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H04B 1/06

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(54) Abstract Title
Calibrating the gain of receiver units for a central terminal of a communications system using a reference signal

(57) The present invention provides a receiver unit for a central terminal of a wireless telecommunications system arranged to receive signals from a plurality of subscriber terminals. The receiver unit comprises a first processing circuit for processing a received signal, passed to the first processing circuit via an input signal path, to produce a processed signal, a reference signal generator 240 for generating a reference signal having a reference signal parameter that is substantially temperature independent over a predetermined temperature range, and an inserter 250 for inserting the reference signal on the input signal path used to pass the received signal to the first processing circuit. Further, the receiver unit comprises a detector 190 for detecting the reference signal parameter of the reference signal output from the first processing circuit, and a gain controller 200, responsive to the reference signal parameter detected by the detector, for adjusting the gain of the first processing circuit to cause the reference signal parameter detected at the detector to be a predetermined reference signal parameter.

By such an approach, the receiver unit can be automatically calibrated so that a signal received at the antenna of the central terminal at a specified power level will produce an output signal from the receiver unit at a desired voltage level. A filter 210 is provided for removing the reference signal.

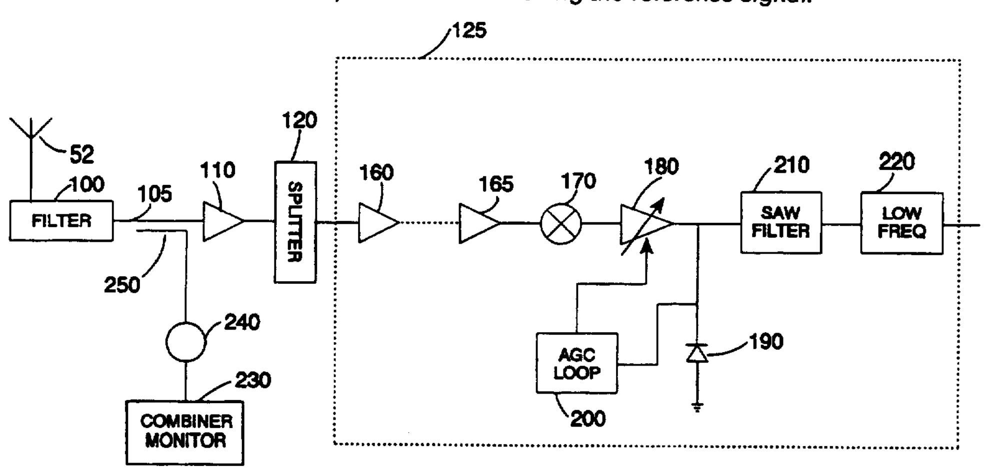

FIG. 6

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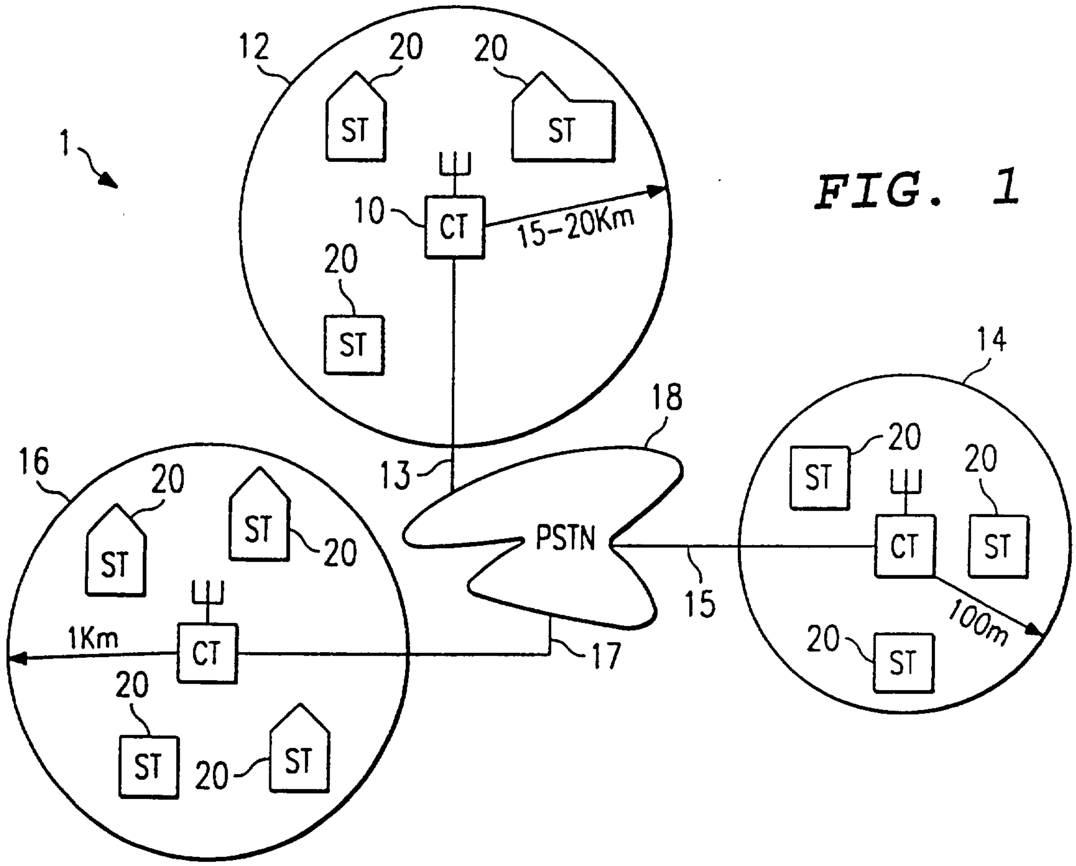
1
12
20
20
ST
ST
CT
10
15-20Km
20
ST
14
18
13
16
20
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ST
PSTN
ST
CT
ST
20
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17
100m
20
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ST
ST
20
ST
20
ST

FIG. 1

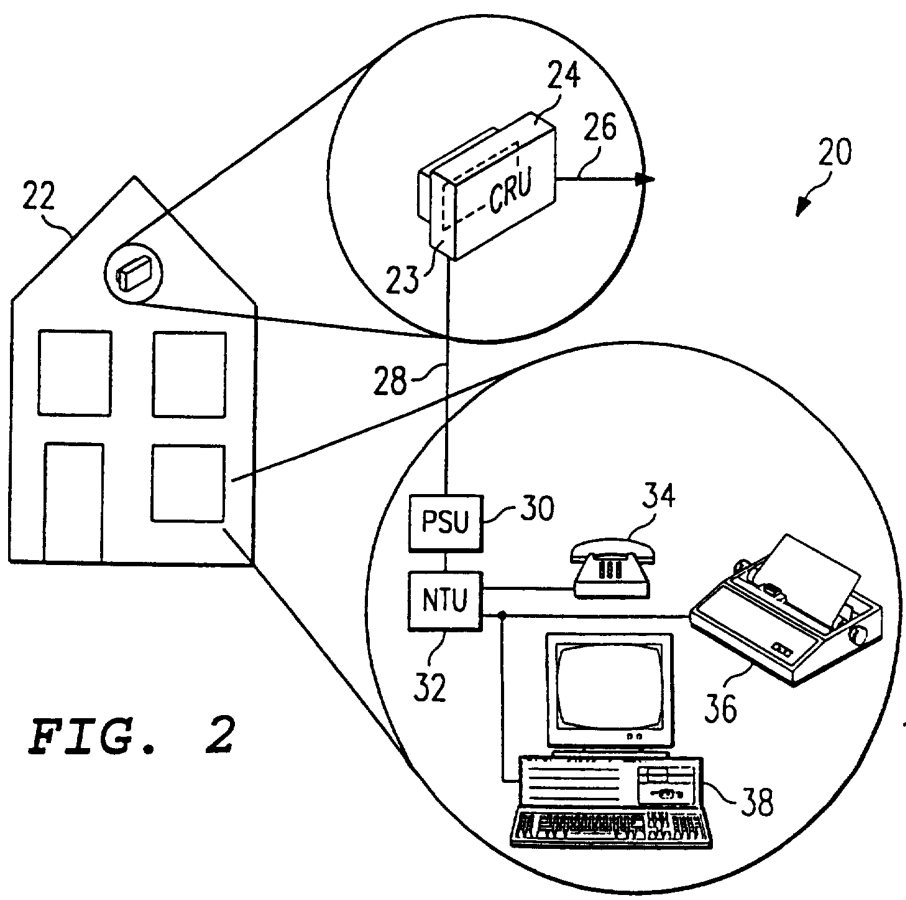

24
26
20
22
CRU
23
28
34
PSU
30
NTU
32
36
38

FIG. 2

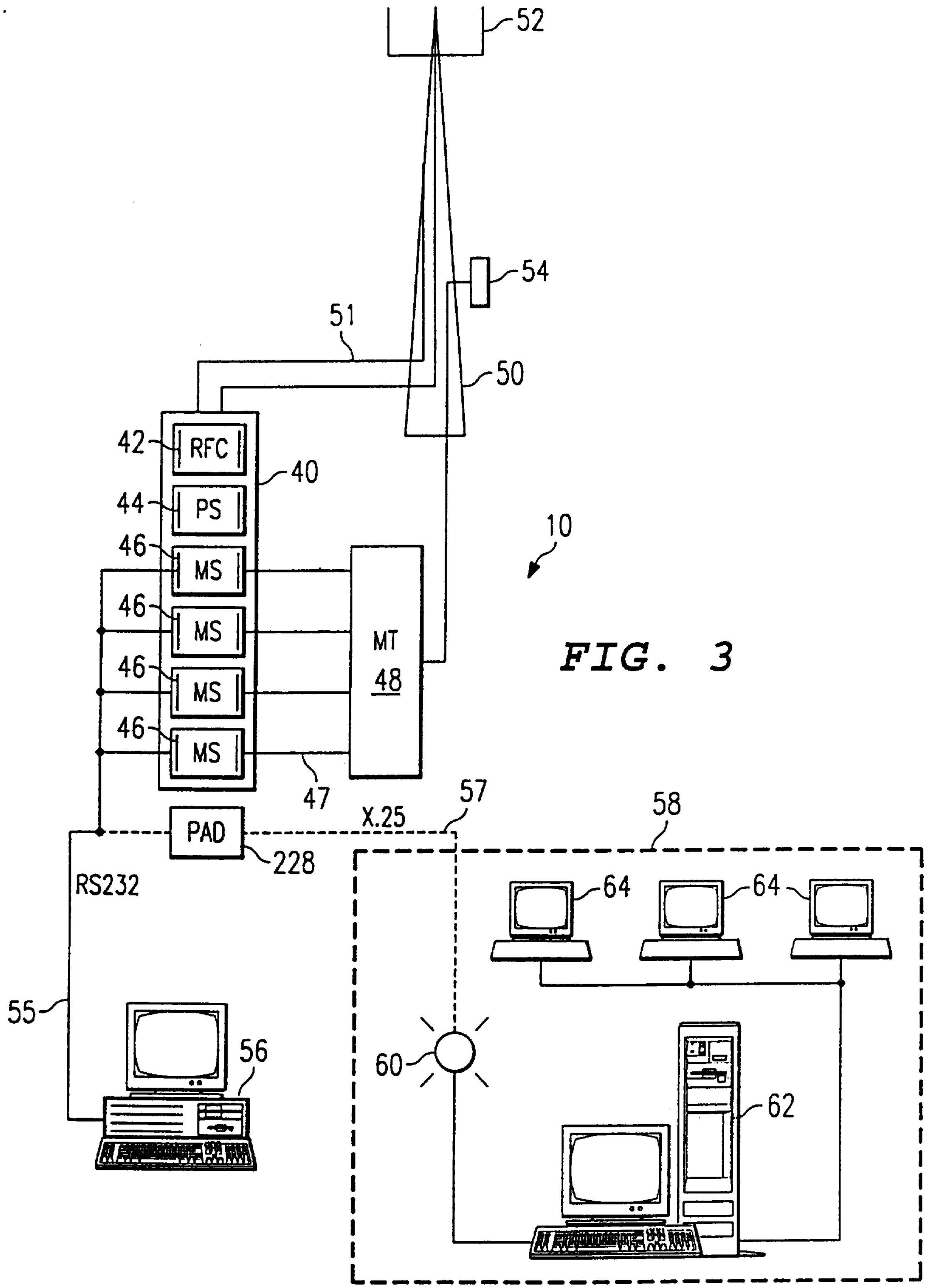

52
54
51
50
42
RFC
40
44
PS
46
MS
46
MS
46
MS
46
MS
MT
48
10
47
57
X.25
58
PAD
228
RS232
64
64
64
55
56
60
62

FIG. 3

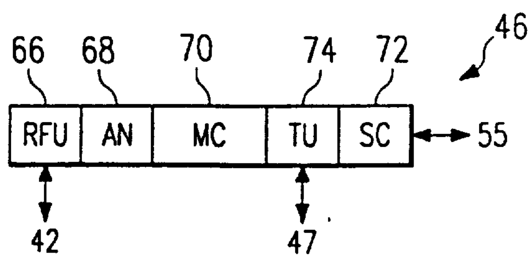
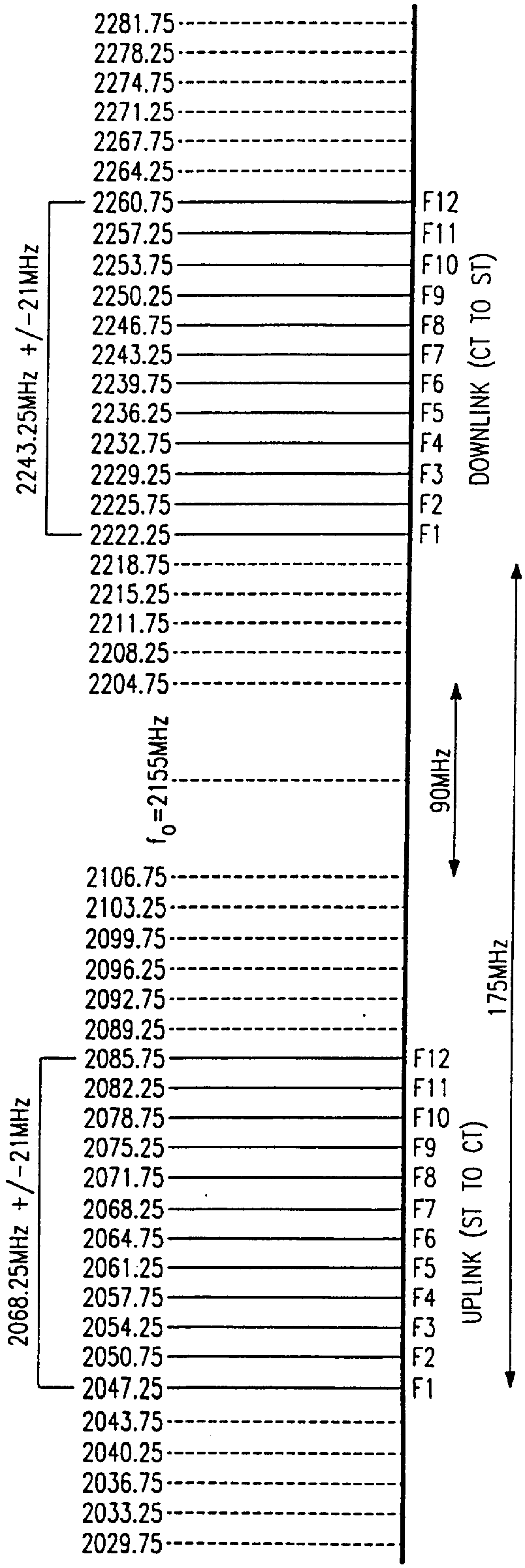

46
66
68
70
74
72
RFU
AN
MC
TU
SC
55
42
47

FIG. 3A



2281.75
2278.25
2274.75
2271.25
2267.75
2264.25
2260.75
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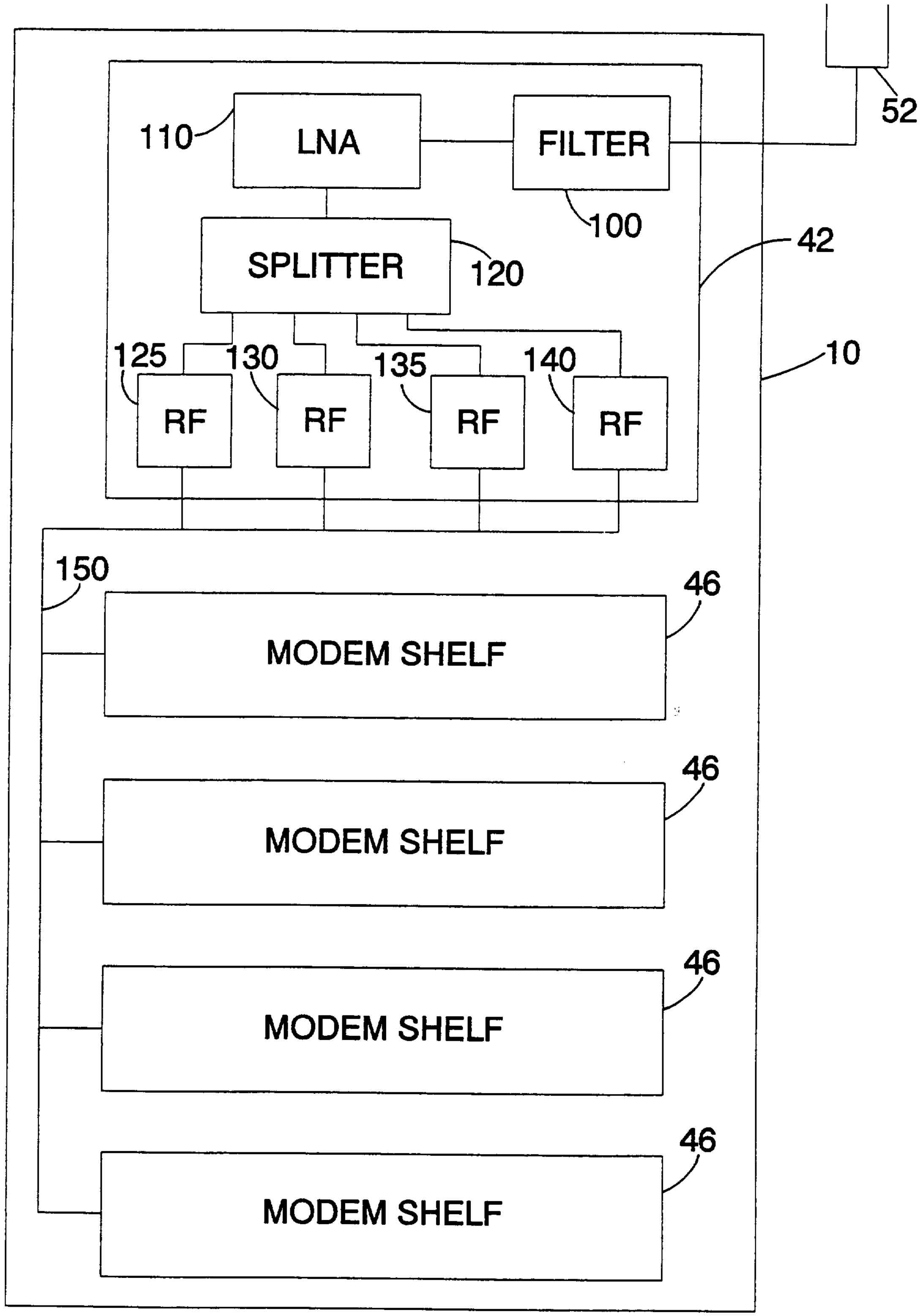
2253.75
2250.25
2246.75
2243.25
2239.75
2236.25
2232.75
2229.25
2225.75
2222.25
2218.75
2215.25
2211.75
2208.25
2204.75
2243.25MHz +/-21MHz
F12
F11
F10
F9
F8
F7
F6
F5
F4
F3
F2
F1
DOWNLINK (CT TO ST)
f_o=2155MHz
90MHz
175MHz
2106.75
2103.25
2099.75
2096.25
2092.75
2089.25
2085.75
2082.25
2078.75
2075.25
2071.75
2068.25
2064.75
2061.25
2057.75
2054.25
2050.75
2047.25
2043.75
2040.25
2036.75
2033.25
2029.75
2068.25MHz +/-21MHz
F12
F11
F10
F9
F8
F7
F6
F5
F4
F3
F2
F1
UPLINK (ST TO CT)

FIG. 4



52
110
LNA
FILTER
100
SPLITTER
120
42
125
130
135
140
10
RF
RF
RF
RF
150
46
MODEM SHELF
46
MODEM SHELF
46
MODEM SHELF
46
MODEM SHELF

FIG. 5

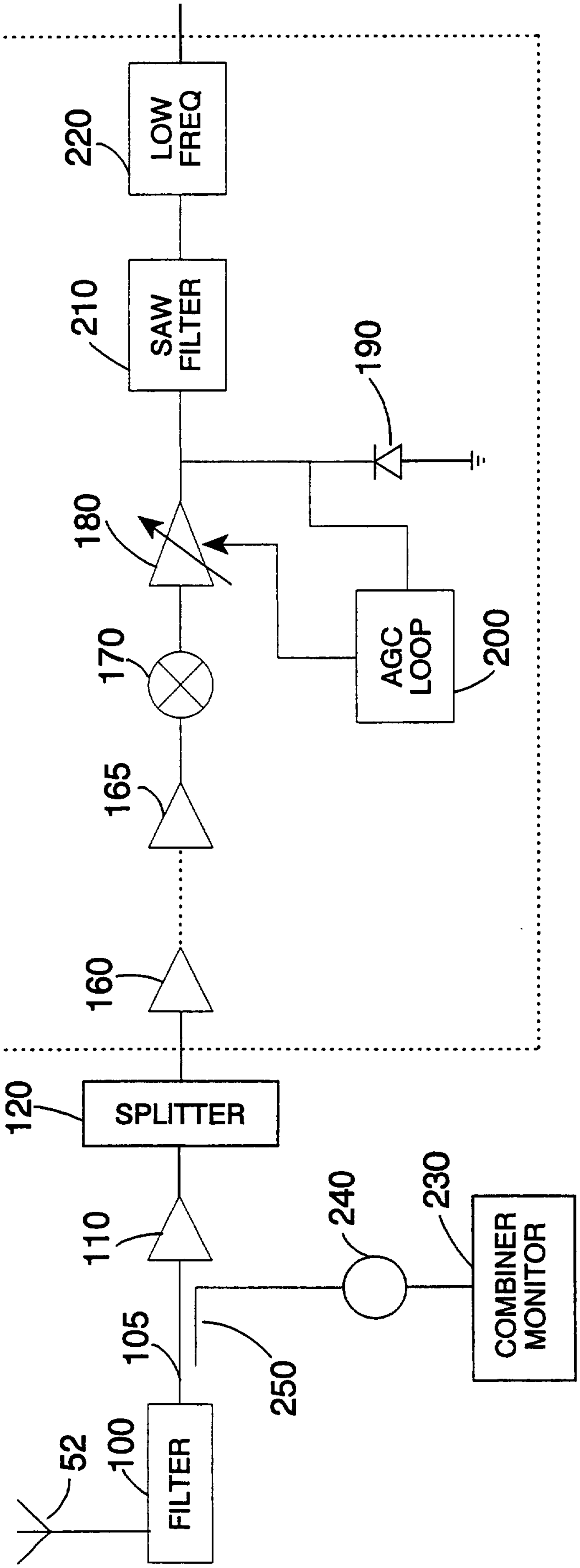

LOW FREQ
220
SAW FILTER
210
190
180
170
165
125
160
AGC LOOP
200
SPLITTER
120
110
240
230
COMBINER MONITOR
105
250
52
100
FILTER

FIG. 6

A RECEIVER UNIT FOR A CENTRAL TERMINAL OF A WIRELESS TELECOMMUNICATIONS SYSTEM

Field of the Invention

The present invention relates to a receiver unit for a central terminal of a wireless telecommunications system, the wireless telecommunications system including a plurality of subscriber terminals that are arranged to communicate with the central terminal via wireless links.

Background of the Invention

A wireless telecommunications system has been proposed in which a geographical area is divided into cells, each cell having one or more central terminals (CTs) for communicating over wireless links with a number of subscriber terminals (STs) in the cell. These wireless links are typically established over predetermined frequency channels, a frequency channel typically consisting of one frequency for uplink signals from a subscriber terminal to the central terminal, and another frequency for downlink signals from the central terminal to the subscriber terminal.

The system finds a wide variety of possible applications, for example in rural, remote, or sparsely populated areas where the cost of laying permanent wire or optical networks would be too expensive, in heavily built–up areas where conventional wired systems are at full capacity or the cost of laying such systems would involve too much interruption to the existing infrastructure or be too expensive, and so on.

The central terminal is typically connected to a telephone network and exists to relay messages from subscribers in the cell controlled by the central terminal to the telephone network, and vice versa. In a typical arrangement, a central terminal may have a plurality of modems for supporting a plurality of wireless links to subscriber terminals.

When a signal from a subscriber terminal is received at the antenna of the central terminal, the signal is processed by a receiver unit before being passed to the appropriate modem for further processing by the central terminal. During an acquisition mode of operation where a subscriber terminal is attempting to establish a wireless link with the central terminal, a signal is transmitted by the subscriber terminal to the central terminal, and the power of the signal transmitted by the subscriber terminal is increased until the signal output by the receiver unit of the central terminal for subsequent processing by the modem is at a predetermined voltage. This predetermined voltage will correspond to a particular power level of the signal when received at the antenna of the central terminal.

During subsequent communications, the output power level from the subscriber terminal will be such as to maintain a constant, specified power level of the signal as received at the antenna of the central terminal, and hence maintain a signal at said predetermined voltage at the output of the receiver unit. A suitable technique for controlling the output power of the subscriber terminal to ensure a constant power level is received at the antenna of the central terminal is described in GB–A–2,301,736, in which a power control signal is included in an overhead channel signal from the central terminal to the subscriber terminal, the power control signal being used by the subscriber terminal to determine what adjustments, if any, are needed to its transmitting power.

For each central terminal in the wireless telecommunications system, it is desirable that a signal of said specified power level at the antenna of the central terminal should result in the receiver unit producing an output signal at the same predetermined voltage, irrespective of the central terminal. This requirement means that the receiver unit needs to be calibrated when installed in the central terminal, to compensate for the tolerances of the components within the receiver unit.

It is often the case that the modems within the central terminal are grouped into a number of modem shelves, and that the receiver unit includes circuitry which is replicated for each modem shelf. This replicated circuitry may be contained on a circuit board, hereinafter referred to as an RF card, one RF card being installed for each modem shelf. Clearly, if a signal from an ST is received at the antenna of the central terminal at the specified power level, then the output signal from an RF card should be at the same predetermined voltage, irrespective of which RF card processed the received signal. To achieve this, it is necessary for each RF card to be calibrated when it is installed in the central terminal, since the properties of each RF card will vary slightly due to the tolerances of the components used on the RF card.

In current central terminals, the above calibration process is performed as follows. When the receiver unit is installed in the central terminal, a test subscriber terminal is connected via a RF cable to the antenna input of the receiver unit, and then the test ST is used to generate a signal which is of the specified power level when received an the antenna input. This will cause an output signal to be generated by the receiver unit, having a measurable voltage value at some predetermined point (such as the input to further processing circuitry in the central terminal). This voltage value is compared with the predetermined voltage value that the further processing circuitry should receive, and then automatic gain control circuitry within the receiver unit is used to alter the output signal from the receiver unit until the measured voltage is equal to that predetermined voltage.

If the receiver unit has a number of RF cards as discussed earlier, then this calibration process has to be performed for each RF card. Whilst this calibration is taking place, the central terminal has to be taken out of commission, since a test ST has to be hard wired to the antenna terminal of the receiver unit in order for the calibration process to be performed. Hence, if a new modem shelf is added to a central terminal to increase the capacity of the central terminal, and hence an additional RF card needs to be added, then that central terminal typically needs to be taken out of commission whilst the new RF card is calibrated.

It is an object of the present invention to improve the process used to calibrate the receiver unit, or specific RF cards within the receiver unit.

Summary of the Invention

Viewed from a first aspect, the present invention provides a receiver unit for a central terminal of a wireless telecommunications system arranged to receive signals from a plurality of subscriber terminals, the receiver unit comprising: a first processing circuit for processing a received signal, passed to the first processing circuit via an input signal path, to produce a processed signal; a reference signal generator for generating a reference signal having a reference signal parameter that is substantially temperature independent over a predetermined temperature range; an inserter for inserting the reference signal on the input signal path used to pass the received signal to the first processing circuit; a detector for detecting the reference signal parameter of the reference signal output from the first processing circuit; and a gain controller, responsive to the reference signal parameter detected by the detector, for adjusting the gain of the first processing circuit to cause the reference signal parameter detected at the detector to be a predetermined reference signal parameter.

By such an approach, the receiver unit can be automatically calibrated so that a signal received at the antenna of the central terminal at the specified power level will produce an output signal from the receiver unit at the predetermined voltage level required by further processing circuitry within the central terminal.

In accordance with the present invention, a reference signal is inserted by the receiver unit into the signal path of the signal received from the subscriber terminal prior to the signal being passed through a first processing circuit of the receiver unit. The reference signal has a reference signal parameter that is substantially temperature independent over a predetermined temperature range, the predetermined temperature range preferably being broad enough to encompass the anticipated range of operating temperatures of the central terminal. Hence, any change in the reference signal parameter as measured at the output of the first processing circuit can be attributed to the components within the first processing circuit. In preferred embodiments, the reference signal parameter is the voltage of the reference signal.

As mentioned earlier, it is required that, for a signal received at a specified power level at the antenna of the CT, the corresponding signal output by the receiver unit should have a predetermined voltage value. This requirement can be used to determine the value of the reference signal parameter that should be detected at the output of the first processing circuit if the components of the receiver unit are to convert a signal received at the antenna having the specified power level in to an output signal having the predetermined voltage value.

Hence, the actual reference signal parameter measured at the output of the first processing circuit can be compared with a predetermined reference signal parameter that is expected, and a gain controller can be used to alter the gain of the first processing circuit so as to cause the detected reference signal parameter to be equal to the predetermined reference signal parameter. When the reference signal parameter measured at the output of the first processing circuit equals the predetermined reference signal parameter, this means that an ST signal arriving at the antenna of the CT with the specified power level will be output by the first processing circuit with the predetermined voltage level required by further processing circuitry of the central terminal.

Hence, when subsequently the output power of the ST is ramped up during the acquisition mode until the output signal from the CT's receiver unit is at said predetermined voltage, it is then known that the power of the signal received at the antenna of the CT will be of the desired, specified value.

It is desirable for the power of the signal at the antenna of the central terminal to be a fixed, specified power level, irrespective of the subscriber terminal generating the signal, since this defines the path loss between the subscriber terminal and the central terminal, as will be discussed in more detail later.

In preferred embodiments, the receiver unit further comprises a filter to remove the reference signal from the processed signal output from the first processing circuit. The reference signal is only used for the purpose of calibrating the first processing circuit within the receiver unit, and is not required by any further circuitry in the central terminal.

In preferred embodiments, the signal output from the filter is of a lower frequency than the received signal processed by the first processing circuit, and the receiver unit further comprises a second processing circuit for performing additional processing on the lower frequency signal output by the filter. It has been found that most of the signal variations in the receiver unit occur when processing the high frequency received signal in the first processing circuit, and hence the variations exhibited by different receiver units, and by different RF cards within receiver units, is predominantly attributable to the first processing circuit. Thus, it is sufficient to perform calibration using the reference signal on the first, high frequency, processing circuit, but not to calibrate the later, lower frequency circuitry. However, it will be appreciated that, if desired, the first processing circuit can be defined as embodying not only the high frequency processing elements, but also any number of the low frequency processing elements of the receiver unit as well, and the detector would then be positioned appropriately to measure the reference signal parameter of the reference signal output from that first processing circuit.

The received signals from said plurality of subscriber terminals may be received on a number of frequency channels. Preferably, the reference signal generator is arranged to produce a reference signal on a further frequency channel different to any of said number of frequency channels. This avoids the reference signal from being combined with the received signal. Further, the reference signal injected on the input signal path by the inserter is preferably at a higher power level than the received signal. This ensures that the detector at the output of the first processing circuit is able to accurately measure the reference signal parameter, as the signal detected at this point is dominated by the reference signal.

In preferred embodiments, the reference signal parameter is a voltage value of the reference signal. Further, the reference signal generator is preferably a temperature controlled voltage controlled oscillator (TCVCO) for producing a reference signal with a voltage value that is substantially temperature independent over said predetermined temperature range.

The detector may be any appropriate detector for measuring the reference signal parameter at the output of the first processing circuit. In preferred embodiments, the detector comprises a detector diode reverse–biased across the output of the first processing circuit, this providing a cheap and reliable detector.

In preferred embodiments, the inserter comprises a coupler for inserting the reference signal on the input signal path. A coupler provides a suitable means for injecting the reference signal on to the input signal path carrying the received signal. Preferably, a coupler with a high coupling figure, for example 20dB, is chosen to avoid any appreciable losses to the received signal caused by the coupler.

Viewed from a second aspect, the present invention provides a central terminal comprising a receiver unit in accordance with the first aspect of the invention.

As mentioned earlier, the processed signal output by the receiver unit typically needs to have a predetermined voltage value at an input to further processing circuits in the central terminal, and the central terminal preferably comprises: a subscriber terminal controller, responsive to a determination that the processed signal has a voltage other than the predetermined voltage value at said input to said further processing circuits, for passing instructions to the subscriber terminal from which the signal has been received to cause the subscriber terminal to adjust its output power.

Preferably, the subscriber terminal controller is arranged to insert said instructions within a channel of a signal transmitted by the central terminal to the subscriber terminal, the instructions including information to enable the subscriber terminal to determine the output power that should be employed for signals transmitted by the subscriber terminal to the central terminal. Typically, the subscriber terminal controller is provided on each modem within the central terminal.

In preferred embodiments, the central terminal comprises a plurality of modem shelves for processing signals output by the receiver unit, the receiver unit comprising a plurality of RF cards, one for each modem shelf, at least one of said RF cards comprising said first processing circuit, said detector and said gain controller.

Viewed from a third aspect, the present invention provides a method of processing signals received by a central terminal of a wireless telecommunications system from a plurality of subscriber terminals, the method comprising the steps of: (a) employing a first processing circuit to process a received signal, passed to the first processing circuit via an input signal path, to produce a processed signal; (b) generating a reference signal having a reference signal parameter that is substantially temperature independent over a predetermined temperature range; (c) inserting the reference signal on the input signal path used to pass the received signal to the first processing circuit; (d) detecting the reference signal parameter of the reference signal output from the first processing circuit; and (e) responsive to the detected reference signal parameter, adjusting the gain of the first processing circuit to cause the reference signal parameter detected at said step (d) to be a predetermined reference signal parameter.

Brief Description of the Drawings

An embodiment of the invention will be described hereinafter, by way of example only, with reference to the accompanying drawings in which like reference signs are used for like features and in which:

Figure 1 is a schematic overview of an example of a wireless telecommunications system in which the present invention may be employed;

Figure 2 is a schematic illustration of an example of a subscriber terminal of the telecommunications system of Figure 1;

Figure 3 is a schematic illustration of an example of a central terminal of the telecommunications system of Figure 1;

Figure 3A is a schematic illustration of a modem shelf of a central terminal of the telecommunications system of Figure 1;

Figure 4 is an illustration of an example of a frequency plan for the telecommunications system of Figure 1;

Figure 5 is a schematic illustration of a central terminal of the wireless telecommunications system; and

Figure 6 is a diagram illustrating the processing performed by the RF combiner shelf of a central terminal in accordance with preferred embodiments of the present invention.

Description of Preferred Embodiment

For the purpose of describing a preferred embodiment of the present invention, a central terminal of a wireless telecommunications system will be described, in which a receiver unit in accordance with preferred embodiments of the invention is employed to handle signals received from subscriber terminals.

Figure 1 is a schematic overview of an example of a wireless telecommunications system. The telecommunications system includes one or more service areas 12, 14 and 16, each of which is served by a respective central terminal (CT) 10 which establishes a radio link with subscriber terminals (ST) 20 within the area concerned. The area which is covered by a central terminal 10 can vary. For example, in a rural area with a low density of subscribers, a service area 12 could cover an area with a radius of 15–20Km. A service area 14 in an urban environment where there is a high density of subscriber terminals 20 might only cover an area with a radius of the order of 100m. In a suburban area with an intermediate density of subscriber terminals, a service area 16 might cover an area with a radius of the order of 1Km. It will be appreciated that the area covered by a particular central terminal 10 can be chosen to suit the local requirements of expected or actual subscriber density, local geographic considerations, etc, and is not limited to the examples illustrated in Figure 1. Moreover, the coverage need not be, and typically will not be circular in extent due to antenna design considerations, geographical factors, buildings and so on, which will affect the distribution of transmitted signals.

The central terminals 10 for respective service areas 12, 14, 16 can be connected to each other by means of links 13, 15 and 17 which interface, for example, with a public switched telephone network (PSTN) 18. The links can include conventional telecommunications technology using copper wires, optical fibres, satellites, microwaves, etc.

The wireless telecommunications system of Figure 1 is based on providing fixed radio links between subscriber terminals 20 at fixed locations within a service area (e.g., 12, 14, 16) and the central terminal 10 for that service area. In one embodiment, each subscriber terminal 20 is provided with a permanent fixed access link to its central terminal 10. However, in alternative embodiments, demand–based access could be provided, so that the number of subscribers which can be serviced exceeds the number of available wireless links.

Figure 2 illustrates an example of a configuration for a subscriber terminal 20 for the telecommunications system of Figure 1. Figure 2 includes a schematic representation of customer premises 22. A customer radio unit (CRU) 24 is mounted on the customer's premises. The customer radio unit 24 includes a flat panel antenna or the like 23. The customer radio unit is mounted at a location on the customer's premises, or on a mast, etc., and in an orientation such that the flat panel antenna 23 within the customer radio unit 24 faces in the direction 26 of the central terminal 10 for the service area in which the customer radio unit 24 is located.

The customer radio unit 24 is connected via a drop line 28 to a power supply unit (PSU) 30 within the customer's premises. The power supply unit 30 is connected to the local power supply for providing power to the customer radio unit 24 and a network terminal unit (NTU) 32. The customer radio unit 24 is also connected via the power supply unit 30 to the network terminal unit 32, which in turn is connected to telecommunications equipment in the customer's premises, for example to one or more telephones 34, facsimile machines 36 and computers 38. The telecommunications equipment is represented as being within a single customer's premises. However, this need not be the case, as the subscriber terminal 20 preferably supports either a single or a dual line, so that two subscriber lines could be supported by a single subscriber terminal 20. The subscriber terminal 20 can also be arranged to support analogue and digital telecommunications, for example analogue communications at 16, 32 or 64kbits/sec or digital communications in accordance with the ISDN BRA standard.

Figure 3 is a schematic illustration of an example of a central terminal of the telecommunications system of Figure 1. The common equipment rack 40 comprises a number of equipment shelves 42, 44, 46, including a RF Combiner and power amp shelf (RFC) 42, a Power Supply shelf (PS) 44 and a number of (in this example four) Modem Shelves (MS) 46. The RF combiner shelf 42 allows the modem shelves 46 to operate in parallel. If 'n' modem shelves are provided, then the RF combiner shelf 42 combines and amplifies the power of 'n' transmit signals, each transmit signal being from a respective one of the 'n' modem shelves, and amplifies and splits received signals 'n' way so that separate signals may be passed to the respective modem shelves. The power supply shelf 44 provides a connection to the local power supply and fusing for the various components in the common equipment rack 40. A bidirectional connection extends between the RF combiner shelf 42 and the main central terminal antenna 52, such as an omnidirectional antenna, mounted on a central terminal mast 50.

This example of a central terminal 10 is connected via a point–to–point microwave link to a location where an interface to the public switched telephone network 18, shown schematically in Figure 1, is made. As mentioned above, other types of connections (e.g., copper wires or optical fibres) can be used to link the central terminal 10 to the public switched telephone network 18. In this example the modem shelves are connected via lines 47 to a microwave terminal (MT) 48. A microwave link 49 extends from the microwave terminal 48 to a point–to–point microwave antenna 54 mounted on the mast 50 for a host connection to the public switched telephone network 18.

A personal computer, workstation or the like can be provided as a site controller (SC) 56 for supporting the central terminal 10. The site controller 56 can be connected to each modem shelf of the central terminal 10 via, for example, RS232 connections 55. The site controller 56 can then provide support functions such as the localisation of faults, alarms and status and the configuring of the central terminal 10. A site controller 56 will typically support a single central terminal 10, although a plurality of site controllers 56 could be networked for supporting a plurality of central terminals 10.

As an alternative to the RS232 connections 55, which extend to a site controller 56, data connections such as an X.25 links 57 (shown with dashed lines in Figure 3) could instead be provided from a pad 228 to a switching node 60 of an element manager (EM) 58. An element manager 58 can support a number of distributed central terminals 10 connected by respective connections to the switching node 60. The element manager 58 enables a potentially large number (e.g., up to, or more than 1000) of central terminals 10 to be integrated into a management network. The element manager 58 is based around a powerful workstation 62 and can include a number of computer terminals 64 for network engineers and control personnel.

Figure 3A illustrates various parts of a modem shelf 46. A transmit/receive RF unit (RFU – for example implemented on a card in the modem shelf) 66 generates the modulated transmit RF signals at medium power levels and recovers and amplifies the baseband RF signals for the subscriber terminals. The RF unit 66 is connected to an analogue card (AN) 68 which performs A–D/D–A conversions, baseband filtering and the vector summation of 15 transmitted signals from the modem cards (MCs) 70. The analogue unit 68 is connected to a number of (typically 1–8) modem cards 70. The modem cards perform the baseband signal processing of the transmit and receive signals to/from the subscriber terminals 20. This may include 1/2 rate convolution coding and x 16 spreading with "Code Division Multiplexed Access" (CDMA) codes on the transmit signals, and synchronisation recovery, de–spreading and error correction on the receive signals. Each modem card 70 in the present example has two modems, and in preferred embodiments there are eight modem cards per shelf, and so sixteen modems per shelf. However, in order to incorporate redundancy so that a modem may be substituted in a subscriber link when a fault occurs, only 15 modems on a single modem shelf 46 are generally used. The 16th modem is then used as a spare which can be switched in if a failure of one of the other 15 modems occurs.

The modem cards 70 are connected to the tributary unit (TU) 74 which terminates the connection to the host public switched telephone network 18 (e.g., via one of the lines 47) and handles the signalling of telephony information to the subscriber terminals via one of 15 of the 16 modems. Further, each modem shelf 46 includes a shelf controller 72 that is used to manage the operation of the whole of the modem shelf and its daughter network sub-elements (NSEs). The shelf controller (SC) is provided with a RS232 serial port for connection to the site controller 56 or to the pad 228. The shelf controller communicates control and data information via a backplane asynchronous bus directly with the other elements of the modem shelf. Other network sub-elements are connected via the modem cards.

The wireless telecommunications between a central terminal 10 and the subscriber terminals 20 could operate on various frequencies. Figure 4 illustrates one possible example of the frequencies which could be used. In the present example, the wireless telecommunication system is intended to operate in the 1.5–2.5GHz Band. In particular the present example is intended to operate in the Band defined by ITU–R (CCIR) Recommendation F.701 (2025–2110MHz, 2200–2290MHz). Figure 4 illustrates the frequencies used for the uplink from the subscriber terminals 20 to the central terminal 10 and for the downlink from the central terminal 10 to the subscriber terminals 20. It will be noted that 12 uplink and 12 downlink radio channels of 3.5MHz each are provided centred about 2155MHz. The spacing between the receive and transmit channels exceeds the required minimum spacing of 70MHz.

In the present example, each modem shelf is arranged to support 1 frequency channel (i.e. one uplink frequency plus the corresponding downlink frequency), with techniques such as 'Code Division Multiplexed Access' (CDMA) being used to enable a plurality of wireless links to subscriber terminals to be simultaneously supported on each frequency channel.

Typically, the radio traffic from a particular central terminal 10 will extend into the area covered by a neighbouring central terminal 10. To avoid, or at least to reduce interference problems caused by adjoining areas, only a limited number of the available frequencies will be used by any given central terminal 10. This is discussed in more detail in GB–A–2,301,751, which also provides further details on CDMA encoding/decoding, and on the signal processing stages employed in the subscriber terminals and central terminal to manage communications between them.

Having described a wireless telecommunications system in which a receiver unit in accordance with preferred embodiments of the present invention may be employed, a receiver unit in accordance with a preferred embodiment of the present invention will now be discussed with reference to Figures 5 and 6. In preferred embodiments of the present invention, the receiver unit is provided by the RF combiner shelf of the central terminal. Figure 5 illustrates the main elements of the RF combiner shelf used for processing a signal received from a subscriber terminal.

When a signal from a subscriber terminal is received at the antenna 52 of the central terminal 10, that signal is first passed to a filter 100, which defines the band of operation by only allowing signals within a predetermined band of frequencies to be passed through the filter for further processing by the subscriber terminal. Then the signal is passed from the filter 100 to a low noise amplifier (LNA) 110, where the filtered signal is amplified. The output from the LNA is then passed to a splitter 120, which splits the signal "n" ways so that the signal may be passed to each of "n" RF cards provided on the RF combiner shelf 42. In the example illustrated in Figure 5, there are four RF cards 125, 130, 135, 140, one for each of the modem shelves 46 provided within the central terminal 10.

In a fixed assignment system, one RF card will always be assigned to one of the modem shelves, and that RF card will be responsible for processing all signals received by the antenna 52 and destined for a modem on that particular modem shelf 46. However, in a Demand Assignment system, more than one of the modem shelves may be used to handle the signals from a particular subscriber terminal, and hence there would typically not be a fixed relationship between a particular RF card and a particular modem shelf. Rather, a signal routed through any of the RF cards 125, 130, 135, 140 could be passed to any of the modem shelves 46.

A backplane 150 is provided for routing signals from the RF cards 125, 130, 135, 140 to the modem shelves 46. In a fixed assignment system, four separate backplanes are typically provided, one for each RF card to modem shelf connection. In a Demand Assignment system, the backplanes 150 will be arranged to preferably enable any of the RF cards to communicate with any of the modem shelves.

As mentioned previously, the modems on the modem shelf 46 require the signal passed to them by an RF card, this signal being referred to hereinafter as the I/Q signal, to have a predetermined voltage value. Any I/Q signal reaching any modem on any of the modem shelves 46 should always have the same predetermined voltage value, irrespective of which RF card 125, 130, 135, 140 has processed the signal prior to its receipt by the modem, and irrespective of which subscriber terminal has transmitted the original signal received by the central terminal 10.

Hence, when an I/Q signal is received by a modem, a signal level estimator is used to check the voltage level of the I/Q signal, a signal level estimator being provided on each modem. Whenever an uplink communication path is established, or is in the process of being established, between the subscriber terminal and the central terminal 10, a corresponding downlink communication path from the central terminal 10 to that subscriber terminal will exist, and an overhead channel is provided on that downlink communication path for carrying control information used to establish and maintain the downlink and uplink communication paths. Within the overhead channel, a power control signal can be transmitted by the central terminal to instruct the subscriber terminal concerning the transmitting power that should be produced by that subscriber terminal's transmitter.

Hence, if the signal level estimator within a modem determines that the I/Q signal has a voltage which is not equal to the predetermined voltage value required by that modem, then a decision circuit within the modem is employed to generate an appropriate power control signal to be transmitted by the central terminal to cause the subscriber terminal to increase or decrease its transmitting power accordingly.

When a subscriber terminal is seeking to establish an uplink communication path with the central terminal 10, the transmitting power of the subscriber terminal's transmitter is initially set to a minimum value on command from the central terminal via the power control signal of the overhead channel. The power control signal is then subsequently used to incrementally adjust the transmitting power of the subscriber terminal's transmitter, until the I/Q signal produced by the RF cards has the predetermined voltage value. At this point, the uplink communication path is deemed to have been acquired, and subsequently the power control signal is used merely to maintain a constant I/Q signal voltage.

As mentioned earlier, it is desirable for the power of the signal received at the antenna 52 of the central terminal to be a fixed, specified power level, for any uplink communication path that has been established, irrespective of the subscriber terminal generating the signal. In preferred embodiments, this specified power level is chosen to be −95dBm. By setting a specified power level for signals received at the antenna, a maximum path loss, often referred to as a path budget, can be defined for the signal transmitted between the subscriber terminal and the central terminal. As an example, if the maximum transmitting power of the subscriber terminal is '21dBm', and both the subscriber terminal and the central terminal have an antenna gain of '10dB', then the total path budget will be 136dB (21 + 95 + 10 + 10). If a subscriber terminal is not able to transmit a signal that is received at the antenna of the central terminal with the specified power level (e.g. −95dBm), even when the subscriber terminal is transmitting at its maximum transmitting power, then the subscriber terminal will be deemed to be out of range of the central terminal.

Given that every signal from a subscriber terminal should have the specified power level of '−95dBm' when received at the antenna 52 of the central terminal 10, and that the I/Q signal passed from the RF combiner shelf 42 to the modem shelf 46 should have a predetermined voltage value, then it is clear that any received signal processed by the RF combiner shelf 42 should be subject to the same losses within the RF combiner shelf, irrespective of how the signal is routed through the RF combiner shelf 42, and, in particular, irrespective of which RF card 125, 130, 135, 140 is used to process that received signal.

As discussed earlier, in the past this has required each RF card to be calibrated when it is installed within the central terminal. Since this calibration process required a test subscriber terminal to be connected to the antenna input of the central terminal, then the central terminal has previously had to be taken out of commission whilst the calibration process is performed.

However, in accordance with preferred embodiments of the present invention, a technique is provided for automatically calibrating the RF cards 125, 130, 135, 140 without the need for the central terminal to be taken out of commission. The elements of the RF combiner shelf 42 required to perform this automatic calibration in accordance with preferred embodiments of the present invention are illustrated in Figure 6.

Since the I/Q signal output by the RF combiner shelf needs to be of a fixed, predetermined voltage level, any gain level variations in the receive chain will affect the gain control level to which the central terminal RF card should be set in order to convert a received signal at the antenna at a power level of –95dBm to an I/Q signal having the predetermined voltage level. It has been found that most of this gain level variation results from the high frequency front end components within the RF card, particularly amplifiers. At high frequencies, due to the lower device gain, the amount of amplifier feedback that can be applied is dramatically reduced, and in the absence of significant feedback, the full extent of device-device variation is exposed. Hence, in preferred embodiments, a technique is used to calibrate the high frequency components of each RF card, these high frequency components being referred to hereinafter collectively as the first processing circuit of the RF card.

With reference to Figure 6, as discussed earlier, when a signal is received at the antenna 52 of the central terminal, it is initially passed via the filter 100 (typically part of a diplexer), a low noise amplifier 110 and a splitter 120, before being passed to the RF cards. In preferred embodiments, the signal will at this point have a frequency of the order of 2GHz. For the sake of clarity, only one RF card 125 is shown in Figure 6, but identical elements would also be provided on the other RF cards 130, 135, 140 in preferred embodiments of the present invention. Once the signal from the splitter 120 is passed to the RF card 125, it is processed by a first processing circuit consisting of a number of amplifiers 160, 165, a mixer 170 and a variable amplifier 180. Typically a local oscillator signal is also input to the mixer 170, and the signal output from the mixer will have a frequency of the order of 70 MHz. As mentioned earlier, any gain level variations in the elements of the first processing circuit would result in variations in the voltage of the I/Q signal ultimately generated by the RF card 125.

Once the signal has been output from the first processing circuit, it is passed through a saw filter 210, in preferred embodiments the saw filter having a 3.5MHz bandwidth. Hence, a signal having a lower frequency is output from the saw filter 210 for processing by low frequency circuitry 220. This low frequency circuitry may include an I/Q demodulator, baseband filter, etc. The output of the low frequency circuitry 220 will be an I/Q signal that will be passed to the appropriate modem shelf for further processing.

In accordance with preferred embodiments of the present invention a reference signal is generated by a reference signal generator 240, in preferred embodiments, the reference signal generator being a temperature controlled voltage controlled oscillator (TCVCO). A combiner monitor 230 on the RF combiner shelf 42 is used to select the frequency of the reference signal to be generated by the TCVCO 240. In preferred embodiments, the combiner monitor is arranged to select a frequency that is different to any of the frequencies used for signals received from subscriber terminals.

The reference signal generated by the TCVCO is passed to a coupler 250, which inserts the reference signal onto the input signal path 105. Preferably, the coupler has a high coupling figure, for example 20dB, thereby avoiding any appreciable losses to the received signal passing from the filter 100 to the LNA 110 via the input signal path 105. From here, the received signal and the reference signal both pass through the splitter 120 and the first processing circuit 160, 165, 170, 180 of the RF card 125. At the output of the first processing circuit, the voltage of the reference signal is determined by the reverse–biased detector diode 190. The reference signal generated by the TCVCO 240 is preferably at a higher power level than the received signal, for example the reference signal may have a power level in the region of −60 to −80dBm. Given that the reference signal is at a significantly higher power level than the received signal, the detector diode 190 will accurately measure the voltage of the reference signal at the output of the first processing circuit, the voltage of the received signal being insignificant in comparison with the voltage of the reference signal.

As mentioned earlier, the reference signal has a voltage that is substantially temperature independent over a predetermined temperature range, the predetermined temperature range preferably being broad enough to encompass the anticipated range of operating temperatures of the central terminal. Hence, any change in the voltage of the reference signal as measured by the detector diode can be attributed to the components within the first processing circuit. Further, the requirements that the signal received at –95dBm at the antenna 52 should be converted into an I/Q signal of a predetermined voltage value can be used to determine the value of the reference signal voltage that should be detected at the output of the first processing circuit if the components of the RF combiner shelf are to convert a signal received at the antenna at –95dBm into an I/Q signal having the predetermined voltage value.

Thus, the voltage of the reference signal detected by the detector diode 190 can be compared with a predetermined reference signal voltage, and a simple OP–AMP loop 200 can then be used to adjust the AGC voltage until the voltage of the reference signal detected by the detector diode 190 is equal to the predetermined reference signal voltage.

By this approach, gain variations in the RF and IF sections prior to the saw filter 210 are automatically compensated for, without the need for the central terminal to be taken out of commission. Although gain sections between the saw filter 210 and the I/Q outputs of the RF combiner shelf 42 will not be compensated for, the variations of these lower frequency sections is much smaller.

By using a reference signal inserted into the path of the received signal to automatically calibrate the high frequency components of the RF card, it is possible to calibrate the RF combiner shelf 42 of a central terminal whilst the central terminal is operational. Further, a new CT modem shelf can be added, along with a corresponding RF card, without taking the central terminal out of commission, and without the requirement for an external test subscriber terminal. The system can be expanded to add further RF channels without disrupting traffic.

No calibration work needs to be performed by an engineer when installing a central terminal, or any additional RF cards within the central terminal, since the RF cards are automatically calibrated by monitoring the reference signal voltage, and furthermore will remain correctly calibrated during subsequent use of the central terminal, since the AGC loop 200 will always ensure that the gain levels of the first processing circuit are such as to cause a received signal at –95dBm to be converted into an I/Q signal having the predetermined voltage value, in preferred embodiments, the predetermined voltage being in the region of 100mV.

By employing the technique of the preferred embodiment, component, temperature, and aging variations are all automatically compensated for during the life of the RF cards of the central terminal.

Although a particular embodiment has been described herein, it will be appreciated that the invention is not limited thereto and that many modifications and additions thereto may be made within the scope of the invention.

CLAIMS

1. A receiver unit for a central terminal of a wireless telecommunications system arranged to receive signals from a plurality of subscriber terminals, the receiver unit comprising:

a first processing circuit for processing a received signal, passed to the first processing circuit via an input signal path, to produce a processed signal;

a reference signal generator for generating a reference signal having a reference signal parameter that is substantially temperature independent over a predetermined temperature range;

an inserter for inserting the reference signal on the input signal path used to pass the received signal to the first processing circuit;

a detector for detecting the reference signal parameter of the reference signal output from the first processing circuit; and

a gain controller, responsive to the reference signal parameter detected by the detector, for adjusting the gain of the first processing circuit to cause the reference signal parameter detected at the detector to be a predetermined reference signal parameter.

2. A receiver unit as claimed in Claim 1, further comprising a filter to remove the reference signal from the processed signal output from the first processing circuit.

3. A receiver unit as claimed in Claim 2, wherein the signal output from the filter is of a lower frequency than the received signal processed by the first processing circuit, and the receiver unit further comprises a second processing circuit for performing additional processing on the lower frequency signal output by the filter.

4. A receiver unit as claimed in any of claims 1 to 3, wherein the received signals from said plurality of subscriber terminals may be received on a number of frequency channels, and the reference signal generator is arranged to produce a reference signal on a further frequency channel different to any of said number of frequency channels.

5. A receiver unit as claimed in Claim 4, wherein the reference signal injected on the input signal path by the inserter is at a higher power level than the received signal.

6. A receiver unit as claimed in any preceding claim, wherein the reference signal parameter is a voltage value of the reference signal.

7. A receiver unit as claimed in any preceding claim, wherein the reference signal generator is a temperature controlled voltage controlled oscillator (TCVCO) for producing a reference signal with a voltage value that is substantially temperature independent over said predetermined temperature range.

8. A receiver unit as claimed in any preceding claim, wherein the detector comprises a detector diode reverse–biased across the output of the first processing circuit.

9. A receiver unit as claimed in any preceding claim, wherein the inserter comprises a coupler for inserting the reference signal on the input signal path.

10. A central terminal comprising a receiver unit as claimed in any preceding claim.

11. A central terminal as claimed in Claim 10, wherein the processed signal output by the receiver unit needs to have a predetermined voltage value at an input to further processing circuits in the central terminal, the central terminal comprising:

a subscriber terminal controller, responsive to a determination that the processed signal has a voltage other than the predetermined voltage value at said input to said further processing circuits, for passing instructions to the subscriber terminal from which the signal has been received to cause the subscriber terminal to adjust its output power.

12. A central terminal as claimed in Claim 11, wherein the subscriber terminal controller is arranged to insert said instructions within a channel of a signal transmitted by the central terminal to the subscriber terminal, the instructions including information to enable the subscriber terminal to determine the output power that should be employed for signals transmitted by the subscriber terminal to the central terminal.

13. A central terminal as claimed in Claim 11 or Claim 12, wherein the subscriber terminal controller is provided in each modem within the central terminal.

14. A central terminal as claimed in any of claims 10 to 13, comprising a plurality of modem shelves for processing signals output by the receiver unit, the receiver unit comprising a plurality of RF cards, one for each modem shelf, at least one of said RF cards comprising said first processing circuit, said detector and said gain controller.

15. A method of processing signals received by a central terminal of a wireless telecommunications system from a plurality of subscriber terminals, the method comprising the steps of:

(a) employing a first processing circuit to process a received signal, passed to the first processing circuit via an input signal path, to produce a processed signal;

(b) generating a reference signal having a reference signal parameter that is substantially temperature independent over a predetermined temperature range;

(c) inserting the reference signal on the input signal path used to pass the received signal to the first processing circuit;

(d) detecting the reference signal parameter of the reference signal output from the first processing circuit; and

(e) responsive to the detected reference signal parameter, adjusting the gain of the first processing circuit to cause the reference signal parameter detected at said step (d) to be a predetermined reference signal parameter.

16. A receiver unit, substantially as hereinbefore described with reference to the accompanying drawings.

17. A central terminal, substantially as hereinbefore described with reference to the accompanying drawings.

18. A method of processing signals received by a central terminal of a wireless telecommunications system, substantially as hereinbefore described with reference to the accompanying drawings.

The Patent Office

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Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): G1U UR3500 H3G GSE,GCX H3Q QAX H4D DMXX H4L LECX

Int Cl (Ed.6): G01R 35/00 G01S 7/40 H03G 1/00 H04B 1/06,1/16 H04Q 7/30

Other: ONLINE:WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	US4994810	(ALLIED) whole doc.	1,6-15 at least
X	US4633173	(ANRITSU) whole doc.	"
X	US4538150	(WESTINGHOUSE) whole doc.	"
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