Monopole Antennas

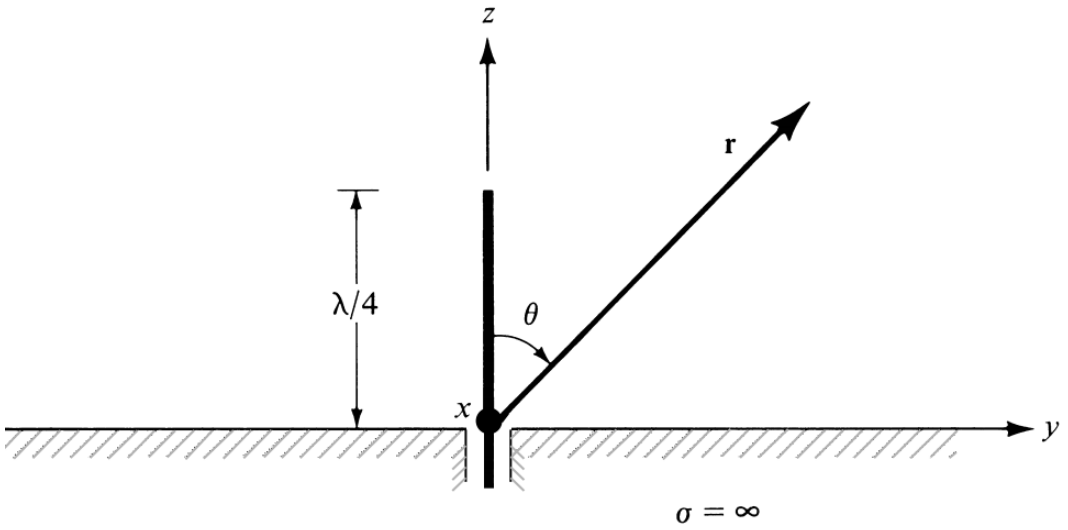
Prof. Girish Kumar
Electrical Engineering Department, IIT Bombay

gkumar@ee.iitb.ac.in
(022) 2576 7436

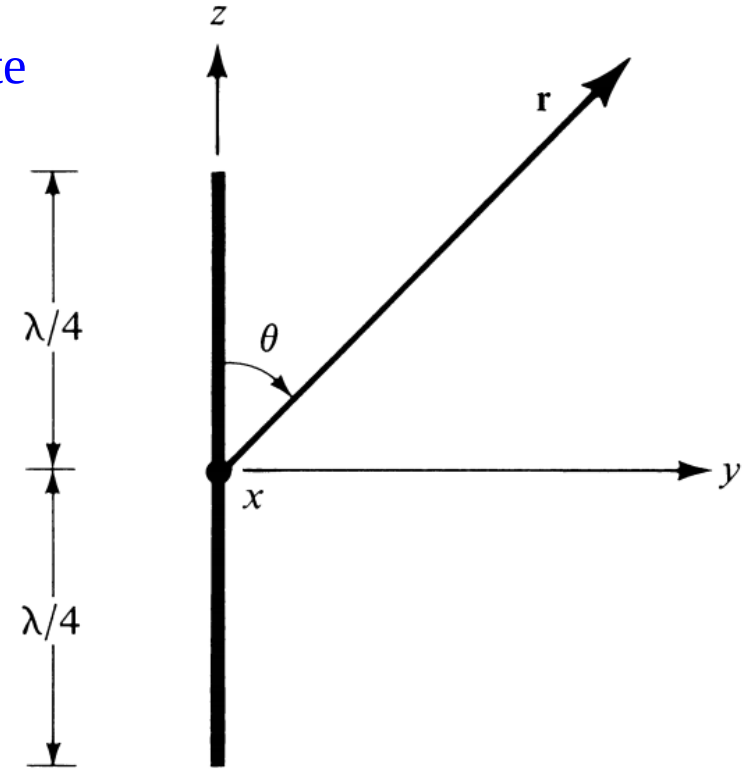
Monopole Antenna on Infinite Ground Plane

Quarter-wavelength monopole Antenna on Infinite Ground Plane

Note: $\lambda/4$ length is only valid when ground plane size is infinite



$\lambda/4$ monopole on infinite electric conductor



Equivalent $\lambda/2$ dipole

Monopole Antenna on Infinite Ground Plane

Far fields - Electric and Magnetic fields

Far-fields E and H for the $\lambda/4$ monopole above the ground plane are same as that of dipole antenna

$$E_\theta \simeq j\eta \frac{I_0 e^{-jkr}}{2\pi r}\left[\frac{\cos\left(\frac{\pi}{2}\cos\theta\right)}{\sin\theta}\right], H_\phi \simeq j\frac{I_0 e^{-jkr}}{2\pi r}\left[\frac{\cos\left(\frac{\pi}{2}\cos\theta\right)}{\sin\theta}\right]$$

Input Impedance

$$Z_{in}(monopole) = \frac{Z_{in}(dipole)}{2} = \frac{73 + j42.5}{2} = 36.5 + j21.25$$

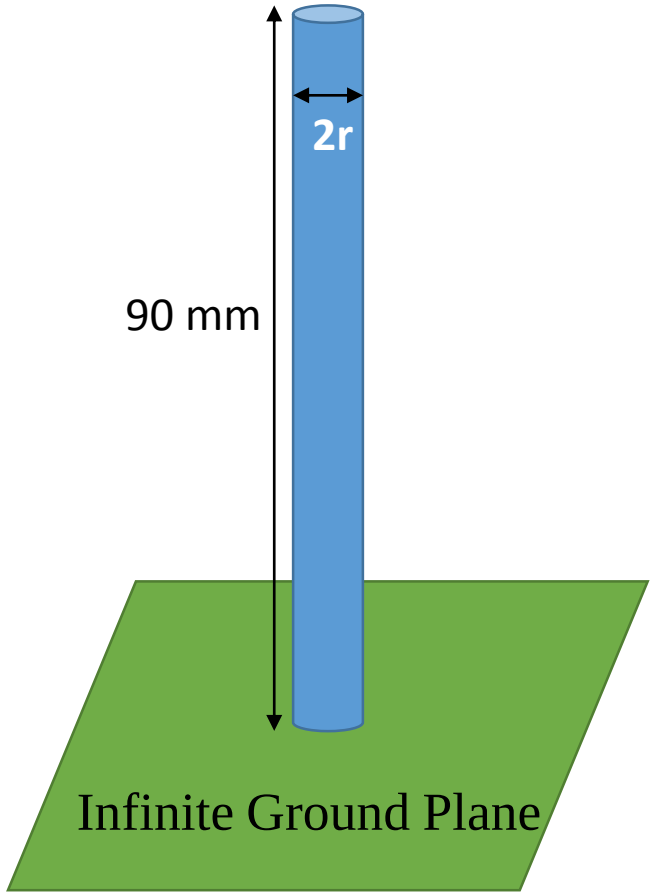
Directivity

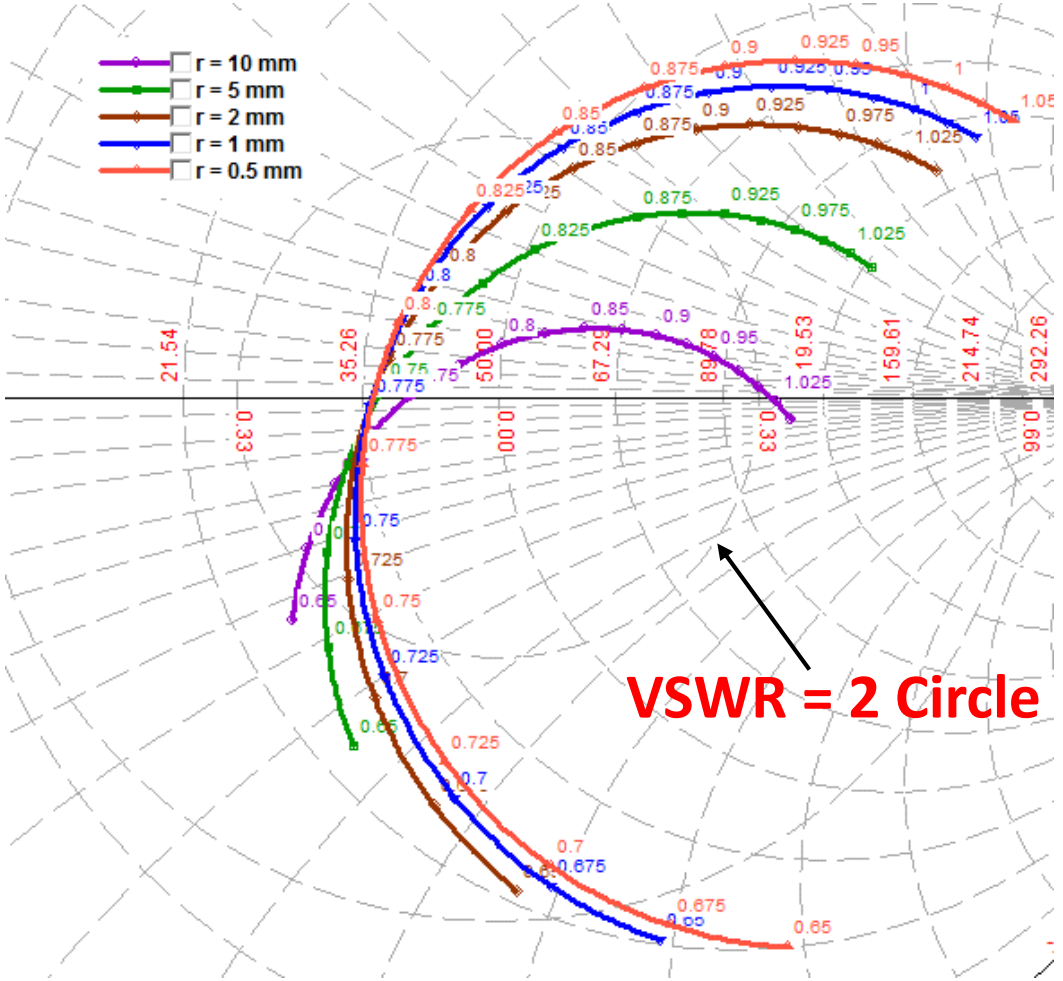
$$\mathrm{D}(monopole) = 2 * \mathrm{D}(dipole) = 2 * 1.643 = 3.286$$

Height h for Real Input Impedance

h + r $\simeq 0.24\lambda$, where r is the radius of wire and r < $\lambda/20$

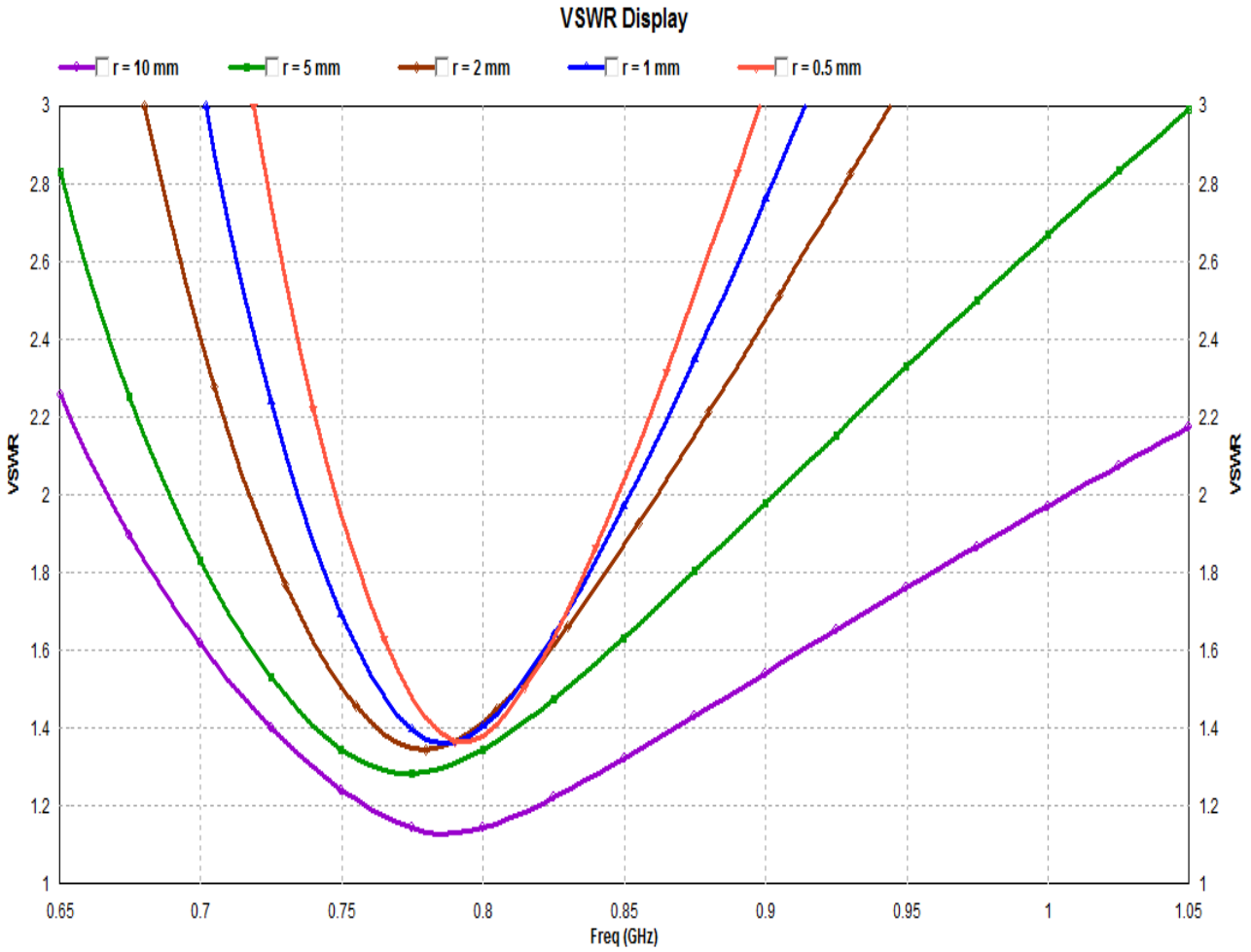
Effect of Varying Radius of Monopole on Infinite Ground Plane on Impedance Plot





As radius r of monopole increases, its inductance decreases and hence impedance plot shifts down.

Effect of Varying Radius of Monopole on Infinite Ground Plane on VSWR Plot



Resonance frequency calculation using

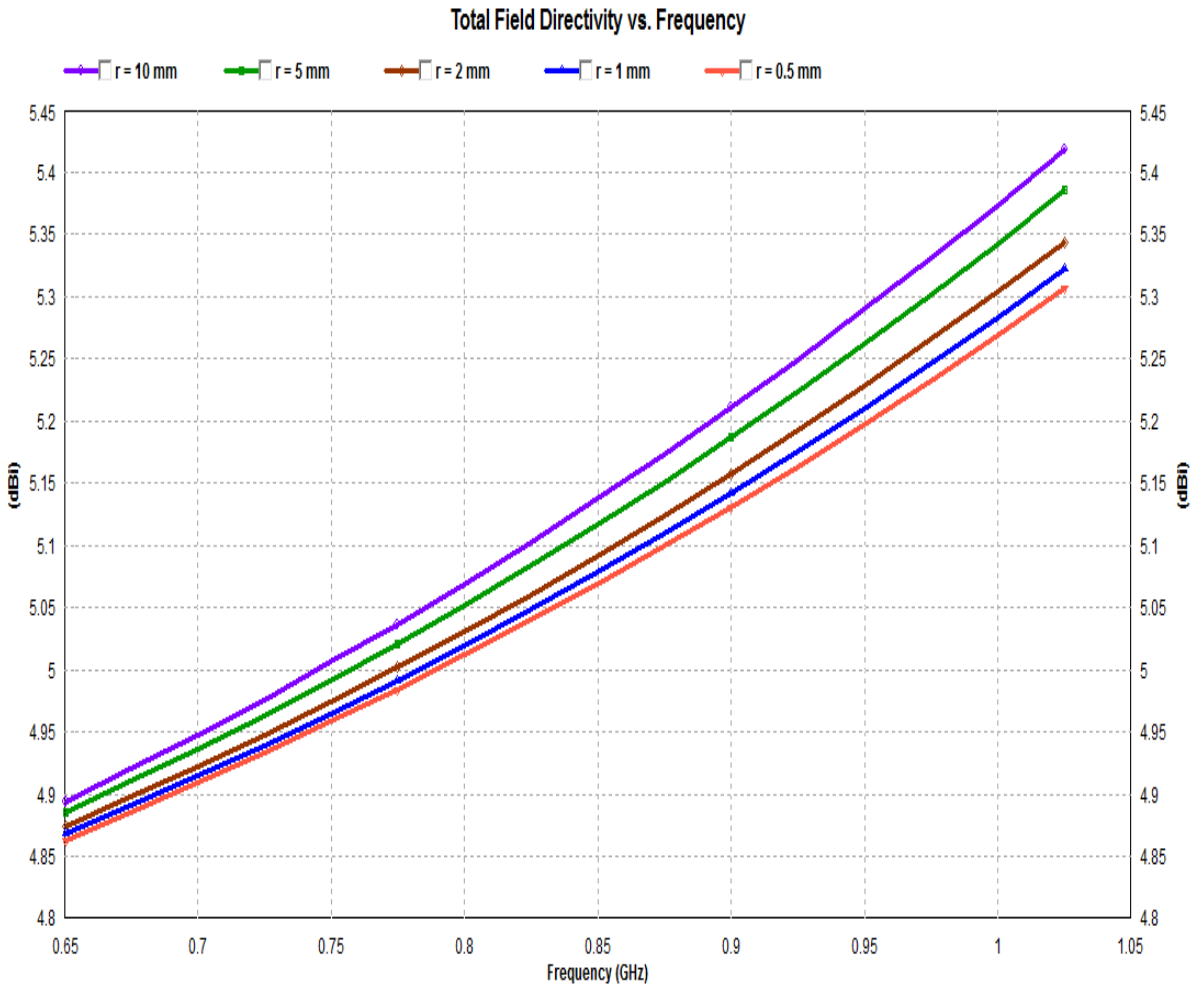
$$h + r = 0.24\lambda$$

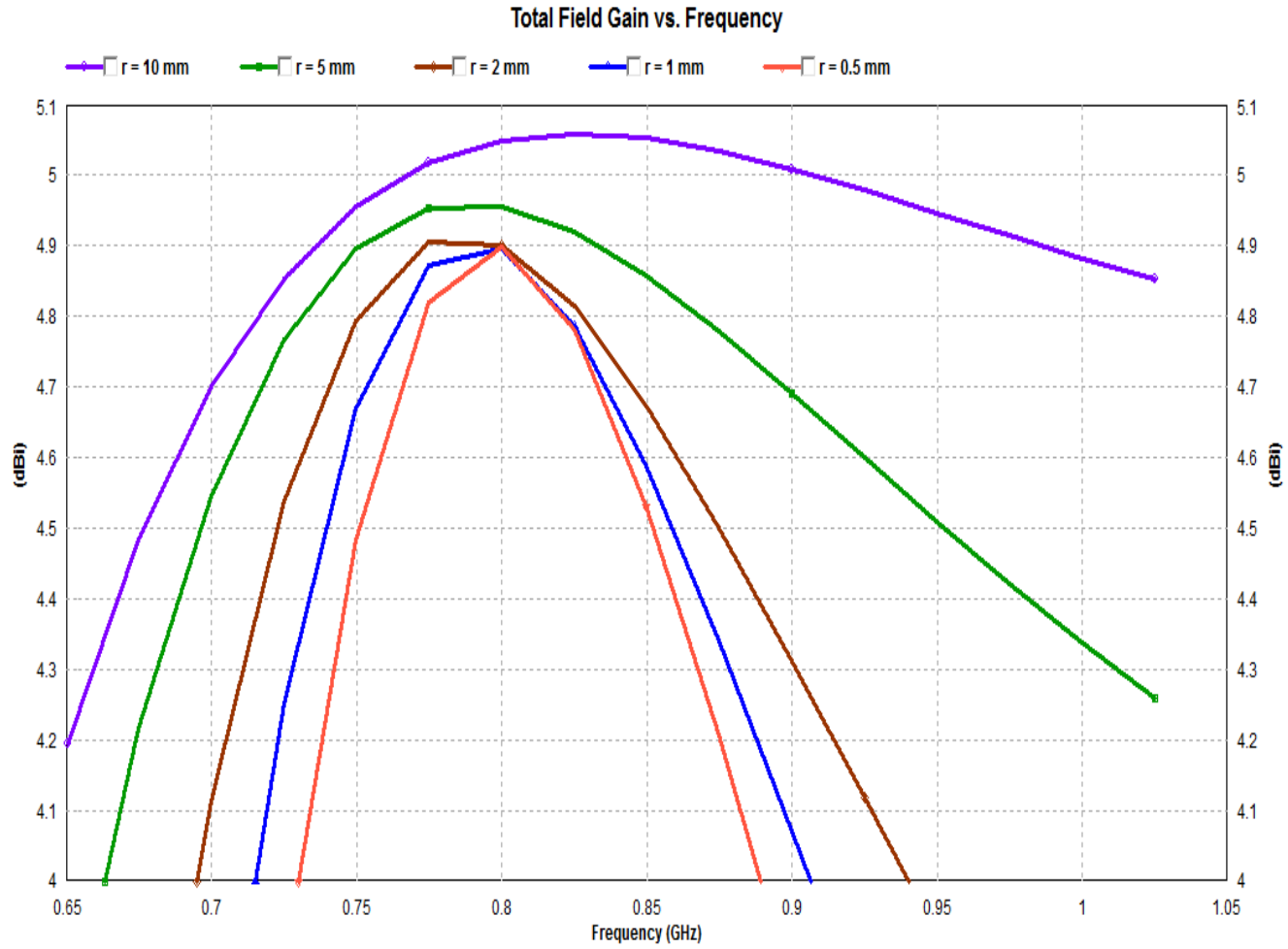
$$f = 0.24\ c / (h + r)$$

Radius (in mm)	Theoretical frequency (in MHz)	Bandwidth for VSWR < 2 (in MHz)	%BW
0.5	795.6	748 to 847	12.4%
1	791.2	734 to 852	14.9%
2	782.6	717 to 861	18.3%
5	757.9	689 to 903	26.9%
10	720.0	667 to 1007	42.1%

As radius of monopole increases, resonance frequency decreases slightly but BW increases significantly.

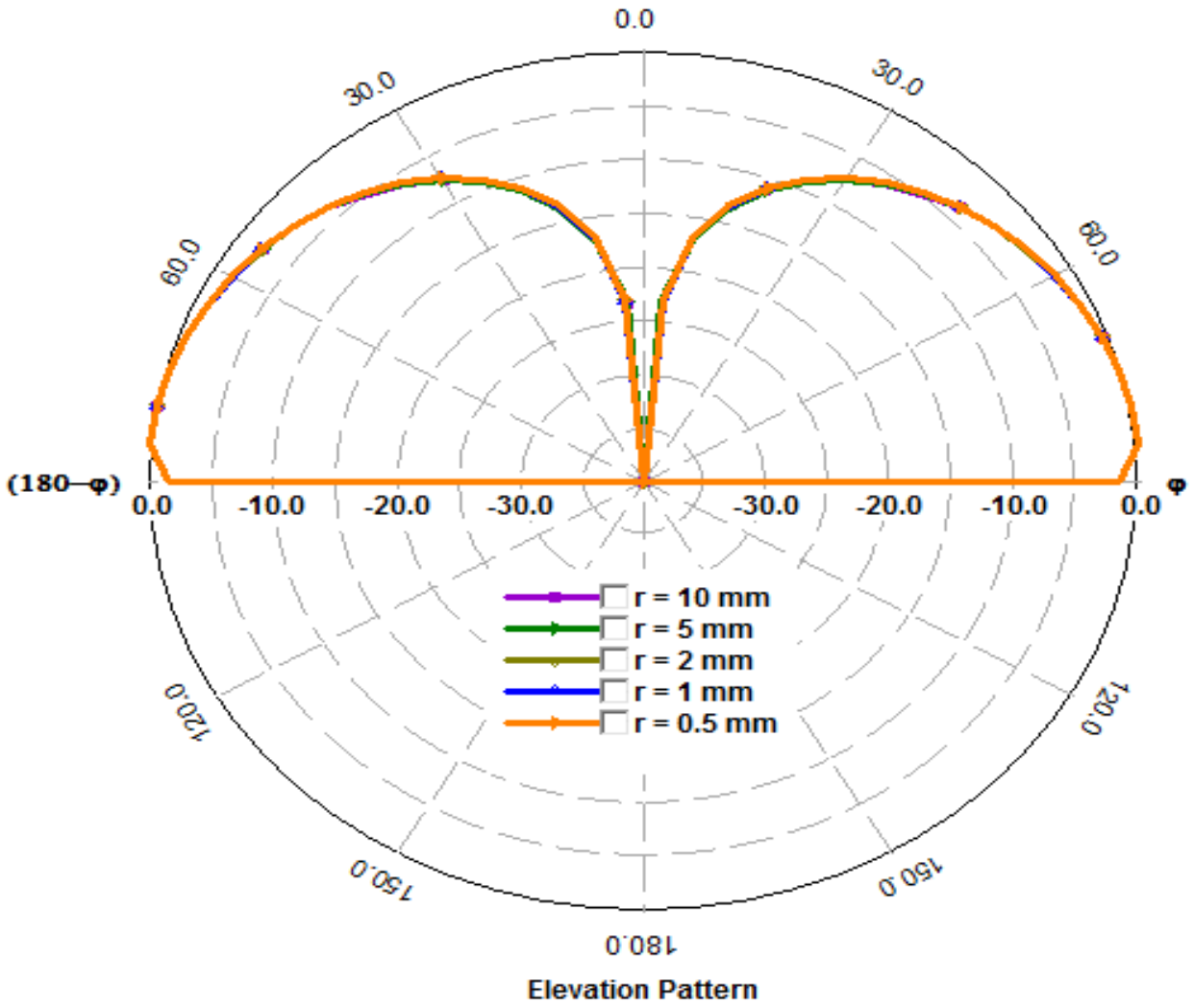
Effect of varying Radius of Monopole on infinite Ground Plane on Directivity and Gain





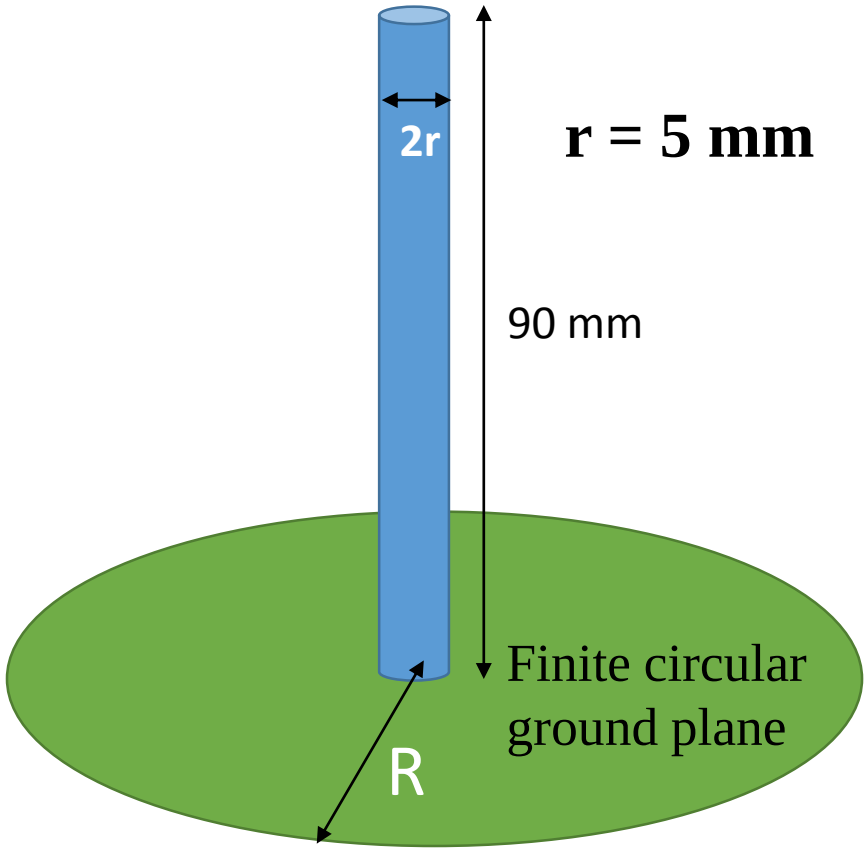
As radius of monopole increases, the directivity increases marginally by 0.05 dB at center frequency but gain BW increases significantly

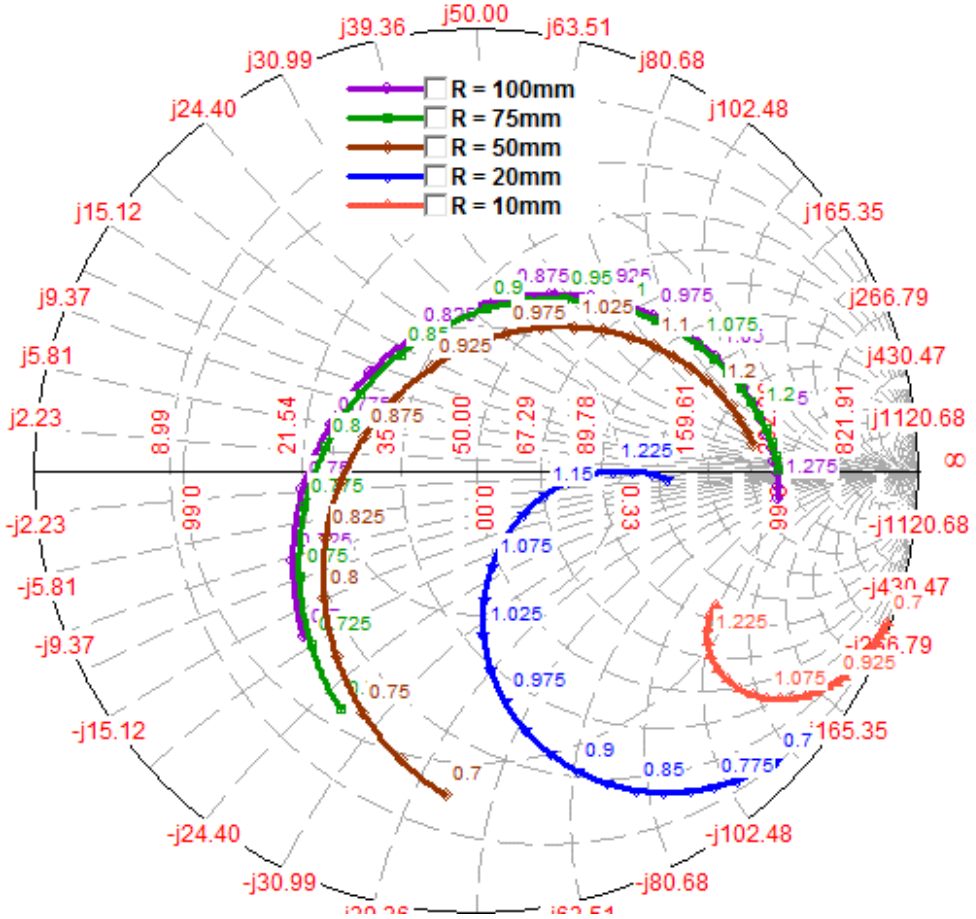
Effect of Varying Radius of Monopole on Infinite Ground Plane on Radiation Pattern



With change in the radius of monopole, there is no significant change in the radiation pattern.

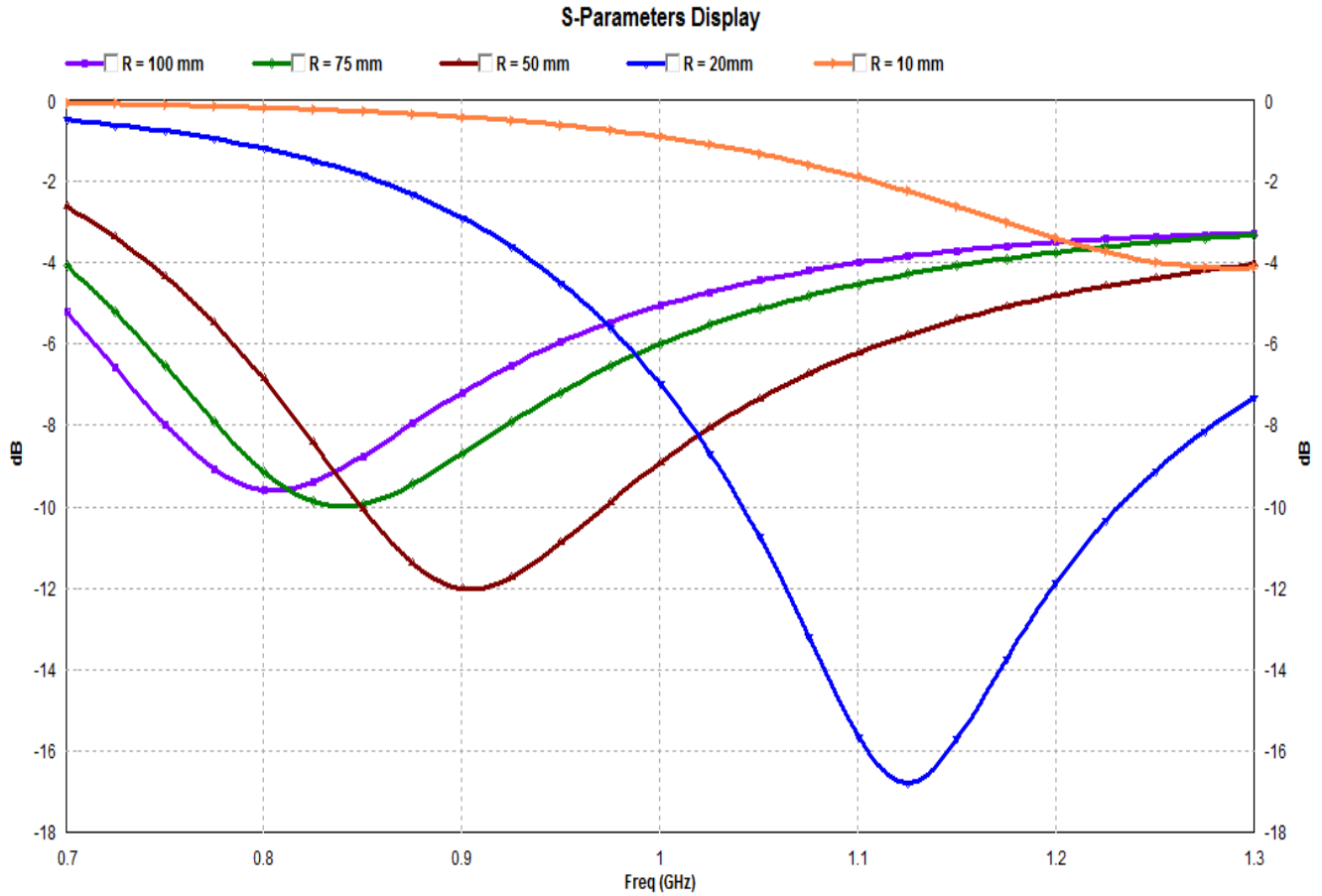
Effect of Varying Finite Ground Plane Size on Input Impedance of Monopole





As Ground Plane Radius R increases, the impedance plot shifts towards inductive region. Hollow cylindrical monopole can be taken.

Effect of Varying Size of Finite Ground Plane on S_{11} Plot (h = 90 mm, r = 5mm)

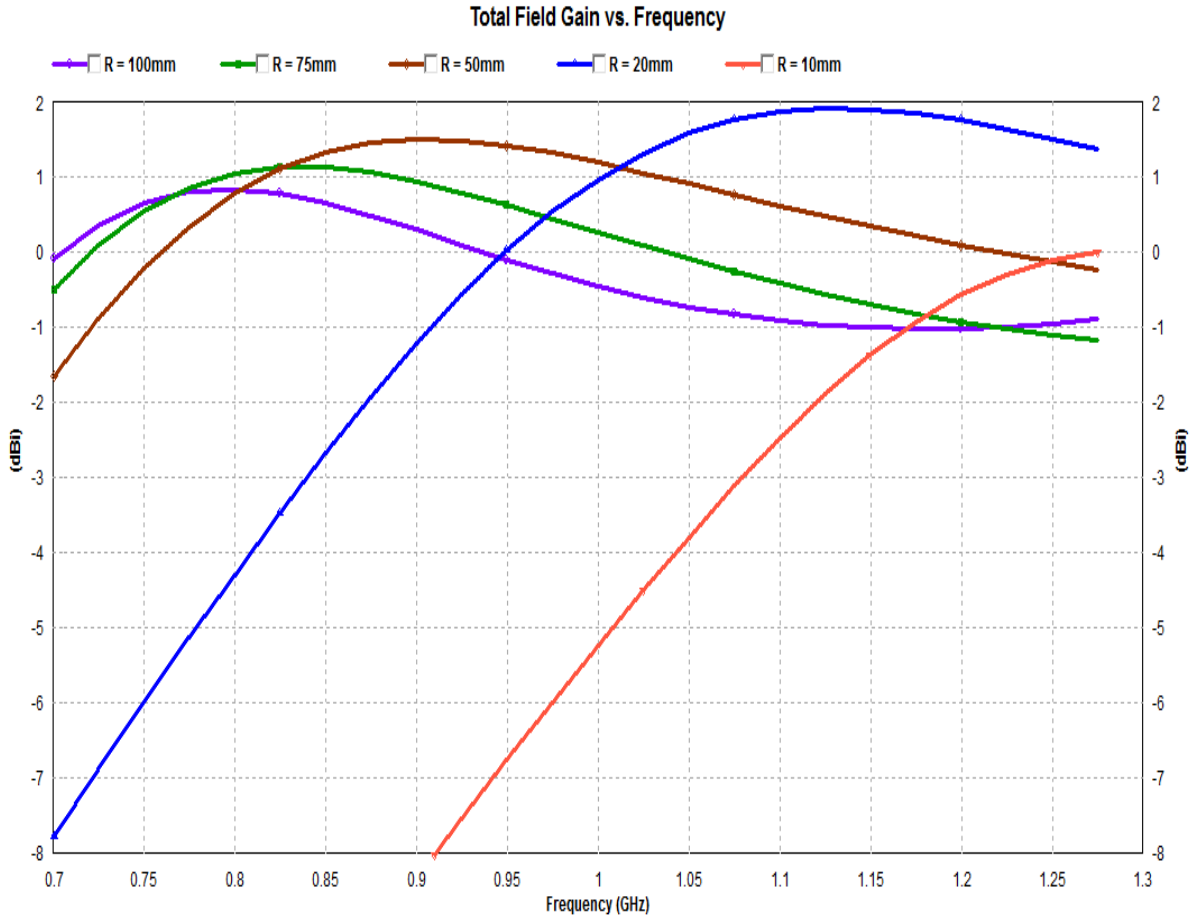


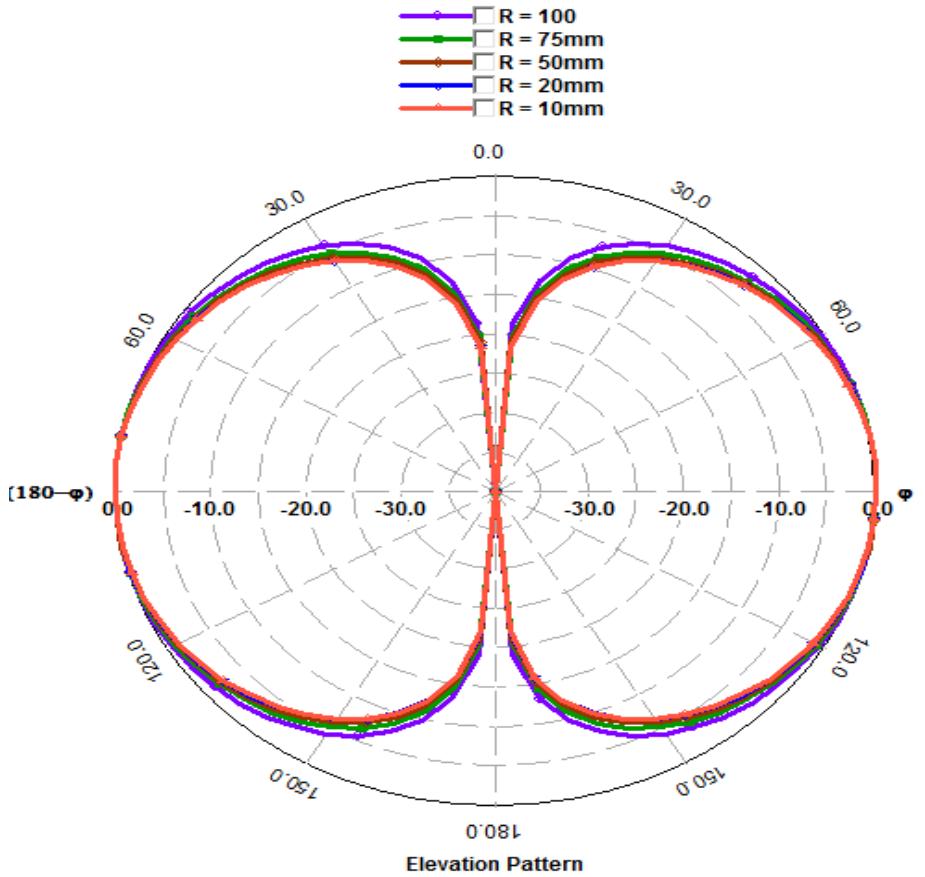
Radius (R) of Ground Plane (in mm)	Simulated Center frequency f_o (in MHz)	At f_o Simulated Input Impedance (in Ω)
10	1280	95-j99
20	1120	84.6-j1
50	905	33.5+j13
75	840	29+j15
100	800	28+j14
Infinite	775	41+j7.6

As Ground Plane Radius R increases, the resonance frequency decreases.

Applications – Cellular and cordless telephones, walkie-talkies, CB radios, etc.

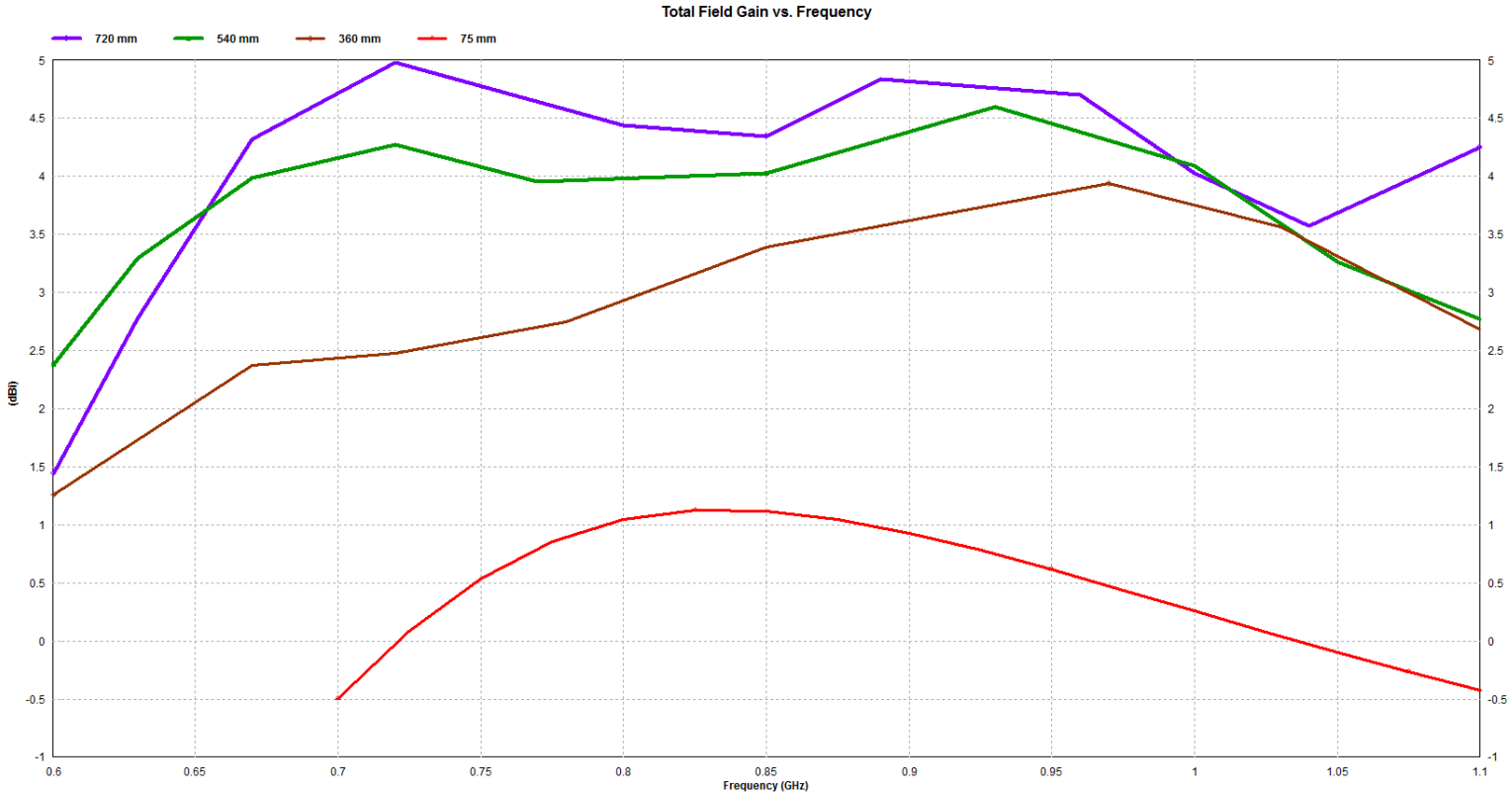
Effect of Varying Size of Small Ground Plane on Gain and Radiation Pattern (h = 90 mm, r = 5mm)

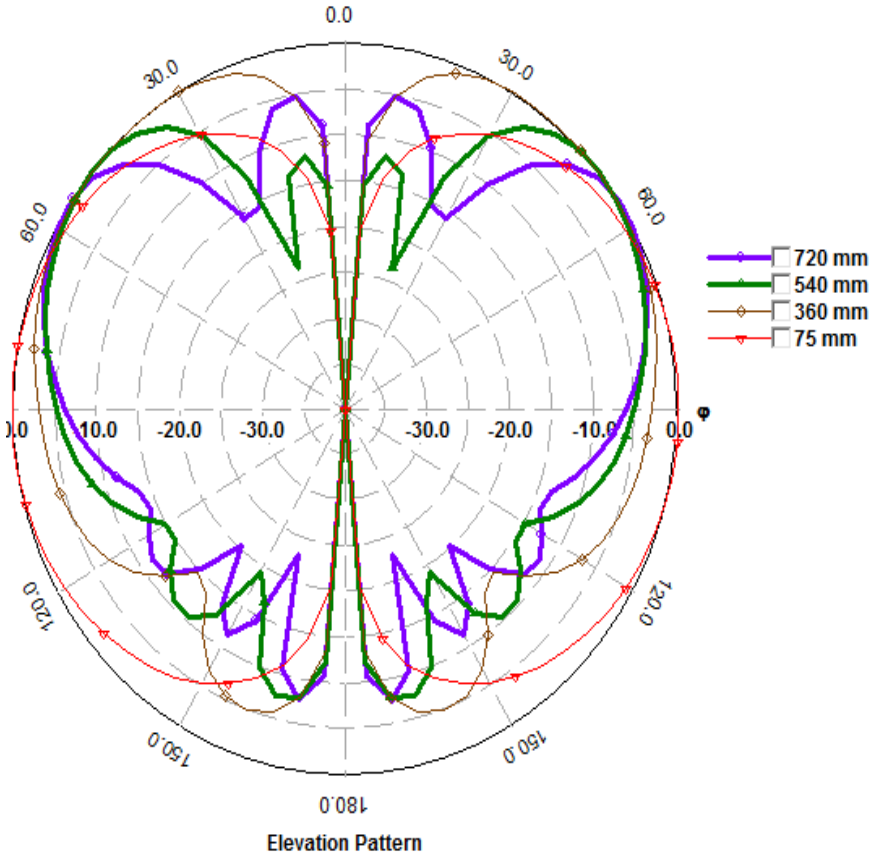




As Ground Plane Radius R increases, the gain maxima shifts towards lower resonance frequency. Gain and radiation pattern of a monopole antenna on small ground plane (< λ) are similar to that of dipole antenna.

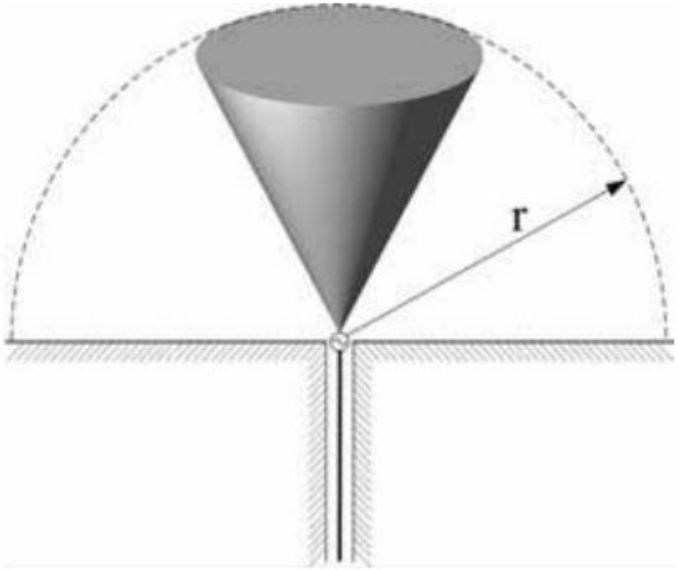
Effect of Varying Size of Large Ground Plane on Gain and Radiation Pattern



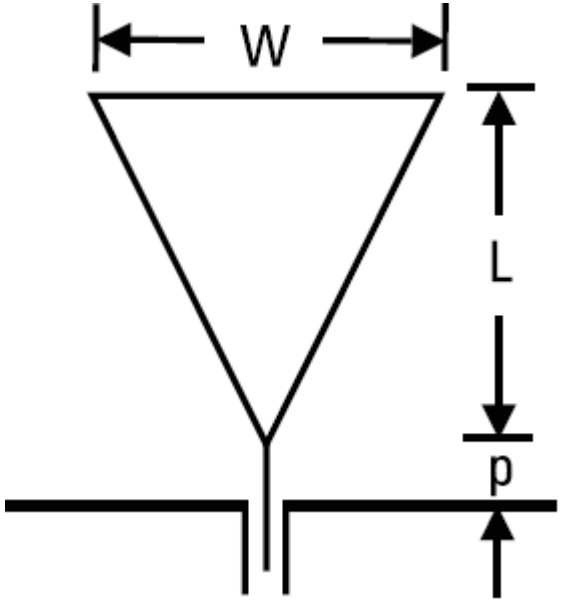


Gain of monopole antenna on large ground plane (> λ) is greater than that of dipole antenna and it approaches to gain of around 5 dB, which is for infinite ground plane.

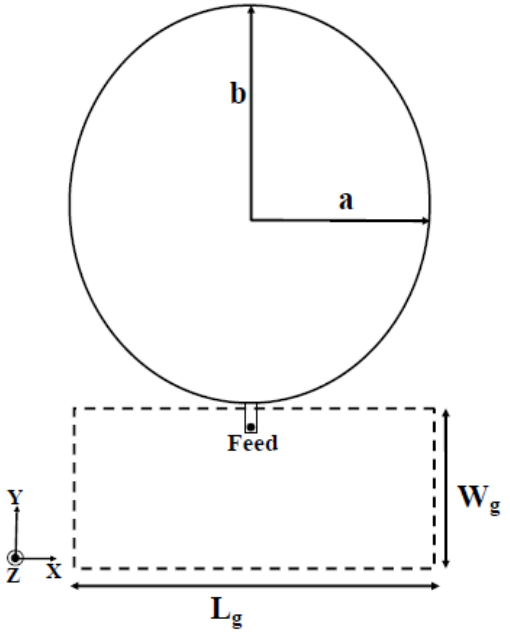
Broadband Monopole Antenna Configurations



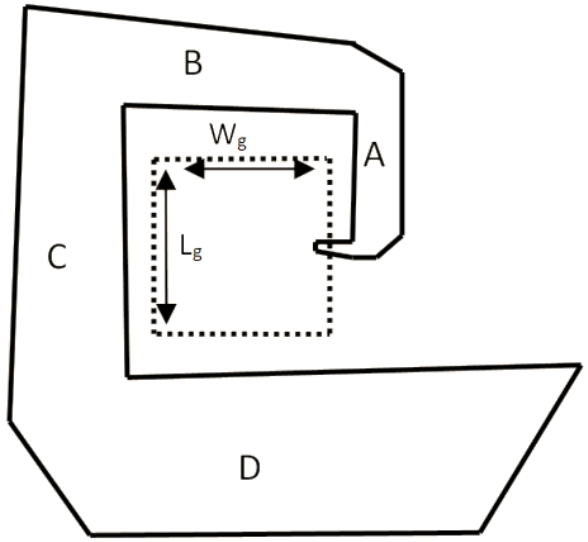
Conical Monopole Antenna



Triangular Monopole Antenna



Printed Elliptical Monopole Antenna



Bent Monopole Antenna

Conical Monopole Antenna

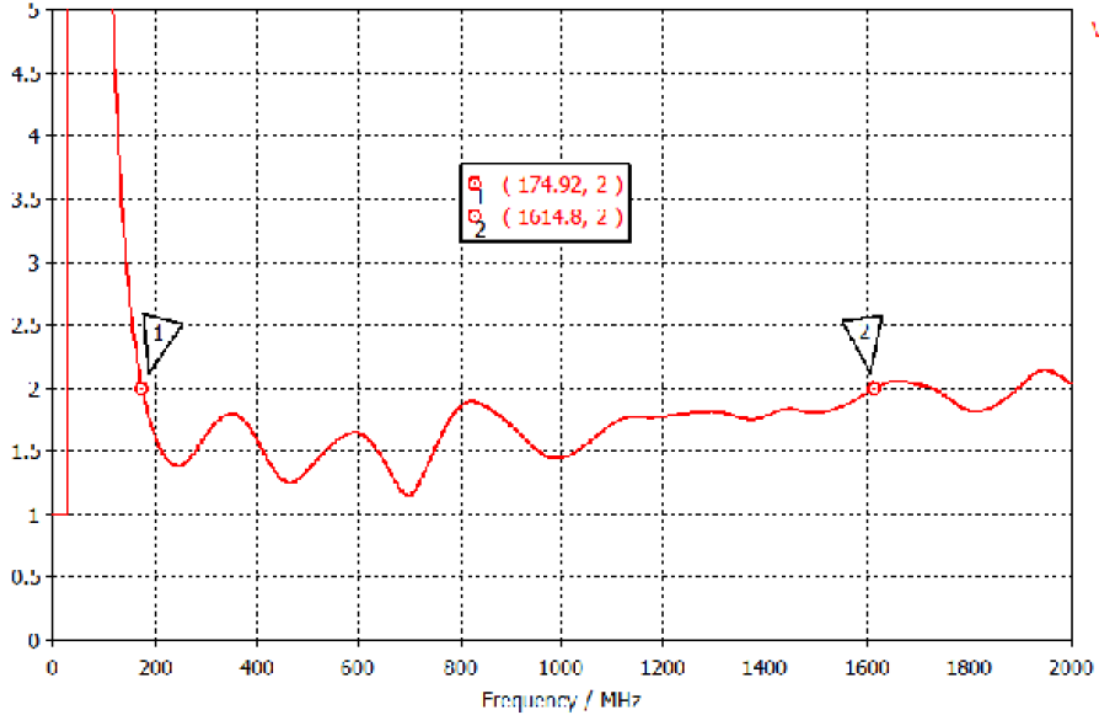
Physical Specifications	
Height of cone	300 mm
Maximum radius of cone	300 mm
Minimum radius of cone	5 mm
Distance from ground	2 mm
Cone angle	90°

Slant length = λ/4 at lowest frequency of operation.

$$Z_{in} = 60 \ln\left[\cot\left(\frac{\alpha}{4}\right)\right]$$

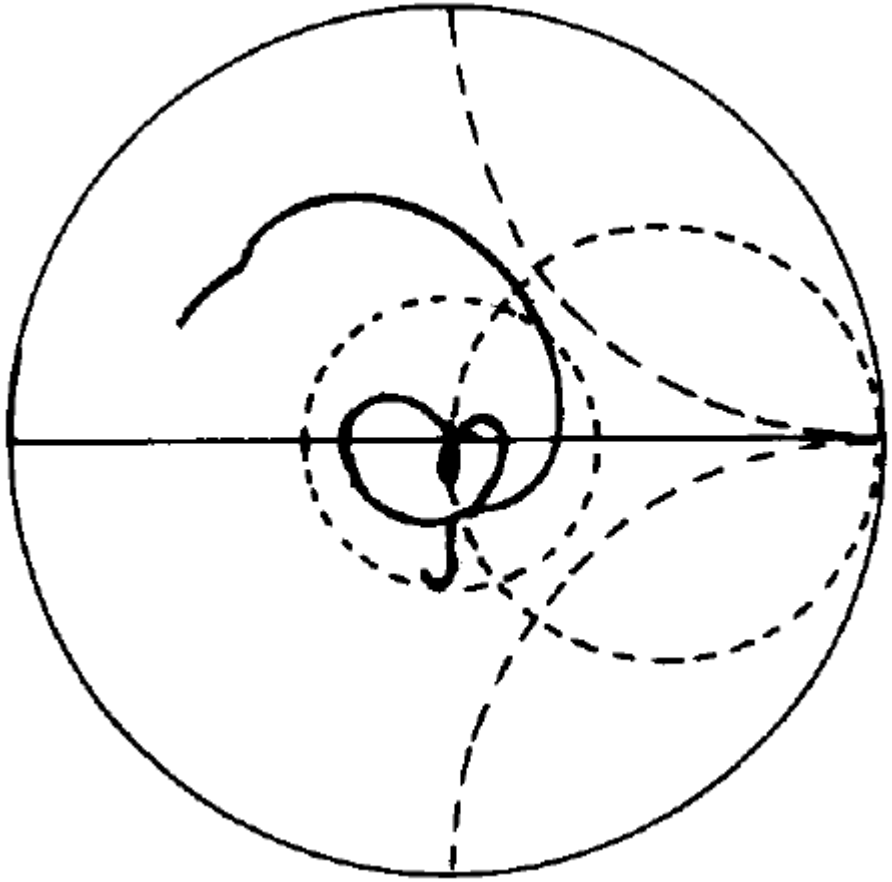
where α is cone angle.

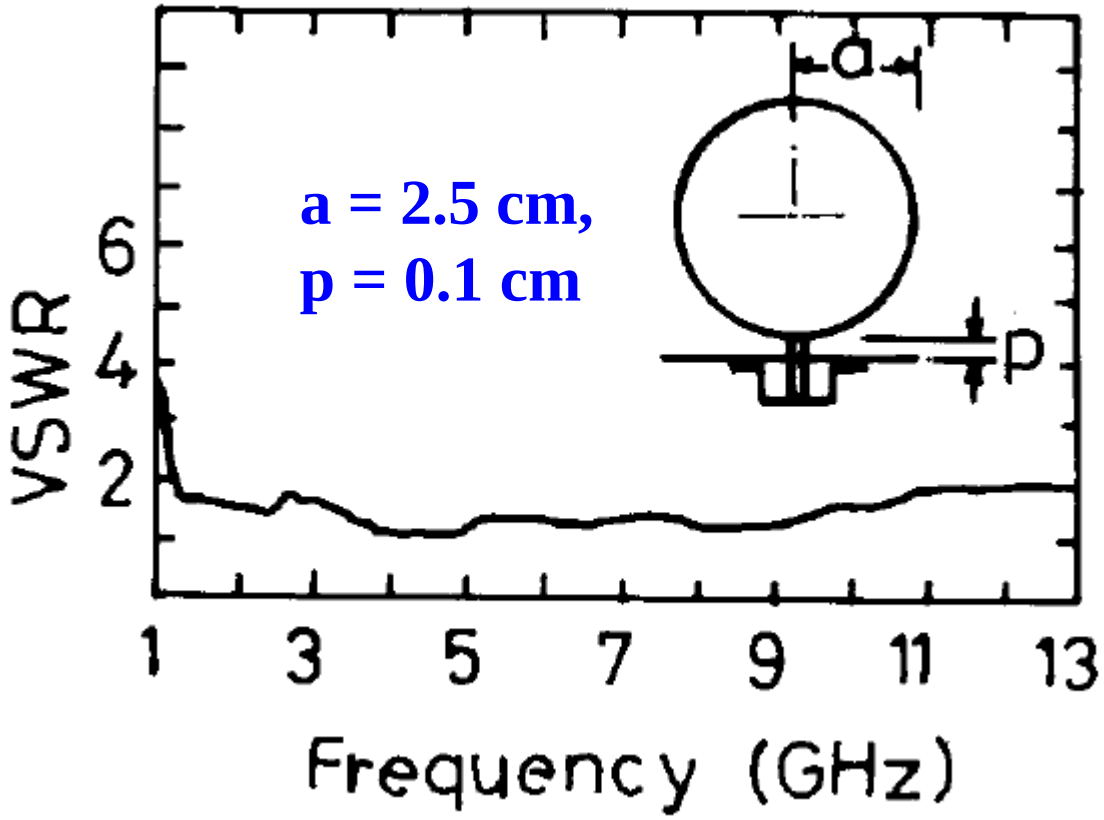
For $\alpha = 90^0$, $Z_{in} = 52.9\ \Omega$



Bandwidth for VSWR ≤ 2 is from 175 to 1615 MHz.

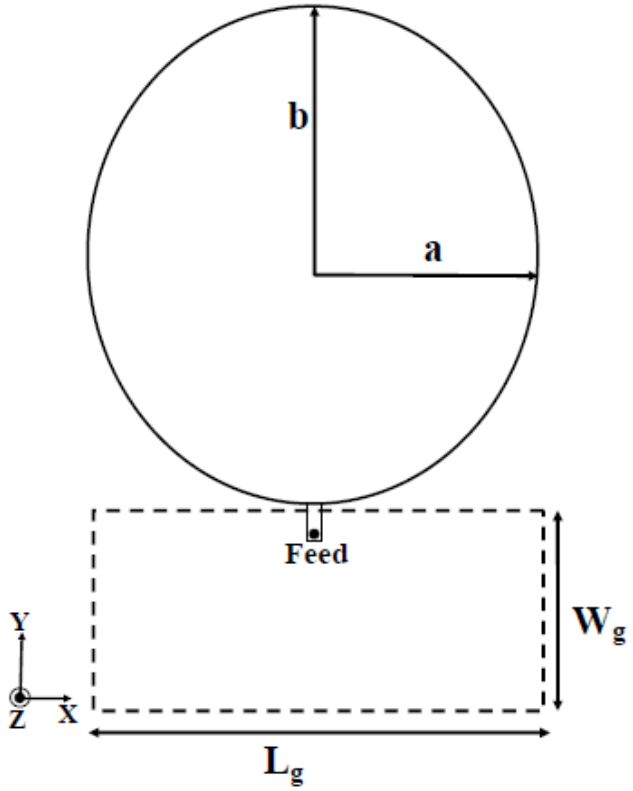
Broadband Circular Monopole Antenna

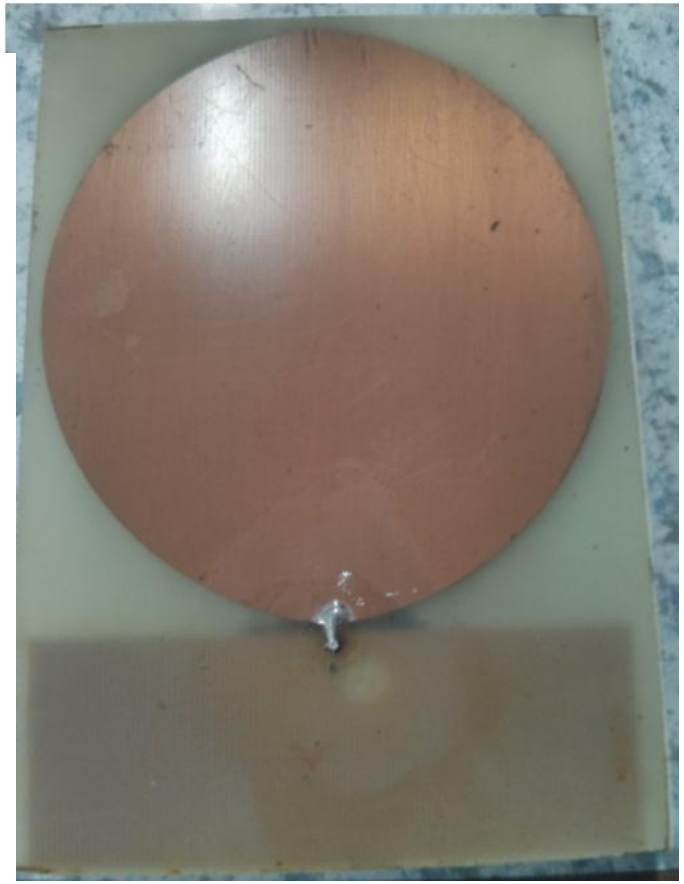


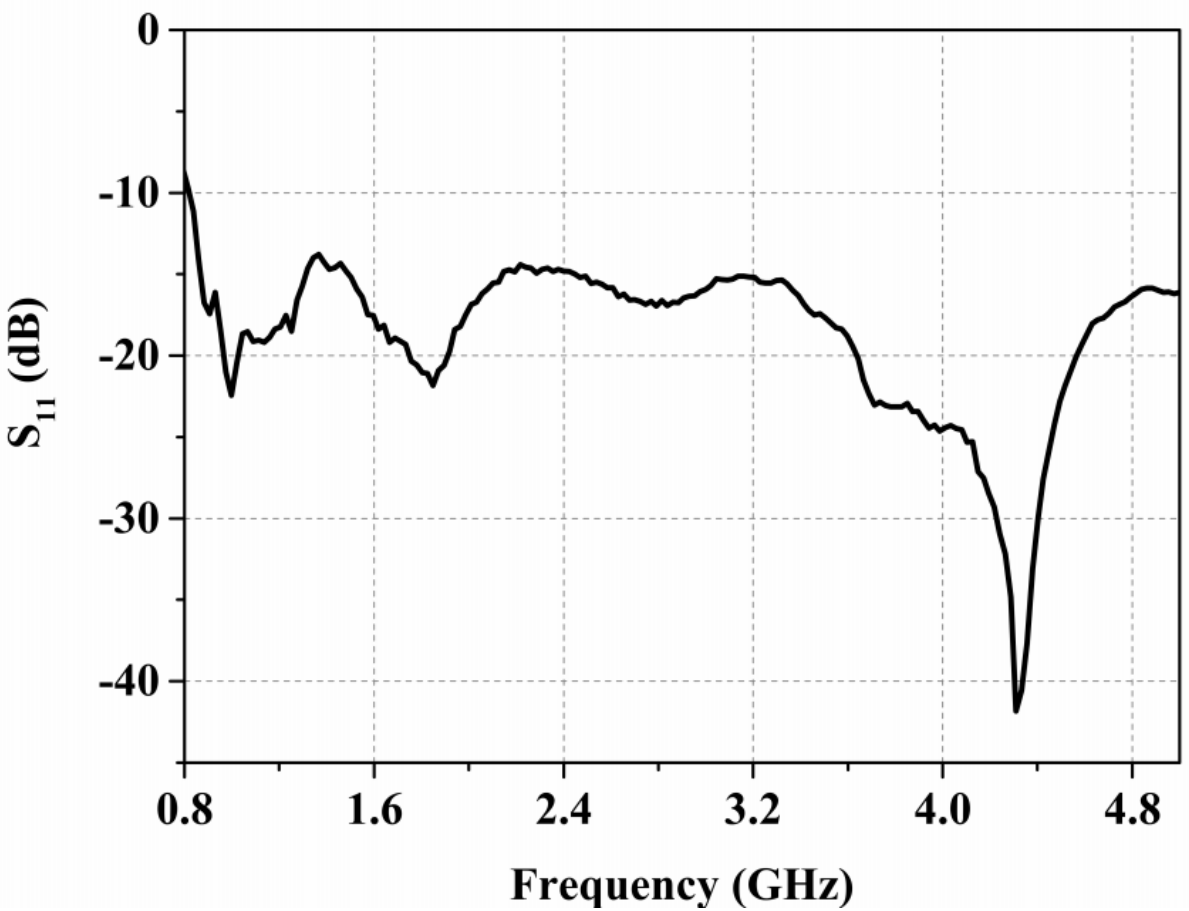


Bandwidth for VSWR $\leq$ 2 is from 1.17 GHz to 12 GHz, which corresponds to BW ratio of 1:10.2 but radiation pattern varies over the bandwidth.

Printed Broadband Elliptical Monopole Antenna

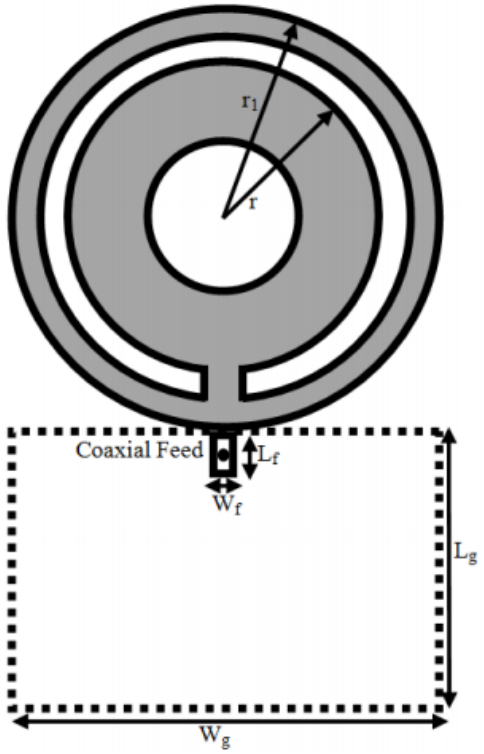


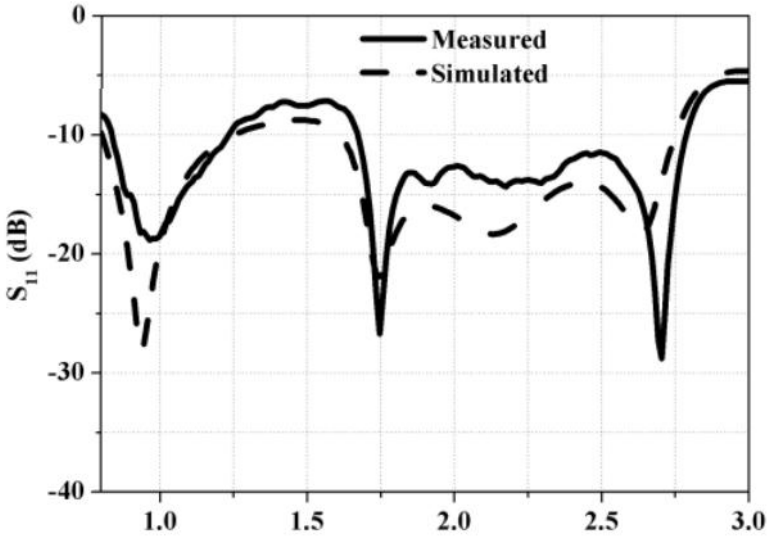


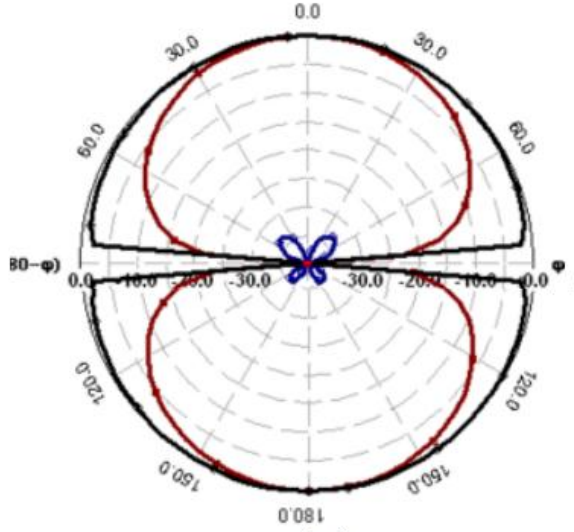


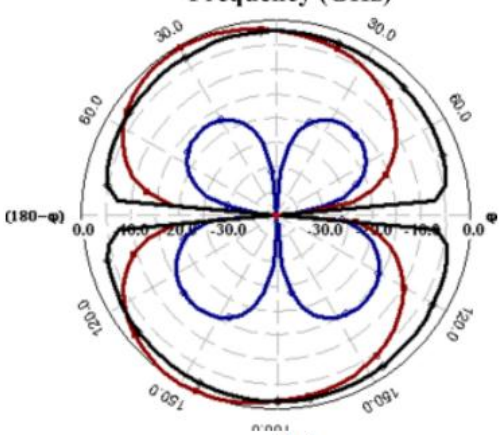
Bandwidth for $|S_{11}| < -10$ dB is very large but radiation pattern varies over the bandwidth.

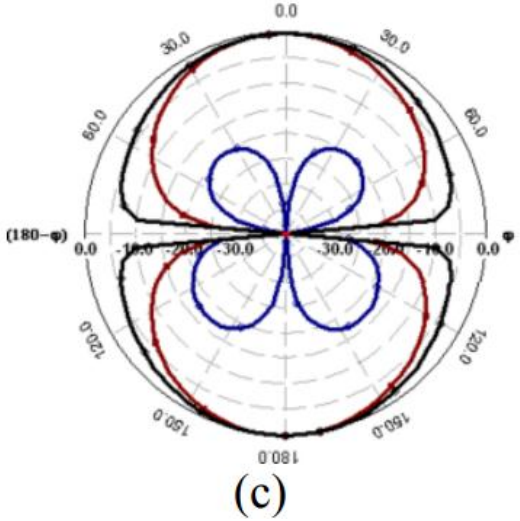
Dual Band Dual Ring Monopole Antenna





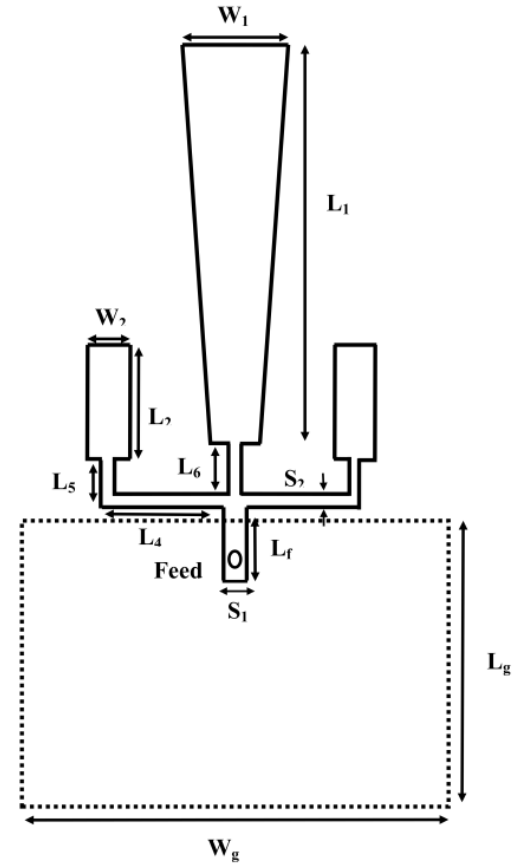

(a)

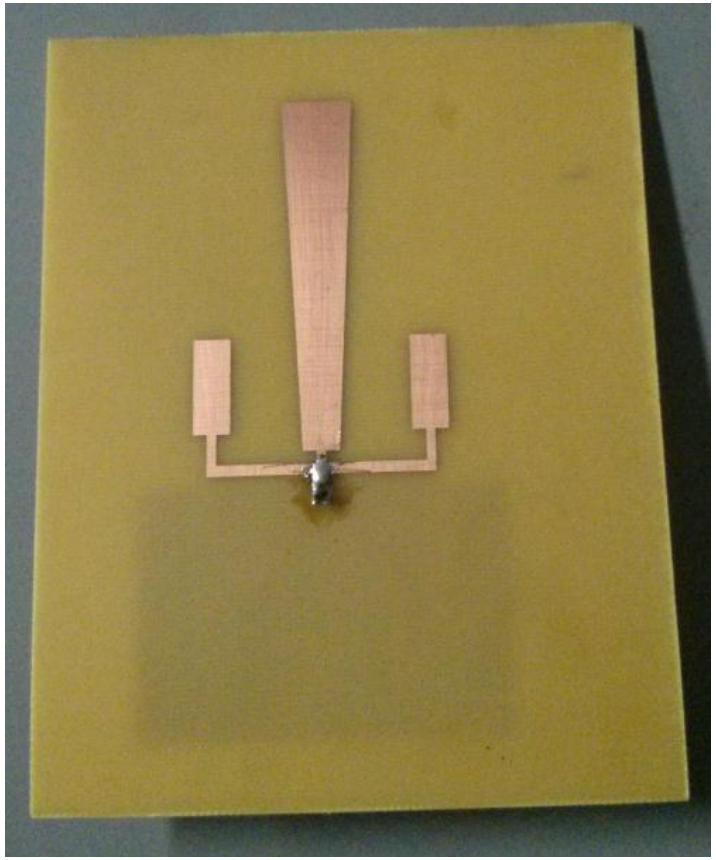

(b)

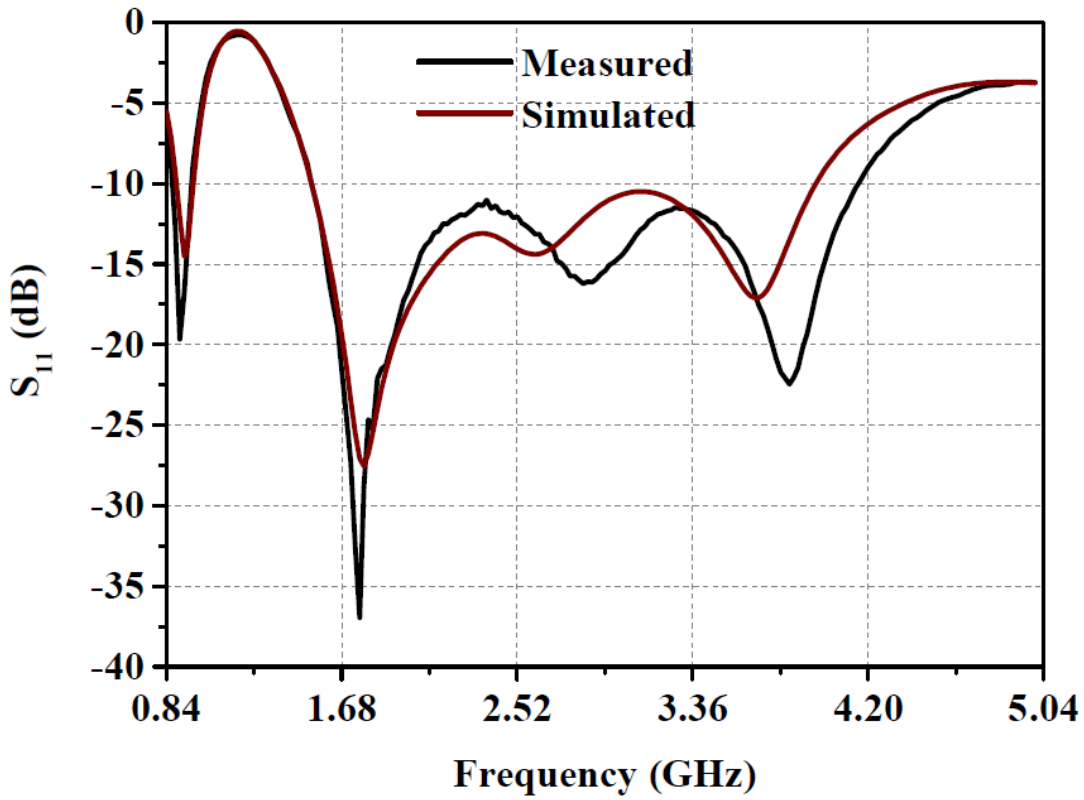

(c)

Radiation Pattern at (a) 0.9, (b) 1.8 and (c) 2.1GHz

Dual Band Trident Monopole Antenna



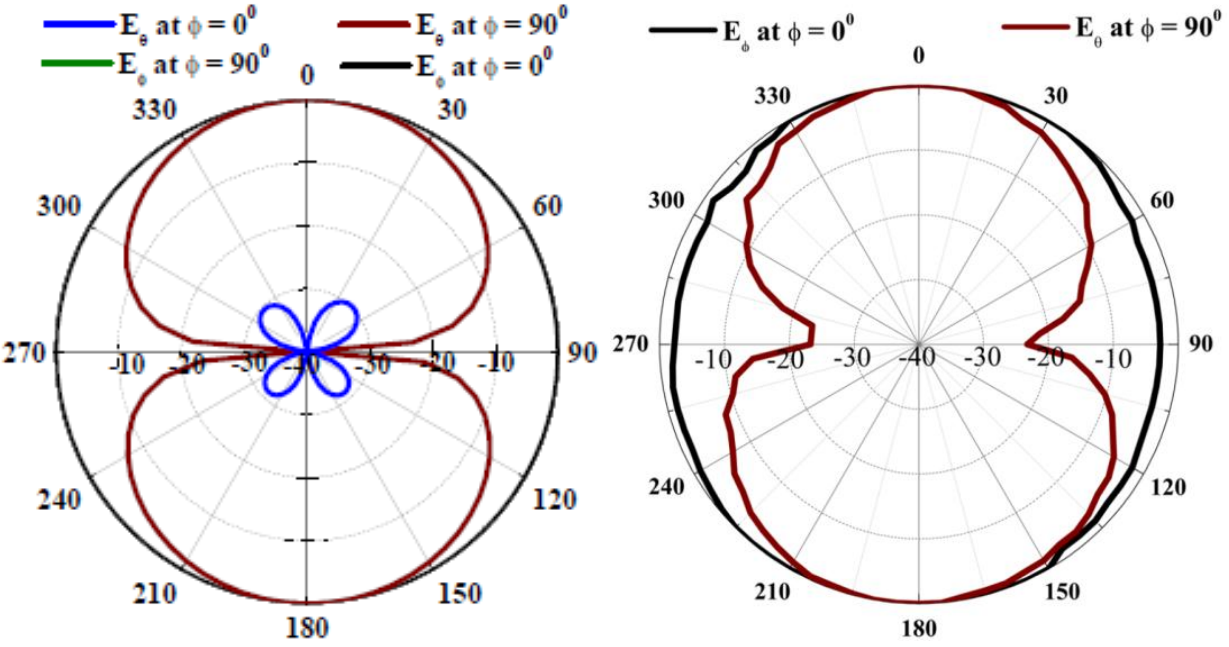




Central monopole is designed to resonate at GSM 900 band. Two monopoles placed on each side of central monopole resonate at GSM1800 band.

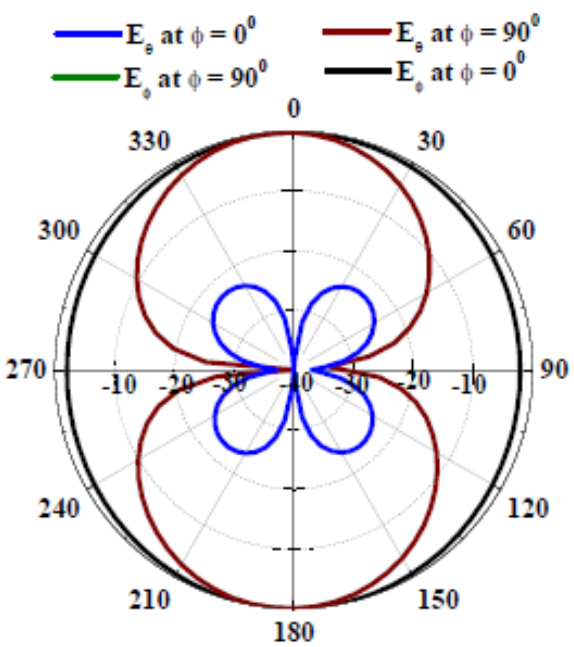
Bandwidth = 870-980MHz
1.5 to 4.2GHz

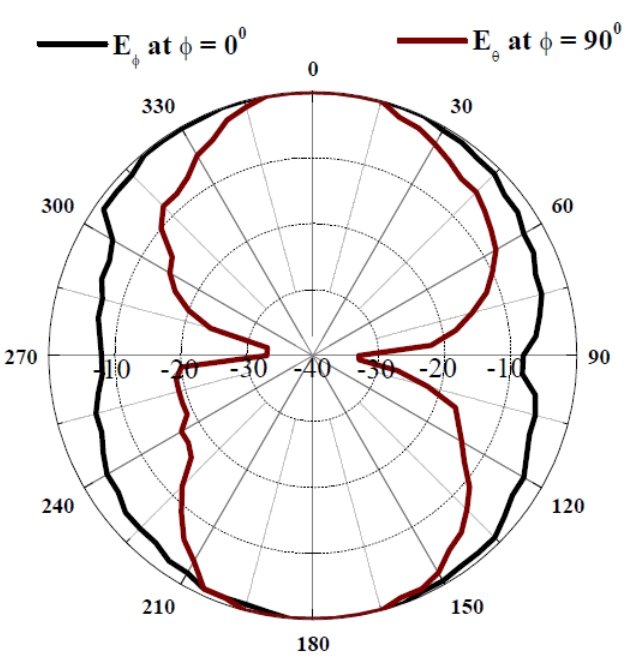
Dual Band Trident Monopole Antenna



Simulated and Measured Radiation Patterns at 920MHz

HPBW in E-plane = 80°

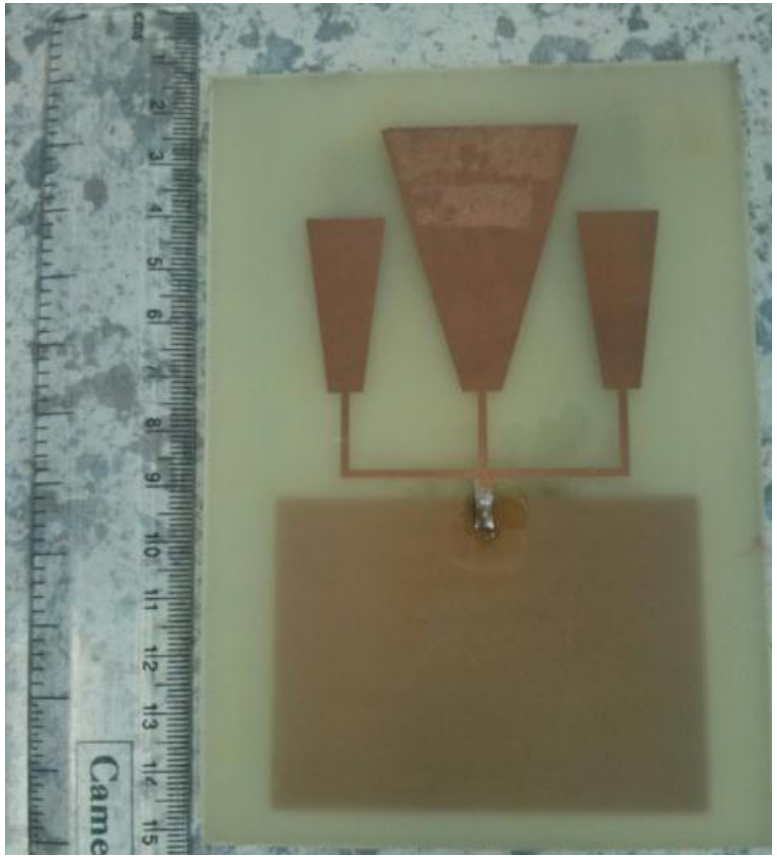


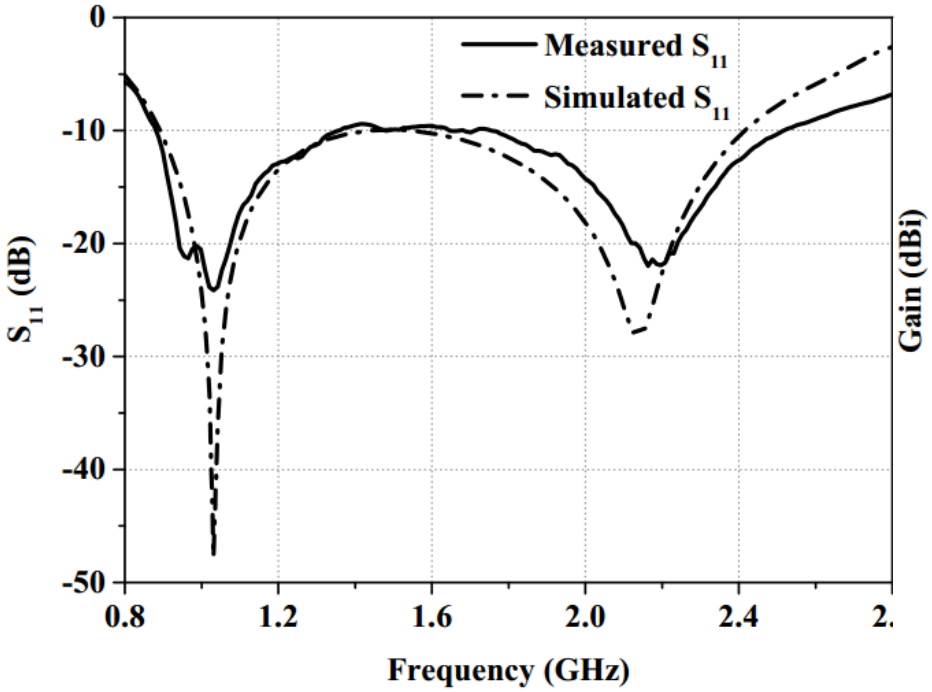


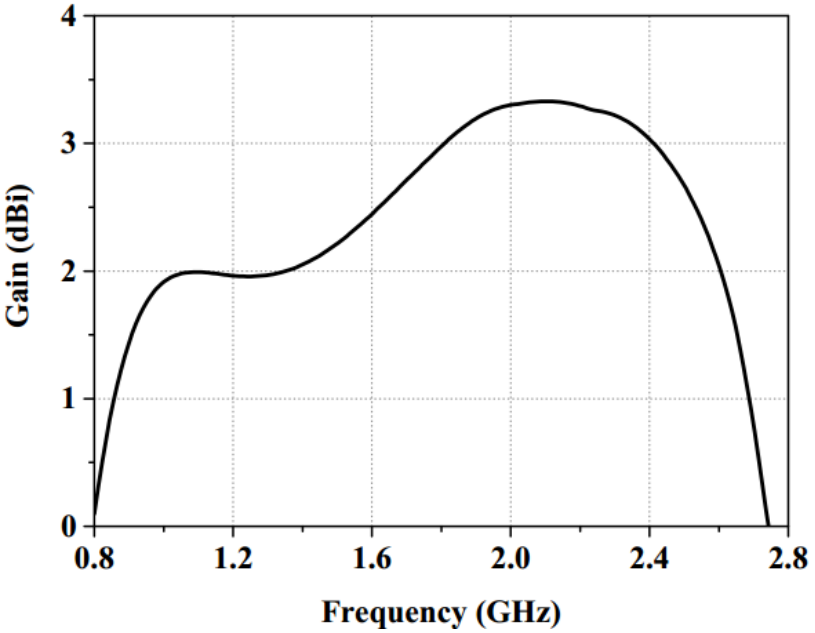
Simulated and Measured Radiation Patterns at 2150MHz

HPBW in E-plane = 55°

Broadband Trident Monopole Antenna

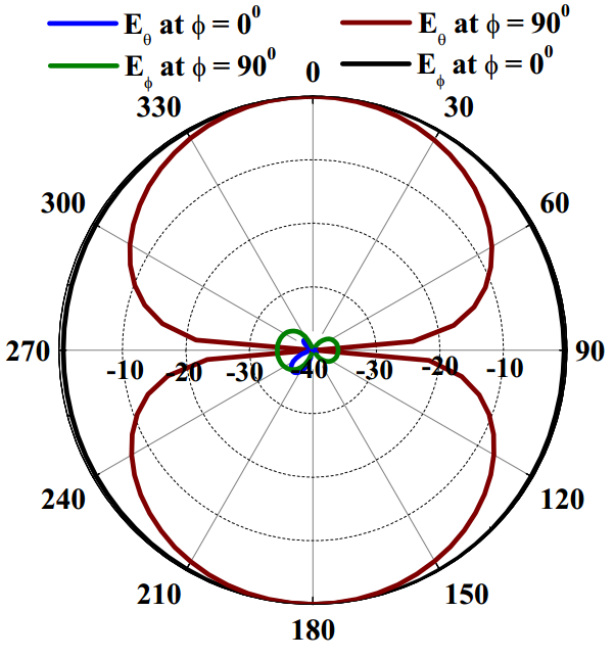




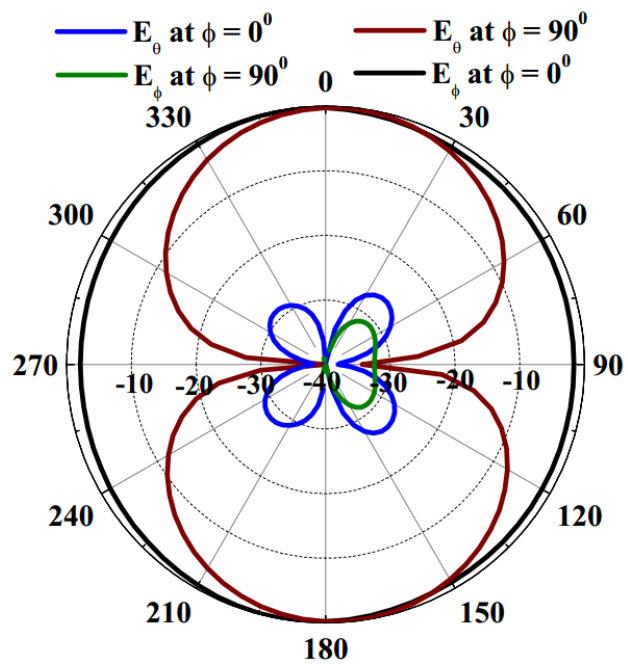


Bandwidth of the trident monopole antenna is increased by flaring all three monopoles

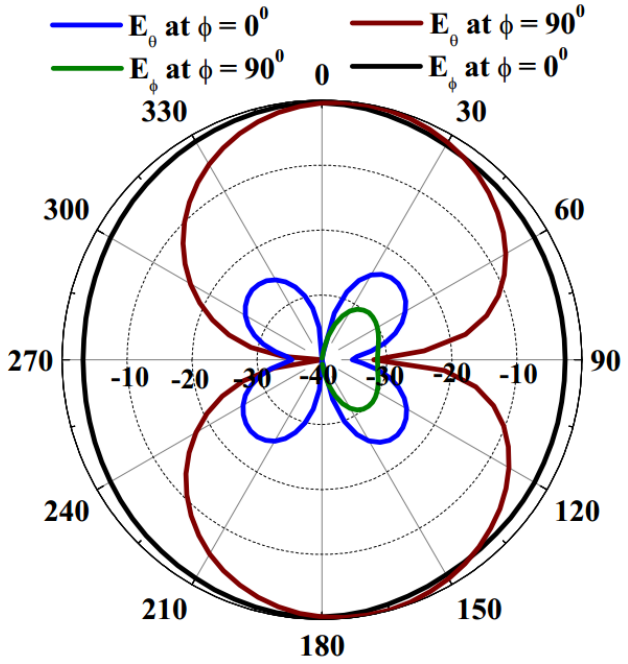
Broadband Trident Monopole Antenna Pattern



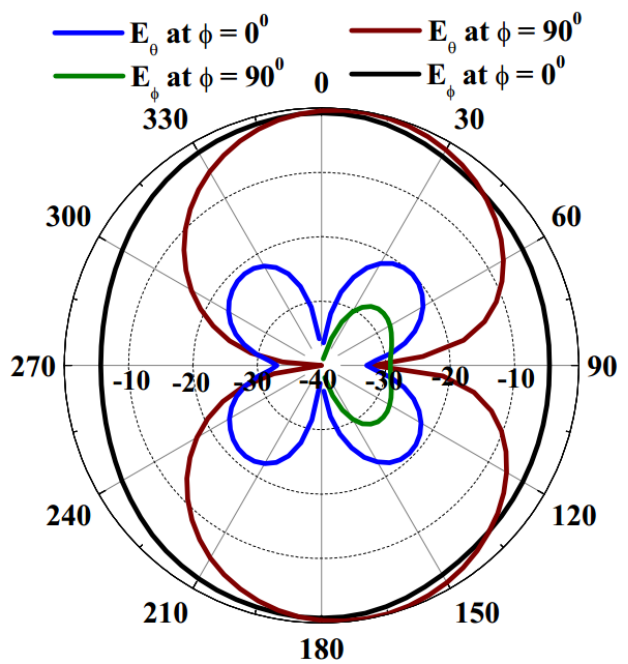
(a) 950 MHz



(b) 1850 MHz



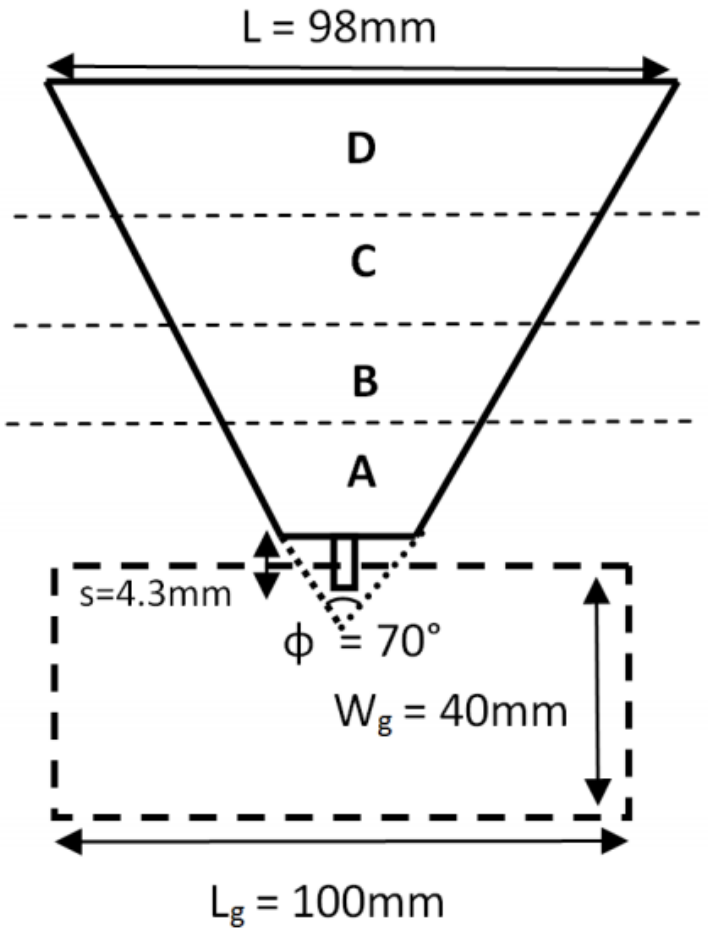
(c) 2150 MHz

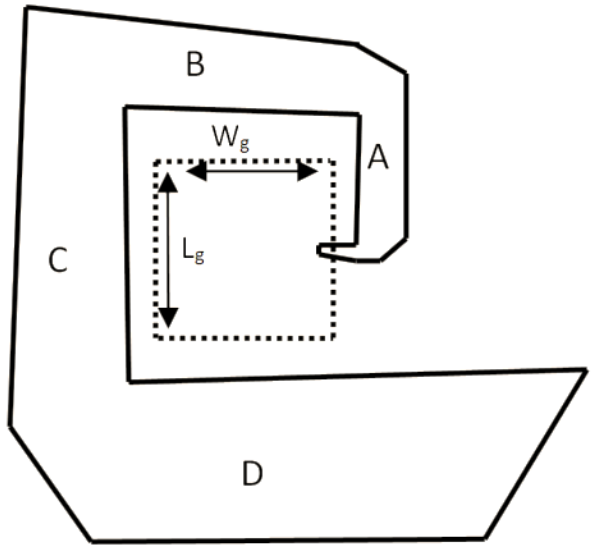


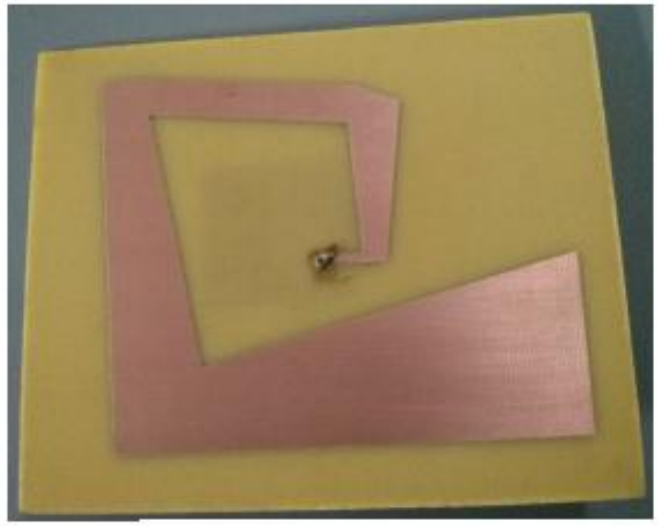
(c) 2450 MHz

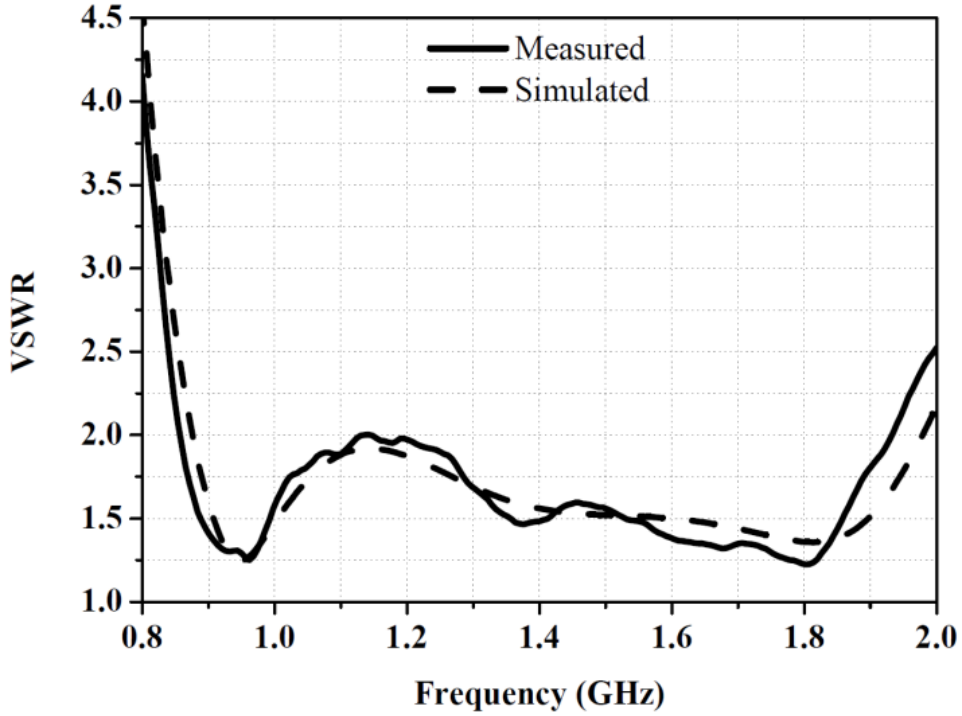
Radiation pattern of the broadband trident monopole antenna at (a) 950 MHz, (b) 1850 MHz, (c) 2.15 GHz, and (d) 2.45 GHz

Broadband Dual Polarized Bent Triangular Antenna

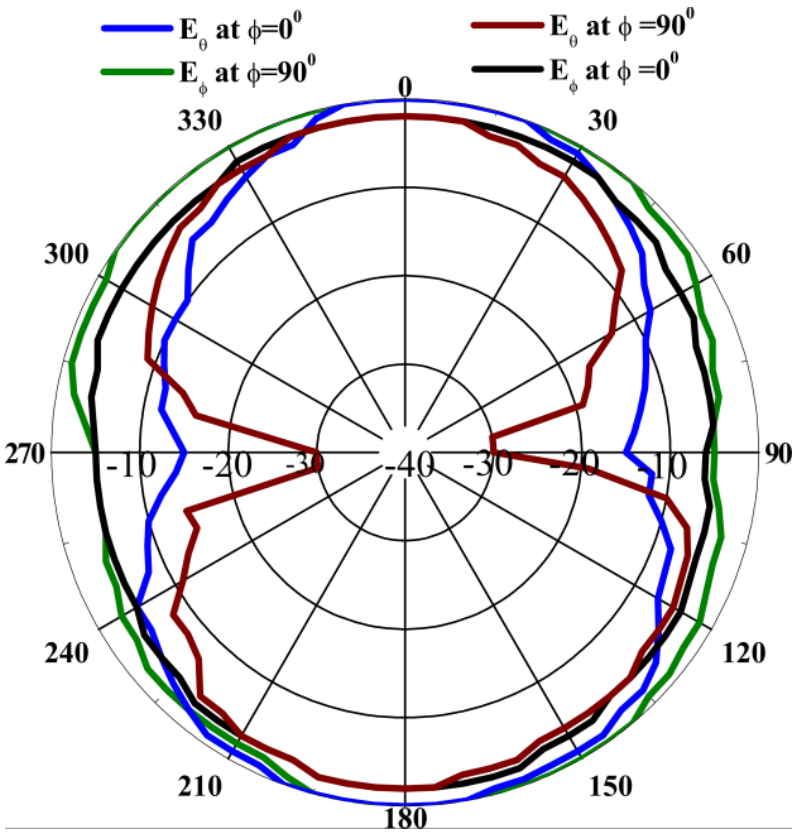




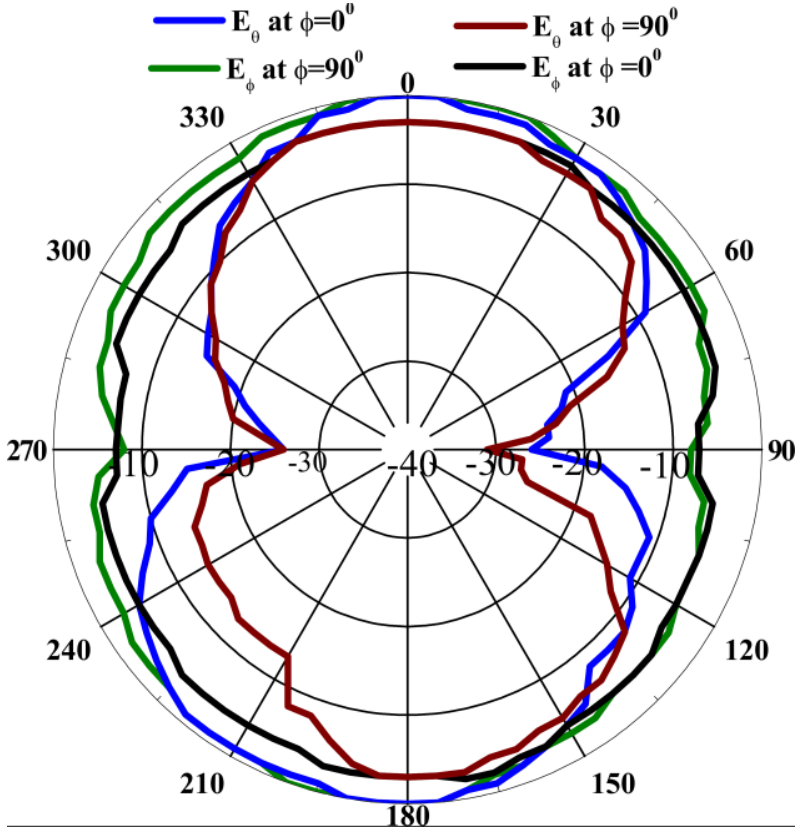




Bent Triangular Antenna Radiation Pattern



At 950MHz



At 1850MHz

Measured radiation pattern of the broadband bent triangular antenna.
Both H and V polarizations are present.