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(54) Title: WIDEBAND RADIATING ELEMENTS

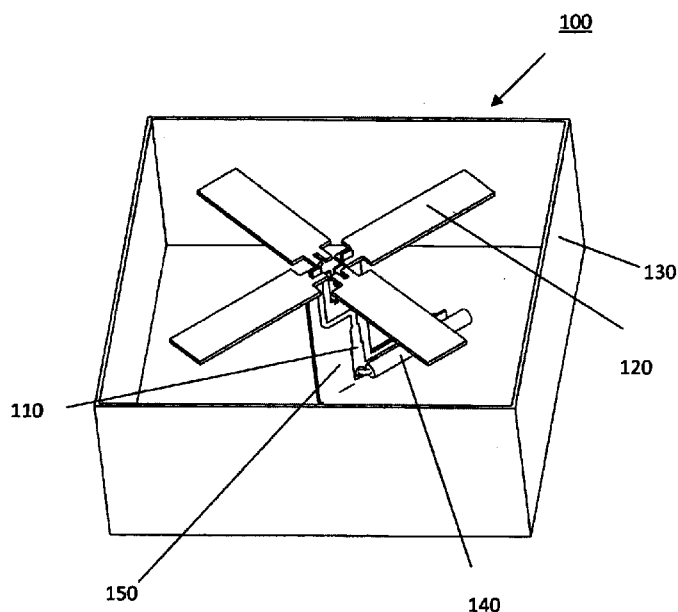


FIG. 1

(57) Abstract: A wideband radiating element (100, 400), an antenna, and methods of transmitting and receiving signals are provided. The wideband radiating element (100, 400) comprises: a section of waveguide (130, 430), at least one dipole antenna element (120, 420), and at least one tuned circuit. The section (130, 430) of waveguide has a length that is a quarter of a guide wavelength or about a quarter of the guide wavelength and is short circuited at one end and open circuited at the other end to provide a waveguide aperture. Each dipole antenna element (120, 420) is disposed within the waveguide section (130, 430) as a feed for the waveguide section (130, 430). Each tuned circuit is coupled to a respective dipole antenna element (120, 420) as a feed for the dipole antenna element (120, 420). The tuned circuit comprises at least one transmission line feed (110, 410) and a shunt resonator (140, 440) formed from a segment of transmission line.

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WIDEBAND RADIATING ELEMENTS

RELATED APPLICATION

The present application claims the benefit of the earlier filing date, including
5 under 35 USC §119 in the United States, of Australian Provisional Patent
Application No. 2011900647, which is incorporated by reference herein in its
entirety, filed on 24 February 2011 in the name of Argus Technologies (Australia)
Pty Ltd et al.

10 TECHNICAL FIELD

The present invention relates generally to antennas and in particular to
wideband antennas and in particular for such antennas for use base station in wireless
telecommunications.

15 BACKGROUND

International (PCT) Patent Publication No. WO 2006/135956 published on 28
December 2006 (International Patent Application No. PCT/AU2006/000814 filed on
15 June 2006 filed in the name of Argus Technologies (Australia) Pty Ltd et al)
discloses dual-polarized patch antennas having reduced beamwidths. Such a patch
20 antenna comprises a ground plane, a patch radiator, and a feed. The patch radiator is
suspended above the ground plane and fed by a central symmetrical loop or by two
loops symmetrically disposed about the centre of the patch in a plane normal to the
patch between the patch and the groundplane. The feed excites opposite sides of the
patch radiator in antiphase.

25 International (PCT) Patent Publication No. WO 2010/042976 published on 22
April 2010 (International Patent Application No. PCT/AU2009/001343 filed on 12
October 2009 filed in the name of Argus Technologies (Australia) Pty Ltd et al)
describes wideband radiating elements that have a wide bandwidth for a relatively
constant beamwidth and comprises a section of waveguide, a patch radiator, and one
30 or more tuned loops. The waveguide section is a quarter of a guide wavelength long
or thereabouts, short circuited at one end, and open circuited at the other end. The

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patch radiator is disposed within the waveguide section. The tuned loops are coupled to the patch radiator as a feed for the patch radiator in a plane normal to the patch radiator. The width of the waveguide section is between about 0.7 wavelengths and about 1.3 wavelengths and the patch radiator is located at a height of 0.125

5 wavelengths or thereabouts above the short-circuited end of the waveguide section.

The radiofrequency spectrum being made available for wireless voice and data services served by basestation antennas is continually increasing. Currently, there is a requirement for up to 50% bandwidth to be achieved with an impedance match of 15dB. Therefore, a need exists for an improved antenna having wider

10 bandwidth.

SUMMARY

In accordance with an aspect of the invention, there is provided a wideband radiating element, comprising: a section of waveguide having a length that is a
15 quarter of a guide wavelength or about a quarter of the guide wavelength, the waveguide section being short circuited at one end and open circuited at the other end to provide a waveguide aperture; at least one dipole antenna element disposed within the waveguide section as a feed for the waveguide section; and at least one tuned
20 circuit coupled to each respective dipole antenna element as a feed for the dipole antenna element, the tuned circuit comprising at least one transmission line feed and a shunt resonator formed from a segment of transmission line.

The width of the waveguide section may be between about 0.7 wavelengths and about 1 wavelength.

The dipole antenna element may be located at a height of 0.25 wavelengths or
25 about 0.25 wavelengths above the short-circuited end of the waveguide section.

The waveguide section may have a cross-section along the longitudinal extent of the waveguide section that is square, rectangular, or circular in form.

The wideband radiating element may further comprise an additional tuning element.

30 The additional tuning element may comprise a dielectric sheet coupled to the waveguide section.

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The dielectric sheet may be disposed across at least a portion of the waveguide aperture of the waveguide section.

The dielectric sheet may be disposed within the waveguide section.

5 The waveguide section, the dipole antenna element, and the at least one tuned circuit may be configured to radiate over a fifty percent (50%) bandwidth with return loss in excess of 15 dB.

The waveguide section, the dipole antenna element, and the at least one tuned circuit may be coupled together provide an equal ripple band-pass filter.

10 The wideband radiating element may comprise one tuned circuit configured to feed a single polarized dipole antenna element, or two tuned circuits orthogonally configured as dual polarization feeds to feed orthogonally polarized dipole antenna elements.

The wideband radiating element may further comprise at least one printed circuit board, a tuned circuit formed on each printed circuit board.

15 Each tuned circuit may comprise at least one network of metallised components.

The wideband radiating element may comprise: two dipole antenna elements configured orthogonally relative to each other and disposed within the waveguide section as a feed for the waveguide section to radiate orthogonal polarizations; and
20 two tuned circuits each coupled to a respective dipole antenna element as a feed for the respective dipole antenna element, each tuned circuit comprising at least one transmission line feed and a shunt resonator formed from a segment of transmission line.

In accordance with another aspect of the invention, there is provided a stand-alone antenna, comprising a wideband radiating element in accordance with the
25 foregoing aspect.

In accordance with still another aspect of the invention, there is provided an array antenna comprising a plurality of wideband radiating elements, each radiating element in accordance with the foregoing aspect.

30 The array antenna may be configured as a wideband, cellular base-station antenna array.

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In accordance with a further aspect of the invention, there is provided a method of transmitting a signal using a wideband radiating element. The signal is coupled from at least one tuned circuit to at least one dipole antenna as a feed for the dipole antenna element. The tuned circuit comprises at least one transmission line feed and a shunt resonator formed from a segment of transmission line. The signal is radiated from each dipole antenna element disposed within a waveguide section as a feed for the waveguide section. The section of waveguide has a length that is a quarter of a guide wavelength or about a quarter of the guide wavelength. The waveguide section is short circuited at one end and open circuited at the other end to provide a waveguide aperture.

In accordance with a further aspect of the invention, there is provided a method of receiving a signal using a wideband radiating element. The signal is received at at least one dipole antenna element disposed within a waveguide section. The section of waveguide has a length that is a quarter of a guide wavelength or about a quarter of the guide wavelength. The waveguide section is short circuited at one end and open circuited at the other end to provide a waveguide aperture. The signal is coupled at at least one tuned circuit coupled to the dipole antenna element, the tuned circuit comprising at least one transmission line feed and a shunt resonator formed from a segment of transmission line.

The waveguide section may have a cross-section along the longitudinal extent of the waveguide section that is square, rectangular, or circular in form.

The width of the waveguide section may be between about 0.7 wavelengths and about 1 wavelength.

The dipole antenna element may be located at a height of 0.25 wavelengths or about 0.25 wavelengths above the short-circuited end of the waveguide section.

These and other aspects of the invention are described in detail hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention are described hereinafter with reference to the drawings, in which:

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Fig. 1 is a perspective view of a wideband radiating element, i.e., a wideband dipole-fed cavity radiator, shown with one of the two polarization feeds removed for clarity, in accordance with an embodiment of the invention;

Fig. 2 is a perspective view of another wideband radiating element, i.e., a wideband dipole-fed cavity radiator, comprising an isolated dipole antenna element and a waveguide section with the matching feed network omitted for ease of illustration;

Fig. 3 is an S-parameter polar plot showing the optimised impedance match of the dipole/waveguide combination of Fig. 2 (1710MHz-2690MHz) from 3D electromagnetic analysis;

Fig. 4 is a perspective view of an example of a waveguide/dipole/feed network combination to achieve wideband impedance matching and stable radiation pattern with frequency (single polarisation only shown); and

Figs. 5A and 5B are polar and rectangular plots of optimized impedance match using a transmission line and shunt resonator to feed the dipole/waveguide combination, as shown in Figs. 2 and 3.

DETAILED DESCRIPTION

Wideband radiating elements, methods of transmitting and receiving signals using a wideband radiating element, standalone antennas, and array antennas are described hereinafter. More particularly the wideband radiating element is a wideband dipole-fed cavity radiator. In the following description, numerous specific details, including frequency ranges, cables, dielectric materials, conductive materials, waveguide cross-sectional shapes, and the like are set forth. However, from this disclosure, it will be apparent to those skilled in the art that modifications and/or substitutions may be made without departing from the scope and spirit of the invention. In other circumstances, specific details may be omitted so as not to obscure the invention.

International (PCT) Patent Publication No. WO 2010/042976 published on 22 April 2010 (International Patent Application No. PCT/AU2009/001343 filed on 12

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October 2009 filed in the name of Argus Technologies (Australia) Pty Ltd et al) is incorporated herein by reference.

In accordance with the embodiments of the invention, the wideband radiating element is a wideband dipole-fed cavity radiator comprising: a section of waveguide, one or more dipole antenna elements, and one or more tuned circuits. The waveguide section has a length that is a quarter of a guide wavelength or about a quarter of the guide wavelength. The waveguide section is short circuited at one end and open circuited at the other end to provide a waveguide aperture. Each dipole antenna element is disposed within the waveguide section as a feed for the waveguide section.

Each tuned circuit is coupled to a respective dipole antenna element as a feed for the dipole antenna element. The tuned circuit comprises at least one transmission line feed and a shunt resonator formed from a segment of transmission line. The wideband radiating element can be used to transmit and/or receive signals. The signal can be fed to the tuned circuit and radiated from the dipole antenna element.

In turn, the dipole antenna element is a feed for the waveguide section, which radiates the signal from the wideband radiating element to transmit the signal. Similarly, a signal can be received by the wideband radiating element.

The wideband dipole-fed cavity radiator can radiate single or dual linear polarization and is a suitable radiating element for wideband, cellular base-station antenna arrays. Dipole antenna elements are commonly used as radiating elements in cellular base station antennas. Arrays covering DCS1800, UMTS and WiMax/LTE bands (1710-2690 MHz.) may use these wideband radiating elements, but the embodiments of the invention are not limited in application to these particular bands. The resulting radiating element, i.e. the wideband dipole-fed cavity radiator, is capable of operating over a fifty percent (50%) bandwidth with return loss in excess of 15 dB. The variation in radiation pattern across this band is relatively small. For example, a cellular base-station panel antenna designed to have a 65° horizontal beamwidth varies in 3 dB beamwidth by less than $\pm 7^\circ$ over a 57% bandwidth.

With optimum selection of dimensions, the configuration of the wideband radiating element becomes a three resonator filter that can be designed to match the impedance of the input transmission line of a feed to the impedance at the open

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waveguide radiator. The width of the waveguide section may be between about 0.7 wavelengths and about 1 wavelength. The dipole antenna element may be located at a height of 0.25 wavelengths or about 0.25 wavelengths above the short-circuited end of the waveguide section. The waveguide section may have a cross-section along the longitudinal extent of the waveguide section that is square, rectangular, or circular in form. The bandwidth of the resulting radiating element is significantly increased by the waveguide section. The waveguide, suitably dimensioned, also stabilises the radiation pattern, so that there is minimal variation in radiation pattern across the impedance bandwidth.

Optionally, a dielectric body of suitable thickness, physical characteristics, and dielectric constant can be located within the waveguide as a tuning element to provide adjustment of the Q of the open waveguide radiator and can be used to optimise the impedance characteristics across the band of operation. That is, the wideband radiating element may further comprise an additional tuning element. The additional tuning element may comprise a dielectric sheet coupled to the waveguide section. The dielectric sheet may be disposed across at least a portion of the waveguide aperture of the waveguide section. The dielectric sheet may be disposed within the waveguide section.

Dual linear polarization can be achieved by means of two orthogonal crossed dipole antenna elements. An equi-ripple impedance response can be achieved by suitably adjusting the resonant frequencies and couplings between the three resonators, namely the tuned circuit, the dipole antenna element and the waveguide section. The wideband radiating element(s) can be used to implement a stand-alone antenna, or an array antenna comprising a number (e.g., 10) of wideband radiating elements as a cellular base-station antenna array. The wideband radiating element provides a relatively constant beamwidth and wide bandwidth. These and other aspects are described hereinafter in greater detail with reference to the embodiments shown in Figs. 1 to 5.

As shown in Fig. 1, a wideband radiator 100 comprises a short section 130 of waveguide, short circuited at one end and open circuited at the other end where radiation occurs. The waveguide section 130 is fed by one or more dipole antenna

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elements 120 disposed within the waveguide section 130; in this embodiment there are two dipole antenna elements 120 configured in an orthogonal arrangement. The dipole antenna elements 120 are in turn fed by one or more transmission line sections 110 and one or more shunt resonators 140. Such a radiating element 100 is capable
5 of operating over a 50% bandwidth with return loss in excess of 15 dB, can radiate single or dual linear polarization, and forms a satisfactory radiating element for wideband cellular basestation antenna arrays. The variation in radiation pattern across this band is acceptable for cellular basestation applications.

In the embodiment shown in Fig. 1, the dipole antenna elements 120 are
10 suspended above the shorted section of waveguide 130 on a printed circuit board 150 mounted between the dipole antenna elements 120 and the waveguide section 130. The transmission line sections 110 are implemented on the printed circuit board 150. The shunt resonator 140 is coupled to the transmission line section 110 in Fig. 1 adjacent the shorted section of waveguide 130.

15 For ease of illustration only a single transmission line section 110 on a printed circuit board 150 with a shunt resonator 140 is shown. This feeds a single dipole antenna element 120. A further transmission line section on another printed circuit board with a shunt resonator is omitted to simplify the diagram. The waveguide section 130, the one or more dipole antenna element 120, and one or more tuned
20 circuit 110 may be configured to radiate over a fifty percent (50%) bandwidth with return loss in excess of 15 dB. The waveguide section 130, the dipole antenna element 120 and the at least one tuned circuit 110 may be coupled together providing an equal ripple band-pass filter. The wideband radiating element 100 may comprise one tuned circuit configured to feed a single polarization dipole antenna element 120,
25 or the wideband radiating element 100 may comprise two tuned circuits orthogonally configured as dual polarization feeds to feed orthogonally polarized dipole antenna elements 120, as shown in Fig. 1. Accordingly, the wideband radiating element 100 may comprise at least one printed circuit board, with a tuned circuit formed on each printed circuit board. Each tuned circuit may comprise one or more sections of
30 transmission line and a single shunt resonator.

Alternatively, each wideband radiating element 100 may comprise at least one tuned circuit feed, with each tuned circuit feed comprising a network of any conductive parts suitably arranged to form one or more transmission line sections and a shunt resonator

5 The wideband radiating element 100 comprises: two dipole antenna elements 120 configured orthogonally relative to each other and disposed within the waveguide section 130 as a feed for the waveguide section to radiate orthogonal polarizations; and two tuned circuits each coupled to a respective dipole antenna element 120 as a feed for the respective dipole antenna element 120. Each tuned
10 circuit 11 comprises at least one transmission line feed 110 and a shunt resonator 140 formed from a segment of transmission line on a printed circuit board 150. The waveguide section 130 of Fig. 1 has a square cross-section, however, other shapes may be practiced without departing from the scope of the invention.

 The possibility of using components other than a printed circuit board to
15 realise the feed network exists. This could be done instead of using a printed circuit board

 The method of wideband impedance matching is implemented as follows. Firstly, consider a single-polarization dipole antenna element 220, centrally located within a suitably dimensioned waveguide section 230, as depicted in Figure 2. The
20 width of the waveguide 230 is normally between 0.7 wavelengths and 1 wavelength, and the length of the waveguide section 230 is normally close to a quarter guide wavelength. On its own without the waveguide component 230, the dipole antenna element 220 displays a single resonance in its impedance response with frequency. The variation of the impedance with frequency of this isolated dipole antenna
25 element 220 is too large to permit operation over a bandwidth useful for wideband cellular basestation antennas. However, if the dipole antenna element 220 is located within the cavity of the waveguide section 230 and the dipole arms are optimized in length to obtain a resonance at the desired frequency, the impedance variation can be greatly reduced, allowing an impedance match over a much wider frequency range to
30 be achieved. The waveguide 230 also stabilizes the pattern so that there is minimal

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variation in radiation pattern across the impedance bandwidth. Again, the waveguide section 230 is short circuited at one end and open circuited at the other end.

Fig. 3 shows a polar reflection coefficient plot of the dipole/waveguide combination 220, 230 of Fig. 2 after the dipole antenna element 220 and the waveguide section 230 are optimized as described hereinbefore. The plot shows the reflection coefficient for 1.71 GHz to 2.69 GHz. The dual-resonance, wideband nature of the frequency response is evident. On a polar plot such as this, a dipole's frequency response displays a wide arc over a 57% bandwidth. It is difficult to design a compact matching network to transform an arc such as this to the terminating impedance and provide a 15dB return loss. Instead of this, the polar plot in Fig. 3 shows a dual-resonance response where the single-resonance arc has been transformed into a compact loop, with a much reduced spread of impedance with frequency. To match this combination 220, 230 to the required terminating impedance (typically 50 ohms) and to provide maximum bandwidth, one or more sections of transmission line (not shown in Fig. 2) in combination with a shunt resonator (not shown in Fig. 2) can be used at the feed point of the dipole antenna element 220.

The shunt resonator can also perform the function of a balun, which transforms an unbalanced transmission line feed into a balanced feed as required by the dipole antenna element 220. The transmission line sections act as impedance transformers to bring the impedance of the dipole antenna element 220 to the required terminating impedance. The shunt resonator acts to further reduce the impedance variation with frequency.

Fig. 4 shows a typical example of such a waveguide/dipole/feed network combination 400, where the feed-network transmission lines 410 and shunt resonator 440 are realized with microstrip tracks on a printed circuit board 450. This figure corresponds to that shown in Fig. 1 except that an extra dipole antenna element 420 is omitted.

Fig. 5 shows a possible match of the dipole/waveguide represented in Figs. 2 and 3, achieved after optimization of a feed network comprising a single length of transmission line of approximately $\frac{1}{4}$ wavelength long in combination with an

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approximately $\frac{1}{4}$ wavelength long shunt resonator. A theoretical impedance match of greater than 20dB return loss can be achieved over a 50% bandwidth with such a matching network. The plots in Figs. 5A and 5B display the wideband triple-tuned response achieved with this configuration.

5 Thus, a broadband radiating element has been described comprising a section of waveguide of square, circular, or other cross section, which is approximately a quarter of a guide wavelength in length and is fed by a dipole antenna element. The dipole antenna element is in turn fed by one or more sections of transmission line that are resonated with a shunt section of transmission line. These radiating elements
10 may be used in an array antenna on a ground plane or as a stand-alone antenna. Additional tuning elements such as a dielectric sheet placed across the waveguide aperture or elsewhere in the waveguide may be practiced. Further, wideband radiating elements with dual polarization feeding may be practiced in the form of orthogonal dipoles so as to radiate orthogonal polarizations. The coupling of 3 or
15 more resonant elements may be selected in such a way as to approximate an equal ripple band-pass filter.

 In one embodiment of the invention, there is provided a method of transmitting a signal using the foregoing wideband radiating element. The signal is coupled from at least one tuned circuit to at least one dipole antenna as a feed for the
20 dipole antenna element. The tuned circuit comprises at least one transmission line feed and a shunt resonator formed from a segment of transmission line. The signal is radiated from each dipole antenna element disposed within a waveguide section as a feed for the waveguide section. The section of waveguide has a length that is a quarter of a guide wavelength or about a quarter of the guide wavelength. The
25 waveguide section is short circuited at one end and open circuited at the other end to provide a waveguide aperture.

 In another embodiment of the invention, there is provided a method of receiving a signal using a wideband radiating element. The signal is received at at least one dipole antenna element disposed within a waveguide section. The section
30 of waveguide has a length that is a quarter of a guide wavelength or about a quarter of the guide wavelength. The waveguide section is short circuited at one end and

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open circuited at the other end to provide a waveguide aperture. The signal is coupled at at least one tuned circuit coupled to the dipole antenna element. The tuned circuit comprises at least one transmission line feed and a shunt resonator formed from a segment of transmission line.

5 The waveguide section has a cross-section along the longitudinal extent of the waveguide section that is square, rectangular, or circular in form.

 The width of the waveguide section is between about 0.7 wavelengths and about 1 wavelength.

 The dipole antenna element is located at a height of 0.25 wavelengths or
10 about 0.25 wavelengths above the short-circuited end of the waveguide section.

 Wideband radiating elements, methods of transmitting and receiving signals using a wideband radiating element, standalone antennas, and array antennas have been described. In view of this disclosure, it will be apparent to one skilled in the art that modifications and/or substitutions may be made without departing from the
15 scope and spirit of the invention.

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CLAIMS

1. A wideband radiating element, comprising:
a section of waveguide having a length that is a quarter of a guide wavelength
5 or about a quarter of the guide wavelength, said waveguide section being short
circuited at one end and open circuited at the other end to provide a waveguide
aperture;
at least one dipole antenna element disposed within said waveguide section as
a feed for said waveguide section; and
10 at least one tuned circuit coupled to each respective dipole antenna element as
a feed for said dipole antenna element, said tuned circuit comprising at least one
transmission line feed and a shunt resonator formed from a segment of transmission
line.
2. The wideband radiating element as claimed in claim 1, wherein the
15 width of said waveguide section is between about 0.7 wavelengths and about 1
wavelength.
3. The wideband radiating element as claimed in claim 1 or 2, wherein
said dipole antenna element is located at a height of 0.25 wavelengths or about 0.25
wavelengths above said short-circuited end of said waveguide section.
- 20 4. The wideband radiating element as claimed in any one of claims 1 to
3, wherein said waveguide section has a cross-section along the longitudinal extent of
the waveguide section that is square, rectangular, or circular in form.
5. The wideband radiating element as claimed in any one of the
preceding claims, further comprising an additional tuning element.
- 25 6. The wideband radiating element as claimed in claim 5, wherein said
additional tuning element comprises a dielectric sheet coupled to said waveguide
section.
7. The wideband radiating element as claimed in claim 6, wherein said
dielectric sheet is disposed across at least a portion of the waveguide aperture of said
30 waveguide section.

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8. The wideband radiating element as claimed in claim 6, wherein said dielectric sheet is disposed within said waveguide section.

9. The wideband radiating element as claimed in any one of the preceding claims, wherein said waveguide section, said dipole antenna element, and said at least one tuned circuit are configured to radiate over a fifty percent (50%) bandwidth with return loss in excess of 15 dB.

10. The wideband radiating element as claimed in any one of the preceding claims, wherein said waveguide section, said dipole antenna element, and said at least one tuned circuit coupled together provide an equal ripple band-pass filter.

11. The wideband radiating element as claimed in any one of the preceding claims, comprising one tuned circuit configured to feed a single polarized dipole antenna element.

12. The wideband radiating element as claimed in any one of claims 1 to 10, comprising two tuned circuits orthogonally configured as dual polarization feeds to feed orthogonally polarized dipole antenna elements.

13. The wideband radiating element as claimed in any one of the preceding claims, further comprising at least one printed circuit board, a tuned circuit formed on each printed circuit board.

14. The wideband radiating element as claimed in any one of the preceding claims, wherein each tuned circuit comprises at least one network of metallised components.

15. The wideband radiating element as claimed in any one of the preceding claims, comprising:

two dipole antenna elements configured orthogonally relative to each other and disposed within said waveguide section as a feed for said waveguide section to radiate orthogonal polarizations; and

two tuned circuits each coupled to a respective dipole antenna element as a feed for the respective dipole antenna element, each tuned circuit comprising at least one transmission line feed and a shunt resonator formed from a segment of transmission line.

16. A stand-alone antenna, comprising a wideband radiating element as claimed in any one of claims 1 to 15.

17. An array antenna comprising a plurality of wideband radiating
5 elements, each radiating element as claimed in any one of claims 1 to 15.

18. The array antenna as claimed in claim 17 configured as a wideband, cellular base-station antenna array.

19. A method of transmitting a signal using a wideband radiating element, said method comprising the steps of:

10 coupling said signal from at least one tuned circuit to at least one dipole antenna as a feed for said dipole antenna element, said tuned circuit comprising at least one transmission line feed and a shunt resonator formed from a segment of transmission line; and

radiating said signal from each dipole antenna element disposed within a
15 waveguide section as a feed for said waveguide section, said section of waveguide having a length that is a quarter of a guide wavelength or about a quarter of the guide wavelength, said waveguide section being short circuited at one end and open circuited at the other end to provide a waveguide aperture.

20. A method of receiving a signal using a wideband radiating element,
20 said method comprising the steps of:

receiving said signal at at least one dipole antenna element disposed within a waveguide section, said section of waveguide having a length that is a quarter of a guide wavelength or about a quarter of the guide wavelength, said waveguide section being short circuited at one end and open circuited at the other end to provide a
25 waveguide aperture; and

coupling said signal at at least one tuned circuit coupled to the dipole antenna element, said tuned circuit comprising at least one transmission line feed and a shunt resonator formed from a segment of transmission line.

21. The method as claimed in claim 19 or 20, wherein said waveguide
30 section has a cross-section along the longitudinal extent of the waveguide section that is square, rectangular, or circular in form.

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22. The method as claimed in claim 19 or 20, wherein the width of said waveguide section is between about 0.7 wavelengths and about 1 wavelength.

23. The method as claimed in claim 19 or 20, wherein said dipole antenna element is located at a height of 0.25 wavelengths or about 0.25 wavelengths above
5 said short-circuited end of said waveguide section.

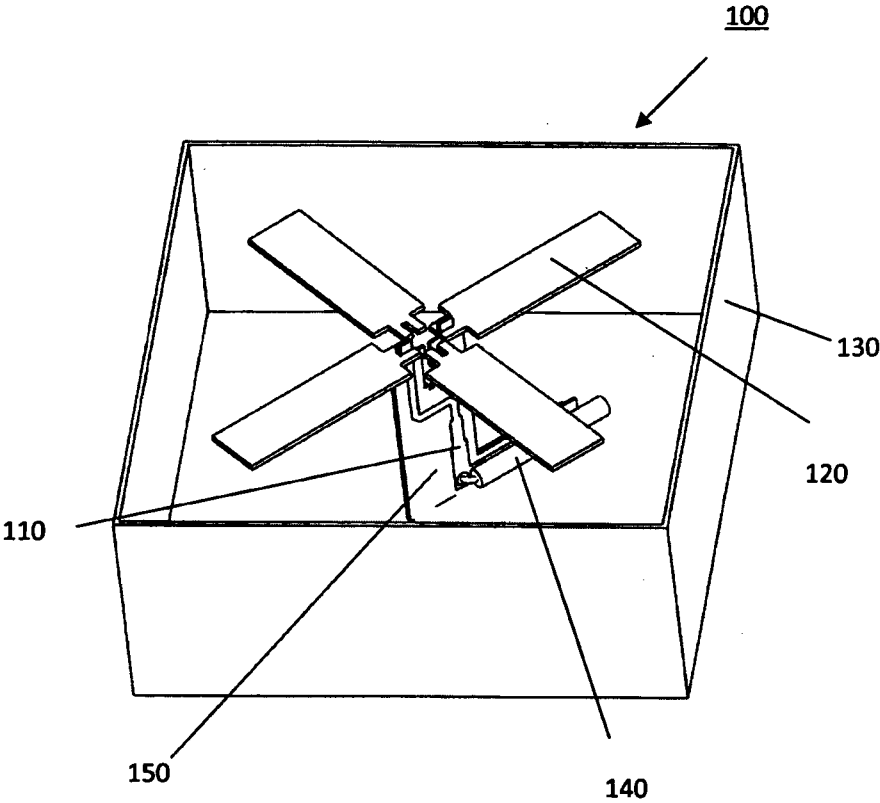


FIG. 1

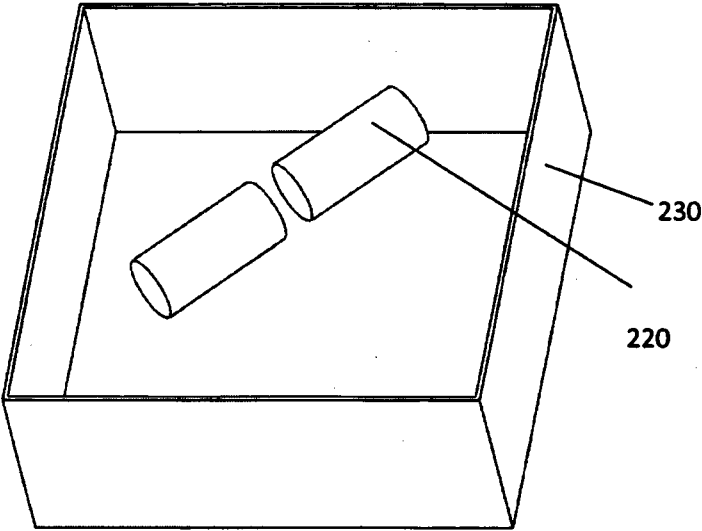


FIG. 2

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S11

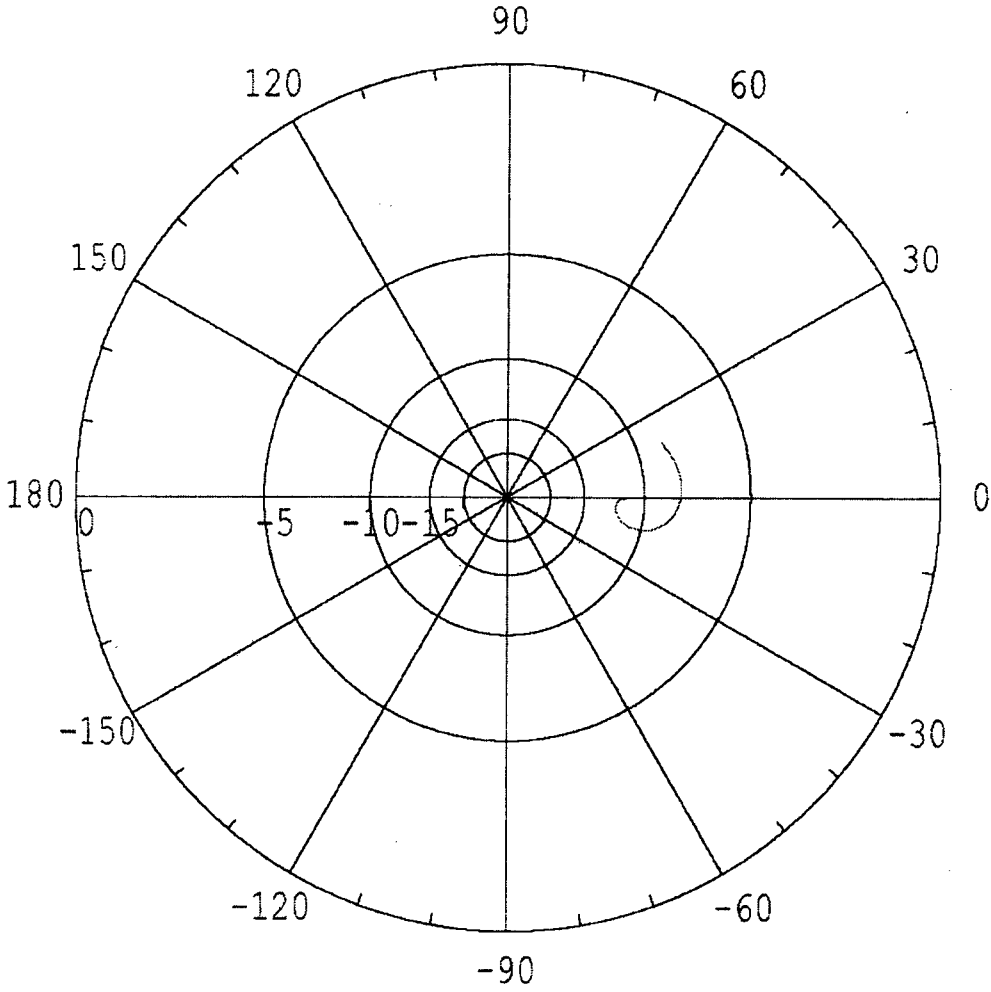


FIG. 3

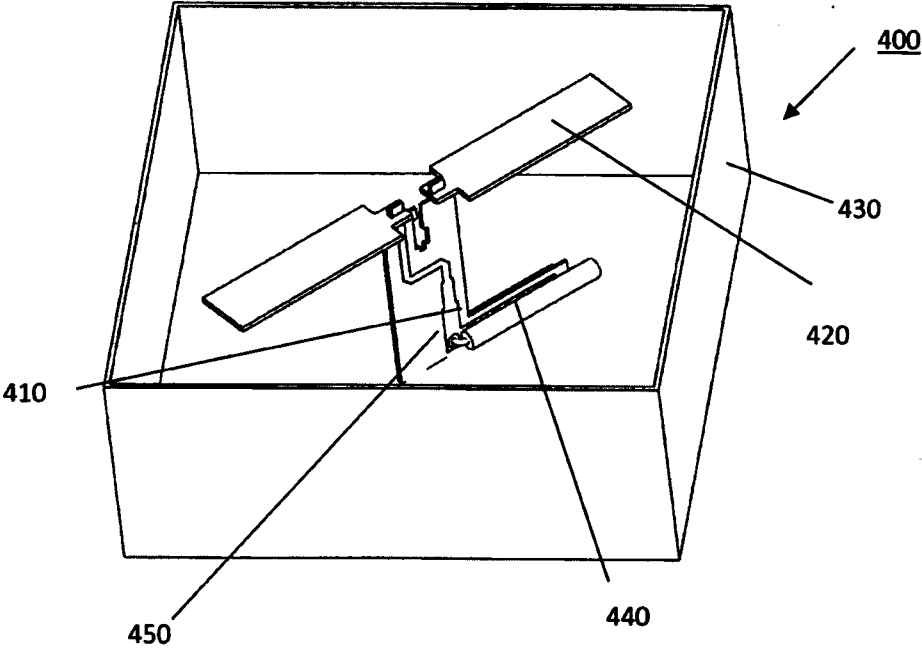


FIG. 4

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S11

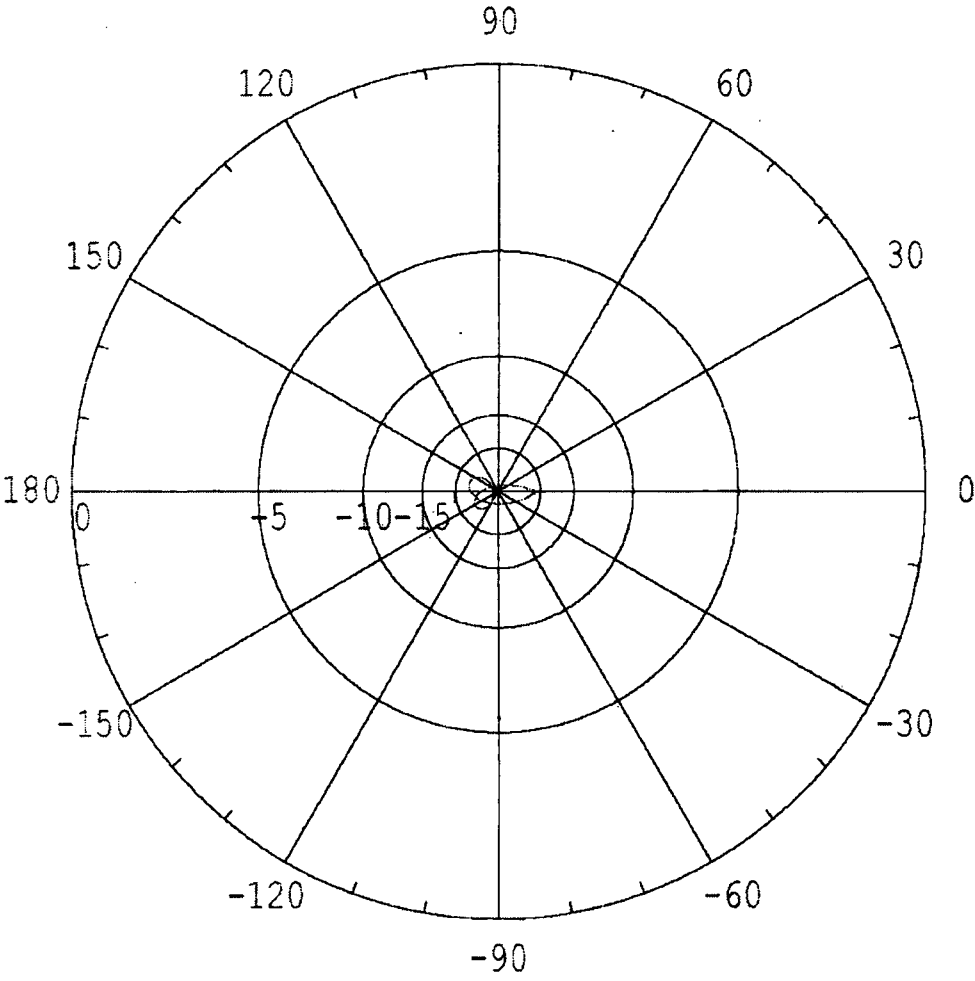


FIG. 5A

-5/5-

After Optimisation

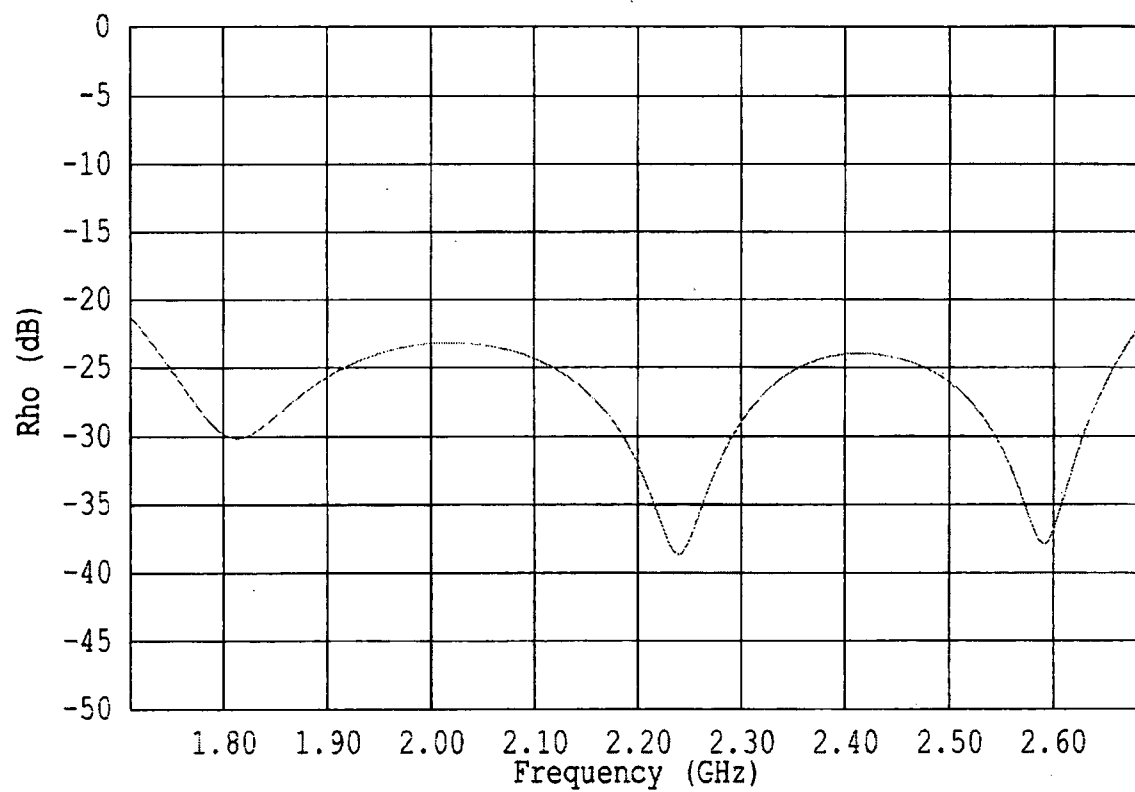


FIG. 5B

INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU2012/000174

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

H01Q 9/04 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI: radiator, antenna, waveguide, dipole and similar terms

Google Patents Espacenet: wideband antenna waveguide dipole

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 438 162 B (THOMSON-CSF) 8 October 2008 Fig. 3; page 6, line 1-page 7 line 6	1-23
A	US 2005/0110695 A1 (JUNG et al.) 26 May 2005 Fig. 2; paras. [0021]-[0030]	



Further documents are listed in the continuation of Box C



See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"E" earlier application or patent but published on or after the international filing date

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"O" document referring to an oral disclosure, use, exhibition or other means

"&" document member of the same patent family

"P" document published prior to the international filing date but later than the priority date claimed

Date of the actual completion of the international search
30 April 2012Date of mailing of the international search report
30 April 2012

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/AU2012/000174

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report				Patent Family Member			
GB	2438162	AU	2007253094	CA	2652756	CN	101808899
		EP	2019777	JP	2009538251	NO	20085286
		US	2010065683	WO	2007135373		
US	2005110695	KR	20050049630	US	7212162		
Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.							
END OF ANNEX							