

# Metamaterial Inspired Microstrip Offset Feed Truncated Antenna for Automotive Radar Application



K.Arunkumar, S.Srinivasan, A.Beno, W.Mesiya Stalin

**Abstract:** A state-of-the-art design of microstrip offset feed truncated antenna for automotive radar applications operating at 24 GHz UWB band is proposed. The rectangular patch is truncated and ring shaped co directional complementary split ring resonator is imprinted on edge truncated rectangular patch to radiate in the short-range radar UWB band. The proposed antenna with Co-directional complementary split ring resonator antenna is having measurement of 5.1 x 4.65 x 1.6 mm<sup>3</sup> with operating frequency ranges from 24.6 to 30.3 GHz. This work comprises the thorough inquiries such as return loss, distribution of surface current, gain and radiation pattern. With the help of parametric analysis width of slit (z), width of feed (Wf) and length of feed (lf) the dimension of the proposed antenna is obtained. Simulation have shown decent fairness which proves the feasibility of the projected antenna for the automotive short-range RADAR application.

**Keywords:** Codirectional CSRR, Near range automotive RADAR, truncated antenna, UWB.

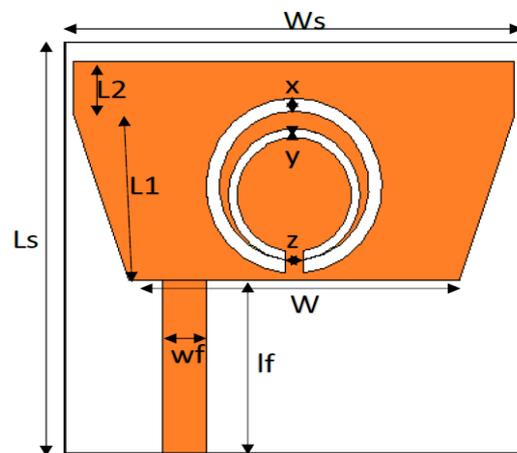
## I. INTRODUCTION

The research on UWB antenna stated evolving after the consent of the FCC1-2. If the bandwidth is greater than 500 MHz then it is called as Ultra Wide Band (UWB). In UWB spectrum band for bounded communications, for automotive of short-range and long-range RADAR the frequency bands 3.1 to 10.6 GHz, 22 to 29 GHz and 77 to 81 GHz are used. The opportunity of presence of 24 GHz frequency band for automotive RADAR for the near future [3] is mentioned by European Telecommunications Standards Institute (ETSI). The automotive RADAR for short range, helps in reducing accident is used by the automotive can scan and identify any objects in its range.

The total effectiveness of the short-range RADAR circuit is directly depending on the effectiveness of the antenna which is the vital part of the RADAR. Most of the antenna designers concentrate on indoor UWB antenna design which ranges from 3.1 to 10.6 GHz, but the researchers not concentrated more on UWB range of 22 to 29 GHz for automotive applications short-range RADAR.

Microstrip fed antennas with Truncation of patch, fractal, metamaterial, slotted patch and ground have been projected for bounded communication range from 3.1 to 10.6 GHz [4,5]. In most of the automotive applications require to operate in 22 to 29 GHz. Hence, this work suggests metamaterial inspired truncated patch antenna solely operating from 22 to 29 GHz band.

MTM has electromagnetic properties not available in nature, which has the properties because of its structure [6-10]. SRR, CSRR, S shaped resonators and omega shaped resonators are some of the metamaterial structures are widely used by the researchers.



**Fig. 1 Antenna Geometry**

In this work a two-ring shaped Co directional CSRR is proposed. We propose a truncated radiating element on a FR-4 of 0.8 mm thickness substrate with CSRR etched on the truncated radiating element. The frequency range 24.6 GHz-30.3 GHz is the operating frequency of the designed metamaterial inspired truncated microstrip feed patch antenna.

## II. ANTENNA DESIGN

The projected structure which is designed on a FR-4 substrate of 4.4  $\epsilon_r$  and 0.02  $\tan \delta$  with thickness of 1.6 mm.

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The conservative rectangular patch is changed by cutting the radiating element and CSRR is etched in the radiating element. The rectangular patch antenna is transformed by feed offset, edges truncation and engraving codirectional ring

CSRR in truncated rectangular patch to develop the projected antenna. The impedance matching is achieved with the help of truncating patch and offset feeding. The proposed antenna and its parameter values are depicted in figure 1 and in Table I.

**Table 1. Constraints of the Antenna (in mm)**

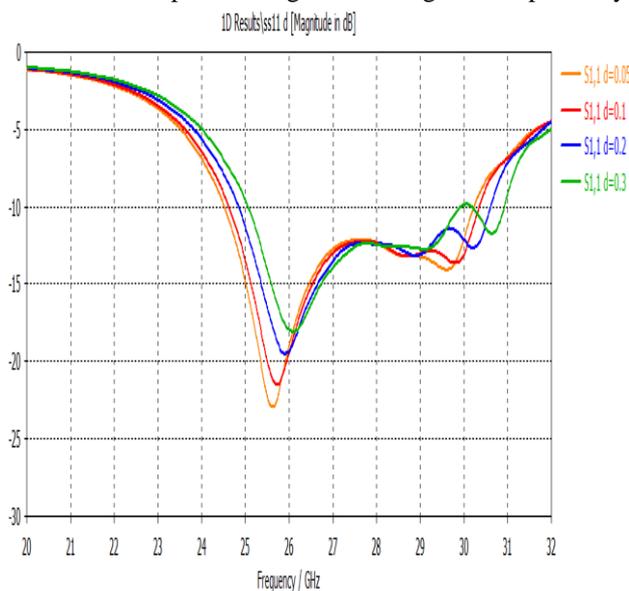
H	lf	wf	Ls	Ws	L2
1.6	1.75	0.4	4.65	5.1	0.625
X	Y	W	Z	L1	t
0.15	0.1	3.75	0.2	1.575	0.35

The electric field formed by the conventional radiating element will induce the codirectional CSRR etched on the truncated rectangular radiating element. The electromotive force created in the complementary split ring resonator creates a vacillating voltage between the CSRR slots. As a result, electric field in gap of dielectric creates mutual capacitance and inductance are created. Thus, the complementary split ring resonator act as parallel resonating LC structure.

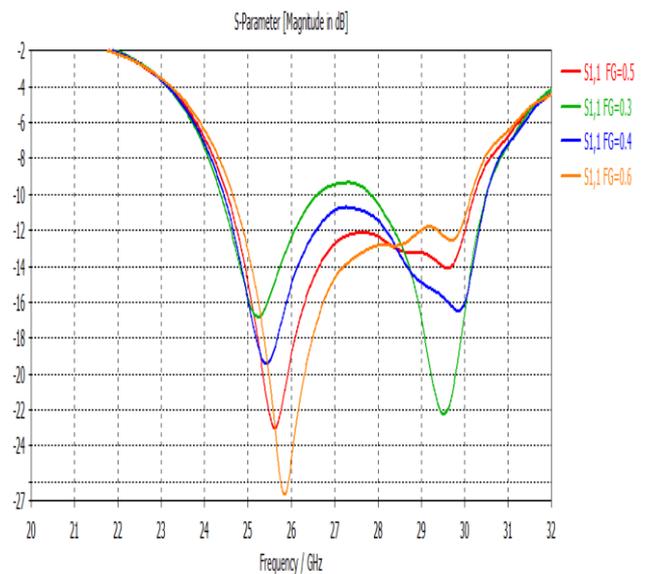
### III. PARAMETRIC STUDY

To choose the optimum values of the critical parameters of the proposed structure the parametric analysis is done with width of slit (z), width of feed (wf) and length of feed (lf). The width of slit is varied from 0.05mm to 0.3mm and 0.05mm is selected as the optimum value since it is producing good impedance matching in the desired resonating band it is proved from the figure 2.

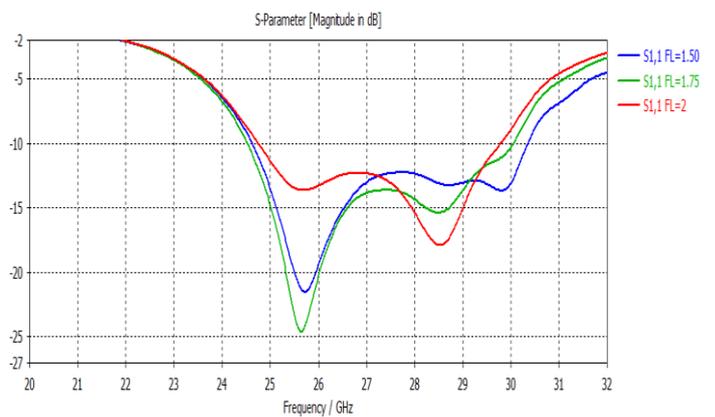
In order to select the finest value of the feed width, the value of  $w_f$  is varied from 0.3mm to 0.6mm. The value of 0.4mm is carefully chosen because it is providing very decent bandwidth. The feed length is chosen by varying it's the length of the feed from 1.5mm to 2mm and 1.75mm is designated to design the proposed short-range RADAR. The parametric analysis of the above mentioned parameters are depicted in figure 3 and figure 4 respectively.



**Fig. 2. Slit width Parametric analyses**



**Fig. 3. Feed width parametric analyses**



**Fig. 4. Feed length parametric analyses**

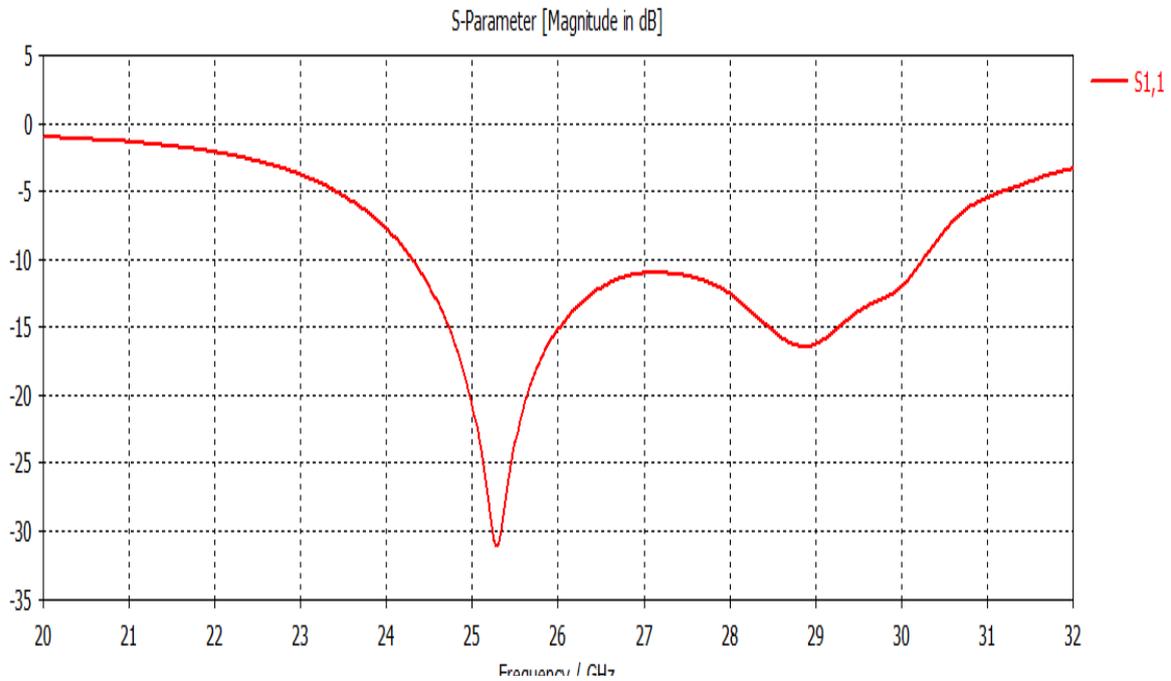


Fig. 5. S11 characteristics of projected RADAR antenna

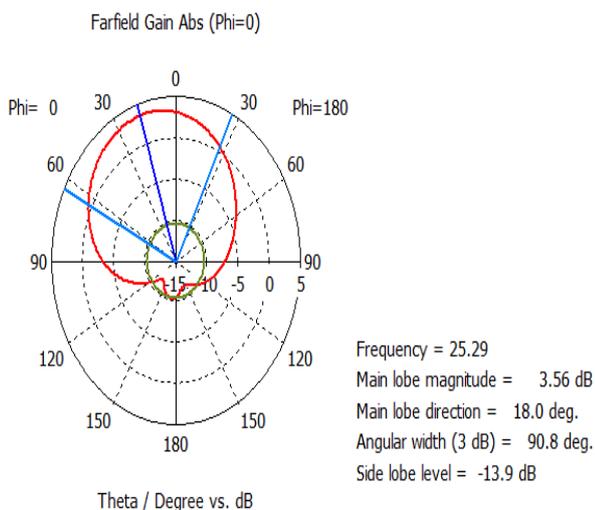
IV. RESULTS AND DISCUSSION

In Table II the simulated results of the proposed metamaterial inspired offset feed truncated are presented and fig. 5 depicts that the wide band from 24.6 GHz to 30.3GHz is achieved which is used for the automotive radar short range application. The far field pattern at 25.3 GHz frequency is depicted in fig 6. In fig. 7, the surface current distribution is presented from than we can infer that the projected metamaterial inspired microstrip offset feed truncated antenna has a wide band characteristics because of the distribution of surface current is more in the two ring

shaped complementary split ring resonator at the resonant frequency.

Table II Projected RADAR Antenna Result

PROPOSED ANTENNA	FREQUENCY BAND OF OPERATION GHz	S11 dB	% BANDWIDTH	GAIN dBi
Simulation Result	24.26 – 30.28	-31.34 @25.29GHz	22.07%	3.14



a) E plane  
b) H plane

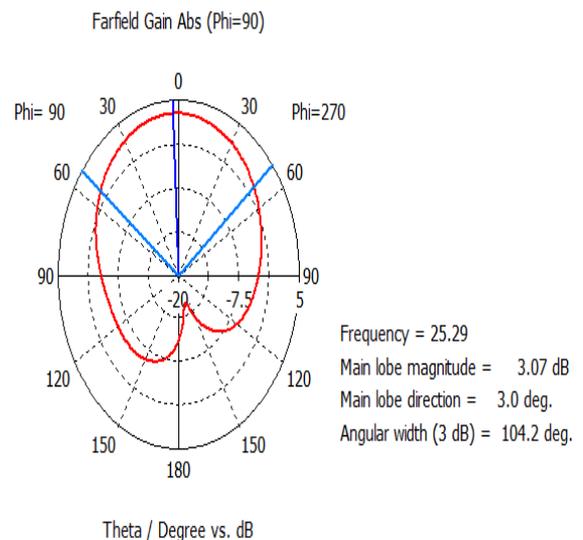
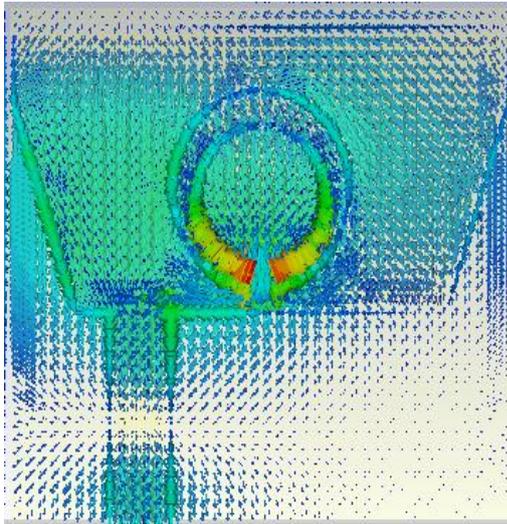
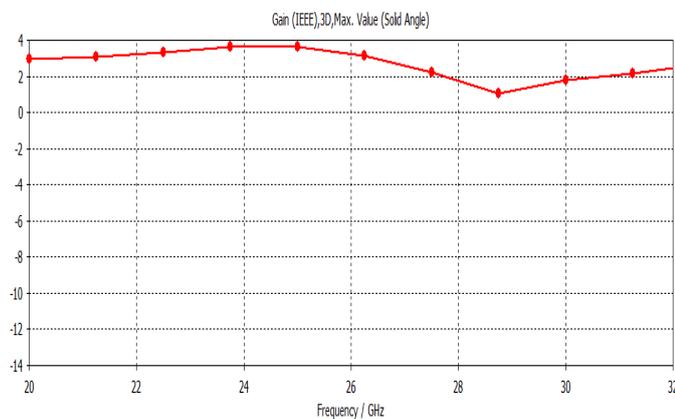


Fig. 6. RadarAntenna E& H Plane at 25.3 GHz



**Fig. 7. Current distribution of 25.3GHz**

The gain of the proposed Radar antenna is consistent in the entire operating band of frequency with the maximum peak gain of 3.14 dBi at the frequency of resonance.



**Fig. 8. Gain Vs Frequency plot**

## V. CONCLUSION

Two codirectional ring shaped CSRRs loaded in the microstrip feed truncated radiating element to yield decent antenna for automotive short-range RADAR application. The simulated results of  $s_{11}$  characteristics, Gain plot, E & H field patterns and distribution of surface current shows that all the values are in the best ranges for the proposed application. So, the proposed offset feed truncated CSRR inspired patch antenna is the right choice for the short-range radar locomotive application.

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