Design and Development of U-Shaped Antenna Structure for Wireless Communication

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Abstract: The WiMax/WLAN antenna is used to provide a full-duplex radio communication system. This report's antenna design included a triple-band operation with a large impedance bandwidth for WLAN/WiMAX systems. The antenna is built as a U-shaped antenna with a modest dimension of 20X18mm2. The antenna's overall performance on three separate bands The U shaped antenna is used to operating frequencies for 2.5GHz to 5.5GHz. The findings were simulated and validated using the HFSS simulator. The return loss is obtained at maximum value -28.05dB and minimum value is -18.05dB. The gain is obtained at maximum value 7.2dB and minimum value is 4.2dB. The VSWR is obtained at maximum value 1.8 and minimum value is 1.4. As a consequence of the modelling findings and parameter settings, the antenna may concurrently function in the WLAN, WiMAX, and MIMO frequency bands.

Keywords:- U Shaped, Gain, Return Loss, VSWR and Radiation Pattern

1. INTRODUCTION

The fast development of microstrip antenna technology started in the late 1970s. Basic microstrip antenna elements and arrays were reasonably well established in terms of design and modelling by the early 1980s. Printed antennas have received a lot of attention in recent years because of their benefits over existing radiating systems, which include light weight, small size, cheap cost, conformability, and simplicity of integration with active devices. Microstrip Patch antenna consists of a radiating patch on one side of a dielectric substrate with a ground plane on the other. The patch is usually composed of copper or gold, which conducts electricity. On the dielectric substrate, the radiating patch and feed lines are normally photo etched. The fringing fields between the patch edge and the ground plane are what cause microstrip patch antennas to emit. The study has been done at the centred frequencies 28GHz and 38GHz in the reference publication [10], where the transformer coupling is utilised. The H-slot and E-slot were used to construct an antenna for the concentrated frequency of 60GHz in the reference work]. Their gain is 5.48 decibels, while their reflection coefficient is -40.99 decibels [1]-[5]

Due to the availability of extremely broad spectrum bands in several sectors, particularly in mobile communications, millimetre wave bands have attracted a lot of attention in recent years. Wireless cellular network development has accelerated in recent decades, and applications such as smart phones, tablets, and video streaming have a strong need for high-quality data transmission. The capacity of cellular networks in 2020 is expected to be 1000 times that of current fourth generation (4G) technology. In the meanwhile, it is expected that the cellular network will be capable of connecting 50 billion devices for wireless services. mm wave frequencies typically vary from 6GHz to 100GHz, with 6GHz, 15GHz, 28GHz, 38GHz, 60GHz, and E-band(71-76GHz,81-86GHz)] being the most common. The vast majority of communication systems run at frequencies below 3GHz, and accessible spectrum, particularly in the microwave bands, is becoming scarce. As a result, millimetre wave bands must be used since they have a large untapped spectrum ranging from 20GHz to 90GHz.. The 5th generation wireless system is abbreviated as 5G. It denotes the predicted phase of mobile telecommunications, which goes much above the current 4G standards, which have a throughput speed of 1Gbps and a connection speed of 25Mbps. 5G supports a variety of network types, while 6G aggregates them dynamically. The federal communication commission has designated a frequency spectrum for 6G that ranges from 95GHz to 3THz, which is not presently utilised in any consumer electronic products and has a greater bandwidth and large potential for data streaming. For operating frequencies greater than 10GHz, commercially accessible substrates are being used to fabricate antennas., while the Rogers RT/Duroid 5880 is an exception. The tensile strength and water absorption properties of Rogers substrate are both high. When compared to the other substrates, it has the lowest electric loss, which results in outstanding return loss and bandwidth values, as well as the lowest voltage standing wave ratio [6]-[10]. The micro strip patch antenna is the most basic antenna to construct, and it has attractive properties such as a low profile, light weight, tiny size, and cheap cost, and it is ideally suited for planar and non-planar surfaces. The use of an array is critical for improving gain and other radiation parameters [6], and this study offers both an array and an antenna. The suggested antenna features a substrate sandwiched between the ground plane and the radiating element patch on one side and the ground plane on the other. Metal has been utilised for the ground and patch. Microstrip line feeding is employed because it is easy to simulate. An adjustable inkjet printed antenna for 5G millimetre wave wireless applications has been created in reference paper, with a bandwidth of up to 10GHz and an omni-directional radiation pattern. A millimetre wave microstrip patch antenna has been built for predicted 5G communication at the centred frequencies of 38GHz and 54GHz, with bandwidths of 1.94GHz and 2GHz, and gain of 6.9dB and 7.4dB, respectively, in reference document . The reference study proposes a PIFA antenna with concentrated frequencies of 28GHz and 38GHz and a greater bandwidth. The study has been done at the centred frequencies 28GHz and 38GHz in the reference publication, where the transformer coupling is utilised. The H-slot and E-slot were used to construct an antenna for the concentrated frequency of 60GHz in the reference work [11]-[14]. Their gain is 5.48 decibels, while their reflection coefficient is -40.99 decibels. The suggested U-shaped antenna for 5G communication operates at centred frequencies of 24.6GHz and 41.1GHz, with greater bandwidths, reduced insertion loss, and a very low reflection coefficient (return loss) (expressed in dB) Another U-shaped antenna is planned for 6G communication, with concentrated frequencies of 100GHz and 189GHz and a greater bandwidth.

2. DESIGN OF U-SHAPED STRUCTURE

A design approach is presented based on the simplified formulation that has been provided, which leads to feasible designs of rectangular micro strip antennas. The process assumes that the required information comprises the substrate's dielectric constant (r), resonant frequency (fr), and substrate height (h). The steps are as follows:
Specify the following values: r, fr (in Hz), and h, Determine the following: W, L. The following are summaries of fundamental operation for the parameters of a microstrip patch antenna. The dielectric constant of the antenna substrate is given as r. The r has the most impact on the antenna's bandwidth and radiation efficiency. The lower the permittivity, the broader the impedance bandwidth and the lower the excitation of surface waves.
The antenna substrate thickness is denoted by the height h. The bandwidth and coupling level are affected by the substrate thickness. For a given aperture size, a thicker substrate results in a larger bandwidth but less coupling. The length of the microstrip patches is L. The antenna's resonance frequency is determined by the length of the patch radiator is shown in table 1. The width of the microstrip patches is provided as w. The antenna's resonant resistance is affected by the patch width, w, with a broader patch having a lower resistance.

Table.1. Design Parameters

Sl.No	Parameters	Value
1	Size	20X18mm2
2	Length of the Patch (L)	20.5mm
3	Width of the Patch (W)	16.5mm
4	Substrate	FR4
5	Thickness of the Substrate	1.6mm
6	Loss Tangent	0.008
7	Operating Frequencies	2.5GHz to 5.5GHz

3. RESULTS AND DISCUSSION

When the load is mismatched with the load, the whole power is not provided to the load, and the power is returned, which is referred to as a loss, and the loss that is returned is referred to as the return loss. The U shaped structure antenna is shown n figure .1. A larger return loss means that the antenna is radiating more power, which raises the gain. The u-shape microstrip patch antenna resonating at 2.5GHz with a maximum return loss of -28.05dB and an impedance bandwidth of 180MHz is shown in figure 2.

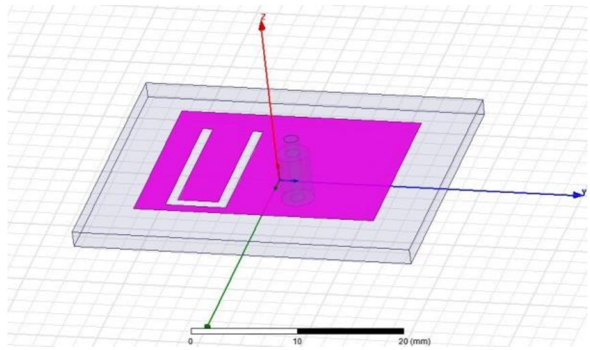


Figure.1. U-Shaped Structure Antenna

The antenna gain is a number that represents the antenna's performance, or its capacity to concentrate energy in one direction to provide a better image of the radiation performance. This is measured in decibels, and in a nutshell, it corresponds to the direction of highest radiation. The computed gain of the proposed antenna is shown in Figure 3. The greatest gain possible is 3dB. All communication equipment must comply with the VSWR standard. It determines how effectively an antenna is matched to the cable impedance when the reflection is equal to zero. This indicates that there is no reflection and that full power is delivered to the antenna. The Voltage Standing Wave Ratio (VSWR) simulation result is presented in Fig.4.

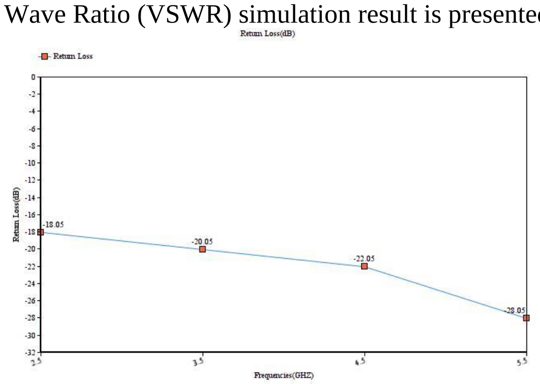
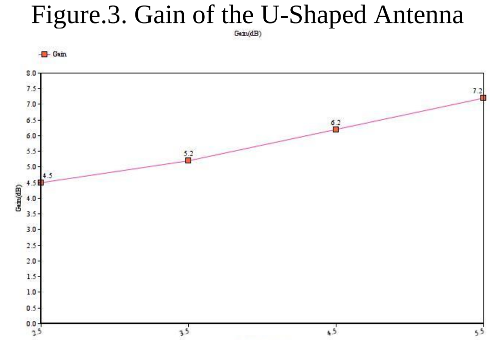


Figure.2. Return Loss of the U-Shaped Antenna

The power emitted or received by the antenna determines the radiation pattern of the microstrip Patch Antenna. It is a function of the antenna's angular location and radial dispersion. Figures.5. depict the proposed microstrip patch antenna's radiation pattern.

Figure.3. Gain of the U-Shaped Antenna



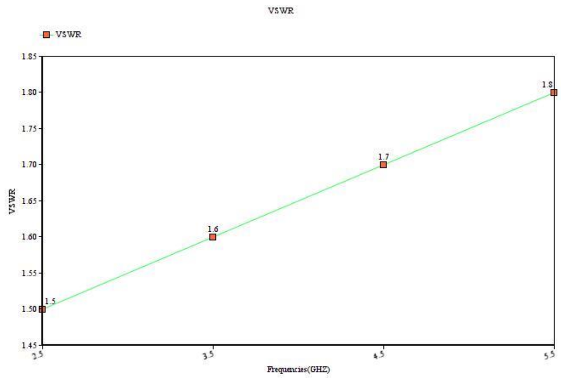
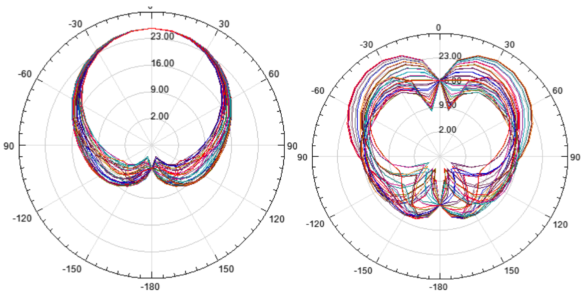
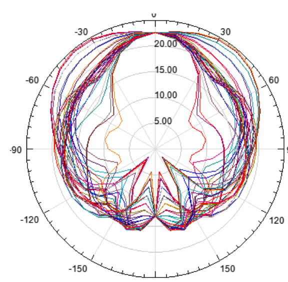


Figure.4. VSWR of the U-Shaped Antenna



(a)



(b)

Figure.5. Radiation Pattern of the U-Shaped Antenna

4. CONCLUSION

We constructed a patch antenna that operates from 2.5GHz to 5.5GHz and compared the results for various slots in this study. We may argue that numerous factors such as antenna size, substrate selection, feed method, and operating frequency can all have an impact on the antenna's performance. After simulation, the findings show a bandwidth of 5% and a gain of 7.2 dB. As a consequence, we find that the U-Shape slot design delivers better bandwidth and gain than other slot outcomes. It is critical to consider the feed method, impedance, and substrate as primary characteristics. The antenna's performance is also influenced by where the Feed line is terminated. Array antennas and other feeding methods may be used in the future to enhance the gain.

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