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Mode Transformation for C Band Frequency

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Abstract —A rectangular to circular waveguide converter is investigated numerically and characterized experimentally for microwave devices characterization. The converter is designed as an excitation method of circular waveguide to produce its dominant mode as the problem of circular waveguide in the excitation process. A rectangular waveguide transducer with working on C Band frequency TE10 mode is used as the wave exciter to be converted to circular waveguide. Prior to the design, physical parameters of converter including length of rectangular segment, length of transition segment and length of circular segment are analyzed to obtain the optimum design. It shows and finds experimentally that the length of transition segment affects to the return loss of converter and its length to produce TE11 mode of circular waveguide smoothly. Application point of view uses this design and also help full to us at radar application as well as test bench setup. Using CST Microwave Studio, design rectangular to circular waveguide mode convertor, and also understanding concept of mode and generating codes of modes using MATLAB

Keywords-component; formatting; Rectangular waveguide, Mode, circular waveguide, Mode converter, CST, MATLAB

1. INTRODUCTION

Transmission of Energy from one place to any other place is always through channel or media. This media is either guided media or unguided media. When energy take place in guided media and if it is in form of high frequency signal there is always need of waveguide for reduce attenuation and confine this energy.

Waveguide is a metallic structure which is used for a transmission of an electromagnetic energy between two points. Waveguides, like transmission lines, is structures used to guide electromagnetic waves from point to point. However, the fundamental characteristics of waveguide and transmission line waves (modes) are quite different. The differences in these modes result from the basic differences in geometry for a transmission line and a waveguide.

The electromagnetic waves that make electromagnetic radiation can be predict as a self-propagating transverse oscillating wave of electric and magnetic fields. Electromagnetic waves are used to transmit long/short/FM wavelength radio waves, and TV/telephone/wireless signals or energies. They are also responsible for transmitting energy in the form of microwaves, infrared radiation (IR), visible light (VIS), ultraviolet light (UV), X-rays, and gamma rays. Each region plays an important part in our lives, and in the business involving communication technology. Electromagnetic wave consists of two components one is electric field and other is magnetic fields. Direction within a waveguide or transmission line decides a mode of Propagation. If both E and H field are transverse to the direction of propagation it called a TEM (Transverse electric and magnetic) mode, if only E field is transverse to direction of propagation it is a TE (Transverse Electric) mode and if only H field is transverse to direction of propagation it is TM (Transverse Magnetic)mode.

This transverse component can determine only from axial component of E and H using "Maxwell's Wave Equations". Using these equations, in a waveguide when E and H both field are transverse All component of E and H become a Zero means there is no TEM mode in a waveguide only TE and TM mode are exist .one more important thing is that in unbounded transmission we can consider a Component Ex, Ey, Hx and Hy to be infinite or a long enough, but in a Bounded transmission means in a waveguide this could not be assumed so propagation constant which is consist of attenuation constant and phase constant.

In a waveguide that can support more than one propagation mode, the mode that propagates with the minimum degradation, *i.e.* the mode with the lowest cutoff frequency is known as a dominant mode. Example: TE10 for rectangular waveguides and TE_{11} for circular waveguides. There are some higher order mode which exist having a same cut-off frequency is called degenerate mode. Mode excitation process of assert a waveguide in particular single or multi mode operation depart from its dominant mode. Excitation of a single hollow waveguide can made using inhomogeneous anisotropic sub wavelength structures.

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2. IMPLUSE

Waveguide has a very broad application, and every waveguide can operate in a different mode. Every mode has its own characteristics and advantages. Depend on application need to operate a waveguide in a particular mode out of available of many. So mode excitation will come into a picture. But Mode excitation is difficult and complicated for some of the mode. Along with that propagation in some particular mode has serious disadvantages. Also some waveguides have difficult structure design. With this idea came into my mind about mode converter so we can take advantages of specific structures, modes and excitation methods

3. WAVE GUIDE AND ITS PROPERTY

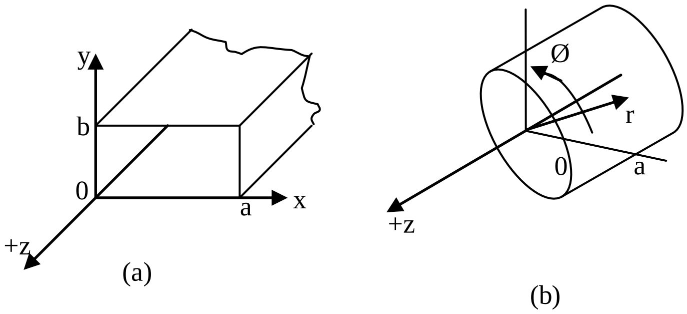

Figure 1.Waveguide (a) Rectangular (b) circular

The waveguide is positioned with the longitudinal direction along the z axis

- guide walls have $\sigma_c = \infty$ (perfect conductor)
- dielectric-filled hollow has:
    1. $\sigma_c = 0$ (perfect conductor)
    2. $\mu = \mu_o \mu_r$
    3. $\varepsilon = \varepsilon_o \varepsilon_r$
    4. assumed $\rho = 0$ (no free charge)

The dimensions for the cross section are inside dimensions. Figure 1(a) is a rectangular waveguide shown in Cartesian coordinate system; Figure 1(b) shows a circular or cylindrical waveguide of radius a in a cylindrical coordinate system. The time dependence $e^{j\omega t}$ will be assumed for the electromagnetic field in the dielectric core. The following expressions for the field vector **F** (which stands for either **E** or **H**), assuming the wave is propagating in the +z direction.

Rectangular coordinates F = F(x, y) e^{-jkz} where:

$$F(x,y) = F_x(x,y)a_x + F_y(x,y)a_y + F_z(x,y)a_z \equiv F_T(x,y) + F_z(x,y)a_z$$

Cylindrical coordinates $F = f(r,\phi)e^{-jkz}$ where:

$$F(r,\phi) = F_r(r,\phi)a_r + F_\phi(r,\phi)a_\phi + F_z(r,\phi)a_z \equiv F_T(r,\phi) + F_r(r,\phi)a_z$$

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The wave will propagate without attenuation, because the dielectric is lossless (σ = 0). Let $k\left(\frac{2\pi}{\lambda}\right)$ (in Rad/m) be the wave number and is constrained to be real and positive. The reason for separating the field vector into a transverse vector component $\mathbf{F}_T$ and an axial vector component $F_z\mathbf{a}_z$ is two-fold. The complete **E** & **H** fields in the waveguide are known once either Cartesian component D_z or H_z is known

In a waveguide a signal will propagate as an electromagnetic wave. Even in a transmission line the signal propagates as a wave because the current in motion down the line gives rise to the electric and magnetic fields that behaves as an electromagnetic field. The transverse electromagnetic (TEM) field is the specific type of field found in transmission lines. We also know that the term "transverse" implies to things at right angles to each other, so the electric and magnetic fields are perpendicular to the direction of travel. These right angle waves are said to be "normal" or "orthogonal "to the direction of travel.

The boundary conditions that apply to waveguides will not allow a TEM wave to propagate. However, the wave in the waveguide will propagate through air or inert gas dielectric in a manner similar to free space propagation, the phenomena is bounded by the walls of the waveguide and that implies certain conditions that must be met. The boundary conditions for waveguides are, the electric field must be orthogonal to the conductor in order to exist at the surface of that conductor and The magnetic field must not be orthogonal to the surface of the waveguide.

The waveguide has two different types of propagation modes to satisfy these boundary conditions

1. TE – transverse electric ($E_z = 0$)
2. TM – transverse magnetic ($H_z = 0$)

From Maxwell's equation each pair of nonnegative integers (m, n) –with the exception of (0, 0) which will result in a trivial solution-identifies a distinct TE mode, indicated as TE_{mn}. This mode has the axial field

$$\mathrm{H}_{zmn}(x,y)=\mathrm{H}_{mn}\cos\frac{m\pi x}{a}\cos\frac{n\pi y}{b}$$

And the transverse field is obtained through (3) – (refer to pages 2-3 of these notes). The critical wave number for TE_{mn} is:

$$k_{c\mathrm{TE}mn}=\sqrt{\left(\frac{m\pi}{a}\right)^2+\left(\frac{n\pi}{b}\right)^2}$$

This is in terms of which the wave number and the wave impedance for TE_{mn} are:

$$k_{\mathrm{TE}mn}=\sqrt{\omega^2(\mu)(\varepsilon)-k_{c\mathrm{TE}mn}^2}$$

$$\eta_{\mathrm{TE}mn}=\frac{\omega(\mu)}{\sqrt{\omega^2(\mu)(\varepsilon)-k_{c\mathrm{TE}mn}^2}}$$

4. MODE CONVERTER DESIGN

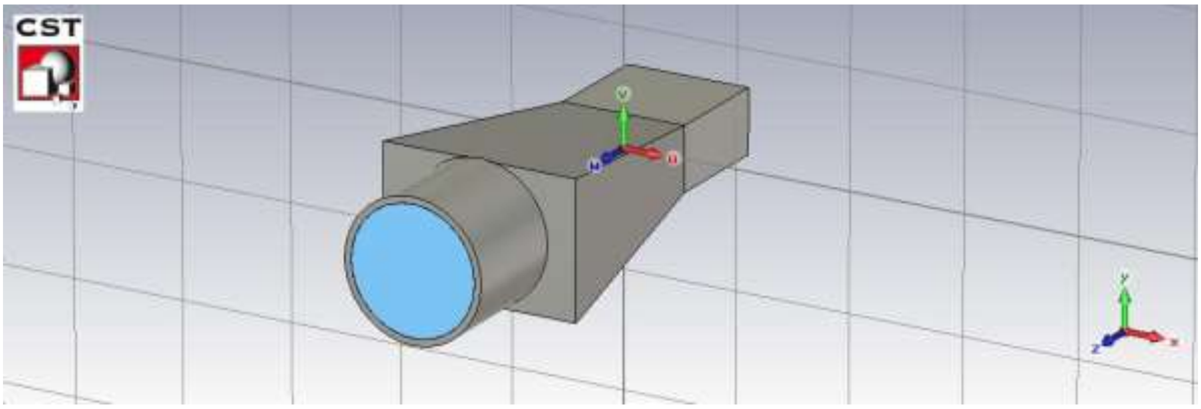

Figure 2. TE10-TE11 Waveguide Mode Converter

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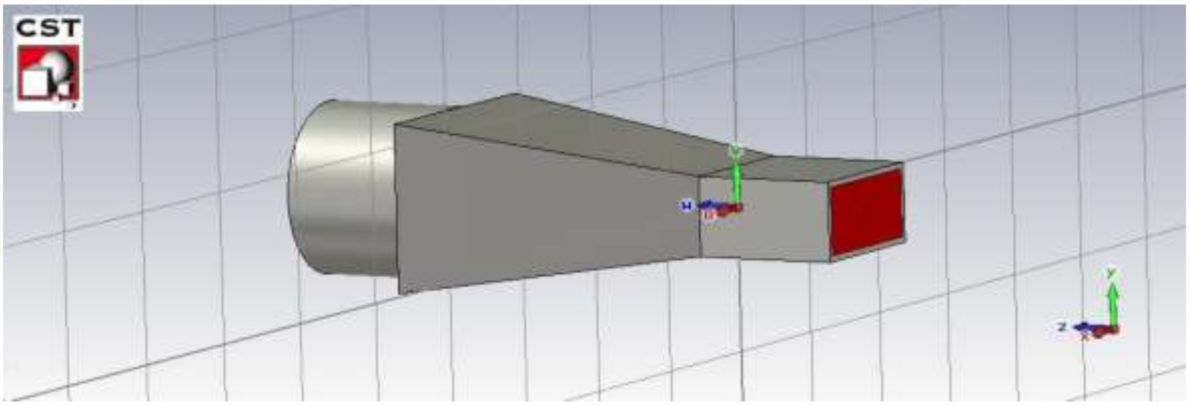

Figure 3. TE10-TE11 Waveguide Mode Converters

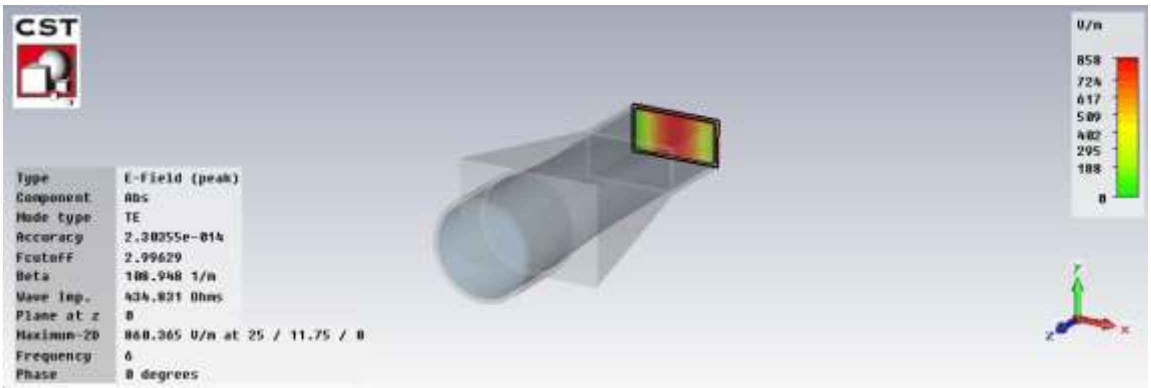

Figure 4.E-Fields -TE10 of Input Port

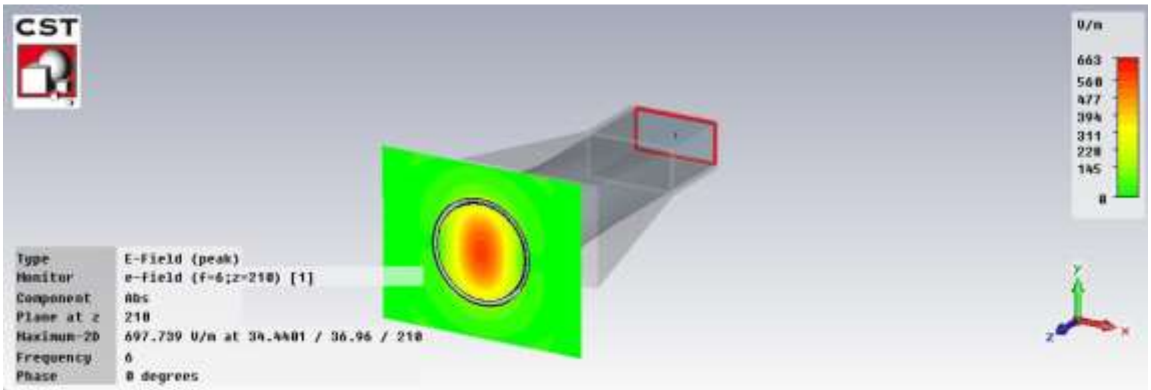

Figure 5.E-Field -TE11 of Output Port

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5. RESULT ANALYSIS

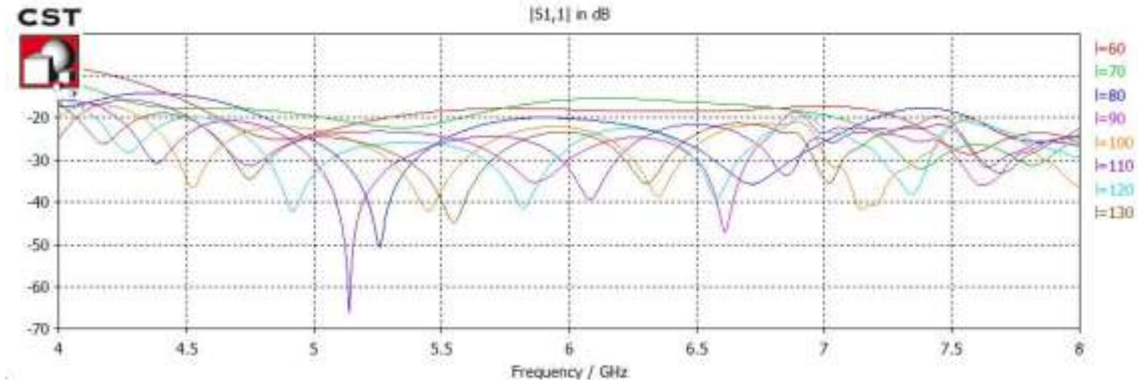

Figure 6. VSWR for Different Length of Transition Region

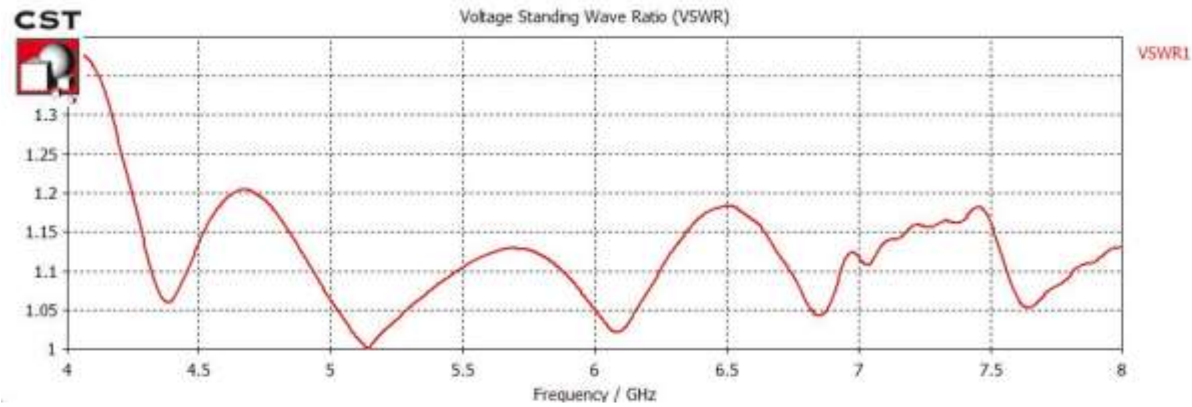

Figure 7.VSWR of Mode Converter

6. CONCLUTION

After Designing a Rectangular To circular waveguide mode Converter for C band in CST microwave studio and analyzing a simulation result it found that it Converting dominate mode TE10 of Rectangular to Dominate mode TE11 of circular waveguide at tolerable return losses. This result also verify with electric and magnetic field generation for TE10 and TE11 modes using MATLAB Coding. By varying a Length of Transition Segment it found that it affecting on Return Loss, after analysis Results for different-different length come on conclusion that transition segment length should be greater than guided wave length for optimum Result in sense of return loss. In addition based on experimental measurement of two parameter, Length of Rectangular and Length of Circular segment it noted that for adequate return loss length should be equal to guided wavelength. finally come on conclusion that total length of Mode Converter would be 4 time greater than its guided wavelength for optimum result.

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7. REFERENCE

[1] Abdelwahed Tribak, Jamal Zbitou, Angel Mediavilla, and Naima A. Touhami," ultra-broadband high efficiency mode converter", Progress in Electromagnetic Research C, Vol. 36, 145-158, 2013.

[2] Matheson. Ronald K., SpeirsD.C. Phelps A.D.R. and Cross A.W. "An X-band Rectangular TE10 to Circular TE01 Marie Converter", SUPA, Department of Physics, University of Strathclyde, Glasgow, G4 0NG, UK.

[3] C.Read Predmore. "Helical Coupler from rectangular to circular waveguide". IEEE Transactions on Microwave theory and Techniques, Vol. MTT-24, NO. 11, November 1976.

[4] Zemlyakov V.V., Zargano G.F., Sinyavskiy G.P. "mode transformation due to curvature and diameter Variation in smooth wall-Circular waveguide" msmw'o4 Symposium Proceedings. Kharkov, Ukraine, June 21-26. 2004

[5] Xu Shouxi, Pu-Kun Liu, Zhang Shi-Chang, Du Chao-Hai and Gu Wei. "Design of an Ka- Band Mode Converter"IEEE,978-1-4244-8660-1/11,2011

[6] Muhammad Fathi Yakan Musthofa, Achmad Munir. "Design of Rectangular to Circular Waveguide Converter for S-Band Frequency" International Conference on Electrical Engineering and Informatics, Bandung, Indonesia. 17-19 July 2011

[7] Yeddulla Muralidhar, Tantawi Sami, Guo Jiquan, and Dolgashev Valery, "An Analytical Design and Analysis Method for a High-Power Circular to Rectangular Waveguide Mode Converter and Its Applications IEEE Transactions on Microwave theory and techniques, vol. 57, no. 6, June 2009.

[8] Yadav Vivek, Singh Udaybir and Sinha AK, "Analysis and design of broad-band Square-to-Circular Waveguide Transitions" international journal of microwave and optical technology, vol.5 no.3 may 2010.

[9] Eisenhart Robert L., "a novel wideband tmo1-to-te11 mode convertor", IEEE MTT-S digest 0-7803-4471-5/98, 1998.

[10] Eva-RajoIglesias, Oscar Quevedo teruel, matilde senchez-fernandez, "Compact multimode Patch antenna for MIMO application "

[11] S.H.Mohseni Armaki, F.Hojat Kasani, J.R.mohassel, M.naser-moghadasi "Design and Realization of Tracking Feed antenna System" IEICE Electronics Express, Vol 8, No.5, 908-915

[12] C. F. Yu, T. H. Chang "high performance circular TE01, mode converter" IEEE transactions on microwave theory and techniques, vol. 53, no. 12, December 2005

[13] Dietrich Marcuse, Richard Derosier "Mode conversation caused by Diameter Change of Round Dielectric Wave guide" Bell System Technical Journal, December 1969.

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