AT Technical Document Series
AT/39.3/127
May 2, 2006

THE AUSTRALIA TELESCOPE NATIONAL FACILITY

Cryogenic Performance of Millitech Model FBI-22 Waveguide Isolator.

Russell Bolton
Russell Gough

Two model FBI-22 waveguide isolators, serial numbers 574 and 575, were supplied by the manufacturer for testing at cryogenic temperatures. This report describes tests performed on the isolators.

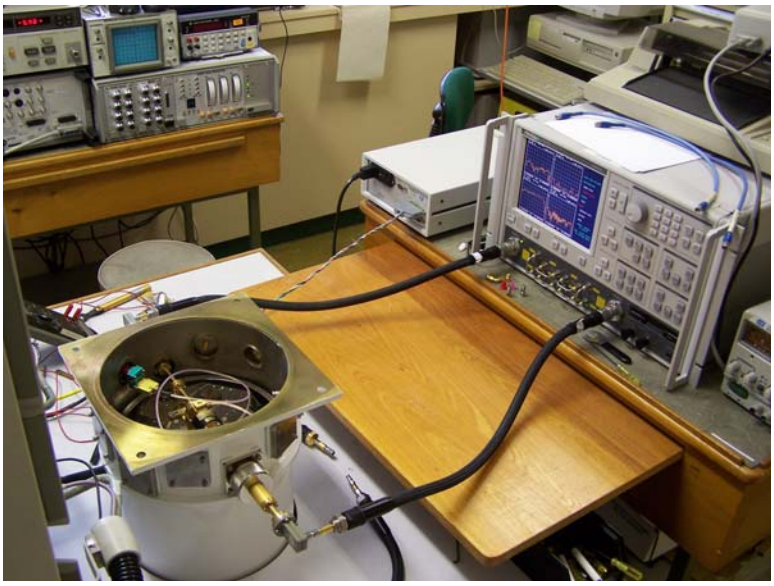
Each isolator was installed in a cryostat with lengths of WR-22 waveguide providing input and output connection to room temperature Agilent, model Q281A, waveguide to coaxial adapters. Fig. 1 is a photograph of the test set-up. The waveguides in the dewar use custom 19.1 mm diameter flanges. Adapters are used to connect the 19.1 mm diameter flanges to standard WR-22 flanges. 50 mm long, thin-walled stainless steel, waveguides are connected to both flanges of the isolator to provide thermal isolation and copper straps are used to connect the cold ends of the stainless steel waveguides to the cold plate. Waveguide vacuum windows were installed in the ends of the sliding waveguide sections so the dewar could be evacuated prior to cooling. The operating temperature of the isolator is measured using a temperature sensor on the isolator input waveguide. When the cold mounting plate within the dewar is cooled to 12 Kelvin, the isolator temperature reaches 19 Kelvin.

S-parameters of the isolator were measured using an Anritsu model 37377D vector network analyzer. The network analyzer was calibrated, at the flanges where the isolator is connected, using the LRL/LRM method. The waveguide calibration standards used were a through connection, a 3.039 mm length of WR-22 waveguide and a short circuit. Only one calibration was performed, but the calibration was checked after the series of tests. The calibration of S_{21} was found to have drifted about 0.08 dB higher mid-band and 0.2 dB higher at the band edges over the 7 day duration of the tests.

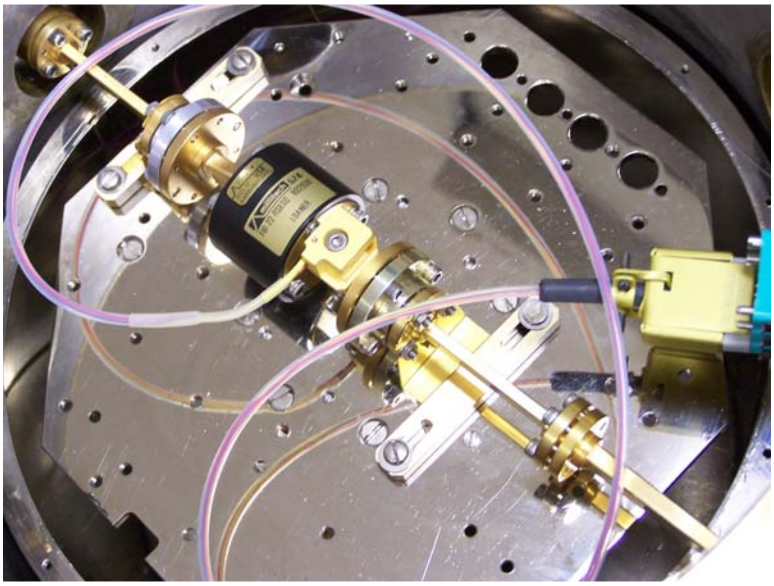
Note that when the isolator is cooled, the waveguide sections operate at a lower temperature than when the calibration was performed. This effect is mainly associated with the stainless steel waveguide sections. When the waveguides are cooled, their loss decreases by about 0.1 dB at 30 GHz, but is unchanged at 50 GHz. This results in about a 0.15 dB underestimation of the loss of the cooled isolator at 30 GHz, and a 0.1 dB underestimation of loss mid-band.

Isolator serial number 574 was cooled to 19 Kelvin once and isolator serial number 575 was cooled to 19 Kelvin three times. As we were not certain the isolators would operate successfully at cryogenic temperatures, the performance of the first isolator (serial number 574) was measured as it was cooled, at 250 Kelvin, 200 Kelvin, 150 Kelvin, 100 Kelvin, 77 Kelvin, 50 Kelvin and finally at 19 Kelvin. Fig. 2 shows the performance of this isolator at room temperature, as supplied by the manufacturer, and at 19 Kelvin.

Fig. 3 shows the performance of isolator serial number 575 at room temperature, as supplied by the manufacturer, and at 19 Kelvin after the third cooldown. The isolators were measured at room temperature after each cooldown and no significant change in performance was discernable. Fig. 4 shows the performance of isolator serial number 575 at room temperature after the third cooldown. The difference in S_{21} between Fig. 3(a) and Fig. 4 is less than the drift in the calibration, so these tests show there was no significant change in the performance of the isolator as a result of it being cooled down to 19 Kelvin and warmed up three times.

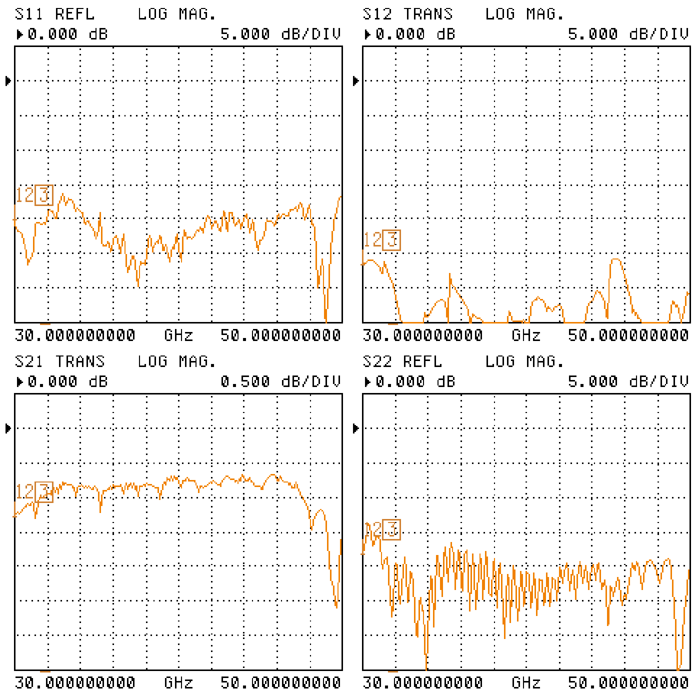


(a)

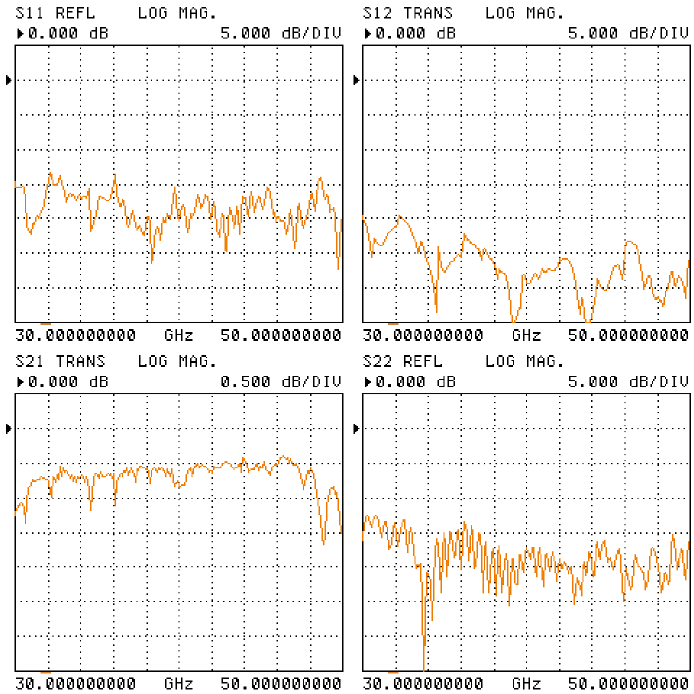


(b)

Fig 1 Measurement setup for cryogenic testing of isolator model FBI-22
(a) view showing test dewar and vector network analyser, and
(b) view showing detail of isolator and temperature sensor in test dewar.

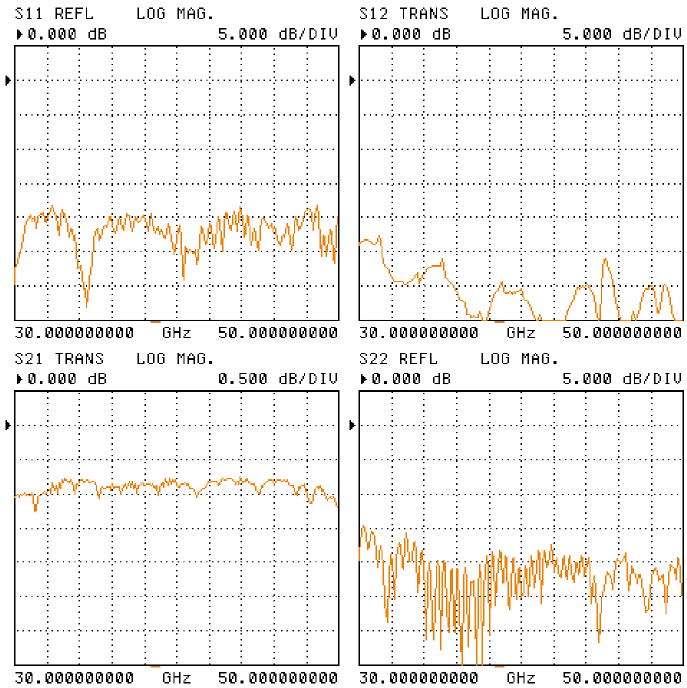


(a)

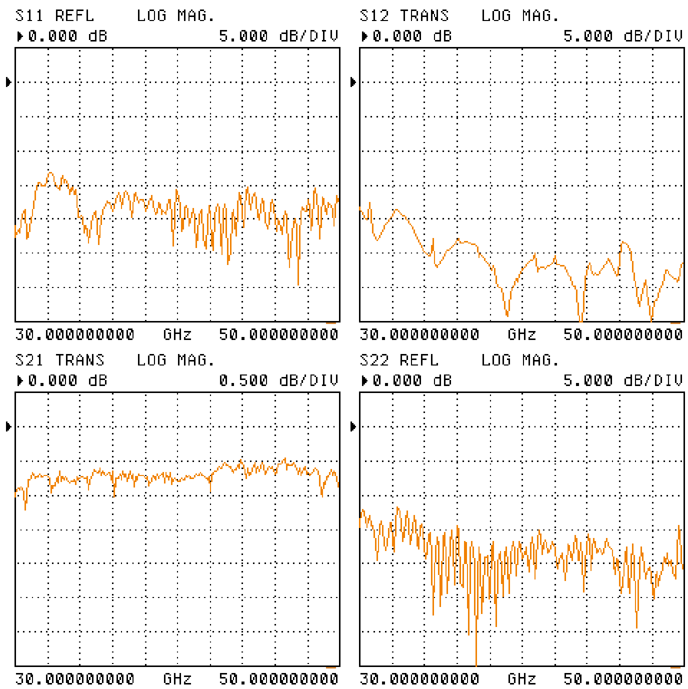


(b)

Fig 2. Isolator model FBI-22, serial number 574
(a) at room temperature, as supplied, and
(b) at 19 Kelvin.



(a)



(b)

Fig 3. Isolator model FBI-22, serial number 575
(a) at room temperature, as supplied, and
(b) at 19 Kelvin, after the third cooldown.

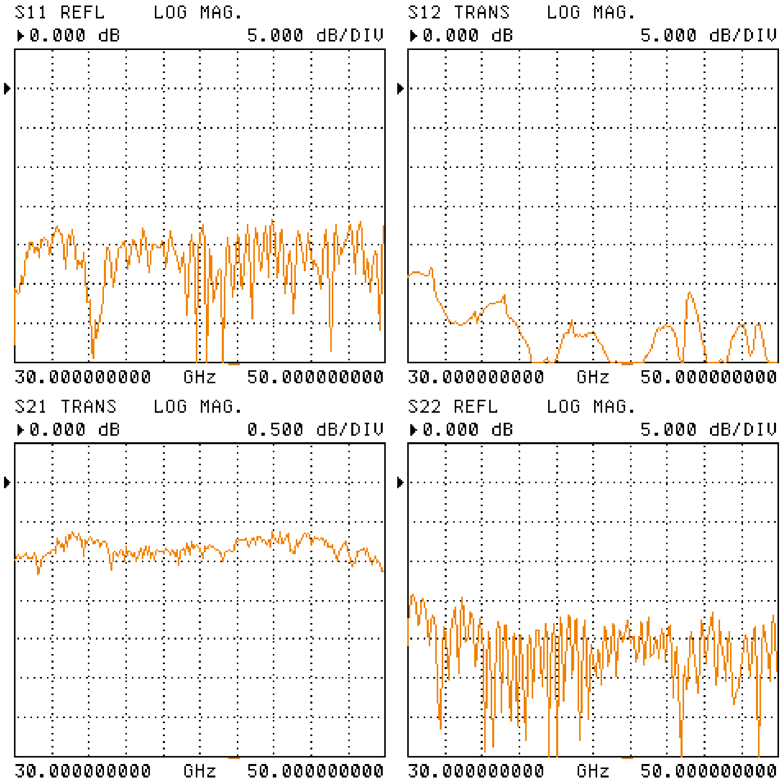


Fig 4. Isolator model FBI-22, serial number 575, at room temperature, after the third cooldown.