Impact Factor (SJIF): 4.542

International Journal of Advance Research in Engineering, Science & Technology

e-ISSN: 2393-9877, p-ISSN: 2394-2444

Volume 4, Issue 4, April-2017

Design and Analysis of Orthomode Transducer

Dhara Pandya[1], Pratik Patel[2]

[1]*Electronics and Communication Department, SVBIT*
[2]*Electronics and Communication Department, SVBIT*

Abstract —This paper represent design of compact high performance Orthomode Transducer with a circular waveguide input and four rectangular waveguide output Tthe design is based on the use of a turnstile junction at Ku frequency band from 10.5 to 14.5 GHz. HFSS simulation tools for Finite Element Method is used for analysis and optimization of the structure. Design OMT will be the part of feed system of the Earth Station Antenna used for Satellite Communication. the input return loss was less than -28db.

Keywords- Orthome Transducer ,Tturnstile junction, Tunning Stub

I. INTRODUCTION

An Orthomode Transducer (OMT), which allows to combine or separate two orthogonal polarizations within the same frequency band, represents a very interesting alternative to a conventional quasi-optical wire grid polarizer for cryogenic low noise receivers in the domain of radio astronomy and for communication systems [4]. When an OMT is used into a feed system only single feed horn is required, thus reducing the dimensions of the cryostat and the alignment problems with the incoming signal. An OMT generally consists of a three-port network, an input port with square or circular waveguide cross section (to interface with the feed horn) and four rectangular waveguide output ports, one output for each polarization.turnstile junction consists of a circular or square waveguide input port and four rectangular waveguide outputs.

An orthomode transducer (OMT) is core components in the antenna feed system with use of dual polarization to utilize high capacity transceiver. An OMT is a polarization diplexer that combine and separates two signals of orthogonal dominant modes provided at the common port, and supplies them to the fundamental mode of the allocated single interface ports within the same frequency band. The OMT has a considerable impact in the entire antenna feed system, and its typical performance criteria are return loss, insertion loss, cross-polarization, isolation, and power handling capabilities.

II. TYPES OF OMT

OMT are basically classified into two main group based on Percentage of bandwidth which are Narrow-Band Orthomode Transducer and Broad- Band Orthomode Transducer. Narrow band OMT are also classified into four types which are Taper/Branching OMT, Septum/Branching OMT, Actute Angle or Longitudinal Orthomode Branching and Short Circuited Common Waveguide. In spite of a need to develop a broadband OMT, there are few types of broadband OMTs [1]-[3]. The typical examples of broadband OMTs are classified with waveguide to waveguide transitions in two main groups. The first group based on the Bøifot junction has ports of side wall dual-junction, ports of longitudinal dual-junction, a septum within branching region, and capacitive compensation pins [1],[2]. The second group based on the turnstile junction has four longitudinal dual junction ports and concentric matching tuning stub inserted within the common waveguide [3]. The latter has advantage of that neither pins nor septum are needed to achieve polarization separation with lover a broadband performance. However, the OMT in [3] needs complex structure and large size with respect to the common waveguide axis.

III. THEORY AND DESIGN OF OMT

The Turnstile junction is the key component of the OMT. Physically, it is a five-port two-mode structure composed of a common port and four single-mode ports shows in Fig1. The S-matrix of the ideal Turnstile junction is:

$$\mathbf{S}=\left[\begin{array}{cc:cccc} 0 & 0 & \varepsilon & \varepsilon & 0 & 0 \\ 0 & 0 & 0 & 0 & \varepsilon & \varepsilon \\ \hdashline \varepsilon & 0 & 0 & 0 & \gamma & -\gamma \\ \varepsilon & 0 & 0 & 0 & -\gamma & \gamma \\ 0 & \varepsilon & \gamma & -\gamma & 0 & 0 \\ 0 & \varepsilon & -\gamma & \gamma & 0 & 0 \end{array}\right]$$

$$\text{, with } \quad |\varepsilon|^2=|\gamma|=1/2$$

The device works in the same way for both polarizations: it separates each one into two halves of equal power which are routed through dedicated ports situated facing each other. OMT is based on the design of a turnstile junction in order to separate two orthogonal polarizations wave within the same frequency band. The turnstile junction is a component for OMT designs for high performance in terms of polarization port to port isolation and input return loss of the design. It consists of a common circular waveguide at the input and four rectangular waveguide outputs, as shown in Fig. 1. In this turnstile junction Each of the two incoming polarizations, Pol. 1 and Pol. 2, at the circular waveguide input and coming from the horn antenna, is equally separated by the turnstile junction in two 180 out-of-phase RF signals, called Pol. 1+, Pol. 1- and Pol. 2+, Pol. 2-,respectively. Thus, the two polarizations can be simultaneously processed without the need to use a wire-grid diplexer and two horns antennas. So with use of an Orthomode transducer there are reduced number of horn antenna for particular both polarization signal and does not required wire grid calibration to isolate both polarization

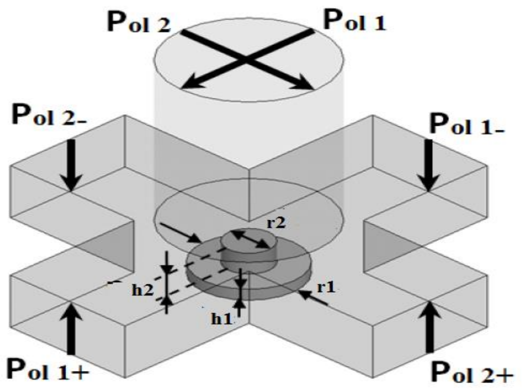


Fig1: Structure Of the Orthomode Transducer

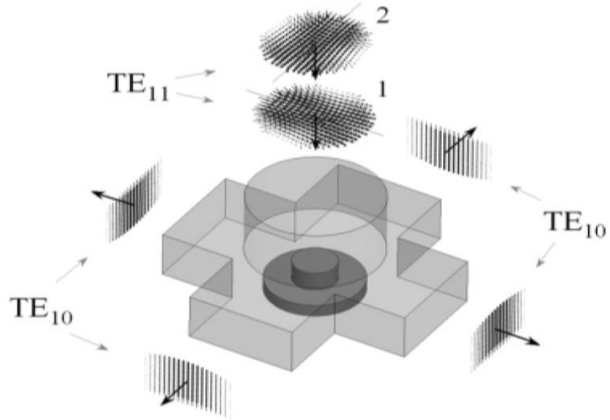


Fig2: Turnstile Spiting Junction with two cylinder internal obstacle

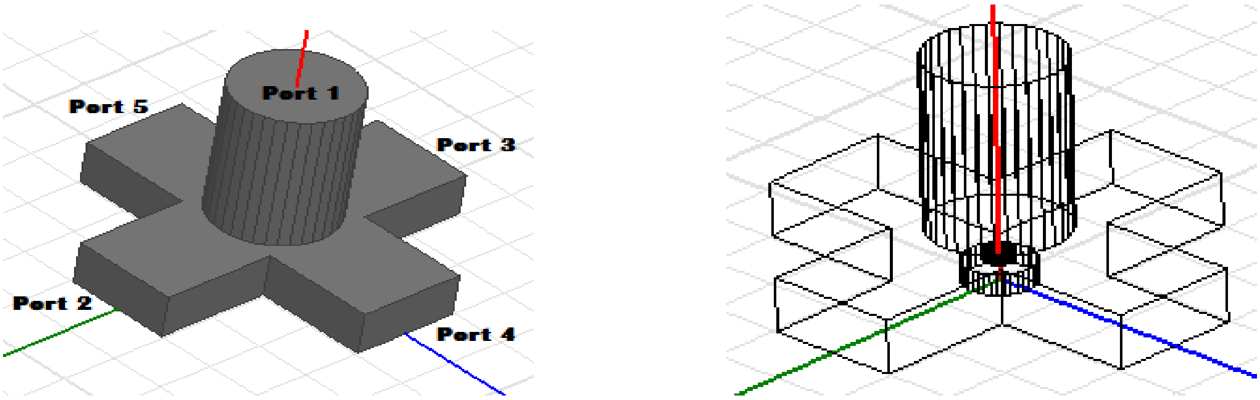
In order to design of the OMT at Ku frequency band ranging from 10.5 to 14.5 Ghz frequency band the dimensions of waveguide are 19.06 × 9.52mm (WR75). The input circular waveguide radius is selected as per circular waveguide are passed only dominant mode and does not propagate higher order mode of the waveguide. For high performance OMTs, with high polarization isolation, the return loss at the circular waveguide input must be carefully optimized using a matching element placed at the center of the turnstile junction. Various matching structures were investigated and simulated to identify the best return loss (S11) over the largest bandwidth (see Fig. 1).

Turnstile Junction splitting a dually polarized TE11 mode into its constituent arts. The splitting junction is located at the geometric center of the device in order to maintain the highly symmetric nature of the device. [5] If the design is not restricted by the radius of the antenna horn and there is enough space in the footprint it is convenient to match cutoff frequencies of circular TE11 / square TE10/TE01 and rectangular TE10 fundamental modes. This will increase operational bandwidth in some cases by choosing appropriate dimensions. Very good positioning of the matching element, in the center of the turnstile junction, is crucial in order to efficiently separate the two orthogonal polarizations. Otherwise, RF performances could be significantly deteriorated.

The concept of OMT design is based on the following rules are 1) The matching element should not be split into four identical blocks intersecting on the axis of the input circular waveguide (as described in [6]); 2) The matching element should not be a mobile part to be glued, screwed, soldered or just Compact inserted in the center of the turnstile junction (as described in [6] and [7]); and 3) the total number of blocks to assemble the OMT should be minimized.

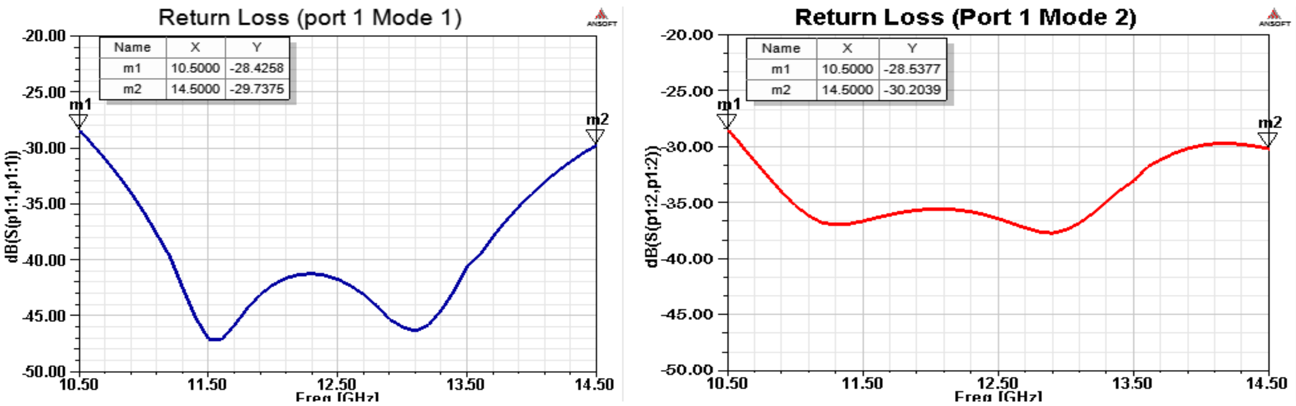
IV. SIMULATION AND ANALYSIS OF DESIGN

The simulation for our project has been done on HFSS (High Frequency Structure Simulation). HFSS is the industry standard software for S-parameter and 3D electromagnetic field simulation of high-frequency components. The reason we have chosen this software is that HFSS makes it easy to design, simulate, and validate complex high-performance microwave device. The result from this device is approximately same as in the real time environment. Design of two Rectangular waveguide and single circular waveguide which are intersect to each other at the center of the structure, An internal obstacle is placed inside the junction in order to improve matching properties for incident modes. Different shapes of this obstacle yield different results for return losses, transmission coefficient .After optimization of the radius(r1:5mm, r2:1mm)and height(h1:3.6mm, h2:2mm) of the two stage cylinder stub placed inside of turnstile junction.and Matching can be further improved by providing a more gradual change in the radius of the input circular waveguide.



(a) (b)

Fig3 : Design of Turnstile Junction in HFSS



(a) (b)

Fig4 : Return loss of Common Circular port

Fig 4 shows response of the return loss of circular port 1 with both horizontal and vertical polarization mode which are less than -28db at both mode of the design. Fig 4 shows graph return loss at input circular port. At Ku band frequency from 10.5 to 14.5 GHz achieve 33% Bandwidth which are used at broadband performance of the OMT.

V. CONCLUSION

In this paper, an orthomode transducer (OMT) with a circular waveguide input and two rectangular waveguide outputs for the at Ku frequency band was studied and design. The OMT consists of a matched turnstile junction that uses two superimposed cylinders placed at the base of the junction. The design is carried out by using Finite Element Method with use of High Frequency Structure Simulator tool. The return losses at the inputs and outputs of the four OMT prototypes are better than -28dB. Both polarizations and isolation levels between the two rectangular waveguide outputs are higher than 50 dB in the 10.5 to 14.5 GHz(33% bandwidth)

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