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GMRT mechanical system: present status and future plans

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Abstract. An overview of mechanical systems of the GMRT, their main features, current status and future plans are presented here.

Keywords : Radio Antenna, parabolic dish, GMRT

1. The mechanical system of the GMRT: introduction and overview

The GMRT (Swarup et al. 1991) is an aperture synthesis array, consisting of 30 fully steerable antennas of 45 metre diameter. Instead of solid panels, a wire mesh reflector is used to reduce weight and cost of the dishes. The antenna structure was designed to maintain a low deflection of the dish at all elevation angles. The mechanical drive system allows the antennas to point to and track sources, maintaining the required accuracy. Specific system details are as follows:

Antenna structure: The GMRT Antenna is a alt-azimuth mounted dish (Fig. 1a) having a paraboloid reflector supported by 16 Parabolic Radial Frames (PRFs), connected to a hub at the centre and a rim at the periphery (Tata Consulting Engineers 1990). The hub is connected to a cradle which is connected to the two elevation bearings held by the yoke horns, for rotation about the elevation axis. The yoke is mounted on the inner ring of the azimuth slew ring bearing, for rotation about the azimuth axis. The outer ring of the azimuth bearing is bolted to the RCC tower.

Reflector: It is a welded wire mesh of stainless steel wires (Φ = 0.55 mm). The mesh size is matched to the wavelengths of operation and varies in 3 steps (10x10, 15x15 and 20x20 mm) from the inner to the outer parts. The mesh is stretched over a

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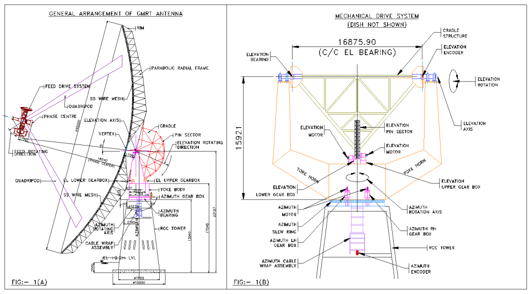

Figure 1.

rope truss which is a grid of wire ropes laid in radial and circumferential directions, interconnected at nodal points, and mounted on the PRFs (Fig. 2b). The PRFs (whose top chord is a parabola, Fig. 2c) and radial ropes gives curvature in the radial direction. The rope truss is pulled at the nodes to give curvature in the circumferential direction. By this arrangement, we get a series of plane facets which approximate a paraboloid, with rms error 10 to 20 mm. This scheme known as SMART (Stretched Mesh Attached to Rope Trusses), is a unique feature of the GMRT, and allows a very low solidity ratio (0.05 - 0.11) to be achieved. This reduces weight and wind load of the reflector, thereby reducing size and weight of the backup structure, and results in drive units of much lesser rating.

Mechanical drive system: This steers the antenna in the Azimuth and Elevation axes, for slewing as well as tracking operations. DC Servo motors with fail safe electromagnetic brakes coupled with speed reduction gearboxes are used for driving the antennae. By default, the brakes are applied, and are released for antenna movement. The elevation drive system consists of a pin type bull gear mounted on the cradle and driven by two pinions. When the pinions rotate, cradle and dish rotate around the elevation axis. The azimuth drive system has a bull gear (outer ring of slew ring), driven by two pinions, mounted on the yoke. While rotating on their axis, the pinions go around the bull gear on a planetary configuration, making the yoke (and dish) rotate in azimuth. For both the axes, the two drive pinions are coupled with a common bull gear which exerts torque in the opposite direction. This ensures both the pinions are always pressed on the bull gear teeth, thereby eliminating backlash in the drive system: in the no load condition, the torques are equal and opposite and the antenna does not move; for a change in load in a given direction, one motor increases its torque while the other reduces its torque by the same amount, which produces a net torque causing the antenna to move. The counter torque arrangement of the servo system calculates and ensures the necessary torque for both the motors independently. A cable wrap arrangement is provided to avoid cable damage during rotation. Limit switches are provided to stop antenna movement when operational limits are exceeded.

Feed drive system: Four feeds are mounted 90 degrees apart on a rotating feed turret at which is rotated by a feed gearbox and induction motor drive. When a particular

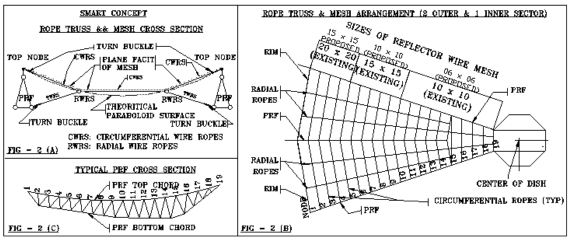

Figure 2.

Table 1. Technical specifications of the GMRT antenna.

1	Aperture/Focus distance	1590 m^2 / 18540 mm
2	Feed support/Feed Types	Quadripod / Feeds: 150, 610/233, 327 & 1420 MHz
3	Steerability	Azimuth : +/- 270^o; Elevation : $+15^o$ to 110^o
4	Azimuth Speed	Track : 150 arcmin/min to 5 arcmin/min; Slew : 30^o/min
5	Elevation Speed	Track : 15arcmin/min to 5arcmin/min; Slew : 20^o/min
6	Slewing speed	Azimuth : 30^o/min ; Elevation : 20^o/min
7	Total gear reduction ratio	Azimuth : 18963; Elevation : 25162
8	Peak Torque (1:1 axis)	Azimuth :80100 kgf.m; Elevation : 74000 kgf.m
9	Mesh size (mm)	Inner 1/3 :10x10; Middle 1/3 :15x15; Outer 1/3:20x20
10	Safe Wind speed	Track : <= 40 kmph; Slew : <= 80kmph; Survival : 133kmph
11	Tracking accuracy	1 arc min/min (wind < 20 kmph)
12	Total Weight on tower	122 MT

feed is positioned at focus, its phase center coincides with the focal point. Limit switches prevent excess rotation. and an incremental encoder (1 arc-sec) is provided for feed positioning.

Operation & Maintenance: Checking and maintenance of the drive system components, limit switches, gearboxes etc. is carried out periodically. Corrosion in the structural elements and health of the painting are checked at regularl intervals and corrective action is taken as and when required. After 15 years of service, the gear box replacement has become essential. New gearboxes and spares (for both axes) have been developed, using local vendors within the country. These are presently under trial.

2. Future plans

As part of the upgrade of the GMRT (Gupta, this volume), several improvements are envisaged for the mechanical system:

Antennas structure and surface improvements: Corrosion damage is a major source of problems. Work is underway to rectify / replace those pipe members of the antennae structure where corrosion damage is significant. To reduce corrosion problems for the future, it is proposed to upgrade the painting scheme with a 350 μ

DFT Epoxy + PU system. It is also planned to replace the damaged or corroded P3 items (turnbuckles, wire rope, angles, mesh etc) and improve the reflecting surface for 5 of the worst affected antennas in the 1st phase and then review the process and decide about the remaining antennas. It is also proposed to implement an improved design for the counterweights to achieve better antenna balancing and uniform loading of the drives.

Reducing reflecting surface error by denser wire mesh: It is proposed to explore the option of replacing the existing mesh by a denser mesh to increase the antenna efficiency (due to higher reflectivity of mesh and lower ground radiation leakage) at higher frequencies (L-Band and higher) (Swarup 2011). This needs a careful study of increase in wind load due to the denser mesh, and the ability of the backup and drive structure to handle the same. Detailed studies for this are on at present, including accurate estimates of the coefficient of drag for various proposed geometries.

Improvements in the drive systems: A feasibility study will be carried out for replacing the existing pin type elevation bull gear by a spur gear to reduce pinion wear and increase the performance accuracy. A prototype will be manufactured and tested. For the feed positioning system, a new backlash free gearbox with a higher torque rating), alongwith a 5:1 backlash free encoder gearbox (for more accurate reading) is being developed and is presently under testing. This will increase pointing accuracy also allow us to use heavier feeds in the futur. An alternate arrangement using a linear encoder is also under consideration.

Improvements of Machinery & Equipment: In addition to regular upgrading of the machinery and equipment, it is proposed to build an additional workshop, a little bit away from the observatory, to enhance manufacturing capabilities without increasing interference effects. Two new High Lift Platforms have recently been procured, and the older ones will be refurbished to give better support for maintenance and upgrade activities.

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