

Optimizing the Directionality and Minimizing the Reflections using Lenses



Md. Javeed Ahammed, R. Praveena

Abstract: In antenna propagation waves should be guided from leakages and directionality which has become more essential now a days due to number of hurdles which scatters the signal. In this paper we design a leaky lens antenna of UWB frequency and simulate that using CST tool in parallel plate waveguide that works efficiently in high frequency range of 6-30GHz. This approach is totally based on propagation of leaky waves by focusing on the lenses properties. Eventually we increase the gap between the lens and slot for optimal directivity in antenna and then for optimizing the transmission coefficient and minimizing the reflection we use the Matching layer in it. As a result directional radiation will be obtained which is much more achieved than any other antenna of Ultra Wide Band Range and the minimum bandwidth is required which is less than -10dB for radiation.

Keywords: UWB, leaky waves, hurdles, directivity, radiation.

I. INTRODUCTION

In now a day's communication technology ultra wide band range antennas are used specifically for indoor applications which are shorter range but high speed [1]. In present the radio range of UWB technology has increased in their spectrum of 4-12 GHz frequency which is unauthenticated but it's required for full filling the need of present technology. For UWB frequency technology the antennas works as filters which are very critical for this technology and reduces the pulse based and time based major problems in UWB antennas [2].

For more than a decade range of bandwidth these antennas should have non dispersive nature.

The main objective of this paper is to have an novel design of antenna which provides high frequency range of 6-30GHz with a parallel plate waveguide in UWB antenna as shown in figure.1. That is a simple example for waveguide of parallel plate of TEM horn type antenna. We use 2 antennas of horn type and link with SMA connectors which are used for waveguide feeding. Same the separation is designed for 2 parallel plates for preventing the transmission of first higher mode [3]. For the antenna design we have some setups to follow.

Main task is to mix a leaky wave transmission with leaky lens of lens antennas that is proposed for dispersion reduction [4]. This process of design have major 3 blocks that is feeding structure, lens and matching layers. We use only CST tool for all designs simulation.

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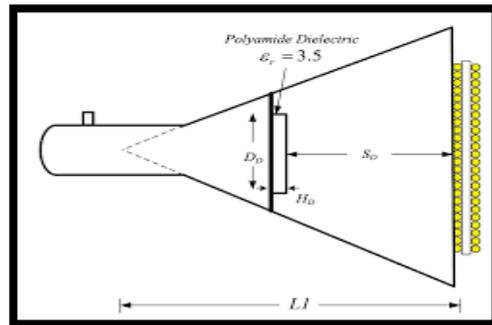


Figure.1: TEM horn antenna with lens

Ultra Wide Band Range

As we considered that UWB plays a major role in modern communication technology in which with very less power bands of frequency are transmitted over a wide spectrum for digital data transmission [5]. Generally we have 2 definitions for UWB bandwidth description. Where the first definition is bandwidth which is larger than 500MHz; whereas second definition refers to the twenty percent more the bandwidth [6]. As we considered that this technology is limited for indoor short range and high speed communication but by the help of hopping of frequency and technology of direct-sequence we can spread the signal for a larger bandwidth and with very less amplitude which is less than the noise amplitude [6].

By using UWB frequency technology we have lots of advantages. Such as extreme Gbps capacity of ultra wide bandwidth which is very variable and in range of up to decades of meters distance. Next one is sharing of bandwidth with other users due to heavy traffic of signals. Other one is due to its characteristics of noise like we have signal security but it's not so difficult to user to identify it unintended detection [5].

II. ANTENNA DESIGN

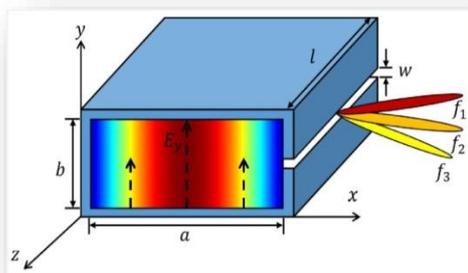


Figure.2: leaky wave antenna.

When we observe an continuous radiation in the waveguide of electromagnetic wave transmission path propagation from inside to outside we call as leaky wave antenna and radiation is called leaky wave radiation. Figure.2 gives the best example of leaky wave radiation antenna which describes that waveguide of parallel plate is placed with a dipole of electric and the silicon is filled in the outer space. In the dielectric silicon from slot of waveguide a wave is propagated which is generated by dipole that is a leaky wave. It's a planar beam which is generated by the leaky wave antenna. These antennas are one of the classes of antenna structure in which guides are used for travelling wave as major source of radiation operation [15].

III. LEAKY LENS ANTENNA

Using lens is the only way to concentrate the rays in a specific direction of propagation and is placed at the feeding structures top. This lead to radiation symmetric pattern which is guaranteed by a broadband width leaky slot and a structure of symmetric lens [4]. So, this compulsion of lens and leaky wave antennas is known as leaky lens antennas. The figure.3 below gives the basic structure of leaky lens antennas. Lenses are capable to gather these scattered rays and concentrate at one particular point. The points B and B' are the area of focus, and if rays scattered in unuseful direction then they gets lost due to split over of rays [5]. We have further 2 structural types of lenses which we further discuss.

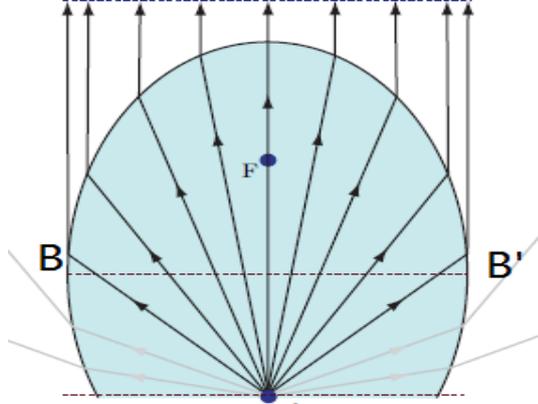


Figure.3: leaky lens antenna.

Leaky boundary and shadow boundary waveguide concept

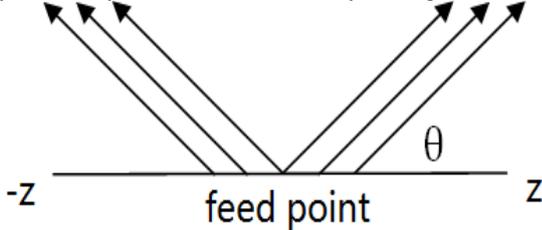


Figure.4: Shadow boundary

This above figure 4 represents the radiation pattern of leaky wave. There is attenuation in both directions exponentially in far field which is very hard to observe and it is, $z = \pm\infty$. In the X-axis leaky wave have symmetric pattern of radiation. For every model we have specifically a θ_0 angle.

We have strong leaky wave when if the specific angle is equal to $\theta = \theta_0$, leaky waves strength weakens when the angle deviates from each other where θ deviates from θ_0 and we call this angle as leaky wave angle. Whereas we call Shadow Boundary to this specific angle we have θ_0 . If $\theta = 0^\circ$

then there is significant increase in field strength till the leaky wave angle similarly if it reaches to above shadow boundary then it decreases [8]. Feeding structure parameters are as shown below.

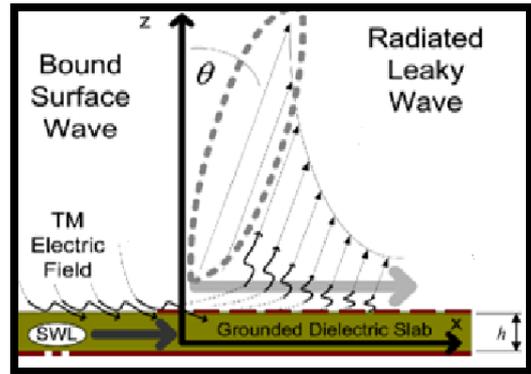


Figure.5: Feed Structure.

As shown in figure.5 above is a structure of feeding to leaky wave overview model and this may be considered as foundation part of antenna. Reducing the coefficient of reflection is main thing due to which our directionality increases. Due to the reflection of interface of lens air we have an increase in curve of reflection coefficient which is illustrated in next step due to adding lens on top of feeding structure. In leaky wave transmission direction we have to assume that a lens part is in shape of semi infinite space. Here we consider that w as width and h as substrates thickness with L as the length of the strip as shown in figure.6 below.

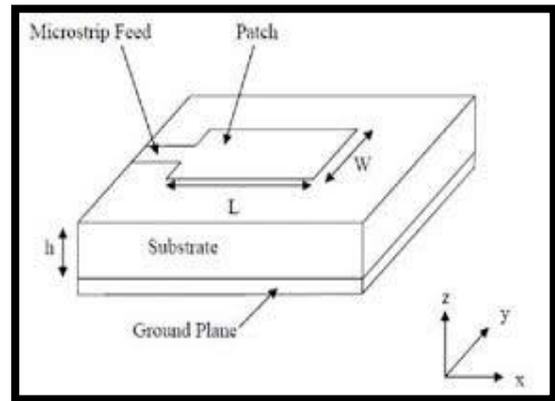


Figure.6: Side view micro strip antenna

We introduced micro strips here as an basic tapered antenna which is a new design this is called tapering and in matching line networks, filters, couplers etc, these microstrip transmission lines are highly important with its increasing importance [9]. As length varies the tapered microstrips propagation constant also varies. If the width is not uniform for microstrip then we call as tapered microstrip. On basis of shape and size of tapered design we have different types of tapers. Klopfenstein, triangular, exponential, rectangular, square, etc are the examples for tapers of antennas [10].

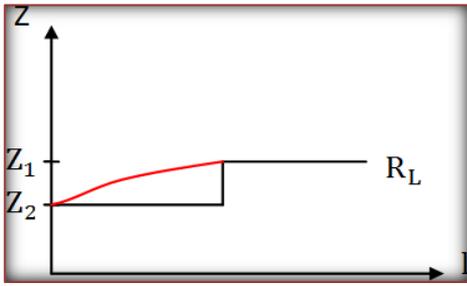


Figure.7: Tappers

Above figure.7 above gives the shift in tapered microstrip line impedance. We have convenience with both the designs of tapers such as continuous and multi section impedance taper designs. The second design is used in this for impedance match status attaining at the interface of port, we have impedance of desired at Z_2 and fixed impedance at Z_1 which is 50Ω . So, as result the corresponding width can be adjusted of microstrip line for required impedance modification. The tapered line of microstrip is as shown in below figure.8. so, number of problems which arises by this microstrip line width and metallic size etc can be modified or overcome in this way.

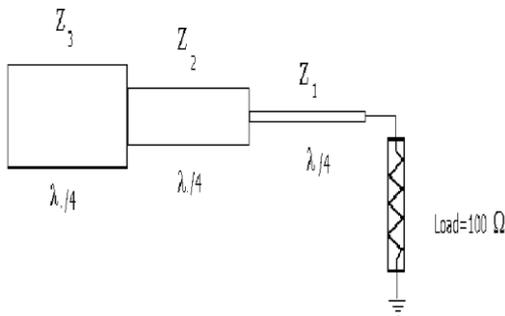


Figure.8: Tapered line.

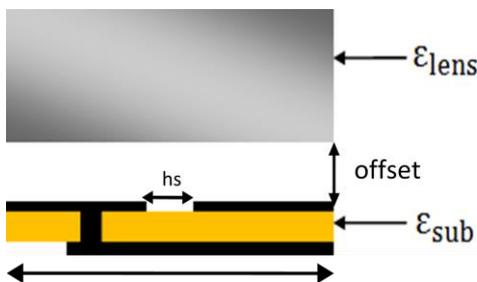


Figure.9: Feeding structure Side view

Table.1: Feeding parameters.

Parameter	size	Parameter	size
h	5mm	t	0.127mm
h _s	0.5mm	t _{pec}	0.018mm
l	70mm	w1	0.39mm
l _s	60mm	w2	0.7mm
offset	0.225mm	ε _{sub}	2.2
R _{via}	0.25mm	ε _{lens}	11.67

As shown in above figure.9 which is the side view of feeding structure and its parameters of design are shown in table below. Where the substrate thickness is considered as t and

the material is Rogers RT5880 (loss). Whereas the layer of slotted line is above the substrate and it is made of copper material whereas same is used for microstrip also. Remaining parameters such as length and width are h_s and l_s of the slotted line. Via radius of the material is metallic represented as R_{via} . gap between slot and lens is called as offset.

IV. SIMULATION RESULTS

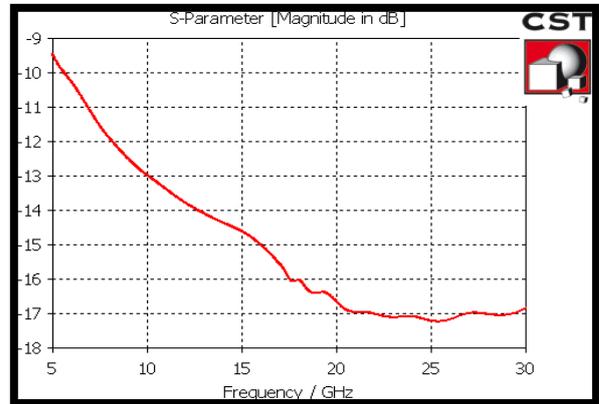


Fig.10: feeding structure port signal.

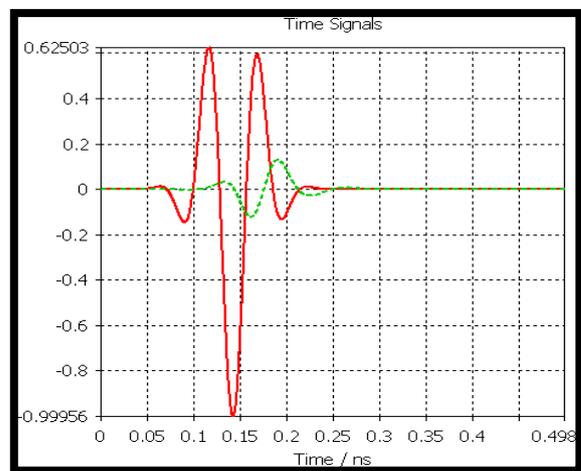


Fig.11: S11 of the feeding structure.

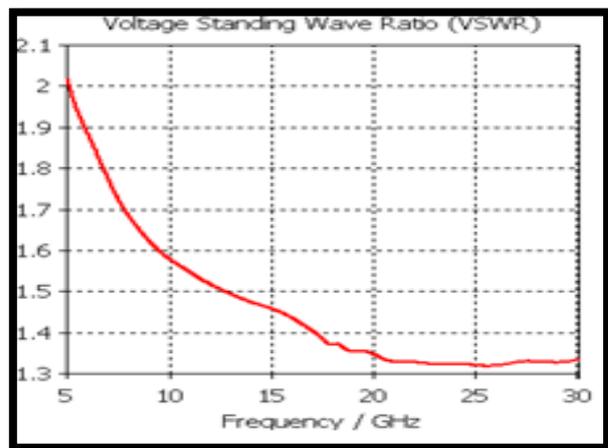


Fig.12: feeding structur VSWR.

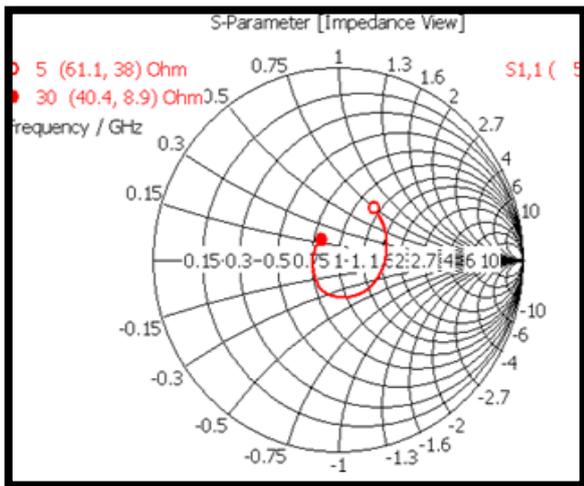


Fig.13: Smith chart

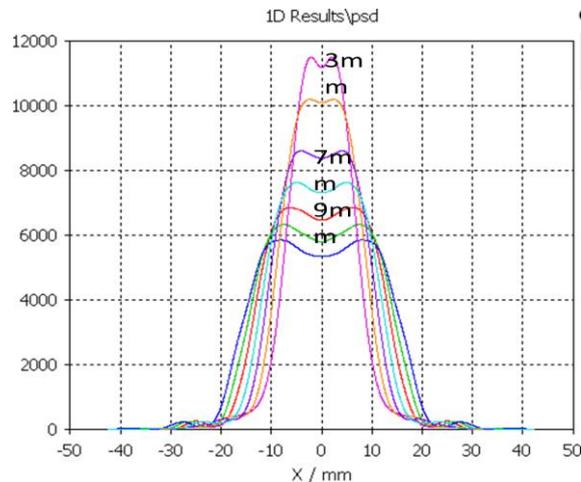


Fig.15: Power flow distributions at 15GHz.

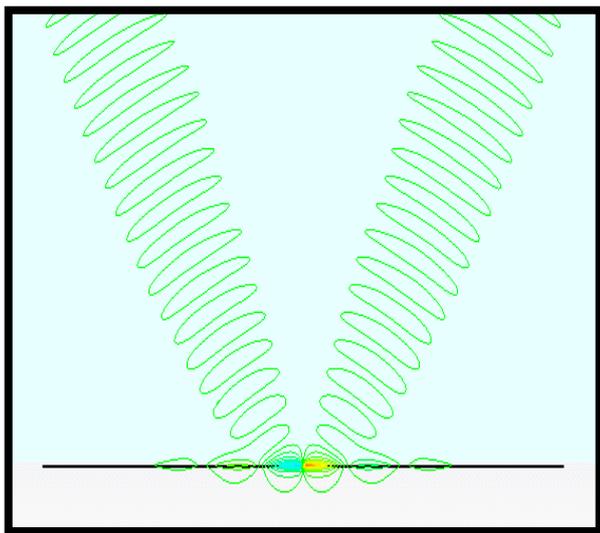


Fig.14: At 15GHz leaky wave propagation.

The scattering parameter is initiated as S-parameter, which gives the bandwidths coefficient of reflection which is considered. For measuring the performance of antenna it is an important parameter and measurement of amplitude is in decibel values. Such as, S11=0dB says that without any transmission all the energy is reflected. As shown in above figure we have less than -10dB values for all s11 which is except in only 5GHz band for whole frequency band of 5-30GHz. As we compare the high band frequency performance is better than the low frequency band performance which is specifically for range of 15-30GHz, where as the S-parameter is further lower than -15dB [13].

$$VSWR = \frac{1+|\Gamma|}{1-|\Gamma|}$$

Here reflection coefficient is represented as Γ . If VSWR=1 then it's ideal case, means impedance is perfectly matching and there is no occurrence of reflection. So, the VSWR minimal value is 1. Relation between VSWR and reflection coefficient can't be seen directly through equation above. From fig.12 we can say the VSWR has trend of S- parameter which increase or decrease simultaneously.

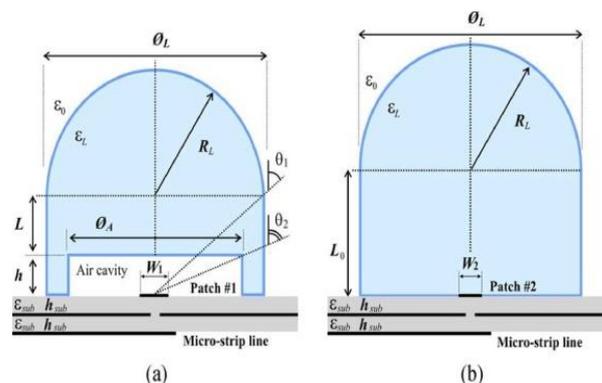


Fig.16: Extended semi- circular lens model.

As shown in figure above it's an extended semi- circular lens model which is used to increase the directionality as its extended model. Its simulation results give the exact difference between actual model and extended model. The impedance real part is near to 50Ω and imaginary is near to 0 Ω near high band of frequency than the low frequency band. Because of reflections inside lenses impedance oscillations occur. Fig.17 gives the H-plane distribution of electric field at 30 GHz. At lens top we have main beam. In short the extended elliptical lens parameters looks much efficient than normal lenses.

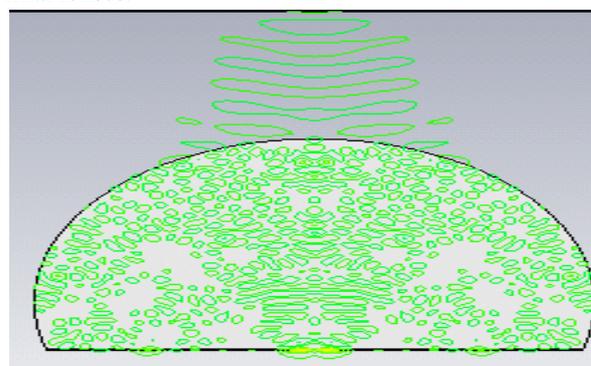


Fig.17: E-field in the elliptical lens model at 30GHz.

This extended lens is made without any focus area change where the elliptical lens is changed with a semi circular lens with exact length of extension.

In short the focus area function for both elliptical and synthesis lens are same. So, it should be superimposed by the extension L adequately by 2 lenses [11]. These yields:

$$L + r = b + c$$

Here r is the radius of semi circular axis, b is the semi major axis, "a" is semi-minor axis, and we denote focal length with L. by using all the equation we have the lens parameters. The exact extended model is as shown in figure.18.

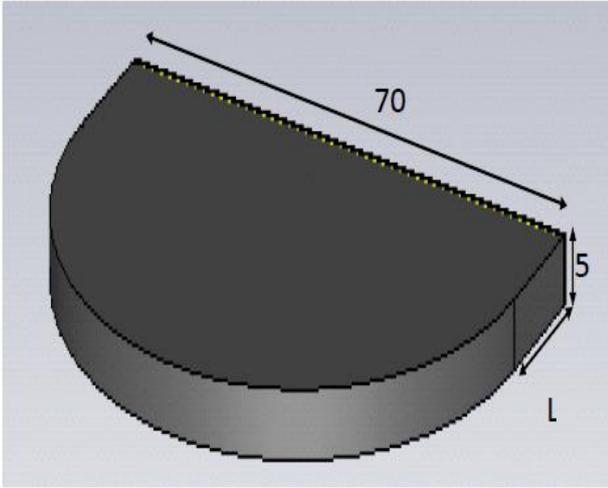


Fig.18: Extended semi-circular lens model.

Graphical figure below 19 gives the S-parameter extended model of elliptical lens, which covers the band of 5-30GHz. Less than -10dB is usual for S11 in range of 20 GHz. However, in the range of 5-15GHz, the performance is much worse in normal elliptical model but it change in extended elliptical model where the performance is slightly increased in same range. The reflections inside the lens are very complicated in normal but there is less complexity in extended model. Impedance performance for extended model is also shown which is much optimized than previous which is as shown in fig.20 below.

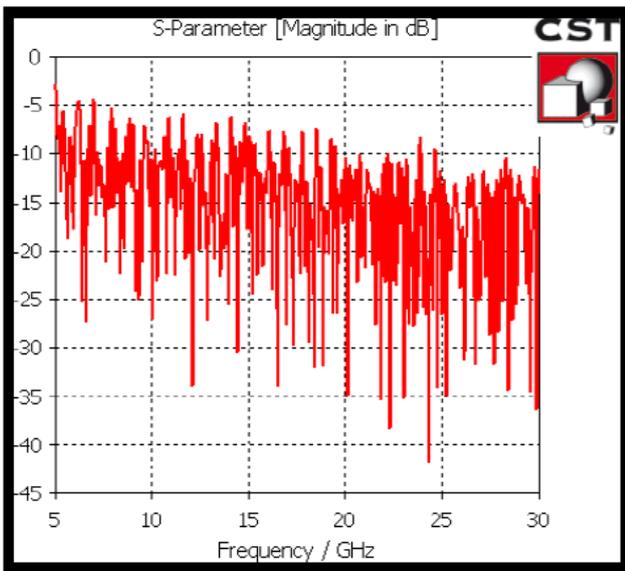


Fig.19: elliptical lens model of S11.

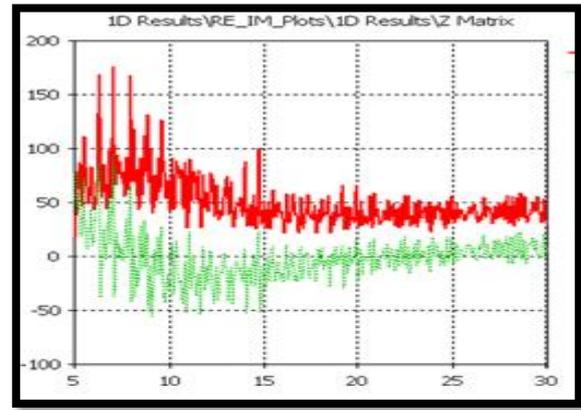


Fig.20: Impedance of elliptical lens model.

V. CONCLUSION

An UWB range leaky lens antenna is designed successfully for waveguides which is simulated in the frequency range of 5-30GHz. Where the results of both elliptical and semi circular lenses are compared and studied that reflection coefficient for 6-30 GHz frequency is less than -10dB, same radiation patterns in single lobes level, we have low dispersion at center. Fabrication of this antenna is essential with frequency and time domain measurements. In both the cases impedance at 5-10GHz doesn't match efficiently which can be left for future scope.

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