Tests of the Final ATA feed

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Abstract

This is a description of some Radio Frequency tests of a version of the ATA feed which is complete in all electromagnetic details. These are measurements of the input reflection coefficient and transmission coefficient to various standard antennas. The feed is found to operate over the band from 500 MHz to 14.5 GHz, somewhat wider than the original specification of 0.5 GHz -12 GHz. High spectral resolution transmission tests show there are nearly no resonant drop-outs either in the antenna itself or in the dewar cavity where the transmission lines to the LNA are located. One small resonance was found in one of the two polarizations at 9.3 GHz. The time gating provision of the HP 8722ES network analyzer allows a study of the reflection coefficient of the feed by itself and the reflection coefficient at the point where the LNA will be located. For the feed, the peak reflection over the 0.5 - 12 GHz band is -17.5 db, corresponding to a VSWR of 1.3. For the LNA location, the peak reflection is -10db. The additional reflection appears to be due to the junction between the balun and the following transmission line. -10db is quite adequate, although some effort may be put into slightly improving the match at the output end of the balun. A small reflection is also found due to the shortest standoffs of the feed. These could be removed.

1 Introduction

A version of the final feed has been constructed which is complete in all the electromagnetic details but without having the LNA installed. Thus, it contains the dewar, the feed tip circuit, the glass window to the dewar with its matching circuit, the transmission lines to the passive balun, and the balun up to the location of the LNA. In place of the LNA, a coaxial cable six feet in length connects to the outside of the pyramid. Both polarizations are brought out. The reflection coefficient is measured with an HP 8722ES network analyzer. transmission is also measured to a number of test antennas.

2 Transmission from the Antenna to Various Test Antennas

Figure 1 shows the transmission to a small spiral antenna that nominally operates over 2 GHz - 18 GHz. The figure shows that the feed and balun operate up to 14.5 GHz, significantly beyond the specification of 12 GHz. This is not surprising since neither the feed nor balun are resonant devices. In addition to the this wideband scan, the spiral has been used at higher spectral resolution for a search for transmission resonances. Figure 2 is an example of one of the scans which covers 1 - 4 GHz with 801 points, giving a resolution of about 3 MHz. Evidently there are no sharp resonant dropouts associated with either the feed or the dewar structure in this scan. In one polarization there are no dropouts in any part of the spectrum. In the other polarization there is one sharp but shallow resonance at 9.3 GHz. There is also a broad minimum of about 3 db depth at 5.3 GHz in both polarizations which is discussed below. The feed also transmits to a simple low frequency dipole down to 500 MHz.

3 Cross coupling Between the two Polarizations

The spectrum of transmission between the two polarizations shows a maximum of about -30db. This includes both the coupling between the two polarizations on the antenna and coupling between the two transmission lines in the dewar. The low value should permit good polarization measurements with the feed.

4 Input Impedance Measurements of the Feed

With a frequency scan over .05 to 12GHz comverted to a time delay echo measurement using the Fourier transform option, it is possible to measure separately the reflection coefficient of the separate components along the line and at the feed. The delay to the feed tip was measured by placing a razor blade across the feed tip and noting the spike in the scan. Introducing a time gate after the feed tip, and then turning off the transform shows the reflection coefficient of the antenna alone. This is shown in Figure 3. It is important to correct for the losses in the input cable. These were measured separately. The line in the figure starting at the -17.5 db level at .05 GHz and passing through the -23 db point at about 10 GHz shows the effect of the cable loss. This line should be viewed as the corrected -17.5 db reflection level. This level, corresponding to a VSWR of 1.3, shows that the antenna is an excellent match except for the region around 5.3 GHz. This point corresponds to a place on the feed where the feed standoffs closest to the tip are located. Both polarizations show the same effect, and it can be identified by placing one's figures on the feed at the standoffs. The simplest cure for this problem is to leave these standoffs off. Another possibility would be to try to find thinner standoffs. Either way the effect can be eliminated.

Figure 4 is a drawing of the region interior to the pyramid where the dewar is located. The dewar glass seal is located at 1.692 inches from the tip. In front of it at 1.129 and 1.419 inches are two teflon disks which improve the electrical match of the glass seal. The tip of the radiation shield is at 3.166 inches, and the transition between the transmission lines and the tip of the baluns is at 3.707 inches. The baluns end at 8.593 inches. Setting a gate at the end of the balun and then turning off the transform shows the spectrum of the reflection coefficient, S_{11}, as it will be seen by the LNA when it is in place. Figure 5 shows the spectrum of the reflection, at a maximum of about -10db. The cable loss correction is also included in this figure. -10db is a satisfactory input termination for the LNA, although we may try to lower it a little to perhaps -13db. It appears to be due largely to the transition between the input two wire transmission line and the tip of the balun, probably associated with the discontinuity between the glass balun and air.

Figure 1: A scan of the transmission between the ATA feed and a small equiangular spiral antenna that operates over 2 - 18 GHz. The ATA feed and balun evidently work all the way to about 14.5 GHz. This is just one polarization, and the other polarization looks essentially the same.

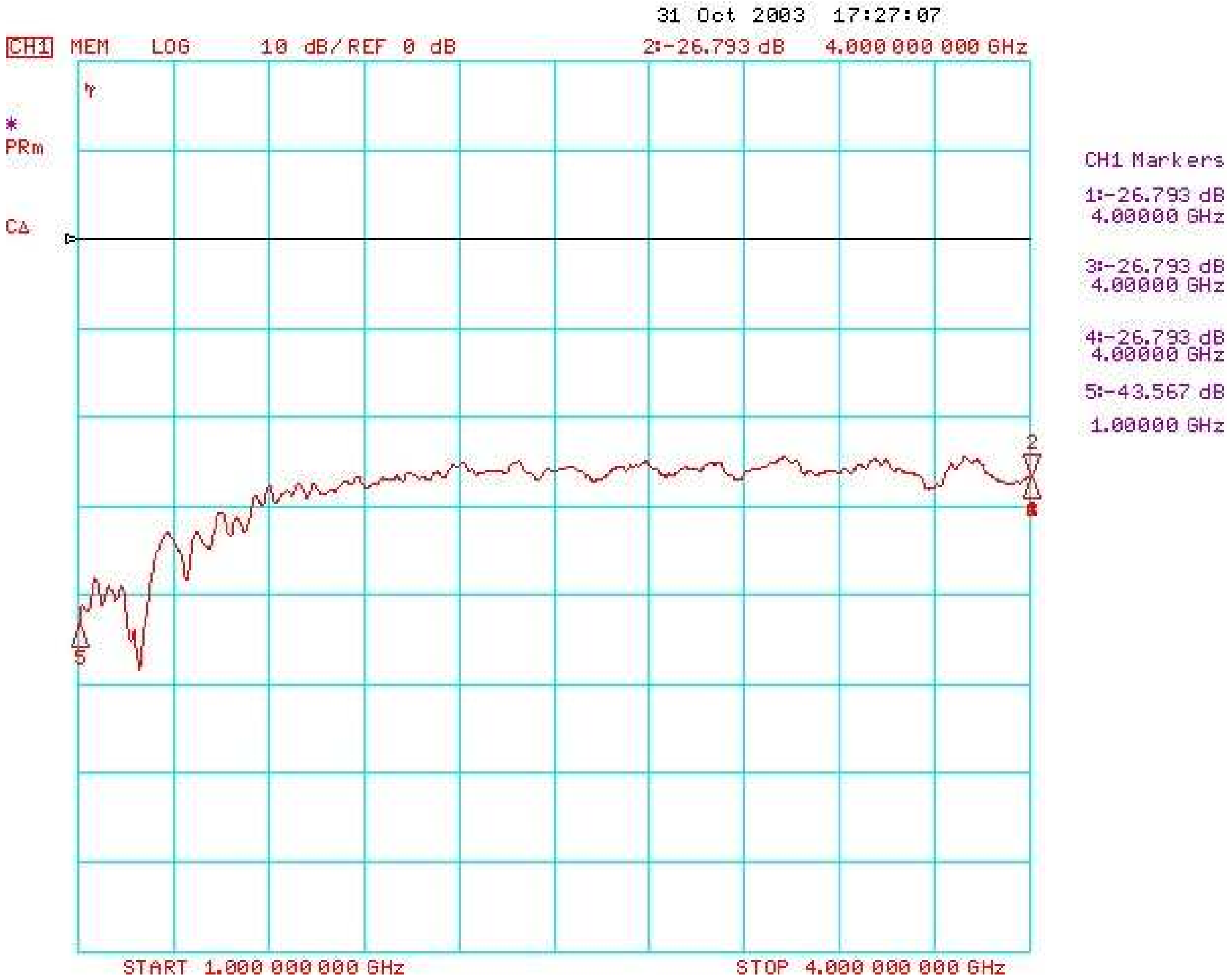

Figure 2: A high resolution scan of the transmission between the ATA feed and the spiral antenna: 1 - 4GHz with 801 spectral points. The spectral resolution is about 3 MHz, and no sharp resonant drop-outs are observed. Thus, neither the antenna nor the region of transmission through the dewar show any resonant transmission nulls.

Figure 3: Spectrum of S_{11} with a time gate placed just past the tip circuit board. This shows the input match of the antenna only. The solid line beginning at -17.5 db and dropping down to -22.5db at 8.4 GHz shows the correction for the round trip loss of the input cable. This line represents the corrected -17.5 db reflection level, the maximum level of reflection, except at 5.3 GHz, corresponding to a maximum VSWR pf 1.3. The excess reflection at 5.3 GHz is due to the the first set of standoffs on the antenna.

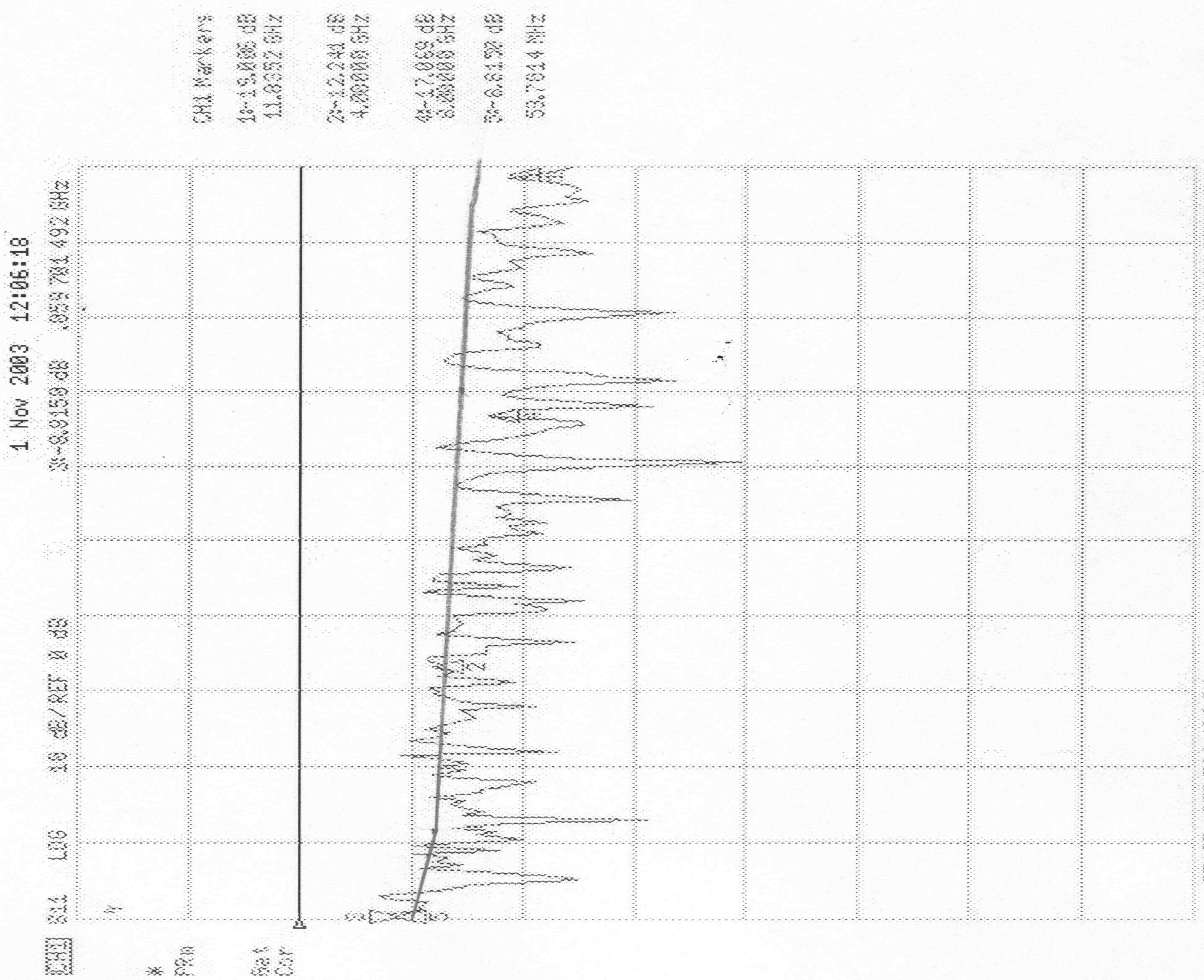

Figure 5: Spectrum of S_{11} with a time gate set for the location of the LNA to show the match faced by the LNA. The downs loping solid line represents the round-trip loss in the input cable, beginning at zero at the -10db line. It represents the corrected -10db level. The match is thus -10db or better as seen by the LNA.