Multiband Microstrip Patch Antenna for IoT Applications

J C Narayana Swamy , D Seshachalam

Abstract: ***In this paper, a planar multiband microstrip patch antenna is presented for narrow band internet of things (NB-IoT) applications. The simple planar structure covers three of the approved bands (830-840 MHz), (850-890 MHz) and (1190-1200 MHz). The return loss at resonance frequencies is less than-20dB and radiation pattern is omnidirectional as desired, for all the bands. Simple basic equations of microstrip patch antenna are used for design. The simulation and performance analysis is done using HFSS tool. The design considers simple, easily available printed circuit board (PCB) with FR4 dielectric material between the patch and ground plane. Which is inexpensive, fulfills the basic need of the application. The optimetrics of the HFSS simulation tool are handy, used extensively to find appropriate feed position, optimize return loss, gain and to tune the resonance frequencies.***

Keywords **: Narrow band internet of things, NB-*IoT, multi-band microstrip patch antenna, planar structure antenna, simulation using HFSS, triple band antenna.***

I. INTRODUCTION

IoT is the buzzword used for short range communication. Most of the IoT applications need narrow bandwidth [4]. Usually BW varies from 10MHz to 100MHz [2]. Short range, low power, omnidirectional and seamless connectivity for short time duration are some of the general specifications of Internet of Things. As there is exponential growth in demand for Internet of Things, the spectrum regulatory authorities world wide have been releasing new frequency bands at various spectrum range from sub GHz to several GHz. The Antenna design for IOT applications should fit in the range of spectrum released for the purpose.

This paper makes an attempt to design an Antenna for IOT needs in the allocated frequency bands ie (830 to 840MHz), (850 to 890MHz) and (1190 to 1200MHz) range. The focus of this work is on the tight narrow band criteria essential for the above need.

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II. THEORY AND DESIGN

This planar Microstrip patch Antenna is designed based on well-established theory of design of Antennas [1] for high frequencies (above few hundred MHz) by simple planar structures. Which are readily available, affordable PCB like structures [6].

The present work considered simple PCB board with glass epoxy (FR4) as the dielectric material of thickness, h=0.1589cm, thin copper or any other material which is perfect electric conductor(PEC) on both sides of the dielectric material. The physical shape, dimensions and the feeding method for excitation are mentioned in Fig. 1

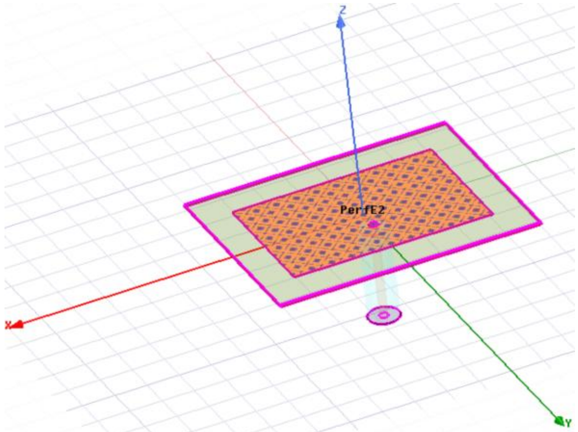

Fig. 1. Planar microstrip patch antenna.

The special feature of this design is just maintaining the proper dimensions and appropriate feeding position as shown in Fig. 2 and Table I, is sufficient to radiate or receive the signals in the appropriate frequency bands. To design a simple planar microstrip patch antenna requires three important equations [1] ie Eq 1, Eq 2 and Eq 3 as shown below. The mathematical expressions and relations used to design and meet the specifications [1] [9] mentioned in the table are,

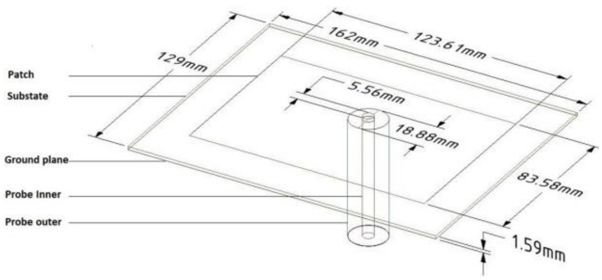

Fig. 2. Dimensions of the planar microstrip patch antenna.

Table- I: Key Antenna dimensions

Name	*Value*	*Unit*	*Evaluated value*
subH	0.1589	cm	0.1589cm
subX	16.2	cm	16.2cm
subY	12.9	cm	12.9cm
coax_outer_rad	0.944	cm	0.944cm
feedY	1.43374	cm	1.43374cm
gnd_x	subX		12.9cm
feedX	0	cm	0cm
gnd_y	subY		12.9cm
patchX	12.36096	cm	12.36096cm
patchY	8.35822	cm	8.35822cm
coax_inner_rad	0.278	cm	0.278cm
Feed lenth	6.105	cm	6.105cm

Length of the patch is

$$L = L_{eff} - 2\Delta L = \frac{c}{(2 f_0 \sqrt{\epsilon_{eff}})} \quad \text{-----(1)}$$

where

$$\Delta L = \frac{h}{\sqrt{\epsilon_{eff}}}$$

$$W = \frac{c}{2 f_0 \sqrt{\frac{\epsilon_r + 1}{2}}} \quad \text{------(2)}$$

$$\epsilon_{eff} = \frac{\epsilon_r + 1}{2} + \frac{\frac{\epsilon_r - 1}{2}}{\sqrt{1 + \frac{10h}{W}}} \quad \text{-------(3)}$$

where

ΔL - fringing filed length along radiating edge of the patch.

h -thickness of the substrate.

ϵ_{eff} - effective permittivity of the dielectric.

ϵ_r - relative permittivity of the substrate

W- width of the patch.

L- length of the patch.

c- velocity of free space.

ϵ_o - permittivity of free space ie air.

f_o - resonance frequency of the antenna.

III. RESULTS

In this work the important specification focused during design is to maintain specified narrow bandwidth, 10MHz at fr1 (m1), 40MHz at fr2 (m2) and 10MHz at fr3 (m3). Fig. 3, frequency plot w.r.t. return loos s11, depicts meeting the design specification and the need.

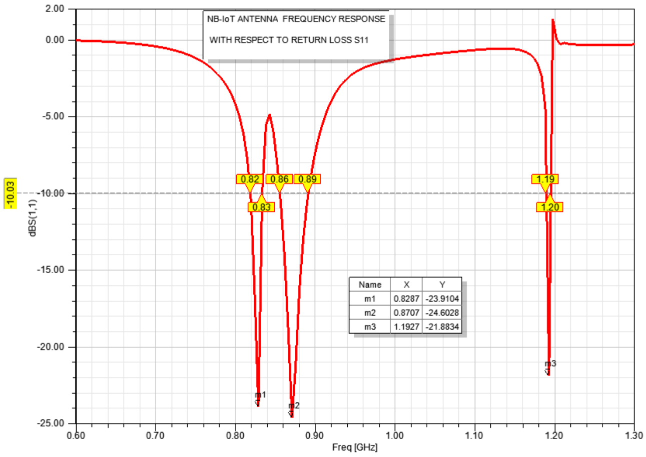

Fig. 3. Frequency response wrt to return loss s11 in dB.

The IOT applications demand omnidirectional antennas [5], the same is fulfilled by having almost uniform far field radiations except at θ = 0^o and θ = 180 o . The Fig. 4 depicts the same.

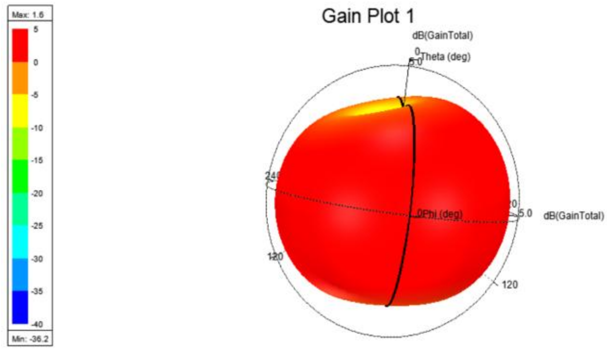

Fig. 4. Omnidirectional radiation pattern with gain variation.

The smith chart plot, Fig. 5 explains the variations of the input impedance for different values of the frequency. Helpful to position feed point appropriately along the Y axis and to tune optimally for achieving the desired results.

IV. CONCLUSION

In this paper the focus to design multiband IoT antenna with notch bandwidth of 10MHz, 40MHz and 10MHz at approximate resonate frequencies 825MHz,870MHz and 1195MHz is simulated using HFSS software. The return loss achieved at resonance frequencies, meet the minimum criteria and optimized to -20dB. Which is far better than the minimum requirement of -10dB. Hence the performance of the antenna to meet the specifications of the application are fulfilled. Further focus to optimize return loss below -20dB and to improve radiation efficiency is the future scope of this work.

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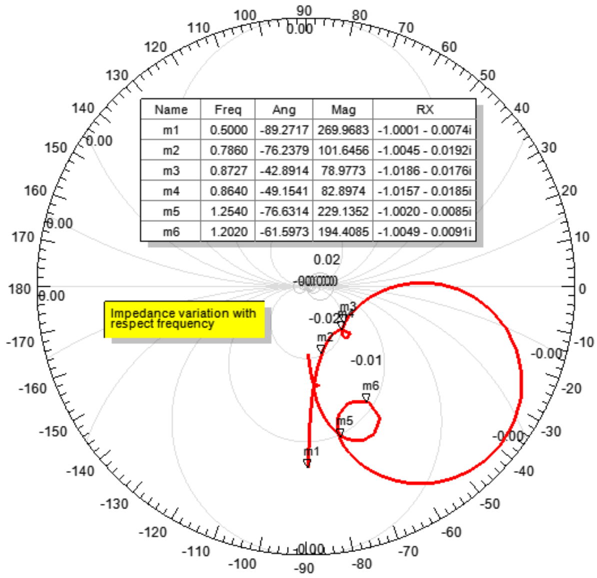

Fig. 5. Specifications of impedance variation at different frequencies.

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