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Original Research Article

Variable Length Dipole Antenna with Split Ring Resonators

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Abstract: A Microstrip patch antenna is used in various applications (like Radar, Satellites) with different length dipoles. The value of return loss must be substantially good enough to meet the required performance level for the particular application. For this, length of dipoles is adjusted according to the material used in ground reflector to get a good value of return loss. A conventional SDP antenna consisting of two dipoles of different length and a ground reflector, which are serially connected with a transmission line, is designed for operating frequency range 1.7-2.7 GHz. The proposed antenna is designed on FR-4 substrate having Є=4.3 using electromagnetic simulator software called CST Microwave Studio Suite®. To improve the performance characteristics of the designed antenna regarding Directivity, Return Loss and gain a Split Ring Resonator (SRR) is mounted on top of the designed SDP. Numerical results show the improved results with improved operating frequency up to 3.2 GHz, enhanced directivity of 9.29dBi and increased gain of 7.98 dB.
Keywords: Microstrip Patch Antenna-MSA; SDP- Series-fed Dipole pair; Computer Simulation Technology (CST).

INTRODUCTION

There are various technologies being used for modern age communication systems like cellular communication, satellite communication and radar. Recent technological developments enable communication devices to become physically smaller in size. For very small sized devices Microstrip patch antennas (MSA) are good options for narrow band applications. MSAs are the most commonly used antennas for versatile applications in different kind of communication systems. This is because they provide a large number of useful properties such as small size, low profile, light weight, ease of installation and easy to integrate with feed networks. Very narrow bandwidth of MSAs is a major limiting factor in its performance [1]. However, this is the major research area these days to improve bandwidth and other characteristics to make it useful for various applications. To improve the bandwidth of MSA, Series fed dipole pair (SDP) antenna is used. For further improvements in characteristic performance of small antennas for wireless and RF communication, a split ring resonator (SRR) of different size is proposed to attach with it [2, 3]. A split ring resonator (SRR) is an artificial metamaterial structure having two enclosed loops separated with a little gap having small split in each loop in opposite directions. The separation gap between the two loops is helpful in increasing the capacitance to reduce the resonant frequency. The resonant wavelength supported by the loop is increased by making a small split in the loop, instead of changing its diameter [4]. Metamaterials are artificial materials made of two or more natural materials arranged in a compact periodic unique structure. These are having some very special characteristics like negative refractive index for which the permittivity and permeability are also negative [5].

ANTENNA DESIGN

The proposed antenna is designed and simulated using electromagnetic simulator software-CST Studio Suite®. In the proposed system, Series fed dipole pair (SDP) antenna is designed on FR-4 substrate having Є=4.3. The SDP antenna consists of two strip dipole elements D1 and D2 and a ground reflector R. The width of two dipoles is kept same but their lengths are different. However, distance between two dipoles is kept constant. The elements of SDP antenna are serially connected by coplanar strip (CPS) line. Coaxial probe feeding is used here to match the input impedance of antenna with 50Ω line.

Conventioanl SDP Antenna

A conventional SDP antenna consists of two strip dipole elements of different length named as dipole 1 and dipole 2 and a ground reflector (R0). The length and width of dipole1 is L1 and W1, respectively, and that of dipole2 is L2 and W2, respectively. The length and width of R0 is Lg and Wg, respectively. The distance between R0 and dipole1 is S1, and that between dipole1 and dipole2 is S2. The two dipoles and the ground reflector are serially connected with a coplanar strip (CPS) line of width wcps. An integrated balun between the microstrip (MS) and CPS lines is implemented on the CPS line to match the input impedance of the antenna with the 50Ω feed line, and the end of the MS line is shorted with a shorting pin at the feed point. The widths of slot line is denoted as ws. The width of the MS feed line is wf , and the MS feed is offset from the center at a distance of xf .

All the design parameters are shown in Table 1.

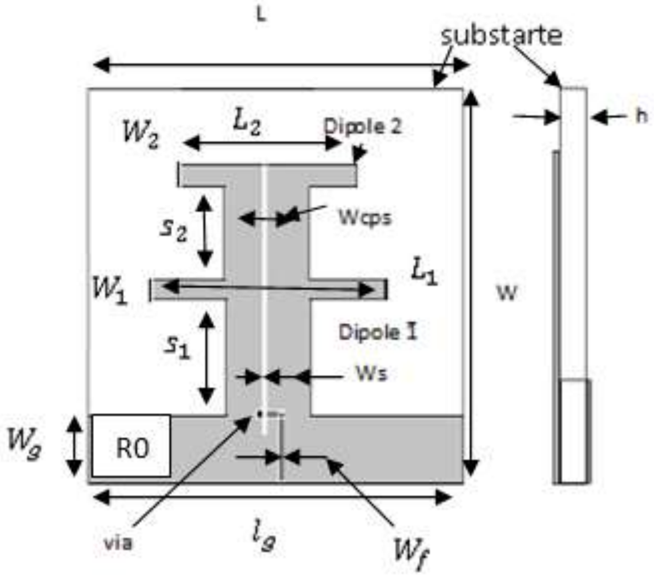

Fig-1: Conventional SDP antenna

Table 1: design parameters of conventional SDP antenna

Parameter	Value [mm]	Type
Dp	6	Gap D2 str
Gap	5	Strip distance
H	1.6	Substrate Height
L	80	Dipole length/2
L1	72	Length dipole1
L2	50.4	Length Dipole2
Ld	28.8	Length strip director
Lg	90	Length Reflector
N	5	Strip Length in multiples of N*gap
R	1	Wire radius
S1=S2	36	Separation
W	135	Width of substrate
W1=W2	7.5	Width of dipole
Wcps	20	
Wd	22.5	Width of strip director
Wg	15	Width reflector
Ws	0.7	Separation width

SIMULATION RESULTS

The proposed work is implemented in CST (computer simulation tool) and results are discussed below:

Port Signals

The port signal includes both input and output signals. For better operation, both these signals will have to die out after some span of time

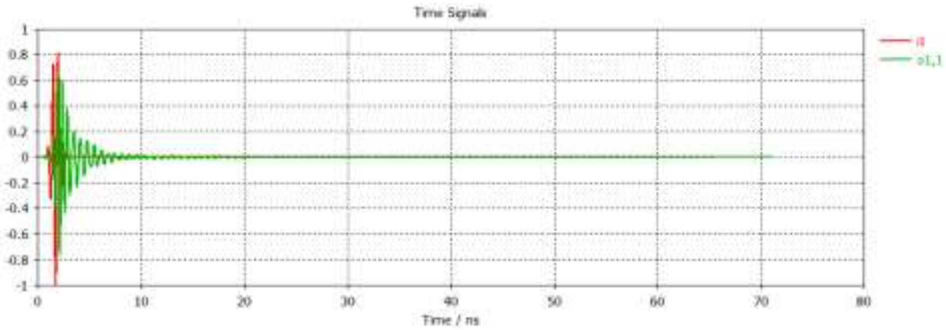

Fig-2: Input and Output Port Signals

S- Parameters

The given antenna shows multi band operation. The antenna resonates at 1.54GHz and 2.68GHz. But the values of return loss at these frequencies are -10.85dB and 9.61dB respectively as shown in figure 3. Also, the bandwidth calculated from this graph comes out to be 50MHz.

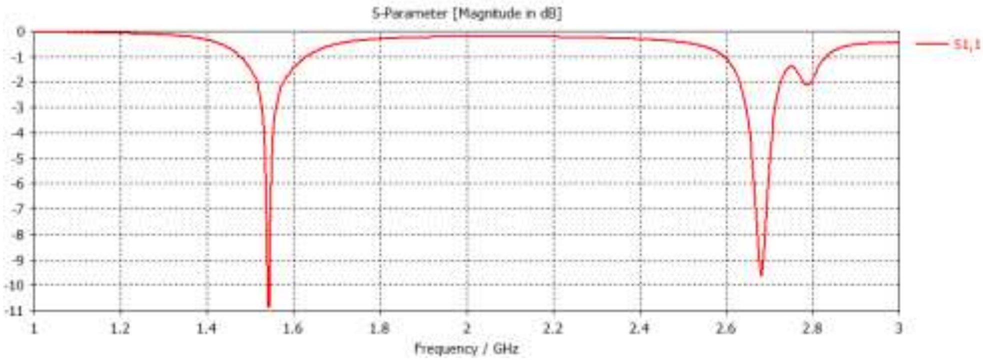

Fig-3: S-Parameters (Operating Frequency - 1.54 GHz and 2.68GHz)

VSWR (voltage standing wave ratio)

The value of VSWR is very crucial in deciding the nature of designed antenna. Since it gives information about the wave reflected, so its value should be as low as possible. Practically, its value must be less than 2. For this antenna it is 1.5 as shown in figure 4.

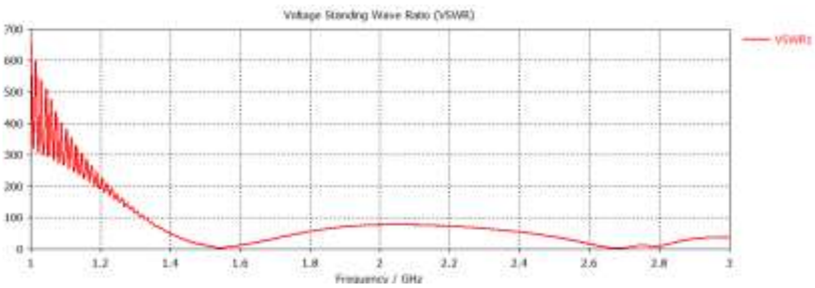

Fig-4: VSWR

Far-field Pattern

The far field pattern gives information about the directivity and gain of antenna. There values must be positive for better results. In our case, directivity is 2.51dBi.

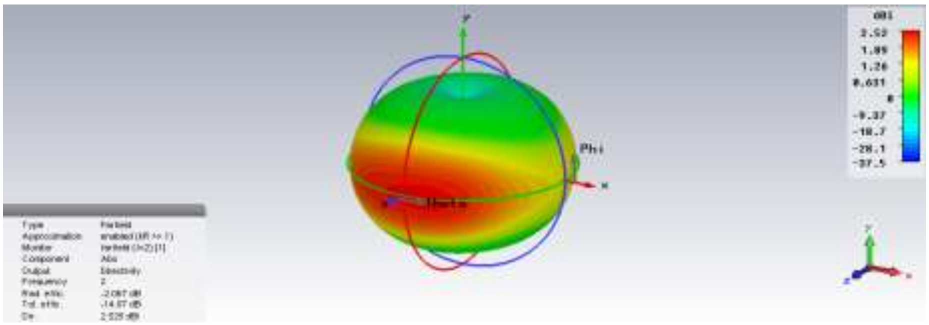

Fig-5: Far-field Plot

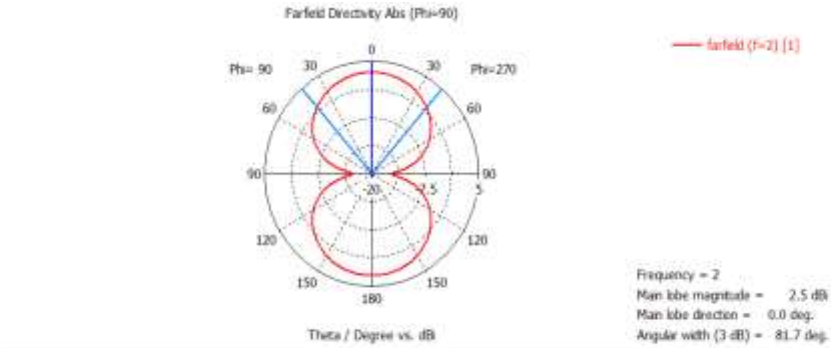

Fig-6: Polar plot

SDP ANTENNA WITH SRR

To further improve the performance of conventional SDP antenna in respect of gain, diversity and return loss we propose a design of SDP antenna with a Split Ring Resonator (SRR). In the proposed antenna, SRR is appended to dipole2 of the conventional SDP antenna. The distance between Ds1 and Ds2 is gd, whereas that between D2 and Ds2 is Ds. The center line of the CPS acts as the plane of symmetry for the SRR pair and the gap in the SRR is oriented outside for optimum performance [6]. The antenna is printed on an FR4 substrate having a dielectric constant of 4.4 (loss tangent = 0.025), and the thickness h = 1.6 mm. The length and width of the substrate are L and W, respectively.

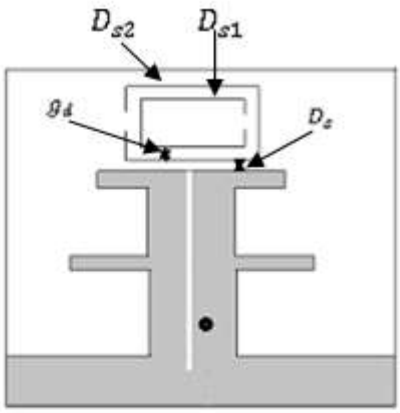

Fig-7: SRR (Split Ring Resonator) design

Design parameters for the proposed antenna are given below in Table 2.

Table 2: design parameters for SDP antenna with SRR

Parameter	Description	Value [mm]
L	Substrate Length	135
W	Substrate Width	90
H	Substrate thickness	1.6
L1	D1 Length	72
L2	D2 Length	50.4
S	Separation	36
W1	Dipole width	7.5
Wr	Reflector Width	15

SIMULATION RESULTS

The Proposed antenna is designed and simulated on CST Microwave Studio Suite software. This software is based on FEM (Finite Element Method) which is better than Moments of Method (MOM) solver for Antenna applications. This simulator provides a variety of solvers. We have chosen Time domain solver for simulation purposes. The input impedance of antenna is matched with 50Ω coplanar line. On simulation, we investigate various parameters that are discussed below:

Port Signals

The port signals graph is shown in figure 8. It shows input and output signal graph. Both the signals die out after some 2.5ns which is desirable.

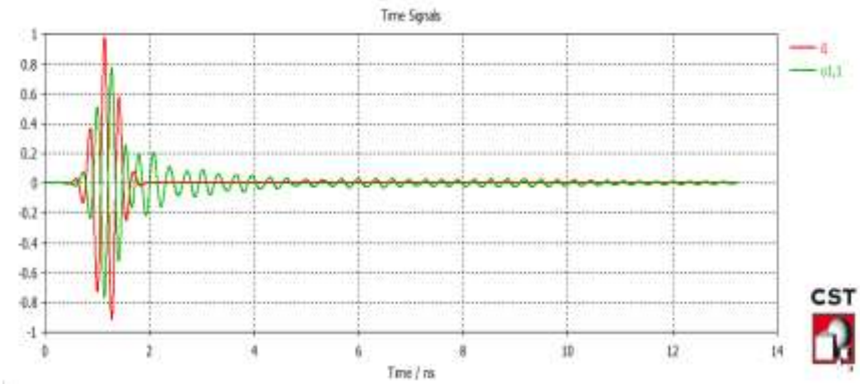

Fig-8: Port Signals

Return Loss (S_{11} in dB)

This is most important result of simulation as it shows the frequency on which antenna is resonating. The value of return loss must not be positive. It can be as good as more negative value is achieved. In our case antenna resonates at 3.2GHz and at this frequency, the value of return loss is -20.44dB as shown in Fig.9 below.

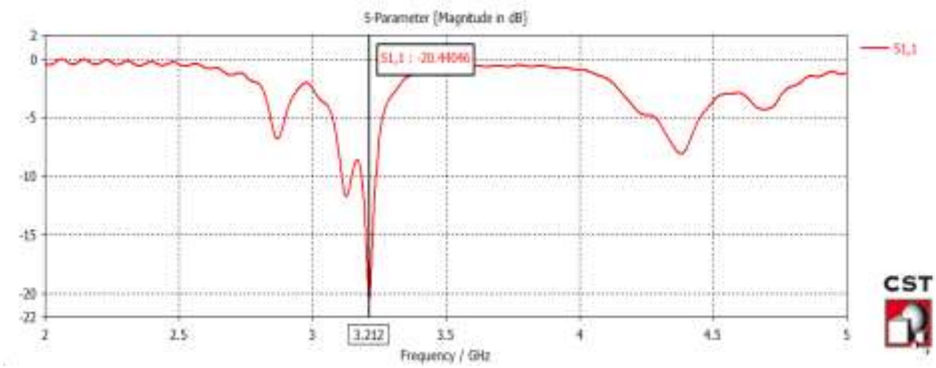

Fig-9: Return Loss Curve

VSWR Plot

VSWR is another important parameter for judging the antenna characteristics. For stable design, value of VSWR must be less than 2 at resonant frequency. In our case, it is 1.21 at resonant frequency as shown in figure 10 below:

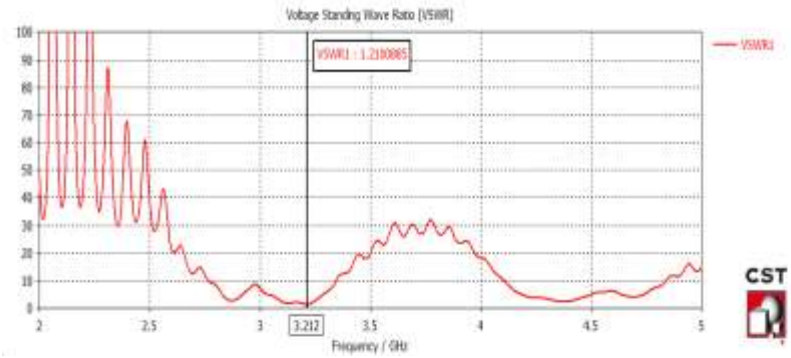

Fig-10: VSWR Plot

Gain (dB) and Directivity (dBi)

The directivity curve is a 3D plot which shows the value of directivity property of antenna throughout the structure. It is displayed in fig. 11 below. For the proposed antenna, the value of directivity comes out to be 9.29dBi.

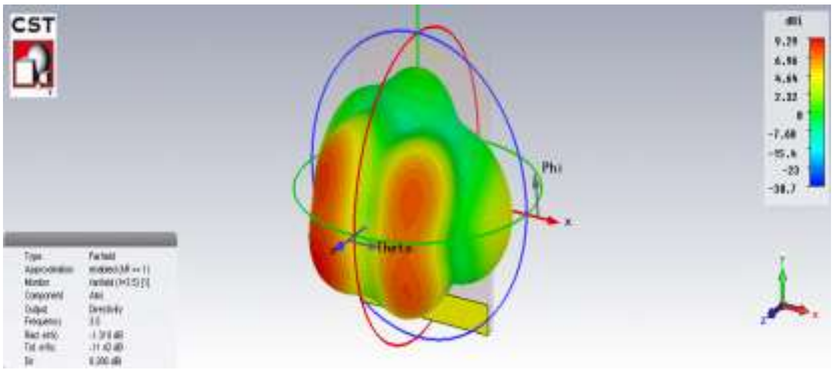

Fig-11:Directivity Plot

The IEEE gain is also shown on same 3D plot and its value comes out to be 7.98dB which is very good. The gain must be positive value and in this case its value makes it useful in applications where high gain is required.

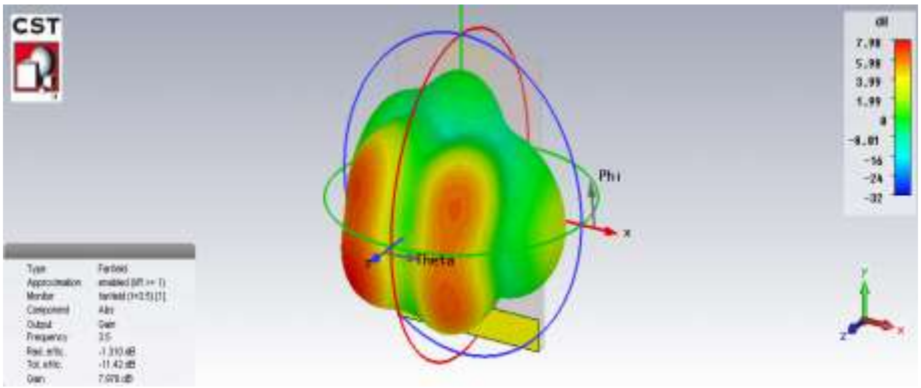

Fig-12: Gain Plot

The antenna resonates at 3.2GHz means it is useful for S- band applications.

CONCLUSION

In this paper we designed an SDP antenna and further improved its performance at par the level required for S band applications using SRR. Proposed antenna is designed on FR4 substrate. The SRR is mounted over SDP antenna. It resonates at 3.2GHz which makes it useful in S-band applications. Also VSWR value is less than 2 which signifies its stable operation. By using SRR to the SDP antenna, Gain and directivity is also enhanced significantly. So this antenna can be used in RADAR, amateur satellite etc. applications.

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REFERENCES

1. Balanis CA. Antenna Theory: Analysis and Design. John Wiley & Sons, Inc., Hoboken
2. Wu WJ, Yin YZ, Zuo SL, Zhang ZY, Hu W. Dual-Wideband Monopole Loaded With Split Ring For WLAN Application Progress In Electromagnetic Research Letters. 2011; 21;11-18.
3. Yeo J, Lee JI, Park JT. Broadband series-fed Dipole pair antenna with parasitic strip pair director," Progress In Electromagnetic Research C. 2013; 45:1-13.
4. Pendry JB, Holden AJ, Robbins DJ, Stewart WJ. Magnetism from conductors and enhanced nonlinear phenomena. IEEE Trans. Microwave Theory Tech. 1999;47:2075-2084.
5. Benabdelouahab O, Aznabet I, Aznabet M, El Mrabet O, Khalladi M, Floc'h J, Drissi M, Falcone F. December. A dual-band compact antenna with SRR for wireless communication systems. In Proceedings of 2014 Mediterranean Microwave Symposium (MMS2014). IEEE. 2014;1-3.
6. Kim DO, Yoon U. Mutual Coupling between Parasitic Elements of Split Ring Resonator on Antenna Progress In Electromagnetic Research Proceedings. 1890;2015.
7. Gemio J, Parron J, de Paco P, Junkin G, Marin J, Menendez O. A split-ring-resonator loaded monopole for triple band applications. Journal of Electromagnetic Waves and Applications. 2010; 24(2–3):241–250.
8. Emhemmed Adel S, Ian M, Khaled E. 200GHz Broadband Proximity Coupled Patch Antenna",IEEE International Conference on Ultra Wideband (ICUWB-2009). 2009;404-407.