The Omnidirectional RFI Monitoring System of GMRT

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Abstract: RFI is a major concern at GMRT and there are number of tools for studying interference. We describe here an omnidirectional RFI monitoring system (ORMS) that has been recently developed. It consists of 4 log periodic antennas (LPA) pointing to the east, west, north and south directions mounted on a tower at a height of 20m. The RF spectrum in the four directions is recorded sequentially. Software tools have been developed to display the data and estimate the direction of the incoming RFI.

Introduction: The radio astronomy community is facing a serious problem of frequency protection for scientific observation. Although a lot of the progress has been made in radio observation technology, the radio environment is deteriorating and we stand virtually at the same place facing new RFI problems and trying to find some solution. The GMRT (Giant Meter-wave Radio Telescope) though located in a remote location is still facing these difficulties. Radio interference recorded over the year 2001-2002 in the 150, 233 and 327 MHz bands clearly indicate the problems from artificial RFI is worsening.

Hardware details: Fig.1 shows basic hardware of ORMS. A radiation pattern in the E-plane at 150 MHz is shown in Fig. 2.

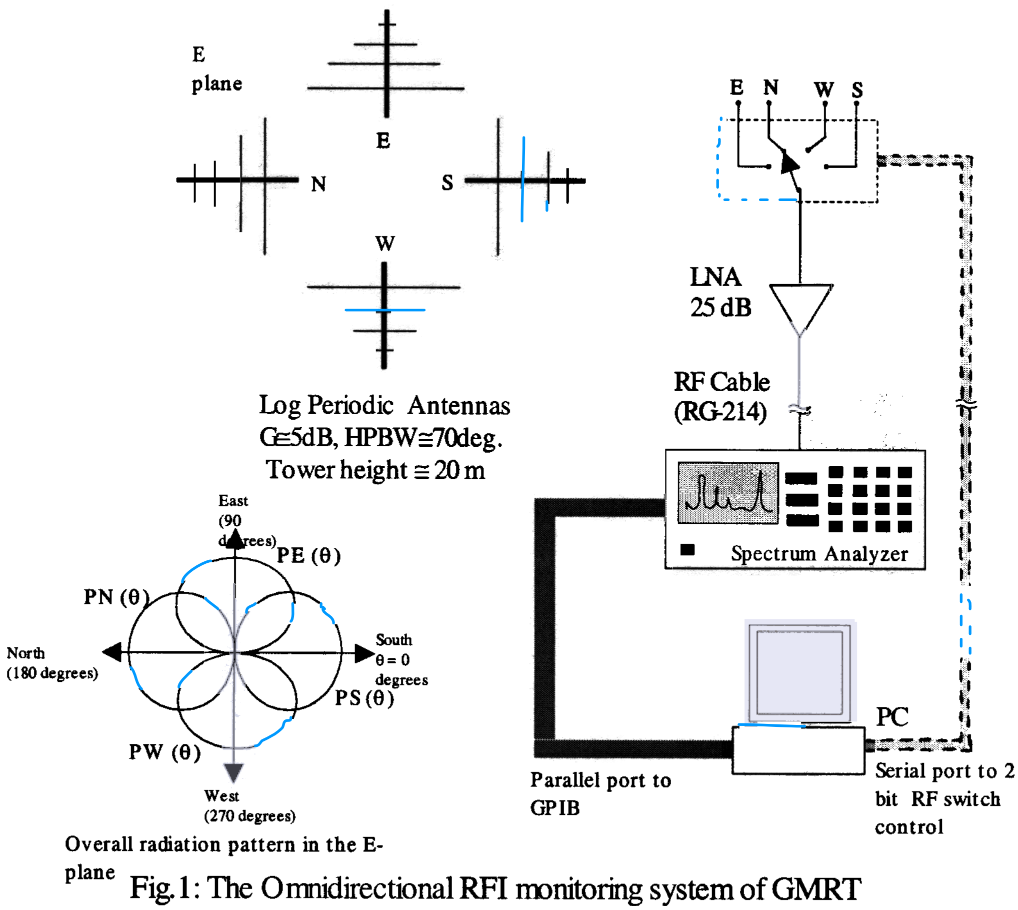

Fig.1: The Omnidirectional RFI monitoring system of GMRT

Hardware details: Fig.1 shows basic hardware of ORMS. A radiation pattern in the E-plane at 150 MHz is shown in Fig. 2.

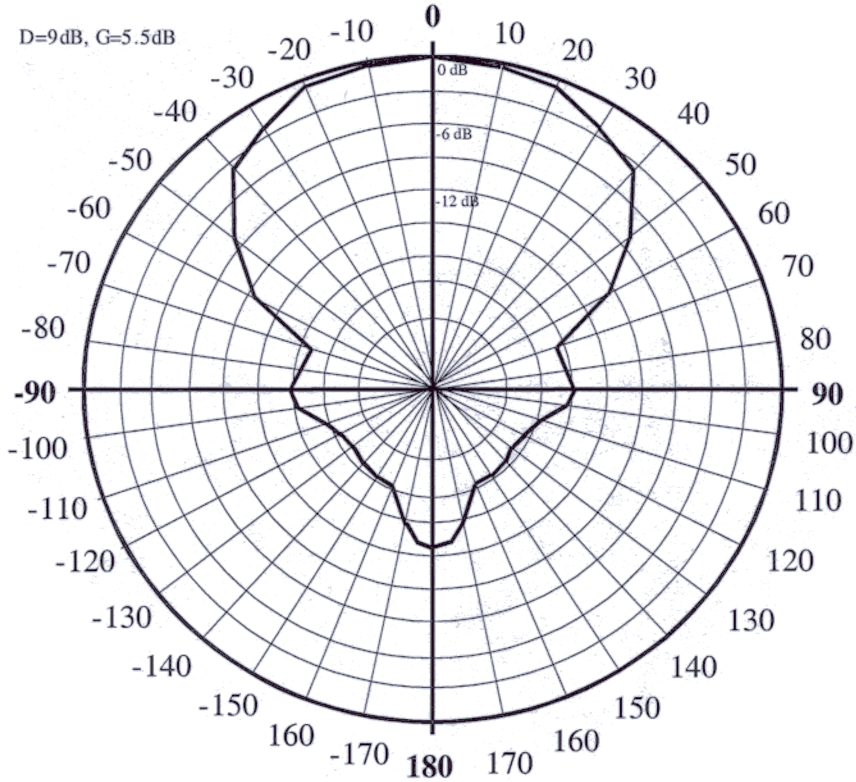

Fig.2: E-Plane radiation pattern at 150 MHz of the LPAs used in ORMS

The rest of the RF characteristics are listed below:-

Antenna characteristics:

Frequency (MHz)	***Gain (dB)***
150	5.67
233	4.7
327	4.2
610	4.4

RF switch:

RF Switch type	*Manufacturer*	*Model no.*	*Insertion loss (dB)*
SP4T	Mini Circuits	ZSDR-425	1.1

LNA:

Model No.	*Manufacturer*	*Avg. Gain (dB) measured*	*Noise Fig. (dB)*
ZFL-1000LN	Mini Circuits	25	2.9

Spectrum Analyzer: HP 8590 L

RF Cable: An RF cable (RG-214) of 100 m length is connected after the LNA to the spectrum analyzer. The cable loss is listed below:

Frequency(MHz)	*150*	*233*	*327*	*610*
Cable loss (dB)	1.4	2.2	2.9	6.1

System: The LNA receiver temperature is calculated as 754 K. 75% of the antenna beam faces the sky and the rest faces the ground.

Frequency (MHz)	*150*	*233*	*327*	*610*
Sky temperature (K)	308	99	40	10
Antenna temperature (K)	306	149.25	105	82.5
System temperature (K)	1062	903	859	836.5

Sensitivity: Minimum resolution bandwidth = 3 KHz.
Minimum receptable signal by the spectrum analyzer = -125 dB
S = (4 π Pin)/(G λ^2) ....(1)
Pspec = (Pin Gamp)/(Lswitch Lcable) ....(2)

where,

S = Power flux density per unit area appearing at the antenna.
Pin = Power appearing at the antenna terminals.
G = gain of the antenna (frequency dependent).
Pspec = Power reaching the spectrum analyzer
Gamp = Gain of the LNA (almost constant over 30 – 1000 MHz).
Lswith = Insertion loss of the RF switch (nearly constant over 30 - 1000 MHz).
Lcable = Loss of the RF cable (frequency dependent).

Frequency (MHz)	*150*	*233*	*327*	*610*
S (mW/m^2)	2.68 10^-15	1.14 10^-14	3.6 10^-14	1.9 10^-13

Software: There are two types of software; one for operating the system and the other for analysing the data.

System operating software: The output from the antennas are multiplexed using a computer controlled RF switch followed by an LNA and the signal is fed to the spectrum analyzer through an RF cable of 100m length. The spectrum analyzer is also controlled by the same PC using a printer-port to GPIB conversion software. The PC also participates in data dumping by the spectrum analyzer and its storage.

Spectrum analyzer control through GPIB (Printer port GPIB communication software):

Most of the computers available today have a bidirectional printer port. The GPIB has 3 control bits which are connected to 3 control lines of the printer port. The 8 data lines of the GPIB is mapped 1:1 by the printer port data lines. The end or identify (EOI) line of the GPIB is connected to one of the five status lines of the printer port. The actual operation is software based which functions in the following manner:

Initialization: The PC identifies and initializes the connected device (Spectrum Analyzer).

Writing string into the device: The PC writes the command strings into the Spectrum Analyzer's buffer.

Get data string from the device: When the Spectrum analyzer indicates that the data is ready the PC reads this data from the buffer in the form of a strings.

The first step is executed once at the start. Later the second and the third steps follow each other till the data acquisition is complete.

SP4T RF Switch controller:

The SP4T switch requires two TTL inputs for port selection, viz.00-East, 01-West, 10-North, 11-South. The DTR (Data Terminal Ready) and RTS (Request to Send) bits in the modem control register of the UART of a serial communication port of a PC can be held in 0 or 1 positions. Since the output of a serial port is RS-232, the voltage levels are converted to TTL first before sending it to the switch.

After one set of data collection through GPIB

The overall system operation through software is shown in figure 3.

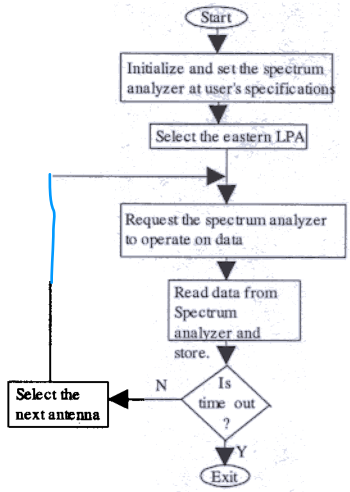

Fig 3. flow chart for system operation

Data analysis software: Fig.4 shows the basic flow chart of the data analysing software.

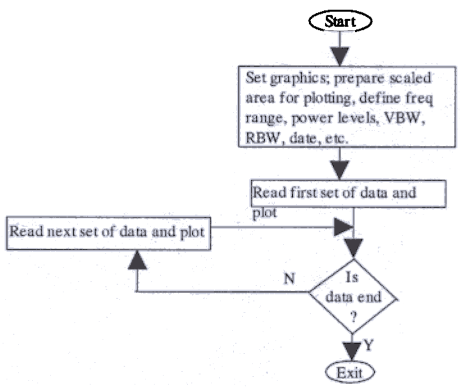

Fig 4. flow chart for data analysis

RFI Direction finding: The actual direction of the incoming signal is obtained from some algorithms based on the radiation patterns. The entire azimuth angle can be divided into four quadrants, viz. E-N, N-W, W-S and S-E. Let the normalized radiation patterns of the east, west north and south antennas be expressed as a function of azimuth angle θ , viz. $P_E(\theta)$, $P_W(\theta)$, $P_N(\theta)$, $P_S(\theta)$. The ratio of the radiation pattern of adjacent antennas falling in a quadrant for the 150 MHz is shown in fig.5.

To detect the direction of an RFI line, the power levels are various antennas are compared first. The antenna pair delivering largest and the second largest power signifies the azimuth quadrant of the incoming RFI. The direction angle θ corresponding to the ratio of largest power to second largest power is found from a graph shown in fig.5.

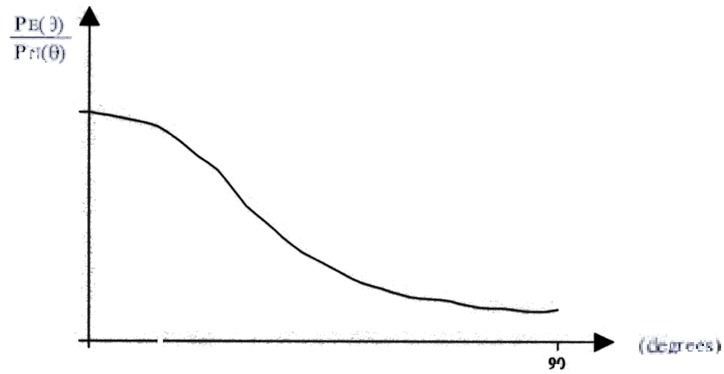

Fig.5 Adjacent antenna's radiation pattern ratio
Reference Antenna: East, 150 MHz

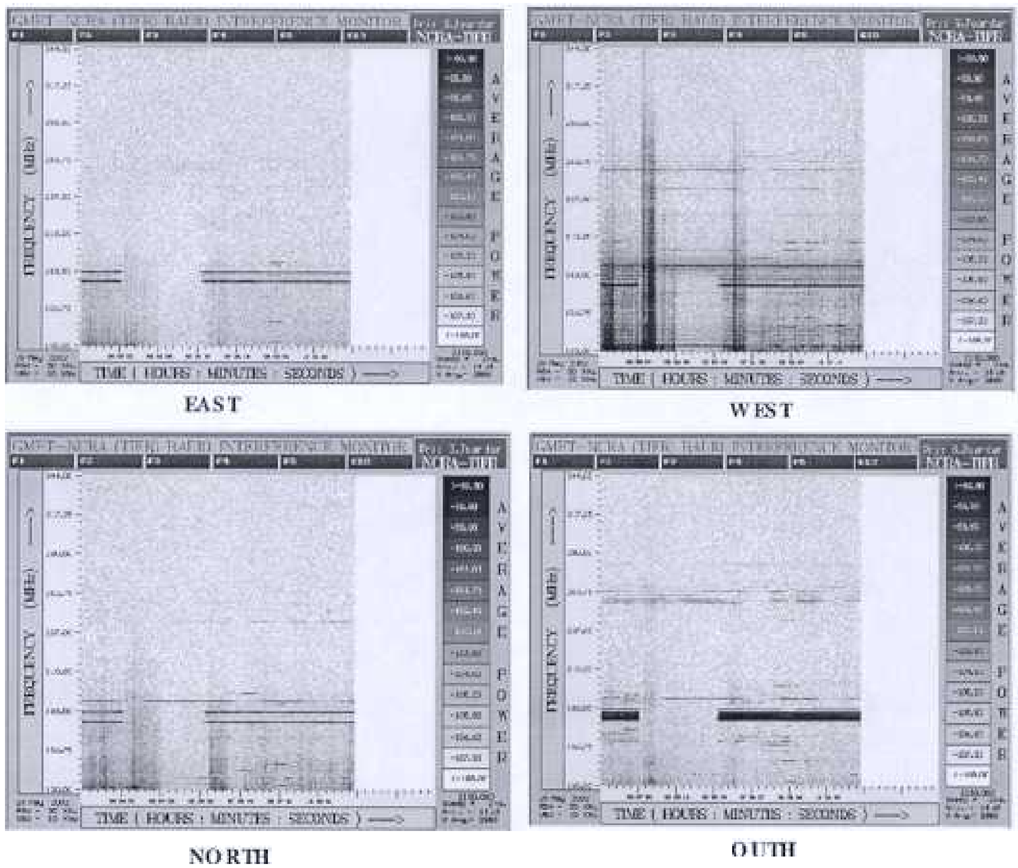

Fig 6: Power line and TV Interference; data taken in GMRT

Fig. 6 shows a set of gray plot data observed using the GMRT RFI monitoring system.

The vertical dark patches spread over wide frequency shows the power line interference from high tension ac lines in the N-W quadrant. There was a power failure between 2:35 to 5:30 hrs where we find the patches absent.

The two dark lines and some of their sister lines sitting near 175 MHz are from a TV transmitter located towards south.

To conclude, the GMRT is facing the problems from RFI. Instrumentation like ORMS are being added to assist the GMRT. .

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