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# COMPACT ULTRA-WIDEBAND MONOPOLE ANTENNA FOR 5G WIRELESS COMMUNICATION SYSTEMS

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## ABSTRACT

*This works involves designing of printed monopole antenna for ultra-wideband applications, which consists of an annular monopole patch and a trapeziform ground plane with a pointed CPW feeder in the middle. The simulated and tentative results establish that this antenna accomplishes a ratio impedance bandwidth of more than 10:1 for VSWR 1, and displays the nearly omnidirectional radiation pattern with a simple arrangement. The proposed antenna shows characteristics needed for the 5G communication systems. The simulated and measured results confirm that the antenna contains the needs for ultra-wideband applications and the simulation is carried out by using industrial simulation software called CST Microwave Studio. The monopole antenna will be fabricated and both simulation and experimental results show good agreement.*

***Keywords: UWB, CPW Fed Annular Monopole Antenna, 5G Wireless Communication.***

## 1. INTRODUCTION

In last ten years, due to the video content the immense mobile data condition has enriched. It requires the data rate of 15.4Mbps because of the high capacity of mobile receivers supporting 4K resolution (Haitham et al., 2018). This growth is due to the accumulative number of user and viewing time. This will result in an annual traffic of 296.8 excabytes (EB) by 2019 (Huang et al., 2018). Therefore, 5G communication network (IMT 2020) is the possible solution to counterpart this great data request, with a capability of attainment up to data rate of 20Gbps. 5G is not only guiding improved mobile broadband (eMBB), but also it has varied usage states including, ultra-reliable and low latency communication (URLLC) and massive machine type communication(mMTC). Frontend antenna layout for base stations and mobile handset is a sharp area of research in order to encounter with the design tasks of 5G (Usman et al., 2018). Due to its outstanding features, technology of ultra-wideband has received high importance and growth in wireless communication systems.

Federal Communication Commission (FCC) has allocated the Frequency band ranging from 3.12GHz to 10.64GHz (Jianchun et al., 2018; X.-L. Liang et al., 2019). These systems are considered by extreme high data rates over their wide bandwidth (Wong et al., 2019; Wang et al., 2018), low power consumptions. Thus designing a Compact Antenna with high stability and performance of operating frequency radiation pattern power gain and fabrication cost remains a challenging task. This paper is structured as follows. In section 2, antenna structure, design, and simulation are explained. In section 3, simulation results compare with the measured results. Finally, in section 4, conclusions are drawn.

## 2. ANTENNA DESIGN

The proposed UWB monopole antenna with a trapeziform ground plane is developed from the discone antenna first developed by Kandoian in 1945 (Usman 2016), which offers acceptable impedance performance over a wide frequency range and maintains nearly directional radiation characteristics. Fig. 1 shows the proposed UWB printed antenna consisting of an annular ring monopole patch and trapeziform ground plane.

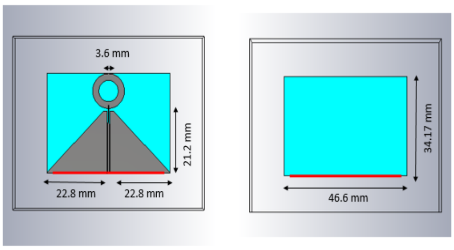


***Fig.1: Front and back view of CPW Fed annular monopole antenna***

The CST Microwave studio software is based on the method of Finite Integration Technology (FIT) simulates the proposed UWB antenna. The FR4 substrate with relative permittivity εr=4.5 (Usman et al., 2018) and thickness h=1.6 mm is chosen. The length of the substrate is 46.6 mm and width of the substrate is 34.17 mm. The radius of the outer circle is 3.6 mm and radius of inner circle is 2.8 mm. The distance between the feed and the annular ring is 21.2 mm. The proposed antenna is very small and can be used for wireless communication systems and it shows good performance in the UWB range.

## 3. RESULTS AND DISCUSSIONS

### 3.1. SIMULATION RESULTS

#### 3.1.1. S-PARAMETERS

The proposed antenna is designed and simulated using CST microwave studio. The reflection coefficient of the antenna determines the performance of the antenna and in our proposed system the bandwidth is seen to be increased from 3.0 GHz to 11 GHz.

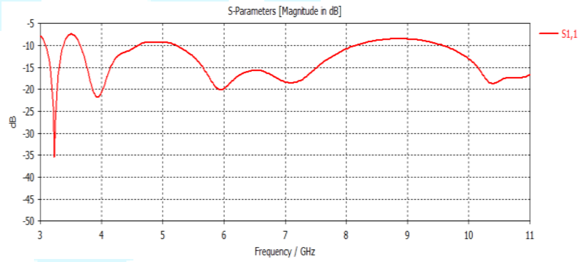


***Fig.2: Reflection coefficient of antenna***

The resonating Frequencies are 3.16 GHz 3.85 GHz, and 6.0 GHz. The s11 value of the antenna is -35 dB for the operating frequencies.

#### 3.1.2. VSWR

VSWR stands for Voltage Standing Wave Ratio and is related to as Standing Wave Ratio (SWR). VSWR is a function of the reflection coefficient (Jayalakshmi et al., 2020), which describes the power reflected from the antenna. The

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VSWR of the proposed antenna is shown in figure 3, 4 and 5. It can be seen from the below figure the voltage standing wave ratio (VSWR) value is 1.148 which is very much equalto the ideal value.

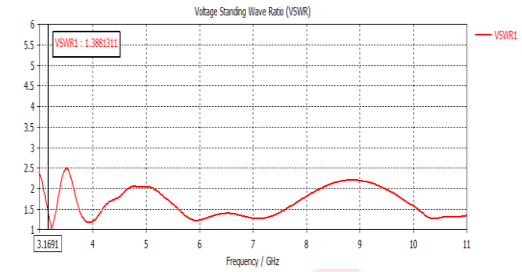


*Fig.3: VSWR of the proposed antenna at 3.16 GHz*

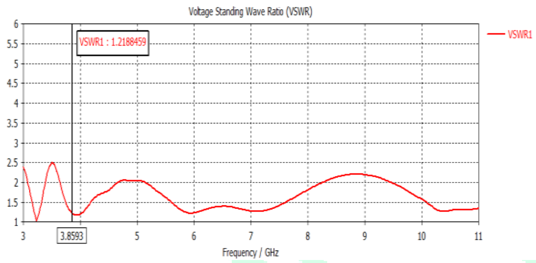


*Fig.4: VSWR of the proposed antenna at 3.85 GHz*

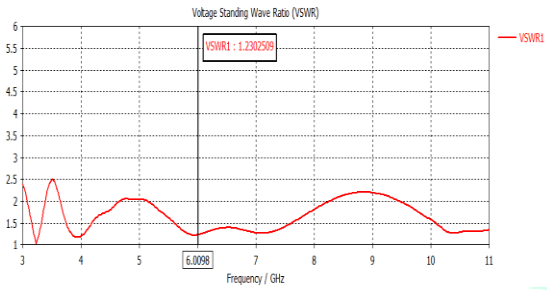


*Fig.5: VSWR of the proposed antenna at 6.0 GHz*

It can be realised from the figure 4 the voltage standing wave ratio (VSWR) value is 1.071 and it can be seen from the figure 5 the voltage standing wave ratio (VSWR) value is 1.127.

### 3.1.3. RADIATION PATTERN

The Farfield gain of the antenna at the resonating frequencies 3.16 GHz, 3.85 GHz and 6.0 GHz in polar view are shown in the figure 6, 7 and 8.

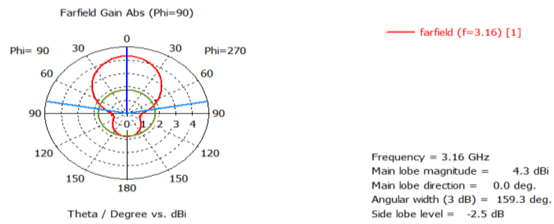


*Fig.6: Farfield gain of the antenna at 3.16 GHz*

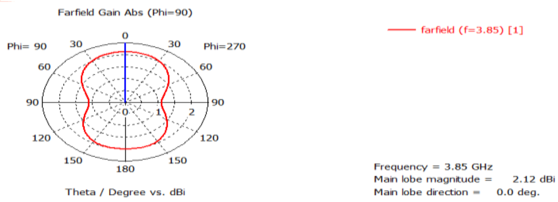


*Fig.7: Farfield gain of the antenna at 3.85 GHz*

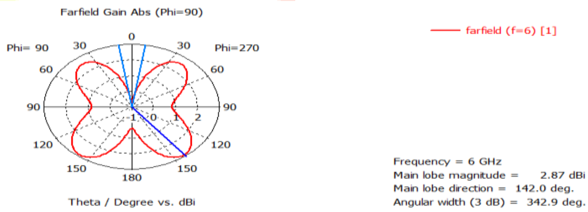


*Fig.8: Farfield gain of the antenna at 6.0 GHz*

The following figure 9, 10, 11 shows the 3D view of far field gain of the proposed antenna at 3.16 GHz, 3.85 GHz and 6.0 GHz respectively.

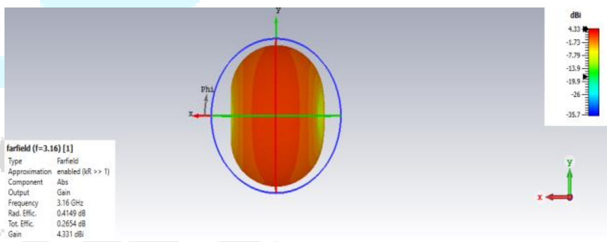


*Fig.9: 3D view of Farfield gain of the antenna at 3.16 GHz*

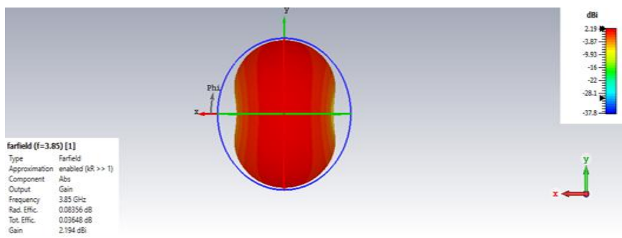


*Fig.10: 3D view of Farfield gain of the antenna at 3.85 GHz*

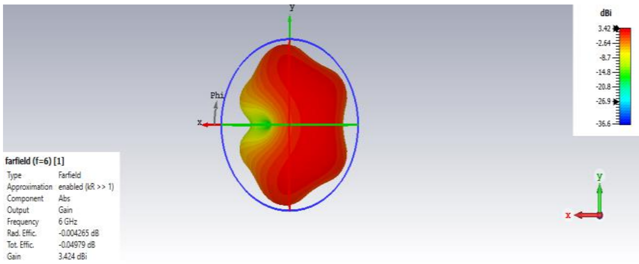

*Fig.11: 3D view of Farfield gain of the antenna at 6.0 GHz*

The effectiveness of an antenna is a ratio of the power transported to the antenna virtual to the power radiated from the antenna. A high efficiency antenna has maximum of the power present at the antenna's input radiated away (Vanitha et al., 2019). A low efficiency antenna has most of the power fascinated as loses within the antenna, or reflected away due to impedance mismatch.

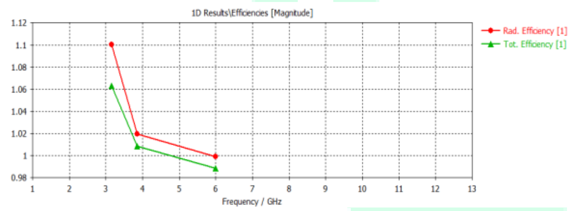


*Fig.12: Radiated and total efficiency of the antenna*

As it can be seen in the above figure the total efficiency is almost 99% for the antenna operating at the resonant frequencies.

### 3.2. PROTOTYPE AND FABRICATION RESULTS

#### 3.2.1. FABRICATED ANTENNA

The proposed monopole antenna is fabricated using conventional printing technology. To feed the antenna a 50Ω SMA connector (Ramesh et al., 2013) is used at the center of the ground plane. The final fabricated antenna is illustrated in Fig.13.

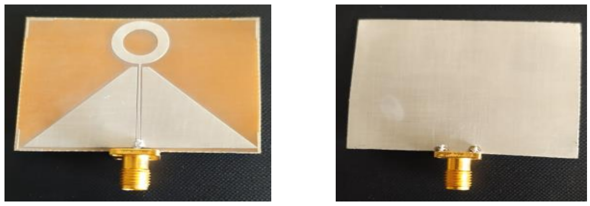

*Fig.13: Front and back view of the fabricated antenna*

#### 3.2.2. EXPERIMENTAL SETUP

The ultra wideband CPW annular fed antenna is observed using the VNA. Figure 14 shows the experimental result of the antenna in the device of network analyzer with SMA (Subminiature Version A) connector, which has an impedance of 50Ω.

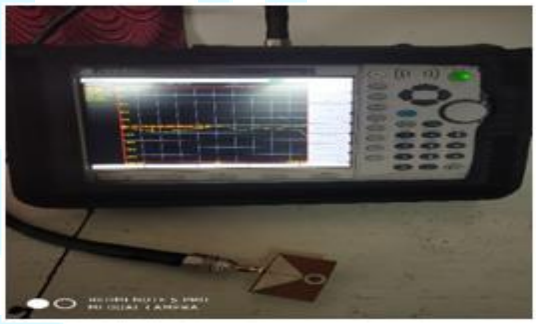

*Fig.14: Antenna with VNA*

#### 3.2.3. MEASURED S-PARAMETER

Figure 15 shows the evaluation of the simulated and measured reflection coefficient (S11).

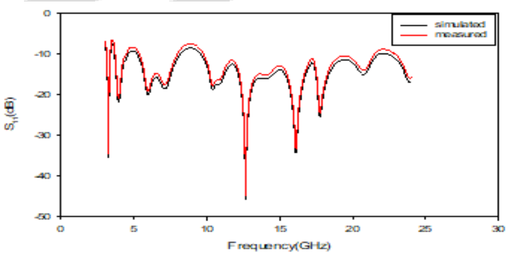


*Fig.15: Comparison of measured result and simulated result (CST) of S11*

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#### 3.2.4. Measured radiation pattern

The antenna radiation patterns in various frequencies are shown in Fig.16 and 17.

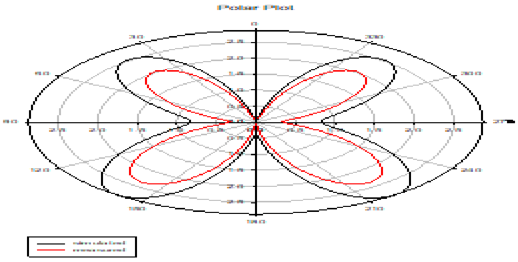

*Fig.16: Comparison of measured result and simulated result (CST) of Radiation pattern at 3.85 GHz*

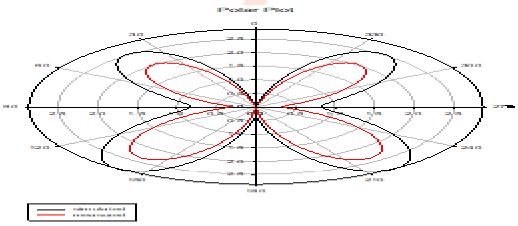

*Fig.17: Comparison of measured result and simulated result (CST) of Radiation pattern at 6.0 GHz*

Thus, the presented antenna performance are compared with simulated and measured results are shown in Table 1.

*TABLE 1: Comparison of simulated antenna performance with expected result and measured results.*

| *Parameters* | *Expected result* | *Simulated result* | *Measured result* |
|---|---|---|---|
| **Return Loss** | -28 dB to -30 dB | -29 dB | -30.35 db |
| **VSWR** | Between1 to 2 | 1.05 | 1.1 |
| **Gain** | Above 7 dBi | 14.20 dBi | Bi |

## 4. CONCLUSION

The antenna is simulated and analysed using the CST Microwave Studio-3D electromagnetic solver. The proposed monopole antenna shows characteristics needed for the UWB applications and especially it shows good performance in the 5G communication systems. The proposed antenna is small in size and low cost and energy efficient, which is the main demand in 5G wireless communication systems. The reflection coefficient of the antenna is around -22dB and the VSWR value is approximately equal to one, which is the ideal value.

## 5. ACKNOWLEDGEMENT

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