RFI MONITORING SYSTEM OF GMRT

AND RADIO INTERFERENCE ANALYSIS

ON VARIOUS RADIO-ASTRONOMY BANDS

Shubhendu Joardar
Giant Meterwave Radio Telescope, Tata Institute of Fundamental Research, Narayangaon, Pune-410504, India
joardar@ncra.tifr.res.in

ABSTRACT

Recording and analysis of terrestrial spectrum termed as Radio Frequency Interference (RFI) within radio astronomy has become a routine affair for predicting free cosmic bands, detecting out-of-band and spurious emissions form transmitters, power line interference and regulate the growth of new transmitters in the region. The RFI spectrum monitoring system of GMRT consist of four log-periodic antennas positioned at 20 meter height in the E-plane, pointing towards East, West, North and South directions. The antenna signal outputs are multiplexed in cycles, amplified and fed to a spectrum analyzer situated 120 meters away in a building. The spectrum analyzer is GPIB interfaced with a computer which multiplexes the antennas through a serial port. Time stamped directional spectrums are recorded. Incoming RFI directions are found by relating the powers with radiation patterns. Omni-directional RFI analysis is done by relating the four spectrums. Algorithms for separating narrow and broad band RFI is also developed. The automated instrumentation of the spectrum monitoring system and results of different analysis are presented.

INTRODUCTION

All terrestrial radio sources are categorized as RFI from the radio astronomical point of view. These could be narrow band type, like communication signals, or wide band type, like arc-welding, automobile ignition, high voltage power lines etc. Terrestrial radio spectrum monitoring assists radio astronomy by providing information, like free cosmic frequency bands, out-of-band and spurious emissions form transmitters, power line interference and the growth of new transmitters in the region. It has other applications, like studying radio propagations and radio direction finding. Magnitude spectrum of radio signals available from a region is useful for generating radio availability statistics and studying radio properties over time etc. The RFI monitoring system of GMRT [1], [2] is a magnitude spectrum monitoring system but posses the capability of radio direction finding [3] using software. The system has been developed for different radio sciences including radio astronomy. The scope of this paper is the broad technical system details, radio direction finding usage and omni-directional spectrum data analysis results in relation to radio astronomy.

SYSTEM HARDWARE

Fig.1 and Fig.2 respectively shows the antenna mountings on a tower and the block details of the omni-directional RFI spectrum monitoring system of GMRT [1] [2]. Four identical log periodic dipole arrays with their maximum directivity pointing towards east, west, north and south directions are mounted twenty meters above the ground plane. The antennas are positioned in the E-plane (parallel to the ground). The computer selects the antennas in a cyclic order, viz. *east*, *west*, *north* and *south* via a 4PST RF-switch using its serial port. The corresponding RF powers from the antennas are amplified suitably and fed to the spectrum analyzer kept inside the lab building through an RF-cable. The traces of the spectrum analyzer are re-displayed and saved by the computer with time and directional stampings using its parallel port to GPIB interface. The frequency range of the system is from 50 MHz to 1250 MHz. Settings of the spectrum analyzer and observation period are user defined and set using the computer. The computer cycles the antennas over the entire period of observation and keeps recording the data in five different data files.

SYSTEM SOFTWARES

The system is operated using a software running on Linux platform. The settings of the observation are first entered into the GUI fields, viz., *duration* of observation, *center frequency*, *frequency span*, *RBW*, *VBW*, *number of averages*, and *filename* to save data etc. Four files are created for saving individual antenna spectrum data along with a common file holding all the four spectrum data. The software is accessible via local area network. Fig.3 shows the GUI objects of the system running software. The back window is the system settings window. The details of the spectrum analyzer's traces

Fig. 1. Spectrum monitoring tower of GMRT.

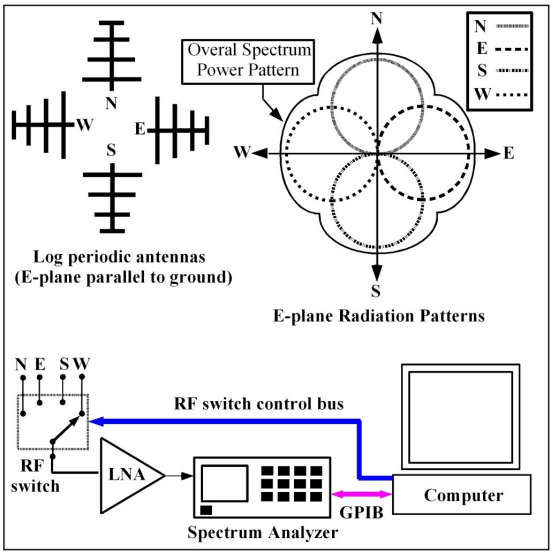

Fig. 2. Block diagram of the spectrum monitoring system.

are visible on a GUI (top window in the Fig.3). It also displays the antenna selected, time progress bar, time remaining etc. Fig.4 shows the GUI of the data visualizing software capable of being operated by any terminal connected to the local area network. This tool is used to view the completed data files or can be directly connected online to the system operating software using shared memory techniques. The data of a single cycle consisting of East, West, North and South directional spectrums can be seen in four different colours. A crosswire can be positioned by the mouse on the spectrum to visualize the power levels from all four directions for any particular frequency. The radio direction of that selected frequency appears in a vector plot GUI sitting on top of Fig.4. This innovative method compares the RF-power levels with the antenna radiation patterns and finds the radio direction. It can generate time averaged plots from completed data and also visualize the data trace by trace over the observed time.

OFFLINE ANALYSIS SOFTWARES

Offline softwares are developed for extracting the narrow band (communication signals) and broad band (high tension

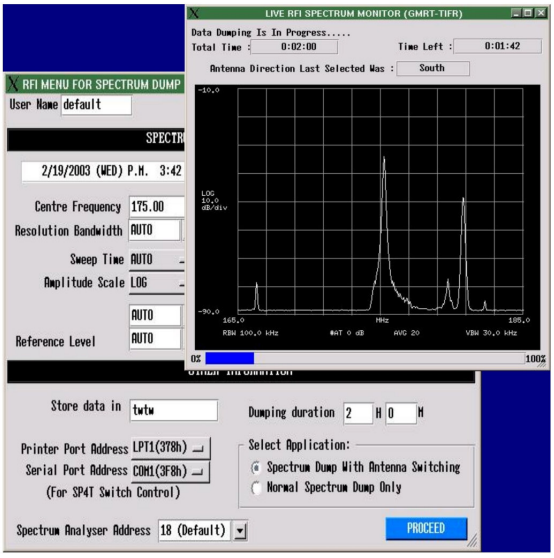

Fig. 3. GUIs of the systems operating software.

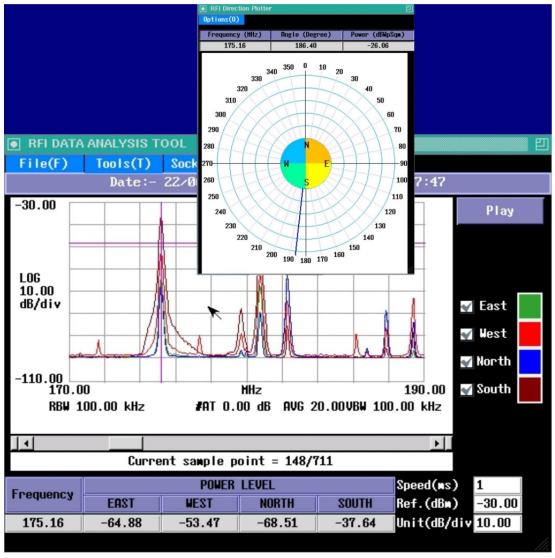

Fig. 4. GUIs of the data visualizer and direction finder.

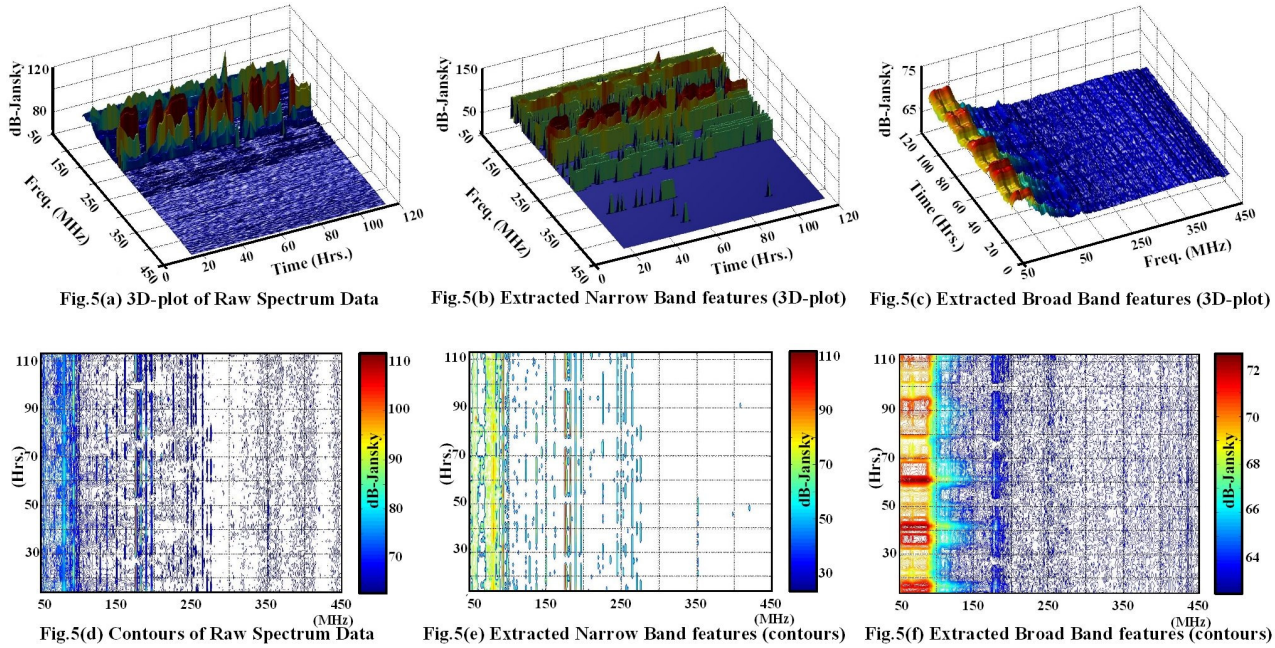

Fig.5(a) 3D-plot of Raw Spectrum Data
Fig.5(b) Extracted Narrow Band features (3D-plot)
Fig.5(c) Extracted Broad Band features (3D-plot)
Fig.5(d) Contours of Raw Spectrum Data
Fig.5(e) Extracted Narrow Band features (contours)
Fig.5(f) Extracted Broad Band features (contours)

Fig. 5. 50-450MHz spectrum analysis: Raw data, extracted Narrow Band and Broad Band spectrums from raw data.

power line interference /spread spectrum /electric arc welding /automobile ignition /base level variation of the system etc.) spectrum features with statistical analysis. Fig.5, Fig.6 and Fig.7 shows the results of the time averaged omni-directional spectrum over various frequency bands, viz. 50 - 450 MHz, 450 - 850 MHz and 850 MHz - 1250 MHz. In (a) and (d) of each figure, the raw data spectrum is shown. In (b) and (e), the extracted narrow band RFI spectrum from raw data is shown. In (c) and (f), the extracted wide band RFI spectrum is shown. The averaged omni-directional flux density near the antennas is expressed in dB-Jansky. Statistics of the narrow and broad band RFI occupancy over the complete observation time is shown in Fig.8 for all the frequency bands corresponding to Fig.5, Fig.6 and Fig.7.

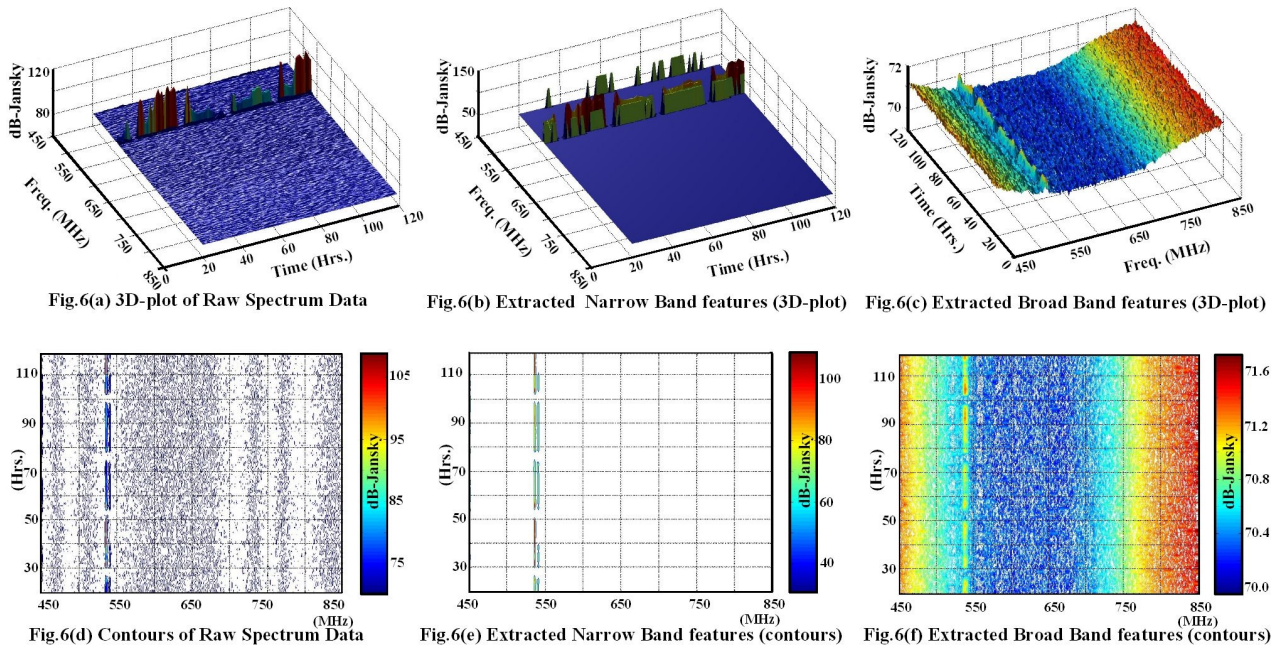

Fig.6(a) 3D-plot of Raw Spectrum Data
Fig.6(b) Extracted Narrow Band features (3D-plot)
Fig.6(c) Extracted Broad Band features (3D-plot)
Fig.6(d) Contours of Raw Spectrum Data
Fig.6(e) Extracted Narrow Band features (contours)
Fig.6(f) Extracted Broad Band features (contours)

Fig. 6. 450-850MHz spectrum analysis: Raw data, extracted Narrow Band and Broad Band spectrums from raw data.

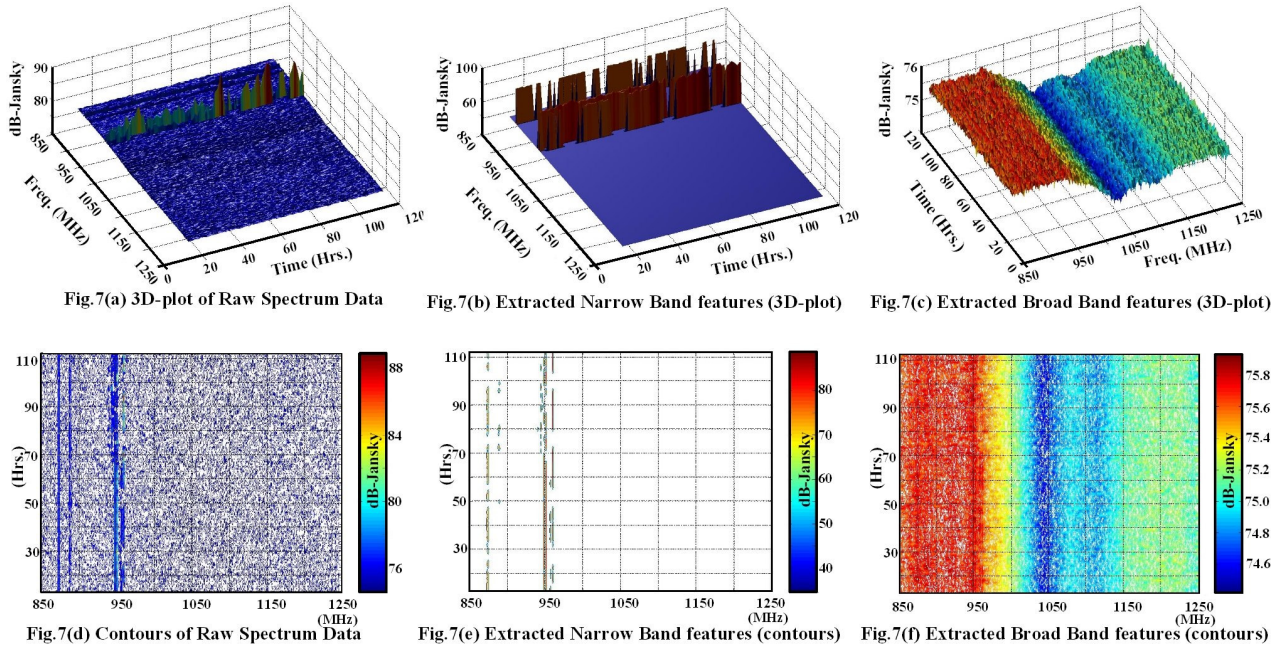

Fig.7(a) 3D-plot of Raw Spectrum Data
Fig.7(b) Extracted Narrow Band features (3D-plot)
Fig.7(c) Extracted Broad Band features (3D-plot)
Fig.7(d) Contours of Raw Spectrum Data
Fig.7(e) Extracted Narrow Band features (contours)
Fig.7(f) Extracted Broad Band features (contours)

Fig. 7. 850-1250MHz spectrum analysis: Raw data, extracted Narrow Band and Broad Band spectrums from raw data.

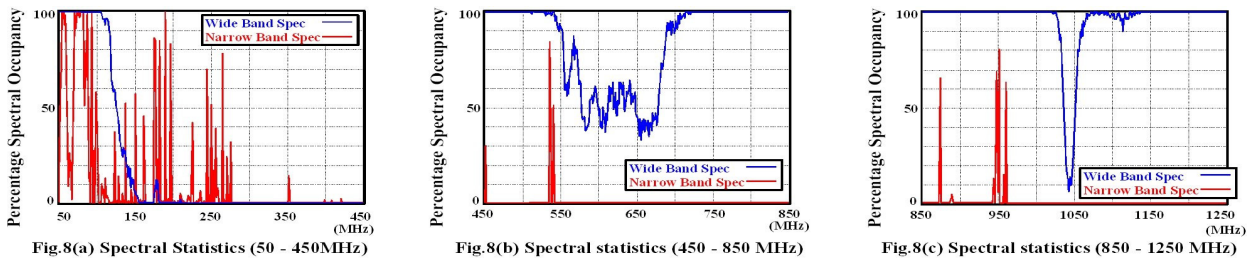

Fig.8(a) Spectral Statistics (50 - 450MHz)
Fig.8(b) Spectral statistics (450 - 850 MHz)
Fig.8(c) Spectral statistics (850 - 1250 MHz)

Fig. 8. Statistics of the spectral occupancy over the complete observation period for all frequency bands.

UPGRADATIONS AND PLANNINGS

The frequency range of the system is soon to be upgraded to the range 50 to 2000 MHz. New antennas possessing both horizontal and vertical polarizations are about to be introduced. Planning for covering the upper sky is on.

ACKNOWLEDGEMENTS

The author is indebted to Prof. Ashit Baran Bhattacharya, Department of Physics of the University of Kalyani for his valuable guidance and review of this work. The author also extends his thanks to the staff members of GMRT, especially to the director Prof. Rajaram Nityananda and for their suggestions, encouragement and support.

REFERENCES

[1] Shubhendu Joardar, “The Omnidirectional RFI monitoring system of GMRT-TIFR,” Summer School on Spectrum Management, NRAO, West Virginia, USA, June 2002.
[2] Shubhendu Joardar, Lecture presentation “The E-plane Omnidirectional RFI monitoring system for GMRT,” NCRA Engg. Committee Internal report, GMRT, Pune, January 2003.
[3] Shubhendu Joardar, “Radio Direction finding using 'N' switchable antennas and RFI estimation,” INC-URSI, NPL, New Delhi, November 2003.