



INTEGRATED DIRECTIONAL ANTENNA

The present invention relates to an integrated directional antenna.

It has been proposed to provide a radio telephone system where a plurality of
5 fixed location subscriber terminals communicate with a fixed central terminal to
provide radio telephone lines. In order that such a system is viable and attractive to
potential customers, it is necessary that the radio equipment at the customer premises
is inexpensive to purchase and operate, reliable and visually attractive.

In accordance with a first aspect of the present invention, therefore, there is
10 provided an integrated directional antenna comprising a radome, means defining a
resonant cavity within the radome, and a microstrip radiator and a patch re-radiator
positioned within the resonant cavity to provide a directed or focused beam.

According to another aspect of the invention there is provided, an integrated
directional antenna comprising a radome and reflective rear and side walls defining
15 a cavity, a microstrip radiator, arranged substantially parallel to said rear wall, and
a patch re-radiator positioned within said cavity.

The use of an integrated antenna means that the antenna can be compact and
visually attractive. It also means that components can be sealed in the antenna for
increased reliability. Moreover, the use of a microstrip/patch radiator/re-radiator
20 construction in combination with a resonant cavity results in a highly directional
antenna for transmission and/or reception reducing losses due to beam spreading.

The resonant cavity can be used to adjust the 'Q' factor of the antenna,
focusing the beam energy within desired operating frequencies. As a result, the
signal strength on transmission can be kept low and the gain on reception can be kept
25 high. It will be appreciated that the terms 'radiator' and 're-radiator' to describe the
microstrip and patch combination, is intended to apply equally for transmission and
reception.

The means for defining the resonant cavity can comprise a reflective rear wall
substantially parallel to the microstrip and side walls around the microstrip.

30 Preferably, the radome is provided with means for locating the patch a
predetermined distance in front of a ground plane of the microstrip. This enables the
antenna to be tuned.



In a preferred embodiment of the invention, the radiator is a compound radiator comprising a single microstrip having a ground plane on a first side thereof with first and second coupling slots in the ground plane, the coupling slots being spaced from each other, and two re-radiator (reflector) patches, each located in front
5 of a respective coupling slot. This enables increased performance to be achieved with small overall dimensions. The microstrip can be constructed with, on the side opposite to the ground plane, a long line RF feeder leading to an RF feeder strip for the two coupling slots.

Preferably, also, a first radiator for signal transmission and a second radiator
10 for signal reception is provided. This enables simultaneous transmission and reception using respective radiators. As the transmission and reception frequencies will typically differ, the long line RF feeder on at least one microstrip can be provided with a tuning stub, for fine tuning.

Preferably, the antenna comprises a chassis member locatable within
15 the radome, the chassis member having a rear wall with a rim projecting forwards from the wall to define a dished cavity. The chassis member can be made of plastics material with a metallised layer within the dished cavity for forming the resonant cavity.

Preferably, the radome and/or the chassis member are provided with
20 formations permitting the selective location of alternative microstrip/patch combinations for accommodating different frequencies. More particularly, the radome and the chassis member are provided with cooperating features for locating the microstrip at a predetermined distance in front of the rear wall.

Where separate transmitting and receiving radiators are provided, the chassis
25 member and/or the radome preferably include a central wall for providing separate transmitter and receiver cavities.

Preferably, also, the chassis member has a further rim projecting rearwardly from the rear wall to define a rear cavity.

A metallised layer can also be provided within the rear cavity for
30 electromagnetically shielding electronic components within the rear cavity.

A rear cover is preferably provided for closing the rear cavity.

In a preferred configuration, the fixing of the rear cover sandwiches the



component parts of the antenna in a fixed spatial relationship within the radome. This reduces manufacturing costs by avoiding or reducing the need separately to secure components within the antenna.

5 The rear cover can typically be made at least partially of plastics material with a metallised layer thereon. Alternatively, the rear cover can be made at least partially of cast metal.

The rear cover can also incorporate an integral heat sink for dissipating heat from electronic components within the rear cavity.

10 Preferably, means can be provided for thermally coupling the electronic components within the antenna to the heat sink. Thermally conducting foam can be used for this process. However, such foam is expensive. More preferably, therefore, pedestals can be provided for thermally coupling the electronic components to the heatsink.

15 The antenna can be provided with an antenna mounting bracket, preferably integral to the rear cover.

Preferably, the antenna mounting bracket comprises first and second spaced mounting points, the mounting bracket being arranged to cooperate with a further mounting bracket for connection to a fixed support, the further mounting bracket being arranged to support the antenna mounting bracket at a selected one of the first and second mounting points for selecting a pivot point for rotating the antenna at a selected side of the antenna, thereby to provide a high angular range of mounting positions of the antenna to the fixed support.

20 In accordance with another aspect of the invention, there is provided an integrated directional antenna comprising a radome, a chassis member located within the radome and a rear cover, the chassis member defining a front cavity containing radio transmission and/or receiving elements and a rear cavity contain electronic circuitry, the rear cavity being electromagnetically shielded from the first cavity and from the outside of the integrated antenna by a metallic layer on or forming the chassis member and on or forming the rear cover.

30 In accordance with a further aspect of the invention, there is provided an integrated directional antenna comprising a radome, a chassis member located within the radome and separating a front cavity containing radio transmission and/or

receiving elements from a rear cavity contain electronic circuit elements, and a rear cover, wherein the chassis member, the radio transmission and/or receiving elements and the electronic circuit elements are sandwiched together in a desired configuration by fixing the rear cover to the radome.

5 As mentioned above, the invention finds particular application to an integrated customer radio unit for a radio telephony system.

Preferably the antenna comprises a rear cavity containing RF circuitry and modem circuitry for the transmission and/or reception of telephony signals. By integrating this circuitry within the antenna, the additional circuitry within the
10 subscriber's premises can be kept to a minimum.

A compact construction and high performance of the radio circuitry can be enhanced where each the microstrip comprises a stud which extends between the resonant cavity and the rear cavity for direct coupling of the radiator to the RF circuitry.

15 Embodiments 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 an example of the present invention is included;

20 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;

25 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;

Figures 5A and 5B are schematic diagrams illustrating possible configurations for cells for the telecommunications system of Figure 1;

30 Figure 6 is a schematic diagram illustrating aspects of a code division multiplex system for the telecommunications system of Figure 1;

Figure 7 is a schematic diagram illustrating signal transmission processing

stages for the telecommunications system of Figure 1;

Figure 8 is a schematic diagram illustrating signal reception processing stages for the telecommunications system of Figure 1;

Figure 9 is a front view of an integrated antenna for forming a customer radio
5 unit for the subscriber terminal of Figure 2;

Figure 10 is a plan view of a first example of an integrated antenna from the direction A shown in Figure 9;

Figure 11 is an exploded section of the integrated antenna of Figure 10, taken
10 along line B-B adjacent the horizontal axis of the antenna and viewed in the direction A shown in Figure 9.

Figure 12 is a section through the vertical axis of the integrated antenna along the line C-C and in the direction D shown in Figures 9 and 10;

Figure 13 is a plan view, partially in section of a second embodiment of an integrated antenna;

15 Figure 14 is a rear view of the antenna of Figure 13;

Figure 15 is an exploded side view in the direction E of the antenna of Figure 13;

Figure 16 is a schematic representation of the inside of a radome for an integrated antenna according to Figures 9 to 15; and

20 Figure 17 is a schematic representation of the two sides of a microstrip.

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
25 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
30 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.

5 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.

10 The wireless telecommunications system of Figure 1 is based on providing fixed microwave 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 a preferred embodiment each subscriber terminal 20 is provided with a permanent fixed access link to its central terminal 10. However, in alternative embodiments
15 demand-based access could be provided, so that the number of subscribers which can be serviced exceeds the number of telecommunications links which can currently be active.

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
20 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
25 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
30 connected to 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
5 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
10 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 four modem shelves 46 to operate in parallel. It combines and amplifies the power of four transmit signals, each from a respective one of the four modem shelves, and amplifies and
15 splits received signals four 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, typically an omnidirectional antenna, mounted
20 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
25 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.

30 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 includes 1/2 rate convolution coding and x 16 spreading with 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, each modem supporting one subscriber link (or two lines) to a subscriber terminal 20. Thus, with two modems per card and 8 modems per modem shelf, each modem shelf could support 16 possible subscriber links. However, in order to incorporate redundancy so that a modem may be substituted in a subscriber link when a fault occurs, only up to 15 subscriber links are preferably supported by a single modem shelf 46. 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, for example, up to 15 subscriber terminals (each via a respective one of 15 of the 16 modems).

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, as mentioned above, each modem shelf will support 1 frequency channel (i.e. one uplink frequency plus the corresponding downlink frequency). Up to 15 subscriber links may be supported on one frequency channel, as will be explained later. Thus, in the present embodiment, each central terminal 10 can support 60 links, or 120 lines.

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.

Figure 5A illustrates one cellular type arrangement of the frequencies to mitigate interference problems between adjacent central terminals 10. In the arrangement illustrated in Figure 5A, the hatch lines for the cells 76 illustrate a frequency set (FS) for the cells. By selecting three frequency sets (e.g., where: FS1 = F1, F4, F7, F10; FS2 = F2, F5, F8, F11; FS3 = F3, F6, F9, F12), and

arranging that immediately adjacent cells do not use the same frequency set (see, for example, the arrangement shown in Figure 5A), it is possible to provide an array of fixed assignment omnidirectional cells where interference between nearby cells can be avoided. The transmitter power of each central terminal 10 is set such that
5 transmissions do not extend as far as the nearest cell which is using the same frequency set. Thus each central terminal 10 can use the four frequency pairs (for the uplink and downlink, respectively) within its cell, each modem shelf in the central terminal 10 being associated with a respective RF channel (channel frequency pair).

With each modem shelf supporting one channel frequency (with 15 subscriber
10 links per channel frequency) and four modem shelves, each central terminal 10 will support 60 subscriber links (i.e., 120 lines). The 10 cell arrangement in Figure 5A can therefore support up to 600 ISDN links or 1200 analogue lines, for example. Figure 5B illustrates a cellular type arrangement employing sectorized cells to mitigate problems between adjacent central terminals 10. As with Figure 5A, the different
15 type of hatch lines in Figure 5B illustrate different frequency sets. As in Figure 5A, Figure 5B represents three frequency sets (e.g., where: FS1 = F1, F4, F7, F10; FS2 = F2, F5, F8, F11; FS3 = F3, F6, F9, F12). However, in Figure 5B the cells are sectorized by using a sectorized central terminal (SCT) 13 which includes three central terminals 10, one for each sector S1, S2 and S3, with the transmissions for
20 each of the three central terminals 10 being directed to the appropriate sector among S1, S2 and S3. This enables the number of subscribers per cell to be increased three fold, while still providing permanent fixed access for each subscriber terminal 20.

A seven cell repeat pattern is used such that for a cell operating on a given frequency, all six adjacent cells operating on the same frequency are allowed unique
25 PN codes. This prevents adjacent cells from inadvertently decoding data.

As mentioned above, each channel frequency can support 15 subscriber links. In this example, this is achieved using by multiplexing signals using a Code Division Multiplexed Access (CDMA) technique. Figure 6 gives a schematic overview of CDMA encoding and decoding.

30 In order to encode a CDMA signal, base band signals, for example the user signals for each respective subscriber link, are encoded at 80-80N into a 160ksymbols/sec baseband signal where each symbol represents 2 data bits (see, for

example the signal represented at 81). This signal is then spread by a factor of 16 using a respective Walsh pseudo random noise (PN) code spreading function 82-82N to generate signals at an effective chip rate of 2.56Msymbols/sec in 3.5MHz. The signals for respective subscriber links are then combined and converted to radio
5 frequency (RF) to give multiple user channel signals (e.g., 85) for transmission from the transmitting antenna 86.

During transmission, a transmitted signal will be subjected to interference sources 88, including external interference 89 and interference from other channels 90. Accordingly, by the time the CDMA signal is received at the receiving antenna
10 91, the multiple user channel signals may be distorted as is represented at 93.

In order to decode the signals for a given subscriber link from the received multiple user channel, a Walsh correlator 94-94N uses the same pseudo random noise (PN) code that was used for the encoding for each subscriber link to extract a signal (e.g, as represented at 95) for the respective received baseband signal 96-96N. It will
15 be noted that the received signal will include some residual noise. However, unwanted noise can be removed using a low pass filter.

The key to CDMA is the application of orthogonal codes that allow the multiple user signals to be transmitted and received on the same frequency at the same time. To avoid the noise floor rising during spreading of the signals using PN
20 codes as the number of user signals increases, Rademacher-Walsh codes are used to encode the spread user signals. Once the bit stream is orthogonally isolated using the Walsh codes, the signals for respective subscriber links do not interfere with each other.

Walsh codes are a mathematical set of sequences that have the function of
25 "orthonormality". In other words, if any Walsh code is multiplied by any other Walsh code, the results are zero.

The following example will illustrate this using a four bit spreading code for ease of illustration, rather than the 16 bit spreading code preferred in practice.

12

	Incoming User Bit Stream	PN Code Spreading (x4)	Application of Walsh Codes	Transmit Code
5	'1'	1011	0000	0000
	'0'	1010	1100	1000
				0010
	'1'	0110	1010	0100
10	'1'	0111	1001	1110

Figure 7 is a schematic diagram illustrating signal transmission processing stages as configured in a subscriber terminal 20 in the telecommunications system of Figure 1. The central terminal is also configured to perform equivalent signal transmission processing. In Figure 7, an analogue signal from one of a pair of telephones is passed via a two-wire interface 102 to a hybrid audio processing circuit 104 and then via a codec 106 to produce a digital signal into which an overhead channel including control information is inserted at 108. The resulting signal is processed by a convolutional encoder 110 before being passed to a spreader 116 to which the Radermacher-Walsh and PN codes are applied by a RW code generator 112 and PN Code generator 114, respectively. The resulting signals are passed via a digital to analogue converter 118. The digital to analogue converter 118 shapes the digital samples into an analogue waveform and provides a stage of baseband power control. The signals are then passed to a low pass filter 120 to be modulated in a modulator 122. The modulated signal from the modulator 122 is mixed with a signal generated by a voltage controlled oscillator 126 which is responsive to a synthesizer 160. The output of the mixer 128 is then amplified in a low noise amplifier 130 before being passed via a band pass filter 132. The output of the band pass filter 132 is further amplified in a further low noise amplifier 134, before being passed to power control circuitry 136. The output of the power control circuitry is further amplified in a further low noise amplifier 138 before being passed via a further band

pass filter 140 and transmitted from the transmission antenna 142.

Figure 8 is a schematic diagram illustrating the equivalent signal reception processing stages as configured in a subscriber terminal 20 in the telecommunications system of Figure 1. The central terminal is also configured to perform equivalent signal reception processing. In Figure 8, signals received at a receiving antenna 150 are passed via a band pass filter 152 before being amplified in a low noise amplifier 154. The output of the amplifier 154 is then passed via a further band pass filter 156 before being further amplified by a further low noise amplifier 158. The output of the amplifier 158 is then passed to a mixer 164 where it is mixed with a signal generated by a voltage controlled oscillator 162 which is responsive to a synthesizer 160. The output of the mixer 164 is then passed via the de-modulator 166 and a low pass filter 168 before being passed to an analogue to digital converter 170. The digital output of the A/D converter 170 is then passed to a correlator 178, to which the same Radermacher-Walsh and PN codes used during transmission are applied by a RW code generator 172 (corresponding to the RW code generator 112) and a PN code generator 174 (corresponding to PN code generator 114), respectively. The output of the correlator is applied to a Viterbi decoder 180. The output of the Viterbi decoder 180 is then passed to an overhead extractor 182 for extracting the overhead channel information. The output of the overhead extractor 182 is then passed via a codec 184 and a hybrid circuit 188 to a two wire interface 190 where the resulting analogue signals are passed to a selected telephone 192.

Figure 9 is a front view of an integrated antenna unit 200 forming a customer radio unit 24 in the subscriber terminal 20 of Figure 2. A substantially rectangular radome forms the front of the antenna unit and has a substantially flat front face, which will typically be mounted with the plane of the front face substantially vertical, and a rearwardly extending peripheral wall. Figure 9 illustrates a part of the front of the radome removed to show a seal 210 for sealing the radome 202 to a rear cover 214. This construction provides for a minimum of external components, facilitating the weatherproofing of the unit. The radome is preferably made of a rigid, UV and relatively fire resistant plastics material (e.g. and ABS material such as Terblend (TM) manufactured by BASF) which is transparent to radio waves. The rear cover can be made of a similar plastics material or of metal (e.g. cast metal such

as an aluminium alloy) or a combination of both.

Figure 10 is a plan view of a first example of an integrated antenna from the direction A in Figure 1. X represents a typical total width of the antenna unit of 300mm.

5 An antenna mounting bracket 204 can be seen to the rear of the radome 202 in Figure 10. In this embodiment the rear cover is received within the rearwardly extending wall of the radome and accordingly does not appear in the Figure. However, the antenna mounting bracket is typically formed integrally with, or is secured to the rear cover, rather than being secured to the radome. The antenna
10 mounting bracket can be substantially 'U'-shaped, wherein Figure 10 shows the upper limb of the 'U'.

Two mounting positions (e.g., bores 210) are provided at either side of the antenna mounting bracket for attaching the antenna mounting bracket to a further mounting bracket 206 configured to cooperate with the antenna mounting bracket and
15 to be secured to a wall 208 or to another fixed structure (e.g., a mast). The two brackets can be secured together using a bolt 212 and nut (not shown), with locking washers, etc. as required, to provide a secure fixing. By providing mounting bores 210 at either side of the rear cover of the antenna, a particularly compact mounting of the antenna to a wall or other structure can be provided. In particular, the antenna
20 mounting bracket 204 can be mounted at a selected one of the two mounting bores 210 for selecting an appropriate pivot point for rotating said antenna to a selected side, thereby to provide a high angular range of mounting positions of said antenna with respect to the fixed support. This enables the antenna unit 200 to be mounted in an unobtrusive manner close to the wall 208 while still allowing it to be swivelled
25 through substantially 180° so that the antenna can be pointed towards the central terminal for establishing a radio link.

The mounting brackets can be made of a suitable metal, for example a cast aluminium alloy.

Figure 11 is an exploded section of the integrated antenna of Figure 10, taken
30 along line B-B adjacent the horizontal axis of the antenna and viewed in the direction A shown in Figure 9.

Figure 11 illustrates a chassis member 250 located within the radome 202.

A vertically extending wall 216 of the chassis defines a rear wall for first and second resonant cavities 226 defined to the front of the wall 216. The rear wall 216, in combination with a peripheral, forwardly extending wall 219 and a horizontal, forwardly extending wall 217 define upper and lower dish, resonant cavities above and below, respectively, the horizontal wall 217.

The chassis member is preferably made of the same plastics material as the radome, although other plastics or other materials could be used. The forwardly facing surface of the vertically extending wall 216, the inwardly facing surfaces of the peripheral wall 219 and both sides of the horizontally extending wall 217 are preferably metallised, for example with a deposited layer of aluminium or an aluminium alloy for reflecting radio waves to define the resonant cavities.

Part of the horizontal wall 217 is cut away in the lower part of the Figure to show part of a microstrip radiator element 220 and patch re-radiator (reflector) 224. A stud 222 extends from the microstrip 220 and through the wall 216 to couple radio energy through the wall 216. The radiator element construction will be described in more detail below.

The chassis member 250 also has a rearwardly extending peripheral wall 251 for defining a rear cavity 238 for containing electronic components on one or more printed circuit boards. In Figure 11, an RF board 228 having radio frequency circuitry 230 is provided which, when inserted in cavity 238, cooperates with the stud 222 on the microstrip 220. Also shown is a modem board 232 having modem circuitry for processing received signals from and for providing transmission signals to the RF circuitry 230. The modem circuitry 234 is then connected via a drop cable (not shown) which passes through the gland 235 in the rear cover 214 to the power supply unit 30 shown in Figure 2.

The rear side of the wall 216 and the insides of the peripheral wall 251, as well as the inside of the rear cover 214, can be metallised to provide electromagnetic shielding for the electronic components in the rear cavity 238.

The rear cover 214 is secured to the radome by screws located at 236. In this embodiment of the invention, the chassis member 250 is secured to the radome by screws 218. However, in alternative embodiments of the invention, the chassis member, the radome and the rear cover, along with the other components of the

antenna unit, can be configured such that screwing on the rear cover sandwiches all of the internal components in their desired position, thus reducing the number of stages in the manufacturing process and reducing manufacturing costs.

Figure 12 is a section through the vertical axis of the integrated antenna of Figure 10 along the line C-C and in the direction D shown in Figures 9 and 10. Figure 12 shows the antenna unit when assembled with the internal units of the antenna sandwiched between the radome 202 and the rear cover 214. In this Figure the horizontal wall 217 separating the upper and lower resonant cavities can be seen. Within each cavity a microstrip radiator element 220 and two patch reflectors 224 are shown. The patch reflector elements, which can be made, for example, from aluminium or aluminium alloy or the like, are secured on posts 227 on the inside of the radome 202 (e.g., by ultrasonic welding). The microstrip elements 220 are clamped between formations 232, 236 and 240 on the chassis member 250 and cooperating formations 234, 238 and 242, respectively, on the radome during assembly of the antenna unit.

A second embodiment of the invention will now be described with reference to Figures 13 to 15. Figure 13 is a plan view, partially in section of the second embodiment of an integrated antenna. Figure 14 is a rear view of the antenna of Figure 13. Figure 15 is an exploded side view of the second embodiment in the direction E shown in Figure 13.

This second embodiment is substantially similar to the previous embodiment so that only the differences will be explained. In this embodiment the screws 218 are dispensed with, the internal components of the antenna unit being held in place by being sandwiched in position on screwing the rear cover in place.

However, the main difference between the embodiments is the use of a rear cover having a peripheral portion 260 of plastics material and a central portion 258 formed of aluminium alloy with integral fins 256 to form an integral heat sink. The provision of a heat sink enables heat to be dissipated from electronic components sealed within the integrated antenna units. A bracket 204 is secured to the heatsink by screws 264 (see Figure 14) although it could be formed integrally with the aluminium portion 258 of the rear cover. Figure 13 shows an 'O'-ring seal 264 for sealing the rear cover 260 to the radome when the cover is secured thereto by screws



262. The aluminium portion 258 can be screwed at locations 266 to the peripheral plastics portion and sealed using conventional silicon sealant materials. The inside of the plastics portion 260 of the cover preferably has an aluminium coating to reduce electromagnetic interference.

- 5 In an alternative embodiment, the whole of the rear cover could be made of metal, for example, a cast aluminium alloy including the heat sink fins 256 and possibly the bracket 204.

To increase the heat transfer from the electronic components to the heatsink, the heatsink can be provided with internal pedestals 254 for contacting the circuits, or the circuit boards, directly. Alternatively, or in addition, heat conductive foam 10 252 can be used to couple the heat from the electronic components to the heat sink. This embodiment is particularly advantageous where a lot of heat is generated from the electronic components or when the antenna is used in warm environments, in order to avoid overheating of the components within the sealed unit.

- 15 Figure 16 is a schematic representation of the inside of a radome for an integrated antenna according to Figures 9 to 15. Figure 11 shows the position where the horizontal wall 217 of the chassis member separates the antenna area into transmit and receive cavities.

In each cavity a microstrip radiator 220 (shown hatched) is located on locating and clamping formations 236, 238 and 242 formed within the radome. The 20 formations 234 and 242 are in the form of pillars with a flat top and, in the middle of the flat top, a pin shaped portion for cooperating with a corresponding hole in a microstrip. A similar pillar 243 can also be provided at the position where the stud 222 is located in order to support the stud during assembly of the antenna unit.

25 Formations 238, and similar formations 286 are formed as supporting walls.

In each cavity two patches 224 (also shown hatched) are secured by ultrasonic welding or the like on the top of posts 227 so that they are located between the microstrip and the radome at a spacing from the ground plane of the microstrip to maximise the Q factor for the radiator. The size and spacing required for the patch 30 re-radiators 224 is calculated in order to give a desired gain for a desired frequency in accordance with conventional calculation techniques.

For example, in one specific example of an integrated antenna for use with the



frequencies described with reference to Figure 4, both the transmit and receive cavities are 238mm long by 188mm wide. Both the transmit and receive microstrip boards are 203mm long by 73mm wide and 0.5mm thick. Both of the transmit patches are 50mm by 51mm and both of the receive patches is 50mm by 49mm. Each patch is located 8.2mm from the ground plane of the respective microstrips and the microstrips are spaced by 7.7mm from the chassis wall 216 forming the rear of the cavities 226. It will be appreciated that these dimensions are given by way of example only, and that dimensions of the components for any particular embodiment will depend on the frequency characteristics of the transmit and receive signals required.

Figure 17 is a schematic representation of the two sides of a microstrip radiator. Side A represents the ground plane side of the microstrip, which in use will face backwards, that is away from the re-radiator patches and towards the rear wall of the chassis member showing two 'H'-shaped coupling slots 302 in solid lines. It should be noted that other shapes could be used for the dipole coupling slots. Many alternative shapes are known, for example dumbbells. It should be appreciated that the coupling slots are formed by openings in the ground plane layer on the microstrip. Typically they do not form slots which extend through the substrate onto which the ground plane is formed. The holes 306 form holes in the microstrip substrate for cooperating with the pins on the posts 242 formed on the inside of the radome.

Also shown in hatched lines in Figure 17 are the elements on the other side of the microstrip 220. In particular, the stud 222 is connected via a long line RF feeder 296 to an RF feeder strip 300 to the location of the coupling slot 302. A tuning stub 298 can be provided for fine phase tuning of the radiator. This is useful, for example, where the same dimensions are used for the transmit and receive radiators. In this case, because of the difference in the transmit and receive frequencies, (see Figure 4) the individual microstrips can be fine tuned to optimise the 'Q'-factor of the antenna for the particular frequency used.

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.

For example, although the antenna has been described for use at a subscriber

station in wireless telecommunications system, the principle of housing separate transmit and receive radiators in a common housing could be applied to the sectorized central terminal antenna for the wireless telecommunications network.



CLAIMS

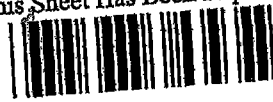
1. An integrated directional antenna comprising a radome, means defining a resonant cavity within said radome, and a microstrip radiator and a patch re-radiator
5 positioned within said resonant cavity to provide a directed beam.
2. An antenna according to Claim 1, wherein said means defining a resonant cavity comprises a reflective rear wall substantially parallel to said microstrip and side walls around said microstrip.
10
3. An integrated directional antenna comprising a radome and reflective rear and side walls defining a cavity, a microstrip radiator, arranged substantially parallel to said rear wall, and a patch re-radiator positioned within said cavity.
- 15 4. An antenna according to Claim 3, wherein said rear wall and said side walls define a resonant cavity and said microstrip radiator and patch re-radiator are positioned within said resonant cavity to provide a directed beam.
- 20 5. An antenna according to any preceding Claim, wherein said radome is provided with means for locating said patch a predetermined distance in front of a ground plane of said microstrip.
- 25 6. An antenna according to any preceding Claim, wherein said radiator is a compound radiator comprising a single microstrip having a ground plane on a first side thereof with first and second coupling slots in said ground plane, said coupling slots being spaced from each other, and two reflector patches, each located in front of a respective coupling slot.
- 30 7. An antenna according to Claim 6, wherein said microstrip comprises, on the side opposite to said ground plane, a long line RF feeder to an RF feeder strip to said two coupling slots.





8. An antenna according to Claim 7, comprising a first radiator for signal transmission and a second radiator for signal reception, wherein said long line RF feeder for at least one microstrip includes a tuning stub.
- 5 9. An antenna according to any preceding Claim, comprising a first radiator for signal transmission and a second radiator for signal reception.
- 10 10. An antenna according to Claim 9, comprising a reflective intermediate wall dividing said cavity into separate transmit and receive cavities for receiving said first radiator for signal transmission and said second radiator for signal reception, respectively.
- 15 11. An antenna according to any preceding Claim, comprising a chassis member locatable within said radome, said chassis member having a rear wall with a rim projecting forwards from said wall to define a dished cavity.
- 20 12. An antenna according to Claim 11, wherein said chassis member is made of plastics material with a metallised layer within said dished cavity for forming said resonant cavity.
- 25 13. An antenna according to Claim 11 or Claim 12, wherein said radome and/or said chassis member are provided with formations permitting the selective location of alternative microstrip/patch combinations for accommodating different frequencies
14. An antenna according to any one of Claims 11 to 13, wherein said radome and said chassis member are provided with cooperating features for locating a said microstrip at a predetermined distance in front of said rear wall.
- 30 15. An antenna according to any one of Claims 11 to 14, wherein said chassis member and/or said radome includes a central wall for providing separate transmitter and receiver cavities.





16. An antenna according to any one of Claims 11 to 15, wherein said chassis member has a further rim projecting rearwardly from said rear wall to define a rear cavity.
- 5 17. An antenna according to Claim 16, wherein said chassis member is made of plastics material with a metallised layer within said rear cavity for electromagnetically shielding electronic components within said rear cavity.
- 10 18. An antenna according to Claim 17, comprising a rear cover for closing said rear cavity.
- 15 19. An antenna according to any one of Claims 11 to 18, comprising a rear cover and fixing means for said rear cover, said radome, said rear plane and said chassis member being configured such that fixing of said rear cover sandwiches the component parts of said antenna in a fixed spatial relationship within said radome.
20. An antenna according to Claim 18 or Claim 19, wherein said rear cover is made at least partially of plastics material with a metallised layer thereon.
- 20 21. An antenna according to any one of Claims 18 to 20, wherein said rear cover is made at least partially of cast metal.
- 25 22. An antenna according to Claim 22, wherein said rear cover incorporates and integral heat sink for dissipating heat from electronic components within said rear cavity.
- 30 23. An antenna according to Claim 22, comprising electronic circuit components within said rear cavity, and means for thermally coupling said electronic components to said heat sink.
24. An antenna according to Claim 23, wherein said thermal coupling means comprises thermally conducting foam.





25. An antenna according to Claim 24, comprising pedestals for thermally coupling said electronic components to said heatsink.
26. An antenna according to any preceding Claim, comprising an antenna
5 mounting bracket.
27. An antenna according to any one of Claims 18 to 26, wherein said rear cover comprises an integral antenna mounting bracket.
- 10 28. An antenna according to Claim 26 or Claim 27, wherein said antenna mounting bracket comprises first and second spaced mounting points, said mounting bracket being arranged to cooperate with a further mounting bracket for connection to a fixed support, said further mounting bracket being arranged to support said antenna mounting bracket at a selected one of said first and second mounting points
15 for selecting a pivot point for rotating said antenna at a selected side of said antenna, thereby to provide a high angular range of mounting positions of said antenna to said fixed support.
29. An integrated directional antenna comprising a radome, a chassis member
20 located within the radome and a rear cover, said chassis member defining a front cavity containing radio transmission and/or receiving elements and a rear cavity containing electronic circuitry, said rear cavity being electromagnetically shielded from said first cavity and from the outside of said integrated antenna by a metallic layer on or forming said chassis and on or forming said rear cover.
- 25 30. An integrated directional antenna comprising a radome, a chassis member located within said radome and separating a front cavity containing radio transmission and/or receiving elements from a rear cavity contain electronic circuit elements and a rear cover, wherein said chassis member, said radio transmission and/or receiving
30 elements and said electronic circuit elements are sandwiched together in a desired configuration by fixing the rear cover to the radome.



31. An antenna according to any preceding Claim forming an integrated customer radio unit for a radio telephony system.
32. An antenna according to Claim 31, comprising a rear cavity containing RF
5 circuitry and modem circuitry for the transmission and/or reception of telephony signals.
33. An antenna according to Claim 32, wherein each said microstrip comprises a stud which extends between said resonant cavity and said rear cavity for direct
10 coupling of said radiator to said RF circuitry.

