A PROJECT REPORT
ON

ABSOLUTE CALIBRATION OF RFI(RADIO FREQUENCY INTERFERENCE) DETECTION SYSTEM AT GMRT(GIANT METERWAVE RADIO TELESCOPE)

By

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CERTIFICATE

This is to certify that Miss JHARNA MANNA students of Institute of Radio Physics & Electronics, Calcutta University, has carried out the project entitled "ABSOLUTE CALIBRATION OF RFI DETECTION SYSTEM AT GMRT" satisfactorily under my guidance during the puja vacation 2006 and submitted the project report as per the requirement of GMRT.

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CONTENTS

ABSTRACT:

A systematic recording and analysis of the signal received by GMRT antenna system and omni directional RFI monitoring system (ORMS) in the frequency range 500-600 MHz is done to find a relation between the power measured by these two receiver system. The project focuses on the TV transmission in band 39 (539 MHz) from Simhegad s-s-w of GMRT . This notes also shows the variation of the power received by radio telescope as a function of azimuthal and elevation angle and simultaneously the power received by ORMS . This will help to establish an absolute calibration relation between an RFI signal power recorded by ORMS in dedicated manner and the power received by GMRT antenna as it is rotated to look at different areas of the sky as a part of the scientific observational program.

CHAPTER 1

1.0 INTRODUCTION:

GMRT consists of an array of 30 antennas . Each antenna has been designed to operate at a range of frequencies from 50 MHz to 1450 MHz . Each antenna operates at frequencies 150 MHz,233 MHz,327 MHz, 610 MHz,1420 MHz. The four feeds are mounted on four faces of the rotating turret at 90 deg apart. Each antenna receives data from different sources by changing azimuth and elevation angle .

There is another antenna system at GMRT which is designed by Mr. Shubhendu Joardar , known as omni directional RFI monitoring system (ORMS) that has been recently developed. It consists of 4 log periodic antennas (LPA) pointing to the east, west,south and north directions mounted on a tower at a height of 20 m (i.e. the direction of each antenna is fixed).

The aim of the project is to find the relationship between power flux density received by these two receivers system and the variation of the power received by these two antenna system at same time corresponding to a source frequency . Now since the project is focused on the TV transmitter at PUNE ,so the source frequencies are 535 MHz for picture signal and 540 MHz for sound signal. All the experiments are done at frequency range 500MHz to 600 MHz . The experiments are done in three steps , in first part of the experiment power flux density of the power received by the two antenna system are calculated and then they are compared ,in second part of the experiment , the GMRT antenna is rotated in azimuth with the 610 MHz feed pointed to horizontal and simultaneously data is recorded by ORMS receiver .In the third part of the experiment data is recorded as the regular use mode of GMRT antenna and ORMS simultaneously. For the whole purpose of the experiment 610 MHz feed is used for radio telescope . Since GMRT is located 80 Km north of PUNE so all the calculations are done by taking the spectrum along south direction only.

CHAPTER 2

2.O A BRIEF INTRODUCTION OF ANTENNAS USED:

Since for this project two antenna systems are used ,so brief introduction of each antenna system are described here.

2.1 Introduction of GMRT antenna:

Fig-1: An illuminated GMRT antenna at twilight

NCRA (National Center for Radio Astrophysics) has set up a unique facility for radio astronomical research using the metrewavelengths range of the radio spectrum, known as the Giant Metrewave Radio Telescope (GMRT), it is located at a site about 80 km north of Pune . GMRT consists of 30 fully steerable gigantic parabolic dishes of 45m diameter each spread over distances of up to 25 km. Each antenna has been designed to operate at a range of frequencies from 50 MHz to 1450 MHz . Their reflecting surface consists of panels of wire mesh .This design has very low wind loading as well as low total weight for each antenna. GMRT is one of the most challenging experimental programmes in basic sciences undertaken by

Indian scientists and engineers.

The meter wavelength part of the radio spectrum has been particularly chosen for study with GMRT because man-made radio interference is considerably lower in this part of the spectrum in India. Although there are many outstanding astrophysics problems which are best studied at meter wavelengths, there has, so far, been no large facility anywhere in the world to exploit this part of the spectrum for astrophysical research.

The site : The site for GMRT, about 10 km east of Narayangaon town on the Pune-Nasik highway, was selected after an extensive search in many parts of India, considering several important criteria such as low man-made radio noise, availability of good communication, vicinity of industrial, educational and other infrastructure and,a geographical latitude sufficiently north of the geomagnetic equator in order to have a reasonably quiet ionosphere and yet be able to observe a good part of the southern sky as well.

Antenna configuration : The number and configuration of the dishes was optimized to meet the principal astrophysical objectives which require sensitivity at high angular resolution as well as ability to image radio emission from diffuse extended regions. Fourteen of the thirty dishes are located more or less randomly in a compact centre array in a region of about 1 sq km. The remaining sixteen dishes are spread out along the 3 arms of an approximately ' Y' shaped configuration over a much larger region, with the longest interferometric baseline of about 25 km . The array will operate in six frequency bands centered around 50, 153, 233, 325, 610 and 1420 MHz. All these feeds provide dual polarization outputs. In some configurations, dual-frequency observations are also possible.

GMRT antenna specifications: The large size of the parabolic dishes implies that GMRT will have over three times the collecting area of the Very Large Array (VLA) in New Mexico, USA which consists of 27 antennas of 25 m diameter and is presently the world's largest aperture synthesis telescope operating at centimeter wavelengths. At 327 MHz, GMRT will be about 8 times more sensitive than VLA because of the larger collecting area, higher efficiency of the antennas and a substantially wider usable bandwidth because of the low level of man-made radio interference in India.

Feeds of GMRT antennae: Feed Positioning System as the name suggest is used to precisely position or focus the feeds that are located on the four faces of the rotating turret. The Telescope is to be operated at 150,233,327,610 and 1420 MHZ.The feed can be positioned for desired frequency by rotating the feed turret .

0 deg ==>233/610 MHz
90 deg==> 150 MHz
180 deg ==> 1420 MHz
270 deg ==> 325 MHz

Fig-2: The four feeds mounted on the rotating turret

GMRT receiver system: The GMRT receiver chain is shown schematically in Fig-3. The first block is the multi-frequency front end. This is located in a rotating turret at the prime focus. All the feeds and low noise RF front-ends have been configured to receive dual polarization signals. Lower frequency bands (from 50 to 610 MHz) have dual circular polarization channels, i.e. left hand circular and right hand circular polarizations which have been labeled as CH1 and CH2 respectively. The L-band (1000-1450 MHz) system has dual linear polarization channels, i.e. vertical and horizontal polarizations (also labeled CH1 and CH2 respectively).

The first local oscillator (I LO, situated at the base of the antenna, inside a shielded room) converts the RF band to an IF band centered at 70 MHz. After passing the signal through a bandpass filter of selectable bandwidth, the IF at 70 MHz is then translated (using II LO) to a second IF at 130 MHz and 175 MHz for CH1 and CH2, respectively. The maximum bandwidth available at this stage is 32 MHz for each channel. This frequency translation is done so that signals for both polarizations can be frequency division multiplexed onto the same fiber for transmission to the CEB.

At the CEB, these signals are received by the Fiber-Optic Receiver and the 130 and

175 MHz signals are then separated out and sent for base band conversion. The baseband converter section converts the 130 and 175 MHz IF signals first to 70 MHz IF (using III LO), these are then converted to upper and lower side bands (each at most 16 MHz wide) at 0 MHz using a tunable IV LO. There are also two Automatic Level Controllers (ALCs) in the receiver chain (not shown in Figure). The first is just before the Fiber Optic transmitter and the second is at the output of the baseband unit.

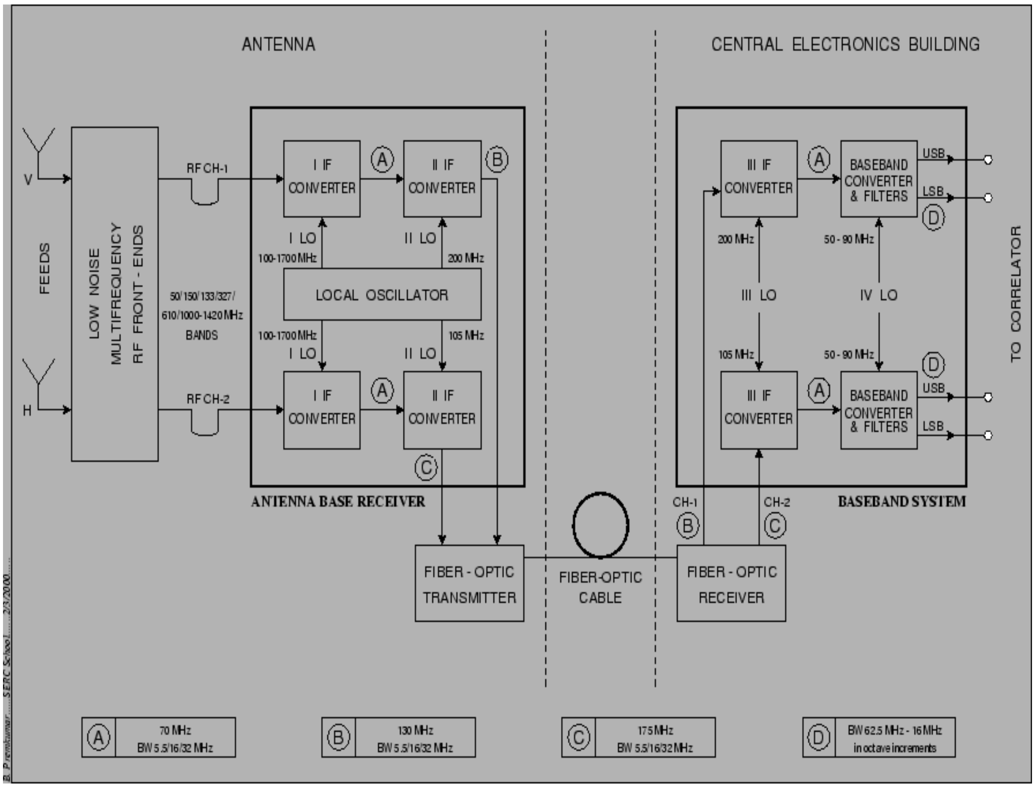
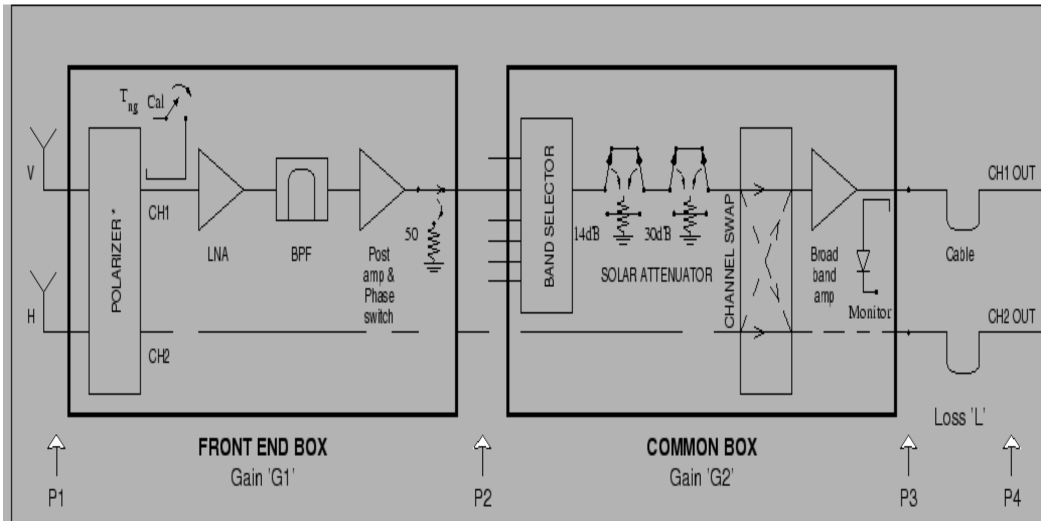


Fig-3: Schematic block diagram of the GMRT receiver.

A Schematic block diagram of frontend box and common box of the receiver system is shown in the following figure.



FREQ. BAND (MHz)	T_{sys} (K)	P1 (dBm)	G1 (dB)	P2 (dBm)	G2 (dB)	P3 (dBm)	L (dB)	P4 (dBm)
150	580	- 98	34	- 62	28	- 34	8	- 42
233	234	- 100	37	- 63	27	- 36	9	- 45
327	108	- 103	38	- 65	27	- 38	11	- 49
610	101	- 104	35	- 69	26	- 43	15	- 58
1060	83	- 104	50	- 54	25	- 29	22	- 51
1170	77	- 105	49	- 56	24	- 32	23	- 55
1280	74	- 105	49	- 56	23	- 33	24	- 57
1390	72	- 105	47	- 58	23	- 35	26	- 61

Note : Power levels are over 32 MHz BW; with 0dB solar attenuator - * The L-Band (1000 - 1400 MHz) FE does not have the polarizer

Fig-4: The RF power levels for a 32 MHz bandwidth at various locations in the RF receiver chain for the different GMRT frequency bands and sub bands. It is assumed that the solar attenuator has been bypassed and that the noise diode is off.

2.2 Introduction of Omnidirectional Monitoring System (ORMS) of GMRT:

Fig-5: Spectrum monitoring tower

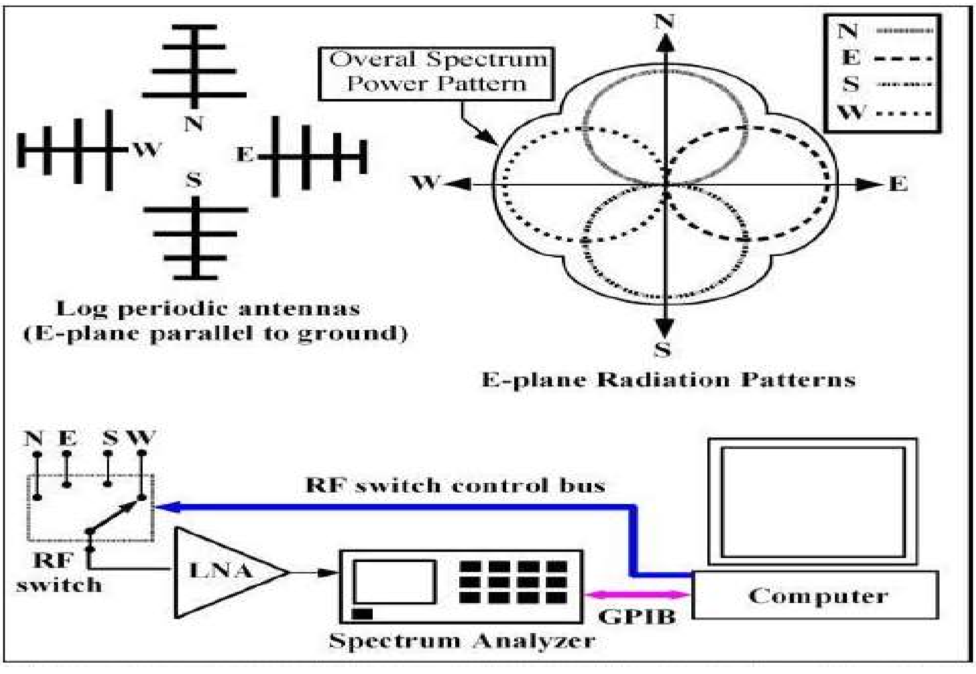


Fig-6: The Omni directional RFI monitoring system of GMRT

RFI is a major concern at GMRT and there are number of tools for studying interference .The omni directional RFI monitoring system (ORMS) that has been recently developed , consists of 4 log periodic antennas (LPA) pointing to the east,west,north and south directions mounted on a tower at height of 20m. The antennas are designed to cover the upper VHF and lower UHF bands (70 MHz to 1800 MHz). The plane of polarization is kept parallel to the ground (E-plane) .The block diagram of a four-antenna spectrum monitoring system located at GMRT site is shown Fig-6. The computer selects the antennas in c cyclic order , viz. East , West, North and South through an RF switch . The corresponding multiplexed RF powers from the antennas are amplified using an LNA (Low Noise Amplifier) and fed to the spectrum analyzer kept inside the building through an RF-cable . The trace outputs from the spectrum analyzer is displayed and saved by the computer ,each of which is a 401-point data with time stamp for individual directions. Settings of the spectrum analyzer and observation period are user defined . The computer continuously multiplexes the antennas over the entire period of observation and records the data corresponding to the antennas . Table 1 lists the used specifications and characteristics of the devices and instruments used.

Table-1: Used specifications and characteristics of the devices and instrument used.

Device	Type / Settings / Specifications
Log periodic Dipole Array Antenna	G_{Ant}=4.5dBi, Frequency Range:70MHz-1800MHz
Low Noise Amplifier	[MAR-6,MAR-3,MAV-11A combination,from Mini Circuits] Max. noise figure NF(LNA)=3.5dB, G(LNA)=40 dB
Spectrum Analyzer	HP-8590L, $\Delta\nu_{vid}$=1 KHz $\Delta\nu_{res}$=1 KHz Noise Floor =-110dBm
RF-switch	GSWA-4-30,Insertion loss=1.5dB (typical)
RF-cable-1	RG-223, Length = 2m
RF-cable-2	LMR-400,Length = 120m

CHAPTER 3

CALCULATION OF POWER FLUX DENSITY

3.0 INTRODUCTION :

Three experiments are done for this project purpose. In first part of the experiment power flux density for both GMRT antenna system and omni directional RFI monitoring system are calculated and they are compared.From this result conclusion is drawn.

3.1 Theory:

Power flux density of any antenna is defined as power received by the antenna terminal per unit area. This is a constant quantity for a particular source and is a function of azimuth and elevation angle of the antenna . So if P_R is the power received by antenna at terminal , A_e is the effective area offered by the feed of the antenna and S is the power flux density then according to the definition of the power flux density

$$S = P_R \; / \; A_e \qquad (1)$$

where SI unit of P_R is watt , SI unit of effective area A_e is meter ^{2} and SI unit of S is watt / meter ^{2}.

Now if G is the gain of the antenna and λ is the wavelength of the signal then the relationship between G and A_e is given by

$$G = 4 \; \Pi \; A_e / \; \lambda^2 \qquad (2)$$

Where the SI unit of λ is meter.

Now the power received by the antenna (at off source frequency) which is seen in the spectrum is the noise level produced by the system and modified by gain of the amplifier system , it is not the noise level of the spectrum analyzer . If the power level is defined as P_N , then

$$P_N = KTG'B \qquad (3)$$

Where K is the Plank's constant

$K = 1.38 * 10^{-23}$ Joules / ^{0} K

B is the resolution bandwidth of the spectrum analyzer and its unit is KHz and T is the system temperature or antenna off source temperature. and G' is the gain of the amplifier system .

So by knowing the value of P_N from spectrum we can calculate G' by using the equation (3) . Now the gain of the each antenna that is GMRT antenna and log periodic antenna is fixed and we know the frequency of operation that is the value of λ is known , so by using equation (2) we can calculate the value of A_e .

Now if the power received by the antenna and amplified by the amplifier system at the source frequency is defined as P_S then the power received by the antenna at terminal (P_R) is the difference of the power P_S and the gain of the amplifier system G' . So we can get the value of P_R and A_e and by using equation (1) we can calculate the value of power flux density S at antenna terminal for both GMRT antenna and log periodic antenna.

3.2 Power flux density received by GMRT antenna systems :

To calculate the power flux density the required experiment is done at C02 antenna. Since the frequency of interest is 500-600 MHz band so 610 MHz feed is used .In this part of the experiment the feed is faced towards different direction by changing azimuthal angle and elevation angle of the antenna is kept fixed at 90 degree . The spectrum for all four directions (north,south,east and west) are taken by connecting spectrum analyzer (8590L) with both CH-1 and CH-2 i.e. for both left hand circular polarization and right hand circular polarizations. Since here the source is TV transmitter at PUNE which is towards the south direction from GMRT ,so power flux density is calculated only for south direction .

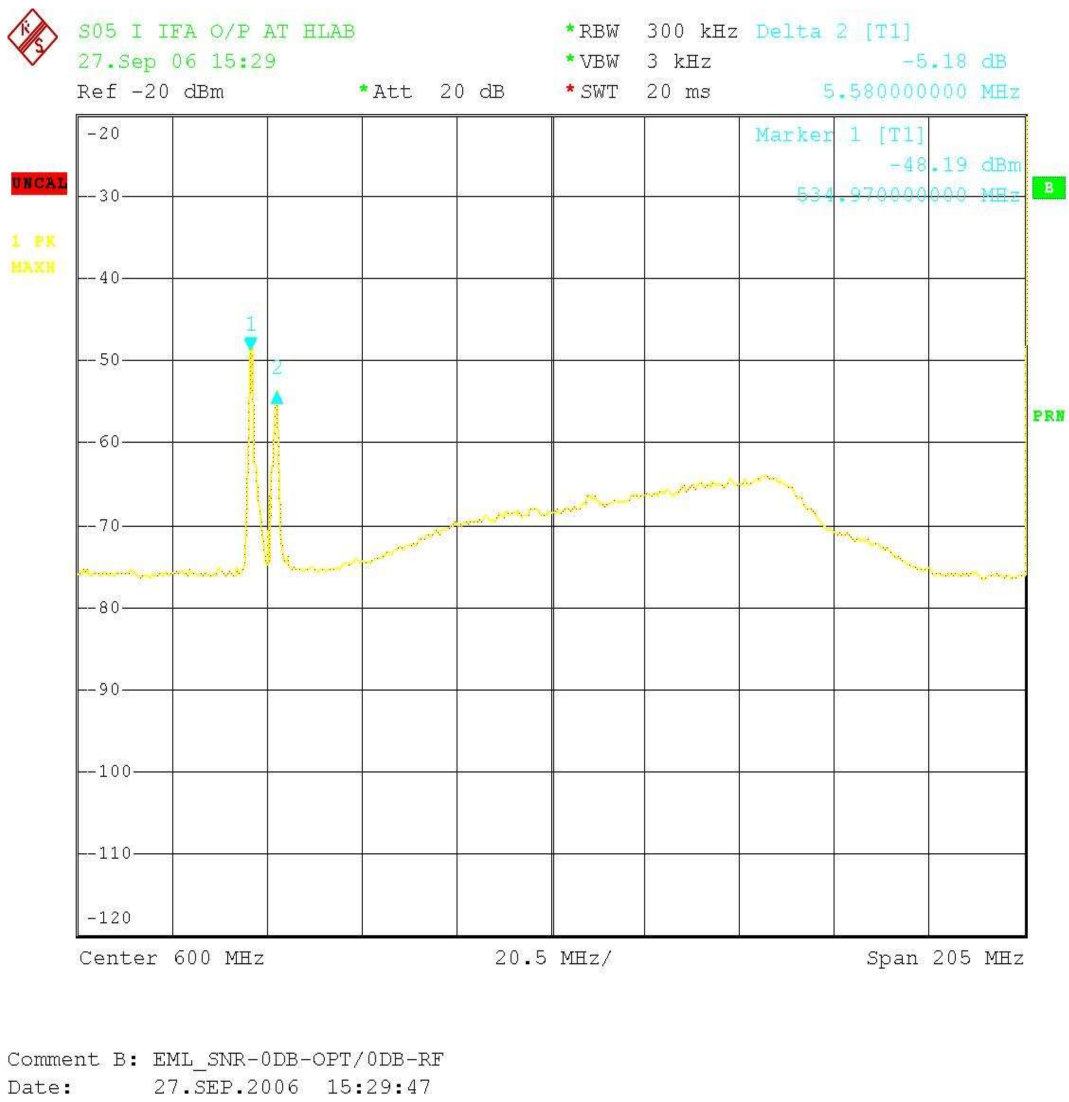


Fig-7: Spectrum of the power received by GMRT antenna for CH1

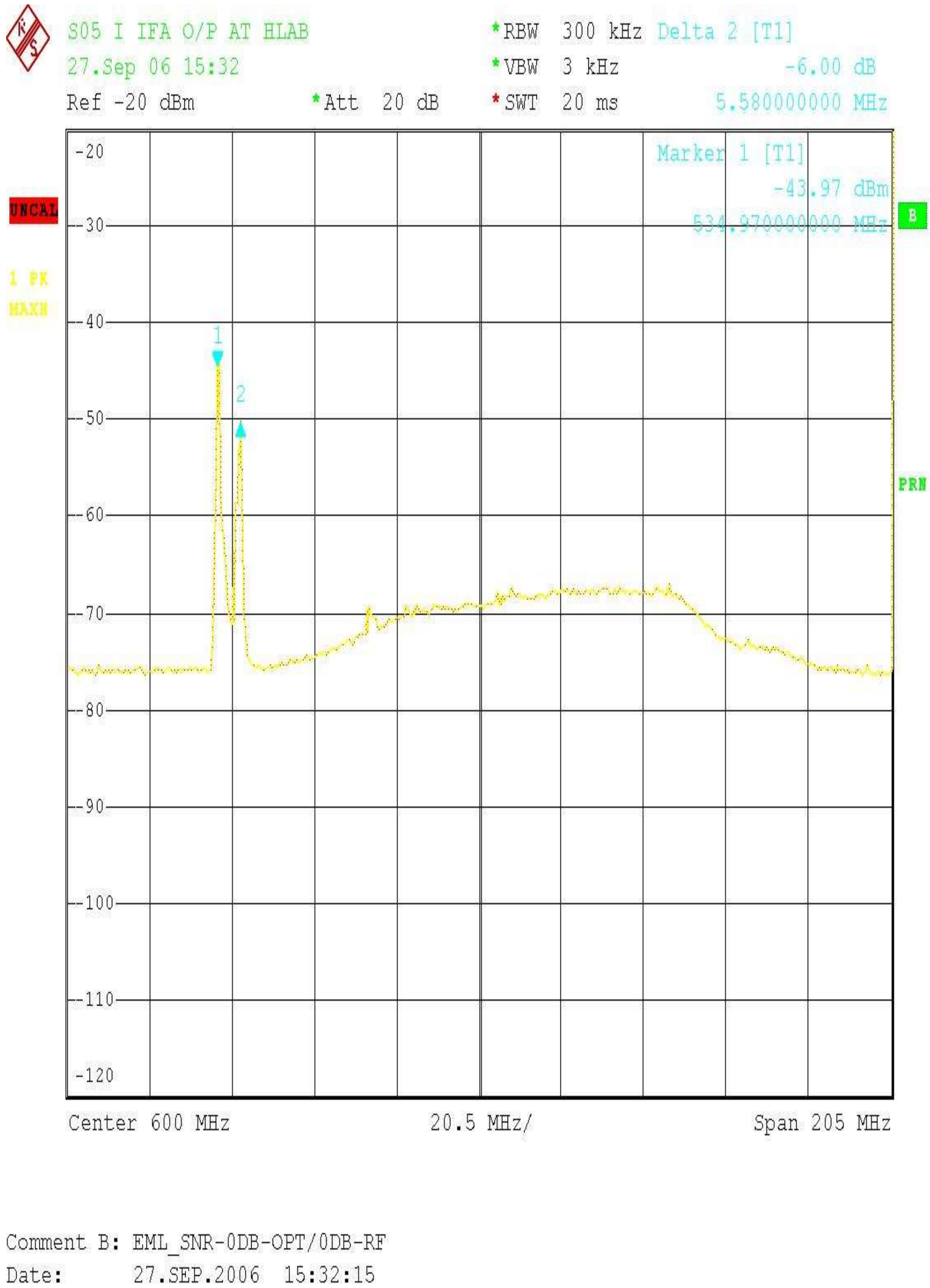


Fig-8 : Spectrum of the power received by GMRT antenna for CH2.

3.3 Calculation of power flux density for GMRT antenna :

Since there are two channels CH1 and CH2 one for left circular and other for right circular polarization , so calculation are done separately for each channel . And since the source is TV signal at PUNE so the spectrum has two peaks , one corresponding to picture signal and other is corresponding to sound signal so the power flux density for each peak has been calculated here.

Now from the spectrum (shown in Fig-7 and Fig-8) the system noise level P_N is equal to

$$P_N = -76 \text{ dB m}$$

The system temperature T is 101 K corresponding to the 601 MHz frequency (it is taken from the table of Fig - 4). And from the spectrum the resolution bandwidth is 300 kHz . So from equation (3)

$$G' = P_N / KTB$$
$$\equiv 48 \text{ dB} \qquad (3a)$$

This gain of the amplifier system is same (48 dB m) for both CH1 and CH2.

For CH1 :

Since the spectrum has two peak corresponding to picture signal at 535 MHz frequency and sound signal at 540 MHz frequency , so the power received at picture signal is - 48.19 dB m and the power received at sound signal is - 53.37 dB m (from Fig -7) that is

$$P_S = -48.19 \text{ dB m for picture signal}$$
$$\text{and } P_S = -53.37 \text{ dB m for sound signal}$$

Now from the theory the power received at the antenna terminal i.e. P_R is given by

$$P_R = (-48.19 - 48) \text{ dB m}$$
$$= -96.19 \text{ dB m for picture signal} \qquad (4)$$

$$P_R = (-53.37 - 48) \text{ dB m}$$

$= - 101.37$ dB m   for sound signal   (5)

Now the wavelength λ for picture signal and sound signal are

λ = velocity of light at free space / frequency of the signal

$= 3 * 10^{8} / 535 * 10^{6}$
$= 0.56$ meter   for picture signal   (6)

Where the velocity of light at free space is $3 * 10^{8}$ meter / sec

$\lambda = 0.555$ meter   for sound signal   (7)

Now the gain of the GMRT antenna at 610 MHz frequency is 8 dB (which is taken from the paper ' PRIME FOCUS FEEDS FOR GMRT ANTENNA ' name of the writers are given in reference section) that is the gain factor G = 6 .3
So from equation (2) ,

$A_e = G \lambda^{2} / 4 \Pi$
$= 0.158$ meter^{2} for picture signal   (8)

$A_e = 0.155$ meter^{2} for sound signal   (9)

Now from equation (1) the power flux density S for CH1 is

$S = 2.5 * 10^{-13} / 0.158$ watt / meter^{2}
$= 15.83 * 10^{-13}$ watt / meter^{2}
$= - 88$ dB m / meter^{2} for picture signal   (10)

(For this calculation P_R in dB m is converted into watt)

Similarly for sound signal the value of P_R and λ are taken from equation (5) and (7) and by using equation (1) the calculated value of power flux density S is

$S = - 93.3$ dB m / meter^{2} for sound signal   (11)

For CH 2 :

Now for CH 2 value of G' is same and the value of P_S for both picture and sound signal are taken from Fig-8 which are

P_S = - 44 dB m for picture signal
P_S = - 50 dB m for sound signal

So P_R for these two signals are

P_R = - 92 dB m for picture signal (12-a)
P_R = - 98 dB m for sound signal (12-b)

Now taking the value of A_e from equation (8) and (9) and by using the equation (1) , the value of power flux density S are given by

S = - 84 dB m / $meter^2$ for picture signal (13)
S = - 90 dB m / $meter^2$ for sound signal (14)

So power flux density S at GMRT antenna system for both CH 1 and CH 2 and for both picture and sound signal are given in equation (10),(11), (13) and (14) .

3.4 Calculation of power flux density for OMNIDIRECTIONAL RFI MONITORING SYSTEM (ORMS) :

In this system the trace outputs from the spectrum analyzer is displayed and saved by the computer. Each 401 -point data with time stamp for individual directions are stored in the file which is given by user . Since the settings of the spectrum analyzer and observation time are user defined so, in this experiment the settings of the spectrum analyzer are

Center frequency = 550 MHz
Span = 100 MHz
Resolution band width = 300 kHz
Video bandwidth = 3 kHz

Now the acquired data which are stored in the file , are plotted by GNU plot . For GNU plot a program of awk function is written for that data . **The program of awk function is given below.**

```
#!/usr/bin/gawk -f

BEGIN {FS=" "; k==0; t_samps = 15}
{
        if(NF >13)
        {
                for(j=0; j< t_samps; j++)
                {
                        for(i=1; i<402; i++)
                        {
                                if(j==k)
                                {
                                vector[j,i] = $i;
#print j, i, $i;
                                }
                        }
                }
        k++;
        }
}

END {
        for(i=1; i<402; i++)
        {
                printf("%2.2f\t", (500+(100/400)*i)-0.25);

                for(j=0; j< t_samps; j++)
                {
                        printf("%2.2f\t", vector[j,i]);
                }

        printf("\n");
        }
}
```

By using the above program the data in the file are converted into column format whose first column is corresponding to the frequency and the other columns are corresponding power level . Now by using GNU plot the data are plotted . The spectrum is given below .

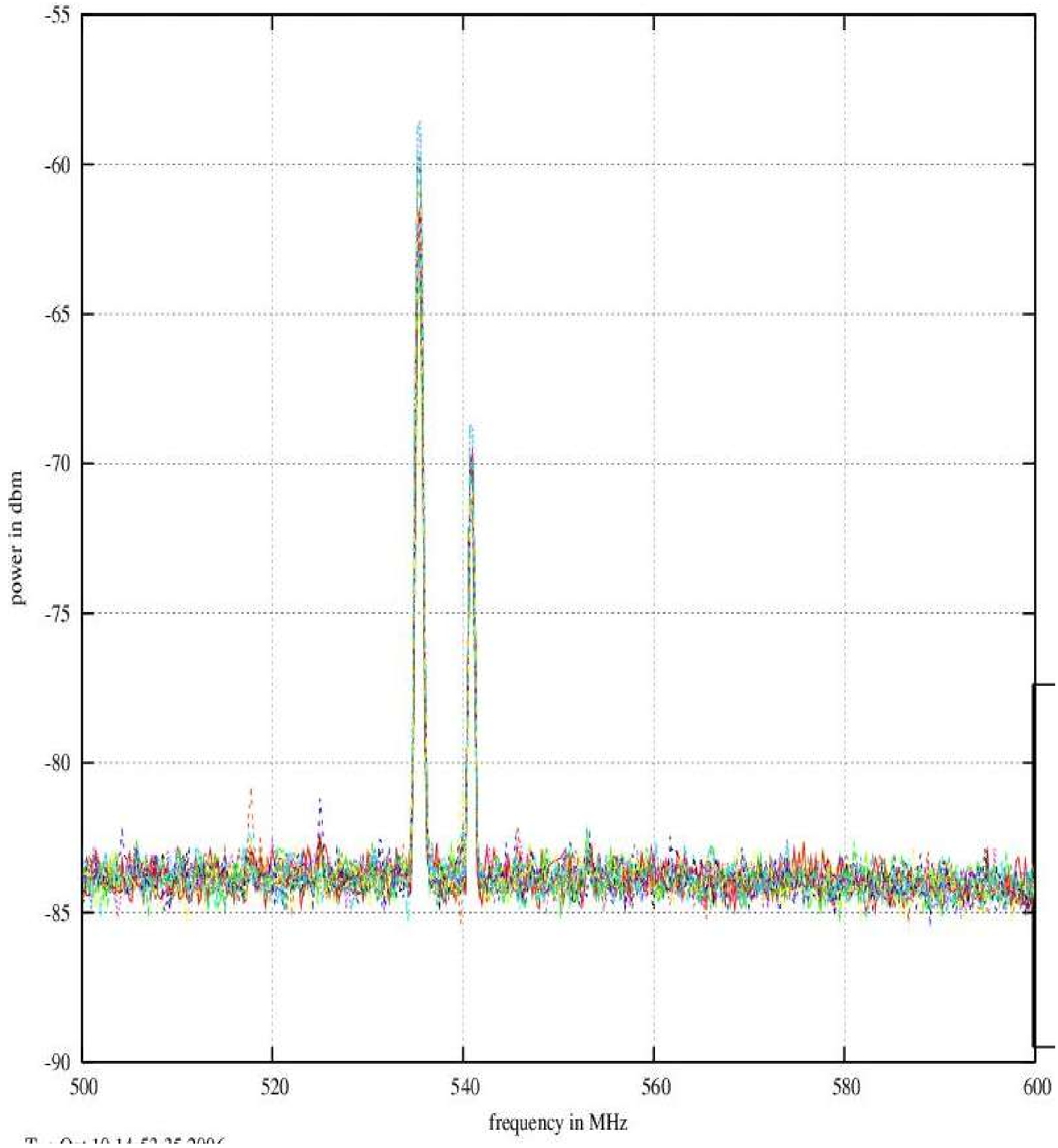


Fig-9: Spectrum of ORMS data along south direction .

Now from the spectrum P_N = - 84 dB m and from the settings of the spectrum analyzer B = 300 KHz . Here the off source antenna temperature is 155 K corresponding to the 500 MHz frequency (it is taken from the paper ' SIMULTANEOUS RESOLVING OF FREQUENCY SEPARATED NARROW BAND TERRESTRIAL RADIO SOURCES BY MULTI ANTENNA SPECTRUM MONITORING SYSTEMS ASSISTING RADIO ASTRONOMY ' written by S . Joardar)

Now from equation (3) ,

G' = 38 dB (15)

From Fig -9 , P_S = - 58 dB m for picture signal

= - 67 dB m for sound signal

From the theory power received at the antenna terminal is

P_R = - 96 dB m for picture signal (16)
= -105 dB m for sound signal (17)

The gain of the log periodic antenna G_{Ant} = 4.5 dB i (it is taken from Table-1) . So the gain factor G = 2.82 . From equation (6) and (7) we know the value of λ for picture and sound signal . From equation (2)

A_e = 0.07 meter ^{2} for picture signal (18)
= 0.068 meter ^{2} for sound signal (19)

Now from equation (1) the power flux density S is

S = - 84.5 dB m / meter ^{2} for picture signal (20)

= - 93.3 dB m / meter ^{2} for sound signal (21)

3.5 Results of the calculation

Table – 2 : Value of P_S in dB m

	For GMRT antenna system	For ORMS system
For picture signal	CH1 : -48.2 CH2 : -44	-58
For sound signal	CH1 : -53.4 CH2: -50	-67

Table -3 : value of S dB m / meter ^{2}

	For GMRT antenna system	For ORMS system
For picture signal	CH1 : - 88 CH2 : - 84	-84.5
For sound signal	CH1 : -93.3 CH2: -90	-93.3

3.6 CONCLUSION :

Since the source is TV transmitter at pune which is 80 km far from GMRT and the distance between radio telescope and log periodic antenna (ORMS) is small compare with that distance, so the power flux density S at the antenna terminal(in the free space) should be same for both the system . The result in table-3 shows that the value of S is nearly same , the variation is very small (± **2** dB m / meter ^{2} for picture signal and ± 1.5 dB m / meter ^{2} for sound signal) . So he theory matches with the measured value which is calculated above.

CHAPTER 4

4.0 INTRODUCTION :

This chapter contains analysis of data which is acquired by simultaneous experiment. A simultaneous experiment is done i.e. data is acquired simultaneously by GMRT antenna (c03 antenna is used) and ORMS receiver and simultaneously a program is started in control room which records the position of the antenna with time. Data of GMRT antenna is acquired by using LAB VIEW (Laboratory Virtual Instrument Engineering Workbench) software at antenna base (by connecting the spectrum analyzer with computer by GPIB cable) . Data of ORMS system is acquired by computer (which is described in section 2.2). In antenna base two experiments are done , in first part the antenna is rotated in azimuth with 610 feed pointed to horizontal kepping elevation angle fixed at 90 deg. the data is acquired by the software in every 1.5 sec. This is done for both channels(CH1 and CH2).In second part, the feed is focused and for a particular value of azimuthal angle(0, 45, 90, 135, 180, 225, -45 , -90 degree) data is acquired by changing the elevation angle from its maximum limit to minimum limit (which is 90 degree to 17 degree). This is done only for CH1 and for eight direction of azimuthal angle. The data analysis of the two system is done in the following way

4.1 Analysis of data acquired at c03 antenna base :

The data which is recorded at the antenna basein the first part of the experiment(discussed in section 4.0) is plotted by GNU plot and for that a C -program is used which is given below. Each plot is divided into several region (A,B,C,D,E,F,G,H,I) to explain the whole thing. Fig-10 shows the power pattern of TV picture signal for different azimuthal angle and fixed elevation angle (90 deg.) at C03 antenna base for CH1.

```
#include <stdio.h>

#define LINELEN 4096


int main (int argc, char *argv[])
{
	char fin[128], fout[128];
	char line[LINELEN];
	int hr, min,mm,date,yr;
	char dummy[3];

	FILE *fdin, *fdout;

	if(argc != 3 ) {fprintf(stderr, "USAGE:%s infile outfile\n",
argv[0]); return -1;}

	strcpy(fin, argv[1]);
	strcpy(fout, argv[2]);

	if(((FILE *)fdin=fopen(fin,"r"))==NULL) {perror(fin);return
-1;}
	if(((FILE *)fdout=fopen(fout,"w"))==NULL) {perror(fout);return
-1;}

	while((fgets(line,LINELEN-1,fdin))!= NULL){
	  line[strlen(line)-1]='\0';
		sscanf(line, "#%d/%d/%d %d:%d %s",
&mm,&date,&yr,&hr,&min, dummy);
		if(strcmp(dummy, "PM") == 0){
			if(hr != 12) fprintf(fdout, "%7.4f ",
hr+min/60.0+12.0);
			else fprintf(fdout, "%7.4f ", hr+min/60.0);
		}
	else fprintf(fdout, "%7.4f ", hr+min/60.0);
		fgets(line,LINELEN-1,fdin);
//	  line[strlen(line)-1]='\0';
    fprintf(fdout, "%s", line);
		fgets(line,LINELEN-1,fdin);
	}
	fclose(fdin);
	fclose(fdout);
}
```

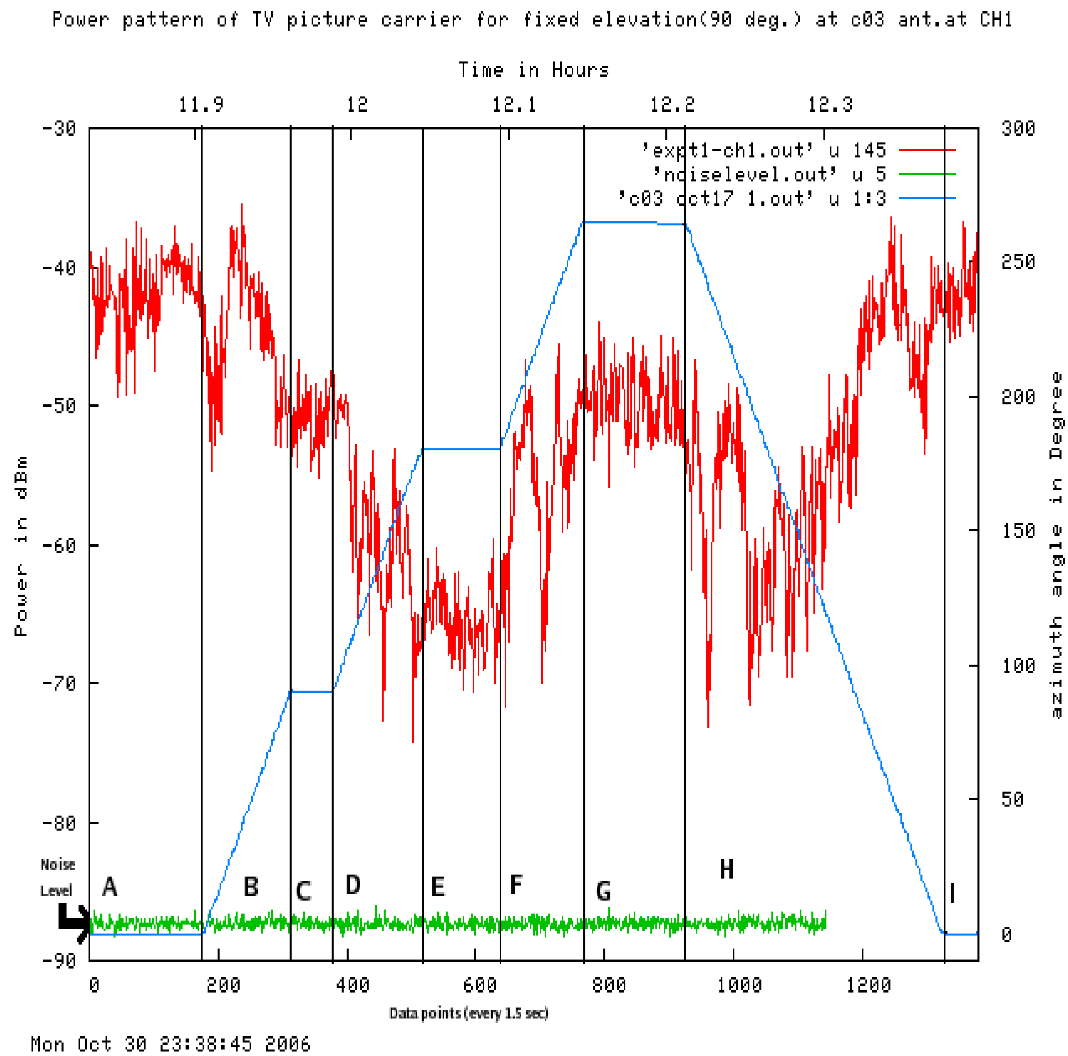


Fig-10: Power pattern of TV picture carrier for different azimuth angle and fixed elevation angle(90 deg.) at c03 antenna base for CH1

The following conclusions are drawn from the fig-10 .

For region A,C,E,G,I :

In region A the feed is faced along south direction. And in region C , E, G,I it is faced along west , north , east and again south direction . Since in that particular regions the feed is fixed along a particular direction and the source is constant so, power received by the antenna in each region should be constant . But due to the interference of the broadband signal caused by different signal, the power varies . Now the received average power level in each region are different . This can be explained in the following way.

The average power level in region A is maximum than the other regions because the source is TV transmitter at pune which is towards south from GMRT . So the receiver receives much power towords source direction.The average power level in region C is nearly 10 dB m lees than in region A and in region E it is nearly 15 dB m less than in region C . But the average power level in region C and G are nearly same because these two directions are same degree apart from the source direction . And the average power level in region A and I are same because in these two regions the feed is faced along same direction (south) .Now since the source is constant and the gain of the antenna and receiver system are constant for a particular frequency so , the changes of power level is due to the changes of effective area of feed with the direction of the antenna. If south direction is taken as reference and since the average power level in reg. C is nearly 10 dB less than in reg. A , so the effective area of the feed in that direction is 10 times less than the effective area towards the reference direction .The average power level in reg . G is nearly same as in reg. C so , the effective area of the feed in that direction is same as in reg. C . The reason of that is the C and G reg. corresponds to the west and east direction and both are 90 deg . differ from the source direction so, the feed offers nearly same effective area for this two directions. Now the region F which corresponds north direction and just opposite to the direction of the source so, the average power level is minimum . And since it is nearly 15 dB m less than the average power level in reg. C , so the effective area of feed is 15 times less than the effective area offered by the feed in reg. C . So from the above explanation it can be concluded that the variation of the received average power level with different directions is due to the different effective area offered by the feed for a particular source.

For region B, D , F and H :

In region B the antenna is rotated from south to west direction . In region D , the antenna is rotated from west to north , in reg. F it was rotated from north to east and in reg. H it is rotated from east to south. Here the variation of the power level is varies rapidly than the reg. A, C,E, G and I because due to the rotation of antenna the effective area offered by feed changes fast and also due to the broadband signal interference . Now in Fig-10 there are two peaks in reg. B and at the end of the reg. H. The reason is that the source is not exactly south direction it is 20 or 30 deg. apart from south towards west direction . So, these two peaks corresponds to max. power received by the antenna along exactly to the source direction .

Noise level :

The spectrum analyzer noise level is shown in the Fig -10 . From the figure it is seen that the noise level is very below from the power level ,so the the measurement which are done in the experiment are not noise limited .

The above explanation is for picture signal only at CH1 of the C03 antenna base . The plot of the same thing for sound signal is given below (Fig-11) and the explanation is the same as above .

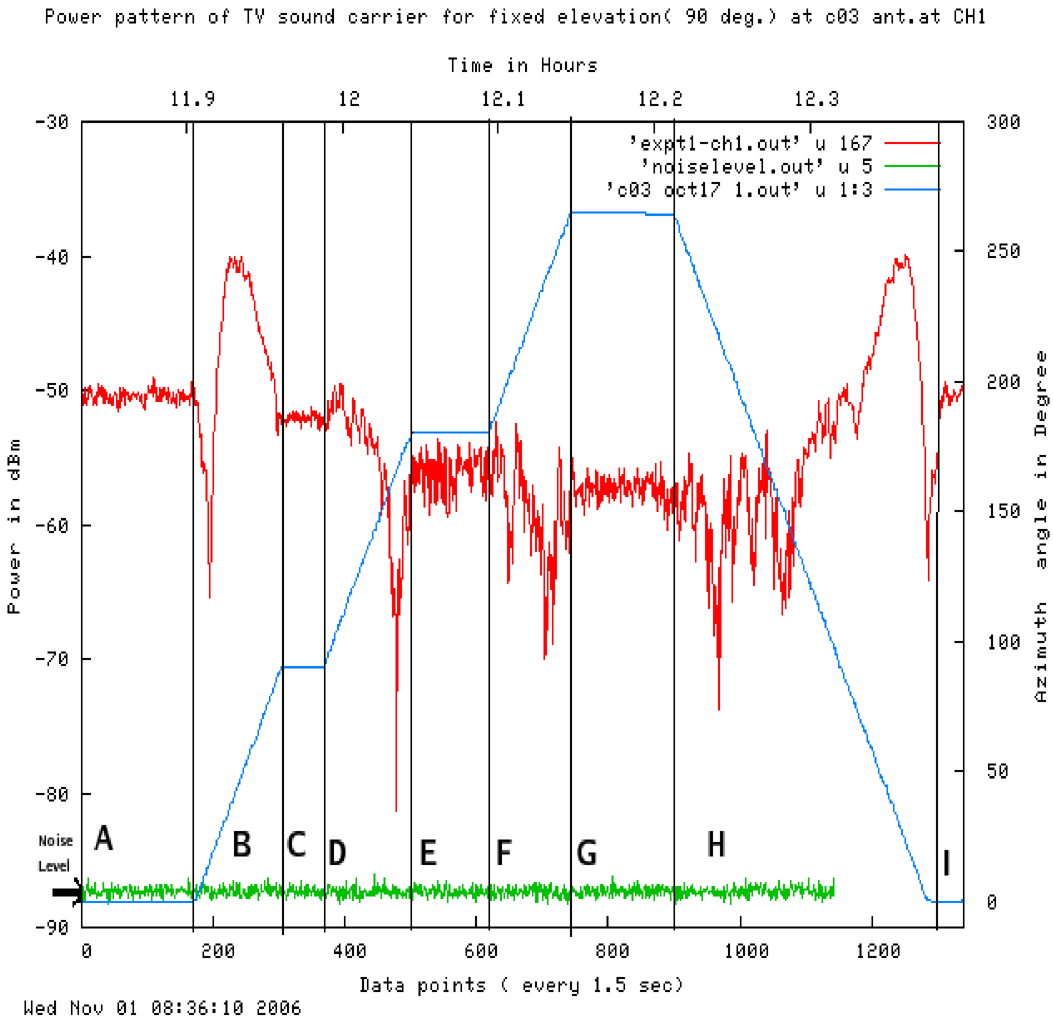


Fig-11: Power pattern of TV sound carrier for different azimuth angle and fixed elevation angle(90 deg.) at c03 antenna base for CH1

The same plots are given below for CH2 for both picture signal (fig-12) and sound signal (fig-13).

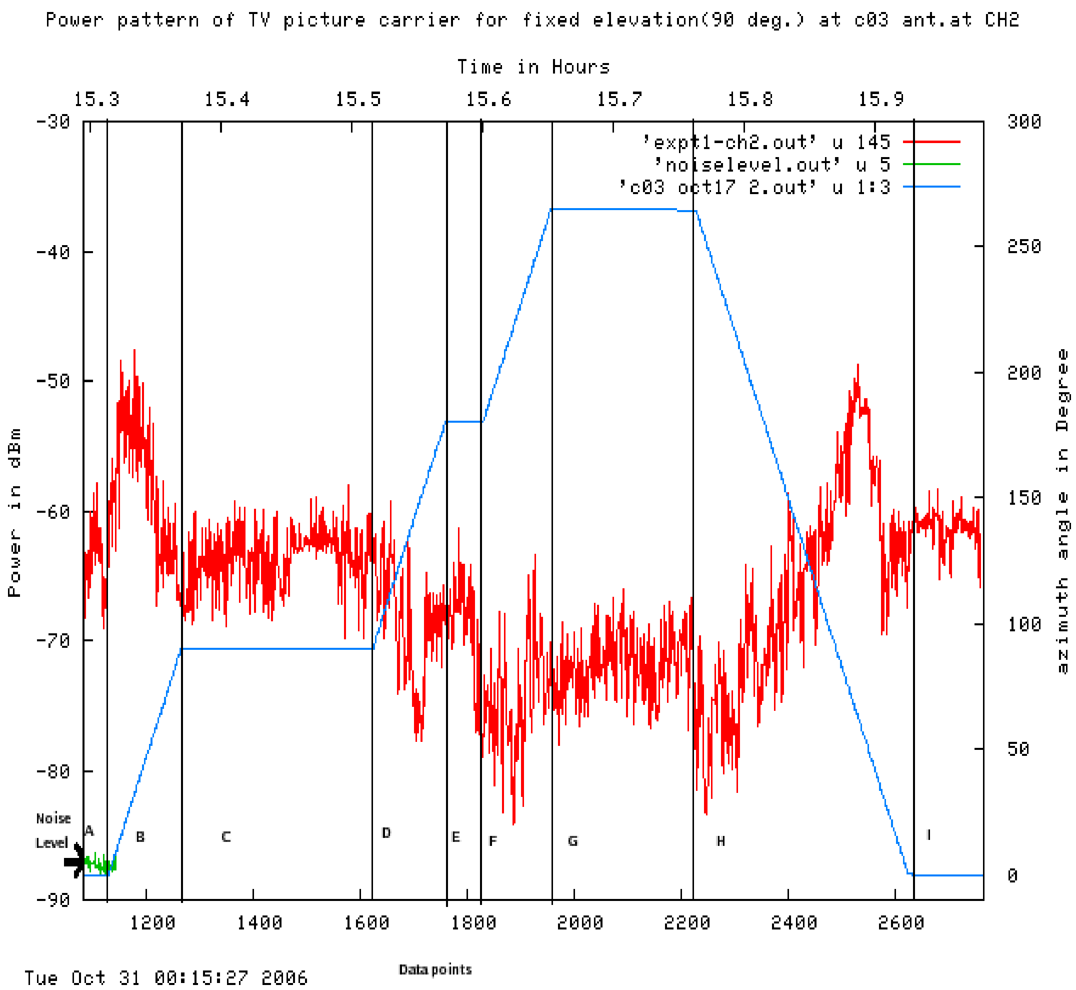


Fig-12: Power pattern of TV picture carrier for different azimuth angle and fixed elevation angle(90 deg.) at c03 antenna base for CH2

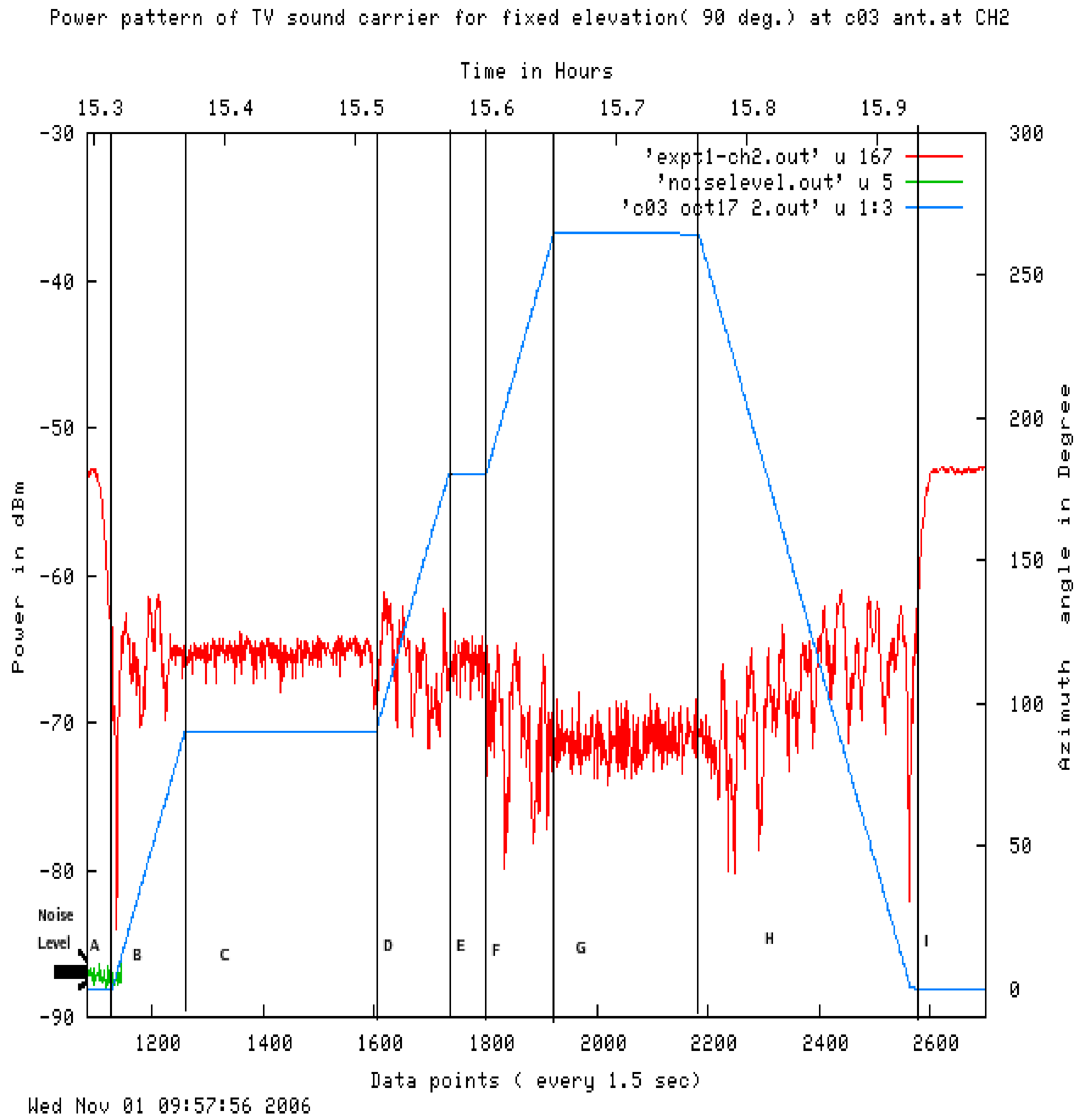


Fig-13: Power pattern of TV sound carrier for different azimuth angle and fixed elevation angle(90 deg.) at c03 antenna base for CH2

In the second part of the experiment (discussed in section 4.0), the feed is focused . Now the data (which is acquired by the LABVIEW program) is plotted by GNU plot .Each plot shows the variation of power with elevation angle for a particular angle azimuth angle . The plots are given below.

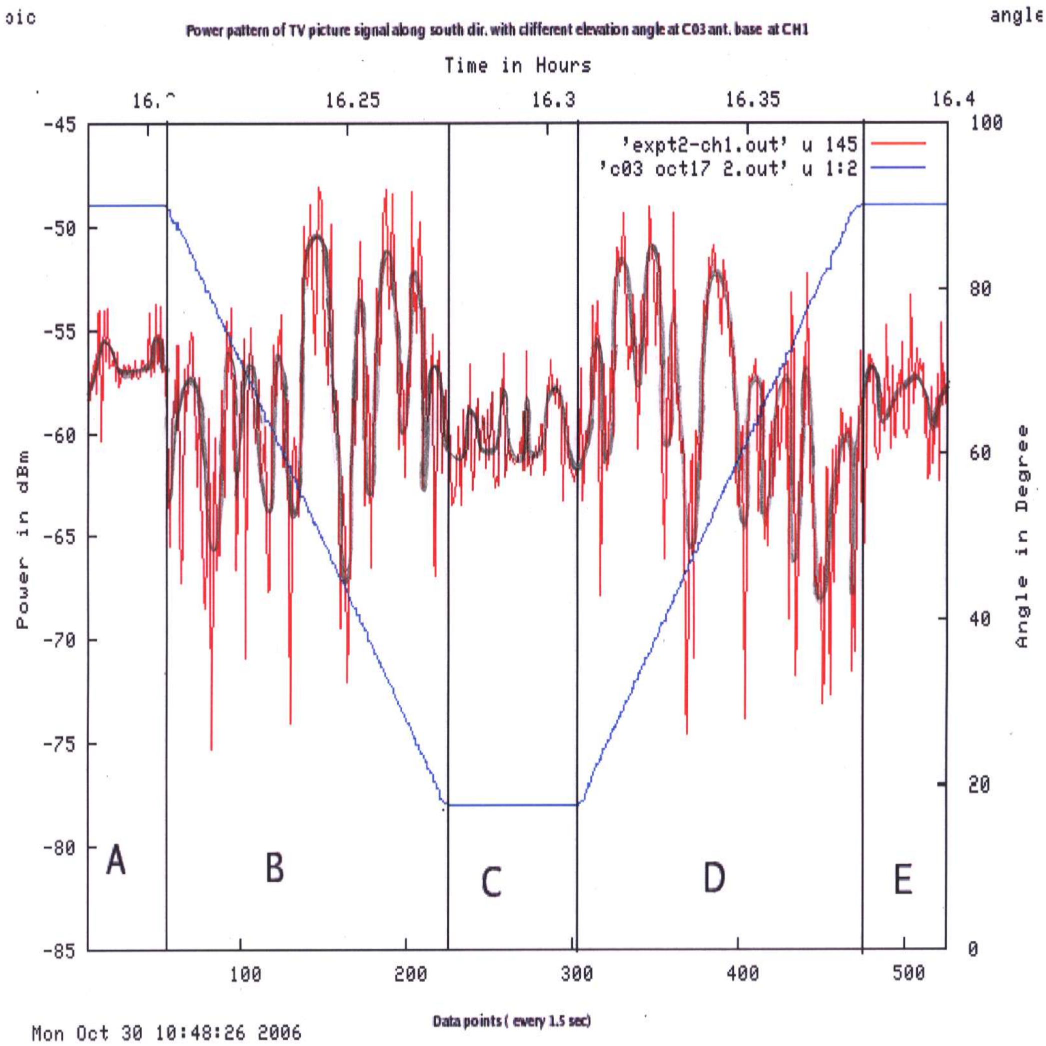


Fig-14: Power pattern of TV picture signal along south direction (azimuthal angle = 0 deg.) with different elevation angle at C03 antenna base at CH1.

The above plot (Fig-14) shows the variation of power with elevation angle for fixed value of azimuthal angle (which is zero deg) . For explanation of the whole thing the plot is divided into several regions. each region is explained in the following way .

For region A and C :

In these regions the feed is focused and the antenna is directed towards south direction and the elevation angle is also constant(90 deg.) , so the power level should be constant here because the source is constant . But there is small variation of the power level this is due to the interference of broadband signal caused by different sources .The average power level in these two regions are nearly same because the azimuthal and elevation angle are constant.

For region B and D :

In these region the elevation angle is changed from its maximum limit to minimum limit (i.e.90 deg. to 17 deg.) . The power varies very rapidly with time . When the elevation angle changes , the feed offers different effective area which changes very rapidly with time and for that reason the power level changes rapidly .

For region C :

In this region the elevation angle is fixed at 17 deg. and the azimuth angle is also fixed at zero deg. . For this reason the variation of power is small .

Now the traced of the plot which gives the average variation of the power level , shows mirror symmetry about the central line of the plot . This is the cross check of the experiment and from here we can conclude that the effective area offered by the feed changes in the same manner when the elevation angle changes from maximum to minimum and minimum to maximum.

The plots of other directions (north , west , east , south-west,west-north) for picture signal are given below . The explanation of each plot are same as above .

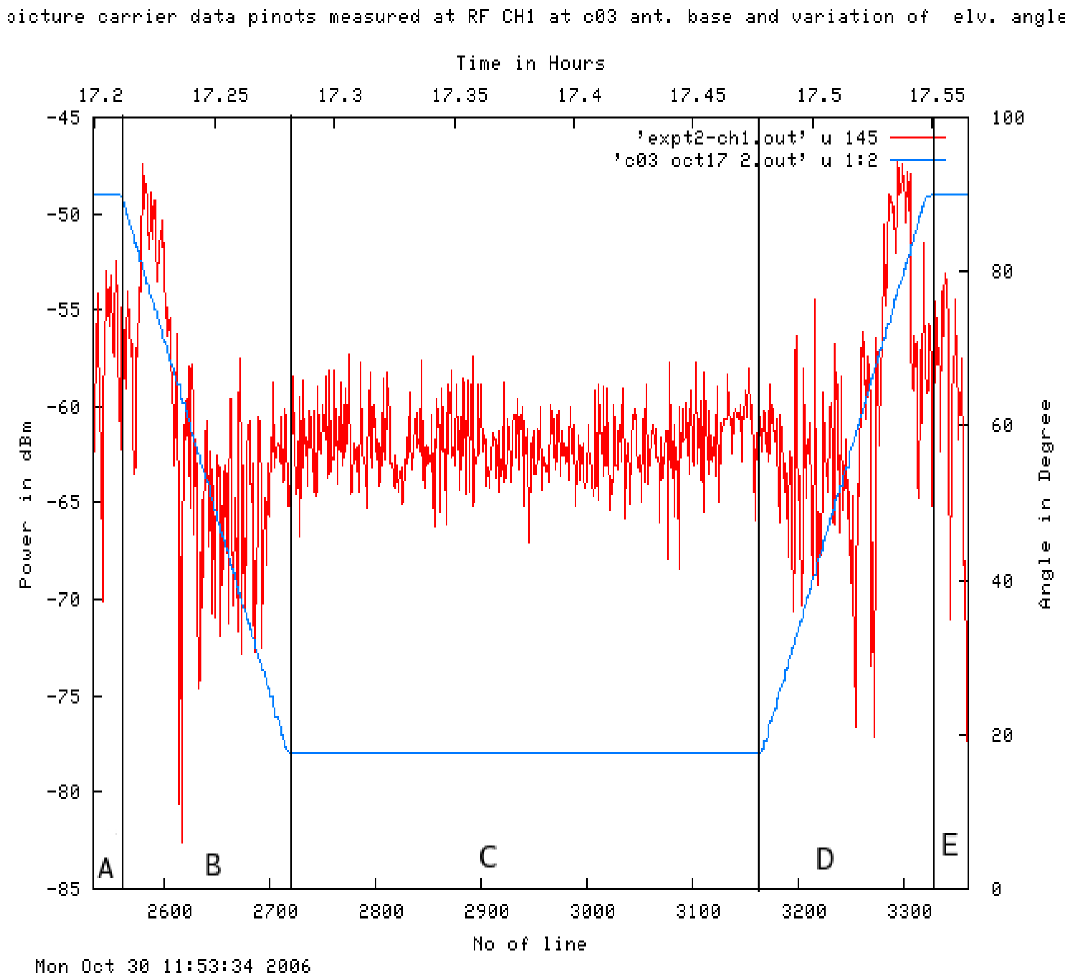


Fig-15: Power pattern of TV picture signal along north direction (azimuth = 180 deg.) with different elevation angle at C03 antenna base at CH1.

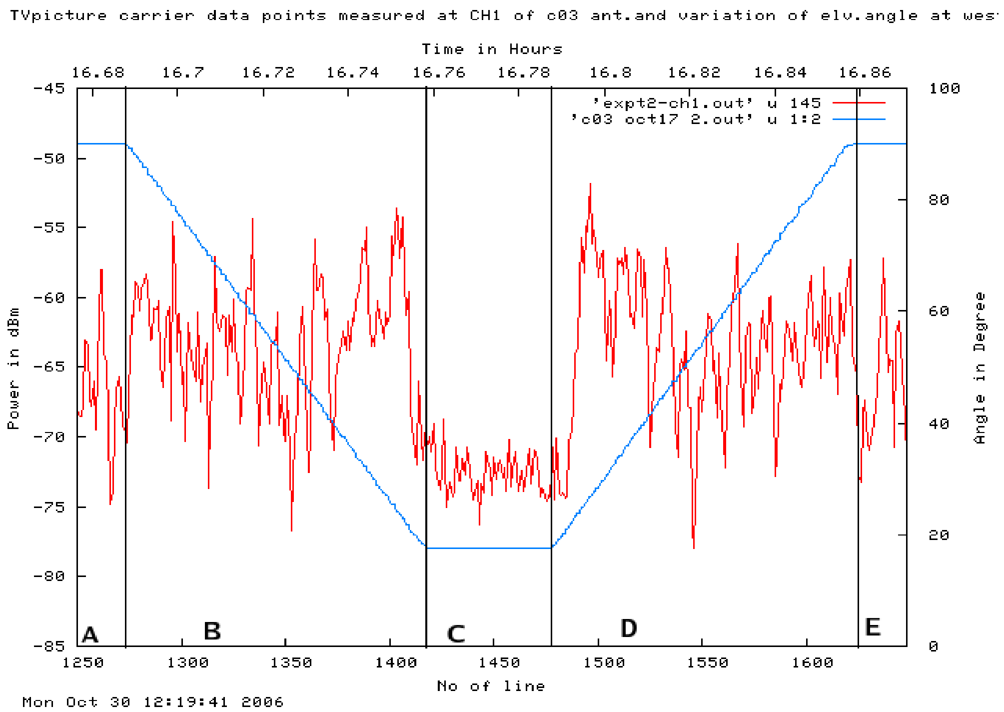


Fig-16: Power pattern of TV picture signal along west direction (azimuth = 90 deg.) with different elevation angle at C03 antenna base at CH1.

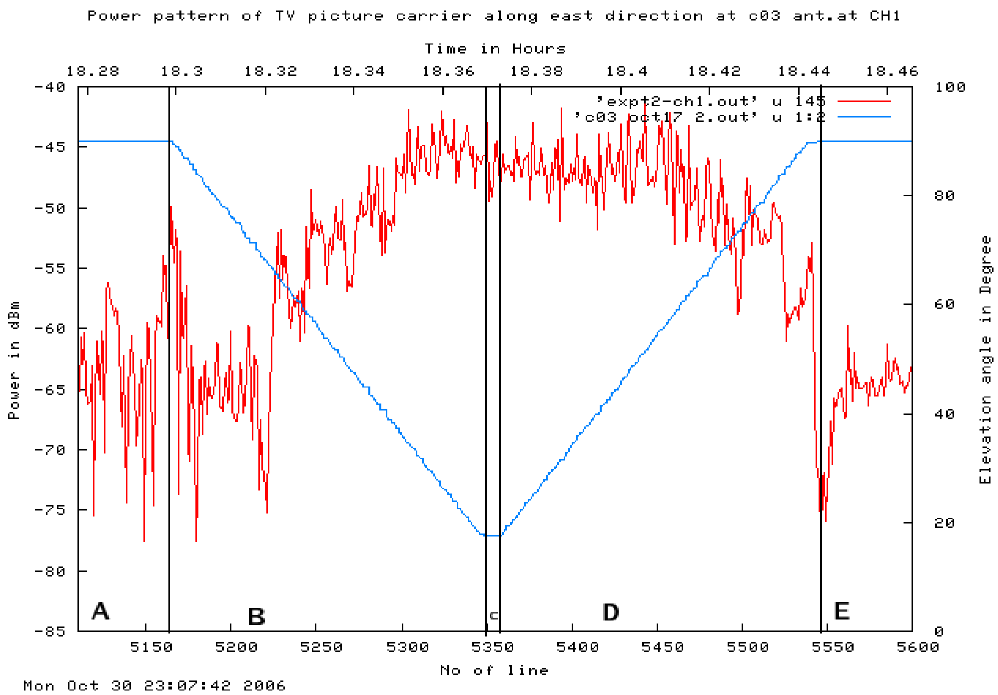


Fig-17: Power pattern of TV picture signal along east direction (azimuthal angle = - 90 deg.) with different elevation angle at C03 antenna base at CH1.

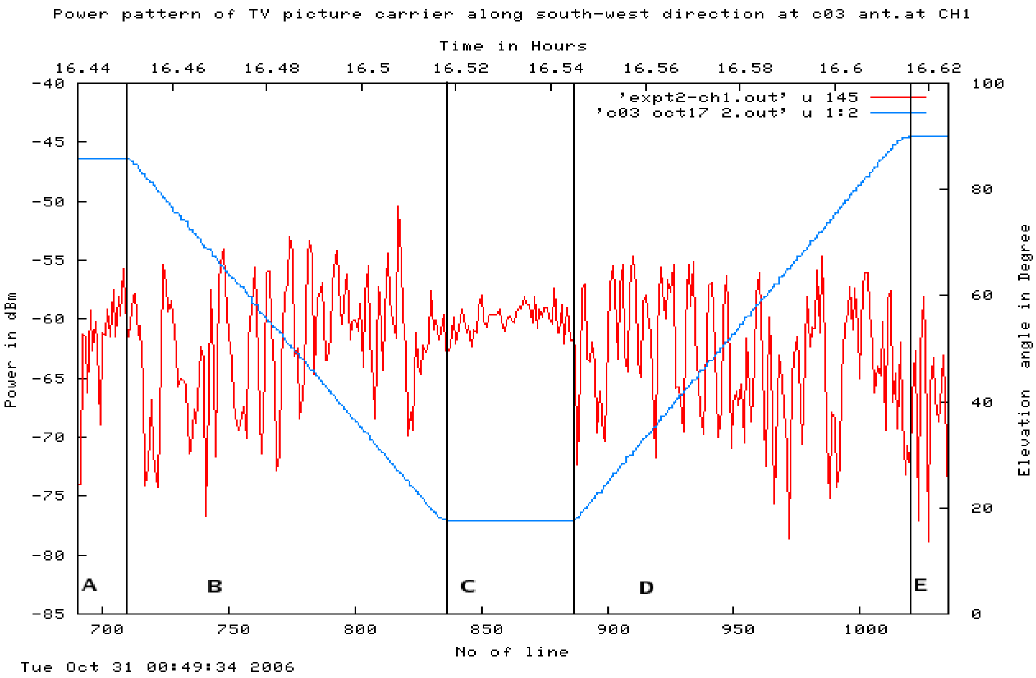


Fig-18: Power pattern of TV picture signal along south-west direction (azimuth = 45 deg.) with different elevation angle at C03 antenna base at CH1.

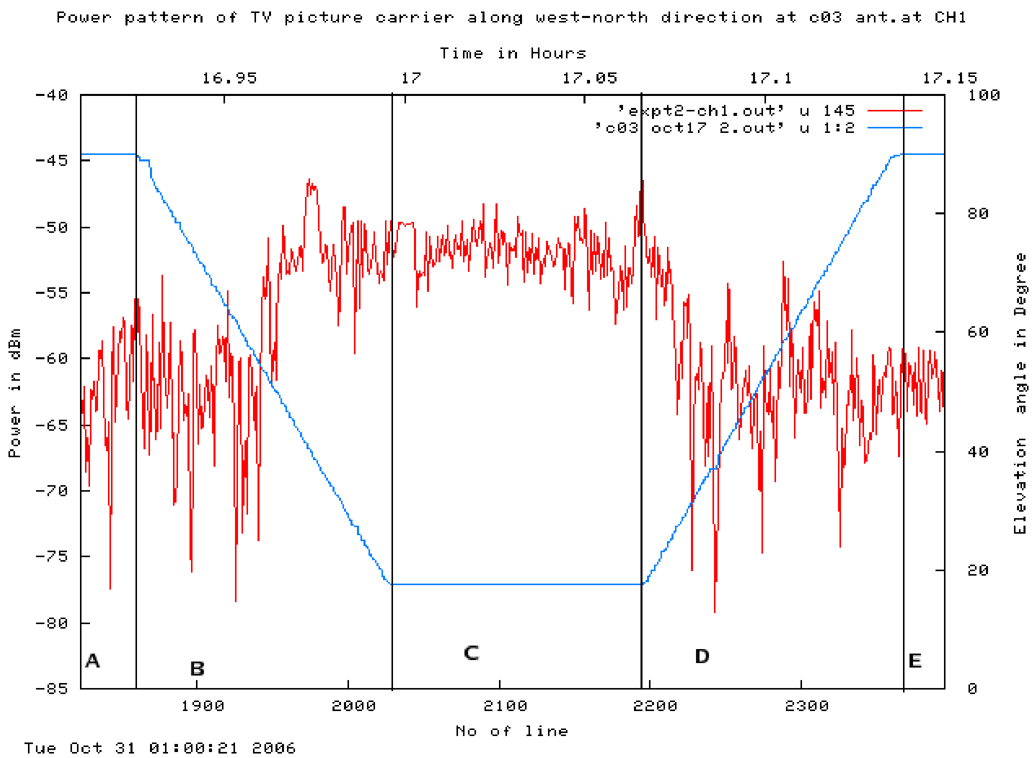


Fig-19: Power pattern of TV picture signal along west -north direction (azimuth = 135 deg.) with different elevation angle at C03 antenna base at CH1.

4.2 Analysis of data acquired by ORMS system :

In this system data is stored in another computer simultaneously when measurement is done at C03 antenna . Since the time of the software (which acquires data) can not be changed so it is not possible to synchronize that time with the time of on time program (which takes the data of different position of antenna) . For that the time difference of these two clock is taken . The time of RFI software is 32 min 44 sec. ahead of the on time program .So these value is subtracted in C-program (which is used to plot the data) The program which is used for plotting the data is given below .

```
#include <stdio.h>

#define LINELEN 4096

      int main (int argc, char *argv[])

      {
           char fin[128],fout[128];
           char line[LINELEN];
           int hr,min,sec;
           float td=0.5455;

   FILE *fdin,*fdout;

        if(argc !=3) {fprintf(stderr,"USAGE:%s infile outfile\n",argv
[0]);return-1;}

          strcpy(fin,argv[1]);
          strcpy(fout,argv[2]);


       if(((FILE *)fdin=fopen(fin,"r"))==NULL){perror(fin);return-1;}
       if(((FILE *)fdout=fopen(fout,"w"))==NULL){perror(fout);return-
1;}
          //printf("enter the time diff\n");
          //scanf("%f",&td);


             fgets(line,LINELEN-1,fdin);
             fgets(line,LINELEN-1,fdin);
             fgets(line,LINELEN-1,fdin);
             fgets(line,LINELEN-1,fdin);

      while((fgets(line,LINELEN-1,fdin))!=NULL){
           line[strlen(line)-1]='\0';
           sscanf(line,"%d %d %d\n",&hr,&min,&sec);
           fprintf(fdout,"%7.4f ",hr+min/60.0+sec/3600.0);
```

```
            fprintf(fdout,"%7.4f",hr+min/60.0+sec/3600.0-td);
            fgets(line,LINELEN-1,fdin);
            fgets(line,LINELEN-1,fdin);
            line[strlen(line)-1]='\0';
            fprintf(fdout,"%s\n",line);
            fgets(line,LINELEN-1,fdin);

          }

            fclose(fdin);
            fclose(fdout);
    }
```

Since the feed of the log periodic antenna (LPA) is fixed so , the data in four directions is taken and since the source is along south direction so the variation of power along south direction is drawn for both picture signal and sound signal . These plots are given below (Fig-15 and Fig-16) . Here the variation of power pattern is small because the feeds are fixed . This small variation is due to the inference of broadband signal.

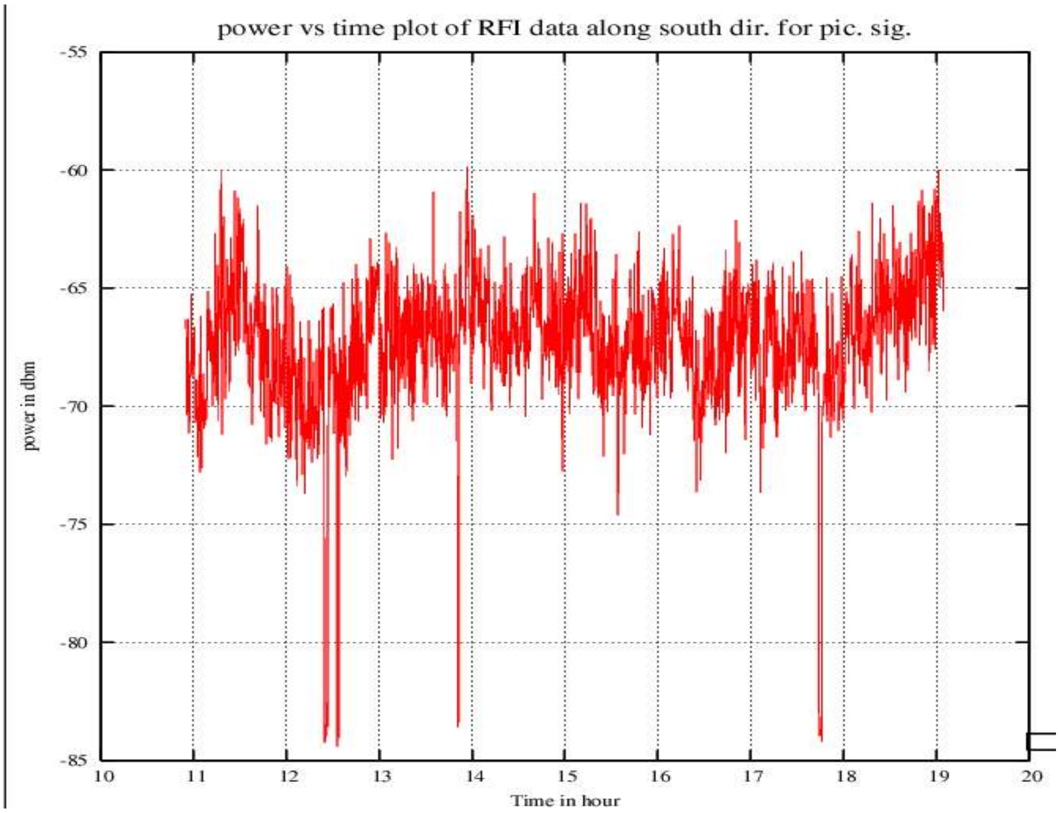


Fig-20: Variation of power with time along south direction of RFI system of picture signal .

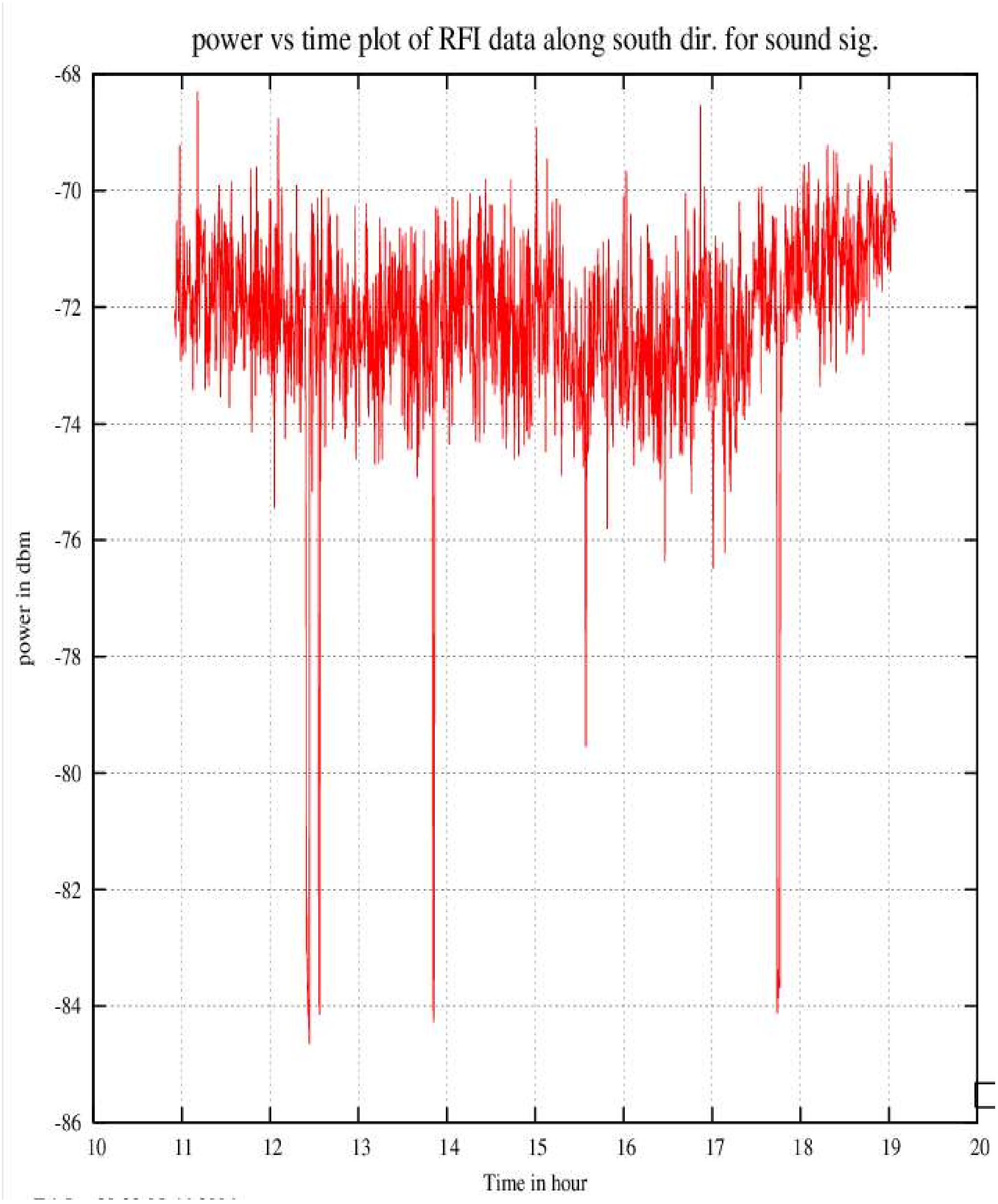


Fig-21: Variation of power with time along south direction of RFI system of sound signal .

4.3 Comparative study of power pattern of the two antenna system :

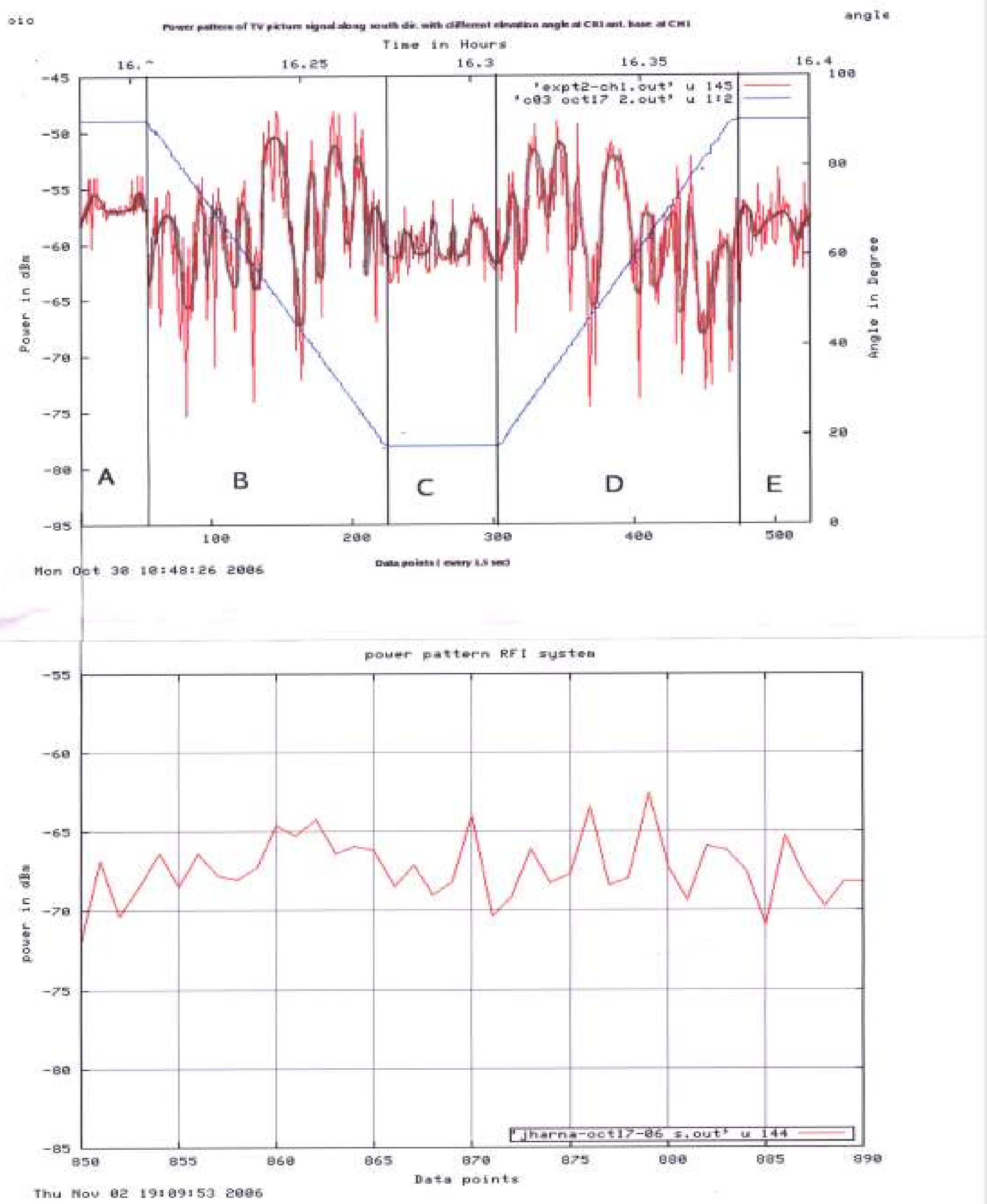


Fig-22: Comparison of power pattern of RFI system and GMRT antenna system for different elevation angle towards south direction for picture signal.

The variation of power received by GMRT antenna as a function of azimuthal and elevation angle and the variation of power received by RFI system is given in the same plot . The upper portion of the plot in Fig- 22 shows the variation of power received by GMRT antenna with elevation angle when the feed is focused and the azimuthal angle is 0 deg. (towards south direction) and the lower portion of the plot shows variation of power of RFI system towards south direction corresponding to the same time (which is 16.185 to 16.4) .The plot shows the power level of RFI system is nearly constant and the power level of GMRT antenna system varies in differently with different elevation angle towards south direction. From this plot a relation between the power received by two antenna system could be established. The variation of power of GMRT antenna with elevation angle for 6 directions (south, north , east , west . south-west and west-north) of azimuth for picture signal are given in this paper from these plot the relation between the power received by GMRT antenna with different elevation angle and different azimuthal angle (here 6 directions are available) and the power received by RFI system could be established .

CHAPTER 5

CONCLUSION AND SCOPE OF FUTURE WORK

A methodology to estimate the power that will be received by the GMRT antenna as a function of the antenna's azimuth and elevation position based on the signal as received by the ORMS system has been established . The scope of the work can be easily extended to the RFI sources in other frequency band and location as well as for individual antenna of GMRT .

CHAPTER 6

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   Mr. Shubhendu Joardar