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(54) **DATA COMMUNICATION AND RADIO SYSTEM**

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(58) **Field of Search** **375/265, 341**;
370/537, 538, 540, 542, 543, 544

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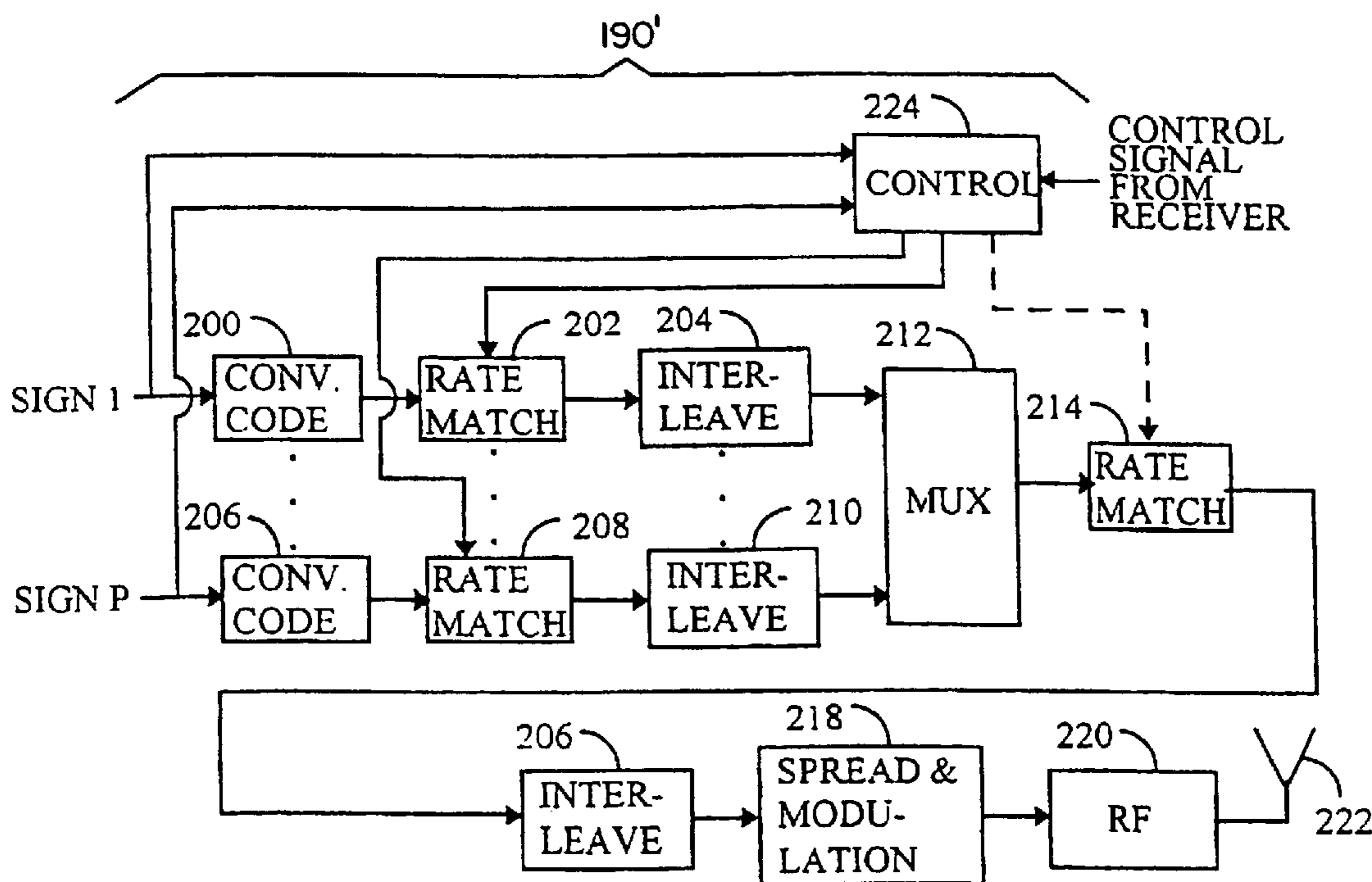
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(57) **ABSTRACT**

Provided is a method and system for a radio system including at least one base station and terminal equipment including a receiver and a transmitter. The transmitter is structured and arranged to independently adjust a symbol rate of at least two signals and combine the two signals after adjusting the symbol rate. The transmitter then transmits the combined signal along one physical path. By adjusting the signal rate before combining the two signals, the transmitter optimizes the signal qualities of each of the signals.

18 Claims, 2 Drawing Sheets



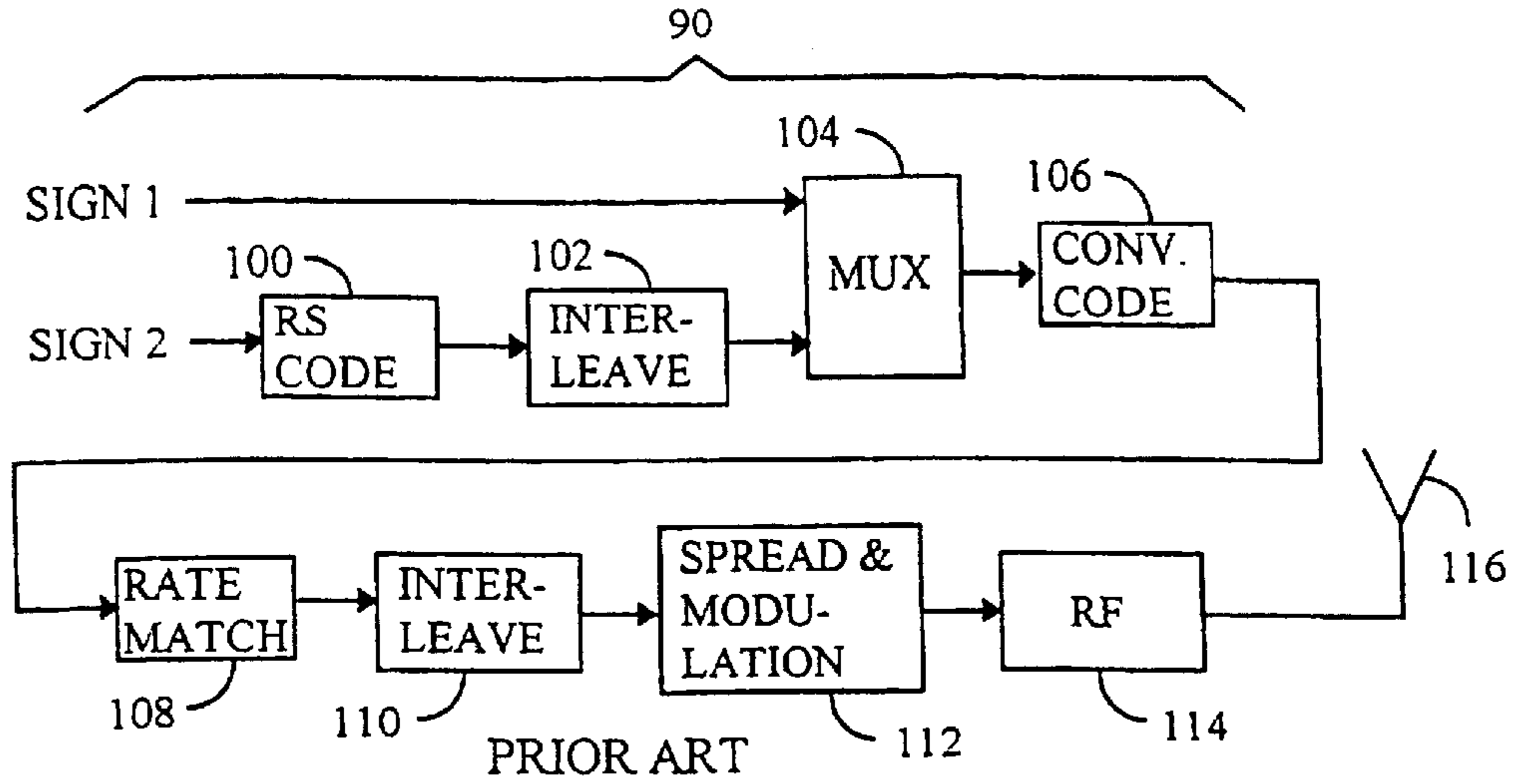


FIG. 1

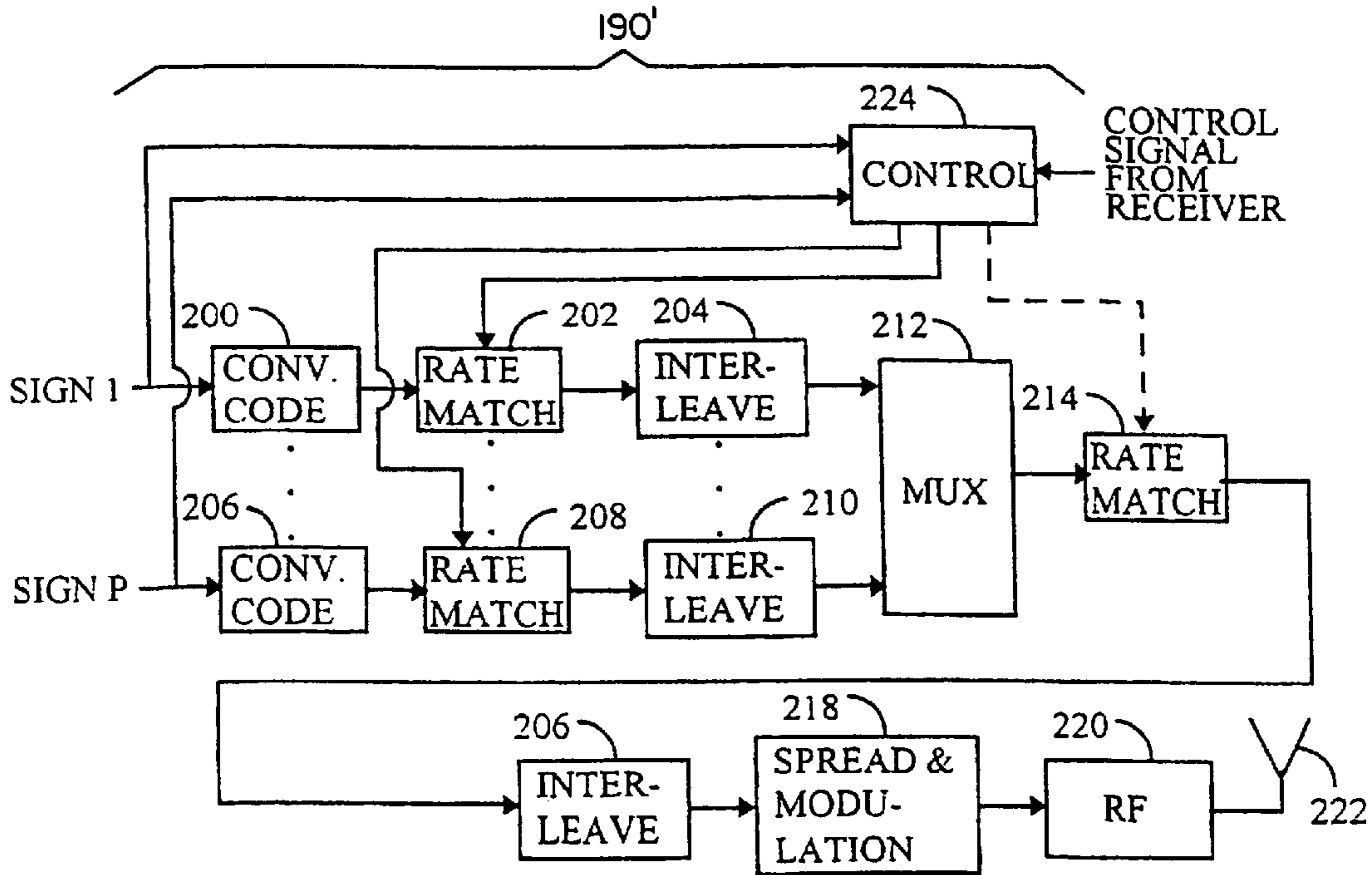


FIG. 2

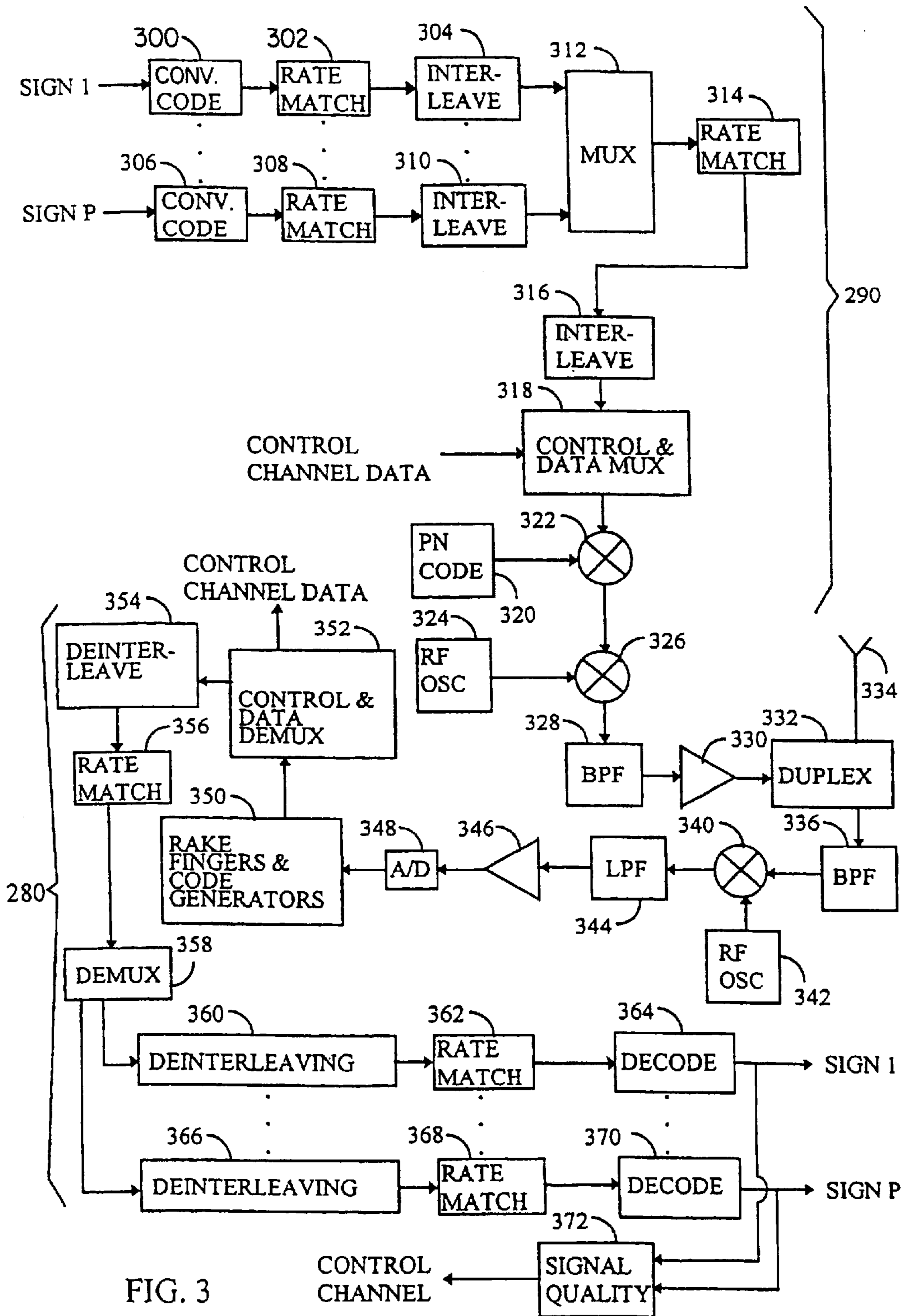


FIG. 3

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DATA COMMUNICATION AND RADIO SYSTEM

Matter enclosed in heavy brackets [] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

This application is the national phase of international application PCT/FI99/00248 filed Mar. 25, 1999 which designated the U.S.

FIELD OF THE INVENTION

The invention relates to a data transmission method, which is used in a radio system comprising at least one base station and terminal equipment comprising a receiver and a transmitter and communicating with each other over at least one physical channel.

The invention further relates to a radio system, particularly a radio system comprising at least one base station and terminal equipment comprising a receiver and a transmitter and communicating with each other over at least one physical channel.

BACKGROUND OF THE INVENTION

Present mobile telephone systems attempt to provide the user with increasingly versatile services. This goal is shared by IMT-2000 (International Mobile Telecommunications for the Year 2000) services which aim to offer high-quality speech/audio signal transmission, high-rate data transfer, photograph transmission and video image transmission. In addition, the IMT-2000 service encompasses interactivity, multimedia electric mail, video conferences and target location determination, for example.

Transferring different data requires different symbol rate and signal transmission power. In the present radio systems the symbol rate is not optimized for the changing channel conditions since the symbol rate of several signals cannot be adapted in one physical channel. If, for example, two service signals transmitted over the same physical channel have differing quality requirements when received and the signals act differently when the delay profile of the channel changes, problems affecting the power level of the two signals occur. Such a problem typically arises when Reed-Solomon coding and convolution coding are used together. When the channel delay profile changes, a situation may arise when the first signal in accordance with the example is barely acceptable in terms of quality, while the other signal is of unnecessarily high quality. The simulation is particularly critical when a service signal only requiring a low symbol rate forces a service signal requiring a high symbol rate to use extra transmission power. The prior art solutions fail to resolve this disparity. Unresolved, the disparity will cause interference over the whole area of the radio system.

BRIEF DESCRIPTION OF THE INVENTION

An object of the invention is thus to provide a method and a radio system implementing the method so as to solve the above problems and balance the signal quality. This is achieved by a method of the type described in the introduction, the method being characterized by the transmitter transmitting at least over one physical channel at least two signals having differing quality requirements when received, and the transmitter changing, if necessary, signal-specifically the symbol rates of the signals used over the physical channel in order to meet the quality requirements.

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The radio system of the invention is characterized by the transmitter being arranged to transmit over one physical channel at least two signals having differing quality requirements when received, the transmitter therefore comprising at least means for changing the symbol rate of the signals signal-specifically in order to meet the quality requirements, and combination means for combining the signals in the same physical channel.

A plurality of advantage can be achieved with the method and system of the invention. The desired quality requirements of a signal to be received can be balanced, which enables optimized transmission power to be used. The result is less interference in the radio system.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is now described in closer detail in connection with the preferred embodiments with reference to the accompanying drawings, in which

FIG. 1 shows a prior art transmitter,

FIG. 2 shows a transmitter of the invention, and

FIG. 3 shows a transceiver of the invention.

DETAILED DESCRIPTION OF THE #INVENTION

The solution of the invention is suited particularly for WCDMA (Wideband Code Division Multiple Access), UMTS (Universal Mobile Telephone System) and IMT-2000 radio systems. Hence, the invention is suitable for at least TDMA-based (Time Division Multiple Access) and CDMA-based radio systems.

Examine first by means of FIG. 1 how data is transmitted in accordance with the prior art. In the present example, a transmitter **90** only transmits a signal **1** and a signal **2** over the same physical channel, but the same principle applies also to three or more signals to be transmitted. The signals typically have differing quality standards when received. A carrier-to-interference ratio or for instance a bit error rate BER can be used as the quality standard. The BER of the signal **1** is for example $BER_1=e^{-3}$ and the BER of the signal **2** is $BER_2=e^{-6}$. Since the quality requirements are signal-specific, the signals should be transmitted at different transmission power/symbol rates. The signal **2** to be transmitted is first encoded by for example Reed-Solomon coding at means **100**. This coding can also be some other coding. Next, at means **102**, the signal **2** is interleaved, in other words the bits or symbols of the signal are rearranged such that the signal **2** becomes more tolerant of fading. The signal **1** and the signal **2** are combined into a combined signal at a combination means **104**, which can be a multiplexer. Next, the combined signal is convolution-coded at a coder **106**. The symbol rate and thus also the transmission power—of the combined signal is changed by removal coding or repetition coding, if necessary, at means **108**. The removal coding or repetition coding increases or decreases the number of bits to be transmitted, affecting the two signals in a similar manner. The signal is further interleaved at means **110**. Eventually, the signal is modulated into a radiofrequency signal at radio frequency means **114** in a manner obvious to one skilled in the art, and the radiofrequency signal is transmitted by an antenna **116**. The fact that only one shared unit **148** is provided to adapt the symbol rate prevents the signal power levels from being optimized.

Examine now a solution of the invention by means of FIG. 2. A transmitter **190** transmits a total of P signals having differing quality requirements. The number P of the signals

to be transmitted is two or more. Before being combined, a signal **1** is encoded by a coder **200**, the symbol rate is adapted at means **202** and interleaved at means **204**. Other signals are processed in a similar manner, a signal **P** is thus encoded at a coder **206**, the symbol rate is adapted at means **208** and interleaved at means **210**. Although being typically employed in a radio system transmitter, the coders **200**, **206** and the interleaving means **204**, **210** are irrelevant to the invention. Hence, in addition to or instead of the codes **200**, **206** and the interleaving means **204**, **210**, the solution of the invention can further comprise other signal processing means. Essential in the inventive solution is that the signals in this embodiment at least have the unique means **208** and **210** affecting the symbol rate which change the symbol rate by removal coding and/or repetition coding, if necessary. Changing the symbol rate also changes the signal transmission power; changing the symbol rate is thus equivalent to changing signal transmission power. The signals are combined at a combination means **212**, which is a multiplexer. In the solution of the invention, the symbol rate of the combined signal can be further changed at means **214**, if necessary. The means **214** also performs removal coding and/or repetition coding. In the solution of the invention, it is not, however, necessary to change the symbol rate at this point. The subsequent operation of the transmitter **190** is irrelevant to the inventive solution. Typically, however, the signal is interleaved at means **206**, spreading-coded and modulated in one or more manners at means **218**, modulated into a radio-frequency signal at means **220**, and transmitted via an antenna **222**. Hence, at least two different signals that are usually associated with different services are transmitted over the same physical channel. A physical channel is here defined as a channel based on the use of one or more spreading codes.

In a preferred embodiment of the invention the symbol rate of the transmitter **190** can be controlled by a receiver. In such a case, a control signal (CONTROL SIGNAL FROM RECEIVER) is supplied from the receiver to a control unit **224** of the transmitter, the control unit controlling the blocks **202**, **208** changing the symbol rate as instructed by the control signal. The control block **224** can also control the block **214** changing the symbol rate if such a block is in use at the transmitter **190**. The signals **1** to **P** are also supplied to the control block **224**, whereby the control block **224** knows the required symbol rate. Removal coding and/or repetition coding changing the symbol rate and the transmission power is performed both for the transmitter and the receiver in a known manner. Consequently, the change does not otherwise affect the data transmission.

FIG. **3** shows the features of the inventive solution in greater detail. The base stations and terminal equipment of the radio system are transceivers, the block diagram of FIG. **3** showing such a transceiver in general. The transceiver transmits **P** signals, which a transmitter **290** first encodes at means **300**, **306**, adapts the symbol rates at means **302**, **308**, and interleaves at means **304**, **310** as in FIG. **2**. Henceforth, the signal processing also proceeds in accordance with FIG. **2**, in other words the signals are combined by a combination means **312**, the symbol rate of the combined signal is further adapted at means **314**, and the combined signal is interleaved at means **316**. Next, at a typical transmitter part **290**, control data is added to the signal to be transmitted at means **318**, preferably being a multiplexer. Next, the signal is spreading-coded, which is performed in such a manner that the signal is multiplied at a multiplier **322** by a spreading code supplied from a spreading code generator **320**. The spreading-coded signal is modulated into a radiofrequency

signal by multiplying at a multiplier **326** the signal by a carrier supplied from an RF oscillator **324** and by filtering the signal at a filter **328**. The radio-frequency signal is amplified at an RF power amplifier **330** and transferred via a duplex-filter **332** to an antenna **334** to be transmitted.

In the solution of the invention, a receiver **280** operates in the following manner. The antenna **334** receives the signal, which is a combination signal consisting of several signals. The received signal propagates via the duplex-filter **332** to a filter **336**, which only allows the desired band to pass. The filtered signal is demodulated by multiplying the signal at a multiplier **340** by the signal of a local oscillator **342**, and low-pass-filtering the signal at a filter **344**. Next, the aim is to keep the power level of the received signal unchanged with an ACC amplifier **346**. The signal is changed to digital by an analogue/digital converter **348**. Since the signal is a multipath-propagated signal, the aim is to combine the signal components propagated via different paths in a block **350** which, in accordance with the prior art, comprises a plurality of RAKE branches. The signal components received by the RAKE branches at different delays are searched by correlating the received signal with the spreading codes used, which are delayed by predetermined delays. When the signal component delays are found out, signal components belonging to the same signal are combined. Simultaneously, the spreading coding of the signal components is decoded. Next, the control signals and data signals included in the received signal are separated by demultiplexing at means **352**. The signal part containing data is conveyed to be deinterleaved at means **354**. Here, the interleaving of the block corresponding to the interleaving means **316** is thus deinterleaved. Next, at means **356**, the signal undergoes an inverse operation of the symbol rate change corresponding to the transmitter block **314**. Hence, if the transmitter block **314** has performed removal coding, the block **356** performs repetition coding of a corresponding extent. Next, the combination signal is divided into **P** signals at demultiplexing means **358**. The interleaving of the first signal is deinterleaved at deinterleaving means **360**, the symbol rate is inversely adapted in relation to the adaptation of the transmitter block **302** at means **362** and the signal coding is decoded at the means **362**, in which case the signal **1** is available to the receiver. A similar procedure is repeated in connection with other demultiplexed signals; similarly, the interleaving of the signal **P** is deinterleaved at means **366**, removal coding or repetition coding is performed at means **368**, and the signal is decoded at means **370**. The means **300**, **306** of the transmitter usually perform convolution coding, the convolution coding being decoded by the means **364**, **370** of the receiver.

The receiver **280** further comprises a block **372** measuring the signal quality. If any of the received signals does not meet the quality requirements or exceeds the quality requirements too dramatically, in other words deviates too much from a predetermined quality requirement, a signal controlling the symbol rate is supplied from the block **372** to the block **318** of the transmitter part for the control channel.

The solution of the invention is also suited for radio systems wherein the physical channel is based on bursts instead of spreading code(s), as is the case with the TDMA-based transmissions for example in a GSM radio system. In such a case, a plurality of service signals can be transmitted at an optimal power level in the same burst. The advantage of this is that the receiver does not need to receive separate signals from each service. This also applies to the TDMA/CDMA radio system wherein spreading coding is used within the burst. Hence, several different services can be

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simultaneously placed for the code or group of codes to be used in the burst. FIGS. 1 to 3 show transmitters and receivers using spreading coding. Truly TDMA-based transmitters and receivers are similar to the ones shown in FIGS. 1 to 3 as regards the rest of the blocks, but spreading coding is naturally ignored at the blocks 112, 218, the means 320 and 322 also being unnecessary. Furthermore, neither are the delays of the received signal caused by multipath-propagation searched on the basis of the spreading code at the block 350 in such a case. In the TDMA receiver, the block 350 performs equalization wherein the received signal is multiplied by an estimate of the impulse response of the channel. The impulse response estimate is formed, in turn, by means of a training sequence or another known sequence in a manner obvious to one skilled in the art. Both transmission and reception modes are employed in the TDMA/CDMA transceivers.

Although the invention is described above with reference to the example in accordance with the accompanying drawings, it is obvious that the invention is not restricted thereto but can be modified in various ways within the scope of the inventive idea disclosed in the attached claims.

What is claimed is:

1. A data transmission method used in a radio system including at least one base station and terminal equipment, [the terminal equipment including at least a transmitter and a receiver, the transmitter and the receiver being adapted to communicate with each other over at least one physical channel,] the method comprising:

receiving in [the] a transmitter, at least two signals, each having [a unique] differing signal quality requirements; independently adjusting a symbol rate of the at least two received signals if [a] signal quality requirement of one of the at least two received signals is different from [a] the signal quality requirement of the other of the at least two received signals by a predetermined amount, the adjusting compensating for the difference;

combining the at least two received signals to produce a combined signal; and

transmitting the combined signal along [the] at least one physical path configured to carry communication between the transmitter and a receiver,

wherein independently adjusting a symbol rate is performed prior to combining the at least two received signals.

2. The method of claim 1, wherein the transmitter employs at least one of removal coding and repetition coding.

3. The method of claim 2, wherein the removal coding and repetition coding are performed in a predetermined manner, wherein the change in the symbol rate does not interfere with transmission of the combined signal.

4. The method of claim 1, wherein the transmitter adjusts the symbol rate of each of the at least two received signals in such a way that a symbol rate of the combined signal is kept unchanged.

5. The method of claim 1, wherein the receiver indicates to the transmitter that a need exists to change the symbol rates of the at least two received signals when the quality of one or more of the at least two received signals does not meet a predetermined quality requirement at the receiver.

6. The method of claim 1, wherein the transmitter is configured to adjust, if necessary, the symbol rate of the combined signal.

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7. The method of claim 1, further comprising the transmitter interleaving the at least two received signals.

8. The method of claim 1, wherein the transmitter is configured to perform at least one of convolution coding and Reed-Solomon coding of the at least two received signals.

9. The method of claim 1, wherein the signal [qualities] quality requirements are signal-specific.

10. A radio system including at least one base station and terminal equipment, [the terminal equipment] at least one of which including a receiver [and] or a transmitter, the receiver and the transmitter being configured to communicate with each other over at least one physical channel, wherein the transmitter is structured and arranged to transmit at least two received signals over one physical path, [each] the received [signal] signals having [a unique] differing signal quality requirements, the transmitter comprising at least:

a symbol rate adjuster configured to independently adjust a symbol rate of each of the at least two received signals if [a] signal quality requirement of one of the at least two received signals is different from [a] signal quality requirement of the other of the at least two received signals by a predetermined amount; and

a combiner configured to combine the at least two received signals to produce a combined signal for transmission along the at least one physical path;

wherein the symbol rate adjuster adjusts, if necessary, the symbol rate of at least one of the at least two received signals before the combiner combines the at least two received signals.

11. The radio system of claim 10, wherein the symbol rate adjuster is configured to employ at least one of removal coding and repetition coding.

12. The radio system of claim 11, wherein the at least one of the removal coding and repetition coding is known to the transmitter and the receiver.

13. The radio system of claim 10, wherein the symbol rate adjuster is configured to change the symbol rate of the at least two received signals prior to combination in such a way that the symbol rate of the combined signal is unchanged by operation of the symbol rate adjuster.

14. The radio system of claim 10, wherein the receiver is configured to measure the quality of the at least two received signals and to indicate to the transmitter that a need exists to change the symbol rates of the at least two received signals if the quality of one or more of the at least two received signals does not meet a predetermined quality requirement at the receiver.

15. The radio system of claim 10, wherein the transmitter is configured to change, if necessary, a symbol rate of the combined signal.

16. The radio system of claim 10 or 15, wherein the transmitter is configured to interleave the at least two received signals.

17. The radio system of claim 10 or 15, wherein the transmitter is configured to perform at least one of convolution coding and Reed-Solomon coding on the at least two received signals.

18. The radio system of claim 10, wherein the signal [qualities] quality requirements are signal specific.