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(54) **Radio systems**

(57) A radio system employs a
method of controlling the transmitted
power of a radio signal such that a
minimum power level for efficient
reception is maintained. Data is
simultaneously transmitted between
two radio stations (10, 20) using an
error correction code. Each block of
the code is accompanied by a power
bit. The transmitted power bit is set
high or low in dependance upon
whether the number of errors in a
sample of received blocks, as
determined by processing of the
received code, is equal to, above or
below a predetermined threshold
value. At the other station the
received power bit is directed to a
power control device (18) and used to
adjust the output power of the
transmitter of that station by
continuously variable slope delta
demodulation.

FIG. 1.

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Fig. 1.

BLOCK OF (7,4,1)
ERROR CORRECTING CODE
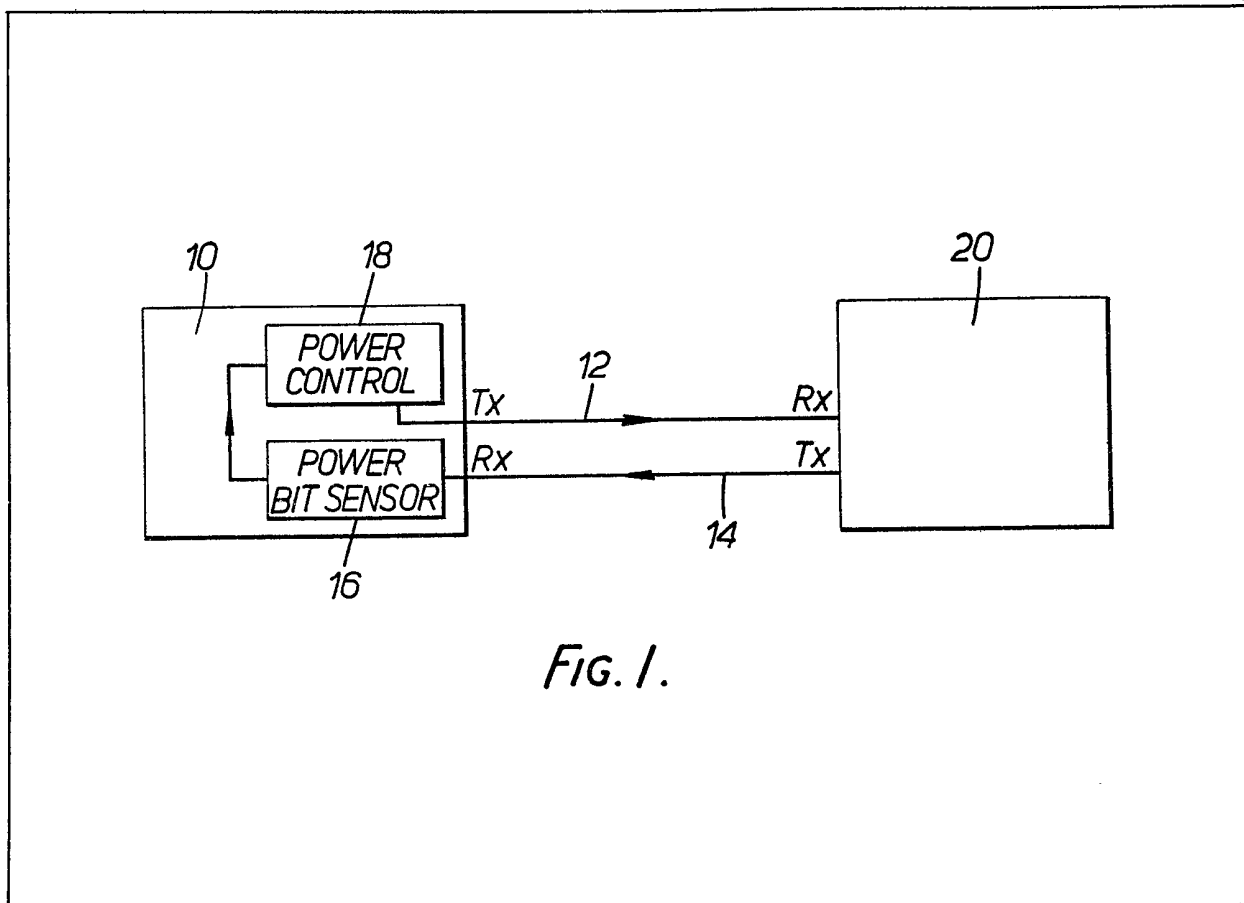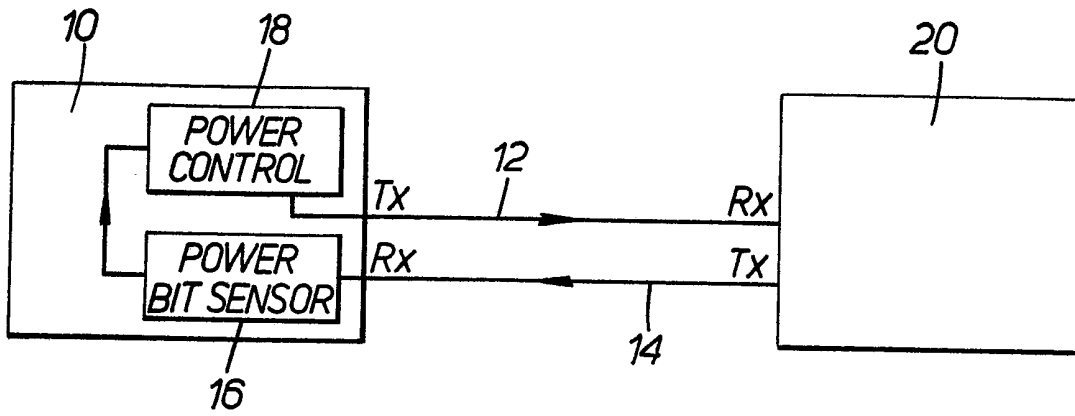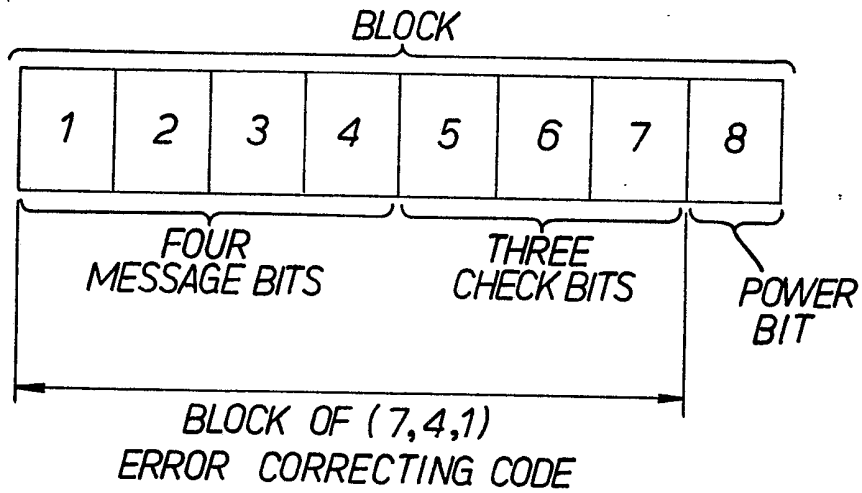
Fig. 2.

SPECIFICATION
Radio systems

The present invention relates to radio systems
and, more specifically, to radio systems adapted to
5 operate at a minimum effective power
transmission level. The invention also relates to
methods of controlling the transmitted power of a
radio signal.
In order to provide maximum security against
10 reception of a transmitted signal by an
unauthorised third party, it is desirable to use the
lowest possible transmission power that enables
effective reception to be achieved at the desired
receiving station. During a normal radio
15 transmission there may occur transient losses in
signal strength which are known as "fading". Such
fading may arise from cancellation of one
incoming wave with another which has travelled
from the transmitting radio by a different path.
20 Therefore it is not sufficient merely to set the
transmitted power level at a suitable minimum
value, as any fading during transmission will cause
errors at the receiving station.
Accordingly, the present invention provides a
25 radio system for simultaneous digital
communications between two radio stations using
data blocks each of which includes a plurality of
message bits and at least one non-message bit,
each radio station including means for monitoring
30 transmission received from the other radio station
and setting the or one non-message bit to be
transmitted by the receiving station to the
transmitting station to indicate to the transmitting
station whether the transmitted signal power is to
35 be increased or decreased to maintain reception,
and means at each station for sensing the setting
of said non-message bit to adjust the power of the
transmitted signal.
The invention further provides a method, for
40 use in a radio system wherein two radio stations
are transmitting to each other, of controlling the
transmitted power of a radio signal such that a
minimum power level to ensure efficient reception
is maintained, comprising the steps of detecting at
45 each station the error level in the received
transmission from the other station and
periodically transmitting to the other station an
indication of whether the transmitted power
should be increased or decreased in dependence
50 on whether the error level detected immediately
prior to transmission of said indication was above
or below a predetermined threshold value
respectively.
An embodiment of the invention will now be
55 described, by way of example only, with reference
to the accompanying diagrammatic drawings in
which:
Figure 1 represents a radio system in
accordance with the present invention; and
60 Figure 2 represents a block of an error
correction code for use in the radio system of
Figure 1.
The radio system illustrated schematically in
Figure 1 comprises a pair of radio stations 10 and

65 20 which are capable of simultaneous
transmission to each other. The transmission path
from the transmitter of radio station 10 to the
receiver of radio station 20 is denoted by the line
12 and, similarly, the transmission path from the
70 transmitter of radio station 20 to the receiver at
radio station 10 is denoted by the line 14.
The radios 10, 20 may employ any appropriate
modulation technique for transmitting digital data
in a block format. The radios may employ a static
75 carrier frequency or use a spread spectrum
technique. The spread spectrum technique
described in our co-pending Patent Application
No. 82.   may advantageously be used
with the present power control technique.
80 Signals are transmitted between the radio
stations 10 and 20 in digital form using an error
correcting code, for example a (7,4,1) code. In
such an error correcting code the data is
transmitted in blocks which may be separated and
85 defined by appropriate synchronisation signals. A
typical block as used for transmission in the
present system is illustrated in Figure 2. This block
consists of eight data bit positions of which the
first seven are taken up with any conventional
90 (7,4,1) error correcting code. In such a code the
first four bit positions may be regarded as
message bits, whilst the following three bits
introduce sufficient redundancy to enable the
presence of up to one error in the transmitted
95 seven data bit block to be detected. Any suitable
technique can be used for converting a message
to be transmitted into a digital data stream which
is encoded with the selected (7,4,1) error
correcting code and transmitted as the first seven
100 bits of each block. At the receiving station the first
seven data bits of a received block are decoded by,
for example, comparing with the contents of a
stored lock-up table. During the decoding process
it is possible to determine whether there has been
105 one error in transmission of the code block.
Data bit position 8 is taken up by a power bit
which is set in dependence on the error level
detected in a sample of data received by the
transmitting station from the receiving station.
110 This power bit is a feed back signal which enables
the station to alter its transmitted power in
dependence on the error level in the transmission
as received by the other station. The value of the
power bit is determined by the error level in a
115 sample of received blocks taken over a time
interval of, say, one millisecond. The number of
blocks received in such a time interval will clearly
vary in dependance on the transmission rate.
Assuming that the transmission rate is such that
120 sixteen complete blocks are received in the
selected sampling time interval, then if the error
level in those sixteen blocks, as determined by the
decoding of the data transmitted using the (7,4,1)
error correcting code in the receiver, is above a
125 preset error threshold, the power bit to be
transmitted in the next sixteen blocks transmitted
by the receiving station will be set high. If the
detected error level is below the threshold the
power bits transmitted in those blocks will be set

low and, if the error level falls exactly on the error threshold, then the power bits of the next sixteen blocks can be set alternately high and low. It will be appreciated that the power bit in a transmitted
5 block relates not to the error level in the transmission in which it is contained but the transmission being received from the other radio station by the station transmitting the power bit.

Both radio stations 10 and 20 include a power
10 bit sensor 16. This power bit sensor detects whether the power bit at position 8 in each received block is a 0 or a 1. The power bit sensor is coupled to a power control device 18, the device 18 sets the transmitted output power from
15 the radio transmitter, if the received power bit is high then the power control device operates to increase the transmitted power level. The power control device 18 is preferably a continuously variable slope delta demodulator which operates
20 so as to continuously change the output power, the received power bit being utilised to govern the rate of change. Thus if the received power bit is 0, indicative of the error level in a sample received by the other radio station being below the threshold,
25 the power control device 18 operates either to increase the rate by which the output power is falling if the previously received power bit was also 0, or, if the previous power bit was 1 and so the output power was increasing, to cause the
30 output power to start to fall. It will be appreciated that the amounts by which the rate of change of output power may be varied in particular conditions can be selected in dependence on the characteristics of the fading which is to be
35 tracked.

If the two radio stations 10, 20 are, for example, 30 kilometers apart, the transmission time between them will be approximately 100 microseconds. Therefore there will be a time delay
40 of approximately 1 millisecond plus 200 microseconds between the time when the blocks making up a sample are transmitted from one radio station and the power bit which provides an indication of whether the error level in the
45 received sample is above or below the threshold value, is received in a block transmitted from the other radio station to the originating radio station.

Typically, fading of a transmitted signal may occur at a rate of the order of 50 times a second.
50 Therefore the duration of a signal fade will be approximately 20 milliseconds. With the above mentioned delay between the error sampling and the time the power bit is returned to the transmitter to enable satisfactory restoration of
55 the minimum power level, it is readily possible to track a fade which has a duration of 20 milliseconds with the present system. In a typical fade the rate of attenuation may rapidly increase particularly towards the point of maximum
60 attenuation of the fade. For this reason it is desirable to use the above mentioned continuously variable slope delta modulation.

The block format which has been illustrated in Figure 2 is not the only one suitable for use in the
65 present system. In particular, it is possible to

employ any type of error correcting code that enables the error level in a sample to be monitored. Moreover the particular order of the data bit positions illustrated is not essential. For
70 example the bit positions may be rotated in each successive block so that the bit position occupied by the power bit is moved by one place in each successive block. Alternatively the bit positions could be 'shuffled' in accordance with a
75 predetermined pseudorandom sequence between successive blocks.

It will be further be appreciated that, although a sixteen block sampling system has been described, any suitable sample size may be
80 employed, provided only that the returned power bit is representative of the received error level. Additionally it would also be possible to employ overlapping samples of blocks so as to prevent too large a number of identical power bits being
85 transmitted.

CLAIMS
1. A radio sytem for simultaneous digital communications between two radio stations using data blocks each of which includes a plurality of
90 message bits and at least one non-message bit, each radio station including means for monitoring the transmission received from the other radio station and setting the or one non-message bit to be transmitted by the receiving station to the
95 transmitting station to indicate to the transmitting station whether the transmitted signal power is to be increased or decreased to maintain reception, and means at each station for sensing the setting of said non-message bit to adjust the power of the
100 transmitted signal.

2. A system as claimed in Claim 1, wherein each data block comprises a plurality of bits which make up an error correcting code adapted to detect the presence of at least one error in said
105 received plurality of bits in each block, said monitoring means comprising means for utilising said code to determine the error level in a sample of the received blocks in relation to a predetermined threshold value and setting said
110 one non-message bit of a block to be transmitted from the receiving station to a value to indicate that the transmitted signal power is to be increased if the error level exceeds said predetermined threshold value.

115 3. A system as claimed in claim 2, wherein said error correcting code is a (7,4,1) code.

4. A system as claimed in any one of the preceding claims, wherein the sensing means employs a continuously variable slope delta
120 demodulator to determine the rate at which the transmitted power is to be adjusted in dependence on the setting of the received non-message bits.

5. A method for use in a radio system wherein two radio stations are transmitting to each other,
125 of controlling the transmitted power of a radio signal such that a minimum power level to ensure efficient reception is maintained, comprising the steps of detecting at each station the error level in

the received transmission from the other station
and periodically transmitting to the other station
an indication of whether the transmitted power
should be increased or decreased in dependence
5 on whether the error level detected immediately
prior to transmission of said indication was above
or below a predetermined value respectively.
  6. A method as claimed in Claim 5, wherein
digital signals are transmitted between the
10 stations using an error correcting code, each block
of said code being accompanied by a bit which is
set to provide said indication.
  7. A method as claimed in Claim 5 or 6,

wherein the rate and sense of the change in
15 transmitted power is determined by the received
indications.
  8. A radio system substantially as herein
described with reference to the accompanying
drawings.
20   9. A method for use in a radio system wherein
two radio stations are transmitting to each other,
of controlling the transmitted power of a radio
signal such that a minimum power level to ensure
efficient reception is maintained substantially as
25 herein described with reference to the
accompanying drawings.