DESIGN OF THE TRANSITION (MODE CONVERTER) FROM FUNDAMENTAL CIRCULAR WAVEGUIDE TO FREE SPACE GAUSSIAN BEAM

HIREN DHUDA[#1], DR. YOGESH KOSTA[#2], SUNERA KARGATHARA[#3], DR. HITESH PANDYA [#4]

[1]M.E. Student, EC Department, Marwadi Group of Institutions, Rajkot, Gujarat, India
[2] Director, Marwadi Group of Institutions, Rajkot, Gujarat, India
[3]Assi.Professor, EC Department, Marwadi Group of Institutions, Rajkot, Gujarat,India
[4]Scientist-SE, ITER, IPR, Gandhinagar, Gujarat, India

[1]hiren.dhuda@gmail.com,[2]ypkosta@gmail.com,[3]kargtharasunera@gmail.com, [4]hiteshkumarb@yahoo.co.uk

ABSTRACT : *A quasi optical focusing mirror is used in a transmission line of the millimeter wave frequency range of 100th of GHz. In this, sometime one needs to couple the power from the quasi optical component to the fundamental rectangular waveguide. The size of the fundamental rectangular waveguide is very small (i.e. half wavelength of the operating frequency). This gives poor power coupling between the quasi optical component and the fundamental waveguide. Therefore, it is required to have transition for efficient coupling between these two. Many types of transition are possible to design. One is tapper transition from the fundamental rectangular waveguide to the large opening size. Other type of transition is from the rectangular waveguide to a circular corrugated transition of large size opening. In these two types; the corrugated transition has efficient coupling (~ 98 %) from the quasi optical components; while the rectangular transition has a power coupling of 88%. Therefore; we decided to design of the transition from the fundamental waveguide to the circular corrugated. In a taper transition from the fundamental circular waveguide of D-band to the corrugated waveguide is going to be designed. The theory of taper transition shall be used for this. In the design, the tapering of the corrugation depth is starting from λ/2 at tapper input to λ/4 at tapper output. First the dimensions of the transition are determined by using theory. These dimensions shall be used in to the numerical simulation of the taper and determined the optimum dimensions of the transition for the mechanical fabrication.*

KEYWORDS: Corrugation, hybrid mode and mode converter

1.INTRODUCTION

The corrugated waveguide is very useful in communication when the frequency range is very high (100th of GHz); because it has a low side lobes and symmetrical beam. A corrugated waveguide that has a circular cross section and a series of equally spaced ridges. Circular waveguide can be excited in any combination of polarizations.

TE_{10} rectangular waveguide mode can be converted to the TE11 circular waveguide mode by using waveguide transition.TE11 mode is a fundamental mode of the circular waveguide, and it has a poor radiation pattern and poor coupling to the quasi optical components.. Therefore one needs to use transition from circular waveguide to corrugated waveguide for optimum coupling. This transition converts from the TE11 mode to HE11 mode. This converted HE11 mode is very good for field radiation, radio links, radar, remote sensing etc.

2.CORRUGATION

The corrugation is defined as "discrete periodic grooves". For the corrugated circular waveguide, it defined as, "A circular waveguide that has a circular cross section and a series of equally spaced ridges."In Corrugation there is a combination of the TE and TM mode, and generate hybrid mode called as HE mode. In hybrid mode cross polarization is very low and band width response is wide.

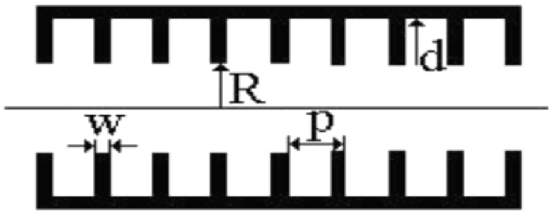

Fig. 1 Corrugation[6]

3. EQUATION FOR THE GEOMETRY OF THE CORRUGATED WAVEGUIDE

Design of D band circular waveguide mode converter, which has a frequency range, is 110 GHz to 170 GHz The operational principle of the circular corrugated waveguide physically explained in the figure2.

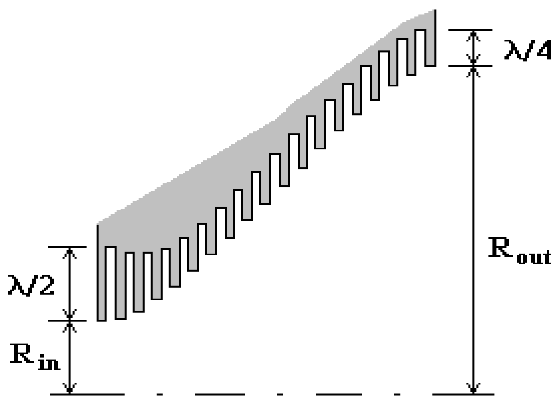

Fig. 2 Corrugation in circular waveguide[6]

The generated HE11 mode is combination of TE (Transverse Electric) mode and TM (Transverse Magnetic) mode. The ratio of the TE11 and TM11 mode is 85% and 15% respectively. For this combination ratio, we achieve the approximately 99% pure HE11 mode, which is almost the Gaussian beam type power pattern. Important parameters for the design of the corrugated wave guide mode converter are (1) period (p), (2) corrugation depth (d), (3) corrugation width (w), (4) input radius (r) .All these parameters are depends upon the wavelength (λ), and wavelength is calculated by the mid frequency of the frequency band for optimum performance. Here we are considering D band frequency range (110 GHz to 170 GHz) The mid frequency is 140 GHz for this frequency range and the wavelength is 2.14mm. As per theory period of the corrugation is λ/3 or λ/5; For our calculation we take λ/3. Width of the ridge is p/2 or p/3, We consider p/2 in our calculation. Corrugation depth starts from λ/2 and decrease to λ/4. Input radius is 0.39*λ and profile angle α is 5 degree. Design parameters equations and its calculated values of the D band corrugated waveguide mode converter is shown in below table 1.

Input Radius (Rin)	0.39 * λ	0.8346 mm
Horn Antenna length (L)	L = 23 * λ	49.22 mm
Corrugation Depth (d)	λ / 2 to λ / 4	1.07 to 0.535 mm
Period (P)	λ / 3	0.7133 mm
Duty Cycle (w)	P / 2	0.3565 Mm

Table 1 Calculated parameters of corrugated waveguide mode converter

4.NUMERICAL RESULT AND SIMULATION

The simulation of corrugated waveguide mode converter was obtained by using CST . Simulation result of the return loss shown in figure 4.Return loss is small lower than -22 dB in the frequency band of 110GHz to 170 GHz. E field Distribution of HE11 mode shown fig. 5. FIg.6 shows the 3-D view of the E-field distribution.

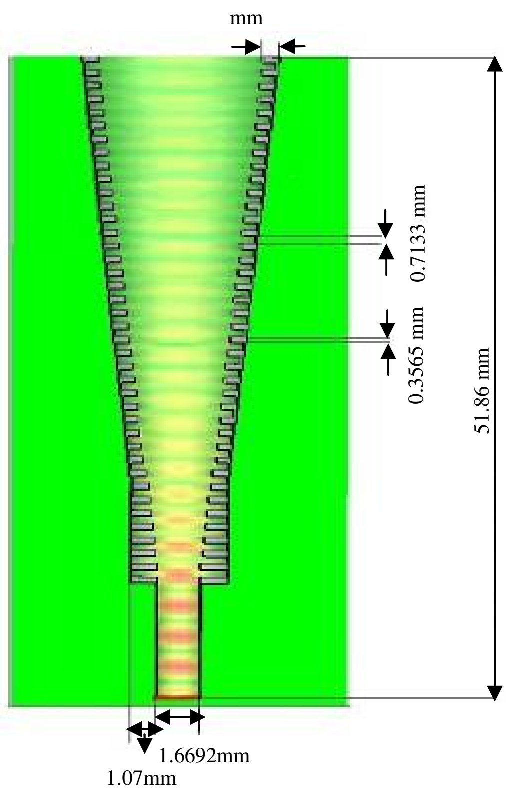

Fig.3Designed Corrugated Waveguide modeconverter

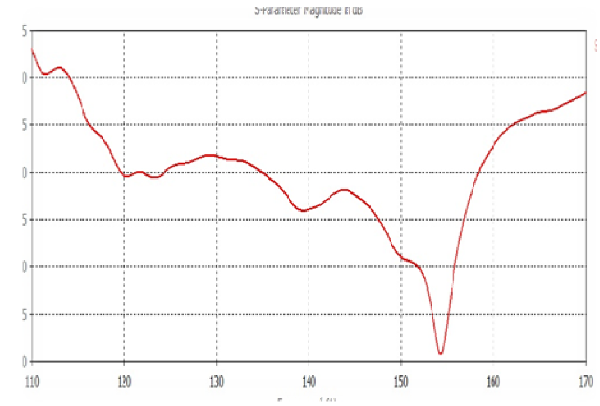

Fig. 4 Return Loss

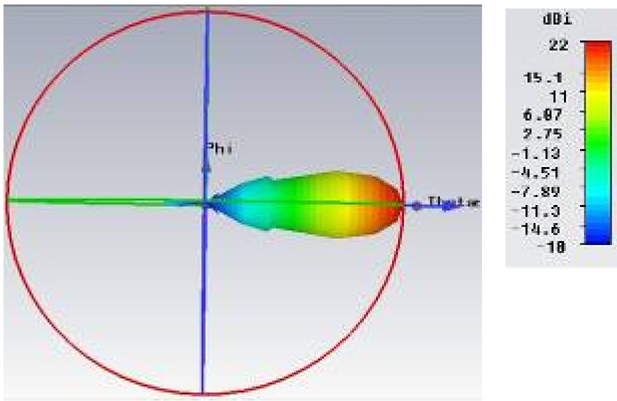

Fig. 7 far field distribution of E field

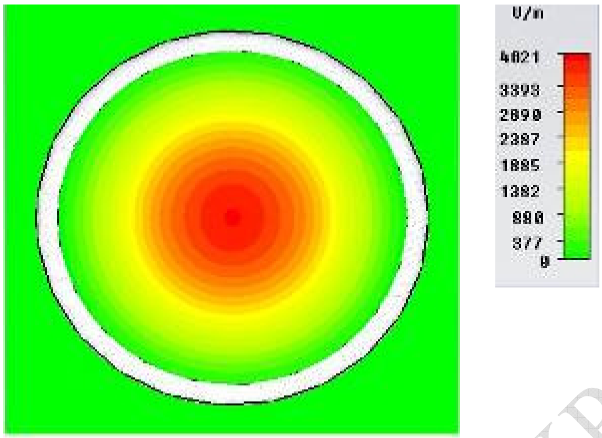

Fig. 5 E field Distribution of HE11 mode

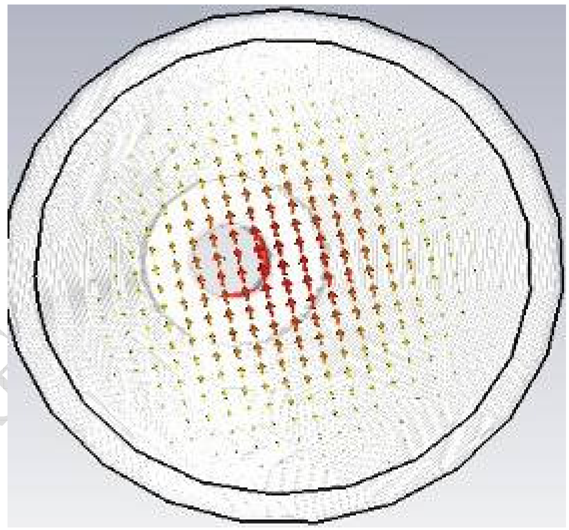

Fig. 8 Linearly Polarized (LP) mode of E field

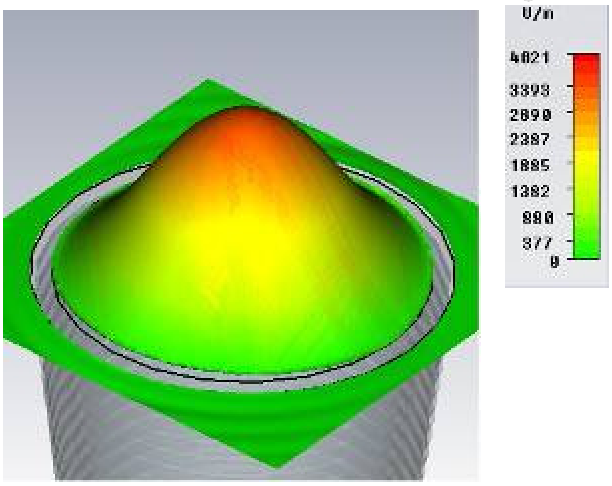

Fig. 6 E field Distribution of HE11 mode contour

5.CONCLUSION

The paper describes a theoretical design for a high frequency (110GHz to 170GHz) corrugated circular waveguide. The suitable corrugated circular waveguide has been designed and simulated. The output of the simulation gives HE11 mode and return loss for input dimensions of the transition. The simulation results are encouraging to fabricate the transition for D-Band frequency range.

5. REFERENCES

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