

AN ANTENNA AND A METHOD OF FABRICATING AN ANTENNA

TECHNICAL FIELD

The present invention relates to antennas and methods of fabricating antennas.

BACKGROUND ART

5 An antenna is a device which converts an electrical signal from a conductor to an electromagnetic signal which can be transmitted and received through a transmission medium. For example microstrip antennas generally include a dielectric substrate with a radiating patch on one side and a ground plane on the opposite side. This traditional microstrip design may have low profile, small
10 size and low cost, but typically have relatively low gain and/or narrow bandwidth. Typically microstrip antennas have been employed in mobile radio communications devices and wireless local areas networks (WLAN).

Various methods have been devised to improve the bandwidth and/or gain of microstrip antennas, for example W. K. Wan Ali, "Broadband square microstrip
15 patch antenna with suspended parasitic element," IEEE Proceedings on Antennas, Propagation and EM Theory, pp. 50-53, Oct-Nov. 2003, S. Sakai, H. Arai, "Directivity gain enhancement of small antenna by parasitic patch," IEEE International Symposium on Antennas and Propagation Society, Vol. 1, pp. 320-323, Jun. 1998, R. V. Ketineni, U. Bafaji, A. Das, "Improvement of bandwidth in
20 microstrip antennas using parasitic patch," IEEE International Symposium on Antennas and Propagation Society, Vol. 4, pp. 1943-1947, Jul. 1992, U. S. Patent No. 3,978,487, U. S. Patent No. 4,370,657, Jan., 1983, U. S. Patent Publication No. 2003/0206138, U. S. Patent Publication No. 2005/0110692 and U. S. Patent No. 2005/0285795, Dec., 2005. However even with the above
25 improvement, the bandwidth of microstrip antennas is still relatively narrow-band and inadequate for some applications.

Ultra WideBand (UWB) communication is becoming increasingly popular. UWB allows a relatively high data transmission rate and is designed for short

- distances. For example currently UWB is understood to mean transmission from an antenna for which the -10dB bandwidth exceeds the lesser of 500 MHz or 20% of the centre frequency. The Federal Communications Commission (FCC) in the United States of America has currently authorised commercial
- 5 UWB devices to operate in the 3.1–10.6 GHz band. Some applications such as UWB may require an antenna with a relatively wide bandwidth. For example planar monopole antennas generally include a dielectric substrate with a radiating patch on one side, a ground plane beside or on the opposite side of a feed, and have a wide bandwidth.
- 10 In some applications, it may be necessary to modify the bandwidth of a UWB device. Various methods have been devised to modify the bandwidth, for example K. Chung, J. Kim and J. Choi, "Wideband microstrip-fed monopole antenna having frequency band-notch function," IEEE Microwave and Wireless Components Letters, Vol. 15, No. 11, pp. 766-768, Nov. 2005 and H. Yoon, H.
- 15 Kim, K. Chang, Y. J. Yoon and Y.-H. Kim, "A study on the UWB antenna with band-rejection characteristics," International Symposium on Antennas and Propagation, Vol. 2, pp. 1784-1787, Jun. 2004.

SUMMARY

- In general terms in a first aspect the invention proposes a monopole antenna
- 20 with a parasitic region. This may have one or more of the advantages of improved gain, improved efficiency, and reduced size.

- In a second independent aspect the invention proposes a monopole antenna with a slot in the active region configured to restrict the higher frequency limit. This may have one or more of the advantages of improved omnidirectionality
- 25 and improved gain in the null regions.

In a first specific expression of the invention there is provided a broadband monopole antenna comprising:

a dielectric substrate,
an active patch on the substrate,
a feed to electrically connect to the active patch, and
a parasitic patch on the substrate to electromagnetically couple to the
5 active patch.

In a second specific expression of the invention there is provided a monopole antenna comprising:

a dielectric substrate,
an active patch on the substrate,
10 a feed to electrically connect to the active patch, and
a slot in the active patch configured to restrict the higher frequency limit of the antenna.

In a third specific expression of the invention there is provided method of manufacturing a monopole antenna comprising:

15 providing a conductive sheet attached to a dielectric sheet,
planar etching the conductive sheet to form a plurality of antenna elements including an active patch and a parasitic patch,
providing a protective layer on the antenna elements,
singulating the sheets to form a plurality of individual antennas, and
20 attaching connectors to each antenna.

In a forth specific expression of the invention there is provided a method of manufacturing an monopole antenna comprising:

providing a conductive sheet attached to a dielectric sheet,
planar etching the conductive sheet to form a plurality of antenna
25 elements including an active patch and a slot in the active patch,
providing a protective layer on the antenna elements,
singulating the sheets to form a plurality of individual antennas, and
attaching connectors to each antenna.

BRIEF DESCRIPTION OF THE DRAWINGS

One or more non-limiting embodiments will now be described for the sake of example only with reference to the following figures in which:

FIG. 1a is a front view of an antenna according to an exemplary embodiment
5 drawn as if the substrate were transparent.

FIG. 1b is the side view the antenna in Figure 1.

FIG. 2 is a graph of the return loss against frequency of the antenna in Figure 1, with & without the slot.

FIG. 3 is a graph of the radiation pattern of the antenna in Figure 1 at 4.5 GHz
10 in the y-z plane, with and without the slot.

FIG. 4 is a front view of an antenna according to a further exemplary embodiment.

Figure 5 is a flow diagram of a method of manufacturing an antenna according to a still further exemplary embodiment.

15 DETAILED DESCRIPTION

In an exemplary embodiment a monopole antenna 100 is configured as shown in Figures 1(a) and 1(b). The antenna 100 includes a dielectric substrate 102, an active region or patch 104, a parasitic region or patch 106, a feed 108, a ground plane 110 and a slot 111 in the active patch 104. The antenna 100 may
20 also be called a UWB antenna, a planar monopole antenna, other technically similar terms or combinations thereof.

In operation the antenna 100 may either transmit or receive an electromagnetic signal. When the antenna 100 acts as a transmitter; an electrical signal is

received through the feed 108 which causes an electrical standing wave in the active patch 104. The parasitic patch 106 is electromagnetically coupled to the active patch 104. The standing wave in the active patch 104 and the parasitic patch 106 together generate an electromagnetic signal which is transmitted
 5 through the air to a remote receiving antenna.

When the antenna 100 acts as a receiver; the operation occurs in reverse. The electromagnetic signal travels from a remote transmitter and causes a standing wave in the active patch 104 and the parasitic patch 106, which in turn generates an electrical signal in the feed 108.

10 In order to generate or decode the electrical signal in the feed 108, hardware (not shown) may be provided such as a digital signal processor (DSP) and associated electronics. The DSP may be programmed using software according to a desired modulation technique such as orthogonal frequency division multiplexing (OFDM) across the UWB bandwidth.

15 The substrate 102 is a cuboid made from a dielectric of approximately 0.8mm thickness and a dielectric constant in the range of 3.33 to 3.43. In plan view the substrate 102 is generally rectangular shaped with an imaginary longitudinal centre line 112. The substrate has two opposed major surfaces; a first surface 114 and a second surface 116. An x-y plane is defined on the first surface 114,
 20 with a z axis perpendicular to the first surface 114.

The antenna 100 may be provided in a housing (not shown but including at least one non metallic section that will pass the electromagnetic signal) and may be generally oriented so that that the centre line 112 is vertical and the first surface 114 is facing in a first direction.

25 The active patch 104 is attached to the first surface 114 and is elliptical in shape (although circles and rectangles may also be used); with an imaginary minor axis 118 centred on the centre line 112 and an imaginary major axis 120

bisecting the centre line 112 at approximately $\frac{1}{3}$ of its length (measured from a first end of the substrate 102). The shape may be described as an elongated ellipse with a shorter minor axis compared to the major axis. The active patch 104 may be made of a conductor such as copper and may for example have a thickness of 0.5mm to 1mm. The length of the major axis 120 may determine the centre frequency of the operating bandwidth. The major axis 120 may be substantially $0.5\lambda_g$ in length, (although other lengths such as $0.25\lambda_g$ or λ_g may also be used) where λ_g is the wavelength in the substrate of the centre frequency. The minor axis may be approximately half the length of the major axis.

The parasitic patch 106 is attached to the first surface 114 and is elliptical in shape (again circles and rectangles may also be used); with an imaginary minor axis 122 on the centre line 112 and an imaginary major axis 124 bisecting the centre line 112 at approximately $\frac{2}{3}$ of its length (measured from the first end). The shape may be described as an elongated ellipse with a shorter minor axis compared to the major axis. The parasitic patch 106 may be the same material and thickness as the active patch 104. The parasitic patch 106 may be slightly larger than the active patch 104. For example the major axis 124 may be between $0.5\lambda_g$ and $0.7\lambda_g$ in length, for example $0.6\lambda_g$ (generally the parasitic patch would be longer than the active patch so if the active patch were $0.25\lambda_g$ or λ_g the parasitic patch would be correspondingly changed). The parasitic patch 106 may provide improved gain and efficiency in a relatively small sized antenna configuration.

The centre frequency may be defined as the midpoint between the lower frequency limit (where the return loss is -10dB or the VSWR is 2:1 eg: 3.9 GHz for 202 in Figure 2) and higher frequency limit (eg: 6 GHz for 202 in Figure 2). So in Figure 2 the centre frequency for 202 is 4.95GHz. Note that other definitions are possible. For example, it may be defined as the return loss (s11) dip. For 202, the return loss dip is 4.8GHz as shown in Figure 2.

For a dielectric constant of 3.38 and a centre frequency of 4.95GHz, an example length of the major axis is 16mm and the minor axis 6mm for the active patch 104 and for the parasitic patch 106 a major axis of 20mm and a minor axis of 16mm.

- 5 In Figure 1(a) a gap 126 is shown between the parasitic patch 106 and the active patch 104. Varying this gap 126 may be used to improve impedance matching. For example the gap 126 may be less than $0.03\lambda_g$.

The slot 111 may provide improved omnidirectivity and/or improved gain in the null regions. The slot 111 is parallel with the minor axis 118 and terminates at
10 the major axis 120 at substantially $0.125\lambda_g$ from the minor axis (for example between $0.12-0.13\lambda_g$). The slot 111 is rectangular in shape with a width the same as the feed 108.

Figure 2 shows the difference in bandwidth, with and without a slot. If a -10dB threshold is applied, the bandwidth 200 without a slot covers a much larger
15 portion of the FCC UWB band compared to the bandwidth 202 with a slot (between 3.9GHz and 6GHz). So in this case the slot has restricted the higher frequency limit to 6GHz. This graph was prepared using a simulation of a configuration similar to the exemplary embodiment described above.

Figure 3 shows the difference in the radiation pattern in the y-z plane, with and
20 without a slot. With the slot the gain 300 in the null regions is improved by 15-20dB compared to the gain 302 without a slot. Using a slot also improves the omnidirectionality in the x-z plane. This graph was prepared using a simulation of a configuration similar to the exemplary embodiment described above.

The feed 108 is attached to the first surface 114 along the centreline 112,
25 extending from the first end to the active patch 104. The feed 108 is rectangular in shape and is connected to an electrical signal source, thereby supplying the electrical signal to the active patch 104. Feed 108 is a

microstripline, for example having a characteristic impedance of 50Ω . The feed 108 may be the same material and thickness as the active patch 104.

The ground plane 110 is attached to the second surface 116 covering the entire width of the substrate 102, and extending from the first end to a point close to the active patch 104. In Figure 1(a) a gap 128 is shown between the ground plane 110 and the active patch 104. Varying this gap 128 may be used to improve the impedance matching. For example the gap 128 may be less than $0.04\lambda_g$.

In a further exemplary embodiment an antenna 400 is configured as shown in Figure 4. Generally the further exemplary embodiment in Figure 4 is similar to the exemplary embodiment shown in Figure 1, however there are several differences. For example, the ground plane 410 lies on the first surface 414 and has two portions on either side of the feed 408, both spaced by a gap 430.

The feed 408 is a coplanar waveguide (CPW), for example having a characteristic impedance of 50Ω .

In a still further exemplary embodiment an antenna may be fabricated according to the method 500 shown in Figure 5. In step 502 a copper sheet is attached to a dielectric sheet. In step 504 planar etching is used to form the individual elements, such as the patches, feed and ground planes. In step 506 a protective resin layer is coated over the copper elements. In step 508 the sheets are cut to singulate each antenna. In step 510 a connector is attached to each feed for later connection to signal processing hardware.

CLAIMS

1. A monopole antenna comprising:
a dielectric substrate,
5 an active patch on the substrate,
a feed to electrically connect to the active patch, and
a parasitic patch on the substrate to electromagnetically couple to the
active patch.
- 10 2. The antenna as claimed in claim 1 further comprising a slot in the active
patch.
3. The antenna as claimed in any one of the preceding claims wherein the
substrate has two opposed surfaces and the active patch and parasitic patch
15 are on a first of the opposed surfaces.
4. The antenna as claimed in any one of the preceding claims further
comprising a gap between the active patch and the parasitic patch.
- 20 5. The antenna as claimed in claim 4 wherein the gap is less than $0.03 \lambda_g$,
where λ_g is the wavelength of the centre frequency in the substrate
6. The antenna as claimed in any one of the preceding claims, wherein the
active patch is elliptical in shape, having a minor axis and a major axis.
25
7. The antenna as claimed in claim 6 wherein the length of the major axis of
the active patch is substantially $0.5\lambda_g$, where λ_g is the wavelength of the centre
frequency in the substrate.
- 30 8. The antenna as claimed in any one of the preceding claims wherein the
parasitic patch is elliptical in shape, having a minor axis and a major axis.

9. The antenna as claimed in claim 8 wherein the length of the major axis of the parasitic patch is between $0.5\lambda_g$ and $0.7\lambda_g$, where λ_g is the wavelength of the centre frequency in the substrate.
- 5 10. The antenna as claimed in any one of the preceding claims wherein the shape the active patch and the parasitic patch is an elongated ellipse.
11. The antenna as claimed in claim 3 or any one of claims 4 to 10 when dependant on claim 3, wherein the feed is a microstripline, and further
10 comprising a ground plane on a second of the opposed surfaces adjacent to the feed.
12. The antenna as claimed in claim 3 or any one of claims 4 to 15 when dependant on claim 3, wherein the feed is a coplanar waveguide (CPW) and
15 further comprising a ground plane on the first surface having two portions either side of the feed.
13. The antenna as claimed in claim 12 further comprising a feed gap between feed and the ground plane.
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14. The antenna as claimed in any one of claims 11 to 13 further comprising a active gap between the active patch and the ground plane.
15. The antenna as claimed in claim 14 wherein the active gap is less than
25 $0.04\lambda_g$, where λ_g is the wavelength of the centre frequency in the substrate.
16. A monopole antenna comprising:
a dielectric substrate,
an active patch on the substrate,
30 a feed to electrically connect to the active patch, and
a slot in the active patch configured to restrict the higher frequency limit of the antenna.

17. The antenna as claimed in any one of claims 2, 16 or claims 3 to 15 when dependant on claim 2 wherein the slot is parallel to the minor axis, spaced from the minor axis substantially by $0.125\lambda_g$ and terminates substantially at the major axis, where λ_g is the wavelength of the centre frequency in the substrate.
18. The antenna as claimed in claim 17, wherein the slot has substantially the same width as the feed.
19. The antenna as claimed in any one of the preceding claims wherein the antenna is an Ultra WideBand (UWB) antenna and/or a planar monopole antenna.
20. A method of manufacturing an monopole antenna comprising:
 providing a conductive sheet attached to a dielectric sheet,
 planar etching the conductive sheet to form a plurality of antenna elements including an active patch and a parasitic patch,
 providing a protective layer on the antenna elements,
 singulating the sheets to form a plurality of individual antennas, and
 attaching connectors to each antenna.
21. A method of manufacturing an monopole antenna comprising:
 providing a conductive sheet attached to a dielectric sheet,
 planar etching the conductive sheet to form a plurality of antenna elements including an active patch and a slot in the active patch,
 providing a protective layer on the antenna elements,
 singulating the sheets to form a plurality of individual antennas, and
 attaching connectors to each antenna.