Current Status of the GMRT : Receiver Systems

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Abstract :

We present the specifications, design and performance details of the existing GMRT receiver system. The GMRT operates in five frequency bands between 130 MHz and 1500 MHz with uncooled low-noise receivers and maximum instantaneous bandwidth of 32 MHz in dual orthogonal polarizations. The signals from the 30 antennas are transported to the central building using optical fibers. The baseband converted signals are digitised and converted to 256 spectral channels in the digital backend, in which a FX correlator (for interferometry) and array combiner followed by a pulsar receiver (for pulsar observations) are the main constituents.

1 Summary

The Giant Metrewave Radio Telescope (GMRT), set up near Khodad, approximately 80 Km north of Pune in India, is a frontline observing facility. It consists of 30 antennas of 45 metre diameter each, arranged in an approximately Y-shaped layout, with 12 antennas in a closely spaced configuration within a 1 Km X 1 Km square and the remaining 18 antennas located along the three arms of the "Y". Each antenna is connected to the central receiver building via a pair of optical fibers which bring back the astronomy signal from the antenna, and also carry the control and telemetry information to and fro from the antenna. Presently the GMRT is operational at five Frequency bands: 130-230 MHz, 215-255 MHz, 305-345 MHz, 580-640 MHz and 1000-1450 MHz. For each of these bands, the GMRT uses a superheterodyne receiver architecture to process the faint astronomical signals, providing high sensitivity and dynamic range. In this paper, we describe the details of the receiver system for the GMRT.

The feeds and RF electronics are located on the four faces of a rotating turret at the focus of the parabolic reflector of each GMRT antenna. For 130-230 MHz and 305-325 MHz, dipoles are used as feeds, while dual co-axial waveguide feeds are used for the 215-255 MHz and 580-640 MHz bands. Corrugated horns are used for the 1000-1450 MHz band. The 1000-1450 MHz band has been split into four sub-bands centred at 1060 MHz, 1170 MHz, 1280 MHz, 1390 MHz, each with a bandwidth of 120 MHz. The lower frequency bands provide dual orthogonal circular polarization channels as the final output, while the 1000-1450 MHz provides dual linear polarization outputs. The RF Front-End electronics at the prime focus includes uncooled low noise amplifiers (LNAs), calibrated noise injection and band selectors. Two low loss phase stable coaxial cables are used to bring the RF signals down to the dish base.

A coherent local oscillator at the dish base converts the RF signals in each polarization channel to an intermediate frequency (IF) centred at 70 MHz. Surface Acoustic Wave (SAW) filters are used at the IF stage to select any one of the bandwidths among 5.5MHz, 16 MHz, 32 MHz. The IF signals are then translated to 130 MHz and 175 MHz (for the two polarizations). All local oscillators used in the frequency conversions are synthesised from the reference signals derived from the Master Time & Frequency Reference. This reference standard is located at the Central Electronics Building (CEB) and distributed to each antenna through the forward optical fiber link.

The two IF signals are transported to the CEB using return fiber-optic links. The analog forward and return fiber-optic links consist of direct intensity modulated laser diode transmitters and PIN photodiode receivers operating at a wavelength of 1300 nm. A total length of about 67 Kms of single-mode optical fibers have been laid at the GMRT, for connecting all the antennas to the CEB.

At the CEB, the IF signals are further downconverted to Baseband (BB) frequencies, finally providing two sidebands (Upper & Lower) of maximum 16 MHz bandwidth, for each polarization channel. There is also a facility to select bandwidths from 62 KHz to 16 MHz in each sideband.

The signals are then digitised, delay compensated and passed through ASIC based FFT engines to generate 128 spectral channels for each sideband. There are various digital backend options available for processing the FFT output. Of these, the main system is the FX correlator which is used for all interferometric work, continuum as well as spectral line observations. The GMRT also supports an array mode of observations, where the spectral data from the FFT output of each antenna is sent to the GMRT Array Combiner which provides coherent and incoherent array outputs for any set of selected antennas. Each of these is connected to a DSP based pulsar receiver which provides data at time and frequency resolutions useful for pulsar observations. Full polarimetry output is available from the pulsar receiver, for the phased array mode of operation.

Various initiatives have been taken in the past few years to minimise the effects of Radio Frequency Interference (RFI) to GMRT data. Efforts to strengthen the elecrical distribution network, to fix the unstable television booster amplifiers and coordinate with cellular mobile operators have yielded good results.