# High Performance Cryogenic Fractal 180° Hybrid Power Divider with Integrated Directional Coupler

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## Extended Abstract

We propose a 180° hybrid and a directional coupler for the P-band cryogenic receiver of the Sardinia Radio Telescope operating between 300 and 410 MHz. An in-depth study of the issues related to the use of microwave components for cryogenic radio astronomy receivers is carried out to select the best suited technology and configuration. Then, a planar fractal 180° hybrid available in the literature [1] has been optimized to achieve a very compact realization and increase the operating bandwidth. The design specifications are: planar dimension less than 100 x 100 mm$^2$, and, over the operating frequency band, Return Loss larger than 20 dB, amplitude imbalance less than 0.5 dB, phase imbalance between 170° and 190°. In order to achieve this performance, the Ghali's configuration [1] has been modified by splitting the fractal ring into four sections with impedances $Z_1$, $Z_2$, and $Z_3$ (see Figure 1a). A trial and error optimization with respect to $Z_1$, $Z_2$, and $Z_3$ has been performed using Ansys HFSS, and the best results are achieved for: $Z_1 = 63.9\Omega$, $Z_2 = 65.4\Omega$, $Z_3 = 74.8\Omega$. The simulated and measured results (at room temperature) of the 180° hybrid in Figure 1a are reported in Figure 1b. The modified configuration comply with the requirements of the P-band receiver and improves the RL bandwidth (from 27% to 34%) and the 0.5dB amplitude imbalance bandwidth (from 24% to 32%), compared to the standard Ghali's configuration. A coupled lines directional coupler with weak coupling and high isolation, used to calibrate the receiver, is cascaded to the 180° hybrid and realized in the same layout to save space inside the cryostat. The final device (Figure 1c), consisting of the 180° hybrid and the directional coupler, realized using an Arlon AD1000 substrate of thickness 3.2258 mm, has been manufactured and tested at the temperature of 20 K (Figure 1d).

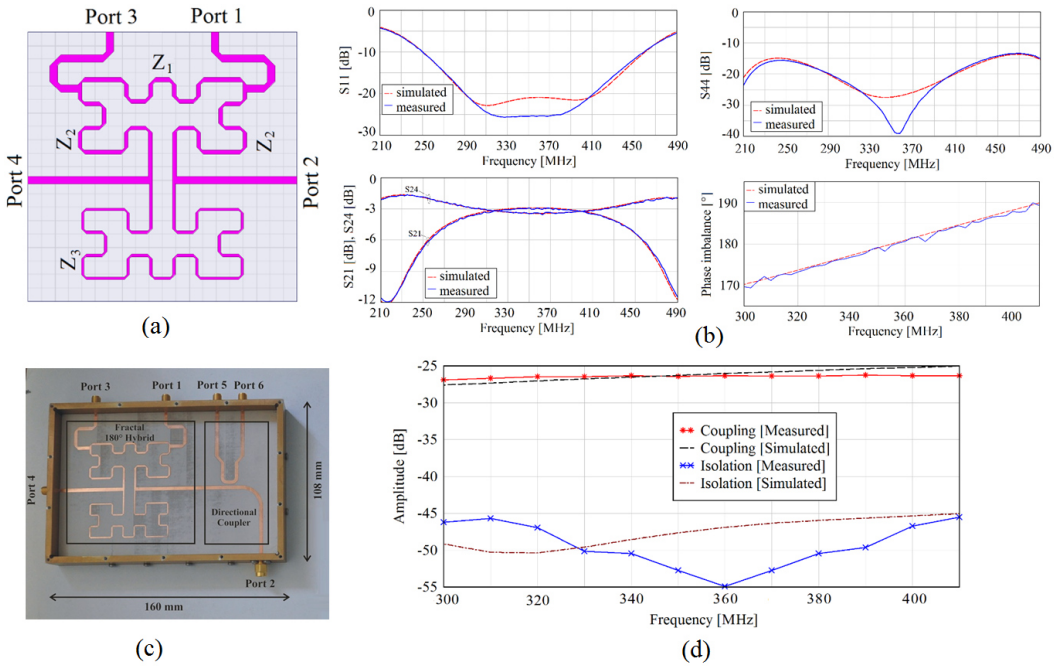


**Figure 1.** (a) Optimized hybrid proposed in this paper; (b) frequency response of the hybrid in (a); (c) prototype of 180° Hybrid and directional coupler; (d) frequency response of the complete device shown in (c), measured at 20 K.

## References

1. H. Ghali, T. A. Moselhy, "Miniaturized Fractal Rat-Race, Branch-Line, and Coupled-Line Hybrids," IEEE Transactions on Microwave Theory and Techniques, 2004, **52**, (11), pp. 2513–2520.