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DESIGN AND ANALYSIS OF MULTI-RESONANT SYMMETRICAL MEANDER-LINE DIPOLE ANTENNA FOR WIRELESS APPLICATIONS

Anilkumar Tirunagari, Department of ECE, GMR Institute of Technology, Rajam, AP, India.
anilkumar.t@gmrit.edu.in
Gurucharan Kapila, Department of ECE, Lendi Institute of Engineering & Technology, Jonnada, Vizianagaram, AP, India.

ABSTRACT
This paper explores the design of multi-resonant symmetrical meander-line dipole antenna. The antenna is designed on FR-4 substrate with relative permittivity 4.4 and has the footprint of 12 x 50 x 1.6mm^3. The meander-line structure is designed in an open curve pattern with order 10. The multi-resonant characteristics of the proposed antenna are found due to the increased order of the meander-line geometry. It produces four resonant frequencies at 4.08 GHz, 4.72 GHz, 5.28 GHz, and 5.82 GHz. The antenna was modeled and simulated in ANSYS HFSS simulation tool and the required antenna parameters like reflection coefficient, phase characteristics, gain, radiation patterns in 2D and 3D were presented for understanding the antenna performance.
Keywords: Multi-resonant antennas, Ansys HFSS, Meander-line curves.

I. Introduction
In contemporary communication systems, when a single device needs to communicate across various frequency ranges, the multi-resonant antennas [1-5] are helpful. The purpose of multi-resonant antennas is to provide effective operation across a range of frequency bands. Through a variety of design strategies, multi-resonant antennas are able to accomplish this, making them extremely adaptable and effective in a wide range of applications, such as satellite communications, wireless networks, and mobile phones. Among the several forms of multi-resonant antennas are printed Monopole Antennas [6-8], Slot Antennas [9-11], Planar Inverted-F Antennas (PIFA) [12-15], and Dielectric Resonator Antennas (DRA) [16-19] etc.. Designing for many resonances, balancing size and performance, preserving constant impedance matching, and guaranteeing isolation are challenges in multi-resonant antenna design [20-23].

II. Antenna Design
The proposed antenna is designed on the flame retardant grade-4 substrate FR-4 with dielectric constant of 4.4 and loss tangent of 0.02. The substrate is considered with the dimensions of 12 x 50 x 1.6mm^3. The structure of the printed dipole is formed on one side of the substrate i.e., upper side of the substrate and the other side is not metallized. The geometry of the antenna is shown in Fig. 1. The geometrical parameters of the antenna are mentioned in Table 1. The proposed antenna is designed based on open-meandering structure with an order of 10.

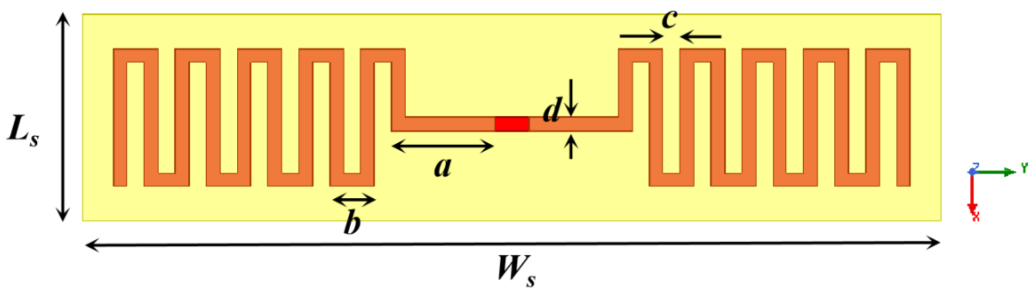


Figure 1: Geometry of Meander-line dipole antenna

Table 1: Geometrical parameters of the proposed meander-line dipole antenna

Parameter	L_s	W_s	h	a	b	c	d
Value in mm	12	50	1.6	6	2.6	1	0.8

III. Results and Discussion

The antenna is operating in four resonant frequencies at 4.08 GHz, 4.72 GHz, 5.28 GHz and 5.82 GHz respectively covering the spectrum of 4-6 GHz band. The antenna is said to be quad-band antenna. The operating band characteristics are presented in Table 2.

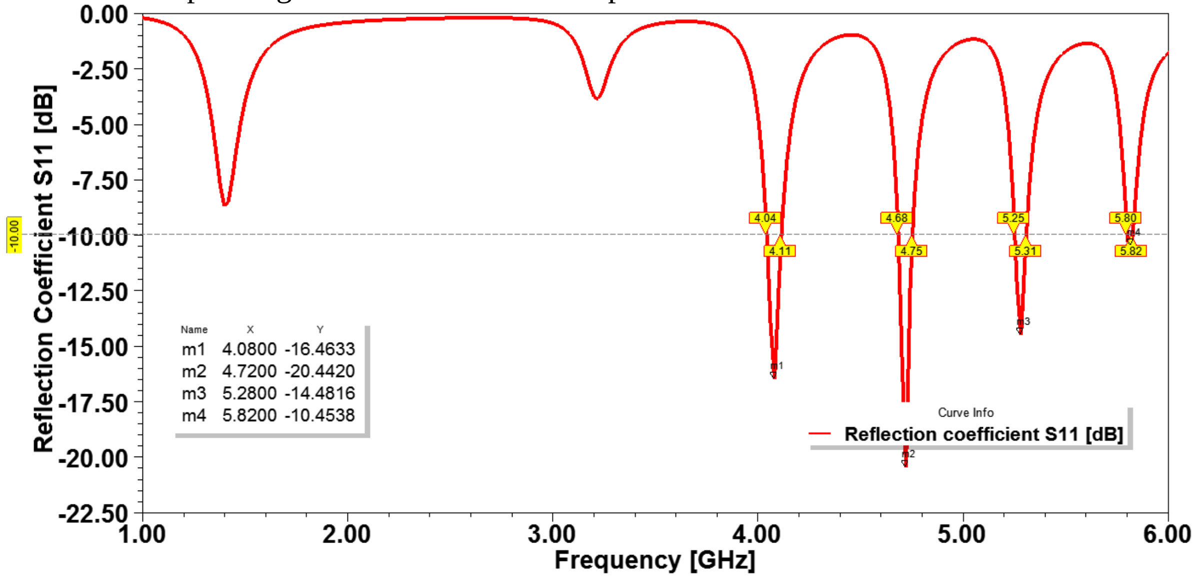


Figure 2: Reflection coefficient vs Frequency characteristics of proposed antenna

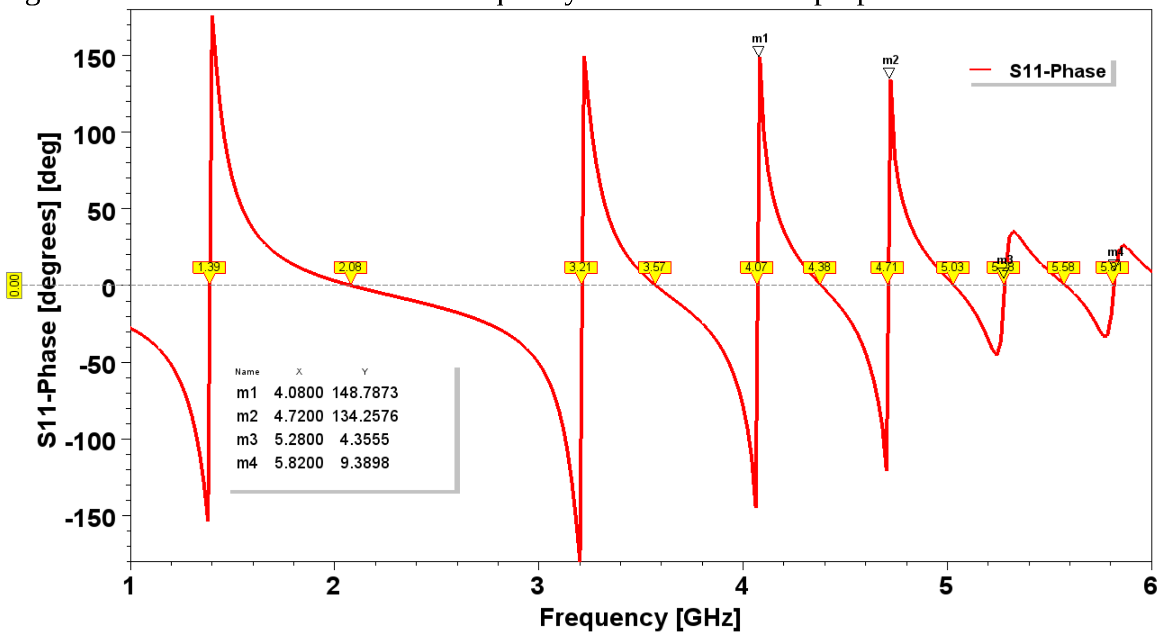
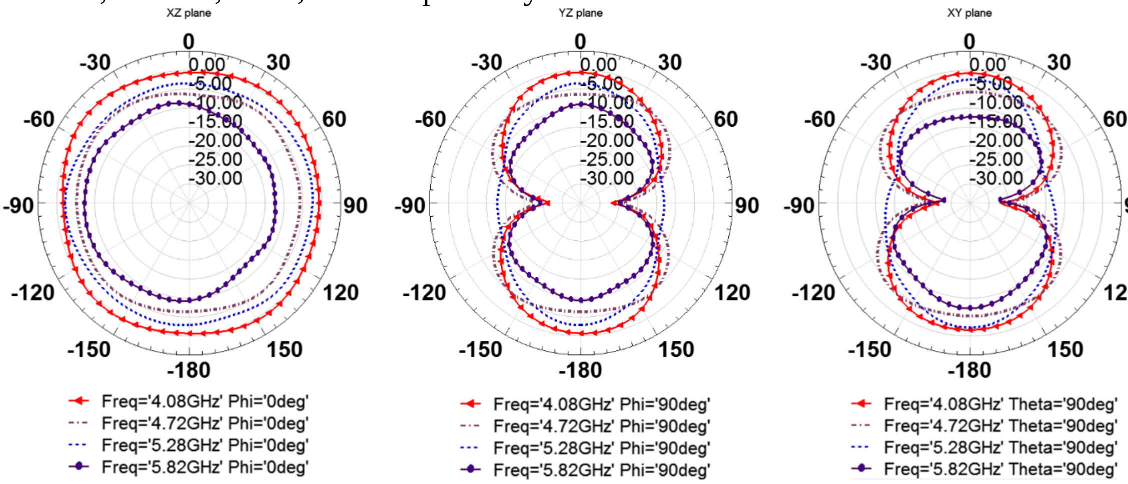


Figure 3: Reflection Phase vs Frequency characteristics of proposed antenna

Table 2: Operating band characteristics of proposed antenna

Operating bands	**Cut-off frequencies**	**% Bandwidth**	**Resonant Frequency f_r [GHz]**	**S_{11} [dB]**
Band-1	4.04-4.11 GHz	1.72	4.08	-16.46
Band-2	4.68-4.75 GHz	1.48	4.72	-20.44
Band-3	5.25-5.31 GHz	1.14	5.28	-14.48
Band-4	5.8-5.82 GHz	0.34	5.82	-10.45

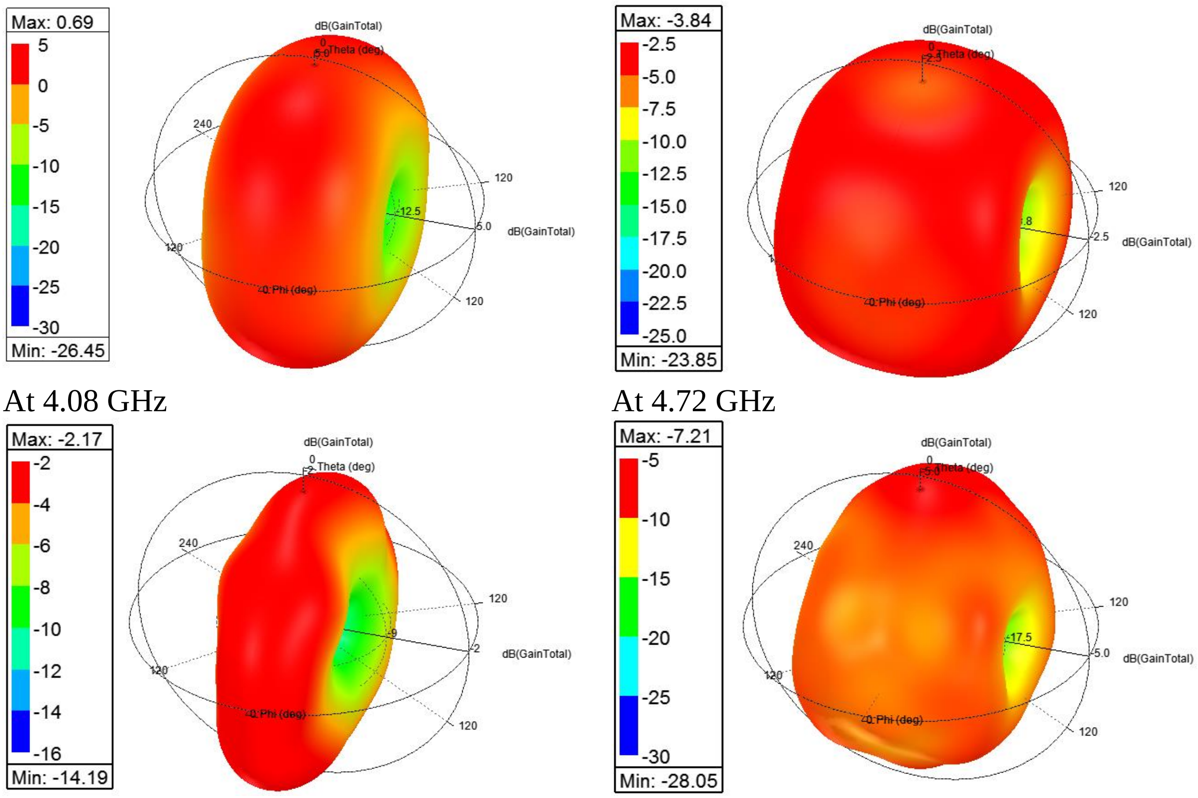
Band-1 is distributed from 4.04-4.11 GHz with percentage bandwidth of 1.72% and resonating at 4.08 GHz offering return loss of -16.46 dB respectively. Similarly remaining band characteristics can be seen from Table 2. Among all the resonant frequencies 4.72 GHz gives good reflection coefficient properties compared to others resonances. The S11 phase characteristics shown in Fig. 3 depicts that at resonant frequencies 4.08, 4.72, 5.28, 5.82 GHz the phase reflection coefficients are found to be 148.78^0, 134.25^0, 4.35^0, 9.38^0 respectively.



(a) XZ-plane (b) YZ-plane (c) XY-plane

Figure 4: 2D far-field characteristics in XZ, YZ and XY planes at all resonant frequencies

The shape of the radiation patterns in XZ-plane are transforming from omni-directional to quasi-omnidirectional as frequency increases whereas the dumbell shaped patterns were seen in YZ and XY-planes respectively. In those planes the gain is considerably decreasing in 0-180deg direction.



At 4.08 GHz At 4.72 GHz

At 5.28 GHz At 5.82 GHz

Figure 5: 3D far-field radiation characteristics of proposed antenna at operating bands

The 3D far-field radiation characteristics are obtained from antenna simulations, plotted at four of its resonant frequencies 4.08 GHz, 4.72 GHz, 5.28 GHz and 5.82 GHz respectively as shown in Fig. 5. The obtained gain values are 0.69 dB, -3.84 dB, -2.17 dB and -7.21 dB respectively.

IV. Conclusion

The proposed design uses the symmetrical meander-line structure in printed dipole configuration. The open meander-line structure of the 10^{th} order has caused the antenna to operate in four resonant bands. The proposed antenna has quad-narrow bands of having 1.72%, 1.48%, 1.14% and 0.34% respectively. As the antenna is very compact in nature as per its dimensional relation with resonant length, the gain is limited which can be improved by arraying techniques.

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