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ECRA dynamic spectrograph - design and test results

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Abstract. Eastern Centre for Research in Astrophysics (ECRA) set up by the University Grants Commission in 1993, involving Universities and Research Institutes of Eastern Region with Calcutta University as the nodal centre, started initial activities with a thrust in Solar Radio Astronomy. For studies of the dynamic spectra of solar meter-wave bursts a dynamic spectrograph was developed for ECRA at the Institute of Radio Physics and Electronics, University of Calcutta in collaboration with the GMRT group of NCRA (TIFR). The development was planned in two stages. Firstly, a dynamic spectrograph based on spectrum analyzer was developed and installed at the low noise ECRA field site at Kalyani University campus. Secondly, the design of a high resolution dynamic spectrograph based on a hardware based FFT system of GMRT electronics has been completed and its development is underway for completion by 1997. The structure of the dynamic spectrographs of ECRA and their salient features together with some initial studies of RFI in the field site made by the dynamic spectrograph are presented in this paper.

Key words : dynamic spectrograph - results

1. Design of dynamic spectrograph

The ECRA dynamic spectrograph consists of three parts (1) array of 4 LPDA, (2) A Spectrum analyzer with a 30 dB preamplifier (3) A PC based data acquisition system, as shown in Fig. 1.

Log periodic dipole array : A log periodic dipole antenna is a wide band antenna which provides uniform gain over a wide band of frequency and hence, very useful in the spectrum analysis of meter-wave radio bursts.

Four log periodic antennas have been fabricated at Calcutta, and one more antenna was purchased for calibration.

The four ECRA log periodic antennas have been designed for frequency band 40-1000

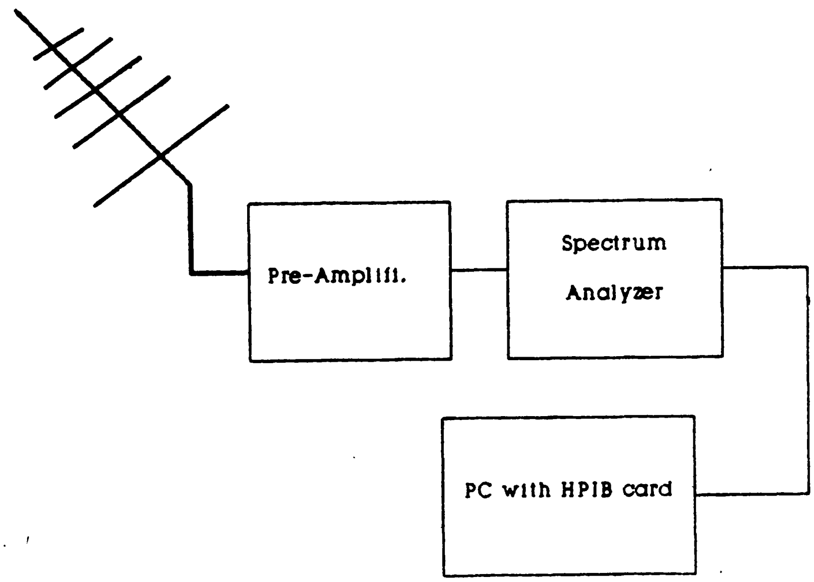

Figure 1. The circuit diagram of the ECRA Dynamic Spectrograph.

MHz. Each consists essentially of two booms and the elements are attached alternately with the two booms. The separation as well as the length of the elements are decreased in the logarithmic scale.

Characterisation of the log periodic antenna : For characterisation of the log periodic antenna, we have taken the second channel of Doordarshan (i.e. DD2) at 182 MHz and observed signal strength of DD2 at various angular orientation of the antenna.

Receiver of the spectrograph : The receiver of the spectrograph consists of a preamplifier and a spectrum analyzer. The preamplifier has a noise figure of 3dB.

The spectrum analyzer has a facility of being operated at various band width, integration time and scan rate. The frequency chosen in this case 40-215 MHz, and the spectrum is available in 600 data points on a GPIB port, which is connected to a PC having an HPIB card for data acquisition. The 600 data points are available in a single trace after every scan and the computer takes 10 sec to access the data through GPIB port and to write in a data file in the hard disk.

The software for data browsing : The dynamic spectrum consists of three parameters. (1) Time, (2) Frequency, (3) Intensity of the spectrum.

To plot these parameters, we have to take the help of a special type of diagram called gray level plotting, where time comes along x-axis, frequency along the y axis, and the intensity comes in a form which is called the grayness of a particular cell, as shown in Fig.2.

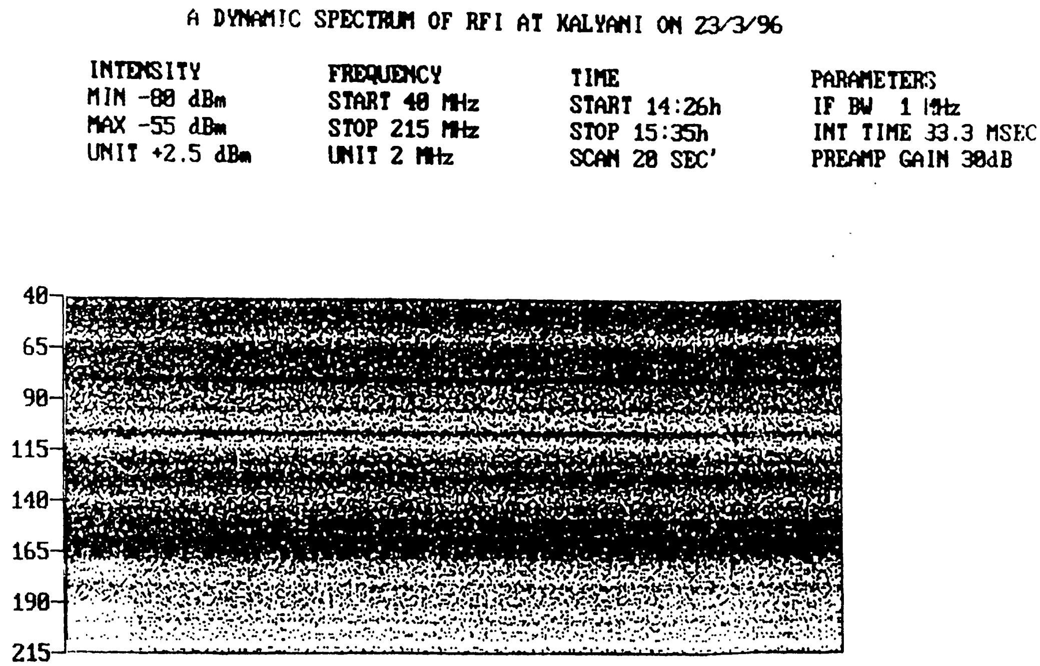

Figure 2. Gray level plot of the RFI study of the Kalyani Field station. The X-axis indicates time, the Y-axis gives the frequency in MHz and the intensity is represented by the grayness.

Here in our software (GRAYLEV), which is designed at ECRA, the screen is divided into an array of cells which consists of nine points. The intensity is quantised into 10 levels and according to this quantised intensity n ($0 < n < 9$) a particular cell is blackened, i.e. for $n = 5$, five points out of the nine points of a particular cell is blackened. In this way the data file of a particular observation is displayed. The steady interference (i.e. TV, radio, wireless) will come as a line parallel to the time axis. And in case of a solar burst we will observe a curved or diagonal line in the plot. We can change the level of quantisation to any order and hence, can display any change in the frequency pattern.

Computer Aided Design of LPDA : This LPDA is designed using computer Aided Design Software developed at the Institute of Radio Physics & Electronics and fabricated at Calcutta with a band width of 40-1000 MHz and of Gain 7 dB.

This antenna is calibrated with the help of an imported LPDA (ANRITSU MP 635A). It is found that the antenna developed is having a Gain 7dB with the proper matching. Both the antennas were pointed towards the TV station and then their angle with the TV station was varied in steps. The resultant e.m. patterns displayed in the spectrum analyser were plotted.

It may be mentioned here that more compact ultrabroad Biconilog Antenna covering 30-1000 MHz, similar to that developed by EMCO and HP is under development at

Calcutta University, for future developments of longer antenna arrays, having sharper beam. Ultimately a cross polarised biconilog antenna array will be developed for the frequency range 30-1000 MHz.

Data Acquisition : The spectrum analyser is set to 5 sec scan mode from 40-3000 MHz with 20 dB attenuation inside. It gives 500 data per scan through GPIB port. This port is connected with the PC via H. P. basic card and the data is acquired in a data file for 20 mins. i.e. (12 × 20 = 240 scans) (240 × 500 = 12,0000 data). This data is fed to the software programme developed in this department to obtain gray level plots. This software asks for minimum and maximum signal value and divides the data in 9 gray levels.

2. Possibility of solar observations

With this spectrum analyser with 0.1 msec integration time and 120 KHz bandwidth we can detect signals of strength - 73 dBm. With the ANRITSU LNA, the sensitivity is improved by 25 dB and with the provision of an Avantek LNA the sensitivity is further improved by another 27 dB. So the overall sensitivity goes up to −125 dBm, with both the Avantek LNA and ANRITSU LNA connected in cascade. For a 120 KHz bandwidth the sensitivity would be 135 dBm.

As 1 s.f.u. is – 190 dBm/Hz/m^2, hence with a band width of 120 KHz it comes down to 150 dBm/m^2, with 2 log periodic antenna (as one antenna has an area of 0.58 λ^2), it is possible to detect solar bursts of magnitude of the order of 30 s.f.u.