Design of ANN-DE Based Reconfigurable Slot Antenna for WLAN/INSAT Applications

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Abstract

There is gigantic progress in wireless communications from last two decades. Due to this advancement, the need of inventing and modifying the antennas is also increasing so that a single antenna could be used for multiple applications. In the proposed work, a novel reconfigurable antenna with Bow-Tie shape is designed and simulated for WLAN and satellite communication (INSAT) applications. The optimization of designed antenna is done using the Differential Evolution (DE) algorithm for achieving better results at anticipated frequency bands. The antenna resonates at4.5GHz, 4.7GHz, 5.36GHz and 5.4GHz with a return loss of -14.74dB, -26.08dB and -27.8dB and -36.87dB respectively which is less than -10dB and achieved positive antenna gains of 4.3dBi,5.4dBi, 5.5dBi and 4.3dBi for all these frequencies. The model of planned antenna is also fabricated and verified.

Keywords[1]

Bow-Tie, DE (Differential Evolution), ANN, Reconfigurable, WLAN, INSAT

1. Introduction

Wireless communication is a huge field consisting of number of wireless applications like WLAN, INSAT, Bluetooth, ZigBee and many more. With the increasing number of applications, need of multiband application antennas has also increased. From the past years many antennas for WLAN[1]–[4], INSAT [5]-[6] applications had been designed. The microstrip patch antennas designed earlier could only be used for a single application. So, many reconfigurable antennas are designed according to the need that is either for frequency reconfiguration, polarization reconfiguration or Hybrid multimethod reconfiguration[7]–[9]. For improving the results slots could be introduced in microstrip or any reconfigurable antenna as slots increases the current distribution in antenna[10].

In this project, DE based optimized antenna is considered for WLAN/INSAT applications. The advantage of the antenna is its reconfigurability for WLAN & INSAT applications. The results show the effectiveness of proposed ANN-DE optimization technique by attaining the return loss of -14.742dB, -26.08dB, -27.834dB and -36.87dB in different applications.

2. Differential Evolution

Differential evolution (DE), is very efficient algorithm. This method had been successfully usedfor nonlinear, raucous, flat, non-differentiable, and multi-dimensional complications[11] It's basically a modification of Genetic Algorithm but then, proven more efficient in many cases [12]. The DE

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system is based on real-value operators. It is dependent upon four techniques, namely Initialization, Mutation, Crossover, and Selection.DE's reimbursements comprise simplicity, high performance and uniformity, a negligeablequantity of control parameters, in addition with low space complexity. In proposed work, ANN is used for training data set using backpropagation algorithm to achieve a defined fitness function. The trained fitness function derived is then used in DE algorithm for optimizing the feed point of the proposed geometry. The optimized feed point is further applied in the proposed geometry for attaining the desired results at different frequency bands.

3. Proposed Antenna Geometry

Proposed antenna is designed in the shape of Bow-Tie with two slots on each side of the Bow-Tie shape as shown in Figure 1(a). Both sides of the Bow antenna are joined with the extended arms. FR4 substrate is used for designing the antenna with thickness of substrate 1.6mm. The Dielectric Constant, ε_r is 4.4 for FR4 substrate and Loss Tangent,is 0.008. Figure 1(a) also displays allantenna dimensions that are used for designing the antenna. Figure 1(b), shows the antenna design with switches which are added in the lower slots, on both sides of proposed design.

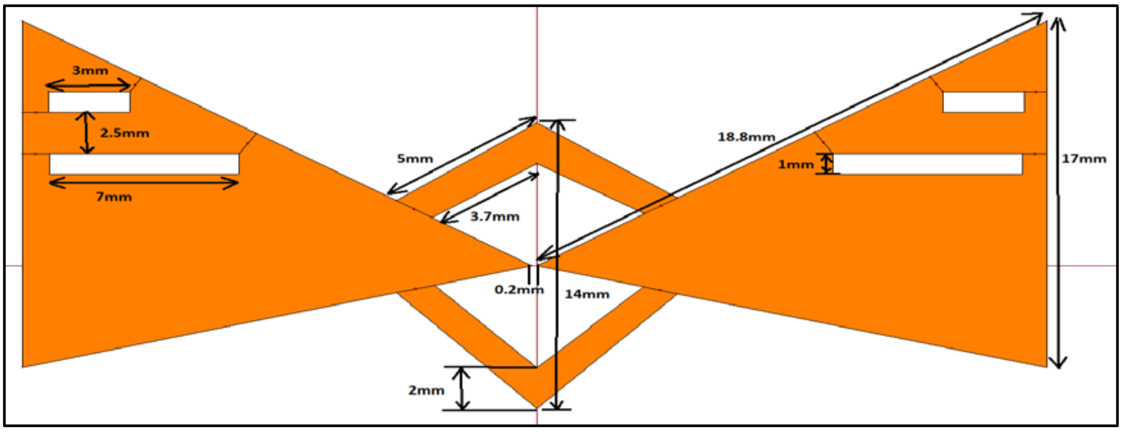

Figure 1(a)

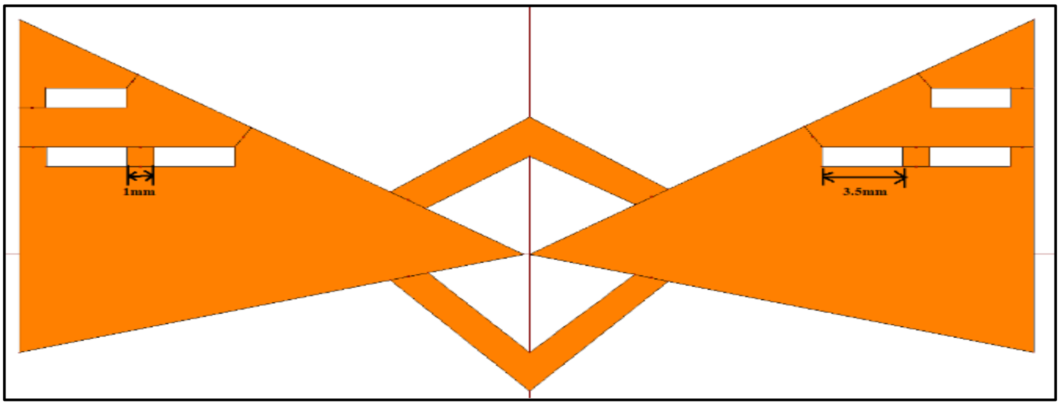

Figure 1(b)

Figure1: (a) Configurations of Bow-Tie Antenna (without switches) Figure 1(b) Bow-Tie antenna (with switches)

The proposed antenna is designed using Zeland IE3D software (2008). This antenna is simulated repeatedly, in the same software and the results are used for creating the data set for training in ANN.

Proposed Bow-Tie antenna has a novel geometry, getting its feed location for achieving results is slightly difficult. So, firstly after simulation the collected data set is fed to ANN training tool which uses Backpropagation algorithm for training the data set and the desired fitness function is used in the DE algorithm for optimization. DE is chosen because of the geometry as it allows the optimization of the non-continuous function also. After optimization the desired feed location or the optimized feed point is attained and antenna is simulated in Zeland IE3D.

4. Results and Discussions

The proposed antenna is tested multiple times that is before optimization, after optimization and after fabrication, for attaining the results at desired frequency bands. Before optimization, it is noted that the antenna resonates at two frequencies 4.68GHz & 5.37GHz with Switches 'ON' and resonates at 4.9GHz with switches 'OFF' with the return loss of -15.02dB, -33.23dB and -35.26dB respectively. After optimizing the Feed location, the antenna starts resonating at three frequencies that are 4.5GHz, 4.7GHz and 5.36GHzhaving return loss of -14.742dB, -26.08dB and -27.834dB respectively, with the switches in 'OFF' condition. While in the Switches 'ON' condition the antenna resonates at 5.4GHz with a good return loss of -36.87dB. The figures below show the simulation results of antenna after optimization.

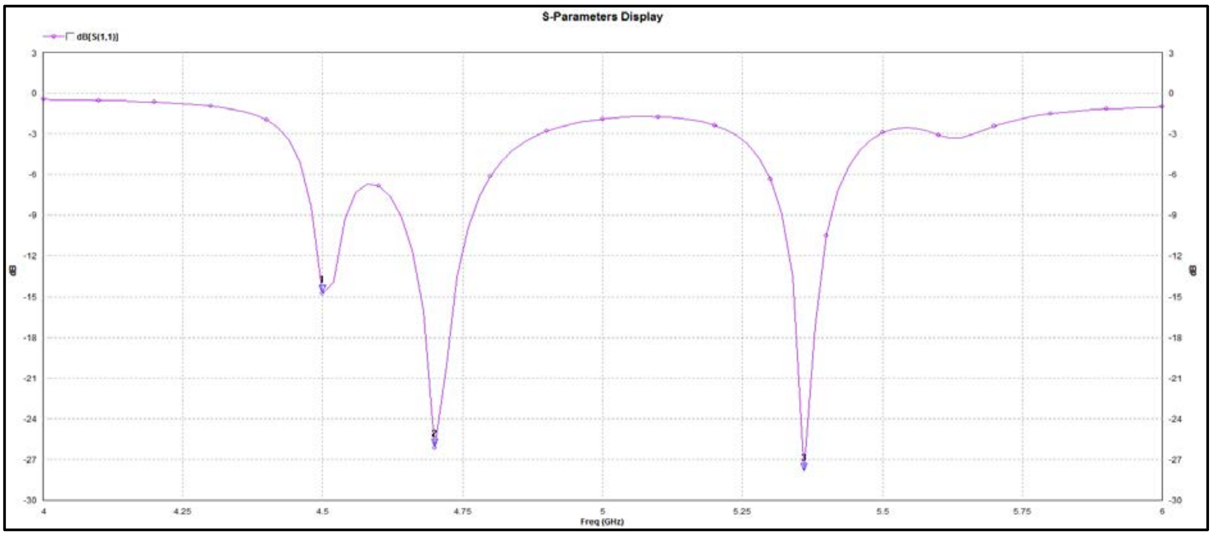

Figure 2: S_{11} parameters of antenna (Switches OFF)

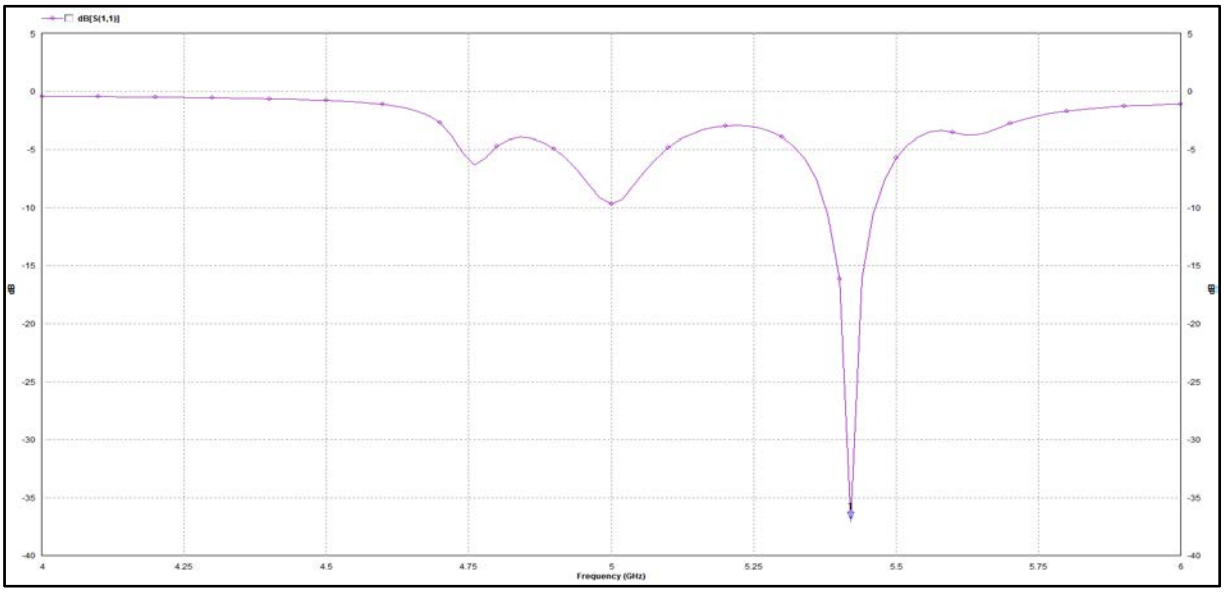

Figure 3: S_{11} parameters of antenna (Switches OFF)

The antenna gain attained for all the frequencies is positive. For frequencies 4.5GHz antenna gain is 4.303dBi, for 4.7GHz is 5.429dBi and for 5.36GHz is 5.501dBi for switches OFF.

For Switch ON condition, the antenna attained gain of 4.28dBi at 5.41GHz.

The following Figure 4(a) & 4(b), displays antenna architype ofproposed antenna design. The material that has been used for fabrication is FR4 material, having thickness = 1.6mm.

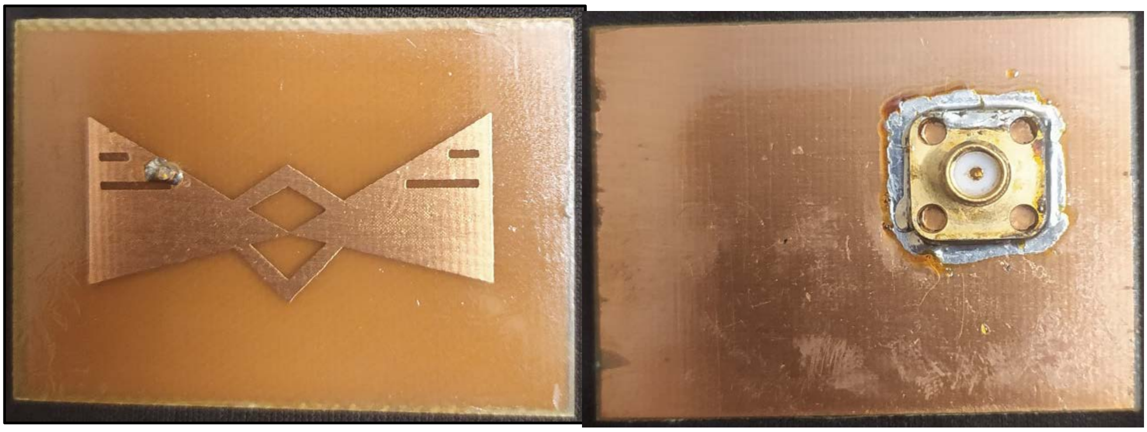

Figure 4: (a) Front View of Fabricated Antenna **Figure 4 :** (b) Backside with connector

The investigational results have been measured using Vector Network Analyzer. The antenna model shows resonance at 4.658GHz, 4.77GHz and 5.36GHz with switches OFF & at 5.68GHz with switches ON. The S_{11} parameters, Frequency v/s Return loss graph, ofantenna are displayed in figure below.

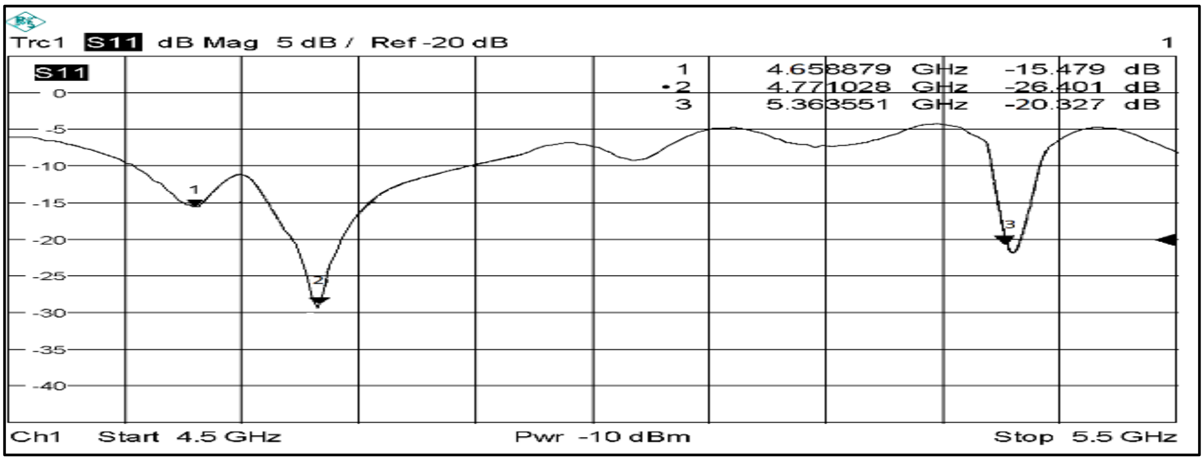

Figure 5 (a): Return Loss of Fabricated Antenna with Switches

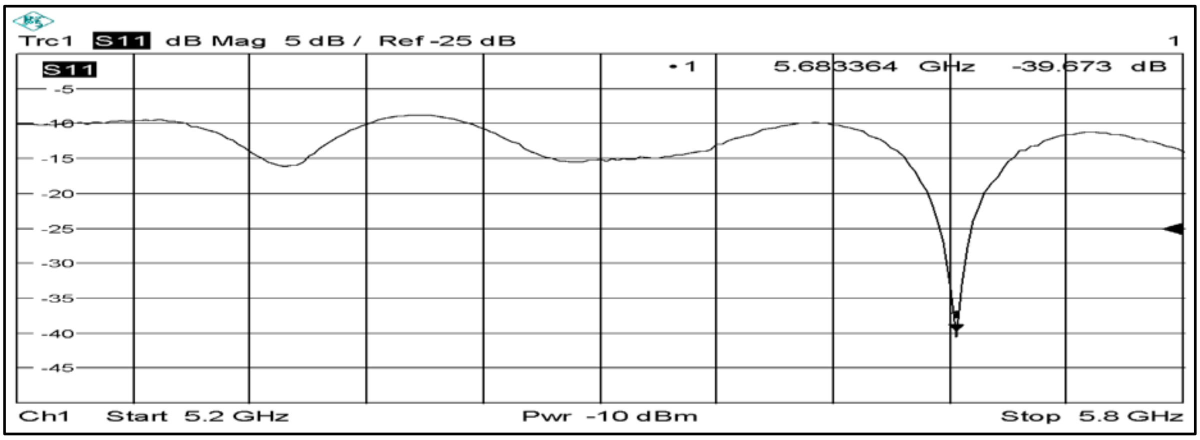

Figure 5 (b): Return Loss of Fabricated Antenna with Switches ON

There are frequency shifts as compared to the simulated results but, the frequency bands are same and can be used for WLAN and INSAT applications. The frequency shifts are because of the fabrication losses and the environmental aspects that disturbs the performance offabricated antenna.

The simulation results of proposed antenna are compared with the previous antenna designed for the same applications. The comparison is shown in the Table 1.

Table 1 Comparison of Proposed Antenna's Results with Previous Work

Referred Paper	Frequency Range (in GHz)	Return Losses (in dB)	Antenna's Gain (in dBi)	Applications
[4]	4.9-5.5	-24 to -31	-0.8 - 1.9	WLAN
[6]	4.2-11.9	-12.57 to-15.65	N.A.	Wireless Local Area Network& Satellite Communications
PresentedAntenna Results	4.5-4.7	-14.74to-26.08	4.3- 5.43	Indian National Satellite (INSAT or Satellite Communications)
	5.36-5.41	-27.83to-36.87	4.28 -5.5	Wireless Local Area Network

5. Conclusion

The reconfigurable antennas are known for its effective results in noisy situations for various applications. The simulation & experimental results shows that the antenna achieved efficient return loss and gain at frequency ranges of 4.5-4.77GHz and 5.36-5.68GHz considering both switching conditions of reconfigurable antenna. The 4.5GHz-4.8GHz range is used for satellite communications and 5GHz band is used for WLAN application. In the upcoming years, this antenna could be utilized at other frequency bands also, by modifying the antenna dimensions and can be used in mobile telecommunications and even in radio location applications.

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