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(71) Applicant(s)
Harada Industries (Europe) Limited
(Incorporated in the United Kingdom)
Bell Heath Way, Woodgate Business Park,
Clapgate Lane, BIRMINGHAM, B32 3BZ,
United Kingdom

(72) Inventor(s)
Richard Jonathan Langley
Lazoros Economou

(74) Agent and/or Address for Service
Mathys & Squire
100 Grays Inn Road, LONDON, WC1X 8AL,
United Kingdom

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UK CL (Edition S) H1Q QCX QDN QJC QKA
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(54) Abstract Title

Multiband PIFA patch antenna for vehicles

(57) A multiband PIFA-type antenna for installation in a vehicle has first, second and third elongated patch elements spaced apart from, and extending generally parallel to, a ground plane. The first and second patch elements each have a respective shorting pin connecting it to the ground plane, and the third patch element has a feed probe for supplying signals to, or receiving signals from, the antenna. The third patch element is capacitively coupled to the first and second patch elements such that the antenna exhibits resonances tuned to at least two microwave frequency bands: at one frequency, one patch resonates, whilst at the other frequency both patches resonate together. This second resonant frequency can be broad. In one embodiment, the antenna is capable of being tuned to the GSM900 900MHz band at one resonance and to both the DCS1800 1.8GHz and UNITS 2.0GHz bands at another resonance.

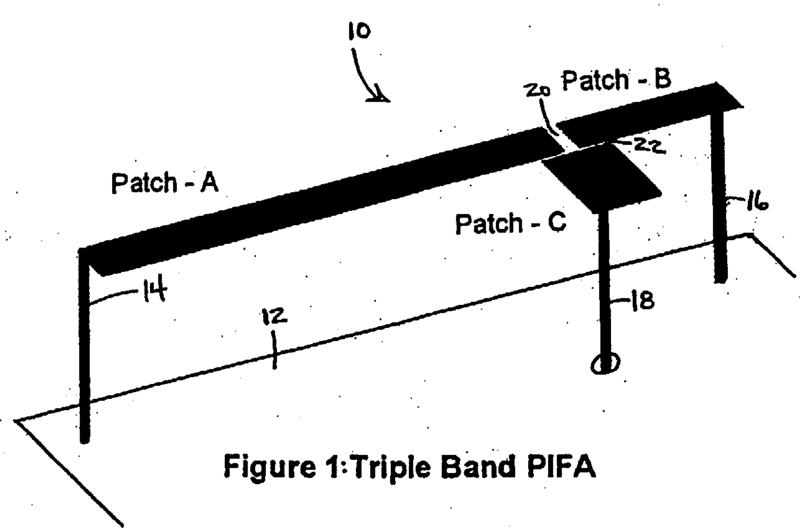

Figure 1:Triple Band PIFA

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

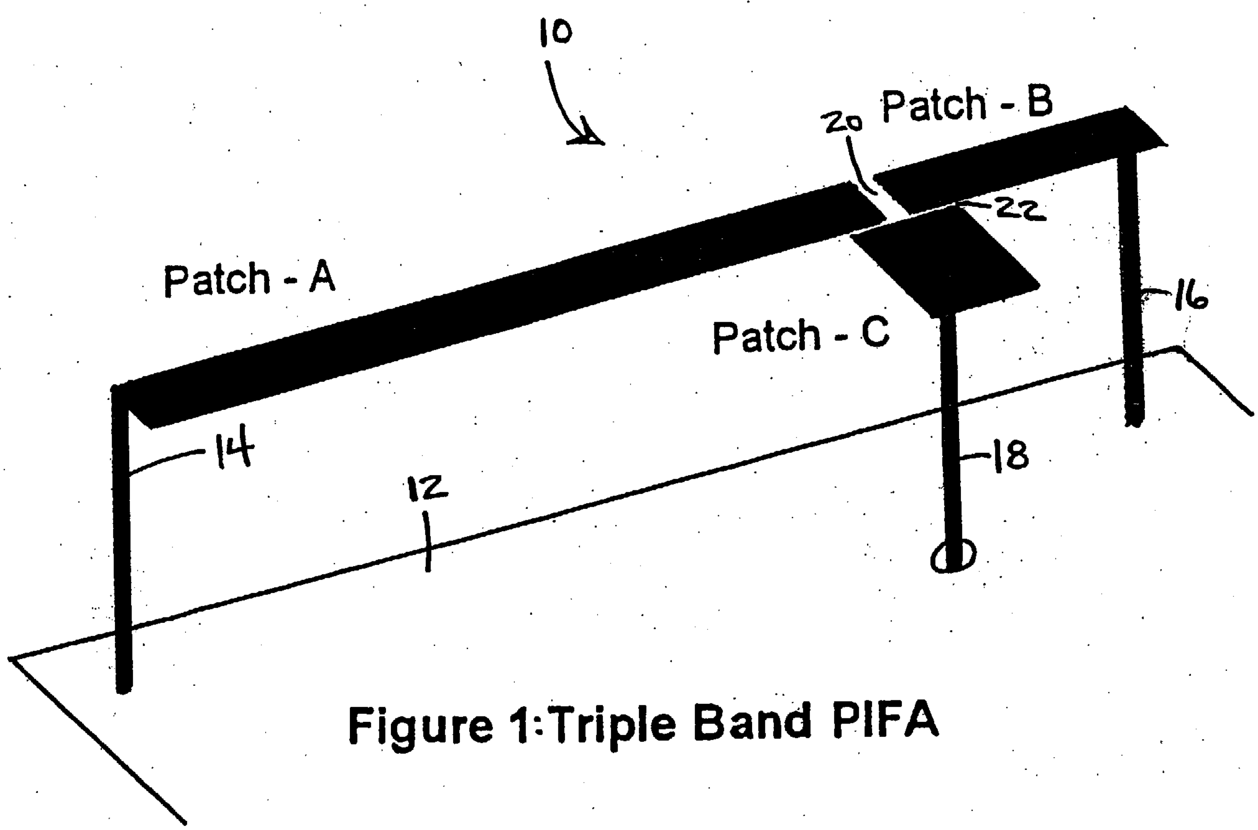

Figure 1:Triple Band PIFA

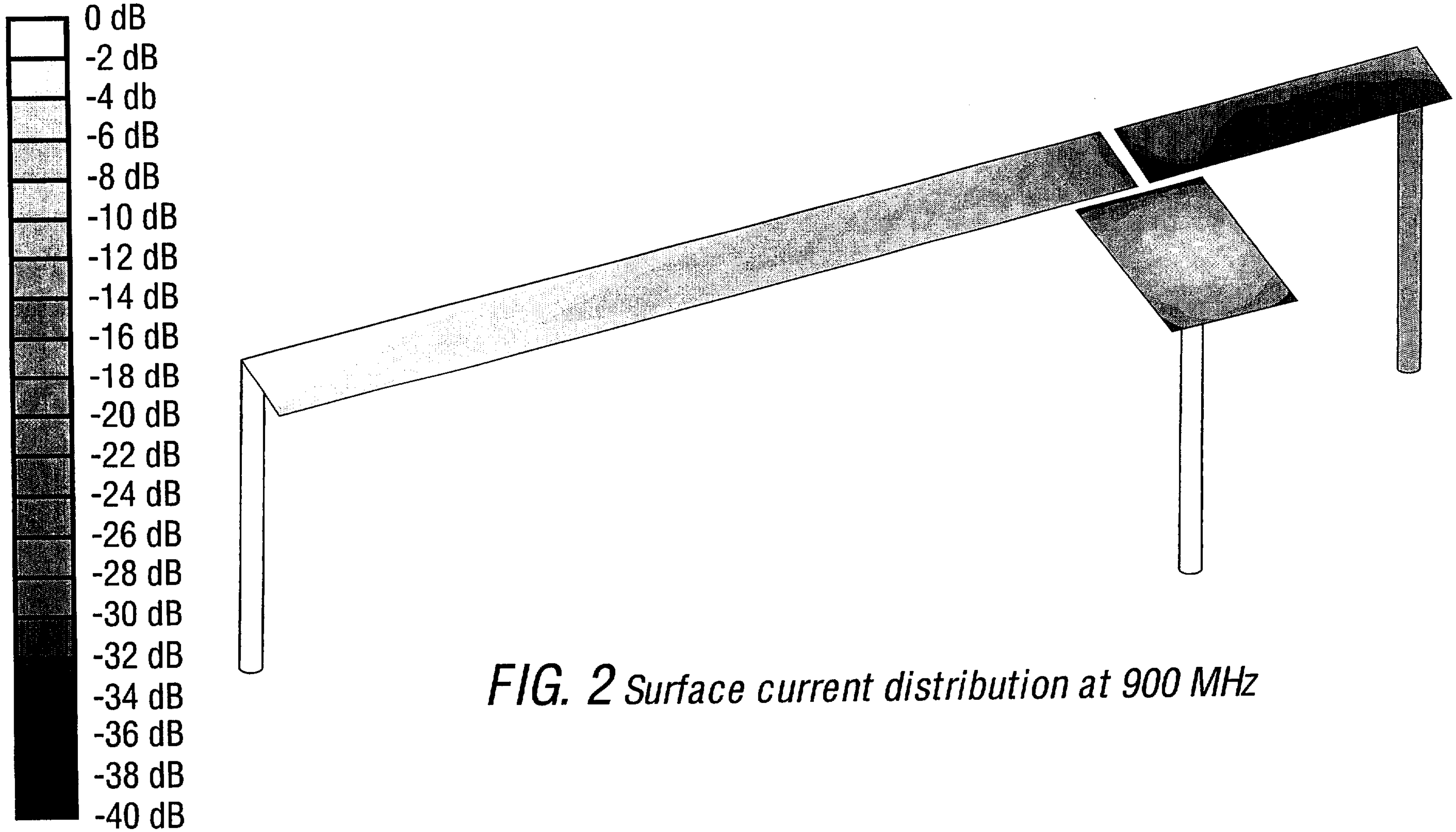

FIG. 2 Surface current distribution at 900 MHz

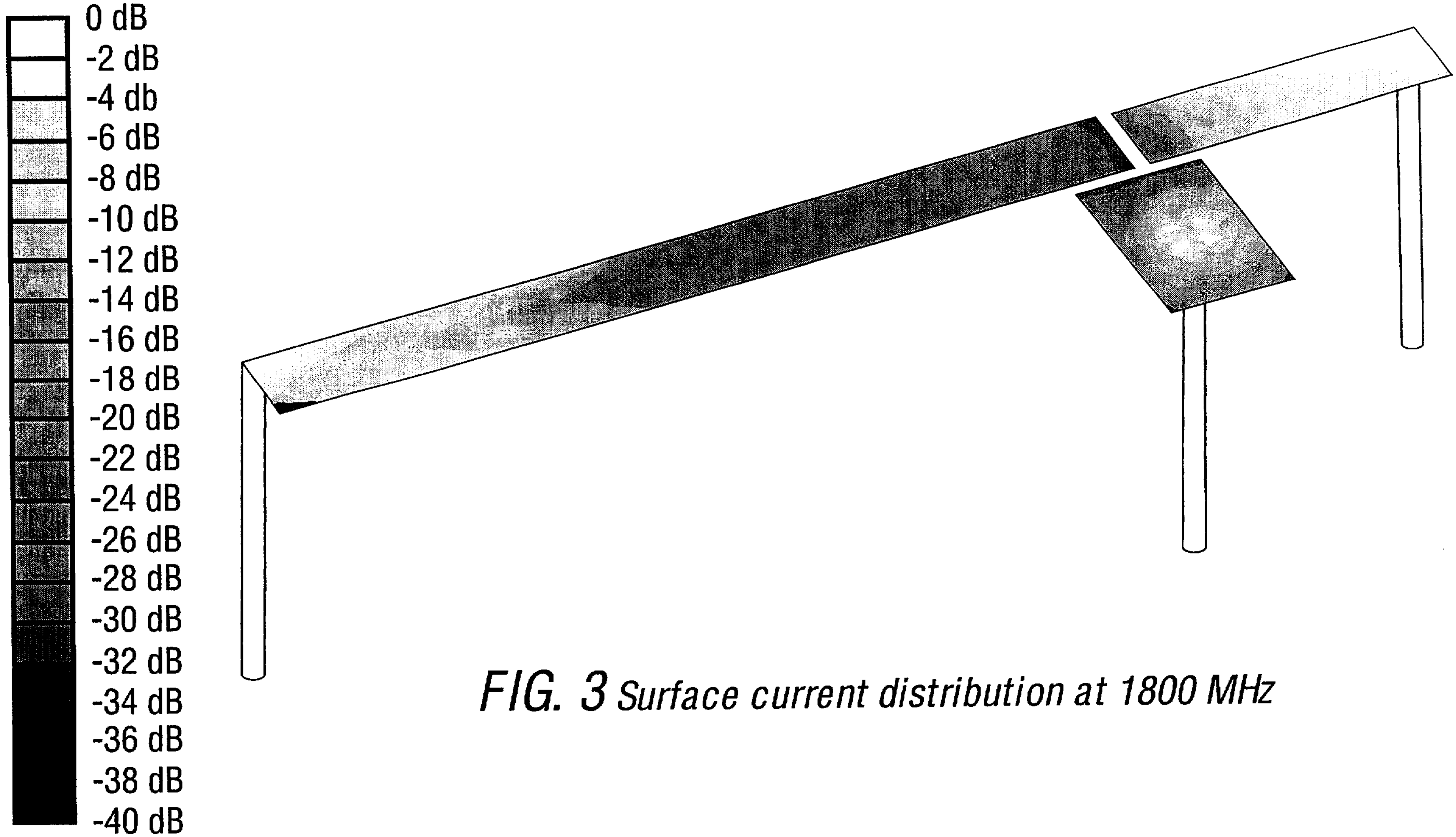

FIG. 3 Surface current distribution at 1800 MHz

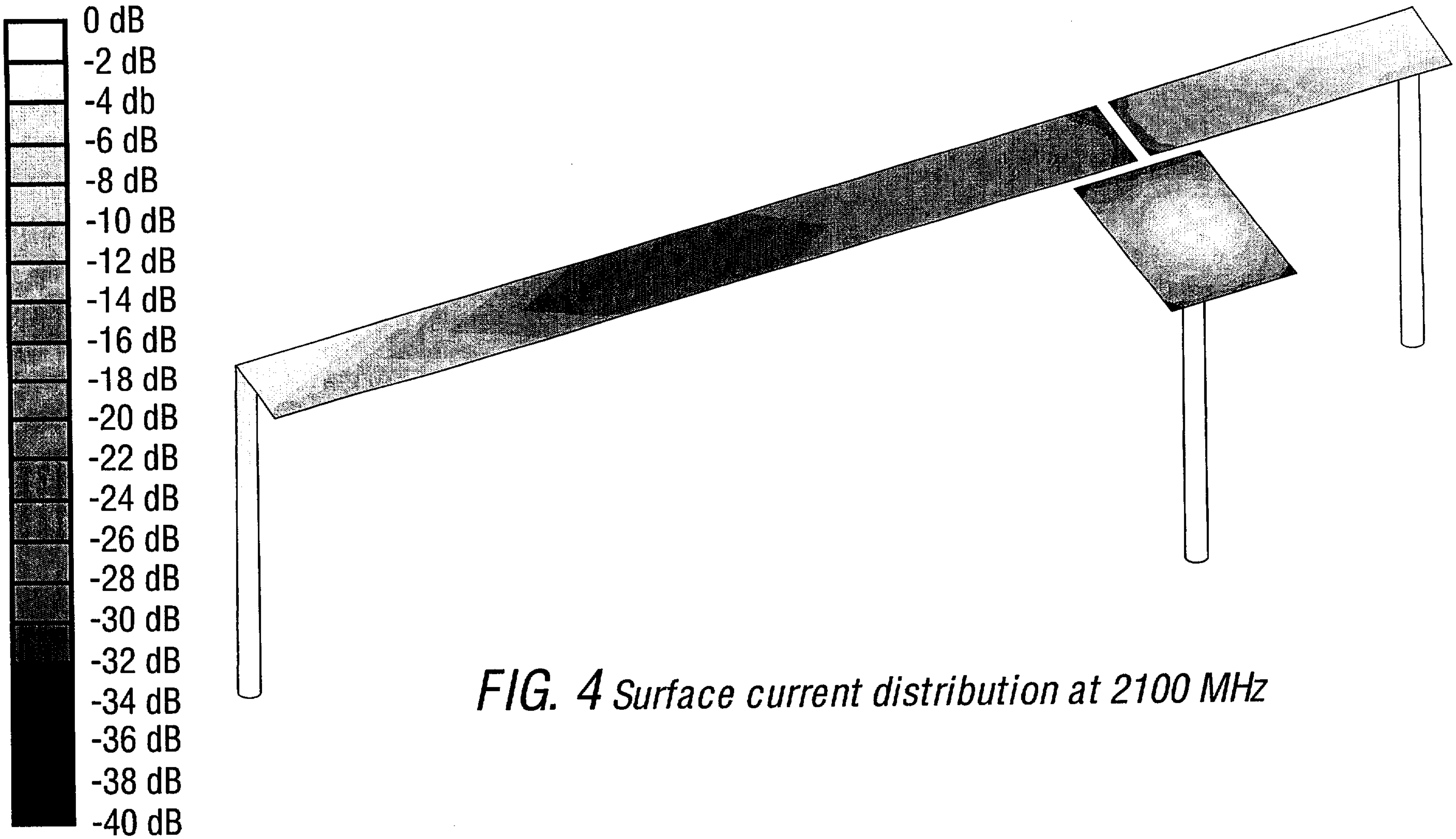

FIG. 4 Surface current distribution at 2100 MHz

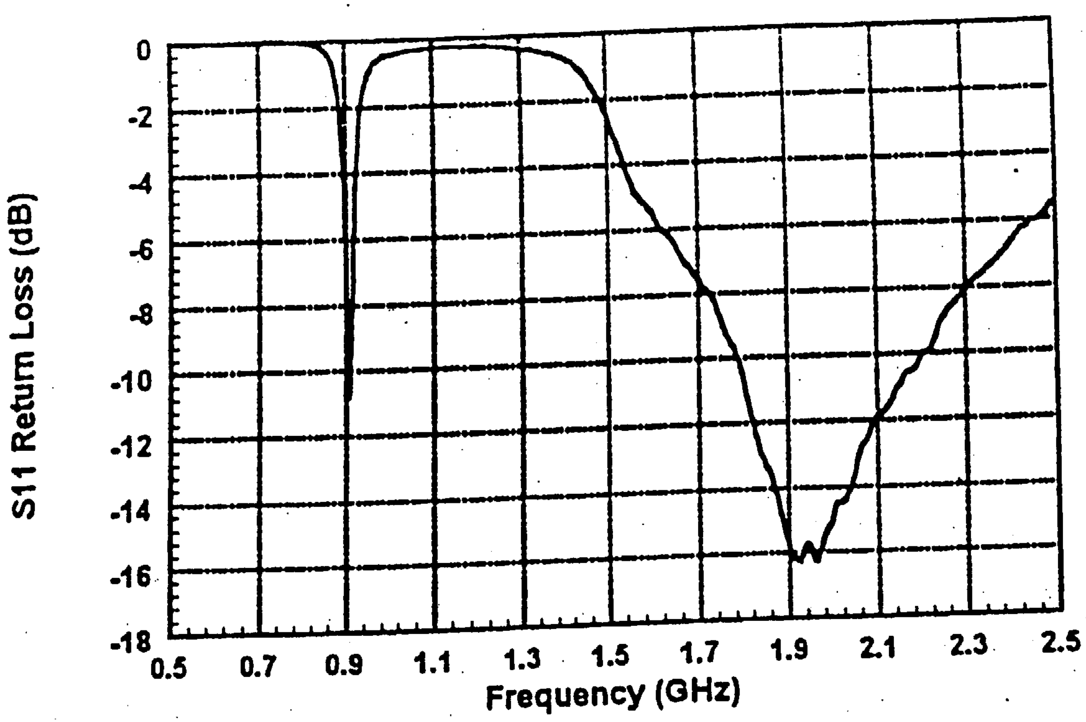

Figure 5 Measured return Loss vs Frequency

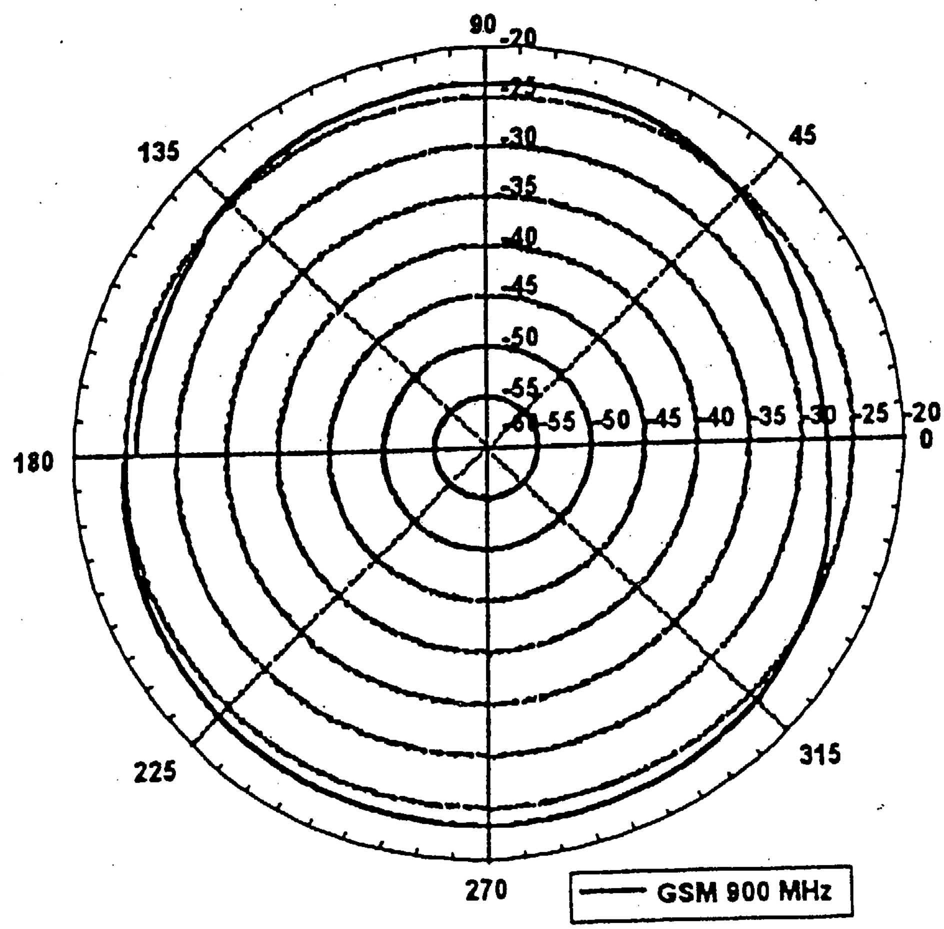

Figure 6 Polar Azimuth Radiation Pattern for GSM900

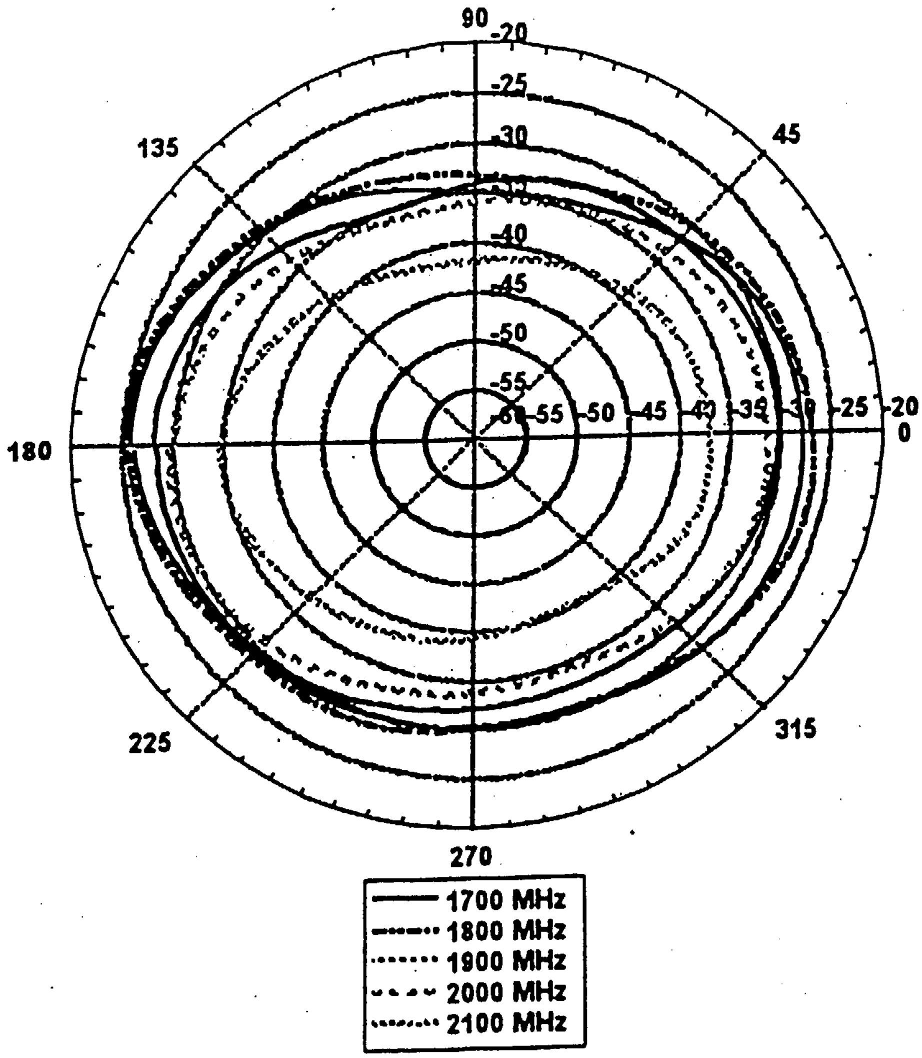

Figure 7 Polar Azimuth Radiation Patterns for DCS1800-UMTS

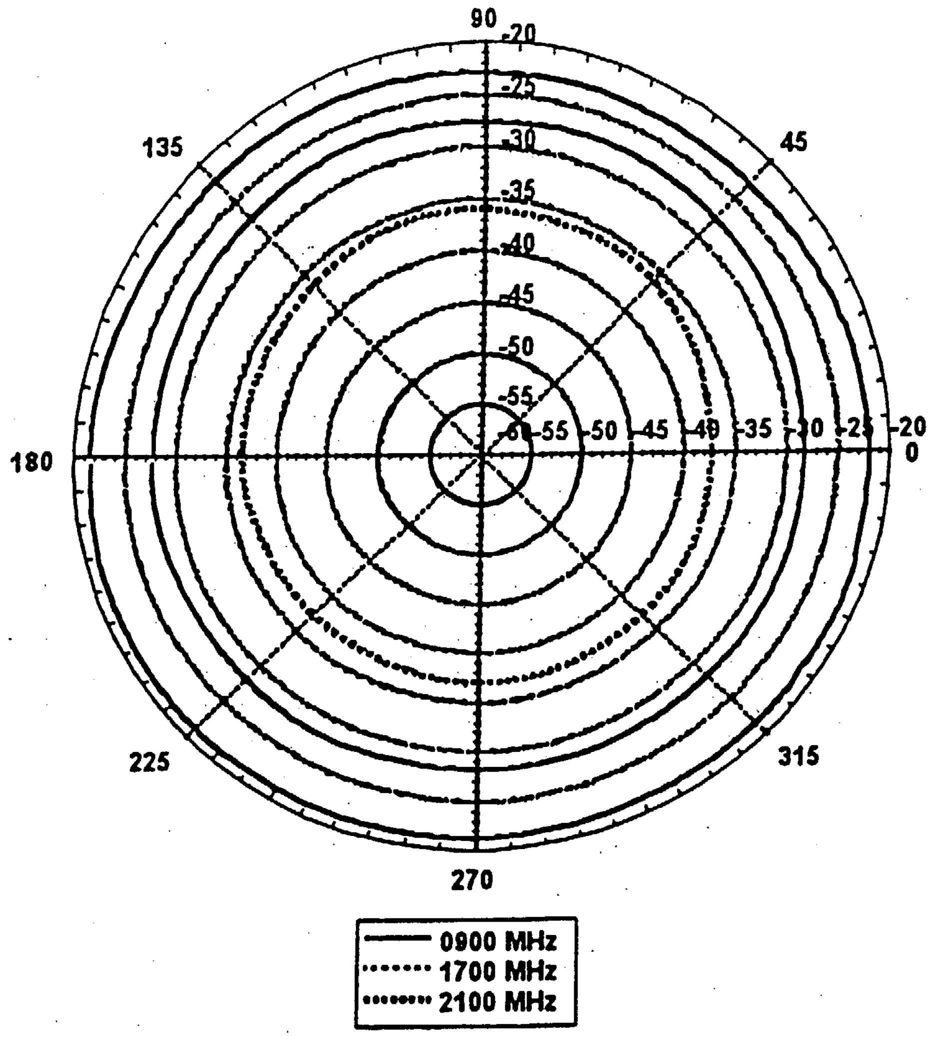

Figure 8 Polar Azimuth Radiation Patterns for a λ/4 monopole

MULTIBAND PIFA-TYPE ANTENNA FOR VEHICULAR APPLICATIONS

The invention relates to a multiband antenna, and more particularly (but not exclusively) to a Printed Inverted-F Antenna (PIFA) -type for use in vehicular applications.

PIFA-type antennas have become very popular for mobile phone applications in recent years. They have the advantages of being easy to design and easily modifiable to produce omnidirectional patterns in the polar azimuth planes, and are also not subject to inherent bandwidth limitations of other microstrip antennas. Although they have been used in many types of mobile phones, they tend to rely more on the receiver's sensitivity than intrinsic bandwidth. This is associated with the shorting pins/planes found with PIFAs, which tend to produce very high reactance that makes it difficult to take full advantage of the bandwidth. As a new era is entered in mobile communications, it is essential for mobile phone antennas to be able to operate in all three frequency bands of interest to such phones (GMS900, DCS1800 and UMTS). During roaming, mobile phones need to be able to "camp" on any network, giving the user the benefit of constant high-quality coverage. This is a heavy requirement for antennas in terms of bandwidth and multi-band operation.

One object of the preferred embodiment of the subject invention is to describe a triple-patch PIFA antenna that allows satisfactory camping at all three frequency bands of interest.

The PIFA of the subject invention is a capacitively-fed three-patch antenna. It is basically a dual-band antenna but, since the DCS-1800 and UMTS (1920 to 2175 MHz) bands are adjacent, it has been designed that the upper resonance covers both those upper bands -- making it, in effect, a tri-band antenna.

The high bandwidth requirements are met by elevating the patch elements of the antenna at a suitable height above the ground plane. This results in the input impedance being highly inductive. One way of compensating for this high-inductance impedance is to feed the antenna capacitively via a strip-line. Although this approach compensates for the high inductance, the fabrication process is complicated and overall cost of the antenna correspondingly increased.

It is another object of the preferred embodiment of the subject invention is to describe a PIFA that has comparable compensation for high-inductance impedance to a conventional antenna but is cheaper to produce.

The invention is a multiband antenna for installation in a vehicle, comprising a ground plane, first and second elongated patch elements spaced apart from and extending generally parallel to the ground plane, each patch element having a respective shorting pin connecting it to the ground plane, and a third patch element having a feed for supplying and/or receiving signals to or from the antenna, the third patch element being capacitively coupled to the first and second patch elements, the antenna exhibiting resonances tuned to at least two microwave radio bands.

The antenna may exhibit a resonance associated with the first patch element and a resonance associated with both the first and second patch elements. The resonance associated with the first patch element may encompass the GSM900 900MHz band, and the resonance associated with both the first and second patch elements may encompass the DCS1800 1.8GHz and UMTS 2.0GHz bands.

Preferably, the first and second patch elements are coplanar, and may be oriented such that the longitudinal centreline of one is substantially in-line with that of the other. Respective first ends of the first and second patch elements may be proximate and separated from each other by a gap having a width less than approximately one-tenth of the length of the shorter of the first and second patch elements. The shorting pins may respectively connect to the first and second patch elements at respective second ends of the patch elements, and at positions that are proximate a side edge on the same side of the longitudinal centreline of those patch elements.

The third patch element may be coplanar with the first and second patch elements. The third patch element may be positioned proximate one side edge of the first and second patch elements and be oriented such that its longitudinal centreline extends generally normal to that of the first and second patch elements. The one side of the first and second patch elements may be the side opposite to the side on which the shorting pins connect to the respective first and second patch elements. The third patch element may be positioned relative to the first and second patch elements such that a projection of the longitudinal centreline of the third patch element extends from a first end of the third patch element through the gap separating the proximate first ends of the first and second patch elements. The first end of the third patch element may be separated from the one edge of the first and second patch elements by a gap having a width less than approximately one-tenth of the length of the third patch element.

The first patch element may be approximately three times as long as the second patch element. The first and second patch elements may be sized so as to have approximately the same width, with the length/width ratio of the first patch element being approximately ten, and the length/ width ratio of the second patch element being approximately three. The distance between the three patch elements and the ground plane may be approximately 20mm.

The space between the ground plane and the three patch elements may be an air gap or filled with a foamed dielectric or a solid dielectric.

In one configuration, the first patch element may be approximately 45.5mm long and approximately 4.7mm wide, the second patch element may be approximately 16mm long and approximately 4.7mm wide, and the third patch element may be approximately 11mm long and approximately 7mm wide.

Preferred features of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:-

Figure 1 is a perspective view of a triple-band PIFA of the preferred embodiment of the subject invention;

Figure 2 is the surface current distribution at 900 MHz for the triple-band PIFA of the preferred embodiment;

Figure 3 is the surface current distribution at 1800 MHz for the triple-band PIFA of the preferred embodiment;

Figure 4 is the surface current distribution at 2100 MHz for the triple-band PIFA of the preferred embodiment;

Figure 5 is the measured S11 return loss as a function of frequency for the triple-band PIFA of the preferred embodiment;

Figure 6 illustrates the polar azimuth radiation pattern for the triple-band PIFA of the preferred embodiment in the GMS900 frequency band;

Figure 7 illustrates the polar azimuth radiation pattern for the triple-band PIFA of the preferred embodiment in the DCS1800/UMTS dual-frequency band; and,

Figure 8 illustrates the polar azimuth radiation pattern for a conventional λ/4 monopole antenna.

With respect to Figure 1, the antenna of the preferred embodiment is generally designated 10, and is comprised of three coplanar patch elements A, B and C, a ground member 12, and three legs 14, 16 and 18 respectively supporting patch elements A, B and C in parallel, spaced relationship with the ground member 12. The two legs 14 and 16 are 20.8mm-long shorting pins of 1.2mm tinned wire, while the third leg 18 is a feed probe that is a standard SMA connector. Patch element A is 45.5mm long and 4.7mm wide, patch element B is 16.0mm long and 4.7mm wide, and patch element C is 7.0mm long (length being measured in the same direction as the length of patches A and B) and 11.0mm wide. The space between ground plane 12 and patch elements A, B and C is filled with 20mm of air foam and a 0.8mm FR4 layer (ϵ_r=4.5).

The GSM900 900MHz resonant frequency band is associated with the presence of patch elements A and C only, while the DCS1800/UMTS dual-frequency band is associated with the presence of all three patch elements A, B and C. Shorting pins 14 and 16 have the important function of causing symmetrical radiation (omnidirectional) in the polar azimuth plane. Pin 14 is connected to a corner of patch element A that is diagonally across from that one of the corners of patch element A that is closest to patch element C; pin 16 is connected to a corner of patch element B that is diagonally across from that one of the corners of patch element B that is closest to patch element C. The feed probe 18 is connected to a central position on patch element C. A gap 20 that separates proximate first ends of patch elements A and B is 1.2mm wide, while a gap 22 separating a first end of patch element C from the adjacent sides of patch elements A and B is 0.5mm wide.

Figures 2, 3 and 4 illustrate surface current distributions that result when signals at 0.9 GHz, 1.8GHz and 2GHz are received or transmitted from the antenna. Both shorting pins 14 and 16 are excited at the upper bands, while at 900 MHz only pin 14 is excited. This gives rise to vertical polarised symmetrical waves in the azimuth plane.

Measured return loss is shown in Figure 5. There is a first narrow dip in the curve at 0.9GHz for the GSM900 band, and a broader one centred on 1.9GHz for the DCS1800/UMTS dual frequency band. At -12dBm, the broader band extends from approximately 1.8GHz to 2.1GHz, which is sufficient to cover both the DCS1800 and UMTS bands. The GSM900 band is not very well-matched; however, this is not a problem since the antenna is very sensitive in that band.

The polar azimuth radiation patterns of the antenna at the two frequency bands of interest (GMS900 and DCS1800/UMTS) were measured and compared with those of a quarter-wavelength monopole. The respective results are shown in Figures 6, 7 and 8, and are also set out in the following table:

Frequency (GHz)	Antenna (dBm)		Monopole (dBm)	
	Min	Max	Min	Max
0.900	-27.7	-23.2	-23.1	-21.1
1.700	-34.8	-25.8	-28.3	-27.2
2.100	-46.8	-34.1	-37.5	-35.8

The maximum levels of radiation are of the same order in both cases. The differences in the minimum are due to an egg-shaped pattern of the antenna.

Although the bandwith of the antenna of the invention is smaller compared with that of a quarter-wavelength monopole at the GSM900 band, their sensitivity is of the same order. However, the antenna of the invention has advantages in being a low-profile antenna having a height of only 2.1cm compared to the 8cm-height of the monopole, and in combining three antennas into a single design, suitable for rooftop mounting.

While the present invention has been described in its preferred embodiment, it is to be understood that the words which have been used are words of description rather than limitation, and that changes may be made to the invention without departing from its scope as defined by the claims. For instance, the patch elements A, B and C need not necessarily be coplanar, but could each be in a separate plane closely spaced from the others. Also, the patch elements could overlap each other slightly in their separate planes to create the same effect as the slight gap spacing between them described in the preferred embodiment.

Each feature disclosed in this specification (which term includes the claims) and/or shown in the drawings may be incorporated in the invention independently of other disclosed and/or illustrated features.

The text of the abstract filed herewith is repeated here as part of the specification.

A multiband PIFA-type antenna for installation in a vehicle has first, second and third elongated patch elements spaced apart from, and extending generally parallel to, a ground plane. The first and second patch elements each have a respective shorting pin connecting it to the ground plane, and the third patch element has a feed probe for supplying signals to, or receiving signals from, the antenna. The third patch element is capacitively coupled to the first and second patch elements such that the antenna exhibits resonances tuned to at least two microwave frequency bands. In one embodiment, the antenna is capable of being tuned to the GSM900 900MHz band at one resonance and to both the DCS1800 1.8GHz and UMTS 2.0GHz bands at another resonance.

What is claimed is:

1. A multiband antenna for installation in a vehicle, comprising a ground plane, first and second elongated patch elements spaced apart from and extending generally parallel to the ground plane, each patch element having a respective shorting pin connecting it to the ground plane, and a third patch element having a feed for supplying and/or receiving signals to or from the antenna, the third patch element being capacitively coupled to the first and second patch elements, the antenna exhibiting resonances tuned to at least two microwave frequency bands.

2. A multiband antenna according to claim 1, wherein the antenna exhibits a first resonance associated with the first patch element and a second resonance associated with both the first and second patch elements.

3. A multiband antenna according to claim 2, wherein the first resonance encompasses the GSM900 900MHz band, and the second resonance encompasses the DCS1800 1.8GHz and UMTS 2.0GHz bands.

4. A multiband antenna according to claim 1, wherein the first and second patch elements are coplanar.

5. A multiband antenna according to claim 4, wherein the first and second patch elements are oriented such that the longitudinal centreline of one is substantially in-line with that of the other.

6. A multiband antenna according to claim 5, wherein

respective first ends of the first and second patch elements are proximate, and separated from each other by a gap having a width less than approximately one-tenth of the length of the shorter of the first and second patch elements.

7. A multiband antenna according to claim 6, wherein the shorting pins respectively connect to the first and second patch elements at the respective second ends of the patch elements.

8. A multiband antenna according to claim 7, wherein the shorting pins connect to the respective first and second patch elements proximate a side edge on the same side of the longitudinal centreline of those patch elements.

9. A multiband antenna according to claim 8, wherein the third patch element is coplanar with the first and second patch elements.

10. A multiband antenna according to claim 9, wherein the third patch element is positioned proximate one side edge of the first and second patch elements and is oriented such that its longitudinal centreline extends generally normal to that of the first and second patch elements.

11. A multiband antenna according to claim 10, wherein the one side of the first and second patch elements is the side opposite to the side on which the shorting pins connect to the respective first and second patch elements.

12. A multiband antenna according to claim 11, wherein the third patch element is positioned relative to the first

and second patch elements such that a projection of the longitudinal centreline of the third patch element extends from a first end of the third patch element through the gap separating the proximate first ends of the first and second patch elements.

13. A multiband antenna according to claim 12, wherein the first end of the third patch element is separated from the one edge of the first and second patch elements by a gap having a width less than approximately one-tenth of the length of the third patch element.

14. A multiband antenna according to any preceding claim, wherein the first patch element is approximately three times as long as the second patch element.

15. A multiband antenna according to any preceding claim, wherein the first and second patch elements have approximately the same width, the length/width ratio of the first patch element is approximately ten, and the length/ width ratio of the second patch element is approximately three.

16. A multiband antenna according to any preceding claim, wherein the distance between the three patch elements and the ground plane is approximately 20mm.

17. A multiband antenna according to any preceding claim, wherein the space between the ground plane and the three patch elements is filled with a foamed and/or solid dielectric.

18. A multiband antenna according to any preceding claim, wherein the first patch element is approximately 45.5mm long and approximately 4.7mm wide, the second patch element is approximately 16mm long and approximately 4.7mm wide, and the third patch element is approximately 11mm long and approximately 7mm wide.

19. A multiband antenna substantially as herein described with reference to and as shown in the accompanying drawings.

Application No: GB 0030418.8
Claims searched: all

Examiner: Dr E.P. Plummer
Date of search: 16 July 2001

Patents Act 1977
Search Report under Section 17

Databases searched:

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

UK Cl (Ed.S): H1Q (QJC, QDN, QCX, QKA)

Int Cl (Ed.7): H01Q 9/04, 5/00, 5/01, 19/00, 21/30

Other:

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB2355114A	HARADS INDUSTRIES whole document	1,4
X	GB2067842A	SECRETARY OF STATE FOR DEFENCE Figure 5 embodiment; column 2 lines 24 to 42 imply dual frequency.	1,4,17
X	EP0831548A1	MURATA MANUFACTURING Figure 3 embodiment; column 1 lines 8 & 9	1,4,17
X	EP0831547A1	MURATA MANUFACTURING whole document; nb column 1 lines 8 & 9	1,4,17
X	EP0790663A1	MURATA MANUFACTURING figure 6 & 7 embodiment	1,4,17
X	EP0655797A1	MOTOROLA whole document	1,4,17
X	US5943016	ATLANTIC AEROSPACE ELECTRONICS whole document, in particular figure 13	1,4

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Application No: GB 0030418.8
Claims searched: all

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Date of search: 16 July 2001

Category	Identity of document and relevant passage		Relevant to claims
X	US4783661	STC whole document	1,4,17
X	US4575725	ALLIED CORP whole document	1,4,17
X	US4218682	FROSCH & YU whole document	1,17
X	US4074270	USA whole document	1,4,17

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.