# Extremely Wideband Semi Elliptical Antenna for 5G Application

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**Abstract- The design evolution and investigation of a semi-elliptical patch antenna having a slot in the ground plane is discussed in this paper. The proposed prototype delivers extraordinarily wide impedance bandwidth ranges from 10.5GHz to 40.0GHz and beyond. In the design of this antenna, a semi-elliptical patch is fed by a tapered feed line, which is backed by a square-shaped ground plane that is slotted with an elliptical-shaped slot. The antenna is small in size, with a dimension (L*W*h) of 39.0mm × 39.0mm × 1.59mm and gives desired radiation characteristics including the stable radiation pattern. The gain value within the impedance bandwidth region is almost steady and positive. The antenna performance is optimized with CST Microwave Studio 2017. The designed antenna will be a useful candidate for the recent 5G technology as this technology requires a very high bandwidth with sustained gain to transmit the data at a high speed.**

**Keywords–**Semi elliptical patch antenna, impedance bandwidth, slotted ground, radiation pattern.

## 1. INTRODUCTION

The approach of the new information era has introduced a novel aspect to wireless communication technology, which has essentially affected and profited human life. It has been raised to previously unheard-of levels by the application of new advances, such as mobile and satellite system networks. Advanced wireless communications have been driven to the periphery of communication systems due to the proliferation of communication systems. Loaded with front-line innovations, the wireless industry has uncovered a huge development as of late. The phenomenal advancements in the widespread wireless network are responsible for this massive improvement. A couple of major issues that need to be addressed for these communication systems include Extreme Wideband (EWB) and miniaturization [1].

A printed antenna, which is an essential component for any communication system, can address these issues of compact size with extremely wideband features in line with sustained radiation performance. Because of their distinguishing characteristics, such as ease of fabrication (simple structure) and low cost, these printed antennas found widespread application in such a system [2].

Many techniques may be found in the open literature to overcome this issue of low impedance bandwidth. Some of the impedance bandwidth enhancement techniques include multilayer stacking arrangement of the antenna [3], the introduction of a low permittivity substrate [4] in-between ground and patch, different types of slots and strips introduced on the top metallic patch or/and on the ground [5-6], the arrangement of multiple resonators in the same plane coupled directly with each other or/and by some gap [7-8], etc. All these techniques have their own pros and cons and can be applied at the system's convenience. The basic and most commonly utilized methodology is to consolidate different shapes and sizes of spaces into the fundamental radiator [9-10].

In recent years, the coplanar waveguide feed mechanism has been one of the optimum choices since; in this case, the ground is taken in the plane of the patch radiator. Also, this technique can be applied to the partial ground with some modification.

This article presents the design of a half elliptical patch backed by an elliptical slotted ground for extreme wideband application. The article is classified into the following sections, including the introduction, concept of the antenna design, results, discussion and conclusions.

## 2. CONCEPT OF THE ANTENNA DESIGN

Fig. 1 (a-c) displays the evolution steps of the proposed half-elliptical microstrip patch antenna (HEMA). The antenna is simulated and planned on an inexpensive and easily available FR-4 substrate. The material properties are as follows: having a $\varepsilon_r = 4.4$ (value of dielectric constant), h =1.59mm (value of substrate height), and tan δ = 0.025 (value of loss tangent).

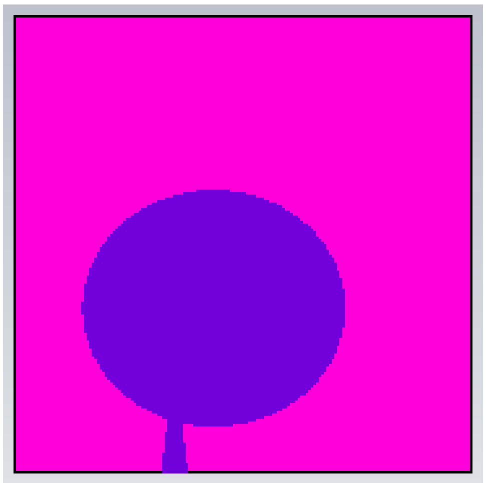
Initially, a standard elliptical microstrip antenna (EMA) labeled antenna 1 is created on top, and this will act as a radiating patch. The other side (bottom side) of the double copper cladding sheet is accompanied by a finite-sized ground plane of square shape. This model depicted in Fig. 1(a) and labeled antenna 1 is excited with a tapered microstrip-line.

A microstrip feed line in tapered form is used because it provides not only a smooth current flow but also a wider impedance bandwidth over a range of frequencies. The ground plane's overall dimension is calculated as 39.0mm*39.0mm*1.59 mm. As shown in Fig. 1, the structure is put in the X-Y plane, with an upright direction similar to the Z-axis.

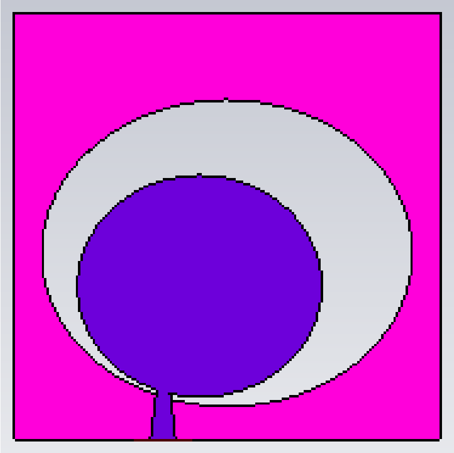
A 50Ω microstrip feed is linked to simulate the proposed antenna. An SMA (Sub Miniature Version A) connector is joined to the port of the microstrip feed line. A commercially available finite integration technique-based CST Microwave Studio is used for all the simulations in this study [11].

In the second step Fig. 1(b), a nearly elliptical slot having a dimension of a2 × b2=17.0× 14.0mm$^2$ is inserted in to a square ground patch. This antenna is also fed with the same feed line without any change in the feed dimension.

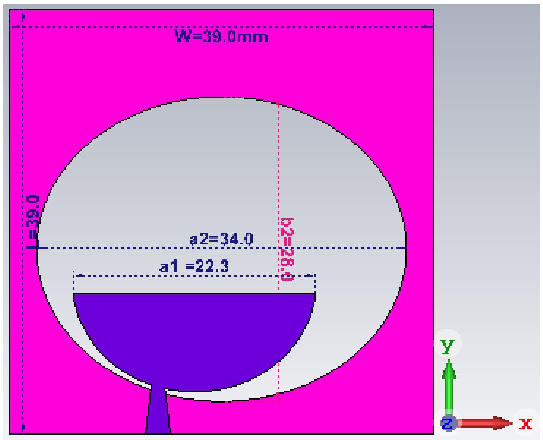
In the concluding step, the elliptical patch is trimmed and transformed into a semi-elliptical patch, as revealed in Fig. 1(c). The dimensional specifications of the projected configuration are described in Table -1.



(a) First modification 'antenna 1'



(b) Second modification 'antenna 2'



(c) Final design of offered antenna

**Figure 1 :( a-c)** – Evolution of prototype designed antenna

**Table 1:** Design specifications of the offered antenna

| S. No. | Specifications | Value (In mm) |
|---|---|---|
| 1 | Width of ground W | 39.0 |
| 2 | Length of ground L | 39.0 |
| 3 | The semi-major axis of patch a1 | 22.3 |
| 4 | The semi-major axis of the slot in ground a2 | 34.0 |
| 5 | The semi-minor axis of patch b1 | 14.0 |
| 6 | Semi minor axis of slot in ground b2 | 28.0 |

## 3. RESULTS AND DISCUSSION

The offered antenna layout is designed using the CST Microwave Studio Tool [11], which is an electromagnetic (EM) software based on the technique of finite integration. This software works in both domains, including the frequency domain and the time domain. The results that feature the behavior of the antenna, including the reflection coefficient, gain, and radiation pattern, are presented and discussed.

The reflection coefficient variation for the final design (Fig. 1(c)) in reference to the frequency is illustrated in Fig 2. It is witnessed that this antenna gives an extremely wide impedance bandwidth, ranging from 10.5GHz to more than 40.0GHz corresponding to -10dB. In lieu of this, as the maximum value of frequency in simulation increases, it requires a large amount of time for simulation, and as the limited system requirement is available for large frequency systems, it hangs and does not support the simulation outcomes, authors are bound to choose the maximum frequency up to 40.0GHz.

The variation of gain for the offered antenna geometry with frequency is shown in Fig. 3, The offered antenna layout is designed using the CST Microwave Studio Tool [11], which is an electromagnetic (EM) software based on the technique of finite integration. This software works in both domains, including the frequency domain and the time domain. The results that feature the behavior of the antenna, including the reflection coefficient, gain, and radiation pattern, are presented and discussed.

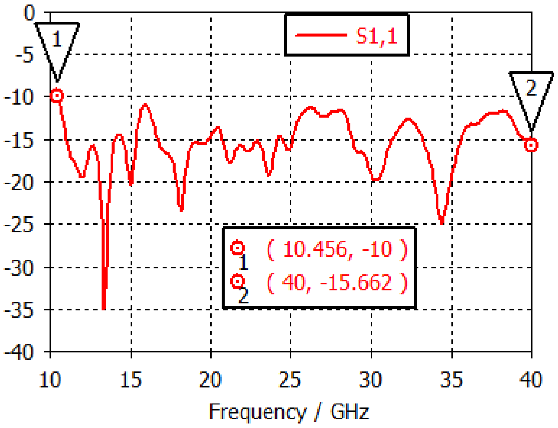


**Figure 2:** Reflection coefficient variation concerning frequency for offered antenna

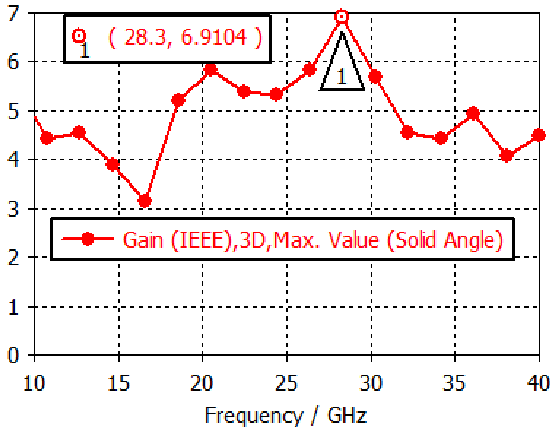
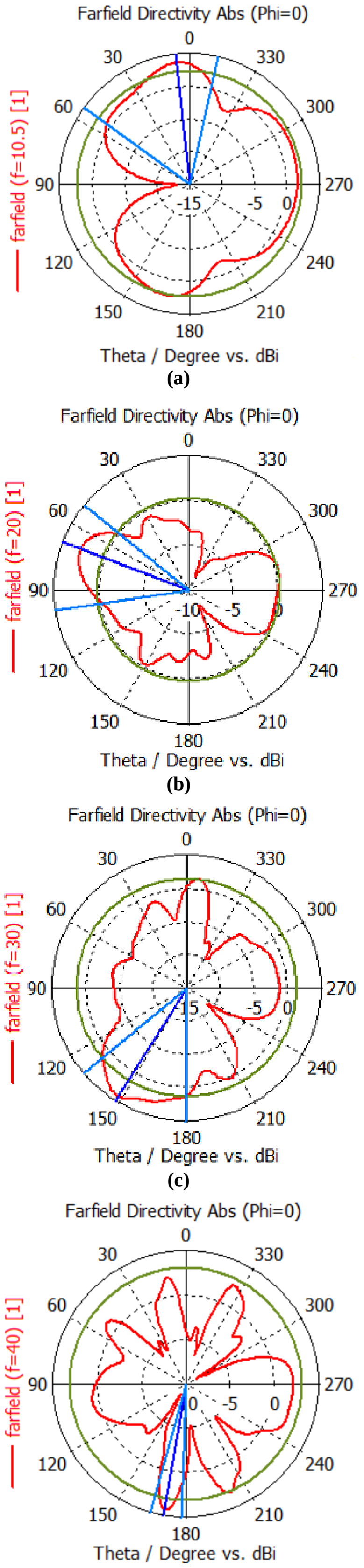


**Figure 3:** Variation of gain concerning frequency for offered antenna



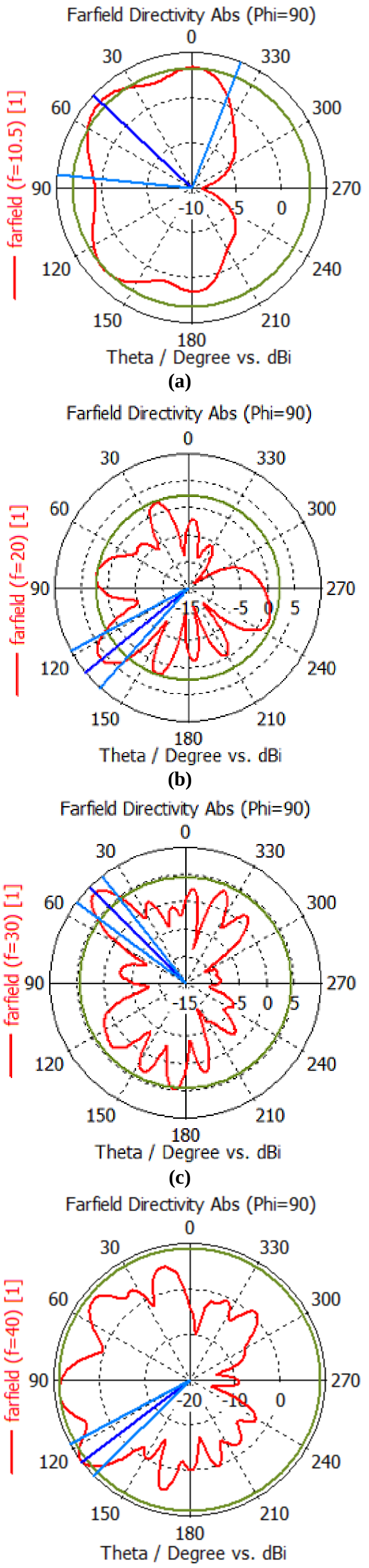
**(a)**

**(b)**

**(c)**

**(d)**

**Figure 4 :( a-d)** Radiation pattern of the offered antenna for phi = 0 (XZ- plane)



(a) (b) (c) (d)

**Figure 5 :(a-d)** Radiation pattern of the proposed antenna for phi = 90 (YZ- plane)

## 4. CONCLUSIONS

In this article, a tapered microstrip line fed an extremely wideband defected ground half-elliptical patch antenna has been designed and verified with simulations. An extremely wide impedance bandwidth ranging from 10.5GHz to more than 40.0GHz, corresponding to a -10dB point in the reflection versus frequency graph, is achieved. The gain and radiation patterns were found satisfactorily in an interesting range of frequencies. This antenna is found to be practically suitable for use in short-range and long-range wireless communication systems, including short-range radar (21.4–27.0GHz) and radio astronomy (22.5GHz, 24.05–27.0GHz, and 36.43–36.50 GHz).

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