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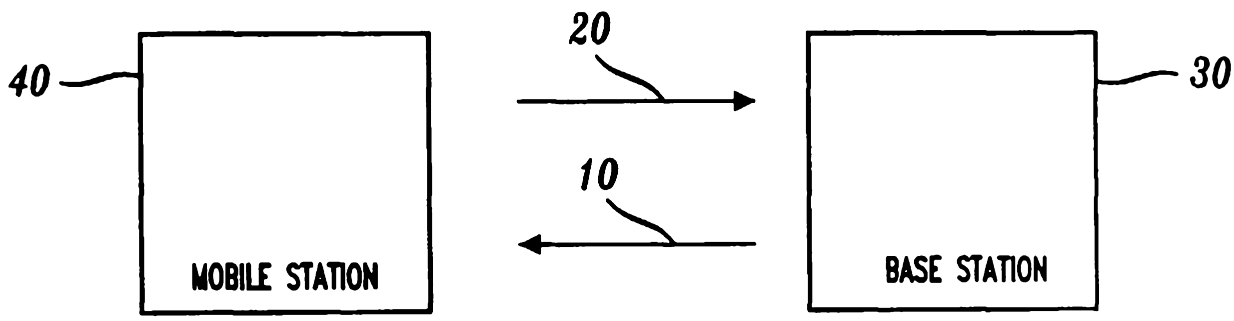
A METHOD OF POWER CONTROL FOR A WIRELESS COMMUNICATION SYSTEM HAVING MULTIPLE INFORMATION RATES

Abstract

A method of controlling the power in a wireless communication system (200). In one embodiment of the invention, a base station (210) determines the information rate of a signal to be transmitted (270) to a mobile station (220), and obtains the variable power control scaling factor (245) based on this information rate. The base station (210) then transmits the variable power control scaling factor (245) to the mobile station (220). The mobile station (220) determines a target signal quality measurement (130) for a received signal (270) from the base station (220), such as a target E_b/N_0 (130), and scales the target E_b/N_0 (130) by the variable power control scaling factor (245). The mobile station (220) also obtains an information rate scaling factor based on the information rate of the received signal (270), and further scales the target E_b/N_0 by this information rate scaling factor. The mobile station (220) then compares the target E_b/N_0 (130) to a measured E_b/N_0 (160) of the received signal (270). An increase in power of the received signal (270) is requested when the measured E_b/N_0 (160) of the received signal (270) is smaller than the scaled E_b/N_0 (260). A decrease in power of the received signal (270) is requested when the measured E_b/N_0 (160) of the received signal (270) is larger than the scaled E_b/N_0 (260). Providing the variable power control scaling factor (245) to the mobile station (220) allows frames having an information rate lower than the full rate to be transmitted at a power even lower than the power of a frame having an information rate equal to the full rate times the information scaling factor.

Figure 3.

FIG. 1



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COMPLETE SPECIFICATION

FOR A STANDARD PATENT

ORIGINAL

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Invention Title:	A Method of Power Control for a Wireless Communication System Having Multiple Information Rates

The following statement is a full description of this invention, including the best method of performing it known to me/us:-

A METHOD OF POWER CONTROL FOR A WIRELESS COMMUNICATION SYSTEM HAVING MULTIPLE INFORMATION RATES

Field of the Invention

The present invention relates generally to wireless communications systems and, in particular, to power control in wireless communications systems having multiple information rates.

Background of the Invention

Wireless communications systems use power control to improve system performance and increase system capacity. Power control involves tracking possible fading of communication channels and using that tracked fading to manage the power at which signals are being transmitted from base stations (in order to compensate for the fading). Conventional Code Division Multiple Access (CDMA) wireless communications systems based on the well-known IS-95 standard use error indicator bits to assist in controlling transmission power at the base station. Power control is implemented in the following manner.

When a call is set up in a CDMA wireless communications system, a base station and a mobile station communicate over a forward and a reverse link. The forward link includes communication channels for transmitting signals from the base station to the mobile station and the reverse link includes communication channels for transmitting signals from the mobile station to the base station. The base station transmits control information to the mobile station over a communication channel referred to herein as a forward control channel, and the mobile station transmits control information to the base station over a communication channel referred to herein as a reverse control channel. The base station transmits voice or data to the mobile station over a communication channel referred to herein as a forward traffic channel, and the mobile station transmits voice or data to the base station over a communication channel referred to herein as a reverse traffic channel. In either traffic channel, voice or data is transmitted over 20 milli-seconds (ms) time intervals referred to herein as frames.

A set number of voice or data bits are transmitted within each frame, typically reported as the number of bits transmitted per second, referred to herein as a channel rate. The channel rate does not change and is typically dependent on the rate of the coder in the system, i.e. the rate of the speech or data coder. However, the amount of information within each frame of the signal does change, particularly for voice signals. Therefore the number of bits of information transmitted per second, referred to herein as the information rate, can change.

Four different information rates are possible in the traffic channel: full rate, ½ rate, ¼ rate and 1/8 rate. At the full rate the information rate and the channel rate are the equal. The information rate of the forward traffic channel is at the full rate when a large amount of information is being transmitted from the base station to the mobile. The information rate of the forward traffic channel is at the 1/8 rate when a small amount of information is being transmitted from the base station to the mobile. The ½ and the ¼ rate are transitional rates. For example, in a telephone conversation between a mobile station user and a second user communicating with the mobile station user, a voice signal from the second user is transmitted to the base station, which transmits it to the mobile station over the forward traffic channel. During a part of the conversation, the second user is talking. Therefore, the information rate of the forward traffic channel would be high because a large amount of information is being transmitted on the forward traffic channel. In this case, the information rate would be the full rate. During another part of the conversation, the second user is listening. Therefore, the information rate of the forward traffic channel would be low because a small amount of information is being transmitted on the forward traffic channel. In this case, the information rate would be equal to the 1/8 rate.

When the information rate is ½, ¼, or 1/8, the channel rate is higher than the information rate, and the information is repeated several times per frame. For example, with the ½ rate information is repeated twice each frame; with the ¼ rate the information is repeated four times per frame; and with the 1/8 rate the information is repeated eight times per frame. Repeating the information several times per frame permits the information to be transmitted at a correspondingly lower power. The power is scaled by an information rate scaling factor, which is equal to the information rate. For a frame whose information rate is equal to the 1/8 rate, the information rate scaling factor is 1/8, and the power can be reduced to 1/8 of the power of the frame at the full rate.

The bits in the frame are spread in time, referred to herein as interleaved. Interleaving typically spreads out important bits in time so that if there is a deep fade or noise burst the important bits are not corrupted by one deep fade or noise burst. This reduces the number of frames containing errors, referred herein as a frame error rate.

When system conditions are equal, frames that have an information rate lower than the channel rate have a lower frame error rate than frames whose information rate is equal to the full rate. This is due to the synergistic effects of combining interleaving with the repeating of the bits in the frame. The lower frame error rate of the frames having the lower information rate allows these frames to be transmitted at an even lower power. For example, for a frame whose information rate is 1/8, the power can be reduced to below 1/8 the power of a frame whose information rate is the full rate. The base station can adjust the power of a frame having an information rate lower than the full rate.

Referring to Figure 1, in conventional CDMA systems, each forward traffic frame 10 (i.e., frames transmitted over the forward traffic channel) includes voice or data and error control information, typically in the form of a cyclical redundancy code (CRC). By contrast, each reverse traffic frame 20 (i.e., frames transmitted over the reverse traffic channel) includes voice or data and error indicator bits (EIB) for indicating whether the last forward traffic frame is a good frame or in erasure, i.e., a bad frame.

When base station 30 transmits forward traffic frame 10, mobile station 40 receiving forward traffic frame 10 will check the CRC to determine whether forward traffic frame 10 is good or not. Mobile station 40 will indicate such determination to base station 30 using the EIB in the next reverse traffic frame the mobile station will transmit. For example, a zero error indicator bit indicates no error in the forward traffic frame, and a positive error indicator bit indicates the forward traffic frame is a bad frame. Upon receiving reverse traffic frames from the mobile station, the base station examines the EIB and determines whether its forward link to the mobile station is in fading, and adjusts the power of its forward link accordingly. For example, if the base station receives one or more successive EIB denoting erred forward traffic frames, the base station may determine that its forward link is in fading and increase the power of its forward link. This is to ensure that the frame error rate is kept to an acceptable percentage, typically between 1% and 3%, depending on the desired system performance.

Therefore, in a conventional CDMA wireless communications system, a power control decision to either adjust the power or keep the power at its current level occurs once every frame, when the EIB is received. In newly proposed CDMA wireless communications system (hereinafter referred to as CDMA 2000), the forward link power control is much faster. The forward link power control is at 800 Hz rate, which means that power control information, referred to herein as a power control bit, is sent every 1.25 ms, or once for every power control group. Therefore, the base station cannot wait until the end of the forward traffic frame to determine if the power should be adjusted. Referring to Figure 2, in CDMA 2000 power control is effected using slow outer loop 100 and fast inner loop 110. In outer loop 100 mobile station 120 determines a target signal to noise ratio using target frame error rate 124, which is typically between 1% and 3%, depending on the desired system performance. Signal to noise ratios are often expressed as the ratio E_b/N_0, where E_b is the energy per information bit and N_0 is the power spectral density of the interference seen by the receiver. Thus, target E_b/N_0 130 can be used for the target signal to noise ratio. Target E_b/N_0 130 is determined for each frame. Thus, for a 20 ms frame the speed of the outer loop is 50 Hz. After target E_b/N_0 130 is determined, it is passed to inner loop 110. In inner loop 110, target E_b/N_0 130 is compared to measured E_b/N_0 160 of the received signal, which is measured for the 1.25 ms since the last comparison. When measured E_b/N_0 160 is smaller than target E_b/N_0 130 the mobile station 120 requests an increase in power. When measured E_b/N_0 160 is larger than target E_b/N_0 130 the mobile station 120 requests a decrease in power.

A problem with this system is that it does not allow frames whose information rate is lower than the channel rate to be transmitted at lower power than the full rate power scaled by the information rate scaling factor. For example, for a particular system, a frame having an information rate equal to the 1/8 rate transmitted at 1/16 the power of a frame at full rate may have an acceptable frame error rate, and because the information rate is 1/8 the target E_b/N_0 130 will be 1/8 of a target E_b/N_0 130 when the information rate is equal to the full rate. Base station 180 will transmit a frame having an information rate of 1/8 at 1/16 the power of a frame at a full rate, which will produce a measured E_b/N_0 of about 1/2 the target E_b/N_0 130. Mobile station 120 receives the bits in the first 1.25 ms of the frame, and measures the E_b/N_0 of these bits. Mobile station 120 then compares this measured E_b/N_0 to the target E_b/N_0 130. Because target E_b/N_0 130 is larger than the measured E_b/N_0, the mobile station will continue requesting an increase in power until the frame is being transmitted at 1/8 the power of a frame at full rate, therefore eliminating the reduction in power that was available due to the synergistic effects of combining interleaving with the repeating of the bits in the frame.

Summary of the Invention

The invention solves the above problems by providing a variable power control scaling factor to the mobile station. The mobile station determines a target signal quality measurement for transmitting a signal, and scales this target signal quality measurement by the variable power control scaling factor. Providing the variable power control scaling factor to the mobile station allows frames having an information rate lower than full rate to be transmitted at a power even lower than the information scaling factor times the power of the frame having an information rate equal to the full rate.

In another embodiment of the invention, the base station determines an information transmission rate of a signal to be transmitted. The base station then obtains a variable power control scaling factor based on the information transmission rate, and transmits the variable power control scaling factor.

Brief Description of the Drawings

Figure 1 illustrates power control in a conventional CDMA system;

Figure 2 illustrates power control in a CDMA 2000 system; and

Figure 3 illustrates power control using a variable power control scaling factor in a CDMA 2000 system.

Detailed Description

Figure 3 illustrates a wireless communication system 200 having base station 210 and mobile station 220 used in accordance with the present invention. Base station 210 and mobile station 220 communicate using forward link 230 and reverse link 240 employing well-known Code Division Multiple Access (CDMA) 2000 techniques. This should not be construed to limit the present invention to base stations and mobile stations employing CDMA 2000 techniques. The present invention may equally be applicable to base stations and mobile stations employing other CDMA techniques and other multiple access techniques.

Each forward traffic frame (i.e., frames transmitted over the forward traffic channel) includes voice or data, and error control information, typically in the form of a cyclical redundancy code (CRC). Variable power control scaling factor 245 can also be transmitted on the forward traffic channel. As explained above, the information content of the forward traffic frames can have different information rates. Typically, there are four information rates full rate, ½ rate, ¼ rate, and 1/8 rate. When the information rate of a frame is lower than the channel rate, the frame can be transmitted at a power that is even lower than the power of a frame having an information rate equal to the full rate times the information rate scaling factor. The factor by which the power of the frame having the lower information rate can be reduced and still have an acceptable frame error rate is the variable power control scaling factor. The variable power control scaling factor is based on system conditions such as the mobility of the system, the typical number of users in the system, the size of areas covered by base stations in the system referred to hereinafter as cells, the interference in the system from buildings or other objects, and any other factors that determine the amount of power needed to maintain an acceptable frame error rate. Furthermore, because these conditions can vary from cell to cell, each base station can determine its own variable power control scaling factor. The variable power control scaling factor 245 can be empirically obtained in drive test. In a typical system, variable power control scaling factor 245 can be: about 1 for frames having an information rate equal to the full rate; about 7/8 for frames having an information rate equal to the ½ rate; about ¾ for frames having an information rate equal to the ¼ rate; and about ½ for frames having an information rate equal to the 1/8 rate.

The variable power control scaling factor can be transmitted as part of any of the messages of the forward traffic channel, such as a handoff direction message or a power control parameter message. Alternatively, the base station can transmit the variable power control scaling factor as a message on any of the control channels, for example as a message on the paging channel. Preferably, variable power control scaling factor 245 is in a system parameter message or channel assignment message of the paging channel. Although the variable power control scaling factor is being described with reference to the forward link this should not be construed to limit the present invention to power control on the forward link. The present invention may be applicable to power control on the reverse link.

Each reverse traffic frame (i.e., frames transmitted over the reverse traffic channel) includes voice. However, the power control bits are now transmitted on the reverse pilot channel. Each frame of the reverse pilot channel comprises sixteen 1.25 ms time intervals referred to herein as power control groups, each including power control bits for indicating whether the transmit power should be increase or decreased based on the last forward traffic power control group.

In wireless communication system 200, power control of the forward link is effected using slow outer loop 100 and fast inner loop 250. In outer loop 100 mobile station 220 determines a target signal quality measurement, preferably target E_b/N_0 130, using target frame error rate 124, which is typically between 1% and 3%, depending on the desired system performance. The signal quality measurement can be any measurement that indicates the quality of the signal received from base station 210 by mobile station 220. Preferably, the signal quality measurement is either the signal to noise ratio or the E_b/N_0, which is often used to express the signal to noise ratio. Target E_b/N_0 130 is determined for each frame. After target E_b/N_0 130 is determined, it is passed to inner loop 250. In inner loop 250, target E_b/N_0 130 is scaled by variable power scaling factor 245 to produce scaled target E_b/N_0 260. Scaled target E_b/N_0 260 is compared to measured E_b/N_0 160 of the received signal, which is measured for the 1.25 ms since the last comparison. When measured E_b/N_0 160 is smaller than scaled target E_b/N_0 260 the mobile station 220 transmits information indicating that power should be increased. Base station 210 responds to this request by increasing the power of the forward traffic channel. When measured E_b/N_0 160 is larger than scaled target E_b/N_0 260 the mobile station 220 transmits information indicating that power should be decreased. Base station 210 responds to this request by decreasing the power of the forward traffic channel.

Wireless communication system 200 allows frames whose information rate is lower than the channel rate to be transmitted at lower power than the power of a frame having an information rate equal to the full rate, scaled by the information rate scaling factor. For example, when the variable power scaling factor is ½ for a frame having an information rate of 1/8, the base station transmits the frame at 1/16 the power of a frame having an information rate equal to the full rate. This will produce a measured E_b/N_0 of about 1/2 the target E_b/N_0 130. Mobile station 220 receives the bits in the first 1.25 ms of the frame, and measures the E_b/N_0 of these bits. Mobile station 220 then compares this measured E_b/N_0 to the scaled target E_b/N_0 260. Because information rate scaling factor 140 is 1/8 the target E_b/N_0 130 is 1/8 of the E_b/N_0 130 of a frame whose information rate is equal to the full rate. Since variable power control scaling factor 245 is ½, the scaled target E_b/N_0 260 is 1/2 of target E_b/N_0 130. When there is no fading or noise bursts the measured E_b/N_0 and the scaled E_b/N_0 are about equal. The mobile station will not request a change in power, therefore allowing the system to use the reduction in power available due to the synergistic effects of combining interleaving with the repeating of the bits in the frame.

Variable power control scaling factor can also be used in the power control of the reverse link. The base station determines a target signal quality measurement for a received signal on the reverse link. The base station would also obtain a variable power control scaling factor, and then scale the target signal quality measurement by the variable power control scaling factor. Scaled target signal quality measurement is compared to measured signal quality measurement of the received signal. When measured signal quality measurement is smaller than scaled target signal quality measurement the base station request that the mobile station increase the transmit power. When measured signal quality measurement is larger than scaled target signal quality measurement the base station requests that the mobile station decrease the transmit power.

While the invention has been described with reference to a preferred embodiment, it will be understood by those skilled in the art having reference to the specification and drawings that various modifications may be made and various alternatives are possible therein without departing from the spirit and scope of the invention.

~~Claims~~: The claims defining the invention are as follows:

1. A method for controlling the power in a wireless communication system (200), the method CHARACTERIZED BY the steps of:

determining a target signal quality measurement (130) for a received signal (270);

obtaining a variable power control scaling factor (245);

scaling the target signal quality measurement (130) by the variable power control scaling factor (245).

2. The method of claim 1, CHARACTERIZED IN THAT the signal quality measurement is a signal to noise ratio.

3. The method of claim 1, CHARACTERIZED IN THAT the signal quality measurement is an E_b/N_0.

4. The method of claim 1, further CHARACTERIZED BY the steps of:

measuring a signal quality measurement (160) of the received signal (270);

comparing the measured signal quality measurement (160) of the received signal (270) to the scaled target signal quality measurement (260);

requesting an increase in power of the received signal (270) responsive to the measured signal quality measurement (160) of the received signal (270) being smaller than the scaled target signal quality measurement (260); and

requesting a decrease in power of the received signal (270) responsive to the measured signal quality measurement (160) of the received signal (270) being larger than the scaled target signal quality measurement (260).

5. The method of claim 1, CHARACTERIZED IN THAT the obtaining step comprises receiving the variable power control scaling factor (245).

6. The method of claim 5, CHARACTERIZED IN THAT the variable power control scaling factor (245) is received in a message of the paging channel.

7. The method of claim 5, CHARACTERIZED IN THAT the variable power control scaling factor (245) is received in a message of the traffic channel.

8. The method of claim 5, CHARACTERIZED IN THAT the variable power control scaling factor (245) is received in a message of the reverse pilot channel.

9. A method for controlling transmitter power in a wireless system (200), the method CHARACTERIZED BY the steps of:

determining an information rate of a signal to be transmitted (270);

obtaining a variable power control scaling factor (245) based on the information rate;

transmitting the variable power control scaling factor (245).

10. The method of claim 9, CHARACTERIZED IN THAT the step of transmitting the variable power control scaling factor (245) comprises transmitting the variable power control scaling factor (245) in a message of the forward control channel.

11. The method of claim 9, CHARACTERIZED IN THAT the step of transmitting the variable power control scaling factor (245) comprises transmitting the variable power control scaling factor (245) in a message of the paging channel.

12. The method of claim 9, CHARACTERIZED IN THAT the step of transmitting the variable power control scaling factor (245) comprises transmitting the variable power control scaling factor (245) in a message of the forward traffic channel.

13. The method of claim 12, CHARACTERIZED IN THAT the forward traffic channel is a handoff direction message.

14. The method of claim 9, further CHARACTERIZED BY the step of scaling the transmitter power by the variable power control scaling factor (245).

15. A method for controlling the power in a wireless communication system, said method being substantially as described herein with reference to Fig. 3.

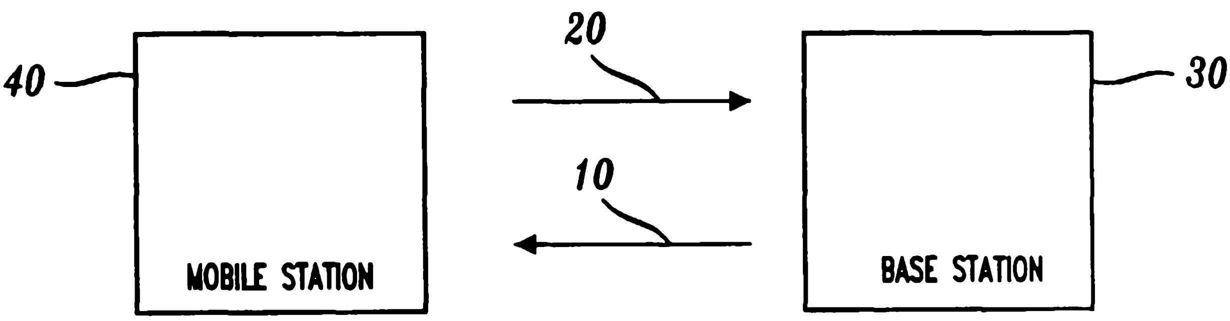
DATED this Third Day of March, 2000

Lucent Technologies Inc.

Patent Attorneys for the Applicant

SPRUSON & FERGUSON

FIG. 1



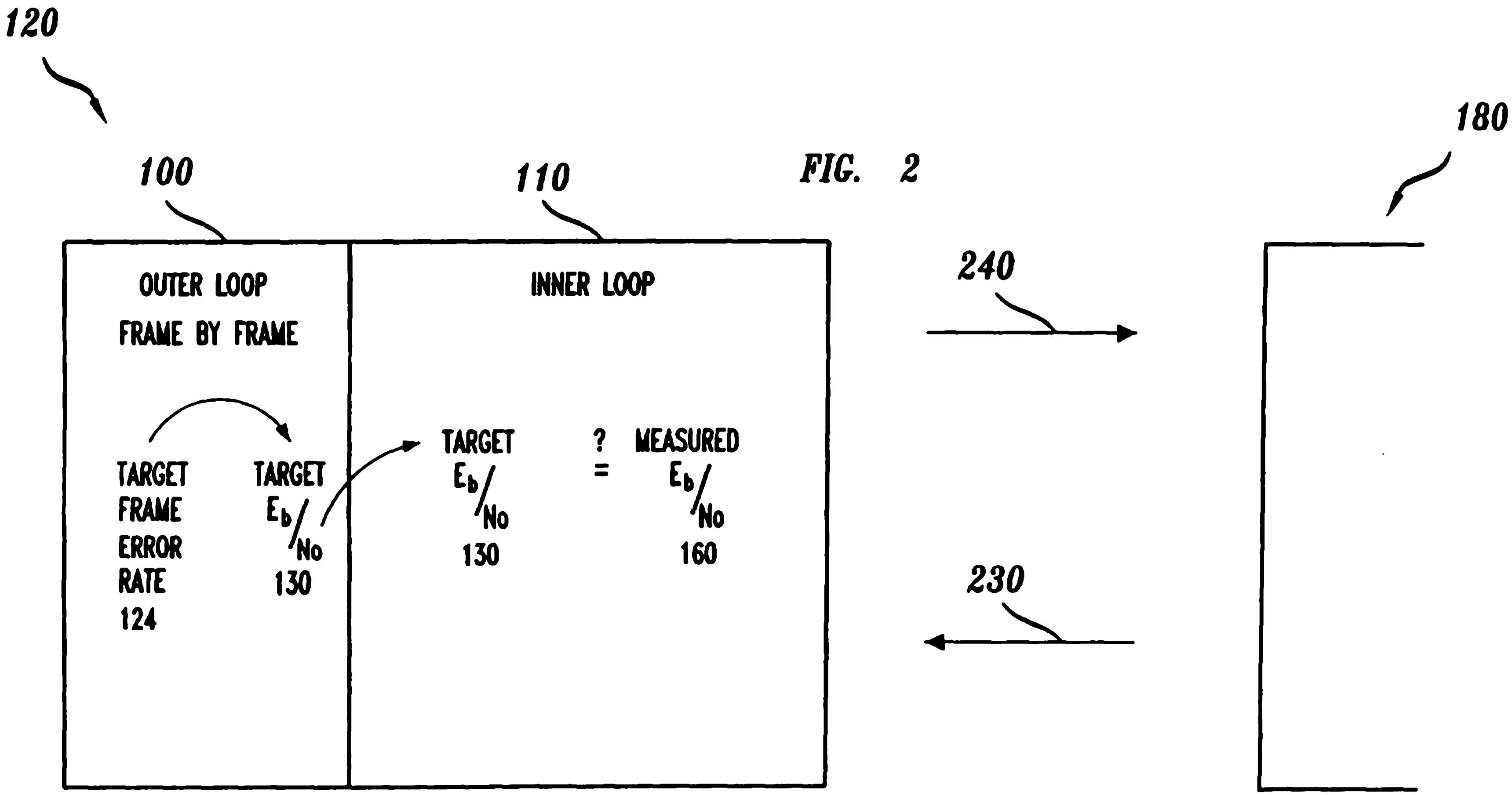

120
100
110
180
OUTER LOOP
FRAME BY FRAME
TARGET FRAME ERROR RATE 124
TARGET E_b/N_o 130
INNER LOOP
TARGET E_b/N_o 130
?=
MEASURED E_b/N_o 160
240
230

FIG. 2

6 02 00 20666

200

FIG. 3