A PROJECT REPORT ON

RADIO FREQUENCY INTERFERENCE MONITORING AT GAURIBIDANUR

CARRIED OUT AT

RAMAN RESEARCH INSTITUTE, BANGALORE

SUBMITTED BY

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In the partial fulfillment of the requirement for the award of degree of

Bachelor of Engineering
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UNDER THE GUIDANCES OF

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CERTIFICATE

Certified that the project work entitiled "**Radio Frequency Interference Monitoring at Gauribidanur** ", is a bonafied work carried out by *Amarendra K . V* and *Ravi M . S* in partial fulfillment for the award of degree of Bachelor of Engineering in Electronics and Communication of the **Visveswatraiah Technological University**, Belgaum during the year 2001-02. It is certified that all corrections/suggestions indicated for Internal Assessment have been incorporated in the Report deposited in the departmental library. The project report has been aproved as it satisfies the academic requirements in respect of Project work prescribed for Bachelor of Engineering Degree.

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Certificate

This is to certify that the project titled

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under my guidance.

This project is in partial fulfillment of the requirement for the award of Bachelor's Degree in Electronics and Communication for the Visveshwaraiah Technological University during the academic year 2001-2002.

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ABSTRACT

Radio astronomy is a field of science in which the study of the universe is carried out using radio telescope. This is done by acquiring the sky signal with the help of the radio telescope. In general, the strength of the sky signal is as weak as 10^{-26} to 10^{-30} W/(m^2-Hz). So the receiver built to acquire data will be highly sensitive. Therefore if the sky observation has to be carried out, the environment must be free from radio frequency interference. If not it will mask the signature of the astronomical sources in the sky data. So before any astronomical observation is done, the survey of interference should be carried out.

A similar exercise forms the main work of this project. In this project work interference monitoring was carried out at Gauribidanur to assess the status of RFI level there.

Contents

List of Tables

List of Figures

Chapter 1
Introduction

1.2 Definition of Interference

In the context of Radio Astronomy, *"Interference"* can be defined as any undesired signal in the frequency band of observation.

1.2 Classification of Interference

Depending upon the power level and duration of occurrence, interference can be classified into the following two main categories

1. Low level Interference.
2. High level Interference.

Both high level and low level interference can be furthur classified into "Continuous" and "Intermittent" interference. Figure 1.1 shows the classification of interference

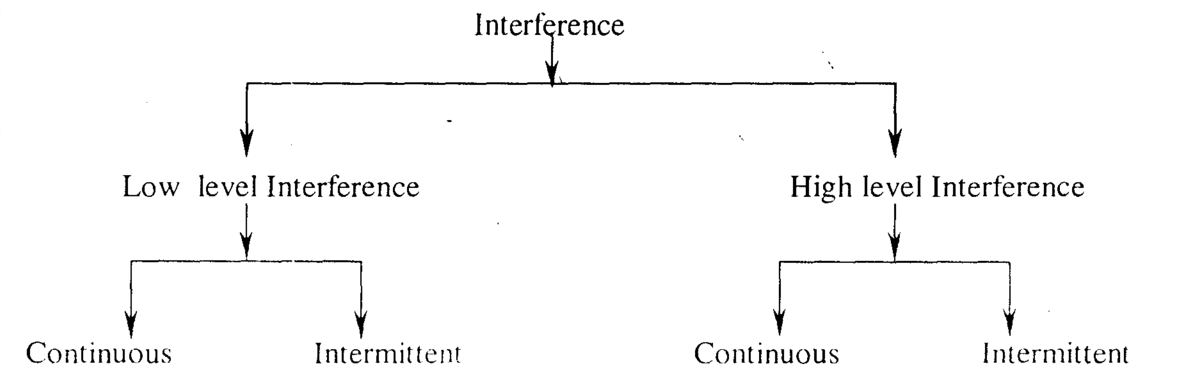


Figure 1.1 : *Classification of interference*

In general, the interfering signal is considered to be of low level if it is completely hidden in the noise floor of measuring instrument. *"Continuous"* interfering signal is one that appears most of the time in the spectral band of observation. On the other hand, if interference occurs once in a while in the spectral band of observation, it will be known as *"intermittent"*. The main objective of our project is to monitor only *"high level continuous"* interference .

1.3 Importance of Interference monitoring in Radio Astronomy

It is very much necessary to make a survey of the interference before carrying out any radio astronomical observations, in order to make sure that no interference line exists in the frequency band of observation. The effect of the interference line on the radio observation is of dual fold:

i) In continuum radio observation, the presence of interference line compoletely masks the signature of the astronomical source

ii) Since the receiver will be very sensitive to low level signals, it will be driven into saturation by a strong interference. Once the receiver gets saturated, the system will no longer work in the linear regime.

Interference monitoring gives information about the interrfering signals, their intensity and duration of occurrence.

1.4 Interfering Signal Properties

The following are some of the important properties of the interfering signals that should be measured for characterizing them.

1.*Polarization matrix vs Time*

This gives the polarization information of the interference lines. By having this information we can plan to observe the sky in a polarization mode much different from that of the interfering line .

2.*Direction vs time*

This indicates the direction of source of interfering signal. By knowing the direction, we can minimize the effect of interference by completely avoiding that direction for radio observation.

3.*Frequency and Bandwidth*

This gives us the information about spectral components of the interfering signal. Also it gives us some information about the modulation of interfering lines.

Any communication service, whatever be its purpose, must be established and must operate in such a manner as not to cause harmful interference to the radio services of recognized operating agencies. Many cases of harmful interference are caused by non-confirming assignments or out-of-band operations.

Chapter 2

International Telecommunication Union specifications on various aspects of Radio Communications

The International Telecommunication Union is responsible for the regulation of spectrum usage for various telecommunication purposes. The usage of spectrum has been regulated in a manner to avoid mutual interferences between the services by mere agreement. To achieve this, the ITU has set up the Radiocommunication sector which has brought the various communication services under several study groups. Some of the study groups are specified below.

1.Study Group 1	Spectrum Management
2.Study Group2	Interservice sharing and compatibility
3.Study Group3	Radio wave propagation
4.Study Group4	fixed satellite service
5.Study Group7	Science services
6.Study Group8	Mobile, radio determination, amateur and related satellite services
7.Study Group9	Fixed service

The standard specifications for Radio Astronomy comes from the Study Group 7.

2.1 Frequency Allocation

The Radio Regualations are made by the ITU for usage of the spectrum in planned manner. To achieve this, the whole world is divided into three regions. For any particular frequency band, allocations may be different in different regions. The frequency bands allocated to various radio astronomy services are listed in Table 2.1. The choice of the frequency band for Radio astronomy depends upon the type of observation.

Table 2.1 : Frequency Bands allocated to the radio astronomy service that are preferred for continuum observations (secondary allocations are contained within brackets)

Frequency Band (MHz)	Bandwidth (%)	Frequency Band (GHz)	Bandwidth (%)
13.36 – 13.41	0.37	10.6 – 10.7	0.94
25.55 – 56.67	0.49	(14.47 – 14.5)	(0.21)
(37.5 – 38.25)	(1.98)	15.35 – 15.4	0.33
73 –74.6	2.17	22.21 – 22.50	1.3
150.05 –153	1.95	23.6 – 24.0	1.68
322 – 328.6	2.03	31.3 – 31.8	1.58
406.1 – 410	0.96	42.5 – 43.5	2.33
608 – 614	0.98	86 – 92	6.74
1400 – 1427	1.91	105 – 116	9.95
1660 – 1670	0.60	164 – 168	2.41
2690 – 2700	0.37	182 – 185	1.63
(2655- -2690)	(1.31)	217 - 231	6.25
(4800 – 4990)	(3.88)	265 - 275	3.70
4990 - 5000	0.20		

2.2 Vulnerability of Radio Astronomy Obsevations to Interference

Radio astronomy is a passive service in the sense that it can only receive the signal instead of transmitting. The signals in radio astronomy are as weak as 10^{-26} to 10^{-30} W/(m^{2-} ^{H}z). The power flux densities of these signals are 40 to 100 dB below those utilised by other communication services. Therefore the receiver system because of its higher sensivity is highly vulnerable to interference.

2.3 Basic Assumptions in calculation of Interference level

Following are some of the important assumptions made to calculate the interference

1. The antenna is large enough to have very narrow main loibe beam width, so that the interference entering through the main lobe is highly insignificant. Therefore for all considerations, interference entering only through the sidelobes may be taken intop account.

2. Time averaging the signal reduces the noise fluctuations in it. Time averaging can be carried out in two stages. In the first stage averaging is done in the instrument while acquiring data. Later on averaging is done in the computer during analysis of the recorded data. As per the ITU specifications, the minimum averaging time prefered is 2000 sec. Integration time as high as 3600sec may be used for high sensivity observations.

2.4 Criteria for an interference to be detrimental to Radio Astronomy

1. ***Power level*** of the interfering signal is considered to be harmful if the interfering signal increases the output of the receiving system by 10% of the r.m.s output fluctuations due to the system noise.
2. The ***total time lost*** for interference must not be more thasn 10% of the total observation period.

2.5 Theoretical considerations while determining the sensivity of a receiver.

Let P represent the average noise power at the output of the receiver, N represent the numbr of independent samples of the output power acquired. Then minimum detectable power by the receiver is given by

$$\Delta P = \frac{P}{\sqrt{N}} \qquad \text{.......(2.1)}$$

The number of independent samples/sec that can be acquired is given by twice the bandwidth of the receiver. So as the bandwidth is increased, the number of samples/sec can also be increased. Also if the acquisition is made for τ seconds, then the number of independent samples becomes $2B\tau$, where B is the bandwidth of the receiver.

$$\therefore \text{ Minimum detectable power } \Delta P = \frac{P}{\sqrt{2B\tau}} \qquad \text{......(2.2)}$$

i.e.

$$\frac{\Delta P}{P} = \frac{K}{\sqrt{(B\tau)}} \qquad \ldots\ldots(2.3)$$

If the power is expressed in terms of the temperature, the above equation becomes

$$\frac{\Delta T}{T} = \frac{K}{\sqrt{(B\tau)}} \qquad \ldots\ldots.(2.4)$$

Where ΔT is the minimum detectable temperature. ΔT determines the sensivity of the receiver.

2.6 Threshold Interference levels

The threshold interference level is one which changes the output by 10% of the r.m.s system noise fluctuations .i.e.

$$\Delta P_I = 0.1\ (k\ \Delta T\ B)\ \ (W) \qquad \ldots\ldots\ (2.5)$$

$$\Delta T_I = 0.1\ \Delta T\ \ (^{\circ}k) \qquad \ldots\ldots\ (2.6)$$

where ΔP_I is the threshold interference level. Any interference at the input which increases the value of the noise at the output greater than ΔP_I is considered to be harmful. The tables 2.2 and 2.3 is the threshold levels of interference levels at various Radio astronomical frequencies both for continuum as well as spectral line observations.

Table 2.2 Threshold Levels of Interference detrimental to radio astronomy continuum observations[1]

Centre Frequency	Assumed Spectral line Channel Bandwidth	Minimum Antenna Noise Temperature	Receiver Noise Temperature	System sensitivity (noise fluctuations)		Threshold Interference Levels		
				Temperature	Power Spectral Density	Input Power	Power Flux Density	Spectral Power Flux Density
f (MHz)	ΔfA (MHz)	TA (K)	TR (K)	ΔT (mk)	ΔPs (dB(W/Hz))	ΔPH (dBW)	SHΔf (dB(W/m2))	SH (dB(W/(m2Hz)))
13.385	0.05	50000	60	5000	-222	-185	-201	-248
25.610	0.12	15000	60	972	-229	-188	-199	-249
73.8	1.6	750	60	14.3	-247	-195	-196	-258
151.525	2.95	150	60	2.73	-254	-199	-194	-259
325.3	6.6	40	60	0.87	-259	-201	-189	-258
408.05	3.9	25	60	0.96	-259	-203	-189	-255
611	6.0	20	60	0.73	-260	-202	-185	-253
1413.5	27	12	10	0.095	-269	-205	-180	-255
1665	10	12	10	0.16	-267	-207	-181	-251
2695	10	12	10	0.16	-267	-207	-177	-247
4995	10	12	10	0.16	-267	-207	-171	-241
10650	100	12	10	0.049	-272	-202	-160	-240
15375	50	15	15	0.095	-269	-202	-156	-233
23800	400	15	30	0.050	-271	-195	-147	-233
31550	500	18	65	0.083	-269	-192	-141	-228
43000	1000	25	65	0.064	-271	-191	-137	-227
89000	600	30	100	0.037	-273	-185	-125	-222
110500	11000	40	100	0.030	-274	-184	-121	-222
166000	4000	40	100	0.049	-272	-186	-120	-216
224000	14000	40	130	0.032	-274	-182	-114	-215
270000	10000	40	130	0.038	-273	-183	-113	-213

(1) Calculation of interference levels is based on the center frequency shown in this column although not all regions have the same allocations

(2) The Interference levels given are those which apply for measurements of the total power received by a single antenna . Less stringent levels may be appropriate for other types of measurements.

Table 2.3 Threshold Levels of Interference detrimental to radio astronomy Spectral-line observations

Centre Frequency f (MHz)	Assumed Spectral line Channel Bandwidth ΔfA (MHz)	Minimum Antenna Noise Temperature TA (K)	Receiver Noise Temperature TR (K)	System sensitivity (noise fluctuations)		Threshold Interference Levels		
				Temperature ΔT (mk)	Power Spectral Density ΔPs (dB(W/Hz))	Input Power ΔPH (dBW)	Power Flux Density SHΔf (dB(W/m2))	Spectral Power Flux Density SH (dB(W/(m2Hz)))
327	10	40	60	22.3	-245	-215	-204	-244
1420	20	12	10	3.48	-253	-220	-196	-239
1612	20	12	10	3.35	-253	-220	-194	-238
1665	20	12	10	3.48	-253	-220	-194	-237
4830	50	12	10	2.20	-255	-218	-183	-230
14500	150	15	15	1.73	-256	-214	-169	-221
22200	250	35	30	2.91	-254	-210	-162	-216
23700	250	35	30	2.91	-254	-210	-161	-215
43000	500	25	65	2.84	-254	-207	-153	-210
48000	500	30	65	3.00	-254	-207	-152	-209
88000	1000	30	100	2.91	-254	-204	-144	-204
98000	1000	40	100	3.13	-254	-204	-143	-203
115000	1000	40	100	3.35	-254	-204	-141	-201
140000	1500	40	100	2.55	-255	-203	-139	-200
178000	1500	40	100	2.55	-255	-203	-136	-198
220000	2500	40	130	2.40	-255	-201	-133	-197
265000	2500	40	130	2.40	-255	-201	-131	-195

Calculation of interference levels is based on the center frequency shown in this column although not all regions have the same allocations

(2) The Interference levels given are those which apply for measurements of the total power received by a single antenna . Less stringent levels may be appropriate for other types of measurements.

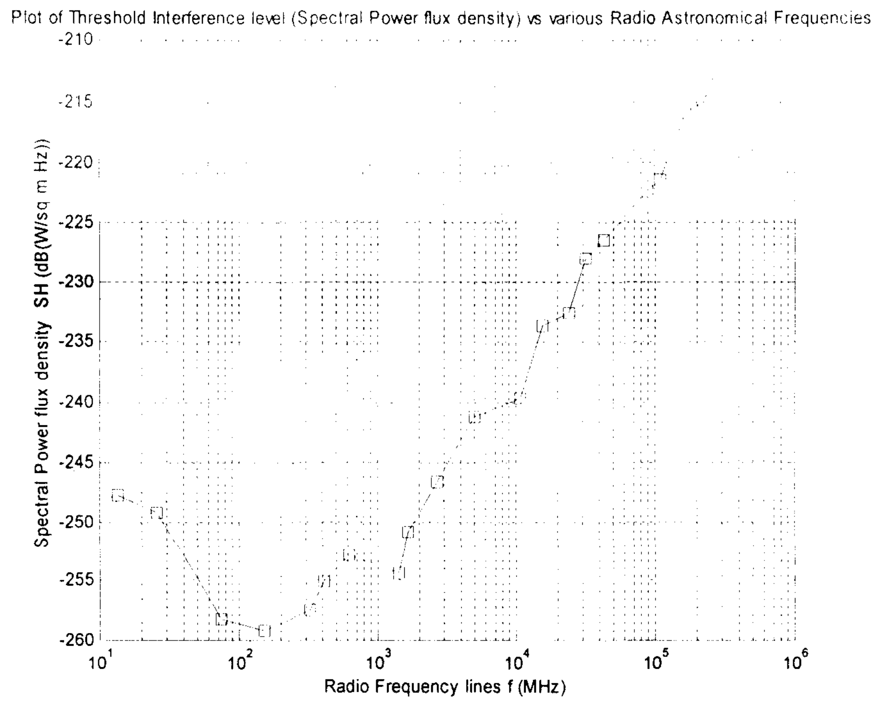


Figure 2.1 : ***Threshold Interference levels for various radio astronomical frequencies***

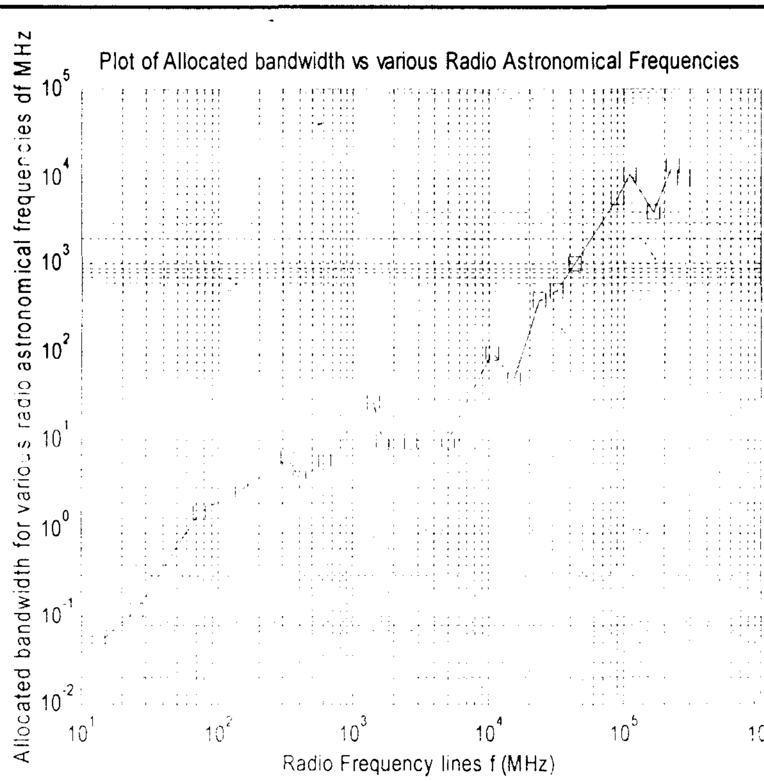


Figure 2.2 : ***Allocated bandwidth for various radio astronomical services***

The figures 2.1 and 2.2 show the threshold interference levels and allocated bandwidths at various radio astronomical frequencies. The threshold interference levels and the allocated bandwidth increase in general with the radio astronomical frequencies.

2.7 Better understanding of Interference

Interfering signals with power levels 10dB higher than threshold are considered to be the most damaging for radio astronomy observations. Interference out side the pass band of the radio receiver can be rejected using band pass filters. It is possible to reduce the effect of interference by some techniques which are briefly discussed below

- The effect of the interfering signals can be reduced by continuously and repetatively monitoring the same spectral band several times so that the intermittent interference lines get averaged out.
- Offline interference reduction techniques reduce the effect of lower level interference only to an smaller extent. To completely eliminate the low interference, level continuum interference monitoring for long time is imperrative.
- By having a better monitoring system it is possible to detect the continuous interference signals and the output of the receiver can be blanked out at those particular frequency(s).

Chapter 3
Interference Monitoring system

If the interference monitoring has to be carried out according to the specifications given by ITU, a continuum receiver which can be tuned to different frequencies having different bandwidths is required.

Since the receiver with the above specifications does not exist at present, we could not adhere to the ITU specification while monitoring. An alternative experimental setup was used for monitoring interference and is shown in figure 3.1

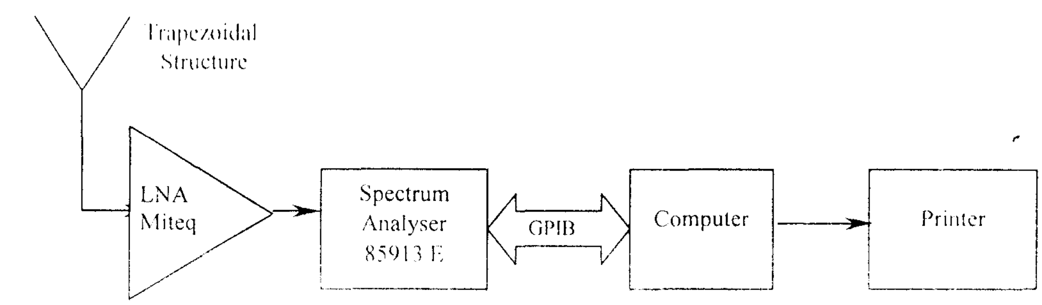


Figure 3.1 *Experimental Setup for Interference Monitoring*

The setup consists of a trapezoidal structure which is a modified version of the log periodic antenna having a bandwidth ratio of 1:10. The antenna used in the setup is designed to operate over 1.5GHz to 8GHz. The signal collected by the antenna is passed through an amplifier and the output of which is directly connected to a spectrum analyser. The spectrum analyser outputs are directly stored in the computer.

3.1 Experimental Setup for Interference Monitoring

The Experimental setup consists a trapezoidal antenna, a Low-Noise Amplifier, a spectrum analyzer, a computer and a printer. The design and the directional properties of the trapezoidal structure and the LNA are explained in the following sections.

Photo1:- Trapezoidal antenna

Photo2:- Trapezoidal antenna on the mount

Photo3:- Experimental setup for interference monitoring

PHOTO - 2

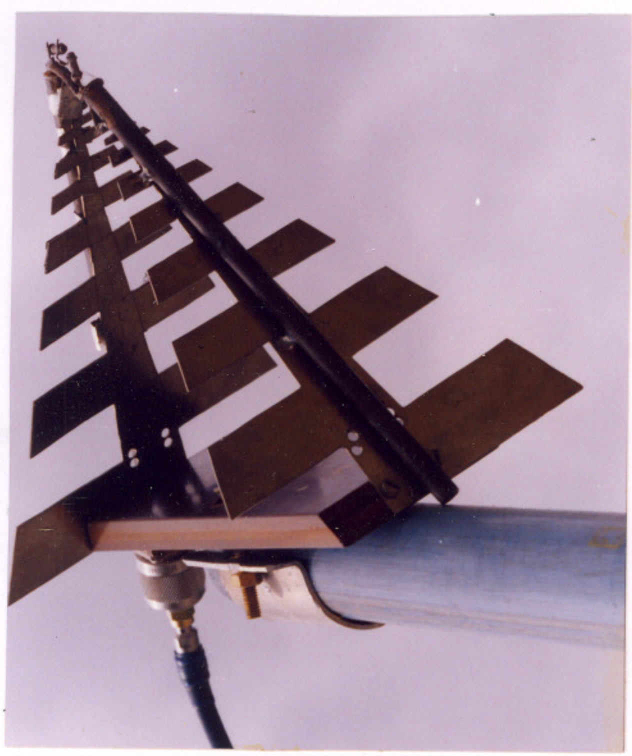


PHOTO - 1

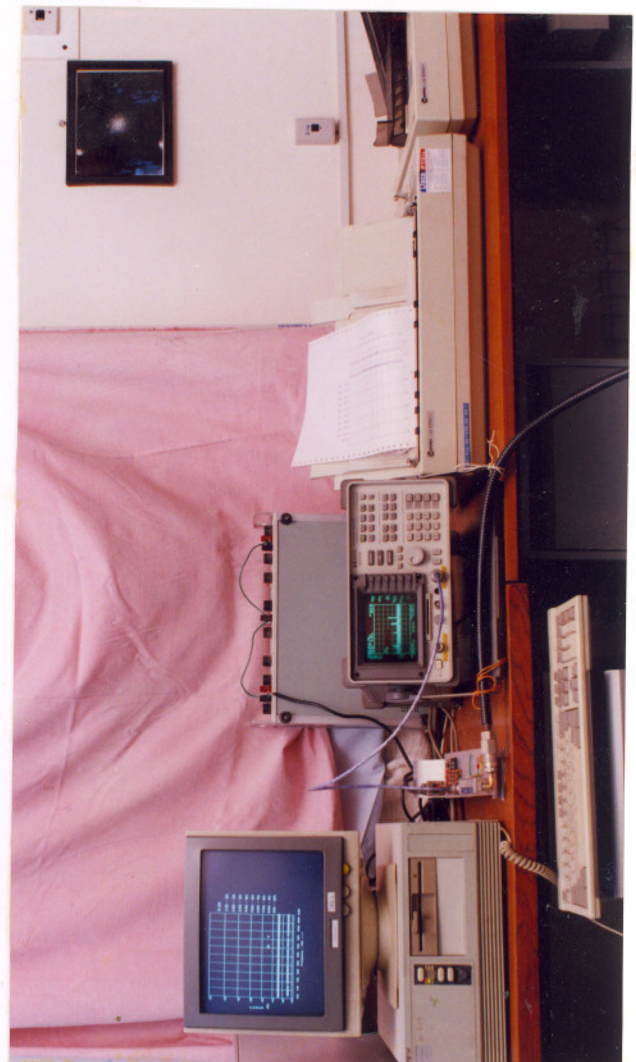


PHOTO - 3

3.1.1 Design of Trapezoidal structure

The logarithmically periodic antennas have pattern and impedance characteristics which are essentially independent of frequency over large bandwidths. The geometry of logarithmic periodic antenna structures is so defined that the electrical characteristics repeat periodically with the logarithm of the frequency.

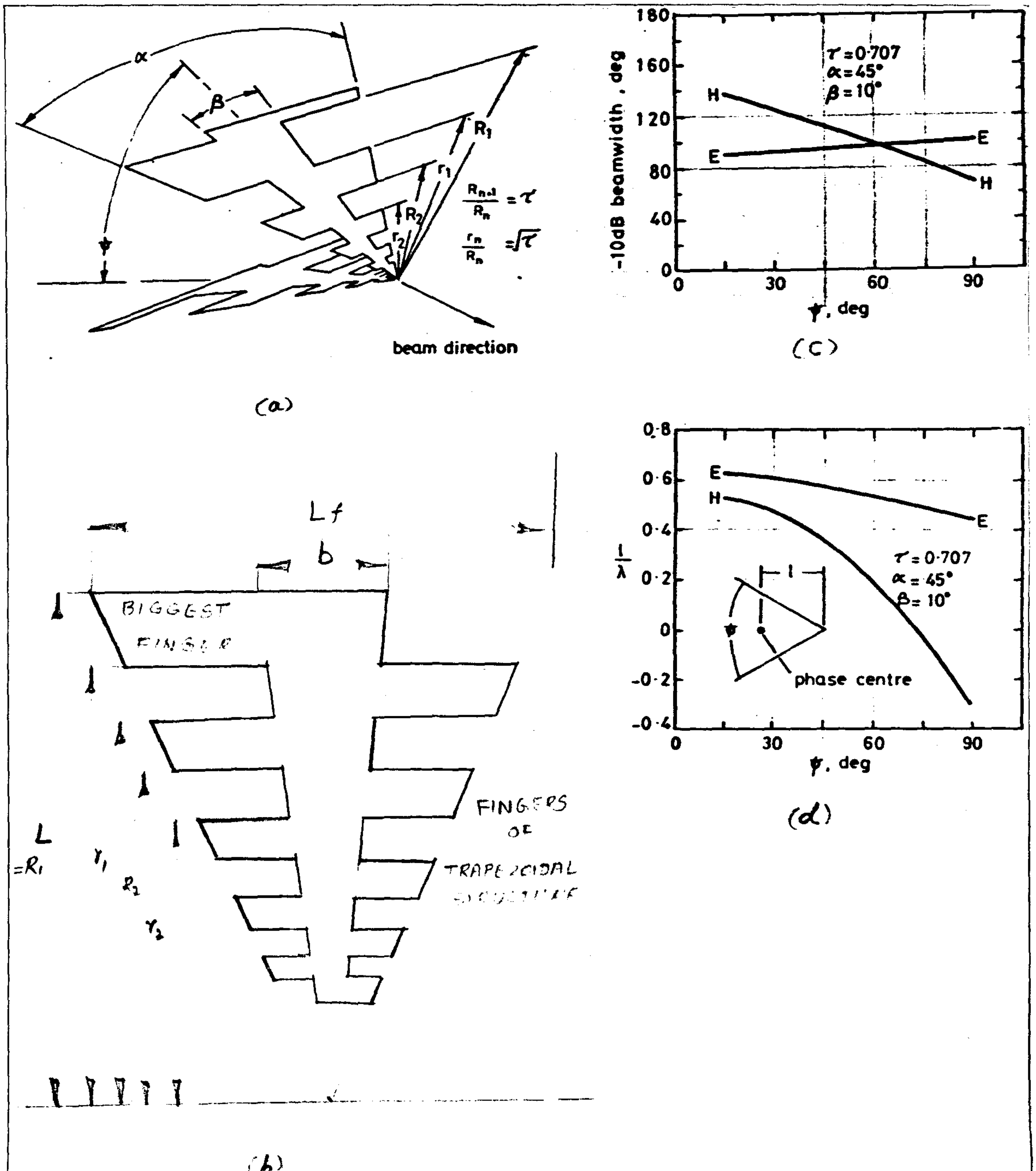


Figure 3.2 : *(a) & (b) Log-periodic trapezoidal tooth structure*
(c)E- and H- plane –10dB beamwidths (d) Location of Phase centre versus ψ

Normally the H plane radiation pattern is much wider than the E plane radiation pattern, this drawback is overcome in the trapezoidal structure. The trapezoidal structure is obtained by separating the two halves of the log-periodic antenna by some angle (ψ). By doing so the H plane radiation patern can be made equal to the E plane radiation pattern and thus making the antenna patterns symmertical. A typical structure is shown in figure 3.2 The various antenna parameters to be determined while designing the trapezoidal structure are

i) Lengths of biggest and smallest finger

ii) Angles α, β, ψ and τ which are defined in the figure 3.2(a)

iii) Dimensions L_f and b

Design

The experimentally optimized values for the trapezoidal structure are given below

$\alpha = 45°$

$\beta = 10°$

$\psi = 60°$

$\tau = 0.707$

The calue of ψ is chosen to be 60° in order to make E and H plane patterns identical.(Refer figure 3.2 (c)). Since the antenna si designed to operate from 500 MHz to 7.0 GHz, the wavelength corresponding to lowest frequency is 60 cm. The length L_f is fixed at half the wavelength at the lowest frequency.

$L_f = 60 / 2 = 30$ cm

Also, $L = (L_f / 2) / \tan(\alpha / 2)$ 3.1

The various dimensions, R1,R2...,Rn and r1,r2,...r_n are calculated using the relations given in the equation given in equation 3.2 and 3.3. The values obtained are given in the table 3.1

$$\frac{Rn+1}{Rn} = \tau = 0.707$$

......3.2

$$\frac{rn}{Rn} = \sqrt{\tau} = 0.8408$$

........3.3

Table 3.1: Trapezoidal structure dimensioins

Parameter	Dimension	Parameter	Dimension
R1(=L)	36.2	r1	30.4
R2	25.6	r2	21.5
R3	18.1	r3	15.2
R4	12.8	r4	10.8
R5	9.0	r5	7.6
R6	6.4	r6	5.4
R7	4.5	r7	3.8
R8	3.2	r8	2.7
R9	2.2	r9	1.8
R10	1.6	r10	1.3
R11	1.1	r11	0.9
R12	0.8	r12	0.7
R13	0.56	r13	0.5
R14	0.4	r14	0.3
R15	0.3	r15	0.25
R16	0.2	r16	0.17
R17	0.1	r17	0.08

3.1.2 Measurement of return loss the trapezoidal structure

When the load impedance is not matched, not all power delivered to the load from the generator will be absorbed. So this will become loss of power. This loss is called "*Return loss*". It is defined in terms of dB as follows.

$RL = 20 \log(|V_r / V_I|) = 20 \log (1 / |\Gamma|)$ dB 3.3

Where,

$\Gamma = V_r / V_I$ 3.4

where V_r is the reflected voltage

V_I is the incident voltage

Γ is the voltage reflection coefficient which is defined as the ratio of the reflected voltage to the incident voltage at the input terminals of 2 port network.The value of Γ lies in the range $0 \leq \Gamma \leq 1$.

Figure 3.3 shows the experimental setup to measure the return loss of the trapezoidal Structure. It consists of scalar network analyser, frequency synthesizer and directional bridge Initially the setup is made without connecting the antenna. The frequency range is set between 500MHz to 10 GHz. Its power level is set at 0dBm. The system is calibrated only for the return loss using the standart loads like open/short, averag. Then the antenna is connected to measure its return-loss characteristics. The return loss response obtained using the scalar network analyser is shown in figure 3.4

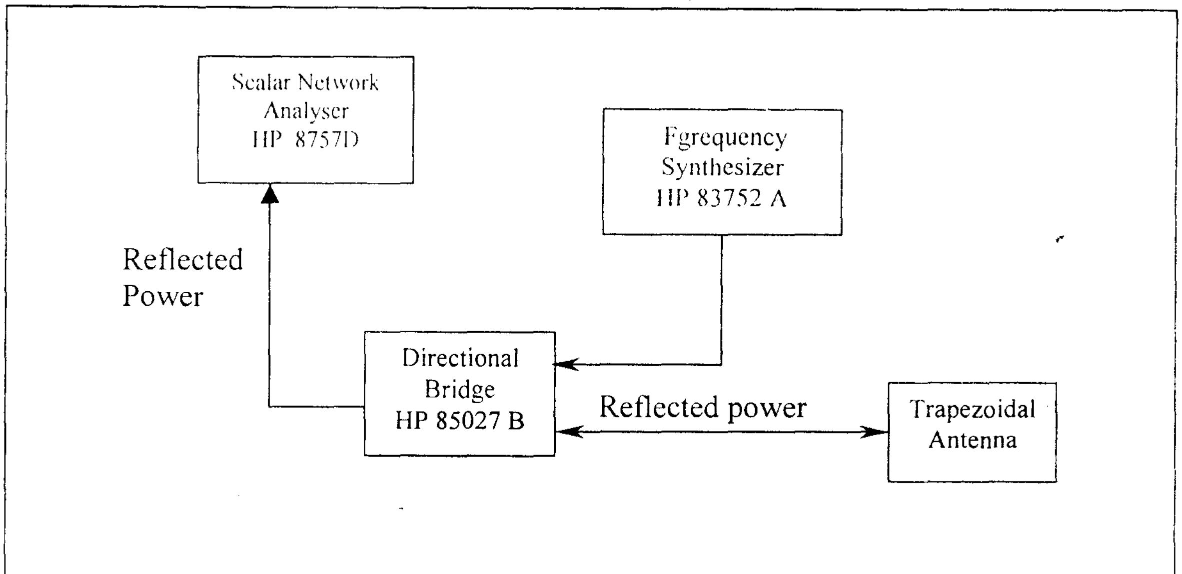


Figure 3.3 : ***Experimental setup for the measurement of Return loss and VSWR of the Trapezoidal antenna***

Table 3.2 Return loss of Trapezoidal structure at various frequencies

Frequency in MHz	Return loss in dBm
400	-2.30
500	-1.81
600	-1.81
700	-2.54
800	-4.00
900	-2.14
1000	-3.23
1100	-7.89
1200	-7.31
1300	-5.39
1400	-6.92
1500	-9.28
1600	-5.74
1700	-6.81

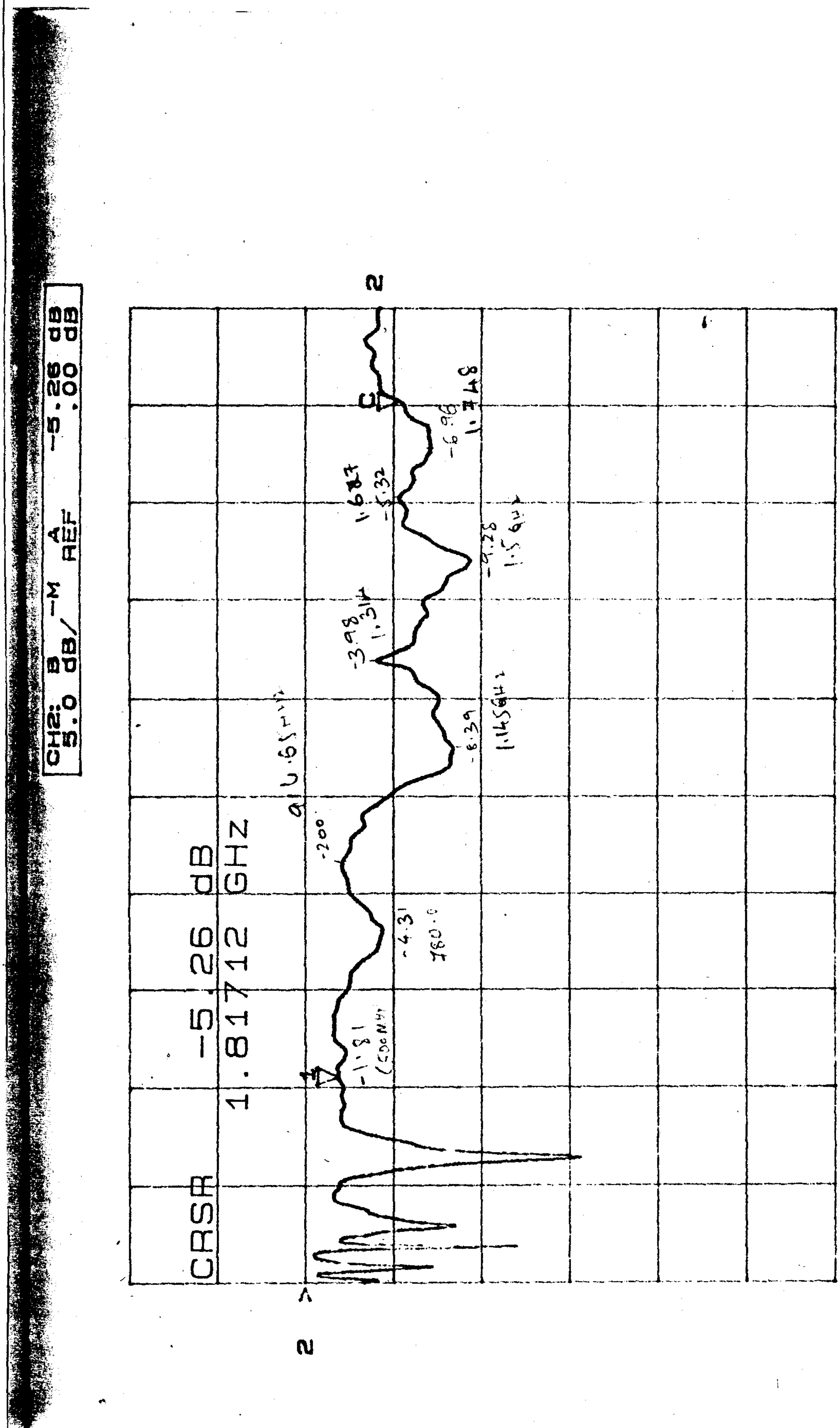


Fig 3.4: Return Loss Characteristics of Antenna

3.1.3 Measurement of the Radiation Pattern of the Trapezoidal structure

The radiation pattern of an antenna shows the gain variation of the antenna as a function of angle on either sides of the antenna axis. Normally two radiation patterns are measured. They are

i) E plane pattern

ii) H plane pattern

E plane pattern gives the gain variation of he antenna in the direction of electric field in the aperture. On the other hand, the H plane pattern gives the gain variation of the antenna in a direction perpendicular to the electric field.

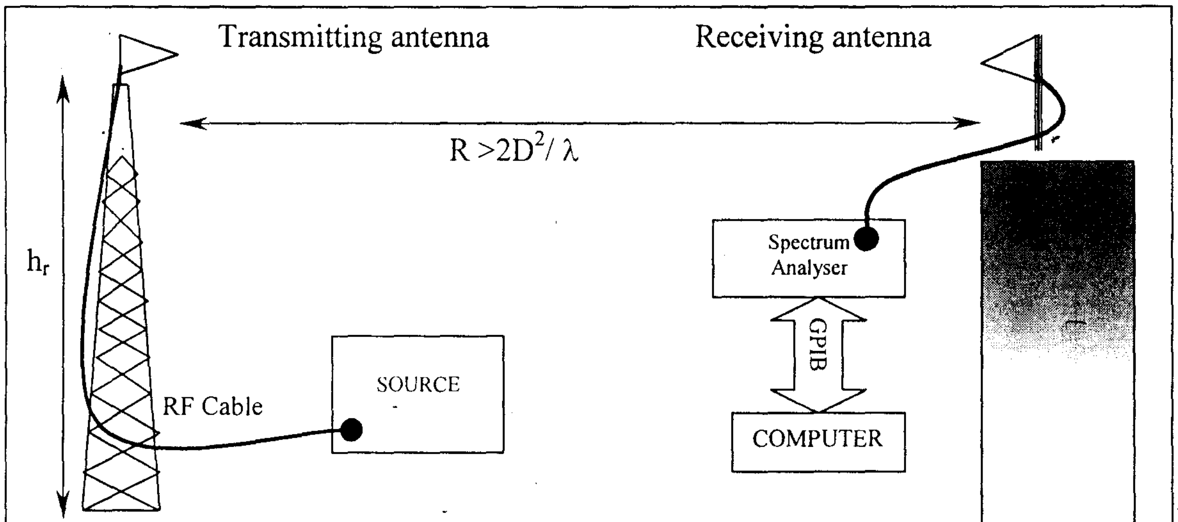
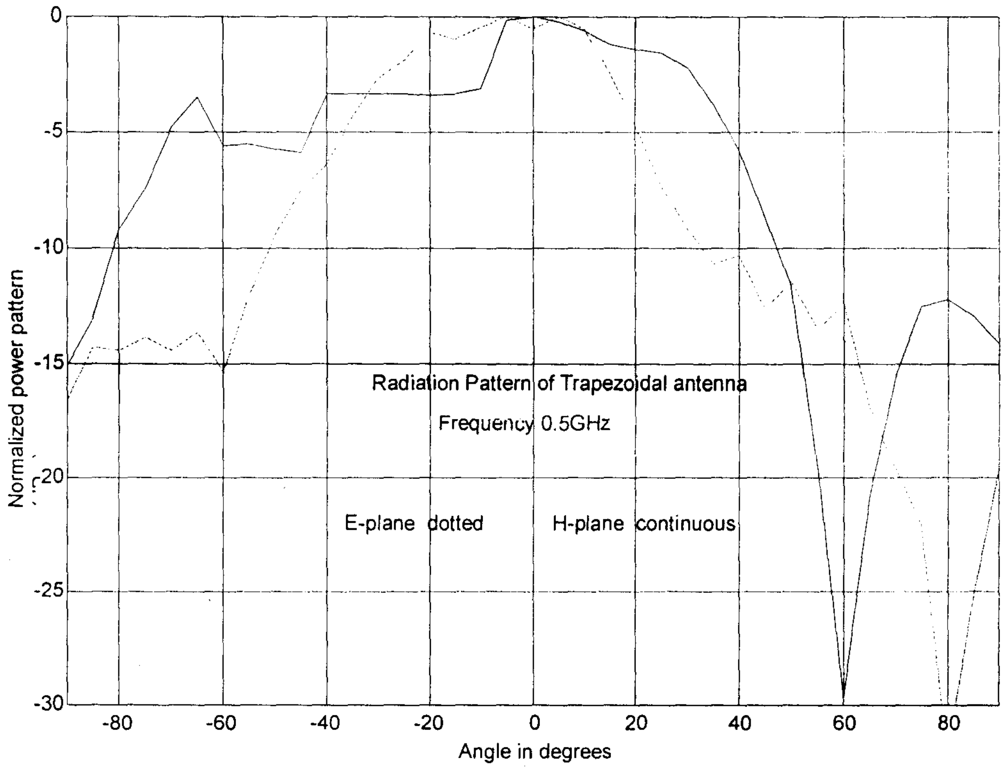


Figure 3.5 : ***Radiation Pattern Measurment of Trapezoidal Structure***

The experimental setup for the measurement of radiation pattern of the trapezoidal structure is shown in figure 3.5. The trapezoidal antenna whose radiation pattern has to be measured is mounted on the tower. Another trapezoidal structure similar to the test antenna is used as a transmitter and is mounted on another tower. The height (h_r) of the tower was set such that the following condition is satisfied. $h_r \geq 4D$, where D is the aperture diameter. The separation distance between the transmitter and the test antenna was such that the test antenna was in the far field distance of the transmitting antenna. Both transmitting and receiving antennas were positioned such that their polarizations were identical. A CW source was connected to the transmitting antenna and the output of the antenna under test is connected to spectrum analyser. After setting the frequency of the continuous wave source, the test antenna which is mounted on a rotating platform was rotated at various angles from $-90°$ to $+90°$. At each location the spectal output was read into the computer and stored. The above procedure was repeated for various frequencies and polarization. The stored data in the computer was plotted against the azimuth angle to get the beam pattern of the antenna. Beam patterns at various frequencies are shown in the figure 3.6 (a)-(f)



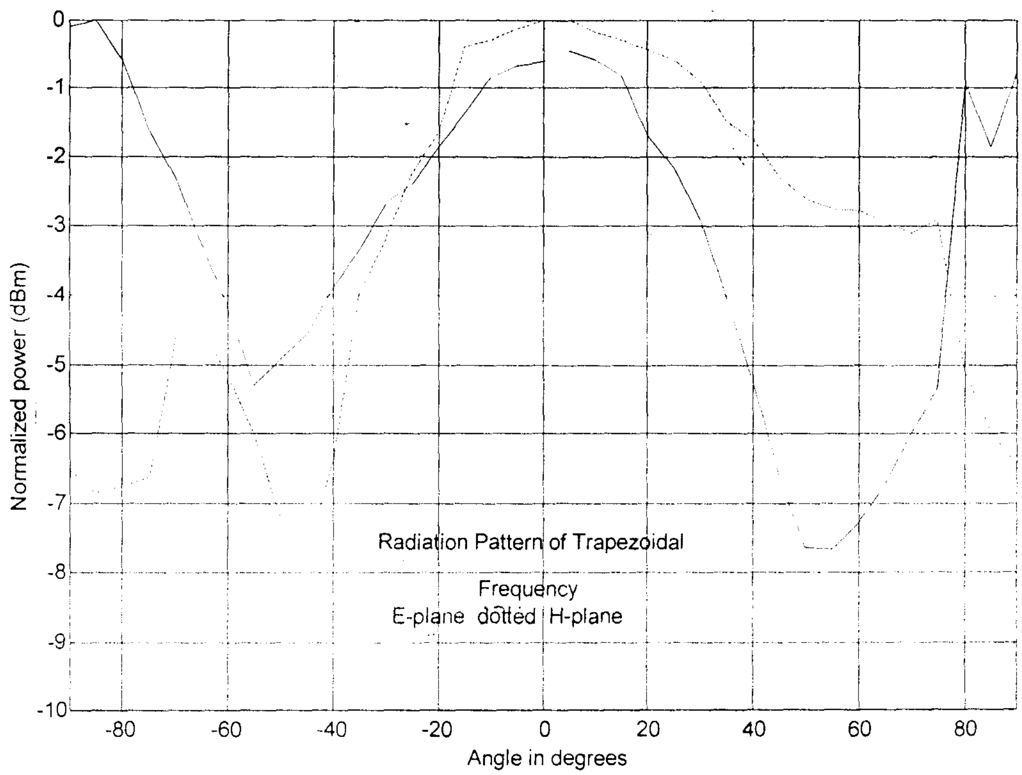


Figure 3.6 (a),(b) : Beam pattern of the trapezoidal structure

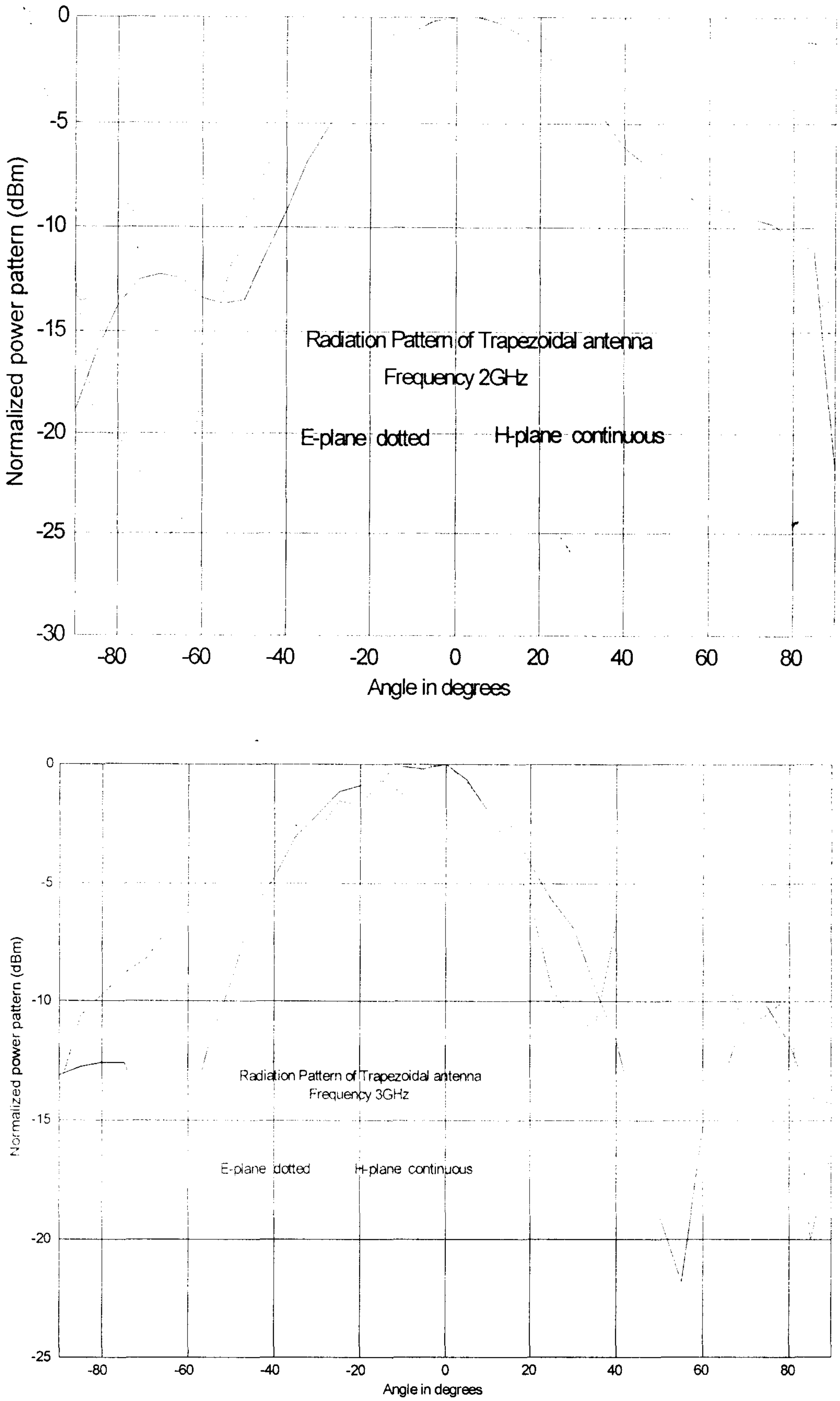
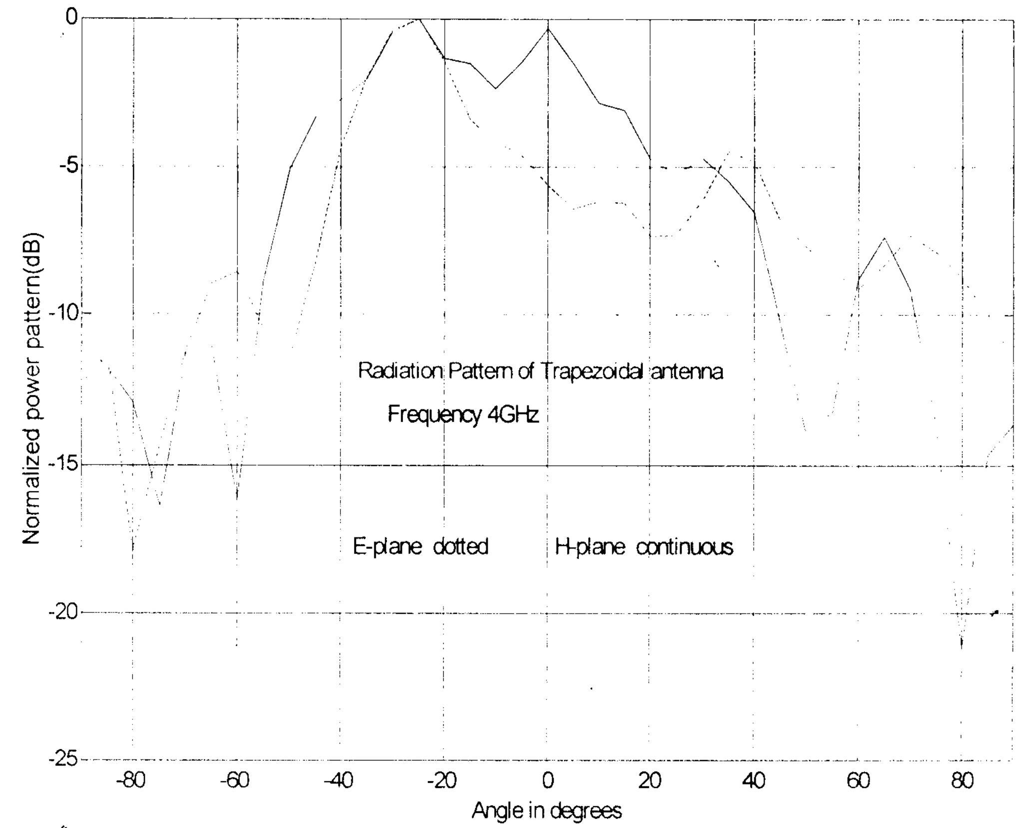
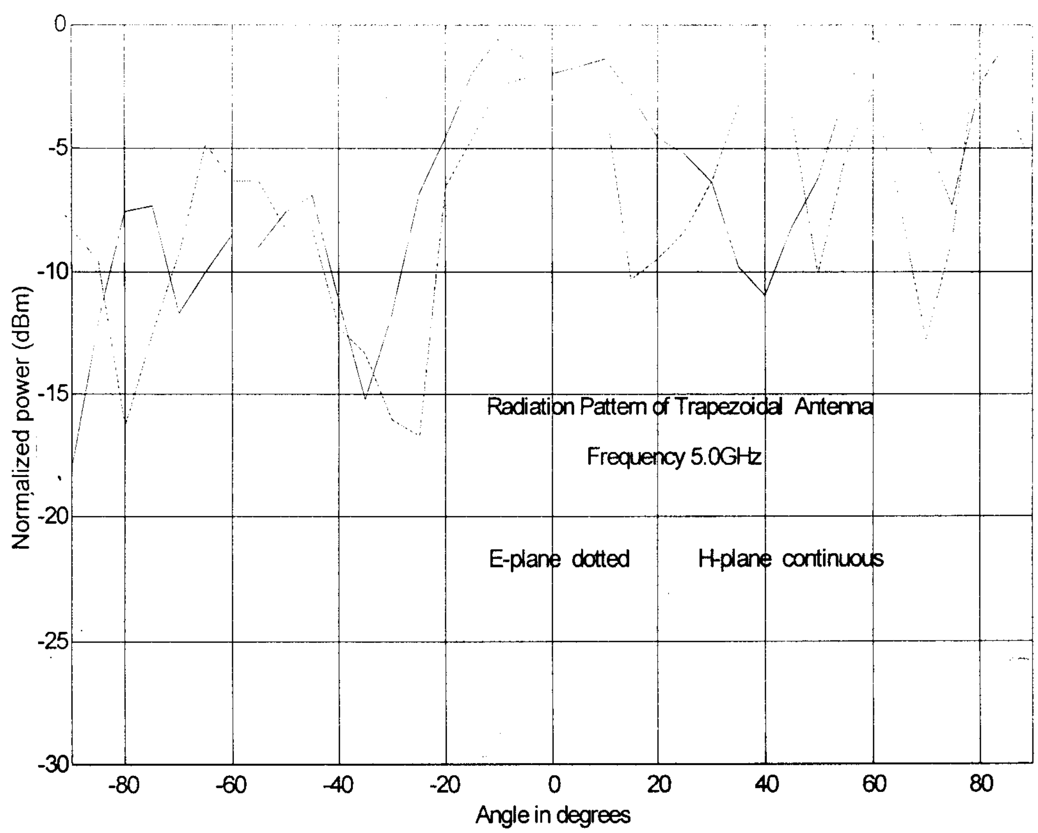


Figure 3.6 (c),(d) : Beam pattern of the trapezoidal structure


Radiation Pattern of Trapezoidal antenna
Frequency 4GHz
E-plane dotted
H-plane continuous
Normalized power pattern(dB)
Angle in degrees
0
-5
-10
-15
-20
-25
-80
-60
-40
-20
0
20
40
60
80


Radiation Pattern of Trapezoidal Antenna
Frequency 5.0GHz
E-plane dotted
H-plane continuous
Normalized power (dBm)
Angle in degrees
0
-5
-10
-15
-20
-25
-30
-80
-60
-40
-20
0
20
40
60
80

3.2 Characterization of Low Noise Amplifier

The LNA used in the experimental setup was characterized for its gain and noise figures using the setup shown in figure 3.7 and figure 3.8.

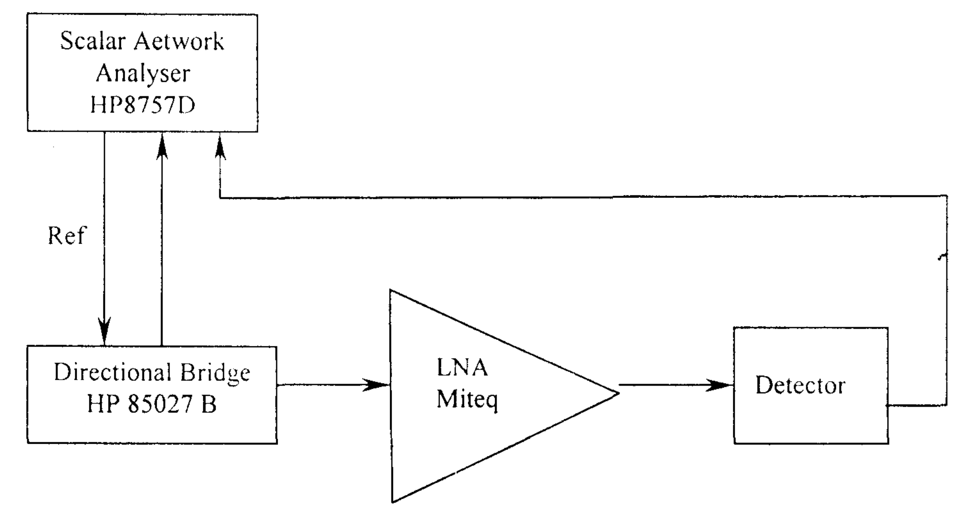


Figure 3.7 : ***Experimental setup for the measurement of Gain and Return loss of the Low Noise Amplifier.***

3.2.1 Measurement of Gain and Return loss of Low Noise Amplifier

The experimental setup sonsists of the scalar network analyser, the directional bridge, the Detector and the LNA. The set was caliberated for gain and return loss using the standard load open/short and load. After calibration the LNA was introduced into the setup to measure Gain and return loss.The measured response is shown in the figure 3.9

3.2.2 Measurement of Noise Figure of the Low Noise Amplifier

The experimental setup sonsists of a Noise Figure Meter, a bandpass filter, amixer, a 5dB ENR noise source, a circulator and other RF modules are as shown in the figure 3.8 Before the measurement is taken, the setup was calibrated without including the DUT i.e. Miteq LNA. After calibration, the LNA was included and its noise temperature wass measured. The response of the amplifier is shown in the figure 3.10.

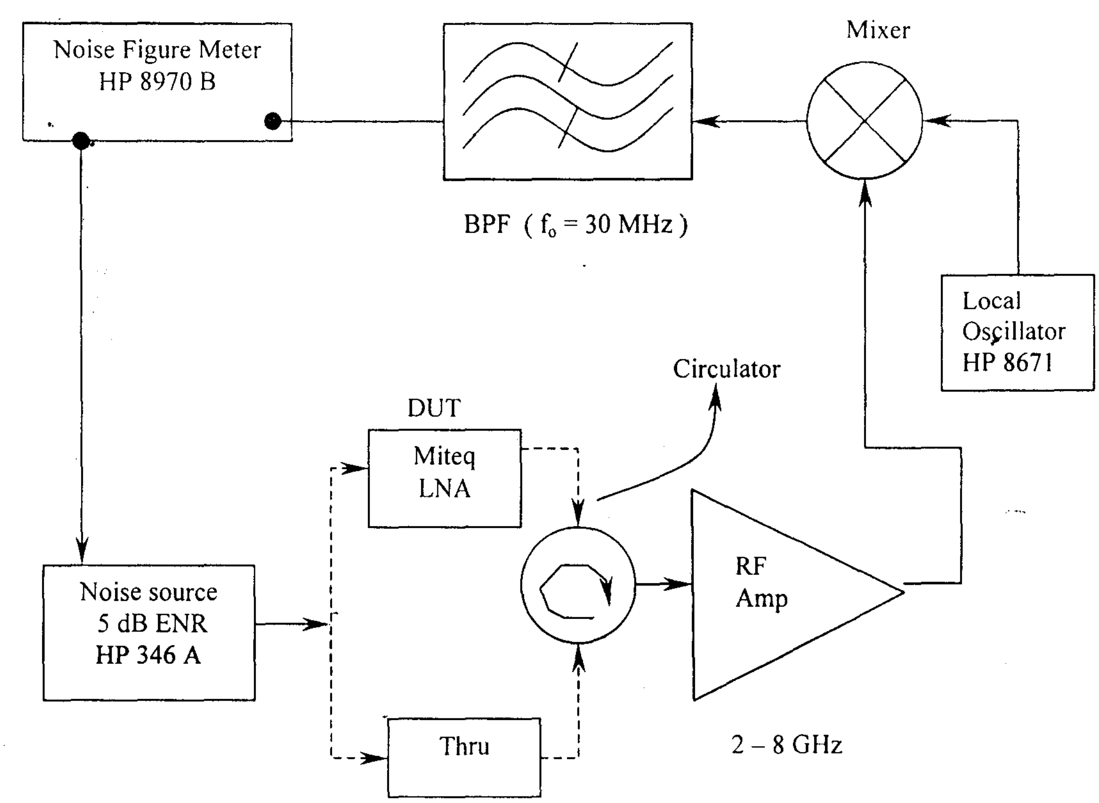


Figure 3.8 : ***Experimental setup for the measurement of Noise Figure of the Low Noise Amplifier.***

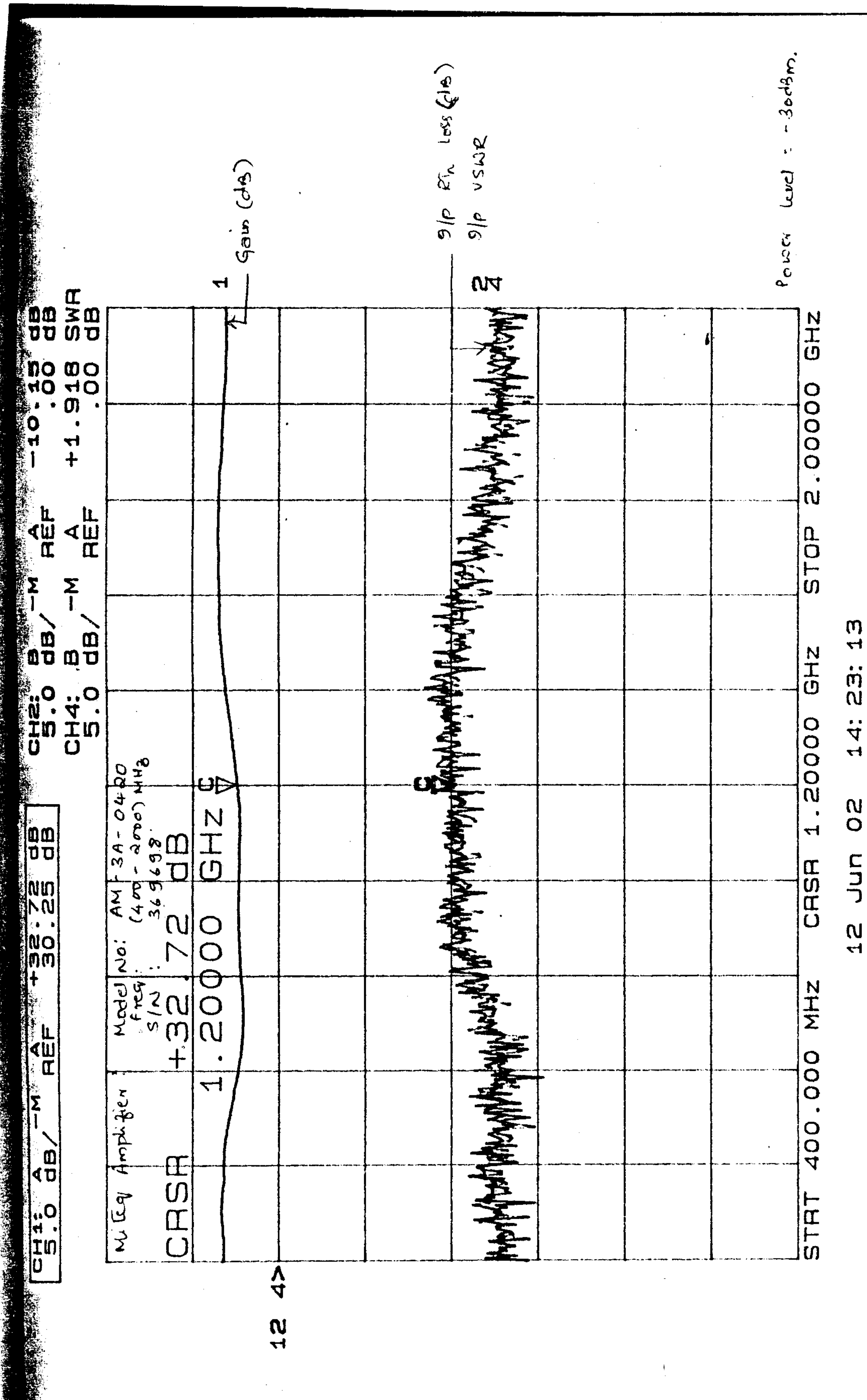

CH1: A dB/ -M A REF +32.72 dB
5.0 30.25 dB
CH2: B dB/ -M A REF -10.15 dB
5.0 .00 dB
CH4: B dB/ -M A REF +1.918 SWR
5.0 .00 dB
Mi Eq Amplifier Model No: AM-3A-0420
Freq: (400-2000) MHz
S/N: 369698
CRSR +32.72 dB
1.20000 GHz
Gain (dB)
Power level : -30dBm
STRT 400.000 MHz CRSR 1.20000 GHz STOP 2.00000 GHz
12 Jun 02 14: 23: 13

Fig 3.9

Chapter 4

Measurement Results

4.1 Method of Monitoring

The experimental setup shown in the figure 3.1 was used for interference monitoring at Gauribidanur. The RF spectrum covering 400 MHz to 1700 MHz was monitored. While monitoring this wide frequency range was divided into 4 bands each of 400 MHz with an overlap of 100 MHZ. All the 4 bands were observed in time sequence for equal time duration. The four sub bands ibserved are

1) 400 MHz to 800 MHz
2) 700 MHz to 1100 MHz
3) 1000 MHz to 1400 MHz
4) 1300 MHz to 1700 MHz

The spectrum analyser was used for monitoring the radio frequency spectrum with the following settings.

- Ampliture reference - -20 dBm
- Span - 400MHz
- Resolution Bandwidth - 1.0 MHz

The Spectrum analyser gives out the trace information in the form of 400 points. Hence for 400 MHz span, the spectrum can be read out with a resolution of 1MHz for 400MHz span. But while analysing the data, every 4 points were averaged to get intotal 100 points. This resulted in the resending of the spectral resolution from 1MHz to 4MHz. This was done only to reduce the amount of data getting stored into the computer.

Each of the above band was observed for 15 seconds. Each time the trace data was analysed and stored in the dynamic memory. This was carried out for half an hour at the end of which stored data was dumped into the hard disk. In this manner observation for each band was carried out for a total time duration of 4 Hrs, for one particular direction and for one particular polarization.The orientation of the antenna was changed periodically to monitor the RFI in all the four directions. In addition to it in each orientation, observation was carried out in both Vetrical and Horizontal polarizations.

4.2 Software developed for acquiring interference data

Before running the data acquisition program, several parameters have to be passed on to the computer and the instrument. This includes spectrum analyser settings like start frequency, stop frequency, resolution bandwidth its frequency of acquiring the trace and data and the total time of observation. These parameters have to be given to the program in a format given below.

start_freq	stop_freq	rbw	ref_amp	scale	traces	delay	Destination file name	Iterations

where

start_freq - Start frequency (MHz) of the band under observation.
stop_freq - Stop frequency (MHz) of the band under observation
rbw - Resolution Bandwidth (MHz)
ref_amp - Reference amplitude (dBm)
scale - width of each bin (power range (dBm))
traces - User defined number of traces
delay - user specified delay between traces (min)
destination filename - The binary data is stored
iterations - Number of times the, user defined number of traces is to be taken

Example: -

1000	800	1	-20	10	120	0.25	Sample.data	8

After acquiring each trace, 400 data points of it are averaged to get 100 data points. The power level was monitored at each frequency for the entire band. After acquiring the specified number of traces, a consolidated report in which the total time duration each frequency component spent in different power levels is obtained through the program. Figure 4.1 shows one such output. In this output, the two integers 6 and 1 in the power range –60 dBm to –70dBm indicate that two frequencies corresponding to 940 MHz and 952 MHz with the average power of –65 dBm has occurred for about 60 to 70 % and 10 to 20 % of the total time duration of observation respectively.

Figure 4.2 shows the flow chart of the software.The software program to acquire interference monitoring data can be found in Appendix A, and the soft copy is made available in the compact-disc along with this report.

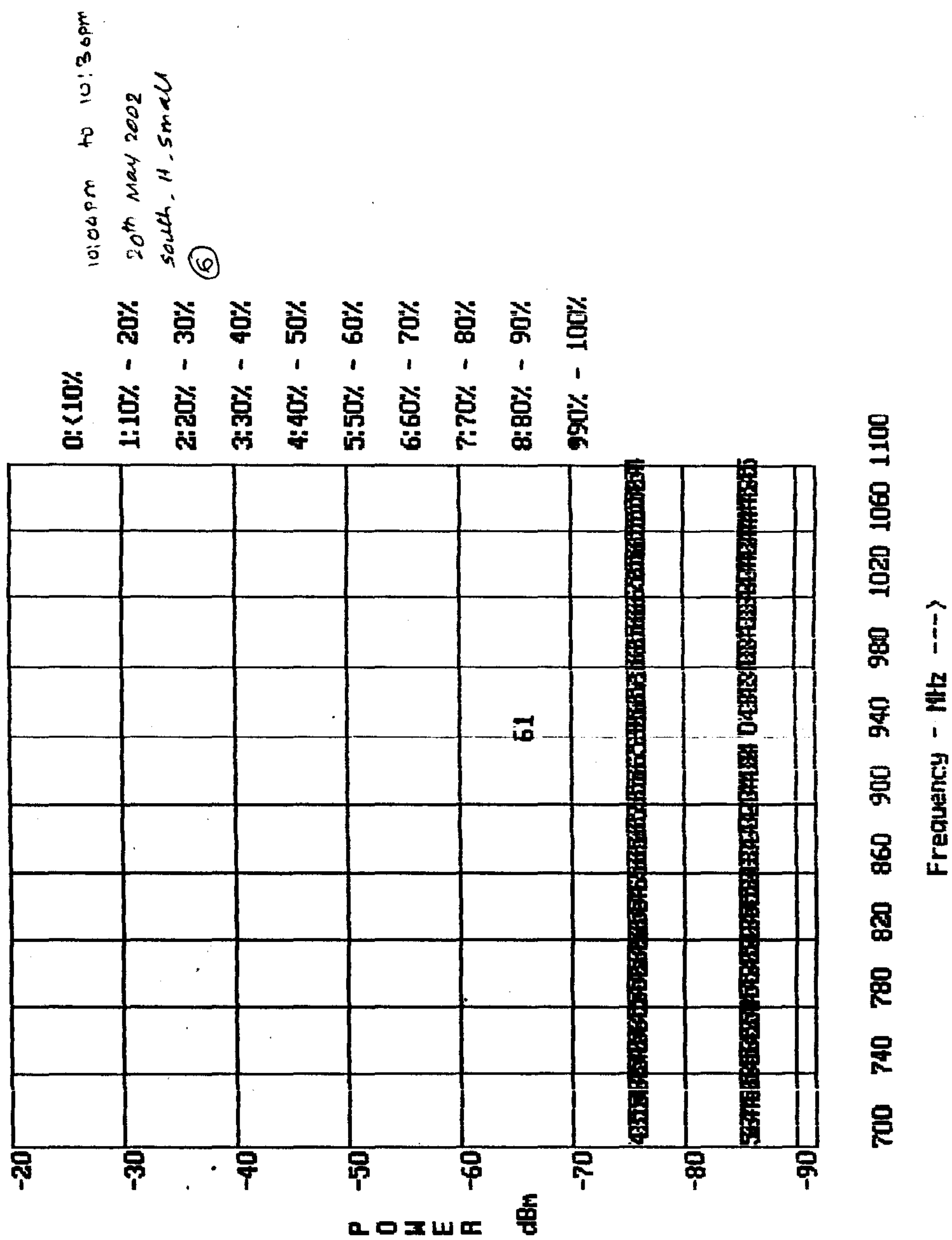


Figure 4.1 : ***Output given by the computer every half an hour***

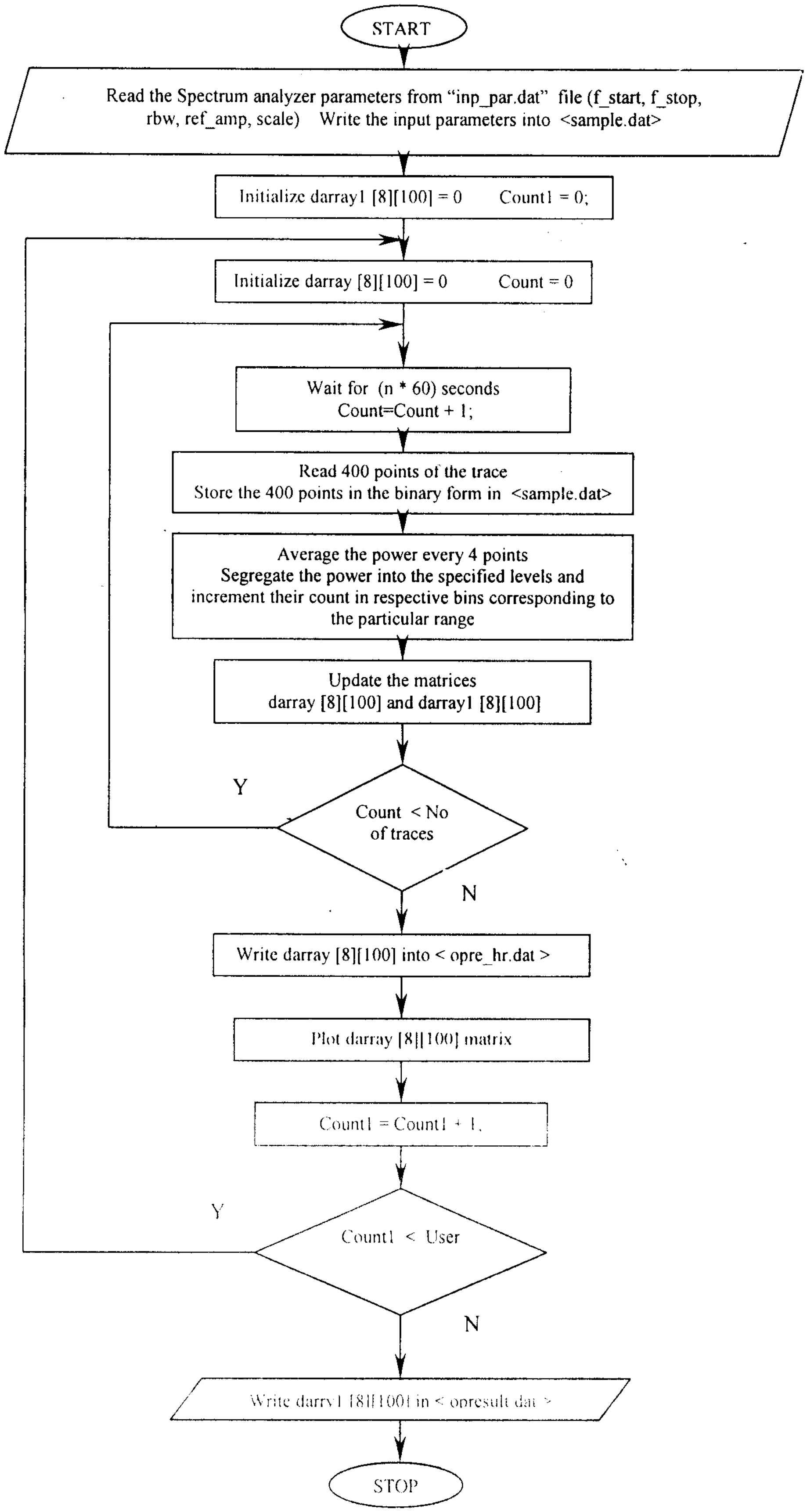


Figure 4.2 : ***Flow chart of the Program used for Interference monitoring***

4.3 The Data Structure

The Interference data collected is in the form of a two dimensional matrix of size 100 X 8, where 100 represents the number of frequency channels being monitored and 8 the total number of power levels. Basically this matrix represents the frequency spectrum given out by the spectrum analyzer. The numeral in each column in the matrix represents the number of times the signal at a particular frequency has occurred during the period of observatio (ref. Fig. 4.3). If N is the total number of traces acquired , then each number in a given power level in the matrix represents the total number of times the signal at a particular frequency has occurred. The sum of all the numbers in each row represents the total number of traces acquired. This two dimensional matrix of dimension 100 X 8 will be produced at the end of every half an hour provided 120 traces are acquired at a rate of 15sec. Each matrix will be referred to as a ***'Frame'*** in the following sections.

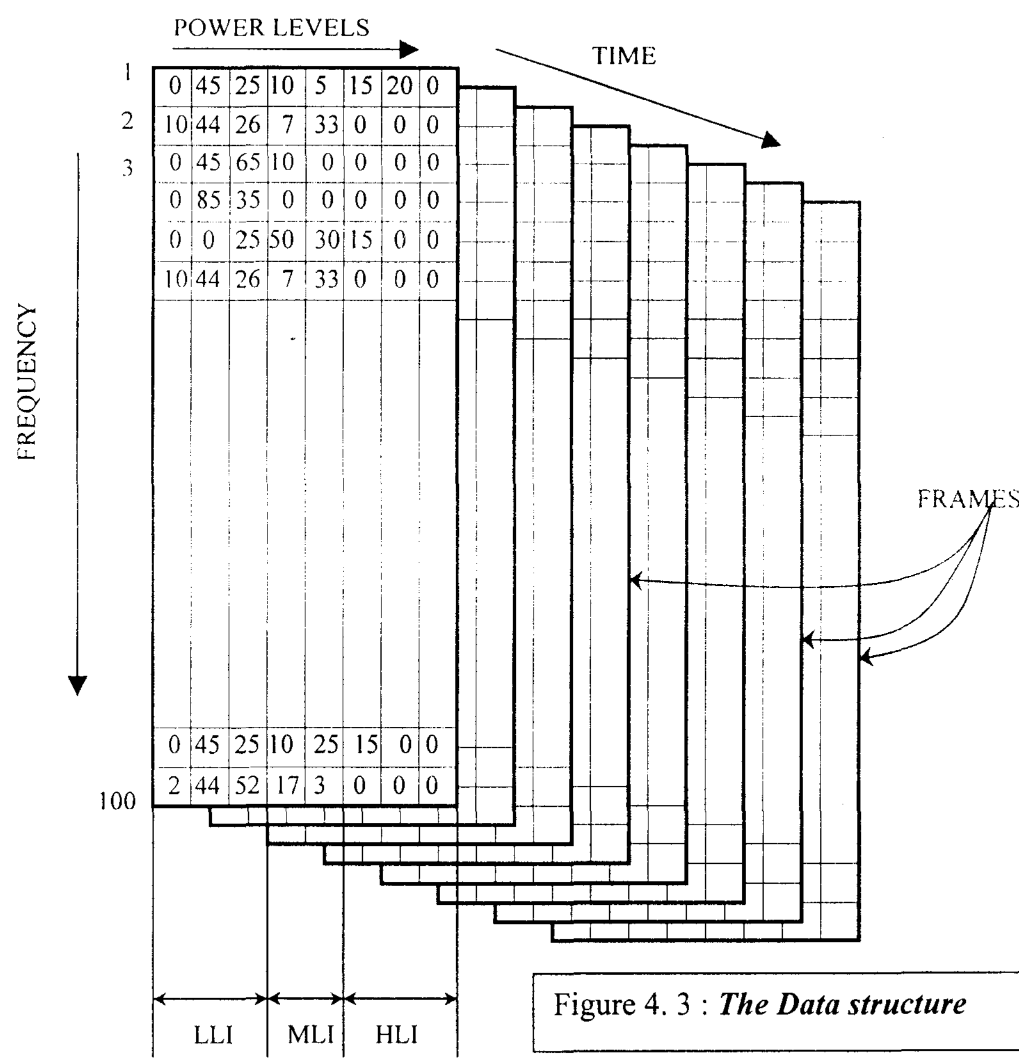


Figure 4. 3 : ***The Data structure***

LLI :- Low level interference (-100 dBm to –70 dBm)

MLI :- Medium level interference (-70 dBm to –50 dBm)

HLI :- High level interference (-50 dBm to –20 dBm)

4.4 Software written in Matlab for interference Analysis

Codes have been written to analyse the data and produce

1. ***A list of all the interfering frequencies***
2. ***A plot of the variation of interference signal strength with time.***
3. ***Plot of the number of interference frequencies as a function of duration of occurence.***
4. ***Plot the frequency spectra over the entire range 400 MHz to 1700 MHz obtained in 4 directions***

The first three outputs were obtained by executing the program **'int_ana1.m'** and the last output is obtained by running the program **'int_ana2.m'**. Ref. Figs 4.5 & 4.6 for the flow chart and apendix B & C for the codes.

4.4.1 Method adopted to list out the interference frequencies.

✓ List all the signals in each frame whose amplitude lies within the user defined power range (-20 dBm to –70 dBm)

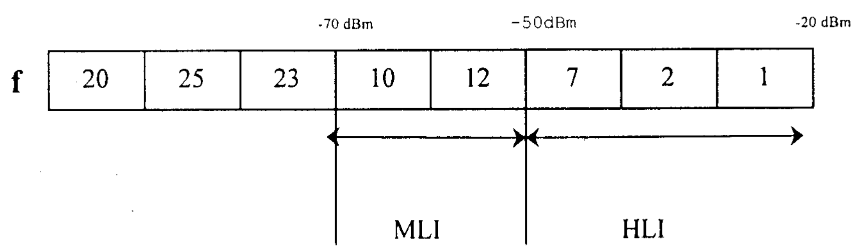
✓ This is done for all the frames obtained during the period of observation.

It is to be noted that the interfering lines are listed irrespective of its frequency of occurrence (the interfering line could be either periodic or intermittent).

4.4.2 Method adopted to plot interference signal strength with time

For each signal identified as interfering line from the list produced earlier, its percentage of occurrence in each frame is found out in both medium level as well as in high level power ranges. The percentage of occurrence is calculated by dividing the number of occurrences in a particular power level by the total number of traces acquired.

As an example, let a signal having a frequency 'f ' has its power distribution over 120 traces as shown below



Number 10 in the power level <-70 to –60 dBm > indicates that the signal had its power level in that range over (10 / 120) = 9.44% of the total time of observation. similarly in the power range < –60 to –50 dBm > number 12 indicates that the signal had its power level over (12 / 120) ≑ 10 % of the total time of observation.

This exercise is carried out for all the frames for a particular frequency, to know the variation of interference signal strength with time. The same procedure is carried out for other interfering frequencies also (ref. fig. 4.4).

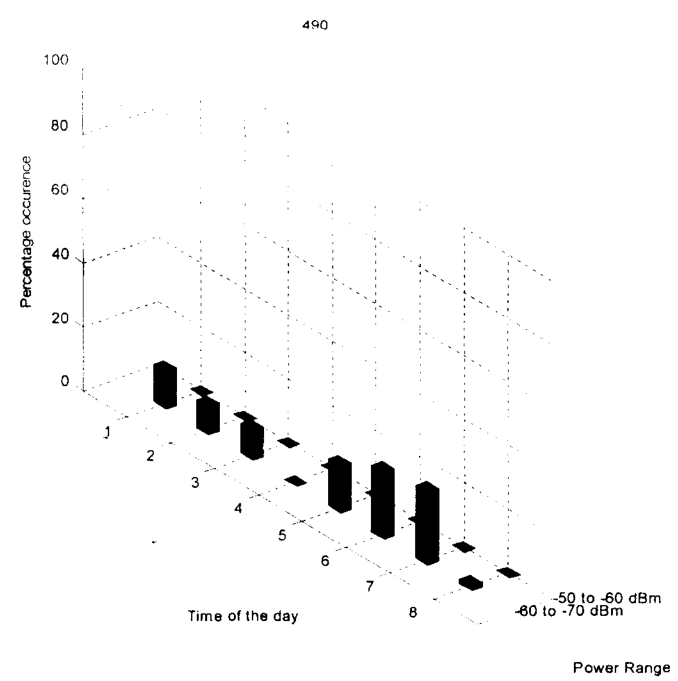


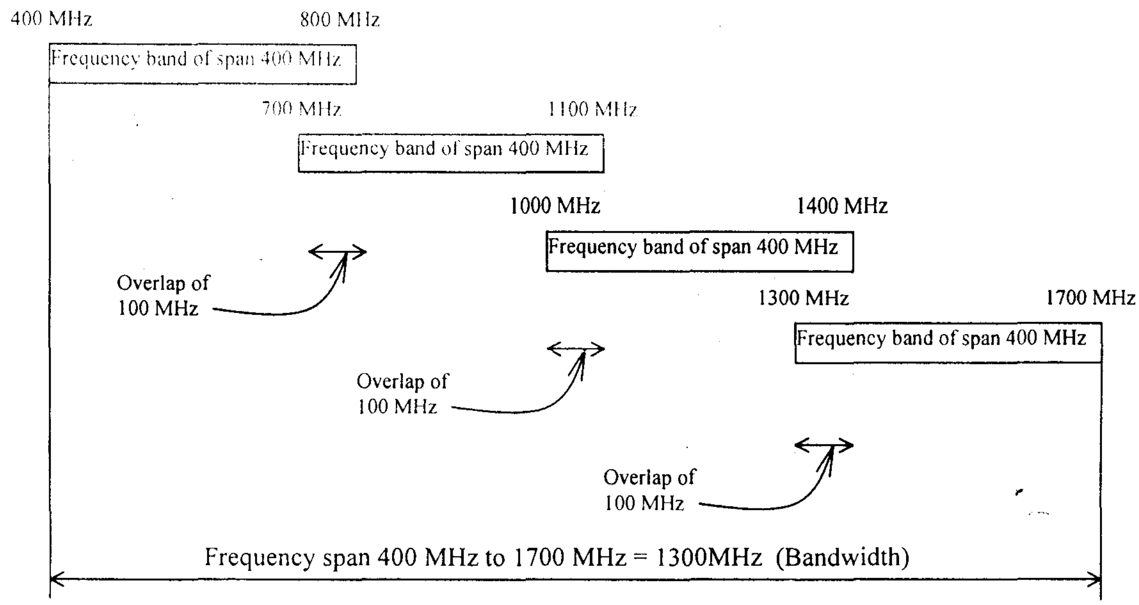
Figure 4. 4 : ***Plot of variation of interference signal strength with time***

4.4.3 Method adopted to plot the number of Interfering Frequencies as a function of frequency of occurrence

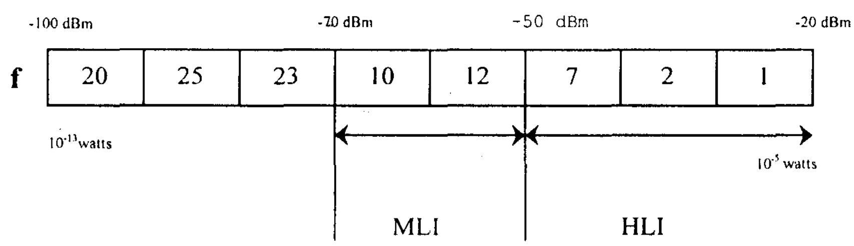
For each frequency identified as interfering line, the percentage of occurrence is calculated. All the interfering frequencies falling within the identical range of occurrences (eg 0 to 10%, 10 to 20 %, 20 to 30 %.....90 to 100 %) are grouped together. Finally a plot of number of interfering frequencies as a function of duration of occurrences is plotted.

4.4.4 Method Adopted to Plot the frequency spectra over the entire range 400 MHz to 1700 MHz obtained in 4 directions (Int ana2.m)

1. First load the files corresponding to four bands for a particular direction.



2. Calculate the average power at each frequency over half an hour for each band (120 traces) to get four 100 X 1 matrices . As an example, let a signal having a frequency ‘f ‘ has its power distribution over 120 traces as shown below



Then the average power of frequency ‘f’ over half an hour is calculated as

$$\{10^{-12.5}X20 + 10^{-11.5}X25 + 10^{-10.5}X23 + 10^{-9.5}X10 + 10^{-8.5}X12 + 10^{-7.5}X7 + 10^{-6.5}X2 + 10^{-5.5}X1\}/120 = -62.25dBm$$

3. The overlapping frequencies between different bands are averaged to get finally 325 frequency channels spanning 1300MHz (400 MHz to 1700 MHz).
4. All the identified interfering frequencies are scaled according to the gain and return loss.
5. Knowing the effective area of the antenna, the power of the interfering signal over an unit area is calculated at each frequency.

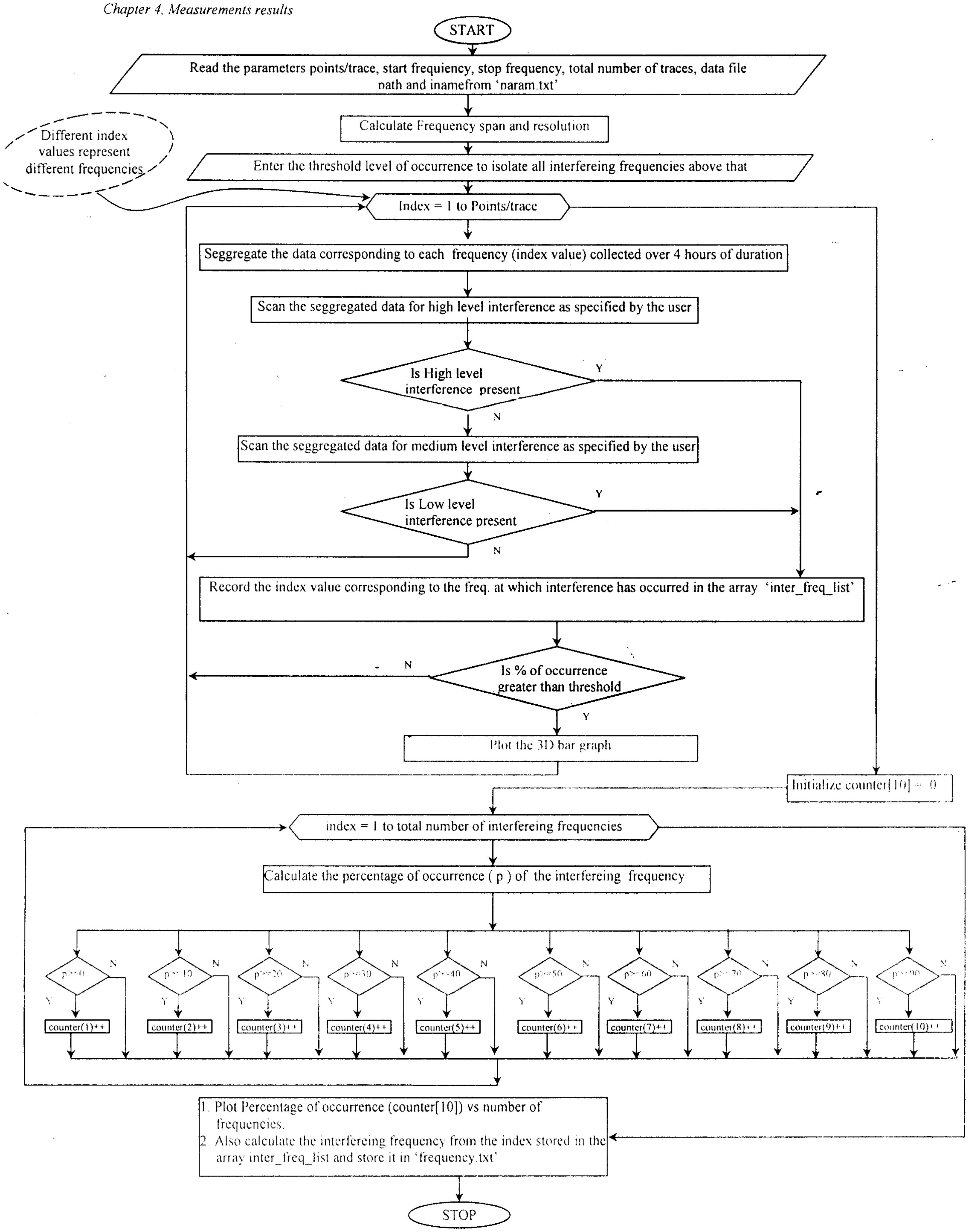


Figure 4.5 : ***Flow chart of the program 'Int_ana1.m'***

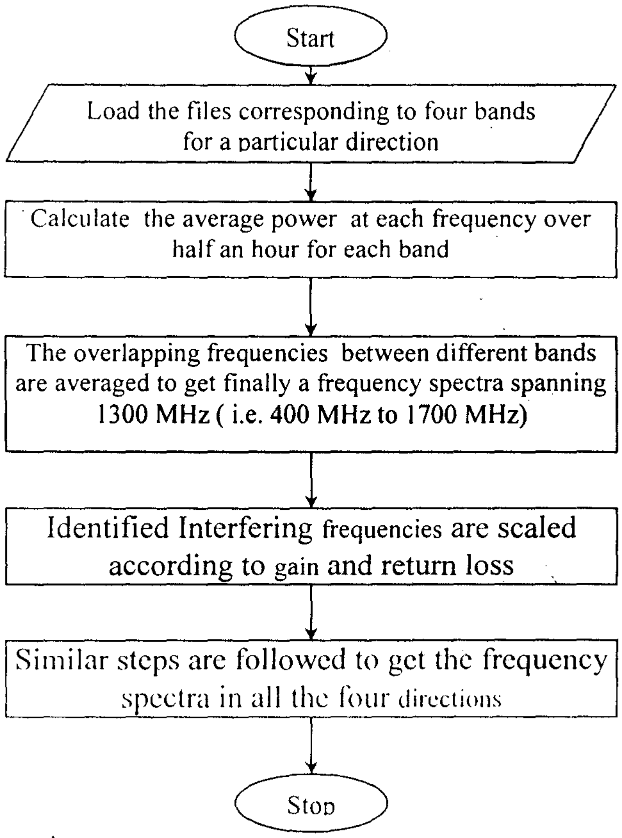


Figure 4.6: ***Flow chart of the program 'Int_ana2.m'***

4.5 Results Obtained

4.5.1 The List of Interfering frequencies

The results obtained after analysis of the interference data, are presented in this session. The list of all the interfering frequencies occuring continuously as well as intermittantly are given in the table 4.1. The available interference-free bandwidth around the allocated nradio astronomical frequencies are shown in tablle 4.2

Table 4.1 : The List of interfering frequencies

Continuously intefering frequencies MHz	Intermittently interfering frequencies MHz
461	515
487	703
492	704
937	731
945	743
991	744
	753
	760
	761
	845
	865
	1088
	1097
	1090
	1127
	1322
	1627

Table 4.2 : The available bandwidth for radio astronomical usage without interference at Gauribidanur

Allocated Radio Bandwidth (MHz)	Centre Frequency of the Allocated Radio Band width (MHz)	Available bandwidth for usage without interference (MHz)
406-410	408.0	4
608 – 614	611.0	6
1400 – 1427	1413.5	27
1660 –1670	1665	10

4.5.2 Plots of variation of interference signal strength with time.

The plots of variation of interference signal strength with time are shown in figures 4.7(a) to 4.7(p)

1) Interfering frequency 1: 414 MHz (Frequency Range : 400 MHz to 800 MHz)

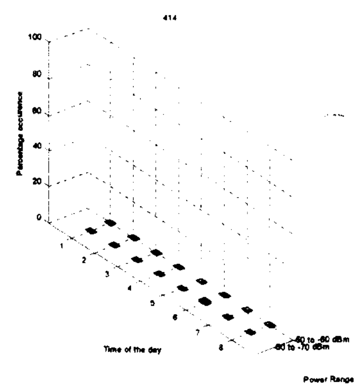
Duration :- 3 PM to 7 PM 14th May 2002 **Direction**:- SOUTH **Polarization** :- Vertical

Duration :- 3 PM to 7 PM 15th May 2002 **Direction** - WEST **Polarization** :- Vertical

Duration :- 3 PM to 7 PM 18th May 2002 **Direction**:- NORTH **Polarization** :- Vertical

Duration :-3 PM to 7 PM 19th May 2002 **Direction**:- EAST **Polarization** :- Vertical

Duration :- 3 PM to 7 PM 20th May 2002 **Direction** :- SOUTH **Polarization** :- Horizontal



Duration :- 3 PM to 7 PM 21st May 2002 **Direction**:- WEST **Polarization** :- Horizontal

Duration:- 6 PM to 9 PM 22nd May 2002 **Direction**:- NORTH **Polarization** :- Horizontal

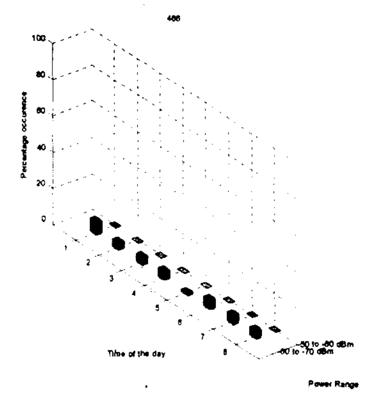
Duration :- 3 PM to 7 PM 3rd June 2002 **Direction**:- EAST **Polarization** :- Horizontal

Figure 4.7(a)

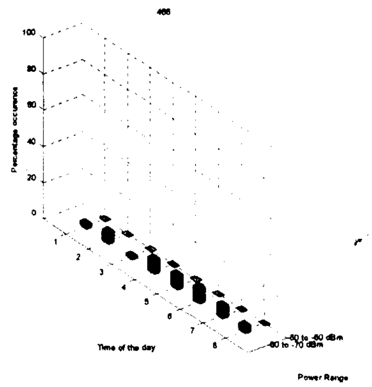
2) Interfering frequency 2: 466 MHz (Frequency Range : 400 MHz to 800 MHz)

Duration :- 3 PM to 7 PM 14th May 2002 **Direction**:- SOUTH **Polarization** :- Vertical

Duration :- 3 PM to 7 PM 15th May 2002 **Direction**:- WEST **Polarization** :- Vertical

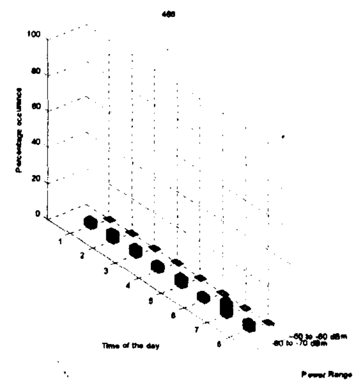


Duration :- 3 PM to 7 PM 18th May 2002 **Direction**:- NORTH **Polarization** :- Vertical

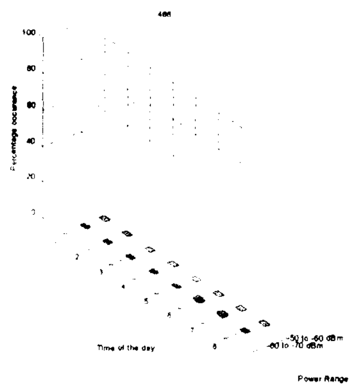


Duration :-3 PM to 7 PM 19th May 2002 **Direction**:- EAST **Polarization** :- Vertical

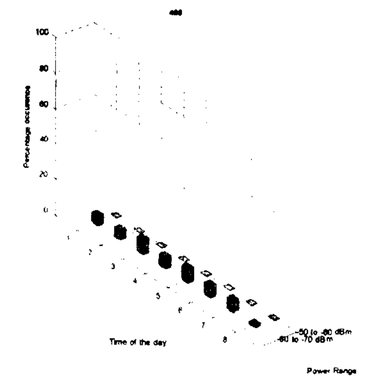
Duration :- 3 PM to 7 PM 20th May 2002 **Direction** :- SOUTH **Polarization** :- Horizontal



Duration :- 3 PM to 7 PM 21st May 2002 **Direction**:- WEST **Polarization** :- Horizontal



Duration:- 6 PM to 9 PM 22nd May 2002 **Direction**:- NORTH **Polarization** :- Horizontal

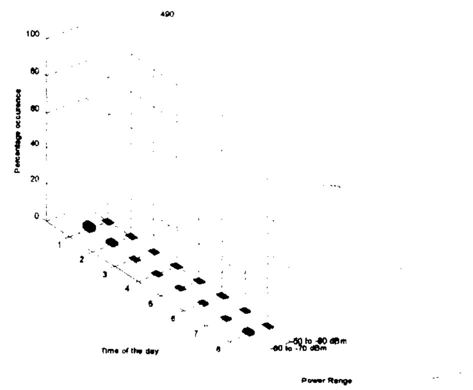


Duration :- 3 PM to 7 PM 3rd June 2002 **Direction**.- EAST **Polarization** :- Horizontal

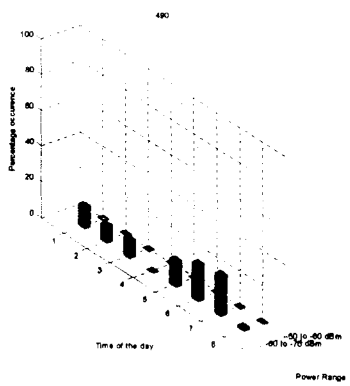
Figure 4.7(b)

3) Interfering frequency 3: 490 MHz (Frequency Range : 400 MHz to 800 MHz)

Duration :- 3 PM to 7 PM 14th May 2002 **Direction**:- SOUTH **Polarization** :- Vertical



Duration :- 3 PM to 7 PM 15th May 2002 **Direction**:- WEST **Polarization** :- Vertical



Duration :- 3 PM to 7 PM 18th May 2002 **Direction**:- NORTH **Polarization** :- Vertical

Duration :-3 PM to 7 PM 19th May 2002 **Direction**:- EAST **Polarization** :- Vertical

Duration :- 3 PM to 7 PM 20th May 2002 **Direction** :- SOUTH **Polarization** :- Horizontal

Duration :- 3 PM to 7 PM 21st May 2002 **Direction** :- WEST **Polarization** :- Horizontal

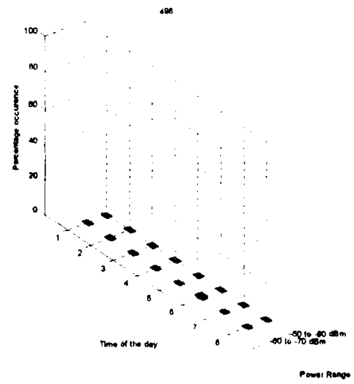
Duration:- 6 PM to 9 PM 22nd May 2002 **Direction**:- NORTH **Polarization** :- Horizontal

Duration :- 3 PM to 7 PM 3rd June 2002 **Direction**:- EAST **Polarization** :- Horizontal

Figure 4.7(c)

4) Interfering frequency 4: 498 MHz (Frequency Range : 400 MHz to 800 MHz)

Duration :- 3 PM to 7 PM 14[th] May 2002 **Direction**:- SOUTH **Polarization** :- Vertical

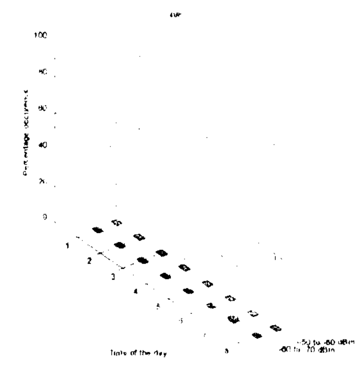


Duration :- 3 PM to 7 PM 15[th] May 2002 **Direction**:- WEST **Polarization** :- Vertical

Duration :- 3 PM to 7 PM 18[th] May 2002 **Direction**:- NORTH **Polarization** :- Vertical

Duration :-3 PM to 7 PM 19[th] May 2002 **Direction**:- EAST **Polarization** :- Vertical

Duration :- 3 PM to 7 PM 20[th] May 2002 **Direction** :- SOUTH **Polarization** :- Horizontal



Duration :- 3 PM to 7 PM 21[st] May 2002 **Direction**:- WEST **Polarization** :- Horizontal

Duration:- 6 PM to 9 PM 22[nd] May 2002 **Direction**:- NORTH **Polarization** :- Horizontal

Duration :- 3 PM to 7 PM 3[rd] June 2002 **Direction**:- EAST **Polarization** :- Horizontal

Figure 4.7(d)

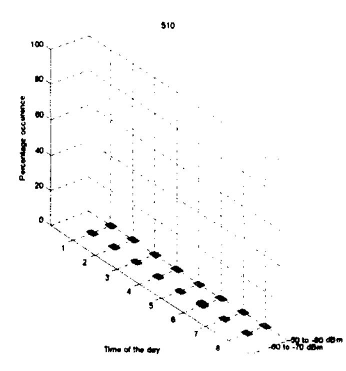
5) Interfering frequency 5: 510 MHz (Frequency Range : 400 MHz to 800 MHz)

Duration :- 3 PM to 7 PM 14th May 2002 **Direction**:- SOUTH **Polarization** :- Vertical

Duration :- 3 PM to 7 PM 15th May 2002 **Direction**:- WEST **Polarization** - Vertical

Duration :- 3 PM to 7 PM 18th May 2002 **Direction**:- NORTH **Polarization** :- Vertical

Duration :-3 PM to 7 PM 19th May 2002 **Direction**:- EAST **Polarization** :- Vertical



Duration :- 3 PM to 7 PM 20th May 2002 **Direction** :- SOUTH **Polarization** :- Horizontal

Duration :- 3 PM to 7 PM 21st May 2002 **Direction**:- WEST **Polarization** :- Horizontal

Duration:- 6 PM to 9 PM 22nd May 2002 **Direction**:- NORTH **Polarization** :- Horizontal

Duration :- 3 PM to 7 PM 3rd June 2002 **Direction**:- EAST **Polarization** :- Horizontal

Figure 4.7(e)

6) Interfering frequency 6: 590 MHz (Frequency Range : 400 MHz to 800 MHz)

Duration :- 3 PM to 7 PM 14th May 2002 **Direction**:- SOUTH **Polarization** :- Vertical

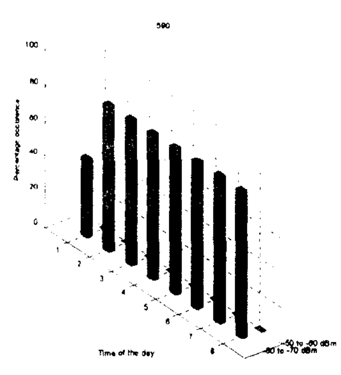
Duration :- 3 PM to 7 PM 15th May 2002 **Direction**:- WEST **Polarization** :- Vertical

Duration :- 3 PM to 7 PM 18th May 2002 **Direction**:- NORTH **Polarization** :- Vertical

Duration :-3 PM to 7 PM 19th May 2002 **Direction**:- EAST **Polarization** :- Vertical

Duration :- 3 PM to 7 PM 20th May 2002 **Direction** :- SOUTH **Polarization** :- Horizontal

Duration :- 3 PM to 7 PM 21st May 2002 **Direction**:- WEST **Polarization** :- Horizontal



Duration - 6 PM to 9 PM 22nd May 2002 Direction:- NORTH Polarization :- Horizontal

Duration :- 3 PM to 7 PM 3rd June 2002 Direction:- EAST Polarization :- Horizontal

Figure 4.7(f)

7) Interfering frequency 7: 594 MHz (Frequency Range : 400 MHz to 800 MHz)

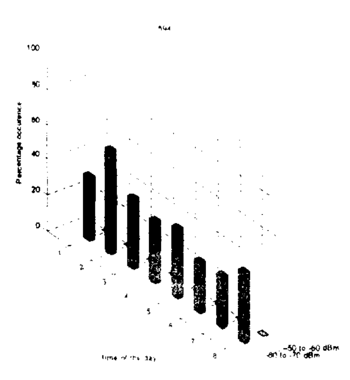
Duration :- 3 PM to 7 PM 14th May 2002 **Direction**:- SOUTH **Polarization** :- Vertical	**Duration** :- 3 PM to 7 PM 15th May 2002 **Direction**:- WEST **Polarization** :- Vertical
Duration :- 3 PM to 7 PM 18th May 2002 **Direction**:- NORTH **Polarization** :- Vertical	**Duration** :-3 PM to 7 PM 19th May 2002 **Direction**:- EAST **Polarization** :- Vertical
Duration :- 3 PM to 7 PM 20th May 2002 Direction :- SOUTH Polarization :- Horizontal	Duration :- 3 PM to 7 PM 21st May 2002 Direction :- WEST Polarization :- Horizontal
 **Duration**:- 6 PM to 9 PM 22nd May 2002 **Direction**:- NORTH **Polarization** :- Horizontal	**Duration** :- 3 PM to 7 PM 3rd June 2002 **Direction**:- EAST **Polarization** :- Horizontal

Figure 4.7(g)

8) Interfering frequency 8: 770 MHz (Frequency Range : 400 MHz to 800 MHz)

Duration :- 3 PM to & PM 14th May 2002 **Direction**:- SOUTH **Polarization** :- Vertical

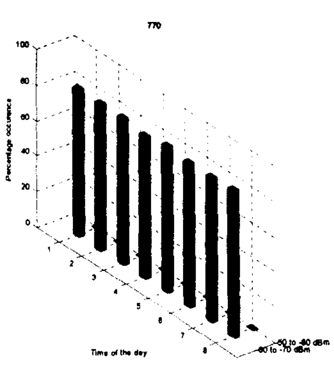
Duration :- 3 PM to 7 PM 15th May 2002 **Direction**:- WEST **Polarization** :- Vertical

Duration :- 3 PM to 7 PM 18th May 2002 **Direction**:- NORTH **Polarization** :- Vertical

Duration :-3 PM to 9 PM 19th May 2002 **Direction**:- EAST **Polarization** :- Vertical

Duration :- 3 PM to 7 PM 20th May 2002 **Direction** :- SOUTH **Polarization** :- Horizontal

Duration :- 3 PM to 7 PM 21st May 2002 **Direction**:- WEST **Polarization** :- Horizontal



Duration:- 6 PM to 9 PM 22nd May 2002 **Direction**:- NORTH **Polarization** :- Horizontal

Duration:- 3 PM to 7 PM 22nd May 2002 **Direction**:- EAST **Polarization** :- Horizontal

Figure 4.7(h)

9) Interfering frequency 9: 770 MHz (Frequency Range : 700 MHz to 1100 MHz)

Duration :- 7 PM to 11 PM 14th May 2002 Direction:- SOUTH **Polarization** :- Vertical

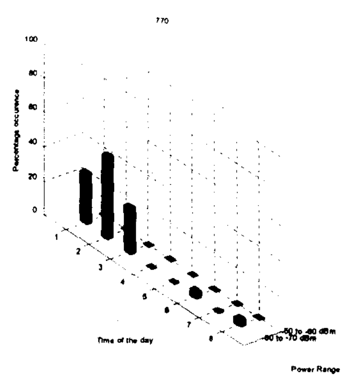
Duration :- 7 PM to 11 PM 15th May 2002 **Direction**:- WEST **Polarization** :- Vertical

Duration :-7 PM to 11 PM 18th May 2002 Direction:- NORTH Polarization :- Vertical

Duration:-7 PM to 11 PM 19th May 2002 Direction:- EAST Polarization :- Vertical

Duration:- 7 PM to 11 PM 20th May 2002 **Direction**:- SOUTH **Polarization**:- Horizontal

Duration:- 7 PM to 11 PM 21st May 2002 **Direction**:- WEST **Polarization** :- Horizontal



Duration:- 9 PM to 12 PM 22nd May 2002 **Direction**:- NORTH **Polarization**:-

Duration :- 7 PM to 11 PM 3rd June 2002 **Direction**:- EAST **Polarization** :- Horizontal

Figure 4.7(i)

10) Interfering frequency 10: 774 MHz (Frequency Range : 400 MHz to 800 MHz)

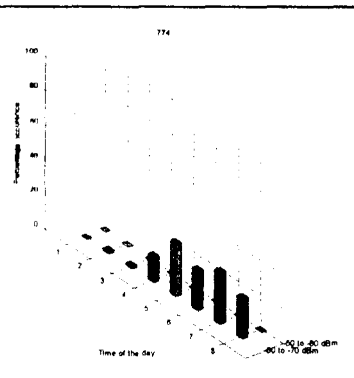
Duration :- 3 PM to 7 PM 14th May 2002 **Direction**:- SOUTH **Polarization** :- Vertical	**Duration** :- 3 PM to 7 PM 15th May 2002 **Direction**:- WEST **Polarization** :- Vertical
Duration :-3 PM to 7 PM 18th May 2002 **Direction**:- NORTH **Polarization** :- Vertical	**Duration**:-3 PM to 7 PM 19th May 2002 **Direction**:- EAST **Polarization** :- Vertical
Duration:- 3 PM to 7 PM 20th May 2002 **Direction**:- SOUTH **Polarization**:- Horizontal	**Duration**:- 3 PM to 7 PM 21st May 2002 **Direction**:- WEST **Polarization** :- Horizontal
	
Duration - 6 PM to 9 PM 22nd May 2002 Direction - NORTH Polarization:- Horizontal	Duration - 3 PM to 7 PM 3rd June 2002 Direction - EAST Polarization - Horizontal

Figure 4.7(j)

11) Interfering frequency 11: 778 MHz (Frequency Range : 400 MHz to 800 MHz)

Duration :- 3 PM to 7 PM 14th May 2002 **Direction**:- SOUTH **Polarization** :- Vertical

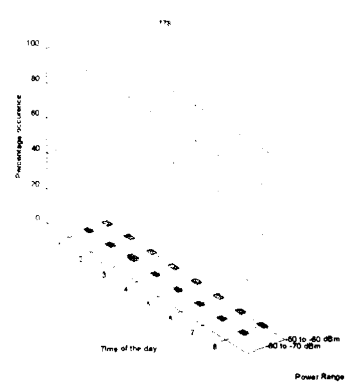
Duration :- 3 PM to 7 PM 15th May 2002 **Direction**:- WEST **Polarization** :- Vertical

Duration :- 3 PM to 7 PM 18th May 2002 **Direction**:- NORTH **Polarization** :- Vertical

Duration :-3 PM to 7 PM 19th May 2002 **Direction**:- EAST **Polarization** :- Vertical

Duration - 3 PM to 7 PM 20th May 2002 Direction :- SOUTH **Polarization** :- Horizontal

Duration :- 3 PM to 7 PM 21st May 2002 **Direction**:- WEST **Polarization** :- Horizontal



Duration:- 6 PM to 9 PM 22nd May 2002 **Direction**:- NORTH **Polarization** :- Horizontal

Duration :- 3 PM to 7 PM 3rd June 2002 **Direction**:- EAST **Polarization** :- Horizontal

Figure 4.7(k)

12) Interfering frequency 12: 906 MHz (Frequency Range : 700 MHz to 1100 MHz)

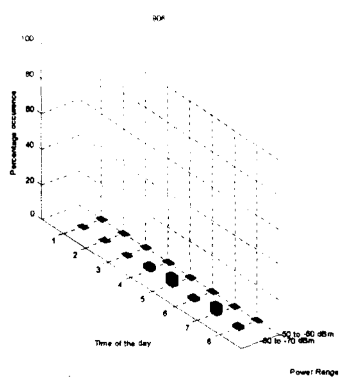
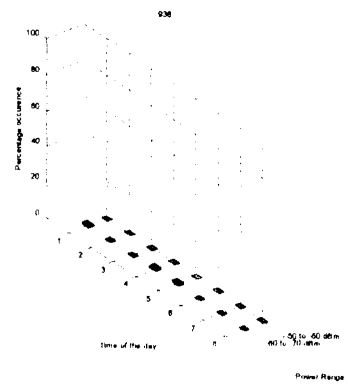
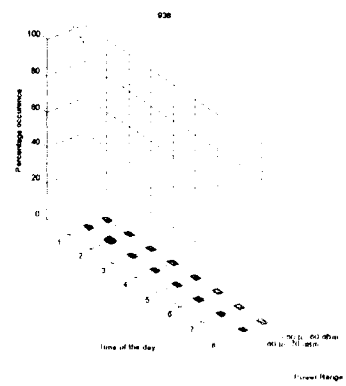
Duration:- 7 PM to 11 PM 14^{th} **May** 2002 **Direction**:- SOUTH **Polarization** :- **Vertical**	**Duration** :- 7 PM to 11 PM 15^{th} **May** 2002 **Direction**:- WEST **Polarization** :- **Vertical**
Duration:- 7 PM to 11 PM 18^{th} May 2002 Direction:- NORTH **Polarization** :- Vertical	**Duration** :-7 PM to 11 PM 19^{th} May 2002 **Direction**:- EAST **Polarization** :- Vertical
Duration:-7 PM to 11 PM 20^{th} May 2002 **Direction** :- SOUTH **Polarization** :- Horizontal	**Duration**:-7 PM to 11 PM 21^{st} **May** 2002 **Direction**:- WEST **Polarization** :- Horizontal
	
Duration:-9 PM to 12 PM 22^{nd} May 2002 **Direction**:-NORTH **Polarization**:- Horizontal	**Duration** :- 7 PM to 11 PM 3^{rd} June 2002 **Direction**:- EAST **Polarization** :- Horizontal

Figure 4.7(l)

13) Interfering frequency 13: 938 MHz (Frequency Range : 700 MHz to 1100 MHz)



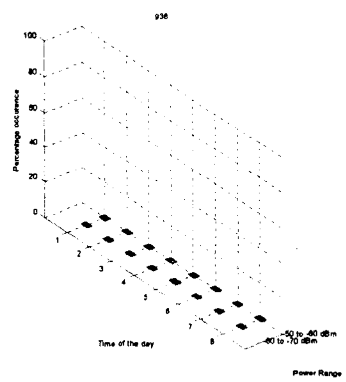
Duration :- 7 PM to 11 PM 14th May 2002 **Direction**:- SOUTH **Polarization** :- Vertical



Duration:- 7 PM to 11 PM 15th May 2002 **Direction**:- WEST **Polarization**:- Vertical

Duration:- 7 PM to 11 PM 18th May 2002 **Direction**:- NORTH **Polarization** :- Vertical

Duration:-7 PM to 11 PM 19th May 2002 **Direction**:- EAST **Polarization** :- Vertical



Duration:-7 PM to 11 PM 20th May 2002 **Direction** :- SOUTH **Polarization** :- Horizontal

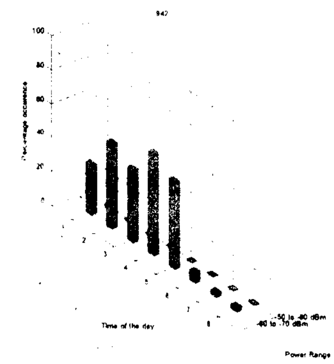
Duration:-7 PM to 11 PM 21st May 2002 **Direction**:- WEST **Polarization** :- Horizontal

Duration:-9 PM to 12 PM 22nd May 2002 **Direction**:-NORTH **Polarization**:- Horizontal

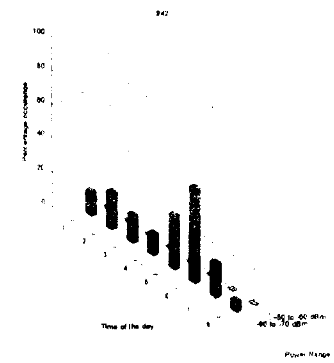
Duration :-7 PM to 11 PM 3rd June 2002 **Direction**:- EAST **Polarization** :- Horizontal

Figure 4.7(m)

14) Interfering frequency 14: 942 MHz (Frequency Range : 700 MHz to 1100 MHz)

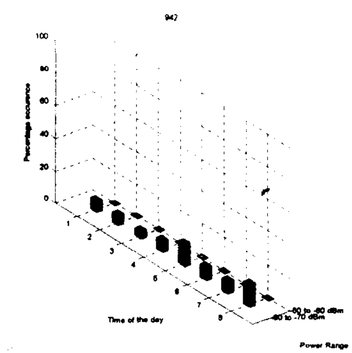


Duration :- 7 PM to 11 PM 14th May 2002 **Direction**:- SOUTH **Polarization** :- Vertical

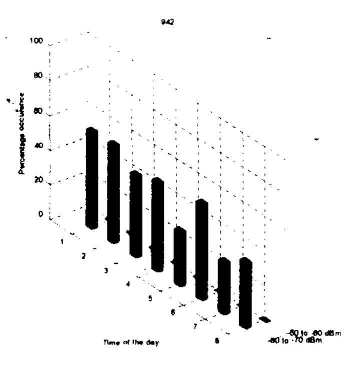


Duration :- 7 PM to 11 PM 15th May 2002 **Direction**:- WEST **Polarization** :- Vertical

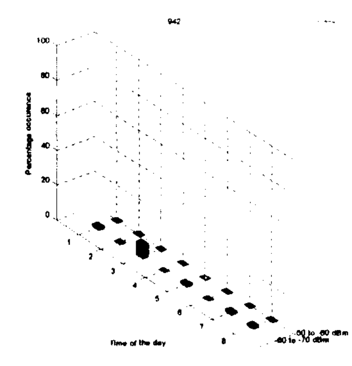
Duration:-7 PM to 11 PM 18th May 2002 **Direction**:- NORTH **Polarization** :- Vertical



Duration :-7 PM to 11 PM 19th May 2002 **Direction**:- EAST **Polarization** :- Vertical



Duration :- 7 PM to 11 PM 20th May 2002 **Direction**:-SOUTH **Polarization** :- Horizontal



Duration:- 7 PM to 11 PM 21st May 2002 **Direction**:- WEST **Polarization** :- Horizontal

Duration:-9 PM to 12 PM 22nd May 2002 **Direction**:-NORTH **Polarization**:- Horizontal

Duration :-7 PM to 11 PM 3rd June 2002 **Direction**:- EAST **Polarization** :- Horizontal

Figure 4.7(n)

15) Interfering frequency 15: 950 MHz (Frequency Range : 700 MHz to 1100 MHz)

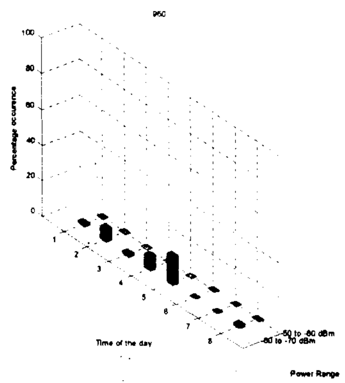
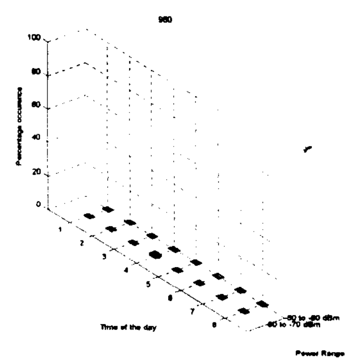
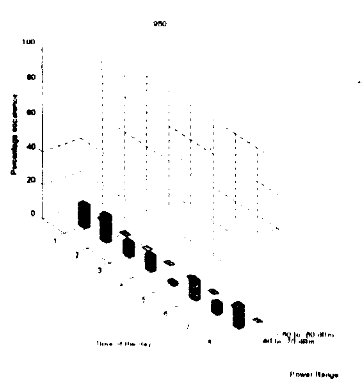
	
Duration :- 7 PM to 11 PM 14th May 2002 **Direction**:- SOUTH **Polarization** :- Vertical	**Duration** :- 7 PM to 11 PM 15th May 2002 **Direction**:- WEST **Polarization** :- Vertical
	
Duration:-7 PM to 11 PM 18th May 2002 **Direction**:- NORTH **Polarization** :- Vertical	**Duration** :-7 PM to 11 PM 19th May 2002 **Direction**:- EAST **Polarization** :- Vertical
	
Duration:- 7 PM to 11 PM 20th May 2002 **Direction**:- SOUTH **Polarization**:- Horizontal	**Duration** :-7 PM to 11 PM 21st May 2002 **Direction**:- WEST **Polarization** :- Horizontal
Duration:-9 PM to 11 PM 22nd May 2002 **Direction**:-NORTH **Polarization**:- Horizontal	**Duration** :- 7 PM to 11 PM 3rd June 2002 **Direction**:- EAST **Polarization** :- Horizontal

Figure 4.7(o)

16) Interfering frequency 16: 994 MHz (Frequency Range : 700 MHz to 1100 MHz)

Duration :- 7 PM to 11 PM 14th May 2002 **Direction**:- SOUTH **Polarization** :- Vertical

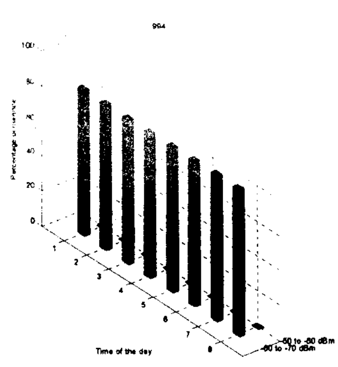
Duration :- 7 PM to 11 PM 15th May 2002 **Direction**:- WEST **Polarization** :- Vertical

Duration :-7 PM to 11 PM 18th May 2002 **Direction**:- NORTH **Polarization** :- Vertical

Duration :-7 PM to 11 PM 19th May 2002 **Direction**:- EAST **Polarization** :- Vertical

Duration :- 7PM to 11PM 20th May 2002 **Direction** :- SOUTH **Polarization** :- Horizontal

Duration :- 7 PM to 11 PM 21st May 2002 **Direction**:- WEST **Polarization** :- Horizontal



Duration:-9 PM to 12 PM 22nd May 2002 **Direction**:-NORTH **Polarization**:-Horizontal

Duration :- 7 PM to 11 PM 3rd June 2002 **Direction**:- EAST **Polarization** :- Horizontal

Figure 4.7(p)

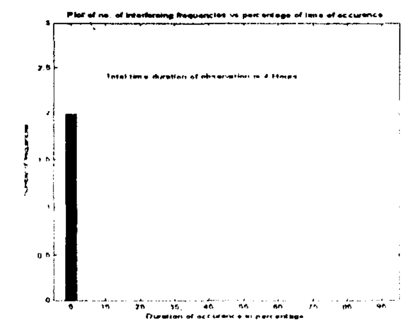
4.5.3 Plot of number of interference frequencies as a function of duration of occurrence

The plots of number of interference frequencies as a function of duration of occurrence in percentage of the total observing time period are shown in figures 4.8(a) to 4.8(d)

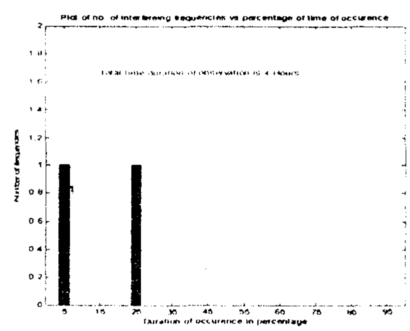
Frequency Range 400 MHz to 800 MHz

No observation was carried out in this frequency band on this day

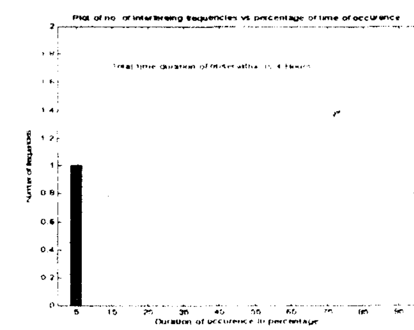
Duration :- 3 PM to 7 PM 14th May 2002 Direction:- SOUTH Polarization:-V



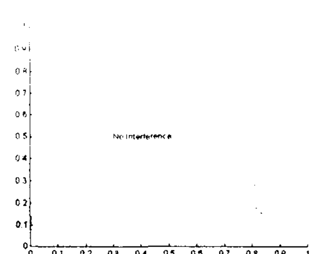
Duration :- 3 PM to 7 PM 15th May 2002 Direction:- WEST Polarization :- V



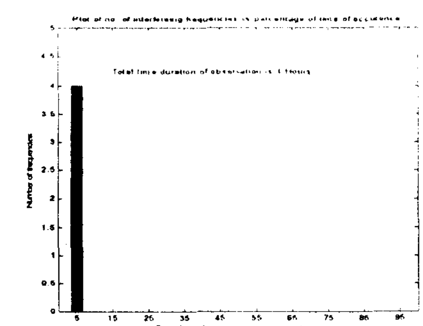
Duration :- 3 PM to 7 PM 18th May 2002 Direction:- NORTH Polarization :- V



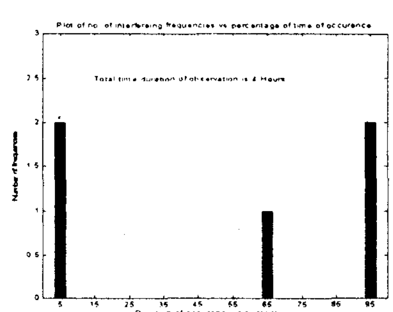
Duration :-3 PM to 7 PM 19th May 2002 Direction:- EAST Polarization :- V



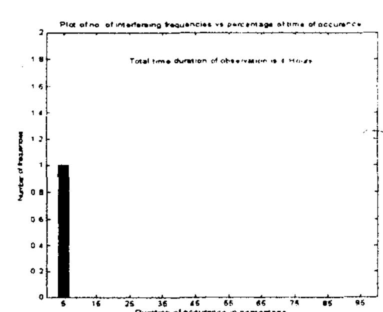
Duration :- 3 PM to 7 PM 20th May 2002 Direction :- SOUTH Polarization :- H



Duration :- 3 PM to 7 PM 21st May 2002 Direction:- WEST Polarization :- H



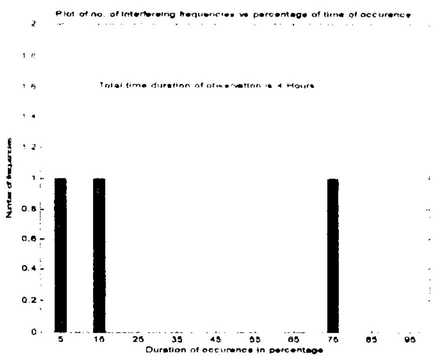
Duration:- 6 PM to 9 PM 22nd May 2002 Direction:- NORTH Polarization :- H



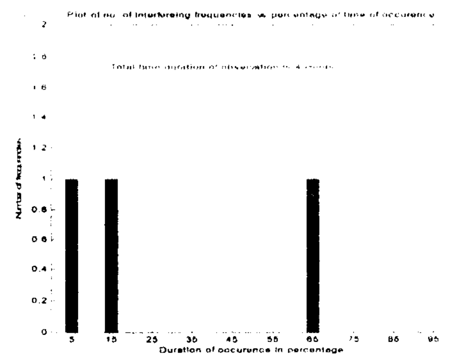
Duration :- 3 PM to 7 PM 3rd June 2002 Direction:- EAST Polarization :- H

Figure 4.8(a)

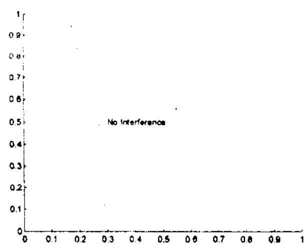
Frequency Range : 700 MHz to 1100 MHz



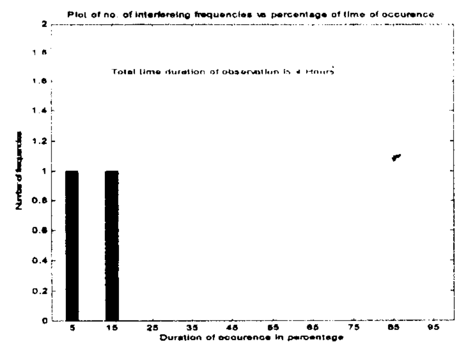
Duration :- 7 PM to 11 PM 14th May 2002 **Direction**:- SOUTH **Polarization** :- V



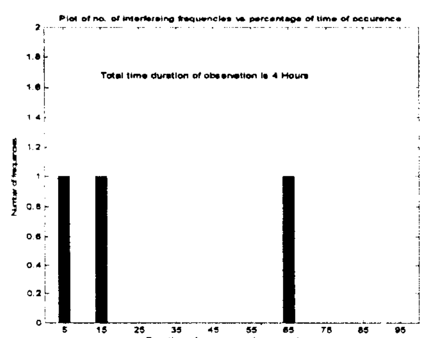
Duration:- 7 PM to 11 PM 15th May 2002 **Direction**.- WEST **Polarization**:- V



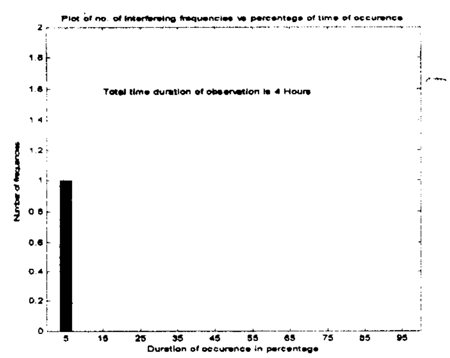
Duration:- 7 PM to 11 PM 18th May 2002 **Direction**:- NORTH **Polarization** :- V



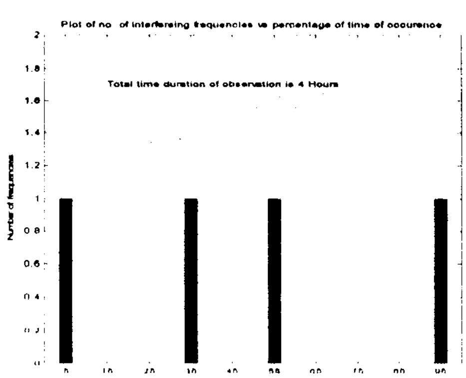
Duration:-7 PM to 11 PM 19th May 2002 **Direction**:- EAST **Polarization** :- V



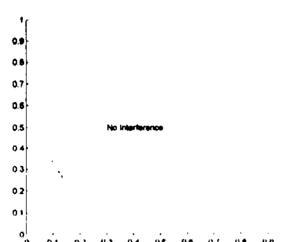
Duration:-7 PM to 11 PM 20th May 2002 **Direction** :- SOUTH **Polarization** :- H



Duration:-7 PM to 11 PM 21st May 2002 **Direction**:- WEST **Polarization** :- H



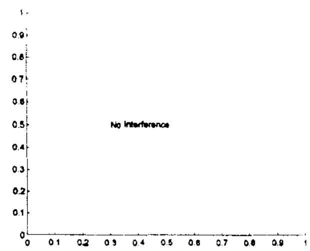
Duration:-9 PM to 12 PM 22nd May 2002 **Direction**:-NORTH **Polarization**:- H



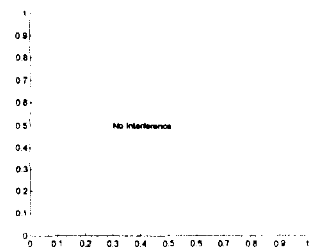
Duration :-7 PM to 11 PM 3rd June 2002 **Direction**:- EAST **Polarization** :- H

Figure 4.8(b)

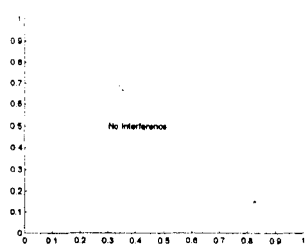
Frequency Range : 1000 MHz to 1400 MHz



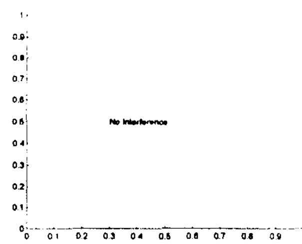
Duration:-11PM 14th May 2002 to 3AM 15th May 2002 **Direction:**- SOUTH **Polarization:**-V



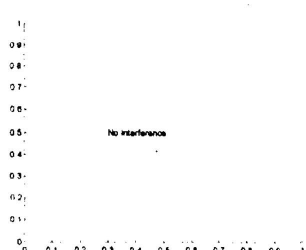
Duration:- 11PM 15th May 2002 to 3AM 16th May2002 **Direction:**- WEST **Polarization:**- V



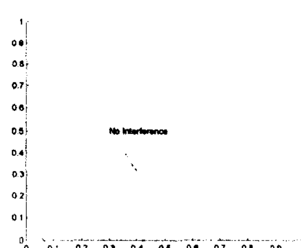
Duration:-11PM 18th May 2002 to 3AM 19th May 2002 **Direction:**-NORTH **Polarization:**-V



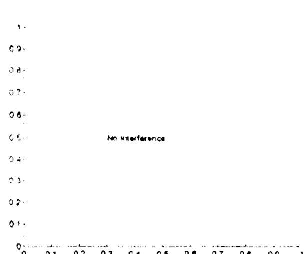
Duration:-11PM 19th May 2002 to 3AM 20th May 2002 **Direction:**-EAST **Polarization:**- V



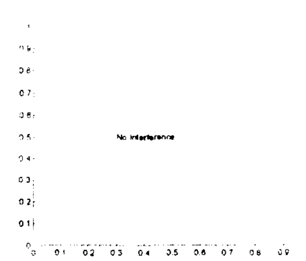
Duration:-11PM 20th May 2002 to 3AM 21st May 2002 **Direction:**-SOUTH **Polarization:**-H



Duration:-11PM 21st May 2002 to 3AM 22nd May 2002 **Direction:**-WEST **Polarization:**-H



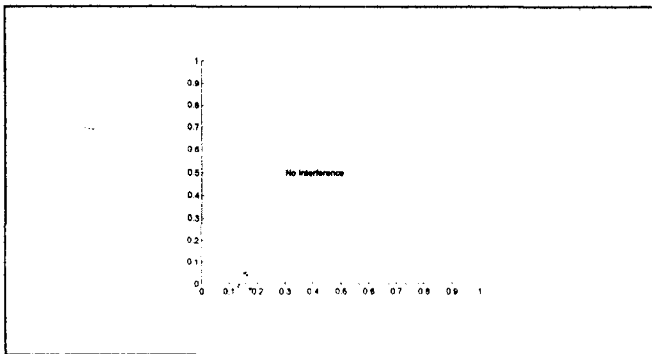
Duration:-1 AM to 4 AM 23rd May 2002 **Direction:**-NORTH **Polarization:**- H



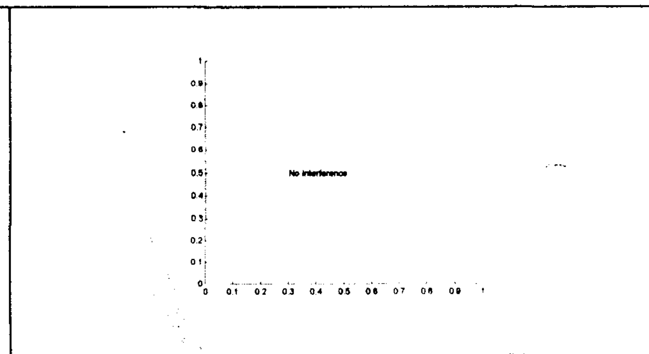
Duration:-11 PM 3rd Jun 2002 to 3 AM 4th Jun 2002 **Direction:**-EAST **Polarization:**-H

Figure 4.8(c)

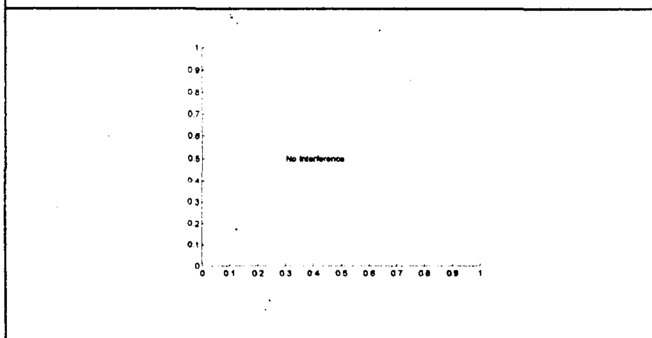
Frequency Range : 1300 MHz to 1700 MHz



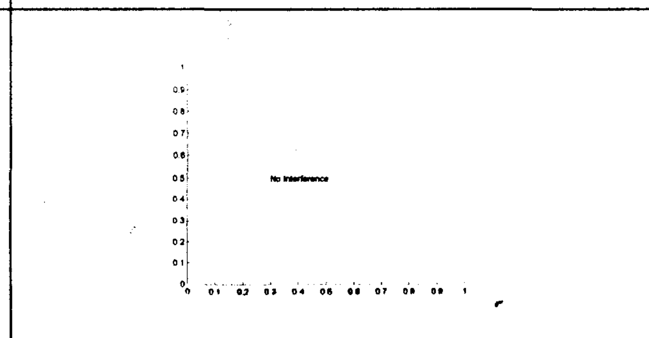
Duration :- 4 AM to 8 AM 15th May 2002 Direction:- SOUTH Polarization :- V



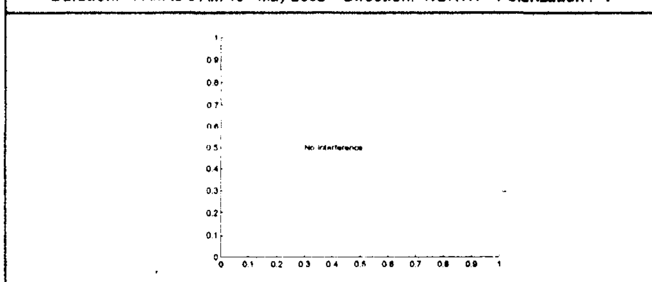
Duration:- 4 AM to 8 AM 16th May 2002 Direction:- WEST Polarization:- V



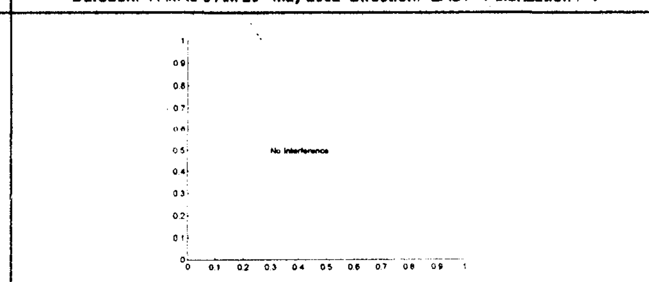
Duration:- 4 AM to 8 AM 19th May 2002 Direction:- NORTH Polarization :- V



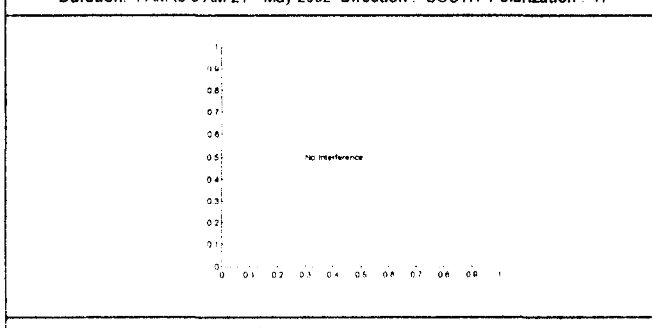
Duration:-4 AM to 8 AM 20th May 2002 Direction:- EAST Polarization :- V



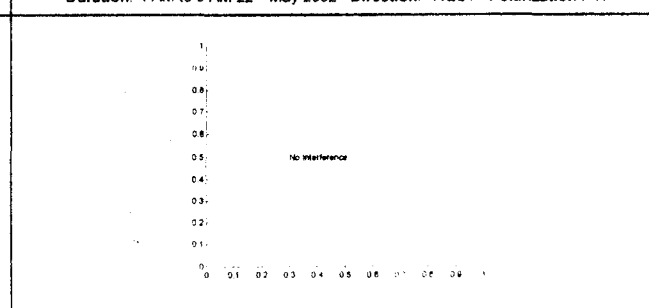
Duration:-4 AM to 8 AM 21st May 2002 Direction :- SOUTH Polarization :- H



Duration:-4 AM to 8 AM 22nd May 2002 Direction:- WEST Polarization :- H



Duration -1 AM to 4 AM 23rd May 2002 Direction:-NORTH Polarization - H



Duration -4 AM to 8 AM 4th June 2002 Direction:- EAST Polarization - H

Figure 4.8(d)

4.5.4 Frequency spectra over the entire range, obtained in 4 directions

The frequency spectra in all the four directions and two polarizations covering the entire frequency range starting from 400 MHZ to 1700 MHz are shown in figures 4.9(a) and 4.9(b)

Radio Spectra at Gauribidanur in different directions

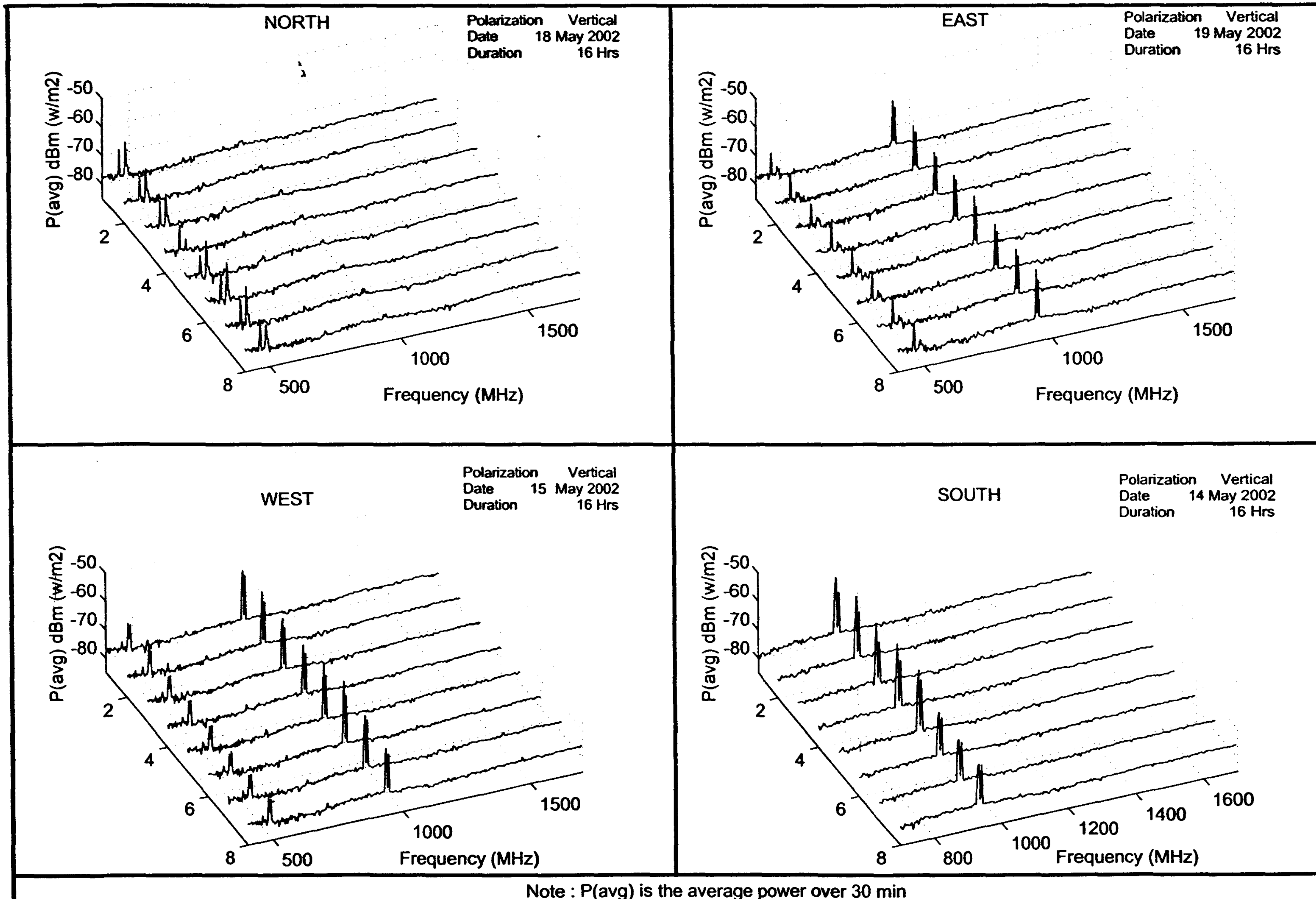


Figure 4.9 (a) : Radio Spectra in all the 4 directions for Vertical Polarization

Radio Spectra at Gauribidanur in different directions

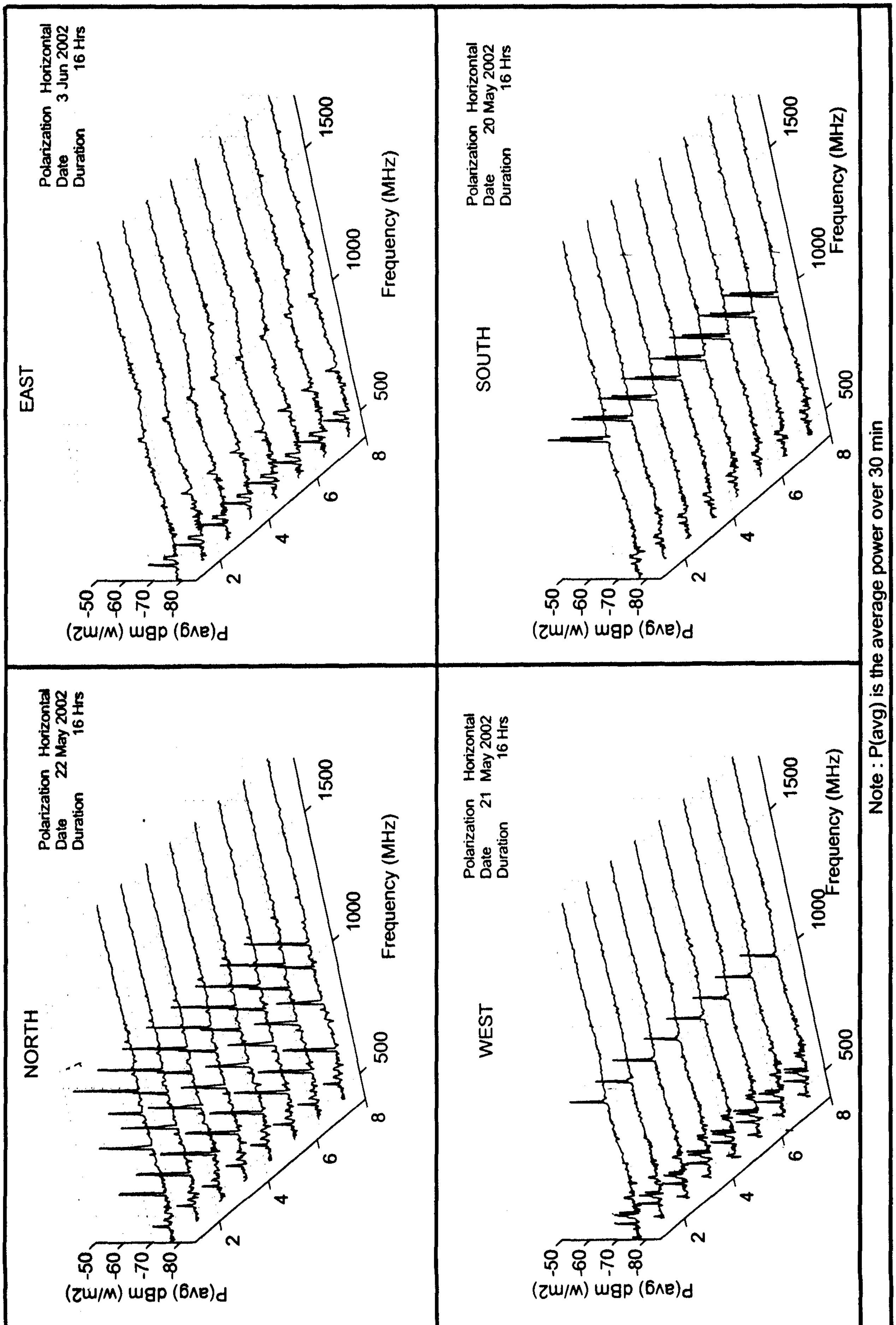


Figure 4.9 (b) : Radio Spectra in all the 4 directions for Horizontal Polarization

Chapter 5

Conclusion

Our goal was to carry out interference monitoring over the frequency range 400 MHz to 1700 MHz in two polarizations and in all four directions at Gauribidanur and the same has been successfully carried out by us. As an outcome of our project, work we have listed all the frequencies which have occurred both intermittently and continuously. In addition, we also have produced plots of the radioo frequency spectrum covering the entire frequency range of our interest in all the four directions and the two polarizations .

Scope for further work

1. A wideband continuum receiver could be built, to monitor RF spectrum continuously over a averaging time duration of 2000 seconds .
2. If the spectrum analyser itself is used for data acquition, a software can be developed in order to monitor automatically all the sub-bands of our interest without user intervention.

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Appendix A

Software Program to acquire interference Monitoring data

```
                /* program to control HP spectrum analyser-8591E */
    /* This program acquires the 400 points of each trace as many times*/
       /* as User gives as segregates the signals according to the  */
                        /* power levels */
                  /* File Name : < inter_f.c > */

#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <dos.h>
#include <graphics.h>
#include <conio.h>
#include <math.h>
#include <complex.h>
#include "c:\tc\include\decl.h"
#include <time.h>
#define SIZE 401    /*401*/
int plot_histo();

int i,j=0,k=0,dvm1,ret,retu,x=0,test=1000,u,m,n,l,z,s ;
unsigned char  carray1[401];
int iarray1[400],x1,y,numb,no_sec,user,user1,darray[8][100],darray1[8][100];
float power;
int temp,temp1=0,temp2=0,temp3=0,temp4=0,temp5=0,temp6=0,temp7=0,temp8=0;
float str_f,stp_f,rbw,amp_ref,scale,acq_rate,r1,r,rec_perc,perc,user_inv;
char f1[10],f2[10];

FILE *fp1, *fp2,*fp3,*fp4,*fp5;
char string[15],freq[10],f_str[10],fre2[10],f_stp[10],rsbw[10],ref_amp[10],a[15];
char *fa="FA",*fb="FB", *mhz="MHZ",*rb="RB",*rl="RL",*dm="DM" ;
time_t  time_str,time_end ; -

unsigned int c;
unsigned int lb1,hb1,lb2,hb2;

int driver,mode ;

    int  main(void)
    {
     struct REGPACK reg;
       struct  time t;
     int gdriver = DETECT, gmode, errorcode;

     dvm1=ibfind("SPA");

     if((fp4=fopen("d:\\raghu\\cct\\rec_par.dat","w"))==NULL)
         printf("There is some problem in opening\n");


     if((fp3=fopen("d:\\raghu\\cct\\inp_par.dat","r"))==NULL)
         printf("There is some problem in opening\n");

     if((fp5=fopen("opre_hr.dat","at"))==NULL)
         printf("There is some problem in opening\n");


     fscanf(fp3,"%f %f %f %f %f",&str_f,&stp_f,&rbw,&amp_ref,&scale);

     gcvt(str_f,7,freq);    /* converts float-pt(str_f) to string(freq) */
     strcpy(f_str,fa);      /* "FA" is copied into fre2                 */
     strcat(f_str,freq);    /* freq string is cct'nated to string f_str */
     strcat(f_str,mhz);     /* "MHZ" is conctd to f_str to get "FAfreqmhz"*/
     gcvt(stp_f,7,freq);    /* converts float-pt(stp_f) to string(start)      */
     strcpy(f_stp,fb);      /* "FA" is copied into fre2                       */
```

```
    strcat(f_stp,freq);   /* start string is cct'nated to string fre2       */
    strcat(f_stp,mhz);    /* "MHZ" is concatenated to fre2 to get "FR1000MZ"*/
    gcvt(rbw,7,freq);     /* converts float-pt(rbw) to string(rsbw)         */
    strcpy(rsbw,rb);      /* "RB" is copied into rsbw                       */
    strcat(rsbw,freq);    /* start string is cct'nated to string fre2       */
    strcat(rsbw,mhz);     /* "MHZ" is concatenated to fre2 to get "FR1000MZ"*/
    gcvt(amp_ref,7,freq); /* converts float-pt(rbw) to string(rsbw)         */
    strcpy(ref_amp,rl);   /* "RL" is copied into rsbw                       */
    strcat(ref_amp,freq); /* start string is cct'nated to string fre2       */
    strcat(ref_amp,dm);   /* "MHZ" is concatenated to fre2 to get "FR1000MZ"*/

    ibwrt(dvm1,f_str,20L);            /* start frequency      */
    ibwrt(dvm1,f_stp,15L);            /* Stop frequency       */
    ibwrt(dvm1,rsbw,15L);             /* resolution bandwidth */
    ibwrt(dvm1,ref_amp,15L);          /* reference amplitude  */
    ibwrt(dvm1,"lg\n\r",4L);
    ibwrt(dvm1,"det smp \n\r",10L);   /* Puts the det.in the sample mode */
    ibwrt(dvm1,"TDF b \n\r", 7L);
    ibwrt(dvm1,"MDS b\n\r",8L);

    fflush(stdin);
    fscanf(fp3,"%d %f %s %d",&user,&acq_rate,string,&user1);

 fp1=fopen(string,"ab");  /* ORIGINAL IS "ab" */

 time_str = time(NULL);

 fprintf(fp1,"%f %f %f %f %f %d %d",str_f,stp_f,rbw,amp_ref,scale,user,user1);

 for(z=0;z<user1;z++)
    {                        /* Begining of outer most loop */
      for(s=0;s<100;s++)
       {
        for(i=0;i<8;i++)
         darray1[i][s] = 0 ;  /*  Initialising the darray */
        }
      for(j=0;j<(user+1);j++)      /* USER SPECIFIED no. of traces */
        {
          fp2=fopen("opresult.dat","w");

                sleep(acq_rate*60);
         printf("present acquisition is %d th one\n",j);
         ibwrt(dvm1,"TRA? \n\r",7L);
         ibrd(dvm1, carray1,400L) ; /*the value read is stored in *char"store"*/

         for(i=0;i<400;i++)
             iarray1[i]= *(carray1+i) ;

        if(j > 0)
         {
          for(i=0;i<400;)
           {
            temp = (iarray1[i]+iarray1[i+1]+iarray1[i+2]+iarray1[i+3])*0.25 ;
            power =    ((32*(temp))-8000)*0.01 + amp_ref ;
            if(power <=-20  && power > -30)
                {
                  darray[0][1] = darray[0][1] + 1;
                  darray1[0][1] = darray1[0][1] + 1;
                }
              else if(power <=-30  && power > -40)
                {
                  darray[1][1] = darray[1][1] + 1;
                  darray1[1][1] = darray1[1][1] + 1;
                }
               else if(power <= -40  && power > -50)
                {
                  darray[2][1] = darray[2][1] + 1 ;
                  darray1[2][1] = darray1[2][1] + 1 ;
                }
```

```
                else if(power <=-50  && power > -60)
                 {
                   darray[3][l] = darray[3][l] + 1;
                   darray1[3][l] = darray1[3][l] + 1;
                  }
                else if(power <=-60  && power > -70)
                 {
                   darray[4][l] = darray[4][l] + 1;
                   darray1[4][l] = darray1[4][l] + 1;
                  }
                else if(power <=-70  && power > -80)
                 {
                   darray[5][l] = darray[5][l]+ 1 ;
                   darray1[5][l] = darray1[5][l]+ 1 ;
                  }
                else if(power <= -80  && power > -90)
                 {
                   darray[6][l] = darray[6][l] + 1;
                   darray1[6][l] = darray1[6][l] + 1;
                  }
                else if(power <=-90  && power > -100)
                 {
                   darray[7][l] = darray[7][l] + 1;
                   darray1[7][l] = darray1[7][l] + 1;
                  }
               i = i+4 ;
               l = l+1;

            }   /* End of 100 points for storing */

           fwrite(iarray1,2,400,fp1) ;


         }     /* End of j > 0 loop */
        i=0;l=0;

           for(m=0;m<100;m++)
            {
             fprintf(fp2,"%d %d %d %d %d %d %d %d \n",
             darray[7][m],darray[6][m],darray[5][m],darray[4][m],
             darray[3][m],darray[2][m],darray[1][m],darray[0][m]);

            }
            fclose(fp2);

           }           /* end of user loop  = 12 * 10 * j : No. of traces */




 /*  request auto detection */


if (errorcode != grOk)  /* an error occurred */
{
   printf("Graphics error: %s\n", grapherrormsg(errorcode));
   printf("Press any key to halt:");
   getch();
   exit(1);             /* return with error code */
}


/* initialize graphics mode */
initgraph(&gdriver, &gmode, "");

/* read result of initialization */
errorcode = graphresult();
```

```
setcolor(WHITE);
line(50,0,50,getmaxy()-60);
line(50,getmaxy()-60,450,getmaxy()-60);
line(50,0,450,0);
line(450,0,450,getmaxy()-60);

line(50,40,450,40);
line(50,80,450,80);
line(50,120,450,120);
line(50,160,450,160);
line(50,200,450,200);
line(50,240,450,240);
line(50,280,450,280);

line(50+40,getmaxy()-60,50+40,0);
line(50+80,getmaxy()-60,50+80,0);
line(50+120,getmaxy()-60,50+120,0);
line(50+160,getmaxy()-60,50+160,0);
line(50+200,getmaxy()-60,50+200,0);
line(50+240,getmaxy()-60,50+240,0);
line(50+280,getmaxy()-60,50+280,0);
line(50+320,getmaxy()-60,50+320,0);
line(50+360,getmaxy()-60,50+360,0);



setcolor(WHITE);
outtextxy(210,getmaxy()-20,"Frequency - MHz --->");
setcolor(WHITE);
outtextxy(0,120,"P");
outtextxy(0,130,"O ");
outtextxy(0,140,"W");
outtextxy(0,150,"E ");
outtextxy(0,160,"R");
outtextxy(0,180,"dBm");
setcolor(WHITE);

/* Y- Axis  */
r1 = (80*0.3125*0.01) ;    /*  dBm/pixel  */


outtextxy(25,280,itoa((amp_ref-7*scale),a,10));
 putpixel(50,280,WHITE);
outtextxy(25,240,itoa((amp_ref-6*scale),a,10));
 putpixel(50,240,WHITE);
outtextxy(25,200,itoa((amp_ref-5*scale),a,10));
 putpixel(50,200,WHITE);
outtextxy(25,160,itoa((amp_ref-4*scale),a,10));
 putpixel(50,160,WHITE);
outtextxy(25,120,itoa((amp_ref-3*scale),a,10));
 putpixel(50,120,WHITE);
outtextxy(25,80,itoa((amp_ref-2*scale),a,10));
 putpixel(50,80,WHITE);
outtextxy(25,40,itoa((amp_ref-1*scale),a,10));
 putpixel(50,40,WHITE);
outtextxy(25,0,itoa((amp_ref-0*scale),a,10));
 putpixel(50,0,WHITE);

     /* X-Axis */
r = (stp_f-str_f)/400;

outtextxy(50,getmaxy()-40,itoa((str_f+r*40*0),a,10));
 putpixel(50,getmaxy()-60,WHITE);
outtextxy(50+40,getmaxy()-40,itoa((str_f+r*40*1),a,10));
 putpixel(50+40,getmaxy()-60,WHITE);
outtextxy(50+80,getmaxy()-40,itoa((str_f+r*40*2),a,10));
 putpixel(50+80,getmaxy()-60,WHITE);
```

```
        outtextxy(50+120,getmaxy()-40,itoa((str_f+r*40*3),a,10));
         putpixel(50+120,getmaxy()-60,WHITE);
        outtextxy(50+160,getmaxy()-40,itoa((str_f+r*40*4),a,10));
         putpixel(50+160,getmaxy()-60,WHITE);
        outtextxy(50+200,getmaxy()-40,itoa((str_f+r*40*5),a,10));
         putpixel(50+200,getmaxy()-60,WHITE);
        outtextxy(50+240,getmaxy()-40,itoa((str_f+r*40*6),a,10));
         putpixel(50+240,getmaxy()-60,WHITE);
        outtextxy(50+280,getmaxy()-40,itoa((str_f+r*40*7),a,10));
         putpixel(50+280,getmaxy()-60,WHITE);
        outtextxy(50+320,getmaxy()-40,itoa((str_f+r*40*8),a,10));
         putpixel(50+320,getmaxy()-60,WHITE);
        outtextxy(50+360,getmaxy()-40,itoa((str_f+r*40*9),a,10));
         putpixel(50+360,getmaxy()-60,WHITE);
        outtextxy(50+400,getmaxy()-40,itoa((str_f+r*40*10),a,10));
         putpixel(50+400,getmaxy()-60,WHITE);

         outtextxy(460,20,"0");
         outtextxy(465,20,":<10%");
         outtextxy(460,40,"1");
         outtextxy(465,40,":10% - 20%");
         outtextxy(460,60,"2");
         outtextxy(465,60,":20% - 30%");
         outtextxy(460,80,"3");
         outtextxy(465,80,":30% - 40%");
         outtextxy(460,100,"4");
         outtextxy(465,100,":40% - 50%");
         outtextxy(460,120,"5");
         outtextxy(465,120,":50% - 60%");

         outtextxy(460,140,"6");
         outtextxy(465,140,":60% - 70%");
         outtextxy(460,160,"7");
         outtextxy(465,160,":70% - 80%");
         outtextxy(460,180,"8");
         outtextxy(465,180,":80% - 90%");
         outtextxy(460,200,"9");
         outtextxy(460,200,":90% - 100%");

for(i=0;i<100;i++)
  {
   perc=(darray1[0][i]/((float)user));
       x = 52 + i * 4 ;
       y = 20 ;
       plot_histo() ;
   perc=(darray1[1][i]/((float)user));
       y = 60  ;
       plot_histo() ;
   perc=(darray1[2][i]/((float)user));
       y = 100 ;
       plot_histo() ;
   perc=(darray1[3][i]/((float)user));
       y = 140 ;
       plot_histo() ;
   perc=(darray1[4][i]/((float)user));
       y = 180 ;
       plot_histo() ;
   perc=(darray1[5][i]/((float)user));
       y = 220  ;
       plot_histo() ;
   perc=(darray1[6][i]/((float)user));
       y = 260  ;
       plot_histo() ;
   perc=(darray1[7][i]/((float)user));
       y = 300 ;
       plot_histo() ;

       y = 0;
   }
```

```
intr(5, &reg);    /* dos command to dump the screen to */

            gettime(&t);
            fprintf(fp5," %2d:%02d:%02d.%02d\n",
            t.ti_hour, t.ti_min, t.ti_sec, t.ti_hund);


            for(m=0;m<100;m++)
             {
              fprintf(fp5,"%d %d %d %d %d %d %d %d \n",
              darray1[7][m],darray1[6][m],darray1[5][m],darray1[4][m],
              darray1[3][m],darray1[2][m],darray1[1][m],darray1[0][m]);
             }

                   time_end = time(NULL);
                   closegraph();
             }     /* End of outermost loop */

      fclose(fp3);
      fclose(fp1);
      fclose(fp4);
      difftime(time_end,time_str)) ;

      ibwrt(dvm1,"clrdsp\n\r",8L);
      ibwrt(dvm1,"conts\n\r",7L);
      ibloc(dvm1);


   return 0;


 }


plot_histo()
 {
   if(perc >= 0 && perc <0.1 && perc != 0)
       { putpixel(x,y,WHITE);
       outtextxy(x,y,"0");
       }
   else if(perc >=0.1 && perc <0.2 && perc != 0)
       { putpixel(x,y,WHITE);
       outtextxy(x,y,"1");
       }
   else if(perc >=0.2 && perc <0.3 && perc!= 0)
       { putpixel(x,y,WHITE);
       outtextxy(x,y,"2");
       }
   else if(perc >=0.3 && perc <0.4 && perc != 0)
       { putpixel(x,y,WHITE);
       outtextxy(x,y,"3");
       }
   else if(perc >=0.4 && perc <0.5 && perc != 0)
       { putpixel(x,y,WHITE);
       outtextxy(x,y,"4");
       }
   else if(perc >=0.5 && perc <0.6 && perc != 0)
       { putpixel(x,y,WHITE);
       outtextxy(x,y,"5");
       }
   else if(perc >=0.6 && perc <0.7 && perc != 0)
       { putpixel(x,y,WHITE);
       outtextxy(x,y,"6");
       }
   else if(perc >=0.7 && perc <0.8 && perc != 0)
       { putpixel(x,y,WHITE);
       outtextxy(x,y,"7");
      }
```

```
else if(perc >=0.8 && perc <0.9 && perc != 0)
     { putpixel(x,y,WHITE);
      outtextxy(x,y,"8");
      }
else if(perc >=0.9 && perc <=1.0 && perc != 0)
     { putpixel(x,y,WHITE);
    outtextxy(x,y,"9");
      }

return 0;
}
```

Appendix B

Code written in Matlab to analyse interference data

Program :- Int_anal.m

```
%Program "Int_anal.m"
%Program To analyse Interference data
%Format of the parameters to be entered into param.txt
%ppt,strf,stpf,Ref,L_HLI,L_MLI,diff,file
%ppt    =  points per trace
%strf   =  start frequency in MHz
%stpf   =  stop frequency in MHz
%Ref    =  Reference level in dB
%L_HLI  =  Lower power value of High level interference in dB
%L_MLI  =  Lower power value of Medium level interference in dB
%diff   =  power capacity of each power bin
%file   =  path specification of the interference data file

clear;             % Clear the contents of work space
close all;            % closes all the previously opened figures, if any
[points_per_trace,start_freq,stop_freq,maxl,hl,ml,dbc,file]=
                         textread('param.txt','%d %d %d %d %d %d %d %s');
file=char(file);
d=load(file);
traces=sum(d(1,:));
[ma,n]=size(d);
m=ma/points_per_trace;
fclose('all');
span=stop_freq-start_freq;
res=span/points_per_trace;
inter_freq_list=[0];
inter_hli=[0];
inter_mli=[0];
threshold=input('Enter the threshold level of occurence (in %age)       ');
disp('List of interfereing frequencies appearing for more
                              than the specified threshold level are  ');
 fig=1;
 hli_range=(n+1-(maxl-hl)/dbc):n;
 mli_range=min(hli_range)-((hl-ml)/dbc):min(hli_range)-1;

 for index=1:points_per_trace
    flag=1;
    flag1=1;
    for i=1:m
       for j=1:n
          x(i,j,index)=d(((100*(i-1))+index),j);
        end
    end

    b_hli=0;
    b_mli=0;

    b_hli=hli(x(:,:,index));
    b_mli=mli(x(:,:,index));

    if (b_hli==1)
       for ih=1:m
          for inh=min(hli_range):max(hli_range)
       inth(ih,(inh-min(hli_range)+1))=100*d(((100*(ih-1))+index),inh)/traces;
          end
       end
       inter_freq_list=[inter_freq_list index];
       flag=0;
```

```
inter_hli=[inter_hli index];
if(max(sum(inth'))>=threshold)
   figure(fig);
   set(fig,'Position',[5   338   587   612]);
   fig=fig+1;

   bar3((inth/traces)*100,0.3);
   axis([0 length(hli_range) 0 m+1 0 100]);
   eff_freq=round(start_freq+res*index+(res/2));
   tle=sprintf('Frequency = %d MHz (High level interference)',eff_freq);
   title(tle);
   hval=hl+dbc;
   lval=hval-dbc;
   for hrange=1:length(hli_range)
      txt=sprintf('%d to %d dBm',hval,lval);
      text(hrange,m+1,txt)
      lval=hval;
      hval=hval+dbc;
   end

   xlabel('Power Range ');
         ylabel('Time of the day');
   zlabel('Percentage occurence');
   disp(eff_freq);
   flag1=0;

  end
 end
 if(b_mli==1)
   for im=1:m
     for inm=min(mli_range):max(mli_range)
      intm(im,(inm-min(mli_range)+1))=100*d(((100*(im -1))+index),inm)/traces;
      end
   end
     if(flag)
       inter_freq_list=[inter_freq_list index];
     end
     inter_mli=[inter_mli index];
     if(max(sum(intm'))>=threshold)
     figure(fig);
     set(fig,'Position',[5   338   587   612]);
     fig=fig+1;
     bar3((intm/traces)*100,0.3);
     axis([0 length(mli_range) 0 m+1 0 100]);
     eff_freq=round(start_freq+res*index+(res/2));
     tle=sprintf('Frequency = %d MHz (Medium level interference)',eff_freq);
     title(tle);
     hval=ml+dbc;
     lval=hval-dbc;
     for mrange=1:length(mli_range)
       txt=sprintf('%d to %d dBm',hval,lval);
       text(mrange,m+1,txt);
       lval=hval;
       hval=hval+dbc;
     end
     xlabel('Power Range');
     ylabel('Time of the day');
     zlabel('Percentage occurence');
     if(flag1)
        disp(eff_freq);
     end
   end
end
```

```
end

fid=fopen('frequency.txt','A');
ne=length(inter_freq_list);
count(1:10)=0;

for in=2:ne
   index=inter_freq_list(in);
   for i=1:m
      for j=min(mli_range):max(hli_range)
         intma(i,(j+1-min(mli_range)))=d(((100*(i-1))+index),j)/traces*100;
      end
   end
   eff_freq=round(start_freq+res*index+(res/2));
   if(~check(eff_freq))
      fprintf(fid,'%d\n',eff_freq);
   end
   b=max(sum(intma'));
   if(b>0 & b<=10)
      count(1)=count(1)+1;
      end
   if(b>10 & b<=20)
      count(2)=count(2)+1;
   end
   if(b>20 & b<=30)
      count(3)=count(3)+1;
   end
   if(b>30 & b<=40)
      count(4)=count(4)+1;
   end
   if(b>40 & b<=50)
      count(5)=count(5)+1;
   end
   if(b>50 & b<=60)
      count(6)=count(6)+1;
   end
   if(b>60 & b<=70)
      count(7)=count(7)+1;
   end
   if(b>70 & b<=80)
      count(8)=count(8)+1;
   end
   if(b>80 & b<=90)
      count(9)=count(9)+1;
   end
   if(b>90)
      count(10)=count(10)+1;
   end
end

% Plot of total number of frequencies interfering vs percentage of
                                                            occurance


figure(fig);
set(fig,'Position',[5   338   587   612]);
text(0.3,0.5, 'No Interference');
xax=5:10:95;

if(nem > 1 | neh>1)

bar(xax,count,0.3);
   axis([0 100 0 max(count+1)]);
```

```
title('Plot of no. of interfereing frequencies vs
                                     percentage of time of occurence');

xlabel('Duration of occurence in percentage');
ylabel('Number of frequencies');
gtext('Total time duration of observation is 4 Hours ');
fig=fig+1;
end

fclose(fid);

b=load('frequency.txt');     %copy the contents of file frequency.txt
                               into the variable b.
fid1=fopen('frequency.txt','w');
b=del(b);                    % Remove the duplicate values and
                               sort it in ascending order
 if(length(b)>0)
    for i=1:length(b)
       fprintf(fid1,'%d \n',b(i));
    end
    fclose(fid1);
 end

 if(length(inter_hli))
    disp('The Higher level interfereing frequencies are');
    for i=2:length(inter_hli)
       eff_freq=round(start_freq+res*inter_hli(i)+(res/2));
       disp(sprintf('     %d MHz',eff_freq));
    end
 end

 if(length(inter_mli))
    disp('The Medium level interfereing frequencies are');
    for i=2:length(inter_mli)
       eff_freq=round(start_freq+res*inter_mli(i)+(res/2));
       disp(sprintf('     %d MHz',eff_freq));
    end
 end


 % end of the program
```

Appendix C
Code written in Matlab to analyse interference data
Program 2 :- Int ana2.m

```
% PROGRAM TO PLOT THE FREQUENCY SPECTRA OF
% INTERFERENCE MONITORING AT GAURIBIDANOOR
% THIS USES 64 HOURS OF DATA ACQUIRED.
% 16Hrs OF DURATION IS DEDICATED TO EACH
% DIRECTION (North,East,South and West)
%
% This Program is to plot spectra for E polarization in all 4 directions
clear;

d1=load ('d:\Project_RAM\gauri_data\15151519.res');
d2=load ('d:\Project_RAM\gauri_data\15191523.res');
d3=load ('d:\Project_RAM\gauri_data\15231603.res');
d4=load ('d:\Project_RAM\gauri_data\16041608.res');


f1=freq_resp(d1,400,800);
f2=freq_resp(d2,700,1100);
f3=freq_resp(d3,1000,1400);
f4=freq_resp(d4,1300,1700);
fa=[];

fa=f1(1:75,:);
fa=[fa ;0.5*(f1(76:100,:)+f2(1:25,:))];
fa=[fa ;f2(26:75,:)];
fa=[fa ;0.5*(f2(76:100,:)+f3(1:25,:))];
fa=[fa ;f3(26:75,:)];
fa=[fa ;0.5*(f3(76:100,:)+f4(1:25,:))];
fa=[fa ;f4(26:100,:)];

subplot(2,2,3);
multiline(fa,400,1700);
view(67,62);
title(' WEST ');
ylabel('Frequency (MHz)');
zlabel('P(avg) dBm (w/m2)');
grid on;

d1=load ('d:\Project_RAM\gauri_data\18151819.res');
d2=load ('d:\Project_RAM\gauri_data\18191823.res');
d3=load ('d:\Project_RAM\gauri_data\18231903.res');
d4=load ('d:\Project_RAM\gauri_data\19041908.res');


f1=freq_resp(d1,400,800);
f2=freq_resp(d2,700,1100);
f3=freq_resp(d3,1000,1400);
f4=freq_resp(d4,1300,1700);
fb=[];

fb=f1(1:75,:);
fb=[fb ;0.5*(f1(76:100,:)+f2(1:25,:))];
fb=[fb ;f2(26:75,:)];
fb=[fb ;0.5*(f2(76:100,:)+f3(1:25,:))];
fb=[fb ;f3(26:75,:)];
fb=[fb ;0.5*(f3(76:100,:)+f4(1:25,:))];
fb=[fb ;f4(26:100,:)];

subplot(2,2,1);
```

```
multiline(fb,400,1700);
view(67,62);
title(' NORTH ');
ylabel('Frequency (MHz)');
zlabel('P(avg) dBm (w/m2)');
grid on;

d1=load ('d:\Project_RAM\gauri_data\19151919.res');
d2=load ('d:\Project_RAM\gauri_data\19191923.res');
d3=load ('d:\Project_RAM\gauri_data\19232003.res');
d4=load ('d:\Project_RAM\gauri_data\20042008.res');


f1=freq_resp(d1,400,800);
f2=freq_resp(d2,700,1100);
f3=freq_resp(d3,1000,1400);
f4=freq_resp(d4,1300,1700);
fc=[];

fc=f1(1:75,:);
fc=[fc ;0.5*(f1(76:100,:)+f2(1:25,:))];
fc=[fc ;f2(26:75,:)];
fc=[fc ;0.5*(f2(76:100,:)+f3(1:25,:))];
fc=[fc ;f3(26:75,:)];
fc=[fc ;0.5*(f3(76:100,:)+f4(1:25,:))];
fc=[fc ;f4(26:100,:)];

subplot(2,2,2);
multiline(fc,400,1700);
view(67,62);
title(' EAST ');
ylabel('Frequency (MHz)');
zlabel('P(avg) dBm (w/m2)');
grid on;

d2=load ('d:\Project_RAM\gauri_data\14191423.res');
d3=load ('d:\Project_RAM\gauri_data\14231503.res');
d4=load ('d:\Project_RAM\gauri_data\15041508.res');


f2=freq_resp(d2,700,1100);
f3=freq_resp(d3,1000,1400);
f4=freq_resp(d4,1300,1700);
fd=[];

fd=f2(1:75,:);
fd=[fd ;0.5*(f2(76:100,:)+f3(1:25,:))];
fd=[fd ;f3(26:75,:)];
fd=[fd ;0.5*(f3(76:100,:)+f4(1:25,:))];
fd=[fd ;f4(26:100,:)];

subplot(2,2,4);
multiline(fd,700,1700);
view(67,62);
title(' SOUTH ');
ylabel('Frequency (MHz)');
zlabel('P(avg) dBm (w/m2)');
grid on;
```

```
% PROGRAM TO PLOT THE FREQUENCY RESPONSE OF
% INTERFERENCE MONITORING AT GAURIBIDANOOR
% THIS USES 64 HOURS OF DATA ACQUIRED.
% 16Hrs OF DURATION IS DEDICATED TO EACH
% DIRECTION (North,East,South and West)
%
% This Program is to plot spectra for H polarization in all 4 directions

clear;

%Plot of the spectra in south direction
d1=load ('d:\Project_RAM\gauri_data\20152019.res');
d2=load ('d:\Project_RAM\gauri_data\20192023.res');
d3=load ('d:\Project_RAM\gauri_data\20232103.res');
d4=load ('d:\Project_RAM\gauri_data\21042108.res');


f1=freq_resp(d1,400,800);
f2=freq_resp(d2,700,1100);
f3=freq_resp(d3,1000,1400);
f4=freq_resp(d4,1300,1700);
f=[];

f=f1(1:75,:);
f=[f ;0.5*(f1(76:100,:)+f2(1:25,:))];
f=[f ;f2(26:75,:)];
f=[f ;0.5*(f2(76:100,:)+f3(1:25,:))];
f=[f ;f3(26:75,:)];
f=[f ;0.5*(f3(76:100,:)+f4(1:25,:))];
f=[f ;f4(26:100,:)];

subplot(2,2,4);
multiline(f,400,1700);
view(67,62);
title(' SOUTH ');
ylabel('Frequency (MHz)');
zlabel('P(avg) dBm (w/m2)');
grid on;

%plot of the spectra in west direction

d1=load ('d:\Project_RAM\gauri_data\21152119.res');
d2=load ('d:\Project_RAM\gauri_data\21192123.res');
d3=load ('d:\Project_RAM\gauri_data\21232203.res');
d4=load ('d:\Project_RAM\gauri_data\22042208.res');


f1=freq_resp(d1,400,800);
f2=freq_resp(d2,700,1100);
f3=freq_resp(d3,1000,1400);
f4=freq_resp(d4,1300,1700);
f=[];

f=f1(1:75,:);
f=[f ;0.5*(f1(76:100,:)+f2(1:25,:))];
f=[f ;f2(26:75,:)];
f=[f ;0.5*(f2(76:100,:)+f3(1:25,:))];
f=[f ;f3(26:75,:)];
f=[f ;0.5*(f3(76:100,:)+f4(1:25,:))];
f=[f ;f4(26:100,:)];

subplot(2,2,3);
multiline(f,400,1700);
```

```
view(67,62);
title(' WEST ');
ylabel('Frequency (MHz)');
zlabel('P(avg) dBm (w/m2)');
grid on;

% Plot of the spectra in north direction

d1=load ('d:\Project_RAM\gauri_data\22182221.res');
d2=load ('d:\Project_RAM\gauri_data\22212300.res');
d3=load ('d:\Project_RAM\gauri_data\23012304.res');
d4=load ('d:\Project_RAM\gauri_data\23042307.res');

f1=freq_resp(d1,400,800);
f2=freq_resp(d2,700,1100);
f3=freq_resp(d3,1000,1400);
f4=freq_resp(d4,1300,1700);
f=[];

f=f1(1:75,:);
f=[f ;0.5*(f1(76:100,:)+f2(1:25,:))];
f=[f ;f2(26:75,:)];
f=[f ;0.5*(f2(76:100,:)+f3(1:25,:))];
f=[f ;f3(26:75,:)];
f=[f ;0.5*(f3(76:100,:)+f4(1:25,:))];
f=[f ;f4(26:100,:)];

subplot(2,2,1);
multiline(f,400,1700);
view(67,62);
title(' NORTH ');
ylabel('Frequency (MHz)');
zlabel('P(avg) dBm (w/m2)');
grid on;

%plot of the spectra in east direction

d1=load ('d:\Project_RAM\gauri_data\03150319.res');
d2=load ('d:\Project_RAM\gauri_data\03190323.res');
d3=load ('d:\Project_RAM\gauri_data\03230403.res');
d4=load ('d:\Project_RAM\gauri_data\04040408.res');

f1=freq_resp(d1,400,800);
f2=freq_resp(d2,700,1100);
f3=freq_resp(d3,1000,1400);
f4=freq_resp(d4,1300,1700);
f=[];
f=f1(1:75,:);
f=[f ;0.5*(f1(76:100,:)+f2(1:25,:))];
f=[f ;f2(26:75,:)];
f=[f ;0.5*(f2(76:100,:)+f3(1:25,:))];
f=[f ;f3(26:75,:)];
f=[f ;0.5*(f3(76:100,:)+f4(1:25,:))];
f=[f ;f4(26:100,:)];

subplot(2,2,2);
multiline(f,400,1700);
view(67,62);
title(' EAST ');
ylabel('Frequency (MHz)');
zlabel('P(avg) dBm (w/m2)');
grid on;
```