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Real time RFI monitoring for Radio Telescope array

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Abstract

These paper presents how the multiple RF channels that are coming from the remote antenna location is monitored.

Index Terms —Giant Metrewave Radio Telescope (GMRT), monitoring, remote location, Waterfall plot, central electronics building (CEB).

1 Introduction

The Giant Meterwave Radio Telescope (GMRT) [1] is a large low frequency radio telescope array and radio frequency interference (RFI) with reasonably dense population around is a challenge for the instrument. The RFI present both in band and out of band saturate the receiver at various stages and produce in band intermodulation products and make the available frequency spectrum unusable. Distinguishing the intermodulation products and the real interference signal in the receiver is a challenge when they are random in nature and do not show its presence in all antennas. Also localized radio frequency interference shows in few antennas and not in the entire array. A centralized single monitoring station could not meet this requirement of a radio telescope array of antennas spread over large area. A distributed monitoring facility of the array will help in distinguishing these RFI with location. GMRT uses a distributed radio frequency interference monitoring system which monitors the signals directly from frontend systems at the centrally located signal processing station. The RF over fiber link which bring in the radio astronomy signals directly from the frontend system from remote antenna help in setting it up the RFI monitoring station at one location where 30 antenna signals are monitored. A 60 channel RF spectrum monitoring is a real time monitoring of signals from 30 antennas for dual polarization. The RFI received from antenna depends on the location, its azimuth and elevation angle of observation. The multichannel real time monitoring system runs for 24 x7, displays and records real time location specific signal of remote antenna. It displays the output in the form of RF spectrum, waterfall plot and data can be post processed to analyze in deep. Different parameters of RFI, like its dependence on antenna position, channel bandwidth, power level and its activity over the day, location of RFI source within the antenna array can be predicted. It consists of RF switches, ADC and LabVIEW software for switching control. With this we can keep an eye while observation to check the present RFI, and same can be flagged from the observation data. Designed System has very high isolation, so that there should not be any inter channel interference that could enter into the main receiver chain.

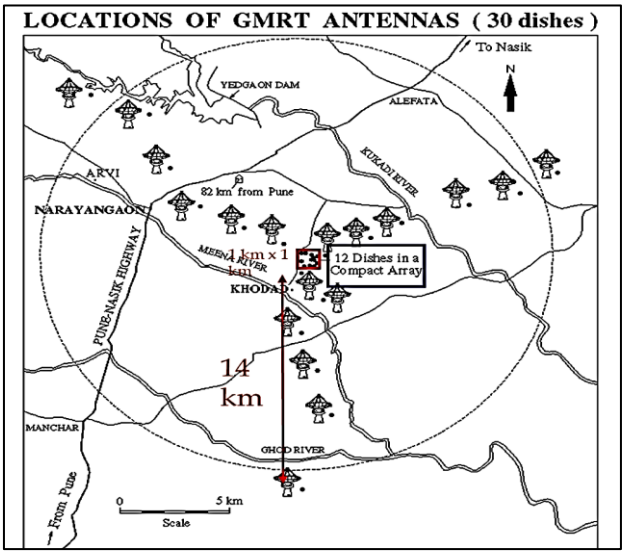

Figure 1. Distribution of GMRT antennas.

2 System Design

The GMRT array of 30 antennas bring in two broadband RF signals from the remotely located antennas to CEB.

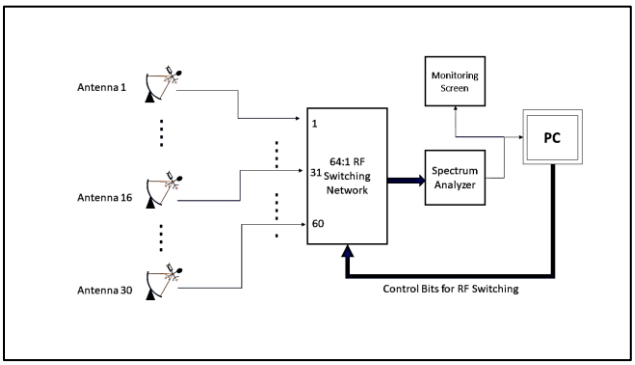

Figure 2. Block diagram of RF switching network with ADC card, PC for switch control and monitoring screen .

Operating frequency band is from 30 to 1500 MHz. The quality of data and interference present in remotely located frontend system is monitored and diagnosed using the received RF signal. This needs a real time RF monitoring system with 60 channels (30 antennas x 2 polarization).

In figure 2, the system consists of 64:1 RF switch network, the RF signal coming from 30 antennas (60 channels) is selected in sequential manner, the RF switching network is controlled using DIO cards programmed in LabVIEW, the digitize data of ADC is stored in computer and simultaneously it also displayed in monitoring window.

4 Results

The system performance was studied after integration of full system, the following parameters were tested like isolation between channels, switching time, losses due to switch.

Sr. No	Parameters	Value	Units
1	Switching time per channel	< 500	ms
2	Adjacent channel isolation	>100 @ 1 GHz	dB
3	Non adjacent channel isolation	>120 @ 1 GHz	dB
4	Isolation between Switch ON-OFF condition	100 @ 300 MHz	dB
5	Switch Loss	10	dB

Table 1. Switching network parameters.

5 Application

The Realtime RFI monitoring setup can be used in variety of application like

1. Real time RFI monitoring in the band of observation
2. Antenna sensitivity measurement
3. Real time data can be displayed as spectrogram plot
4. Stability of the receiver system is studied using spectrum recording
5. Daily report generation and archiving
6. Localised RFI in the array could be identified
7. Could be integrated with noise cancellation system for real time mitigation

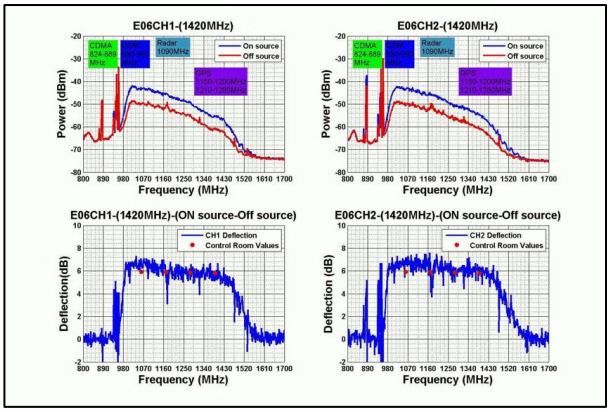

Figure 3. Antenna sensitivity measurement

Figure 3 shows the deflection measurement done with the monitoring system, the blue trace in the top subplot shows the ON source power level i.e., antenna focused towards astronomical source and red trace shows the off-source power level, the blue trace in the below subplot is deflection data through which sensitivity can be calculated.

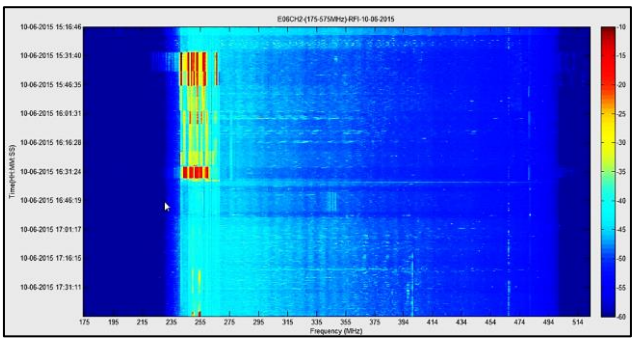

Figure 4. spectrogram plot of monitoring signal

Figure 4. shows the spectrogram plot made after the data acquisition, horizontal scale shows the frequency in MHz and horizontal scale shows the time scale. The blue patches show the out of band signal power levels i.e., noise floor, the light blue patch is the astronomical band of observation. During observation when satellite comes in antenna beam it will be stronger red patch and when it is away it will be seen as faint in color.

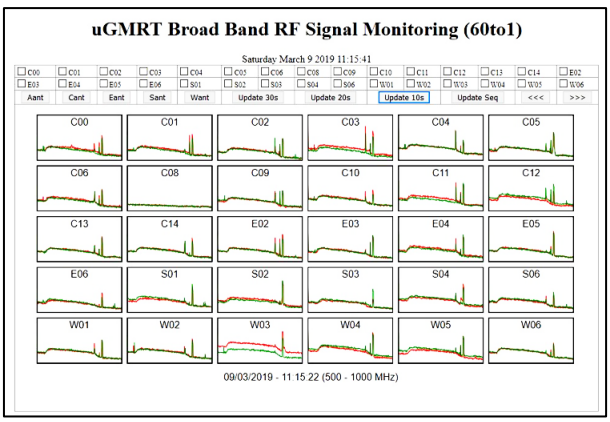

Figure 5. 30 Antenna display of GMRT

Figure 5. shows the 30 antennas display of GMRT, the acquired data of all antenna is stored, and a dedicated machine with plotting software continuously fetches the data and plot to display on monitoring window as well as it can accessed through online remotely. In a single window the RFI ambience as well as data quality can be monitored.

6 Conclusion

60 channel real time RF monitoring system for the 30-antenna array of GMRT is implemented. There is wide scope to build various application for spectrum monitoring and characterization with the developed hardware in real time. In addition, software application can also developed to find the localised interference source in the array.

7 References

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