AT/ 39.3/085

AT Subreflector Adjustment - Theory and Practice

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December 2, 1998

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1 Theory

The subreflector assembly is shown in figure 1. The subreflector has a space frame bolted to the back surface. This frame is attached to the quadrupod with three structural elements :

- The Jack. This controls the axial position of the subreflector.
- The Lower Cables. These play the major role in controlling the lateral position of the subreflector in the focal plane.
- The Upper Cables. These control the tilt of the subreflector and contribute about 10% to the lateral position of the subreflector.

The adjustment procedure needs to vary the cable lengths so that the subreflector's axis of symmetry coincides with the main reflector's axis.

The axial position of the subreflector varies with observing frequency; the focussing range is from -20mm (for 2.5 GHz observations) to +20mm (for 4.0 GHz observations).

2 Practice

2.1 Cable Tension

The essential requirement is that the cables always remain in tension. This means that with the antenna at the zenith the tension in the Lower Cables should be a bit larger than 25% of the subreflector weight which is $\sim$ 200 kg. I suggest aiming for 75 kg.

The load on the Upper Cables is rather less. 25kg would be a reasonable target.

The upper limit to the cable tension is set by the jack capacity. The cables stretch as the subreflector moves away from the neutral focus position; more importantly, an axial load is developed on the jack since the cables are no longer at right angles to the axis.

The cable parameters are listed in Table 1

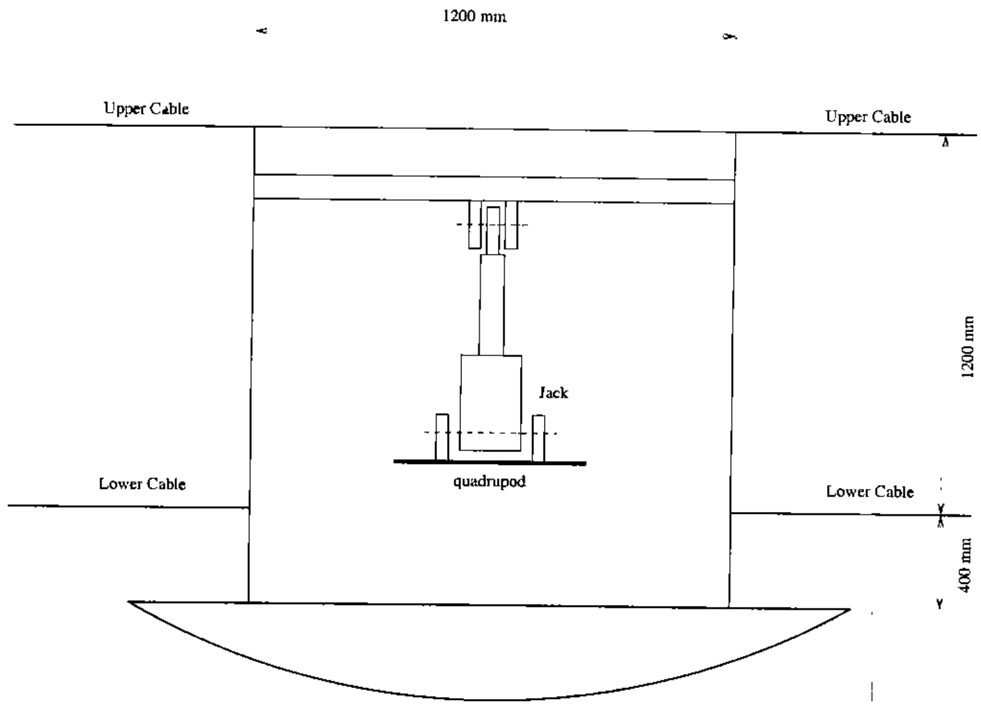

Figure 1: The subreflector assembly - see EDE drawing BI-6471-117-002

Young's Modulus	$2.10^6 kg/cm^2$
cable diameter	10 mm
cable length	920 mm
effective spring constant (k)	1700 kg/mm
total length (cable + ferrules)	1250 mm

Table 1: The cable details - see EDE drawing BI-6471-117-002

The maximum cable extension, at the +/- 20mm focus limits, is 0.16mm which implies a tension increase of 270kg. The inclination of the cables to the focal plane at these limits is :

$$\tan(\zeta) = \frac{20}{1250}$$

$\zeta = 0.9$ degrees. The axial load contributed by each cable is

$$F_{axial} = Tension * \sin(\zeta)$$

The total axial load of the cables at the focus limits is thus

$$L = 16 * Tension * (20/1250)$$

or about 80 kg for the suggested loading. For reference, the subreflector weighs about 200 kg.

There is no strong case for symmetry in the cable tensions. If the jack is correctly installed on axis, then there will be a tendancy for the cable tensions to equalise. A distinct lack of symmetry in the cable tensions may be an early indication that the jack is off-centre.

We noted, at Mopra, that the subreflector remained correctly aligned at all axial focus settings even when the tensions were not all equal.

2.2 Jack Location

The jack should be installed so that its axis is parallel to the subreflector's axis of symmetry. There are upper and lower pivots in the jack assembly, both pivots parallel to the elevation axis; this means that the installation precision requirements are modest in the N-S direction (normal to the elevation axis). Matters are a bit more serious in the E-W direction: there is a spherical bearing at the upper pivot, but no relief at the lower pivot. There are two areas of concern:

- The base of the jack may be shimmed incorrectly, leaving in the jack's axis at an angle to the reflector axis. Extension of the jack will push the subreflector sideways, subject to the jack's torque limits.

- There is just a limited amount of freedom in the jack pivots for subreflector movement E-W; Once that slack is taken up, the jack will be subjected to considerable sideways forces, and may bend or bind.

2.3 Adjustment strategies

- Is the subreflector tilted? The machined rim of the subreflector is probably the best guide here: measure the distance between the rim and the inner edge of the inner ring of panels. If the distance is constant all the way round the subreflector, then the subreflector's axis is closely parallel to the axis of the main reflector. We were able, at Mopra, to read these distances to an accuracy of 1 mm.
- Subreflector tilt adjustment. Dial gauges can be placed to monitor the position of the subreflector rim. These provide an accurate guide as the upper cables are adjusted.
- Is the subreflector centred? The first estimate should come from the distances between the subreflector rim and the survey targets on the outer ring of panels. We able to measure these distances to an accuracy of a few mm. The real test for this positioning must come from the beam pattern measurements - the sidelobes should be symmetrical.

- Is the jack aligned with the optical axis? The essential requirement is that the subreflector's axis remain aligned with the main reflector's axis throughout the entire focussing travel. This can be checked with dial gauges monitoring the upper surface at the subreflector rim.

  A keen eye is probably adequate to position the jack; a more sophisticated procedure would take the antenna to the zenith, place the subreflector frame on blocks. The jack could then be released; allow it to hang freely, then tighten carefully after gently taking up some load on the jack.

3 Mopra Results

The distance "subreflector rim - inner ring of panels" is constant to within 1 mm.

The subreflector axis is within 2 mm of the main reflector axis (ie, the positioning in the focal plane).

The subreflector tracks axially with no detectable wobble.

The 80 GHz coma lobe is essentially undetectable.

3.1 Deformation of the subreflector frame

We have observed that on all the CA antennas the subreflector moves away from the vertex by ~ 1 mm as the antenna tips from the zenith to the horizon. Much of this effect is due to a deformation in the beam which connects the jack to the subreflector mounting frame.

3.2 Lateral movement of the subreflector as the cables stretch

The cables will stretch by

$$\Delta x = \frac{W/4}{k} = \frac{50}{1750} = 0.3mm$$

as the antenna tips from the zenith to the horizon.

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