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Investigations on Metamaterial based Log Periodic Dipole Antenna

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Abstract

In this paper, the application of metamaterial to the accustomed log periodic dipole antenna (LPDA) for ground penetrating radar is presented. The metamaterial based Split Ring Resonator (SRR) is loaded with dipole in accustomed LPDA. The proposed antenna is printed on FR4 substrate with length and width 81.9 x 65.5mm. The antenna has 68% size reduction as compared to accustomed antenna. The simulation results show that the proposed antenna has wide bandwidth and high gain, which is suitable for Ground Penetrating Radar (GPR) applications.

Keywords: *Split Ring Resonator, Log periodic dipole antenna, Ground penetrating Rada*

INTRODUCTION

Ground Penetrating Radar (GPR) is most widely used geophysical technique for detecting and identifying aquifer water and non metallic mines. Antenna is the one of the most significant hardware components for the conduct of ground penetrating radar (GPR) [3, 4]. Ground penetrating radar is specific application using ultra-wideband antennas. It operates within frequency range from 10 MHz to 10 GHz (Archaeology and Architecture (0.01–2 GHz), military (0.5–3 GHz)) [1].

Most of the works reported on modifying dipole length or shape for enhancing bandwidth and miniaturization in size of the Log periodic dipole array (LPDA). For the first time, metamaterial based Log periodic dipole array is investigated for GPR applications [2-4].

ANTENNA GEOMETRY

The name "log periodic" comes from the uniform spacing between the resonance frequencies of the antenna, when plotted in a logarithmic scale. The log periodic antennas are frequency independent antennas, introduced by Du Hamel and IsBell in 1957 [5]. The designed accustomed LPDA structure and SRR loaded LPDA are shown in Figures (1-2).

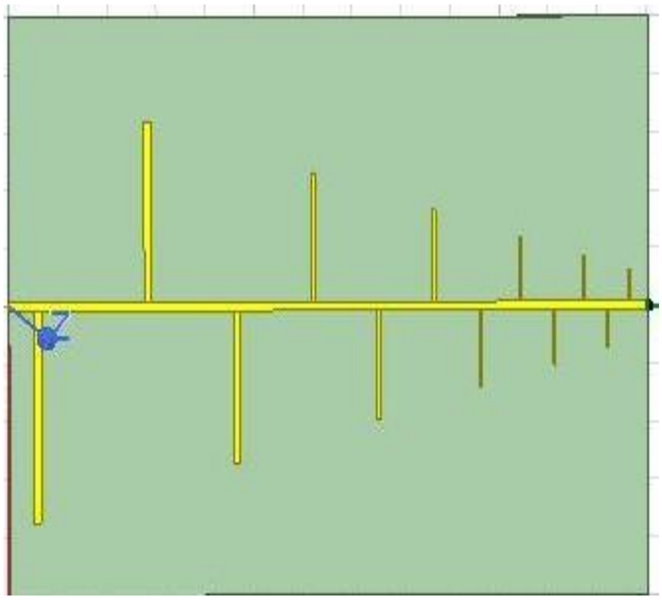

Fig. 1.Accustomed LPDA.

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Accustomed LPDA:

S.No	symbol	Description	Value
1	h	Height of the substrate	1.4mm
2	l	Length of the substrate	250mm
3	w	Width of substrate	200mm
4	t	Thickness of copper	0.017mm
5	L1	Length of the first element	150mm
6	W1	Width of the first element	3.4mm
7	S1	Spacing	33.75mm
8	τ	Scaling factor	0.85

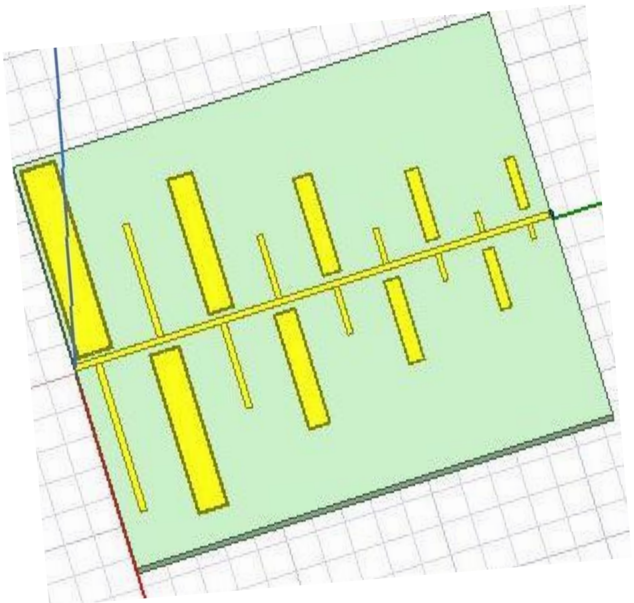

Fig. 2. SRR loaded LPDA.

SRR loaded LPDA:

S.No	symbol	Description	Value
1	h	Height of the substrate	1.4mm
2	l	Length of the substrate	81.9mm
3	w	Width of substrate	65.5mm
4	t	Thickness of copper	0.017mm
5	L1	Length of the first element	49.152mm
6	W1	Width of the first element	1.11mm
7	S1	Spacing	11.05mm
8	τ	Scaling factor	0.85
9	LSR1	Length of SRR 1	9.83mm
10	WSR1	Width of SRR1	1.96mm
11	τx	Spacing factor	0.95

RESULTS AND DISCUSSION

The accustomed LPDA and Split ring resonator (SRR) loaded LPDA are designed using HFSS software. Both antennas are simulated on FR4 substrate. By loading split ring resonator, the area saved by up to 68%. The gain of accustomed LPDA and SRR loaded LPDA are given by 7.2 dB and 8.2 dB. The 3D radiation pattern of proposed antenna at 1.5 GHz frequency is shown in Figure 2. The 2D plot of proposed antenna radiation pattern is shown in Figure 4. The 3D radiation pattern of SRR loaded LPDA is given in Figure 5.

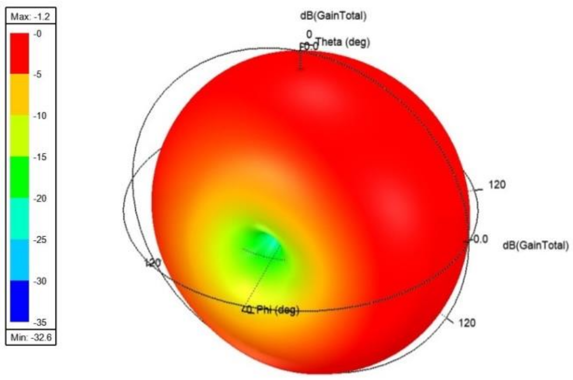

Fig. 3 Radiation pattern 3D plot of SRR loaded LPDA at 1.5 GHz

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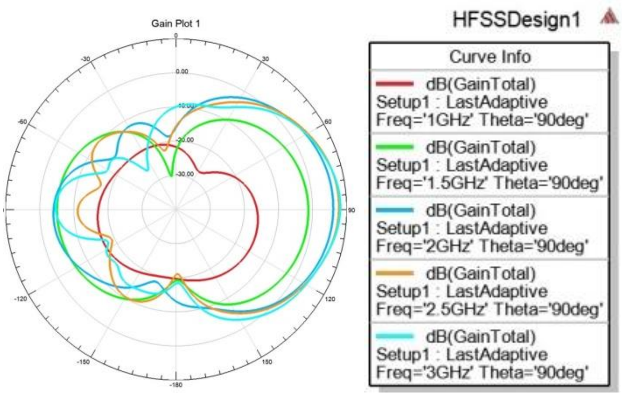

Fig. 4 2D radiation pattern of SRR loaded LPDA.

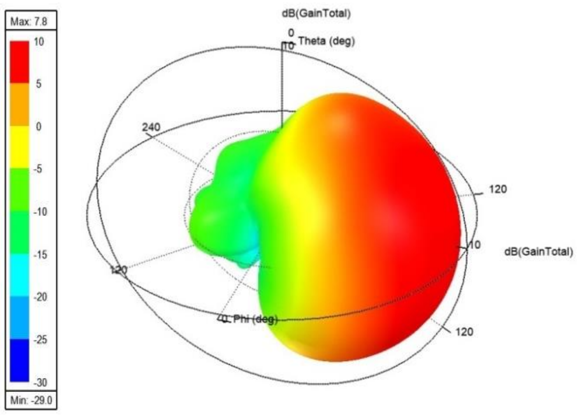

Fig. 5 Gain - 3D plot of SRR loaded LPDA at 2.5 GHz

CONCLUSION

A newly developed metamaterial antenna is proposed for GPR applications. Both Accustomed

LPDA and SRR loaded LPDA are simulated on FR4 substrate. The size miniaturization and improvement in gain are achieved with the loading of split ring resonator. The operating frequency of proposed antenna is within the GPR frequency range, it is suitable for GPR applications.

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