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(71) Applicant *(for all designated States except US)*: WORLDSPACE MANAGEMENT CORPORATION [US/US]; 2400 N Street, N.W., Washington, DC 20037 (US).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: CAMPANELLA, S., Joseph [US/US]; 18917 Whetstone Circle, Gaithersburg, MD 20879 (US).

(74) Agents: HOLMES, John, E. et al.; Roylance, Abrams, Berdo & Goodman, LLP, 1225 Connecticut Avenue, N.W., Washington, DC 20036 (US).

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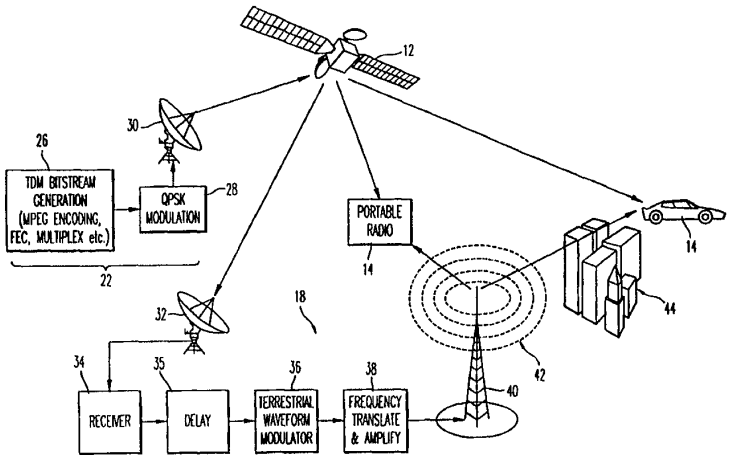

(57) Abstract

A digital broadcast system is provided which uses a satellite direct radio broadcast system having different downlink modulation options in combination with a terrestrial repeater network employing different re–broadcasting modulation options to achieve high availability reception by mobile radios (14), static radios and portable radios (14) in urban areas, suburban metropolitan areas, and rural areas, including geographically open areas and geographic areas characterized by high terrain elevations. Two–arm and three–arm receivers are provided which each comprise a combined architecture for receiving both satellite and terrestrial signals, and for maximum likelihood combining of received signals for diversity purposes. A terrestrial repeater is provided for reformatting a TDM satellite signal as a multicarrier modulated terrestrial signal. Configurations for indoor and outdoor terrestrial repeaters are also provided.

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DIGITAL BROADCAST SYSTEM USING SATELLITE DIRECT BROADCAST AND TERRESTRIAL REPEATER

Field of Invention

A digital broadcast system is provided which uses a satellite direct radio broadcast system having different downlink options in combination with a terrestrial repeater network employing different re-broadcasting options to achieve high availability reception by mobile radios, static radios and portable radios in urban areas, suburban metropolitan areas, rural areas, including geographically open areas and geographic areas characterized by terrain having high elevations.

Background of the Invention

Receivers in existing systems which provide digital audio radio service (DARS) have been radically affected by multipath effects which create severe degradations in signal quality, such as signal fading and inter-symbol interference (ISI). Fading effects on broadcast channels to receivers can be sensitive to frequency, particularly in an urban environment or geographic areas with high elevations where blockage of line of sight (LOS) signals from satellites is most prevalent. Locations directly beneath a satellite (hereinafter referred to as the sub-satellite point) inherently have the highest elevation angles, while locations that depart from the sub-satellite point inherently have decreasing elevation angles and, accordingly, an increase of the earth center angle subtended between the sub-satellite point and the reception location. Locations that are near the sub-satellite point typically enjoy virtually unblocked LOS reception. Thus, the need for terrestrial reinforcement of potentially blocked LOS signals is minimal. When the LOS elevation angle to the satellite becomes less than about 85 degrees, however, blockage by tall buildings or geological elevations (i.e., on the order of 30 meters) becomes significant. Terrestrial re-radiation for gap filling is needed to achieve satisfactory coverage for mobile radios, static radios, as well as portable radios. In areas where the heights of buildings or geological sites are relatively low (i.e., on the order of less than 10 meters), the blockage is not significant until the LOS elevation angle is lower than 75 degrees. Thus, at the mid-latitude and high latitude locations within the coverages of one or more broadcast satellites, terrestrial re-radiation is needed to achieve suitable radio reception. A need exists for fully satisfactory radio reception that combines satellite LOS transmission and terrestrial re-radiation of a satellite downlink signal waveform.

Summary of the Invention

In accordance with one aspect of the present invention, a digital broadcast system (DBS) is provided which overcomes a number of disadvantages associated with existing broadcast systems and realizes a number of advantages. The DBS of the present invention comprises a TDM carrier satellite delivery system for digital audio broadcasts (DAB) and other digital information which is combined with a network of terrestrial

repeaters for the re-radiation of satellite downlink signals toward radio receivers. The terrestrial repeaters are configured to employ multipath-tolerant modulation techniques.

In accordance with another aspect of the present invention, a satellite delivery system and a terrestrial repeater operate using different carrier frequencies. The terrestrial repeater employs multipath-tolerant modulation techniques.

In accordance with yet another aspect of the present invention, a satellite delivery system and a terrestrial repeater both employ multipath-tolerant modulation techniques and can be configured to use the same or different carrier frequencies, depending on the type of waveform used. The satellite delivery system preferably employs a TDM or code division multiple access (CDMA)-type waveform. The terrestrial repeater preferably employs a multipath-tolerant waveform such as CDMA, Adaptive Equalized TDM (AETDM), Coherent Frequency Hopping Adaptively Equalized TDM (CFHATDM) or Multiple Carrier Modulation (MCM).

In accordance with still another aspect of the present invention, a single geostationary satellite transmits downlink signals which can be received by radio receivers in the LOS of the satellite signal, as well as by terrestrial repeaters. Each terrestrial repeater is configured to recover the digital baseband signal from the satellite signal and modulate the signal using multicarrier modulation (MCM) for retransmission toward radio receivers. Radio receivers are configured to receive both a quadrature phase shift keyed (QPSK) modulated TDM bit stream, as well as an MCM stream. Radio receivers are programmed to select a broadcast channel demodulated from the TDM bit stream and the MCM bit stream, and to select the broadcast channel recovered with the least errors using a diversity combiner.

In accordance with still yet another aspect of the present invention, a DBS is provided which comprises two geostationary satellites in combination with a network of terrestrial repeaters. The terrestrial repeaters are configured to process satellite downlink signals to achieve the baseband satellite signal and to modulate the signal using MCM. Radio receivers are configured to implement a diversity decision logic to select from among three diversity signals, including the two satellite signals and the MCM signal. Each radio receiver employs maximum likelihood combining of two LOS

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