A REVIEW OF VARIOUS MULTI- BAND ANTENNAS

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Abstract: In recent year, the demand for multiple frequency band antennas has increased vastly for a number of RF and microwave applications. For Public and Commercial use, FCC has assigned a specific bandwidth range of 3.1-10.6 GHz. Today our main concern shifted towards the development of multiple frequency band antenna system having numerous features like compact size, easy to fabricate, low power consumption, and which can operate at high data rates. For this purpose, there are various type of antennas for example CPW fed Triple Band Antenna, CPW-fed Fork-Shaped Antenna, LTCC Triple Band Antenna having Meander Line Structure and many more. In the given paper, a planar triple symmetric arm dipole antenna is specifically studied which can exclusively operate at 900/1800/2450 MHz successfully. Such antennas can be used in wide range of applications which include Wi-Fi, Wi-Max, medical devices, multimedia and PCS.

Keywords - Electromagnetic Interference (EMI), Triple Symmetric Arms Dipole Antenna (TSAD), Coplanar Waveguide (CPW), Long Term Evolution (LTE), Worldwide Interoperability for Microwave Access (WIMAX), Federal Communications Commission (FCC), Low Temperature Cofired Ceramic technology(LTCC)

I. INTRODUCTION

Antenna is the most essential device for mobile handsets in order to transmit and receive signals. Reduced size, lower cost and easy fabrication are vital features for designing an antenna that can be used in various wireless applications. These attractive features are well possessed by Planar Antennas. Hence, many studies were carried out for Planar Antennas and these are most widely used in GSM and RFID [1]. The communication quality of mobile handsets directly related to the performance of antennas. Nowadays, the necessity for mobile handsets is that they must be capable to operate at multiple frequency bands. On the other hand, Dual-band RFID antenna is having an attractive feature with which it can work with both bands and fascinates more courtesy in forthcoming applications. The multiple frequency band antennas has played a major role in Electronics and Communication (EC) industry [2]. For Public and Commercial use, FCC has allocated a specific bandwidth range of 3.1-10.6 GHz. Such antenna can be used in wide range of applications which include Wi-Fi, Wi-Max, medical devices, multimedia and PCS.

II. TRIPLE SYMMETRIC ARMS DIPOLE ANTENNA

For wireless applications, the low-profile antenna that is mainly recommended is triple symmetric arms dipole antenna (TSAD). To design a TSAD antenna all the three symmetric arms i.e. lower, middle and upper arms are etched on single sided Printed Circuit Board (PCB). In order to design and fabricate the antenna suitable for operating at multiple frequency bands (i.e. 900/1800/2450 MHz) successfully, the symmetric arm parameters can be adjusted accordingly. The IE3D software can be used to design and pick the significant parameters needed to construct the required antenna. A simple low-profile planar TSAD antenna proposed is given in the figure 1 below. From figure 1 it is found that there are three symmetric arms i.e. L1 (the lower), L2 (the middle) and S (upper arms) which are used to control the resonant frequency and impedance bandwidth. The geometric parameters of the symmetric arms are well selected so that the antenna which is proposed can operate at multiple frequency bands 900/1800/2450MHz successfully. So, a low profile planar TSAD antenna having dimensions of 43mm×20mm×1.6mm is shown in the present paper [3].

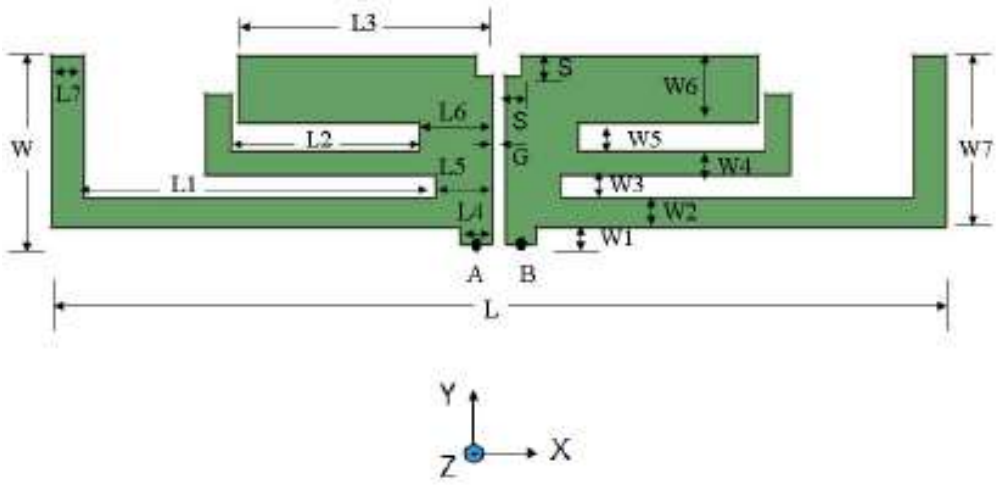

Figure 1. Parameters for the Planar TSAD Antenna [3]

Figure 1, shows the required configuration for the planar TSAD antenna that have a compressed volume $_{L*20mm*}$1.6mm.Here to obtain operating frequency bands, all the three arms i.e. L1, L2 and S symmetric arms are etched on the single sided PCB board. The feeding points A and B are also given in the figure 1. To notice the variations w.r.t the resonant frequencies and impedance bandwidth we adjust the L1, L2, and S (the lower arm length, the middle arm length and upper arm corner parameters respectively).Various dimension parameters given in above figure 1 are mentioned as: W=20, W1=2, W2=3, W3=2.5, W4=2.5, W5=3, W6=7, W7=18,G=0.5, L3=31, L4=4, L5=7, L6=9, L7=4 (all dimensions are in mm).For testing purpose fifty ohm (50 ohm) coaxial connector was adopted.

III. DIPOLE ANTENNA THEORY

Today the dipole antenna theory is used in a wide range of applications, which was originally developed by Heinrich Rudolph Hertz at the end of the 19th era. A basic dipole antenna consists of two equal straight lines lying on the same axis having the similar length and is separated by a minor gap. In figure 2, it is shown that to transmit or receive electromagnetic (EM) radiation the antenna must fed from the center point, or the feeding point.

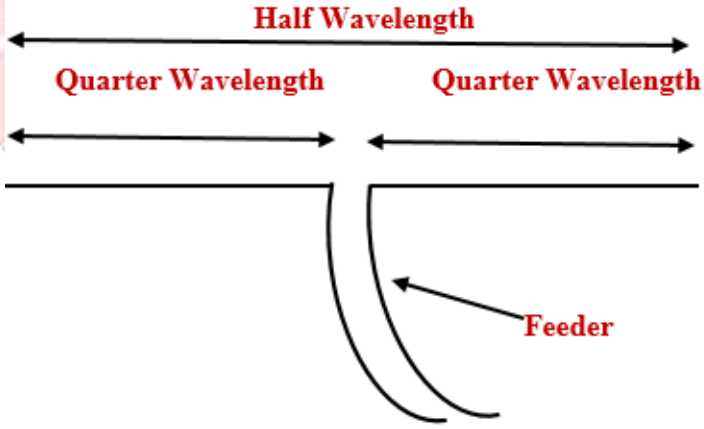

Figure 2:- Half wavelength dipole antenna theory [4]

A. CURRENT DISTRIBUTION

The current distribution have a sinusoidal shape which is shown in Fig. 3 below with a constant minimum value at the ends, and a maximum value at the feeding point (that is the case opposite to the distribution of voltage). The current varies according to the equation as given below:-

$$\mathbf{I = I_o e^{jwt} \cos kl}$$

This yields that to transmit the same frequency variable lengths of the antenna can be used. Note that one wing will be the reflection of other wings [4]. Since at the feed point the distribution of current is having the maximum value, whereas the value of input impedance will be minimum so there is an inverse relationship between them. In figure 3, V max, V min are the maximum and minimum voltage levels, lambda/2, lambda/4 are half dipole lengths and quarter wave dipole lengths.

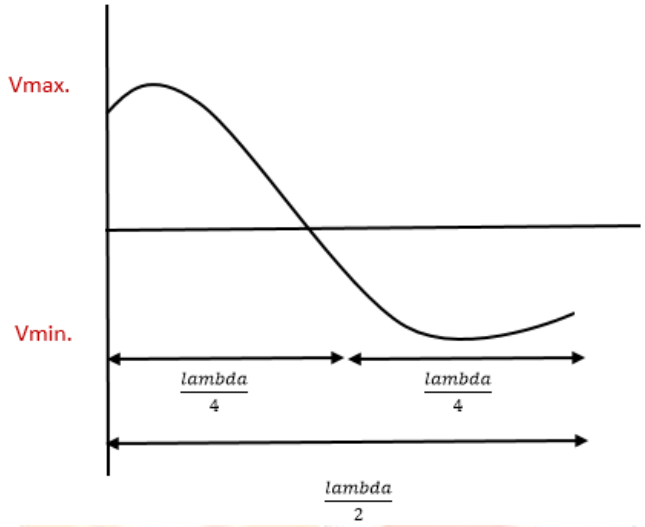

Figure 3:- Current Distribution for half wave dipole antenna

B. ANTENNA LENGTH

Length of the antenna is particularly used for determining the frequency. Antenna length (l) and frequency (f) both are inversely proportional to each other. The length for a half wave dipole (l) can be calculated according to the formula below, where c denotes the speed of light.

$$\mathbf{l = 0.44.\frac{c}{f}}$$

IV. EMI SENSORS

An EMI sensor is an antenna used in receiving mode. For transmission wired antennas are most widely used and it is necessary to place a sensor for EMI measurements in order to receive the radiations coming from equipment. The term "wire" used here denotes highly conducting wire-like structures. To attain self-resonance, length of the antenna becomes very large, whereas resonant length of the antenna can be reduced by doing proper loading of the antenna. The term Antenna Factor is used to characterize the performance of EMI sensors for the preferred and cross-polarized electric field [5]. Electromagnetic compatibility (EMC) testing of electronic devices is needed in order to avoid the EMI and other hazards. For measuring EMI it is necessary to calculate the strength of electric field using a sensor at the point of measurement. To use sensor for the measurement propective, calibration data is required which is related to the electric field, as for the accurate measurements in any field requires a perfectly calibrated device The Antenna Factor which is the performance describer of EMI sensor is stated as the ratio of the sensor incident electric field (E_i) to the voltage received (V) at the terminal of antenna when the terminal is ended by load of 50ohm.

A. INPUT IMPEDANCE

After defining the distribution of current, Input Impedance is defined as the ratio of V_{in} i.e. the input voltage to I_{in} the input current as given in equation below. Input Impedance is denoted as Z_{in}.

$$\mathbf{Zin = \frac{Vin}{Iin}}$$

B. ANTENNA FACTOR

Antenna Factor is used to characterize the performance of sensor and is given as the ratio of the sensor incident electric field (E_i) to the voltage received (V) at the terminal of antenna when the terminal is ended by load of 50ohm.

$$\text{ANTENNA FACTOR} = \frac{\text{INCIDENT ELECTRIC FIELD (Ei)}}{\text{RECEIVED VOLTAGE (V)}}$$

V. OVERVIEW OF VARIOUS TYPES OF TRIPLE BAND ANTENNAS

A. CPW FED TRIPLE BAND ANTENNA

In this paper, it is observed that to design and develop triple band antenna Coplanar Waveguide (CPW) feeding technique has been employed. In CPW based antenna, radiating patch and ground are on same plane. By varying the size and shape of ground conductor, we can adjust the resonant frequency accordingly. The proposed antenna is observed at three significant bands i.e. 720, 1300 and 1170 MHz bandwidth and having a peak gain of 5.22 dBi [6]. It is compact size, low profile, and easy to fabricate with microwave monolithic integrated circuits and other electronic devices. The proposed antenna was designed on RT6010 substrate with dimension 44 x 34.3 x 0.254 mm3 which is shown in figure 4 below:-

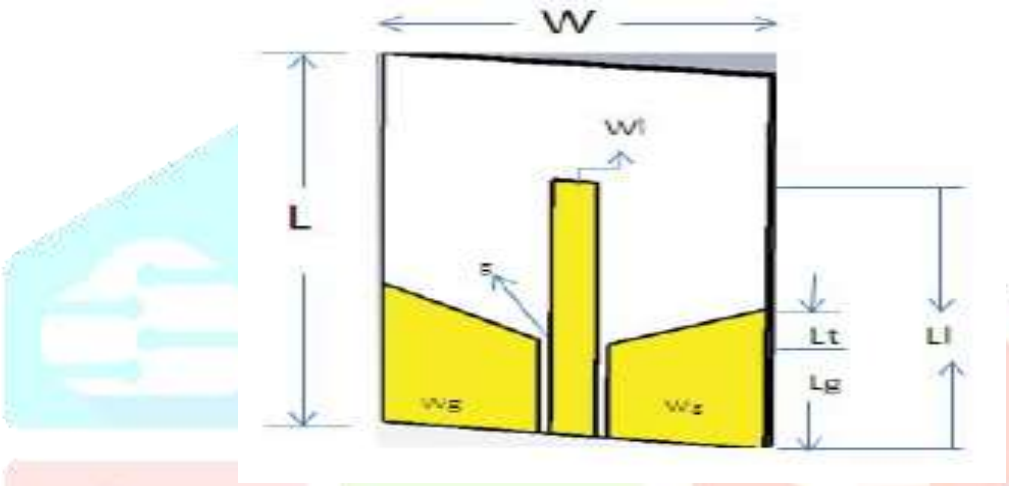

Figure 4 Top view of proposed antenna [6]

The dimension parameters of the given antenna are listed as W= 34.3, L= 44, W g= 14.7, L g = 12, W1= 4, L1= 33, Lt= 6, g= 0.2 (all dimensions are in mm).

B. CPW-FED TRIPLE-BAND FORK-SHAPED ANTENNA

This paper presents, a low-profile triple-band fork-shaped CPW fed antenna for LTE and WIMAX applications. The various dimension parameters of the given antenna are designed and fabricated so that the proposed antenna may be able to operate at 900MHz, 1800MHz and 3500MHz successfully. The observed ultimate gains of the designed antenna at 900/1800/3500 MHz are 1.29dBi, 1.65dBi and 5.41dBi, respectively [7]. It can be used in LTE 900/1800MHz and 3.5GHz TD-LTE/WIMAX frequency bands. The various size parameters of the proposed antenna given in Figure 5 are: L1=54, L2=3, L3=20, L4=11, L5=24.5, L6=4, L7=1, G=0.5, W1=91, W2=31.5, W3=39, W6=9.5 and W7=2(all dimensions are in mm).

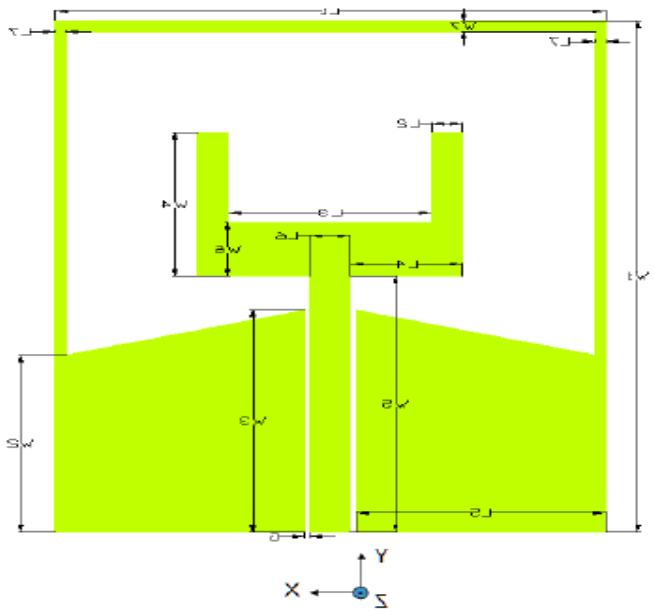

Figure 5 Configuration for the proposed antenna [7]

C. TRIPLE-BAND LTCC ANTENNA USING MEANDER LINE STRUCTURE

This paper, gives that the proposed antenna is fabricated basically to cover the Digital Audio Broadcasting (DAB) and L-band which cover frequency range from 1.452 to 1.493 GHz, GSM range from (890 to 960 MHz) and DCS (the Digital Communication System) range from 1710 to 1880 MHz [8] .This paper gives that the proposed antenna is designed to operate at multi bands having the bandwidth of 110 MHz (the lower), 140 MHz (the middle), and 60 MHz (the upper band). Figure 6 gives the Geometry of Triple band LTCC based antenna having gap stubs in between them. Size parameters of the Triple band LTCC based antenna are 20*10*0.85 mm^3.

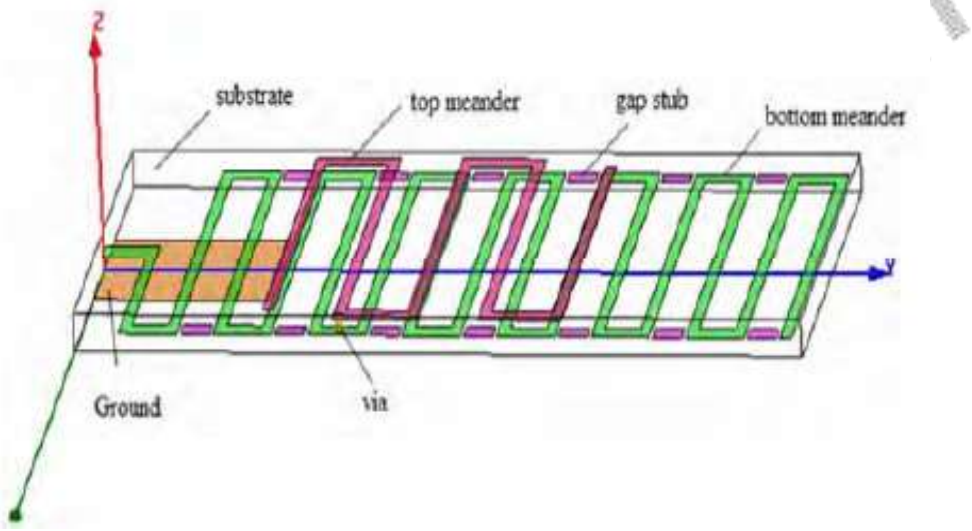

Figure 6: Geometry of the Triple-band LTCC Antenna [8]

VI. CONCLUSION

In this paper, the triple symmetric arm antenna which exhibits the simple planar structure and fabricated to operate in triple frequency band (900/1800/2450 MHz) has been studied. It indicates that omnidirectional radiation pattern of the proposed antenna is good for mobile devices. In this study Dipole antenna theory is described along with various antenna

parameters such as its current distribution pattern, Antenna length, Antenna factor and its applications as EMI sensors. After this an overview of various triple band antennas has taken and it is noted that CPW fed antenna is capable of avoiding interference and frequency collision, is well suited for Wi-MAX/PCS system and sensor applications. The manufacturing cost of antenna is reduced when the fabricated antenna is built as an on-board antenna.

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