 전환하기 위한 신호를 출력한다.

절전모드로 전환하기 위한 신호를 입력받은 상기 전원관리 마이컴(2)은 상기 시스템 컨트롤러(6)로 현재 작업중인 데이터를 저장하라는 신호를 출력한다.

상기 전원관리 마이컴(2)에서 출력되는 신호에 의해 상기 시스템 컨트롤러(6)는 작업중인 데이터를 저장하기 시작하고, 저장이 완료되면 저장이 완료되었음을 알리는 신호를 상기 전원관리 마이컴(2)으로 출력한다.

이때, 상기 전원관리 마이컴(2)은 컴퓨터 시스템을 절전모드로 전환하기 위해 상기 전원공급부(1)로 컴퓨터 시스템에 공급되는 전원을 차단하도록 하는 신호를 출력한다.

그러면, 상기 전원공급부(1)는 컴퓨터 시스템에 공급되는 전원을 차단함과 동시에 도시되지 않은 배터리의 전원이 상기 전원관리 마이컴(2)에 공급되도록 하여 컴퓨터 시스템에 전원이 공급되지 않아도 리모콘(3)에서 입력되는 데이터를 상기 리모콘관리 마이컴(3)이 수신할 수 있게 한다.

다음으로, 갑작스럽게 정전이 발생한 경우에 데이터를 보호하기 위한 전원 관리기능에 대하여 설명하면 다음과 같다.

정전이 발생하면 상기 전원공급부(1)는 정전과 동시에 컴퓨터 시스템에 공급되는 전원을 차단하고 도시되지 않은 배터리의 전원이 상기 전원관리 마이컴(2)에 공급되도록 한다.

이때, 상기 전원관리 마이컴(2)은 정전 발생을 감지하여 상기 시스템 컨트롤러(6)로 현재 작업중인 데이터를 저장하기 위한 신호를 출력한다.

상기 시스템 컨트롤러(6)는 상기 전원관리 마이컴(2)에서 입력되는 신호에 의해 작업중인 데이터를 저장하기 시작하고, 저장이 완료되면 저장이 완료되었음을 알리는 신호를 상기 전원관리 마이컴(2)으로 출력한다.

작업중인 데이터의 저장이 완료되었음을 알리는 신호를 입력받은 상기 전원관리 마이컴(2)은 도시되지 않은 배터리의 전원을 오프시켜 데이터 백업을 완료한다.

두 번째로, 리모콘 관리기능에 대하여 설명하면 다음과 같다.

컴퓨터 시스템에 전원이 정상적으로 공급되는 상태일 경우 상기 리모콘관리 마이컴(5)은 상기 전원공급부(1)로부터 전원을 공급받아 동작하고, 상기 리모콘 수신부(4)가 리모콘(3)에서 송신되는 데이터를 입력받아 출력하는 신호를 입력받는다.

상기 리모콘관리 마이컴(5)은 리모콘 수신부(4)에서 출력되는 신호를 입력받아 컴퓨터 시스템에 전달될 수 있도록 상기 시스템 컨트롤러(6)로 출력한다.

그러나, 컴퓨터 시스템이 절전 모드로 동작하거나 정전이 발생하면, 상기 리모콘관리 마이컴(5)은 도시되지 않은 배터리로부터 전원을 공급받아 동작하며, 상기 리모콘 수신부(4)가 리모콘(3)에서 송신하는 데이터를 입력받아 출력하는 신호를 입력받는다.

상기 리모콘관리 마이컴(5)은 리모콘 수신부(4)에서 출력되는 신호를 입력받아 컴퓨터 시스템에 전달될 수 있도록 상기 시스템 컨트롤러(6)로 출력한다.

고안이 이루고자 하는 기술적 과제

그러나, 종래의 전원관리 기술은 전원관리와 리모콘관리를 위한 제어장치는 절전기능 및 정전시에 데이터를 보호하기 위한 전원관리 기능을 수행하기 위한 마이컴과 리모콘에서 송신되는 데이터를 입력받기 위한 리모콘관리 기능을 수행하기 위해 마이컴을 별도로 사용해야 하므로 비용이 많이 들고, 기능을 수행하는데 복잡한 문제점이 있다.

그러므로, 이 고안의 목적은 상기 종래의 문제점을 해결하기 위한 것으로 컴퓨터 시스템이 일정한 시간동안 동작하지 않을 때 전력 소비를 줄이기 위해 수행되는 절전기능 수행시와 정전시에 작업중인 데이터를 보호하기 위한 전원 관리기능과 리모콘에서 송신되는 데이터를 입력받는 수신기능을 하나의 마이컴으로 수행할 수 있는 전원 관리기능과 리모콘 관리기능이 가능한 제어장치를 제공하기 위한 것이다.

고안의 구성 및 작용

상기 목적을 달성하기 위한 수단으로서 이 고안의 구성은,

컴퓨터 시스템에 전원을 공급하기 위한 전원공급수단과;

리모콘에서 무선으로 입력되는 데이터를 수신하기 위한 무선입력수단과;

컴퓨터 시스템의 동작 상태에 따라 상기 전원공급수단의 동작 상태를 제어하고, 해당장치로 작업중인 데이터를 보호하기 위한 신호를 출력하고, 상기 무선입력수단을 통해 리모콘에서 송신되는 데이터를 입력받아 출력하는 제어수단과;

컴퓨터 시스템의 동작 상태를 감지하여 상기 제어수단으로 컴퓨터 시스템에 공급되는 전원공급 상태를 전환하기 위한 신호를 출력하고, 상기 제어수단에서 입력되는 신호에 의해 작업중인 데이터를 저장하고, 상기 제어수단을 통해 리모콘에서 송신되는 신호를 입력받는 처리하는 시스템 컨트롤러로 이루어진다.

이하, 이 발명이 속하는 기술 분야에서 통상의 지식을 가진 자가 이 발명을 용이하게 실시할 수 있는 가장 바람직한 실시예를 첨부된 도면을 참조로 하여 설명하기로 한다.

컴퓨터 시스템에 전원을 공급하기 위한 전원공급부(1)와;

리모콘(3)에서 무선으로 입력되는 데이터를 수신하기 위한 리모콘 수신부(4)와;

컴퓨터 시스템의 동작 상태에 따라 상기 전원공급부(1)의 동작 상태를 제어하고, 해당장치로 작업중인 데이터를 보호하기 위한 신호를 출력하고, 상기 리모콘 수신부(4)를 통해 리모콘(3)에서 송신되는 데이터를 입력받아 출력하는 마이컴(7)과;

컴퓨터 시스템의 동작 상태를 감지하여 상기 마이컴(7)으로 컴퓨터 시스템을 절전 모드로 전환하기 위한 신호를 출력하고, 상기 마이컴(7)에서 입력되는 신호에 의해 작업중인 데이터를 저장하고, 상기 마이컴(7)을 통해 리모콘(3)에서 송신되는 신호를 입력받아 처리하는 시스템 컨트롤러(6)로 이루어진다.

상기한 구성에 의한, 이 발명의 실시예에 따른 전원 관리기능과 리모콘 관리기능이 가능한 제어장치의 동작을 설명하면 다음과 같다.

첫 번째로, 절전기능과 정전시에 데이터를 보호하기 위한 전원 관리기능의 수행 과정에 대하여 설명하면 다음과 같다.

먼저, 절전기능시 데이터 백업의 위한 전원 관리기능에 대하여 설명하면 다음과 같다.

상기 시스템 컨트롤러(6)는 컴퓨터 시스템의 동작 상태를 감지하여, 컴퓨터 시스템이 일정한 시간이 경과하도록 동작하지 않으면 상기 마이컴(7)으로 컴퓨터 시스템을 절전 모드로 전환하기 위한 신호를 출력한다.

컴퓨터 시스템을 절전모드로 전환하기 위한 신호를 입력받은 상기 마이컴(7)은 상기 시스템 컨트롤러(6)로 현재 작업중인 데이터를 저장하라는 신호를 출력한다.

상기 시스템 컨트롤러(6)는 상기 마이컴(7)에서 출력되는 신호에 의해 작업중인 데이터를 저장하기 시작하고, 저장이 완료되면 저장이 완료되었음을 알리는 신호를 상기 마이컴(7)으로 출력한다.

이때, 상기 마이컴(7)은 컴퓨터 시스템을 절전모드로 전환하기 위해 상기 전원공급부(1)로 컴퓨터 시스템에 공급되는 전원을 차단하도록 하는 신호를 출력한다.

이때, 상기 전원공급부(1)는 컴퓨터 시스템에 공급되는 전원을 차단함과 동시에 도시되지 않은 배터리의 전원이 상기 마이컴(7)에 공급되도록 하여 컴퓨터 시스템에 전원이 공급되지 않아도 상기 리모콘(3)에서 입력되는 데이터를 상기 마이컴(7)이 수신할 수 있게 한다.

다음으로, 갑작스럽게 정전이 발생한 경우에 데이터 백업을 수행하기 위한 전원 관리기능에 대하여 설명하면 다음과 같다.

정전이 발생하면 상기 전원공급부(1)는 정전과 동시에 컴퓨터 시스템에 공급되는 전원을 차단하고 도시되지 않은 배터리를 온시켜 상기 마이컴(7)에 전원을 공급한다.

그러면, 상기 마이컴(7)은 정전 발생을 감지하여 상기 시스템 컨트롤러(6)로 현재 작업중인 데이터를 저장하기 위한 신호를 출력한다.

상기 시스템 컨트롤러(6)는 상기 마이컴(7)에서 입력되는 신호에 의해 작업중인 데이터를 저장하기 시작하고, 저장이 완료되면 저장이 완료되었음을 알리는 신호를 상기 마이컴(7)으로 출력한다.

작업중인 데이터의 저장이 완료되었음을 알리는 신호를 입력받은 상기 마이컴(7)은 도시되지 않은 배터리의 전원을 오프시켜 데이터 백업을 완료한다.

두 번째로, 리모콘 수신기능에 대하여 설명하면 다음과 같다.

컴퓨터 시스템에 전원이 정상적으로 공급되면, 상기 마이컴(7)은 상기 전원공급부(1)로부터 전원을 공급받아 동작하면서, 상기 리모콘 수신부(4)가 리모콘(3)에서 송신하는 데이터를 입력받아 출력하는 신호를 입력받는다.

상기 마이컴(7)은 리모콘 수신부(4)에서 출력되는 신호를 입력받아 컴퓨터 시스템에 전달될 수 있도록 상기 시스템 컨트롤러(6)로 출력한다.

그러나, 컴퓨터 시스템이 절전모드로 동작하거나 정전이 발생하면, 상기 마이컴(7)은 도시되지 않은 배터리로부터 전원을 공급받아 동작하며, 상기 리모콘 수신부(4)가 리모콘(3)에서 송신하는 데이터를 입력받아 출력하는 신호를 입력받는다.

상기 마이컴(7)은 리모콘 수신부(4)에서 출력되는 신호를 입력받아 컴퓨터 시스템에 전달될 수 있도록 상기 시스템 컨트롤러(6)로 출력한다.

고안의 효과

하나의 마이컴으로 절전기능 수행시와 정전시에 데이터를 보호하기 위한 전원 관리기능과 리모콘에서 송신되는 데이터를 입력받는 리모콘 관리기능이 가능하므로 시스템 로직이 단순화되어 비용을 절감할 수 있으며, 동작을 안정화시킬 수 있다.

(57) 청구의 범위

청구항 1

컴퓨터 시스템에 전원을 공급하기 위한 전원공급수단과;

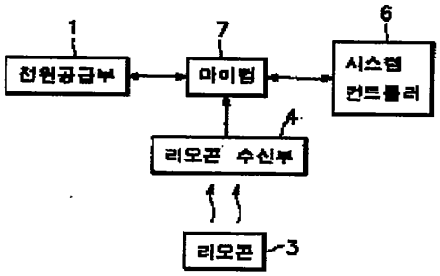
리모콘에서 무선으로 입력되는 데이터를 수신하기 위한 무선입력수단과;

컴퓨터 시스템의 동작 상태에 따라 상기 전원공급수단의 동작 상태를 제어하고, 해당장치로 작업중인 데이터를 보호하기 위한 신호를 출력하고, 상기 무선입력수단을 통해 리모콘에서 송신되는 데이터를 입력받아 출력하는 제어수단과;

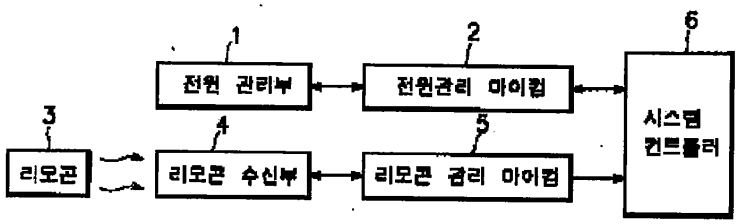
컴퓨터 시스템의 동작 상태를 감지하여 상기 제어수단으로 컴퓨터 시스템에 공급되는 전원공급 상태를 전환하기 위한 신호를 출력하고, 상기 제어수단에서 입력되는 신호에 의해 작업중인 데이터를 저장하고, 상기 제어수단을 통해 리모콘에서 송신되는 신호를 입력받는 처리하는 시스템 컨트롤러를 포함하여 이루어지는 전원 관리기능과 리모콘 관리기능이 가능한 제어장치.

도면

도면1



도면2



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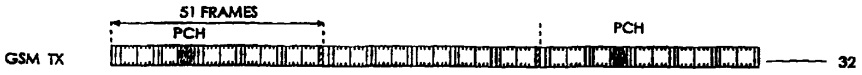

(57) Abstract

Concurrent receipt of incoming calls from both a private radio communications network connected to a public switched telephone network and a wide area cellular network also connected to the public switched telephone network are provided by a radio communications mobile terminal supporting concurrent receipt of incoming calls from the two uncoordinate networks. The mobile terminal wakes up from a lower power sleep mode to monitor for paging messages on the paging channel of the wide area cellular network. The mobile terminal also wakes up to monitor for beacon transmissions from the private radio communications network on the beacon channel of the private radio communications network. When incoming calls are indicated as pending in either network, the mobile terminal accesses the network having an incoming call and receives the call. The mobile terminal may optionally deregister from the wide area cellular network when it establishes access to a private radio communications network and only periodically wake up from its lower power sleep mode to monitor for incoming calls on both the wide area cellular network and the private radio communications network.

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METHODS AND SYSTEMS FOR CONCURRENT RECEIPT OF INCOMING CALLS FROM A WIDE AREA CELLULAR NETWORK AND A PRIVATE RADIO COMMUNICATIONS NETWORK

Field of the Invention

This invention relates to communication systems and more particularly to private radio communication networks within the coverage area of a wide area cellular network.

Background of the Invention

Public cellular networks (public land mobile networks) are commonly employed to provide voice and data communications to a plurality of subscribers. For example, analog cellular radiotelephone systems, such as designated AMPS, ETACS, NMT-450, and NMT-900, have been deployed successfully throughout the world. More recently, digital cellular radiotelephone systems such as designated IS-54B in North America and the pan-European GSM system have been introduced. These systems, and others, are described, for example, in the book titled *Cellular Radio Systems* by Balston, et al., published by Artech House, Norwood, MA., 1993.

Traditional analog radiotelephone systems generally employ a system referred to as frequency division multiple access (FDMA) to create communications channels. As a practical matter well-known to those skilled in the art, radiotelephone communications signals, being modulated waveforms, typically are communicated over predetermined frequency bands in a spectrum of carrier frequencies. These discrete frequency bands serve as channels over which cellular radiotelephones communicate with a cell, through the base station or satellite serving the cell. In the United States, for example, Federal authorities have allocated to cellular communications a block of the UHF frequency spectrum further subdivided into pairs of narrow frequency bands, a system designated EIA-553 or IS-19B. Channel pairing results from the frequency duplex arrangement wherein the transmit and receive frequencies in each pair are offset by 45 Mhz. At present there are 832, 30-Khz wide, radio channels allocated to cellular mobile communications in the United States.

The limitations on the number of available frequency bands present several challenges as the number of subscribers increases. Increasing the number of subscribers in a cellular radiotelephone system generally requires more efficient utilization of the limited available frequency spectrum in order to provide more total channels while maintaining communications quality. This challenge is heightened because subscribers may not be uniformly distributed among cells in the system. More channels may be needed for particular cells to handle potentially higher local subscriber densities at any given time. For example, a cell in an urban area might conceivably contain hundreds or thousands of subscribers at any one time, easily exhausting the number of frequency bands available in the cell.

For these reasons, conventional cellular systems employ frequency reuse to increase potential channel capacity in each cell and increase spectral efficiency. Frequency reuse involves allocating frequency bands to each cell, with cells employing the same frequencies geographically separated to allow radiotelephones in different cells to simultaneously use the same frequency without interfering with each other. By so doing, many thousands of subscribers may be served by a system of only several hundred frequency bands.

Another technique which may further increase channel capacity and spectral efficiency is time division multiple access (TDMA). A TDMA system may be implemented by subdividing the frequency bands employed in conventional FDMA systems into sequential time slots. Although communication on frequency bands typically occur on a common TDMA frame that includes a plurality of time slots, communications on each frequency band may occur according to a unique TDMA frame, with time slots unique to that band. Examples of systems employing TDMA are the dual analog/digital IS-54B standard employed in the United States, in which each of the original frequency bands of EIA-553 is subdivided into 3 time slots, and the European GSM standard, which divides each of its frequency bands into 8 time slots. In these TDMA systems, each user communicates with the base station using bursts of digital data transmitted during the user's assigned time slots.

A channel in a TDMA system typically includes one or more time slots on one or more frequency bands. As discussed above, traffic channels are used to communicate voice, data or other information between users, for example, between a mobile terminal such as a radiotelephone and a network base station. In this manner, each traffic channel forms one direction of the duplex communications link established by the system from one user to another. Traffic channels typically are dynamically assigned by the system when and where needed. In addition, systems such as the European GSM system, may "frequency hop" traffic channels, i.e., randomly switch the frequency band on which a particular traffic channel is transmitted. Frequency hopping reduces the probability of interference events between channels, using interferer diversity and averaging to increase overall communications quality.

Typically included in the dedicated control channels transmitted in a cell are forward control channels which are used to broadcast control information in a cell of the wide area cellular network to radiotelephones which may seek to access the network. The control information broadcast on a forward control channel may include such things as the cell's identification, an associated network identification, system timing information and other information needed to access the wide area cellular network from a radiotelephone.

Forward control channels, such as the Broadcast Control Channel (BCCH) of the GSM standard, typically are transmitted on a dedicated frequency band in each cell. A radiotelephone seeking access to a system generally "listens" to a control channel in standby mode, and is unsynchronized to a base station or satellite until it captures a base station or satellite control channel. In order to prevent undue interference between control channels in neighboring cells, frequency reuse is conventionally employed, with different dedicated frequency bands being used for the control channel in neighboring cells, according to a frequency reuse pattern that guarantees a minimum separation between cochannel cells. Frequency hopping, which might allow denser reuse of control channel frequency bands, is typically not employed because an unsynchronized radiotelephone generally would have difficulty capturing a

frequency-hopped control channel due to lack of a reference point for the frequency hopping sequence employed. Moreover, for private uncoordinated radio communications systems, a frequency reuse pattern cannot be used because each private radio communications system typically operates independently of other potentially interfering systems including the wide area cellular network.

The past decades have shown a considerable rise in the deployment of mobile telephony. With a slow start of the analog standards like AMPS, NMT and TACS, mobile telephony has really hit the consumer markets with the advanced digital standards incorporating TDMA like GSM and D-AMPS. In addition to progress in mobile terminal features like size and battery life, much progress has been made at the network side as well. Increasingly dense cell reuse plans have been complemented with hierarchical cell structures, where macrocells cover entire districts, microcells cover smaller parts like streets, and picocells cover very small areas the size of a few rooms. Important for the hierarchical cell structure is that each base station deployed (ranging from macro to pico base stations) is part of the same Public Land Mobile Network (PLMN), also referred to as a wide area cellular network. When a mobile user wanders from a macrocell to a microcell area, the call can be handed off from a macro base station to a micro base station without the user noticing it. This is particularly true for digital phone systems that apply TDMA: being handed off from one base station to another within a coordinated wide area cellular network for the mobile phone usually only involves the change of a time slot.

Recently, private radio communications networks for residential and business areas are being developed that use the same air-interface as the public cellular network, but do not form an integrated part with the overlaying public cellular network. In this sense, these private systems are not micro or pico networks since there is no direct connection between these private systems and the public cellular network. For example, for residential usage, private base stations can be used as described in US patent No. 5,428,668 which only connect to the PSTN (or ISDN) wired network. In business or office networks applying a Private Branch Exchange ("PBX"), radio base stations belonging to the same

private network communicate with each other, but none of them communicates directly with the overlaying wide area cellular network. A mobile terminal in range of a private communications network typically preferably enters a private mode attaching to the private communications network to enjoy benefits such as lower tariffs, longer talk and stand-by time, and better voice quality.

However, in such systems, the mobile terminal, once it accesses the private communications network, typically cannot receive incoming calls from the wide area cellular network. While it has been suggested to resolve this problem by providing for call forwarding in the wide area cellular network to the PSTN number of the private radio communications network when the mobile terminal is connected to the private radio communications network, this is not always desirable. For example, there may be occasions where call forwarding from the wide area cellular network number to the PSTN number of the private radio communications network is not available. Furthermore, some wide area cellular networks employ a short message service (SMS) which is not defined on wired networks and, accordingly, such short messages are not presently forwarded through call forwarding.

Summary of the Invention

It is, therefore, an objective of the present invention to resolve the problem of providing a mobile terminal capable of receiving incoming calls or messages from a wide area cellular network while the mobile terminal is attached to a private radio communications network. To solve the problem of receiving calls from both a wide area cellular network and a private radio communications network, the present invention provides a mobile terminal for receiving incoming calls, either voice or message, both in the wide area cellular network and the private radio communications network. The mobile terminal periodically wakes up from a power saving sleep mode to monitor for paging messages at the appropriate time on the cellular paging channel ("PCH"). The mobile terminal also wakes up periodically to monitor for the radio beacon signals transmitted by a private radio communications network base station.

Because the wide area cellular network and the private radio communications network generally are uncoordinated, the timing of the wide area cellular network paging channel and the private radio communications network radio beacon transmission will generally be unsynchronized and typically will slide relative to each other periodically. Accordingly, the time for monitoring each signal may occasionally conflict. Given that the transmission frequency for the paging channel and the beacon transmission will typically be distinct frequencies to reduce the likelihood of interference between the signals and that the mobile terminal typically is not provided with redundant radio communications receiving circuitry, the present invention provides for placing priority on monitoring for either the wide area cellular network paging channel or the private radio communications network beacon transmission on any occasion where the time for monitoring each overlaps. This conflict may only occur for a short moment and the likelihood of conflict will be reduced when the duty cycle of the paging channel and/or the beacon transmission decreases. Operations of the mobile terminal where the terminal wakes up for short times to monitor for both the paging channel and beacon transmissions is referred to herein as a dual monitor mode.

When a beacon transmission indicating an incoming call on the private radio communications network is received, the mobile terminal accesses the private radio communications network according to that network's protocol. Likewise, when a paging message is received from the wide area cellular network indicating either an incoming call or a short message service message, the mobile terminal enters the cellular mode and accesses the wide area cellular network according to that network's standard procedures.

In one embodiment of the present invention, a mobile terminal having a sleep mode is provided including receiving means for receiving beacon transmissions and paging message transmissions. A page monitoring means operatively connected to the receiving means receives paging message on the wide area cellular network at a first predetermined time corresponding to the paging channel of the wide area cellular network. A beacon monitoring means, also operatively connected to the receiving means, monitors for beacon transmissions from the private radio communications network at a second predetermined time corresponding to the beacon channel of the private radio communications network. Activating means responsive to the page monitoring means and beacon monitoring means wakes the mobile terminal from a power saving sleep mode at the first predetermined time and the second predetermined time to monitor for the respective signals. Selecting means is provided to selectively operatively connect the page monitoring means or the beacon monitoring means to the receiving means when a collision occurs, *i.e.*, when the first predetermined time and the second predetermined time conflict.

In another aspect of the present invention, the mobile terminal further includes transmitting means for transmitting radio communications to the wide area cellular network and to the private radio communications network. A cellular network access means is operatively connected to the transmitting means and responsive to the page monitoring means to access the wide area cellular network when a paging message is received indicating receipt of an incoming call (which may be voice or message) on the wide area cellular network. A private network accessing means, also operatively connected to the transmitting means,

which is responsive to the beacon monitoring means accesses the private radio communications network when a beacon transmission is received indicating receipt of an incoming call on the private radio communications network.

Also provided are methods for concurrent receipt by a mobile terminal of incoming calls from both a private radio communications network having a beacon channel and a wide area cellular network having a paging channel. The mobile terminal monitors for paging messages from the wide area cellular network at a first predetermined time corresponding to the paging channel of the wide area cellular network. It further monitors for beacon transmissions from the private radio communications network at a second predetermined time corresponding to the beacon channel of the private radio communications network. When the first predetermined time corresponding to the paging channel and the second predetermined time corresponding to the beacon channel conflict, the mobile terminal selects between monitoring for paging messages and monitoring for beacon transmissions.

When a paging message is received indicating receipt of an incoming call (voice or message) on the wide area cellular network, the mobile terminal accesses the wide area cellular network. When a beacon transmission is received indicating receipt of an incoming call on the private radio communications network, the mobile terminal accesses the private radio communications network. Power saving for the mobile terminal is provided by waking up the mobile terminal at the first predetermined time and the second predetermined time to execute the monitoring steps. The mobile terminal is then returned to the sleep mode if no paging or beacon messages are received in the monitoring steps.

In one embodiment of a method of the present invention, the mobile terminal deregisters from the wide area cellular network for voice calls while in a private mode monitoring a private radio communications network. Voice calls over the wide area cellular network may then be forwarded to the wire line number of the private radio communications network. The mobile terminal continues dual monitor operations by periodically monitoring for short

message service transmissions from the wide area cellular network at a predetermined short message service transmission time interval.

In another embodiment of a method according to the present invention, in addition to deregistering from the wide area cellular network for voice calls, the mobile terminal also deregisters for short message service messages. The mobile terminal then suspends monitoring for paging messages from the wide area cellular network and exits dual monitor mode for a period of time. To receive incoming messages or calls which for some reason have not been forwarded from the wide area cellular network number to the wire line number of the private radio communications network, the mobile terminal periodically returns to the dual monitor mode by registering with the wide area cellular network and then monitoring for paging messages from the wide area cellular network.

Accordingly, the dual page monitor operations of the present invention address the problem of receiving incoming calls on both a wide area cellular network and a private radio communications network by providing mobile terminals and methods for using the same which periodically wakes to monitor for paging messages/beacon transmissions from the respective networks. The mobile terminal is thereby able to receive calls from the private radio communications network while concurrently monitoring the wide area cellular network to receive paging messages indicating incoming unforwarded voice calls or incoming messages. The mobile terminal may either maintain registration with both systems and execute dual monitor operations at all times or forward voice calls from the wide area cellular network and use dual monitor only to receive messages on the wide area cellular network or, finally, may entirely deregister from the wide area cellular network when it is connected to a private radio communications network and only periodically enter a dual monitor mode to receive messages or unforwarded calls.

Brief Description of the Drawings

FIG. 1 schematically illustrates a portion of a wide area cellular network including private radio communications networks within the coverage area of the wide area cellular network;

FIG. 2 graphically illustrates a GSM broadcast channel;

FIG. 3 graphically illustrates a GSM paging channel;

FIG. 4 graphically illustrates a radio beacon transmission channel for a private radio communications network;

FIG. 5 graphically illustrates dual page mode synchronization in a mobile terminal according to the present invention;

FIG. 6 is a schematic block diagram of a mobile terminal according to the present invention;

FIG. 7 is a flowchart illustrating operations of a mobile terminal according to the present invention;

FIG. 8 is a flowchart illustrating operations following entering private mode according to an embodiment of the present invention; and

FIG. 9 is a flowchart illustrating an embodiment of periodic dual monitor operations for a mobile terminal in the private mode according to the present invention.

Detailed Description of the Invention

The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Referring now to **FIG. 1**, an operating environment of the present invention will be described. The present invention relates to mobile terminals and methods for using the same within hierarchial cell structures of wide area cellular networks such as advanced cellular phone systems, for

example, in order to increase capacity in densely populated areas. Hierarchial cell structures are typically designed around macrocells **10**, **10'**, **10''** covering cells with radii which may be in the order of a few kilometers. Macrocells **10**, **10'**, **10''** define the cellular structure of the wide area cellular network or PLMN as is well known and will be understood by one of ordinary skill in the art.

Also illustrated in **FIG. 1** are office private radio communications network **14** and residential private radio communications network **12**, **12'**, **12''**. Residential network **12**, **12'**, **12''** may include a private base station such as those described in United States Patent No. 5,428,668, which is incorporated herein by reference as if set forth in its entirety. Residential network **12**, **12'**, **12''** and office network **14** are private radio communications networks which have wire line connections to the public switched telephone network ("PSTN") via a PSTN switch or exchange (not shown) and/or to an ISDN wired network. Accordingly, office network **14** and residential network **12**, **12'**, **12''** have an associated wire line number by which they communicate over the public switched telephone network (or ISDN).

As illustrated in **FIG. 1**, the distinction between private radio communications networks **12**, **12'**, **12''**, and **14** is that the office network typically interfaces to the public switched telephone network by a private branch exchange ("PBX") and includes multiple base stations. Office network **14** as illustrated in **FIG. 1** is a private radio communications network which connects to the PSTN via private branch exchange ("PBX") **22**. Office network **14** further includes base stations **24**. Office network **14** and base stations **24** typically are not controlled by the wide area cellular network as they are not a coordinated part of the wide area cellular network. In addition, signaling through the PSTN line to PBX **22** may create problems when a call on the PSTN line is in progress.

For purposes of the present invention, the distinctions between office and residential private radio communications networks are not critical and the invention will be described herein with reference to private radio communications network **12**. However, it is to be understood that the benefits of

the present invention can be obtained regardless of the type of uncoordinated private radio communications network.

As illustrated in **FIG. 1**, macrocells **10**, **10'**, **10''** of the wide area cellular network each include at least one base station **16**, **16'**, **16''**. Base stations **16**, **16'**, **16''** are connected via a wired infrastructure as is known to those of ordinary skill in the art. As illustrated in **FIG. 1**, the wired infrastructure includes base station controller **18** and mobile services switching center **20**. The particulars of the infrastructure of the wide area cellular network will not be discussed further herein except to note that the wired infrastructure of the wide area cellular network also includes a connection to the PSTN providing the public land mobile network access to the PSTN switch (not shown) (or, alternatively, to an ISDN).

When a mobile terminal user travels in the cellular area of the wide area cellular network, the user's connection is handed off between base station **16**, **16'**, **16''** depending upon the mobile-to-base distance and the interference situation. This assures that the mobile terminal user keeps a high quality channel even as the user moves from one cell to the other. Because base stations **16**, **16'**, **16''** are all interconnected, methods for controlling base station **16**, **16'**, **16''** transmission and re-routing of calls from one base station **16**, **16'**, **16''** to another in order to maintain a high quality channel (handover) is known in current wide area cellular networks.

Mobile terminal **30** operating within the environment illustrated in **FIG. 1** may be described as having two operating modes. In the cellular mode, it acts like an ordinary cellular terminal interacting with the wide area cellular network. In the private mode, it acts like a private cordless phone interacting with the base station of private radio communications network **12**. However, as described in United States Patent No. 5,428,668, the operations of mobile terminal **30** in the private mode are beneficially carried out at cellular frequencies. Furthermore, in accordance with the present invention, mobile terminal **30** operates using time division multiple access (TDMA) framing structures compatible with those of the wide area cellular network.

While mobile terminal **30** has separate operating modes for cellular and private access, it is advantageous for mobile terminal **30** to receive incoming calls from the wide area cellular network even when in the private mode. This is particularly true for the short message service (SMS), which is a defined service available in certain wide area cellular networks but undefined for wire line networks. It is also desirable to receive calls from the wide area cellular network in situations where it is not desired to have call forwarding from the wide area cellular number to the PSTN number of private radio communications network **12**. Therefore, during the private idle mode (or during short intervals in the private idle mode) it is desired that mobile terminal **30** monitors the wide area cellular network paging channel in addition to beacon transmissions from private radio communications network **12**. For purposes of understanding the present invention, the wide area cellular network will be described based on the GSM cellular system standard.

Referring now to **FIG. 2**, the framing of the broadcast channel in GSM is illustrated. As illustrated in **FIG. 2**, the broadcast channel in GSM is based upon a 51-frame multi-frame. The frequency control channel (FCCH) designated **F** in **FIG. 2** is used for frequency synchronization between the wide area cellular network base station **16** and mobile terminal **30**. The synchronization channel (SCH) designated **S** in **FIG. 2** is used for a time synchronization between wide area cellular network base station **16** and mobile terminal **30**. The common control channels (CCCH) designated **C** in **FIG. 2** are used for paging and access control.

The paging channel (PCH) of the wide area cellular network typically uses four consecutive frames of the CCCH. The position of the PCH is determined by the paging group which is derived from the International Mobile Subscription Identity (IMSI). The period of occurrence of the PCH can be set by the operator of the wide area cellular network at between two and nine 51-frame multi-frames. Therefore, in a GSM system as illustrated, the highest PCH rate is once every two 51-frame multi-frames.

A PCH transmission framing for the two multi-frame embodiment is illustrated in **FIG. 3**. As illustrated in **FIG. 3**, the PCH occupies four frames of one CCH every other 51-frame multi-frame. Mobile terminal **30** may have a lower (compared to its active mode) power sleep (idle) mode allowing power savings during idle frames when no communication activity is underway. During normal wide area cellular network operations, mobile terminal **30** in the cellular sleep mode wakes up during its designated PCH channel events and occasionally may also wake up to receive the SCH of other GSM base stations **16'**, **16''** in order to monitor their signal strengths.

Referring now to **FIG. 4**, the framing for an embodiment of a private radio communications network radio beacon is illustrated. The beacon transmission may contain a paging message. The private radio communications system beacon preferably includes an identification of the base station of the private radio communications network **12** and may also include status information. In the embodiment illustrated in **FIG. 4**, the beacon transmission is provided as a beacon channel in a TDMA frame structure having 26-frame multi-frames. As with the wide area cellular network paging channel, the beacon channel may occur once every N x 26 frame multi-frames where N is an integer greater than 1. In the illustration of **FIG. 4**, the radio beacon timing is illustrated for N=2. It is to be understood that the benefits of the present invention may be obtained for an FDMA-based private radio communications network with a repeating periodic radio beacon transmission which may be time synchronized to and monitored by mobile terminal **30**. However, the benefits of the present invention are primarily directed to receiving incoming calls from a wide area cellular network while mobile terminal **30** is connected to a TDMA-based private radio communications network **12** such as that illustrated in **FIG. 4**.

The beacon transmission from private radio communications network **12** may be implemented as a simplified version of the mobile terminal access protocol of a network protocol such as GSM. For example, the beacon transmission from private radio communications network **12** could include an FCCH for frequency synchronization as with GSM followed by a beacon channel

BCH transmission. Both the private radio communications network FCCH and BCH could be transmitted on a periodic basis such as the 2x26 frame TDMA multi-frames illustrated in **FIG. 4**. The BCH slot placement relative to the FCCH could be varied from that used in the GSM wide area cellular network so that the private radio communications network beacon transmission would not be mistaken for an FCCH and SCH pair from the wide area cellular network.

Unlike in the GSM protocol, the BCH frame may include identification and status information rather than simply providing time synchronization. For example, the BCH could include a beacon identity including a network color code and a base color code to provide a unique identifier to a specific base of a private radio communications network **12** for either a residential network **12** or office network **14**.

Mobile terminal **30** according to the present invention in the private idle mode (or sleep mode) wakes up during the beacon events. For mobile terminal **30** to receive incoming calls from both private radio communications network **12** and the wide area cellular network base station **16**, it wakes up during both the GSM PCH and the radio beacon transmission of the private radio communications network in accordance with the present invention. While in the private idle mode, mobile terminal **30** remains synchronized to both the wide area cellular network and private radio communications network **12**. Therefore, when it "wakes up" from sleep mode it is fully synchronized to monitor for pages and/or beacons.

Mobile terminal **30** is synchronized to the wide area cellular network based on a search for cellular synchronization signals initiated when mobile terminal **30** is powered on. In known methods for wide area cellular networks, it may then enter a cellular standby mode where it remains synchronized to the cellular system but sleeps most of the time only waking up to monitor and decode PCH (paging) messages from the wide area cellular network. Mobile terminal **30**, when in range of private radio communications network **12**, will also wake up and scan for a beacon allowing mobile terminal **30** to recognize that it has access to private radio communications network **12** and register on

private radio communications network **12**. As will be described further herein, once mobile terminal **30** is registered with private radio communications network **12**, it may or may not deregister from the wide area cellular network for voice and/or short message service messages. While attached to private radio communications network **12**, mobile terminal **30** is in private mode and if no calls are made, it may enter a private standby mode or sleep mode in which it also remains synchronized to private radio communications network **12**. It may then monitor for beacons from private radio communications network **12** or paging messages from the wide area cellular network indicating receipt of an incoming call as will be described further herein.

An embodiment of the operations of the system of the present invention executing dual monitor mode operations is illustrated in **FIG. 5**. As illustrated in **FIG. 5**, the paging channel transmission of an embodiment of a GSM wide area cellular network is illustrated at **32**. The beacon transmission timing of a private radio communications network **12** as described in connection with **FIG. 4** previously is illustrated at **34**. The dual monitor mode operations of mobile terminal **30** according to the present invention for the illustrated embodiment is shown at **36**.

At times **38**, **38'**, **38''**, mobile terminal **30** wakes up from the sleep mode to monitor for beacon transmissions from private radio communications network **12**. At times **40**, **40'**, mobile terminal **30** wakes up from its sleep mode to monitor for paging messages from the wide area cellular network base station **16**. Also illustrated in **FIG. 5** at **42** is a wake up for mobile terminal **30** to monitor the SCH of other base stations **16'**, **16''** of the wide area cellular network. The different multiframe structure between the wide area cellular network and private network, *i.e.* Nx51 and Mx26, respectively in the illustrated examples, provides a natural sliding effect between the PCH transmissions of the wide area cellular network and the beacon transmissions of private radio communications network **12**. This sliding reduces or eliminates the potential for consecutive conflicting transmissions.

It may be desirable for mobile terminal **30** to wake up to monitor other GSM base stations **16'**, **16''** for cell reselection purposes. However, since private radio communications network **12** is typically located within one cell **10**, **10'**, **10''** of the wide area cellular network and generally is only accessible to mobile terminal **30** while mobile terminal **30** is within the corresponding cell **10**, **10'**, **10''** of the wide area cellular network, it is generally unnecessary for mobile terminal **30** to carry out cell reselection operations while mobile terminal **30** is attached to private radio communications network **12**.

As one of the purposes of utilizing private radio communications network **12** is typically to extend the battery life of mobile terminal **30**, it is desirable for the paging or beacon activity of private radio communications network **12** and the wide area cellular network to be minimized. This may be accomplished by having a large N defining the beacon transmission timing in the private radio communications network **12** and further by having a large PCH period in the wide area cellular network. However, N in the private radio communications network **12** cannot be too long because this will increase the access time to private radio communications network **30** and also reduce monitoring features (such as may be useful for office network **14**). An N in the order of 2 is suitable for use with the present invention although other values of N may also be successfully utilized and obtain the benefits of the present invention.

The PCH period for the wide area cellular network as discussed above can be increased up to 9 multi-frame periods. This also increases the access time for the wide area cellular network but if short message service delivery is the main purpose for dual page monitor, this may not be a limitation since short message service is generally not time critical. In such a case, mobile terminal **30** has to process a PCH transmission once every nine 51-frame multi-frames for the examples described herein corresponding to approximately once every two seconds. Furthermore, as discussed above, the effort for monitoring surrounding wide area cellular network base stations **16'**, **16''** can be reduced considerably or even eliminated due to the restricted movements of mobile

terminal **30** when in the private mode connected with private radio communications network **12**. Each of these options may contribute to reducing power consumption by mobile terminal **30** during private mode.

Additional power consumption reductions can be obtained by entering mobile terminal **30** into the dual monitor mode only a portion of the time. Accordingly, most of the time mobile terminal **30** may be in a private sleep mode and only periodically enter the dual monitor mode for a short period of time to monitor both private radio communications network **12** and the wide area cellular network. This mode will be described further in connection with **FIG. 9**.

Referring now to **FIG. 6**, an embodiment of a mobile terminal **30** according to the present invention is illustrated. Mobile terminal **30** includes portable housing **50** or other housing means. Mobile terminal **30** is provided with means in housing **50** for concurrent receipt of incoming calls from both private radio communications network **12** paged through the beacon channel of private radio communications network **12** and from wide area cellular network base station **16** paged through the paging channel of base station **16**. Mobile terminal **30** includes a receiver **52** or other receiving means for receiving the beacon channel of private radio communications network **12** and the paging channel transmitted by base station **16** of the wide area cellular network. Cellular page monitor circuit **54** or other page monitoring means for receiving paging messages from the wide area cellular network at a first predetermined time interval corresponding to the paging channel of the wide area cellular network is operatively connected to receiver **52**. Private beacon monitor circuit **56** or other beacon monitoring means for monitoring beacon transmissions from private radio communications network **12** at a second predetermined time interval corresponding to the beacon channel of private radio communications network **12** and decoding received beacons is also operatively connected to receiver **52**. Private radio communications network **12** may be a TDMA protocol radio communications network and the beacon channel for private radio

communications network **12** may be a designated time slot or slots at a designated frequency. Alternatively, private radio communications network **12** may be an FDMA-based system, the beacon channel may be a repeating periodic transmission burst at a predetermined frequency.

Synchronize circuit **57** or other means for maintaining synchronization of mobile terminal **30** with both the wide area cellular network and private radio communications network **12** is operatively connected to cellular page monitoring circuit **54** and private beacon monitoring circuit **56**. Synchronize circuit **57** synchronizes mobile terminal **30** to both networks so that mobile terminal **30** maintains synchronization and may continue to wake from sleep mode at the appropriate time to monitor for incoming calls on both networks. It is to be understood that synchronization of mobile terminal **30** by synchronize circuit **57** further provides for maintaining synchronization for communications access to both the wide area cellular network by circuit **64** and the private radio communications network **12** by circuit **66** when an incoming call is underway.

Power mode control circuit **58** or other power control means for controlling power usage by mobile terminal **30** is operatively connected to receiver **52**, cellular page monitor circuit **54**, and private beacon monitor circuit **56**. Power mode control circuit **58** includes means for placing mobile terminal **30** in a first lower power sleep mode in which mobile terminal **30** does not communicate with private radio communications network **12** or the wide area cellular network and in a second higher power active mode in which mobile terminal **30** monitors for communications from private radio communications network **12** or the wide area cellular network at least during paging message or beacon transmission time intervals.

Power mode control circuit **58** enters the active mode responsive to cellular page monitor circuit **54** and private beacon monitor **56** at the first predetermined time interval corresponding to the paging channel of the wide area cellular network and the second predetermined time interval corresponding to the beacon channel of private radio communications network **12** responsive to signals

from cellular page monitor circuit **54** and private beacon monitor circuit **56**, respectively. In the active mode, power mode control circuit **58** provides power and, optionally, an indication to receiver **52** to enable receipt of radio communications by receiver **52**. In addition, the active mode of power mode control circuit **58** may further provide additional power or signals to cellular page monitor circuit **54** and private beacon monitor circuit **56** to support additional operations by those circuits necessary for their respective monitor operations.

Select circuit **60**, or other selecting means for selectively operatively connecting either cellular page monitor circuit **54** or private beacon monitor circuit **56** to receiver **52** when the first predetermined time interval and the second predetermined time interval conflict, is operatively connected to receiver **52**. As illustrated in **FIG. 6**, select circuit **60** is part of receiver **52**.

Mobile terminal **30** further contains means for receiving incoming calls or messages from the wide area cellular network or private radio communications network **12** when a monitored paging channel or beacon channel indicates an incoming call. Transmitter **62** or other transmitting means for transmitting radio communications to the wide area cellular network base station **16** or private radio communications network **12** is located within housing **50**. Receiver **52** and transmitter **62** typically connect to antennas (not shown) extending within and from portable housing **50**. Transmitter **62** provides for the transmit portion of two-way communications between mobile terminal **30** and the wide area cellular network or private radio communications network **12**. It is to be understood that while receiver **52** and transmitter **62** are illustrated in **FIG. 6** as separate circuits, they may be embodied as a transceiver providing both receiving and transmitting capabilities for uplink and downlink radio communications traffic.

Cellular access circuit **64** or other cellular network accessing means is operatively connected to transmitter **62**. Cellular access circuit **64** provides means for accessing the wide area cellular network when a paging message is received by cellular page monitor circuit **54** indicating receipt of an incoming call on the wide area cellular network. While cellular network **64** as

illustrated in **FIG. 6** only indicates a connection to transmitter **62** and not receiver **52**, it is to be understood that, in practice, cellular access circuit **64** will be operatively connected to receiver **52** to receive the incoming portions of an incoming call or message, as well as to transmitter **62** for providing outgoing call communications.

Private access circuit **66** or other private network accessing means for accessing private radio communications network **12** when a beacon transmission is received by private beacon monitor circuit **56** indicating receipt of an incoming call on private radio communications network **12** is also operatively connected to transmitter **62**. Cellular access circuit **64** and private access circuit **66** access the wide area cellular network and private radio communications network **12**, respectively, responsive to their associated monitor circuits **54**, **56** as indicated by the connecting dotted lines between cellular page monitor circuit **54** and cellular access circuit **64** and private beacon monitor circuit **56** and private access circuit **66**, shown in **FIG. 6**. As with cellular access circuit **64**, it is to be understood that private access circuit **66**, during an incoming call or message, would further be operatively connected to receiver **52** for receiving the incoming portion of a call from private radio communications network **12**.

As illustrated in **FIG. 6**, transmitter **62**, cellular access circuit **64**, and private access circuit **66** are all operatively connected to power mode control circuit **58**. Accordingly, power mode control circuit **58** may provide additional power or signals to transmitter **62**, cellular access circuit **64**, and private access circuit **66** in the higher power active mode to enable operation by these circuits when an incoming call is present. Likewise, in the lower power sleep mode, power mode control circuit **58** can reduce or eliminate power to transmitter **62**, cellular access circuit **64**, and private access circuit **66** to control power usage by mobile terminal **30**. Power mode control circuit **58** may also provide reduced power to transmitter **62**, cellular access circuit **64**, and private access circuit **66** in the lower power sleep mode during idle frames of an ongoing call where there is neither incoming nor outgoing traffic.

As will be appreciated by those of skill in this art, the above-described aspects of the present invention in **FIG. 6** may be provided by hardware, software, or a combination of the above. While the various components of mobile terminal **30** have been illustrated in **FIG. 6** as discrete elements, they may in practice be implemented by a microcontroller including input and output ports and running software code, by custom or hybrid chips, by discrete components or by a combination of the above. For example, cellular page monitor circuit **54**, private beacon monitor circuit **56**, power mode control circuit **58**, private access circuit **66**, synchronize circuit **57**, and cellular access circuit **64** could all be implemented as a single programmable device.

Referring now to **FIG. 7**, an embodiment of the operations of the mobile terminal and method for concurrent receipt of incoming calls from both the private radio communications network **12** having a beacon channel and a wide area cellular network having a paging channel will be described. While mobile terminal **30** may be provided with redundant circuitry enabling monitoring for both a paging channel and a beacon channel at the same time slot, mobile terminal **30** generally does not include such redundant circuitry. Accordingly, as the interval of transmission of the paging channel and beacon channel are preferably at distinct intervals to avoid interference, mobile terminal **30** may be provided in the dual monitor mode with a means for preferentially monitoring either private radio communications network **12** or the wide area cellular network when a conflict occurs.

As illustrated in the embodiment of **FIG. 7**, if a monitor time conflict between the first predetermined time interval corresponding to the paging channel of the wide area cellular network and a second predetermined time interval corresponding to the beacon channel of private radio communications network **12** occurs at block **70**, mobile terminal **30** detects the conflict and selects for execution monitoring for paging messages from the wide area cellular network. It is to be understood that, alternatively, monitoring for beacon transmissions could be given preference when the predetermined time intervals for the paging channel and beacon channel conflict.

At block **72**, when no time conflict has been detected at block **70**, mobile terminal **30** determines if it is at a predetermined time corresponding to the beacon channel of private radio communications network **12**. If so, at block **74**, mobile terminal **30** monitors and decodes beacon transmissions from private radio communications network **12**. At block **76**, mobile terminal **30** determines if the beacon transmission received at block **74** indicates receipt of an incoming call on private radio communications network **12**. If so, at block **78**, mobile terminal **30** accesses private radio communications network **12** to receive the incoming call. While mobile terminal **30** is receiving an incoming call from private radio communications network **12** at block **78**, it typically may not monitor for incoming calls from the wide area cellular network. This is because the paging channel of the wide area cellular network is not typically aligned with an idle frame on the traffic connection between mobile terminal **30** and private radio communications network **12**. Accordingly, the operations illustrated in **FIG. 7** maintain in block **70** and do not return as illustrated in block **70** until the incoming call from private radio communications network **12** is complete and mobile terminal **30** is again able to resume dual monitor mode operations.

If it is not a beacon monitor time at block **72** or if no call is pending at block **76**, mobile terminal **30** determines if it is at a predetermined time corresponding to the paging channel of the wide area cellular network at block **80**. For the embodiment illustrated in **FIG. 7**, if a monitor time conflict is detected at block **70**, operations at block **72**, **74**, **76**, and **78** are bypassed and operations move directly from block **70** to block **80**. If it is time to monitor for the paging channel at block **80**, at block **82** mobile terminal **30** monitors and decodes paging messages from the wide area cellular network. At block **84**, mobile terminal **30** determines if a paging message was received at block **82** indicating receipt of an incoming call or message on the wide area cellular network. If such an incoming call or message has been detected at block **86**, mobile terminal **30** accesses the wide area cellular network to receive the incoming call or message. If it is determined that it is not the paging channel

monitor time at block **80** or if no call is pending at block **84** or after accessing the wide area cellular network at block **86** and completing the call, operations return to block **70**.

While an incoming call is underway at block **86** in **FIG. 7**, mobile terminal **30** typically does not listen to the paging channel of the wide area cellular network. Mobile terminal **30** may be able to continue to receive short message service message notification or call waiting information where these services are available and signaled through a dedicated slow access channel (SACCH) or fast access channel (FACCH). Optionally, mobile terminal **30** may continue to monitor for beacons from private radio communications network **12** where the beacons are transmitted during idle frames of the traffic channel of the wide area cellular network as illustrated in the embodiment shown in **FIG. 4**. If it is desired to continue monitoring for beacons while a call from the wide area cellular network is underway, mobile terminal **30** may continue to periodically carry out the operations illustrated in **FIG. 7** at block **72**, **74**, **76**, and **78**. Otherwise, operations exit from block **86** after completion of the incoming call from the wide area cellular network at block **86**.

As described previously in connection with **FIG. 6**, mobile terminal **30** is provided with a power saving sleep mode requiring mobile terminal **30** to wake up at block **74** and at block **82** to perform monitoring operations. Mobile terminal **30** may then return to the sleep mode if no incoming call has been received at block **76** or block **84**.

It is to be understood from the flowchart of **FIG. 7** that the dual monitor mode operations of the present invention repeat at predetermined time intervals. Accordingly, mobile terminal **30** over time periodically monitors for paging messages from the wide area cellular network at first predetermined time intervals corresponding to the paging channel timing of the wide area cellular network. Likewise, mobile terminal **30** periodically monitors for beacon transmissions from private radio communications network **12** at second predetermined time intervals corresponding to the beacon channel timing of private radio communications network **12**. Mobile terminal **30** may enter a sleep

mode to conserve mobile terminal power when mobile terminal **30** is not monitoring or accessing the wide area cellular network or private radio communications network **12**.

When mobile terminal **30** is in private mode attached to private radio communications network **12**, it is desirable for the wide area cellular network to know when mobile terminal **30** is monitoring for messages from the wide area cellular network and whether mobile terminal **30** wants to accept incoming cellular voice calls and/or short message service messages calls. Various optional modes for accessing incoming calls from the wide area cellular network when mobile terminal **30** is in the private mode will be described with reference to **FIG. 8**.

Referring now to **FIG. 8**, operations of an embodiment of the present invention for providing notice to the wide area cellular network when mobile terminal **30** has attached to private radio communications network **12** are illustrated. While in the private mode, mobile terminal **30** may optionally maintain registration with the wide area cellular network and be registered to both the wide area cellular network and the private radio communications network **12**. This option is illustrated in **FIG. 8** at block **88** and **94** if the "no" operation is selected for both deregistration options and mobile terminal **30** enters dual monitor mode at block **98**. Accordingly, incoming calls to the wide area cellular network number of mobile terminal **30** arrive at mobile terminal **30** through the wide area cellular network. Incoming calls to the wire line number of private radio communications network **12** arrive at mobile terminal **30** through private radio communications network **12**. Using this option, mobile terminal **30** typically maintains dual monitor mode substantially all the time as incoming call messages from both networks generally expect mobile terminal **30** to be monitoring for pages/beacons while mobile terminal **30** is registered. Outgoing calls from mobile terminal **30** may, optionally, be preferentially directed through private radio communications network **12** to obtain the benefits discussed previously.

In an alternative embodiment also illustrated in **FIG. 8**, mobile terminal **30** may obtain additional power savings by entering the periodic dual monitor mode at block **92**. As shown in **FIG. 8**, this mode is entered if deregister voice and SMS is selected at block **88**. To do so, mobile terminal **30** deregisters from the wide area cellular network completely by deregistering for both voice calls and SMS message calls at block **90**. Call forwarding from the wide area cellular network number of mobile terminal **30** to the wire line number of private radio communications network **12** may also be established for voice calls at block **90**. At block **92**, mobile terminal **30** enters periodic dual monitor mode. This mode will be described further in connection with **FIG. 9**.

In another embodiment, mobile terminal **30**, on entering the private mode, may elect to deregister only for voice calls at block **94**. Call forwarding from the wide area cellular network number of mobile terminal **30** to the wire line number of private radio communications network **12** may then be established after deregistering for voice calls at block **96**. Incoming voice calls directed to the wide area cellular network may then be carried through private radio communications network **12**. SMS call delivery can continue to be carried out through the wide area cellular network. Therefore, mobile terminal **30** maintains a dual monitor mode as it continues to be registered with the wide area cellular network for SMS delivery. Outgoing calls from mobile terminal **30** may, optionally, be preferentially routed through private radio communications network **12** to obtain the benefits discussed above.

Mobile terminal **30** may also deregister for voice and SMS calls at block **90** and continue dual monitor mode operations. However, preferably, if mobile terminal **30** is fully deregistered from the wide area cellular network, periodic dual monitor mode is entered to provide for improved power use by mobile terminal **30**.

It is to be understood that mobile terminal **30** deregisters from the wide area cellular network for voice and/or SMS calls typically only if mobile terminal **30** is allowed access and attaches (registers) to a private radio

communications network **12** so that mobile terminal **30** may enter the private mode. Of course, it is to be further understood that for reasons unrelated to the scope of the present invention, mobile terminal **30** may also be deregistered from the wide area cellular network.

Periodic dual monitor mode will now be described with reference to **FIG. 9**. In periodic dual monitor mode, mobile terminal **30** is typically in the private idle or sleep mode most of the time. However, at predetermined time intervals, mobile terminal **30** enters the dual monitor mode. Because mobile terminal **30** is deregistered from the wide area cellular network, entering dual monitor mode includes executing a cellular registration or location update with the wide area cellular network. Call forwarding may then, optionally, be canceled by mobile terminal **30** so that both voice calls and SMS calls may be received from the wide area cellular network. Alternatively, an option may be provided wherein mobile terminal **30** indicates as part of its cellular registration that it is not executing a normal cellular registration but simply a registration preceding a dual monitor period to receive SMS messages. In this case, call forwarding need not be canceled during the periodic dual monitor operations.

As illustrated in **FIG. 9**, mobile terminal **30** is periodically performing single monitor to determine if any incoming calls are indicated in beacon transmissions from private radio communications network **12** at block **100**. Single monitor mode operations at block **100** are as described with respect to block **72**, **74**, **76**, and **78** of **FIG. 7**. At block **102**, mobile terminal **30** determines if it is time to switch to dual monitor mode. A predetermined time is selected for the period between entering dual monitor mode to define the periodic dual monitor mode operations. If a greater time period is selected, there is an opportunity for greater power savings in mobile terminal **30**. However, a greater period between dual monitor periods effectively slows the access time of mobile terminal **30** for accessing messages or unforwarded calls on the wide area cellular network. If it is not time for dual monitor mode at block **102**, mobile terminal **30** continues single monitor mode operations at block **100**. When it is time to execute dual monitor mode at block **102**, mobile terminal **30** registers on the

wide area cellular network for voice and/or SMS at block **104**. At block **106**, mobile terminal **30** executes dual monitor mode operations as described generally for **FIG. 7**.

At block **108**, dual monitor mode operations at block **106** are continued until the end of the dual monitor period. As with the period between entering dual monitor modes, a predetermined time may be selected for the duration of the periodic dual monitor modes. When the predetermined time period for the dual monitor operations in periodic dual monitor mode is completed at block **108**, mobile terminal **30** deregisters for voice and SMS messages from the wide area cellular network at block **110**. It is to be understood that the deregister operation at block **110** as with that described at the corresponding block **90** of **FIG. 8** may also include requesting call forwarding. Mobile terminal **30** then resumes single monitor mode at block **100**.

In the drawings and specification, there have been disclosed typical preferred embodiments of the invention and, although specific terms are employed, they are used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention being set forth in the following claims.

THAT WHICH IS CLAIMED:

1. A method for concurrent receipt by a mobile terminal of incoming calls from both a private radio communications network having a beacon channel and a wide area cellular network having a paging channel, comprising the steps of:

monitoring for paging messages from the wide area cellular network at a first predetermined time interval corresponding to the paging channel of the wide area cellular network;

monitoring for beacon transmissions from the private radio communications network at a second predetermined time interval corresponding to the beacon channel of the private radio communications network;

selecting between executing said monitoring for paging messages step and said monitoring for beacon transmissions step when said first predetermined time interval and said second predetermined time interval conflict;

accessing the wide area cellular network when a paging message is received in said monitoring for paging messages step indicating receipt of an incoming call on said wide area cellular network; and,

accessing the private radio communications network when a beacon transmission is received in said monitoring for beacon transmissions step indicating receipt of an incoming call on said private radio communications network.

2. The method of Claim 1 wherein said selecting step includes the step of selecting for execution said step of monitoring for paging messages when said first predetermined time interval and said second predetermined time interval conflict.

3. The method of Claim 1 wherein the mobile terminal has a sleep mode and wherein the mobile terminal wakes up at the first predetermined time interval to execute said monitoring for paging messages step and at said

second predetermined time interval to execute said monitoring for beacon transmissions step.

4. The method of Claim 3 wherein said monitoring for paging messages step is followed by the step of returning the mobile terminal to the sleep mode if no paging message is received indicating receipt of an incoming call on said wide area cellular network.

5. The method of Claim 3 wherein said monitoring for beacon transmissions step is followed by the step of returning the mobile terminal to the sleep mode if no beacon is received indicating receipt of an incoming call on said private radio communications network.

6. The method of Claim 1 wherein said monitoring for paging messages step is preceded by the step of registering with the wide area cellular network for at least one of voice calls or short message service messages.

7. The method of Claim 6 wherein the private radio communications network has an associated wire line number and wherein said registering step includes the step of registering for voice calls and wherein said monitoring for beacon transmissions step is followed by the steps of:

deregistering from the wide area cellular network for voice calls; and,

forwarding voice calls from the wide area cellular network to the wire line number of the private radio communications network.

8. The method of Claim 7 wherein said deregistering step is followed by the step of monitoring for short message service transmissions from said wide area cellular network at a predetermined short message service transmission time.

9. The method of Claim 6 wherein said deregistering step further includes the step of deregistering from the wide area cellular network for short message service messages.

10. The method of Claim 9 wherein said step of deregistering from the wide area cellular network for short message service messages is followed by the steps of:

suspending monitoring for paging messages from the wide area cellular network for a period of time; then,

registering with the wide area cellular network; and then

monitoring for paging messages from the wide area cellular network.

11. A method for concurrent receipt by a mobile terminal having a sleep mode of incoming calls from both a private radio communications network having a beacon channel and a wide area cellular network having a paging channel, comprising the steps of:

periodically monitoring for paging messages from the wide area cellular network at first predetermined time intervals corresponding to the paging channel timing of the wide area cellular network;

periodically monitoring for beacon transmissions from the private radio communications network at second predetermined time intervals corresponding to the beacon channel timing of the private radio communications network;

selecting between executing said periodically monitoring for paging messages step and said periodically monitoring for beacon transmissions step when said first predetermined time interval and said second predetermined time interval conflict;

accessing the wide area cellular network when a paging message is received in said periodically monitoring for paging messages step indicating receipt of an incoming call on said wide area cellular network;

accessing the private radio communications network when a beacon transmission is received in said periodically monitoring for beacon transmissions step indicating receipt of an incoming call on said private radio communications network; and,

entering the sleep mode to conserve mobile terminal power when the mobile terminal is not performing said steps of monitoring or accessing the wide area cellular network or the private radio communications network.

12. A mobile terminal for concurrent receipt of incoming calls from both a private radio communications network having a beacon channel and a wide area cellular network having a paging channel, comprising:

receiving means for receiving said beacon channel and for receiving said paging channel;

page monitoring means operatively connected to said receiving means for receiving paging messages from said wide area cellular network at a first predetermined time interval corresponding to said paging channel of said wide area cellular network;

beacon monitoring means operatively connected to said receiving means for monitoring beacon transmissions from said private radio communications network at a second predetermined time interval corresponding to said beacon channel of said private radio communications network; and,

power control means responsive to at least one of said page monitoring means or said beacon monitoring means, said power control means comprising means for placing said mobile terminal in a lower power sleep mode in which said mobile terminal does not communicate with said private radio communications network or said wide area cellular network and means for placing said mobile terminal in a higher power active mode in which said mobile terminal monitors for communications from said private radio communications network or said wide area cellular network, at least during said first predetermined time interval or said second predetermined time interval.

13. The mobile terminal of Claim 12 further comprising selecting means operatively connected to said receiving means for selectively operatively connecting either said page monitoring means or said beacon monitoring means to said receiving means when said first predetermined time and said second predetermined time conflict.

14. The mobile terminal of Claim 12 further comprising:

transmitting means for transmitting radio communications to said wide area cellular network and said private radio communications network;

cellular network accessing means operatively connected to said transmitting means and responsive to said page monitoring means for accessing said wide area cellular network when a paging message is received by said page monitoring means indicating receipt of an incoming call on said wide area cellular network; and,

private network accessing means operatively connected to said transmitting means and responsive to said beacon monitoring means for accessing said private radio communications network when a beacon transmission is received by said beacon monitoring means indicating receipt of an incoming call on said private radio communications network.

15. A mobile terminal for concurrent receipt of incoming calls from both a private radio communications network having a beacon channel and a wide area cellular network having a paging channel, comprising:

transceiver means for transmitting and receiving radio communications;

means operatively connected to said transceiver means for monitoring for paging messages from the wide area cellular network at a first predetermined time interval corresponding to the paging channel of the wide area cellular network;

means operatively connected to said transceiver means for monitoring for beacon transmissions from the private radio communications

network at a second predetermined time interval corresponding to the beacon channel of the private radio communications network;

means operatively connected to said transceiver means for accessing the wide area cellular network when a paging message is received in said monitoring for paging messages step indicating receipt of an incoming call on said wide area cellular network; and,

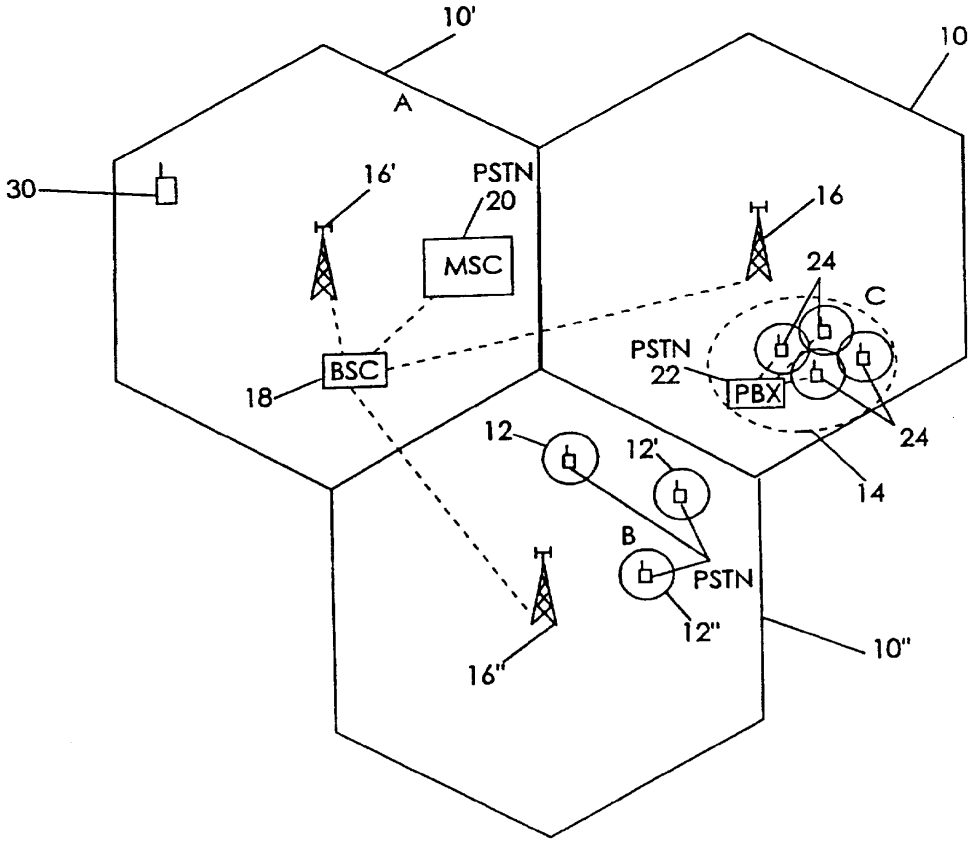
means operatively connected to said transceiver means for accessing the private radio communications network when a beacon transmission is received in said monitoring for beacon transmissions step indicating receipt of an incoming call on said private radio communications network.

16. The mobile terminal of Claim 15 further comprising means operatively connected to said means for monitoring for paging messages and said means for monitoring for beacon transmissions for selecting between executing said monitoring for paging messages step and said monitoring for beacon transmissions step when said first predetermined time interval and said second predetermined time interval conflict.

17. The mobile terminal of Claim 16 further comprising power control means operatively connected to said means for monitoring for paging messages and said means for monitoring for beacon transmissions for placing said mobile terminal in a sleep mode and for placing said mobile terminal in a relatively higher power active mode during said first predetermined time interval to monitor for paging messages and during said second predetermined time interval to monitor for said beacon transmissions.

18. The mobile terminal of Claim 16 wherein said first predetermined time interval and said second predetermined time interval slide relative to each other.

FIG. 1



SUBSTITUTE SHEET (RULE 26)

FIG. 2
PRIOR ART

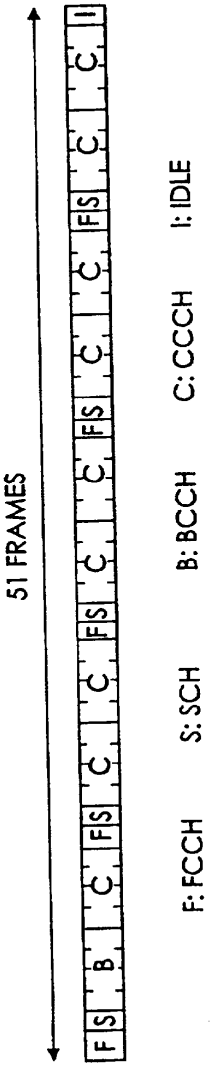


FIG. 3
PRIOR ART

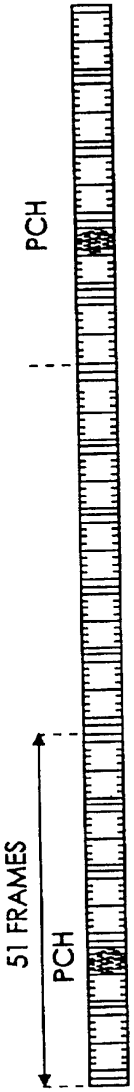


FIG. 4

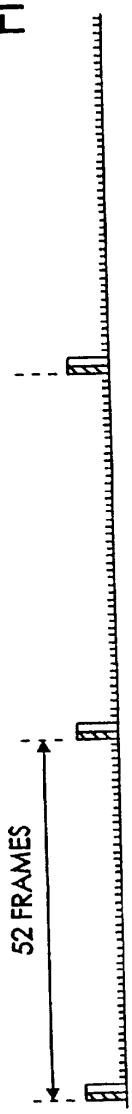

52 FRAMES
SCH
FCCH

FIG. 5

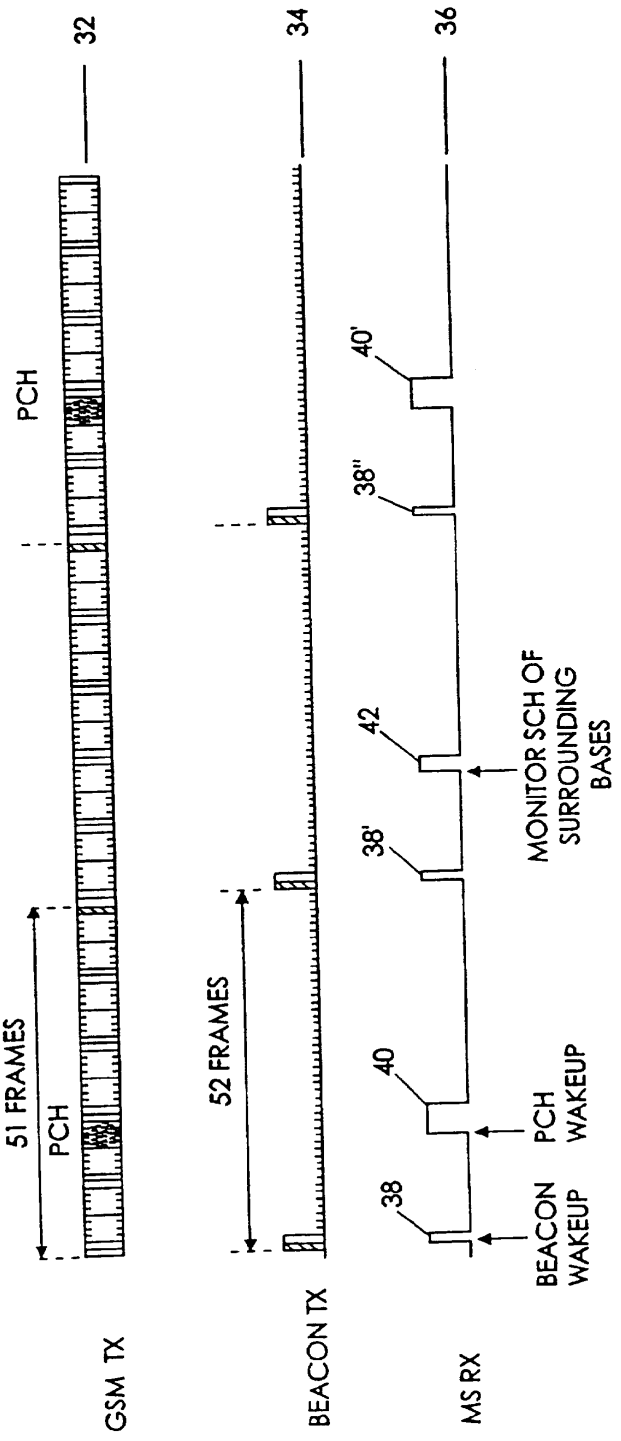

32
34
36
PCH
40'
38''
51 FRAMES
PCH
52 FRAMES
42
38'
MONITOR SCH OF SURROUNDING BASES
40
PCH WAKEUP
38
BEACON WAKEUP
GSM TX
BEACON TX
MS RX

FIG. 6

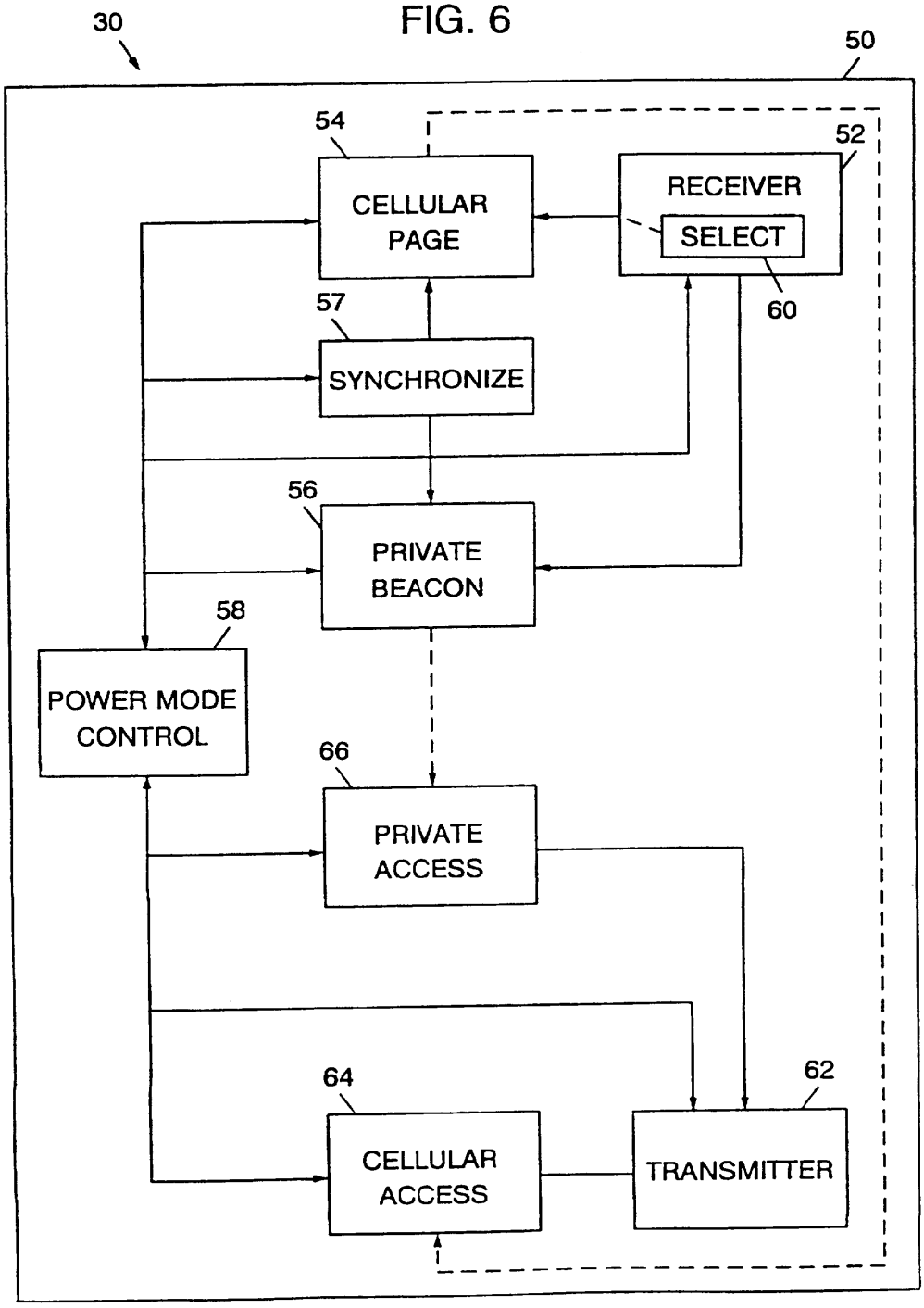
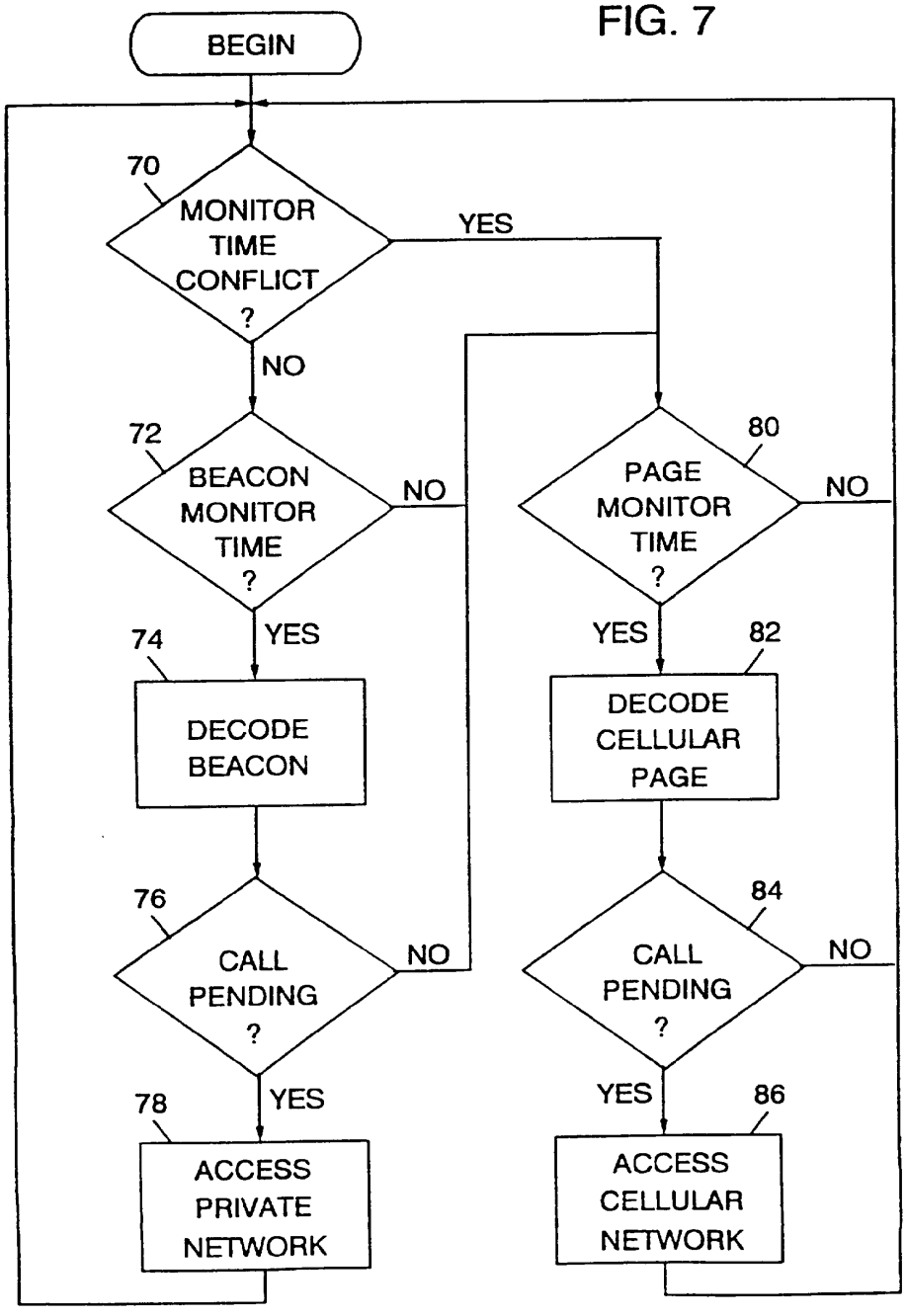

30
50
54
52
CELLULAR PAGE
RECEIVER
SELECT
60
57
SYNCHRONIZE
56
PRIVATE BEACON
58
POWER MODE CONTROL
66
PRIVATE ACCESS
64
62
CELLULAR ACCESS
TRANSMITTER

FIG. 7


BEGIN
70
MONITOR TIME CONFLICT ?
YES
NO
72
BEACON MONITOR TIME ?
NO
YES
74
DECODE BEACON
76
CALL PENDING ?
NO
YES
78
ACCESS PRIVATE NETWORK
80
PAGE MONITOR TIME ?
NO
YES
82
DECODE CELLULAR PAGE
84
CALL PENDING ?
NO
YES
86
ACCESS CELLULAR NETWORK

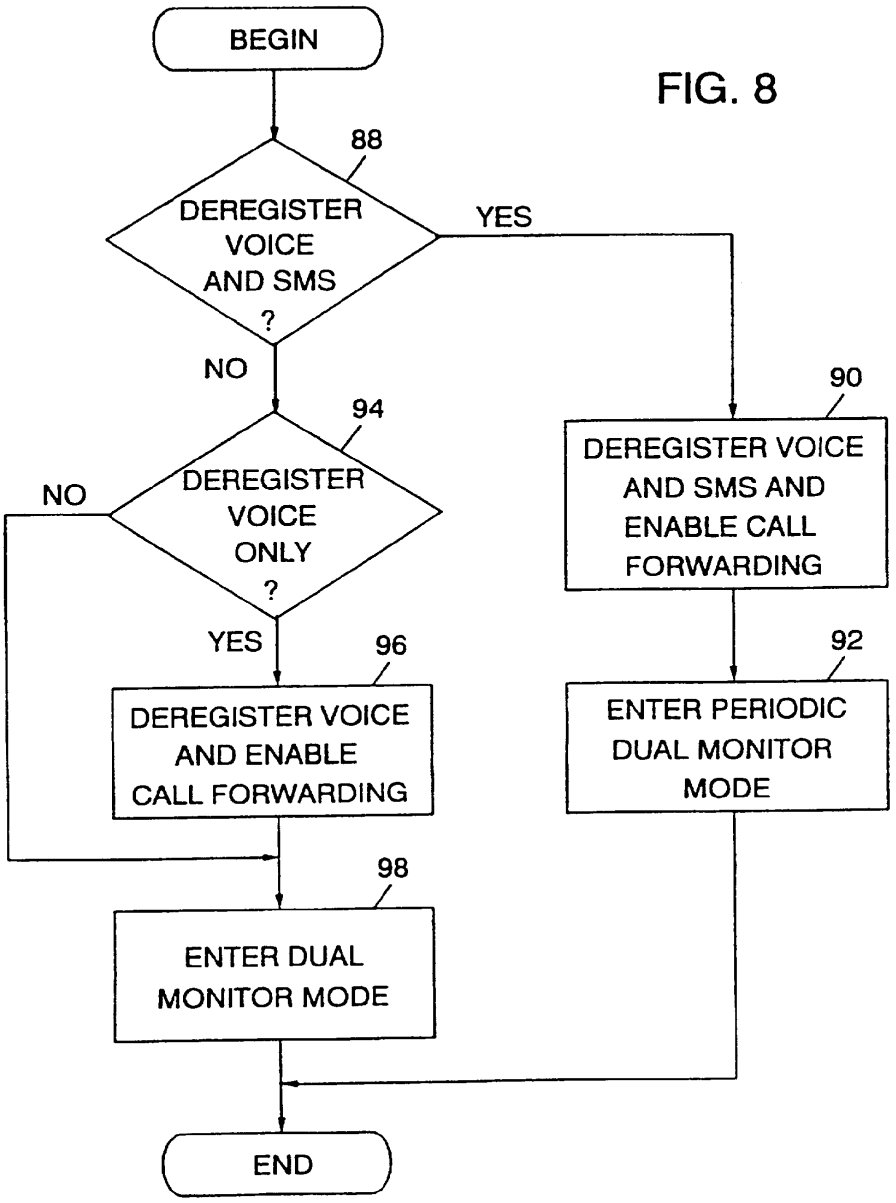

BEGIN
88
DEREGISTER VOICE AND SMS ?
YES
NO
90
DEREGISTER VOICE AND SMS AND ENABLE CALL FORWARDING
94
DEREGISTER VOICE ONLY ?
NO
YES
96
DEREGISTER VOICE AND ENABLE CALL FORWARDING
92
ENTER PERIODIC DUAL MONITOR MODE
98
ENTER DUAL MONITOR MODE
END

FIG. 8

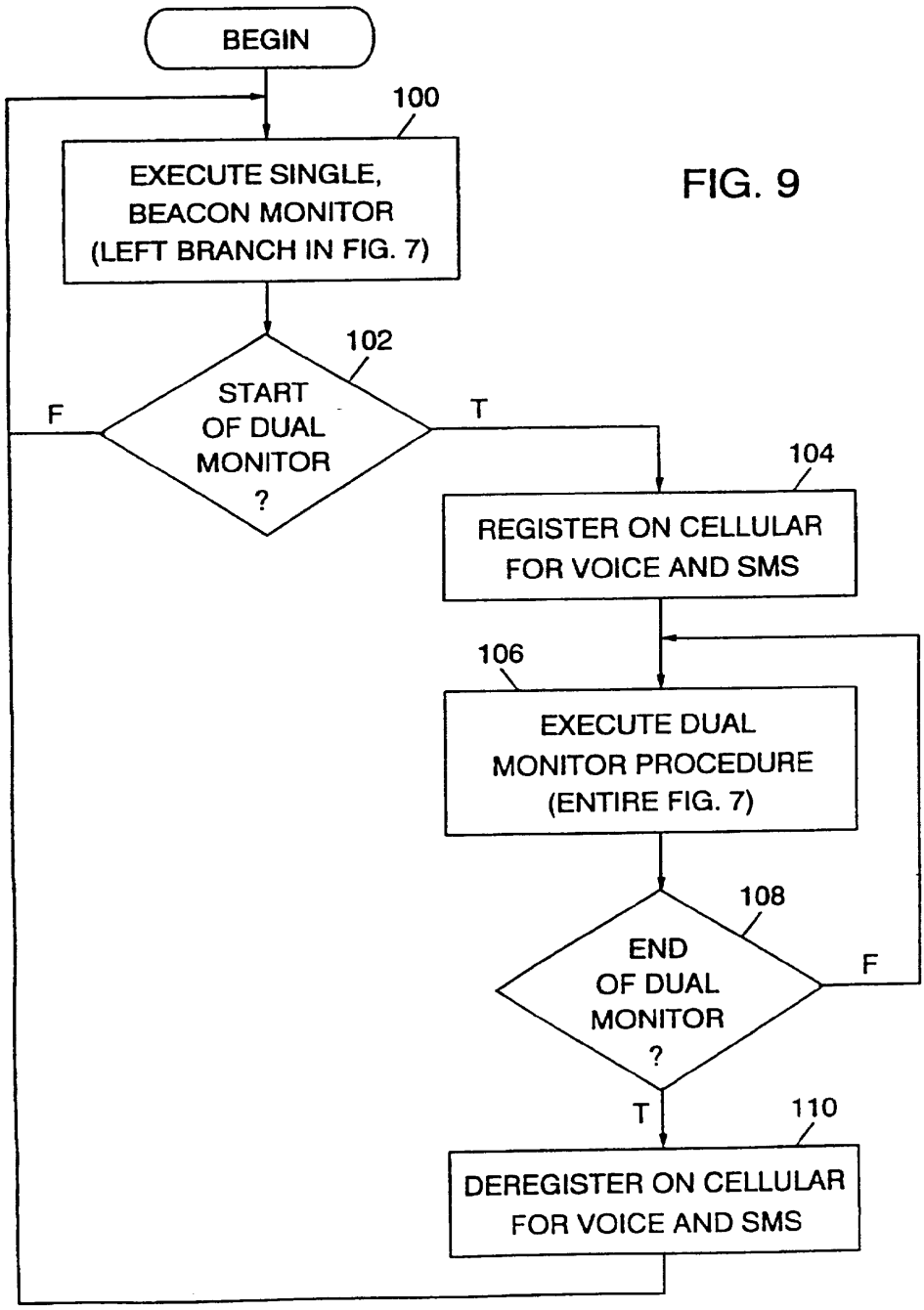

BEGIN
100
EXECUTE SINGLE, BEACON MONITOR (LEFT BRANCH IN FIG. 7)
102
START OF DUAL MONITOR ?
F
T
104
REGISTER ON CELLULAR FOR VOICE AND SMS
106
EXECUTE DUAL MONITOR PROCEDURE (ENTIRE FIG. 7)
108
END OF DUAL MONITOR ?
F
T
110
DEREGISTER ON CELLULAR FOR VOICE AND SMS

FIG. 9

INTERNATIONAL SEARCH REPORT

Interna al Application No
PCT/SE 97/01387

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04Q7/32

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	GB 2 269 723 A (SAGEM) 16 February 1994 see abstract see page 6, line 12 - line 19 see page 7, line 16 - page 8, line 13 see page 10, line 1 - line 11 see page 14, line 23 - page 15, line 5 see figure 2 see figure 6 ---	15 12 1,11-14, 16
Y A	US 5 239 306 A (SIWIAK KAZIMIERZ ET AL) 24 August 1993 see abstract see column 2, line 13 - line 42 see column 6, line 56 - column 7, line 31 see figure 1 see figure 2C --- -/--	12 3,11,17

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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1

Date of the actual completion of the international search	Date of mailing of the international search report
5 November 1997	18. 11. 97
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Lindhardt, U

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INTERNATIONAL SEARCH REPORT

Interna al Application No
PCT/SE 97/01387

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 94 00946 A (MOTOROLA INC) 6 January 1994 see abstract see page 2, line 20 - line 24 see page 5, line 15 - line 28 see page 8, line 16 - line 21 see page 10, line 4 - page 12, line 11 see page 14, line 3 - page 15, line 29 see figure 1 see figure 14 ---	1,2,6-15
A	EP 0 674 454 A (NOKIA MOBILE PHONES LTD) 27 September 1995 see abstract see page 3, line 56 - page 4, line 9 see page 5, line 34 - line 49 see figure 1 see figure 4 -----	1,11-16, 18

1

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Interna[illegible]al Application No
PCT/SE 97/01387

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 2269723 A	16-02-94	FR 2693863 A	21-01-94
		DE 4324094 A	17-03-94
US 5239306 A	24-08-93	CA 2139516 A	06-01-94
		EP 0738442 A	23-10-96
		WO 9400923 A	06-01-94
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08/803,141	19 February 1997 (19.02.97)	US

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(81) Designated States: CA, JP, MX, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

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(54) Title: REMOTE WIRELESS UNIT HAVING REDUCED POWER OPERATING MODE

(57) Abstract

A remote unit for a personal wireless area network includes a receiver, an AC power supply, a battery–backup power supply and a controller. The battery–backup becomes operative when the AC power supply fails and supplies power to the receiver. The controller detects when the AC power supply fails and controls the receiver and the battery–backup power supply by invoking a sleep mode of operation. The sleep mode of operation is periodically interrupted by the controller controlling the receiver and the battery–backup power supply to enter a standby mode of operation in which the receiver scans for a CONNECT message from a base station indicating an incoming call. The controller coordinates the sleep mode and the standby mode of operations based on a frame count that is generated from an identification number of the remote unit. A highly bandwidth–efficient communications method is employed in the base station to enable it to coordinate communication with the remote unit when it changes from the sleep mode to the standby mode.

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REMOTE WIRELESS UNIT HAVING REDUCED POWER OPERATING MODE

CROSS-REFERENCES TO RELATED APPLICATIONS:

The invention disclosed herein is related to the copending US patent application by Alamouti, et al., entitled "METHOD FOR FREQUENCY DIVISION DUPLEX COMMUNICATIONS", serial number _____ filed on the same day as the instant patent application, assigned to AT&T, and incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to improvements to communications systems. More particularly, the present invention relates to wireless discrete tone communications systems.

2. Description of the Related Art

Wireless communications systems, such as cellular and personal communications systems, operate over limited spectral bandwidths and must make highly efficient use of the scarce bandwidth resource for providing good service to a large population of users. Wireless systems consist of cells, each of which include a base station and remote units. The Personal Wireless Access Network described in the Alamouti, et al patent application cited above, is an example of a successsful technology for wireless service.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to improvements to communications systems. More particularly, the present invention relates to wireless discrete multitone spread spectrum communications systems.

2. Description of the Related Art

Wireless communications systems, such as cellular and personal communications systems, operate over limited spectral bandwidths and must make highly efficient use of the scarce bandwidth resource for providing good service to a large population of users. A Code Division Multiple Access (CDMA) protocol has been used by wireless communications systems for efficiently making use of limited bandwidths and uses a unique code for distinguishing each user's data signal from data signals of other users. Knowledge of the unique code with which any specific information is transmitted permits separation and reconstruction of each user's message at the receiving end of the communication channel.

Adaptive beamforming technology has become a promising technology for wireless service providers for offering large coverage, high capacity, and high quality service. Based on this technology, a wireless communication system can improve its coverage capability, system capacity, and performance significantly. A personal wireless access network (PWAN) system, described in the cross-referenced Alamouti, Stolarz, et al. patent applications, uses adaptive beamforming combined with a form of the CDMA protocol known as discrete multitone spread spectrum (DMT-SS) for providing efficient communications between a base station and a plurality of remote units (RUs).

The remote units are powered primarily from AC power sources and include a battery for providing battery backup power when AC power fails. To conserve battery power, an RU has a sleep mode of operation with periodic power-up modes for checking whether any calls are attempting to be connected to the RU. When an RU is in a sleep mode, it expedient that the system operate in such a way so that appropriate actions are taken for completing a call to a sleep mode RU.

One approach for ensuring that calls are completed to a remote unit operating in a sleep mode is to maintain a database at a central location that stores the current operating mode of each remote in the system. When a remote unit enters a sleep mode of operation, the remote unit reports the change of operational status to the database. Similarly, the remote unit reports a change of status back to a standby operating mode.

This approach has a drawback when a number of remote units recorded in the database experience frequent power outages. In such a situation, recording, managing and synchronizing power outage information in the database is particularly cumbersome when the database is large, perhaps holding status information for 3 to 4 thousand remote units. This drawback is further compounded when the database is duplicated multiple times throughout the system. When several thousand subscribers experience a power outage and AC power is restored before the database has completed recording the power outage, a database approach becomes unwieldy. Another complicated situation is when multiple remote units lose power at the same time. The affected remote units cannot all access the channel simultaneously for communicating their status to the database. A collision avoidance scheme must be implemented that spans a period of time and that is open for the possibility of power being restored before the database has been completely revised.

This approach has another drawback in that a remote unit entering the sleep mode consumes system bandwidth in notifying the database. Figure 4 shows an exemplary flow of internal messaging that occurs between various layers of a remote unit when loss of AC power is detected and a database is notified of the operational status change. Time is shown along the vertical axes of Figure 4, with advancing time being indicated toward the bottom of Figure 4. In Figure 4, four layers of the remote unit operating system are shown: Health; OAM&P (Operations, Administration, Maintenance & Provisioning), MAC (Media Access Control) and physical. Only MAC layer of the base station is shown. At 40, AC power failure is detected by the Health layer. At 41, an EVENT message is sent from the Health layer to the OAM&P layer indicating that AC power has failed. The OAM&P layer sends an ACTION message to the MAC layer at 42. The MAC layer responds at 43 by sending an ACTION_RSP message to the OAM&P layer indicating that base station notification is pending. At 44, the MAC layer waits a random length period of time before sending an unsolicited CAC message at 45 to the MAC layer of the base station indicating the need for the remote unit to enter the sleep mode. At 46, the MAC layer of the base station sends an

acknowledgment message to the MAC layer of the remote unit acknowledging receipt of the unsolicited CAC message. In response, the MAC layer of the remote unit sends an EVENT message at 47 to the OAM&P layer that the notification is done. The OAM&P layer first sends an EVENT message to the MAC layer indicating that the sleep mode has been entered at 48, and then sends a message at 49 to the physical layer to power down.

What is needed is a way for a PWAN system to be aware that a remote unit is operating in a sleep mode so that appropriate actions can be taken by the system so that calls can be completed to a remote unit operating in a sleep mode.

SUMMARY OF THE INVENTION

The present invention provides a method for reducing power consumption of a remote unit in a PWAN system. A remote unit is powered using a battery backup power supply when an AC power supply fails at the remote unit. A sleep mode of operation is entered at the remote unit that has a reduced power consumption for the battery backup power supply. The remote unit is synchronized to a TDD timing structure a predetermined period of time after entering the sleep mode of operation. A standby mode of operation is then entered at the remote unit in which a CONNECT message indicating an incoming call for the remote unit is scanned for by the receiver. When no CONNECT message is received, the remote unit reenters the sleep mode of operation. According to the invention, the predetermined period of time is a predetermined number of subframes after a boundary subftame of the TDD timing structure. Preferably, the predetermined number of subframes is based on an identification number of the remote unit.

The present invention also provides a remote unit for a personal wireless area network that includes a receiver, an AC power supply, a battery-backup power supply and a controller. The battery-backup becomes operative when the AC power supply fails and supplies power to the receiver. The controller detects when the AC power supply fails and controls the receiver and the battery-backup power supply by invoking

a sleep mode of operation. The sleep mode of operation is periodically interrupted by the controller controlling the receiver and the battery-backup power supply to enter a standby mode of operation in which the receiver scans a CONNECT message indicating an incoming call. The controller coordinates the sleep mode and the standby mode of operations based on a frame count that is generated from an identification number of the remote unit.

In accordance with another aspect of the invention, a highly bandwidth-efficient communications method is disclosed for the base station to enable it to communicate with a remote unit that is in the sleep mode. The remote unit has a unique identification value that is different from the identification value of other remote units that may be communicating with the base station. The base station begins by establishing a periodic reference instant at the base station and at the remote station. Then the base station determines a delay interval following the periodic reference instant at the base station, the delay interval being derived from the unique identification value of the remote unit. The base station receives spread signals from the remote units with which it communicates, each comprising an incoming data traffic signal spread over a plurality of discrete traffic frequencies. The base station adaptively despreads the signals received it receives by using despreading weights. The base station attempts to initiate a communication with the remote unit that is currently in the sleep mode. If the attempting step fails to initiate communications with the remote unit, the base station concludes that the remote unit is in the sleep mode. In response to this, the base station waits for the delay interval following the periodic reference instant at the base station before transmitting to the remote unit. The base station then transmits to the remote unit a spread signal comprising an outgoing data traffic signal spread over a plurality of discrete traffic frequencies. The remote unit has simultaneously changed from the sleep mode to the standby mode and is able to receive and respond to the spread signal transmitted from the base station.

In accordance additional aspects of the invention, the base station is part of a wireless discrete multitone spread spectrum communications system. Further, the

periodic reference instant is established by a beginning subframe count instant that is incremented by a packet count value at the base station and at the remote unit. In addition, the delay interval is determined by a value N of a quantity of M least signiftcant bits of the unique identification value of the remote unit, the delay interval being an interval required for the occurrence of a plurality of N of the beginning subframe count instants. The resulting invention enables the base station to be aware that a remote unit is operating in a sleep mode so that appropriate actions can be taken by the base station to assure that calls can be completed to the remote unit.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustrated by way of example and not limitation in the accompanying figures in which like reference numerals indicate similar elements and in which:

Figure 1 is an architectural diagram of the PWAN system, including remote stations transmitting to a base station;

Figure 2 is an architectural diagram of the remote station X as a sender;

Figure 3 is an architectural diagram of the remote station X as a receiver;

Figure 4 shows an exemplary messaging flow occurring between various layers of an exemplary remote unit and through an airlink to a base station when a loss of AC power at the remote unit is detected;

Figure 5 shows a message flow sequence for a terminating call for the situation when a target remote unit is operating in the sleep mode;

Figure 6 shows a sequence of events with respect 6 ms subframe structure of the present invention;

Figure 7 is an exemplary graph showing Battery Operating Time, measured in hours, for Sleep Mode Duty Cycle (:1); and

Figure 8 is an architectural diagram of the base station Z.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Figure 1 shows an architectural diagram of the personal wireless access network (PWAN) system described in the referenced Alamouti, Stolarz, et al. patent applications and which is the environment of the present invention. Two users, Alice and Bob, are located at a remote station unit, or remote unit (RU), X and wish to transmit their respective data messages to a base station Z. Remote unit X is positioned to be equidistant from each of antenna elements A, B, C, and D at base station Z. Two other users, Chuck and Dave, are located at a remote station unit Y and also wish to transmit their respective data messages to base station Z. Remote unit Y is geographically different from remote unit X and is not equidistant from each of antenna elements A, B, C, and D of base station Z. Remote units X and Y, and base station Z use a form of the CDMA protocol known as discrete multitone spread spectrum (DMT-SS) which is used for providing efficient communications between base stations and remote units. The DMT-SS protocol is indicated in Figure 1 as a multi-tone CDMA.

In the DMT-SS protocol, a user data signal is modulated by a set of weighted discrete frequencies or tones. The weights are spreading weights that distribute the data signal over many discrete tones covering a broad range of frequencies. The weights are complex numbers having a real component that is used for modulating the amplitude of a tone and a complex component that is used for modulating the phase of the same tone. Each tone in the weighted-tone set bears the same data signal. Plural users at a transmitting station can use the same tone set for transmitting their data, but each of the users sharing the tone set has a different set of spreading weights. The weighted-tone set for a particular user is transmitted to the receiving station where it is processed with despreading weights that are related to the user's spreading weights for recovering the user's data signal. For each of a plurality of spatially separated antennas at the receiver, the received multitone signals are transformed from time-domain signals to frequency-domain signals. Despreading weights are assigned to each frequency component of the signals that are received by each antenna element. The values of the despreading weights are combined with the received signals for obtaining an optimized

approximation of individual transmitted signals characterized by a particular multitone set and transmitting location.

The PWAN system has a total of 2560 discrete tones (carriers) that are equally spaced in 8 MHZ of available bandwidth in the frequency range of 1850 to 1990 MHZ, with a spacing between the tones of 3. 125 KHz. The tones are used for carrying traffic messages and overhead messages between the base station and the plurality of remote units. The total set of tones are numbered consecutively from 0 to 2559, starting from the lowest frequency tone. The tones used for traffic messages are divided into 32 traffic partitions. with each traffic channel requiring at least one traffic partition of 72 tones.

The overhead message tones are used for establishing synchronization and for passing control information between base stations and remote units. A Common Link Channel (CLC) is used by a base station for transmitting control information to remote units. A Common Access Channel (CAC) is used by a remote unit for transmitting messages to the base station. There is one grouping of tones assigned to each channel. The overhead channels are used in common by all remote units when control messages are exchanged with a base station.

Transmission from a base station to a remote unit is called "forward transmission" and transmission from a remote unit to a base station is called "reverse transmission". Time Division Duplexing (TDD) is used by base stations and remote units for transmitting data and control information in both directions over the same multi-tone frequency channel. The time between recurrent transmissions in either direction is called a TDD period which, is equal to 3 ms. For every TDD period, there are four consecutive transmission bursts in each direction. Data is transmitted during each burst using multiple tones. The base station and each remote unit synchronize and conform to a TDD timing structure and framing structure that has 1 frame equal to 8 subframes and 1 sub frame equal to 2 TDD periods. A superframe is 256 subframes, or 1536 ms. All remote units and base stations are synchronized such that all remote units transmit simultaneously and then all base stations transmit simultaneously. When a

remote unit initially powers up, it acquires synchronization from a base station so that control and traffic messages can be exchanged within the prescribed TDD time format. A remote unit must also acquire frequency and phase synchronization for the DMT-SS signals so that the remote unit is operating at the same frequency and phase as an associated base station.

Selected tones within each tone set are designated as pilot tones that are distributed throughout the frequency band and carry known data patterns for enabling an accurate channel estimation. A series of pilot tones, having known amplitudes and phases, are spaced apart in frequency by approximately 30 KHz for providing an accurate representation of a channel response over the entire transmission band, that is, the amplitude and phase distortion introduced by the communication channel characteristics over the transmission band.

FIGURE 2 shows an architectural diagram of remote station X operating as a sender station. Alice and Bob each input data to remote station X. The data is sent to a vector formation buffer 202 and also to a cyclic redundancy code generator 204. Data vectors are output from buffer 202 to a trellis encoder 206. The data vectors are in the form of a data message formed by concatenating a 64K-bit data block with a serially assigned block number. CRC generator 204 generates LCC vectors that are output to trellis encoder 206. The LCC vectors are in the form of an error detection message formed by concatenating a CRC value with the serially assigned block number of the data block. The trellis encoded data vectors and LCC vectors are then output to a spectral spreading processor 208. The resultant data tones and LCC tones are then output from processor 208 to a transmitter 210 for transmission to the base station.

The personal wireless access network (PWAN) system described in the cross-referenced Alamouti, Stolarz, et al. patent application provides a more detailed description of a high-capacity mode, where one traffic partition is used in one traffic channel. A base station transmits information to multiple remote units that are located in the base station's cell. The transmission formats are for a 64 Kbps traffic channel, together with a 4 Kbps Link Control Channel (LCC) between the base station and a

remote unit. A binary source, for example, Alice or Bob, delivers data, or information bits, to a sender transmitter at 64 Kbits/sec. This translates to 48 bits in one transmission burst. The information bits are encrypted according to a triple data encryption standard (DES) algorithm. The encrypted bits are then randomized in a data randomization block. A bit-to-octal conversion block converts the randomized binary sequence into a sequence of 3-bit symbols. The symbol sequence is converted into 16 symbol vectors. The term vector generally refers to a column vector, which is generally complex. One symbol from the LCC is added to form a vector of 17 symbols.

The 17-symbol vector is trellis encoded starting with the most significant symbol (first element of the vector) and is continued sequentially until the last element of the vector (the LCC symbol). This process employs convolutional encoding for converting the input symbol (an integer between 0 and 7) to another symbol (between 0 and 15) and maps the encoded symbol to its corresponding 16 QAM (or 16 PSK) signal constellation point. The output of the trellis encoder is therefore a vector of 17 elements where each element is a signal within a set of 16 QAM (or 16 PSK) constellation signals. (The term signal will generally refer to a signal constellation point.)

A link maintenance pilot signal (LMP) is added to form an 18-signal vector, with the LMP as the first element of the vector. The resulting (18 x 1) vector is pre-multiplied by a (18 x 18) forward smearing matrix yielding an (18 x 1) vector b. Vector b is element-wise multiplied by an (18 x 1) gain preemphasis vector yielding another (18 x 1) vector c. Vector c is post-multiplied by a (1 x 32) forward spatial and spectral spreading vector yielding a (18 x 32) matrix R(p), where p denotes the traffic channel index and is an integer. The 32 columns of matrix R results from multiplying the spectral spreading factor 4 and spatial spreading factor 8. The (18 x 32) matrices corresponding to all traffic channels carried (on the same traffic partition) are then combined (added) for producing a resulting 18 x 32 matrix S.

Matrix S is partitioned by groups of four columns into eight (18 x 4) submatrices A_0 to A_7. The indices 0 to 7 of submatrices A_0 to A_7 correspond to the

antenna elements over which these symbols will eventually be transmitted. Each submatrix is mapped to tones within one traffic partition. A lower physical layer places the baseband signals in discrete Fourier transfer (DFT) frequency bins where the data is converted into the time domain and sent to its corresponding antenna elements (0 to 7) for transmission. This process is repeated from the start for the next 48 bits of binary data to be transmitted in the next forward transmission burst.

Figure 3 is an architectural block diagram of remote station X operating as a receiving station. Data tones and LCC tones are received by remote station antenna X and a receiver 610. Receiver 610 passes the data tones and the LCC tones to a spectral despreading processor 612 which despreads the data tones and LCC tones. The despread signals are then output from processor 612 to a trellis decoder 614. Trellis decoder 614 generates data vectors from the despread signals. The data vectors are then output to a vector disassembly buffer 616. Data for Alice and data to Bob are output from buffer 616 to Alice and Bob, respectively. Data for Alice and Bob are also input to a CRC generator 618. CRC generator 618 computes a new CRC value for every 64 K-bit data block and outputs the new CRC value with the block number to a buffer within a CRC comparison processor 620. The receiving station buffers error detection messages that are received from the link control channel in CRC comparison processor 620 so that the error detection messages are accessible by their block numbers N, N + 1, N + 2, etc. When the receiving station receives a data message on the traffic channel, it performs a CRC calculation on the data block in the message with CRC generator 618 for obtaining a resulting new CRC value. If the comparison determines that there is a difference in the values, then an error signal is generated by an error signal generator 622. The error signal can be processed and used in several ways by an error processor 630. For example, the error signal can initiate a negative acknowledgment signal that is to be sent from the receiving station back to the sender station requesting that the sender repeat transmission of the data block. The error signal can also initiate an update in spreading and despreading weights at the receiving station for improving the signal-to-interference and noise ratio of the traffic channel. Another

use of the error signal is for initiating an alarm used for other real time control. Yet another use of the error signal is as part of a logging signal for compilation of a long term report relating to traffic channel quality.

According to the invention, a remote unit includes a standby mode of operation and a sleep mode of operation. Normally, the standby mode is the mode in which a remote unit scans the CLC channel for a CONNECT message for the remote unit. The sleep mode of operation provides a reduced power consumption operating mode for extending remote unit battery runtime during an AC power outage condition. During the sleep mode of operation, the remote unit periodically switches between the standby mode and sleep mode, with the overall effect being a reduction in the average power required by the remote unit.

Delivery of a CONNECT message to a remote unit operating in the sleep mode is scheduled so that the remote unit is in the standby portion of the sleep mode. That is, the remote unit is synchronized and ready for receiving data from the CLC when the base station begins transmitting on the CLC. In order to achieve synchronization, a system wide Packet Count (PKT_CNT) is used. The basic unit of measure for synchronization is a mod[8] PKT_CNT, which is called a subframe count (SUBFRM_CNT). The SUBFRM_CNT is incremented every 256 PKT_CNTs, or every 6 ms.

The base station and the remote unit both preferably use the least significant 8 bits of the remote unit ID for determining the particular SUBFRM_CNT at which the CLC CONNECT message should be sent to the remote unit and, simultaneously, the appropriate time at which the remote unit should be in the standby portion of the sleep mode for receiving the CONNECT message. When the least significant 8 bits of the remote unit ID are used, the remote unit enters the standby mode once every 256 subframes and is ready for receiving an incoming call. The particular subframe that a remote unit will be ready for receiving an incoming call is called the N_{listen} for the remote unit.

To avoid using a remote unit power status database that is maintained at a

central location, the sleep mode features of the present invention are preferably implemented as part of a standard terminating call retry mechanism. That is, when a terminating call request is received at the base station MAC Layer, the MAC Layer Access Manager proceeds normally through a terminating call setup procedure by transmitting a CONNECT message on the CLC to the target remote unit. In the situation when the target remote unit is operating in the sleep mode at the time of the CONNECT message transmission, the remote unit will generally be unable to process the message. The base station MAC Layer Access Manager will time-out and retry transmission of the CONNECT message. Preferably, a retry timer T_r is nominally set to 72 ms. The base station MAC Layer Access Manager retries the CONNECT message for a predetermined number of tries that is set by a system manager. Preferably, the retry count is 2.

When the number of retries equals the retry count, the base station MAC Layer Access Manager determines that the remote unit is in the sleep mode and, consequently, attempts to deliver the CONNECT message at a scheduled time that is based on the target remote unit ID. The scheduled time is a subframe occurring N_{listen} subframes after the boundary subframe for the TDD timing structure.

The base station MAC Layer Access Manager also reserves the CLC slot(s) required for completing the CLC CONNECT message transmission at the time the N_{listen} subframe number is derived. That is, when the base station MAC Layer Access Manager has reached its retry count for a CONNECT message and has determined the N_{listen} subframe, CLC slot availability is examined for reserving the appropriate CLC slot(s) for use. As an alternative, a remote unit can scan up to 3 CLC slots for a CONNECT message when in the sleep mode so that a base station can select from 3 CLC slots in case a specific slot is unavailable.

Figure 5 shows a message flow sequence for a terminating call for the situation when a target remote unit is operating in the sleep mode. The MAC Layer of the base station receives a terminating call request at 50. At 51, the MAC Layer of the base station sends a CLC CONNECT message to the target remote unit. Since the remote

unit is in the sleep mode, it does not receive the CLC CONNECT message and, therefore, does not respond. Since there is no response from the target remote unit during the T_{retry} period 52, the MAC Layer of the base station sends a second CLC CONNECT message to the target remote unit at 53. The remote unit does not respond during T_{retry} 54. so the MAC Layer of the base station determines the N_{listen} subframe for the remote unit using the least significant 8 bits of the N_{listen} for the remote unit, remote unit ID and waits for the particular N_{listen} subframe at 55 At N_{listen} the MAC Layer of the base station sends a CLC CONNECT message at 56. At the N_{listen} remote unit is in the standby mode and ready to receive the CLC CONNECT message at 57.

In response, the remote unit MAC Layer sends a CAC_ACK message to the base station at 58. The following definitions are used for describing the sleep mode of operation of the present invention:

T_{sleep} = the time that a remote unit is in a low-power mode (i.e., sleeping).

T_{sync} = the time required by a remote unit for re-acquiring synchronization when exiting the sleep mode.

T_{scan_cic} = the time that a remote unit is operating in a standby mode scanning the CLC for a CONNECT message.

$T_{standby}$ = the total time a remote unit is running (i.e., $T_{sync} + T_{scan\_cic}$)

D_{sleep} = $T_{sleep} + T_{standby})/T_{standby}$, that is, the definition of the duty cycle of the sleep mode duty cycle.

Since the base station transmits the CONNECT message at the N_{listen} subframe so that the call can be completed, and the remote unit therefore must be ready for receiving the messages on the CLC channel at the N_{listen} subframe. The remote unit MAC Layer Access Manager is capable of deriving the N_{start_sync} subframe number and insures that all hardware required for the remote unit synchronization and CLC scanning efforts are released from sleep mode at that time. This is done, for example, by using a programmable hardware counter 640 that is clocked in synchronism with the TDD subframe of the system, as shown in Figure 3. Prior to entering the sleep mode,

or at the time the sleep mode is entered. CPU 650 preferably uses the least significant 8 bits of the remote unit ID for determining the N_{listen} subframe for the remote unit. CPU 650 loads counter 640 with a value related to N_{listen} and synchronizes counter 640 using a Start Sync signal. Counter 640 provides an interrupt to CPU 650 once every 256 subfranies, initiating a re-synchronization process. CPU 650 responds by controlling power supply 660 to provide power 661 to the various components of remote unit used for receiving a CLC CONNECT message. CPU 650 also outputs an enabling signal to the spectral despreading processor 612 to enable the remote unit to receive messages from the base station.

The remote unit begins its re-synchronization effort at a subframe N_{start_sync} that occurs some determined period of time prior to the occurrence of the N_{listen} subframe. Simulations of the remote unit synchronization algorithms indicate that a remote unit acquires synchronization with a base station when exiting a period of sleep in a minimum time of 122 ms and a maximum time of 200 ms. The actual time additionally depends on hardware component tolerances, the ambient temperature and numerous other factors. For the purposes of this disclosure, a worst case synchronization acquisition time T_{sync} of 200 ms is used. This equates to approximately 34 subframes. Therefore, $N_{start\_sync} = N_{listen}$ - 34 subframes.

Figure 6 is a timing diagram showing the sequence of events for a remote unit operating in the sleep mode. Each vertical line in Figure 6 represents a subframe boundary. The time between each subframe boundary is 6 ms. A remote unit is shown as being in a sleep mode. At N_{start_sync}, counter 640 sends an interrupt request to CPU 650 (Figure 3). CPU 650 responds by controlling power supply 660 to provide power to the various components of the remote unit needed for receiving a CLC CONNECT message. In Figure 6, the remote unit is in the sleep mode at 60. At 61, N_{start_sync} occurs and the remote unit resynchronizes for a number of subframes. Preferably, about 34 subframes are required for a remote unit to reacquire synchronization. At N_{listen}, the remote unit scans the CLC channel for any CLC CONNECT messages for the remote unit. The remote unit scans for 2 subframes, as shown in Figure 6 at 62. The remote

unit can also be set to scan for a CLC CONNECT message over a different number of subframes other than 2 subframes depending upon system requirements. If no CLC CONNECT message is received at N_{listen} the remote unit returns to the sleep mode at 63. If a CLC CONNECT message is received, the call is established in a normal manner.

As a first illustrative example of the timing aspects of the sleep mode of the present invention, the least significant 8 bits of a remote unit ID are used so that the N_{listen} cycle time is 1536 ms (256 x 6 ms). The remote unit synchronization acquisition time N_{sync} is estimated to be 34 subframes (204 ms), and a CLC scan time for 2 CLC subframes is chosen. It follows that,

T_{sleep} = 220 subframe times = 220 x 6 ms = 1.320 s

T_{sync} = 204 ms = 34 subframes x 6 ms

T_{scan_cic} = 12 ms = 2 subframes x 6 ms

$T_{standby}$ = 212 ms

Therefore, the total sleep mode/standby mode cycle time is 1536 ms, and the total remote unit power-on time is 212 ms. The overall duty cycle is 7.25:1. For this example, the maximum delay for delivery of a CONNECT message is 1.530 seconds (1536 ms - 6 ms). The nominal CONNECT message delay delivery time is about 0.766 seconds.

Using a longer delay in CONNECT message delivery time permits the remote unit to be in the sleep mode for a greater period of time. As another example the N_{listen} subframe is determined by using the least significant 9-bits of a remote unit ID. Thus, the N_{listen} interval is 512 subframes. In this example, even though the sleep time is longer, the maximum synchronization acquisition time T_{sync} remains the same. This is based on the fact that any temperature change of the remote unit is not sufficient for requiring a coarse TDD synchronization to be performed. It follows that,

T_{sleep} = 476 subframe times = 476 x 6 ms = 2.856 s

T_{sync} = 204 ms = 34 subframes x 6ms

T_{scan_clc} = 12 ms = 2 subframes x 6ms

$T_{standby}$ = 212 ms

The total sleep mode/standby mode cycle time is 3072 ms (512 x 6 ms), and the total remote unit power-on time is 212 ms. The overall duty cycle is 14.5:1. For this example, the maximum delay of delivery of a CONNECT message is 3.066 seconds (3072 ms - 6 ms). The nominal time for delivery of a CONNECT message is about 1.536 s. Table I below summarizes various scenarios:

TABLE I

Sleep Time (ms)	Nominal CLC CONNECT message delay time (ms)	RU Synchronization Time (ms)	RU Power Duty Cycle (approx.)	Battery Runtime (approx. hrs)
1320	663	220	7.25:1	11.5
1320	663	150	9:1	12
2856	1428	150	18:1	13.5
2856	1428	200	14:5	13
2856	1428	300	10:1	12

The situation of a call originating from a remote unit that is operating in the sleep mode is straight forward compared to the situation when a call terminates at a sleeping remote unit. That is, the remote unit exits the sleep mode in response to a user command. The originating call delivery time. i.e.. the time taken for delivering an ACCESS message on the CAC, is delayed by approximately 200 ms since the remote unit must re-acquire synchronization before the ACCESS message may be transmitted.

In normal system operation, a base station polls remote units at a periodic rate

for determining status of each remote unit. Each remote unit responds to the Poll Request message with a Poll response message using the CAC channel. When a remote unit is in a sleep mode of operation, the Poll Request message will not be received and, consequently, the remote unit will not respond with a Poll Response message. The present invention provides two alternatives for handling such a situation from the system point of view. The first approach is to always schedule a Poll Request message to arrive at a remote unit during the N_{listen} subframe for the remote unit whether the remote is in the standby or the sleep mode. The remote unit will receive the Poll Request message regardless of AC power status. A disadvantage associated with this approach is that the CAC channel is used by the remote unit for a Poll Response message, causing the remote unit transmitter to be used, effectively wasting battery power when in the sleep mode.

The alternative approach is for a remote unit to ignore the Poll message from the base station during AC power outage situations and allow an OAM&P Layer at the base station to recognize that a non-responsive remote unit may possibly be in the sleep mode and, consequently, be aware of the power status of the remote unit in questions power.

Figure 7 is an exemplary graph showing Battery Operating Time, measured in hours, for Sleep Mode Duty Cycle (:1). From Figure 7, it is apparent that the length of time that a remote unit is sleeping has a significant impact on the run time of the battery. Also, from Figure 7, it is also apparent that the battery run time begins to flatten with duty cycle after about a 10:1 ratio. Lab results for simulated sleep mode operation with a new, 7.2 amp-hour battery installed in a prototype uninterruptable power supply have yielded runtimes between 12 hours, 12 minutes to 12 hours, 32 minutes under the conditions that the remote unit is at room temperature, the sleep mode period is set for 3 seconds, and the sleep mode duty cycle is 10:1 (0.3 s standby state and a 2.7 s sleep state).

A remote unit operating in the sleep mode preferably provides the following characteristics:

Sleep time = 2856 ms

RU Synchronization Time = 200 ms

Call delivery delay = 1428 ms nominally

RU CLC Scan time = 36 ms (i.e., three slots for flexibility at Base MAC Layer)

Total Cycle Time = 3092 ms

Standby Time = 236 ms

Duty Cycle = 13:1 (approx.)

Battery Operating Time = 12.5 hours (approx.)

FIGURE 8 is an architectural diagram of the base station as a sender. The PSTN inputs data to base station Z. The data is sent to the vector formation buffer 502 and also to the cyclic redundancy code generator 504. Data vectors are output from buffer 502 to the trellis encoder 506. The data vectors are in the form of a data message formed by concatenating a 64 K-bit data block with its serially assigned block number. The LCC vectors output from the CRC generator 504 to the trellis encoder 506 are in the form of an error detection message formed by concatenating the CRC value with the block number. The trellis encoded data vectors and LCC vectors are then output to the spectral and spatial spreading processor 508. The resultant data tones and LCC tones are then output from processor 508 to the transmitter 210 for transmission to the remote station.

The base station transmits the CONNECT message at the N_{listen} subframe so that the call can be completed to the remote unit. The base station knows to send the messages on the CLC channel at the N_{listen} subframe. The base station's MAC Layer Access Manager is capable of deriving the N_{start_sync} subframe number. This is done, for example, by using a programmable hardware counter 540 that is clocked in synchronism with the TDD subframe of the system, as shown in Figure 8. When the base station wants to send a message to the remote unit, the CPU 550 preferably uses the least significant 8 bits of the remote unit ID for determining the N_{listen} subframe for the remote unit. CPU 550 loads counter 540 with a value related to N_{listen} and synchronizes counter 540 using a Start Sync signal. Counter 540 provides an interrupt

to CPU 550 once every 256 subframes, initiating a re-synchronization process. CPU 550 responds by outputting an enabling signal to the spectral and spatial spreading processor 508 to enable the base station to transmit messages to the remote unit when the remote unit is in its standby mode.

Still another alternate embodiment applies the above described invention in the PWAN Frequency Division Duplex Communications System described in the Alamouti, Michaelson et al. patent application cited above.

Although the preferred embodiments of the invention have been described in detail above, it will be apparent to those of ordinary skill in the art that obvious modifications may be made to the invention without departing from its spirit or essence. Consequently, the preceding description should be taken as illustrative and not restrictive, and the scope of the invention should be determined in view of the following claims.

CLAIMS

What is claimed is:

1. In a wireless communications network, a method in a base station to communicate with a remote unit that is in a sleep mode, the remote unit having a unique identification value, comprising the steps of:

establishing a periodic reference instant at the base station and at the remote station;

determining a delay interval following said periodic reference instant at the base station, said delay interval being derived from said unique identification value of said remote unit; and

transmitting a message from the base station to the remote unit at a second instant following said delay interval, said remote unit having changed from said sleep mode to a standby mode after said delay interval.

2. The method of claim 1, wherein said base station is part of a wireless discrete multitone spread spectrum communications system.

3. The method of claim 1, wherein said periodic reference instant is established by a beginning subframe count instant that is incremented by a packet count value at the base station and at the remote unit.

4. The method of claim 3, wherein said delay interval is determined by a value N of a quantity of M least significant bits of said unique identification value of said remote unit, the delay interval being an interval required for the occurrence of a plurality of N of said beginning subframe count instants.

5. The method of claim 4, wherein said remote unit changes from said

sleep mode to a standby mode after said delay interval.

6. In a wireless communications network, a method in a base station to communicate with a remote unit that is in a sleep mode, the remote unit having a unique identification value, comprising the steps of:

establishing a periodic reference instant at the base station and at the remote station;

determining a delay interval following said periodic reference instant at the base station, said delay interval being derived from said unique identification value of said remote unit;

attempting to initiate a communication from said base station to said remote unit;

concluding at the base station that the remote unit is in a sleep mode if said attempting step fails to initiate communications with the remote unit;

waiting for said delay interval following said periodic reference instant at the base station; and

transmitting a message from the base station to the remote unit at a second instant following said delay interval, said remote unit having changed from said sleep mode to a standby mode after said delay interval.

7. The method of claim 6, wherein said base station is part of a wireless discrete multitone spread spectrum communications system.

8. The method of claim 6. wherein said periodic reference instant is established by a beginning subframe count instant that is incremented by a packet count value at the base station and at the remote unit.

9. The method of claim 8, wherein said delay interval is determined by a value N of a quantity of M least significant bits of said unique identification value of said remote

unit, the delay interval being an interval required for the occurrence of a plurality of N of said beginning subframe count instants.

10. The method of claim 9, wherein said remote unit changes from said sleep mode to a standby mode after said delay interval.

11. A highly bandwidth-efficient communications method in a base station to communicate with a remote unit that is in a sleep mode, the remote unit having a unique identification value, comprising the steps of:

establishing a periodic reference instant at the base station and at the remote station;

determining a delay interval following said periodic reference instant at the base station, said delay interval being derived from said unique identification value of said remote unit;

receiving at a base station a spread signal comprising an incoming data traffic signal spread over a plurality of discrete traffic frequencies;

adaptively despreading the signals received at the base station by using despreading weights;

attempting to initiate a communication from said base station to said remote unit;

concluding at the base station that the remote unit is in a sleep mode if said attempting step fails to initiate communications with the remote unit;

waiting for said delay interval following said periodic reference instant at the base station; and

transmitting at the base station to the remote unit a spread signal comprising an outgoing data traffic signal spread over a plurality of discrete traffic frequencies.

12. The method of claim 11, wherein said base station is part of a wireless discrete multitone spread spectrum communications system.

13. The method of claim 11, wherein said periodic reference instant is established by a beginning subframe count instant that is incremented by a packet count value at the base station and at the remote unit.

14. The method of claim 13, wherein said delay interval is determined by a value N of a quantity of M least significant bits of said unique identification value of said remote unit, the delay interval being an interval required for the occurrence of a plurality of N of said beginning subframe count instants.

15. The method of claim 14, wherein said remote unit changes from said sleep mode to a standby mode after said delay interval.

16. A remote unit for a personal wireless area network comprising:

a receiver;

an AC power supply coupled to the receiver and supplying power to the receiver;

a battery-backup power supply coupled to the receiver, the battery-backup power supply becoming operative to supply power to the receiver when the AC power supply fails; and

a controller coupled to the receiver, the AC power supply and the battery-backup power supply, the controller detecting when the AC power supply fails and in response controls the receiver and the battery-backup power supply by invoking a sleep mode of operation, the sleep mode operation being periodically interrupted by the controller controlling the receiver and the battery-backup power supply to enter a standby mode of operation in which the receiver scans for a CONNECT message indicating an incoming call, the controller controlling the sleep mode and the standby mode of operations based on a frame count that is generated from an identification number of the remote unit.

17. The remote unit according to claim 1, wherein the receiver scans for a connect message for a predetermined number of subfraines of a TDD timing structure.

18. The remote unit according to claim 17, wherein the predetermined number of sub frames equals 3.

19. The remote unit according to claim 17, wherein when the remote unit enters the standby mode, the remote unit reacquires synchronization to the TDD timing structure.

20. The remote unit according to claim 19, wherein the remote unit reacquires synchronization to the TDD timing structure in about 34 subframes.

21. The remote unit according to claim 19, wherein the remote unit scans for a CONNECT message at a subframe that is related to an identification number of the remote unit.

22. A method for reducing power consumption of a remote unit in a PWAN system, comprising the steps of:

powering a remote unit using a battery backup power supply when an AC power supply fails at the remote unit;

entering a sleep mode of operation at the remote unit, the sleep mode having a reduced power consumption for the battery backup power supply;

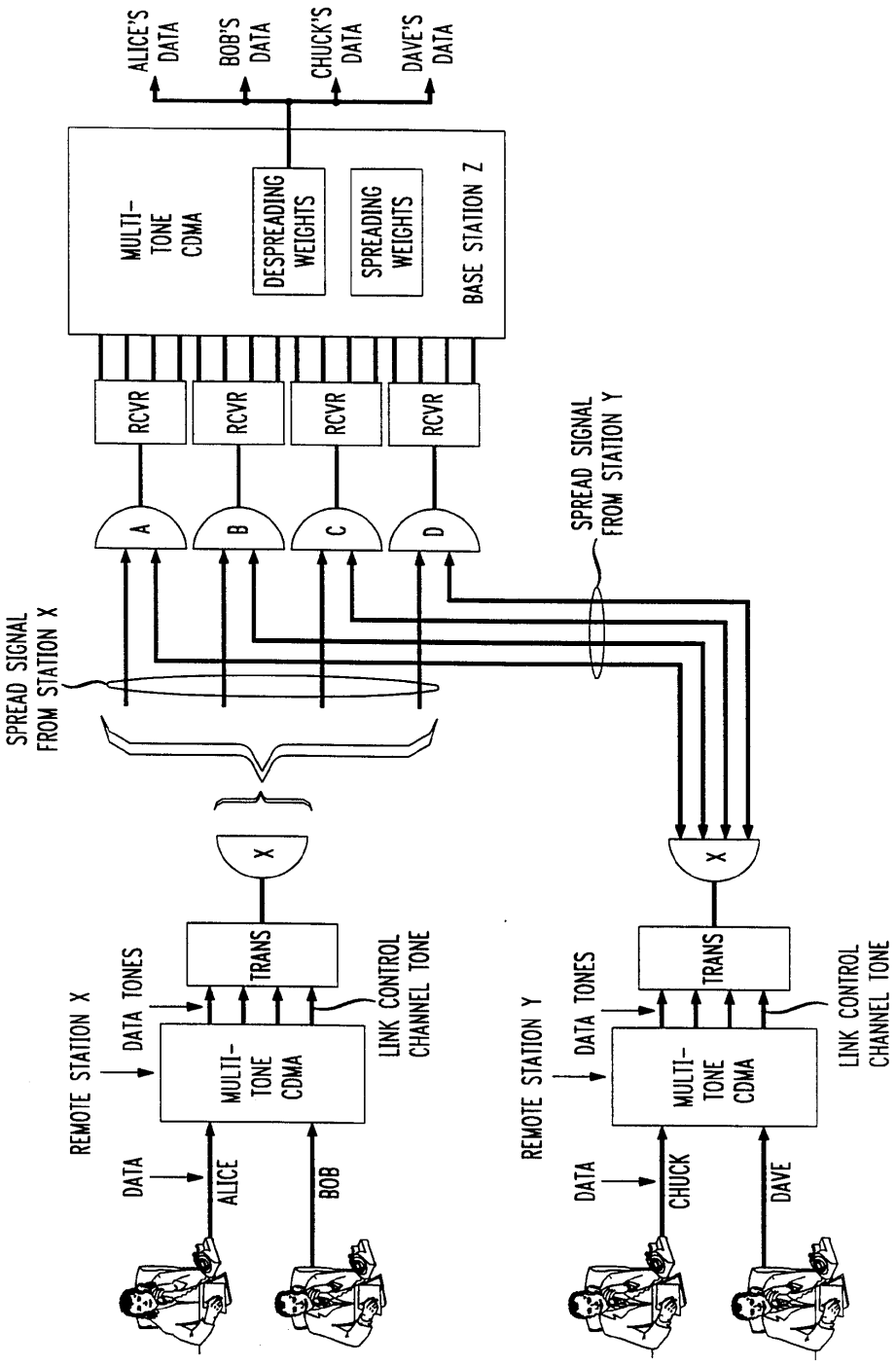
entering a standby mode of operation at the remote unit a predetermined period of time after entering the sleep mode of operation scanning for a CONNECT message indicating an incoming call for the remote unit; and

reentering the sleep mode of operation when no CONNECT message is received.

23. The method according to claim 22, further comprising the step of synchronizing the remote unit to a TDD timing structure before the step of entering the standby mode of operation.

24. The method according to claim 23, wherein the predetermined period of time is a predetermined number of subframes after a boundary subframe of the TDD timing structure.

25. The method according to claim 24, wherein the predetermined number of subframes is based on an identification number of the remote unit.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BOB'S DATA
CHUCK'S DATA
DAVE'S DATA
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SPREADING WEIGHTS
BASE STATION Z
RCVR
RCVR
RCVR
RCVR
A
B
C
D
SPREAD SIGNAL FROM STATION X
SPREAD SIGNAL FROM STATION Y
X
X
TRANS
TRANS
REMOTE STATION X
DATA TONES
LINK CONTROL CHANNEL TONE
MULTI-TONE CDMA
DATA
ALICE
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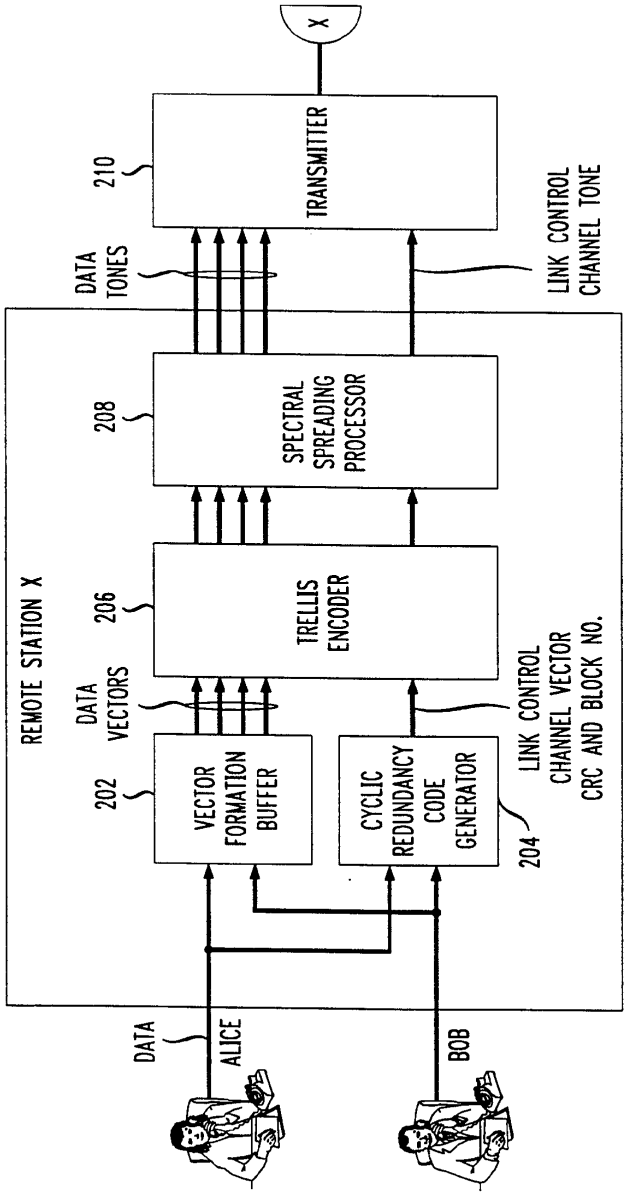
MULTI-TONE CDMA
DATA
CHUCK
DAVE

FIG. 1

FIG. 2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210
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LINK CONTROL CHANNEL TONE
SPECTRAL SPREADING PROCESSOR
208
TRELLIS ENCODER
206
REMOTE STATION X
DATA VECTORS
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VECTOR FORMATION BUFFER
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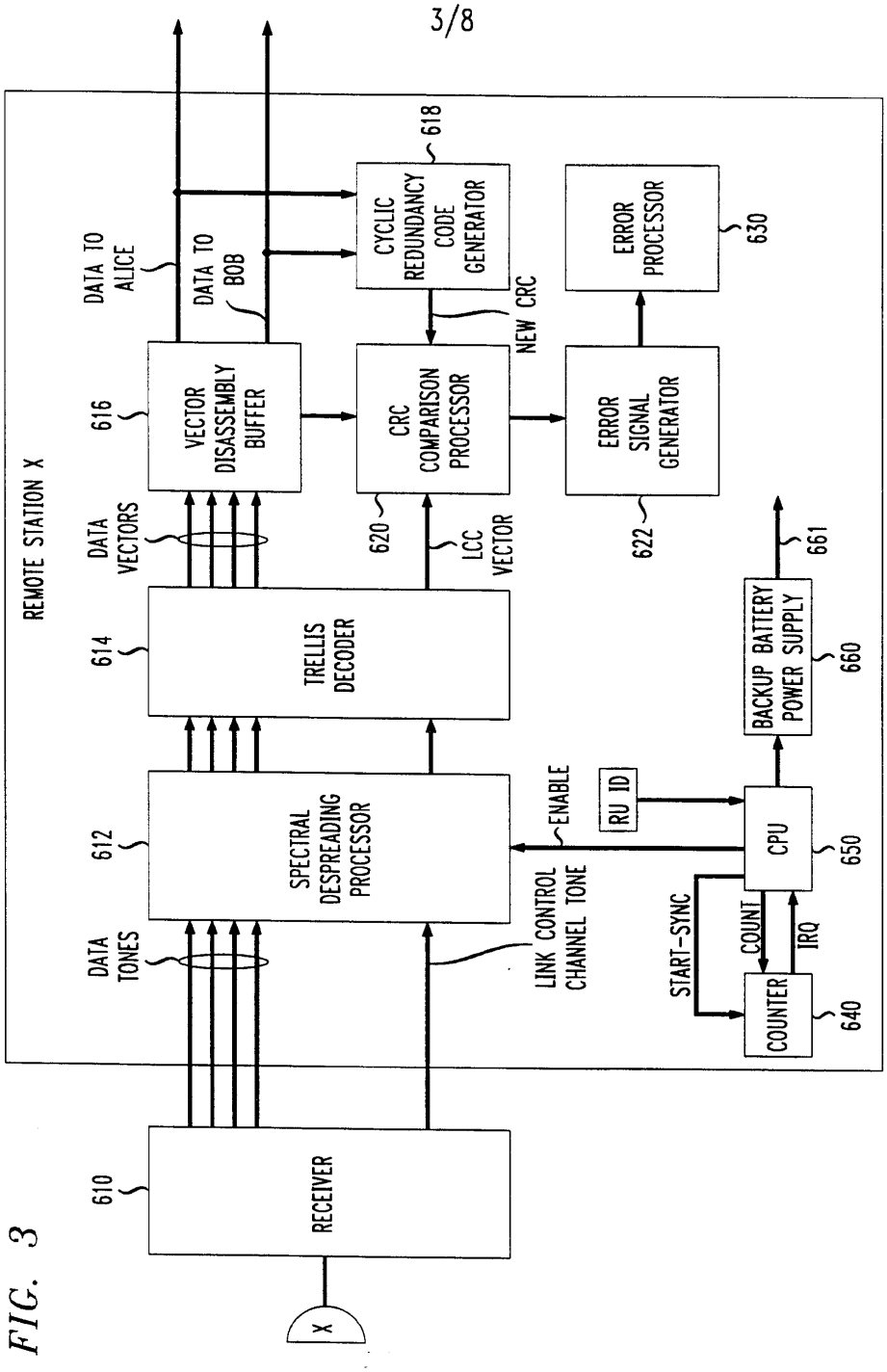
CYCLIC REDUNDANCY CODE GENERATOR
204
DATA
ALICE
BOB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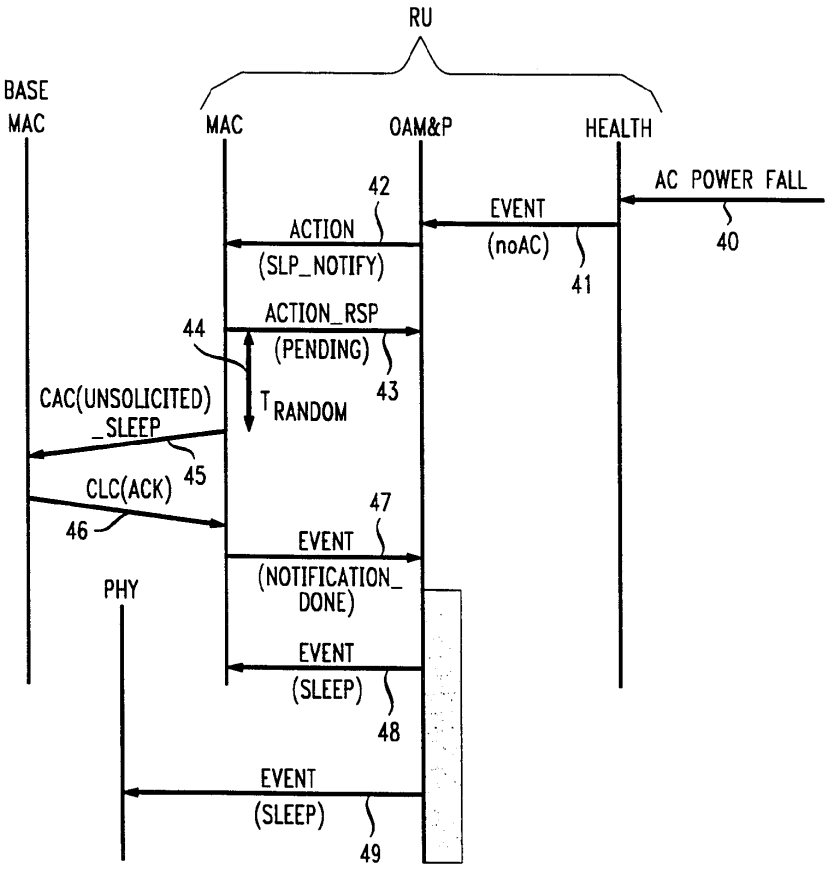
DATA TO ALICE
DATA TO BOB
618
CYCLIC REDUNDANCY CODE GENERATOR
NEW CRC
ERROR PROCESSOR
630
616
VECTOR DISASSEMBLY BUFFER
CRC COMPARISON PROCESSOR
ERROR SIGNAL GENERATOR
DATA VECTORS
620
LCC VECTOR
622
661
614
TRELLIS DECODER
BACKUP BATTERY POWER SUPPLY
660
ENABLE
RU ID
612
SPECTRAL DESPREADING PROCESSOR
CPU
650
DATA TONES
LINK CONTROL CHANNEL TONE
START-SYNC
COUNT
IRQ
COUNTER
640
610
RECEIVER
X

FIG. 3

FIG. 4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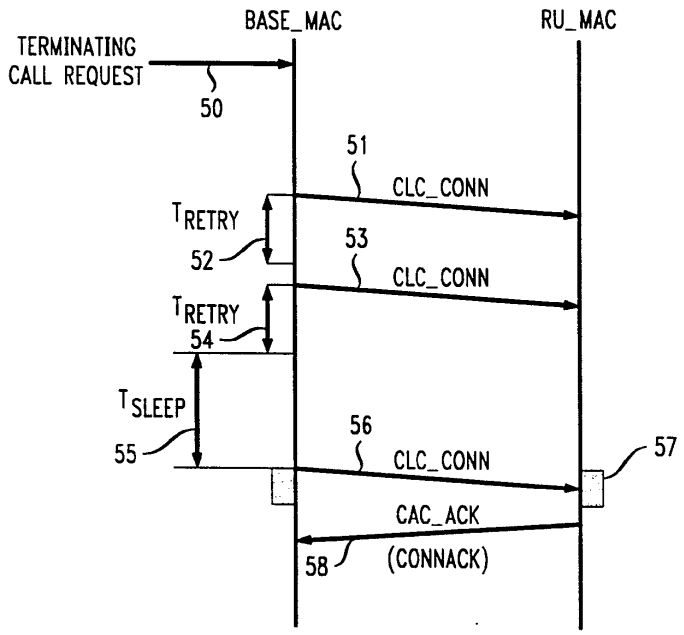
BASE MAC
MAC
OAM&P
HEALTH
AC POWER FALL
40
42
EVENT
(noAC)
41
ACTION
(SLP_NOTIFY)
ACTION_RSP
(PENDING)
43
44
T RANDOM
CAC(UNSOLICITED)
_SLEEP
45
CLC(ACK)
46
47
EVENT
(NOTIFICATION_
DONE)
PHY
EVENT
(SLEEP)
48
EVENT
(SLEEP)
49

FIG. 5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RU_MAC
TERMINATING CALL REQUEST
50
51
CLC_CONN
TRETRY
52
53
CLC_CONN
TRETRY
54
TSLEEP
55
56
CLC_CONN
57
CAC_ACK
(CONNACK)
58

FIG. 6

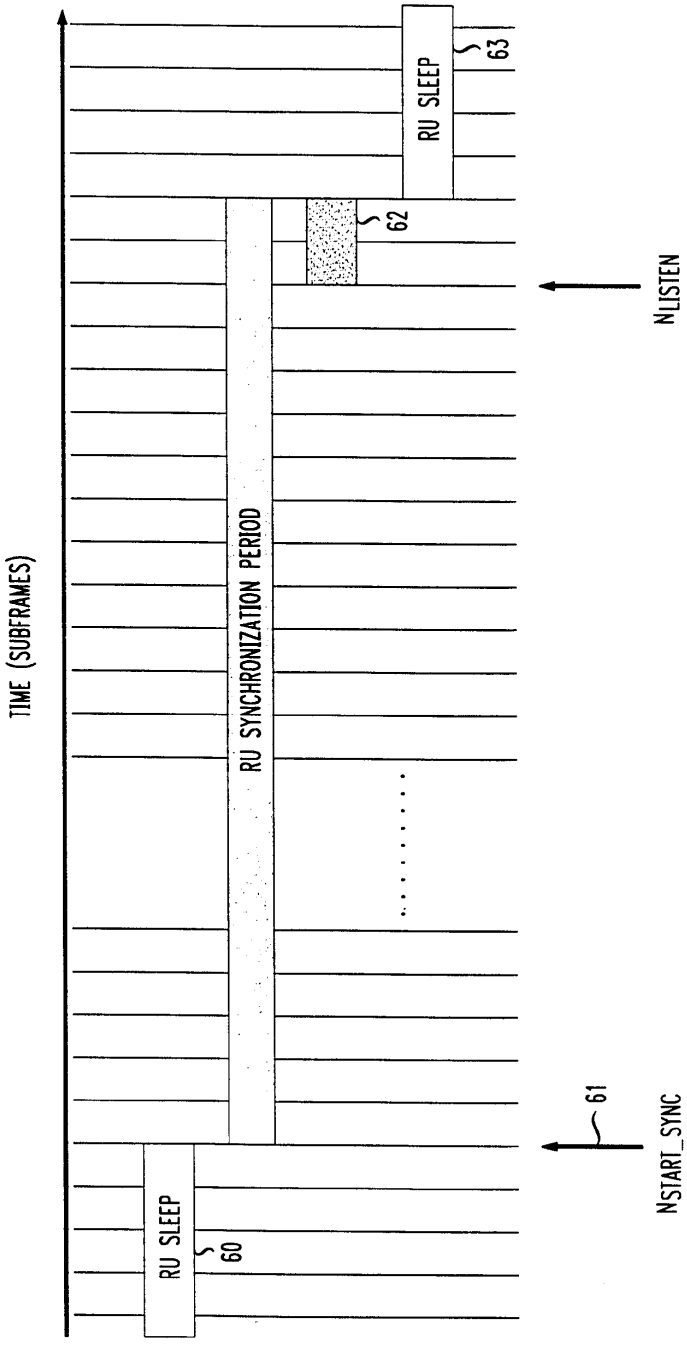
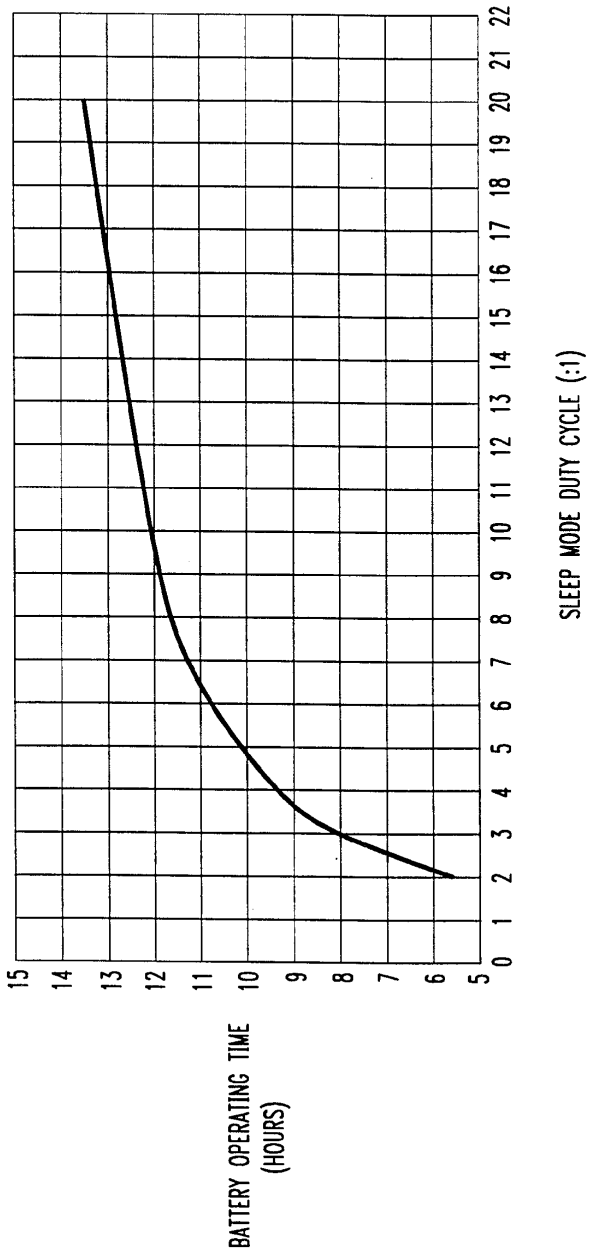

TIME (SUBFRAMES)
RU SLEEP
63
62
NLISTEN
RU SYNCHRONIZATION PERIOD
61
NSTART_SYNC
RU SLEEP
60

FIG. 7


0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
SLEEP MODE DUTY CYCLE (:1)
15 14 13 12 11 10 9 8 7 6 5
BATTERY OPERATING TIME (HOURS)

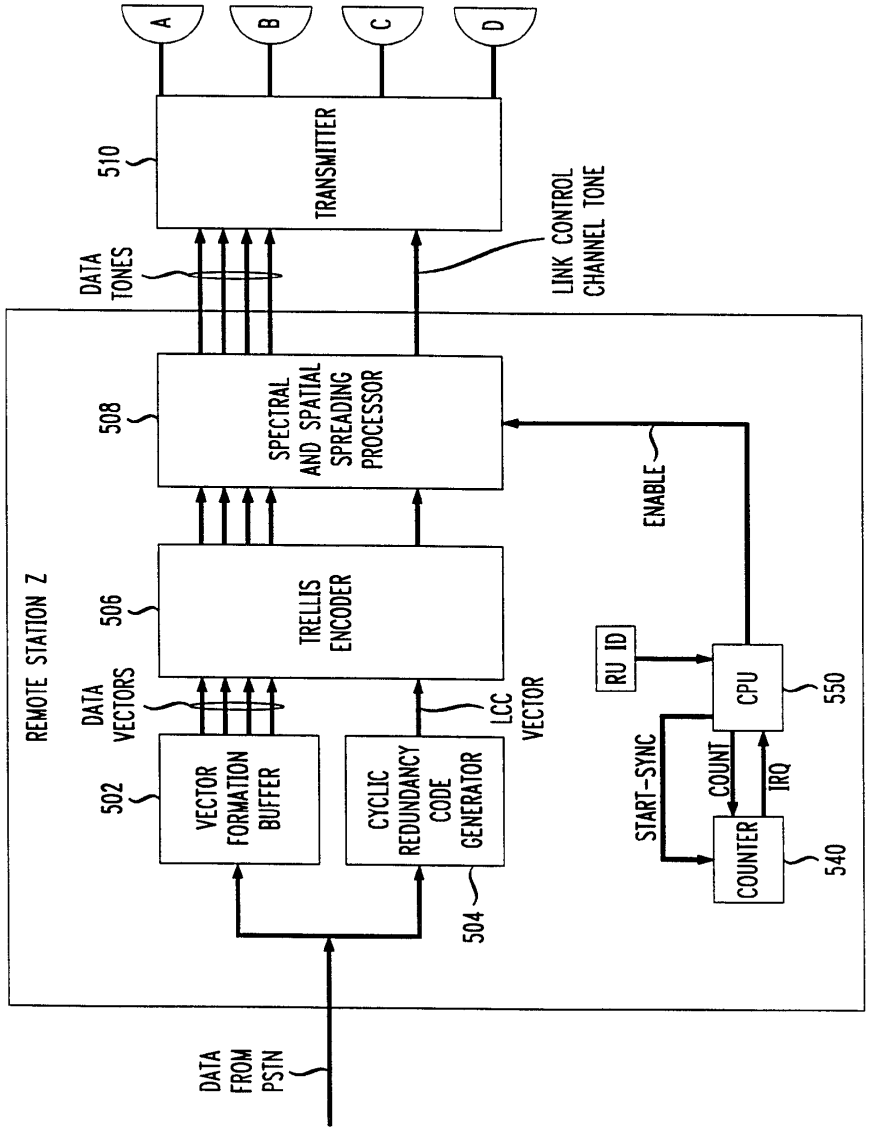

A
B
C
D
510
TRANSMITTER
DATA TONES
LINK CONTROL CHANNEL TONE
REMOTE STATION Z
508
SPECTRAL AND SPATIAL SPREADING PROCESSOR
ENABLE
506
TRELLIS ENCODER
RU ID
CPU
550
DATA VECTORS
LCC VECTOR
502
VECTOR FORMATION BUFFER
CYCLIC REDUNDANCY CODE GENERATOR
START-SYNC
COUNT
IRQ
COUNTER
540
504
DATA FROM PSTN

FIG. 8

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(54) Title: SPLITTERLESS MULTICARRIER MODEM

(57) Abstract

A modem for use in Digital Subscriber Line communications transmits and receives data over the local subscriber loop in common with voice information over the loop, while avoiding the need for voice/data splitters. The modem responds to disruptions associated with "disturbance events" such as on–hook to off–hook transitions and the like by rapidly switching between pre–stored channel parameter control sets defining communications over the loop under varying conditions. In addition to changing parameter control sets responsive to a disturbance event, the modem may also change transmission power levels and other system parameters such as frequency domain equalizer characteristics. Further, provisions are made for reduced bandwidth communications under selected conditions.

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SPLITTERLESS MULTICARRIER MODEM

Cross-reference to related applications:

This application is based in part on the following applications filed by one or more of the inventors herein:

U.S. Provisional Patent Application Serial No. 60/061,689, filed October 10, 1997 by Richard Gross, John Greszcuk, Dave Krinsky, Marcos Tzannes, and Michael Tzannes and entitled "Splitterless Multicarrier Modulation For High Speed Data Transport Over telephone Wires";

U.S. Provisional Patent Application Serial No. **** filed January 16, 1998 by Richard Gross and Michael Tzannes and entitled "Dual Rate Multicarrier Transmission System In A Splitterless Configuration";

U.S. Provisional Patent Application Serial No. *** filed January 21, 1998 by Richard Gross, Marcos Tzannes and Michael Tzannes and entitled "Dual Rate Multicarrier Transmission System In A Splitterless Configuration".

U.S. Provisional Patent Application Serial No. *** filed January 26, 1998 by Richard Gross, Marcos Tzannes and Michael Tzannes and entitled "Multicarrier SystemWith Dynamic Power Levels".

The disclosures of these applications are incorporated by reference herein in their entirety.

Background of the invention

A. Field of the invention.

The invention relates to telephone communication systems and, more particularly, to telephone communication systems which utilize discrete multitone modulation to transmit data over digital subscriber lines.

B. Prior art.

The public switched telephone network (PSTN) provides the most widely available form of electronic communication for most individuals and businesses. Because of its

ready availability and the substantial cost of providing alternative facilities, it is increasingly being called upon to accommodate the expanding demands for transmission of substantial amounts of data at high rates. Structured originally to provide voice communication with its consequent narrow bandwidth requirements, the PSTN increasingly relies on digital systems to meet the service demand.

A major limiting factor in the ability to implement high rate digital transmission has been the subscriber loop between the telephone central office (CO) and the premises of the subscriber. This loop most commonly comprises a single pair of twisted wires which are well suited to carrying low-frequency voice communications for which a bandwidth of 0-4 kHz is quite adequate, but which do not readily accommodate broadband communications (i.e., bandwidths on the order of hundreds of kilohertz or more) without adopting new techniques for communication.

One approach to this problem has been the development of discrete multitone digital subscriber line (DMT DSL) technology and its variant, discrete wavelet multitone digital subscriber line (DWMT DSL) technology. These and other forms of discrete multitone digital subscriber line technology (such as ADSL, HDSL, etc.) will commonly be referred to hereinafter generically as "DSL technology" or frequently simply as "DSL". The operation of discrete multitone systems, and their application to DSL technology, is discussed more fully in "Multicarrier Modulation For Data Transmission: An Idea Whose Time Has Come.", IEEE Communications Magazine, May, 1990, pp. 5-14.

In DSL technology, communications over the local subscriber loop between the central office and the subscriber premises is accomplished by modulating the data to be transmitted onto a multiplicity of discrete frequency carriers which are summed together and then transmitted over the subscriber loop. Individually, the carriers form discrete, non-overlapping communication subchannels of limited bandwidth; collectively, they form what is effectively a broadband communications channel. At the receiver end, the carriers are demodulated and the data recovered from them.

The data symbols that are transmitted over each subchannel carry a number of bits that may vary from subchannel to subchannel, dependent on the signal-to-noise ratio (SNR) of the subchannel. The number of bits that can accommodated under specified

communication conditions is known as the "bit allocation" of the subchannel, and is calculated for each subchannel in a known manner as a function of the measured SNR of the subchannel and the bit error rate associated with it.

The SNR of the respective subchannels is determined by transmitting a reference signal over the various subchannels and measuring the SNR's of the received signals. The loading information is typically calculated at the receiving or "local" end of the subscriber line (e.g., at the subscriber premises, in the case of transmission from the central telephone office to the subscriber, and at the central office in the case of transmission from the subscriber premises to the central office) and is communicated to the other (transmitting or "remote") end so that each transmitter-receiver pair in communication with each other uses the same information for communication. The bit allocation information is stored at both ends of the communication pair link for use in defining the number of bits to be used on the respective subchannels in transmitting data to a particular receiver. Other subchannel parameters such as subchannel gains, time and frequency domain equalizer coefficients, and other characteristics may also be stored to aid in defining the subchannel.

Information may, of course, be transmitted in either direction over the subscriber line. For many applications, such as the delivery of video, internet services, etc. to a subscriber, the required bandwidth from central office to subscriber is many times that of the required bandwidth from subscriber to central office. One recently developed service providing such a capability is based on discrete multitone asymmetric digital subscriber line (DMT ADSL) technology. In one form of this service, up to two hundred and fifty six subchannels, each of 4312.5 Hz bandwidth, are devoted to downstream (from central office to subscriber premises) communications, while up to thirty two subchannels, each also of 4312.5 Hz bandwidth, provide upstream (from subscriber premises to central office) communications. Communication is by way of "frames" of data and control information. In a presently-used form of ADSL communications, sixty eight data frames and one synchronization frame form a "superframe" that is repeated throughout the transmission. The data frames carry the data that is to be transmitted; the synchronization or "sync" frame provides a known bit sequence that is used to synchronize the transmitting and receiving modems and that also facilitates determination of transmission subchannel characteristics such as signal-to-noise ratio ("SNR"), among others.

Although such systems do in fact provide a significantly increased bandwidth for data communications, special precautions are required to avoid interference with, and from, ordinary voice communications and associated signaling that may be taking place over the subscriber line at the same time that the broadband data is being carried. The signaling activities commonly include, for example, the transmission of ringing signals, busy tone, off-hook indications, on-hook indications, dialing signals, and the like, and the actions commonly accompanying them, e.g., taking the phone off-hook, replacing it on-hook, dialing, etc. These voice communications and their associated signaling, commonly referred to as "plain old telephone service" or POTS , presently are isolated from the data communications by modulating the data communications onto frequencies that are higher than those used for POTS ; the data communications and POTS signals are thereafter separately retrieved by appropriate demodulation and filtering. The filters which separate the data communications and the POTS are commonly referred to as "POTS splitters".

The voice and data communications must be separated at both the central office and the subscriber premises, and thus POTS splitters must be installed at both locations. Installation at the central office is generally not a significant problem, since a single modem at the central office can serve a large number of subscribers, and technicians are commonly available there. Installation at the customer premises is a problem. Typically, a trained technician must visit the premises of every subscriber who wishes to use this technology in order to perform the requisite installation. In connection with this, extensive rewiring may have to be done, dependent on the desired location of the ADSL devices. This is expensive and discourages the use of DSL technology on a widespread basis.

DSL systems also experience disturbances from other data services on adjacent phone lines (such as ADSL, HDSL, ISDN, or T1 service). These services may commence after the subject ADSL service is already initiated and, since DSL for internet access is envisioned as an always-on service, the effect of these disturbances must be ameliorated by the subject ADSL transceiver.

Summary of the invention

A. Objects of the invention

Accordingly, it is an object of the invention to provide an improved digital subscriber line communication system.

Further, it is an object of the invention to provide a digital subscriber line communication system which is compatible with existing voice communication services and which does not require the use of POTS splitters.

Another object of the invention is to provide an improved digital subscriber line communication system that efficiently handles data communications despite random interruptions associated with concurrent carriage of voice communications or disturbances that arise from concurrent data services on adjacent phone lines.

B. Summary description of the invention.

Splitterless Operation

The invention described herein is directed to enhancing the accuracy and reliability of communications in systems using discrete multitone technology (DMT) to communicate data over digital subscriber lines (DSL) in the presence of voice communications and other disturbances. For simplicity of reference, the apparatus and method of the present invention will hereinafter be referred to collectively simply as a modem. One such modem is typically located at a customer premises such as a home or business and is "downstream" from a central office with which it communicates; the other is typically located at the central office and is "upstream" from the customer premises. Consistent with industry practice, the modems are often referred to herein as "ATU-R" ("ADSL Transceiver Unit, Remote", i.e., located at the customer premises) and "ATU-C" ("ADSL Transceiver Unit, Central Office"). Each modem includes a transmitter section for transmitting data and a receiver section for receiving data, and is of the discrete multitone type, i.e., it transmits data over a multiplicity of subchannels of limited bandwidth. Typically, the upstream or ATU-C modem transmits data to the downstream or ATU-R modem over a first set of subchannels, commonly the higher-frequency subchannels, and receives data from the downstream or ATU-R modem over a second, usually smaller, set of subchanels, commonly the lower-frequency subchannels.

Heretofore, such modems have required POTS splitters when used on lines carrying both voice and data. In accordance with the present invention, we provide a data modem for use in discrete multitone communication systems which carry voice and data communications simultaneously and which operate without the special filtering provided by POTS splitters; they are thus "splitterless" modems. In the absence of certain disturbances, referred to herein as "disturbance events" and discussed more fully hereinafter, the modem of our invention transmits data at a rate determined by the transmission capabilities of the system without regard to such disturbances. Preferably, this is the maximum data rate that can be provided for the particular communications subchannel, subject to predefined constraints such as maximum bit error rate, maximum signal power, etc. that may be imposed by other considerations. On the occurrence of a disturbance event on the communications channel, however, the modem of the present invention detects the event and thereupon modifies the subsequent communication operations. Among other responses, the modem changes the bit allocations (and thus possibly the corresponding bit rate) and the subchannel gains among the subchannels, so as to limit interference with and from voice communication activities or to compensate for disturbances from other services or sources sufficiently close to the subject subscriber line as to couple interfering signals into the line. The bit allocations and subchannel gains may be altered for communications in either direction, i.e., upstream, downstream, or both. Effectively, this matches the subchannel capacity to the selected data rate so as to ensure that the pre-specified bit error rate is not exceeded. On cessation of the disturbance event, the system is returned to its initial, high-rate, state.

Disturbance Events

Of particular interest to the present invention are disturbance events that arise from the occurrence of voice communication activities over the data link concurrent with the transmission of data over the link. These activities comprise the voice communications themselves, or activities such as signaling associated with such communications, together with the response to such activities, such as taking a phone off-hook or placing it on-hook. Disturbance events also include other disruptive disturbances such as interference from adjacent phone lines caused, for example, by the presence of other DSL services, ISDN services, T1 services, etc. The cessation of a disturbance event may itself also

comprise a disturbance event. For example, the change of a voice communications device such as a telephone from "on-hook" to "off-hook" status can seriously disrupt communications at a modem unless compensated for as described herein or unless otherwise isolated from the modem by means of a POTS splitter as was heretofore done; it is thus a disturbance event that must be dealt with. However, the return of such a device to "on-hook" status can also significantly change the channel characteristics and is therefore also a disturbance event that must be dealt with. The invention described herein efficiently addresses these and other disturbance events.

Channel Control Parameter Sets

In accordance with the present invention, the change in bit allocation is accomplished rapidly and efficiently by switching between stored parameter sets which contain one or more channel control parameters that define data communications by the modem over the subchannels. The parameters sets are preferably determined at the time of initialization of the modem and stored in registers or other memory (e.g., RAM or ROM) in the modem itself, but may instead be stored in devices external to, and in communication with, the modem, e.g., in personal computers, on disk drives etc.

In accordance with one embodiment of this invention, the channel control parameter sets comprise at least a primary set of channel control parameters, stored in a primary channel control table, which defines communications in the absence of voice communication activities or other disturbances; and one or a plurality of secondary sets of channel control parameters, stored in a secondary channel control table, that define data communications responsive to one or more disturbance events. When communicating under control of the primary channel control table, the modem is described hereinafter as being in its "primary" state; when communicating under control of the secondary channel control table, the modem is described hereinafter as being in its "secondary" state. The modem is switched between parameter sets in its primary and secondary states responsive to the occurrence and cessation of disturbance events, as well as among parameter sets in the secondary table responsive to a change from one disturbance event to another. Since the parameter sets are pre-stored and thus need not be exchanged at the time of a disturbance event, the switch is made quickly, limited essentially only by the speed with which the disturbance event is detected and signaled to the other modem participating in the com-

munication, typically not more than a second or so. This greatly reduces the interruption in communications that would otherwise be required by a complete reinitialization of the modems that typically extends over six to ten seconds, and its associated exchange channel control parameters.

As noted previously, in DSL communications, information transmission typically takes place in both directions, i.e. the upstream or ATU-C modem transmits downstream to the ATU-R modem over a first set of subchannels, and the downstream or ATU-R modem transmits upstream to the ATU-C modem over a second, different, set of subchannels. The transmitter and receiver at each modem, accordingly, maintain corresponding channel tables to be used by them in transmitting data to, and receiving data from, the other modem with which it forms a communications pair. Certain parameters such as time and frequency domain equalizer coefficients and echo canceller coefficients are "local" to the receiver with which they are associated, and thus need be maintained only at that receiver. Other parameters such as bit allocations and channel gains are shared with the other modem with which a given modem is in communication (the "modem pair") and thus are stored in both modems, so that during a given communication session, the transmitter of one modem will use the same set of values of a shared parameter as the receiver of the other modem, and vice versa.

In particular, in DSL communications, a key parameter is the number of bits that are to be transmitted over the various subchannels. This is known as the "bit allocation" for the respective subchannels, and is a key element of the primary and secondary parameter sets. It is calculated in a known manner for each subchannel based on the channel SNR, the acceptable bit error rate, and the noise margin of the subchannel. Another important element is the gain for each of the subchannels, and is thus preferably also included in the primary and secondary parameter sets. Thus, each receiver stores a primary channel control table and a secondary channel control table, each of which contains one or more parameter sets that define the subchannel bit allocations to be used by it and by the transmitter of the other modem in communicating with it, and each transmitter also stores a primary channel control table and a secondary channel control table, each of which define the subchannel bit allocations and gains to be used by it for transmission to the other receiver and for reception at that receiver. For the closest match to the actual line over

which they are to communicate, those portions of the primary and secondary channel control table at each receiver that define the parameters for use in transmitting to the particular receiver are preferably determined at the modem at which the receiver is located (the "local modem"), as described herein, but it will be understood from the detailed description herein that such tables may also be determined in other ways.

As long as communications over the subscriber line are not impaired by a disturbance event, the modems use the primary channel control table to define communications over the subchannels. When, however, a disturbance event occurs, the modem that detects the event (herein designated "the local modem"; typically, this will be the subscriber modem, ATU-R, particularly in cases of activation of a voice communications device by the subscriber) notifies the other modem of the need to change to the secondary channel control table, and identifies the specific bit allocation set and/or gain set in the secondary table when more than one such set exists. The notification procedure is described in more detail hereinafter. Communications thereafter continue in accordance with the appropriate parameter set (i.e., bit allocations, subchannel gains, and possibly other parameters) from the secondary channel control table. This condition continues until a new disturbance event is detected, at which time the modems revert to the primary channel control table (in the event the disturbance is simply the cessation of communication-disrupting disturbances or interferences) or to a different parameter set secondary channel control table (in the event that the disturbance event is the occurrence of another communication-disrupting disturbance or interference).

In addition to changes in bit allocation among the subchannels, and changes in subchannel gains, further changes may also be made in such communication parameters as time domain equalizer coefficients, frequency domain equalizer coefficients, and the like. These parameters may also be stored in the channel control tables for use in controlling communications, or may be stored in separate tables. Additionally, changes in power level (and corresponding changes in bit allocation and other communication parameters) for communications in either the upstream or the downsteam direction, or both, may be made, and sets of control parameters may be defined on these power levels as well for use in controlling communications. These changes are described in fuller detail below.

As presently contemplated, each modem on the subscribed side of the DSL line will communicate with a corresponding dedicated modem on the central office side. Thus, each central office modem (ATU-C) need store the primary and secondary tables for a specific subscriber only. However, efficiencies may be achieved whenever it is unnecessary to provide service to each subscriber at all times. Under these circumstances, a central office modem may be shared among two or more subscribers, and switched among them as called for. In such a case, the ATU-C will store or have access to a set of channel control tables for each subscriber modem it is to service.

Table Initialization

In the preferred embodiment of the invention, the primary and secondary channel control tables are determined in an initial "training" session ("modem initialization") in which known data is transmitted by one modem, measured on reception by the other, and the tables calculated based on these measurements. Typically, the training session occurs when the modem is first installed at the subscriber premises or at the central office, and the procedure thus "particularizes" the modem to the environment in which it will operate. This environment includes, in addition to the subject data modem, one or more voice communication devices such as telephone handsets, facsimile machines, and other such devices which communicate over a voice frequency subchannel, typically in the range 0-4 kHz. A primary channel control table, comprising a parameter set including at least a set of subchannel bit allocations, and preferably also subchannel gains, is calculated with each device inactive. A secondary channel control table comprising one or more bit communication parameter sets (bit allocations, gains, etc.) is calculated with each voice communication device activated separately, and/or with groups of devices activated concurrently. The tables so determined are then stored at the receiver of one modem and additionally are communicated to the transmitter of the other modem and stored there for use by both modems in subsequent communications.

An alternative approach determines the secondary channel control table (including one or more parameter sets comprising the table) by calculation from the primary channel control table. This is accomplished most simply, for example, by taking one or more of the parameters (e.g., the bit allocation parameter which defines the number of bits to be used for communication across the respective subchannels) as a percentage, fixed or

varying across the subchannels, of the corresponding primary parameters; or as determined in accordance with a percentage, fixed or varying across the subchannels, of the SNR's of the respective subchannels; or as determined in accordance with a different bit error rate than provided for in the primary channel control table; or by other techniques.

As a specific example, a number of different sets of bit allocations in the secondary channel control table may be determined as differing percentages (fixed or varying across the subchannels) of the corresponding set of bit allocations in the primary channel control table. Each secondary bit allocation set corresponds to the effect commonly produced by a particular device or class of devices, e.g., a telephone handset, a facsimile machine, etc., as determined by repeated measurements on such devices, and thus may be taken to represent the expected effect of that device over a range of communication conditions, e.g., with a particular type of subscriber line wiring, at a given range from the central office, etc. The subchannel gains may also then be adjusted based on the redetermined bit allocations. The bit allocations and subchannel gains so determined form new secondary parameter sets which may be used responsive to detection of the disturbance events they characterize, and which substitute for determination of the secondary bit allocations and gains on the basis of measurements of the actual disturbances being compensated for.

Alternatively, the secondary channel control table may be determined by adding a power margin to the calculations for each of the entries of the primary table of a magnitude sufficient to accommodate the interference from activation of the voice communications device or from other disturbances. This has the effect of reducing the constellation size for the table entries. The margin may be uniform across the table entries, or may vary across them, as may the percentage factor when that approach is used. Multiple secondary bit allocation sets may be defined by this approach, each based on a different power margin.

One example of the use of varying margins is in response to changes in crosstalk (capacitively coupled noise due to nearby xDSL users, where the "x" indicates the possible varieties of DSL such as ADSL, HDSL, etc.). This crosstalk is, in general, more predictable than signaling events associated with voice communications. The crosstalk spectrum of xDSL sources is well characterized: see, for example, the T1.413 ADSL standard published by the American National Standards Institute. From a primary channel control

table associated with a single full initialization, a secondary table comprising a family of bit allocation sets can be calculated, each corresponding to a different crosstalk level. As the number of xDSL systems (and thus crosstalk levels) changes, the ADSL link can quickly switch to one of these automatically generated sets.

The secondary channel control table in the present invention may also be adapted dynamically, e.g., by performing measurements on the transmitted information in each superframe during data communications and monitoring these measurements to determine when the channel performance has sufficiently changed that a different bit allocation set, and possibly different gain set, should be used. We have found that the SNR provides a readily measurable and reliable indicator of the required bit allocations and gains.

In particular, we have found that measurements of the SNR levels across a number of the subchannels during a given communications condition or state provides a "fingerprint" which may reliably be used to quickly select a parameter set, such as the set of bit allocations or the set of gains, for use in subsequent communications during that state. These measurements may be made, for example, on the sync frame that occurs in each superframe or, more generally, during the transmission of reference frames. When the SNR's change by more than a defined amount during communications, the modem at which the measurement is made searches the stored parameter sets for a set whose SNRs on the corresponding subchannels is closest to the measured SNRs, and selects that set for use in subsequent communications. If no parameter set is found within defined limits, the system may be switched to a default state, or a complete reinitialization may be called for, corresponding to a defined pattern of SNR's across some or all of the subchannels, should be used. SNR measurements may also be made on the data carrying signals themselves, i.e., a decision-directed SNR measurement.

Instead of using a multiplicity of secondary subchannel control parameter sets as described above, a simplified approach may construct and use a single secondary set based on a composite of the bit allocation or other characteristics of the individual devices. In one embodiment, the composite is formed by selecting, for each subchannel, the minimum bit allocation exhibited by any device for that subchannel, or the most severe characteristic of any other disturbances, thus forming a single "worst case" set that may be used when any device is activated, regardless of the specific device or disturbance ac-

tually present. Or it may be determined as the actual or calculated capacity of the line when all devices are actually or theoretically actuated simultaneously, or all disturbances are present, or both concurrently. Bit allocations sets may also be determined for combinations of subsets of such devices and disturbances. A similar approach may be used to handle the situation where several devices are activated at the same time, and the effects of other disturbances such as cross talk, etc. may also be incorporated into a composite set.

A particular parameter set of the secondary channel control table remains in use for the duration of the session in which the voice device is active or until another change of state occurs, e.g., a further voice device is activated or some other disturbance takes place. When this occurs, the local modem renews its identification procedure to enable determination of the appropriate parameter set for the new conditions. At the end of the session in which the voice device is active, the device returns to inactive (i.e., "on-hook") status and the system reverts to its original ("on-hook") status in which the primary channel control table once again is used for communications between the central office and the subscriber.

Switching the subchannel parameter sets in accordance with the present invention is extremely fast. It can be accomplished in an interval as short as several frames, and thus avoids the lengthy (e.g., several second) delay that would otherwise accompany determination, communication, and switching of newly-determined sets. Further, it avoids communicating new parameter sets at a time when communications have been impaired and error rates are high. Thus, it minimizes disruption to the communication process occasioned by disturbance events.

Detecting Disturbance Events

During subsequent data communications, identification of the device that is activated is achieved in one of a number of ways. In one embodiment of the invention, a specific activation signal is transmitted from the device to the modem on the same side of the subscriber line as the device (referred to herein as "the local modem") on activation of the device. This signal may be transmitted over the communications line to which the device and the local modem are connected or it may be sent over a dedicated connection

between the device and the local modem.

In the preferred embodiment of the invention, the local modem monitors the subscriber line to which it and the device are connected and detects a change in line characteristics when the device is activated. For example, the signal to noise ratio (SNR) of the various subchannels can quickly be measured and can be used to identify the particular device that is activated. During multiple sets of initializations, corresponding to multiple communication conditions caused by the devices or by other interferences, the SNR measure for each subchannel is determined for each of the conditions to be tracked (i.e., no devices activated, devices activated separately, two or more devices activated concurrently, adjacent channel interference, etc.) and the measures stored, along with identification of the particular parameter set or sets with which they are associated. When a device is activated, the SNR measurements are used to quickly identify the particular device or devices that have been activated, and the local modem can thereafter switch to the appropriate secondary table.

Disturbance events may also be detected in accordance with the present invention by monitoring selected transmission characteristics that are dependent on these events. These may comprise, in addition to any characteristic SNR accompanying them, such measures as errors in the cyclic redundancy code (CRC) that accompanies transmissions and changes in the error rate of this code; changes in the amplitude, frequency or phase of a pilot tone on the subchannels; or other such indicia. Forward error correction code (FEC) is typically used in ADSL transceivers, and changes in the error rate characteristics of this code, such as how many errors have occurred, how many have been corrected, how many are uncorrected, and the like, can be particularly useful in detecting disturbance events.

In monitoring these characteristics, we distinguish between changes caused by momentary or transient events such as lightning or other such burst noise disturbances, and those associated with disturbance events, the latter continuing for a significant interval (e.g., on the order of seconds or more). In particular, in embodiments that monitor CRC errors or error rates in accordance with the present invention, a switch from one parameter set to another is provided when the errors extend over a number of frames or when the error rate changes by a defined amount for a time greater than a defined mini-

mum. For example, on the occurrence of an off-hook event , a severe form of disturbance to data communications over a subscriber loop, the number of CRC errors suddenly increases and remains at an increased level until it is dealt with. This is distinguished from the occurrence of a transient disturbance such as a lightning strike which causes a momentary increase in CRC errors that does not persist as long as the system has not lost synchronization.

Thus, in accordance with the present invention, the detection of an initial change in the CRC error rate over a number of frames in excess of a defined threshold is one example of the detection of a disturbance event that will result in switching parameter sets. Similar procedures may be undertaken in response to measurement of the signal-to-noise ratio of the subchannel in order to detect a disturbance event based on this characteristic. The decision as to whether a disturbance event has occurred may be based on measurements on a single subchannel; on a multiplicity of subchannels (e.g., the decision to switch parameter sets will be made when more than a defined number of subchannels detect a disturbance event); or the like.

An alternative technique for detecting a disturbance event in accordance with the present invention is the use of a monitor signal, e.g., a pilot tone whose amplitude, frequency, phase or other characteristic is monitored during data transmission. A sudden change in one or more of the monitored characteristics from one frame to another, followed by a smaller or no change in subsequent frames, indicates a disturbance event to which the modem should respond. The monitor signal may comprise a dedicated signal carried by one of the subchannels; a signal carried on a separate control subchannel; a disturbance event itself (e.g., ringing tone, dial tone presence, or other common telephone signals); or other signals.

Communicating The Occurrence of Disturbance Events

After a disturbance event is detected and the appropriate parameter set corresponding to the event is identified, the identification is communicated to the remote modem by means of a selection signal to enable it also to switch to the corresponding parameter set in the secondary table. The selection signal may be in the form of a message transmitted over one or more subchannels or using a predetermined protocol for an em-

bedded operations channel, or it may comprise one or more tones that identify the particular parameter set. ADSL systems use a "guard band" of several subchannels between the sets of subchannels used for upstream and downstream transmission. This guard band may be used to transmit the selection tone or tones. In cases where there is only a single parameter set to be designated, the selection signal may comprise a simple flag (an element that has only two states, i.e., on/off, present/absent, etc.) that is sent to the remote modem to select the set.

In a further embodiment of the invention, use is made of the frame counters at the ATU-R and ATU-C modems that are commonly provided in DSL systems. On detecting a disturbance event, the ATU-R modem notifies the ATU-C modem of the event and specifies a frame at which the change in parameter set, or change in power level and any accompanying change in other parameters, is to take place. The specification may be direct (i.e., the notification specifies a particular frame number at which the change to the secondary table is to be made) or indirect (i.e., on receipt of the notification, the change to the secondary table is made at one of a predetermined number of frames, e.g., the next frame number ending in "0", or in "00", etc., or the nth frame after receiving the notification, where n is some number greater than 0). On reaching the designated frame, both modems (i.e., ATU-R and ATU-C) switch to the new bit allocation set, power level, and other designated parameters.

Alternatively, on detection of a disturbance event, the modems perform a "fast retrain" in order to characterize communications under the new operating conditions and determine a power and/or bit allocation set to be used for the communications. A fast retrain performs only a limited subset of the full initialization procedures, e.g., bit allocation and subchannel gain determination,. The retraining modem (typically the modem local to the disturbance initiating the retraining) then compares the newly determined parameter set with previously stored sets. If the newly-determined set is the same as a previously stored set, a message, flag, or tone is communicated by one modem to the other to designate which of the stored secondary allocation sets is to be used. Otherwise, the newly determined set is used for communications. In the latter event, it must be communicated to the other modem in the communication pair, and communications may be interrupted while this occurs. Nonetheless, on cessation of the event which necessitated a

change in parameter sets, the system may simply revert to the primary parameter set, without need for recommunication of that set and thus without further interrupting communications. With proper care in initialization, in most cases a sufficient array of parameter sets may be defined and exchanged at the outset as to avoid the need for subsequent reinitialization in response to most disturbances.

Changing Power Levels

In addition to changing one or more parameter sets in the modem in response to a disturbance event, in accordance with the preferred embodiment of the present invention we also preferably change the communications power level in either the upstream or the downstream direction, or both, in order to further enhance reliable communications. Typically, the change is a reduction in the power level in the upstream direction so as to minimize interference with the voice communications, as well as to reduce echo into the downstream signal, and it will be so described herein. However, it should be understood that there will be some occasions when an increase in power level is called for, such as when interference from adjacent data services requires a higher power level in order to maintain a desired data rate or bit error level, and such a change is accommodated by the present invention in the same manner as that of a decrease. Further, a change in downstream power level may be called for when line conditions change to such an extent that excessive power would otherwise be fed into the downstream channel from the upstream modem

In theory, and in a perfectly linear system, upstream communications activities should have no effect on concurrent voice communications since the two activities occur in separate, non-overlapping frequency bands. However, the telephone system in fact is not a linear system, and nonlinearities in the system can and do inject image signals from the upstream subchannel into the voice subchannel, and possibly into the downstream subchannel as well (i.e., echo), thus producing detectable interference. In accordance with another aspect of the present invention, this effect is reduced below the level of objection by reducing the upstream power level (the power level at which the subscriber or downstream modem transmits to the central office or upstream modem) by a given amount or factor when conditions dictate, e.g., when a voice communications device is off-hook and leakage from the data communications being conducted interferes with the

voice communications.

The amount of power reduction may be set in advance. For example, we have found that a nine db reduction in this power (relative to that typically used in ADSL applications using splitters to separate the data and POTS signals) is sufficient in most cases of common interest; under these circumstances, the system operates in one of two alternative power levels at all times. Alternatively, the downstream modem may select one of several different power levels for use, based on the communication conditions prevailing at the time resultant from the disturbance event. For example, the downstream modem may be activated to send a test signal into one or more upstream subchannels and to monitor the leakage (i.e., the echo) of this signal into one or more downstream subchannels as determined, for example, by the SNRs on these subchannels; the power level at which the downstream modem transmits upstream may then be adjusted accordingly in order to minimize the effects of the echo. Commonly, the downstream transmit power is determined by the ATU-R, since the ATU-R is closest to the cause of the disturbance event. In this event, the ATU-R uses a message, flag, or tone to inform the ATU-C of the desired power level to be used for transmission. In either case, at the end of a session, the power level reverts to that used in the "on-hook" state.

In selecting the desired power level, the transmitting modem signals the receiving modem in the communications-pair of the desired change (including the designation of a particular power level from among several power levels, where appropriate), and thereafter implements the change, including switching to a new parameter set associated with that power level. In another embodiment of the invention, the receiving modem detects the power level change at the transmitting modem and switches to a parameter set associated with that power level; upstream communications (i.e., from the ATU-R to the ATU-C) are thereafter conducted at the new power level until the disturbance event (e.g., off-hook condition, etc.) terminates.

While much of the above has been described in terms of a change in power level in the upstream communications from the subscriber modem to the central office modem, it should be noted that a change in power level in the opposite direction may also sometimes be called for. This may be the case, for example, on short subscriber loops (e.g., less than a mile), where the reduced line loss consequent on the greater proximity to the central

office may result in the central office initially transmitting at an excessive power level. In such cases, the central office or ATU-C modem performs the role previously performed by the subscriber or ATU-R modem, and vice versa, and a change in power level and other parameters on the downstream communications may be performed as described above. Further, it should also be understood that while it is expected that the power change will most commonly be one that reduces the power level used to communicate, it may in some cases increase it. This will occur, for example, when crosstalk from adjacent services requires an increase in power level of the subject service in order to compensate for the crosstalk.

Changing Other Parameters

A further important change made in response to detecting a disturbance event is a change in the frequency domain equalizers ("FDQ's") associated with each subchannel. These equalizers compensate for the differing distortions (e.g., amplitude loss, phase delay, etc.) suffered by the data during transmission over the subchannel. Typically, they comprise finite impulse response filters with complex coefficients. The coefficients are set during the "initialization" or "training" phase of modem setup. They may subsequently be adjusted based on reference (known) data in reference frames or sync frames transmitted over the communication subchannel. In accordance with the present invention, these filters are adjusted responsive to the transmitted reference data when a disturbance event is detected. The coefficient updating may be performed on all subchannels, or selectively on those whose change in error rates, signal-to-noise ratios, or other error indicia, indicate a disturbance event.

In accordance with one embodiment of the present invention, the coefficients of the frequency domain equalizers for communications both in the absence of a disturbance event or disturbance ("primary FDQ coefficients") and in the presence of such an event or disturbance ("secondary FDQ coefficients") are computed and stored during the initialization or training period. Thereafter, these coefficients are switched responsive to a disturbance event, as is the case with the channel control tables, and are returned to an initial state on the cessation of such an event.

In accordance with another embodiment of the invention, the FDQ coefficients are

recomputed responsive to detection of a disturbance event and then used throughout the remainder of the communications session in place of the earlier-stored secondary FDQ tables. The recomputation is accomplished in a short "retrain" session in which known reference data is transmitted between the ATU-R and ATU-C . The received data is compared with the known data and the new FDQ coefficients are determined accordingly. In addition to the frequency domain equalizer coefficients, time domain equalizer coefficients and echo cancellation coefficients may also be determined and stored. Such coefficients are local to the particular receiver, and thus need not be communicated to the other modem of the communications pair. Accordingly, any such retrain will be extremely fast, and any consequent disruption to communication limited.

Excessive Disturbances

In some cases a particular device may cause such interference with communications that compensation for that device by the methods described herein is not practical. This may occur, for example, with antiquated telephones or with particularly complex in-home wiring. In such a case, it is desirable to minimize the disruption caused by such a device by inserting a simple in-line filter between the device and the subscriber line. The filter may comprise, for example, a simple low-pass filter of not more than a cubic inch in volume and a pair of standard connectors such as RJ11 connectors through which the filter connects to the device on one side and to the subscriber line on the other. Unlike POTS splitters, such a connector needs no trained technician to install it, and thus presents no barrier, cost or otherwise, to acceptance of ADSL modems as described herein. Such a device may be detected by measuring the nonlinear distortion of the device when it is activated. This is done by monitoring the echo on the line caused by that device.

Reduced Rate Communications

A further improvement in the operation of the modem of the present invention resides in confining the bandwidth of the downstream transmission to a subset of that normally provided in ADSL communications. This reduces the processing demands on both the local (i.e., central office) and remote (subscriber premises) modems, thereby facilitating the provision of subscriber premises modems at prices more acceptable to consumer, non-business, use; additionally, it further minimizes interference between data transmis-

sion and voice communications. For example, limiting the number of subchannels used by the modem to one hundred and twenty eight as opposed to two hundred and fifty six reduces the downstream bandwidth from 1.1 MHz to approximately 552 kHz. When the modem is used with modems that normally provide a greater number of subchannels for such communications, the bit allocations and gains for the subchannels above one hundred and twenty eight are preferably nulled, i.e., set to zero.

The invention is preferably operable with modems that do not have the capabilities described herein, as well, of course, with modems that do. Accordingly, the modem of the present invention identifies its capabilities, preferably during initialization, preparatory to data exchange with another modem. In accordance with the preferred embodiment of the invention, this is preferably done by signaling between the modems that are to participate in communications. The signaling identifies the type of modems in communication and their characteristics of significance to the communication session. For example, one form of ADSL transceiver uses a reduced number of subchannels (typically, thirty two subchannels upstream and one hundred twenty eight subchannels downstream) and provides lower bandwidth communications. A modem having full ADSL capabilities that encounters a reduced-rate modem can then adjust its transmission and reception parameters to match the reduced-rate modem. This may be done, for example, by transmission from one modem to the other of a tone that is reserved for such purposes.

In particular, in accordance with the present invention, on initiation of communications between a central office modem and a subscriber premises modem, the modems identify themselves as "full rate" (i.e., communicating over two hundred and fifty six subchannels) or "reduced rate" (e.g., communicating over some lesser number of subchannels, e.g., one hundred and twenty eight). The communication may be performed via a flag (two-state, e.g., "on/off", "present/absent"), a tone or tones, a message (n-state, n>2), or other form of communication, and may be initiated at either end of the communication subchannel, i.e., either the central office end or the customer premises end.

Brief description of the drawings

The invention description below refers to the accompanying drawings, of which:

Figure 1 is a block and line diagram of a conventional digital subscriber line

(DSL) system using POTS splitters that is characteristic of the prior art;

Figure 2 illustrates an illustrative bit allocation and gains table used in the apparatus of Figure 1;

Figure 3 is a block and line diagram of a splitterless DSL system in accordance with the present invention;

Figure 4 is a block diagram of a splitterless transceiver in accordance with the present invention;

Figures 5A-5C illustrates channel control tables constructed and used in accordance with the present invention;

Figure 6 is a diagram of one form of disturbance event detector in accordance with the present invention;

Figure 7 illustrates the use of a frame counter for communicating the switching decision to the remote modem;

Figure 8 illustrates the preferred procedure used for performing a fast retrain of the modems in accordance with the present invention;

Figure 9 illustrates the manner in which channel control tables may readily be selected in accordance with the present invention; and

Figure 10 illustrates alternative configuration for interconnection of the modems of the present invention.

Detailed description of an illustrative embodiment

Figure 1 shows an ADSL communications system of the type heretofore used incorporating "splitters" to separate voice and data communications transmitted over a telephone line. As there shown, a telephone central office ("CO") 10 is connected to a remote subscriber 12 ("CP: Customer Premises") by a subscriber line or loop 14. Typically, the subscriber line 14 comprises a pair of twisted copper wires; this has been the traditional medium for carrying voice communications between a telephone subscriber or customer and the central office. Designed to carry voice communications in a bandwidth of approximately 4 kHz (kilohertz), its use has been greatly extended by DSL technology.

The central office is, in turn, connected to a digital data network ("DDN") 16 for sending and receiving digital data, as well as to a public switched telephone network ("PSTN") 18 for sending and receiving voice and other low frequency communications. The digital data network is connected to the central office through a digital subscriber line access multiplexer ("DSLAM") 20, while the switched telephone network is connected to the central office through a local switch bank 22. The DSLAM 20 (or its equivalent, such as a data enabled switch line card) connects to a POTS "splitter" 24 through an ADSL transceiver unit -central office ("ATU-C") 26. The local switch 20 also connects to the splitter.

The splitter 24 separates data and voice ("POTS") signals received from the line 14. At the subscriber end of line 14, a splitter 30 performs the same function. In particular, the splitter 30 passes the POTS signals from line 14 to the appropriate devices such as telephone handsets 31, 32, and passes the digital data signals to an ADSL transceiver unit-subscriber ("ATU-R") 34 for application to data utilization devices such as a personal computer ("PC") 36 and the like. The transceiver 34 may advantageously be incorporated as a card in the PC itself; similarly, the transceiver 26 is commonly implemented as a line card in the multiplexer 20.

In this approach, a communication channel of a given bandwidth is divided into a multiplicity of subchannels, each a fraction of the subchannel bandwidth. Data to be transmitted from one transceiver to another is modulated onto each subchannel in accordance with the information-carrying capacity of the particular subchannel. Because of differing signal-to-noise ("SNR") characteristics of the subchannels, the amount of data loaded onto a subchannel may differ from subchannel to subchannel. Accordingly, a "bit allocation table" (shown as table 40 at transceiver 26 and table 42 at transceiver 34) is maintained at each transceiver to define the number of bits that each will transmit on each subchannel to the receiver to which it is connected. These tables are created during an initialization process in which test signals are transmitted by each transceiver to the other and the signals received at the respective transceivers are measured in order to determine the maximum number of bits that can be transmitted from one transceiver to the other on the particular line. The bit allocation table determined by a particular transceiver is then transmitted over the digital subscriber line 14 to the other transceiver for use by the other

transceiver in transmitting data to that particular transceiver or to any similar transceiver connected to the line 14. The transmission must, of course, be done at a time when the line is not subject to disturbances which may interfere with communications. This is a significant limitation, and restricts the utilization of this approach.

Referring now to figure 2, a bit allocation table 42 such as is used in the customer premises equipment is shown in further detail. Table 40, used at the central office, is essentially the same in construction and operation and will not further be described. Table 42 has two sections, a first section, 42a, which defines certain communication parameters such as bit allocation capacity and subchannel gain parameters that characterize the respective subchannels and which the transmitter section of transceiver 34 will use in transmitting a signal to the other transceiver (26) with which it is in communication; and a section 42b that defines the parameters that the receiver section of transceiver 34 will use in receiving a signal transmitted from the other transceiver. Communications take place over a plurality of subchannels, here shown, for purposes of illustration only, as subchannels "9", "10", etc. in the transmitter section, and subchannels "40", "41", etc. in the receiver section. In a full-rate ADSL system, there are up to two hundred and fifty six such subchannels, each of bandwidth 4.1 kHz. For example, in one embodiment of the inventin, upstream communications (i.e., from the customer premises to the central telephone office) are conducted on subchannels 8 to 29; downstream communications (from the central office to the customer premises) are conducted on subchannels 32 to 255; subchannels 30 and 31 form a guard band between upstream and downstream communications that may be used for signaling as described hereinafter.

For each subchannel ("SC") 50, a field 52 defines the number of bits ("B") that are to be transmitted over that subchannel by the transmitter of a communications or modem pair, and received by the receiver of that pair, consistent with the prevailing conditions on the subchannel, e.g., measured signal-to-noise ratio (SNR), desired error rate, etc.; column 54 defines the corresponding gains ("G") of the subchannels. A first section, 42a, of the table specifies the bit allocations and gains that transceiver 34 will use in transmitting "upstream" to the transceiver 26; and a second section, 42b, specifies the bit allocations and gains that transceiver 34 will use in receiving transmissions from the transceiver 26. Transceiver 26 has a corresponding table 40 which is the mirror image of table 42, that is,

the bit allocations specified for transmission by transceiver 34 are the same as those specified for reception by transceiver 26 and correspondingly for reception by transceiver 34 and transmission by transceiver 26. The table typically may also include a field specifying the gain 54 associated with the particular subchannel.

As noted above, the splitters 24, 30 combine the data and voice communications applied to them for transmission and once again separate these from each other on reception. This is accomplished by means of high pass and low pass filters which separate the low-frequency voice communications from the high-frequency data. The need to utilize such splitters, however, imposes a severe impediment to the widespread adoption of DSL technology by the consumer. In particular, the installation of a splitter at the subscriber premises requires a trip to the premises by a trained technician. This can be quite costly, and will deter many, if not most, consumers from taking advantage of this technology. Nor is incorporating splitters in the communications devices themselves a viable option, since this not only increases the cost of such devices, but requires either the purchase of all new devices or the retrofit of the older devices, which again requires skilled help to accomplish. In accordance with the present invention, we eliminate the splitter at least at the customer premises, thereby enabling adoption and use of DSL modems by the end user without the intervention of trained technical personnel. This, however, requires significant changes in the structure and operation of the DSL transceivers or modems, and the present invention addresses these changes.

In particular, figure 3 shows a DSL transmission system in accordance with the invention in which the composite voice-data signal transmitted from the central office to the subscriber premises is passed to both the subscriber voice equipment 31, 32 and to the data transceiver or modem 34' without the interposition of a splitter at the subscriber premises. In figure 3, components that are unchanged from figure 1 retain the same numbering; components that are modified are designated with a prime superscript. In place of the single table 30 of the transceiver 26 of Figure 1, the transceiver 26' of Figure 3 contains a primary channel control table 41 and a secondary channel control table 43. Similarly, transceiver 34' of Figure 3 contains a primary channel control table 45 and a secondary channel control table 47. It will also be noted that the subscriber side splitter has been eliminated in Figure 3: the reason why this can be done in the present invention

will now be described in detail. It will also be noted that the central office splitter 20 in figure 1 has been retained in the configuration of Figure 3: this is optional, not mandatory. Retaining a splitter at the central office can improve the performance somewhat at little cost, since only a single installation is required and that at the central office itself where technical personnel are commonly available in any event. Where this is not the case, it may be eliminated there also.

Turning now to figure 4, the transceiver or modem 34' is shown in greater detail; the modem 26' is essentially the same for present purposes and will not be separately described. As indicated, modem 34' comprises a transmitter module 50; a receiver module 52; a control module 54; a primary channel control table 45; and a secondary channel control table 47. The primary channel control table is shown more fully in figure 5A.; the secondary channel control table is shown more fully in figure 5B.

In figure 5A, the primary channel control table 45 has a transmitter section 45a which stores a primary set of channel control parameters for use in transmitting to a remote receiver over a DSL line; and a receiver section 45b which stores a primary set of channel control parameters for use in receiving communications over a DSL line from a remote transmitter. The subchannels to which the parameters apply are shown in column 45 c. The channel control parameters in the transmitter section 45a include at least a specification of the bit allocations ("B") 45d and preferably also the gains ("G") 45e to be used on the respective subchannels during transmission. The receiver section similarly includes specification of the bit allocations and gains, and preferably also includes specification of the frequency domain equalizer coefficients ("FDQ") 45f, time domain equalizer coefficients ("TDEQ") 45g, and echo canceller coefficients ("FEC") 45h, among others.

Collectively, the parameters: bit allocation, gain, frequency domain coefficient, time domain coefficient, etc. form a parameter set, each of whose members are also sets, e.g. the bit allocation set defining the allocation of bits to each of the subchannels, the gain setting set defining the gains across the subchannels, etc. In accordance with the preferred embodiment of the present invention, the primary channel control table stores a single parameter set which has at least one member, i.e., a bit allocation set, and preferably a gain allocation set as well; this parameter set defines the default communications conditions to which the system will revert in the absence of disturbance events. The sec-

ondary channel control table, however, has at least two, and typically more, parameter sets for controlling transmission and reception over the subscriber lines by the respective modems; these sets define communications under various disturbance events which change the default conditions.

In particular, in Figure 5B, the secondary channel control table 47 comprises a plurality of parameter sets 47a, 47b, 47c, etc., of which only three sets are shown for purposes of illustration. Each parameter set includes a transmit portion 47 d and a receive portion 47e. In each portion, one or more parameters are specified, e.g., bit allocations 47f and gains 47g in the transmit portion 47d, and frequency domain coefficients 47h, time domain coefficients 47i, and echo cancellation coefficients 47j in the receive portion 47e. The actual values of the coefficients are typically complex numbers and thus they are represented simply by letters, e.g., "a", "b", etc. in the channel control tables of Figures 5A and 5B. Parameter sets 47b, 47c, and the remaining parameter sets are similarly constructed. As was the case for the primary channel control table, each parameter (e.g., bit allocation) is itself a set of elements that define communication conditions, at least in part, across the subchannels to which they apply and which they help characterize.

The primary channel control table containing a bit allocation parameter set is generated in the usual manner, i.e., during initialization (typically, a period preceding the transmission of "working data" as opposed to test data), known data is transmitted to, and received from, the remote modem with which the instant modem is in communication under the conditions which are to comprise the default condition for the modem. Typically, this will be with all disturbing devices inactivated, so that the highest data rate can be achieved, but the actual conditions will be selected by the user. The data received at each modem is checked against the data known to have been transmitted and the primary channel control parameters such as bit allocation, subchannel gains, and the like are calculated accordingly. This table is thereafter used as long as the system remains undisturbed by disturbance events which disrupt communications over the line.

The secondary channel control table may be determined during initialization in the same manner as the primary table, but with devices that may cause disturbance events actuated in order to redetermine the channel control parameters required for communications under the new conditions. These devices may be actuated one by one, and a secon-

dary parameter control set determined for each and stored in the secondary channel control table; or they may be actuated in groups of two or more, and parameter sets determined accordingly; or various combinations of single and group actuations may be performed and the corresponding parameter sets determined. Secondary parameter sets may similarly be determined from actual measurements with interfering sources such as xDSL transmissions in a common binder with the modems in question, and the resultant sets stored in the secondary table.

Other methods of determination of the secondary table may be employed. For example, one or more secondary parameter sets may be derived from the primary table. Thus, the bit allocation on each subchannel in the secondary table may be taken as a percentage, fixed or varying across the subchannels, of the bit allocation for each subchannel defined in the primary table. Alternatively, it may be calculated from the same data as that of the primary table, but using a larger margin; by using a percentage, fixed or varying across the subchannels, of the signal-to-noise ratio used in calculating the primary table; by providing for a different bit error rate than provided for in the primary; or by other techniques, including those described earlier. Portions of the primary and secondary may be recalculated or improved upon during the communication session, and stored for subsequent use. The calculation or recalculation may be a one-time event or may occur repeatedly, including periodically, throughout a communication session.

Further, although use of a multiplicity of parameter sets in the secondary channel control table will generally provide the best match to the actual channel conditions and thus more nearly approach optimum communications conditions, a simplified second table containing a single composite parameter set may also be used. Thus Figure 5C shows a number of sets 49a-49d of bit allocations for the subchannels 49e and which may represent a corresponding number of different communication devices or conditions associated with communications over these subchannels. A single composite parameter set 49f may be formed as a function of the parameter sets 49a-49d by, for example, selecting, for each subchannel, the minimum bit allocation among the sets 49a-49d for each of the subchannels 49e. Such a set represents a "worst case" condition for activation of any of the devices associated with the sets 49a-49d. Other worst case parameter sets may be formed, for example, on selected groups of devices, thus providing for the case when several de-

vices or disturbances are operating simultaneously.

In the absence of a disturbance event, the transceivers 26', 34' use the primary channel control tables 41, 45 for communications. Responsive to detection of a disturbance event, however, the transceivers 26', 34' switch to one of the parameter sets of the secondary channel control tables 43, 47 to continue the communications under the conditions specified by the particular parameter table. These conditions may specify a diminished bit rate while maintaining the same bit error rate as is provided with the primary channel control table; or may specify the same bit rate but at a higher bit error rate; or may specify a diminished bit rate at a correspondingly diminished power level or margin; or other conditions as determined by the specific channel control tables. On termination of the disturbance condition which caused the switch, the transceivers 26', 34' return to use of the primary tables 41, 45.

Typically, the primary tables provide communications at or near the capacity of the communications channel over line 14. The secondary tables provide communications over the channel at a diminished rate. Switching between the primary and secondary tables (that is, switching from a primary parameter set to a secondary parameter set) in accordance with the present invention is fast: it can be accomplished in an interval as short as several frames (each frame being approximately 250 microseconds in current ADSL systems), and thus avoids the lengthy delay (e.g., on the order of several seconds) that would otherwise be required for determination, communication over the subscriber line, and switching of newly-determined bit allocation tables. Further, it avoids communication of such tables over the subscriber line at a time when communications have been impaired and error rates are therefore high. Thus, utilization of prestored parameter sets in accordance with the present invention minimizes disruption to the communication process occasioned by disturbance events.

The channel control tables are stored in a storage or memory for rapid access and retrieval. Preferably, the storage is a random access memory ("RAM") incorporated into the modem itself, but also comprise such a memory located in other components accessible to the modem, e.g., in a stand-alone memory; in a computer such as a personal computer ("PC"); in a disk drive; or in other elements. Further, the storage may include portions of other forms of memory, such as read only memory ("ROM").

In addition to accessing the channel control tables 45 and 47, the control module 54 of Figure 4 preferably also controls formulation of the secondary control table when this table is calculated on the basis of the primary channel control table. Further, the module 54 monitors the SNR on the subscriber line 14 and calculates the primary and secondary channel control parameter sets when these sets are based on measurement of actual conditions of the line, as will most commonly be the case. To this end, the control module is advantageously implemented as a special purpose digital computer or "DSP" chip particularized to the functions described herein. It may, of course, alternatively be implemented as a general purpose computer or in other fashion, as will be understood by those skilled in the art.

In accordance with the present invention, disturbance events on the subscriber line are distinguished from transient events such as lightning impulses by mean of their consequences. In particular, a signaling event such as an off-hook signal or an on-hook signal typically causes sufficient disruption as to preclude further communications without re-initialization. The event is accompanied by an error code indication that persists throughout the disruption; a change in the amplitude and phase of the physical signal carrying the data or of a pilot tone; the application of a substantial voltage to the line; and other indicia. We monitor the subscriber line for the occurrence of one of more of these characteristics in order to detect the event.

Figure 6 illustrates one manner of detecting a disturbance event in accordance with the present invention. A detector 70, which is preferably included in control module 54, receives signals from line 14 and monitors (step 72) the error code (e.g., CRC errors or the FEC error count) associated with the signals for occurrence of an error indication. If no error is detected (step 74), the detector remains in monitoring mode without further action. If an error is indicated by the error code, a counter is incremented (step 76) and the count is then compared with a predefined threshold (step 78). If the count does not exceed the threshold (step 78, ">N?"), the system remains in monitoring mode and continues to accumulate any detected errors. If the count exceeds the threshold (step 78, Y), the detector emits a "disturbance event" detection signal (step 80) which causes the transceiver in which the detector 70 is located to initiate the process of switching to the appropriate parameter set in the secondary table. The count is reset (line 81) when this occurs.

Instead of monitoring the error code for characteristic behavior (i.e., repeated error over successive frames), in accordance with the present invention one may monitor the amplitude and phase of the physical signals transmitting the data over the subchannel or of a pilot tone transmitted between modems. On the occurrence of a disturbance event, the amplitude and phase of the physical signal undergo significant change, i.e., the amplitude suddenly decreases and the phase suddenly shifts to a new value; thereafter, they maintain approximately their new values during successive frames. This behavior may be monitored as shown in Figure 7 in which a monitor 100 monitors, for example, the amplitude of a data signal or a pilot tone on line 14 and sets a flip-flop 102 to an "active" state ("Q") on detecting a change in the amplitude of greater than a predefined threshold value. Flip-flop 102 enables (input "E") a counter 104 connected to receive counting pulses from a frame counter 106 whenever a new frame is transmitted or received by the modem. These counting pulses are also applied to a threshold counter 108 which accumulates the counts applied to it until it reaches a defined count and then applies the resultant count to a comparator 110 where it is compared with the count in counter 104. If the contents of the counters 104 and 108 are equal, comparator 110 provides an output ("Y") which causes the transceiver to initiate the process of switching to the appropriate table. This also resets the counters 104, 108 and the flip-flop 102. These are also reset (input "R") if the counts of counters 104 and 108 do not match ("N" output of comparator 110).

A similar procedure may be used to generate the table-switching signal based on monitoring the phase change of data signals or pilot tones as noted above. Further, although the operation of the event detector of figure 8 has been explained largely in terms of hardware, it will be understood that it may also readily be implemented in software, or in a combination of hardware and software, as is true of most of the elements described herein.

Still a further approach to detecting a disturbance event is to monitor the disturbance event directly. For example, in the case of off-hook or on-hook signals, a 48 volt dc step voltage is applied to the subscriber line. This signal is sufficiently distinct from other signals as to be readily detectable directly simply by monitoring the line for a step voltage of this size and thereafter generating a table-switching signal in response to its

detection. Another approach is to monitor the SNR on one or more subchannels by monitoring the "sync" frames. The presence of a disturbance from data sources on adjacent phone lines manifests itself as a change in the subchannel SNR. A direct method of monitoring disturbance events caused by activation or deactivation of communication-disturbing devices is to directly signal between the device and the local modem on occurrence of either of these events. As shown in Figure 3, for example, signaling lines 35, 37 may be extended directly between the local modem 34' and its associated devices 31, 32 to directly signal a change in these devices, such as their activation ("off hook") or deactivation ("on hook").

In addition to changing the control tables in response to a disturbance event, it is desirable to decrease the upstream transmit power level in order to minimize the interference with the voice communications caused by upstream transmissions, as well as to reduce the leakage of these transmissions into the downstream signal ("echo"). These interferences arise from nonlinearities caused by devices such as telephones that are coupled to the line, especially when the telephones are off-hook. The amount of power reduction required to render the interferences acceptable varies from one telephone to the next. In the preferred embodiment of the invention, a probing signal is used to determine the required decrease in upstream transmit power. In particular, after detecting a disturbance event such as activation or deactivation of a telephone or interference from other sources which can disrupt communications, the transmitter portion of the ATU-R (the "upstream transmitter") transmits a test signal over the subscriber line at varying power levels and measures the echo at the receiver portion of the ATU-R (the "downstream receiver"). The resultant measurement is used to determine an upstream transmission power level that minimizes echo at the downstream receiver or that at least renders it acceptable. The new power level, of course, is typically associated with a corresponding new parameter set in the channel control parameters.

In addition to changing the bit allocation and gain parameters in response to a disturbance event, it is generally necessary to change one or both of the subchannel equalizers, (i.e., the time-domain equalizers or the frequency-domain equalizers), as well as the echo canceller. Appropriate sets of these parameters may be formed in advance in the same manner as the bit allocations and channel gains (i.e., in a preliminary training

session, sending test communications over the subscriber line with various devices connected to the line activated, measuring the resultant communication conditions, and determining the various parameters based on the measurements), and stored in the secondary channel control table for recall and use as required. Alternatively, they may be redetermined quickly during a retraining operation following detection of a disturbance event and without excessivley disrupting communications, since these parameters are local to the receiver and thus need not be transmitted to the other modem in the communications pair.

In particular, in accordance with the preferred embodiment of the invention, on detecting a disturbance event, the transceivers enter a "fast retrain" phase, as shown in more detail in Figure 8. A common disturbance event is taking a telephone off hook or replacing it on hook, and this is commonly detected at the ATU-R. The fast retrain process will be illustrated for such an event, although it will be understood that it is not limited to this, and that the retrain may be initiated for any type of disturbance event, and at either end of the communication. Thus, on detecting such an event (Figure 8, event 200), the ATU-R notifies the ATU-C (step 202) to enter the fast retrain mode. The notification is preferably performed by transmitting a specific tone to the ATU-C, but may also comprise a message or other form of communication. On receiving this notification (step 204), the ATU-C awaits notification from the ATU-R of the power levels to be used for subsequent communications. This includes at least the upstream power level, and may include the downstream power level as well, since changing the upstream power level may impact downstream communications to some extent. For purposes of completeness, it will be assumed that both of these power levels are to be changed, although it will be understood that in many cases, only the upstream power level will be changed.

The new power levels to be used are determined by the ATU-R (step 208), which transmits a channel-probing test signal to the upstream transceiver and measures the resultant echo at the downstream receiver; it then sets the upstream power level to minimize the echo into the downstream signal, and may also set the downstream power level to minimize the effects of leakage of the upstream transmission into the downstream transmission at the upstream transmitter. The ATU-R then communicates (steps 210, 212) to the ATU-C the selected upstream and downstream transmission levels, e.g., by transmit-

ting to the upstream transceiver one or more tones modulated by binary PSK (phase shift keying) signals to ensure robust communication of the power levels. The power levels may be specified directly (e.g., as "-30dbm"), or indirectly (e.g., as "level 3" of a predefined group of levels), and the specification may identify the actual value of the power level, or simply the change in power level to be effectuated.

The ATU-R (step 214) and ATU-C (step 216) next commence transmission at the new power levels for purposes of retraining the equalizers and echo cancellers. Preferably, the change to the new power levels is synchronized through use of frame counters which are used in DSL systems to align transmitters and receivers, but the synchronization may be accomplished by other means (e.g., by transmitting a tone or message or by simply sending a flag) or may be left unsynchronized. Based on the training transmission, the ATU-R and ATU-C determine (steps 218, 220) the time and frequency domain equalizer parameters appropriate to the new power levels, as well as the appropriate echo canceller coefficients. The determination may include calculations based on these measurements in order to determine the coefficients, or the measurements may be used to select a particular set or sets of coefficients from one or more precalculated sets stored at the ATU-R and ATU-C, respectively.

For example, as was the case with determination of the power levels responsive to a disturbance event, the SNRs on various subchannels may be used to identify a particular device or devices associated with the event and thus to select an appropriate prestored parameter set stored at the ATU-R and ATU-C, respectively, simply by transmitting to the other modem in the communication pair a message or tone set that specifies the number of the parameter set to be used for subsequent communications. The SNR measurements thus serve as a "signature" of the device or devices associated with the disturbance event, and allow rapid identification of these devices. This approach can significantly reduce the time required to retrain the equalizers and echo cancellers. And even if training is required under particular circumstances, the training time can be meaningfully reduced by using prestored coefficients as the starting point.

To facilitate use of the SNR measurements in retrieving corresponding parameter sets, it is desirable that the various parameter sets as stored be indexed to sets of SNRs, so that one or more parameter sets associated with particular communication conditions

may quickly be identified and retrieved. One way in which this may be accomplished is shown in Fig. 9A in which the respective parameter sets such as a first set 250, a second set 252, etc. have, in addition to the subchannel (SC) number 254 and the corresponding bit allocation (BA) and gain (G) entries, a SNR entry 260 characteristic of the parameter set appropriate to a given communication condition, such as "on-hook" (table 250), "off-hook" (table 252), etc. Additional parameter sets such as frequency domain equalizer coefficients, time domain equalizer coefficients, and echo cancellation coefficients may also be stored in the tables, as would be appropriate for the receiver portion of the modem; for the transmitter portion, these coefficients are not applicable and thus are not stored.

An alternative means of linking the subchannel SNRs and the corresponding parameter sets is shown in Figure 9B. As there shown, a simple list structure 270 comprises a parameter set identifier 272, and a multiplicity of SNR measures 274, 276, etc. SNRs for some or all of the subchannels may be included. The list may be searched measure for measure to identify the nearest match to a stored parameter set, and that set then retrieved for subsequent use. In either Figure 9A or 9B the parameter set indexed to the SNRs may be a set of multiple parameters, such as bit allocations and gains, among others, of may comprise a single set such bit allocations only, or gains, only, etc.

The identification of the channel control parameter sets to be used for the subsequent communications is exchanged between the transceivers (steps 226-232) which then switch to these parameter sets (234, 236) and commence communications under the new conditions. The message containing the channel control parameters is preferably modulated in a similar manner as the "power level" message, i.e., using several modulating tones with BPSK signaling. The message is therefore short and very robust. It is important that it be short so that the fast retrain time is minimized, since the modem is not transmitting or receiving data during this time and its temporary unavailability may thus be very noticeable, as would be the case, for example, when the modem is being used for video transmission, or internet access, etc. Similarly, it is important that the message transmission be robust , since error-free communication during a disturbance event is very difficult, due to decreased SNR, impulse noise from ringing or dialing, or the like. Thus, the provision and utilization of pre-stored parameter sets significantly enhances the reli-

ability of communications despite the absence of a splitter at at least one of the modems and despite the presence of disturbance events concurrent with data communications.

It is expected that the modems described herein will most commonly be used in dedicated pairs, i.e., each subscriber (ATU-R) modem will communicate with a dedicated central office (ATU-C) modem. However, in certain cases it may suffice to provide a single master central office modem to service two or more subscriber modems. The present invention accommodates that eventuality as well. Thus, in Figure 10, a central office modem 280 communicates through a switch 282 with a plurality of subscriber modems 284, 286, 288 over subscriber lines 290, 292, 294. The modems may be located at differing distances from the central office and in different communication environments, and thus the channel control tables of each may be unique among themselves. Accordingly, the central office modem stores a master set 296 of individual channel control parameter sets 298, 300, 302, etc., one set (both transmit and receive) for each subscriber modem. On initiating communications to a particular subscriber, the central office modem retrieves the appropriate transmission parameter set for the subscriber and uses it in the subsequent communications. Similarly, on initiating communications to the central office, a given subscriber modem identifies itself to enable the central office modem to retrieve the appropriate reception parameter set for that subscriber.

CONCLUSION

From the foregoing it will be seen that we have provided an improved communications system for communication over subchannels of limited bandwidth such as ordinary residential telephone lines. The system accommodates both voice and data communications over the lines simultaneously, and eliminates the need for the installation and use of "splitters", an expense that might otherwise inhibit the adoption and use of the high communication capacity offered by DSL systems. Thus, it may be implemented and used as widely as conventional modems are today, but offers significantly greater bandwidth than is currently attainable with such modems.

CLAIMS

1. Apparatus for use in connection with a wireline data communication system carrying data in a multiplicity of different frequency bands which may be present concurrently on the line, comprising

A. means for detecting a signaling event associated with at least a first of said bands;

B. means responsive to said detecting means for modifying the processing of signals transmitted over at least a second of said bands.

2. Apparatus for use in connection with a wireline data communication system carrying data in a multiplicity of different frequency bands which may be present concurrently on the line and including means responsive to a signal resulting from a disturbance event to modify the transmission of data over said line.

3. Apparatus according to claim 2 in which said signal is a collection of PSK modulated tones.

4. Apparatus according to claim 2 in which said disturbance event is an on-hook to off-hook transition.

5. Apparatus according to claim 2 in which said disturbance event is off-hook to on-hook transition

6. Apparatus according to claim 2 in which said disturbance event is caused by a change in the crosstalk environment.

7. Apparatus according to claim 2 in which said modification of transmission includes sending a sequence of reference frames.

8. Apparatus according to claim 2 in which said modification of transmissionincludes entering a fast retrain mode.

9. Apparatus according to claim 1 in which said detecting means comprises

(1) means for measuring, at a multiplicity of different times, a characteristic of a signal transmitted over said wireline

(2) means for activating said modifying means when samples of the measured characteristics differ in a defined manner at selected different times.

10. Apparatus according to claim 9 in which said measuring means measures the extent of errors in error-correcting code associated with the signals whose processing is to be modified and activates said modifying means only when the extent of said errors exceeds a defined threshold for at least a defined number of times.

11. Apparatus according to claim 10 in which said measuring means activates said modifying means only when the number of errors in each said sample exceeds a defined number in each of two or more samples.

12. Apparatus according to claim 9 in which said measuring means measures a characteristic of signals transmitted over a plurality of different frequency bands and activates said modifying means only when the measured characteristic exceeds defined thresholds associated with each of said plurality of frequency bands.

13. Apparatus according to claim 1 in which said wireline data communication system comprises a telephone subscriber loop carrying both voice and data signals, and in which said signaling event comprises an off-hook event.

14. Apparatus according to claim 1 in which said wireline data communication system comprises a telephone subscriber loop carrying both voice and data signals, and in which said signaling event comprises an on-hook event.

15. Apparatus according to claim 14 which includes a frequency domain equalizer for equalizing the frequency characteristics of each of said frequency bands in accordance with reference signals transmitted over said bands and in which said modifying means comprises means for changing the characteristics of said equalizers in accordance with

measurements on said reference signals.

16. Apparatus according to claim 9 in which said measuring means measures the signal-to-noise ratio of said reference signals and activates said modifying means only when said ratio is less than a defined threshold for at least a defined number of times

17. Apparatus according to claim 9 in which said data communication system includes means for transmitting a pilot tone and in which said apparatus includes means for measuring at least one characteristic of said tone at different times and means for activating said modifying means only when said characteristics manifest changes exceeding a defined threshold for at least a defined number of times.

18. Apparatus according to claim 9 which includes means for transmitting over said wireline information back to a source of said information signals, said means transmitting at a first power level in the absence of detection of a signaling event, and transmitting at a different power level responsive to detection of a signaling event.

19. Apparatus according to claim 9 which includes a first set of stored parameters for use in processing said information when said system is in a first state.

20. Apparatus according to claim 19 which further includes a second set of stored parameters for processing said information when said system switches to a second state responsive to detecting a signaling event.

21. Apparatus according to claim 20 in which said second set is precomputed.

22. Apparatus according to claim 21 in which said second set is computed responsive to reference signals received on said subchannel subsequent to detection of a signaling event.

23. Apparatus according to claim 21 in which said first and second sets are computed on initiating a communications session.

24. Apparatus according to claim 1 including means for varying the data rate at which said modifying meansprocesses said signals.

25. In a modem communicating data over a multiplicity of discrete sub-subchannels, each

characterized by a bit allocation parameter defining the allocation of bits to the corresponding subchannel for communication over said subchannel, the improvement comprising:

A. means for storing a first channel control table for allocating bits to said subchannel during a first communication condition;

B. means defining a second channel control table for allocating bits to said table during a second communication condition;

26. A modem according to claim 25 which includes a

means for switching between said tables on the detection of a defined event.

27. A modem according to claim 25 in which said first table establishes the communications capabilities of said modem during normal operation.

28. A modem according to claim 27 in which said second table establishes the communications capabilities of said modem during diminished operation.

29. A modem according to claim 25 in which said defined event includes signaling events comprising transitions between on-hook and off-hook conditions.

30. A modem according to claim 29 in which said first table defines communications in the absence of a signaling event.

31. A modem according to claim 30 in which said second table defines communications responsive to detection of a signaling event.

32. A modem according to claim 31 in which said switching means switches from said second table to said first table on detection of a signaling event indicative of cessation of a previously-detected signaling event.

33. A modem according to claim 25 in which said first and second tables are determined during an initialization session in which the communication capabilities of said sub-subchannels are determined.

34. A modem according to claim 33 in which said first table is determined in the absence of interfering signaling conditions.

35. A modem according to claim 34 in which said second table is determined as a function of said first table.

36. A modem according to claim 35 in which the bit allocations of said second table are determined as a percentage of the bit allocations of said first table.

37. A modem according to claim 27 in which the bit allocations of second table are determined by adding noise margins to the determination of the bit allocations of the corresponding sub-subchannels of said first table.

38. A modem according to claim 25 in which said second channel control table is determined responsive to a plurality of signaling events created by a corresponding plurality of event-generating sources, each defining a channel control table specific to the given source, and comprises a composite table formed by selecting, for each sub-subchannel, the minimum bit allocation for the corresponding sub-subchannel of the table associated with each of the plurality of sources.

39. A modem according to claim 25 in which said second channel control table is selected from a plurality of tables determined responsive to a plurality of signaling events created by a corresponding plurality of event-generating sources, each defining a channel control table specific to the given source.

40. A modem according to claim 39 which includes means for selecting one of said plurality of tables for use as said second table in accordance with the source generating an event.

41. A modem according to claim 25 which further includes:

C. means for redetermining said channel control tables while said modem is in either of said communication conditions; and

D. means for communicating a redetermined table to a second modem en-

gaged in communication with said modem.

42. A modem according to claim 41 in which said communicating means communicates said redetermined table over a dedicated sub-subchannel selected from among said discrete sub-subchannels.

43. A modem according to claim 41 in which said communicating means further communicates to said second modem information identifying the type of said redetermined table.

44. A modem for use in asymmetric digital subscriber loop communications having both upstream and downstream communication subchannels formed from a plurality of sub-subchannels, said loop adapted to carry both voice and data communications thereon, comprising:

A. means for storing a first table defining data communications between said modem and a second modem connected to said loop during a first communication state;

B. means for storing a second table defining data communications between said modem and said second modem during a second communication state.

45. A modem according to claim 44 that includesmeans for switching between said tables responsive to the occurrence of selected events.

46. A modem for use in asymmetric digital subscriber loop communications having both upstream and downstream communication subchannels formed from a plurality of sub-subchannels, said loop adapted to carry both voice and data communications thereon, comprising:

A. means for storing a first table defining data communications between said modem and a second modem connected to said loop during a first communication state;

B. means for storing a second table defining data communications between said modem and said second modem during a second communication state; and

C. means for selecting between said tables based on signals received from

said second modem.

47. A modem according to claim 44 which includes:

D. means for detecting said selected events, said means including

(1) means for monitoring a selected characteristic of at least one of said communication subchannels during a plurality of communication intervals;

(2) means for determining differences in the selected characteristic over said plurality of intervals;

(3) means for generating a signal initiating switching of said tables when said differences exhibit a defined pattern.

48. A modem according to claim 47 in which said pattern comprises an initial difference above a first threshold amount followed by at least a subsequent differences less than a second threshold amount.

49. A modem according to claim 48 in which said first threshold is greater than said second threshold.

50. A modem according to claim 49 in which said pattern comprises an initial difference above a first threshold amount followed by a plurality of subsequent differences less than a second threshold amount.

51. A modem according to claim 48 in which said selected characteristic is monitored over at least one sub-subchannel.

52. A modem according to claim 48 in which said selected characteristic is monitored over a plurality of sub-subchannels.

53. A modem according to claim 52 which includes means for averaging the monitored values of said selected characteristic over said sub-subchannels for use in comparing said initial difference to said first threshold.

54. A modem according to claim 52 which includes means for averaging the monitored

values of said selected characteristic over said sub-subchannels for use in comparing said subsequent difference to said second threshold.

55. A modem according to claim 49 in which said characteristic comprises an error code error.

56. A modem according to claim 49 in which said characteristic comprises a signal-to-noise ratio.

57. A modem according to claim in which said characteristic comprises a parameter of a pilot tone.

58. A modem according to claim 44 in which said first table establishes a data rate greater than that of said second table.

59. A modem according to claim 58 in which said tables define the number of bits transmitted over the respective sub-subchannels.

60. A modem according to claim 59 in which said events comprise signaling events selected from the group comprising off-hook, on-hook, ringing, and busy.

61. A modem according to claim 47 in which said switching means returns said modem to said first communication state on termination of the event causing the switching.

62. A modem according to claim 44 which includes:

D. means for emitting into said loop a test signal for probing the return characteristics of transmissions into the loop by said modem; and

E. means for limiting the power level of said transmissions in accordance with the measured return characteristics.

63. A modem according to claim 62 in which said probe comprises a tone at a defined amplitude and frequency and in which the measured return characteristics comprise at least one characteristic selected from the group comprising the amplitude and frequency of the signal returned to said modem in response to emission of said tone.

64. A modem according to claim 62 in which said probe comprises a plurality of tones at defined amplitudes and frequencies and in which the measured return characteristics comprise at least one characteristic selected from the group comprising the amplitudes and frequencies of the signal returned to said modem in response to emission of said tone.

65. A modem according to claim 44 which includes equalizers for equalizing the transmission characteristics of said subchannels and in which said tables define:;

(1) coefficients of time domain equalizers or

(2) coefficients of frequency domain equalizers or

(3) coefficients of digital echo cancellers

66. A modem according to claim 44 in which said first table is determined during an initialization process in the absence of a selected event.

67. A modem according to claim 66 in which said second table is determined during an initialization process in the presence of a selected event.

68. A modem according to claim 67 in which said second table is redetermined responsive to occurrence of a selected event.

69. A modem according to claim 68 in which redetermined tables are communicated from a given modem to other modems with which it is in communication during a quiescent state.

70. A modem according to claim 47 in which said generating means causes transmission of a switch-control signal over one of said sub-subchannels in response to detection of a selected event.

71. A modem according to claim 47 in which said generating means causes transmission of a tone in response to detection of a selected event.

72. Apparatus for use in communicating digital data over a digital subscriber line concurrent with voice communications over said line, comprising:

A. a transceiver for communicating digital data to and from said line;

B. a first storage element for storing a first set of communication parameters for use in communicating data under a first communication condition; and

C. a second storage element for storing a second set of communication parameters for use in communicating data under a second communication condition.

73. Apparatus according to claim 72 including a means for monitoring communication conditions on said line and for switching between said first and second sets of communication parameters responsive to changes between said communication conditions.

74. Apparatus according to claim 72 including means responsive to signals communicated to it to switch between said sets of communicaton parameters.

75. Apparatus according to claim 72 which communicates said data over a plurality of subchannels of different frequency and at least potentially different information-carrying capacity and in which said communication parameters comprise at least a channel control table defining the number of bits to be allocated to the subchannels for communications under the respective conditions.

76. Apparatus according to claim 72 which communicates said data over a plurality of subchannels of different frequency and at least potentially different information-carrying capacity and in which said communication parameters comprise subchannel gain tables defining the gain characteristics of the subchannels for communications under the respective conditions.

77. Apparatus according to claim 72 which communicates said data over a plurality of subchannels of different frequency and at least potentially different information-carrying capacity and in which said communication parameters comprise frequency domain equalizers defining the frequency characteristics of the subchannels for communications under the respective conditions.

78. Apparatus according to claim 72 in which both sets of communication parameters are determined during an initialization interval preceding communication of working data.

79. Apparatus according to claim 72 in which said first set of communication parameters is determined during an initialization interval preceding communication of working data and said second set of parameters is determined during a subsequent interval following communication of working data and characterized by said second communications conditions.

80. Apparatus according to claim 79 in which said second set of communication parameters is determined at a first transceiver of a transceiver pair in communication with each other and is communicated to a second transceiver in said pair during a time when said transceivers are operating with an earlier set of set of secondary parameters.

81. Apparatus according to claim 80 in which said transceivers revert to said first set of communications parameters responsive to return of communications to a first communications condition.

82. Apparatus according to claim 72 which includes means for signaling between said transceivers a desired change in communications parameters.

83. Apparatus according to claim 82 in which said signaling means comprises means for transmitting messages over one or more subchannels.

84. Apparatus according to claim 82 in which said signaling means comprises means for transmitting messages over one or more subchannels intermediate subchannels used for upstream and downstream communications.

85. Apparatus according to claim 83 in which said messages comprise tones.

86. Apparatus according to claim 72 in which said transceiver transmits and receives data over a defined number of subchannels and which includes means for identifying the subchannels over which said transceivers will communicate with each other.

87. Apparatus according to claim 86 in which said identifying means includes means for nulling at least those portions of the stored sets of communications parameters that define the bit capacity of the subchanels that are being excluded from communications.

88. Apparatus according to claim 72 in which said second set of parameters includes communication parameters corresponding to a plurality of devices connected for voice communications over said line.

89. Apparatus according to claim 80 in which said second set of parameters includes a plurality of subsets of communications parameters characteristic of a corresponding plurality of voice communication devices for defining communications when a selected device is active.

90. Apparatus according to claim 89 including means for identifying which of said plurality of devices is active and for selecting the corresponding communications parameter set for such device.

91. Apparatus according to claim 90 in which said identifying means includes signaling means interconnecting said voice communication devices to said transceiver.

92. In a communication system using discrete multitone modulation, the improvement comprising storing a first channel control table for use in defining communications under a first communication state and storing at least a second channel control table for communication under a second communication state.

93. A modem for use in symmetric or asymmetric digital subscriber loop communications having both upstream and downstream communication subchannels formed from a plurality of sub-subchannels, comprising:

A. means for storing a first table defining data communications between said modem and a second modem connected to said loop during a first communication state;

B. means for storing a second table defining data communications between said modem and said second modem during a second communication state:

94. A modem according to claim 93 that includes means for switching between said tables responsive to the occurrence of selected events.

95. A modem according to claim 94 in which said selected event includes a transition

from on-hook to off-hook.

96. A modem according to claim 94 in which said selected event includes a transition from off-hook to on-hook.

97. A modem according to claim 94 in which said selected event includes a change in the crosstalk environment.

98. A modem according to claim 93 that includes means for switching between said tables based upon reception of a signal from a remote modem.

99. A modem according to claim 98 in which said signal includes a message.

100. A modem according to claim 98 in which said signal includes a tone or set of tones.

101. A modem according to claim 98 in which said signal includes a flag.

102. A modem according to claim 93 that includes means for switching between said tables at a time that depends upon a frame counter.

103. A modem according to claim 93 that includes means for switching between said tables at a time that depends upon a flag.

104. A multicarrier modem for use in symmetric or asymmetric digital subscriber loop communications having both upstream and downstream communication subchannels formed from a plurality of subchannels that includes a means to select the number of said subchannels that are to be used for communications based upon a signal from a remote modem.

105. A modem according to claim 104 in which said signal is received prior to initialization of modem.

106. A modem according to claim 104 in which said signal is a message dictating how many subchannels are to be used.

107. A modem according to claim 104 in which said signal is a message selecting one of a collection of candidate subchannel selections.

108. A modem according to claim 104 in which said signal is a tone or collection of tones selecting one of a collection of candidate subchannel selections.

109. A multicarrier modem for use in symmetric or asymmetric digital subscriber loop communications having both upstream and downstream communication subchannels formed from a plurality of subchannels that includes a means to signal to a remote modem the number of said subchannels that are to be used for communications.

110. A modem according to claim 109 in which said signal is transmitted prior to initialization of modem.

111. A modem according to claim 109 in which said signal is a message dictating how many subchannels are to be used.

112. A modem according to claim 109 in which said signal is a message selecting one of a collection of candidate subchannel selections.

113. A modem according to claim 109 in which said signal is a tone or collection of tones selecting one of a collection of candidate subchannel selections.

114. A multicarrier modem for use in symmetric or asymmetric digital subscriber loop communications having both upstream and downstream communication subchannels formed from a plurality of subchannels, comprising of a means to limit the number of transmission subchannels in order to communicate with a remote modem that is only capable of receiving the limited frequency band.

115. A multicarrier modem for use in symmetric or asymmetric digital subscriber loop communications having both upstream and downstream communication subchannels formed from a plurality of subchannels, comprising of a means to limit the number of receiver subchannels in order to communicate with a remote modem that is only capable of transmitting the limited frequency band.

116. A multicarrier modem that for use in symmetric or asymmetric digital subscriber loop communications having both upstream and downstream communication subchannels

formed from a plurality of subchannels, comprising of a means to determine the location of a telephone that would benefit from the use of a low pass filter.

117. A multicarrier modem according to claim 116 in which said determination means includes monitoring the signal to noise ratio when said telephone goes off-hook.

118. A multicarrier modem according to claim 116 in which said determination means includes monitoring the echo response of the transmitted signal when said telephone goes off-hook.

119. In a modem communicating data over a wireline via a multiplicity of discrete sub-channels in accordance with a bit-loading specification defining the allocation of bits to the corresponding subchannel for communication thereon, the improvement comprising:

A irst means for storing a primary bit allocation table for allocating said bits during a first communication condition; and

B. second means for storing a secondary bit allocation table for allocating said bits during a second communication condition.

120. A modem according to claim 119 which includes means for switching between bit allocation sets defined by said tables.

121. A modem according to claim 120 in which said switching means is actuated responsive to at least one of the events comprising receipt of a message, a tone, or a flag from a remote modem.

122. A modem according to claim 121 in which switching means includes the use of a frame counter to designate when said switch is to occur.

123. A modem according to claim 119 in which said primary bit allocation table defines communications in the absence of a disturbance event, and in which said secondary bit allocation table defines communications in response to said disturbance event.

124. A modem according to claim 123 in which said secondary bit allocation table defines communications over said subchannels for times when said subchannels are affected by

voice communication activities.

125. A modem according to claim 124 in which said secondary bit allocation table defines communications over said subchannels for times when said subchannels are affected by voice communication devices that have entered the off-hook state.

126. A modem according to claim 124 in which said primary bit allocation table defines communications over said subchannels for times when said subchannels are affected by voice communication devices that have returned from an off-hook state.

127. A modem according to claim 119 in which said primary table is determined in a preliminary training session in which potentially interfering voice communication devices connected to the line are inactive.

128. A modem according to claim 119 in which said primary table is determined in the absence of disturbance events.

129. A modem according to claim 119 in which said primary bit allocation table is determined in advance of installation of said modem.

130. A modem according to claim 119 in which said secondary table is determined in an initial training session based on measurements of communications over said wireline.

131. A modem according to claim 119 in which said secondary table is determined in initial training sessions based on measurements of communications over said wireline with potentially interfering voice communication devices connected to the line selectively activated to thereby form a secondary table comprising a plurality of bit allocation sets corresponding to the plurality of activated devices.

132. A modem according to claim 131 in which said devices are activated one by one so that each bit allocation set corresponds to a single device.

133. A modem according to claim 131 in which said devices are activated in groups of two or more so that each bit allocation set corresponds to one of said groups.

134. A modem according to claim 119 in which said secondary bit allocation table is de-

termined from said primary bit allocation table.

135. A modem according to claim 119 in which the bit allocations of said secondary table are determined as a percentage of the bit allocations of said primary table.

136. A modem according to claim 119 in which the bit allocations of said secondary table are determined based on a percentage of the signal to noise ratios on which the bit allocations of said primary table are determined.

137. A modem according to claim 119 in which the bit allocations of said secondary table are determined based on information defining said primary table but using a different bit error rate

138. A modem according to claim 119 in which said secondary bit allocation table is formed as a composite of the bit loading sets of a multiplicity of voice communication devices and/or disturbances.

139 A modem according to claim 119 in which the bit allocation value for each subchannel in said composite is the worst-case value for the corresponding subchannel in the bit allocation sets defining said devices and/or disturbances.

140. A modem according to claim 119 in which said secondary bit allocation table is determined by adding a power margin to the calculations for the respective entries of the primary table.

141. A modem according to claim 119 in which said secondary table comprises a set of bit allocation tables defining the bit allocations for a corresponding set of devices that may be connected to said wireline.

142. A modem according to claim 119 in which said secondary table comprises a set of bit allocation tables defining the bit allocations for a corresponding set of disturbances on said wireline.

143. A modem according to claim 119 in which said secondary table comprises a set of bit allocation tables defining the bit allocations for a corresponding set of devices and

disturbances on said wireline.

144. A modem according to claim 119 in which a plurality of secondary bit allocation tables are determined by adding a corresponding plurality of power margins to the calculations for the respective entries of the primary table, each secondary table so determined corresponding to a different communications state.

145. A modem according to claim 119 in which said power margin is substantially uniform across the entries of a table.

146. A modem according to claim 119 in which said power margin varies across the entries of a table.

147. A modem according to claim 119 configured to switch to a secondary state corresponding to use of said secondary bit allocation table for communications responsive to occurrence of a disturbance event.

148. A modem according to claim 147 configured to switch to a primary state corresponding to use of said primary bit allocation table for communications responsive to cessation of a disturbance event.

149. A modem according to claim 147 configured to switch to a different secondary state corresponding to use of a different set of bit allocations in said secondary bit allocation table for communications responsive to occurrence of a further disturbance event, different from a disturbance event preceding it, while said modem is in said secondary state.

150. A modem according to claim 119 in which said switching means includes means responsive to a disturbance event to thereby initiate a switch between said tables.

151. A modem according to claim 150 which includes a signaling line connecting a device to said modem for signaling to said modem the occurrence of a disturbance event.

152. A modem according to claim 150 which includes means for detecting a disturbance event on said line.

153. A modem according to claim 152 in which said detecting means includes means for

monitoring the signal to noise ratios on one or more subchannels of said line and means responsive to said ratios for selecting a bit allocation set for use in communications.

154. A modem according to claim 152 in which said detecting means includes means for monitoring a parameter of a tone or collection of tones and means responsive to said parameter for selecting a bit allocation set for use in communications.

155. A modem according to claim 152 in which said parameter includes the amplitude and/or phase of said tone or tones.

156. In a modem communicating data over a wireline via a multiplicity of discrete subchannels in accordance with a gain specification defining the allocation of gains to the corresponding subchannel for communication thereon, the improvement comprising:

A. first means for storing a primary gain set for allocating said gains during a first communication condition; and

B. second means for storing a secondary gain set for allocating said gains during a second communication condition.

157. A modem according to claim 156 which includes means for switching between said gain sets.

158. A modem according to claim 157 in which said switching means is actuated responsive to at least one of the events comprising receipt of a message, a tone, or a flag from a remote modem.

159. A modem according to claim 157 in which said switching means is actuated responsive to its detection of a disturbance event.

160. A discrete multitone modem including a transmitter for communicating to a remote receiver at one of a plurality of power levels associated with particular communication conditions on a digital subscriber line, comprising

A. means for monitoring at least one parameter indicative of communication conditions on said line;

B. means dependent on said parameter for selecting the power level at which said modem either transmits, or receives, data or both.

161. A discrete multitone modem including a transmitter for communicating to a remote receiver at one of a plurality of power levels associated with particular communication conditions on a digital subscriber line and adapted to receive a power select signal indicating a power level to be used for subsequent transmissions.

162. A discrete multitone modem according to claim 160 which includes means for communicating to another modem with which it communicates a power select signal indicating a power level to be used for subsequent transmissions.

163 A discrete multitone modem according to claim 160 which includes means for receiving from another modem with which it communicates a power select signal indicating a power level to be used for subsequent transmissions.

164 A discrete multitone modem according to claim 160 in which said power select signal identifies a specific power level at which said other modem is to receive data from it.

165. A discrete multitone modem according to claim 162 in which said power select signal identifies a specific power level at which said other modem is to transmit data to it.

166. A discrete multitone modem according to either of claims 164 or 165in which said discrete power level comprises one of several predefined power levels for communication between said modems.

167. A discrete multitone modem according to claim 162 in which the means for communicating said power select signal includes means for transmitting said signal over at least one subchannel intermediate an upstream and a downstream set of data subchannels over which said modem communicates.

168. A discrete multitone modem according to claim 167 which the means for communicating said power select signal includes means for transmitting said signal over one or more data subchannels over which said modem communicates.

169. A discrete multitone modem according to claim 160 which includes a plurality of parameter sets stored in said modem and defining communications under a plurality of different communication conditions on said line.

170. A discrete multitone modem according to claim 169 in which said parameter sets include at least a primary set of parameters for controlling communications in the absence of a disturbance event, and a secondary set for controlling communications responsive to a disturbance event.

171. A discrete multitone modem according to claim 169 in which said monitoring means monitors the signal to noise ratio on one or more subchannels over which said modem communicates and selects a parameter set based on said ratio for controlling subsequent communications.

172. A discrete multitone modem according to claim 169 in which said parameter sets include a set of parameters defining the power level at which said modem transmits to other modems.

173. A discrete multitone modem according to 169 in which said parameter sets include a set of parameters defining the power level at which said modem receives communications from other modems.

174. A discrete multitone modem according to claim 173 in which said modem includes means for transmitting to another modem with which it is in communication a signal indicating a parameter set to be used in subsequent communications between said modems.

175. A discrete multitone modem according to claim 172 in which said modem includes means for receiving from another modem with which it is in communication a signal indicating a parameter set to be used in subsequent communications between said modems.

176. A discrete multitone modem according to claim 160 in which said modem communicates to another modem a desired power level by itself changing the power level at which it communicates with said other modem.

177. A discrete multitone modem including a transmitter for communicating to a remote receiver at one of a plurality of power levels associated with particular communication conditions on a digital subscriber line and storing a plurality of sets of channel control parameters corresponding to said power levels, comprising

A. means responsive to a disturbance event to select a power level at which said transmitter transmits to said receiver; and

B. means for communicating the selected power level to said receiver.

178. A discrete multitone modem including a transmitter for communicating to a remote receiver at one of a plurality of power levels associated with particular communication conditions on a digital subscriber line and storing a plurality of sets of channel control parameters corresponding to said power levels and adapted to receive a power select signal indicating a power level to be used for subsequent transmissions.

179. A discrete multitone modem according to claim 177 in which the means for communicating the change in power level transmits a power power select signal to the remote receiver indicative of the change in power level.

180. A discrete multitone modem according to claim 179 in which the transmitting means transmits a tone indicating the desired change in power level to the remote receiver.

181. A discrete multitone modem according to claim 179 in which the transmitting means transmits a plurality of tones indicating the desired change in power level to the remote receiver.

182. A discrete multitone modem according to claim 181 in which the plurality of tones designates a particular one of several power levels to which the remote receiver is to switch.

183. A discrete multitone modem according to claim 179 in which the means for communicating the change in power level designates a particular one of several power levels to which the remote receiver is to switch.

184. A discrete multitone modem according to claim 179 in which the means for communicating the change in power level to the remote receiver includes means for transmitting a power power select signal over at least one subchannel intermediate an upstream and a downstream set of data subchannels over which said modem communicates.

185. A discrete multitone modem according to claim 177 in which the means for communicating the change in power level to the remote receiver comprises

(1) means associated with the transmitter for effectuating the change in power level at said transmitter;

(2) means in the remote receiver responsive to the change in power level at the transmitter for changing the power level of its reception in accordance therewith.

186. A discrete multitone modem according to claim 177 in which the means for communicating the change in power level to the remote receiver transmits to the remote receiver a frame count at which the remote receiver is to effectuate the change in power level.

187. A discrete multitone modem according to claim 178 in which the means for receiving the power select signal inlcudes a frame count at which said modem is to effectuate the change in power level.

188. A discrete multitone modem according to claim 177 including a receiver responsive to communication of a power level change from a remote transmitter to thereby:

(1) measure at least one parameter indicative of communication conditions on said line responsive to said power level change, and

(2) select new channel control parameters from a plurality of sets of prestored channel control parameters based on said measurement.

189. A discrete multitone modem according to claim 188 which said at least one parameter comprises a signal to noise ratio of communications over said line.

190. A discrete multitone modem according to claim 188 which said at least one parameter comprises a characteristic of a monitor tone transmited over said line.

191. A discrete multitone modem according to claim 188 which said characteristic comprises at least the amplitude of said tone.

192. A discrete multitone modem according to claim 188 which said characteristic comprises at least the phase of said tone.

193. A discrete multitone modem according to claim 188 which said characteristic comprises at least the frequency of said tone.

194. A discrete multitone modem according to claim 189 in which said tone is transmitted over over at least one subchannel intermediate an upstream and a downstream set of data subchannels over which said modem communicates.

195. A discrete multitone modem according to claim 189 in which said signal to noise ratio is based on measurements of reference frames transmitted over said line.

196. A discrete multitone modem according to claim 26 in which said signal to noise ratio is based on measurements of data transmitted over said line.

197. A discrete multitone modem according to claim 177 in which the means responsive to a disturbance event comprises means for measuring at least one characteristic of said line indicative of communications on said line and for selecting a power level responsive to said measurement.

198. A discrete multitone modem according to claim 197 in which said characteristic comprises CRC errors and in which said measuring means signals a change in power level when said CRC errors exceed a defined threshold on a selected plurality of successive measurements thereof.

199. A discrete multitone modem according to claim 197 in which said characteristic comprises forward error correction coefficients and in which said measuring means signals a change in power level when the number of errors exceeds a defined threshold.

200. A discrete multitone modem according to claim 199 in which said measuring means signals a change in power level when the number of uncorrected errors exceeds a defined threshold.

201. A discrete multitone modem according to claim 199 in which the means for communicating the change in power level designates a single alternative power level to which the remote receiver is to switch.

202. A discrete multitone modem according to claim 177 which includes means in said modem for at least one parameter indicative of communication

203. A method of transmitting data over a wire line through upstream and downstream channels, respectively, from first and second pluralities of discrete-frequency subchannels, comprising the steps of:

A. storing at least first and second parameter sets defining data communications over said channels under at least two different communication conditions;

B. selecting a parameter set for use in communications in accordance with the prevailing communication condition.

204. The method of claim 203 in which said selecting step includes the step of monitoring communications on said line and transmitting and selecting said parameter set in accordance with said monitoring.

205. The method of claim 204 in which said monitoring step includes the step of measuring at least one communication indicium on said at least one subchannel.

206. The method of claim 205 in which said at least one indicium is selected from the group comprising signal to noise ratios, error rates, and the amplitude and frequency of tones.

207. The method of claims 203 or 206 which includes the step of transmitting over said line a signal that identifies the parameter set to be selected.

208. The method of claims 203 or 206 which includes the step of receiving over said line a signal that identifies the parameter set to be selected.

209. The method of claim 207 in which said signal is transmitted on a subchannel intermediate said upstream and downstream channels.

210. The method of claim 208 in which said signal is received on a subchannel intermediate said upstream and downstream channels.

211. The method of claims 203, 206 or 207 in which said first parameter set defines communications over said line in the absence of a disturbance event and said second parameter set defines communications over said line in the presence of a disturbance event.

212. The method of claims 203 or 211 in which said parameter sets include at least one parameter set from the group comprising subchannel bit allocations subcahnel gains.

213. The method of claims 203 or 211 in which said parameter sets include at least one parameter set from the group comprising subchannel frequency domain coefficients, time domain coefficients, and echo cancellation coefficients.

214. The method of claims 212 or 213 in which said parameter sets include a first section for use in transmitting data over said line and a second portion for receiving data over said line.

215. A method of transmitting data over a wire line through upstream and downstream channels, respectively, from first and second pluralities of discrete-frequency subchannels, comprising the steps of:

A. signaling over said line to a remote receiver the intention to transmit data over said line at a selected one of a plurality of predefined power levels;

B. transmitting data over said line at said selected power level

216. The method of claims 214 or 219 which includes the step of monitoring communications conditions on said line and selecting said power level in accordance therewith.

217. The method of claims 215 or 219 in which the step of selecting said power level includes the step of selecting a first power level in response to detecting the absence of a disturbance event and selecting a second power level in response to detecting the presence of a disturbance event.

218. The method f claim 217 in which said second power level is selected from a group of at least two power levels.

219. A method of transmitting data over a wire line through upstream and downstream channels, respectively, from first and second pluralities of discrete-frequency subchannels, comprising the steps of:

A. signaling to a remote receiver at one of a plurality of power levels;

B. receiving a signal from a receiver that determines said power levels.

220. The method of claim 219 in which said power levels are selected from a plurality of predetermined power levels having corresponding pre-stored parameter sets.

221. The method of claim 219 in which said power levels are received via said signal from said remote receiver.

222. The method of claim 219 in which said signal includes at least one signal selected from the group comprising a message, a tone, a collection of tones, or a flag.

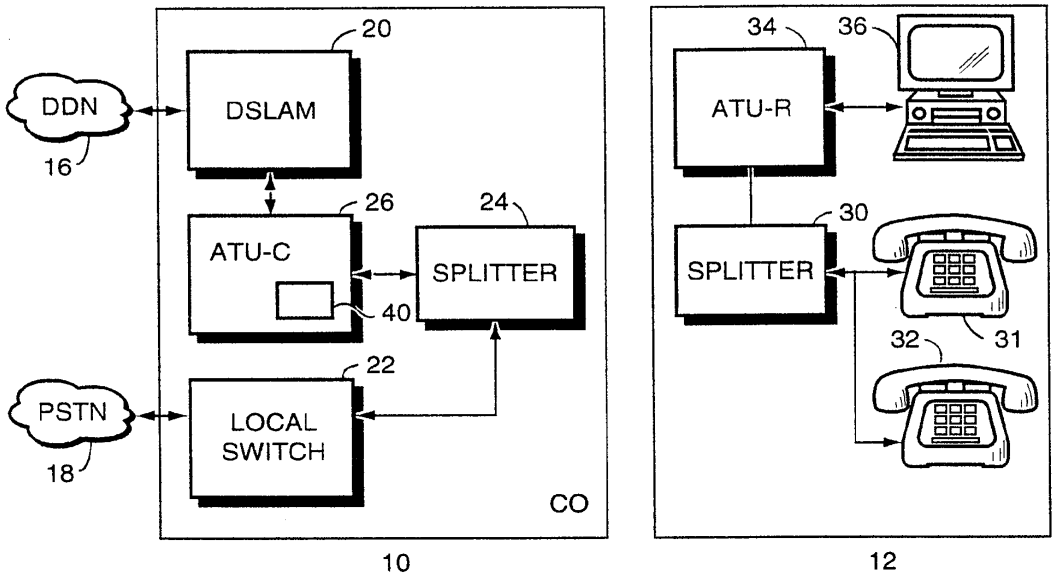

FIG. 1 (PRIOR ART)

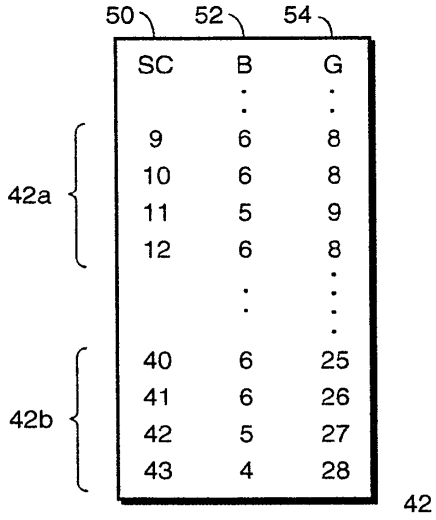

FIG. 2 (PRIOR ART)

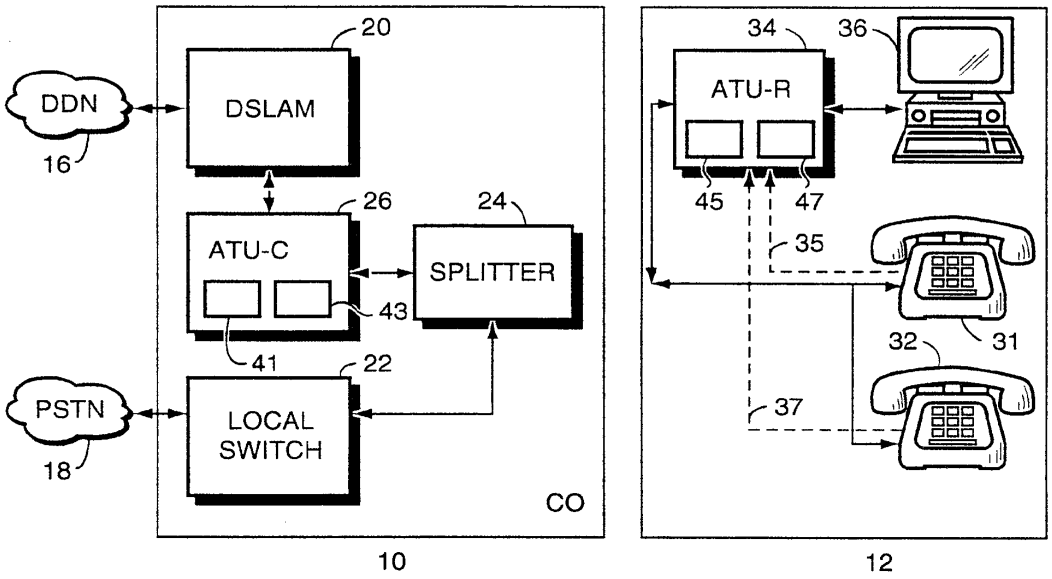
DDN
16
DSLAM
20
ATU-C
26
SPLITTER
24
43
41
PSTN
18
LOCAL SWITCH
22
CO
10
ATU-R
34
36
45
47
35
32
31
37
12

FIG. 3

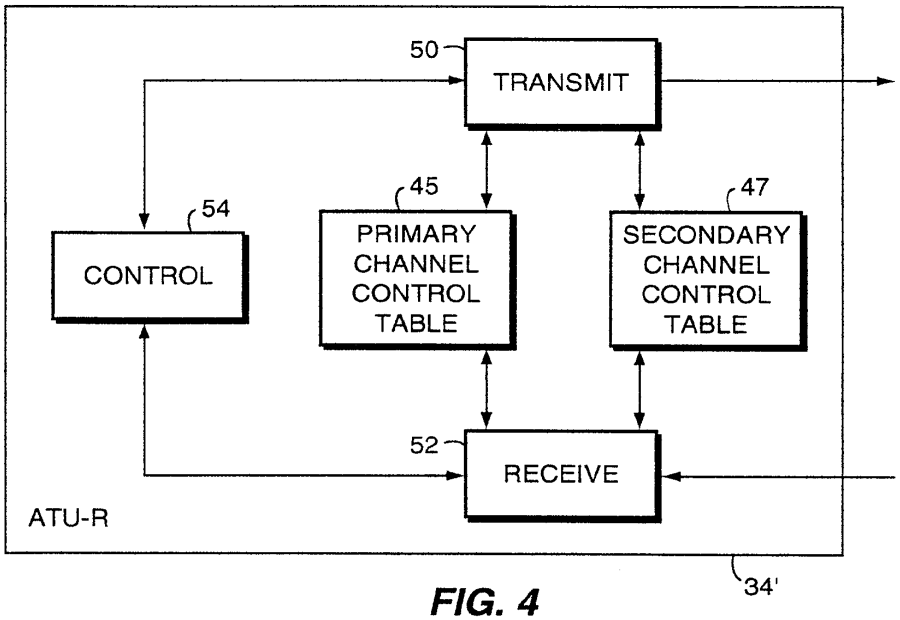
50
TRANSMIT
54
CONTROL
45
PRIMARY CHANNEL CONTROL TABLE
47
SECONDARY CHANNEL CONTROL TABLE
52
RECEIVE
ATU-R
34'

FIG. 4

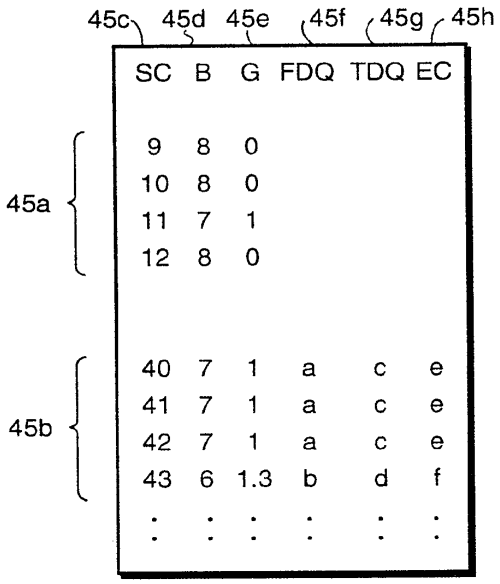
45c
45d
45e
45f
45g
45h
SC B G FDQ TDQ EC
45a
9 8 0
10 8 0
11 7 1
12 8 0
45b
40 7 1 a c e
41 7 1 a c e
42 7 1 a c e
43 6 1.3 b d f

FIG. 5A

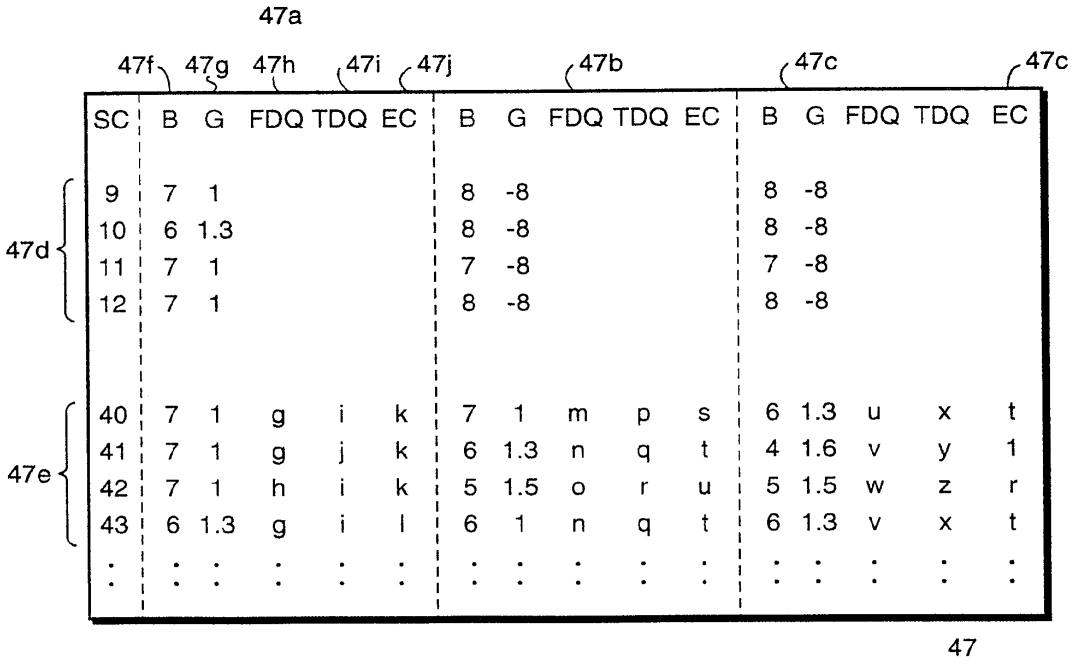
47a
47f
47g
47h
47i
47j
47b
47c
47c
SC B G FDQ TDQ EC B G FDQ TDQ EC B G FDQ TDQ EC
47d
9 7 1 8 -8 8 -8
10 6 1.3 8 -8 8 -8
11 7 1 7 -8 7 -8
12 7 1 8 -8 8 -8
47e
40 7 1 g i k 7 1 m p s 6 1.3 u x t
41 7 1 g j k 6 1.3 n q t 4 1.6 v y 1
42 7 1 h i k 5 1.5 o r u 5 1.5 w z r
43 6 1.3 g i l 6 1 n q t 6 1.3 v x t
47

FIG. 5B

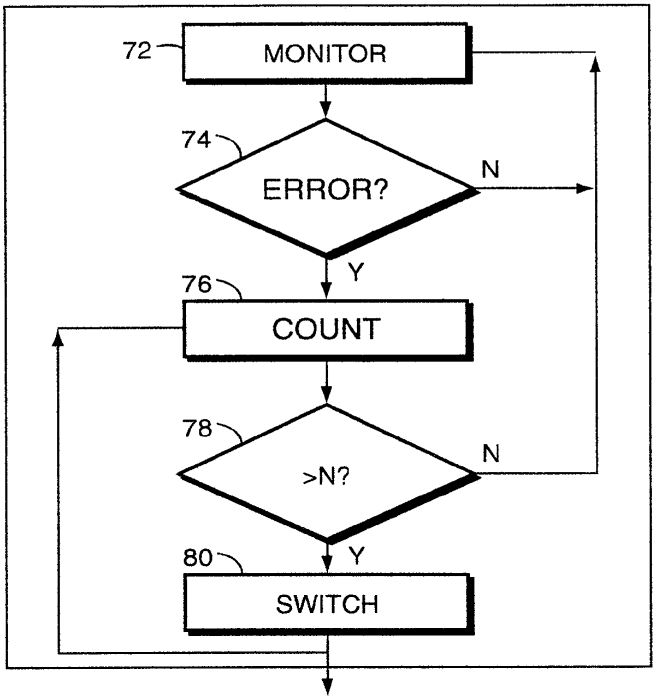
72
MONITOR
74
ERROR?
N
Y
76
COUNT
78
>N?
N
Y
80
SWITCH

FIG. 6

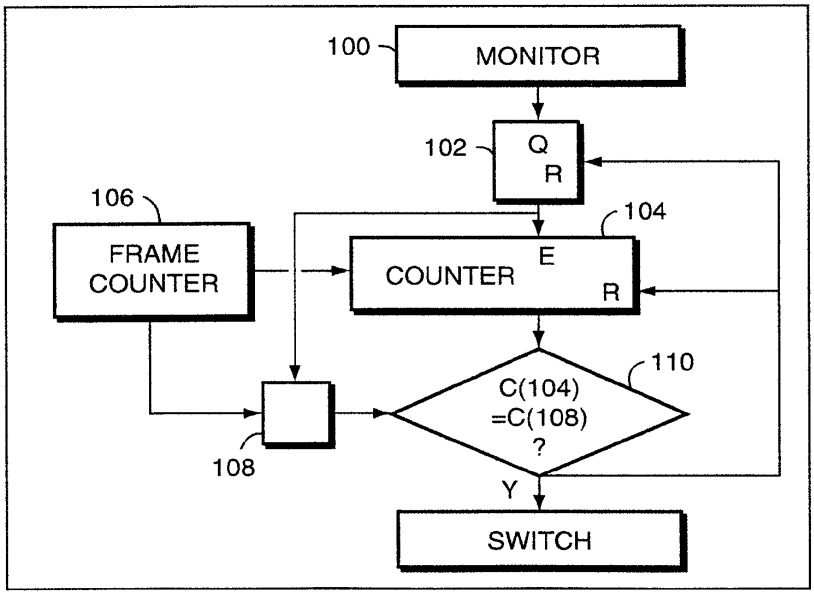
100
MONITOR
102
Q
R
106
FRAME COUNTER
104
COUNTER
E
R
110
C(104) =C(108) ?
108
Y
SWITCH

FIG. 7

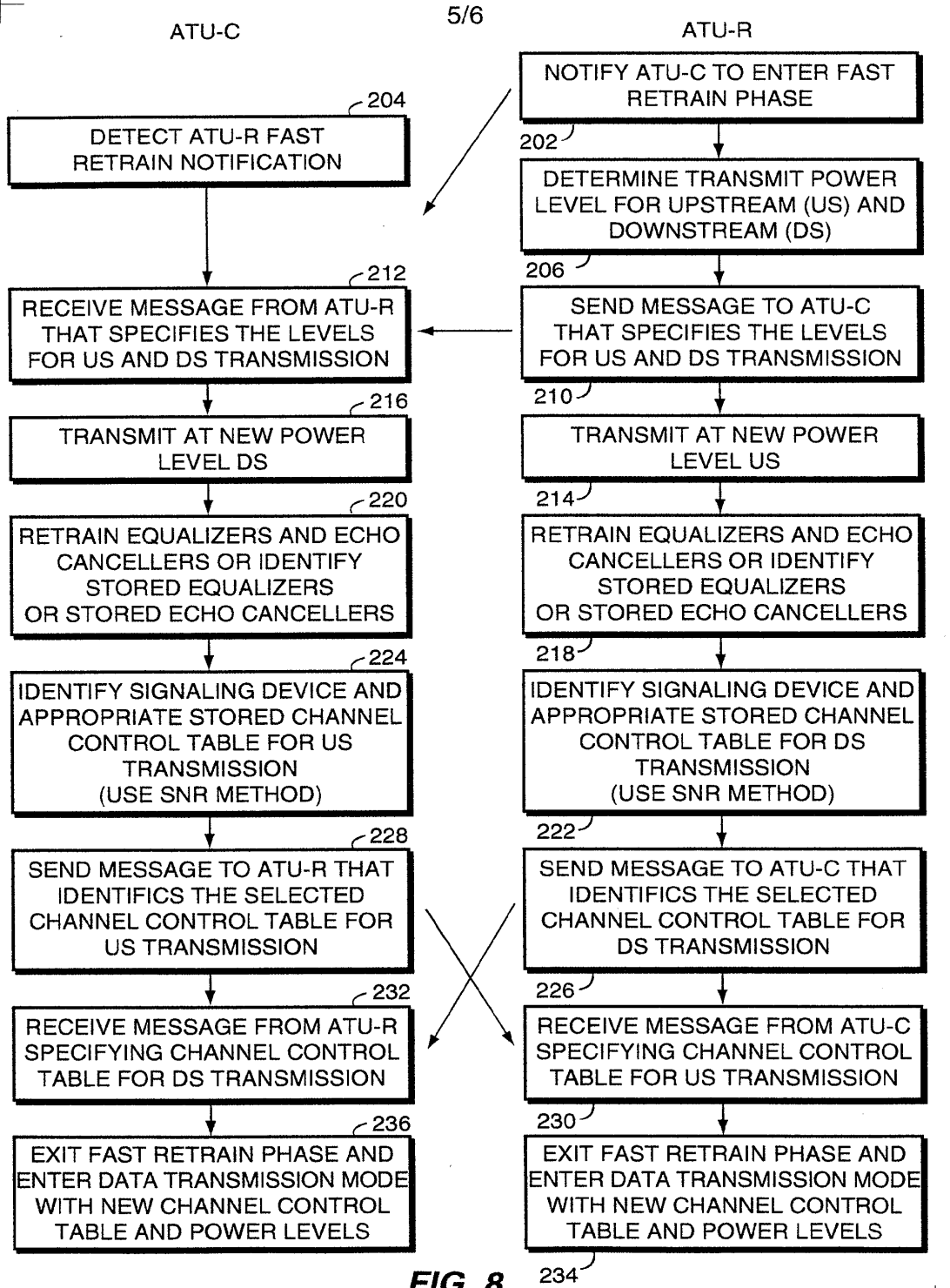
ATU-C
ATU-R
NOTIFY ATU-C TO ENTER FAST RETRAIN PHASE
202
DETERMINE TRANSMIT POWER LEVEL FOR UPSTREAM (US) AND DOWNSTREAM (DS)
204
DETECT ATU-R FAST RETRAIN NOTIFICATION
206
SEND MESSAGE TO ATU-C THAT SPECIFIES THE LEVELS FOR US AND DS TRANSMISSION
212
RECEIVE MESSAGE FROM ATU-R THAT SPECIFIES THE LEVELS FOR US AND DS TRANSMISSION
210
TRANSMIT AT NEW POWER LEVEL US
216
TRANSMIT AT NEW POWER LEVEL DS
214
RETRAIN EQUALIZERS AND ECHO CANCELLERS OR IDENTIFY STORED EQUALIZERS OR STORED ECHO CANCELLERS
220
RETRAIN EQUALIZERS AND ECHO CANCELLERS OR IDENTIFY STORED EQUALIZERS OR STORED ECHO CANCELLERS
218
IDENTIFY SIGNALING DEVICE AND APPROPRIATE STORED CHANNEL CONTROL TABLE FOR DS TRANSMISSION (USE SNR METHOD)
224
IDENTIFY SIGNALING DEVICE AND APPROPRIATE STORED CHANNEL CONTROL TABLE FOR US TRANSMISSION (USE SNR METHOD)
222
SEND MESSAGE TO ATU-C THAT IDENTIFICS THE SELECTED CHANNEL CONTROL TABLE FOR DS TRANSMISSION
228
SEND MESSAGE TO ATU-R THAT IDENTIFICS THE SELECTED CHANNEL CONTROL TABLE FOR US TRANSMISSION
226
RECEIVE MESSAGE FROM ATU-C SPECIFYING CHANNEL CONTROL TABLE FOR US TRANSMISSION
232
RECEIVE MESSAGE FROM ATU-R SPECIFYING CHANNEL CONTROL TABLE FOR DS TRANSMISSION
230
EXIT FAST RETRAIN PHASE AND ENTER DATA TRANSMISSION MODE WITH NEW CHANNEL CONTROL TABLE AND POWER LEVELS
236
EXIT FAST RETRAIN PHASE AND ENTER DATA TRANSMISSION MODE WITH NEW CHANNEL CONTROL TABLE AND POWER LEVELS
234

FIG. 8

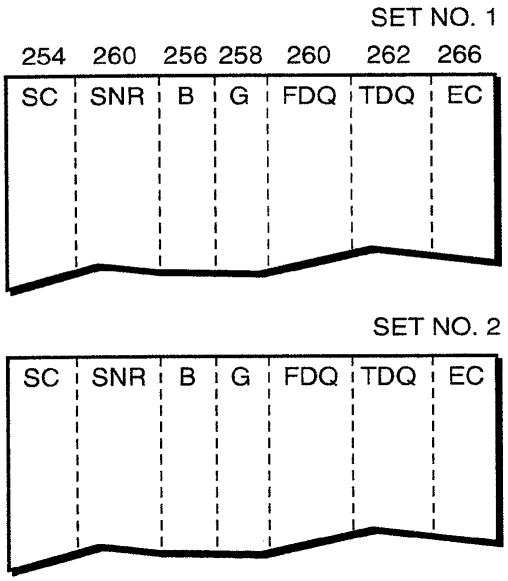

FIG. 9A

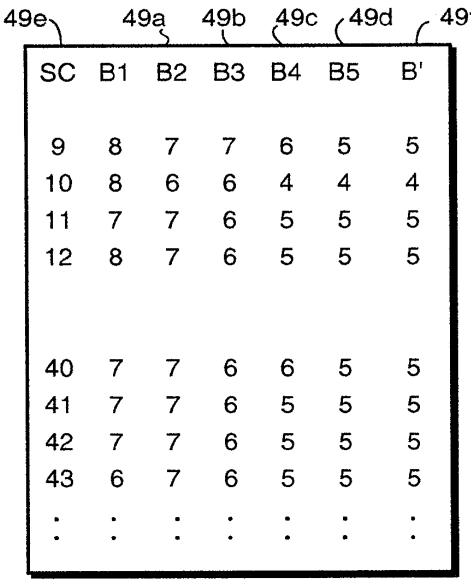

FIG. 5C

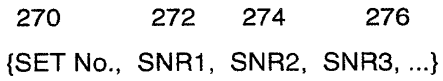

FIG. 9B

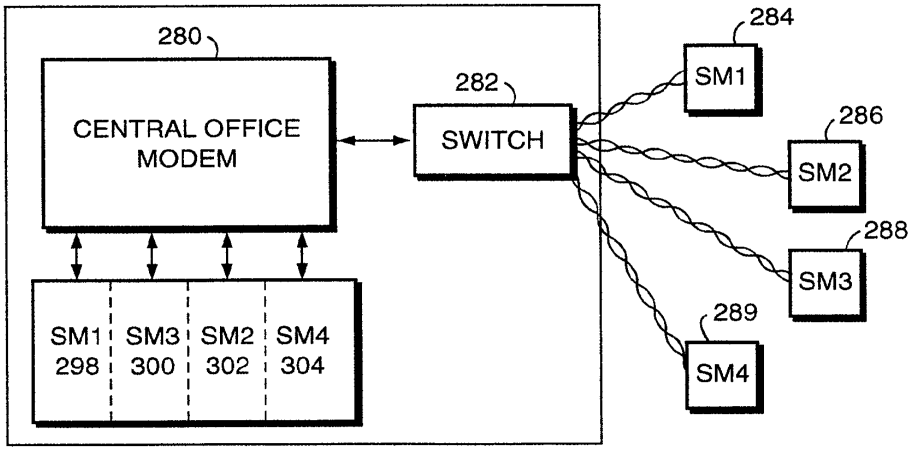

FIG. 10

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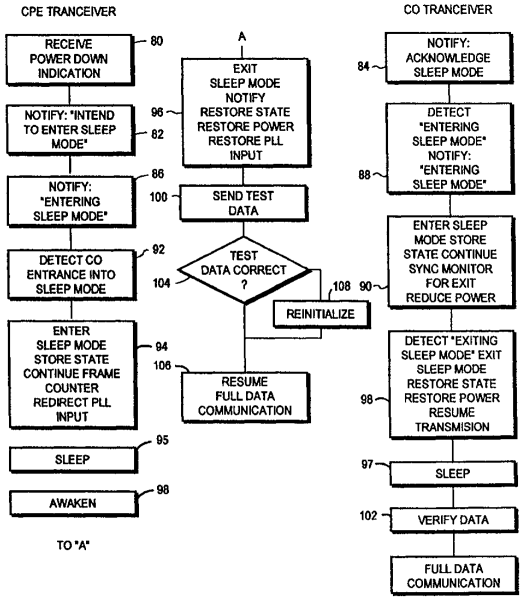
(57) Abstract

A multicarrier transceiver is provided with a sleep mode in which it idles with reduced power consumption when it is not needed to transmit or receive data. The full transmission and reception capabilities of the transceiver are quickly restored when needed, without requiring the full (and time–consuming) initialization commonly needed to restore such transceivers to operation after inactivity.



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MULTICARRIER TRANSMISSION SYSTEM WITH LOW POWER SLEEP MODE AND RAPID-ON CAPABILITY

BACKGROUND OF THE INVENTION

The invention relates to multicarrier transmission systems, and comprises method and apparatus for establishing a power management sleep state in a multicarrier system.

SUMMARY OF THE INVENTION

Multicarrier transmission systems provide high speed data links between communication points. Such systems have recently been introduced for communications over the local subscriber loop that connects a telephone service subscriber to a central telephone office; in this important application they are commonly referred to as "xDSL" systems, where the "x" specifies a particular variant of DSL (digital subscriber loop) communications, e.g., ADSL (asynchronous digital subscriber loop), HDSL (High-Speed Digital Subscriber Loop), etc. These will be referred to generically herein simply as "DSL" systems. In such systems, a pair of transceivers communicate with other by dividing the overall bandwidth of the channel interconnecting the subscriber and the central office into a large number of separate subchannels, each of limited bandwidth, operating in parallel with each other. For example, one common system divides the subscriber line channel into two hundred and fifty six subchannels, each of four kilohertz bandwidth. A first group of these (e.g., one hundred ninety six) is allocated to communications from the central office to the subscriber (this is known as the "downstream" direction); a second group (e.g., fifty-five) is allocated to communications from the subscriber to the central office (this is known as the "upstream" direction). The remaining subchannels are allocated to administrative, control and overhead functions.

Data to be communicated over the link is divided into groups of bits, one group for each subchannel. The group of bits allocated to a given subchannel is modulated onto a carrier whose frequency is specific to that channel. Typically, quadrature ampli-

tude modulation (QAM) is used for this purpose, and the group of bits is mapped into a vector defined by one of the points of a "constellation" which specifies the allowable data points for transmission over that subchannel at a particular time. Each vector or data point thus comprises a unique symbol representing a specific bit configuration for transmission as a group over its associated subchannel. During the time period allocated for transmission of a symbol (commonly referred to as a "symbol period" or "frame"), each subchannel transmits its symbol in parallel with all other subchannels so that large amounts of data can be transmitted during each frame.

The number of bits carried by a symbol is dependent on the characteristics of the subchannel over which it is to be transmitted. This may vary from one subchannel to another. The principal determinant is the signal-to-noise ratio of the subchannel. Accordingly, this parameter is measured from time to time in order to ascertain its value for each subchannel, and thus determine the number of bits to be transmitted on the particular subchannel at a given time.

The telephone channel is subject to a number of impairments which must be compensated for in order to ensure reliable transmission. Phase (delay) distortion of the transmitted signal is typically the most limiting of these impairments. This distortion is frequency-dependent, and thus components of a signal at different frequencies are shifted by varying amounts, thereby distorting the signal and increasing the likelihood of erroneous detection unless provision is made to combat it. To this end, frequency (FDQ) and time delay (TDQ) equalizers are commonly incorporated into the transmission channel in order to equalize the phase (time) delay across the channel frequency band.

Other impairments also exist. For example, frequency-dependent signal attenuation adversely affects signal transmission on the telephone line. This is compensated by the use of gain equalizers on the line. Echo on the line is handled by the use of echo cancellers, and phase and frequency offsets which may arise, for example, from the use of frequency-division-multiplexing in the telephone system must also be corrected for.

The problem of signal impairment is especially serious in those xDSL configurations which carry the DSL communications on a common line with ordinary voice communications but which omit the use of a "splitter" at either the subscriber premises or the central office or both. A "splitter" is basically a filter which separates the low-frequency voice communications (e.g., from zero to four kilohertz) from the higher-frequency data communications (which may extend up into the megahertz band) and provides a strong degree of isolation between the two. In the absence of a splitter, unique provisions must be made to accommodate voice and data communications on the same line. For a more detailed description of the problem and its solution, see the co-pending application of Richard Gross et al. entitled "Splitterless Multicarrier Modem", Serial No. ***, filed ***, and assigned to the assignee of the present invention.

Because of their extensive use in Internet communications as well as in other applications, DSL transceivers are commonly maintained in the "on" state, ready to transmit or receive once they have been installed and initialized. Thus, such modems consume a significant amount of power, even when they are not actively transmitting or receiving data. It is generally desirable to limit this power consumption, both for environmental reasons as well as to prolong the life of the equipment. Further, such modems may be implemented or incorporated in part or in whole in computer equipment such as in personal computers for home and business use, and such computers increasingly incorporate power conservation procedures. See, for example, U.S. Patent No. 5,428,790, "Computer Power Management System", issued June 27, 1995 on the application of L. D. Harper. Thus, it is desirable to provide an ADSL modem which can accommodate power conservation procedures.

Because of the complexity of DSL transceivers, and the conditions under which they must operate, it is necessary to initialize them prior to the transmission and reception of data. This initialization includes, *inter alia*, channel corrections such as "training" the frequency- and time-domain equalizers and the echo cancellers; setting the channel gains; adjusting for phase and frequency offsets; and the like. Additionally, it includes measuring the signal-to-noise ratio of each of the subchannels, calculating the bit-allocation tables characteristic of each under given conditions of transmission, and

exchanging these tables with other modems with a given modem communicates. For more detailed discussion of these procedures, reefer to the application of Richard Gross et al., cited above and incorporated herein by reference. These procedures can require from tens to hundreds of seconds. In a new installation, the time required is inconsequential. However, in an already-operating installation, the time required to initialize or re-initialize the system after a suspension of operation in connection with power conservation is generally unacceptable, since it is typically desired to have the modem respond to request for service nearly instantaneously.

Accordingly, it is an object of the invention to provide a multicarrier transmission system having a low power sleep mode and a rapid-on capability.

Further, it is an object of the invention to provide a multicarrier transmission system for use in digital subscriber line communications that can rapidly switch from a sleep mode to a full-on condition.

Still another object of the invention is to provide a DSL system that can readily be integrated into a computer having a low power sleep mode and which is capable of rapid return to full operation.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention description below refers to the accompanying drawings, of which:

Fig. 1 is a block and line diagram of a multicarrier transmission system in accordance with the present invention; and

Fig. 2 is a flow diagram of the operation of the present invention.

DETAILED DESCRIPTION OF AN ILLUSTRATIVE EMBODIMENT

In Figure 1, a DSL transceiver 10 in accordance with the present invention has a transmitter section 12 for transmitting data over a digital subscriber line 14 and a receiver section 16 for receiving data from the line. The transmitter section 12 is formed from an input buffer and converter 18 that receives a serial string of data (e.g., binary

digits) to be transmitted and converts the data into a plurality of pairs of complex-valued symbols X_i and their conjugates $X_{N-i} = X^*_i$, i = 0, 1, ...N. These pairs of symbols are applied to an Inverse Fast Fourier Transform (IFFT) 20 to provide real time output signals x_j, j = 0, 1, ...N/2 -1. The latter in turn are converted to serial form in a parallel-to-serial converter 22 and then applied to a digital-to-analog converter 24 for application to a line driver 26. The converter may apply a cyclic prefix to the signals x_j to combat intersymbol interference caused by the transmission medium. The driver 26 may incorporate a gain control section 26a for controlling the signal amplitude (and thus power) as it is applied to a communication channel such as a digital subscriber line 24.

IFFT 20 may be viewed as a data modulator. The symbols X_i, and their conjugates X_{N-i}, correspond to data points defining signal vectors in a quadrature amplitude modulation (QAM) constellation set. The converter 18 forms the respective symbols from the input data with the aid of a bit allocation table (BAT) 28 which specifies, for each subchannel, the number of bits to be carried by the symbol transmitted over that subchannel, and thus defines the data point to be associated with the symbol. This table is typically calculated at the transceiver and transmitted to other transceivers with which the instant transceiver communicates, to thereby enable them to decode the symbols received by them from the instant transceiver.

The number of bits which each symbol carries is determined by the characteristics of the subchannel over which the symbol is to be transmitted, and particularly by the signal-to-noise ratio of the subchannel. Procedure for this calculation are known. Figure 1A shows an example of such a table as formed and stored at transceiver 10. Thus, the symbol to be transmitted over subchannel 50 may be determined to have an allocation of six bits; that of subchanel 51, six bits; that of subchannel 52, seven bits, etc.

A Clock 30 controls the timing of the operation of the transmitter 12. It supplies input to a Controller 32 which controls the individual units of the transmitter. In the case of a transceiver located at a central telephone office, the clock 30 typically is a master clock to which a remote transceiver, such as at a subscriber premises, will be synchronized. In the case of a transceiver at the subscriber premises, such as is shown her for purposes of illustration, the clock is derived from the master clock at the central

office as described more fully below in connection with the receiver portion of the transceiver. A Frame Counter (FC) 36 connected to the controller 32 maintains a count of the number of frames of data transmitted or received by the transceiver. Finally, a State Memory (SM) connected to the controller 34 records the state of the transceiver for reasons discussed more fully below.

Turning now to the receiver section 16, it is formed from a line conditioner 50; an analog-to-digital converter (ADC) 52; a serial-to-parallel converter 54; a Fast Fourier Transform (FFT) section 56; a detector 58; and a parallel-to-serial converter 60. The conditioner 50 compensates for transmission distortions introduced by the line 14, and commonly includes a frequency-domain equalizer (FDQ) 50a; a time-domain equalizer (TDQ) 50b; and an echo canceller (EC) 50c, among other elements. The ADC 52 converts the received signal to digital form and applies it to the serial-to-parallel converter 54. The converter 54 removes any cyclic prefix that may have been appended to the signal before it was transmitted, and applies the resultant signal to the FFT 56 which effectively "demodulates" the received signal. The output of the FFT is applied to decoder58 which, in conjunction with a bit-allocation-table 62, recovers the symbols X_i and the bits associated with them. The output of detector 58 is applied to the parallel-to-serial converter 60 which restores the data stream that was originally applied to the transmitter.

A phase-lock loop (PLL) 62 receives from the line conditioner 50 a timing reference signal transmitted from the transmitter with which it communicates (e.g., the CO transceiver). The PLL 62 locks itself to this signal and drives a clock 64 in synchronism with the Master Clock in the driving transmitter. Control of the receiver section is provided by the controller 32.

As noted earlier, the transceiver of the present invention will commonly be incorporated in a computer such as a personal computer; indeed, it may be implemented as an integral part of such a computer, which may have a power conservation capability for activation when the computer is not in active operation. It is thus desirable that the transceiver be able to suspend operations and enter a "sleep" mode in which it consumes reduced power when it is not needed for data transmission or reception, but nonetheless

be able to resume transmission or reception almost instantaneously, e.g., with less than a one-second delay. This is accomplished in the present invention as follows.

For purposes of illustration, the operation of the invention will be explained in terms of a transceiver located at a customer premises (herein termed the "CPE transceiver") communicating data over the customer's data subscriber line to a transceiver located at the central telephone office (herein referred to as the "CO transceiver"). Particular reference will be made to Figures 2 and 3 in connection with this discussion. The power down operation of the CPE transceiver begins on receipt of a power down command (step 80) by the CPE transceiver controller 32. The power down command may be applied to the controller 32 from an external source such as a personal computer in which the transceiver is included; it may be generated within the transceiver itself as a result of monitoring the input buffer 18 and determining that no data has been applied to it for a given time interval; or it may be responsive to a power down command from the CO transceiver.

Considering for the moment the first two cases, the CPE transceiver responds to the command by transmitting to the CO transceiver an "Entering Sleep Mode" signal (step 82). The CO transceiver responds by transmitting an "Acknowledge Sleep Mode" signal (step 84) to the CPE transceiver. Additionally, the CO transceiver transmits to the CPE transceiver a pilot tone (step 86) which enables the CPE transceiver to maintain synchronization with the CO transceiver during sleep mode. Specifically, as shown in Figure 1, the pilot tone is applied from the line conditioner 50 to the PLL 62 which drives the Local Clock 64 in synchrony with the Master Clock 30 at the CO transceiver. Clock 64 in turn drives the Frame Counter 66 in synchrony with the frame counter 36 at the CO transceiver.

The CO transceiver also stores its state (step 88) in receiver section state memory 38. The state preferably includes at least the frequency and time-domain equalizer coefficients (FDQ; TDQ) and the echo-canceller coefficients (ECC) of its receiver and the gain of its transmitter. The CO transceiver will also maintain the frame count and superframe count (step 90) to ensure synchrony with the remote CPE transceiver. It may, at this time, perform its own power reduction (step 92). In particular, it may re-

duce or cut off power to the digital modulator/demodulator portions of its transmitter and receiver sections; this provides a significant power reduction. Power will be maintained, of course, to at least that portion of the analog driver circuitry which transmits the pilot tone and other control signals to the CPE transceiver.

In response to the acknowledgment from the CO transceiver, the CPE transceiver enters the sleep mode (step 94) in which reduced or no power is applied to various components of the transceiver. In particular, it stores its state (step 96) in state memory 38, including preferably at least the frequency and time-domain equalizer coefficients (FDQ; TDQ) and the echo-canceller coefficients (ECC) of its receiver section, the gain of its transmitter section, and phase and frequency offset of its phase-locked loop 62. It then powers down (step 98) its transmitter section, including both the digital modulator/demodulator circuitry and the analog line drivers.

During the sleep mode state, the CO transceiver continues to monitor (step 100) the data subscriber line for an "Awakening" signal from the CPE transceiver (step 104). The CPE transceiver transmits this signal when its controller receives an "Awaken" command (step 102) from an external source such as a computer in which it is installed or from other sources , or when its controller detects the presence of data in the input buffer 18. The CPE transceiver thereupon restores full power to its circuitry (step 106). It also retrieves its stored state from the state memory 38 (step 108). It can then immediately begin transmitting , since it need not repeat the initialization that was earlier required to establish requisite parameters (equalizer coefficients, echo canceller coefficients, gain, phase -lock-loop phase and frequency offsets, etc.). Prior to this time, of course, and in response to the "Awakening" signal from the CPE transceiver, the CO transceiver has restored its power (step 110), restored its state (step 112), and is ready to receive (step 114).

On resuming communication, it may be desirable to transmit several frames of test (known) data (step 116) before resuming transmission of user data. This enables the system to verify that system conditions have not changed so significantly as to require renewed initialization. If the test is satisfactory (step 118), user data transmission

then occurs (step 120). Otherwise, reinitialization must be performed (step 122) before user data transmission occurs.

As noted earlier, the transceiver 10 may alternatively be awakened by the CO transceiver. This is preferably accomplished by means of a tone 120 (Figure 3) transmitted from the latter to the CPE receiver. In response to that tone, the CPE receiver performs the sequence of steps shown at 100-110 in Figure 2.

CLAIMS

1. A multicarrier transceiver having a sleep mode capability , comprising

A. means responsive to a sleep mode command for:

(1) storing selected state parameters characteristic of the communications channel over which the transceiver is operating; and

(2) reducing power to selected portions of transceiver circuitry; and

B. means responsive to a wake-up command for:

(1) restoring the state of said transceiver from said sleep mode; and

(2) restoring power to said transceiver;

to thereby facilitate restoration of communications without reinitialization of said transceiver.

2. A multicarrier transceiver according to claim 1 in which said state parameters include one or more parameters selected from the group comprising frequency-domain equalizer coefficients, time-domain equalizer coefficients, echo canceller coefficients, phase-lock loop frequency offsets, phase-lock loop phase offsets, and channel gains.

3. A multicarrier transceiver according to claim 1 which includes means for receiving from another transceiver a signal defining a timing reference during at least the time when said first transceiver is in sleep mode.

4. A multicarrier transceiver according to claim 1 in which said signal comprises a pilot tone.

AMENDED CLAIMS

[received by the International Bureau on 28 December 1999 (28.12.99);
original claims 1-4 replaced by new claims 1-17 (4 pages)]

1. A multicarrier transceiver having a sleep mode capability, comprising

A. means responsive to a sleep mode command for:

(1) storing selected state parameters characteristic of the communications channel over which the transceiver is operating; and

(2) reducing power to selected portions of transceiver circuitry; and

B. means responsive to a wake-up command for:

(1) restoring power to said transceiver;

(2) restoring the state of said transceiver from said sleep mode by means of said stored parameters; and

C. means for maintaining a common, synchronized data frame count between said transceiver and a remote transceiver with which it communicates, to thereby facilitate restoration of communication without reinitialization of said transceiver.

2. A multicarrier transceiver according to claim 1 in which said state parameters include one or more parameters selected from the group comprising frequency-domain equalizer coefficients, time-domain equalizer coefficients, echo canceller coefficients, bit allocations, coding parameters, fine gains, and subchannel gains.

3. A multicarrier transceiver according to claim 1 in which the means for maintaining said frame count comprises a signal defining a timing reference during at least the time when said first transceiver is in sleep mode.

4. A multicarrier transceiver according to claim 3 in which said signal compirses a pilot tone transmitted from one transceiver to another with which it is in communication.

5. A multicarrier transceiver according to claim 4 in which said pilot tone is transmitted between said transceivers during both normal operation and reduced power operation.

6. A multicarrier transceiver according to claim 1 in which maintaining synchronization includes maintaining synchronization of frame counters between said transceivers.

7. A multicarrier transceiver according to claim 6 in which maintaining synchronization further includes maintaining synchronization of the phase of a synchronizing signal transmitted between said transceivers.

8. A multicarrier transceiver according to claim 1 including means to transmit an idle symbol to said remote transceiver when said transceiver is in sleep mode.

9. A multicarrier transceiver according to claim 1 including means to transmit to said remote transceiver a short test signal on awaking from sleep mode in order to determine whether transmission conditions have changed sufficiently during sleep mode to require reinitialization of said transceiver on emerging from sleep mode.

10. A multicarrier transceiver including

A. mean for storing the state of said transceiver responsive to a state change indicator;

B. means for restoring said state from the stored state parameters to thereby obviate reinitialization of said transceiver on return from sleep mode;

C. means detecting the absence of valid frame information for generating said state change indicator.

11. A multicarrier transceiver including

A. means for storing the state of transceiver responsive to an interruption of valid data transmission;

B. means for entering a sleep mode during said interruption;

C. means for maintaining communication of a synchronizing signal between said transceiver and another transceiver during sleep mode.; and

D. means for restoring said state from the stored state parameters to thereby obviate reinitialization of said transceiver on return from sleep mode.

12. A multicarrier transceiver according to claim 11 in which communication is maintained by transmitting a synchronizing signal to said other transceiver.

13. A multicarrier transceiver according to claim 11 in which communication is maintained by receiving by receiving a synchronizing signal from said other transceiver.

14. A multiracial transceiver according to claim 11 in which said state includes on or more parameters selected from the set comprising frequency-domain equalizer coefficients, time-domain equalizer coefficients, echo cancelled coefficients, bit allocations, coding parameter, fine gains and subchannel gains.

15. A method of providing a sleep mode in a multicarrier transceiver characterized by a plurality of state parameters characteristic of the communications channel over which the transceiver is operating and requiring initialization of said parameters for normal communications, comprising the steps of:

A. storing selected ones of said state parameters in response to a sleep mode command;

B. reducing power to selected portions of the circuitry following said storing;

C. restoring power to said selected portions in response to an awaken signal; and

D. restoring the state of said transceiver from said stored parameters in response to said wakeup signal to thereby obviate reinitialization of said transceiver.

16. A method according to claim 15 in which said selected state parameters comprise one or more parameters selected from the group comprising frequency-domain equalizer

coefficients, time-domain equalizer coefficients, echo canceller coefficients, bit allocations, coding parameters, fine gains, and subchannel gains.

17. A method according to claim 15 or 16 including the step of maintaining synchronization in said transceiver with a synchronization signal transmitted to said said transceiver during the time that said transceiver is in sleep mode.

SUBCHANNEL	BITS
. .	
50	6
51	6
52	7
. .	

FIG. 1B

FIG. 1C

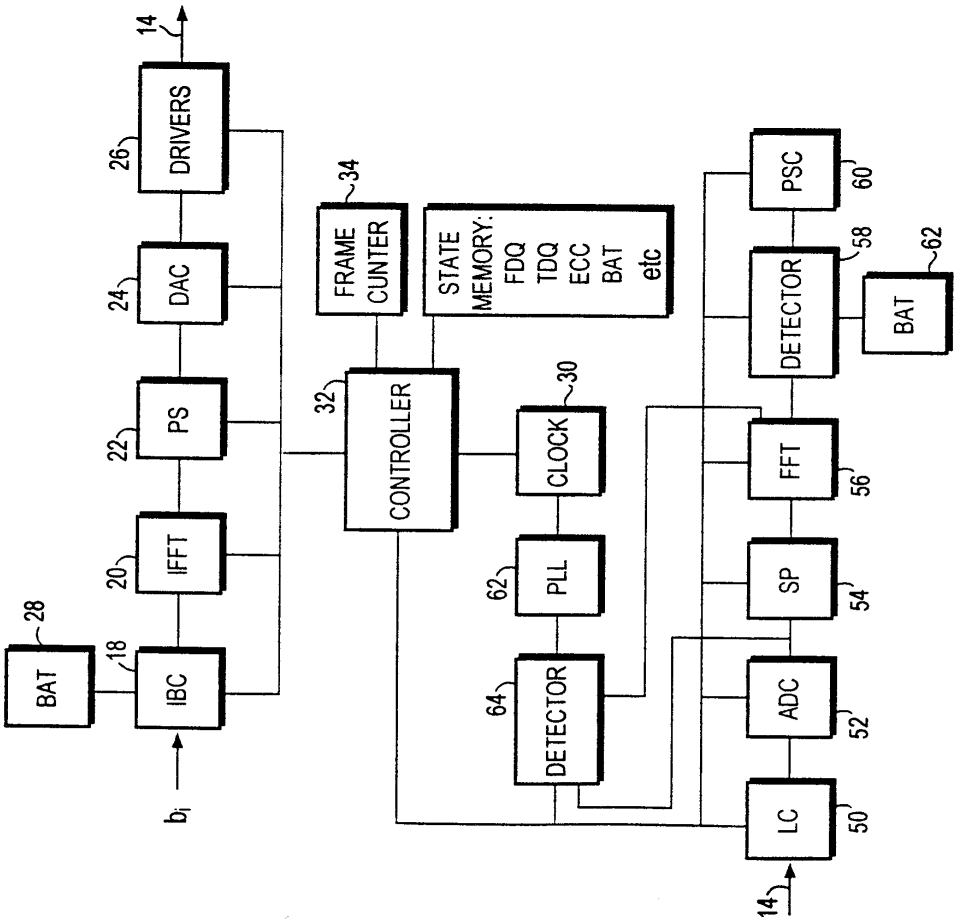

FIG. 1A

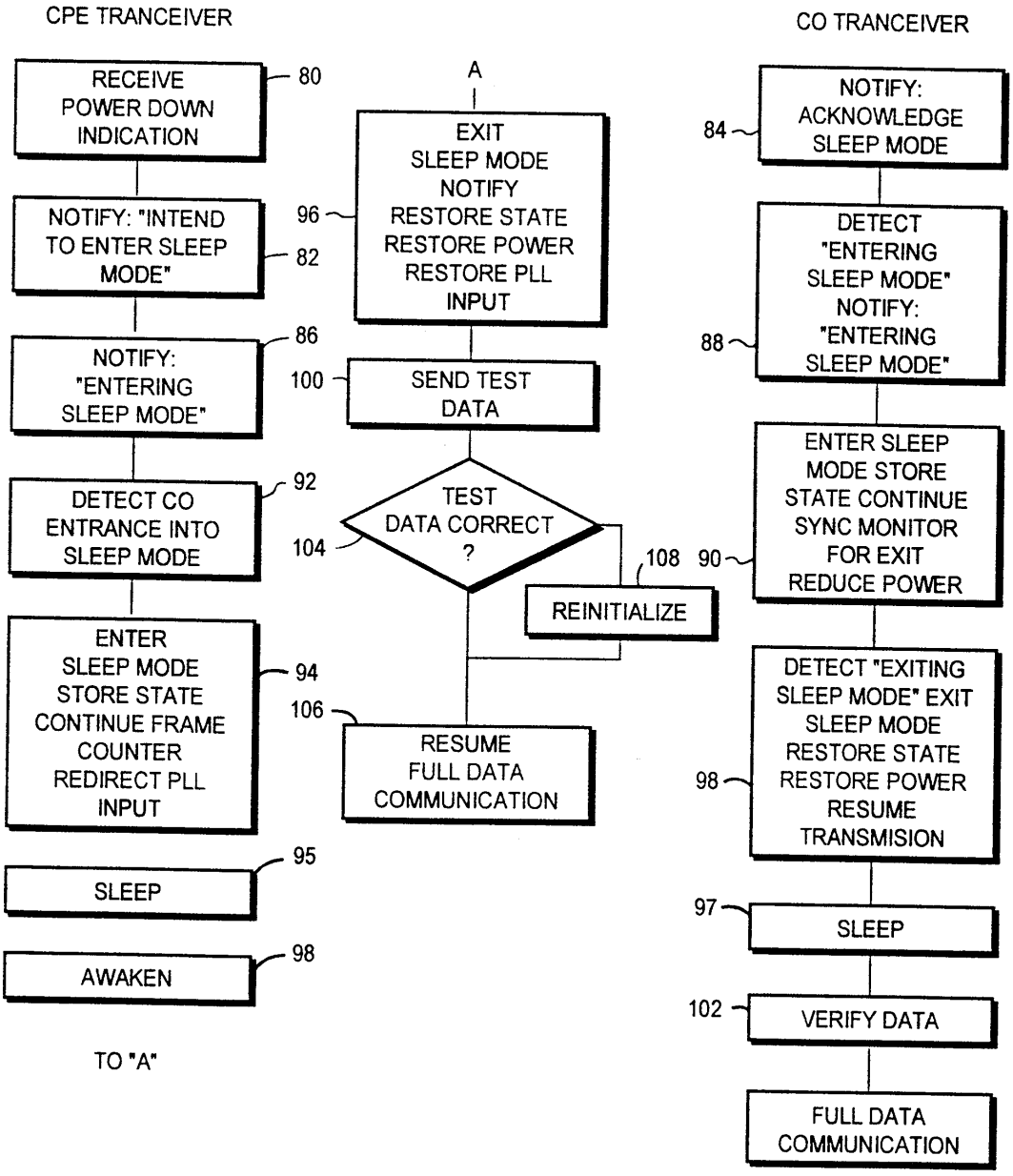
CPE TRANCEIVER
CO TRANCEIVER
RECEIVE POWER DOWN INDICATION
80
NOTIFY: "INTEND TO ENTER SLEEP MODE"
82
NOTIFY: "ENTERING SLEEP MODE"
86
DETECT CO ENTRANCE INTO SLEEP MODE
92
ENTER SLEEP MODE STORE STATE CONTINUE FRAME COUNTER REDIRECT PLL INPUT
94
SLEEP
95
AWAKEN
98
TO "A"
A
EXIT SLEEP MODE NOTIFY RESTORE STATE RESTORE POWER RESTORE PLL INPUT
96
SEND TEST DATA
100
TEST DATA CORRECT ?
104
108
REINITIALIZE
RESUME FULL DATA COMMUNICATION
106
NOTIFY: ACKNOWLEDGE SLEEP MODE
84
DETECT "ENTERING SLEEP MODE" NOTIFY: "ENTERING SLEEP MODE"
88
ENTER SLEEP MODE STORE STATE CONTINUE SYNC MONITOR FOR EXIT REDUCE POWER
90
DETECT "EXITING SLEEP MODE" EXIT SLEEP MODE RESTORE STATE RESTORE POWER RESUME TRANSMISION
98
SLEEP
97
VERIFY DATA
102
FULL DATA COMMUNICATION

FIG. 2

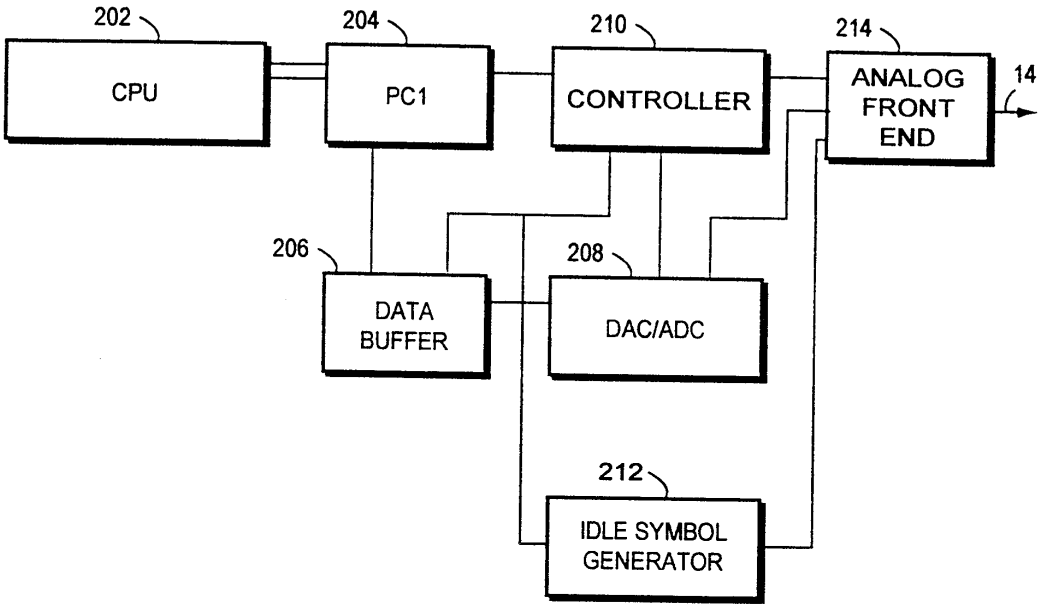
202
CPU
204
PC1
210
CONTROLLER
214
ANALOG FRONT END
14
206
DATA BUFFER
208
DAC/ADC
212
IDLE SYMBOL GENERATOR

FIG. 3

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 99/01539

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04L27/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04L H04M H04B G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 473 465 A (AUDIOVOX CORP) 4 March 1992 (1992-03-04) column 5, line 12 -column 7, line 52; figures 5,6	1,3-13
A	US 5 452 288 A (RAHUEL JEAN-CLAUDE ET AL) 19 September 1995 (1995-09-19) column 5, line 6 -column 5, line 24 column 11, line 45 - line 60; figure 2 column 16, line 18 -column 17, line 62; figures 5,6	1,10,11
A	EP 0 840 474 A (MOTOROLA INC) 6 May 1998 (1998-05-06)	1,10,11

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 October 1999	29/10/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Burghardt, G

2

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

In' ational Application No
Pc[/US 99/01539

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	MACQ D ET AL.: "A CMOS activity detector for ADSL link " ESSCIRC '95. TWENTY-FIRST EUROPEAN SOLID-STATE CIRCUITS CONFERENCE. , 19 - 21 September 1995, page 430-433 XP002119172 Lille, France page 430 -----	1,10,11

2

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Ir ational Application No
PCT/US 99/01539

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0473465 A	04-03-1992	US 5224152 A	29-06-1993
		CA 2043118 A	28-02-1992
		FI 912298 A	28-02-1992
		JP 5095315 A	16-04-1993
US 5452288 A	19-09-1995	FR 2690029 A	15-10-1993
		DE 69320861 D	15-10-1998
		DE 69320861 T	05-08-1999
		EP 0565470 A	13-10-1993
EP 0840474 A	06-05-1998	US 5909463 A	01-06-1999
		CA 2219360 A	04-05-1998

Form PCT/ISA/210 (patent family annex) (July 1992)

P ENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
103118-26PCT		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/US 99/ 01539	26/01/1999	
Applicant		
AWARE, INC. et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 4 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

[ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

[ ] contained in the international application in written form.

[ ] filed together with the international application in computer readable form.

[ ] furnished subsequently to this Authority in written form.

[ ] furnished subsequently to this Authority in computer readble form.

[ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

[ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

[X] the text is approved as submitted by the applicant.

[ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

[ ] the text is approved as submitted by the applicant.

[X] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 2

[ ] as suggested by the applicant.

[X] because the applicant failed to suggest a figure.

[ ] because this figure better characterizes the invention.

[ ] None of the figures.

Form PCT/ISA/210 (first sheet) (July 1998)

Box III TEXT OF THE ABSTRACT (Continuation of item 5 of the first sheet)

line 2, replace "A muticarrier" by "A multicarrier"

INTERNATIONAL SEARCH REPORT

Inter al Application No
PCT/US 99/01539

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04L27/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04L H04M H04B G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 473 465 A (AUDIOVOX CORP) 4 March 1992 (1992-03-04) column 5, line 12 -column 7, line 52; figures 5,6	1,3-13
A	US 5 452 288 A (RAHUEL JEAN-CLAUDE ET AL) 19 September 1995 (1995-09-19) column 5, line 6 -column 5, line 24 column 11, line 45 - line 60; figure 2 column 16, line 18 -column 17, line 62; figures 5,6	1,10,11
A	EP 0 840 474 A (MOTOROLA INC) 6 May 1998 (1998-05-06)	1,10,11

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 October 1999	29/10/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Burghardt, G

2

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 99/01539

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	MACQ D ET AL.: "A CMOS activity detector for ADSL link " ESSCIRC '95. TWENTY-FIRST EUROPEAN SOLID-STATE CIRCUITS CONFERENCE. , 19 - 21 September 1995, page 430-433 XP002119172 Lille, France page 430 -----	1,10,11

2

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 99/01539

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0473465 A	04-03-1992	US 5224152 A	29-06-1993
		CA 2043118 A	28-02-1992
		FI 912298 A	28-02-1992
		JP 5095315 A	16-04-1993
US 5452288 A	19-09-1995	FR 2690029 A	15-10-1993
		DE 69320861 D	15-10-1998
		DE 69320861 T	05-08-1999
		EP 0565470 A	13-10-1993
EP 0840474 A	06-05-1998	US 5909463 A	01-06-1999
		CA 2219360 A	04-05-1998

Form PCT/ISA/210 (patent family annex) (July 1992)

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

MILSTEIN, Joseph B.
Testa, Hurwitz & Thibeault, LLP
High Street Tower
125 High Street
Boston, MA 02110
ETATS-UNIS D'AMERIQUE

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY EXAMINATION REPORT
(PCT Rule 71.1)

Date of mailing *(day/month/year)*	06.12.2000
Applicant's or agent's file reference: AWR-005PC	**IMPORTANT NOTIFICATION**

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US99/01539	26/01/1999	26/01/1999

Applicant: AWARE, INC. et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

No Docketing Necessary

AMK **Administrator** 12-12-00 **Date**

Reviewed & Approved

MAR **Resp. Atty**

Name and mailing address of the IPEA/	Authorized officer 12/13/00 Date
European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Pelatti, V Tel.+49 89 2399-7309

Form PCT/IPEA/416 (July 1992)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
AWR-005PC		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US99/01539	26/01/1999	26/01/1999
International Patent Classification (IPC) or national classification and IPC H04L27/26		
Applicant AWARE, INC. et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 6 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 4 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
25/05/2000	06.12.2000
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Burghardt, G Telephone No. +49 89 2399 8979

Form PCT/IPEA/409 (cover sheet) (January 1994)

I. Basis of the report

1. This report has been drawn on the basis of *(substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments (Rules 70.16 and 70.17).)*:
Description, pages:

1-15	as originally filed			

Claims, No.:

1-17	as received on	02/06/2000	with letter of	25/05/2000

Drawings, sheets:

1/3-3/3	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   ☐ the language of publication of the international application (under Rule 48.3(b)).
   ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   ☐ contained in the international application in written form.
   ☐ filed together with the international application in computer readable form.
   ☐ furnished subsequently to this Authority in written form.
   ☐ furnished subsequently to this Authority in computer readable form.
   ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   ☐ the description, pages:
   ☐ the claims, Nos.:

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-17
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-17
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-17
	No:	Claims	

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

Re Item V

Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Reference is made to the following documents:

   D1: EP-A-0473465
   D2: US-A-5452288
   D3: EP-A-0840474

2. The application meets the requirements of Article 33(3) PCT, because the subject-matter of independent claims 1, 10, 11 and 15 involves an inventive step for the following reasons:

2.1 Document D1, especially column 5, line 12 to column 7, line 52 and Figures 5 and 6, discloses (the references in brackets applying to this document):
A transceiver having a sleep mode (stand-by) capability, comprising
- means responsive to a sleep mode command for storing selected state parameters characteristic of the communications channel over which the transceiver is operating (short-term memory store 104 which stores parameters such as the control channel number; see column 6, line 57 to column 7, line 8);
- reducing power to selected portions of transceiver circuitry; and
- means responsive to a wake-up command (see column 7, lines 29 to 39) for
- restoring power to said transceiver;
- restoring the state of said transceiver from said sleep mode; and
- means for maintaining a common, synchronized data frame count between said transceiver and a remote transceiver with which it communicates to (see column 5, lines 20 to 39).

Document D1 does not disclose the features of claim 1 that it is a multicarrier transceiver and means for restoring the state of said transceiver from said sleep mode by means of said stored parameters to thereby facilitate restoration of communications without reinitialization of said transceiver. The solution suggested in D1, however, would not be suitable for a multicarrier transceiver, because it requires an initialization sequence after activation, which is too time-consuming. Therefore, a person skilled in the art having the knowledge of document D1 would not arrive at the subject-matter of claim 1 without inventive

activity.

2.2 Document D1 discloses the following features of claim 10:
A transceiver including:
- means for storing the state of said transceiver responsive to a state change indicator (short-term memory store 104 which stores parameters such as the control channel number; see column 6, line 57 to column 7, line 8);
- means for restoring said state (see column 7, lines 29 to 39);
- means detecting the absence of valid frame information for generating said state change indicator (see column 3, lines 38 to 49).
Document D1 does not disclose the features of claim 10 that it is a multicarrier transceiver and means for restoring the state of said transceiver from said sleep mode by means of said stored parameters to thereby facilitate restoration of communications without reinitialization of said transceiver.

Therefore, the argumentation related to claim 1 also applies to claim 10.

2.3 Furthermore, document D1 mentions the following features of claim 11:
A transceiver including
- means for storing the state of transceiver responsive to an interruption of valid data transmission (short-term memory store 104 which stores parameters such as the control channel number; see column 6, line 57 to column 7, line 8);
- means for entering a sleep mode (stand-by mode) during said interruption;
- means for maintaining communication of a synchronizing signal between said transceiver and another transceiver during sleep mode (see column 5, lines 20 to 39).
Document D1 does not disclose the features of claim 11 that it is a multicarrier transceiver and means for restoring the state of said transceiver from said sleep mode by means of said stored parameters to thereby facilitate restoration of communications without reinitialization of said transceiver.

Therefore, the argument concerning claim 1 is also valid for claim 11.

2.4 Claim 15 relates to a method of providing a sleep mode in a multicarrier transceiver comprising the corresponding steps. Hence, this claim also meets the requirements of Articles 33(2) and 33(3) PCT.

Re Item VII

Certain defects in the international application

1. Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in the document D1 is not mentioned in the description, nor is this document identified therein.

2. For the document cited on page 3, line 15, the publication number WO-A-9920027 and the publication date (22.04.1999) should have been indicated.

   The phrase "the disclosure of which is incorporated herein by reference" in line 16 and on page 4, line 11 should have been deleted (see the Guidelines II.4.17).

3. The features of the claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).

CLAIMS

1. A multicarrier transceiver having a sleep mode capability, comprising

A. means responsive to a sleep mode command for:

(1) storing selected state parameters characteristic of the communications channel over which the transceiver is operating; and

(2) reducing power to selected portions of transceiver circuitry; and

B. means responsive to a wake-up command for:

(1) restoring power to said transceiver;

(2) restoring the state of said transceiver from said sleep mode by means of said stored parameters; and

C. means for maintaining a common, synchronized data frame count between said transceiver and a remote transceiver with which it communicates, to thereby facilitate restoration of communication without reinitialization of said transceiver.

2. A multicarrier transceiver according to claim 1 in which said state parameters include one or more parameters selected from the group comprising frequency-domain equalizer coefficients, time-domain equalizer coefficients, echo canceller coefficients, bit allocations, coding parameters, fine gains, and subchannel gains.

3. A multicarrier transceiver according to claim 1 in which the means for maintaining said frame count comprises a signal defining a timing reference during at least the time when said first transceiver is in sleep mode.

4. A multicarrier transceiver according to claim 3 in which said signal compirses a pilot tone transmitted from one transceiver to another with which it is in communication.

5. A multicarrier transceiver according to claim 4 in which said pilot tone is transmitted between said transceivers during both normal operation and reduced power operation.

6. A multicarrier transceiver according to claim 1 in which maintaining synchronization includes maintaining synchronization of frame counters between said transceivers.

7. A multicarrier transceiver according to claim 6 in which maintaining synchronization further includes maintaining synchronization of the phase of a synchronizing signal transmitted between said transceivers.

8. A multicarrier transceiver according to claim 1 including means to transmit an idle symbol to said remote transceiver when said transceiver is in sleep mode.

9. A multicarrier transceiver according to claim 1 including means to transmit to said remote transceiver a short test signal on awaking from sleep mode in order to determine whether transmission conditions have changed sufficiently during sleep mode to require reinitialization of said transceiver on emerging from sleep mode.

10. A multicarrier transceiver including

A. mean for storing the state of said transceiver responsive to a state change indicator;

B. means for restoring said state from the stored state parameters to thereby obviate reinitialization of said transceiver on return from sleep mode;

C. means detecting the absence of valid frame information for generating said state change indicator.

11. A multicarrier transceiver including

A. means for storing the state of transceiver responsive to an interruption of valid data transmission;

B. means for entering a sleep mode during said interruption;

C. means for maintaining communication of a synchronizing signal between said transceiver and another transceiver during sleep mode.; and

D. means for restoring said state from the stored state parameters to thereby obviate reinitialization of said transceiver on return from sleep mode.

12. A multicarrier transceiver according to claim 11 in which communication is maintained by transmitting a synchronizing signal to said other transceiver.

13. A multicarrier transceiver according to claim 11 in which communication is maintained by receiving by receiving a synchronizing signal from said other transceiver.

14. A multiracial transceiver according to claim 11 in which said state includes on or more parameters selected from the set comprising frequency-domain equalizer coefficients, time-domain equalizer coefficients, echo cancelled coefficients, bit allocations, coding parameter, fine gains and subchannel gains.

15. A method of providing a sleep mode in a multicarrier transceiver characterized by a plurality of state parameters characteristic of the communications channel over which the transceiver is operating and requiring initialization of said parameters for normal communications, comprising the steps of:

A. storing selected ones of said state parameters in response to a sleep mode command;

B. reducing power to selected portions of the circuitry following said storing;

C. restoring power to said selected portions in response to an awaken signal; and

D. restoring the state of said transceiver from said stored parameters in response to said wakeup signal to thereby obviate reinitialization of said transceiver.

16. A method according to claim 15 in which said selected state parameters comprise one or more parameters selected from the group comprising frequency-domain equalizer

coefficients, time-domain equalizer coefficients, echo canceller coefficients, bit allocations, coding parameters, fine gains, and subchannel gains.

17. A method according to claim 15 or 16 including the step of maintaining synchronization in said transceiver with a synchronization signal transmitted to said said transceiver during the time that said transceiver is in sleep mode.

Electronic Acknowledgement Receipt	
EFS ID:	15702917
Application Number:	13887889
International Application Number:	
Confirmation Number:	8684
Title of Invention:	MULTICARRIER TRANSMISSION SYSTEM WITH LOW POWER SLEEP MODE AND RAPID-ON CAPABILITY
First Named Inventor/Applicant Name:	John A. Greszczuk
Customer Number:	62574
Filer:	Jason Vick/Joanne Vos
Filer Authorized By:	Jason Vick
Attorney Docket Number:	6936-28-CON-7
Receipt Date:	06-MAY-2013
Filing Date:	
Time Stamp:	17:00:59
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		IDS_01.pdf	1012768 95a29440553b288177a2e07112227217 8ecd6bca	yes	9

	Multipart Description/PDF files in .zip description				
	Document Description	**Start**	**End**		
	Transmittal Letter	1	3		
	Information Disclosure Statement (IDS) Form (SB08)	4	9		
Warnings:					
Information:					
2	Foreign Reference	EP0473465A1.pdf	608006 b29714b71bdbe2bf66f83df4b5b06ecf22b624e3	no	12
Warnings:					
Information:					
3	Foreign Reference	EP0840474.pdf	3837818 1a69af8c4c822399b80b75307761506af7711abc	no	28
Warnings:					
Information:					
4	Foreign Reference	JP05095315A.pdf	661139 41204b3e0bd67744e4fbe48a9e118fb3f488b562	no	9
Warnings:					
Information:					
5	Foreign Reference	JP06114196A.pdf	390062 57d34738dfc97845f2e81789b54b9b760f63e6e2	no	8
Warnings:					
Information:					
6	Foreign Reference	JP06169278A.pdf	181051 f31e9afac475397a2e7cca32e58964d734302ac4	no	5
Warnings:					
Information:					
7	Foreign Reference	JP06311080A.pdf	436871 e55ea98069d2fde1f5a364debd64cb157c52780f	no	7
Warnings:					
Information:					
8	Foreign Reference	JP04227348.pdf	593560 dc6b62ac4368e893d2be2ab6b095abf8e96ed84b	no	10
Warnings:					
Information:					

9	Foreign Reference	JP06296176A.pdf	925827 604e898806cae37b433140316b35738ddb37d5f7	no	18
Warnings:					
Information:					
10	Foreign Reference	JP07079265A.pdf	366114 5380ebe0a687e40cdf549496a710b09e1916eebf	no	10
Warnings:					
Information:					
11	Foreign Reference	JP07086995A.pdf	2425168 0531389bdf8100aed8ebadfcfc1eb1c329dddec2	no	42
Warnings:					
Information:					
12	Foreign Reference	JP09275587A.pdf	617328 0d058ff00ce647c45f6085420b8a7689e8962bc8	no	14
Warnings:					
Information:					
13	Foreign Reference	JP10327309A.pdf	1110417 06a72270b7867f534557995cf7d14e32470d91e8	no	27
Warnings:					
Information:					
14	Foreign Reference	KR199826703.pdf	262344 221cf4e09d603f5fc16fbbb90d123342cf2fb4c6	no	6
Warnings:					
Information:					
15	Foreign Reference	WO9809461.pdf	1904070 262f6717b300121b0acf15c0bb916fb5dd9cb2fe	no	46
Warnings:					
Information:					
16	Foreign Reference	WO9835473A2.pdf	1365635 e826a51142c6b079315a81819102d5b0bed30c33	no	36
Warnings:					
Information:					
17	Foreign Reference	WO9920027.pdf	3486020 dc61247a542fb304fef032659a892ce1ce336ba0	no	71
Warnings:					
Information:					

18	Foreign Reference	WO200045559.pdf	826897 55c2242c086c22040717e9ac141c14bc8d5e8f96	no	22
Warnings:					
Information:					
19	Non Patent Literature	Bingham_MulticarrierModulationForDataTransmissionAnIdeaWhoseTimeHasCome.pdf	1525695 1b49c5dcc7d5355d92de493d9e305997e75ce6c0	no	8
Warnings:					
Information:					
20	Non Patent Literature	ITU-T_Recommendation_G992-2_06-1999.pdf	20989447 720d0b31fca353c8b3c0d1fa8a36d25b83e9e2cc	no	179
Warnings:					
Information:					
21	Non Patent Literature	MACQ_A_CMOS.pdf	211042 8fe259fdfa637604a9d59e31e83297d7c53cc563	no	4
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Information:					
22	Non Patent Literature	6936-28-PCT_ISR_10-29-1999.pdf	453014 ed5704190e4bffa3cf89885eeff8432f0b7dc0265	no	5
Warnings:					
Information:					
23	Non Patent Literature	6936-28-PCT_IPER_12-06-2000.pdf	1089591 e6a210ba8894e5785501a6b896a5419afb1ea4a2	no	11
Warnings:					
Information:					
24	Non Patent Literature	6936-28-PAU_OA_2-7-2003.pdf	166958 d0c747969c4cfe7eb4a9b7ffcaa828e3ac204ee3	no	2
Warnings:					
Information:					
25	Non Patent Literature	6936-28-PAU_NOA_07-25-2003.pdf	150508 a9d9fa26c7b4c69e60122eefce9b140394a7d722	no	2
Warnings:					
Information:					
26	Non Patent Literature	6936-28-PCA_OA_11-23-05.pdf	197819 4324b508b0f2bed8bfeb144682ff578283d44866	no	2
Warnings:					
Information:					

27	Non Patent Literature	6936-28-PCA_NOA_12-14-07.pdf	165521 9037d9582b0cb8f76eb9ecb82f38142fb7b7c10f	no	1
Warnings:					
Information:					
28	Non Patent Literature	6936-28-PCA-DIV_OA_10-31-08.pdf	139123 cd443670c03a838d9bec066d07551456636a9437	no	2
Warnings:					
Information:					
29	Non Patent Literature	6936-28-PCA-DIV_OA_8-17-09.pdf	189912 19196e0a019ba0751077b5c81f2f0a43e10c892b	no	2
Warnings:					
Information:					
30	Non Patent Literature	6936-28-PCA-DIV_OA_3-5-10.pdf	164460 d30d0949860d5c074d21355c1210e055c0c082fd	no	1
Warnings:					
Information:					
31	Non Patent Literature	6936-28-PCA-DIV_OA_10_15_10.pdf	306953 8914eb96174e6b41e168ba9817d25dcf09b9daae	no	3
Warnings:					
Information:					
32	Non Patent Literature	6936-28-PEP_NOA_04-22-04.pdf	334505 d5342db2ae739c90f55f9103a9b204a4e3f1a659	no	4
Warnings:					
Information:					
33	Non Patent Literature	6936-28-PEP-2_SR_07-06-05.pdf	278074 9397743c1b70918cc15a0abeee04fc5a29dec5f8	no	3
Warnings:					
Information:					
34	Non Patent Literature	6936-28-PEP-2_NOA_05-07-07.pdf	364430 657e943e637f9258ea8e70e9cb6e8fb81c9c0071	no	4
Warnings:					
Information:					
35	Non Patent Literature	6936-28-PEP-3_Extended_ESR_02-15-2008.pdf	198850 3090a3c5cd2e510d2b7a21f3f99f7eba2af98a50	no	7
Warnings:					
Information:					

36	Non Patent Literature	6936-28-PEP-3_OA_10-9-08.pdf	559889 66ddeb350811047bc25e8b2d21a5c9d528c86cbf	no	7
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37	Non Patent Literature	6936-28-PEP3_OA_5-6-10.pdf	67003 60a8d3b8c2bf47b5a67da816de0f0546b77b10c8	no	3
Warnings:					
Information:					
38	Non Patent Literature	6936-28-PEP-3_Communication_2011-05-30.pdf	881964 84e405fe5252bb2c14cc86c021e2f4a594db0e88	no	21
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Information:					
39	Non Patent Literature	6936-28-PEP-3-DIV-1_ESR_2011-12-21.pdf	333225 e6d5ad52bc05cafe06170e579fe182676bed04d6	no	6
Warnings:					
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40	Non Patent Literature	6936-28-PEP-3-DIV-2_ESR_12-27-2011.pdf	249642 3e45e5379949ff244c6fb1c87147506cf8df2425	no	7
Warnings:					
Information:					
41	Non Patent Literature	6936-28-PJP_OA_8-19-08.pdf	454280 49a24e62272584a900bc46cda6500400cda0fd0e	no	5
Warnings:					
Information:					
42	Non Patent Literature	6936-28-PJP_NOA_03-16-2009.pdf	128563 34c6d355b8438a1368b9a38d7635dd12b39e575a	no	3
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Information:					
43	Non Patent Literature	6936-28-PJP-DIV_OA_2-8-10.pdf	138989 5616ac3717c8fabc9f7bbeeaaeee43e5db4031ef	no	4
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Information:					
44	Non Patent Literature	6936-28-PJP-DIV_OA_03_07_11.pdf	127860 542f0e34833d77ba3654270b7439e832c6987548	no	6
Warnings:					
Information:					

45	Non Patent Literature	6936-28-PJP-DIV_OA_2011-11-28.pdf	65487 e7d9c495c7e27a0316756470242a6d552123f90d	no	1
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Information:					
46	Non Patent Literature	6936-28-PKR_OA_11-15-05.pdf	123574 a576621a6107b7cfddca595d7777dec46536f7d2	no	1
Warnings:					
Information:					
47	Non Patent Literature	6936-28_OA_03-13-02.pdf	442792 3a1cb12d795916e4748bcfc109f6d111875fe2f9	no	6
Warnings:					
Information:					
48	Non Patent Literature	6936-28_NOA_06-17-02.pdf	566950 fd61c2dda2b2238f94e025051c877228bd435681	no	6
Warnings:					
Information:					
49	Non Patent Literature	6936-28-CON_OA_11-17-03.pdf	668209 f76896a14da3aeff61f6a563afc838afc5cfc571	no	7
Warnings:					
Information:					
50	Non Patent Literature	6936-28-CON-1_OA_11-30-04.pdf	275018 c0c4c0ffce281233559205b833a2b92a165d4ea3	no	8
Warnings:					
Information:					
51	Non Patent Literature	6936-28-CON-2_OA_09-12-05.pdf	208850 8f505772813fca42654d8091185d27f394c9f7eb	no	6
Warnings:					
Information:					
52	Non Patent Literature	6936-28-CON-3_OA_03-27-06.pdf	190970 947c56c89011a5ca8a4c3ab4abbc75a628ff7db9	no	5
Warnings:					
Information:					
53	Non Patent Literature	6936-28-CON4_OA_11-28-07.pdf	313852 3d6f1e2987a0df9bd308f34b416d9156e195d22b	no	8
Warnings:					
Information:					

54	Non Patent Literature	6936-28-CON4_OA_8-22-08.pdf	237380 75fe2e489216e9704555dc989bc93f66559b19f4	no	7
Warnings:					
Information:					
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Information:					
56	Non Patent Literature	6936-28-CON4_NOA_9-22-09.pdf	236548 b1f41cb2f2ba57c335d873658525c0fe92481f67	no	5
Warnings:					
Information:					
57	Non Patent Literature	6936-28-CON-5_OA_8_6_10.pdf	207879 9e3e390b5354ea4cc175ad9b9995643e8e9a5876	no	7
Warnings:					
Information:					
		Total Files Size (in bytes):	54707461		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of:	)	Group Art Unit:
John A. Greszczuk	)	Confirmation No.: 8684
Serial No.: 13/887,889	)	Examiner:
Filed: May 6, 2013	)	
Atty. File No.: 6936-28-CON-7	)	INFORMATION DISCLOSURE STATEMENT
Entitled: "MULTICARRIER TRANSMISSION SYSTEM WITH LOW POWER SLEEP MODE AND RAPID-ON CAPABILITY"	)	Electronically Submitted

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

The references cited on attached Form PTO-1449 are being called to the attention of the Examiner.

☒ Copies of the cited non-patent and/or foreign references are enclosed herewith.

☐ Copies of the cited U.S. patents and/or patent applications are enclosed herewith.

☒ Copies of the cited U.S. patents/unpublished patent applications/patent application publications are not enclosed in accordance with 37 C.F.R. § 1.98(a).

☐ Copies of the cited references are not enclosed, in accordance with 37 C.F.R. § 1.98(d), because the references were cited by or submitted to the U.S. Patent and Trademark Office in prior application Serial No. _____ filed _____, which is relied upon for an earlier filing date under 35 U.S.C. § 120.

☒ To the best of applicants' belief, the pertinence of the foreign-language references are believed to be summarized in the attached English translation/abstracts and/or in the figures, although applicants do not necessarily vouch for the accuracy of the translation.

☒ Examiner's attention is drawn to the following related applications:

- Serial No. 09/581,400 filed June 13, 2000 U.S. Patent No. 6,445,730 (Attorney Ref. No. 6936-28)
- Serial No. 10/175,815 filed June 21, 2002 (Attorney Ref. No. 6936-28-CON)
- Serial No. 10/778,083 filed Feb. 17, 2004 (Attorney Ref. No. 6936-28-CON-1)
- Serial No. 11/090,183 filed Mar. 28, 2005 (Attorney Ref. No. 6936-28-CON-2)
- Serial No. 11/289,516 filed Nov. 30, 2005 (Attorney Ref. No. 6936-28-CON-3)

- Serial No. 11/425,507 filed June 21, 2006 U.S. Patent No. 7,697,598 (Attorney Ref. No. 6936-28-CON-4)
- Serial No. 12/615,946 filed Nov. 10, 2009 U.S. Patent No. 7,978,753 (Attorney Ref. No. 6936-28-CON-5)
- Serial No. 13/152,558 filed June 30, 2011 US Patent No. 8,437,382 (Attorney Ref. No. 6936-28-CON-6)

☐ Other:_____

Submission of the above information is not intended as an admission that any item is citable under the statutes or rules to support a rejection, that any item disclosed represents analogous art, or that those skilled in the art would refer to or recognize the pertinence of any reference without the benefit of hindsight, nor should an inference be drawn as to the pertinence of the references based on the order in which they are presented. Submission of this statement should not be taken as an indication that a search has been conducted, or that no better art exists.

It is respectfully requested that the cited information be expressly considered during the prosecution of this application and the references made of record therein.

FEES

☒	**37 CFR 1.97(b)**: No fee is believed due in connection with this submission, because the information disclosure statement submitted herewith is satisfied by one of the following conditions ("X" indicates satisfaction): ☒ Within three months of the filing date of a national application other than a continued prosecution application under 37 CFR 1.53(d), or ☐ Within three months of the date of entry into the national stage of an international application as set forth in 37 CFR 1.491 or ☐ Before the mailing date of a first Office Action on the merits, or ☐ Before the mailing of a first Office action after the filing of a request for continued examination under 37 CFR 1.114. Although no fee is believed due, if any fee is deemed due in connection with this submission, please charge such fee to Deposit Account 19-1970.
☐	**37 CFR 1.97(c)**: The information disclosure statement transmitted herewith is being filed after all the above conditions (37 CFR 1.97(b)), but before the mailing date of one of the following conditions: (1) a final action under 37 C.F.R. 1.113 or (2) a notice of allowance under 37 C.F.R. 1.311, or (3) an action that otherwise closes prosecution in the application. This Information Disclosure Statement is accompanied by: ☐ A Certification (below) as specified by 37 C.F.R. 1.97(e). Although no fee is believed due, if any fee is deemed due in connection with this submission, please charge such fee to Deposit Account 19-1970. OR ☐ Please charge Deposit Account 19-1970 in the amount of $180.00 for the fee set forth in 37 C.F.R. 1.17(p) for submission of an information disclosure statement. Please credit any overpayment or charge any underpayment to Deposit Account 19-1970.

☐	**37 CFR 1.97(d)**: This Information Disclosure Statement is being submitted after the period specified in 37 CFR 1.97(c). ☐ This information Disclosure Statement includes a Certification (below) as specified by 37 C.F.R. 1.97(e) AND ☐ Applicants hereby requests consideration of the reference(s) disclosed herein. Please charge Deposit Account 19-1970 in the amount of $180.00 under 37 C.F.R. 1.17(p). Please credit any overpayment or charge any underpayment to Deposit Account 19-1970. Election to pay the fee should not be taken as an indication that applicant(s) cannot execute a certification.

Certification (37 C.F.R. 1.97(e))
(Applicable only if checked)

☐ The undersigned certifies that:

☐ Each item of information contained in this information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of this statement. 37 C.F.R. 1.97(e)(1).

☐ A copy of the communication from the foreign patent office is enclosed.

OR

☐ No item of information contained in this information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the undersigned after making reasonable inquiry, no item of information contained in this Information Disclosure Statement was known to any individual designated in 37 C.F.R. 1.56(c) more than three months prior to the filing of this statement. 37 C.F.R. 1.97(e)(2).

Respectfully submitted,

SHERIDAN ROSS P.C.

By: _____

Jason H. Vick
Registration No. 45,285
1560 Broadway, Suite 1200
Denver, Colorado 80202-5141
(303) 863-9700

Date: 6 Mar 13

Electronic Acknowledgement Receipt	
EFS ID:	15702987
Application Number:	13887889
International Application Number:	
Confirmation Number:	8684
Title of Invention:	MULTICARRIER TRANSMISSION SYSTEM WITH LOW POWER SLEEP MODE AND RAPID-ON CAPABILITY
First Named Inventor/Applicant Name:	John A. Greszczuk
Customer Number:	62574
Filer:	Jason Vick/Joanne Vos
Filer Authorized By:	Jason Vick
Attorney Docket Number:	6936-28-CON-7
Receipt Date:	06-MAY-2013
Filing Date:	
Time Stamp:	17:03:41
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Non Patent Literature	6936-28-CON-5_NOA_04-25-11.pdf	305518 ffba56c4fc24069a3fd03659f2e1d236af061414	no	6
Warnings:					
Information:					

2	Non Patent Literature	6936-28-CON-6_OA_06-01-2012.pdf	854734 4222214b0bdf9ea7b6529c348c7e0323b809e4c0	no	21
Warnings:					
Information:					
3	Non Patent Literature	6936-28-CON-6_NOA_02-04-2013.pdf	472242 9239dd8d6820fda54faa7f9476e367f8a995a2a1	no	11
Warnings:					
Information:					
		Total Files Size (in bytes):	1632494		

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/AIA/80 (07-12)
Approved for use through 11/30/2014. OMB 0651-0035
U.S. Patent and Trademark Office; U.S DEPARTMENT OF COMMERCE

POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(c).

I hereby appoint:

■ Practitioners associated with Customer Number: 62574

OR

☐ Practitioner(s) named below (If more than ten patent practitioners are to be named, then a customer number must be used):

Name	Registration Number	Name	Registration Number

As attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignments documents attached to this form in accordance with 37 CFR 3.73(c).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(c) to:

■ The address associated with Customer Number: 62574

OR

☐

Firm or Individual Name			
Address			
City		State	Zip
Country			
Telephone		Email	

Assignee Name and Address: TQ DELTA, LLC
805 Las Cimas Parkway, Suite 240
Austin, Texas 78746

A copy of this form, together with a statement under 37 CFR 3.73(c) (Form PTO/AIA/96 or equivalent) is required to be filed in each application in which this form is used. The statement under 37 CFR 3.73(c) may be completed by one of the practitioners appointed in this form, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record

The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

Signature	Mark Roche	Date	10/4/12
Name	Mark K. Roche	Telephone	512-609-1810
Title	Managing Director		

Electronic Acknowledgement Receipt	
EFS ID:	15703279
Application Number:	13887889
International Application Number:	
Confirmation Number:	8684
Title of Invention:	MULTICARRIER TRANSMISSION SYSTEM WITH LOW POWER SLEEP MODE AND RAPID-ON CAPABILITY
First Named Inventor/Applicant Name:	John A. Greszczuk
Customer Number:	62574
Filer:	Jason Vick/Joanne Vos
Filer Authorized By:	Jason Vick
Attorney Docket Number:	6936-28-CON-7
Receipt Date:	06-MAY-2013
Filing Date:	
Time Stamp:	17:13:39
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		Statement_Under_373c_w_POA.pdf	356649 14acc57d104c5b9122efd135fbbf74949b8326dc	yes	3

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Assignee showing of ownership per 37 CFR 3.73.	1	2
	Power of Attorney	3	3
Warnings:			
Information:			
	Total Files Size (in bytes):	356649	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/AIA/96 (08-12)
Approved for use through 01/31/2013. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

STATEMENT UNDER 37 CFR 3.73(c)

Applicant/Patent Owner: TQ DELTA, LLC

Application No./Patent No.: 13/887,889 Filed/Issue Date: May 6, 2013

Titled: MULTICARRIER TRANSMISSION SYSTEM WITH LOW POWER SLEEP MODE AND RAPID-ON CAPABILITY

TQ DELTA, LLC, a Corporation

(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that, for the patent application/patent identified above, it is (choose **one** of options 1, 2, 3 or 4 below):

1. ☑ The assignee of the entire right, title, and interest.

2. ☐ An assignee of less than the entire right, title, and interest (check applicable box):

   ☐ The extent (by percentage) of its ownership interest is _____%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.

   ☐ There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. ☐ The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. ☐ The recipient, via a court proceeding or the like (*e.g.*, bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose **one** of options A or B below):

A. ☐ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel _____, Frame _____, or for which a copy thereof is attached.

B. ☑ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: J. Greszczuk, R. Gross, H. Padir, M. Tzannes To: AWARE, INC.

   The document was recorded in the United States Patent and Trademark Office at
   Reel 011130, Frame 0775, or for which a copy thereof is attached.

2. From: AWARE, INC. To: TQ DELTA, LLC

   The document was recorded in the United States Patent and Trademark Office at
   Reel 029154, Frame 0937, or for which a copy thereof is attached.

PTO/AIA/96 (08-12)
Approved for use through 01/31/2013. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

STATEMENT UNDER 37 CFR 3.73(c)

3. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

4. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

5. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

6. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☑ As required by 37 CFR 3.73(c)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

Signature	May 6, 2013 Date
Jason H. Vick Printed or Typed Name	45,285 Title or Registration Number

Document code: WFEE

United States Patent and Trademark Office
Sales Receipt for Accounting Date: 06/05/2013

MTEKLEMI SALE #00000011 Mailroom Dt: 05/06/2013 191970 13887889
01 FC : 1051 140.00 DA

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 13/887,889	Filing Date 05/06/2013	☐ To be Mailed

ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT

05/06/2013	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 9	Minus	** 20	= 0	X $80 =	0
Independent (37 CFR 1.16(h))	* 1	Minus	***3	= 0	X $420 =	0
☐ Application Size Fee (37 CFR 1.16(s))						
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
					TOTAL ADD'L FEE	0

AMENDMENT

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
☐ Application Size Fee (37 CFR 1.16(s))						
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
					TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

LIE
/CORALIA BETANCOURT/