Proceedings of the International Conference on Communication and Electronics Systems (ICCES 2018)
IEEE Xplore Part Number:CFP18AWO-ART; ISBN:978-1-5386-4765-3

Designing Methodology For Wireless Application Of Multiband Patch Antenna

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***Abstract*— Microstrip patch antennas are advantageous over conventional antennas. So, these antennas are widely used in compact, conformal and low- cost wireless applications. In this paper, various feeding techniques for microstrip patch antenna are discussed and designing methodology for a multiband microstrip patch antenna is given. Proposed antenna is designed and simulated for LTE, Bluetooth, Wi-Max application. It gives good radiation properties and good impedance bandwidth for the desired band. This antenna is a combination of T-shaped patch and parasitic strip. The antenna is fabricated on FR4 substrate. Antenna performance has checked with high frequency structure simulator(HFSS) software. Proposed antenna can be used for multiband application.**

Keywords*— *multiband antenna; microstrip patch antenna; parasitic strip; hfss;

I. Introduction

Wireless communication is one of the evolving and challenging zones in a digital era which is developing at the faster rate. Microstrip antennas have attracted much attention due to rapid growth. An original new radiation component, which gained much attention and many applications from its inception, has been recognized. This component is a simple, light, affordable, low profile and is consistent with the surface [1]. Several patch designs with different techniques and for different frequency operations have been proposed [2]. New wireless technologies are developing to improve the capacity and performance of communication systems every day. In today's generation, technologies growing as to meet the demands of users. With rapid developing communication era, device needs to be not only of small size but also to cover multiple frequencies so that it can useful for multiple operations [3].

In communication devices antenna is required to cover as many bands as possible to be compatible for different needs. It also requires to be low profile to integrate in more devices and give fine look to the device. However, the size reduction of antenna may lead to low radiation resistance and more reactance due to which impedance cannot be match. To combat the conflict between size decreasing and multi-band operations, researchers have proposed various techniques like coupled-fed technology, reconfigurable technology and resonant loop technology and many other technologies [4-9]. Proposed antenna design can be used in the wireless system for multi-band operation. Designed antenna is considered as a candidate for LTE, WWAN and Bluetooth band operation. It is observed that we can use the same antenna for various band operation with selecting proper feeding point location. Advantageous things of the antenna are it is entirely planar, compact size and low cost. In this paper multiband antenna is designed for wireless communication application like LTE band(2300-3400MHz), Bluetooth(2400-2500MHz) and Wi Max application(3300-3600MHz). Detailed design methodology for antenna is explained in section II and different feeding techniques for antenna design are further discussed in section III.

II. Design Procedure

The basic microstrip patch antenna dimensions are designed by transmission line model [1]. This multiband microstrip patch antenna has been designed by calculating Length(L), Width(W), effective dielectric (ϵ_{eff}), effective length extension (L_{eff}), height of substrate(h).

Step 1:

Selection of f_0, ϵ_r ,h *:*

Resonant frequency selected (f_0) :2.4GHz

Dielectric constant (ϵ_r) :4.4

Height(*h*) :0.8 mm

Step 2:
Calculation of Width (W):
The width W of the rectangular patch is as given in Eq.1 concerning the speed of light c and the frequency f_0

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

Where c = 3x10^8 m/s
Step 3:
Calculation of Actual Length (L):

Following Eq.2 is used to calculate the effective length of the rectangular patch,

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

There is a fringing effect described by ΔL in Eq.3,

$$\Delta L = 0.412h \frac{\epsilon_{eff}+3(\frac{w}{h}+0.264)}{\epsilon_{eff}-0.258(\frac{w}{h}+0.8)} \quad (3)$$

Effective dielectric constant ϵ_{eff} can be calculated by Eq.4,

$$\epsilon_{eff} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}(1+12\frac{h}{w})^{1/2} \quad (4)$$

Following Eq.5 is used to calculate the effective length of the radiating patch,

$$L_{eff} == L + 2\Delta L \quad (5)$$

III. Feeding Techniques

For microstrip patch antenna different feeding techniques are used. Feeding methods are classified in two categories

(a)contacting methods

In these methods radio frequency power is fed directly to the radiating patch using a connecting element such as a microstrip line.

(b)non-contacting methods

In these methods electromagnetic field coupling is done to transfer power between the microstrip line and the radiating patch.

The most prevalent feed techniques used are the microstrip line, coaxial probe (both contacting categories), aperture coupling and electromagnetic coupling (both non-contacting categories) [10].

A. Microstrip Line Feed

In microstrip line feed technique as shown in Fig.1, the edge of the microstrip patch and a conducting strip are directly connected. This type of feeding method is advantageous as it has simple planar structure. Microstrip patch is excited by line feed which is smaller in width as compared to the patch. The advantage of this feed system can be applied to the same substrate, so the overall structure is made of planner. The cross-polar level may increase due to the radiation from feed line. This hinders the bandwidth of the antenna.

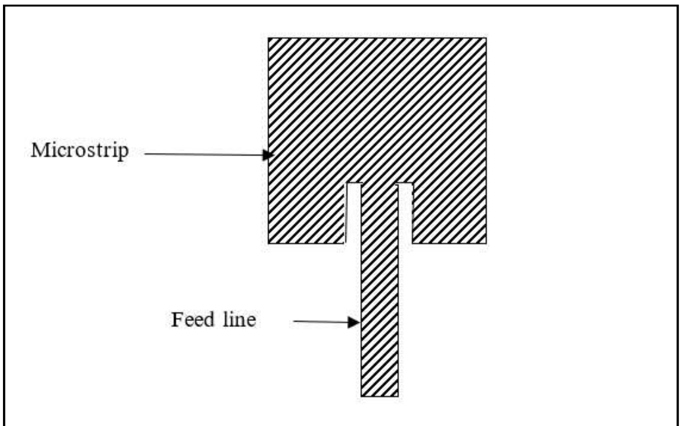


Fig. 1 Microstrip line feed

B. Coaxial or Probe Feed

Coaxial Feed Microstrip is a very common technique used to feed patch antennas. In this type of feeding the internal conductor of the coaxial connector soldered to the radiating patch through the dielectric medium, whereas the outer conductor is connected to the ground plane as shown in Fig.2. This technique is beneficial because the feed can be placed at any desired location inside the patch to match input impedance [2].

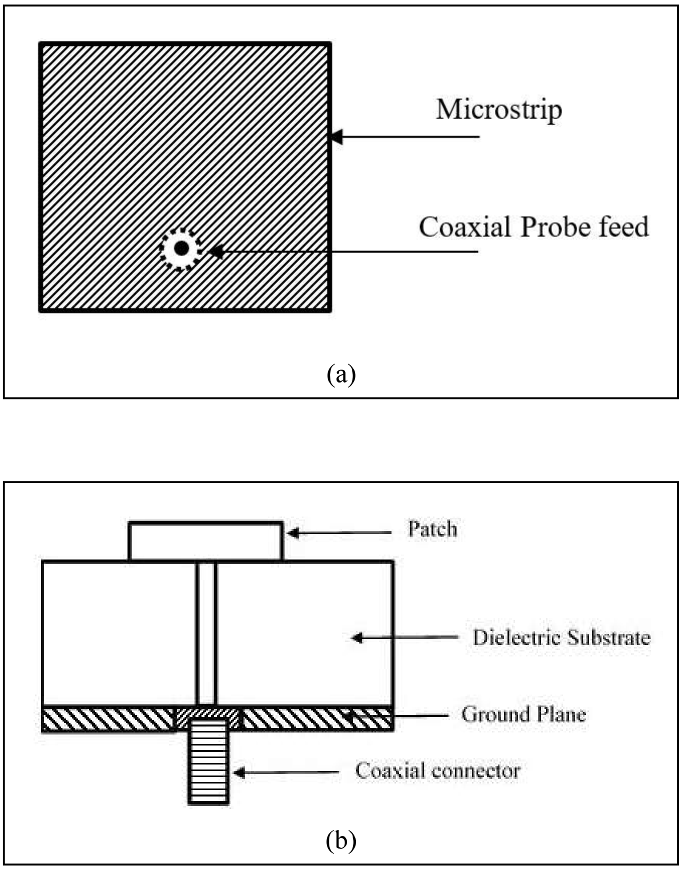


Fig. 2 Coaxial feed (a)Top view(b)Side view

C. Electromagnetic coupled Feed

Such type of feed technology is also known as proximity coupling feed. Two dielectric substrates, such as the one between the two layouts, are used and the radiation patch is above top substrate. This feed technique is beneficial because it eliminates fake feed radiation and the microstrip patches

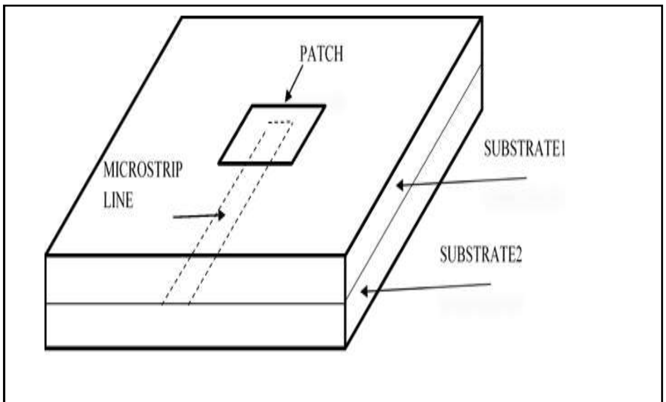


Fig.3 Electromagnetic coupled Feed

provide more bandwidth due to the overall increase in antenna thickness. Fig.3 shows electromagnetic coupled feeding

To increase second individual performance, proximity coupling also offers two different electronic media options for the feed line. This type of feed technology is used to reduce the harmonic radiation applied to the microstrip patch antenna in the multilayer substrate.

D. Aperture coupled feed

Another way of indirectly engaging patches is to attach a pair of apertures coupling. In aperture-coupled microstrip antenna (MSA) configurations as shown in Fig.4. a small aperture or slot in the ground plane is responsible for coupling between feedline and patch. The coupling aperture is usually centered below the patch, due to the uniformity of the configuration, cross-polarization is less. The size and position of aperture determines the amount of coupling from the feed line to the patch. Slot aperture length and width varies coupling and can results in wider bandwidth.

The resonance slot provides another resonance in addition to the patch resonance, so that the bandwidth is increased at the expense of increased radiation. As a result, a non-resonance aperture is usually used. Performance is relatively insensitive for small errors in the alignment of different layers. Like electromagnetic coupling method, substrate parameters of two layers can be selected separately for antenna optimization. This feed method gives rise to bandwidth.

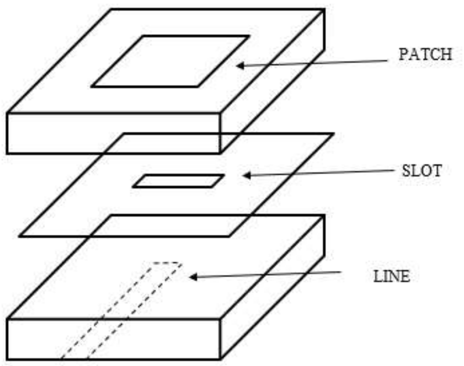


Fig.4 Aperture coupled feed

IV. Design And Analysis Of Multiband Antenna

A. Proposed Antenna Design

With reference to the antenna presented in [5], proposed antenna is designed and simulated using HFSS software. Fig. 5 shows the geometry of the proposed low-profile antenna for multiband applications. In designed antenna, a 0.8mm thick FR4 substrate is used as the system circuit board of 51× 117 mm^2.It is having relative permittivity 4.4 and loss tangent 0.02. The proposed antenna with a small size of 17 × 28 mm^2 is printed directly on the corner of the system circuit board. The system ground planes are printed on the back of the FR4 substrate, including the main ground plane of 50 × 100 mm^2 leaving a no-ground region of 50x15mm^2 to design the proposed antenna. A 50-Ω coaxial feed line whose central conductor and outer metal shield are connected to feeding point A and shorting point, respectively, is used to feed the proposed antenna, and the parasitic shorting strip is directly connected to the main ground plane through a via-hole at point B in the system circuit board. Design of the proposed antenna as in HFSS is as shown in Fig. 5.

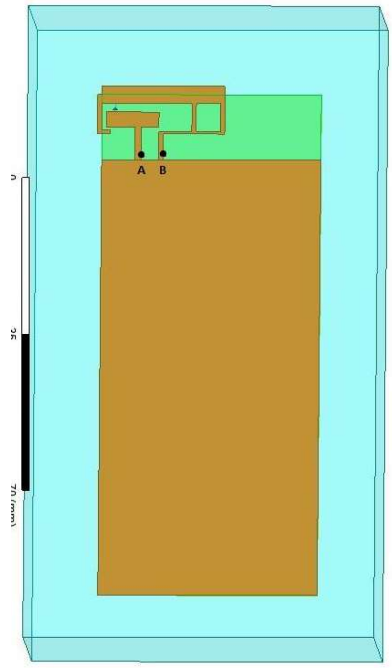


Fig.5 Design of proposed antenna[5]

B. Return Loss

The S11 parameter indicates how much power is reflected from an antenna. S11 equals to 0dB indicates that all the power is reflected from the antenna and nothing is radiated. On the S11 parameter graph, we generally consider operating

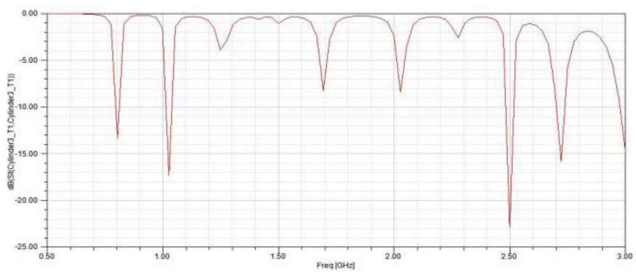


Fig.6 S11 parameter

frequency of antenna whose S11 value is less than -6dB.Fig. 6 implies the operating frequency of an antenna whose S11 value less than - 6dB are 800 MHz, 1700MHz, 2025MHz, 2500MHz, 2720MHz, 3000MHz, 3655MHz.

C. VSWR

It is a Voltage standing wave ratio. It indicates the impedance matching to the transmission line. It should be as minimum as possible. The minimum value of VSWR indicates better matching and more power is radiated to the antenna [3]. The minimum value of VSWR is 1, which is an ideal case, it indicates that no power is reflected from an antenna. Fig. 7 implies the VSWR corresponding to the operating frequencies 800 MHz, 1027MHz, 1694 MHz, 2027MHz, 2500 MHz, 2722MHz are approximately 3dB, 2.3dB, 7dB ,6.9dB, 1.2dB, 2.8dB respectively.

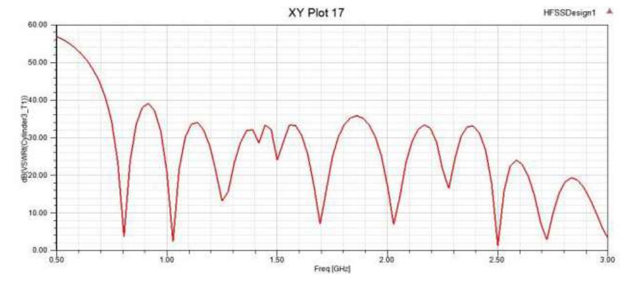
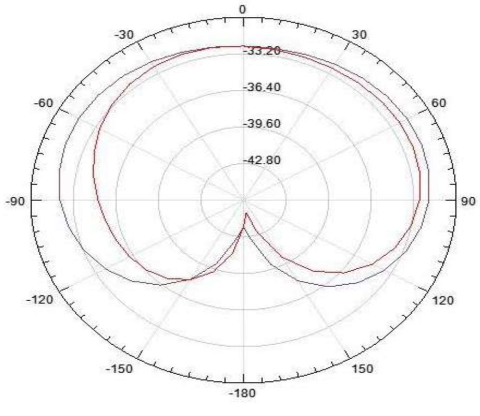


Fig.7 VSWR Plot

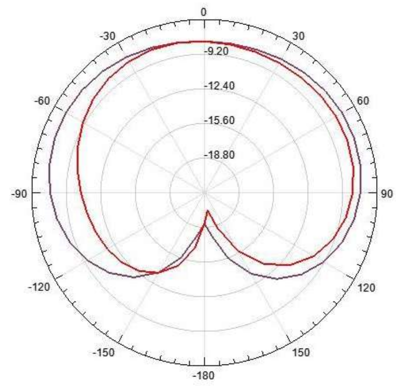
D. Radiation Pattern

A radiation pattern shows the variation of the power radiated by an antenna as a function of the direction away from the antenna. This power variation as a function of the arrival angle is observed in the antenna's far field [1]. The 2-dimensional radiation pattern at various operating frequencies 500 MHz, 2.4GHz of an antenna is shown in Fig.8.

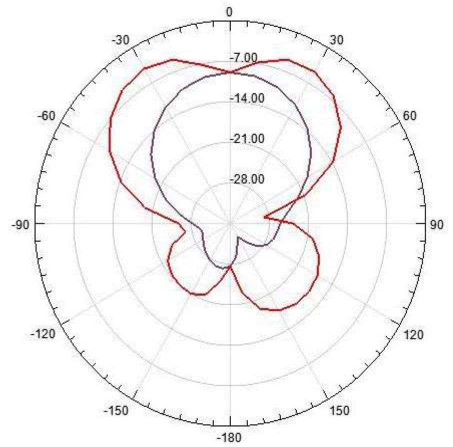
In Fig.8 ,(a) and (b) radiation pattern for total radiated E field (rE Total) at 500MHz and Gain at 500MHz can be simulated respectively whereas, in (c) and (d) radiation pattern for total radiated E field at 2.4GHz and Gain at 2.4GHz can be simulated respectively. These radiation patterns show that very less power is reflected, and most of the power is radiated to the antenna.



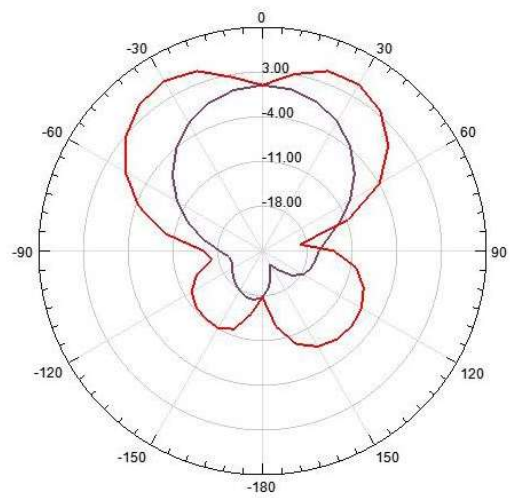
(a)rE Total at 500MHz



(b)Gain Total at 500MHz



(c) rE Total at 2.4GHz



(d) Gain Total at 2.4GHz

Fig8. Radiation Patterns at different frequencies

V. Conclusion

In this paper methodology for designing multiband microstrip patch antenna is explained. The antenna was simulated for multiband operation. According to simulation results low-profile antenna can give good performance for LTE/Bluetooth/Wi-Max bands. In this paper, reflection coefficients, radiation patterns, are also learned. The parametric study of proposed antenna using Ansys HFSS software shows that it achieves a useful impedance matching in the desired bands using coaxial feeding method.

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