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Bistatic Configurational Analysis of Arc Shape Monopole Ultra-Wideband Antenna (UWB) for Detection Applications

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Abstract - *This paper presents a compact arc shape monopole antenna for Ultra-Wideband (UWB) applications is presented. The Bistatic configuration of the proposed UWB antenna investigation based on ground penetrating radar (GPR) technology used for detection applications. It has compact size of 23 mm × 24 mm × 1.6 mm³. The suggested antenna has been design on FR4 substrate with εr = 4.4 with thickness of 1.6mm. The proposed arc shape monopole antenna exhibits the excellent ultra-bandwidth from 2.7 GHz to 11.3 GHz corresponds to 127.15 % impedance bandwidth at VSWR 2:1. This UWB characteristics of antenna has been obtained with the partial tapered gnd and slotted patch concept. The simulated radiation pattern of monopole antenna is nearly omnidirectional in azimuth plane and bidirectional in elevation plane. The proposed arch shaped monopole antenna is good candidate for UWB communication systems.*

***Key Words*: *Monopole, UWB, Bistatic configuration, Partial gnd and arc shape*.**

1. INTRODUCTION

UWB technology offers numerous advantages such as high data rate, low cost, low power consumption and low profile. The UWB frequency range is assigned from 3.1-10.6 GHz by the Federal Communication Commission (FCC) [1-3]. The Different shapes like rectangular, circular, elliptical, and curved monopole antennas have been reported in [4–6] to achieve UWB response. The UWB characteristics of reported antennas has been improved by introducing slots, defective grounding structures[7-9].The all reported UWB antennas doesn't study bistatic analysis for detection applications.

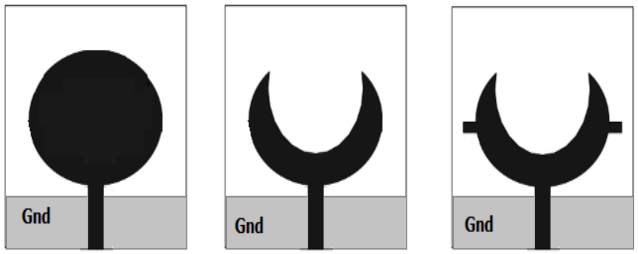
In current scenario, GPR applications uses UWB technology for civilian and military applications such as for the detection of landmines. The number of antennas like horn, Vivaldi, planer, Bow-tie has been reported for GPR applications. But this reported antennas not fulfilling the requirements of bandwidth and design complexity for GPR Application [9-10].

In this paper bi-static analysis of arc shaped monopole UWB for detection application is presented. UWB characteristics obtained by modelling an arch shaped monopole on top of the substrate and tapered partial gnd plane on the bottom side of the substrate. The analysis of modification in gnd plane is study to obtained UWB characteristics.

2. ANTENNA DESIGN CONFIGURATION

The dimensions and geometry of the proposed arch shape monopole antenna is shown in Fig.3. The arc shaped monopole antenna has been printed on top side of FR4 substrate with εr=4.4 and thickness (h) is 1.6mm. Partial ground plane is used to obtain the desired bandwidth and radiation response. The size of the proposed UWB antenna structure is very compact 23×24×1.6 mm³. In Figure 1, Antenna 1 design (Fig.1.a) represents a circular monopole fed with microstrip line covering wideband performance. Next, Antenna 2 (Fig.1.b) design creates arc shape monopole antenna to achieved UWB characteristics. Finally Antenna 3 (Fig.1.c) design create two stub added in arc shape monopole to achieve better impedance matching. The radius (a) of circular monopole antenna is given by, here fc is taken 6.8 GHz which center freq of UWB (3.1+10.6/2=6.8GHz) range.

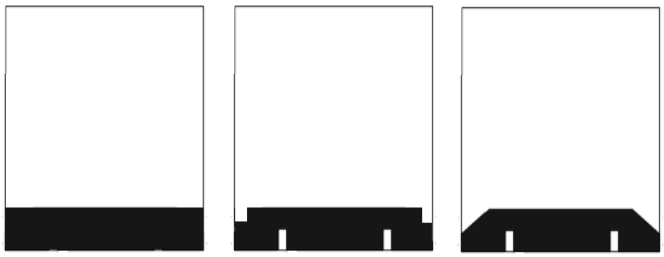
$$a = \frac{\lambda}{4 * \sqrt{\varepsilon_r}} \quad \cdots \quad (1)$$



(a) Antenna 1 (b) Antenna 2 (c) Antenna 3

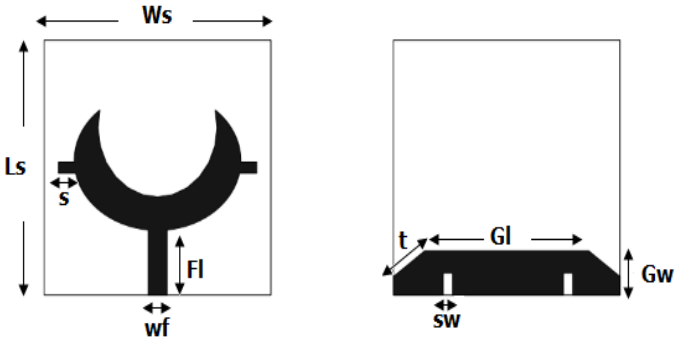
Fig.1. Antenna Evolution Steps

Also different ground plane configuration is investigated to improve UWB characteristics shown in fig.2 .The ground plane is critical parameter in UWB performance



(a) Partial Gnd (b) Partial Slotted Gnd (c) Partial Tapered Gnd

Fig.2. Geometry of the different Gnd Plane Configurations



(a) Top View (b) Bottom View

Fig.3. Geometry of the Proposed Arc Shape Monopole UWB Antenna

Table 1 : Optimized Parameter Values

Parameter's	Ls	Ws	Gl	Gw	t
Dimensions (mm)	23.0	24.0	18.6	4.0	4.0
Parameter's	sw	Fl	wf	Major arc axis	Major arc axis
Dimensions (mm)	1.0	6.0	2.0	17.0	11.0

3. RESULT AND DISCUSSIONS

The proposed Arc shaped monopole UWB antenna has been design using HFSS software. The simulated return loss of antenna evaluation process is shown in figure 4.In result green graph (Antenna 1) getting bandwidth from 2.5-9.2 GHz, Black graph (Antenna 2) getting bandwidth from 2.7-10.6 GHz and red graph (Antenna 3) getting bandwidth from 2.7-10.8 GHz.The excellent impedance matching observed in Antenna 3 design.

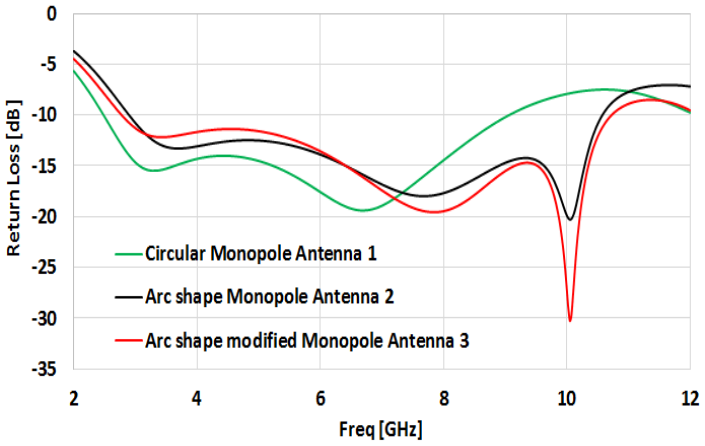


Fig 4. Simulated return loss of antenna evaluation steps

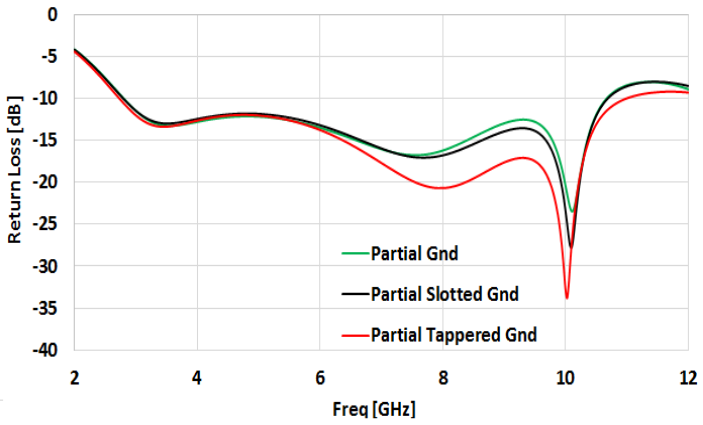


Fig. 5. Simulated return loss of gnd plane evaluations

The simulated return loss of different ground plane configuration is shown in figure 5.In result green graph (partial gnd) getting bandwidth from 2.7-10.7 GHz, Black graph (partial slotted gnd) getting bandwidth from 2.7-10.8 GHz and red graph (partial tapered gnd) getting bandwidth from 2.7-11.3 GHz.The good impedance matching observed in partial tapered gnd design.

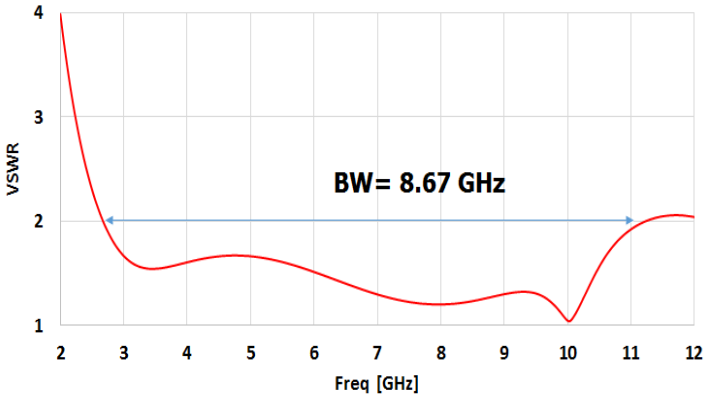
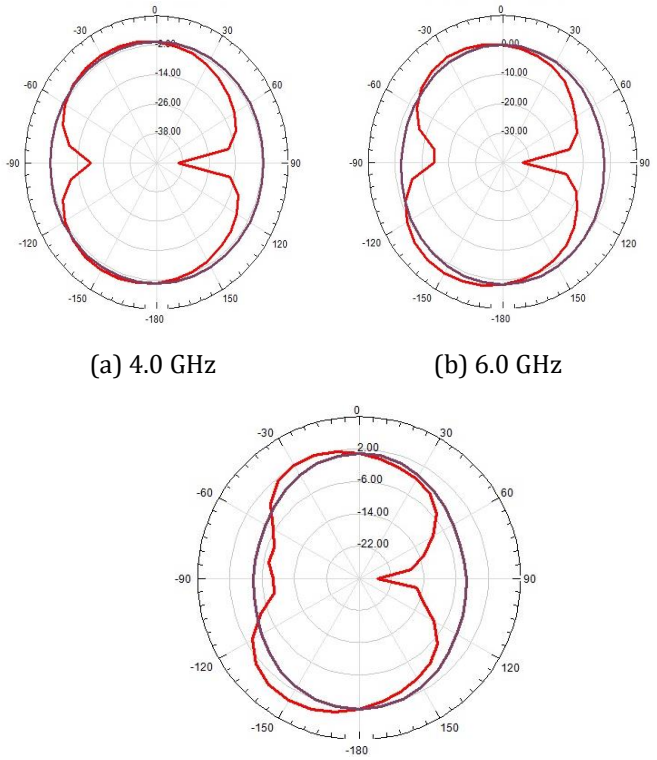


Fig. 6. Simulated VSWR of proposed arc shape monopole UWB antenna

Fig.6 shows the Simulated VSWR of proposed UWB antenna it can conclude that the arc shaped modified monopole antenna with partial gnd exhibits the excellent ultra wide impedance bandwidth of 8.67 GHz (from 2.70 GHz to 11.37 GHz) corresponds to 127.15 % impedance bandwidth.



(a) 4.0 GHz (b) 6.0 GHz

(c) 8.0 GHz

Fig. 7. Simulated Radiation Pattern of proposed arc shape monopole UWB antenna

Table –2 : UWB Antenna Evolution Comparison Table

Sr. No.	Results	Freq range (GHz)	Return loss(dB)	VSWR	BW (MHz)	BW (%)	Gain (dB)
1.	Elliptical monopole UWB Antenna	2.40-9.25	-19.38	1.25	6.85	100.7	3.5
2.	Arc Shape monopole UWB Antenna	2.80-10.67	-17.97	1.28	7.78	115.7	3.4
3.	Arc Shape modified monopole UWB Antenna	2.70-10.80	-19.55	1.24	8.10	119.1	3.3

Table –3 : Partial Gnd Plane Evolution Comparison Table

Sr. No.	Results	Freq range (GHz)	Return loss(dB)	VSWR	BW (MHz)	BW (%)	Gain (dB)
1.	Arc Shape with partial gnd UWB Antenna	2.70-10.70	-16.60	1.34	8.00	117.1	3.3
2.	Arc Shape with partial slotted gnd UWB Antenna	2.70-10.77	-17.03	1.32	8.07	118.6	3.3
3.	Proposed Arc Shape with partial tapered gnd UWB Antenna	2.70-11.37	-20.58	1.20	8.67	127.15	3.3

3.1. BISTATIC CONFIGURATION ANALYSIS OF UWB ANTENNA

In bistatic Analysis model consist of Tx antenna, Wall obstacle, target object and Rx Antenna. The distance between concrete wall (εr =5.2) and human tissue target (εr = 28.2) is 60mm. The thickness of concrete wall is 9 mm. The simulation model of bistatic configuration analysis is shown in the fig.8.

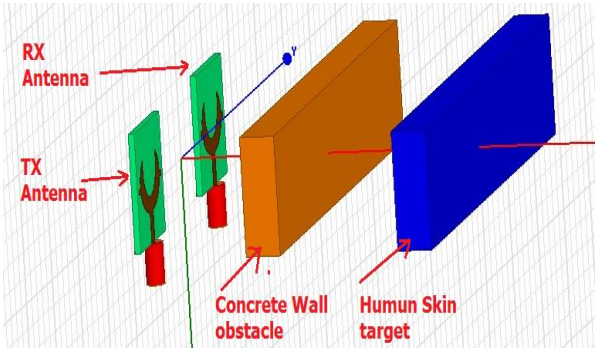


Fig. 8. Bistatic Analysis of Arc shaped UWB antenna Simulation Model

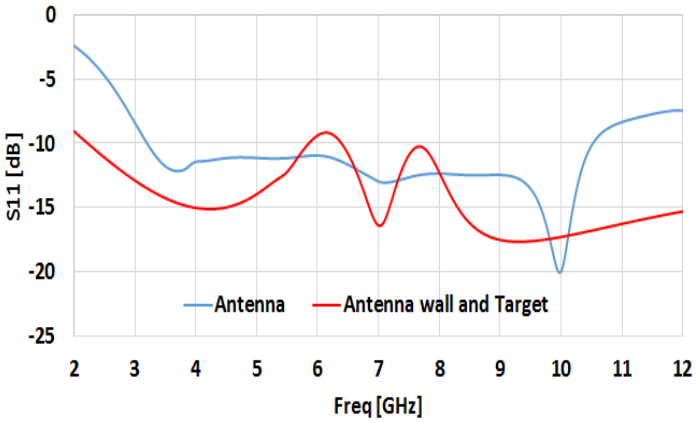


Fig. 9.a. Simulated S11 of Bistatic UWB Antenna Model

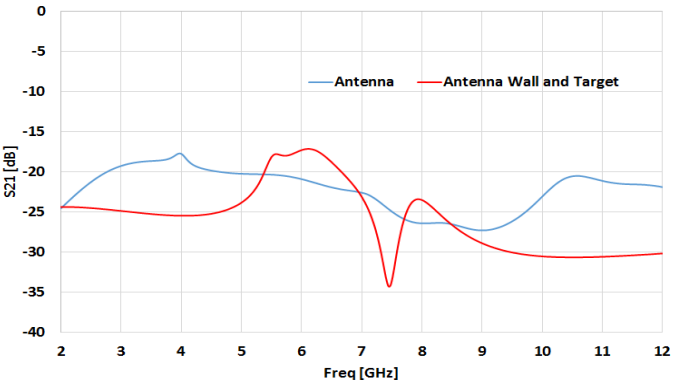


Fig. 9.b. Simulated S21 of Bistatic UWB Antenna Model

From fig.9 conclude that of S11 is changing at around 7.4 GHz with significant resonance is observed which is mainly due to backscattering of the wall. Also target object disturbed S11 characteristics.

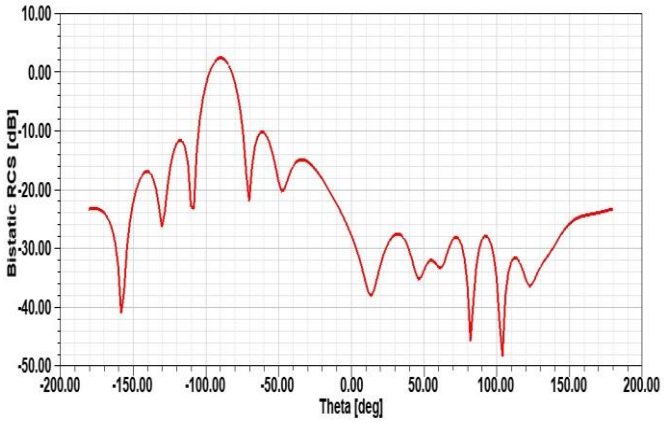


Fig. 10. Simulated Bistatic RCS of UWB Antenna

4. CONCLUSIONS

An ultra-wideband (UWB) printed arc shaped antenna has been presented for detection applications. The overall size of antenna is very small 23 × 24 × 1.6 mm^3. The proposed arch shape monopole antenna offers UWB characteristics from 2.7 GHz to 11.3 GHz at VSWR 2:1. It is observed that the radiation patterns of antenna are omnidirectional in H-plane and bidirectional in E-plane over the entire operating bandwidth. In bistatic analysis has been done using two UWB antennas, one UWB antenna for transmitter and another for receiver of with obstacle between antennae and the targeted human skin. The proposed arc shape monopole antenna is compact, low profile, and offers very large impedance bandwidth required for UWB system.

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