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(54) **Transmission power control for mobile radio**

Übertragungsleistungsregelung für Mobilfunk

Contrôle de puissance de transmission pour radio mobile

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Description

[0001] The present invention relates to a transmission power control method and a communication system using the same, and more particularly to a transmission power control method in a CDMA (Code Division Multiple Access) system which performs multiple access using a spread spectrum technique in mobile communications, and a communication system using this method.

[0002] As is well-known, a CDMA system falls into two classes: a direct sequence (DS) system which spreads a conventionally modulated signal by using a high rate spreading code; and a frequency hopping (FH) system which resolves a symbol into elements called chips, and translates each chip into signals of different center frequencies at a high rate. Since the FH system is difficult to implement in the state of the art, the DS system is usually employed. Spread-spectrum radio systems differ from conventional communication systems for satellite data networks such as SCPC/FDMA (Single Channel Per Carrier/Frequency Division Multiple Access) systems, or TDMA (Time Division Multiple Access) systems in that the spread-spectrum radio systems transmit, at a transmitter side, a signal which is modulated by a common modulation, and then by a secondary modulation using a spreading code, which widens its signal bandwidth. At a receiver side, on the other hand, the wideband received signal is despread to restore the narrow band signal, followed by a conventional demodulation processing. The despreading is performed by detecting correlation between the spread-spectrum sequence of the received signal and a spreading code sequence which is generated at the receiving station, and peculiar to the channel. The capacity in terms of the number of subscribers in a cell is determined by an SIR (Signal-to-Interference Ratio) needed to achieve a required error rate because a CDMA system uses the same frequency band for the subscribers.

[0003] Applying the CDMA system to a mobile communication presents a problem in that received signal levels at a base station from respective mobile stations vary significantly depending on the locations of the mobile stations, and this arises a "near-far problem", in which a large power signal masks a small power signal, thereby reducing the number of mobile stations communicatable at the same time. In other words, a communication quality of a channel is degraded by signals of other communicators because the same frequency band is shared by a plurality of communicators and the signals from the other communicators become an interference.

[0004] Fig. 1 illustrates an interference state in a reverse (from mobile station to base station) channel due to other mobile stations. The reference characters BS1 - BS3 designate base stations, and MS1 - MS3 designate mobile stations in the cell associated with the base station BS1. When the mobile station MS1 closer to the base station BS1 than the mobile station MS2 communicates with the base station BS1 at the same time with the mobile station MS2, the received power of the base station BS1 from the near mobile station MS1 will be greater than that from the faraway mobile station MS2. As a result, the communications between the faraway mobile station MS2 and the base station BS1 will be degraded owing to the interference from the near mobile station MS1.

[0005] To overcome this near-far problem, a transmission power control has been introduced. The transmission power control regulates received power at a receiving station, or the SIR determined by the received power, such that the received power or the SIR becomes constant regardless of the locations of mobile stations, thereby achieving uniform communication quality in a service area.

[0006] Fig. 2 shows a received power level at a base station when the transmission power control in a reverse direction is carried out, in comparison with a received power level when the power control is not carried out. Since a mobile station near the border to an adjacent cell receives interference from the adjacent cell, the degradation of communication quality due to the near-far problem occurs in both reverse and forward (from base station to mobile station) communications.

[0007] Fig. 3 illustrates an interference state of a forward channel from the base station BS1 to the mobile station MS3, due to the base stations BS2 and BS3 of other cells. As shown in this figure, signal powers of the other communicators become interference, and hence, transmission power control must be carried out to prevent the signal powers of the other communicators from growing much larger than the transmission power of the intended channel.

[0008] In particular, with regard to a reverse channel, each mobile station controls transmission power such that the received power thereof at the base station becomes constant. Since the interference is considered as white noise in the CDMA system, an error in the transmission power is the most important factor in determining the capacity in terms of the number of subscribers in a cell. For example, an error of 1 dB in the transmission power will reduce the capacity in terms of the number of the subscribers by about 30%.

[0009] On the other hand, with regard to a forward channel, since the signal of an intended channel and interferences caused by signals for other users within the cell propagate through the same path, they are subject to the same long interval fluctuations, the same short interval fluctuations, and the same instantaneous fluctuations, so that their SIR is kept constant. Therefore, the transmission power control is not necessary if the interference is caused only within a cell. Actually, however, interferences from other cells must be considered. This is because although the interference power from other cells undergoes instantaneous fluctuations due to Rayleigh fading as the interference power within the cell, its fluctuations differ from those of the intended signal.

[0010] Fig. 4 illustrates behavior of a received signal at a mobile station. In a CDMA system standardized by TIA of the United States, the transmission power control is not basically performed in a forward channel. Instead, a base station detects a frame error rate of a received signal, and increases the transmission power to a mobile station if the frame error rate exceeds a predetermined value. This is because a large increase in the transmission power will increase the interference to other cells. The transmission powers from base stations of other cells constitute an interference which fluctuates instantaneously.

[0011] Fig. 5 shows the operation principle of a first conventional closed loop transmission power control which is performed in accordance with a received SIR. In Fig. 5 (and Fig. 6), the reference character S designates the received power of a desired signal, I designates the received power of interferences, and pg designates a processing gain. The first conventional transmission power control in a CDMA system is performed such that an actual SIR agrees with a reference SIR which is determined in advance to provide a required communication quality. Here, the SIR is defined as the ratio of the received power of an intended signal to the interference power which is the sum total of thermal noise and interferences from users other than the intended user. In this first conventional method, an increase in the received signal power of the user to obtain the reference SIR will results in an increase in interference power to other users. This will form a vicious cycle which causes successive increases in transmission powers of respective mobile stations, and each of the mobile stations will come to transmit at its maximum transmission power.

[0012] Fig. 6 illustrates the operation principle of a second conventional closed loop transmission power control based on a received thermal noise level. The second transmission power control is performed in accordance with a ratio $S/(I_{max} + N)$, where S is the received signal level of an intended wave, I_{max} is the maximum interference power caused by the maximum number of users that the system can accommodate, and N is the thermal noise power. In other words, the transmission power control is performed in accordance with the ratio of the level S to the level I_{max}, which levels are measured from the thermal noise level N. In this case, even if the number of actual communicators within the cell is less than the maximum number, a mobile station 'will radiate such transmission power that ensures a required reception quality at the base station on the assumption that the maximum number of users are communicating at the same time (SNR in Fig. 6 will be described later).

[0013] As a result, in either case of Figs. 5 and 6, a mobile station comes to radiate the maximum transmission power corresponding to the maximum capacity in terms of the number of users. This forces the mobile station to consume extra power. A similar problem will occur in a forward channel transmission from base station to mobile stations.

[0014] WO 92/21196 discloses a transmission power control system using a code division multiple access system in which the transmission power is reduced in response to transmission power control bits in received signals from a radio apparatus with which a first radio apparatus is communicating, whilst the transmission power is increased only when all the received transmission power control bits from a number of radio apparatuses include an instruction to increase the transmission power.

[0015] EP-A-0428099 discloses a digital radio link system in which the transmission power is determined by monitoring the received signal level and estimating the error rate at the receiving end. If the error rate increases due to fading, the transmission power is increased, the transmission power then being reduced if the error rate decreases.

[0016] Therefore, an object of the present invention to provide a transmission power control method and a communication system using the same which can prevent the transmission power from being increased to the maximum output power of a transmitter amplifier by controlling the transmission power in accordance with the ratio of the received signal level of a desired wave to the power from other communicators.

[0017] In a first aspect of the present invention, there is provided a transmission power control method for use in first and second communicating radio apparatuses in a code division multiple access system, one of the first and second radio apparatuses being a base station, and the other of the first and second radio apparatuses being a mobile station, the method comprising the steps of:

measuring, at the first radio apparatus, the desired signal received power which is the received power of a signal received from the second radio apparatus;
calculating, at the first radio apparatus, the ratio of said desired signal received power which is the received power of the signal received from the second radio apparatus to the sum of the interference power and thermal noise power from other radio apparatuses; and
transmitting, at the first radio apparatus, a transmission power control bit to the second radio apparatus,
the method being characterised by the steps of:

generating, at the first radio apparatus, the transmission power control bit in accordance with a result of comparison between said calculated ratio and a predetermined threshold value of the ratio of the desired signal received power to the sum of the interference power and thermal noise power;
calculating, at the second radio apparatus, tentative power on (PT) the basis of the transmission power control bit received from the first radio apparatus (SP1; SP11);
deciding, at the second radio apparatus, the transmission power such that said transmission power is made

equal to said calculated tentative power, when said calculated tentative power is less than the predetermined power threshold value (Pmax), and said transmission power is made equal to said predetermined power threshold value, when said calculated tentative power is greater than said predetermined power threshold value (SP2; SP12); and transmitting, at the second radio apparatus, a signal at the transmission power decided by the deciding step (SP3; SP4; SP13; SP14).

[0018] In a second aspect of the present invention, there is provided a radio apparatus for communicating with an opposite radio apparatus in a code division multiple access system, one of said radio apparatus and said opposite radio apparatus being a base station, and the other of said radio apparatus and said opposite radio apparatus being a mobile station, said radio apparatus having a transmission power control function, said radio apparatus comprising:

means (11) for extracting, from a signal received from said opposite radio apparatus, a transmission power control bit included in the signal,
said radio apparatus being characterised by:

means (13) for providing a predetermined power threshold value (Pamx);
decision means (12) for calculating tentative power (PT) on the basis of said extracted transmission power control bit, and making transmission power equal to said calculated tentative power, when said calculated tentative power (PT) is less than said predetermined power threshold value (Pmax), and making the transmission power equal to said predetermined power threshold value (Pmax), when said calculated tentative power is greater than said predetermined power threshold value (Pmax); and
means (19) for transmitting a signal at the transmission power decided by the decision means (12).

[0019] In a third aspect of the present invention, there is provided a transmission power control method in a radio apparatus for communicating with an opposite radio apparatus in a code division multiple access system, one of the radio apparatus or the opposite radio apparatus being a base station, and the other of the radio apparatus or the opposite radio station being a mobile station, the method comprising the steps of:

sending a signal to said opposite radio apparatus;
receiving a transmission power control bit which has been calculated on the basis of said sent signal at said opposite radio apparatus and transmitted by said opposite radio apparatus;
calculating tentative power (PT) on the basis of said received transmission power control bit;
deciding the transmission power such that said transmission power is made equal to said calculated tentative power, when said calculated tentative power is less than a predetermined power threshold value (Pmax), and said transmission power is made equal to said predetermined power threshold value, when said calculated tentative power is greater than said predetermined power threshold value (SP2; SP12); and
transmitting a signal at said transmission power decided by the deciding step (SP3; SP4; SP13; SP14).

[0020] According to the present invention, since an upper limit value of the maximum transmission power of a mobile station is set at such a value that the required quality is satisfied at the base station for the maximum number of subscribers of the system, a transmitter amplifier of the mobile station does not diverge during the transmission power control. A similar transmission power control which can follow the interference power from other cells can also be implemented for a forward channel.

[0021] The above and other objects, effects, features and advantages of the present invention will become more apparent from the following description of the embodiment thereof taken in conjunction with the accompanying drawings.

Fig. 1 is a diagram illustrating interferences from other mobile stations to a reverse channel;
Fig. 2 is a diagram illustrating a received signal level at a base station when a reverse transmission power control is performed in comparison with that when the control is not carried out;
Fig. 3 is a diagram illustrating interferences from other cells to a forward channel;
Fig. 4 is a diagram illustrating received signal and interference levels to a forward channel at a mobile station;
Fig. 5 is a diagram illustrating a first conventional transmission power control in terms of SIR;
Fig. 6 is a diagram illustrating a second conventional transmission power control in terms of a thermal noise level;
Fig. 7 is a diagram illustrating the principle of a transmission power control in accordance with the present invention;
Figs. 8A and 8B are block diagrams showing a portion of a mobile station, which is associated with the transmission power control in accordance with the present invention;
Fig. 9 is a block diagram showing a portion of a base station, which is associated with the transmission power control in accordance with the present invention;

Fig. 10 is a flowchart showing a reverse transmission power control method in accordance with the present invention;
Fig. 11 is a flowchart showing a forward transmission power control method in accordance with the present invention; and
Fig. 12 is a diagram showing the operation of a closed loop transmission power control in accordance with the present invention.

[0022] The invention will now be described with reference to the accompanying drawings.

[0023] Fig. 7 illustrates the operation principle of the transmission power control method in accordance with the present invention. Radio equipment of a base station controls the transmission power of a mobile station such that the ratio S/(N+I) of the received signal power S of a desired signal from an intended mobile station to the sum N+I of thermal noise N and interference power I from other mobile stations satisfies an intended reception quality at the base station. The period of the power control is set equal to or less than a period that can follow instantaneous fluctuations corresponding to the Doppler frequency. When the transmission power P_T of a mobile station increases to the maximum transmission power P_{max} because of increasing interference, the transmission power of the mobile station is fixed to P_{max} which is determined by the maximum capacity in terms of the number of subscribers, the radius of the cell, and an outage probability. The outage probability represents a percentage of areas that cannot satisfy a required channel quality in a service area. Thus, the transmission power of the mobile station cannot exceed the maximum transmission power P_{max} which corresponds to the maximum signal level Smax at the base station. A closed loop transmission power control is also performed in a forward channel in border areas of the cell so that the transmission power can follow instantaneous fluctuations of interferences from other cells. The base station also performs the transmission power control of a forward channel in accordance with the received SIR at a mobile station as in a reverse channel so that the transmission power is fixed at a maximum transmission power P'_{max}, thereby preventing the transmission power of the base station from increasing beyond P'_{max}.

[0024] Figs. 8A and 8B are block diagrams showing a portion associated with the transmission power control in a mobile station.

[0025] In Figs. 8A and 8B, the reference numeral 1 designates an RF downconverter for converting an RF (Radio Frequency) received signal to an IF (Intermediate Frequency) signal. The output signal of the RF downconverter 1 is supplied to an AGC (Automatic Gain Control) amplifier 2 which forms a fixed level signal from the output signal. The output of the AGC amplifier 2 undergoes quadrature detection by a quadrature detector 3. The output of the quadrature detector 3 is despread by a despreading portion 4 composed of matched filters or a sliding correlator. The output of the despreading portion 4 is inputted to a RAKE combiner and demodulator 5, a timing generator 6, a desired received signal power detector 7 and an interference power detector 8.

[0026] The timing generator 6 detects a synchronizing signal from the input signal, and provides the desired received signal power detector 7 and the interference power detector 8 with a timing clock signal on the basis of the detected synchronizing signal. The desired received signal power detector 7 detects the desired received signal power from the input signal on the basis of the timing clock signal. The interference power detector 8 detects the interference power from the input signal on the basis of the timing clock signal. An SIR calculation portion 9 calculates a received SIR from these detected outputs, and supplies the resultant received SIR to a transmission power control bit generator 10. The generator 10 compares the received SIR with a predetermined reference SIR satisfying a predetermined reception quality, and determines a transmission power control bit to be sent to the base station.

[0027] The RAKE combiner and demodulator 5 demodulates a RAKE combined input signal, and provides it to a frame separating portion 11. The frame separating portion 11 extracts the transmission power control bit from a frame, and provides it to a transmission power decision portion 12. The transmission power decision portion 12 determines the transmission power P_T in accordance with the transmission power control bit, compares the transmission power P_T with the maximum power P_{max} calculated by a maximum power calculation portion 13, and outputs a value corresponding to P_T when P_T is less than P_{max}, and a value corresponding to P_{max} when P_T is greater than P_{max}.

[0028] The maximum power calculation portion 13 calculates the maximum power P_{max} as follows: First, the received power S at the base station is expressed by the following equation.

$$SNR = \frac{S}{\frac{N_0}{Ts} + (1+\alpha)\frac{(C-1)S}{pg}} \qquad (1)$$

where SNR is a noise-to-signal ratio of the desired received power to noise power including the interference power, for satisfying a predetermined quality (error rate), N_0 is a power density of thermal noise, T_S is a symbol interval of information data, pg is a processing gain, C is the capacity in terms of the number of subscribers per cell, and α is a ratio of interference power from other cells to that of the cell of interest. The received power S at the base station can be obtained by the following equation derived from equation (1).

$$S = \frac{SNR \cdot N_0 \cdot pg}{Ts[pg - (1 + \alpha)(C - 1)SNR]} \qquad (2)$$

[0029] Considering a propagation loss P_{LOSS}, the maximum transmission power P_{max} of the mobile station is expressed by

$$P_{max} = \frac{SNR \cdot N_0 \cdot pg}{Ts[pg - (1 + \alpha)(C - 1)SNR]} + P_{Loss} \qquad (3)$$

[0030] The maximum transmission power of the base station can be obtained in a similar manner.

[0031] The frame generator 14 forms a frame (reverse frame) including the transmission power control bit from the transmission power control bit generator 10, information data such as voice information, and pilot data for communication control, and provides the frame to a spreading portion 15. The spreading portion 15 spectrum-spreads the signal from the frame generator 14 using a spreading code supplied from a spreading code generator 16, and provides it to a quadrature modulator 17. The quadrature modulator 17 performs quadrature modulation on the signal from the spreading portion 15, and provides the modulated signal to an RF upconverter 18. The RF upconverter 18 converts the signal from the quadrature modulator 17 to an RF signal, and provides it to a power amplifier 19. The power amplifier 19 amplifies the signal from the RF upconverter 18 such that the transmission power of the signal becomes the transmission power determined by the transmission power decision portion 12. The output of the power amplifier 19 is fed to an antenna, and is radiated to the base station. The transmission power control period at the power amplifier 19 is determined at a value that enables the transmission power control to follow instantaneous fluctuations corresponding to the Doppler frequency.

[0032] The mobile station has an arrangement as described above. The base station has a similar arrangement except for a portion shown in Fig. 9. In Fig. 9, a power control portion 20 is connected to the input of an RF upconverter 18'. The power control portion 20 controls (bit shifts) the power of the signal (a baseband signal) outputted from a quadrature modulator 17' in response to the transmission power value supplied from a transmission power decision portion 12'. This facilitates combining a plurality of channels at the baseband and amplifying them all together, which is performed at the base station.

[0033] Fig. 10 is a flowchart showing the transmission power control of the mobile station. The transmission power P_T is calculated on the basis of the transmission power bit sent from the base station at step SP1. Subsequently, the calculated power P_T is compared with the maximum power P_{max} at step SP2. If the calculated power P_T is equal to or less than the maximum power P_{max}, the transmission power is set at P_T at step SP3, whereas if the calculated power P_T is greater than the maximum power P_{max}, the transmission power is set at P_{max} at step SP4.

[0034] Fig. 11 is a flowchart showing the transmission power control of the base station. The transmission power P_T is calculated on the basis of the transmission power bit sent from the mobile station at step SP11. Subsequently, the calculated power P_T is compared with the maximum power P_{max} at step SP12. If the calculated power P_T is equal to or less than the maximum power P_{max}, the transmission power is set at P_T at step SP13, whereas if the calculated power P_T is greater than the maximum power P_{max}, the transmission power is set at P_{max} at step SP14.

[0035] Fig. 12 shows an example of a closed loop transmission power control method in accordance with the present invention. The transmission power control is carried out as follows (the number in brackets correspond to those of Fig. 12.):

[1] The base station measures a desired received power level, and calculates an SIR.

[2] The base station estimates the transmission power at two transmission power control periods later by comparing the measured SIR with a predetermined reference SIR.

[3] The base station generates a transmission power control bit which commands an increment or decrement of transmission power of a mobile station, and inserts it into a forward frame periodically. The insertion period is determined such that the power control can follow instantaneous fluctuations associated with the Doppler frequency.

[4] The mobile station decodes the reverse transmission power control bit included in the forward frame sent from the base station.

[5] The mobile station transmits a signal at the transmission power commanded by the reverse transmission power control bit included the forward frame.

[0036] In reverse communications, a dynamic range of 70 dB or more is necessary for the transmitter amplifier of a mobile station to achieve the communication in a cell whose radius is a few kilometers. In contrast with this, in forward communications, changed amounts of the transmission power of the base station must be limited to a small range of less than 10 dB from the steady state maximum power P'_{max} because increasing the transmission power of the base station when a mobile station receives interference from other cells at an edge of the cell will cause interference to other communicators within the cell.

[0037] The present invention has been described in detail with respect to an embodiment, and it will now be apparent from the foregoing to those skilled in the art that changes and modifications may be made without departing from the invention in its broader aspects, and it is the intention, therefore, in the appended claims to cover all such changes and modifications.

Claims

1. A transmission power control method for use in first and second communicating radio apparatuses in a code division multiple access system, one of the first and second radio apparatuses being a base station, and the other of the first and second radio apparatuses being a mobile station, the method comprising the steps of:

   measuring, at the first radio apparatus, the desired signal received power which is the received power of a signal received from the second radio apparatus;
   calculating, at the first radio apparatus, the ratio of said desired signal received power which is the received power of the signal received from the second radio apparatus to the sum of the interference power and thermal noise power from other radio apparatuses; and
   transmitting, at the first radio apparatus, a transmission power control bit to the second radio apparatus,

   the method being **characterised by** the steps of:

   generating, at the first radio apparatus, the transmission power control bit in accordance with a result of comparison between said calculated ratio and a predetermined threshold value of the ratio of the desired signal received power to the sum of the interference power and thermal noise power;
   calculating, at the second radio apparatus, tentative power (PT) on the basis of the transmission power control bit received from the first radio apparatus (SP1; SP11);
   deciding, at the second radio apparatus, the transmission power such that said transmission power is made equal to said calculated tentative power, when said calculated tentative power is less than the predetermined power threshold value (Pmax), and said transmission power is made equal to said predetermined power threshold value, when said calculated tentative power is greater than said predetermined power threshold value (SP2; SP12); and
   transmitting, at the second radio apparatus, a signal at the transmission power decided by the deciding step (SP3; SP4; SP13; SP14).

2. The transmission power control method as claimed in claim 1, wherein said predetermined power threshold value (Pmax) is determined on the basis of a maximum capacity in terms of number of subscribers in a cell, a radius of the cell, and an outage probability of the cell.

3. A radio apparatus for communicating with an opposite radio apparatus in a code division multiple access system, one of said radio apparatus and said opposite radio apparatus being a base station, and the other of said radio apparatus and said opposite radio apparatus being a mobile station, said radio apparatus having a transmission power control function, said radio apparatus comprising:

   means (11) for extracting, from a signal received from said opposite radio apparatus, a transmission power control bit included in the signal,

   said radio apparatus being **characterised by**:

   means (13) for providing a predetermined power threshold value (Pmax);
   decision means (12) for calculating tentative power (PT) on the basis of said extracted transmission power control bit, and making transmission power equal to said calculated tentative power, when said calculated tentative power (PT) is less than said predetermined power threshold value (Pmax), and making the transmission

power equal to said predetermined power threshold value (Pmax), when said calculated tentative power is greater than said predetermined power threshold value (Pmax); and
means (19) for transmitting a signal at the transmission power decided by the decision means (12).

4. The radio apparatus as claimed in claim 3, further comprising:

a desired received signal power detector (7) for measuring the desired signal received power which is the received power of the signal received from the opposite radio apparatus;
an interference power detector (8) for measuring the sum of the interference power and thermal noise power from other radio apparatuses;
calculating means (9) for calculating the ratio of said desired signal received power to said sum of the interference power and the thermal noise power;
means (10) for generating a transmission power control bit in accordance with the result of a comparison between said calculated ratio and a predetermined threshold value of the ratio of said desired signal received power to said sum of the interference power and the thermal noise power; and
means (14) for generating a transmission signal including said transmission power control bit.

5. The radio apparatus as claimed in claim 3, wherein said means (13) for providing the predetermined power threshold value calculates the predetermined power threshold value on the basis of a maximum capacity in terms of number of subscribers in a cell, a radius of the cell, and an outage probability of the cell.

6. The radio apparatus as claimed in claim 3, wherein the radio apparatus is a mobile station.

7. The radio apparatus as claimed in claim 3, wherein the radio apparatus is a base station.

8. A transmission power control method in a radio apparatus for communicating with an opposite radio apparatus in a code division multiple access system, one of the radio apparatus or the opposite radio apparatus being a base station, and the other of the radio apparatus or the opposite radio station being a mobile station, the method comprising the steps of:

sending a signal to said opposite radio apparatus;
receiving a transmission power control bit which has been calculated on the basis of said sent signal at said opposite radio apparatus and transmitted by said opposite radio apparatus;
calculating tentative power (PT) on the basis of said received transmission power control bit;
deciding the transmission power such that said transmission power is made equal to said calculated tentative power, when said calculated tentative power is less than a predetermined power threshold value (Pmax), and said transmission power is made equal to said predetermined power threshold value, when said calculated tentative power is greater than said predetermined power threshold value (SP2; SP12); and
transmitting a signal at said transmission power decided by the deciding step (SP3; SP4; SP13; SP14).

Patentansprüche

1. Übertragungsleistungssteuerungsverfahren zur Verwendung bei einem ersten und zweiten Kommunikationsfunkgerät in einem Codemultiplexsystem, wobei das erste oder zweite Funkgerät eine Basisstation und das andere eine Mobilstation ist, das Verfahren ist dabei versehen mit den Schritten:

Messen der gewünschten Signalempfangsleistung am ersten Funkgerät, welches die empfangene Leistung eines von dem zweiten Funkgerät empfangenen Signals ist;
Berechnen des Verhältnisses der gewünschten Signalempfangsleistung, welches die Empfangsleistung des von dem zweiten Funkgerät empfangenen Signals ist, zu der Summe aus Interferenzleistung und Wärmerauschleistung von anderen Funkgeräten, am ersten Funkgerät; und
Übertragen eines Übertragungsleistungssteuerbits am ersten Funkgerät an das zweite Funkgerät,

das Verfahren ist **gekennzeichnet durch** die Schritte:

Erzeugen des Übertragungsleistungssteuerbits am ersten Funkgerät gemäß dem Ergebnis eines Vergleichs zwischen dem berechneten Verhältnis und einem vorbestimmten Schwellenwert für das Verhältnis der ge-

wünschten Signalempfangsleistung zu der Summe aus Interferenzleistung und Wärmerauschleistung;
Berechnen einer vorläufigen Leistung (PT) am zweiten Funkgerät auf der Grundlage des von dem ersten Funkgerät (SP1; SP11) empfangenen Übertragungsleistungssteuerbits;
Bestimmen der Übertragungsleistung am zweiten Funkgerät derart, dass die Übertragungsleistung gleich der berechneten vorläufigen Leistung ist, wenn die berechnete vorläufige Leistung weniger als der vorbestimmte Leistungsschwellenwert (Pmax) beträgt, und dass die Übertragungsleistung gleich dem vorbestimmten Leistungsschwellenwert ist, wenn die berechnete vorläufige Leistung größer als der vorbestimmte Leistungsschwellenwert (SP2; SP12) ist; und
Übertragen eines Signals an dem zweiten Funkgerät mit der **durch** den Bestimmungsschritt (SP3; SP4, SP13; SP14) bestimmten Übertragungsleistung.

2. Übertragungsleistungssteuerverfahren nach Anspruch 1, wobei der vorbestimmte Leistungsschwellenwert (Pmax) auf der Grundl-age einer maximalen Kapazität bezüglich der Anzahl von Teilnehmern in einer Zelle, einem Radius der Zelle und einer Ausfallwahrscheinlichkeit der Zelle bestimmt wird.

3. Funkgerät zur Kommunikation mit einem Gegenfunkgerät in einem Codemultiplexsystem, wobei das Funkgerät oder das Gegenfunkgerät eine Basisstation ist und das andere eine Mobilstation ist, das Funkgerät weist dabei eine Übertragungsleistungssteuerfunktion auf und ist versehen mit:

einer Einrichtung (11) zum Extrahieren eines in einem von dem Gegenfunkgerät empfangenen Signal beinhalteten Übertragungsleistungssteuerbits aus dem Signal,

das Funkgerät ist **gekennzeichnet durch**:

eine Einrichtung (13) zur Bereitstellung eines vorbestimmten Leistungsschwellenwerts (Pmax);
eine Bestimmungseinrichtung (12) zum Berechnen einer vorläufigen Leistung (PT) auf der Grundlage des extrahierten Übertragungsleistungssteuerbits, sowie um die Übertragungsleistung gleich der berechneten vorläufigen Leistung zu machen, wenn die berechnete vorläufige Leistung (PT) kleiner als der vorbestimmte Leistungsschwellenwert (Pmax) ist, und um die Übertragungsleistung gleich dem vorbestimmten Leistungsschwellenwert (Pmax) zu machen, wenn die berechnete vorläufige Leistung größer als der vorbestimmte Leistungsschwellenwert (Pmax) ist;
eine Einrichtung (19) zum Übertragen eines Signals mit der **durch** die Bestimmungseinrichtung (12) bestimmten Übertragungsleistung.

4. Funkgerät nach Anspruch 3, ferner mit:

einer Erfassungseinrichtung (7) für eine gewünschte Empfangssignalleistung zum Messen der gewünschten Signalempfangsleistung, welche die empfangene Leistung des von dem Gegenfunkgerät empfangenen Signals ist;
eine Interferenzleistungserfassungseinrichtung (8) zum Messen der Summe aus Interferenzleistung und Wärmerauschleistung von anderen Funkgeräten;
einer Berechnungseinrichtung (9) zum Berechnen des Verhältnisses der gewünschten Signalempfangsleistung zu der Summe aus Interferenzleistung und Wärmerauschleistung;
einer Einrichtung (10) zum Erzeugen eines Übertragungsleistungssteuerbits gemäß dem Ergebnis aus einem Vergleich zwischen dem berechneten Verhältnis und einem vorbestimmten Schwellenwert für das Verhältnis aus der gewünschten Signalempfangsleistung zu der Summe aus Interferenzleistung und Wärmerauschleistung; und
einer Einrichtung (14) zum Erzeugen eines Übertragungssignals mit dem Übertragungsleistungssteuerbit.

5. Funkgerät nach Anspruch 3, wobei die Einrichtung (13) zum Bereitstellen des vorbestimmten Leistungsschwellenwertes den vorbestimmten Leistungsschwellenwert auf der Grundlage einer maximalen Kapazität bezüglich der Anzahl von Teilnehmern in einer Zelle, einem Radius der Zelle und einer Ausfallwahrscheinlichkeit der Zelle berechnet.

6. Funkgerät nach Anspruch 3, wobei das Funkgerät eine Mobilstation ist. ’

7. Das Funkgerät nach Anspruch 3, wobei das Funkgerät eine Basisstation ist.

8. Übertragungsleistungssteuerverfahren bei einem Funkgerät zur Kommunikation mit einem Gegenfunkgerät in einem Codemultiplexsystem, wobei das Funkgerät oder das Gegenfunkgerät eine Basisstation und das andere eine Mobilstation ist, das Verfahren ist dabei versehen mit den Schritten:

Senden eines Signals an das Gegenfunkgerät;
Empfang eines Übertragungsleistungssteuerbits, das auf der Grundlage des gesendeten Signals an dem Gegenfunkgerät berechnet und durch das Gegenfunkgerät übertragen wurde;
Berechnen einer vorläufigen Leistung (PT) auf der Grundlage des empfangenen Übertragungsleistungssteuerbits;
Bestimmen der Übertragungsleistung derart, dass die Übertragungsleistung gleich der berechneten vorläufigen Leistung ist, wenn die berechnete vorläufige Leistung weniger als einen vorbestimmter Schwellenwert (Pmax) beträgt, und dass die Übertragungsleistung gleich dem vorbestimmten Leistungsschwellenwert ist, wenn die berechnete vorläufige Leistung größer als der vorbestimmte Leistungsschwellenwert (SP2; SP12) ist; und
Übertragen eines Signals mit der durch den Bestimmungsschritt (SP3; SP4; SP13; SP14) bestimmten Übertragungsleistung.

Revendications

1. Procédé de commande de puissance d'émission à utiliser dans des premier et deuxième dispositifs de communication radio dans un système d'accès multiple par répartition de codes, l'un des premier et deuxième dispositifs radio étant un poste de base, et l'autre des premier et deuxième dispositifs radio étant un poste mobile, le procédé comportant les étapes dans lesquelles :

on mesure, au premier dispositif radio, la puissance reçue du signal souhaité qui est la puissance reçue d'un signal reçu du deuxième dispositif radio ; on calcule, au premier dispositif radio, le rapport de la puissance reçue du signal souhaité, qui est la puissance reçue du signal reçu du deuxième dispositif radio, à la somme de la puissance d'interférence et de la puissance de bruit thermique provenant d'autres dispositifs radio; et
on émet, au premier dispositif radio, un bit de commande de puissance d'émission envoyé au deuxième dispositif radio,

le procédé étant **caractérisé par** les étapes dans lesquelles :

on produit, au premier dispositif radio, le bit de commande de puissance d'émission conformément à un résultat d'une comparaison entre le rapport calculé et une valeur seuil déterminée à l'avance du rapport de la puissance reçue du signal souhaité à la somme de la puissance d'interférence et de la puissance de bruit thermique ;
on calcule, au deuxième dispositif radio, une puissance (PT) expérimentale sur la base du bit de commande de puissance d'émission reçu du premier dispositif (SP1 ; SP11) radio ;
on décide, au deuxième dispositif radio, de la puissance de transmission, de sorte que la puissance d'émission soit rendue égale à la puissance expérimentale calculée, lorsque la puissance expérimentale calculée est inférieure à la valeur seuil (Pmax) de puissance déterminée à l'avance, la puissance d'émission étant rendue égale à la valeur seuil de puissance déterminée à l'avance, lorsque la puissance expérimentale calculée est supérieure à la valeur (SP2 ; SP12) seuil de puissance déterminée à l'avance ; et
on émet, au deuxième dispositif radio, un signal à la puissance d'émission décidée par l'étape de décision (SP3 ; SP4, SP13 ; SP14).

2. Procédé de commande de puissance d'émission suivant la revendication 1, dans lequel la valeur (Pmax) de seuil de puissance déterminée à l'avance est déterminée sur la base d'une capacité maximum en termes de nombre d'abonnés dans une cellule, un rayon de la cellule et une probabilité d'indisponibilité de la cellule.

3. Dispositif radio pour communiquer avec un dispositif radio opposé dans un système d'accès multiple par répartition de codes, l'un du dispositif radio et du dispositif radio opposé étant un poste de base, et l'autre du dispositif radio et du dispositif radio opposé étant un poste mobile, le dispositif radio ayant une fonction de commande de puissance d'émission, le dispositif radio comportant :

des moyens (11) destinés à extraire, d'un signal reçu du dispositif radio opposé, un bit de commande de puissance d'émission inclus dans le signal, le dispositif radio étant **caractérisé par** :

des moyens (13) pour fournir une valeur (Pmax) de seuil de puissance déterminée à l'avance ;
des moyens (12) de décision pour calculer une puissance (PT) expérimentale sur la base du bit de commande de puissance d'émission extrait, et rendre la puissance d'émission égale à la puissance expérimentale calculée, lorsque la puissance (PT) expérimentale calculée est inférieure à la valeur (Pmax) de seuil de puissance déterminée à l'avance, et rendre la puissance d'émission égale à la valeur (Pmax) de seuil de puissance déterminée à l'avance, lorsque la puissance expérimentale calculée est supérieure à la valeur (Pmax) de seuil de puissance déterminée à l'avance ; et
des moyens (19) pour émettre un signal à la puissance d'émission décidée par les moyens (12) de décision.

4. Dispositif radio suivant la revendication 3, comportant en outre :

un détecteur (7) de puissance de signal reçu souhaité pour mesurer la puissance reçue du signal souhaité, qui est la puissance reçue du signal reçu ;
un détecteur (8) de puissance d'interférence pour mesurer la somme de la puissance d'interférence et de la puissance de bruit thermique provenant de dispositifs radio avec lesquels le dispositif radio n'est pas en communication ;
des moyens (9) de calcul pour calculer le rapport de la puissance reçue de signal souhaité à la somme de la puissance d'interférence et de la puissance de bruit thermique ;
des moyens (10) pour produire un bit de commande de puissance d'émission conformément au résultat d'une comparaison entre le rapport calculé et une valeur seuil déterminée à l'avance du rapport de la puissance reçue du signal souhaité à la somme de la puissance d'interférence et de la puissance de bruit thermique ; et
des moyens (14) pour produire un signal d'émission incluant le bit de commande de puissance d'émission.

5. Dispositif radio suivant la revendication 3, dans lequel les moyens (13) pour fournir la valeur seuil de puissance déterminée à l'avance calculent la valeur seuil de puissance déterminée à l'avance sur la base d'une capacité maximum en termes de nombre d'abonnés dans une cellule, d'un rayon de la cellule et d'une probabilité de défaillance de la cellule.

6. Dispositif radio suivant la revendication 3, dans lequel le dispositif radio est un poste mobile.

7. Dispositif radio suivant la revendication 3, dans lequel le dispositif radio est un poste de base.

8. Procédé de commande de puissance d'émission dans un dispositif radio pour communiquer avec un dispositif radio opposé dans un système d'accès multiple à répartition de code, l'un du dispositif radio ou du dispositif radio opposé étant un poste de base, et l'autre du dispositif radio ou du dispositif radio opposé étant un poste mobile, le procédé comportant les étapes qui consistent :

à envoyer un signal au dispositif radio opposé ;
à recevoir un bit de commande de puissance d'émission qui a été calculé sur la base du signal envoyé au dispositif radio opposé et émis par le dispositif radio opposé ;
à calculer une puissance (PT) expérimentale sur la base du bit de commande de puissance d'émission reçu ;
à décider de la puissance d'émission, de sorte que la puissance d'émission soit rendue égale à la puissance expérimentale calculée, lorsque la puissance expérimentale calculée est inférieure à une valeur (Pmax) de seuil de puissance déterminée à l'avance, et la puissance d'émission est rendue égale à la valeur seuil de puissance déterminée à l'avance, lorsque la puissance expérimentale calculée est supérieure à la valeur (SP2 ; SP12) seuil de puissance déterminée à l'avance ; et
à émettre un signal à la puissance d'émission décidée par l'étape (SP3, SP4 ; SP13 ; SP14) de décision.

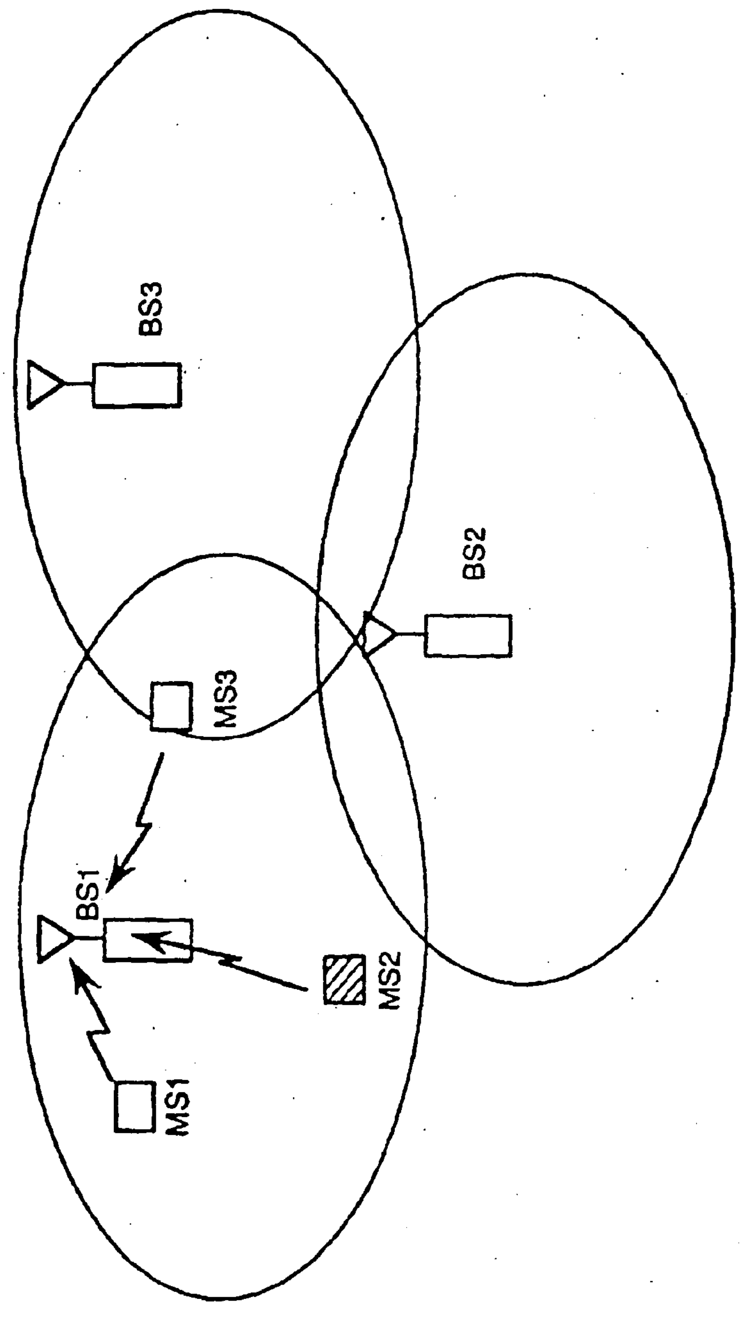

FIG. 1

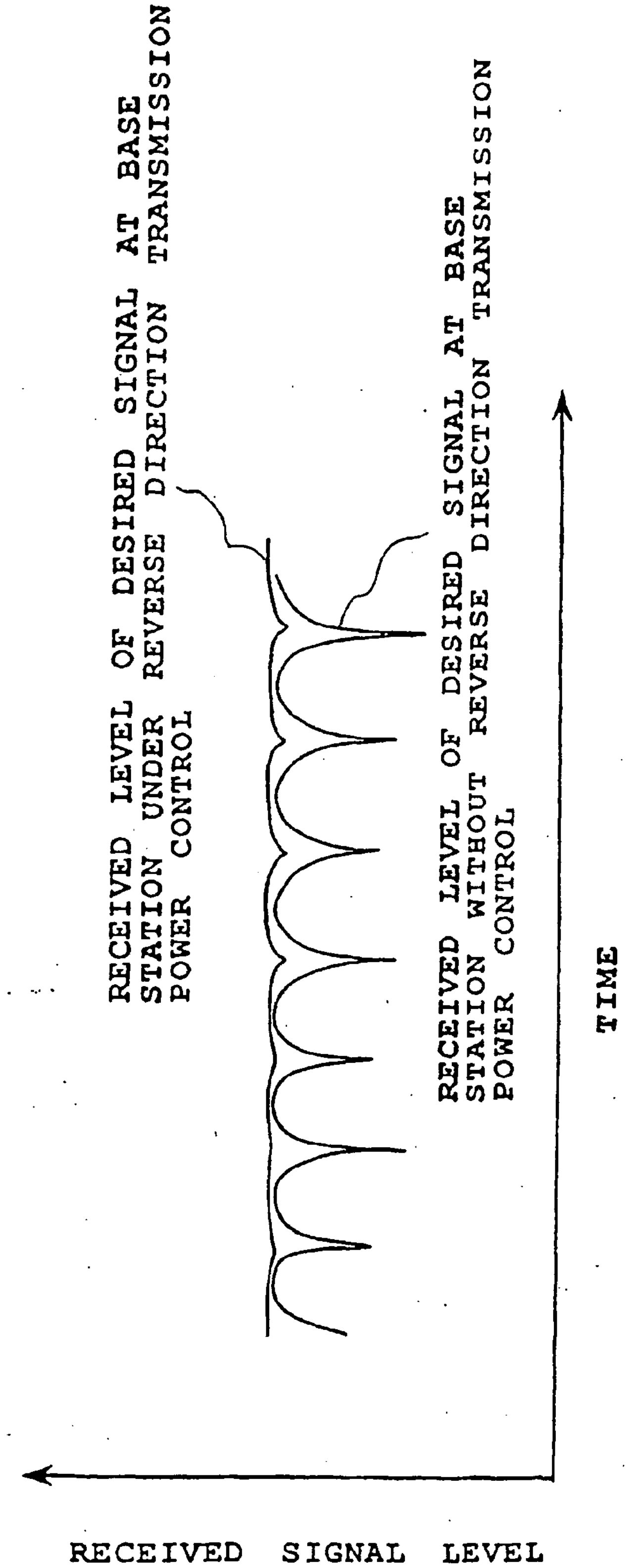
RECEIVED LEVEL OF DESIRED SIGNAL AT BASE STATION UNDER REVERSE DIRECTION TRANSMISSION POWER CONTROL
RECEIVED LEVEL OF DESIRED SIGNAL AT BASE STATION WITHOUT REVERSE DIRECTION TRANSMISSION POWER CONTROL
TIME
RECEIVED SIGNAL LEVEL

FIG. 2

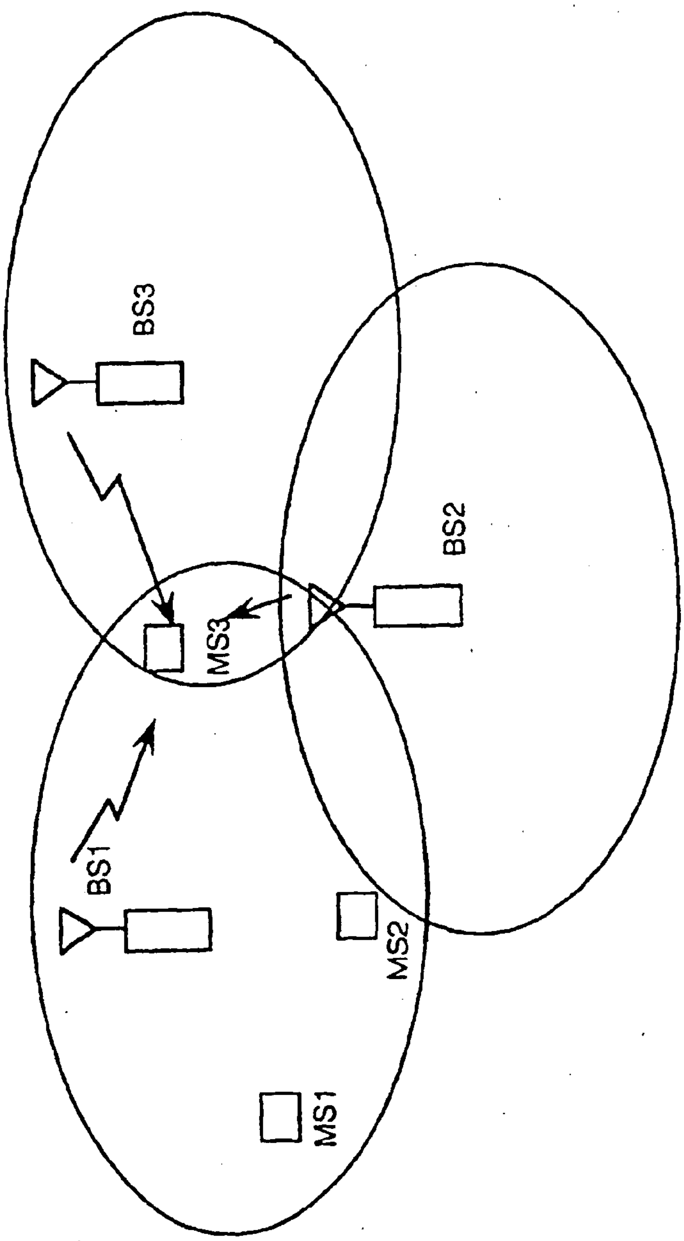

FIG. 3

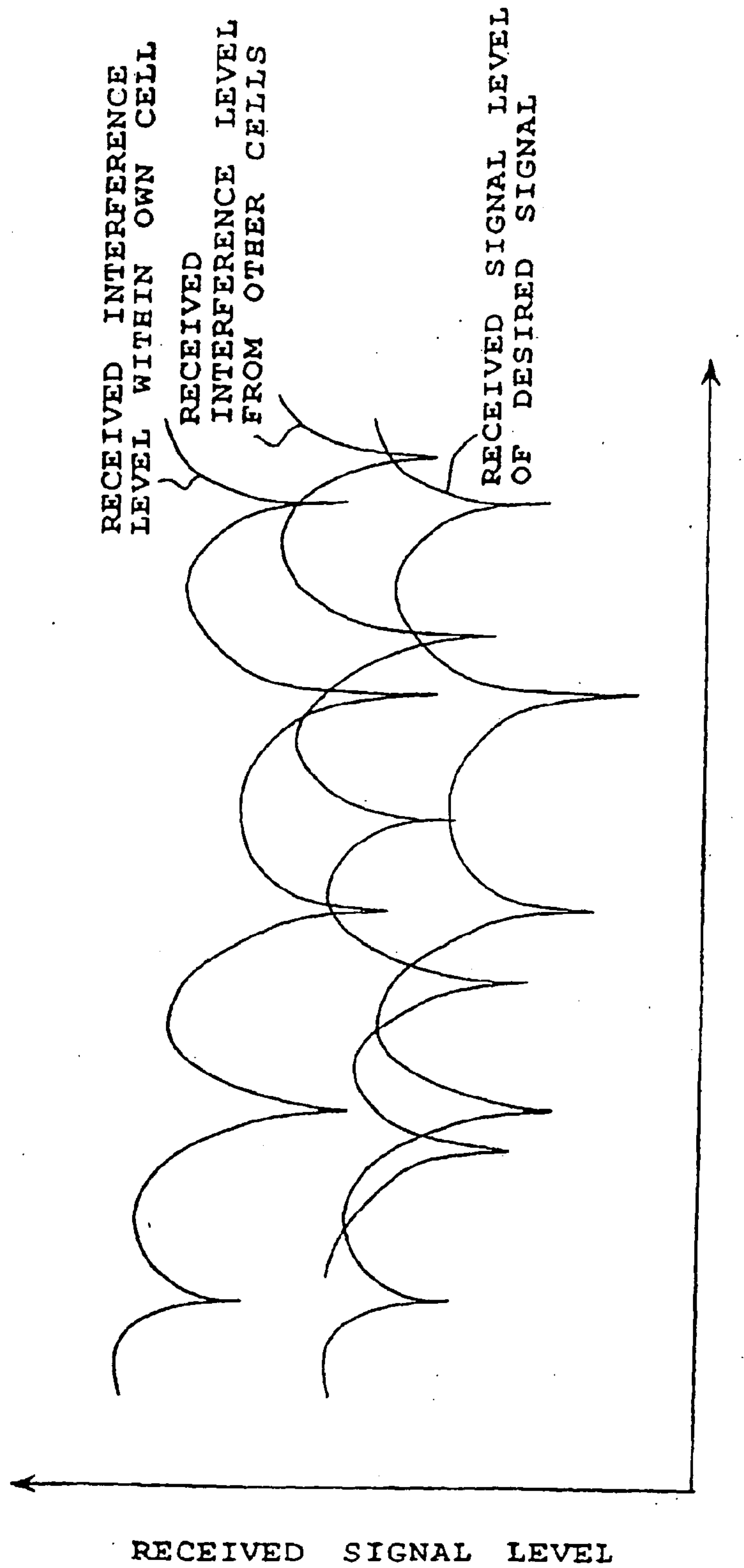
RECEIVED INTERFERENCE
LEVEL WITHIN OWN CELL
RECEIVED
INTERFERENCE LEVEL
FROM OTHER CELLS
RECEIVED SIGNAL LEVEL
OF DESIRED SIGNAL
TIME
RECEIVED SIGNAL LEVEL

FIG.4

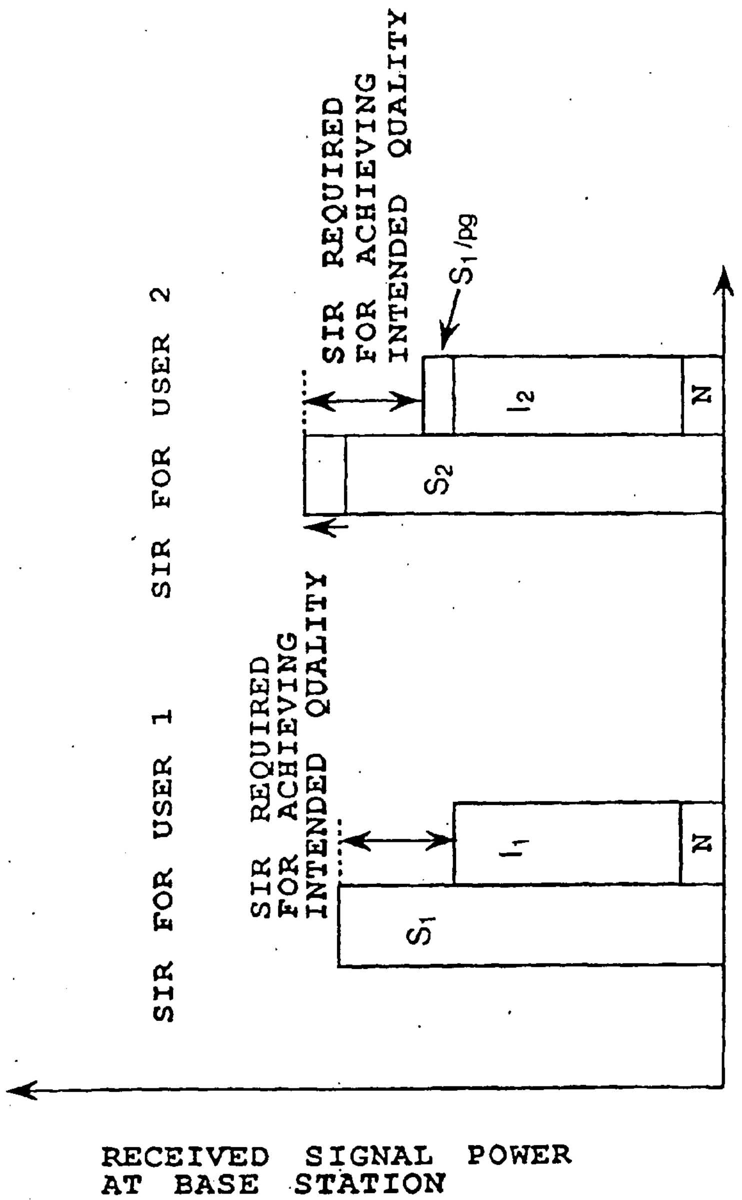
SIR FOR USER 1
SIR FOR USER 2
SIR REQUIRED FOR ACHIEVING INTENDED QUALITY
SIR REQUIRED FOR ACHIEVING INTENDED QUALITY
S1/pg
S1
I1
N
S2
I2
N
RECEIVED SIGNAL POWER AT BASE STATION

FIG. 5

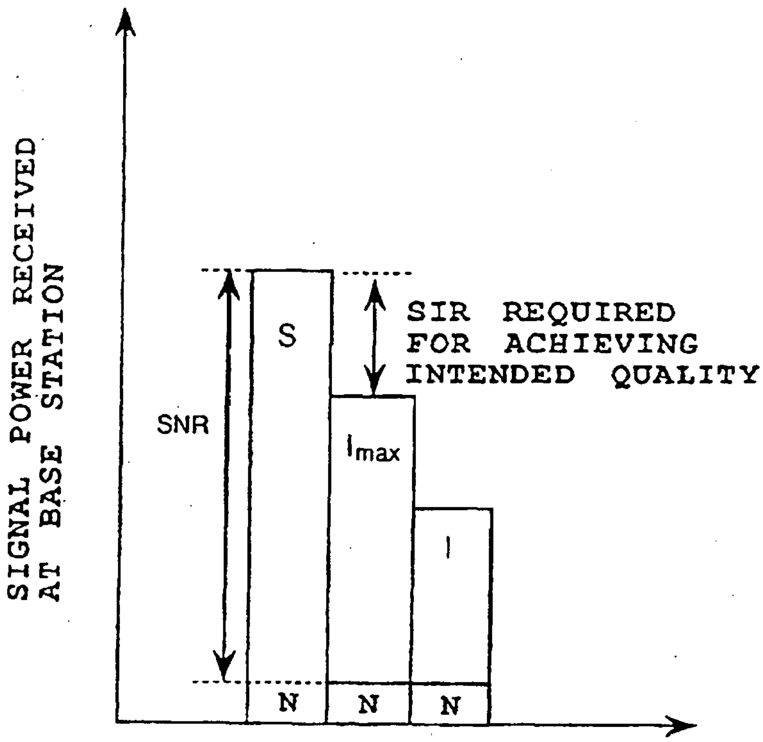
SIGNAL POWER RECEIVED
AT BASE STATION
S
SNR
SIR REQUIRED
FOR ACHIEVING
INTENDED QUALITY
I_{max}
I
N
N
N

FIG.6

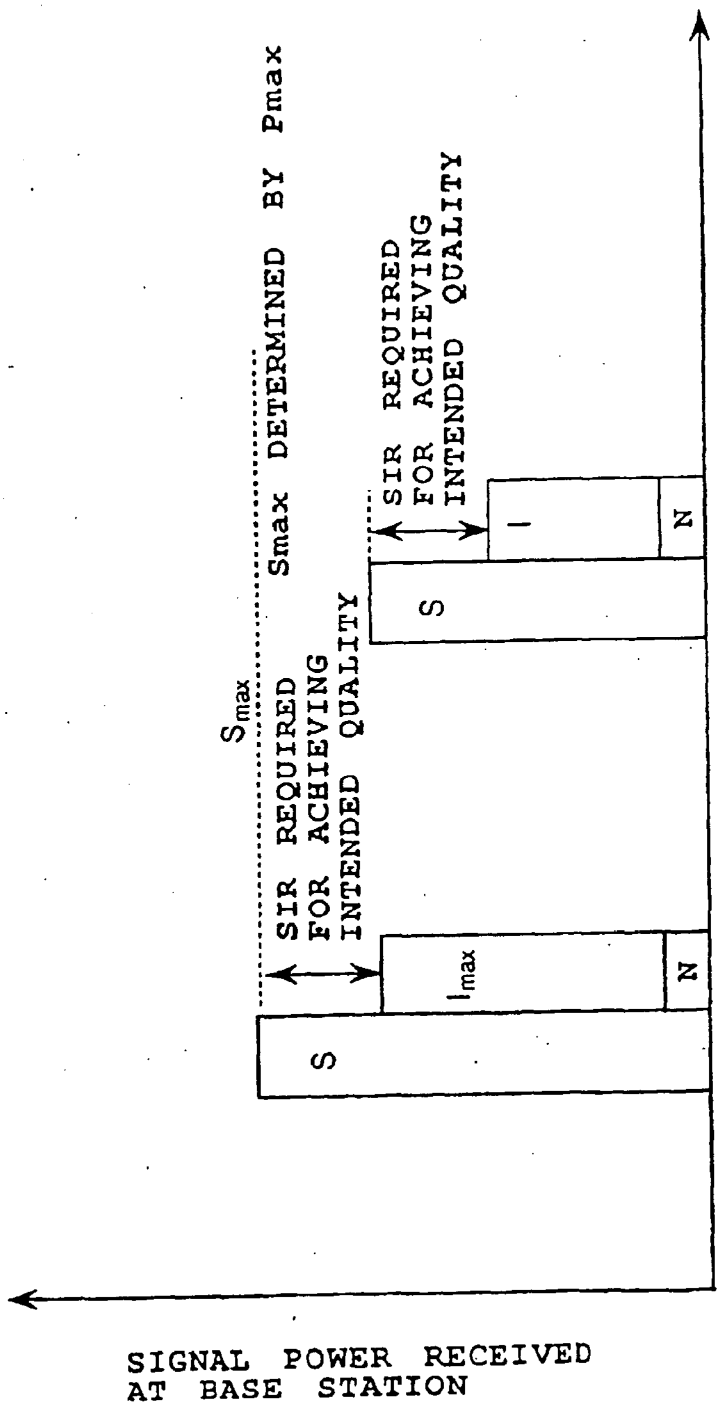
Smax DETERMINED BY Pmax
S_{max}
SIR REQUIRED FOR ACHIEVING INTENDED QUALITY
SIR REQUIRED FOR ACHIEVING INTENDED QUALITY
S
I_{max}
N
S
I
N
SIGNAL POWER RECEIVED AT BASE STATION

FIG.7

FIG.8

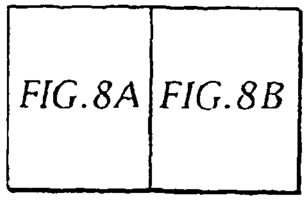
FIG.8A
FIG.8B

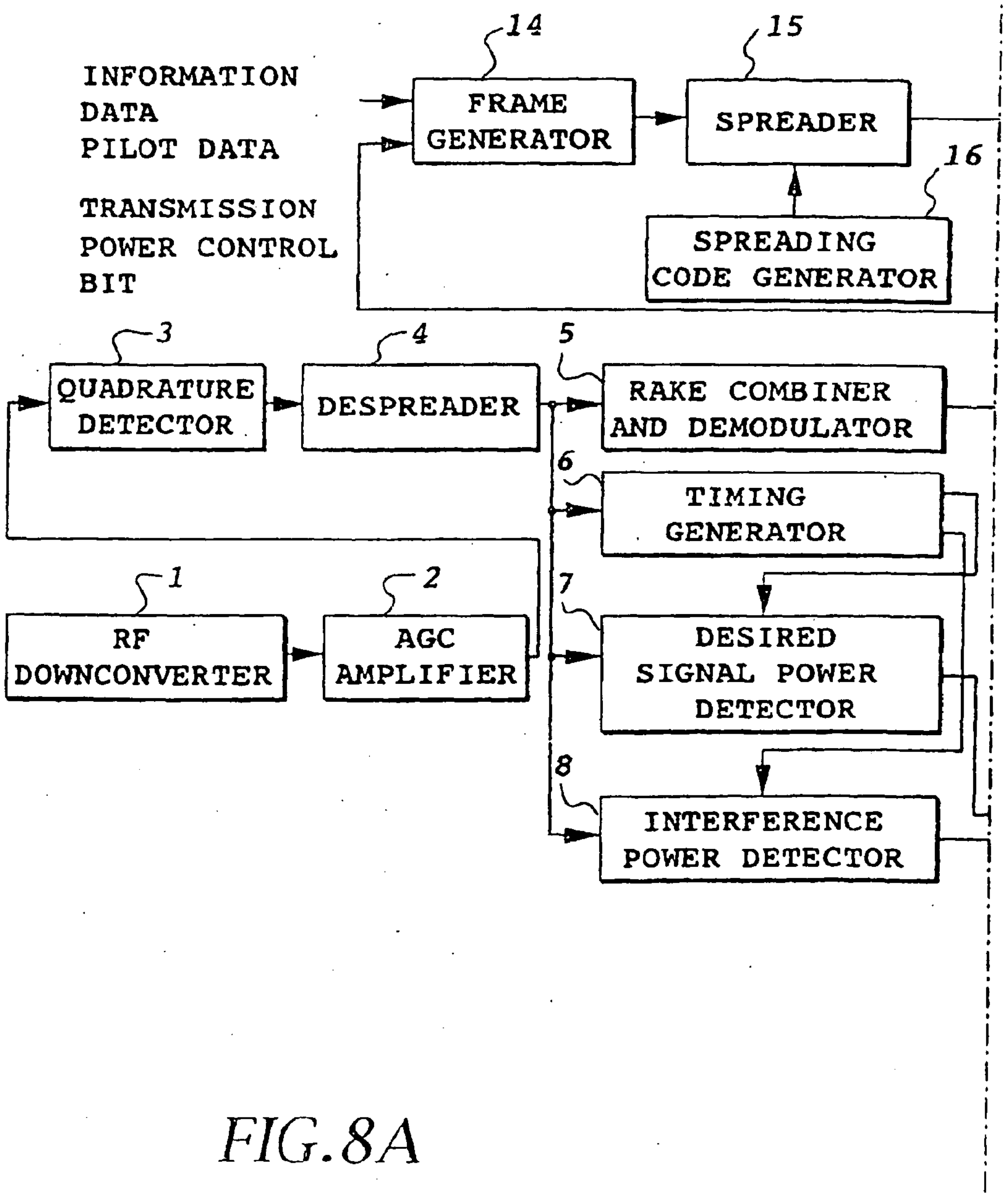
14
15
INFORMATION
DATA
PILOT DATA
FRAME
GENERATOR
SPREADER
16
TRANSMISSION
POWER CONTROL
BIT
SPREADING
CODE GENERATOR
3
4
5
QUADRATURE
DETECTOR
DESPREADER
RAKE COMBINER
AND DEMODULATOR
6
TIMING
GENERATOR
1
2
7
RF
DOWNCONVERTER
AGC
AMPLIFIER
DESIRED
SIGNAL POWER
DETECTOR
8
INTERFERENCE
POWER DETECTOR

FIG.8A

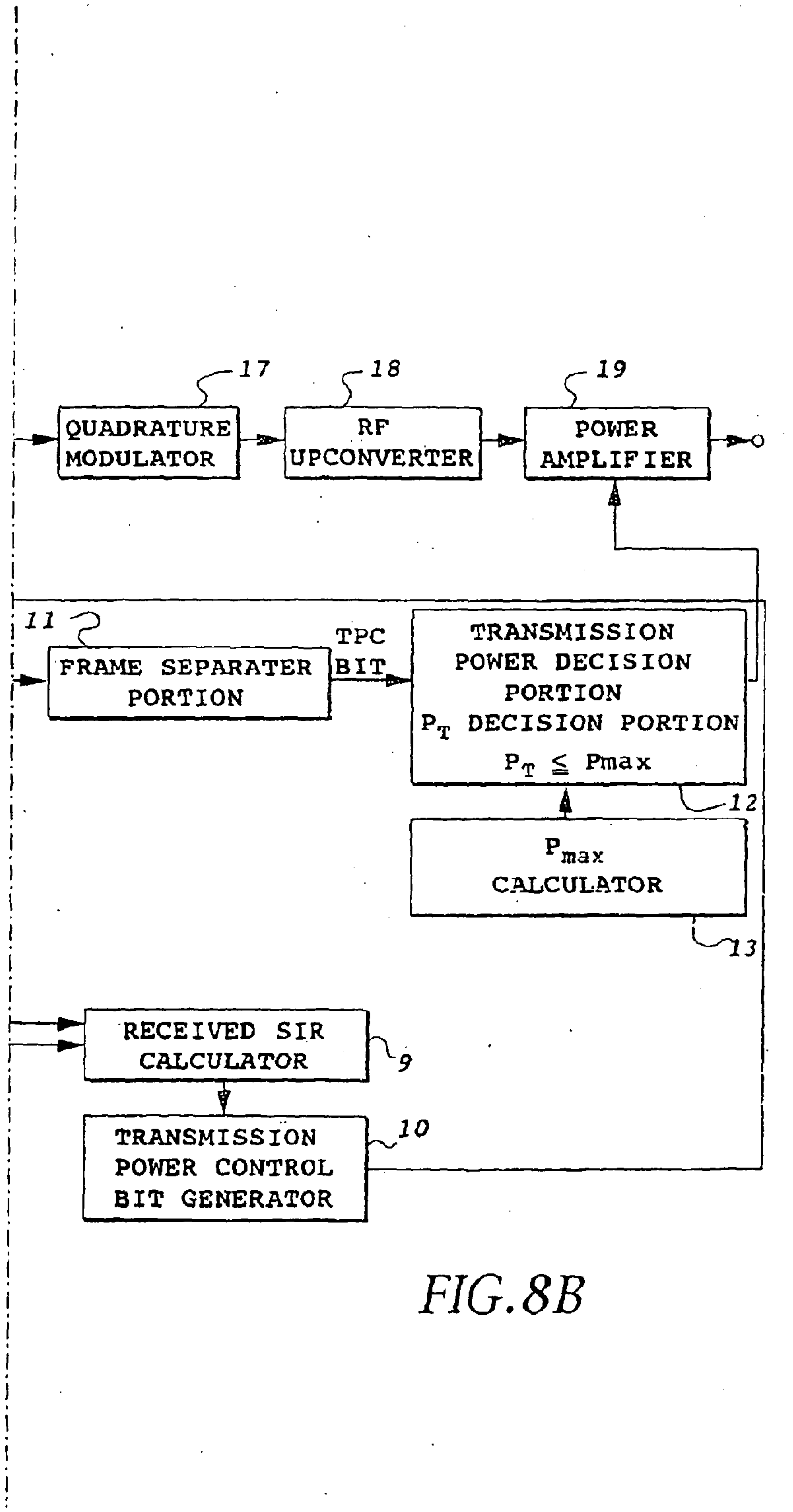
17
18
19
QUADRATURE MODULATOR
RF UPCONVERTER
POWER AMPLIFIER
11
FRAME SEPARATER PORTION
TPC BIT
TRANSMISSION POWER DECISION PORTION
P_T DECISION PORTION
P_T ≦ Pmax
12
P_max CALCULATOR
13
RECEIVED SIR CALCULATOR
9
TRANSMISSION POWER CONTROL BIT GENERATOR
10

FIG.8B

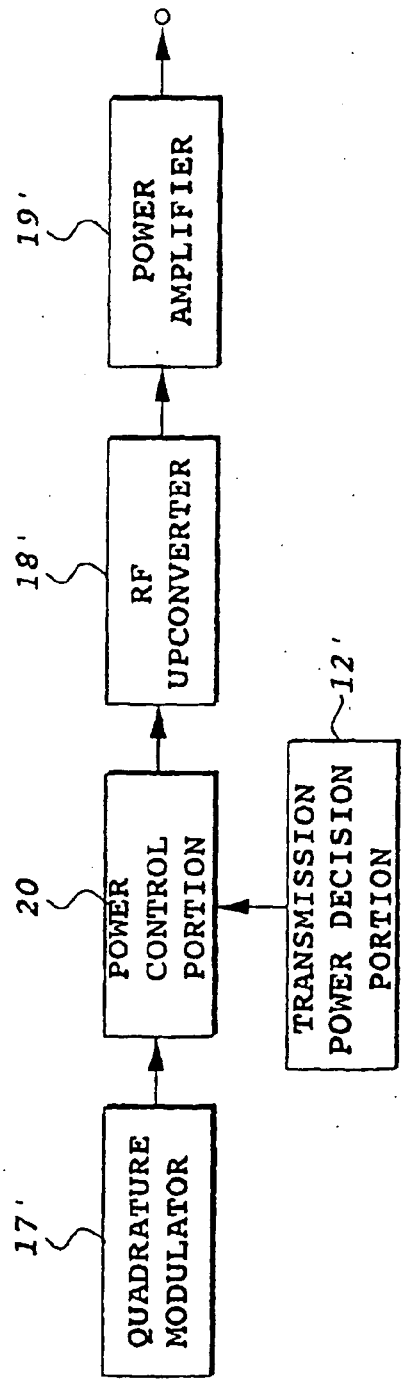
17'
QUADRATURE MODULATOR
20
POWER CONTROL PORTION
12'
TRANSMISSION POWER DECISION PORTION
18'
RF UPCONVERTER
19'
POWER AMPLIFIER

FIG.9

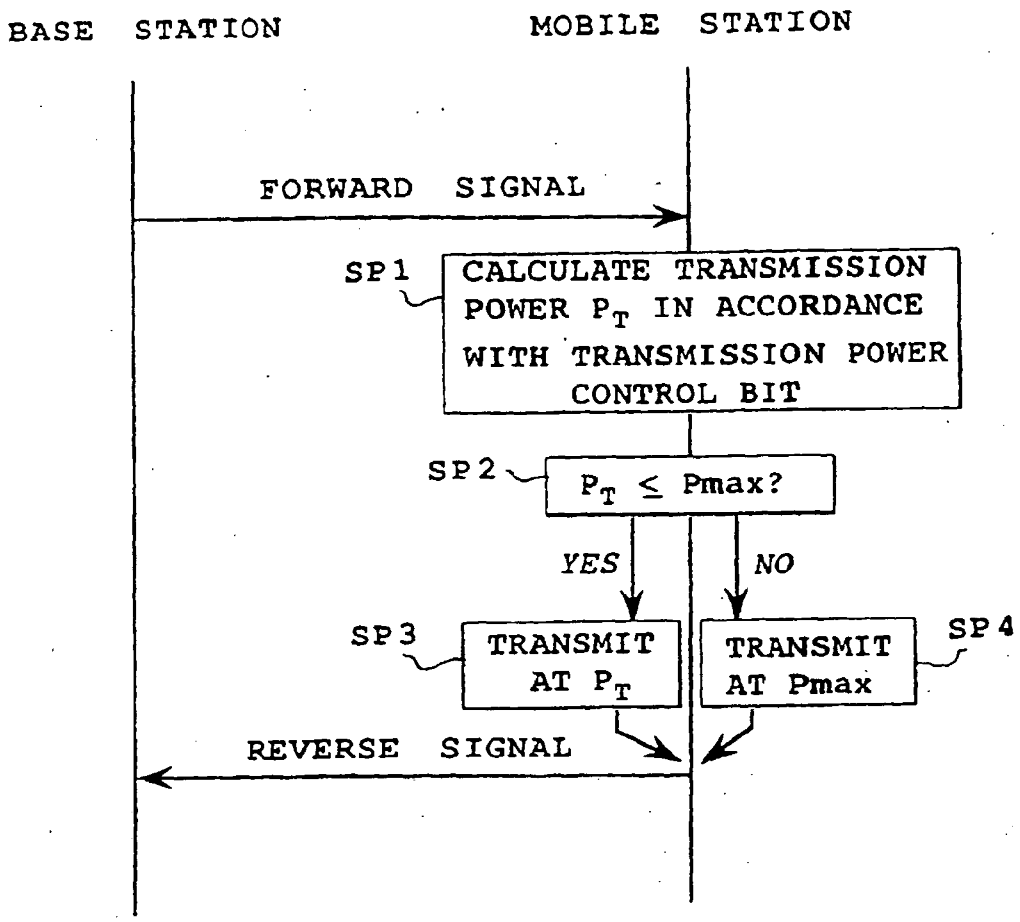
BASE STATION
MOBILE STATION
FORWARD SIGNAL
SP1
CALCULATE TRANSMISSION POWER P_T IN ACCORDANCE WITH TRANSMISSION POWER CONTROL BIT
SP2
P_T ≤ Pmax?
YES
NO
SP3
TRANSMIT AT P_T
TRANSMIT AT Pmax
SP4
REVERSE SIGNAL

FIG.10

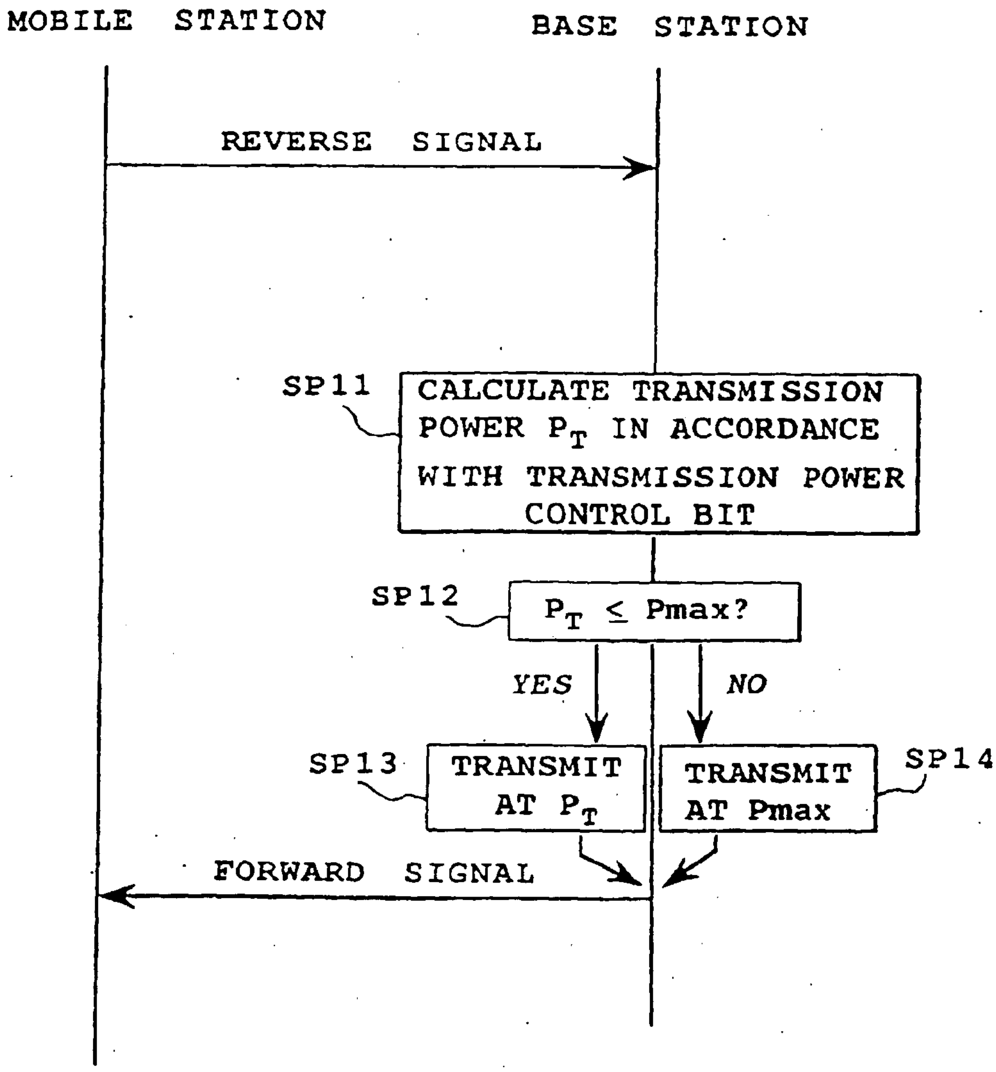
MOBILE STATION
BASE STATION
REVERSE SIGNAL
SP11
CALCULATE TRANSMISSION POWER P_T IN ACCORDANCE WITH TRANSMISSION POWER CONTROL BIT
SP12
$P_T \le$ Pmax?
YES
NO
SP13
TRANSMIT AT P_T
SP14
TRANSMIT AT Pmax
FORWARD SIGNAL

FIG.11

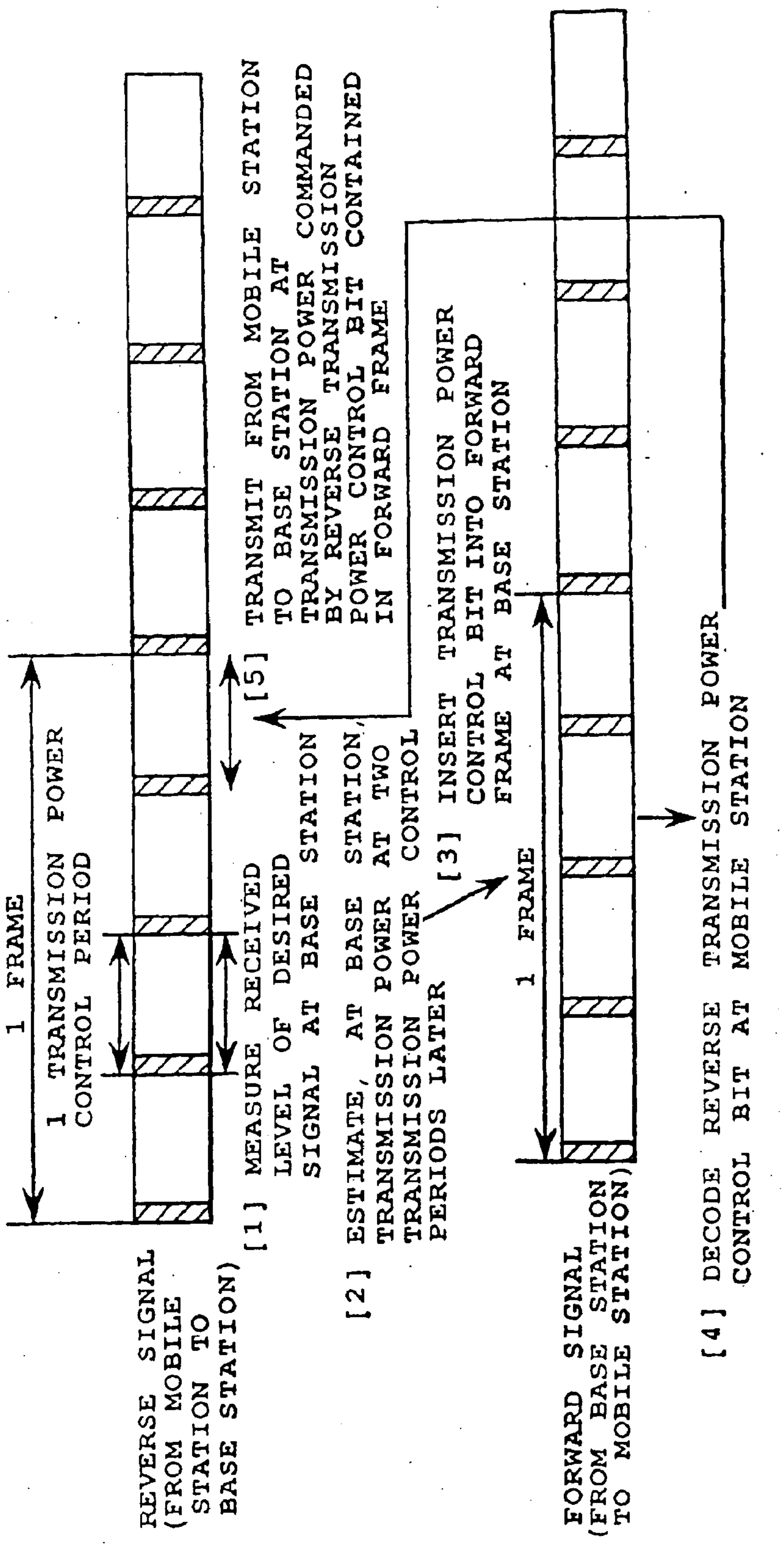
REVERSE SIGNAL (FROM MOBILE STATION TO BASE STATION)
1 FRAME
1 TRANSMISSION POWER CONTROL PERIOD
[1] MEASURE RECEIVED LEVEL OF DESIRED SIGNAL AT BASE STATION
[2] ESTIMATE, AT BASE STATION, TRANSMISSION POWER AT TWO TRANSMISSION POWER CONTROL PERIODS LATER
[5] TRANSMIT FROM MOBILE STATION TO BASE STATION AT TRANSMISSION POWER COMMANDED BY REVERSE TRANSMISSION POWER CONTROL BIT CONTAINED IN FORWARD FRAME
[3] INSERT TRANSMISSION POWER CONTROL BIT INTO FORWARD FRAME AT BASE STATION
FORWARD SIGNAL (FROM BASE STATION TO MOBILE STATION)
1 FRAME
[4] DECODE REVERSE TRANSMISSION POWER CONTROL BIT AT MOBILE STATION
TRANSMISSION POWER

FIG.12

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 9221196 A **[0014]**
- EP 0428099 A **[0015]**