A New Printed Monopole Antenna as EMI Sensor

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ABSTRACT

This paper presents an initial investigation on the performance of multi-band printed rectangular monopole antenna as a sensor for measuring of electromagnetic interference (EMI). The triple-band is designed by etching narrow slots of different lengths. To design and meet the Requirements of multi-band frequency range antennas, several configurations can be used. Here we presented a Triple band of T-shape with a long and short arm. For the antenna design development, slot structures have been used to reduce the size of the antenna. The printed monopole antenna is designed etched onto a FR-4 epoxy substrate with an overall size of 33.06mm × 25mm ×1. 6 mm. The proposed antenna is simulated using Ansoft HFSSv13 software and the practical results are obtained by testing the fabricated antennas on Vector Network Analyzer (E5071C). The rectangular patch is the radiating element combined with ring slot with a plus shape enclosed inside. The inclusion of the ring slot with a plus shape upon its results in the excitation of coverage of the 2.5 to 2.68 GHz band, without increasing the size (since the current is divided between the rectangular patch and the ring slot attaining two resonant frequencies). The U-shaped slot gives resonance in the 3.1 to 4.1 and 5.3 to 6 GHz bands. The combination of the rectangular patch and ground plane results in Triple band resonating frequency (2.6, 3.5, 5.7 GHz) operating antenna (S11 < -10db).

Keywords:
Electromagnetic Interference, Multi Band, Strip Monopole, Printed Antennas.

1. INTRODUCTION

The electromagnetic interference (EMI) has become an important issue in the operation of modern high frequency electronic equipment. The electromagnetic compatibility (EMC) testing is required for EMC compliance of the electronic devices. This involves the measurement of radiated electromagnetic field from the equipment using accurately calibrated EMI sensor [1-2]. The carrying out of a sensor/ antenna depends on its antenna factor, which is the ratio of the incident electric field along the antenna surface of the received voltage at the load end [3]. Loaded wire antennas, dipoles, rectangular waveguides are commonly used as EMI sensors [4 – 7]. A triple-band unidirectional coplanar antenna is presented, but with a large size of 100 * 60 mm2 [8]. Usually, to meet the requirements of multi-band frequency range, at various types of configurations could be applied. In [9], Here we presented T-shape of multi-band frequency with a long and short arm. In [10], the use of U-slots with a combination with an L-probe feed is used to produce dual and multi-band Characteristics. A triangular-slot loaded multi-band antenna excited by the strip monopole is presented in [11]. In [12], the adjustment of the size of the slots on the radiating patch improves the performance of the coplanar waveguide-fed monopole antenna, but with a low antenna gain. Meandering slot antennas, in [13, 14], could also be used as well with different slots to generate two resonant modes. However, the complex structures of these antennas make them unsuitable for the practical applications. In [15] a miniaturize multi-frequency antenna is proposed using circular ring, and a defected ground plane.

2. ANTENNA DESIGN

The patch antenna was designed on the basis of the transmission line model (TLM). The width of the patch is calculated first, given by the formula

$$W = \frac{C}{2f\sqrt{\frac{\varepsilon_r + 1}{2}}}$$

Where ε_r is the substrate dielectric constant, W is the width of the patch and h is the height of the substrate. An effective dielectric constant ε_{reff} is used. The effective dielectric constant is defined as the dielectric constant of the uniform dielectric material so that

$$for\ \frac{W}{h} \geq 1$$

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{-\frac{1}{2}}$$

$$for\ \frac{W}{h} \leq 1$$

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{-\frac{1}{2}} + 0.041\left[1 - \sqrt{\frac{W}{h}}\right]$$

The patch we have used in our model is square patch, so the length and the width are the same. The dimensions of the patch are extended to account the fringing effect; the extension is given by

$$\Delta L = 0.412h\frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)}$$

Since the length has been extended by on each side of the patch, the effective length is given by

$$L_{eff} = \frac{C}{2f\sqrt{\varepsilon_{reff}}}$$

Patch resonant length L is given by,

$$L = L_{eff} - 2\Delta L$$

The configuration of the triple-band antenna is shown in Figures. The rectangular patch is the radiating element combined with ring slot with a plus shape enclosed inside of it shown in figure1 (a). We used a 1.6 mm-thick FR4 epoxy substrate and ε_r = 4.4. The partial ground plane with a U-shaped slot is located on the ground plane of the dielectric substrate, as shown in Figure1 (b). The inclusion of the ring slot with a plus shape upon its results in the excitation of coverage of the 2.5 to 2.68 GHz band, without increasing the size (since the current is divided between the rectangular patch and the ring slot attaining two resonant frequencies). The U-shaped slot gives resonance in the 3.1 to 4.1 and 5.3 to 6 GHz bands. The combination of the rectangular patch and ground plane results in Triple band resonating frequency (2.6, 3.5 and 5.7GHz) operating antenna. The proposed antenna is simulated using Ansoft HFSSv13 software and the practical results are obtained by testing the fabricated antennas on Vector Network Analyzer (E5071C).

The antenna dimensions (in mm)

Parameter	Size (mm)	Parameter	Size (mm)	Parameter	Size (mm)
W	18	D_s	2.10	W_s	7.5
L	33.06	P	1	W_h	5.5
w_f	3	Q	1.5	S_g	2.5
L_r	21	R	2	S	1
S_d	4.4	W_g	25		
W_{fs}	0.9	L_g	9		

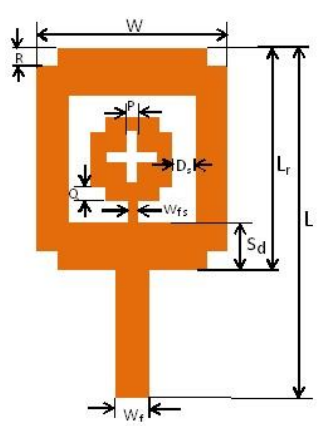

Figure 1 (a): patch

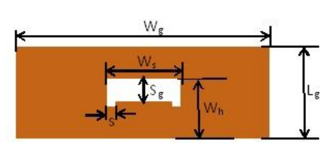

Figure 1 (b): ground

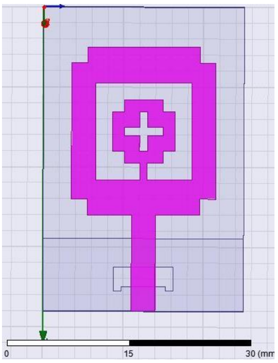

Figure 2(a): patch (HFSS)

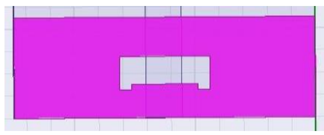

Figure 2(b): ground (HFSS)

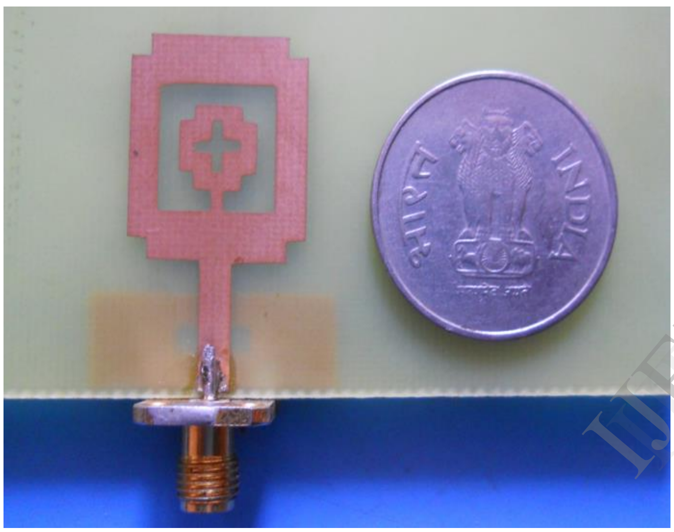

Figure 3(a): patch (Fabricated antenna)

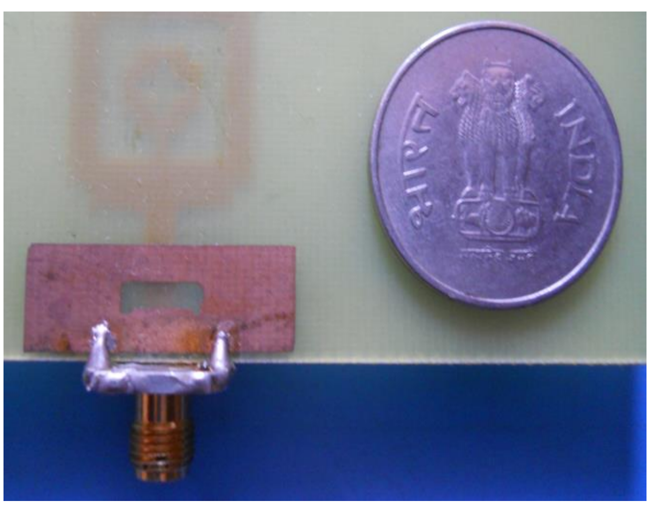

Figure 3(b): ground (Fabricated antenna)

3. RESULTS

3.1 Theoretical Results

The Return Loss observed for the structure shows at return loss of -49dB at 2.6GHz, a return loss of -19dB at 3.5GHz and a return loss of -37dB at 5.7GHz.

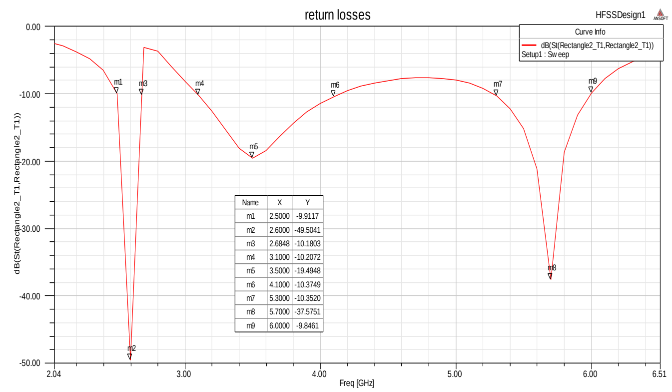

Fig 4 (a) : Return Losses (theoretical)

The VSWR observed in the structure shows 1.13 at 2.6GHz, 1.32 at 3.7GHz and 1.02 at 5.7GHz.

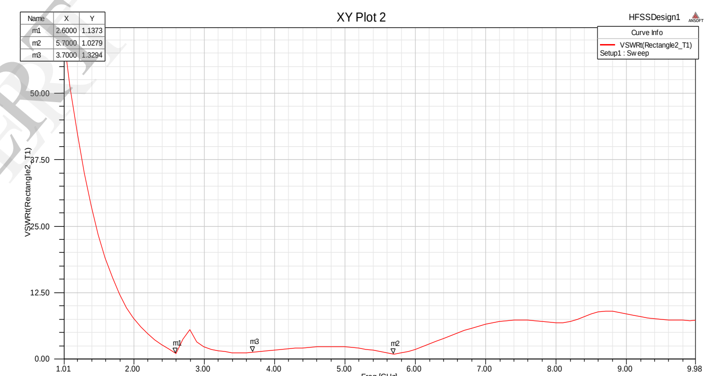

Fig 4 (b) : VSWR (theoretical)

3.2 Practical Results

The Return Loss observed in the structure shows at return loss of -33dB at 2.3GHz, a return loss of -23dB at 3.3GHz and a return loss of -18dB at 6GHz.

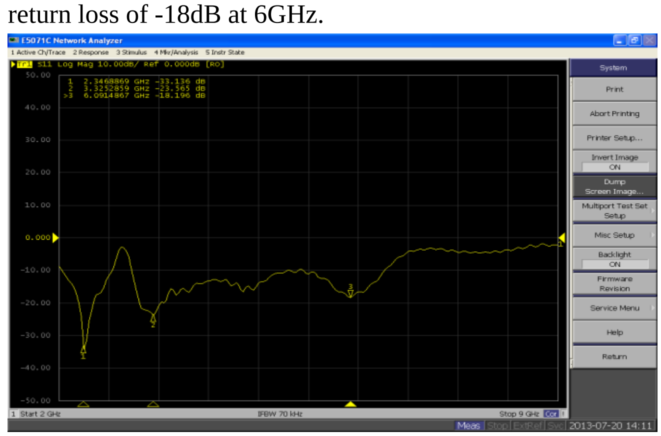

Fig 5 (a) : Return Losses (practical)

The VSWR observed in the structure shows 1.04 at 2.3GHz, 1.14 at 3.3GHz and 1.2 at 6GHz.

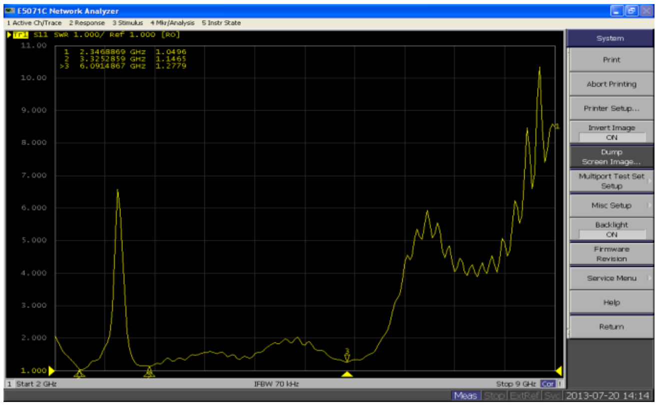

Fig 5 (b) : VSWR (practical)

4 Conclusion

In this paper, a compact Multi-band edge fed antenna proposed as an EMI sensor. The antenna has been fabricated and tested, which are wide enough to cover the required bandwidths of 2.6/3.5/5.7GHz.The percentage bandwidth of 6.9% and 12.2% is observed in the structure at 2.6GHz and 5.7GHz which can be used for sensing EMI. The percentage bandwidth of 28.5% is observed at 3.5GHz and it can be used for broadband applications.

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