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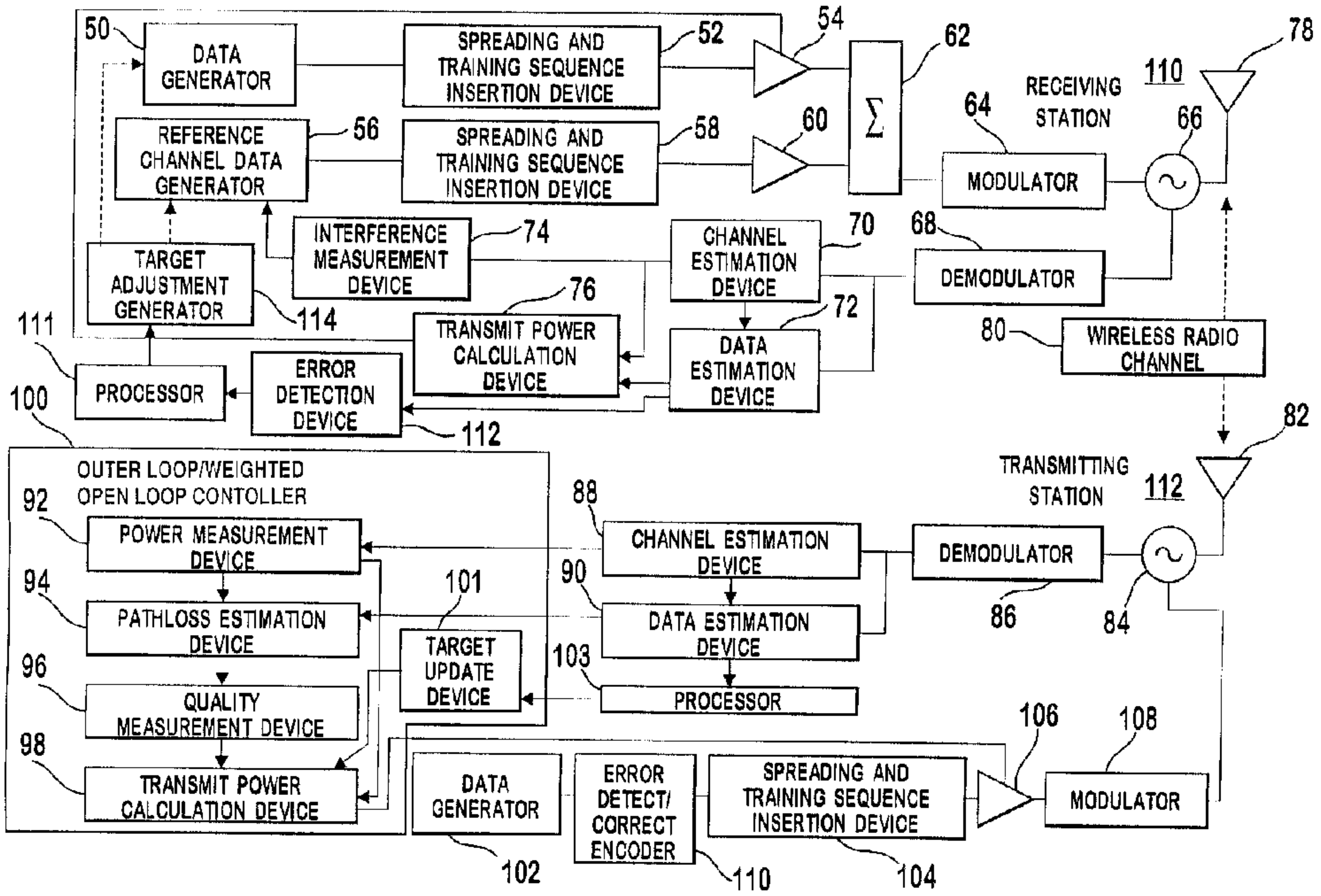
(54) **Titre :** COMMANDE DE PUISSANCE EN BOUCLE EXTERNE/BOUCLE OUVERTE PONDEREE DANS UN SYSTEME DE COMMUNICATIONS DUPLEX A DIVISION DANS LE TEMPS

(54) **Title:** OUTER LOOP/WEIGHTED OPEN LOOP POWER CONTROL IN A TIME DIVISION DUPLEX COMMUNICATION SYSTEM



(57) **Abrégé/Abstract:**

Outer loop/weighted open loop power control controls transmission power levels in a spread spectrum time division duplex communication station. A first communication station (110) transmits a communication to a second communication station including target adjustment information generated at the first station on the basis of measured error rates of communications from the second station to the first station. The second station receives the communication and measures its received power level. Based on in part the received communication's power level and the communication's transmission power level, a path loss estimate is determined. A quality of the path loss estimate is also determined. The transmission power level for a communication from the second station to the first station is based on in part weighting the path loss estimate in response to the estimate's quality and based on the receive target adjusted by the target adjustment information transmitted from the first station.

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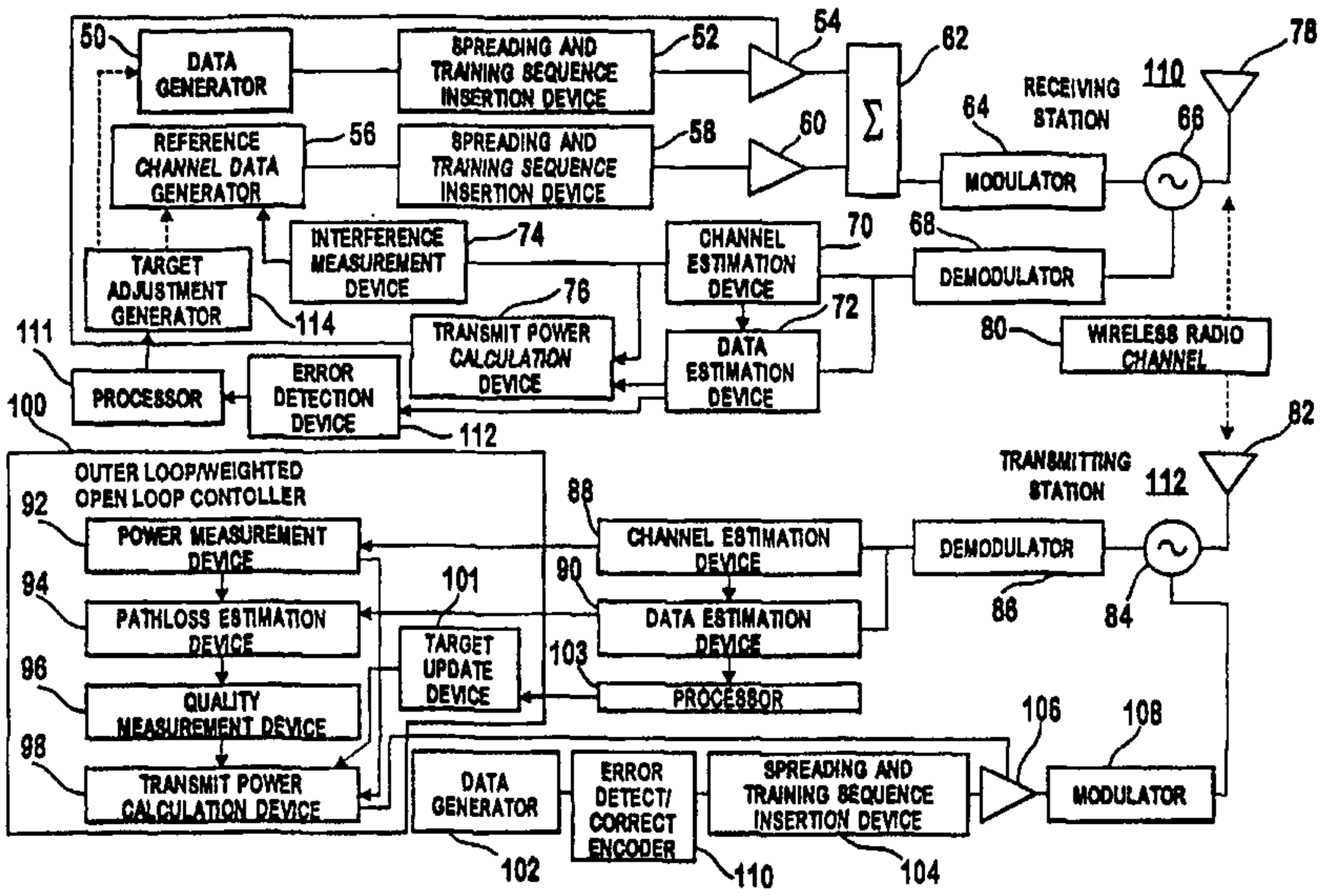
(54) Title: OUTER LOOP/WEIGHTED OPEN LOOP POWER CONTROL IN A TIME DIVISION DUPLEX COMMUNICATION SYSTEM



(57) Abstract

Outer loop/weighted open loop power control controls transmission power levels in a spread spectrum time division duplex communication station. A first communication station (110) transmits a communication to a second communication station including target adjustment information generated at the first station on the basis of measured error rates of communications from the second station to the first station. The second station receives the communication and measures its received power level. Based on in part the received communication's power level and the communication's transmission power level, a path loss estimate is determined. A quality of the path loss estimate is also determined. The transmission power level for a communication from the second station to the first station is based on in part weighting the path loss estimate in response to the estimate's quality and based on the receive target adjusted by the target adjustment information transmitted from the first station.

OUTER LOOP/WEIGHTED OPEN LOOP POWER CONTROL IN A TIME DIVISION DUPLEX COMMUNICATION SYSTEM

BACKGROUND

This invention generally relates to spread spectrum time division duplex (TDD) communication systems. More particularly, the present invention relates to a system and method for controlling transmission power within TDD communication systems.

Figure 1 depicts a wireless spread spectrum time division duplex (TDD) communication system. The system has a plurality of base stations **30_1-30_7**. Each base station **30_1** communicates with user equipment (UEs) **32_1-32_3** in its operating area. Communications transmitted from a base station **30_1** to a UE **32_1** are referred to as downlink communications and communications transmitted from a UE **32_1** to a base station **30_1** are referred to as uplink communications.

In addition to communicating over different frequency spectrums, spread spectrum TDD systems carry multiple communications over the same spectrum. The multiple signals are distinguished by their respective chip code sequences (codes). Also, to more efficiently use the spread spectrum, TDD systems as illustrated in **Figure 2** use repeating frames **34** divided into a number of time slots **36_1-$36_{n,}$**, such as sixteen time slots. In such systems, a communication is sent in selected time slots **36_1-36_n** using selected codes. Accordingly, one frame **34** is capable of carrying multiple communications distinguished by both time slot and code. The combination of a single code in a single time slot is referred to as a resource unit. Based on the bandwidth required to support a communication, one or multiple resource units are assigned to that communication.

Most TDD systems adaptively control transmission power levels. In a TDD system, many communications may share the same time slot and spectrum. When a UE **32_1** or base station **30_1** is receiving a specific communication, all the other communications using the same time slot and spectrum cause interference to the specific communication. Increasing the transmission power level of one communication degrades the signal quality of all other communications within that time slot and spectrum. However, reducing the transmission power level too far results in undesirable signal to noise ratios (SNRs) and bit error rates (BERs) at the receivers. To maintain both the signal quality of communications and low transmission power levels, transmission power control is used.

One approach using transmission power control in a code division multiple access (CDMA) communication system is described in U.S. Patent No. 5,056,109 (Gilhousen et al.). A transmitter sends a communication to a particular receiver. Upon reception, the received signal power is measured. The received signal power is compared to a desired received signal power. Based on the comparison, a control bit is sent to the transmitter either increasing or decreasing transmission power by a fixed amount. Since the receiver sends a control signal to the transmitter to control the transmitter's power level, such power control techniques are commonly referred to as closed loop.

Under certain conditions, the performance of closed loop systems degrades. For instance, if communications sent between a UE and a base station are in a highly dynamic environment, such as due to the UE moving, such systems may not be able to adapt fast enough to compensate for the changes. The update rate of closed loop power control in TDD is typically 100 cycles per second which is not sufficient for fast fading channels.

WO 98 45962 A discloses a method for controlling a transmission power level of a mobile terminal in a satellite communication system. The power control method has both a closed-loop and an open-loop element. For the closed-loop element, the base station calculates the mobile terminal's power setting based on the strength of the signals received from the mobile terminal. The base station takes into account the propagation delays of the satellite system in the power setting determination. For the open-loop element, the strength of the received signal from the base station in each frame is compared to the strength of the signal received in the previous frame. The transmit power of the mobile terminal is adjusted inversely with the variations in the observed signal strength.

U.S. Patent No. 5,542,111 discloses a method for regulating transmission power control of a mobile station using long-term and short-term transmission power control. Long-term power control occurs in a base station on the upper level forming a closed control loop. A decision authority statement is communicated from the base station to the mobile station. The short term transmission power level is determined on the lower loop using an identifier of the long term power and the decision authority.

Accordingly, there is a need for alternate approaches to maintain signal quality and low transmission power levels.

SUMMARY

Outer loop/weighted open loop power control controls transmission power levels in a spread spectrum time division duplex communication system. At a first communication station, errors are measured in a received communication from a second communication station. Based on in part the measured errors, an adjustment in a target level is determined. The first station transmits a communication and the target adjustment to the second station. The second station measures the first station's communication's received power level. Based on in part the received power level, a path loss is determined. The target level is adjusted in response to receiving the target adjustment. The quality of the path loss is determined with respect to a subsequent communication to be transmitted from the second station. The second station's transmission power level for the subsequent communication is adjusted based on in part the determined path loss, the determined quality and the adjusted target level.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates a prior art TDD system.

Figure 2 illustrates time slots in repeating frames of a TDD system.

Figure 3 is a flow chart of outer loop/weighted open loop power control.

Figure 4 is a diagram of components of two communication stations using outer loop/weighted open loop power control.

Figure 5 is a graph of the performance of outer loop/weighted open loop, weighted open loop and closed loop power control systems.

Figure 6 is a graph of the three systems performance in terms of Block Error Rate (BLER).

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The preferred embodiments will be described with reference to the drawing figures where like numerals represent like elements throughout. Outer loop/weighted open loop power control will be explained using the flow chart of **Figure 3** and the components of two simplified communication stations **110**, **112** as shown in **Figure 4**. For the following discussion, the communication station having its transmitter's power controlled is referred to as the transmitting station **112** and the communication station receiving power controlled communications is referred to as the receiving station **110**. Since outer loop/weighted open loop power control may be used for uplink, downlink or both types of communications, the transmitter having its power controlled may be associated with the base station $\mathbf{30}_1$, UE $\mathbf{32}_1$ or both. Accordingly, if both uplink and downlink power control are used, the receiving and transmitting station's components are associated with both the base station **30_1** and UE **32_1**.

The receiving station **110** receives various radio frequency signals including communications from the transmitting station **112** using an antenna **78**, or alternately, an antenna array, **step 38**. The received signals are passed thorough an isolator **66** to a demodulator **68** to produce a baseband signal. The baseband signal is processed, such as by a channel estimation device **70** and a data estimation device **72**, in the time slots and with the appropriate codes assigned to the transmitting station's communication. The channel estimation device **70** commonly uses the training sequence component in the baseband signal to provide channel information, such as channel impulse responses. The channel information is used by the data estimation device **72**, the interference measurement device **74**, and the transmit power calculation device **76**. The data estimation device **72** recovers data from the channel by estimating soft symbols using the channel information.

Prior to transmission of the communication from the transmitting station **112**, the data signal of the communication is error encoded using an error detection/correction encoder **110**. The error encoding scheme is typically a circular redundancy code (CRC) followed by a forward error correction encoding, although other types of error encoding schemes may be used.

Using the soft symbols produced by the data estimation device **72**, an error detection device **112** detects errors in the soft symbols. A processor **111** analyzes the detected error and determines an error rate for the received communication, **step 39**. Based on the error rate, the processor **111** determines the amount, if any, a target level, such as a target signal to interference ration (SIR_{TARGET}), needs to be changed at the transmitting station **112**, **step 40**. Based on the determined amount, a target adjustment signal is generated by the target adjustment generator **114**. The target adjustment is subsequently sent to the transmitting station, **step 41**. The target adjustment is signaled to the transmitting station **112**, such as using a dedicated or a reference channel.

One technique to determine the amount of adjustment in the target level uses an upper and lower threshold. If the determined error rate exceeds an upper threshold, the target level is set at an unacceptably low level and needs to be increased. A target level adjustment signal is sent indicating an increase in the target level. If the determined error rate is below a second threshold, the target level is set at an unnecessarily high level and the target level can be decreased. By reducing the target level, the transmitting station's power level is decreased reducing interference to other communications using the same time slot and spectrum. To improve performance, as soon as the error rate exceeds the upper limit, a target adjustment is sent. As a result, high error rates are improved quickly and lower error rates are adjusted slowly, such as once per 10 seconds. If the error rate is between the thresholds, a target adjustment is not sent maintaining the same target level.

Applying the above technique to a system using CRC and FEC encoding follows. Each CRC block is checked for an error. Each time a frame is determined to have an error, a counter is incremented. As soon as the counter exceeds an upper threshold, such as 1.5 to 2 times the desired block error rate (BLER), a target adjustment is sent increasing the target level. To adjust the SIR_{TARGET} at the transmitting station **112**, the increase in the SIR_{TARGET} is sent (SIR_{INC}), which is typically in a range of 0.25 dB to 4 dB. If the number of CRC frames encountered exceeds a predetermined limit, such as 1000 blocks, the value of the counter is compared to a lower threshold, such as 0.2 to 0.6 times the desired BLER. If the number of counted block errors is below the lower threshold, a target adjustment signal is sent decreasing the target level, SIR_{DEC}. A typical range of SIR_{DEC} is 0.25 to 4 dB. The value of SIR_{DEC} may be based on SIR_{INC} and a target block error rate, $BLER_{TARGET}$. The $BLER_{TARGET}$ is based on the type of service. A typical range for the $BLER_{TARGET}$ is 0.1% to 10%. **Equation 1** illustrates one such approach for determining SIR_{DEC}.

$$SIR_{DEC} = SIR_{INC} \text{ x } BLER_{TARGET}/(1 - BLER_{TARGET}) \qquad \textbf{Equation 1}$$

If the count is between the thresholds for the predetermined block limit, a target adjustment signal is not sent.

Alternately, a single threshold may be used. If the error rate exceeds the threshold, the target level is increased. If the error rate is below the threshold, the target is decreased. Additionally, the target level adjustment signal may have several adjustment levels, such as from 0 dB to ±4 dB in 0.25 dB increments based on the difference between the determined error rate and the desired error rate.

The interference measurement device **74** of the receiving station **110** determines the interference level in dB, I_{RS}, within the channel, based on either the channel information, or the soft symbols generated by the data estimation device **72**, or both. Using the soft symbols and channel information, the transmit power calculation device **76** controls the receiving station's transmission power level by controlling the gain of an amplifier **54**.

For use in estimating the pathloss between the receiving and transmitting stations **110**, **112** and sending data, the receiving station **110** sends a communication to the transmitting station **112**, **step 41**. The communication may be sent on any one of the various channels. Typically, in a TDD system, the channels used for estimating pathloss are referred to as reference channels, although other channels may be used. If the receiving station **110** is a base station 30_1, the communication is preferably sent over a downlink common channel or a common control physical channel (CCPCH). Data to be communicated to the transmitting station **112** over the reference channel is referred to as reference channel data. The reference data may include, as shown, the interference level, I_{RS}, multiplexed with other reference data, such as the transmission power level, T_{RS}. The interference level, I_{RS}, and reference channel power level, I_{RS}, may be sent in other channels, such as a signaling channel.

The reference channel data is generated by a reference channel data generator **56**. The reference data is assigned one or multiple resource units based on the communication's bandwidth requirements. A spreading and training sequence insertion device **58** spreads the reference channel data and makes the spread reference data time-multiplexed with a training sequence in the appropriate time slots and codes of the assigned resource units. The resulting sequence is referred to as a communication burst. The communication burst is subsequently amplified by an amplifier **60**. The amplified communication burst may be summed by a sum device **62** with any other communication burst created through devices, such as a data generator **50**, spreading and training sequence insertion device **52** and amplifier **54**.

The summed communication bursts are modulated by a modulator **64**. The modulated signal is passed thorough an isolator **66** and radiated by an antenna **78** as shown or, alternately, through an antenna array. The radiated signal is passed through a wireless radio channel **80** to an antenna **82** of the transmitting station **112**. The type of modulation used for the transmitted communication can be any of those known to those skilled in the art, such as direct phase shift keying (DPSK) or quadrature phase shift keying (QPSK).

The antenna **82** or, alternately, antenna array of the transmitting station **112** receives various radio frequency signals including the target adjustments. The received signals are passed through an isolator **84** to a demodulator **86** to produce a baseband signal. The baseband signal is processed, such as by a channel estimation device **88** and a data estimation device **90**, in the time slots and with the appropriate codes assigned to the communication burst of the receiving station **110**. The channel estimation device **88** commonly uses the training sequence component in the baseband signal to provide channel information, such as channel impulse responses.

The channel information is used by the data estimation device **90** and a power measurement device **92**.

The power level of the processed communication corresponding to the reference channel, R_{TS}, is measured by the power measurement device **92** and sent to a pathloss estimation device **94**, **step 42**. Both the channel estimation device **88** and the data estimation device **90** are capable of separating the reference channel from all other channels. If an automatic gain control device or amplifier is used for processing the received signals, the measured power level is adjusted to correct for the gain of these devices at either the power measurement device **92** or pathloss estimation device **94**. The power measurement device is a component of an outer loop/weighted open loop controller **100**. As shown in **Figure 4**, the outer loop/weighted open loop controller **100** comprises the power measurement device **92**, pathloss estimation device **94**, quality measurement device **94**, target update device **101**, and transmit power calculation device **98**.

To determine the path loss, L, the transmitting station **112** also requires the communication's transmitted power level, T_{RS}. The communication's transmitted power level, T_{RS}, may be sent along with the communication's data or in a signaling channel. If the power level, T_{RS}, is sent along with the communication's data, the data estimation device **90** interprets the power level and sends the interpreted power level to the pathloss estimation device **94**. If the receiving station **110** is a base station **30_1**, preferably the transmitted power level, T_{RS}, is sent via the broadcast channel (BCH) from the base station **30_1**. By subtracting the received communication's power level, R_{TS}, from the sent communication's transmitted power level, T_{RS}, the pathloss estimation device **94** estimates the path loss, L, between the two stations **110**, **112**, **step 43**. Additionally, a long term estimate of the pathloss, L_0, is updated, **step 44**. One example of a long term pathloss estimate is a long term average. The long term average of the pathloss, L_0, is an average of the pathloss estimates. In certain situations, instead of transmitting the transmitted power level, T_{RS}, the receiving station **110** may transmit a reference for the transmitted power level. In that case, the pathloss estimation device **94** provides reference levels for the pathloss, L.

Since TDD systems transmit downlink and uplink communications in the same frequency spectrum, the conditions these communications experience are similar. This phenomenon is referred to as reciprocity. Due to reciprocity, the path loss experienced for the downlink will also be experienced for the uplink and vice versa. By adding the estimated path loss to a target level, a transmission power level for a communication from the transmitting station **112** to the receiving station **110** is determined.

If a time delay exists between the estimated path loss and the transmitted communication, the path loss experienced by the transmitted communication may differ from the calculated loss. In TDD where communications are sent in differing time slots **36_1-36_n**, the time slot delay between received and transmitted communications may degrade the performance of an open loop power control system. To overcome these drawbacks, weighted open loop power control determines the quality of the estimated path loss using a quality measurement device

96, **step 45**, and weights the estimated path loss accordingly, L, and long term average of the pathloss, L_0.

To enhance performance further in outer loop/weighted open loop, a target level is adjusted. A processor **103** converts the soft symbols produced by the data estimation device **90** to bits and extracts the target adjustment information, such as a SIR_{TARGET} adjustment. A target update device **101** adjusts the target level using the target adjustments, **step 46**. The target level may be a SIR_{TARGET} or a target received power level at the receiving station **110**.

The transmit power calculation device **98** combines the adjusted target level with the weighted path loss estimate, L, and long term average of the pathloss estimate, L_0, to determine the transmission power level of the transmitting station, **step 47**.

Data to be transmitted in a communication from the transmitting station **112** is produced by data generator **102**. The data is error detection/correction encoded by error detection/correction encoder **110**. The error encoded data is spread and time-multiplexed with a training sequence by the training sequence insertion device **104** in the appropriate time slots and codes of the assigned resource units producing a communication burst. The spread signal is amplified by an amplifier **106** and modulated by modulator **108** to radio frequency. The gain of the amplifier is controlled by the transmit power calculation device **98** to achieve the determined transmission power level. The power controlled communication burst is passed through the isolator **84** and radiated by the antenna **82**.

The following is one outer loop/weighted open loop power control algorithm. The transmitting stations's transmission power level in decibels, P_{TS}, is determined using **Equation 2**.

$$P_{TS} = SIR_{TARGET} + I_{RS} + \alpha(L-L_0) + L_0 + \text{CONSTANT VALUE} \quad \textbf{Equation 2}$$

The SIR_{TARGET} has an adjusted value based on the received target adjustment signals. For the downlink, the initial value of SIR_{TARGET} is known at the transmitting station **112**. For uplink power control, SIR_{TARGET} is signaled from the receiving station **110** to the transmitting station **112**. Additionally, a maximum and minimum value for an adjusted SIR_{TARGET} may also be signaled. The adjusted SIR_{TARGET} is limited to the maximum and minimum values. I_{RS} is the measure of the interference power level at the receiving station **110**.

L is the path loss estimate in decibels, T_{RS} - R_{TS}, for the most recent time slot **36_1-36_n** that the path loss was estimated. L_0, the long term average of the path loss in decibels, is the running average of the pathloss estimate, L. The CONSTANT VALUE is a correction term. The CONSTANT VALUE corrects for differences in the uplink and downlink channels, such as to compensate for differences in uplink and downlink gain. Additionally, the CONSTANT VALUE may provide correction if the transmit power reference level of the receiving station is transmitted, instead of the actual transmit power, T_{RS}. If the receiving station **110** is a base station, the CONSTANT VALUE is preferably sent via a Layer 3 message.

The weighting value, α, is a measure of the quality of the estimated path loss and is, preferably, based on the number of time slots **36_1-36_n** between the time slot, n, of the last path loss estimate and the first time slot of the communication transmitted by the transmitting station **112**. The value of α is between zero and one. Generally, if the time difference between the time slots is small, the recent path loss estimate will be fairly accurate and α is set at a value close to one. By contrast, if the time difference is large, the path loss estimate may not be accurate and the long term average path loss measurement is most likely a better estimate for the path loss. Accordingly, α is set at a value closer to one.

Equations 3 and **4** are equations for determining α.

$$\alpha = 1 - (D - 1)/(D_{max}-1) \qquad \textbf{Equation 3}$$

$$\alpha = \max\ \{1-(D-1)/(D_{max\text{ - }allowed} -1),\ 0\} \qquad \textbf{Equation 4}$$

The value, D, is the number of time slots **36_1-36_n** between the time slot of the last path loss estimate and the first time slot of the transmitted communication which will be referred to as the time slot delay. If the delay is one time slot, α is one. D_{max} is the maximum possible delay. A typical value for a frame having fifteen time slots is seven. If the delay is D_{max}, α is zero $D_{max\text{-}allowed}$ is the maximum allowed time slot delay for using open loop power control. If the delay exceeds $D_{max\text{-}allowed}$, open loop power control is effectively turned off by setting $\alpha = 0$. Using the transmit power level, P_{TS}, determined by a transmit power calculation device **98** the transmit power of the transmitted communication is set.

Figures 5 and **6** compare the performance of the weighted outer loop/open loop, open loop and closed loop systems. The simulations in **Figures 5** and **6** were performed for a slightly different version of the outer loop/weighted open loop algorithm. In this version, the target SIR is updated every block. A SIR_{TARGET} is increased if a block error was detected and decreased if no block error was detected. The outer loop/weighted open loop system used **Equation 2**. **Equation 3** was used to calculate α. The simulations compared the performance of the systems controlling a UE's $\mathbf{32}_1$ transmission power level. For the simulations, 16 CRC bits were padded every block. In the simulation, each block was 4 frames. A block error was declared when at least two raw bit errors occur over a block. The uplink communication channel is assigned one time slot per frame. The target for the block error rate is 10%. The SIR_{TARGET} is updated every 4 frames. The simulations address the performance of these systems for a UE $\mathbf{32}_1$ traveling at 30 kilometers per hour. The simulated base station used two antenna diversity for reception with each antenna having a three finger RAKE receiver. The simulation approximated a realistic channel and SIR estimation based on a midamble sequence of burst type 1 field in the presence of additive white Gaussian noise (AWGN). The simulation used an International Telecommunication Union (ITU) Pedestrian B type channel and QPSK modulation. Interference levels were assumed to have no uncertainty. Channel coding schemes were not considered. L_0 was set at 0 db.

Graph **120** of **Figure 5** shows the performance as expected in terms of the required E_S/N_O for a BLER of 10^{-1} as a function of time delay between the uplink time slot and the most recent downlink time slot. The delay is expressed by the number of time slots. E_S is the energy of the complex symbol. **Figure 5** demonstrates that, when gain/interference uncertainties are ignored, the performance of the combined system is almost identical to that of weighted open loop system. The combined system outperforms the closed loop system for all delays.

In the presence of gain and interference uncertainties, the transmitted power level of the open loop system is either too high or too low of the nominal value. In graph **122** of **Figure 6**, a gain uncertainty of -2 dB was used. **Figure 6** shows the BLER as a function of the delay. The initial reference SIR_{TARGET} for each system was set to its corresponding nominal value obtained from **Figure 5**, in order to achieve a BLER of 10^{-1}. **Figure 6** shows that, in the presence of gain uncertainty, both the combined and closed loop systems achieve the desired BLER. The performance of the weighted open loop system severely degrades.

* * *

CLAIMS

1. A method for controlling transmission power levels in a spread spectrum time division duplex communication system having frames with time slots for communication, receiving at a first communication station communications from a second communication station and determining an error rate of the received communications (38, 39), producing target adjustments as needed based on in part the error rate (40), transmitting a first communication having a transmission power level in a first time slot and the target adjustments from the first communication station, receiving at the second communication station the target adjustments and the first communication and measuring a power level of the first communication as received (42, 46), determining a path loss estimate based on in part the measured received first communication power level (43), the method characterized by:

setting a transmission power level for a second communication in a second time slot from the second station to the first station based on in part the path loss estimate weighted by a first factor, a long term pathloss estimate weighted by a second factor, and a target level adjusted by the target adjustments (47), wherein the first and second factors are a function of a time separation of the first and second time slots.

2. The method of claim 1 further characterized by the target level is a target signal to interference ratio.

3. The method of claim 2 further characterized by the adjustments to the target signal to interference ratio are limited to a maximum and minimum value.

4. The method of claim 2 further characterized by each target adjustment is in a range of 0.25 decibels to 4 decibels.

5. The method of claim 2 further characterized by:

a target adjustment increasing the target signal to interference ratio is SIR_{INC};

a target adjustment decreasing the target signal to interference ratio is SIR_{DEC};

a target block error rate is $BLER_{TARGET}$; and

SIR_{DEC} is determined by

$SIR_{DEC} = SIR_{INC} \times BLER_{TARGET}/(1-BLER_{TARGET})$.

6. The method of claim 5 further characterized by the $BLER_{TARGET}$ is in the range of 1% to 10%.

7. The method of claim 1 further characterized by:

if the error rate exceeds an upper or is below a lower threshold, a target adjustment is transmitted; and

if the error rate is between the upper and lower threshold, no target adjustment is transmitted.

8. The method of claim 7 further characterized by the target adjustments increasing the target level are transmitted as soon as an error count exceeds an upper threshold.

9. The method of claim 1 further characterized by:

determining a quality, α, of the pathloss estimate (45) based on in part a number of time slots, D, between the first and second time slot; and

wherein the first factor is α and the second factor is $1-\alpha$.

10. The method of claim 9 further characterized by a maximum time slot delay is D_{max} and the determined quality, α, is determined by

$\alpha = 1 - (D-1)/(D_{max}-1)$.

11. The method of claim 9 further characterized by a maximum allowed time slot delay is $D_{max\text{-}allowed}$ and the determined quality, α, is determined by

$\alpha = \max\{1-(D-1)/(D_{max\text{-}allowed}-1), 0\}$.

12. The method of claim 1 further characterized by the set transmission power level compensates for differences in uplink and downlink gains.

13. The method of claim 1 further characterized by the first station is a base station and the second station is a user equipment.

14. The method of claim 1 further characterized by the first station is a user equipment and the second station is a base station.

15. A spread spectrum time division duplex communication system having a first (110) and second (112) communication station, the system using frames with time slots for communication, the first station (110) receiving communications from the second communication station (112) and determining an error rate of the received communications, producing target adjustments as needed based on in part the error rate, and transmitting a first communication having a transmission power level in a first time slot and the target adjustments, the second station (112) receiving the target adjustments and the first communication and measuring a power level of the first communication as received, and determining a path loss estimate based on in part the measured received first communication power level the system characterized by:

the second station (112) comprising:

means (110) for setting a transmission power level for a second communication in a second time slot from the second station to the first station based on in part combining the path loss estimate weighted by a first factor, a long term pathloss estimate weighted by a second factor and a target level adjusted by the target adjustments, wherein the first and second factors are a function of a time separation of the first and second time slots.

16. The system of claim 15 further characterized by the target level is a target signal to interference ratio.

17. The system of claim 16 further characterized by the adjustments to the target signal to interference ratio are limited to a maximum and minimum value.

18. The system of claim 15 further characterized by each target adjustment is in a range of 0.25 decibels to 4 decibels.

19. The system of claim 15 further characterized by:

if the error rate exceeds an upper or is below a lower threshold, a target adjustment is transmitted; and

if the error rate is between the upper and lower threshold, no target adjustment is transmitted.

20. The system of claim 19 further characterized by the target adjustments increasing the target level are transmitted as soon as an error count exceeds an upper threshold.

21. The system of claim 15 further characterized by:

the second station (112) further comprises means for determining a quality, α, of the pathloss estimate based on in part a number of time slots, D, between the first and second time slot; and

the first factor is α and the second factor is $1-\alpha$.

22. The system of claim 21 further characterized by a maximum time slot delay is D_{max} and the determined quality, α, is determined by

$\alpha = 1 - (D-1)/(D_{max}-1)$.

23. The system of claim 21 further characterized by a maximum allowed time slot delay is $D_{max\text{-}allowed}$ and the determined quality, α, is determined by

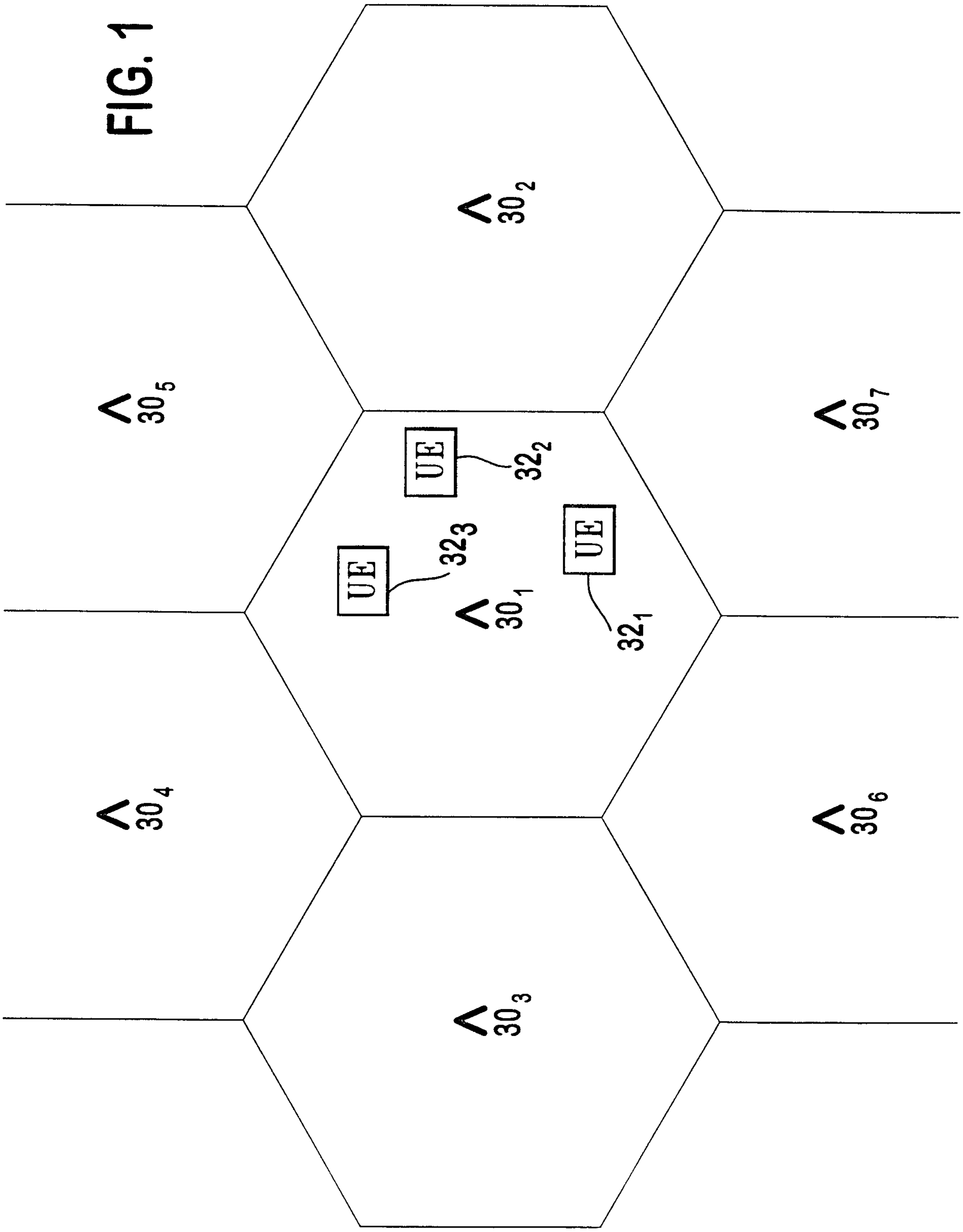
$\alpha = \max \{1-(D-1)/(D_{max\text{-}allowed}-1), 0\}$.

24. The system of claim 15 further characterized by the set transmission power level compensates for differences in the uplink and downlink gains.

25. The system of claim 15 further characterized by the first station (110) is a base station (30) and the second station (112) is a user equipment (32).

26. The system of claim 15 further characterized by the first station (110) is a user equipment (32) and the second station (112) is a base station (30).

FIG. 1



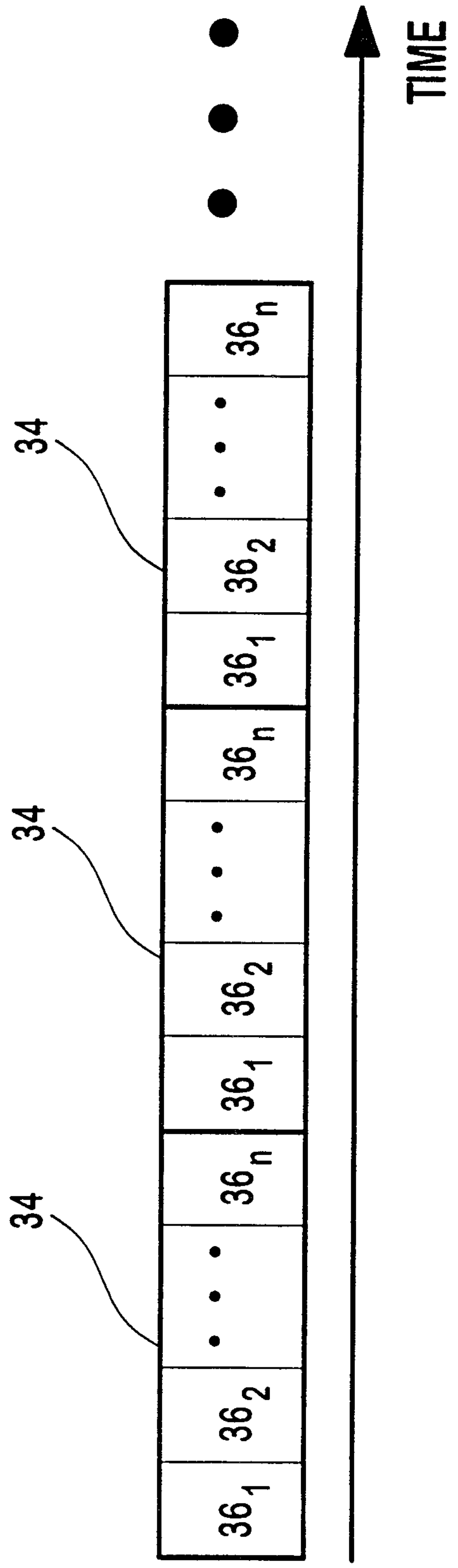
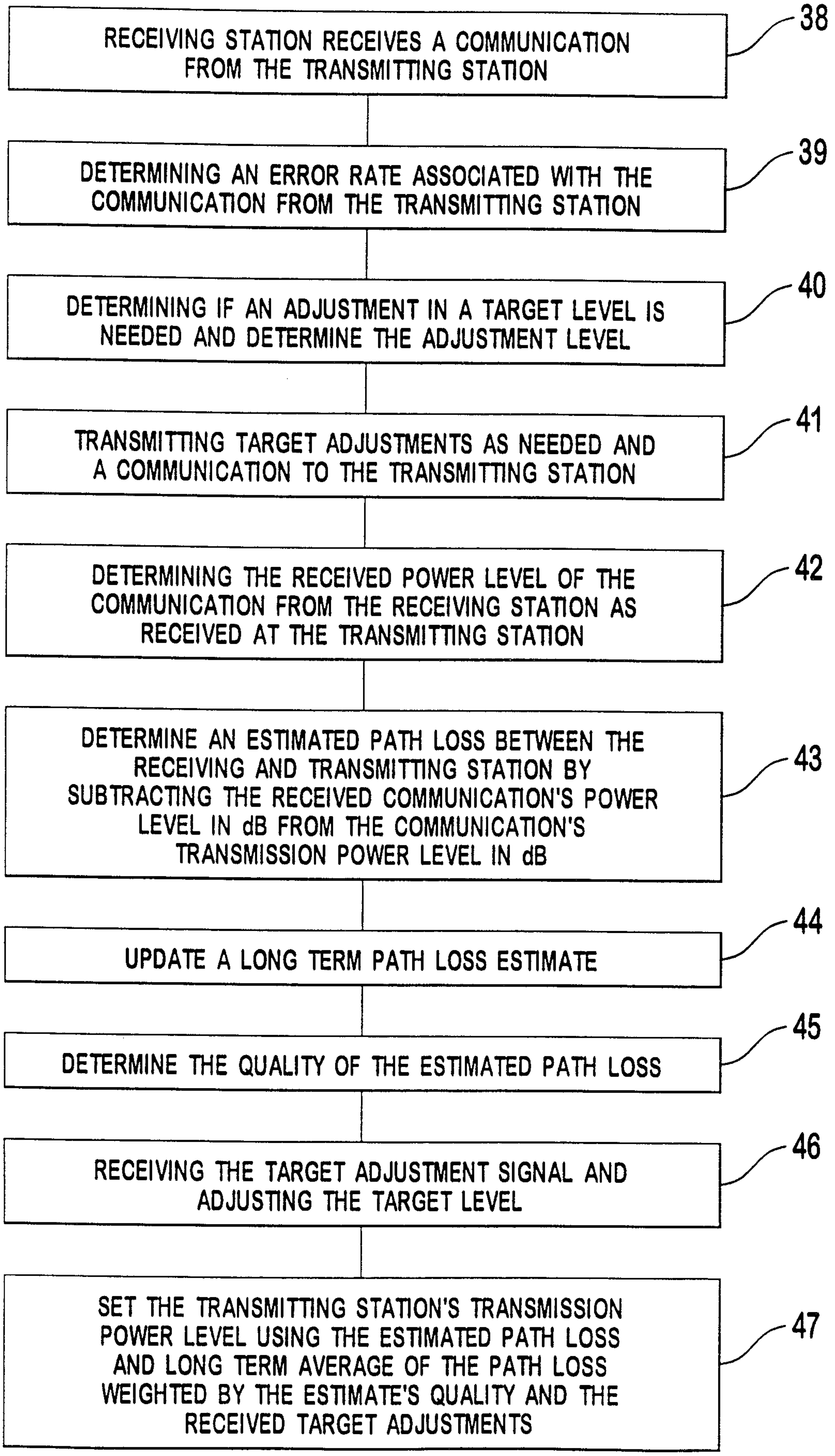


FIG. 2

FIG. 3


RECEIVING STATION RECEIVES A COMMUNICATION FROM THE TRANSMITTING STATION
38
DETERMINING AN ERROR RATE ASSOCIATED WITH THE COMMUNICATION FROM THE TRANSMITTING STATION
39
DETERMINING IF AN ADJUSTMENT IN A TARGET LEVEL IS NEEDED AND DETERMINE THE ADJUSTMENT LEVEL
40
TRANSMITTING TARGET ADJUSTMENTS AS NEEDED AND A COMMUNICATION TO THE TRANSMITTING STATION
41
DETERMINING THE RECEIVED POWER LEVEL OF THE COMMUNICATION FROM THE RECEIVING STATION AS RECEIVED AT THE TRANSMITTING STATION
42
DETERMINE AN ESTIMATED PATH LOSS BETWEEN THE RECEIVING AND TRANSMITTING STATION BY SUBTRACTING THE RECEIVED COMMUNICATION'S POWER LEVEL IN dB FROM THE COMMUNICATION'S TRANSMISSION POWER LEVEL IN dB
43
UPDATE A LONG TERM PATH LOSS ESTIMATE
44
DETERMINE THE QUALITY OF THE ESTIMATED PATH LOSS
45
RECEIVING THE TARGET ADJUSTMENT SIGNAL AND ADJUSTING THE TARGET LEVEL
46
SET THE TRANSMITTING STATION'S TRANSMISSION POWER LEVEL USING THE ESTIMATED PATH LOSS AND LONG TERM AVERAGE OF THE PATH LOSS WEIGHTED BY THE ESTIMATE'S QUALITY AND THE RECEIVED TARGET ADJUSTMENTS
47

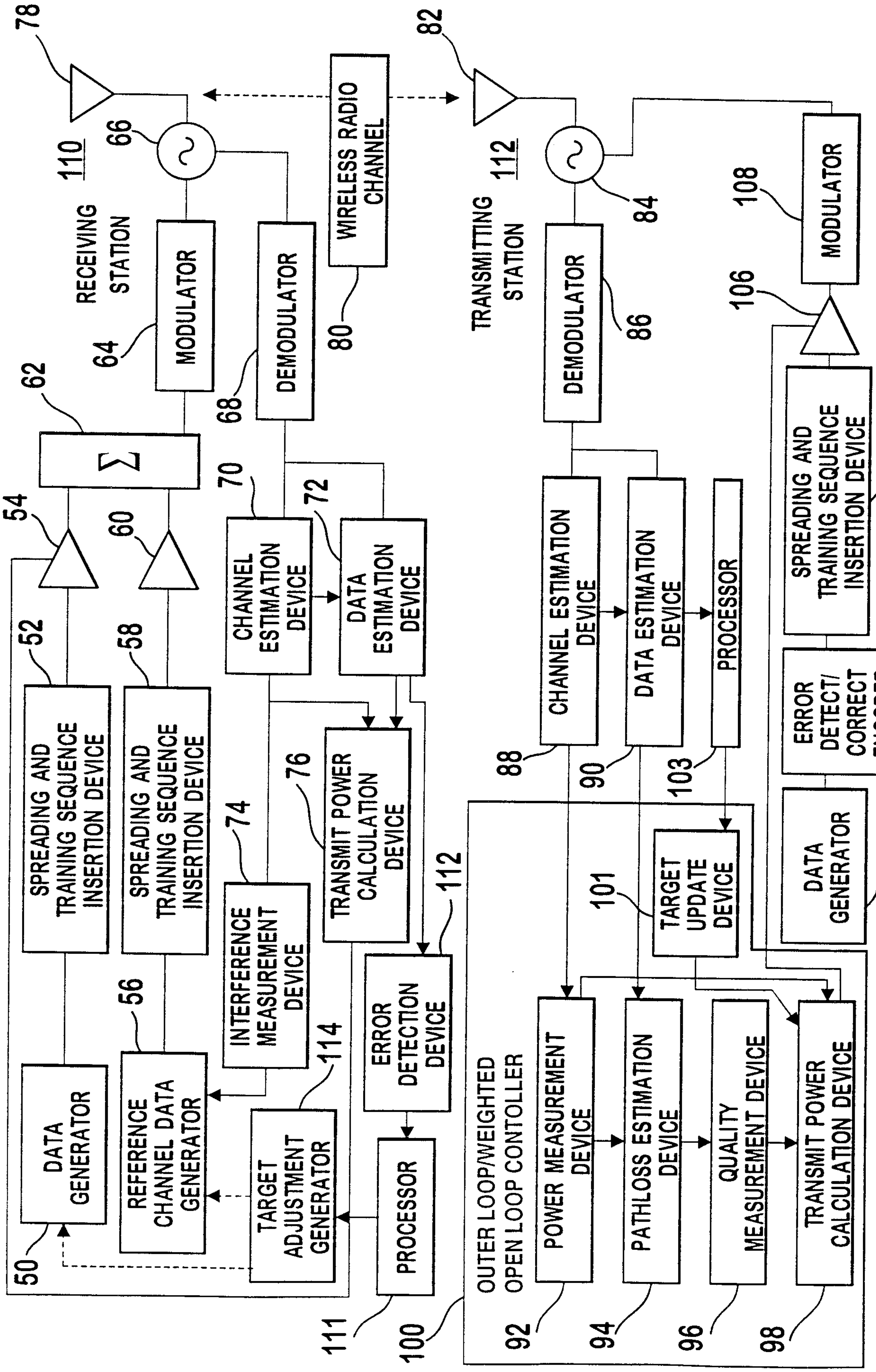

78
110
RECEIVING STATION
66
WIRELESS RADIO CHANNEL
80
82
112
TRANSMITTING STATION
84
MODULATOR
64
DEMODULATOR
68
DEMODULATOR
86
MODULATOR
108
106
62
Σ
54
60
70
72
CHANNEL ESTIMATION DEVICE
DATA ESTIMATION DEVICE
CHANNEL ESTIMATION DEVICE
DATA ESTIMATION DEVICE
PROCESSOR
SPREADING AND TRAINING SEQUENCE INSERTION DEVICE
104
52
58
SPREADING AND TRAINING SEQUENCE INSERTION DEVICE
SPREADING AND TRAINING SEQUENCE INSERTION DEVICE
76
TRANSMIT POWER CALCULATION DEVICE
88
90
103
ERROR DETECT/ CORRECT ENCODER
110
74
INTERFERENCE MEASUREMENT DEVICE
112
TARGET UPDATE DEVICE
101
DATA GENERATOR
102
56
ERROR DETECTION DEVICE
114
DATA GENERATOR
REFERENCE CHANNEL DATA GENERATOR
TARGET ADJUSTMENT GENERATOR
PROCESSOR
OUTER LOOP/WEIGHTED OPEN LOOP CONTOLLER
POWER MEASUREMENT DEVICE
PATHLOSS ESTIMATION DEVICE
QUALITY MEASUREMENT DEVICE
TRANSMIT POWER CALCULATION DEVICE
50
111
100
92
94
96
98

FIG. 4

FIG. 5

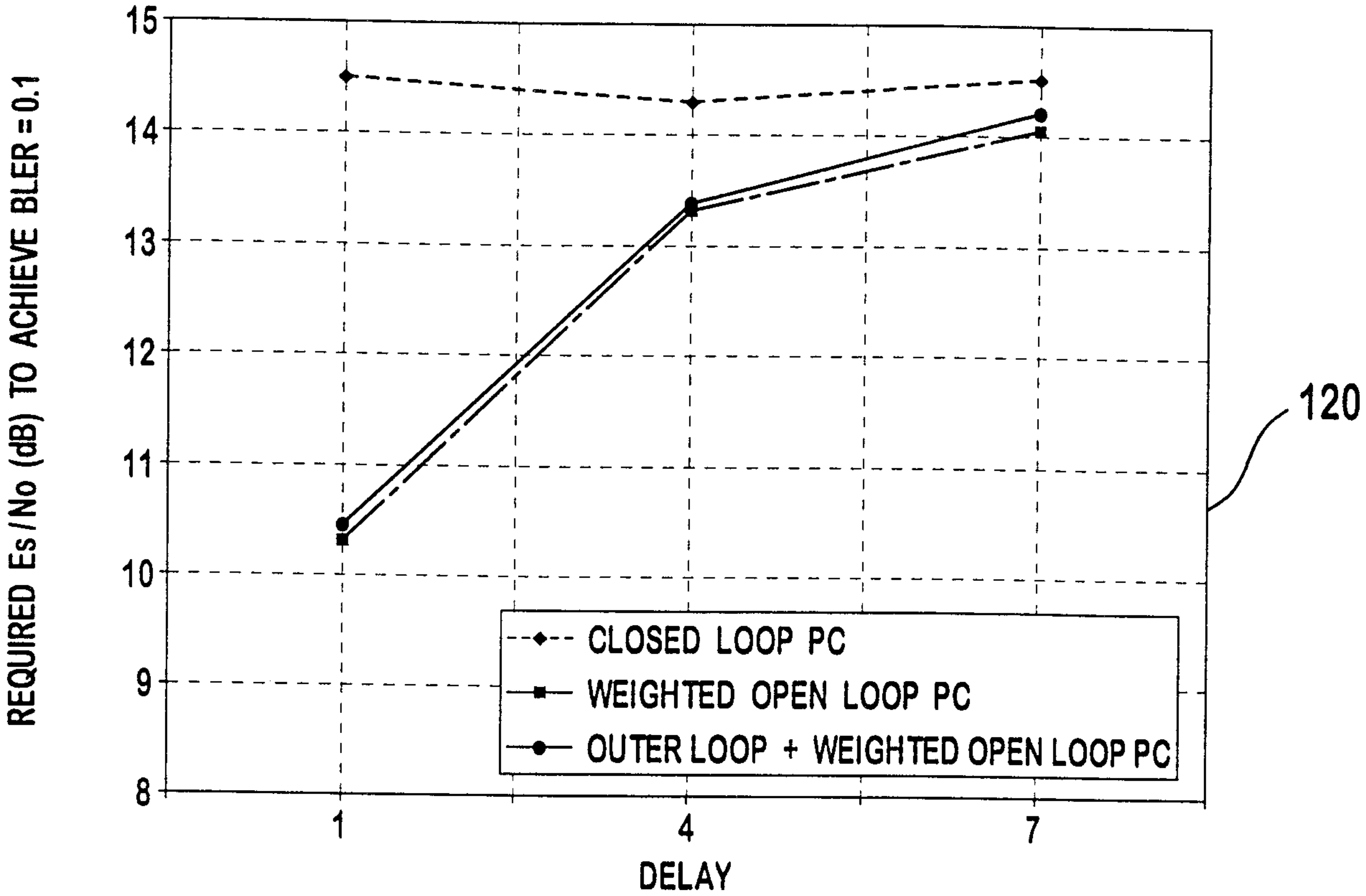
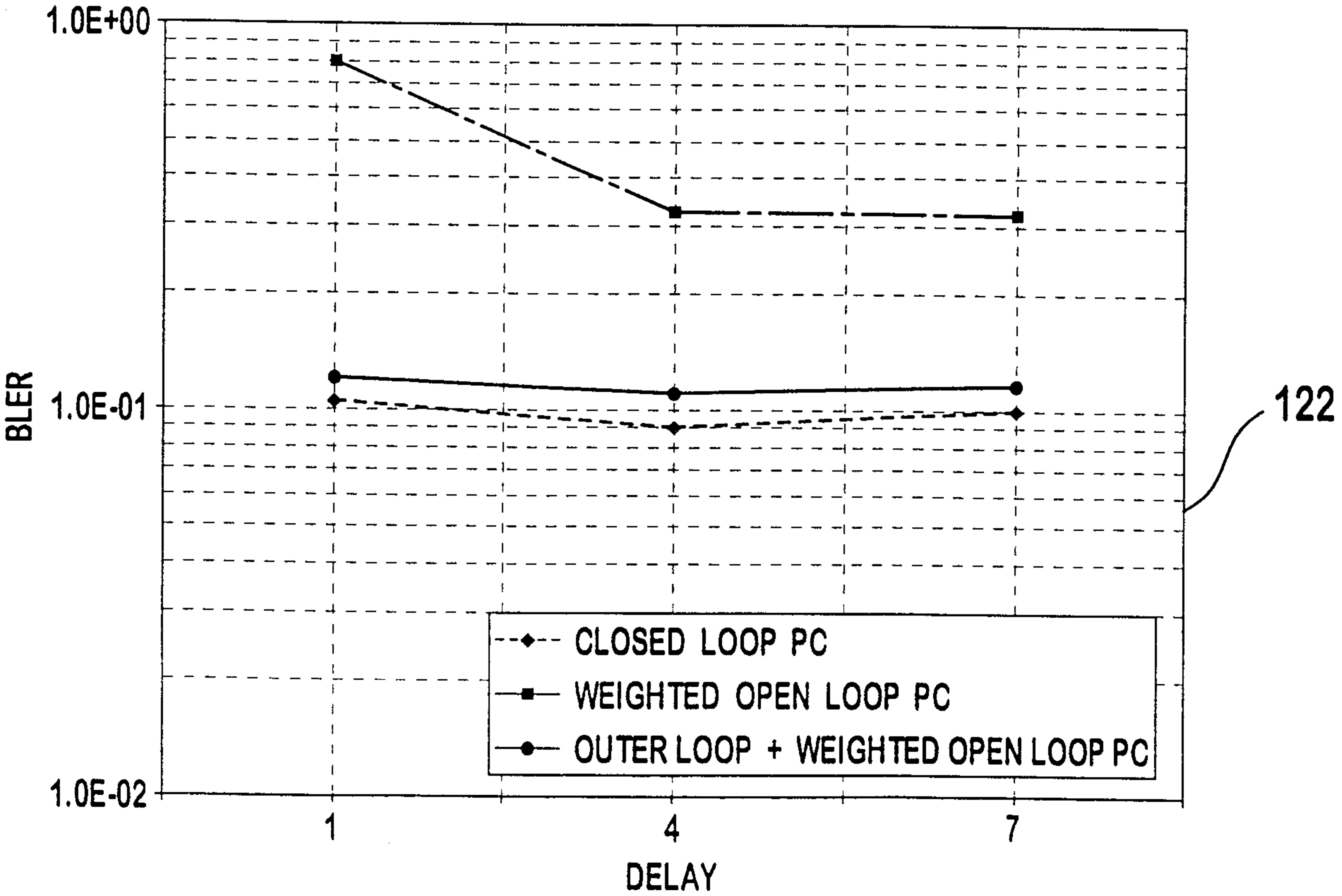
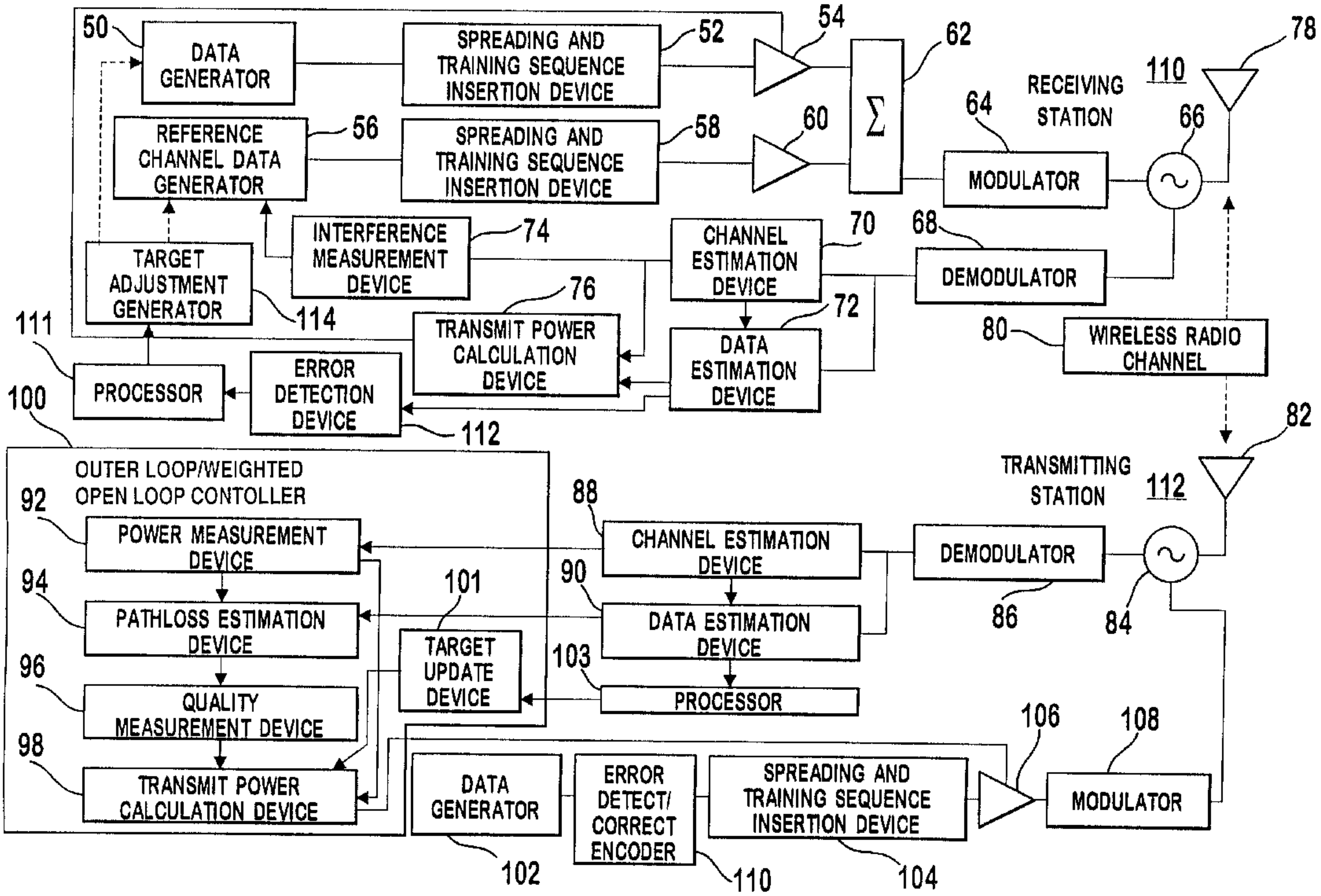

REQUIRED Es/No (dB) TO ACHIEVE BLER=0.1
15
14
13
12
11
10
9
8
1
4
7
DELAY
CLOSED LOOP PC
WEIGHTED OPEN LOOP PC
OUTER LOOP + WEIGHTED OPEN LOOP PC
120

FIG. 6


BLER
1.0E+00
1.0E-01
1.0E-02
1
4
7
DELAY
CLOSED LOOP PC
WEIGHTED OPEN LOOP PC
OUTER LOOP + WEIGHTED OPEN LOOP PC
122


50
DATA GENERATOR
SPREADING AND TRAINING SEQUENCE INSERTION DEVICE
52
54
62
78
Σ
RECEIVING STATION
110
REFERENCE CHANNEL DATA GENERATOR
56
SPREADING AND TRAINING SEQUENCE INSERTION DEVICE
58
60
64
66
MODULATOR
INTERFERENCE MEASUREMENT DEVICE
74
CHANNEL ESTIMATION DEVICE
70
68
TARGET ADJUSTMENT GENERATOR
DEMODULATOR
114
76
TRANSMIT POWER CALCULATION DEVICE
72
DATA ESTIMATION DEVICE
111
80
WIRELESS RADIO CHANNEL
ERROR DETECTION DEVICE
PROCESSOR
100
112
82
OUTER LOOP/WEIGHTED OPEN LOOP CONTOLLER
TRANSMITTING STATION
112
92
88
POWER MEASUREMENT DEVICE
CHANNEL ESTIMATION DEVICE
DEMODULATOR
94
101
90
PATHLOSS ESTIMATION DEVICE
DATA ESTIMATION DEVICE
86
84
TARGET UPDATE DEVICE
96
103
QUALITY MEASUREMENT DEVICE
PROCESSOR
106
108
98
TRANSMIT POWER CALCULATION DEVICE
DATA GENERATOR
ERROR DETECT/ CORRECT ENCODER
SPREADING AND TRAINING SEQUENCE INSERTION DEVICE
MODULATOR
102
110
104