Investigations On Split Ring Resonator For GPR Antenna

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Abstract

A new Microwave frequency range resonator for Ground Penetrating Radar (GPR) antenna is proposed in this paper. An approach based on the effects of the properties of meta material in Split Ring Resonators (SRRs) is used to design a SRR for GPR. The variation of effective permeability and permittivity of Split Ring Resonator (SRR) by change of configuration is reported in this research. Each left handed metamaterial (LHM) unit cell was constructed by modifying a square Split Ring Resonator (SRR), resulting in negative permeability and permittivity with a stable negative refractive index. Investigations are made on shift in resonant frequency due to change in dimensions of the ring, material of the ring.

Keywords: *Metamaterials, Split ring resonator, Ground penetrating Radar*

Introduction

Metamaterials with extra ordinary features have built a new generation in the applications of ultra wide band (UWB) for the implementation of microwave antennas due to their great attainable. A metamaterial is a created electromagnetic structure with some decent properties that are generally not available in nature. By using these negative index features, such as ultra wideband antennas, are evolved, which have external characteristics in terms of permittivity, permeability, return loss, resonant frequency etc. These features make metamaterial loaded ultra wideband antennas of great interest for GPR applications.

Ground Penetrating Radar is one of the fundamental applications of UWB generation that is widely utilized in army and civilian programs which includes the detection of land mines [1]. In addition, GPR is likewise utilized in remote sensing techniques consisting of non damaging checking out of concrete and detection of trapped human beings beneath particles or in opaque surroundings [2].

By loading these split ring resonators on the radiating element or on the ground plane, multi-band characteristics can be realized [3-4]. Metamaterial primarily based antennas are proposed to showcase numerous advantages over conventional antennas such as enhancing the directivity, bandwidth and antenna size [5-6]. The design in [7] uses a metamaterial lens to take full advantage of the antenna gain. The design presented in [7] adopts a metamaterial lens to take complete benefit of the gain. Also, planar metamaterials are used intensively to decrease the antenna length by using the use of exceptional metamaterial unit cells to create 3 resonances through the same antenna, which accomplishes a discount within the antenna size.

Involving some special magnetic resonator structures and popular split ring resonator structures, negative values of permittivity and permeability are obtained. These structures produce strong magnetic coupling to an applied Electromagnetic field which are not available in conventional materials. Though distinct SRR configurations have been investigated, the most standard/ traditional ones are square and circular SRRs. Square SRRs configurations have been extensively used and are manageable at microwave frequencies. These geometries/ structures reveal large magnetic polarizability and negative permeability at resonant frequencies. In this paper, simulation of Left handed metamaterials done successfully using these split ring resonators. The resonators are suitable to load in the GPR antenna as they operate within the GPR range. Here HFSS Software is used.

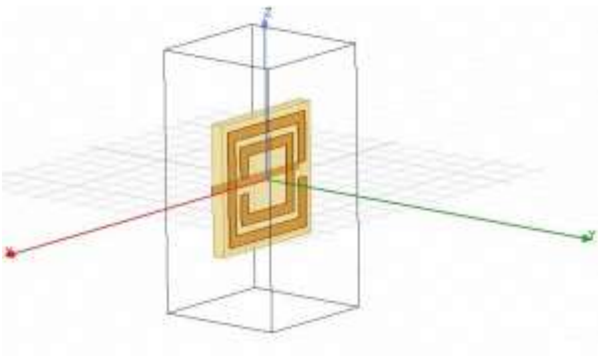

Fig. 1. Square split ring resonator

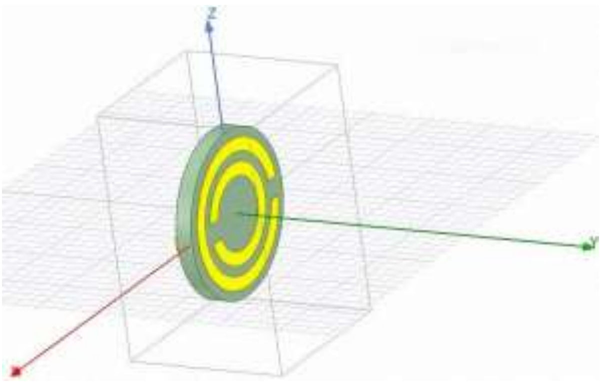

Fig. 2. Circular Split ring resonator

II. Results and discussion

The geometry of Square split ring resonator and Circular split ring resonator are given in figures (1-2). Variation of effective permeability and permittivity due to “a” Simulation were conducted for different values of “a” and results are plotted. From graph X axis represents frequencies in GHz where as Y axis covering effective permeability values.

The variation of permittivity and permeability for various values of “a”, Silver duroid of thickness 0.1mm are shown in figures(3-6). In figures (7-8), the effective permittivity and permeability of Silver duroid of thickness 0.25mm are presented. The change in permeability and permittivity of Copper duroid of thickness 0.1mm for different values of “a” are given in Table1.The effective permittivity and permeability of Copper duroid of thickness 0.25mm are presented are depicted in Table 1. The variation of permittivity and permeability for various values of “a” and for different value of thickness are given in Table 1..

The variation of permittivity and permeability for various values of “a”, Silver square resonator of thickness 0.1mm are shown in figures (9-12). In figures (17-18), the effective permittivity and permeability of Silver square resonator of thickness 0.25mm are presented. Table 2 shows change in permeability and permittivity of Copper square resonator of thickness 0.1mm for different values of “a”. The effective permittivity and permeability of Copper square resonator of thickness 0.25mm are presented in Table 2. The variation of permittivity and permeability for various values of “a”, Tungsten square resonator of different thickness values are presented.

The values of resonant frequency, effective permeability and effective permittivity for different values of a, thickness and material of duroid are given in Table1. The particulars of resonant frequency, effective permeability and effective permittivity of square split ring resonator are presented in Table 2.

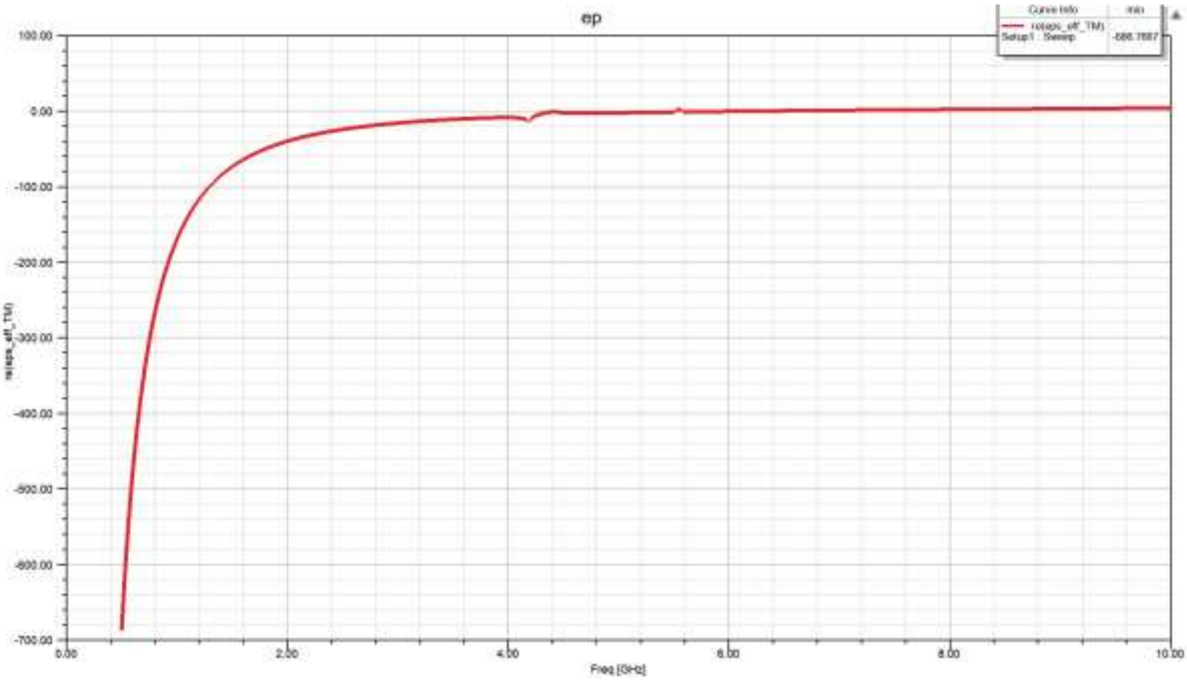

Fig. 3. Permittivity of Silver Duroid when a=5mm, t=0.1mm.

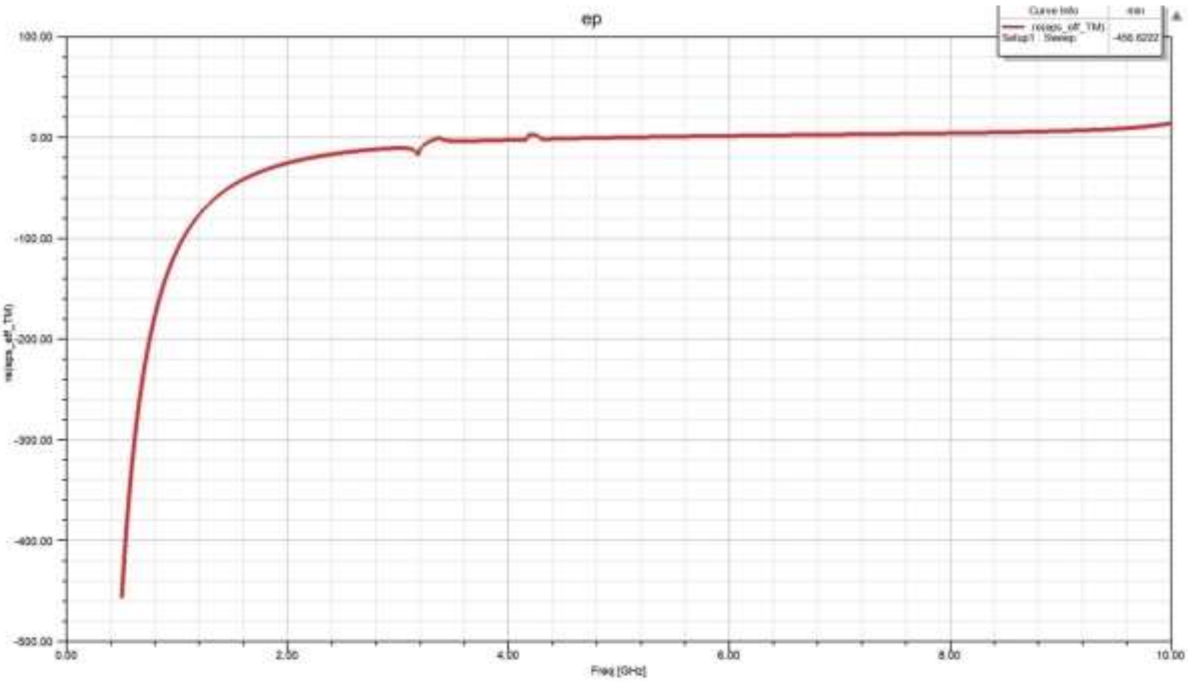

Fig. 4. Permittivity of Silver Duroid when a=6mm, t=0.1mm.

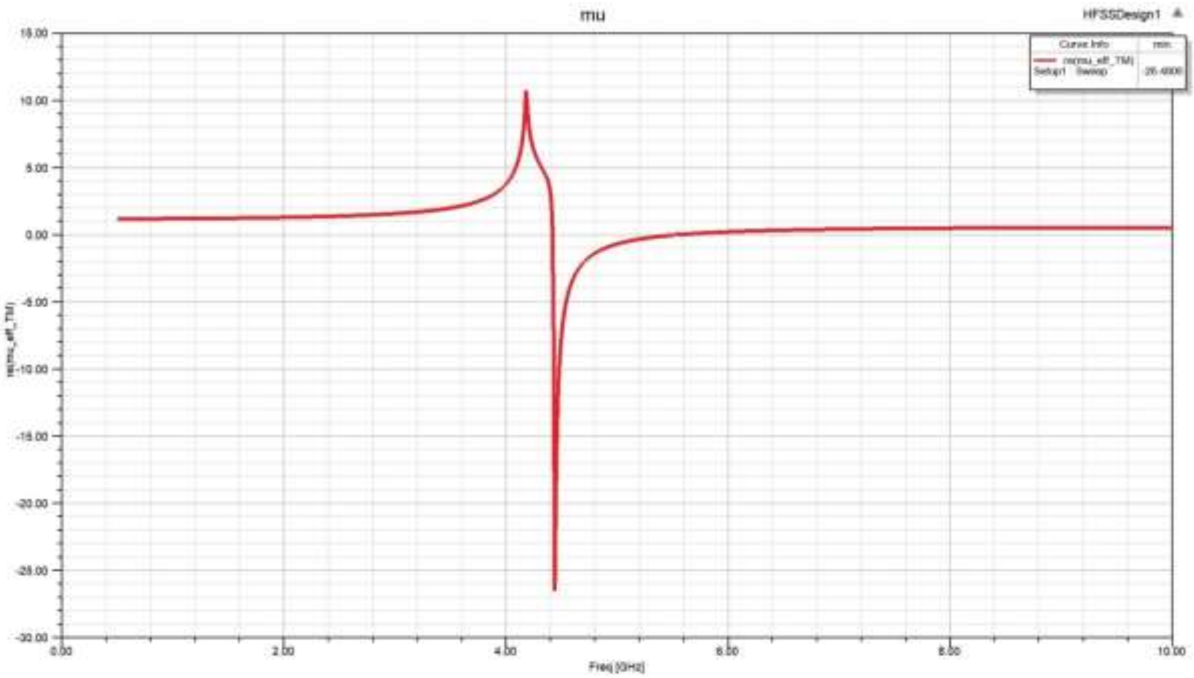

Fig.5. Permeability of Silver Duroid when a=5mm, t=0.1mm.

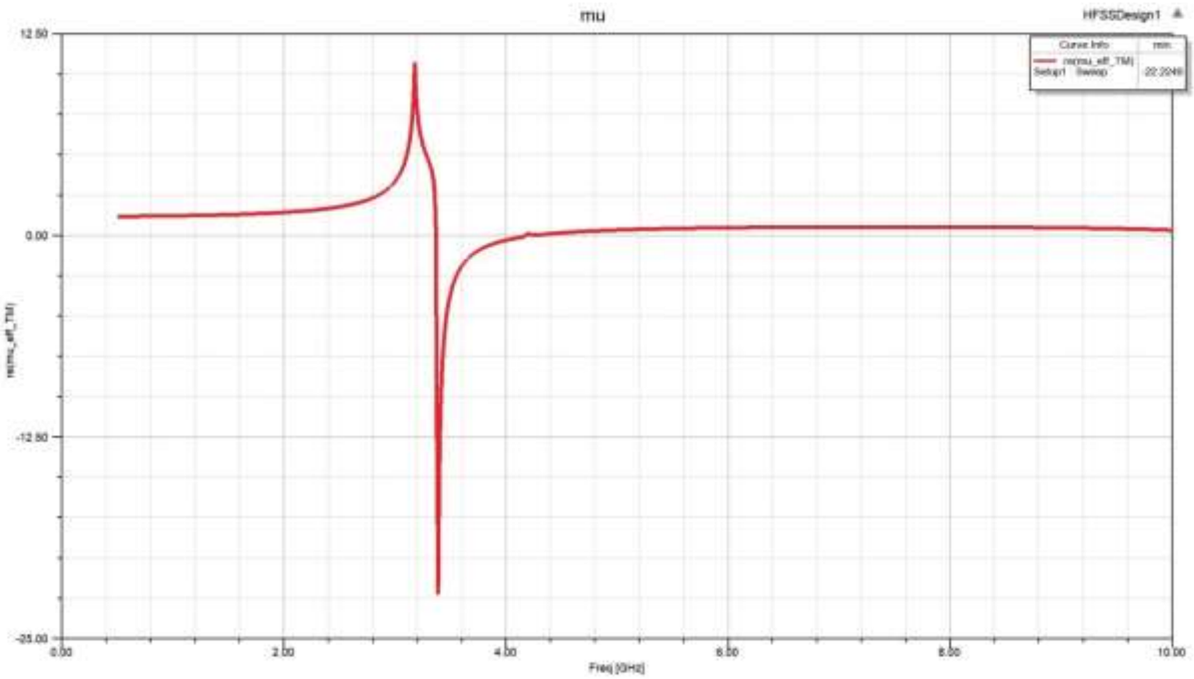

Fig.6. Permeability of Silver Duroid when a=6mm, t=0.1mm.

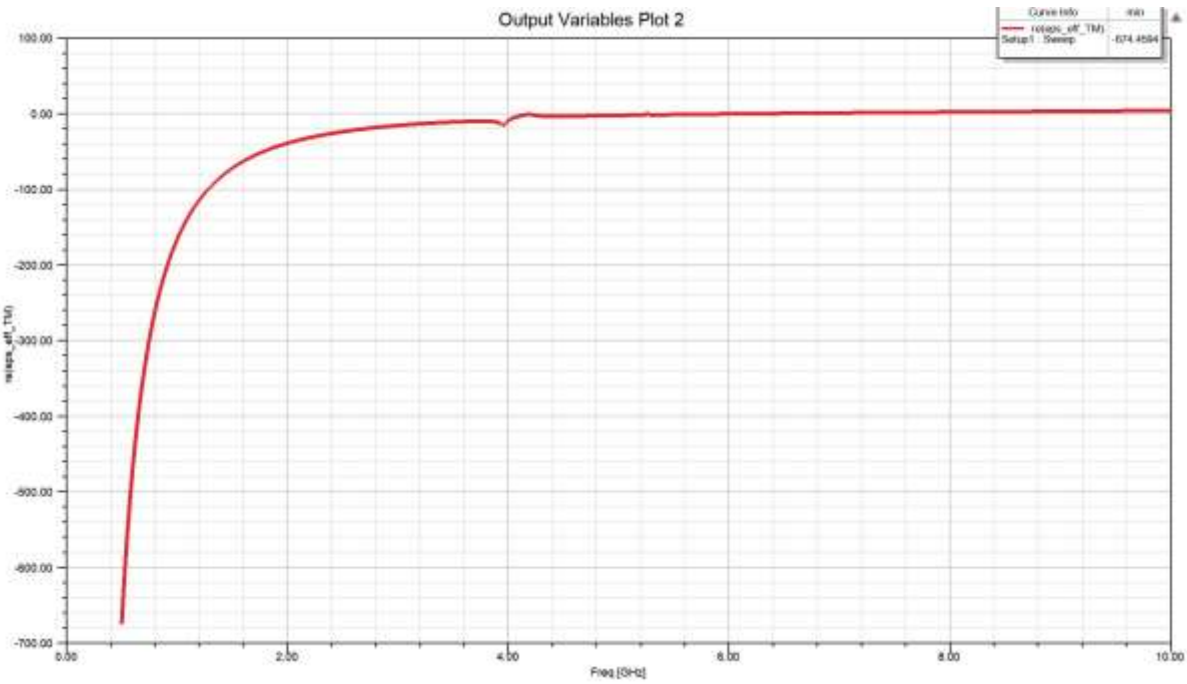

Fig. 7. Permittivity of Silver Duroid when a=5mm, t=0.25mm.

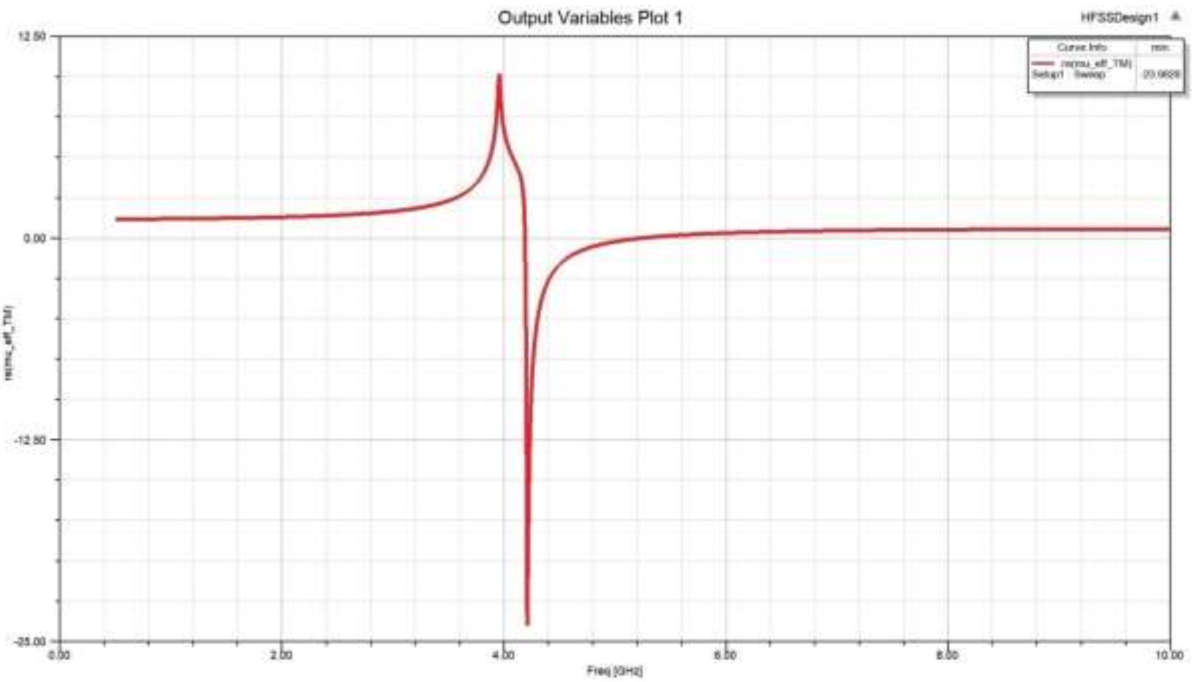

Fig. 8. Permeability of Silver Duroid when a=5mm, t=0.25mm.

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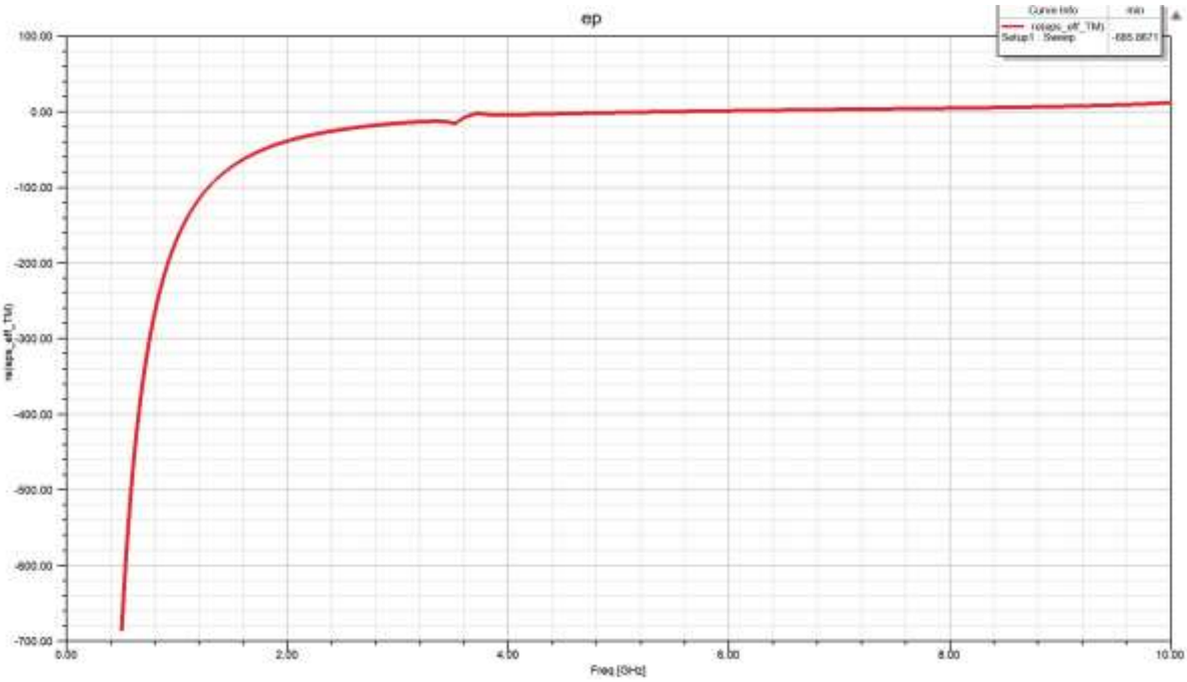

Fig.9. Permittivity of SilverSquare ring resonator when a=5mm, t=0.1mm.

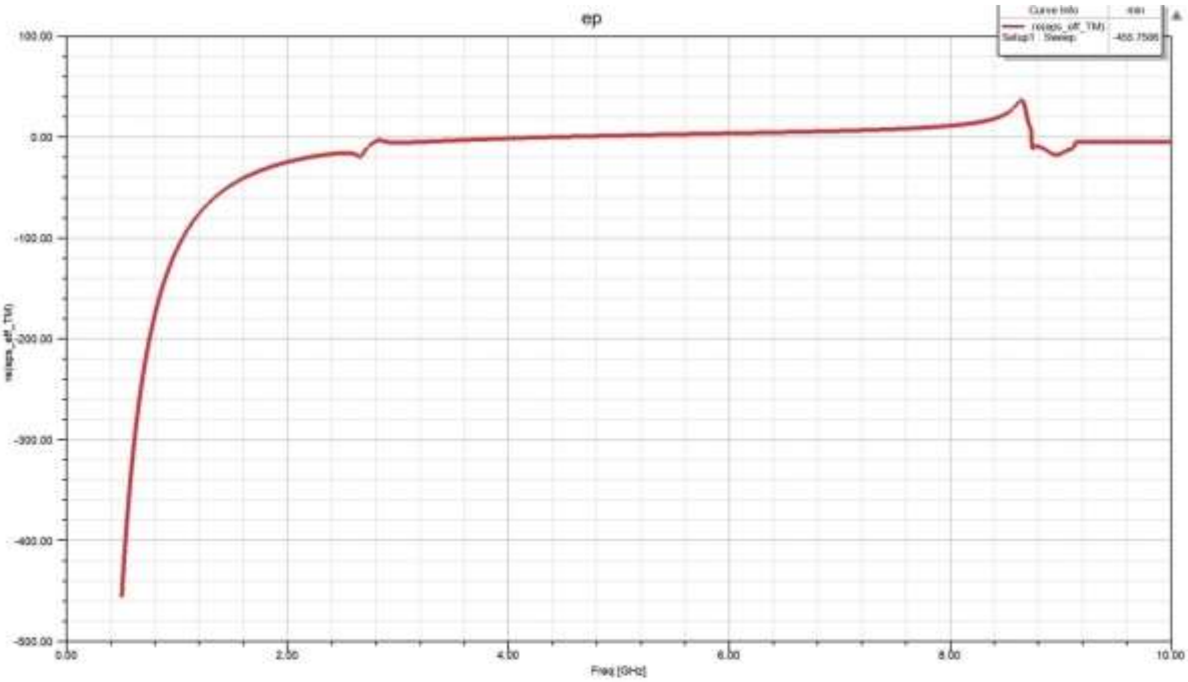

Fig.10. Permittivity of Silver Square ring resonator when a=6mm, t=0.1mm.

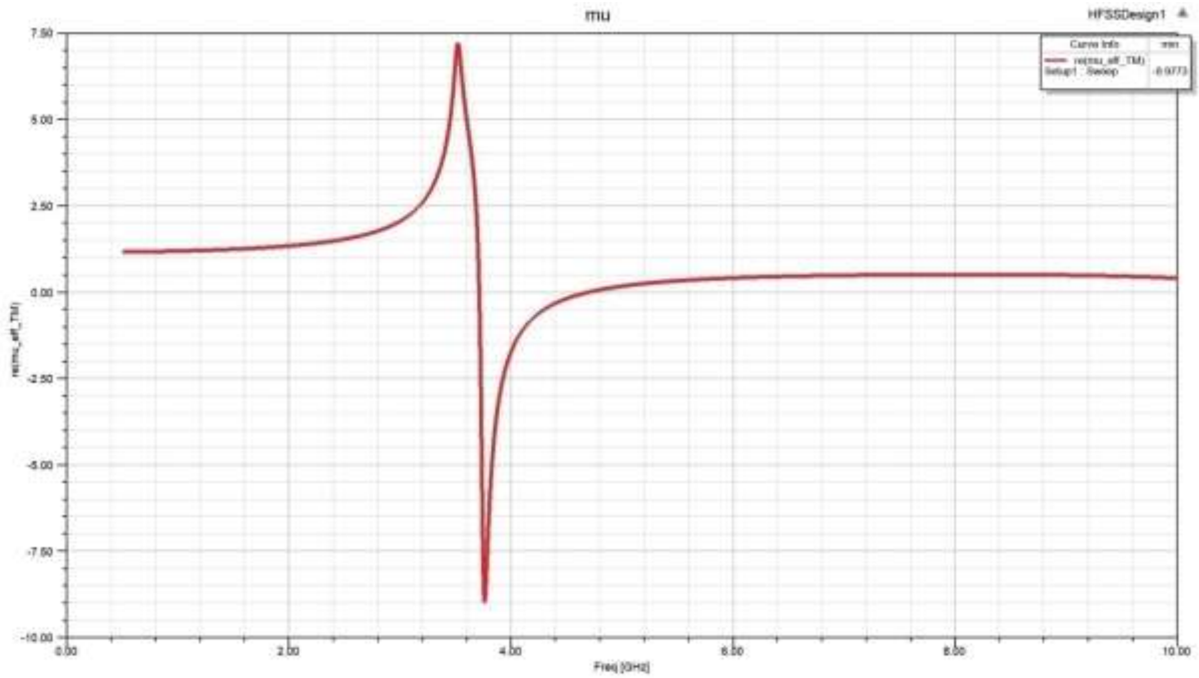

Fig.11. Permeability of SilverSquare ring resonator when a=5mm, t=0.1mm.

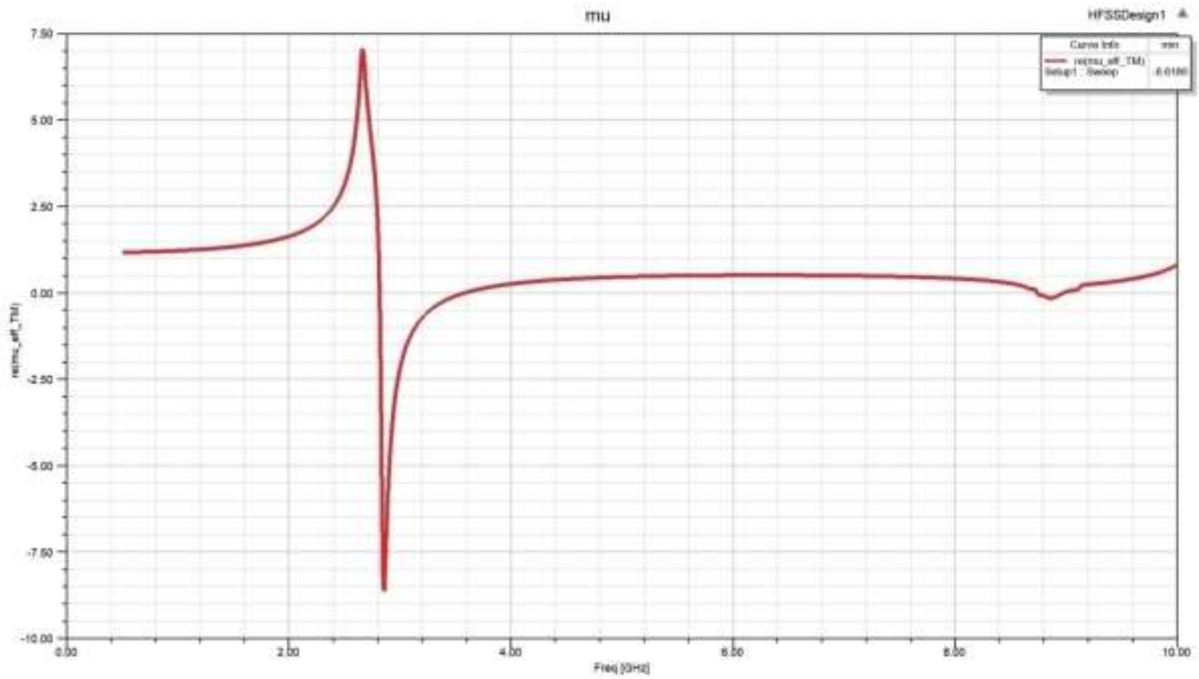

Fig.12. . Permeability of Silver Square ring resonator when a=6mm, t=0.1mm.

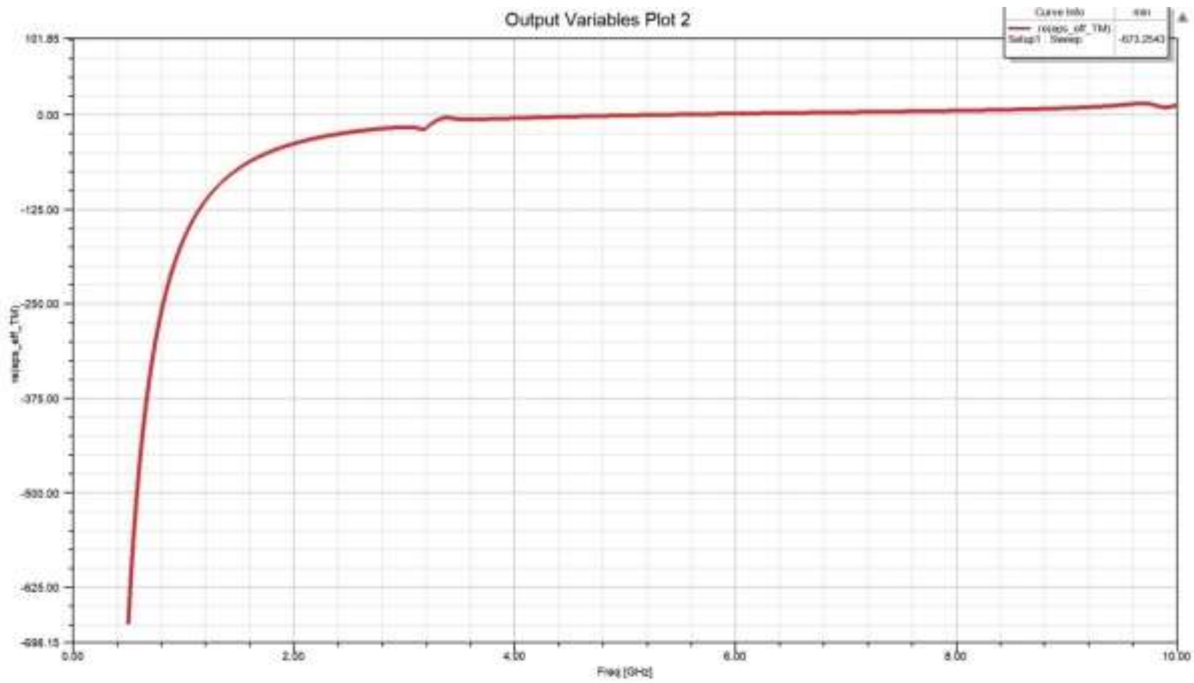

Fig. 13. Permittivity of Silver Square ring resonator when a=5mm, t=0.25mm.

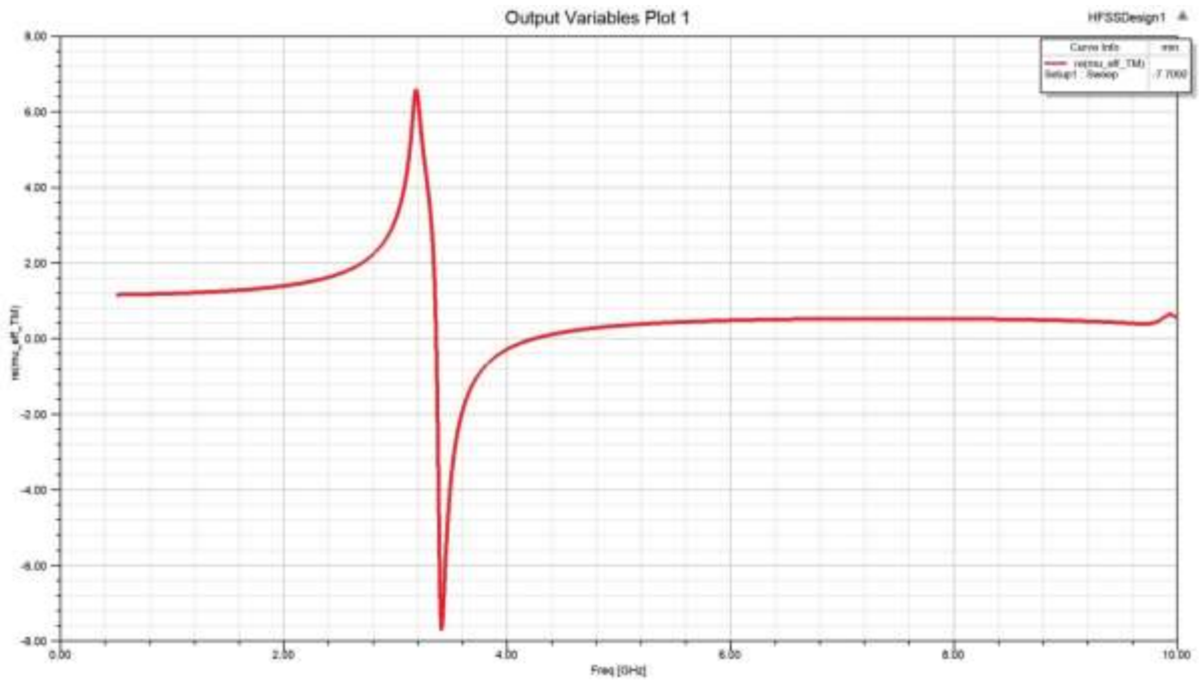

Fig. 14. Permeability of Silver Square ring resonator when a=5mm, t=0.25mm.

Table 1: Particulars of resonant frequency, permeability and permittivity for Duroid

Material		Thickness of substrate	value of a	Resonant frequency (f) in GHz	Permeability (μ)	Permittivity (ε)
Substrate	Metal					
Duroid	Copper	0.25	5	4.22	-23.66	-1.34
			6	3.35	-21.27	-3.41
			7	2.7	-21.92	-6.89
			8	2.15	-19.65	-10.45

		0.1	5	4.45	-26.07	-1.25
			6	3.6	-21.93	-2.95
			7	2.54	-18.85	-6.54
			8	2.1	-13.45	-9.47
	Silver	0.25	5	4.23	-23.98	-0.65
			6	3.35	-21.52	-1.52
			7	2.7	-21.95	-5.21
			8	2.14	-19.85	-9.55
		0.1	5	4.43	-26.48	-0.76
			6	3.3	-22.23	-2.54
			7	2.48	-19.1	-5.09
			8	2.06	-13.59	-8.62
	Tungsten	0.25	5	4.2	-16.89	-0.45
			6	3.32	-15.79	-2.04
			7	2.72	-17.45	-5.74
			8	2.17	-14.47	-9.06
		0.1	5	4.42	-18.02	-0.79
			6	3.4	-16.79	-2.48
			7	2.45	-13.67	-7.8
			8	2.05	-12.13	-17.5

Table 2: Particulars of resonant frequency, permeability and permittivity for Square split ring resonator.

Material		**Thickness of substrate**	**value of a**	**Resonant frequency (f) in GHz**	**Permeability (μ)**	**Permittivity (ε)**
Substrate	**Metal**					
FR-4	Copper	0.25	5	3.4	-7.63	-3.45
			6	2.7	-7.77	-6.35
			7	2.2	-7.97	-8.52
			8	1.76	-7.54	-11.24
		0.1	5	3.76	-8.94	-3.54
			6	2.85	-8.58	-5.41
			7	2.25	-7.97	-8.89
			8	1.72	-7.16	-11.21
	Silver	0.25	5	3.43	-7.71	-2.43
			6	2.73	-7.799	-5.76
			7	2.19	-8.02	-8.31
			8	1.75	-7.57	-11.15
		0.1	5	3.75	-8.98	-1.75
			6	2.9	-8.62	-3.94
			7	2.15	-8.01	-8.65
			8	1.76	-7.2	-14.65
	Tungsten	0.25	5	3.42	-6.87	-2.07
			6	2.75	-7.03	-5.12

			7	2.2	-7.18	-7.84
			8	1.76	-6.75	-10.72
		0.1	5	3.74	-6.99	-2.04
			6	2.75	-6.85	-5.61
			7	2.04	-6.47	-13.05
			8	1.72	-6.56	-16.27

Conclusion:

A newly designed Split Ring Resonators (SRRs) have been proposed and investigated by simulation and measurement of shift in resonant frequency due to change in aspects like a radius and size of the ring, material of the ring. Two types of resonators, square and circular, are designed to cover different frequency ranges. The changes in the resonant frequencies are monitored upon variation of the radius, thickness, and the material of the ring. The results show resonant frequencies suggesting they can be loaded for Ground Penetrating Radar antenna for aquifer water.

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