A Turnstile OMT using Magic-Tees and Integrated Noise-Injection Couplers

Doug Henke[1*], Dave Atherton[2], Ivan Wevers[1], and Adam Densmore[1]

***Abstract*—We present an orthomode transducer (OMT) design based on the turnstile junction that provides balanced signal outputs, suitable for either linear or circular polarization. Hole couplers have been integrated for receiver calibration using noise-injection. The OMT uses magic-tees for recombination which has the advantage of terminating higher-order modes that could arise from fabrication uncertainty. Measurements will be shown for Q-band and applicable to ngVLA band 5.**

***Keywords*—Turnstile OMT, magic-tee, hole coupler, noise-injection.**

I. Introduction

An orthomode transducer (OMT) is used within the front-end of a receiver to separate out the received signal into two linear polarisations. Four common implementations of OMTs for millimetre-wave frequencies include: planar, Bøifot, turnstile junction, and dual-junction (some recent examples are [1]–[7]).

When using a turnstile as the polarisation discriminator, the input signal is split into 2 branch pairs (4 outputs total) where each pair is recombined into the respective polarisation. T-junction or Y-junction power combiners are typically used for recombination, and their effectiveness depends on phase and amplitude balance (180° difference with equal amplitudes). Under ideal symmetric conditions, each polarisation is wholly contained within one branch pair of signals and is fully recombined.

In practice, however, measured performance of OMTs often show sharp signal drops in the gain or "spikes" in the isolation response. There are several contributing factors for this degraded performance, as discussed in [8], and the most common include: branch path length imbalances and layer misalignment. The performance of an OMT is dependent on symmetry of the structure, and any deviation through misalignment or fabrication tolerance will degrade the signal throughput and isolation responses. In turnstile junction OMTs, magic-tees may be used in place of T- or Y-junctions, as shown in Fig. 1, to help mitigate asymmetries.

The advantage of using magic-tees as the branch combining element is that any signal imbalance can be terminated within the sum port of the magic-tee, instead of reflected internally. Fig. 1 also illustrates the inclusion of hole couplers that may be used for noise-injection and receiver calibration.

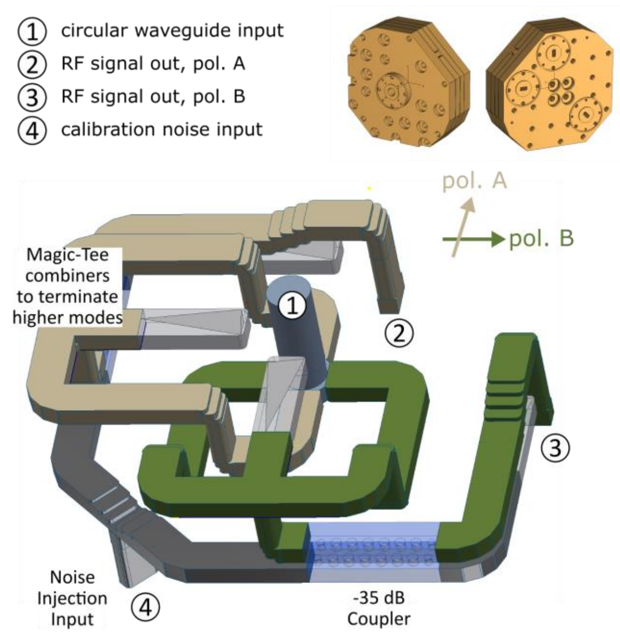

Fig. 1. Illustration of turnstile OMT using integrated noise-injection couplers and magic-tees to recombine turnstile outputs within each branch. Encircled numbers indicate ports as: (1) circular waveguide input; (2) and (3) signal outputs; and (4) noise-injection. The magic-T sum ports and hole couplers each have an internal load that is epoxied within the channel.

Fig. 2 shows the machining approach, whereby the block is sectioned into 4 layers. Waveguide channels are machined into both sides of each platelet and careful attention was given to flatness. While the design is suitable across millimetre-wavelengths, we have demonstrated the approach at Q-band towards the ngVLA Band 5 receiver (30.5–50.5 GHz).

Features of this particular design include:

- balanced amplitude and phase for signal and noise injected paths;
- integrated noise-injection couplers (~-35 dB);
- use of circular waveguide (direct connection to feed horn, no transition);
- integrated magic-T couplers to reduce signal drops from higher-order modes; and
- downward-facing waveguide outputs for symmetric cartridge assembly.

[1]National Research Council Canada, Herzberg Astronomy and Astrophysics (NRC-HAA), Victoria, BC, V9E 2E7. Canada; [2]National Research Council Canada, Design and Fabrication Services (NRC-DFS), Victoria, BC, V9E 2E7, Canada. [*]Corresponding author (email: Doug.Henke@nrc-cnrc.gc.ca).

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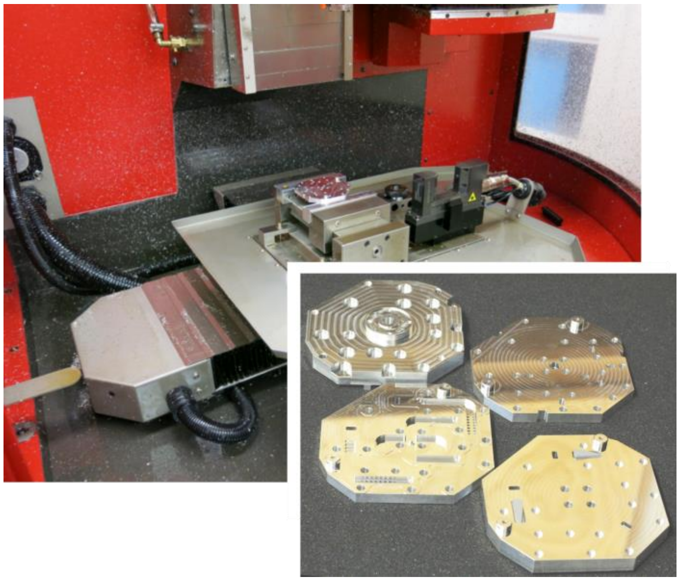
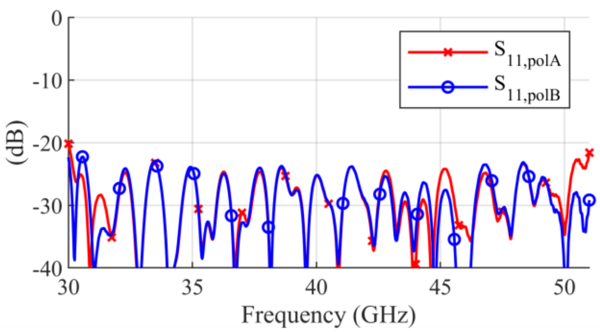
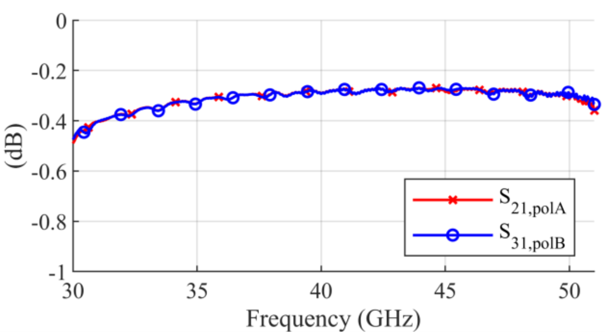


Fig. 2. Machining using the Kern EVO at NRC DFS. The inset shows the resulting 4 layers machined from aluminum.



(a)



(b)

Fig. 3. Simulated reflected power and gain responses, (a) and (b) respectively, assuming a metal conductivity of 2×10^7 S/m to represent room temperature.

Fig. 3 shows the simulated gain and reflected power responses of the OMT.

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