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Broadband feeds, frontend and fiber optic systems for the uGMRT

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Abstract. We present an overview of the broadband feeds, high dynamic range frontend systems and DWDM based fiber optic system being designed for the upgraded GMRT. The main features, current status of the work, and future plans are described.

Keywords : GMRT upgrade – Antenna Feeds – Frontend Receivers – Fiber Optics

1. Introduction

The GMRT (Swarup et al. 1991) has served the global radio astronomy community for over a decade now, producing several interesting results. The GMRT is presently being upgraded (Gupta, 2014) to have a seamless coverage from 50 MHz to 1500 MHz (instead of the spot coverage at 5 different RF bands), with an increase in the instantaneous bandwidth from 32 to 400 MHz. The upgraded GMRT (uGMRT) bands currently being implemented are (i) 130−260 MHz (ii) 250−500 MHz, (iii) 550−900 MHz and (iv) 1000−1450 MHz. Octave width wideband antenna feeds and broadband, high dynamic range frontend systems are being designed and built for each of these bands. A wideabnd signal transport system that can bring back the entire DC - 2 GHz analog signal directly from frontend system to the central receiver building is being implemented.

2. Antenna feeds and frontend systems for the uGMRT bands

The 130−260 MHz band: The antenna feed for this band, which will replace the existing narrow band systems at 150 and 235 MHz, is a cross dipole over a plane

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reflector with a dual beam forming ring design (Fig. 1), which is an modified version of the basic Kildal feed design with single ring (Bhandari et al. 2013). The frontend system uses a two stage HEMT low noise amplifier (LNA) with an improved noise temperature (Raut et al. 2013), with a wireline quadrature hybrid. The configuration has a system temperature of 407 K at 150 MHz, and a total bandwidth of 130 MHz, with a notch filter to reject a nearby TV transmitter at 175 MHz. Two antennas have been fitted with these upgraded units for detailed testing and evaluation, and the system is currently pending finalisation for mass production.

The 250−500 MHz band: The feed for this band, which replaces the existing narrow band system at 327 MHz, consists of a triple sleeved cross dipole placed inside a 70 degree conical reflector (Fig. 2). The frontend uses a commercial broadband polarizer with a HEMT based LNA. The upgrade gives a system temperature of 90 K at 327 MHz, and a 250 MHz bandwidth (compared to 110 K and 40 MHz at present). It has 4 sub-bands with ∼ 100 MHz bandwidth for narrow band applications, alongwith notch filters for rejecting nearby TV tranmitters at 175 and 540 MHz. This system has cleared the prototyping stage and has been installed in 10 antennas.

The 550−900 MHz band: This will replace the current narrow band system at 610 MHz. A cross dipole with a circular sleeve, placed in a conical reflector, is one candidate designs being evaluated; the other is a horn feed designed by the CISRO group. The frontend uses a HEMT based LNA with a commercial polarizer, which gives a somewhat lower system temperature than the present 101 K at 610 MHz. The final design is expected to provide 350 MHz bandwidth (compared to 90 MHz maximum possible with the existing system), and will also have 4 sub-bands of ∼ 100 MHz bandwidth for narrow band applications, alonwith notch filters with sharp cut-off for rejection of the TV line at 540 MHz and mobile phone band near 900 MHz.

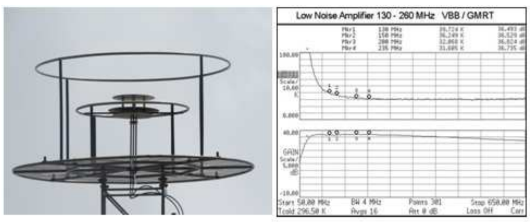

Figure 1a. (130-260 MHz) Feed Figure 1b. (130-260 MHz) LNA Performance

Figure 1. Details of the 130−260 MHz broadband receiver for the uGMRT.

Common, new features of the uGMRT frontend systems: The upgraded frontend systems are broadband (octave bandwidths with switchable sub-band filters) with higher dynamic range than existing (typically ∼ 8-10 dB better), with well designed filters for rejecting known sources of RFI. They are being designed with improved noise injection facilities for calibration purposes, Walsh modulation scheme for reject-

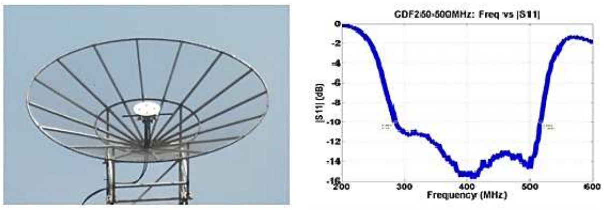

Figure 2a. (250-500 MHz) Cone with cross dipole feed Figure 2b. Feed return loss performance over the band

Figure 2. Details of the 250-500 MHz broadband receiver for the uGMRT.

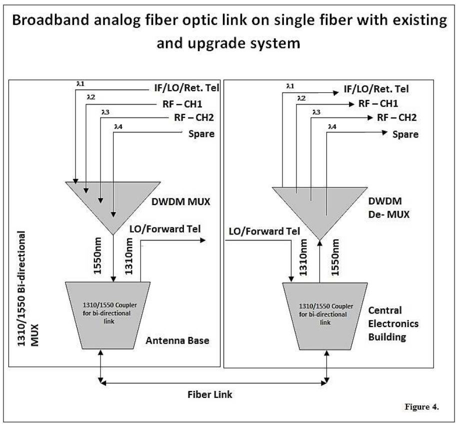

Figure 3. Block Diagram of the Optical Fiber link for the uGMRT.

ing common pick-up of signals, and RF power and temperature monitoring facilities for maintenance and health checks of the system.

3. Fiber optics based signal transport system

The fiber optic system for the GMRT is being upgraded with a DWDM based broadband analog fiber optic links to meet the needs of the uGMRT, while continuing to support the existing GMRT system (figure 3). For the return link from the antennas, the design uses 4 wavelengths multiplexed on a single fiber : two channels carry the broadband RF signal from the uGMRT frontends; the third channel is used to support the IF and telemetry signals of the existing GMRT system; and the fourth channel is available as a spare for future expansions.

The upgraded system supports upto 3 GHz analog bandwidth with a RF gain of 38 dB and has a compression dynamic range of 60 dB, for an instantaneous bandwidth of upto 400 MHz. The DWDM scheme uses a DFB laser with low RIN noise, with an APC for constant optical power and a Peltier cooler to provide constant operating temperature. The optical receiver is a PIN diode with built in transimpedance amplifier of 20 dB gain, designed to operate at a constant optical power of -5 dBm, irrespective of the link distance, and has additional margin to support any unexpected increase in link loss.

The RF interface unit splits the incoming RF signal from the antenna into two copies. One is connected to the narrow band receiver chain of the existing GMRT; the other to the DWDM system, without any IF conversion. The forward link required for telemetry is provided using a 1310 nm wavelength on to the same fiber, in bi-directional mode. The second fibre available between each antenna and the central building is used for implementing a bidirectional 1 Gbit ethernet link for supporing the new monitor and control system being designed for the uGMRT.

4. Conclusions

The work for design and implementation of wideband feeds and high dynamic range frontend systems, alongwith wideband optical fiber signal transport links for the upgraded GMRT, is well underway. The 1000−1500 MHz band is completed for all antennas, the 250−500 MHz band is in mass production with installation completed for 10 antennas, and the 130−260 MHz and 550−900 MHz bands are in final stages of evaluation of the prototypes. Features like sub-band filters, notch filters, noise injection, Walsh modulation, RF power and temperature monitoring are an integral part of these new designs for the uGMRT. A DWDM base broadband analog fiber optic link (that also supports the functioning of the existing GMRT systems) alongwith a bi-directional ethernet link to each antenna, is in mass production with 17 antennas completed. These upgraded activities, when completed, will make the GMRT a much more sensitive and versatile instrument.

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