

"A Broadband Monopole Antenna"

THIS INVENTION relates to a broadband monopole antenna comprising a monopole radiating element and a sleeve element enclosing a part of the monopole radiating element, which antenna is operable over a bandwidth defined between a low operating frequency and a high operating frequency.

In some telecommunication applications a short antenna with a large bandwidth having omni-directional coverage is required. In particular, mobile communication applications such as cellular telephones and portable radio transceivers using a handset demand such a short antenna in order to minimize the size of the portable unit. Quarter wavelength ($\lambda/4$) antennae are very popular in such applications but suffer from a narrow bandwidth. It is known to increase the bandwidth by using matching circuitry incorporating reactive components such as inductors and capacitors. However, such matching circuitry reduces the overall efficiency of the antenna and increases radiation losses.

US 4 509 056 discloses a multi-frequency antenna which can operate effectively at a number of different frequencies. This is achieved by employing tuned sleeve chokes which can be positioned to isolate one end of one of the chokes to form a quarter wave antenna. Such an antenna does not provide an increased bandwidth but merely increases the range of frequencies in which the antenna can operate once it has been tuned by appropriate location of the sleeve chokes.

US 5 231 412 discloses a quarter wavelength helical radiating element coupled with a cylindrical conducting sleeve. The length of the monopole radiating element is a

quarter wavelength of the desired centre frequency of the antenna. It is well known that helical antenna elements have a very narrow bandwidth for omni-directional applications and that the addition of a coupling sleeve would merely increase the bandwidth slightly.

The present invention seeks to provide a broadband monopole antenna with omni-directional radiation having a greater bandwidth than the known monopole antennae and conventional sleeve antennae.

Accordingly, the present invention provides a broadband monopole antenna operable over a bandwidth defined between a low operating frequency f_1 at a wavelength of λ_1 and a high operating frequency f_2 at a wavelength of λ_2 , which antenna comprises: a monopole radiating element; and a sleeve element enclosing at least a part of the monopole radiating element, the sleeve element having a length l_2 of substantially $0.26\lambda_2$ and a selected diameter, the reactance of the input impedance of the antenna tending to zero at the selected diameter.

Preferably, the ratio of $f_2:f_1$ is of the order of 2.275:1 at a VSWR of 2:1, i.e. $\approx 77\%$.

Conveniently, the length of the monopole radiating element is substantially $0.254\lambda_1$.

Advantageously, the monopole radiating element is surrounded by a dielectric which separates the monopole radiating element from the sleeve element.

Preferably, the dielectric is selected to allow operation of the antenna over a desired operating frequency range.

Conveniently, the antenna is manufactured from a length of coaxial cable having a central conductor, a layer of insulating dielectric and a surrounding coaxial conductor, the monopole radiating element comprising the central conductor, the sleeve element comprising the coaxial conductor and the monopole radiating element being separated from the sleeve element by the insulating dielectric.

Advantageously, a broadband monopole antenna is provided in combination with a radio receiver, the sleeve element being located substantially inside the body of the radio receiver, a portion of the monopole radiating element projecting from the sleeve element and the body.

In order that the present invention may be more readily understood, an embodiment thereof will now be described, by way of example, with reference to the accompanying drawings, in which:

FIGURE 1 shows an ideal quarter wavelength monopole antenna on an infinite ground plane;

FIGURE 2 shows a practical quarter wavelength monopole antenna on a finite ground plane having a coaxial feed;

FIGURE 3 shows a radio handset having a quarter wavelength monopole antenna on a limited ground plane;

FIGURE 4 is a perspective view of a monopole antenna embodying the present invention;

FIGURE 5 is a top view of the monopole antenna of Figure 4;

FIGURE 6 shows the experimental results for a monopole antenna embodying the present invention operating between a low operating frequency of 233 MHz and a high operating frequency of 530 MHz; and

FIGURE 7 shows a radio handset including a monopole antenna embodying the present invention.

An ideal quarter wavelength monopole antenna 1 is shown in Figure 1 on an infinite ground plane 2. It is not possible to provide an infinite ground plane 2 in practical situations as the quarter wavelength monopole antenna 1 is often mounted on a very small ground plane 2 such as that provided by a radio handset casing 3 and as shown in Figures 2 and 3.

Referring to Figures 4 and 5, a broadband monopole antenna 5 embodying the present invention comprises a feed connector 6, such as a coaxial feed connector, from which an elongate monopole radiating element 7 and a sleeve element 8 extend. In the present example, the monopole radiating element 7 is an elongate metal core ohmically connected to a core of the coaxial feed connector 6. The sleeve element 8 is made from a conductive hollow copper tube or other equivalent material and is ohmically connected to an outer coaxial conducting portion of the coaxial feed connector 6 which is, in turn, grounded to, for example, a radio handset casing. Thus, the monopole radiating element 7 is coaxially located within the cylindrical sleeve element 8. The sleeve element 8 may also be made from a conductive mesh or braided structure.

The monopole antenna 5 embodying the present invention is specifically designed to operate over a predetermined bandwidth. The bandwidth is determined by

the relative lengths of the monopole radiating element 7 and the sleeve element 8 and the diameter of the sleeve element 8. The length l_1 of the monopole radiating element 7 is approximately $0.26\lambda_1$, where λ_1 is the wavelength of a low operating frequency f_1 . The length l_2 of the sleeve element 8 is approximately $0.26\lambda_2$, where λ_2 is the wavelength of a high operating frequency f_2 . Preferably, the length of the monopole radiating element 7 is $0.264\lambda_1$. The lengths of the monopole radiating element 7 and the sleeve element 8 may vary by $\pm 0.005\lambda_1$ and $\pm 0.005\lambda_2$ respectively. Since λ_1 is greater than λ_2 , a portion 7A of the monopole radiating element 7 projects from the sleeve element 8.

The diameter of the sleeve element 8 is chosen to match the impedance of the antenna 5 such that the reactance element of the impedance tends to zero. Typically the sleeve element 5 will have an internal diameter of $8\text{mm} \pm 2\text{mm}$, i.e. between 6 mm and 10 mm. It should be noted that in conventional quarter wavelength sleeve antennae, the diameter of the sleeve element is irrelevant as the impedance would always be substantially matched. However, since the present invention does not use a conventional quarter wavelength antenna structure, the internal diameter of the sleeve element 8 is important.

Once an internal diameter for the sleeve element 8 has been selected which results in a matched impedance, then if the antenna is required to operate over a higher range of frequencies, a smaller internal diameter is needed and, conversely, if the antenna is required to operate over a lower range of frequencies, a larger internal diameter would be needed.

Because of the specific selection of the relative dimensions of the monopole radiating element 7 and the sleeve element 8, it is possible to achieve a very wide bandwidth. With a voltage standing wave ratio (VSWR) of 2:1, the bandwidth ratio achievable between the high operating frequency f_2 and the low operating frequency f_1 is of the order of 2.275:1, which is considerably larger than that offered by a conventional quarter wavelength monopole mounted on a small ground plane, a helical radiating element coupled with a cylindrical conducting sleeve or a conventional sleeve monopole.

As can be seen from Figure 6, it is possible to configure a broadband monopole antenna having a low operating frequency f_1 of 233 MHz and a high operating frequency f_2 of 530 MHz at a voltage standing wave ratio of 2:1. The percentage bandwidth over centre frequency is, in the example: $(530 \text{ MHz} - 233 \text{ MHz}) / ((530 \text{ MHz} + 233 \text{ MHz}) / 2) = 77.85\%$. None of the presently available monopole antenna structures are capable of providing a bandwidth as wide as that provided by the present invention.

Preferably the monopole radiating element 7 is separated from the sleeve element 8 by a dielectric which can be either a suitable insulating material such as, for example, polyethylene (relative permittivity of 2.28), Teflon or a liquid or gas such as air. In the example shown in Figures 4 and 5, the monopole radiating element 7 is fully surrounded by a dielectric 9 which thereby separates the monopole radiating element 7 from the sleeve element 8. The sleeve element 8 is further separated from the monopole radiating element 7 by a further dielectric 10 located between the sleeve element 8 and the dielectric 9 surrounding the monopole radiating element 7. It is possible in some circumstances for the further dielectric

10 to be air.

It is possible to make a broadband monopole antenna embodying the present invention from a length of commercially available coaxial cable. Commercially available coaxial cable has a central conductor; a layer of insulating dielectric; and a surrounding coaxial conductor. The monopole radiating element 7 comprises the central conductor, the sleeve element 8 comprises the coaxial conductor and the monopole radiating element 7 is separated from the sleeve element 8 by the insulating dielectric 9. The sleeve element 8 and the monopole radiating element 7 are cut to the required lengths ℓ_2 , ℓ_1 , being $0.26\lambda_2$ and $0.264\lambda_1$ respectively.

An advantageous application of the present invention allows the sleeve element 8 of the monopole antenna 5 to be fully housed within the handset 11 of a radio receiver, transmitter or transceiver 12. Such an arrangement is shown in Figure 7. Thus, in contrast to conventional monopole antennae, the feed for the monopole antenna 5 can be located within the handset 11 of the radio transceiver, for example, and the only portion of the monopole antenna 5 projecting from the handset 11 comprises that portion 7A of the monopole radiating element 7 which is not surrounded by the sleeve element 8, this projecting portion 7A having a length of approximately $0.26(\lambda_1 - \lambda_2)$. Such an arrangement provides a considerable space saving over the conventional quarter wavelength monopole antenna which would have a length projecting from the handset of $\lambda/4$, where λ is generally the wavelength corresponding to the desired centre frequency of the antenna.

A broadband monopole antenna 5 embodying the present invention can easily be adapted to operate in

frequency bands other than VHF/UHF frequency bands by selecting the dielectric used and the height and diameter of the monopole radiating element 7 and the sleeve element 8, the relative lengths of the monopole radiating element 7 and the sleeve element 8 being kept within the limits prescribed by the claimed invention.

Typically, the sleeve element 8 can be manufactured from hollow metallic cylindrical structures made of, for example, copper, aluminium or similar electrically conductive material.

**CLAIMS:**

1. A broadband monopole antenna operable over a bandwidth defined between a low operating frequency f_1 at a wavelength of λ_1 and a high operating frequency f_2 at a wavelength of λ_2 , which antenna comprises:

a monopole radiating element; and

a sleeve element enclosing at least a part of the monopole radiating element, the sleeve element having a length l_2 of substantially $0.26\lambda_2$ and a selected diameter, the reactance of the input impedance of the antenna tending to zero at the selected diameter.

2. A broadband monopole antenna according to Claim 1, wherein the internal diameter of the sleeve element is typically $8\text{mm} \pm 2\text{mm}$.

3. A broadband monopole antenna according to Claim 1 or 2, wherein the monopole radiating element has a length l_1 of substantially $0.264\lambda_1$.

4. A broadband monopole antenna according to Claim 1 or 2, wherein the length of the monopole radiating element is $(0.264 \pm 0.005)\lambda_1$.

5. A broadband monopole antenna according to any preceding claim, wherein the ratio of $f_2:f_1$ is of the order of 2.275:1 at a VSWR of 2:1.

6. A broadband monopole antenna according to any preceding claim, wherein the length of the sleeve element is $(0.26 \pm 0.005)\lambda_2$.



7. A broadband monopole antenna according to any preceding claim, wherein the monopole radiating element is separated from the sleeve element by a dielectric.

8. A broadband monopole antenna according to any preceding claim, wherein the monopole radiating element is surrounded by a dielectric which separates the monopole radiating element from the sleeve element.

9. A broadband monopole antenna according to Claim 8, wherein the monopole radiating element surrounded by the dielectric is further separated from the sleeve element by a further dielectric.

10. A broadband monopole antenna according to Claim 9, wherein the further dielectric is air.

11. A broadband monopole antenna according to any one of Claims 7 to 10, wherein the dielectric is selected to allow operation of the antenna over a desired operating frequency range.

12. A broadband monopole antenna according to any preceding claim, wherein the sleeve element is grounded.

13. A broadband monopole antenna according to any preceding claim, wherein the antenna is manufactured from a length of coaxial cable having a central conductor, a layer of insulating dielectric and a surrounding coaxial conductor, the monopole radiating element comprising the central conductor, the sleeve element comprising the coaxial conductor and the monopole radiating element being separated from the sleeve element by the insulating dielectric.



14. A broadband monopole antenna according to any preceding claim, wherein the sleeve element is flexible and is manufactured from a conductive hollow tube or conductive mesh or braided structure.

15. A broadband monopole antenna according to any preceding claim, wherein the antenna is operable over the VHF/UHF frequency range.

16. A broadband monopole antenna according to any preceding claim in combination with a radio receiver, wherein the sleeve element is located substantially inside the body of the radio receiver, a portion of the monopole radiating element projecting from the sleeve element and the body.

17. A broadband monopole antenna according to any one of Claims 1 to 15 in combination with a radio transmitter, wherein the sleeve element is located substantially inside the body of the radio transmitter, a portion of the monopole radiating element projecting from the sleeve element and the body.

18. A broadband monopole antenna according to any one of Claims 1 to 15 in combination with a radio transceiver, wherein the sleeve element is located substantially inside the body of the radio transceiver, a portion of the monopole radiating element projecting from the sleeve element and the body.

19. A broadband monopole antenna according to any one of Claims 16 to 18, wherein the projecting portion of the monopole radiating element is flexible.



20. A broadband monopole antenna according to any one of Claims 16 to 19, wherein the antenna is provided with a coaxial feed.