A Novel Approach Of Microstrip Fed Planar Monopole Antenna For WSN Applications At 2.4ghz ISM Band

P. Saleem Akram, Dr. T. Venkata Ramana

Abstract: In this research article a condensed planar monopole antenna is proposed for wireless sensor networks which operates at 2.4GHz ISM bands. The suggested antenna model is printed on a 16×23×0.8mm^3 FR4 substrate with a dielectric constant ε_r=4.4. We have modeled different U shape slots in various directions on the rectangular patch. At every stage by inserting the slot, we observed the antenna tunes from 4.25 GHz to our required operating frequency 2.4GHz. Simulation results are observed in HFSS V15 and prototype antenna results are matched with the simulated one. In general, the smaller size patch antennas works at high frequencies but the proposed Inverted U shaped slots and the side slots helped to tune the antenna to lower resonance around 2.4GHz with better gain and return loss. Its smaller size makes it very useful for wireless sensor networks applications around 2.4 GHz frequencies.

Keywords: Compact monopole antenna, Wireless Networks, ISM band, U shape slot.

I. INTRODUCTION

Various Printed planar monopole antennas have been designed for variety of applications in antennas like multi band antennas by truncating the patch antenna [1], for UWB applications [2, 3], MIMO applications [4, 5] and other wireless applications. Also, a different types of antennas have been developed to be practiced in wireless sensor networks. The less price directional antennas in 2.4GHz for IEEE 802.15.4 wireless sensor networks implemented in [6] and parasitic smart antennas are discussed in [7]. Likewise, certain antennas for wireless sensor networks were developed over the years. Here when working with the wireless sensor networks a lot of nodes will be installed in a selected area where the data will be processed along the neighboring nodes until it reaches central node. So according to the wireless sensor networks the types of antennas needed will be different. Now a day's most of the wireless sensor networks are portable so the size of each such node is crucial. The need for reducing overall size depends on its building blocks, one such important building block in wireless sensor node is the antenna part which transmits and receives the data. Numerous methods were practiced to diminish the overall scope of the antenna by using diverse miniaturization techniques. And a few were used etching slot mechanism. The interesting topic in maintaining the antenna size compact is fractal antenna and also the metamaterial loaded antenna. A complementary fractal technique is used to design UHF compact antenna in [8]. A compact less cost fractal antenna for UWB applications is designed in [9]. There are several fractal antennas were designed [10-12]. The capability to shrink the overall size of the antenna dimensions has been of a great interest for past half century of thr years. The Metamaterial based EBG structures FSS and Split Ring Resonators are also used to design the compact antennas as Metamaterial proved to be very useful in antenna applications. The geometrical parameters of these arrangements highly effect the orientation of the EM wave propagation and generate a new resonant frequency [13, 14]. An analysis of various miniaturization techniques with an emphasis on Metamaterial is discussed in [15]. Microstrip antenna with complementary MM cells on ground is implemented in [16]. Miniaturizing of circular patch antenna with mm load is verified in [17]. Compact UWB microstrip patch antenna with Metamaterial is implemented in [18 - 21]. Different kinds of shapes have been considered for different applications [22, 23] over the years. In our project we consider a shape that is partially looks like a unit of a fractal shape or metamaterial shape to make a compact design in 2.4GHz for wireless sensor networks.

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II. PROPOSED ANTENNA DESIGN AND SIMULATED RESULTS

The geometry of the recommend compact antenna is presented in the following figure [3] and the dimensions are mentioned clearly in the Table [1]. Initially the rectangular patch antenna with limited ground and fed by 50Ω microstrip line which operates in the band 4.25-8.26GHz band. Then an inverted U shaped slot is embedded on it to make it resonate at lower resonance 3.7GHz and in next step the another inverted U shape slot [24, 25] is embedded inside to make it resonate at same 3.7GHz and also at 5GHz and another slot is made at the end of the U slots to make its resonate at 3.6GHz. Now in the final attempt to make the proposed antenna operate at lower resonance at 2.4GHz another slot is embedded at one side of the patch; the length and positioning of this slot effect the resonance of the recommended antenna to lower and higher around the 2.4GHz range. The step wise configurations are depicted in the following figure [1] and [2].

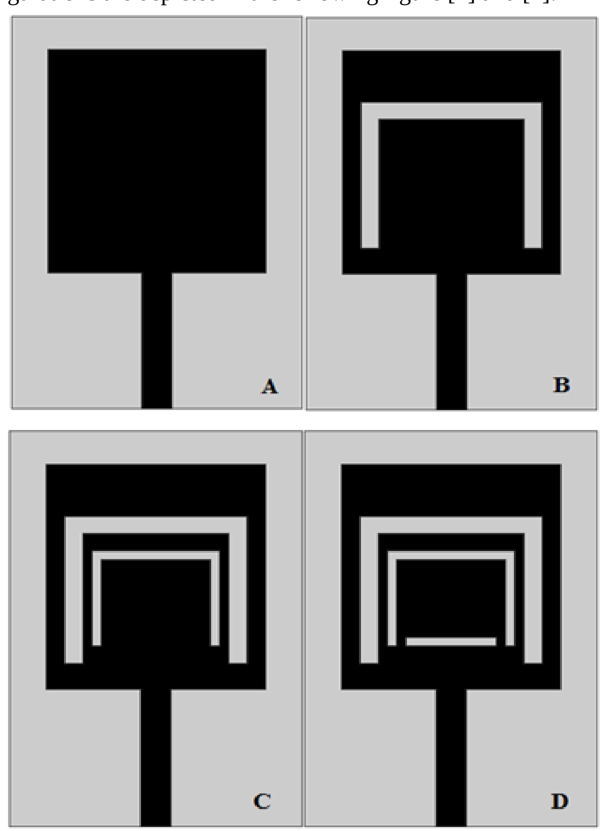


Figure [1] *Design Steps of Proposed Antenna without Tuning Slot (A,B,C,D)*

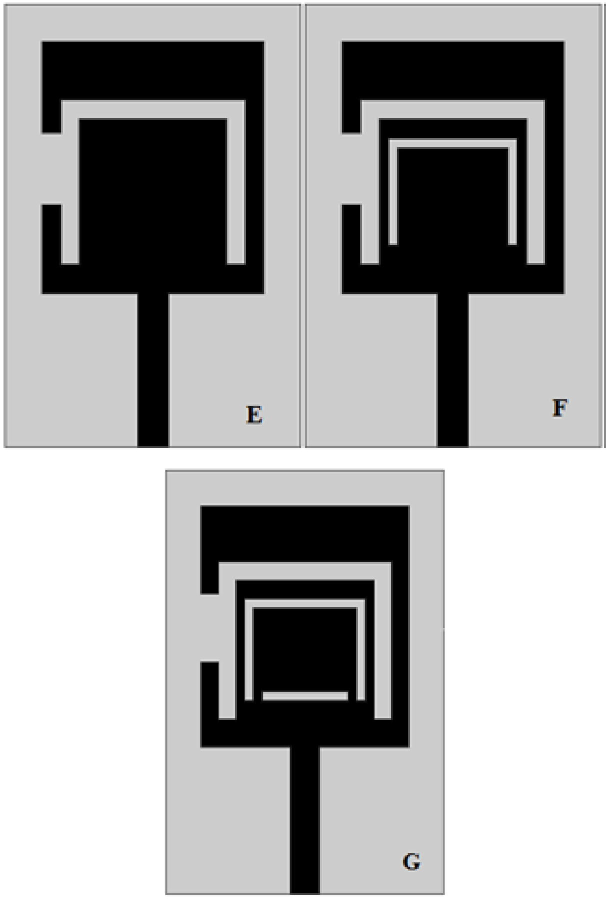
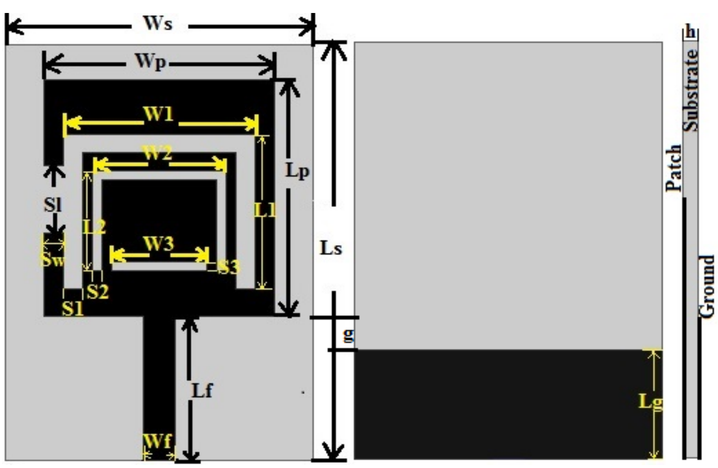


Figure [2] *Design Steps of Proposed Antenna with Tuning Slot (E,F,G)*

in order to achieve the compactness, the antenna overall dimensions are considered only 16×23×0.8 mm^3 and the ground at bottom layer is considered of height 6mm. Here the slot at left side of the patch plays vital role in tuning and also the inverted U slots and the rectangular slots can be tuned to various lengths and slot widths and the position of these slots can be tuned to make this antenna works at other applications too, either ISM or Non-ISM bands [26, 27].



a) Top view b) Bottom view

Figure [3] *Design of Proposed Antenna*

The proposed antenna design is listed in the following In Table 1. Where all measurements are in mm.

Table 1. *Proposed antenna design parameters in mm*

Ws=16	Ls=23	Wp=12	Lp=13	Wf=1.6	Lf=8
Sl=3.7	Sw=1	W1=10	L1=7.5	W2=7	L2=5
W3=5	S1=1	S2=0.5	S3=0.5	Lg=6	h=0.8

The proposed antenna lower resonance frequency can be calculated approximately by [2].

$$Frl = \frac{144}{Lg + Lp + g + \frac{Ws}{2\pi\sqrt{1+\varepsilon_r}} + \frac{Wp}{2\pi\sqrt{1+\varepsilon_r}}} \text{ GHz} \quad (1)$$

The return loss curve characteristics of the configurations shown in figure [1] & [2] are compared in the following figures [4] & [5]. Where these return loss curves explained how the antenna operation is shifted to the lower resonance around 2.4GHz step by step.

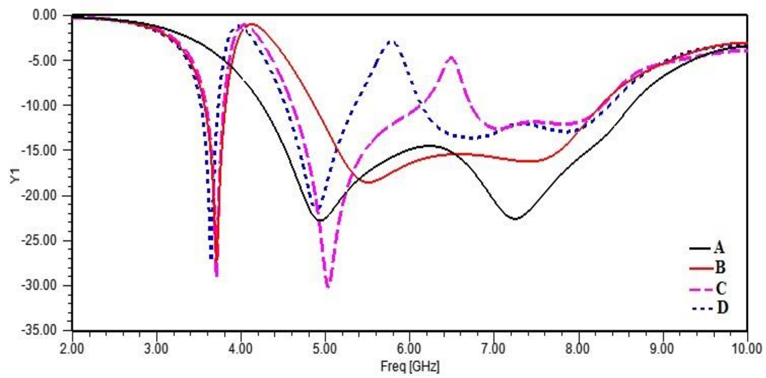


Figure [4] *Return loss Comparison for antenna Configurations A, B, C, & D depicted in Figure [1]*

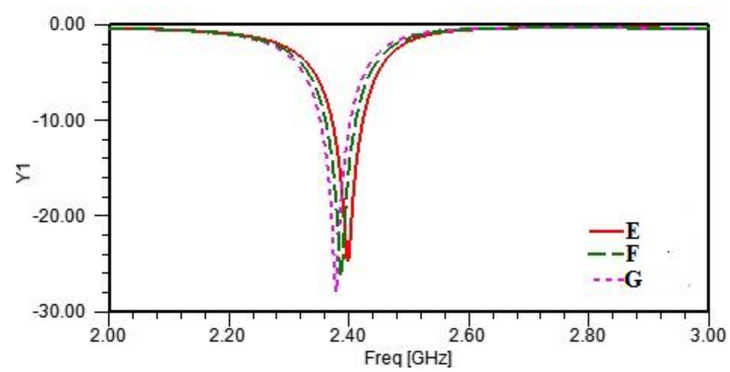


Figure [5] *Return loss curve Comparison for configurations E, F, & G Shown in Figure [2].*

The motivation for our research is to overcome the drawbacks of recent used antennas in wireless sensor networks [28 - 30] and achieve better results compare to [31 – 32] with high Gain and return loss.

III. PARAMETRIC STUDY

The parameters of the proposed antenna are augmented by checking the return loss characteristics for several ground lengths (Lg) and the various side slot lengths (Sl) to attain good impedance matching of the required resonance frequency. The return loss characteristics comparison for various ground lengths [29 - 32] Lg is presented in figures [6] and for various side slot length Sl is presented in figure [7]. Where Lg is varied from 5mm to 7mm with a size of 1mm and also the Sl is varied from 3.5mm to 3.9mm by a step size of 0.2mm.

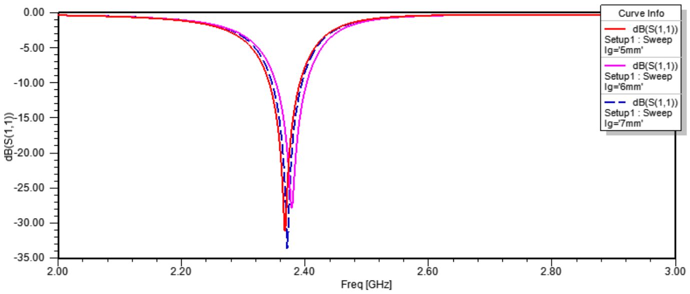


Figure [6] *Return loss comparison for Various Lg values*

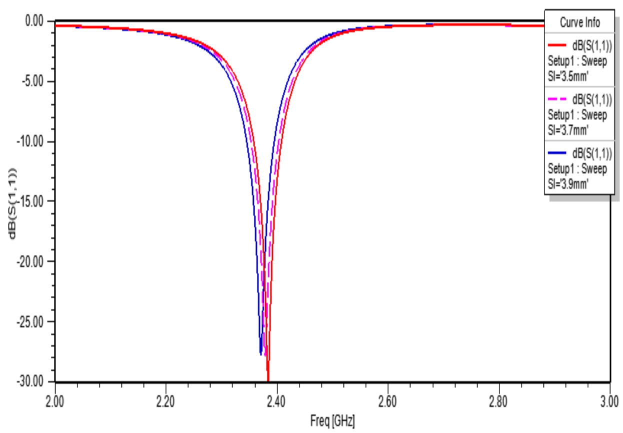


Figure [7] *Return loss comparison for Various Sl values*

IV. DISCUSSION SIMULATED AND MEASURED ANALYSIS OF PROPOSED ANTENNA

The proposed antenna with dimensions mentioned in the Table1 is fabricated which is shown in below figure [8] and the same is tested.

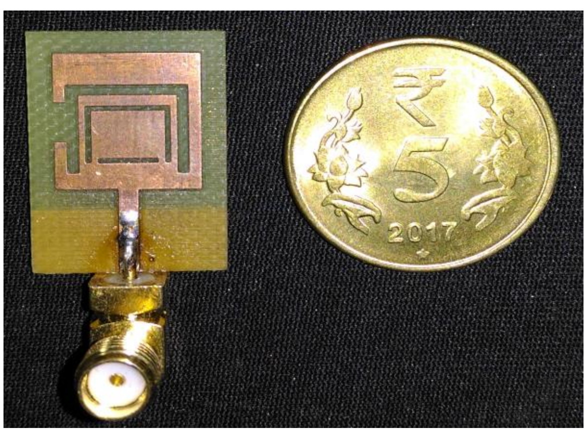


Figure [8] *Snapshot of the Fabricated Proposed Antenna*

The comparison of simulated and measured return loss characteristics is presented in the following figure [9].

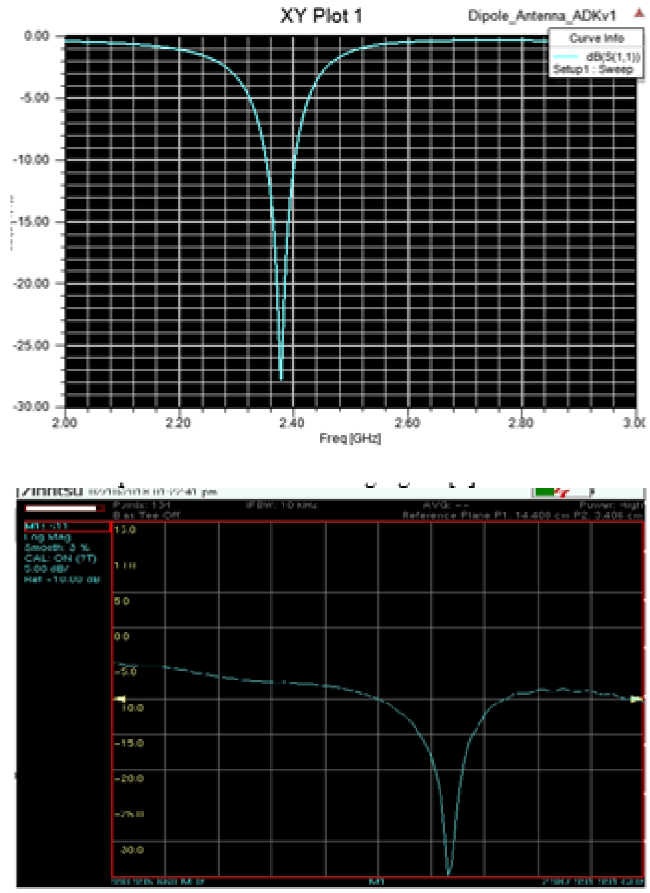


Figure [9] *Return loss Characteristics comparison for Simulated and Measured*

Table 2 *Comparison of Simulated and Measured values of Proposed Antenna*

Proposed Antenna	Frequency (GHz)	Return loss(dB)	Bandwidth
Simulated	2.379	-27.76	50MHz
Measured	2.24	-35	430MHz

The current distribution at 2.379GHz is presented in Figure [10] and also the radiation pattern curves in E- plane and H- Plane in both Theta and Phi direction are presented in figure [11].

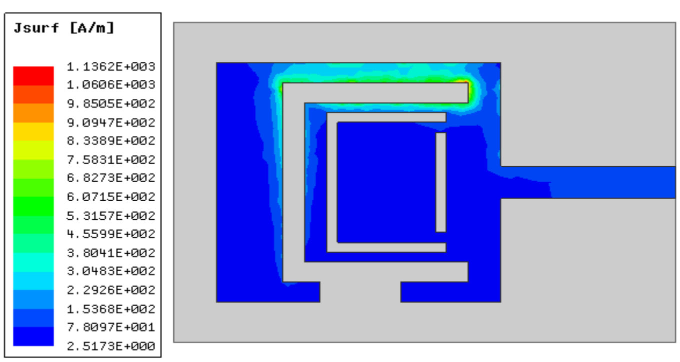


Figure [10] *Current distribution in Proposed antenna*

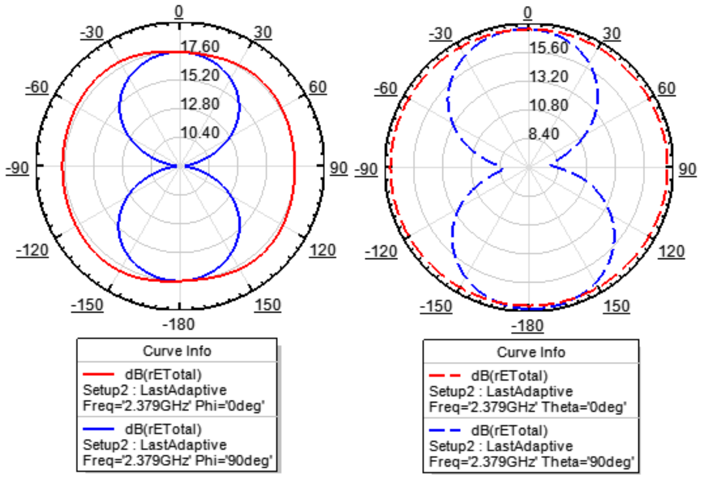


Figure [11] *Radiation pattern curves in E and H plane for theta and Phi directions*

Table 3 *Comparison of Existing antenna with Proposed Antenna*

Referred	Dimensions(mm^2)	Frequency	Total Size in mm^2
[3]	34×30	2.4	1020
[4]	40×25	2.4	1000
[5]	19.18×22.64	2.1	434.2
Proposed	16×23	2.37	368

V. RESULTS AND DISCUSSION

The return loss features of the proposed antenna are measured by Agilent Network Analyzer E8362B. The simulated results are compared with the measured results and the comparison is illustrated in Figure [9], which is listed in Table [2] numerically. A small difference is observed due to fabrication tolerance and soldering of the prototype. From the Table 3, we can clearly evidence that the proposed antenna is small in dimensions i.e miniaturized, which will work on Wireless Sensor Network frequency band i.e 2.4 GHz compared to other reference models [3 – 5].

VI. CONCLUSION

A compact planar Monopole antenna is designed and fabricated at 2.4GHz for wireless sensor applications in 2.4GHz ISM bands. The design achieved a miniaturized antenna with a compact size of 16×23×0.8mm3. Here the recommended antenna is designed from a rectangular patch antenna which have wide band 4.25-8.62GHz. An inverted U shape slot is made on the rectangular patch and the antenna resonates at lower frequency 3.7GHz another inverted U shape slot is made inside the first one and now the antenna resonates at dual band 3.7 and 5GHz. After this another rectangular slot is made at the end of the inverted U slot, which resonates at 3.6GHz. But in order to tune the antenna to even lower frequencies at 2.4GHz another slot is made at one side of the patch. This specific slot length will affect the antenna operating frequency from lower resonance to higher resonance value. So, by tuning the length of the side slot we set the antenna operation at 2.4GHz. The ground plane length also plays significant role in this design which is maintained partially at bottom side of the substrate. In wireless sensor networks applications around 2.4 GHz frequency, we able to designed a miniaturized antenna with best Gain and return loss and the limitation what we can find this structure is, proposed model will work on a specific frequency and for limited (WSN) applications and didn't consider for all other applications.

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