**Analysis of Passband Characteristics of Rectangular Waveguide with and without Slots**

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***Abstract***

Rectangular waveguide is designed at High pass filter for the applications like communications, Medical and Radar by using An-soft HFSS. Assume waveguide is to be aligned along X direction with length 60mm width of the waveguide 22.86mm along Y direction and the height of the waveguide is 10.16mm along Z direction. Square slots of length and width 6x6 mm and Circular slots of radius 1.5mm are placed along Y directed walls of the rectangular waveguide. Various parameters have been observed like return loss, E-field, H-field, transmission co-efficient and also modes of the rectangular waveguide like TE10, TE11 and TE20. Comparison has been done for all these models.

*Keywords:* Rectangular waveguide, Square and circular slots, Return loss, Transmission- coefficient, Modes, An-soft HFSS.

1. **Introduction**

Waveguide is nothing but a transmission line having hollow space which is in the shape of either rectangular or circular to propagate electromagnetic waves. Waveguides plays a major role for propagation of wave and transmitting of signals [1]. The propagation of the signals can be defined by the total internal reflections from the waveguide. Waveguides carry signals up to certain frequency defined as a cut off frequency. The cut-off frequency is the one of the most important parameters of the waveguide. Waveguides have low loss and more power handling capacity having many applications in communication systems, Medical and Radar. Instead of coaxial cables waveguides are also used to reduce the noises which are at microwave frequencies [2]. Square and circular slots are placed on the waveguide to vary the pass band characteristics. Various modes are possible like TE and TM modes but not TEM [3]. TEM mode is defined by electric and magnetic fields which is perpendicular to the direction of propagation and due to the absence of current source, TEM mode does not exist in the waveguide. The mode which is having the lowest cut off frequency is defined as Dominant mode. HereTE10 is the dominant mode for rectangular waveguide [4]. The advantages of the waveguide are power handling capacity and the most important advantage is to propagate the wave for higher frequencies without any losses. Waveguides are widely used in the applications like Optical fibre communications, Photonic integrated circuits [5].

1. **Design Topology**

Rectangular waveguide has been designed by using Ansoft-HFSS. In general waveguides acts as a high pass filter. It will allow all frequencies than cut off frequency [6]. Waveguides work on total internal reflection principle. For better reflections walls are going to be coated with good conducting material like copper, silver and gold. In this work inner walls are coated with copper for better reflection [7]. For varying passband characteristics slots are to be placed on waveguide walls. The Width and the height of the rectangular waveguide is calculated by using the formula given below[8][9].

] 2 (1)

Where is the cut off frequency

m, n are half cycle variations along width and Height

a, b are the width and the height

Propagation constant is represented by γ and is as shown below

(2)

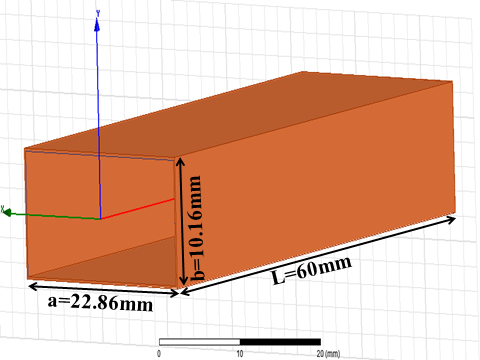
Where is propagation constant

=attenuation constant

= phase constant

**2.1 Rectangular Waveguide**

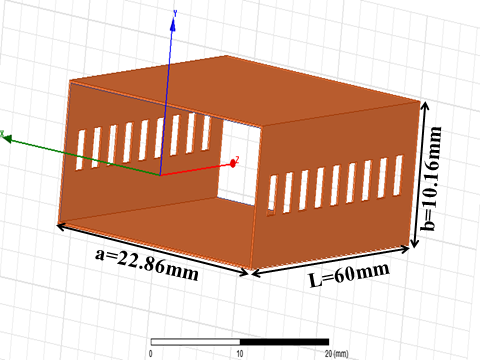
Rectangular waveguide is a Hollow metallic pipe of uniform cross section which is used to propagate the signals from the inner walls of the tube having the dimensions of width a= 22.86mm, height b=10.16mm and length of the waveguide l=60mm.The inner walls of the rectangular waveguide is made with copper material as shown in Figure 1 [10].



**Fig. 1.** Rectangular waveguide

**2.2 Rectangular Waveguide with Square Slots**

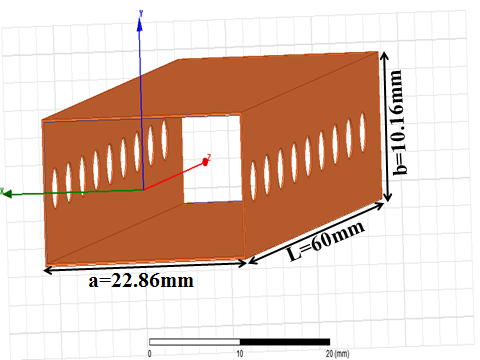
Rectangular waveguide is a Hollow metallic pipe of uniform cross section which is used to propagate the signals from the inner walls of the tube having the dimensions of width a= 22.86mm, height b=10.16mm and length of the waveguide l=60mm.The inner walls of the rectangular waveguide is made with copper material. For varying the passband characteristics square slots are placed at the inner walls of the waveguide. Each square slot having the dimension of 6mmmm.The distance between each square slot is 2mm.The total Nine (9) no of square slots are placed at the inner walls of the wave guide, shown in below Figure 2 [11].

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**Fig. 2.** Rectangular Waveguide with square slots

**2.3 Rectangular Waveguide with Circular Slots**

Rectangular waveguide is a Hollow metallic pipe of uniform cross section which is used to propagate the signals from the inner walls of the tube having the dimensions of width a= 22.86mm, height b=10.16mm and length of the waveguide l=60mm.The inner walls of the rectangular waveguide is made with copper material Circular slots are placed at both inner walls of the waveguide as shown in below Figure 3, for varying the passband characteristics. The dimension of each circular slot is having the radius of 1.5mm [12].



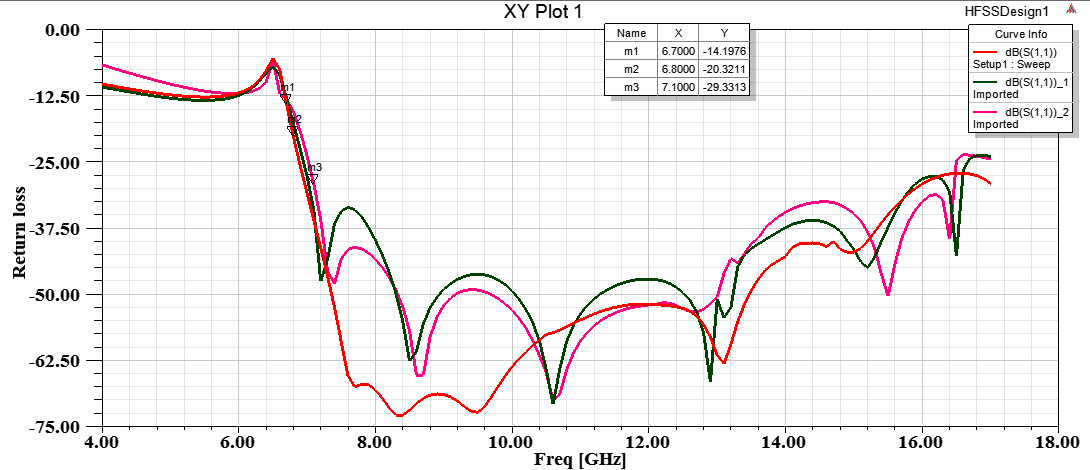
**Fig. 3**. Rectangular waveguide with circular slots

**3. Results and Comparisons**

Rectangular waveguide has been designed and also by using square and circular slots at the inner walls of the waveguide to observe the various parameters like Return loss, E-field, H -field, Transmission co-efficient and also the Modes. We also compared the band shifting for rectangular waveguide and also the rectangular waveguide with square and circular slots.

**3.1 Return Loss**

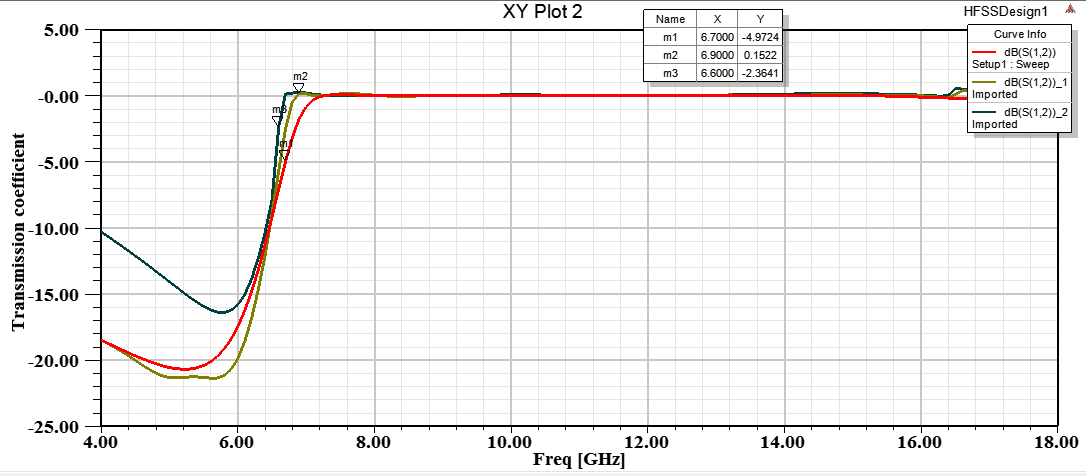
**3.1.1 Return loss**: The return loss for a rectangular waveguide, rectangular waveguide with square and circular slots is as shown below



**Fig. 4**. Return Loss and Pass Band Characteristics

The above Figure 4., represents the return loss and the pass band characteristics of a rectangular waveguide and rectangular waveguide with square and circular slots. The return loss for a rectangular waveguide is at -21.72dB at frequency of 6.6GHz and pass band characteristic of waveguide is more than the cut off frequency i.e. starts from 6.5GHz. The return loss for a rectangular waveguide with square slots is at -20.32dB at frequency of 6.8 GHz. and the pass band characteristics are varying from 6.5GHz. The return loss for a rectangular waveguide with circular slots is -12.94dB at a frequency of 6.6 GHz.

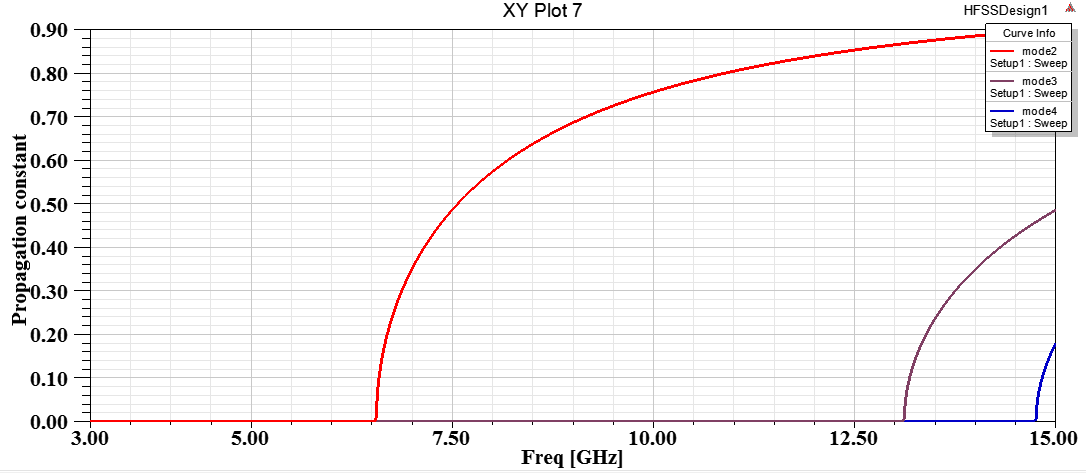
**3.1.2 Transmission coefficient**: The transmission coefficient for a rectangular waveguide, rectangular waveguide with square and circular slots is as shown below



**Fig. 5**. Transmission Coefficient and Pass Band Characteristics

The above Figure 5., represents the Transmission coefficient and the pass band characteristics of a rectangular waveguide and the rectangular waveguide with square and circular slots. The transmission coefficient of a rectangular waveguide is -9dB at a frequency of 6.6GHz and the pass band characteristics are varying from 6.5GHZ. The transmission coefficient of a rectangular waveguide with square slots is -8dB at frequency of 6.6GHz and the pass band varies from 6.5GHz. The transmission coefficient of a rectangular waveguide with circular slots is – 5.01dB at a frequency of 6.5GHz.

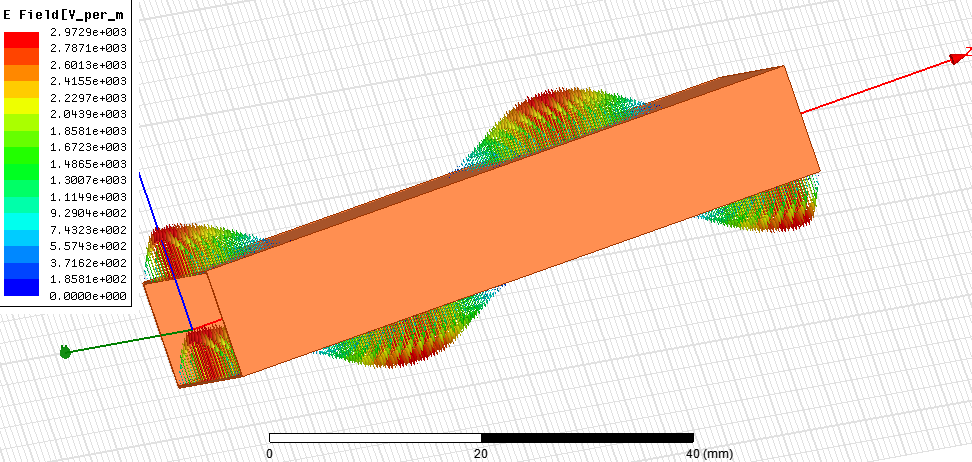
**3.1.3 Modes**



**Fig. 6.** Modes of a Rectangular Waveguide

**3.1.4 E Field**

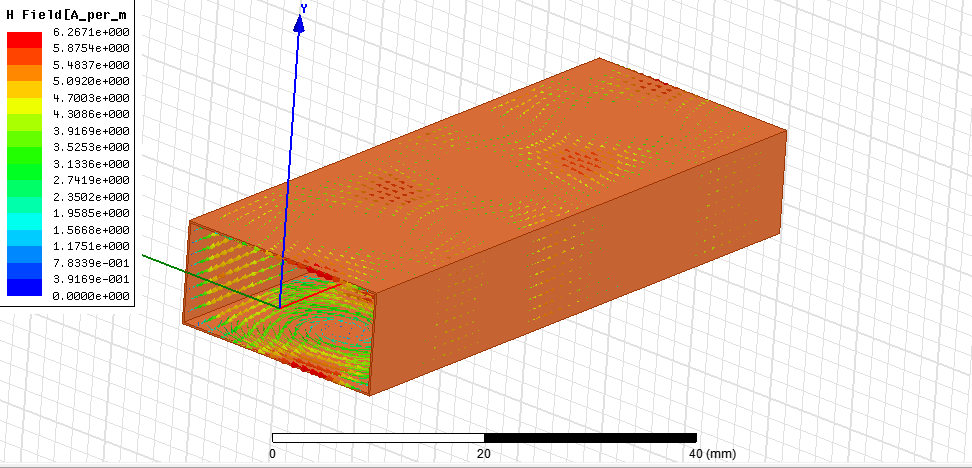
The E Field for a rectangular waveguide without slots is shown given below



**Fig. 7.** E-Field Intensity of a Rectangular Waveguide

**3.1.5 H Field**

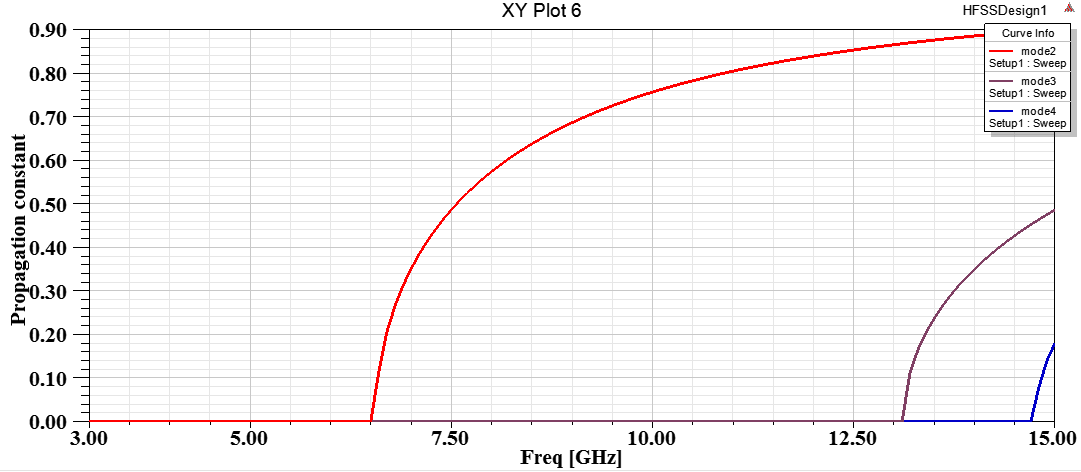
The H Field for a rectangular waveguide without slots is shown given below



**Fig. 8.** H-Field Intensity of a Rectangular Waveguide

**3.2 Rectangular Waveguide with Square Slots**

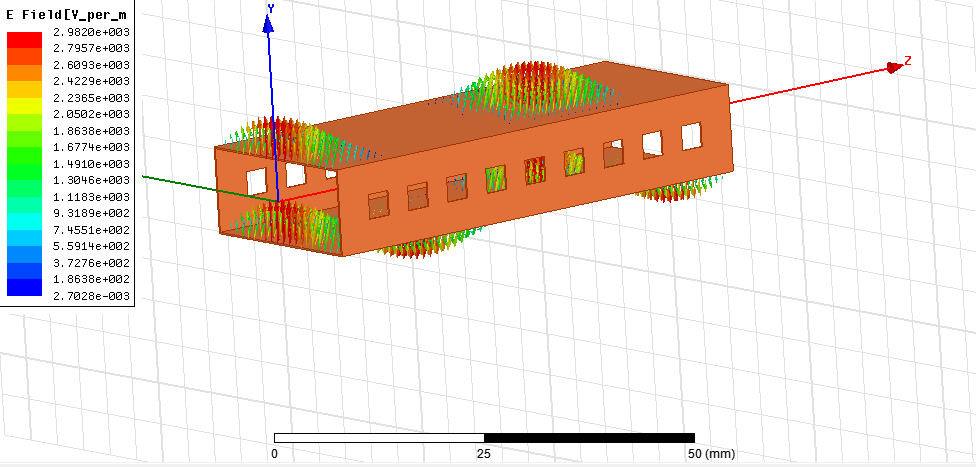
**3.2.1 Modes**



**Fig. 9.** Modes of a Rectangular Waveguide with Square Slot

**3.2.2 E field**

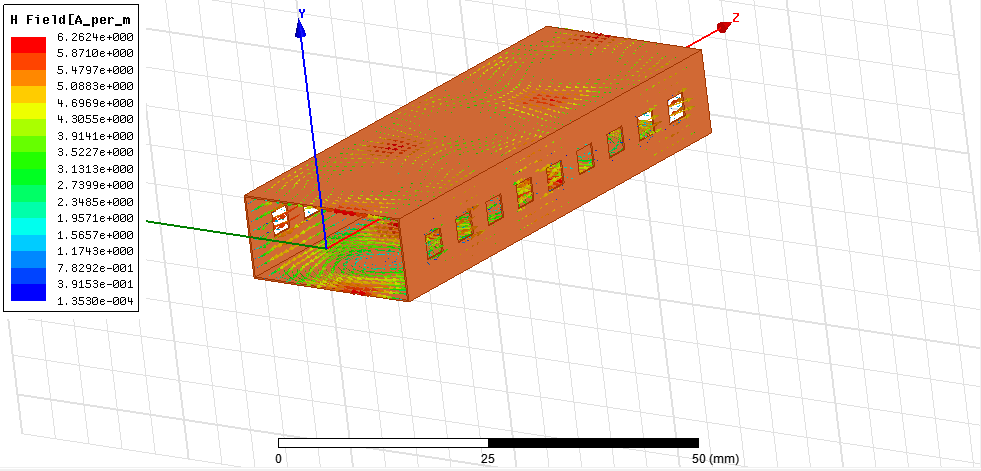
The E Field for a rectangular waveguide with square slots is shown given below



**Fig. 10.** E-Field Intensity of a Rectangular Waveguide with Square Slots

**3.2.3 H field**

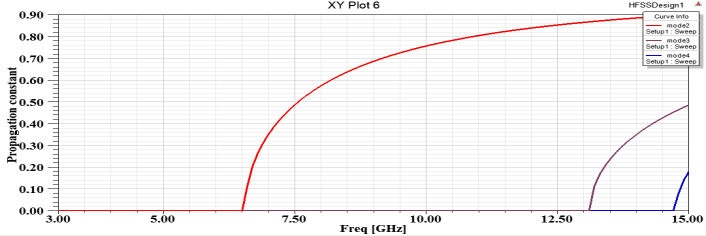
The H Field for a rectangular waveguide with square slots is shown given below



**Fig. 11.** H-Field Intensity of a Rectangular Waveguide with Square Slots

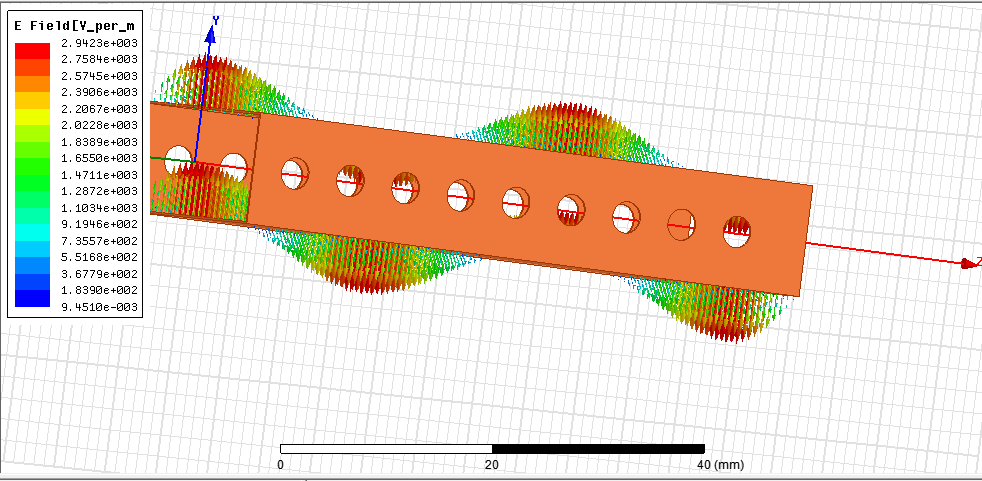
**3.3 Rectangular Waveguide with Circular Slots**

**3.3.1 Modes**

**Fig. 12.** Modes of a Rectangular Waveguide with Circular Slots

**3.3.2 E field**

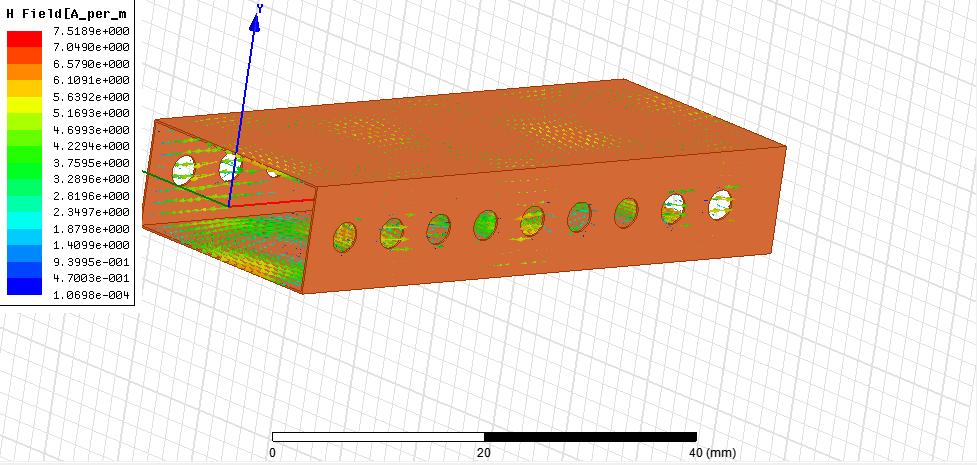
The E Field for a rectangular waveguide with circular slots is shown given below



**Fig. 13.** E-Field Intensity of a Rectangular Waveguide with Circular Slots

**3.3.3 H Field**

The H Field for a rectangular waveguide with circular slots is shown given below



**Fig. 14.** H-Field Intensity of a Rectangular Waveguide with Circular Slots

**4. Conclusion**

Rectangular waveguide is simulated by using An-soft HFSS. The parameters like return loss, Transmission-coefficient, E-field, H-field and modes of the rectangular waveguide are simulated. For the better improvement of the results Rectangular waveguide is placed with square and circular slot. We have also simulated E field and H field for both rectangular waveguide and also with square and circular slots.

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