A Broadband WR-15 Orthomode Transducer

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Abstract- An orthomode transducer (OMT) with a square input port (3.76 mm x 3.76 mm) and two rectangular waveguide output ports (3.76 mm x 1.88 mm) is described in this paper for temperature sounder application. The design of orthomode transducer uses turnstile junction for the separation of V and H polarization in the frequency band of 50 - 60 GHz, and E-plane power combiners are used to combine the outputs of turnstile junction two extract V and H polarizations at two channel. In this design a single tuning stub at the base of the turnstile is used to optimize the performance. The design of the component was done by using HFSS full wave 3D electromagnetic simulator. The OMT was manufactured by electroforming process and then tested using millimeter-wave vector network analyzer. The average return loss for both V and H polarization is -22 dB and the average polarization isolation is -40 dB in the frequency band of 50- 60 GHz.

Index Terms- Orthomode Transducer Turnstile Junction, waveguide transitions, tuning stub.

I. INTRODUCTION

An Orthomode transducer (OMT) is diplexer that separates orthogonal polarizations within the same frequency band. An OMT has three physical ports but electrically it is a four-port device, because the input common port, usually a square waveguide that support two orthogonal TE$_{10}$ and TE$_{01}$ modes or circular waveguide that support two orthogonal TE$_{11}$ and TE$_{11}^{*}$ modes that provides two electrical ports.

A number of waveguide OMT designs based on the BΦiLOT junction [1] have been presented. The device described by Wollack and Grammer [2] uses a thin septum and capacitive compensation pins in the two side arms. The small diameter of the pins and the complexity of the assembly have significant challenge for the realization. Other designs with a thicker have been proposed; here, the pins are removed in favor of short capacitive steps. In this design the mechanical realization of the blocks and the assembly is simplified, the adjustment of the septum inside the waveguide is still a critical part of the design.

II. ORTHOMODE TRANSDUCER DESIGN

OMT consists of a turnstile junction having square waveguide as its input and two E-plane power combiners. Fig.1 shows the internal cavity of the turnstile junction. Two fundamental modes TE$_{10}$ and TE$_{01}$ (Designated as V polarization H and H polarization respectively). Fig.1 Internal cavity of turnstile junction
polarization) can propagate in the square waveguide as orthogonal modes. The turnstile junction splits V polarization signal divided equally between standard WR-15 (3.76 mm X 1.88 mm) rectangular waveguide ports 1 and 3, but does not couple to ports 2 and 4. Similarly, H polarization signal is divided equally between rectangular waveguide ports 2 and 4 but does not couples to rectangular ports 1 and 3. The single cylindrical tuning stub at the base of the turnstile junction does not breaks the symmetry, and enables performance in the band of 50 – 60 GHz with low reflection coefficient. The radius and height of the cylindrical tuning stub was optimized by using HFSS full wave 3D electromagnetic simulator. Fig.2 shows the simulation return loss of one of the fundamental TE\textsubscript{10} mode return loss at the input of square waveguide with all four ports terminated in matched load. The return loss is better than -25 dB in the frequency range of 50 – 60 GHz.

The E-plane power combiner has single section transformer and a linearly square waveguide (3.76mm X 3.76mm) to standard WR-15 rectangular waveguide (3.76mm X 1.88mm) tapered transition. The length and width of the single section transformer, the 90° bend, and the taper length of the transition was optimized by using HFSS full wave 3D electromagnetic simulator. Fig.4 shows the simulation result of E-plane power combiner along with 90° bend. The return loss of port 1 with port 2 and port 3 terminated in matched load is better than -30 dB in the frequency range of 50 - 60 GHz.

Each of the optimized sub components (turnstile junction and E-plane power combiner) are joined together to get the turnstile junction configuration of the OMT. The present configuration of the OMT have three physical ports (one input and two output ports) but electrically it is a four port device (two orthogonal modes at the input of square waveguide and two rectangular waveguide output ports). The internal cavity of the OMT is shown in the Fig.5
The radius, and height of the cylindrical tuning stub, length, and width of single section transformer of E-plane power combiner are re optimized to get the performance of the OMT in the frequency range of 50 - 60 GHz. The simulated results of the OMT are shown in the Fig.6

III. MECHANICAL DESIGN OF OMT
The OMT was fabricated by electroforming technique, where copper is grown over silver plated aluminum mandrel that was sub sequentially dissolved. The mandrel of the OMT was developed with 15-20 micron tolerance.

IV. EXPERIMENTAL RESULTS
The RF performance of the OMT was measured by using agilent PNA with WR-15 calibration kit in the frequency range of 50-60 GHz. Return loss, Insertion loss, and isolation of V and H polarizations of the OMT were measured. The simulation and measured results are shown in the Fig.7-9

The return loss of the V and H polarization were measured by connecting the input square waveguide port with a square waveguide to rectangular waveguide transition and the rectangular port of the transition was terminated with a matched load. The PNA was then connected to one of the outputs while the other was terminated. The square waveguide to rectangular waveguide transition was rotated through 90° to switch between V and H polarization.

The insertion loss of V and H polarizations were measured by shorting the square waveguide input port of the OMT and each of the rectangular waveguide output ports were connected by VNA alternatively. The return loss measured in this configuration is twice the insertion loss of OMT arms.

Polarization isolation of the OMT was measured by connecting the horn antenna through a circular waveguide to square waveguide transition to the input square waveguide port of the OMT and the rectangular waveguide output ports of the OMT were connected to PNA.
V. CONCLUSION

Orthomode Transducer based on turnstile junction was designed, manufactured, and tested for temperature sounder application in the frequency range of 50 - 60 GHz. The OMT was fabricated as a single electroformed component. The measured and simulated results of the OMT has close agreement. In the frequency range of 50 - 60 GHz the average return loss, insertion loss, and isolation of V and H polarization is -21.0 dB, -0.4 dB, and -42.0 dB.

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REFERENCES

