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Jasper et al.

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[54] **METHOD FOR PROVIDING AND SELECTING AMONGST MULTIPLE DATA RATES IN A TIME DIVISION MULTIPLEXED SYSTEM**

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[73] Assignee: **Motorola, Inc.**, Schaumburg, Ill.

[21] Appl. No.: **334,982**

[22] Filed: **Nov. 7, 1994**

[51] **Int. Cl.**[6] **H04B 7/212**

[52] **U.S. Cl.** **370/11**; 370/84; 370/95.3; 375/265; 375/298

[58] **Field of Search** 370/11, 95.3, 84, 370/79; 375/261, 262, 265, 298, 341, 225; 371/43

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Assistant Examiner—Min Jung
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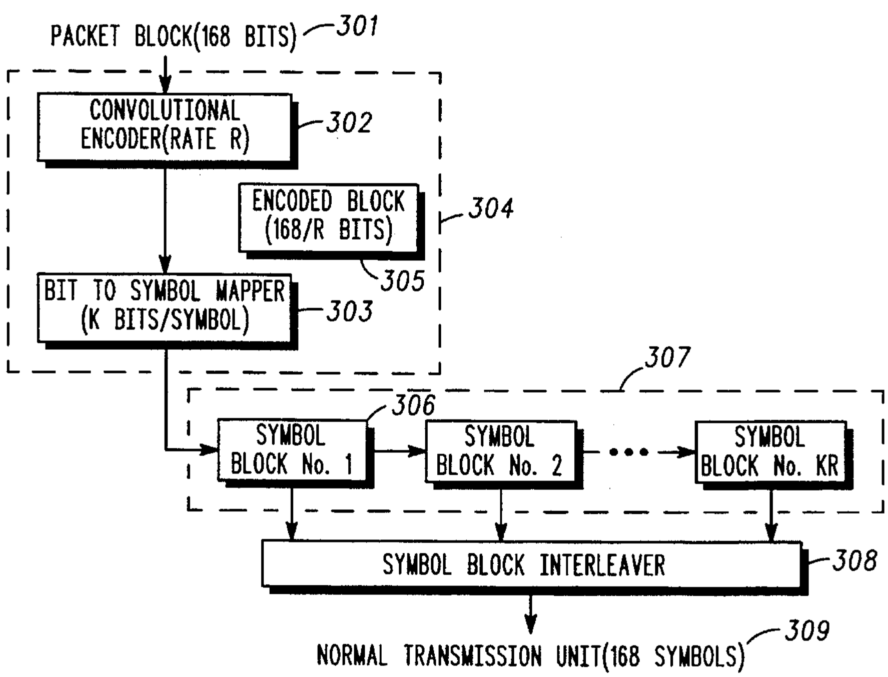
[57] **ABSTRACT**

In a Radio Frequency (RF) communication system using Time Division Multiple Access (TDMA) having time slots of a common duration, a quantity of information bits to be transmitted is provided. Based at least in part on the number of information bits to be transmitted, a modulation technique is selected from a plurality of modulation techniques. Based at least in part on the modulation technique selected and the common duration of the time slots, the information bits are formatted into blocks, each block containing an equal number of information bits. The blocks are transmitted in the time slots such that a predetermined symbol rate is maintained.

23 Claims, 3 Drawing Sheets



FORMAT NUMBER	CODE RATE (R)	MODULATION RATE (K)	INTERLEAVE SIZE (BLOCKS/SLOT)	EFFECTIVE DATA RATE(BITS/SYMBOL)
0	1/2	2 (QPSK)	1	1:1
1	1/2	4 (16QAM)	2	2:1
2	2/3	6 (64QAM)	4	4:1
3	3/4	8 (256QAM)	6	6:1

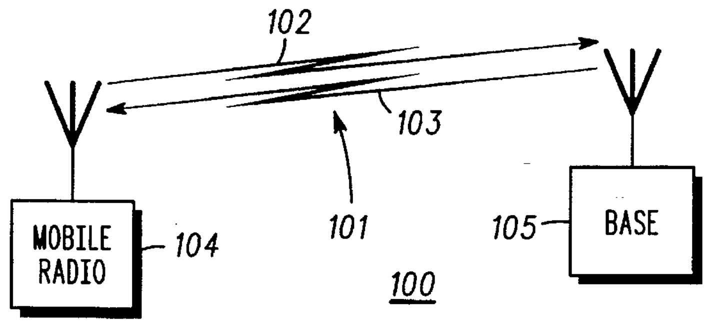


FIG. 1

FIG. 2
200

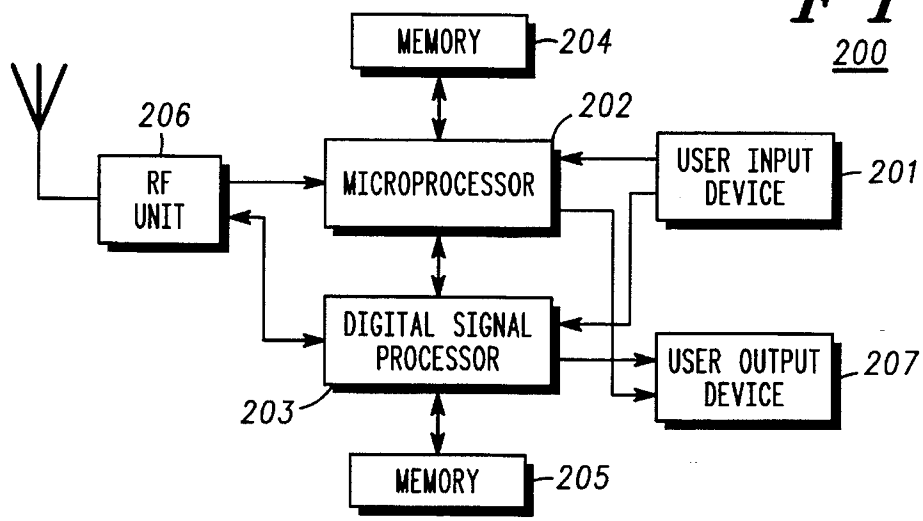


FIG. 3

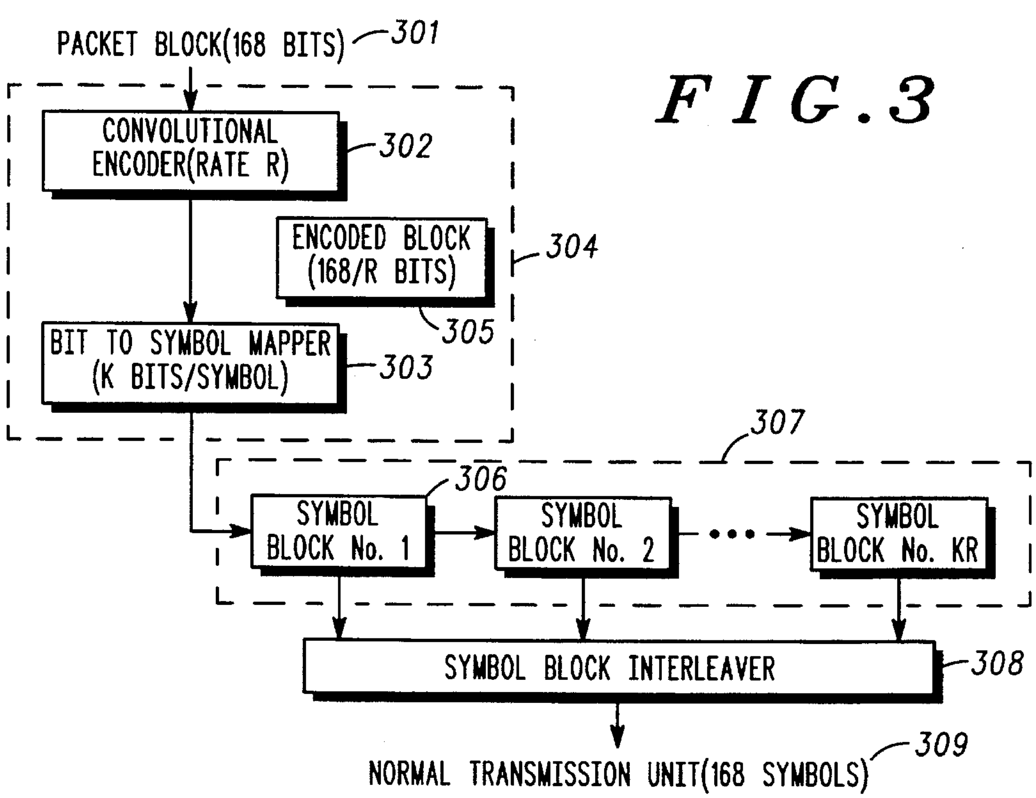


FIG. 4

FORMAT NUMBER	CODE RATE (R)	MODULATION RATE (K)	INTERLEAVE SIZE (BLOCKS/SLOT)	EFFECTIVE DATA RATE(BITS/SYMBOL)
0	1/2	2 (QPSK)	1	1:1
1	1/2	4 (16QAM)	2	2:1
2	2/3	6 (64QAM)	4	4:1
3	3/4	8 (256QAM)	6	6:1

FIG. 5

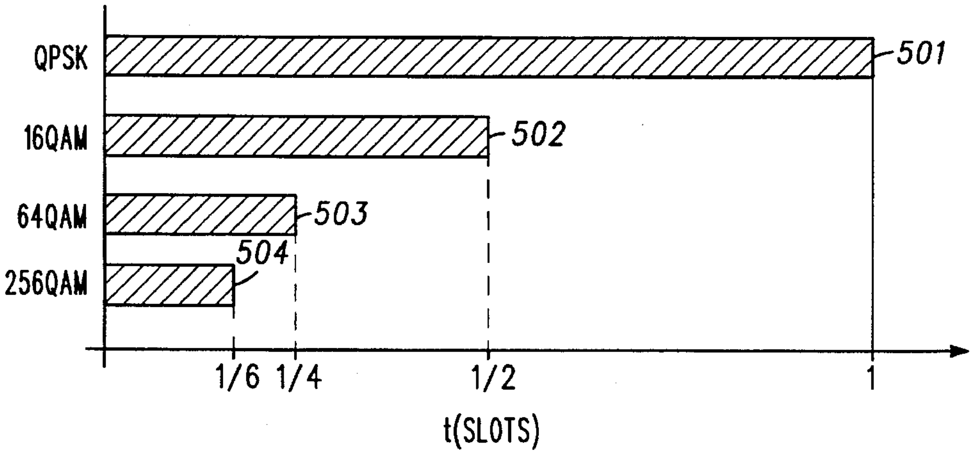


FIG. 6

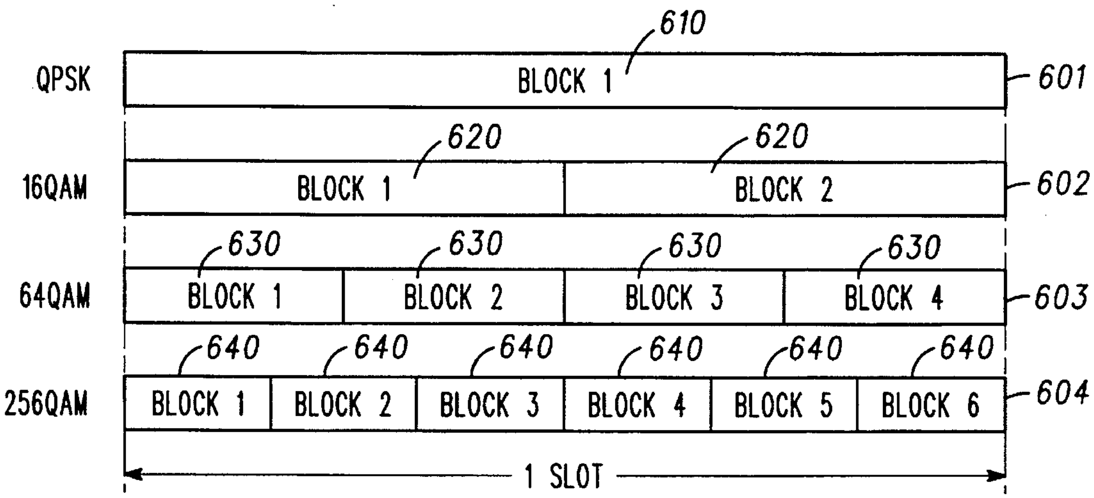
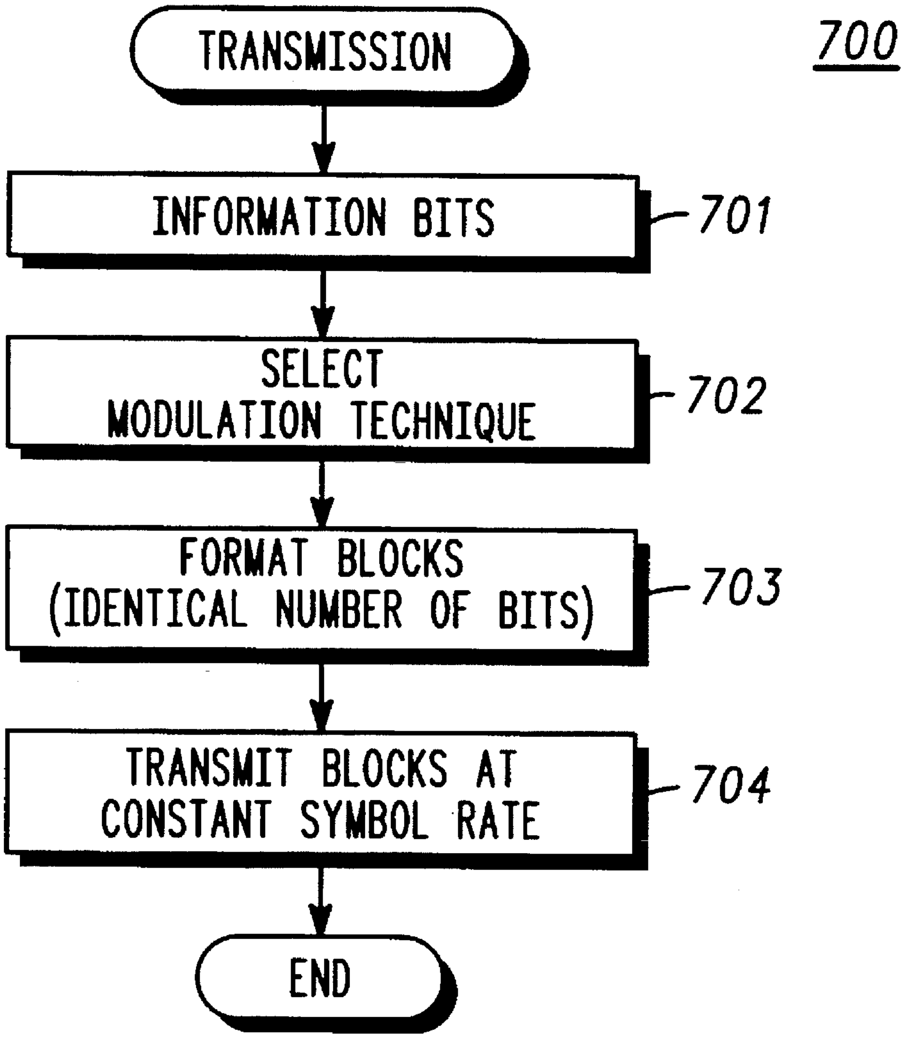


FIG.7


700
TRANSMISSION
INFORMATION BITS
701
SELECT MODULATION TECHNIQUE
702
FORMAT BLOCKS (IDENTICAL NUMBER OF BITS)
703
TRANSMIT BLOCKS AT CONSTANT SYMBOL RATE
704
END

METHOD FOR PROVIDING AND SELECTING AMONGST MULTIPLE DATA RATES IN A TIME DIVISION MULTIPLEXED SYSTEM

FIELD OF THE INVENTION

This invention relates generally to data communication systems

BACKGROUND OF THE INVENTION

Radio frequency (RF) communication systems for the transmission of data information (i.e. binary coded information) are well-known in the art. RF data communication systems generally provide a single channel data rate to their users. In these systems, the modulation and error coding are designed to provide acceptable performance for users at the edge of the desired coverage area, where generally worst case signal quality conditions are experienced.

It is well-known that, at signal quality levels typical of those found in closer proximity to a transmitting antenna (rather than at the edge of a radio coverage area), higher data rates with corresponding higher data throughputs are possible. It is also well-known that a relatively wide dynamic range of signal quality levels (e.g. 20–80 dB or decibels) typically exists within the coverage area of a mobile radio communication system. Therefore, users of prior art data communication systems who experience signal quality levels significantly above those found near the fringe of the coverage area generally suffer a lower grade of performance, in terms of data throughput, than would otherwise be possible.

In the field of wireline telecommunications, data modems that provide multiple data rates in response to signal quality levels are well-known. The methods used in this art, however, are not well-suited for application to radio data systems in general, and particularly to radio systems employing Time Division Multiple Access (TDMA). In TDMA systems, the radio channel is divided into a series of time slots of predetermined constant duration, which are typically further grouped into frames, each frame containing a predetermined number of time slots. Multiple users are allowed to access the radio communication channel by transmitting in one or more time slots in each frame. Thus a complete communication is composed of a series of multiple transmissions, such that the duration of each transmission is equal to the time slot duration.

Radio data communication methods typically transmit data in variable length messages referred to as packets. Packets are formed by dividing the data into a series of fixed-size protocol units referred to as blocks. The combination of the data block size, the data transmission rate, and the TDMA slot size determines how effectively the TDMA channel can be used. For example, if an integer number of blocks would not fit evenly into each time slot, the capacity representing the fractional block may go unused, reducing the available throughput of the channel. Alternately, a synchronization method could be implemented to permit all of the data capacity to be utilized, but such techniques are often complex. This additional complexity manifests itself in increased cost and in additional communication overhead that also reduces available throughput.

Assuming a predetermined time slot duration, it is possible to choose a block size that avoids these problems for a single transmission data rate. A problem arises, however, when seeking to provide a channel that will support multiple data rates.

Accordingly, a need arises for providing a plurality of data rates for use with an RF data system so that users may select that data rate that provides the best performance for their signal quality level. It is further desired that the multiple data rates be provided in a manner such that a TDMA communication channel can be utilized efficiently by a packet data protocol.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of a Radio Frequency communication system in accordance with the present invention.

FIG. **2** is a block diagram of a radio device that may be used to implement the present invention.

FIG. **3** is a block diagram of a general Forward Error Correction (FEC) and formatting procedure in accordance with the present invention.

FIG. **4** is a table illustrating combinations of modulation rates and code rates in accordance with the present invention.

FIG. **5** is a diagram illustrating the duration of data blocks using multiple data rates in accordance with the preferred embodiment.

FIG. **6** is a diagram illustrating the format of TDMA time slots using multiple data rates in accordance with the preferred embodiment.

FIG. **7** is a flow chart illustrating the method of the preferred embodiment.

DETAILED DESCRIPTION

The following paragraphs describe in detail a method for maximizing data communication system throughput in a fashion that avoids the shortcomings revealed in the foregoing discussion of the background art. The method described combines multiple Forward Error Correction (FEC) procedures with multiple modulation constellations, resulting in multiple data rates optimized for a given signal quality measure to provide maximum data throughput for signal conditions.

In a preferred embodiment, the method may be applied to a Radio Frequency (RF) communication system using TDMA (Time Division Multiple Access) to integrate multiple services, such as voice and packet data, within the same RF communication channel. Of course, the principles described herein are equally applicable to many other types of communication systems as well.

Referring to FIG. **1**, the RF communication system (**100**) of the preferred embodiment makes use of one or more RF communication channels (**101**) to provide a variety of communication services, among them voice and data (i.e. binary coded information) communications. Each RF communication channel (**101**) in fact is comprised of two RF frequencies (**102**, **103**), about which the radio signals are modulated. One of the RF frequencies is referred to as the inbound frequency (**102**) and is used for the transmission of information from mobile radio devices (mobile units) (**104**) to base radio devices (base units) (**105**). The second of the RF frequencies is referred to as the outbound frequency (**103**) and is used for the transmission of information from base units (**105**) to mobile units (**104**). Frequency assignments are typically made in a manner such that there is a constant spacing or offset between the inbound and outbound frequency of a communication channel. Further, in the pre-

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