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Parametric Analysis of Various Shapes of Planar Metal Plate Monopole Antenna for UWB Application

Raja Raghuwanshi and Prof Anil Khandelwal
**M.TECH. Scholar, Department of Electronics & Communication Engineering,*
VNS Faculty of Technology, Bhopal, (Madhya Pradesh), India
*** Dean PG, Department of Electronics & Communication Engineering,*
VNS Faculty of Technology, Bhopal, (Madhya Pradesh), India

(Corresponding author: Raja Raghuwanshi)
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ABSTRACT: In this paper various shape planar plate monopole antenna are presented. The antennas of various shapes are elliptical, hexagonal, and circular with the same dimensions of feeder and ground plane. The proposed antennas were simulated using HFSS (High Frequency Structural Simulator). Simulation results and comparison for return loss (S11), gain are Presented and discussed over the UWB frequency.

Keywords: Monopole antenna, ultra-wideband frequency, return loss and gain. I.

I. INTRODUCTION

Antennas are required by any radio receiver or transmitter to couple its electrical connection to the electromagnetic field. Radio waves are waves which carry signals through the air (or through space) at the speed of light with almost no transmission loss. Radio transmitters and receivers are used to convey signals (information) in systems including broadcast (audio) radio, television, mobile telephones, Wi-Fi (WLAN) data networks, trunk lines and point-to-point communications links (telephone, data networks), satellite links, many remote controlled devices such as garage door openers, and wireless remote sensors, among many others [1]. Radio waves are also used directly for measurements in technologies including RADAR, GPS, and radio astronomy. In each and every case, the transmitters and receivers involved require antennas, although these are sometimes hidden (such as the antenna inside an AM radio or inside a laptop computer equipped with Wi-Fi).

A simpler technique, with lower cost, is to replace the cylindrical stub of a conventional monopole with a planar element, yielding a planar monopole. Meinke and Gundlach, who mentioned it as a variant of the cylindrical and conical monopoles, first described the planar monopol. They observed the wide impedance characteristics of this antenna. Later a number of different shapes have been studied which fit into this category of broadband planar monopoles antennas [3].

A. Planar Monopole Antenna

A planar monopole may be realized by replacing the wire element of a conventional monopole with a planar element. The planar element is located at a distance h above the ground plane [1]. The replacing of wire element with planar element, with various shapes, increases the surface areas of the monopoles, there by having a direct impact on BW. Planar monopole antennas provide maximum flexibility by radiating over radio terminal's entire frequency range. They can be developed to cover frequency extremities from GSM900/NADC through GSM1800/PCS1900, IMT-2000, the 2.45GHz and 5.8GHz ISM bands and including UWB [1].

B. Microstrip Antenna

A MSA (Micro Strip Antenna) consists of a dielectric substrate having a metallic radiating part on one side and a metallic ground plane on the other. Common microstrip antenna shapes are square, rectangular, circular and elliptical, because of easy fabrication and easy analysis; but any continuous shape can be used. Some microstrip antennas do not use a dielectric substrate and instead they use a metal patch mounted above a ground plane using dielectric spacers . Such antennas have a very low profile, are mechanically rugged and conformable to planar and non-planar surfaces, they are often mounted on the exterior of aircrafts, or are used in mobile radio communications devices.

Microstrip antennas are also relatively cheap to manufacture using modern Printed-Circuit type technology. They are usually employed at UHF and higher frequencies because the size of the antenna is directly related to the wavelength at the resonant frequency.

C. UWB Technology

UWB (Ultra Wide-Band) is a radio communication technology that uses very low energy pulses & it is intended for short-range-cum-high-bandwidth communications by using a huge chunk of the radio spectrum (in GHz Range) [5].

UWB communications transmit in a way that doesn't interfere with other traditional narrowband and continuous carrier wave systems operating in the same frequency band And UWB is a Very High-speed alternative to existing wireless technologies such as WLAN, HiperLAN.

II. PREVIOUS WORK

Planar Monopole Antenna on Modified Ground Plane Structures for L frequency Band Applications In this several planar such as square, circular, triangular and hexagon shaped monopole antenna with single feeding strip above the modified ground plane structure are presented.[3] It is designed for the 1-2 GHz frequency band for L-band application. Also presented the effects of feeding strip length on the impedance bandwidth.

III. PROPOSED METHODOLOGY

A. Calculation of the Lower Frequency of the Planar Monopole Antennas

In a planar monopole antenna, the lower frequency corresponding to VSWR = 2 can be approximately calculated by equating its area (in this case, a rectangular disc monopole) to that of an equivalent cylindrical monopole antenna of same height L and equivalent radius r, as described below

Which gives

$$r = W/(2\pi)$$
$$L = 0.24\lambda F$$

Where

$$F = (L/r)/(1 + L/r) = L/(L + r)$$

the wavelength λ is obtained as:

$$\lambda = (L + r)/0.24$$

Therefore, the lower frequency fL is given by:

$$fL = c/\lambda = (30 * 0.24)/(L + r) = 7.2/(L + r)\ \text{GHz}$$

It does not account for the effect of the probe length p, which increases the total length of the antenna thereby reducing the frequency. Accordingly, this equation is modified to

$$fL = 7.2/(L + r + p)\ \text{GHz}$$

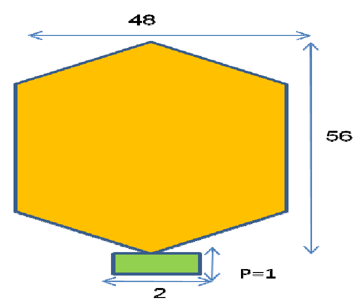
Where L, r, and p are in centimeters.

B. Design of various shapes of Planar Plate Monopole Antenna

It configurations of the Hexagonal, circular and Elliptical planar plate monopole antenna on same square ground plane with different feeding strip length have been designed.

C. Hexagonal Planar Plate Monopole Antenna

The side length l of the hexagon is 28mm. The proposed Hexagonal planar plate monopole antenna is vertically mounted above the square ground plane structure of size 300*300 mm2. The Hexagonal planar plate monopole antenna and single feeding strip are integrated together. Feeding strip has a uniform width of 2 mm and a length of 1 mm and is connected to a centre of the Hexagonal planar plate monopole antenna.



All dimensions in mm

Fig. 1. Hexagonal Planar Plate Monopole Antenna**.**

For the Hexagonal Planar Plate Monopole Antenna values L and r of the Equivalent cylindrical monopole antenna is given by:

$$L = 2l$$
$$r = 3\sqrt{3l/(8\pi)}$$

For these values of L and r, the lower frequency fL is computed from

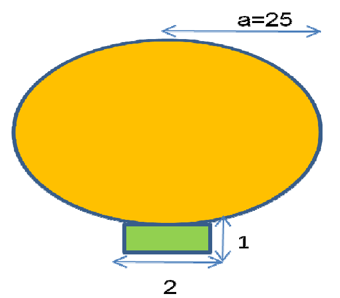
l=2.8cm

p=.1cm

$fL = 1.1$ 1GHz

D. Circular Planar Plate Monopole Antenna

The radius of circular planar plate monopole antenna a is taken equal to 25mm, The proposed circular planar plate monopole antenna is vertically mounted above the square ground plane structure of size 300*300 mm2.The circular planar plate monopole antenna and single feeding strip are integrated together. Feeding strip has a uniform width of 2 mm and a length of 1 mm and is connected to a centre of the circular planar plate monopole antenna.



All dimensions in mm

Fig. 2. Circular Planar Plate Monopole Antenna.

For the Circular Planar Plate Monopole Antenna values L and r of the Equivalent cylindrical monopole antenna is given by:

$$L = 2a$$
$$r = a/4$$

For these values of L and r, the lower frequency $f\,L$ is computed from

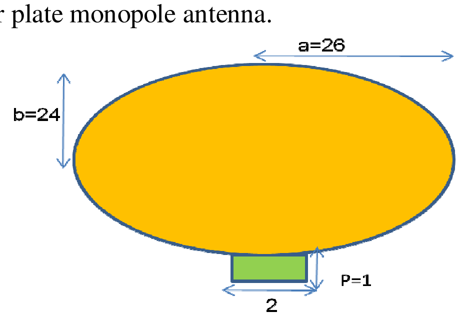
a=2.5cm

p=.1cm

$$fL = 1.25\text{GHz}$$

E. Elliptical Planar Plate Monopole Antenna

The dimensions of the Elliptical planar plate monopole antenna (i.e., major axis length = 2a and minor axis length = 2b). a is taken equal to 26mm The ellipticity ratio is chosen as a/b 1.08,The proposed Elliptical planar plate monopole antenna is vertically mounted above the square ground plane structure of size 300*300 mm2 The Elliptical planar plate monopole antenna and single feeding strip are integrated together. Feeding strip has a uniform width of 2 mm and a length of 1 mm and is connected to a centre of the Elliptical planar plate monopole antenna.



All dimensions in mm

Fig. 3. Elliptical Planar Plate Monopole Antenna.

For the Elliptical Planar Plate Monopole Antenna the L and r of the effective cylindrical monopole are determined by equating its area as:

$$2\pi\, r\, L = \pi ab$$
$$L = 2b$$
$$r = a/4$$

For these values of L and r, the lower frequency $f\,L$ is computed from

a=2.6 cm

b=2.5 cm

p=.1cm

$$fL = 1.2\ 9\text{GHz}$$

IV. EXPERIMENTAL RESULT

In This thesis VSWR is a measure of how much power is delivered to an antenna. This does not mean that the antenna radiates all the power it receives. Hence, VSWR measures the potential to radiate. A low VSWR means the antenna is well-matched, but does not necessarily mean the power delivered is also radiated. An anechoic chamber or other radiated antenna test is required to determine the radiated power. VSWR alone is not sufficient to determine an antenna is functioning properly.

When an antenna and feedline do not have matching impedances, some of the electrical energy cannot be transferred from the feedline to the antenna.[4] Energy not transferred to the antenna is reflected back towards the transmitter.[5] It is the interaction of these reflected waves with forward waves which causes standing wave patterns.[4] Reflected power has three main implications in radio transmitters: Radio Frequency (RF) energy losses increase, distortion on transmitter due to reflected power from load [4] and damage to the transmitter can occur Matching the impedance of the antenna to the impedance of the feed line is typically done using an antenna tuner. The tuner can be installed between the transmitter and the feed line, or between the feed line and the antenna.

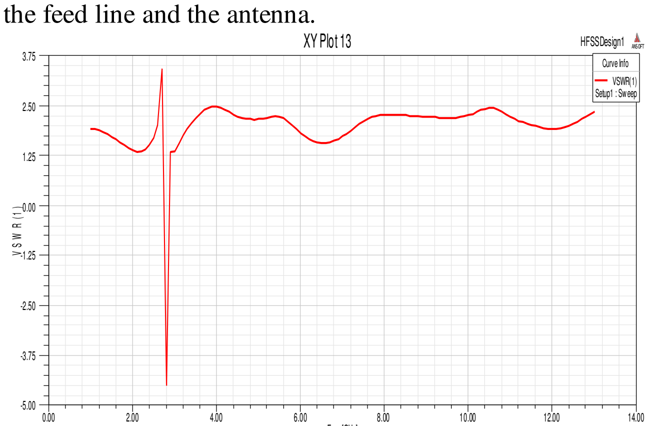


Fig. 4. Hexagonal planar plate monopole antenna with feeding strip length= 1mm.

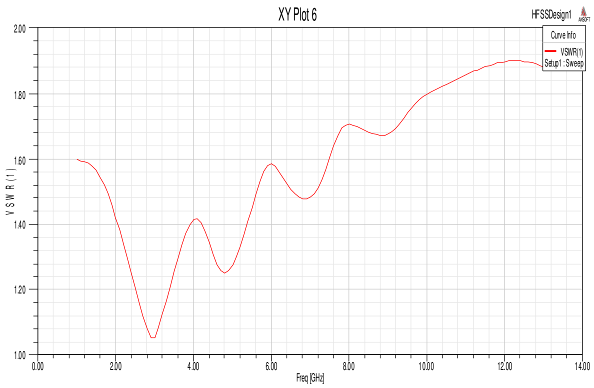


Fig. 5. Circular planar plate monopole antenna with feeding strip length= 1mm.

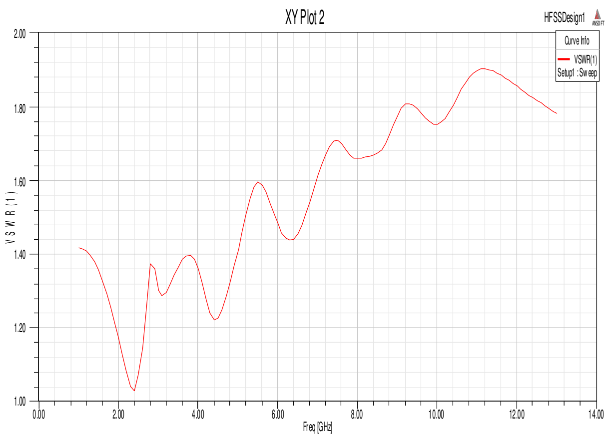


Fig. 6. Elliptical planar plate monopole antenna with feeding strip length =1mm.

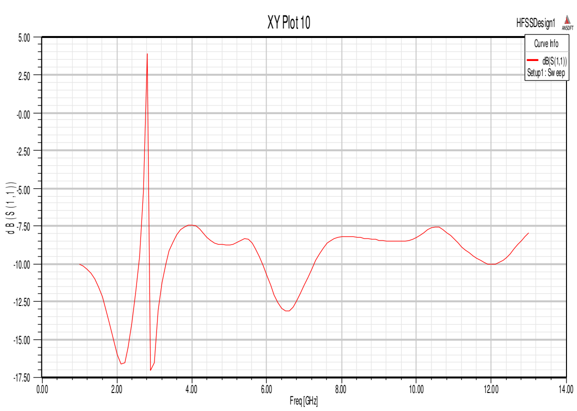


Fig. 7. Hexagonal planar plate monopole antenna with feeding strip length= 1mm.

Both installation methods will allow the transmitter to operate at a low SWR, however if the tuner is installed at the transmitter, the feed line between the tuner and the antenna will still operate with a high SWR, causing additional RF energy to be lost through the feedline.

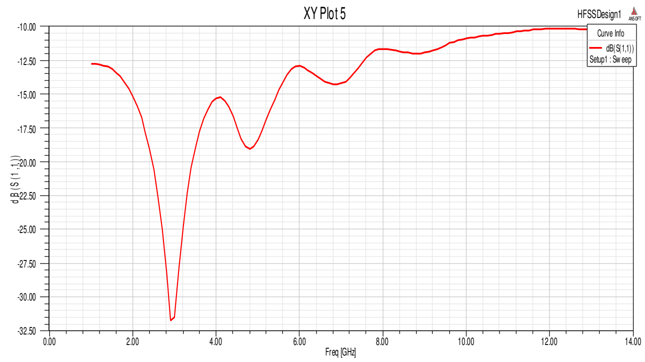


Fig. 8. Circular planar plate monopole antenna with feeding strip length= 1mm.

Table 5.1 Antenna configuration and VSWR.

ANTENNA CONFIGURATION	BANDWITDTH(GHz) (VSWR)
Hexagonal planar plate monopole antenna with feeding strip length= 1mm.	1.6 (1-2.6)
Circular planar plate monopole antenna with feeding strip length= 1mm.	12 (1-13)
Elliptical planar plate monopole antenna with feeding strip length = 1 mm	12 (1-13)

A. Return Loss

S-parameters describe the input-output relationship between ports (or terminals) in an electrical system. For instance, if we have 2 ports (intelligently called Port 1 and Port 2). S11 represents the reflected power radio 1 is trying to deliver to antenna 1.Return loss(S11) is the loss of power in the signal returned/reflected by a discontinuity in a transmission line or optical fiber. This discontinuity can be a mismatch with the terminating load or with a device inserted in the line. Return loss is a measure of how well devices or lines are matched.[4] The bandwidth of the antenna can be said to be those range of frequencies over which the RL is greater than -10 dB It is usually expressed as a ratio in decibels (dB);

$$RL(\mathrm{dB}) = 10\log_{10}\frac{P_\mathrm{i}}{P_\mathrm{r}}$$

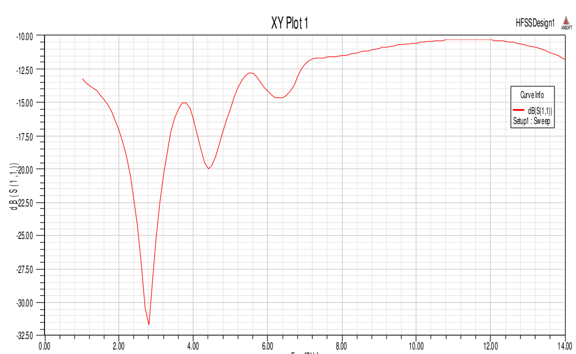


Fig. 9. Elliptical planar plate monopole antenna with feeding length= 1mm.

Table 2: Antenna configuration and Return loss.

ANTENNA CONFIGURATION	BANDWITDTH (GHz)
Hexagonal planar plate monopole antenna with feeding strip length= 1mm.	1.6 (1-2.6)
Circular planar plate monopole antenna with feeding strip length= 1mm.	12 (1-13)
Elliptical planar plate monopole antenna with feeding strip length = 1 mm	13 (1-14)

B. Gain

The antenna gain measurement is linearly related to the directivity measurement through the antenna radiation efficiency. The antenna absolute gain is "the ratio of the intensity, in a given direction, to the radiation intensity that would be obtained if the power accepted by the antenna were radiated isotropically."

$$G = 4\pi U(\theta, \varphi) / Pin$$

Also, if the direction of the gain measurement is not indicated, the direction of maximum gain is assumed. The gain measurement is referred to the power at the input terminals rather than the radiated power, so it tends to be a more thorough measurement, which reflects the losses in the antenna structure.

Antenna gain relates the intensity of an antenna in a given direction to the intensity that would be produced by a hypothetical ideal antenna that radiates equally in all directions (isotropically) and has no losses. Since the radiation intensity from a lossless isotropic antenna equals the power into the antenna divided by a solid angle of 4π steradians, we can write the following equation:

Although the gain of an antenna is directly related to its directivity, the antenna gain is a measure that also takes into account the efficiency of the antenna, that is, the fraction of the input power dissipated in losses such as resistance. In contrast, directivity is defined as a measure that takes into account only the directional properties of the antenna and therefore it is only influenced by the antenna pattern. However, if we assumed an ideal antenna without losses then antenna gain will equal directivity as the antenna efficiency factor equals 1 (100% efficiency). Therefore, for real antennas, the gain of an antenna is always less than its directivity.

Input power is transformed into radiated power and surface wave power while a small portion is dissipated due to conductor and dielectric losses of the materials used. Surface waves are guided waves captured within the substrate and partially radiated and reflected back at the substrate edges.

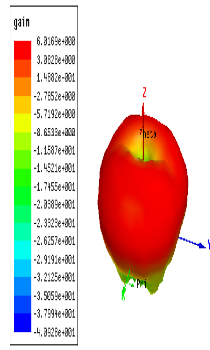


Fig. 10. Gain of hexagonal planar plate monopole antenna with feeding strip length= 1mm.

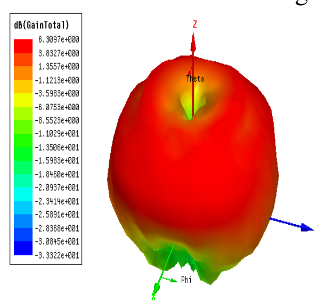


Fig. 11. Gain of circular planar plate monopole antenna with feeding strip length= 1mm.

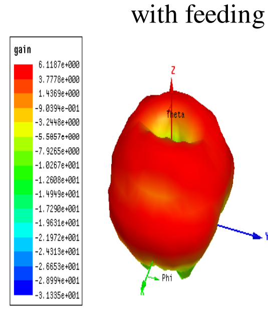


Fig. 12. Gain of elliptical planar plate monopole antenna with feeding strip length= 1 mm.

Table 3: Antenna configuration and Gain at 6.5 GHz'.

ANTENNA CONFIGURATION	GAIN(db)
Hexagonal planar plate monopole antenna with feeding strip length= 1mm.	6.016
Circular planar plate monopole antenna with feeding strip length= 1mm.	6.309
Elliptical planar plate monopole antenna with feeding strip length= 1 mm	6.118

V. CONCLUSION

In this paper provide new configurations of the Hexagonal, circular and Elliptical planar plate monopole antenna on same square ground plane have been investigated. The dissertation can be concluded as following:

Hexagonal planar plate monopole antenna exhibits the bandwidth from 1 GHz to 2.6 GHz which is not suitable for ultra wide bandwidth.

Circular planar plate monopole antenna exhibits the bandwidth from 1 GHz to 13 GHz and Elliptical planar plate monopole antenna exhibits the bandwidth from 1 GHz to 14 GHz..Circular and Elliptical planar plate monopole antenna are suitable for ultra wide bandwidth. But Elliptical planar plate monopole antenna exhibits the bandwidth more than circular planar plate monopole antenna so Elliptical planar plate monopole antenna is more useful for UWB application.

Elliptical planar plate monopole antenna with different feeding strip length has been studied. The antenna bandwidth is decreases with the increment in feeding strip length.

The proposed various shape of planar plate monopole antenna are partially simulated by the help of HFSS Software. Future work can be proposed in the following directions: Investigate the proposed UWB antenna performance in Wireless Body Area Network (WBAN) which is considered as on of most promising technologies for near future. The future scope of work revolves around increasing the gain and directivity by modifications in design. Study the ability to use proposed UWB antennas in Cognitive Radio (CR) by using reconfigurable stop band technique at specific frequencies. Finally, using different feeding technique to increase impedance bandwidth.

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