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# Design of Wide Band Antenna for Base Station Applications

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***Abstract: -*** **A wideband dual-polarized antenna with high isolation and low cross polarization is designed. The overall height of the antenna is 25 mm. We have used a new kind of feeding technique i.e., a defected ground complementary phase micro strip feed in order to decrease the height of the antenna and a metal dipole used to reduce the cost of the antenna. It is observed that the dual polarized base station antenna has VSWR below 2 in the ELTE and GSM850 bands, 10 dB gain, Front to back ratio is less than 25dB, port to port isolation is less than 40 dB and the cross-polarization level is 20 dB below the co polarization level over the entire band. In order to increase the user capacity and sensitivity the antennas are skewed to +45 or -45 degrees. This paper was implemented using EMPIRE-XPU electromagnetic Simulator based on the theory of Finite Difference Time domain Method.**

***Key words:-*** **Feeding,GSM,VSWR,Wide Band, dual-polarized**

## 1. INTRODUCTION

Past few decades have witnessed aggrandizing research in the field of antenna designs. Improvements in the parameters of existing antenna designs and proposal of new structures have been the circumvention of such research. This report examines the possibility of developing a broadband antenna element for base station antenna applications, which operates in the 696-960 MHz frequency band. This band covers the low band frequencies for the current GSM and LTE system. An important factor considered is the height of the dipole antenna. Reduction in cost of the antenna is achieved by reducing the overall mechanical profile in terms of height of the antenna. Also, to improve the capacity of the overall system to communicate is obtained by the implementation polarization diversity. Polarization diversity helps in doubling the communication capacity of the base station. Further, feeding of dipole antenna so designed is an important step in enhancing the practical viability of the design. The reduction of the antenna envisaged is abridged by designing a micro strip based feed. The combination of feed and PD concept eliminates the need for separate power dividing components, and hence brings about novelty, and minimization in cost and size of the sub-systems to the antenna. Modern day communication devices have driven the need for smaller and lighter components, and hence effectively in the need for low-profile antenna designs. This thesis aims to design a dual polarized wideband dipole antenna for base station applications. Further, in this effort a micro strip based feed to the dipole antenna is proposed herein.

## 2. BASIC DESIGN

The configuration of the proposed PD [4] is shown in Fig. 3.6. The three ports of the divider are at the top layer of the printed circuit board (PCB) while the ground plane is at the bottom layer of the circuit. There is a slot in the shape of an arrow rectangle ended with two circles in the middle of the ground plane. This slot irresponsible for guiding the wave from the input port to the output ports.Prior to its design, it is important to understand the operation of this device. The divider utilizes the series type T-junction formed by a slot line and two arms of a microstrip line. The inherent property of this junction is that the signals coupled from the slotline to the two arms of the microstrip line are of equal magnitude but their phases differ by 1800. In order to efficiently (without reflections) couple a signal from the slot line to the micro strip, the end of the slot line needs to be compensated with an inductive element. In order to convert the input port from the slot type to the microstrip type, a wideband slot to microstrip transition needs to be employed [5]. As seen in Fig., the chosen transition is formed by two complementary structures. One includes a microstrip line terminated with a capacitive slot and the other one is a slot line terminated with an inductive slot. The two are electromagnetically coupled

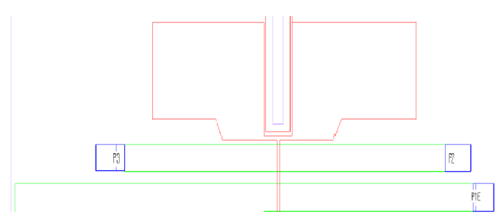

Figure. 1(A) microstrip

Having established the principles of operation of the power divider, a simple procedure can be applied to its design. The width of the input and output microstrip ports is determined assuming 50 characteristic impedance. The distance *d* between the input and output microstrip line does not have to be fine tuned. Here, it is chosen to be a quarter of the effective wavelength at the center frequency of operation (fc). In order to achieve a high return loss at the microstrip ports, the slot width(s) should be chosen to give impedance close to 50 as seen from the microstrip side. At the sometime, the slot width should not be too narrow to avoid problems with the manufacturing errors.

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## 2. BASICS OF DIPOLES

The dipole is, if considered in the simplest case, a two-wire transmission lines shown in Figure. The transmission line is driven by a signal source in one end and an open circuit on the other side. The result of the open circuit is a standing wave on the transmission line. The current at the edges is zero due to a phase shift created in the source. This results in a zero net radiation. Thus, to design a radiating element, the two edges are turned to create the simple wire dipole sketched in Figure. This modification radiates due to the fact that the currents now have the same orientation in space [6]. The current distribution depends on the length L for the dipole. In practice, the most common way is to choose the length to half or a quarter of a wavelength. The radiation resistance for the half wavelength dipole is 73 [3].

**Broadband Dipoles**

In order to reach the required bandwidth, a dipole with broadband Characteristics are required. There are numerous ways for designing such an antenna. For example: dipole arrays, biconical and cylindrical dipoles can all achieve broadband characteristics. However, dipole arrays have large physical dimensions, and considering the requirement for a small structure, a biconical dipole antenna could be a better choice. Furthermore, the design of a biconical antenna is impractical due to the fact that the shell structure is massive [3]. Instead, an approximation of the Biconical antenna, namely a bowtie type antenna, is interesting

## 3. DESIGN SPECIFICATIONS

The design specifications for a base station antenna element operating in the LTE and 2G systems can be seen in Table 1. The limitations for the parameters are set so that the antenna element can operate in an antenna array.

**Frequency band**

The frequency band 696 to 960 MHz includes the current 2G, 3G and the standard for the next generation of wireless mobile system, LTE. In this frequency range, the return loss criterion is 15dB. The broad frequency spectrum requires a high fractional bandwidth, calculated to 32% with ( $f_H = 960$, $f_L = 690$ and $f_0 = 828$ MHz) and $f_b = (f_H - f_L)/f_0$

Table: 1 Project Requirements

| Parameter | Value |
|---|---|
| Frequency band | 790 - 960 MHz |
| VSWR | 1.5:1 |
| Impedance | 50 ohms |
| Horizontal 3dB beam width | 65° |
| Vertical 3 dB beam width | 65° |
| Polarization | Circular |
| Isolation | < -25 dB |
| Cross polarization discrimination | < -20 dB |
| Front to back Ratio | < -25 dB |

## 4. PROPOSED DESIGN

The design evaluated is the bowtie antenna, which is a planar modified biconical antenna. The structure for the bowtie antenna is more complex than the dipole. The design parameters for a basic bowtie antenna are shown in Figure, and are calculated in a similar way as for the dipole.

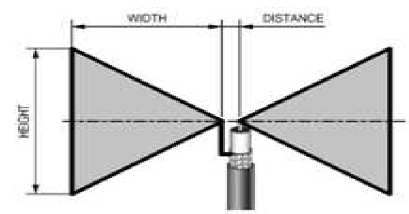


Figure: 1(B) Basic design for the bowtie antenna

*LBow* : *Half* wavelength for the center frequency 0.83 GHz and calculated wit ( $c = 3\times108$ and $r = 1$(air*WBow* : Chosen similar to the width of the design in article [6].

One way to further increase the bandwidth is to add a parasitic element with a15mm height wall, as described by article [1] and [5]. The length and width for the parasitic strip are initially similar to those of the design proposed by article [2]. The design structure for the dipole after adding the parasitic element can be seen in Figure. The parasite increases the bandwidth by adding an extra resonance to the higher frequencies, as long as the dimensions are chosen properly. To achieve a better matching for the lower frequencies, the length L was increased.

## 5. SIMULATION AND MEASUREMENT RESULTS

### 5.1. Antenna with Microstrip feed1 for port1

We have given the power divider1 as a microstrip feed1 for port1 to the simple dipole antenna. This antenna is performing well from 790 to 960 MHz frequency range.

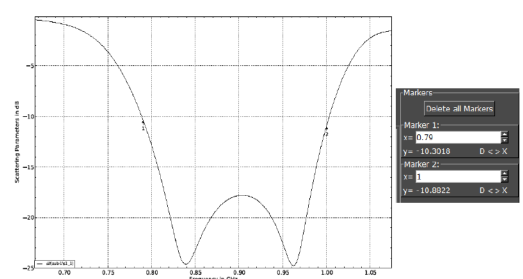

Figure:2 Simulated S11 of the antenna with microstrip

The simulated return loss is as shown in the Figure 3.1. From this figure we can observe that the return loss is below 10 dB from 790MHz to 1GHz that indicates the VSWR is less than 2. The total impedance graph of the antenna is as

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shown in the Figure, from this graph we can observe that high impedance is formed. We can observe that at lower frequencies of the band has inductive effect, have to compensate with the capacitive effect to get the return loss.

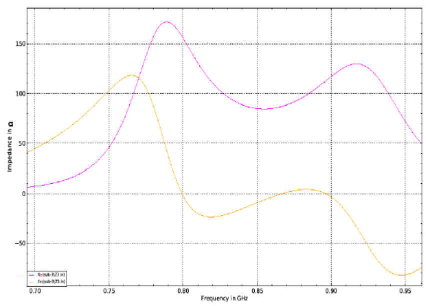

Figure:3 Simulated Impedance of the antenna with microstrip

The simulated horizontal or azimuthally far field parameters of the antenna withport2 at 830MHz is as shown in the Figure. From this graph we can observe that the gain is 9.8 dB and the horizontal beam width is 50.47 degrees, the front to back ratio (FBR) is 26 dB and the cross polarization discrimination is -20 dB.

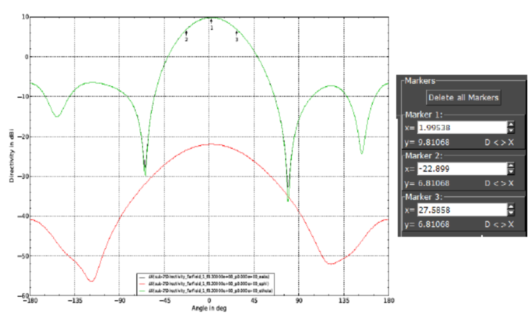

Figure : 4 Simulated elevation Farfield parameters of the antenna with feed1 at 830MHz

The simulated vertical or elevation far field parameters of the antenna with port1 at 830MHz is as shown in the figure From this graph we can observe that the gain is 10dB and the vertical beam width is 64.99dB, the front to back ratio (FBR) is 26 dB and the cross polarization discrimination is -20 dB.

**5.2. Dual Polarization:**

We have given the power dividers as a microstrip feed to the simple dipole antenna. This antenna is performing well from 790 to 900 MHz frequency range i.e.,in ELTE and GSM bands. We are using a metal dipole to reduce the cost of the antenna, to increase the impedance bandwidth of the antenna we are using a parasitic patch with a wall at height of 26.5mm from the reflector plate as shown in the front view and side view of the dual polarized antenna

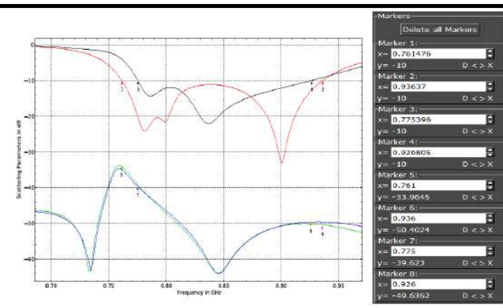

Figure:5 Simulated S11 of the dual polarized antenna

The simulated return loss is as shown in the Figure. From this figure wecan observe that the return loss for the port1 is below 10 dB from 761MHz to54936MHz and for the port2 is below 10dB from 761MHz to 936MHz that indicates the VSWR is less than 2.

The total impedance graph of the antenna is as shown in the Figure. From this graph we can observe that high impedance is formed. We can observe that at lower frequencies of the band has inductive effect, have to compensate with the capacitive effect to achieve the sufficient return loss.

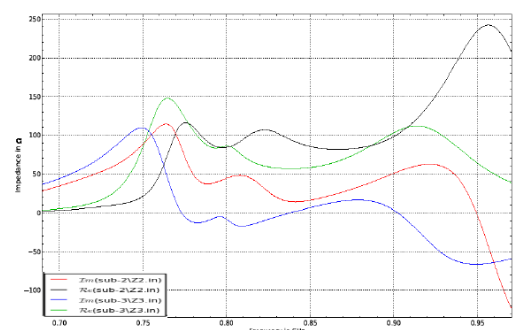

Figure:6 Simulated Impedance of the dual polarized antenna

The simulated horizontal or azimuthal farfield parameters of the dual polarized antenna at 830MHz is as shown in the Figure. From this graph we can observe that the gain is 9.8 dB and the horizontal beam width is 51.20 for port1 and 64.790 for port2, the front to back ratio (FBR) is 26 dB and the cross polarization discrimination is -20 dB for the port1 and port2 respectively.

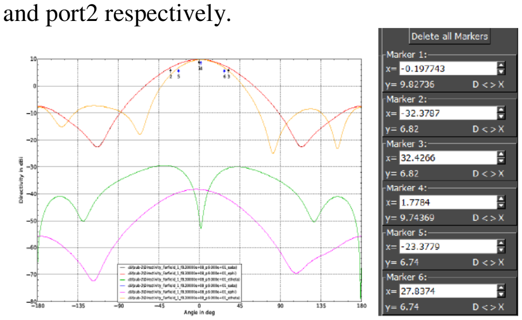

Figure: 7 Simulated azimuthal Farfield parameters of the dual polarized antenna at 830 MHz

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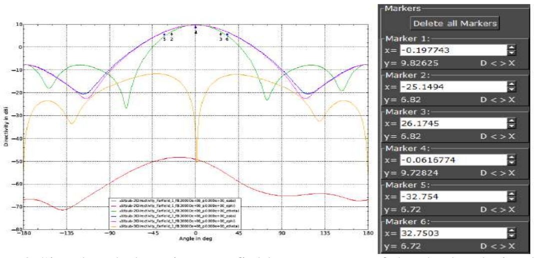

Figure:8 Simulated elevation Far field parameters of the dual polarized antenna at 830MHz

The simulated vertical or elevation far field parameters of the dual polarized antenna at 830MHz is as shown in the Figure. From this graph we can observe that the gain is 10dB and the vertical beam width is 65.40 for port1 and 51.20 for port2, the front to back ratio (FBR) is 26 dB and the cross polarization discrimination is -20dB for port1 and port2 respectively.

The measured S22 of dual polarized antenna is as shown in the Figure the return loss is below 10dB from 817MHz to 874MHz. The difference in the measured results compared to the simulation results is due to the fabrication tolerances.

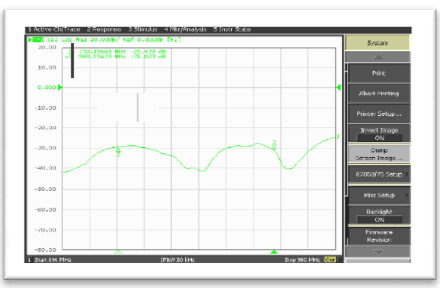

Figure:9 Measured S12 of dual polarizes

The measured S12 of dual polarized antenna is as shown in the figure: The isolation is below 28dB from 696MHz to 960MHz. The difference in the measured results compared to the simulation results is due to the fabrication tolerance

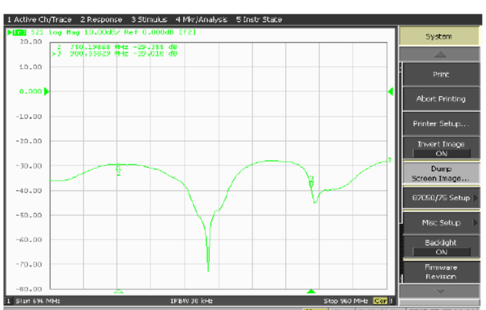

Figure: 11 Measured S21 of dual polarized antenna

The measured S21 of dual polarized antenna is as shown in the Figure. The isolation is below 28dB from 696MHz to 960MHz. The difference theme assured results compared to the simulation results are due to the fabrication tolerances.

## 6. CONCLUSION AND FUTURE SCOPE

Dual polarized base station antenna with complementary phase defected ground structure microstrip based feed is implemented. As the design is implemented using metal dipole and the defected ground microstrip feed, complications were raised in the design of antenna with a height less than 25mm. Fabrication of power dividers and feeding positions are crucial which defines the overall performance of the antenna. The design has to be improved by considering the fabrication tolerances and by adding some slots in the wall as well as in parasitic patch for the improvement of return loss in the required frequency range.

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