SPECTRUM OCCUPANCY ANALYSIS

AND

FUZZY LOGIC SYSTEM

FOR

COGNITIVE RADIO

Submitted in partial fulfillment of the Degree of

Bachelor of Technology

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under the Supervision of

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by

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WAKNAGHAT

Certificate

This is to certify that project report entitled "Spectrum Occupancy Analysis and Fuzzy Logic System for Cognitive Radio", submitted by Abhinav Manik, Kashish Garg and Parthu Balina in partial fulfillment for the award of degree of Bachelor of Technology in Electronics and Communication Engineering to Jaypee University of Information Technology, Waknaghat, Solan, has been carried out under my supervision.

This work has not been submitted partially or fully to any other University or Institute for the award of this or any other degree or diploma.

Date: **Prof. Dr. Ghanshyam Singh**

Professor, Deptt. of ECE

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We would like to express our deep gratitude to our guide Prof. Dr. Ghanshyam Singh for his valuable guidance and his patience with us throughout the course of this project. We would also like to acknowledge the priceless guidance provided to us by Mr. Salman Raju Talluri (Asst. Prof Deptt. of ECE), Mr. S.V.R.K. Rao (Asst. Prof. Deptt. of ECE) and Mr. Abhishek Khandwal (Deptt. of Physics and Material Sciences). Last but not the least we would like to appreciate the amiability of lab engineers Mr. Pramod Kumar, Mr. Mohan, Mr. Kamlesh and Mr. Ajay.

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SUMMARY

In the first part of the project we studied the spectrum usage pattern in Waknaghat in the frequency bands ranging from 80 MHz to 500 MHz. The occupancy is quantified as the amount of spectrum detected above a certain received power threshold. The outcome of this study suggests that we may employ emerging spectrum sharing technology such as the cognitive radio technology for future wireless services.

In the second part we have used a Fuzzy Logic System to arrive at a decision whether to transfer spectrum to a Secondary User i.e. Cognitive Radio User. There are four parameters that we have used here. The Received Signal Strength, Distance between Primary User (i.e. the Licensee) and the Secondary User, Transmission Power required by Secondary User and the Velocity of Secondary User with respect to Primary User.

List of Figures

List of Symbols and Acronyms

γ_s	SNR at Secondary User
l	Length of the element of Antenna
c	Speed of Light in Vacuum
σ	Noise Power

SNR : Signal to Noise Ratio

RF : Radio Frequency

IEEE : Institute of Electrical and Electronics Engineers

CR : Cognitive Radio

VHF : Very High Frequency

UHF : Ultra High Frequency

DSA : Dynamic Spectrum Allocation

FCA : Fixed Channel Allocation

TVWS : Television White Spaces

QoS : Quality of Service

PU : Primary/Licensed User

SU : Secondary User

MF : Membership Function

FCC : Federal Communications Commission

Chapter-1

Introduction

1.1 Overview of the Project

This project deals with the topic of Spectrum Occupancy Analysis, which is a good way to estimate the usage pattern of RF Spectrum at a place or in a region. This serves two purposes.

(a) Drive home the futility of traditional Fixed Channel Allocation in the 21st Century,

(b) Identification of bands that are underutilized which can then be used to meet the demand for spectrum by today's highly networked world.

The second part of the project deals with the process of Spectrum Decision, which is a vital ability of the Cognitive Radio. The white spaces that we found in the first part are to be used by Cognitive Radios, which according to IEEE 802.22 working group will play a significant role in these bands. Therefore we propose a more inclusive decision-making process by the use of Fuzzy Logic, which recognizes "the shades of gray".

1.2 Project description

1.2.1 Purpose

Our objective was to find how the scarce radio spectrum allocated to different services is utilized around the JUIT, Waknaghat campus and identify the bands that could be accessed for future opportunistic use due to their low or no active utilization. Additionally, we wanted to understand how Cognitive Radios (CR) can be made more inclusive by use of a Fuzzy Logic based model.

1.2.2 Scope

This Spectrum Survey is preliminary in nature and of a very small range. We had to limit our project to a very small range because of the unavailability of better equipment. Future studies need to be performed for higher ranges (VHF and UHF bands) to determine potential for secondary users on those channels that have low or no active utilization.

Waknaghat being a rural area; students, staff and faculty may use TV white spaces for a "Super-WiFi" network, i.e. a high speed Wireless Regional Area Network (WRAN). The data rates will be a lot higher as promised by IEEE 802.22. TV white spaces may be exploited by the use of Cognitive Radio, which seems to be a very promising prospect. One can work in the area of spectrum sensing, sharing, decision, mobility, etc. for enabling dynamic spectrum access (DSA).

Exploration along these lines, may one day give people in the rural areas better access to the internet and the possibilities once that happens are simply unlimited.

The Fuzzy Logic based model is also something on which a great deal of research is being conducted by researchers around the world. Due to the potential of the Cognitive Radios to have a huge impact on our day-to-day lives, and the importance of Spectrum Decision in its operations; new parameters such as Interference Temperature that seem to have been abandoned by the FCC due to its difficulty can be used to arrive at a more accurate decision. The field of Cognitive Radio itself is undergoing a great deal of change.

Chapter-2

RF Spectrum

2.1 What is RF Spectrum?

Radio frequency (RF) is a rate of oscillation in the range of around 3 kHz to 300 GHz, which corresponds to the frequency of radio waves, and the alternating currents, which carry radio signals.

Radio Spectrum refers to the part of the electromagnetic spectrum corresponding to RF i.e. frequencies smaller than 300 GHz.

2.2 Fixed Channel Allocation

2.2.1 Overview

Fixed Channel Allocation (FCA) systems allocate specific channels to specific cells. This allocation is static and cannot be changed. For efficient operation, FCA systems typically allocate channels in a manner that maximizes frequency reuse. Also different frequencies have been allotted to use for various purposes as decided by a country's government. These frequencies are exclusively for the use specified by the govt. For eg. The FM Band around 80 MHz to 110 MHz is used for FM Radio ONLY. Other users cannot transmit or receive on these channels, even if this band is lying vacant.

2.2.2 Disadvantages of FCA

1) In this age when there is a heavy demand for spectrum, FCA's scheme of Command and Control is out of place.

2) Vast areas of space and for long periods of time are fixed for usage for specific purposes, which in the age of fast technological changes do not cater to new requirements.

3) Even if the bands are lying unoccupied, nobody else can use these. For eg. There isn’t much of a scope for Maritime Radio in the middle of a desert.

The need therefore is for a more dynamic and need based flexible scheme of allocation.

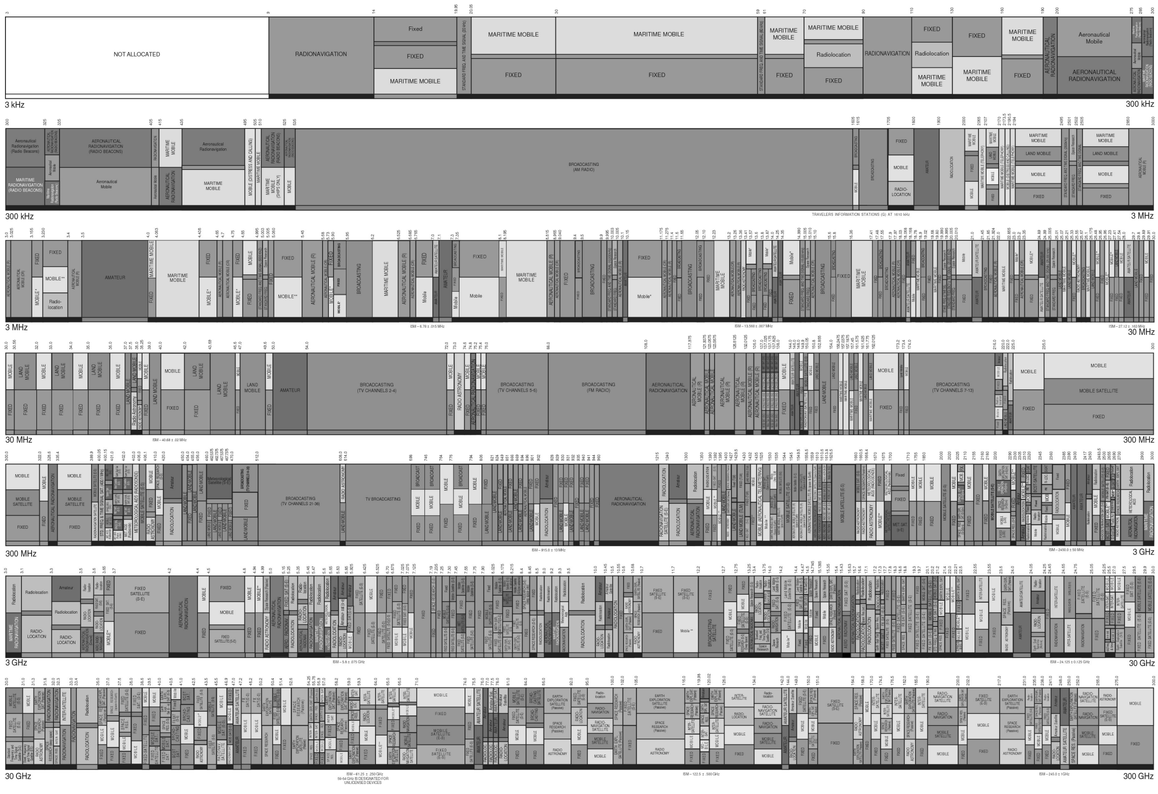

Fig.1. FCC Frequency Allocation Chart for USA

2.3 What are White Spaces?

The term 'White Space' refers to portions of licensed radio spectrum that licensees do not use all of the time or in all geographical locations. TV White Spaces (TVWS) are vacant frequencies made available for unlicensed use at locations where spectrum is not being used by licensed services, such as television broadcasting. This spectrum is located in the VHF (54-216 MHz) and UHF (470-698 MHz) bands and has characteristics that make it highly desirable for wireless communications.

2.4 Origin of TVWS

In the past decade there has been a tremendous push in particular for the switchover from analog to digital television. This frees up large areas of spectrum between about 50 MHz and 700 MHz. This is because digital transmissions can be packed into adjacent channels, while analog ones cannot. This means that the band can be "compressed" into fewer channels, while still allowing for more transmissions. In India this process is expected to be finished by 2014.

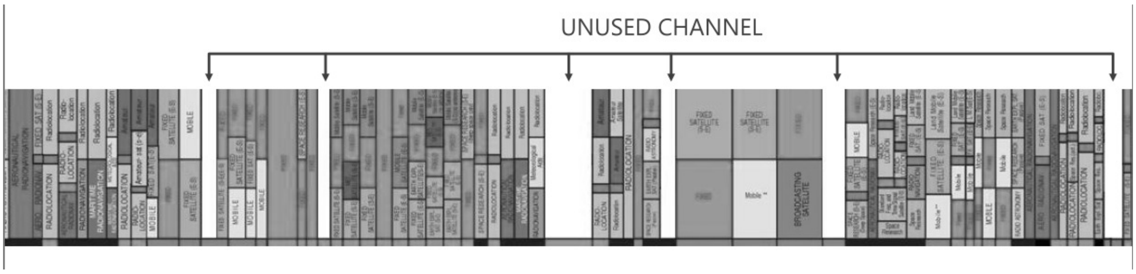

Fig.2. Unused Channels

2.5 IEEE 802.22

IEEE 802.22 is a Long Range WiFi accessible in the radius of 17-33 km and extendable to 100km. Conventional Wi-Fi is relatively weak when it comes to workingin typical physical settings – bumping up against concrete obstructions and many types of walls. Waves in this range however, have high penetrability and can travel greater distances.

2.6 Applications for TVWS

Rural broadband/backhaul, Wide-coverage hotspots, Bridge among small networks, Cellular Offloading, Sensor Network, Wireless Surveillance system, Smart Grid Monitoring, etc.

Sensor network

Chapter-3

Cognitive Radio and Fuzzy Logic

3.1 What is a Cognitive Radio?

Cognitive radio (CR) is a form of wireless communication in which a transceiver can intelligently detect which communication channels are in use and which are not, and instantly move into vacant channels while avoiding occupied ones. This optimizes the use of available radio-frequency (RF) spectrum while minimizing interference to other users.

Possible functions of cognitive radio include the ability of a transceiver to determine its geographic location, identify and authorize its user, encrypt or decrypt signals, sense neighboring wireless devices in operation, and adjust output power and modulation characteristics.

3.2 Cognitive Capability

The Cognitive Capability of CR has four vital functions

(a) Spectrum Sensing : The ability of CR to "sense" the occupancy of the RF environment around it and detect White Spaces/ Spectrum Holes.
(b) Spectrum Decision : The ability of CR to detect the spectrum that best fulfills its requirements of Power Control, QoS requirements, etc.
(c) Spectrum Sharing : Ability of CR to share a Licensee's channel with other users.
(d) Spectrum Mobility : Ability of CR to vacate a band when required by PU and shift to a different band.

3.3 Introduction to Fuzzy Logic

Fuzzy Logic is a form of many-valued logic that deals with approximate-ness rather than exact-ness. Lotfi A. Zadeh introduced Fuzzy Logic in 1965. Fuzzy logic is a superset of conventional (Boolean) logic that has been extended to handle the concept of partial truth -- truth values between "completely true" and "completely false".

3.4 Membership Function

A *membership function* (MF) is a curve that defines how each point in the input space is mapped to a membership value (or degree of membership) between 0 and 1. The input space is sometimes referred to as the *universe of discourse.*

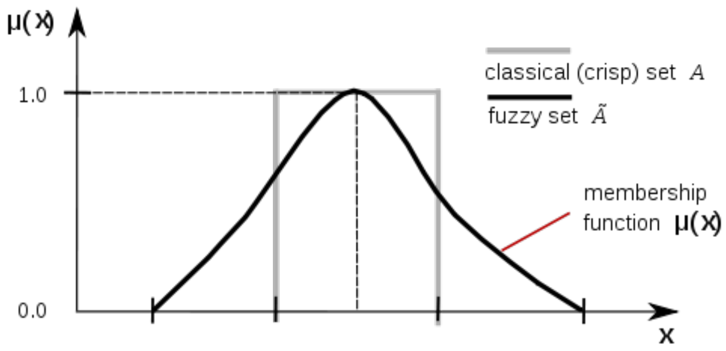

Fig.3. Example of a Membership Function

Membership functions are classified on the basis of shapes as Triangular, Trapezoidal, Gaussian, Sigmoid, etc.

3.5 Fuzzy Inference Process

There are five parts of the fuzzy inference process Fuzzification of the input variables, application of the fuzzy operator (AND or OR) in the antecedent, implication from the antecedent to the consequent, aggregation of the consequents across the rules, and Defuzzfication.

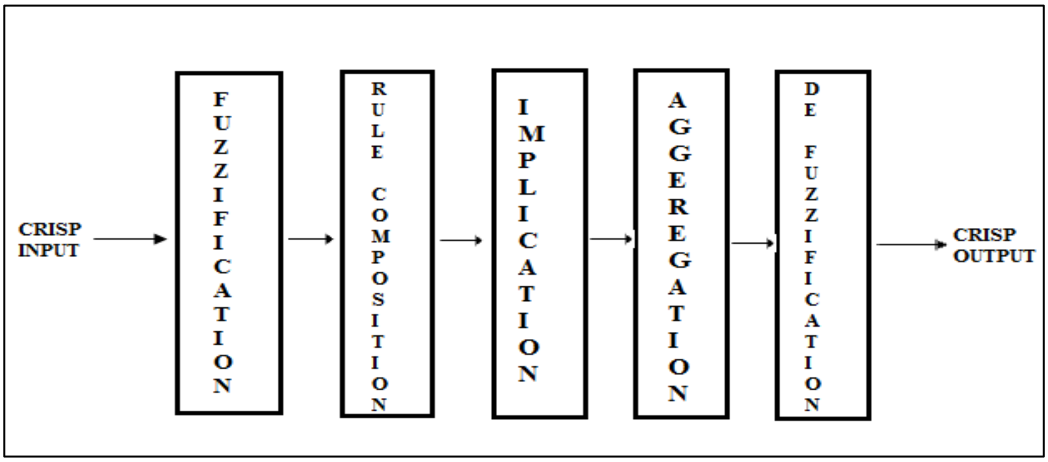

Fig.4. Fuzzy Logic Inference Process Block Diagram

Step 1 : Fuzzification : The first step is to take the inputs and determine the degree to which they belong to each of the appropriate fuzzy sets via membership functions.

Step 2 : Apply Fuzzy operator : Rule Composition : If the antecedent of a given rule has more than one part, the fuzzy operator is applied to obtain one number that represents the result of the antecedent for that rule. The input to the fuzzy operator is two or more membership values from fuzzified input variables. The output is a single truth-value.

Step 3 : Implication : Before applying the implication method, we must take care of the rule's weight. Every rule has a weight (a number between 0 and 1), which is applied to the number given by the antecedent.

Once proper weighting has been assigned to each rule, the implication method is implemented. A consequent is a fuzzy set represented by a membership function, which weights appropriately the linguistic characteristics that are attributed to it. The consequent is reshaped using a function associated with the antecedent (a single number). Implication is implemented for each rule.

Step 4 : Aggregation : The input of the aggregation process is the list of truncated output functions returned by the implication process for each rule. The output of the aggregation process is one fuzzy set for each output variable.

Step 5 : Defuzzification : The input for the Defuzzification process is a fuzzy set (the aggregate output fuzzy set) and the output is a single number. Output for each variable is generally a single number. However, the aggregate of a fuzzy set encompasses a range of output values and so must be defuzzified in order to resolve a single output value form the set.

3.6 Fuzzy Implication :

The process of shaping of the consequent variable based upon antecedent is called implication. There are many fuzzy implications**.** We have used Mamdani Implication.

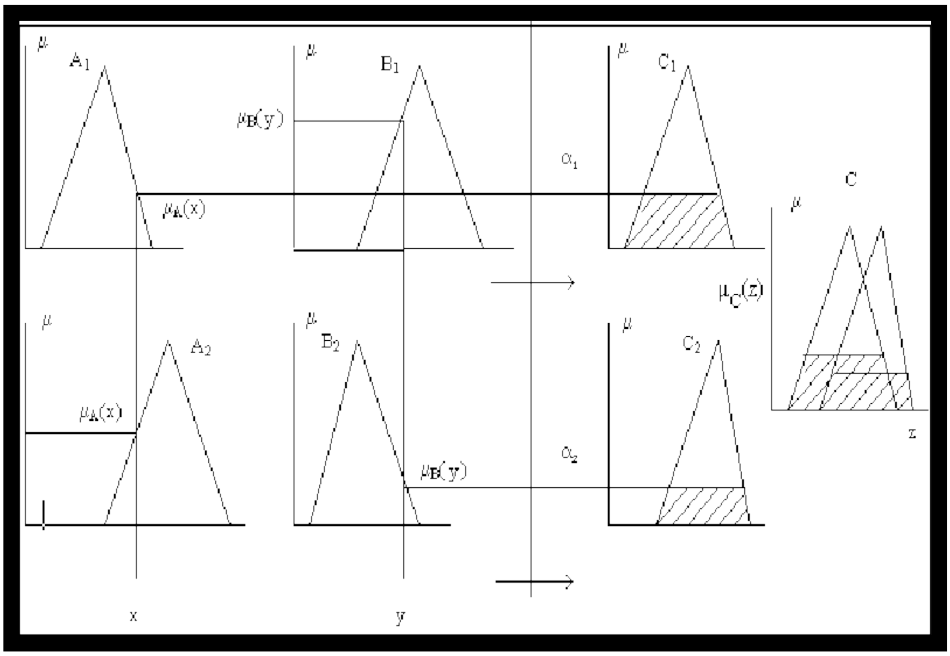

Fig.5. Mamdani Implication Process Diagram

Chapter-4

Work Description

4.1 Spectrum Occupancy Analysis

4.1.1 Apparatus Used

The measurements have been taken on the roof-top (3rd floor) of the Academic Block of the University. The equipment used for the measurement in this study consists of a Yagi-Uda five-element folded dipole antenna with reflector made by Scientech Technologies. The antenna has a frequency range of upto 800 MHz. The antenna is connected by a low loss cable to spectrum analyzer of model SA3005 manufactured by Aplab. For calibrating the scale on this spectrum analyzer we used a TDS 2002 signal generator made by Tektronix. MATrix LABoratory (R2010b) was used to plot all graphs.

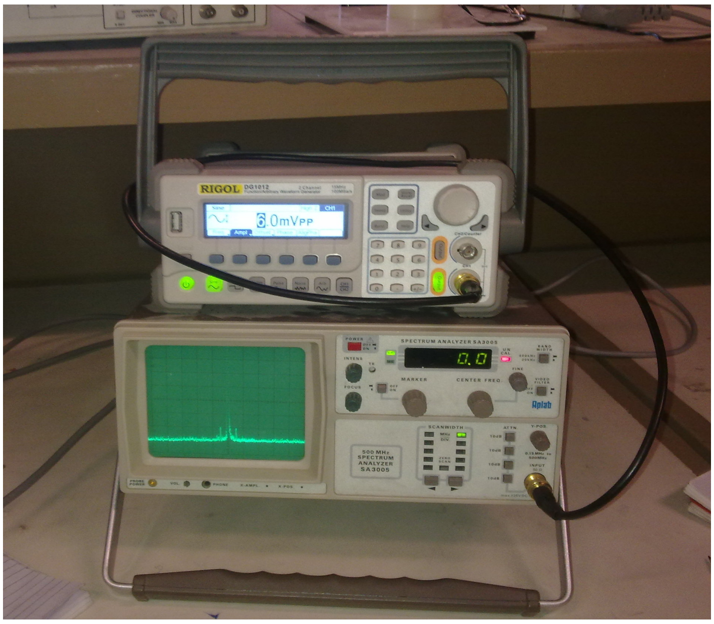

Fig. 6. The setup used to calibrate the scale of the Spectrum Analyzer

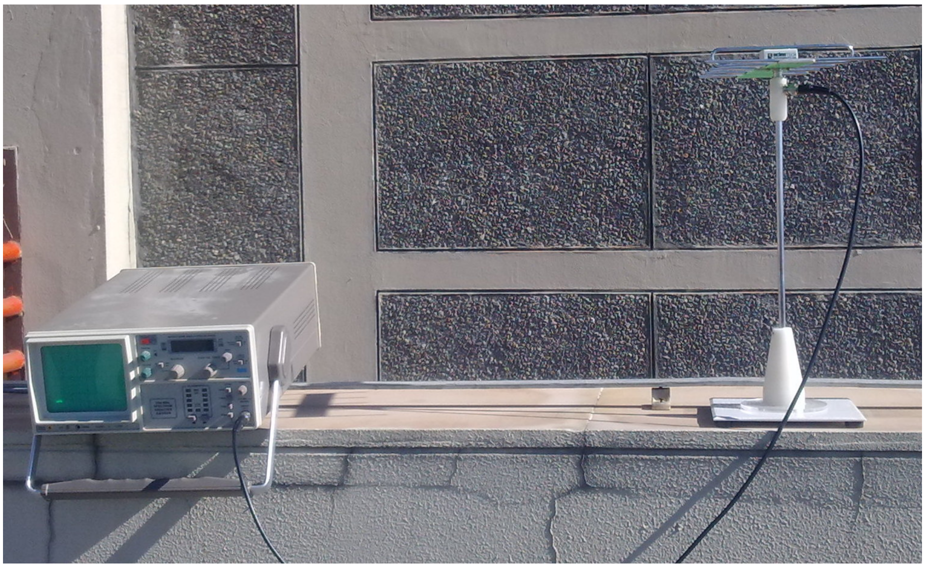

Fig. 7 The Setup used in the Survey.

4.1.2 Methodology

The spectrum survey is performed over 3 weekday periods across a frequency range of 80 MHz to 500 MHz. To get the omnidirectional effect, the antenna is rotated manually each day by 120^{o}. The overall frequency range is divided into several bands each having a frequency span of 50 MHz. Each 50 MHz frequency band has 20 frequency points, i.e. the separation between two consecutive frequency points is 2.5 MHz. For each frequency point, the raw data represent the received signal power level measured at the spectrum analyzer for that frequency. For each 50 MHz frequency band, the measurement is carried out around every 60 minutes. Therefore, for each frequency point, we have received data samples from 6- hour measurement and a total of $6\times 3 = 18$ samples for the whole three day observation period. A total of 3024 readings in all.

The range of the Yagi-Uda antenna was measured by measuring the length of the driven element, which comes out to be 16.5 cm. This was then equated to 0.44λ .

The equations used for this purpose are listed below

$$l = 0.44\lambda$$

$$\lambda = c*f$$

Solving these two equations gives frequency as 800 MHz.

The spectrum analyzer available at the university does not have markings of Power in dB, therefore we had to firstly calibrate these. This was done with the help of a signal generator. A signal of known voltage is generated and its power is calculated on the spectrum analyzer by taking into account the fact that, internal resistance of cable that we have used is 50 **Ω.** Power is calculated by using the equation

$$P= V^2 /R$$

A table containing our observations is provided in Appendix A.

Once the scale had been calibrated, we move to the core part of the work, i.e. to conduct the survey. We conducted the survey on the 3rd floor of the university for 6 hours everyday for four days.

Readings were taken at taken on an hourly basis from 1100 h to 1600 h. During this period the entire band from 80 MHz to 500 MHz was covered. Since the equipment used was very old, all readings had to be noted manually. Power level noted at a particular frequency point, was matched to Table 1. Power levels lesser in value than -35 dBm are considered as noise. The average power level for each frequency point was compiled at the end of each day.

At the start of a new day, the antenna was rotated 120° over the previous day. This was done to get an omnidirectional effect. Thereafter the procedure of the previous day was repeated.

On the fourth day we specifically analyzed three bands.

1) The band allocated for FM radio transmission (85 MHz – 115 MHz). Frequency points were taken with a spacing of 100 KHz.
2) The band from (174 MHz – 230 MHz). Frequency points were taken with a spacing of 500 KHz.
3) The band from (470 MHz – 486 MHz). Frequency points were taken with a spacing of 100 KHz.

Average duty cycle of a band was calculated thereafter. The word duty cycle here, represents the time for which a certain frequency is occupied. For example if the power level at a certain frequency point is greater than -30 dBm at 1100h, 1200h and at 1400h, and it is below -35 dBm for the rest of the day, then its average duty cycle/ occupancy is 50%.

Finally the following graphs were plotted: -

1) Frequency versus time versus power of a band.
2) Frequency versus average occupancy of a band.

These led us to identifying certain frequencies where there is low / absolutely no received power, i.e. White Spaces.

4.2 Parameters Used for Spectrum Decision

We have used four factors to arrive at the Spectrum Decision. Corresponding membership functions have been shown.

4.2.1 Received Power Factor

The first factor that we have considered is the power received/ sensed by SU over the channel. In our case based upon our experiments we have taken -50 dBm to -35 dBm as LOW and -10dBm to 15 dBm as HIGH.

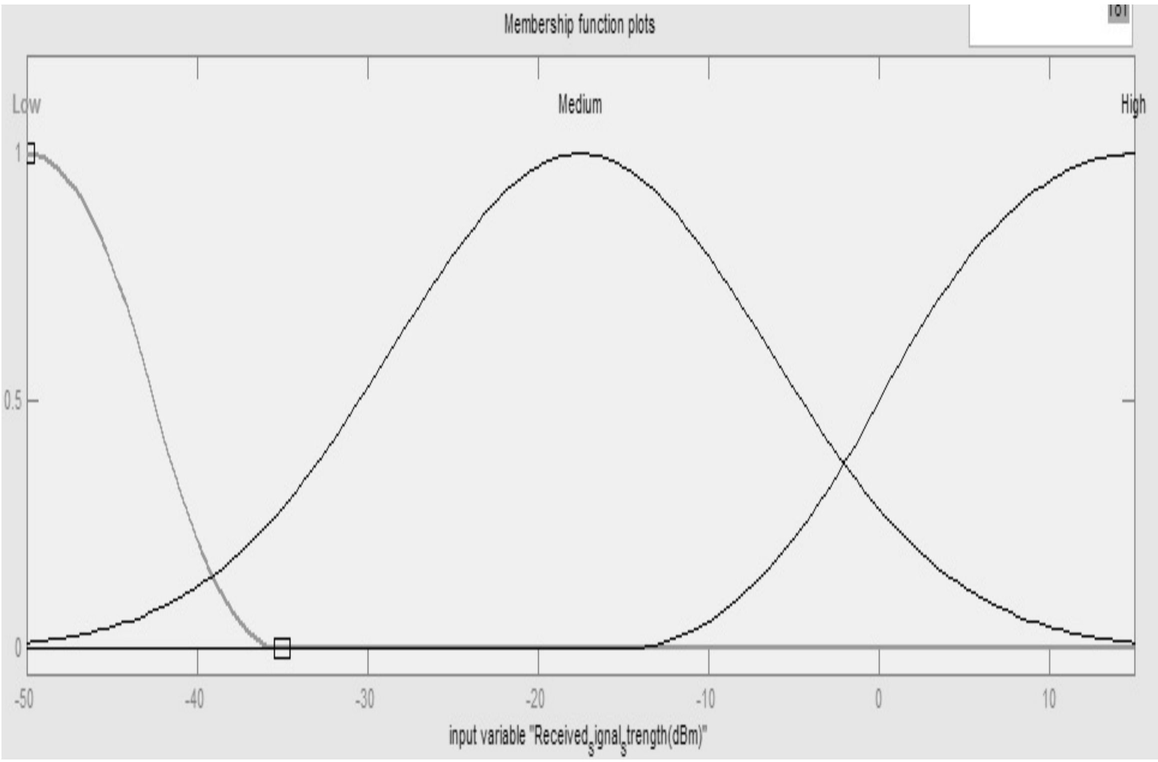

Fig.8. Membership Function of Received Power

4.2.2 Velocity Factor

The second factor is the velocity of SU wrt PU. In the bibliography that we studied, it has been observed that bit error probabilities increase as a function of velocity. Therefore we have taken 0 kmph to 15 kmph as LOW and 50 kmph to 100 kmph as HIGH.

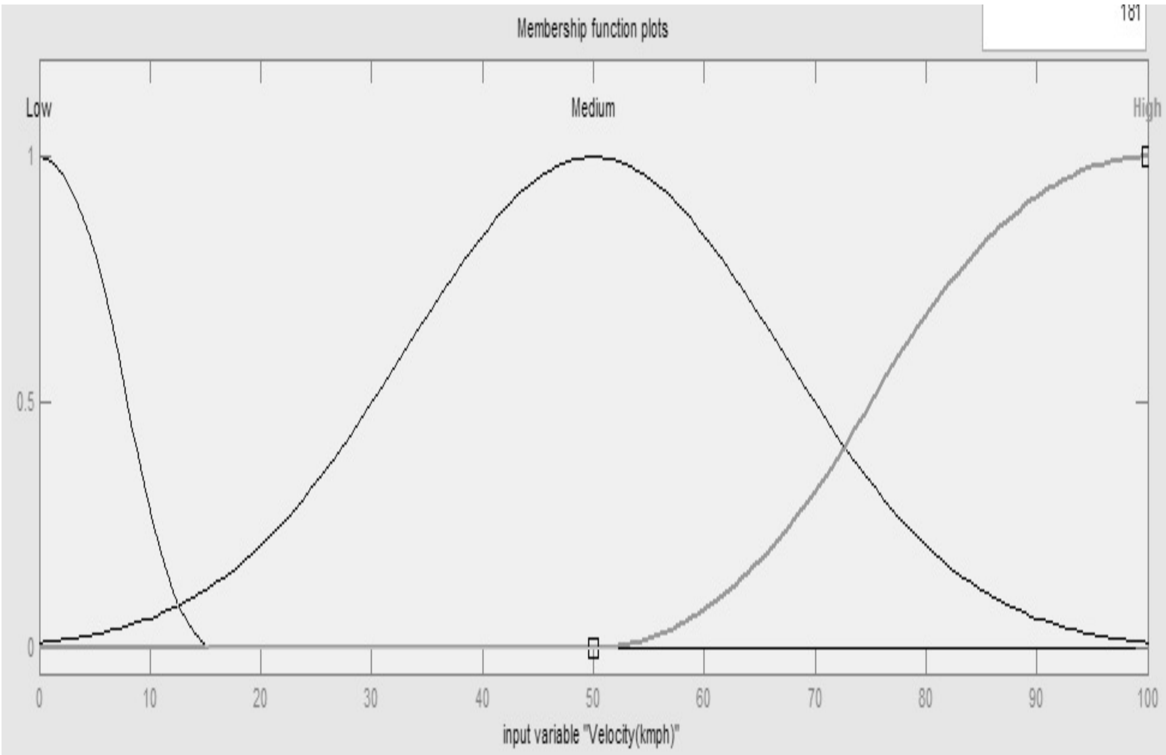

Fig.9. Membership Function of Velocity (kmph)

4.2.3 Transmission Power Factor

The third factor is the transmission power required by SU to transmit over the channel. This depends on factors such as Interference temperature, Distance between SU and PU, etc. In our case we have taken 0 dBm to 15 dBm as LOW and 30 to 50 dBm as HIGH.

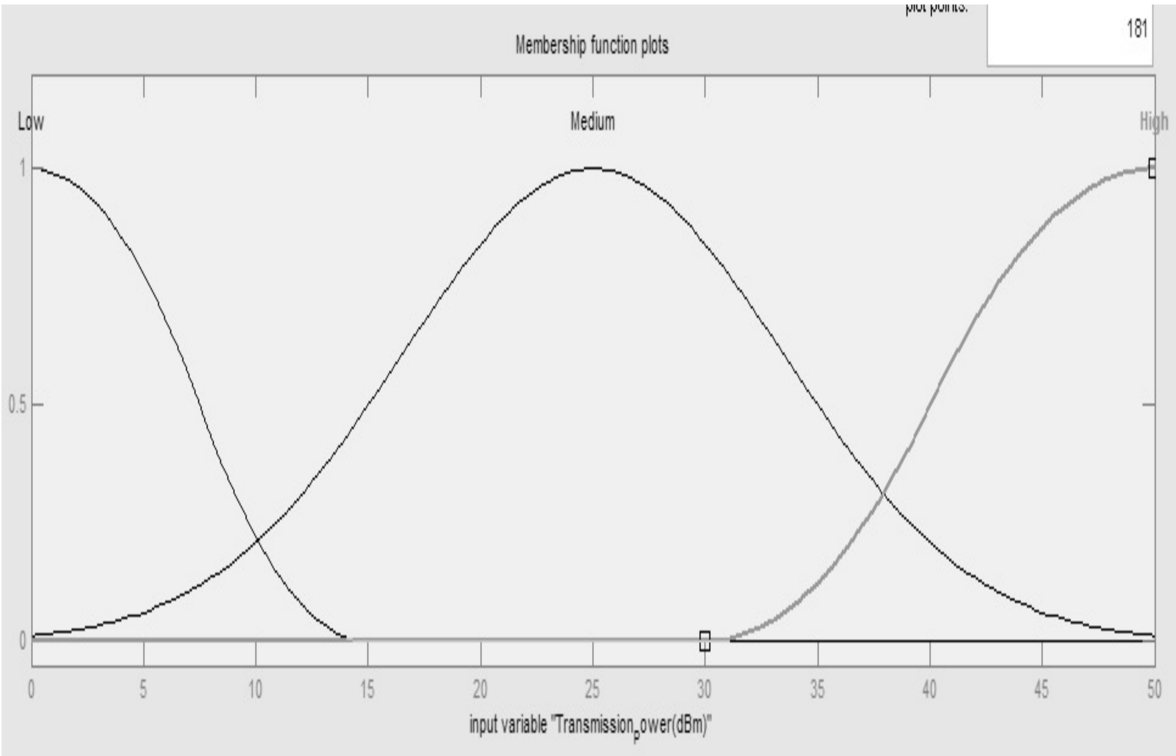

Fig.10. Membership Function of Transmission Power

4.2.4 Distance Factor

The last factor Distance of the SU is another important factor because SU at a closer distance should be given priority to access spectrum, which depends upon the SNR, γ_s, at the secondary user given by,

$$\gamma_s = 10 \log \left(\frac{P_1 g(R)}{\sigma^2}\right)$$

where P_1 is the transmit power user, σ is the noise power and R is the distance between the PU and the SU which can be calculated from the given formula. In our case we have taken distances upto 1 kilometer as LOW and from 5 to 10 km as HIGH.

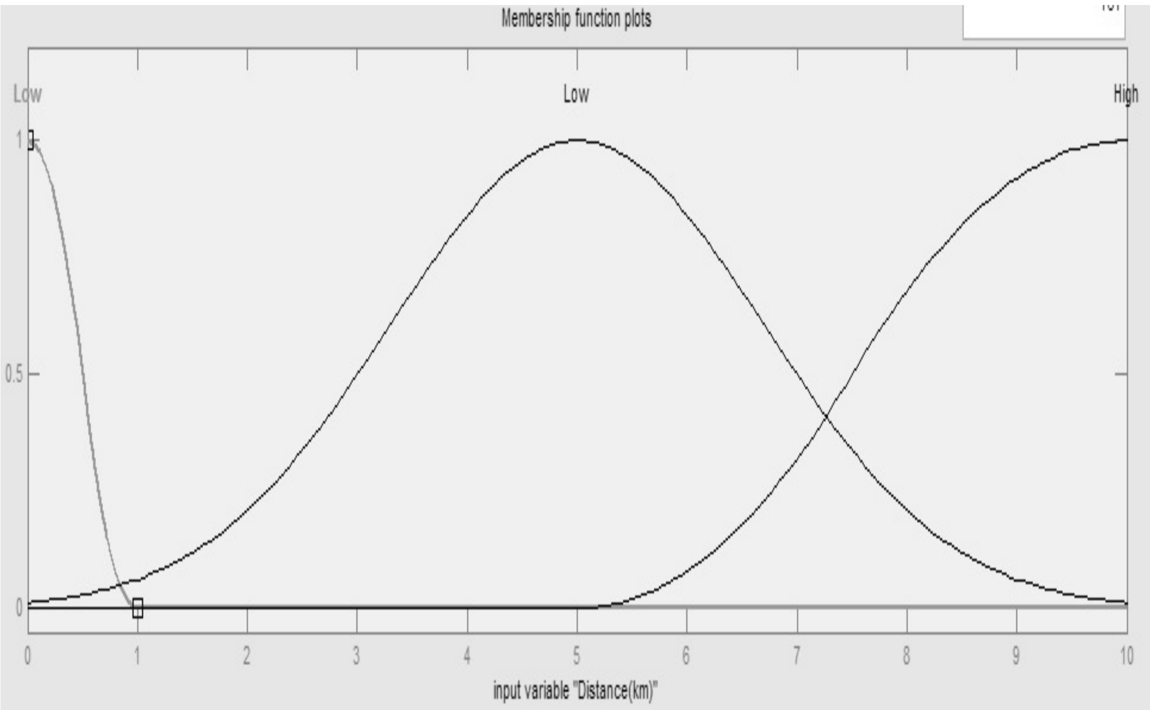

Fig.11. Membership Function of Distance between PU and SU (km)

The decision was made on the basis of the following membership function.

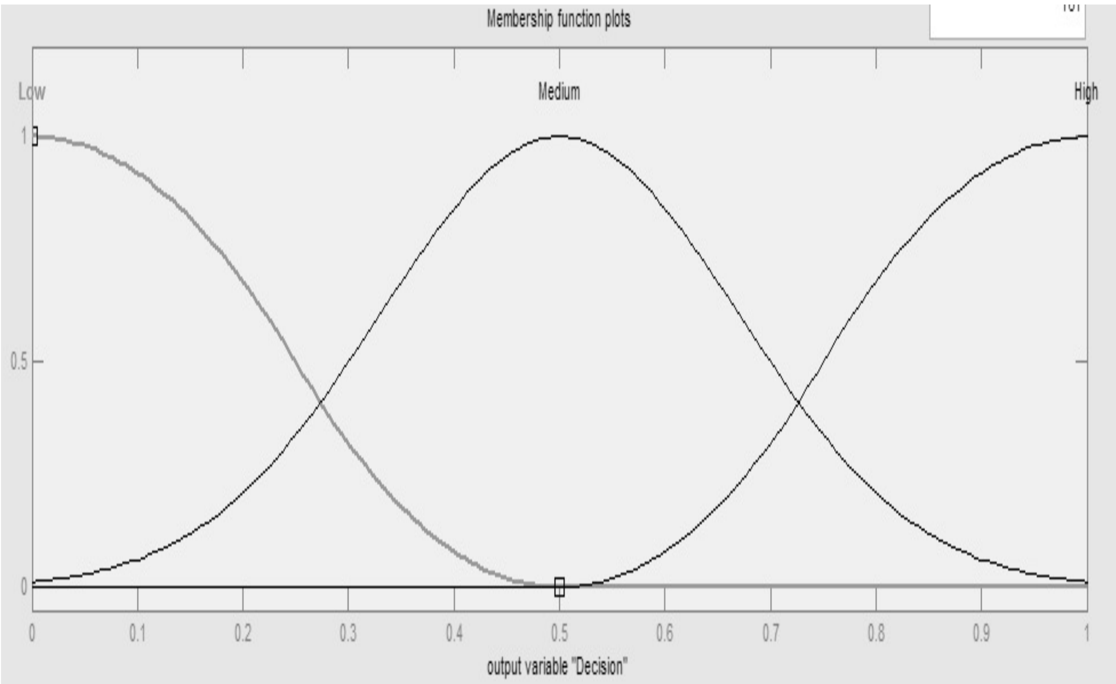

Fig.12. Membership Function for Decision

Chapter-5

Results

5.1 Spectrum Occupancy Analysis Results

Here we present the band-by-band spectrum occupancy results, where each of the spectrum occupancy plots consists of two subplots.

1) The upper sub-plot depicts the average received power at the antenna versus frequency measured during the entire 3-day period. For each frequency point, the average received power is determined by taking average of all 18 received samples of that frequency point.
2) The lower sub-plot shows the received power versus time and frequency.

Before moving to our band-by-band spectrum occupancy analyses, in Fig. 3, we show the received power versus frequency plot for the whole frequency range of the measurement study (80 MHz to 500 MHz). It indicates that overall spectrum utilization in the whole frequency range of our study is quite low.

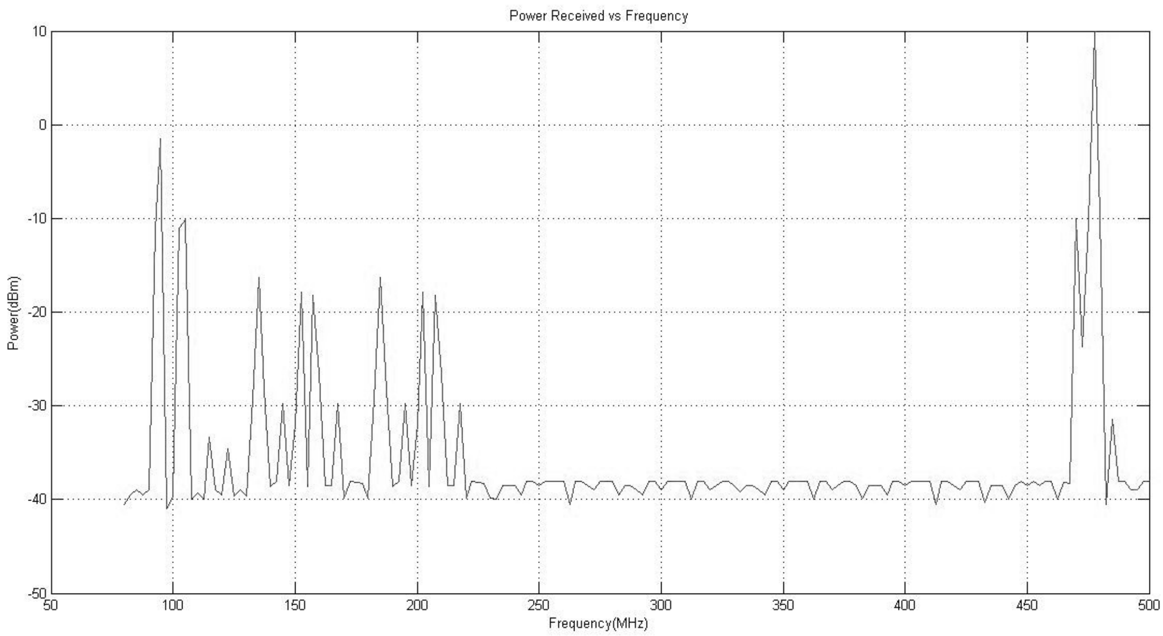

Fig. 13. Full band 80 MHz- 500 MHz observed power

However, this does not give us a detailed picture of how spectrum is utilized in different bands allocated to different services. Therefore, for a better view of the band-by-band occupancy pattern, we zoom into these bands.

The first band we analyzed was 80 MHz to 130 MHz. This band by Government of India (GoI) regulations is earmarked for demonstration of equipment on Non Interference and Non Protection Basis, for Aeronautical Radio and Mobile and for FM broadcasting. Average duty cycle for this band is 26.98%. (Fig. 13-14)

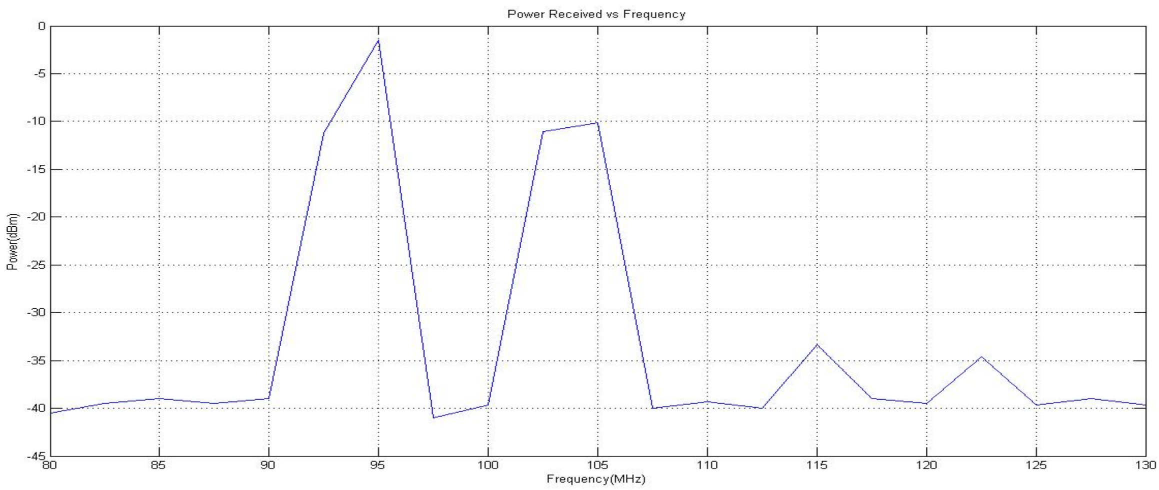

Fig. 14 - Average Received Power Levels for 80-130 MHz Band

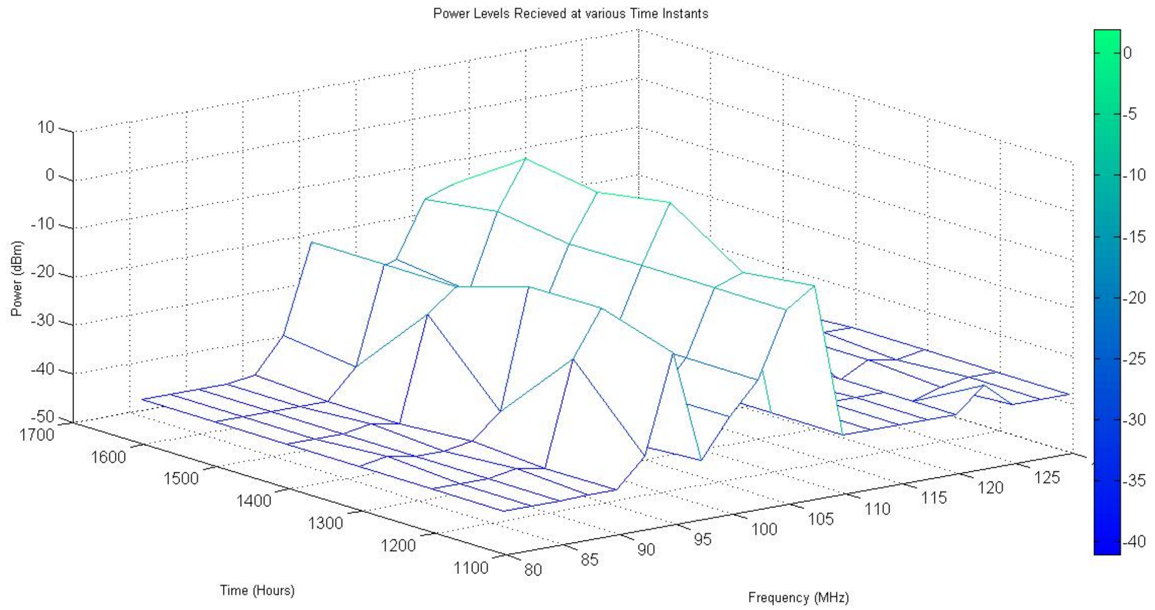

Fig. 15 – Occupancy Levels during the observation period 80-130 MHz.

The second band we analyzed was 130 MHz to 180 MHz. This band by GoI regulations is earmarked for Mobile Satellite Service uplink and downlink, amateur satellite, port operations etc. Average duty cycle for this band comes out to be 7.93%. (Fig. 15-16)

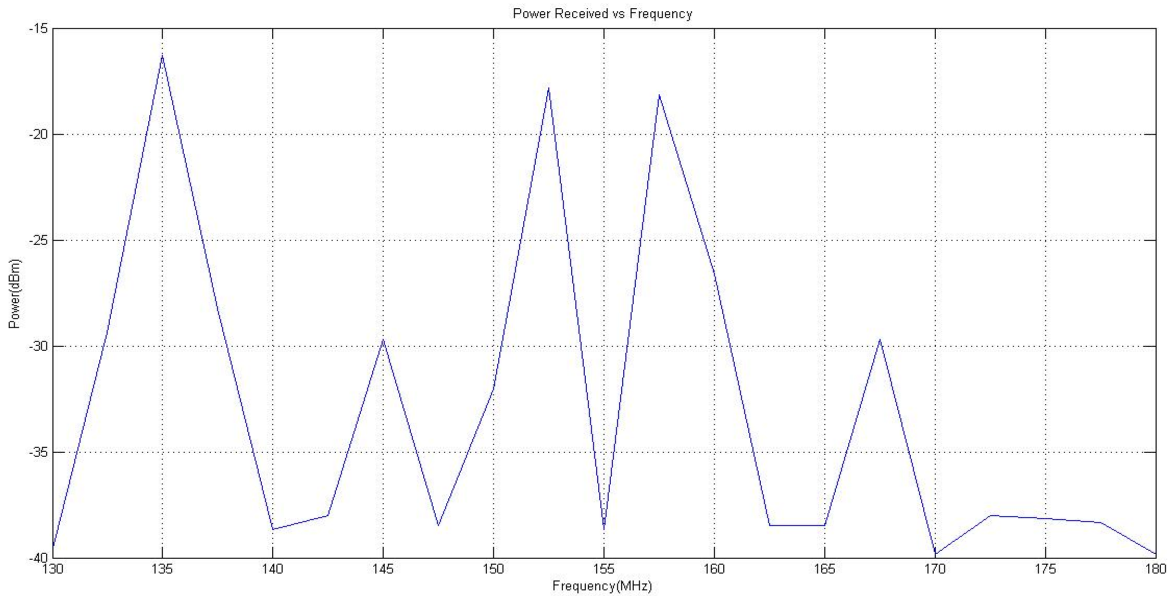

Fig. 16 - Average Received Power Levels for 130-180 MHz Band

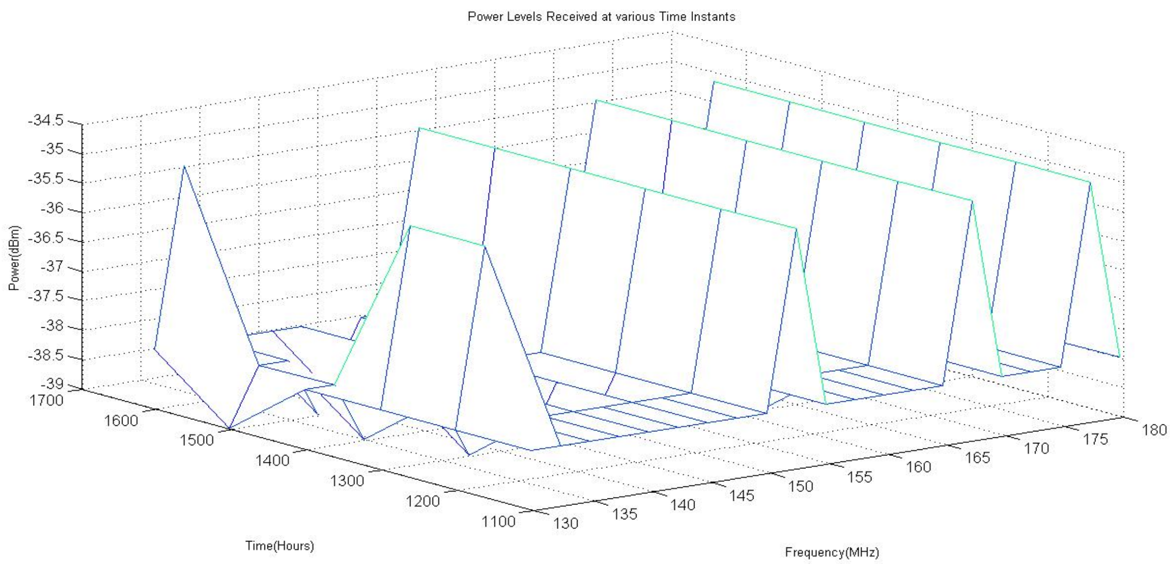

Fig. 17 – Occupancy Levels during the observation period 130-180 MHz.

The third band we analyzed was 180 MHz to 230 MHz. This band by GoI regulations is earmarked for Fixed Mobile Broadcasting and Aeronautical radio navigation. Average duty cycle for this band is 28.56%. (Fig. 17-18)

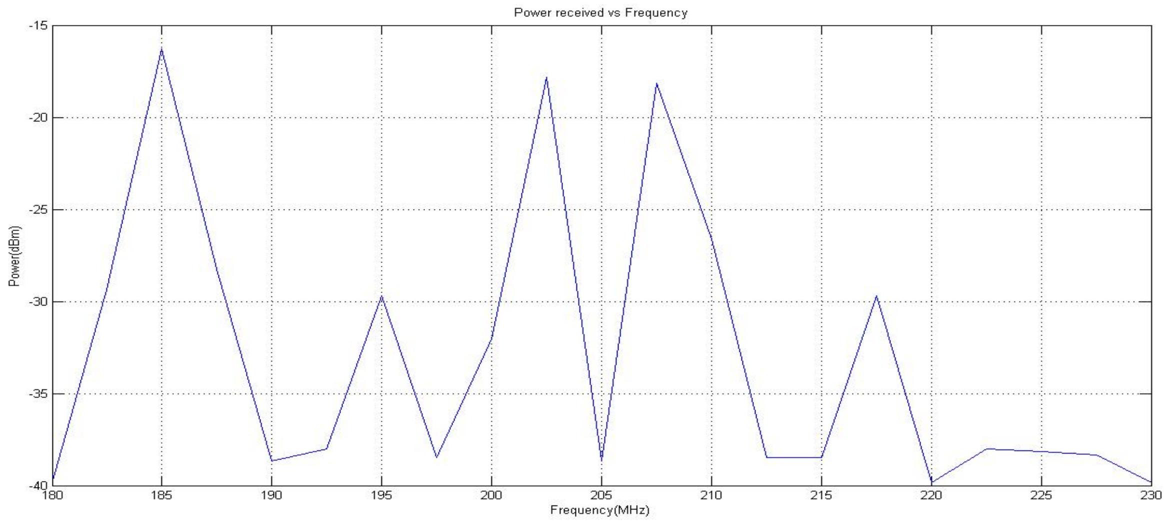

Fig. 18 - Average Received Power Levels for 180-230 MHz Band

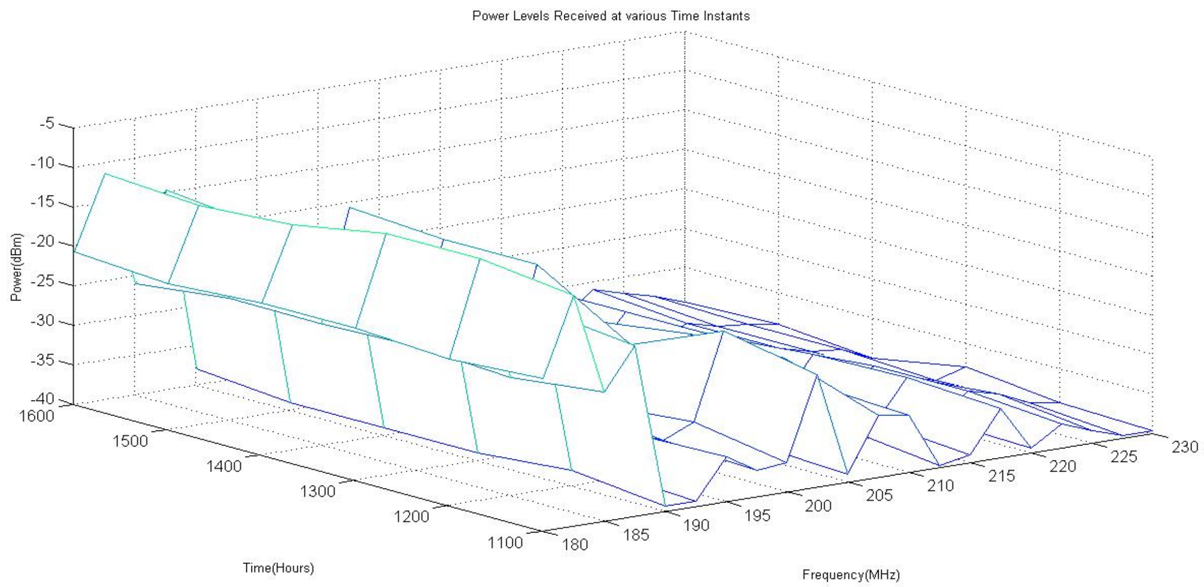

Fig. 19 – Occupancy Levels during the observation period 180-230 MHz.

The fourth band we analyzed was 230 MHz to 280 MHz. This band by GoI regulations is earmarked for Space Operation (space-to-earth) and Fixed Mobile. Average duty cycle for this band is 0%, which is to say, the band is unoccupied. (Fig. 19-20)

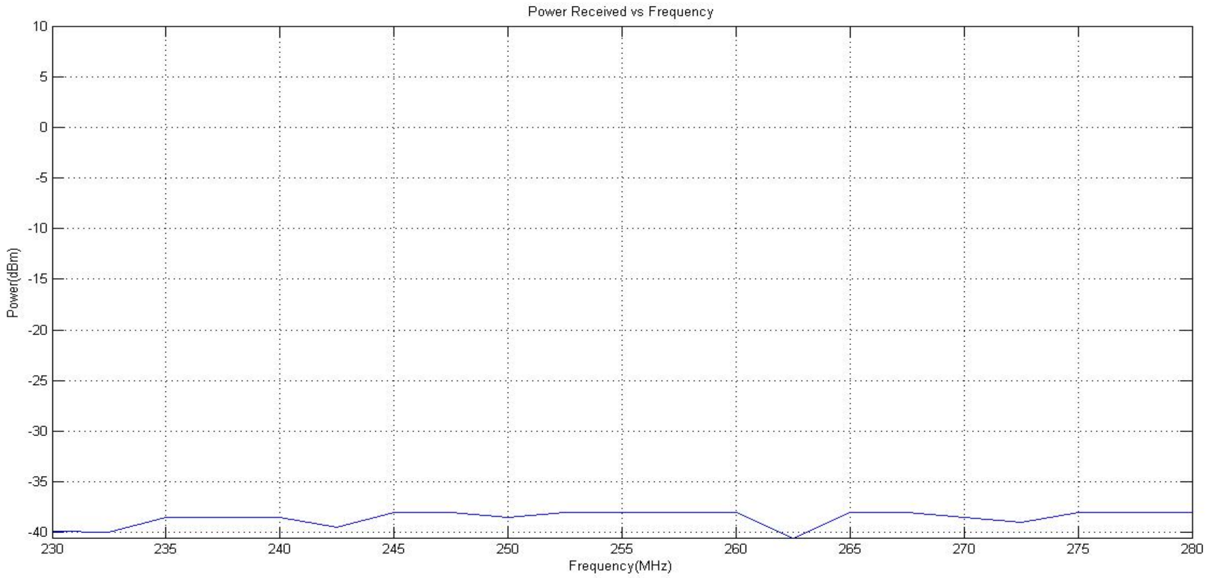

Fig. 20 - Average Received Power Levels for 230-280 MHz Band

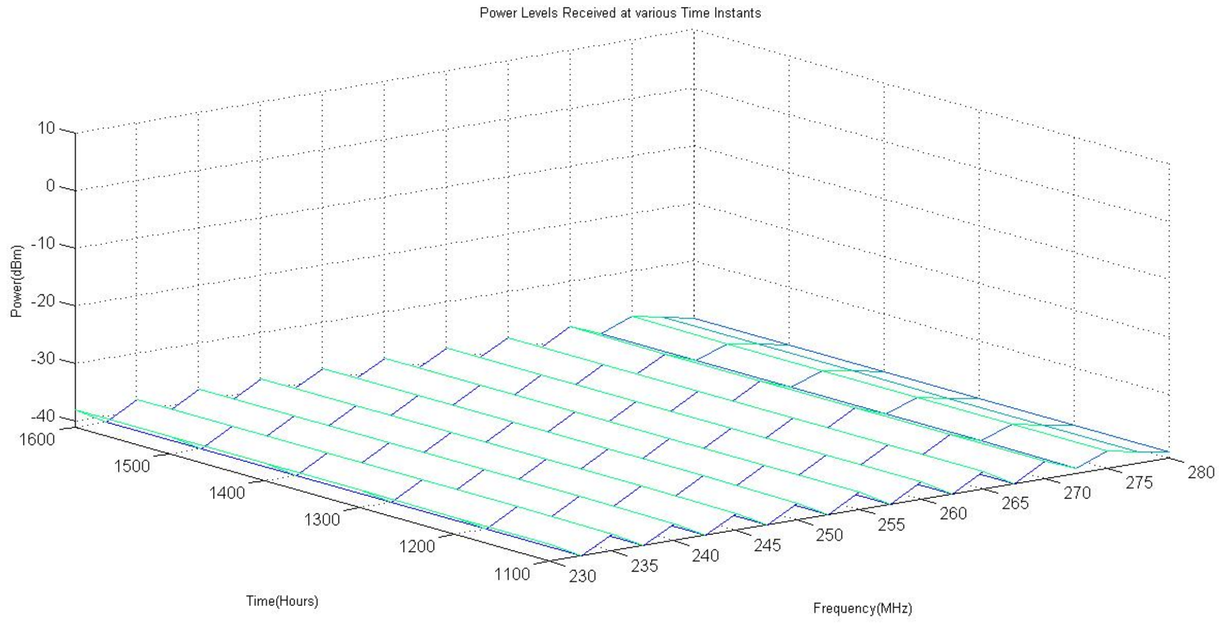

Fig. 21 – Occupancy Levels during the observation period 230-280 MHz.

The fifth band we analyzed was 280 MHz to 330 MHz. This band by GoI regulations is earmarked for Space Operation (earth-to-space) and Mobile Radio Astronomy and Aeronautical Radio Navigation. Average duty cycle for this band is 0%, which is to say, the band is unoccupied. (Fig. 21-22)

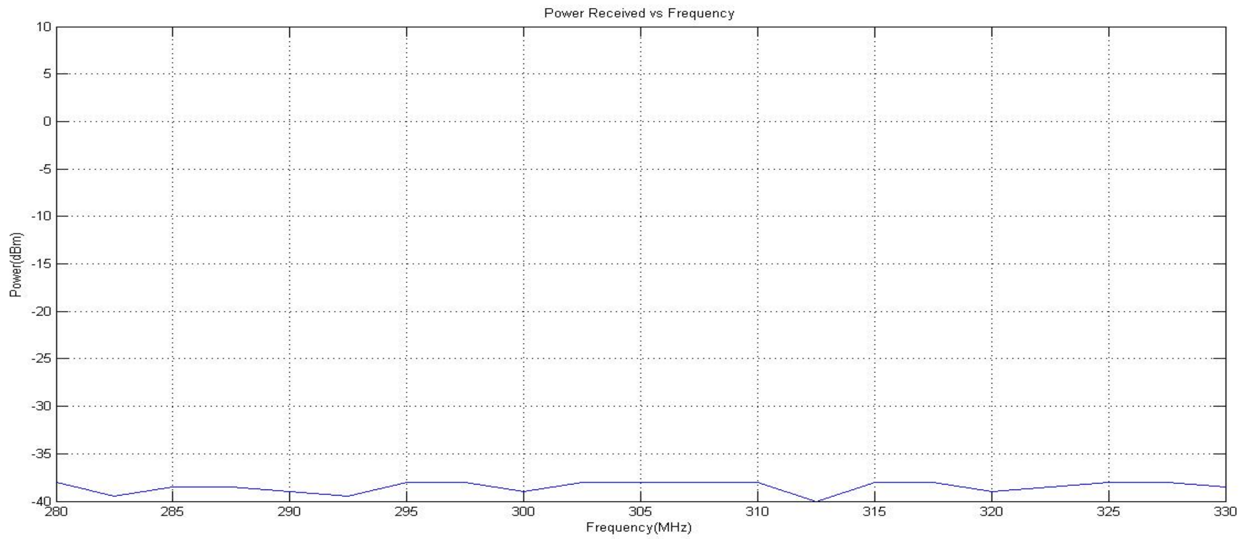

Fig. 22 - Average Received Power Levels for 280-330 MHz Band

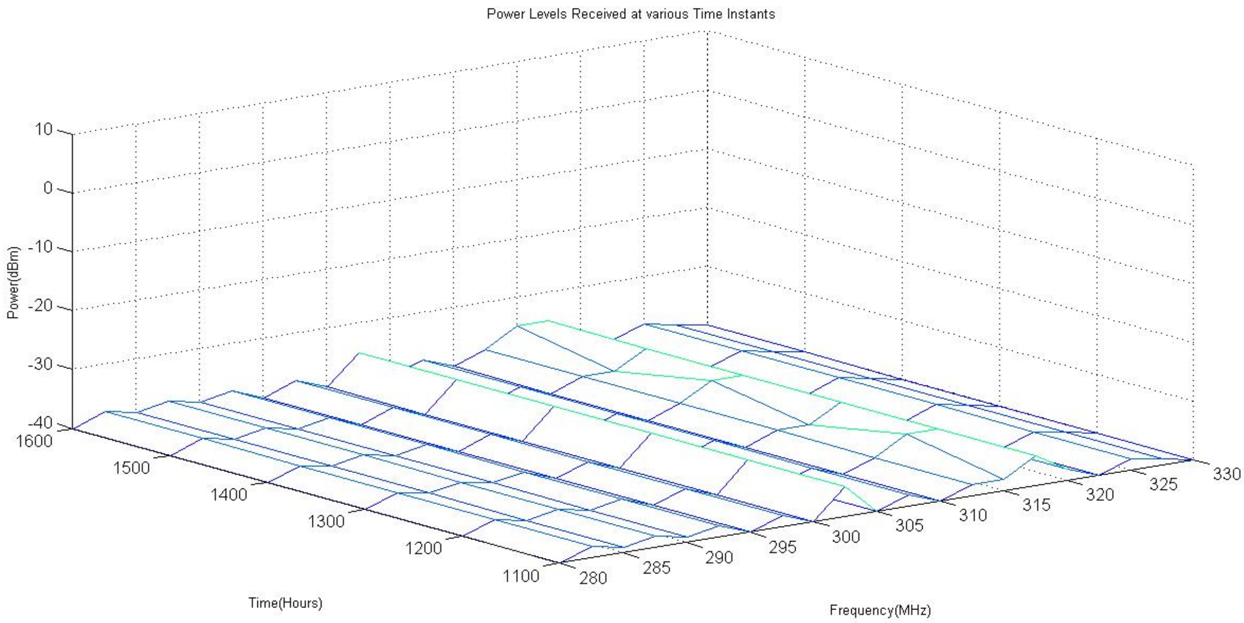

Fig. 23 – Occupancy Levels during the observation period 280-330 MHz.

The sixth band we analyzed was 330 MHz to 380 MHz. This band by GoI regulations is earmarked for Mobile Satellite. Average duty cycle for this band is 0%, which is to say, the band is unoccupied. (Fig. 23-24)

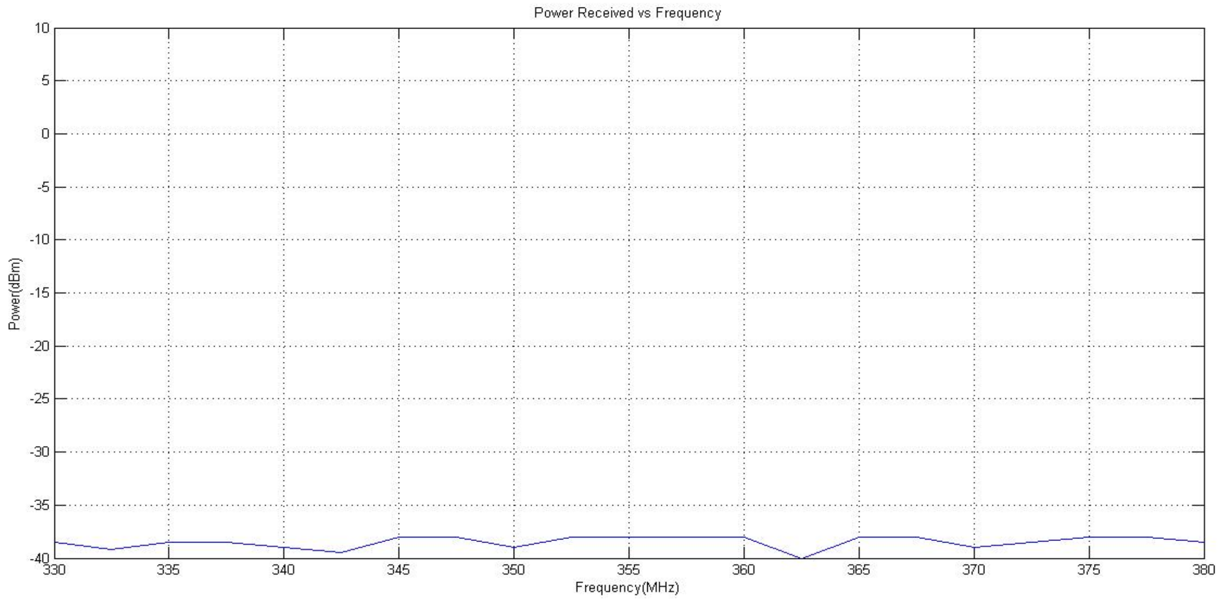

Fig. 24 - Average Received Power Levels for 330-380 MHz Band

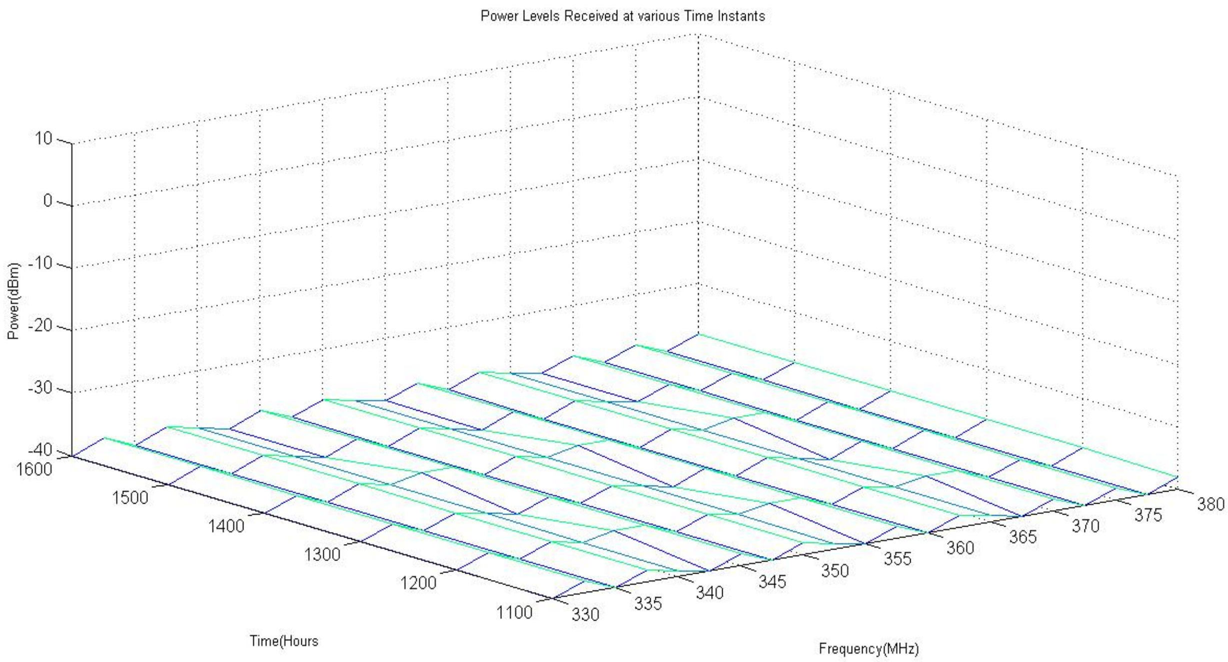

Fig. 25 – Occupancy Levels during the observation period 330-380 MHz.

The seventh band we analyzed was 380 MHz to 430 MHz. This band by GoI regulations is earmarked for Meteorological Aids and Satellite explorations. Average duty cycle for this band is 0%, which is to say, the band is unoccupied. (Fig. 25-26)

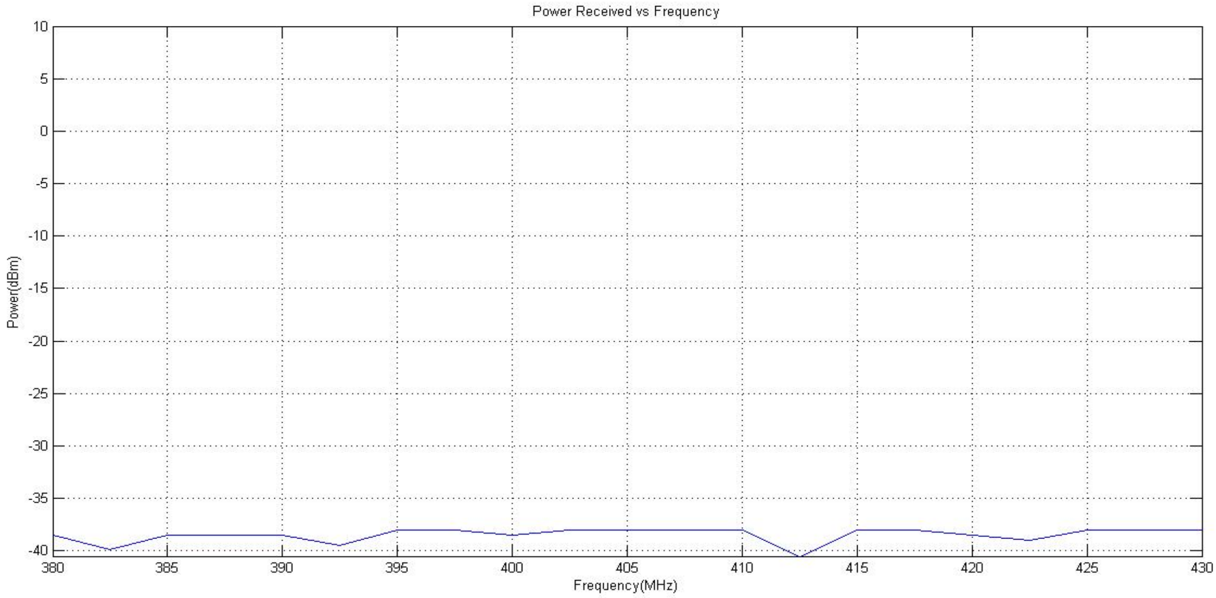

Fig. 26 - Average Received Power Levels for 380-430 MHz Band

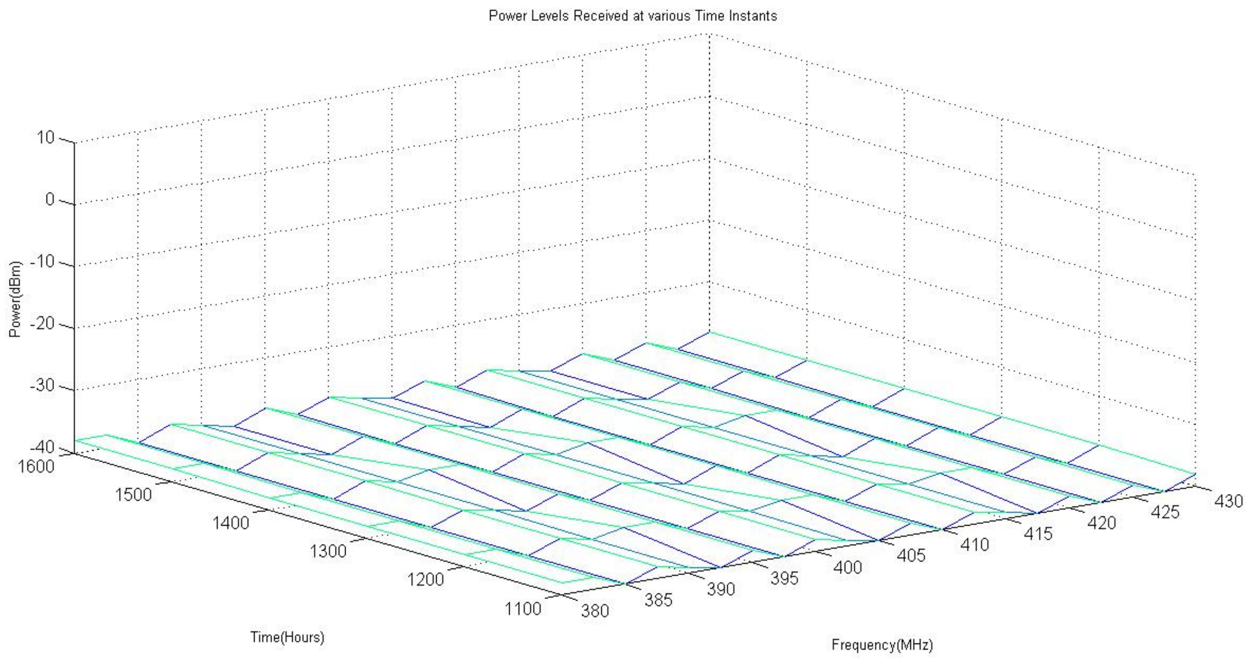

Fig. 27 – Occupancy Levels during the observation period 380-430 MHz.

The eighth band we analyzed was 430 MHz to 480 MHz. This band by GoI regulations is earmarked for Fixed Mobile Broadcasting. Average duty cycle for this band is 17.56%. (Fig. 27-28)

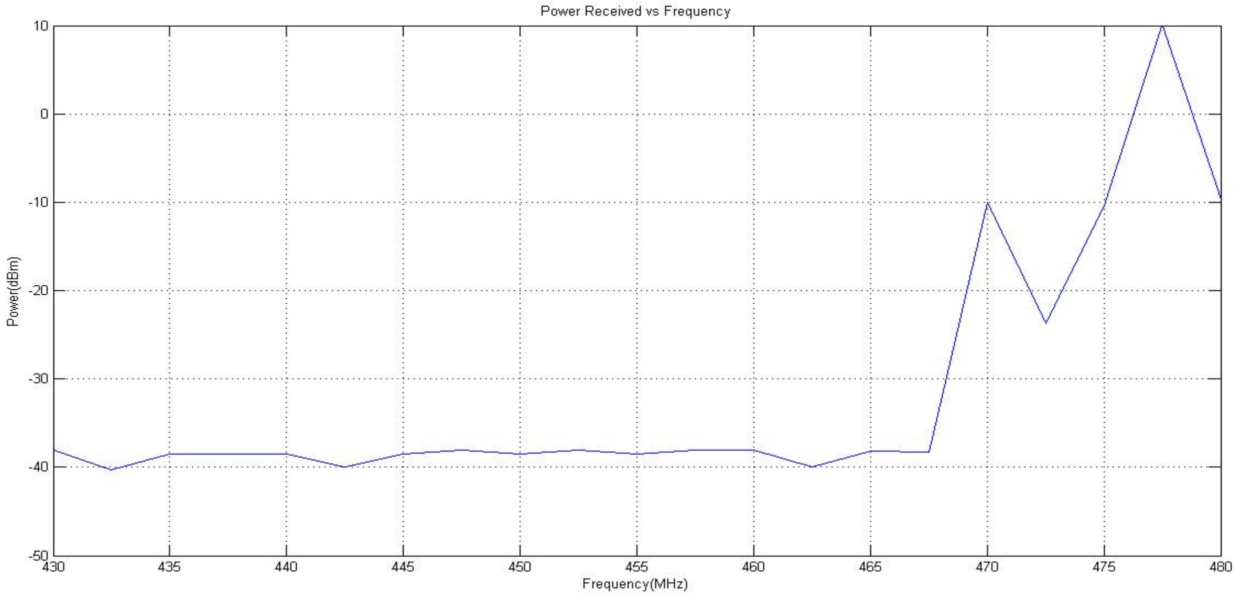

Fig. 28 - Average Received Power Levels for 430-480 MHz Band

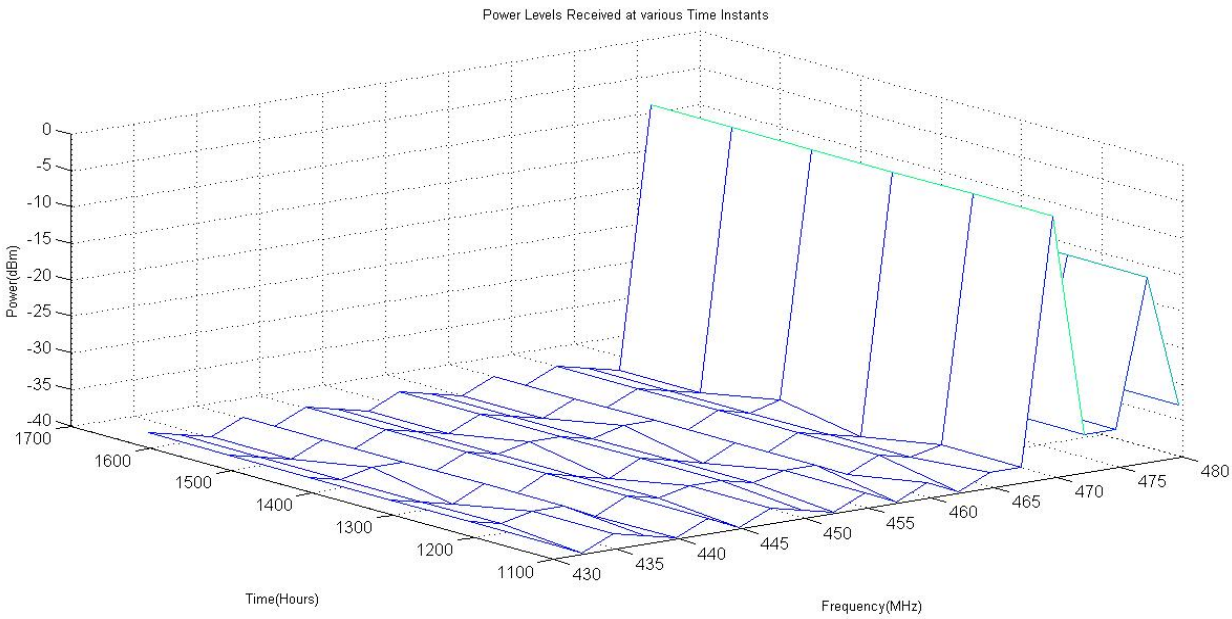

Fig. 29 – Occupancy Levels during the observation period 430-480 MHz.

The ninth band we analyzed was 480 MHz to 500 MHz. This band by GoI regulations is earmarked for Fixed Mobile Broadcasting. Average occupancy for this band is 11.11%. (Fig. 29-30)

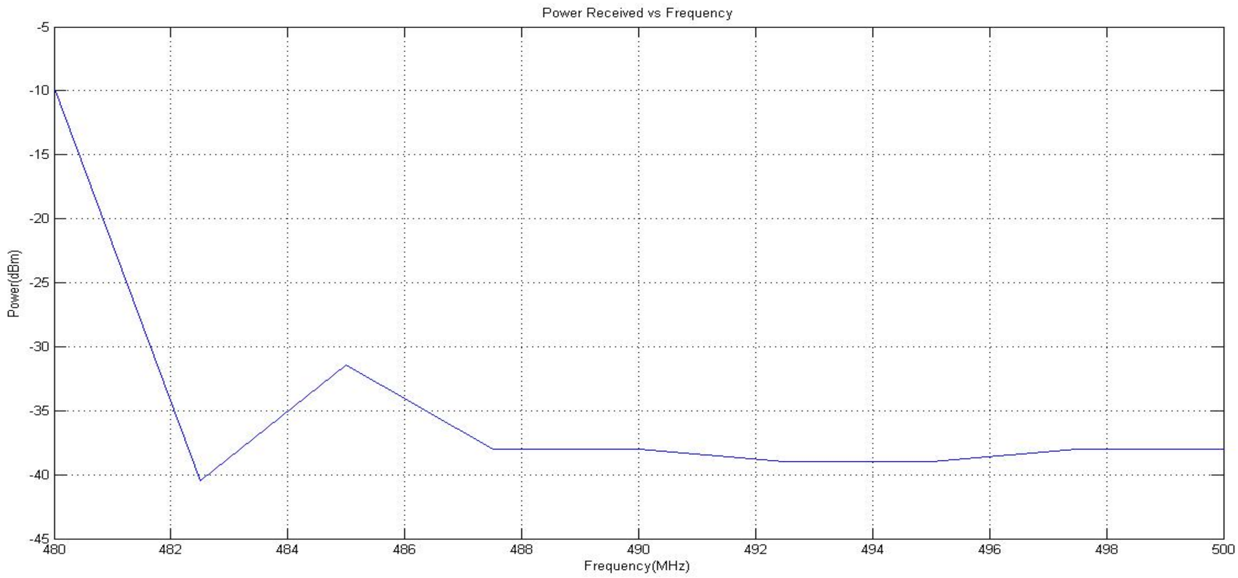

Fig. 30 - Average Received Power Levels for 480-500 MHz Band

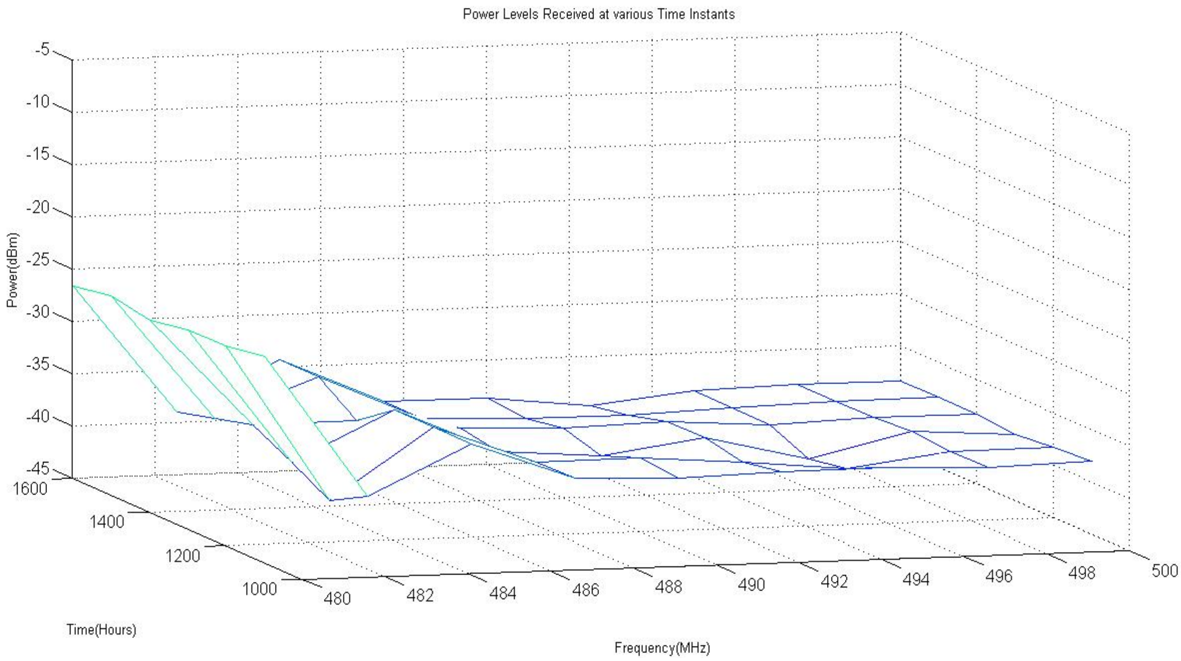

Fig. 31 – Occupancy Levels during the observation period 480-500 MHz.

Additionally we covered three of these bands in more detail and these were our observations:

1) 85 MHz – 112.5 MHz (average occupancy = 18.75%). (Fig. 31)

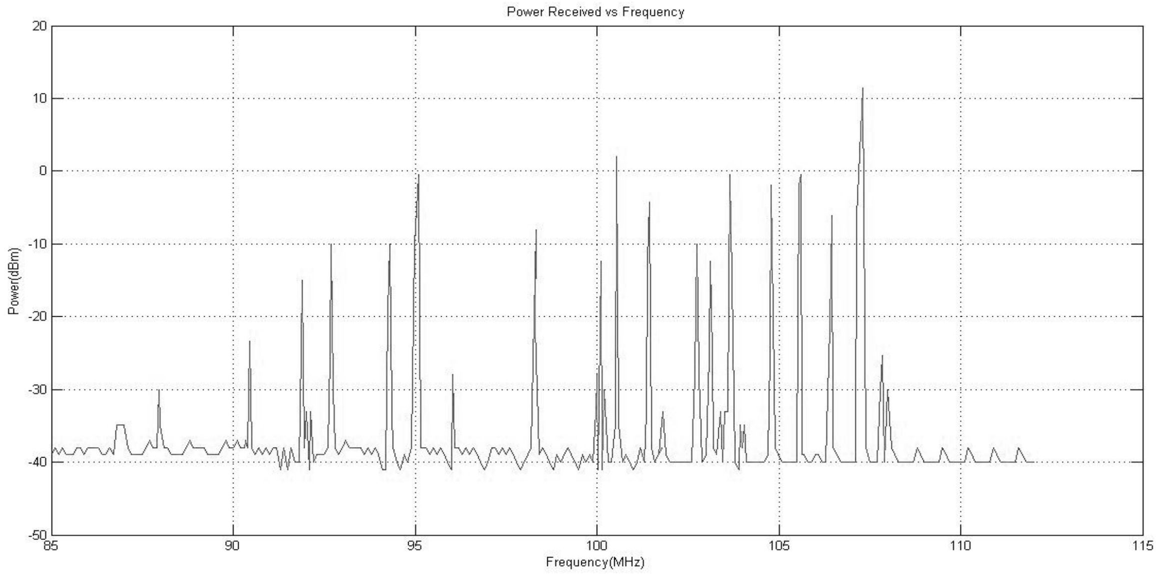

Fig. 32 - Average Received Power Levels for 85-112.5 MHz Band

2) 175 MHz – 230 MHz (average occupancy = 19.66%). (Fig. 32)

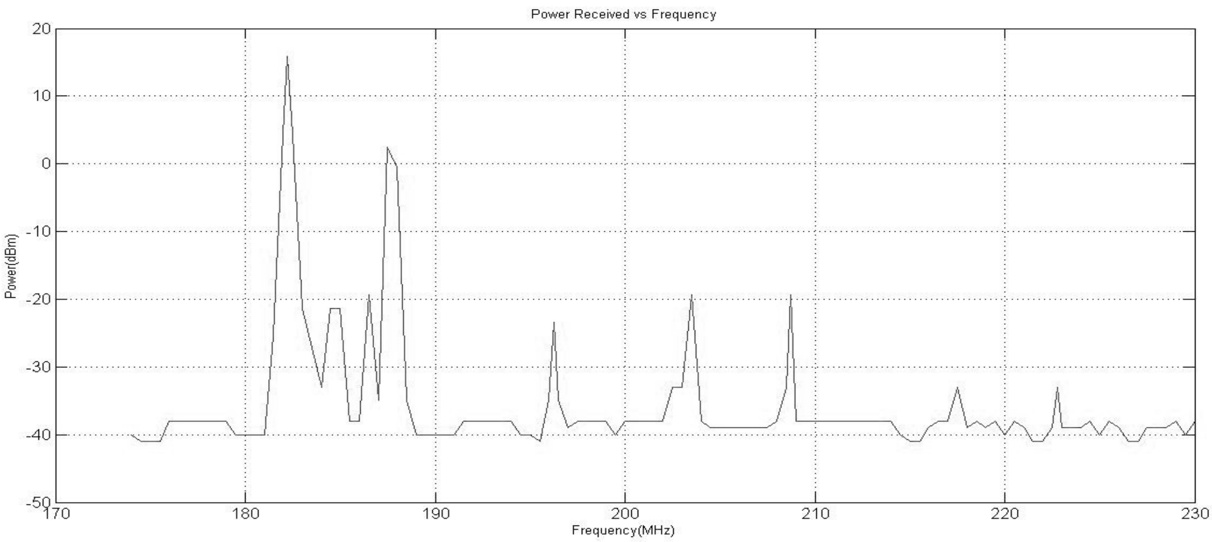

Fig. 33 - Average Received Power Levels for 175-230 MHz Band

3) 470 MHz – 486 MHz (average occupancy = 58.38%). (Fig. 33)

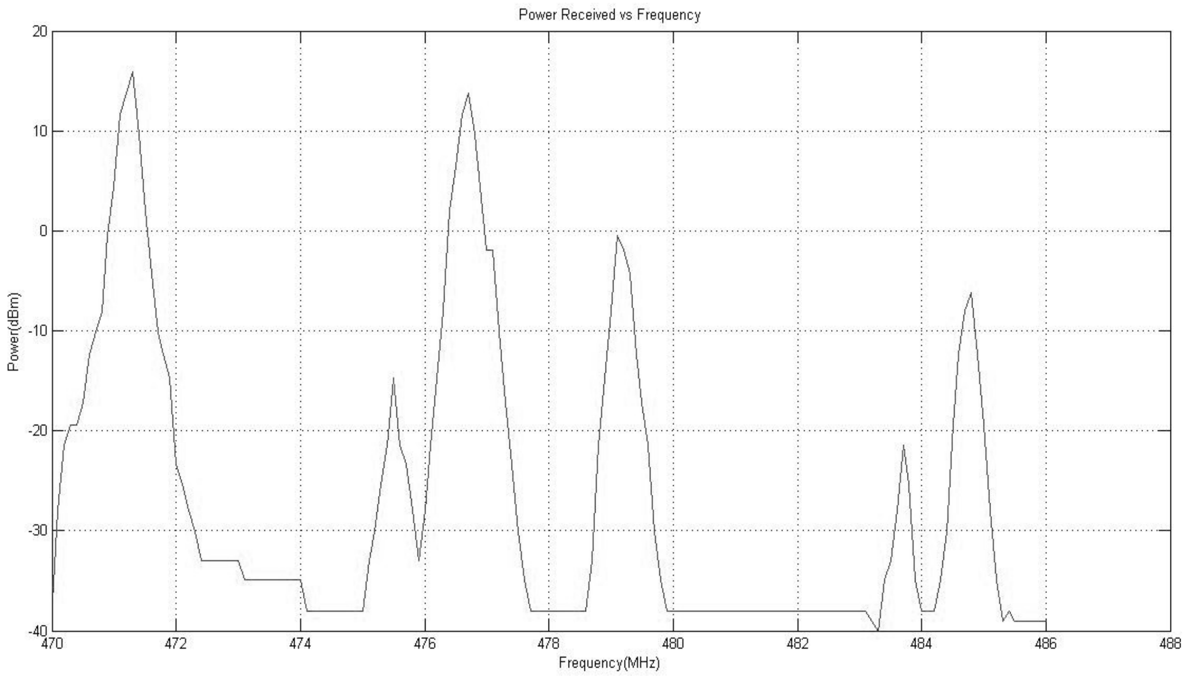

Fig. 34 - Average Received Power Levels for 480-500 MHz Band

5.2 Fuzzy Implementation Results

The results of Simulation on Matlab are as under. The decision axis is the z-axis.

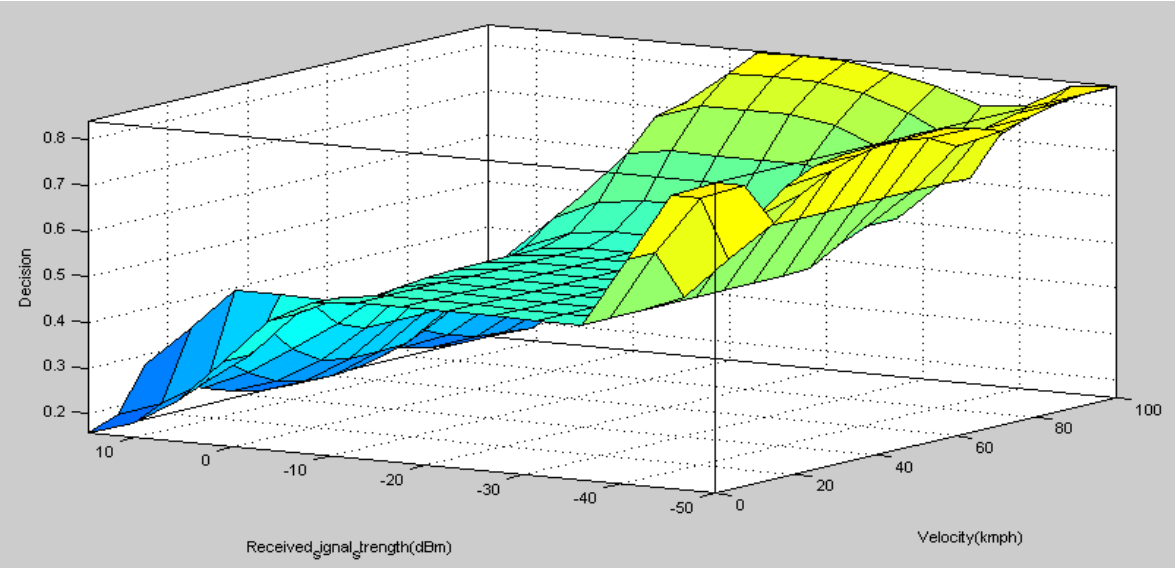

Fig. 35. Received Power vs Velocity vs Decision

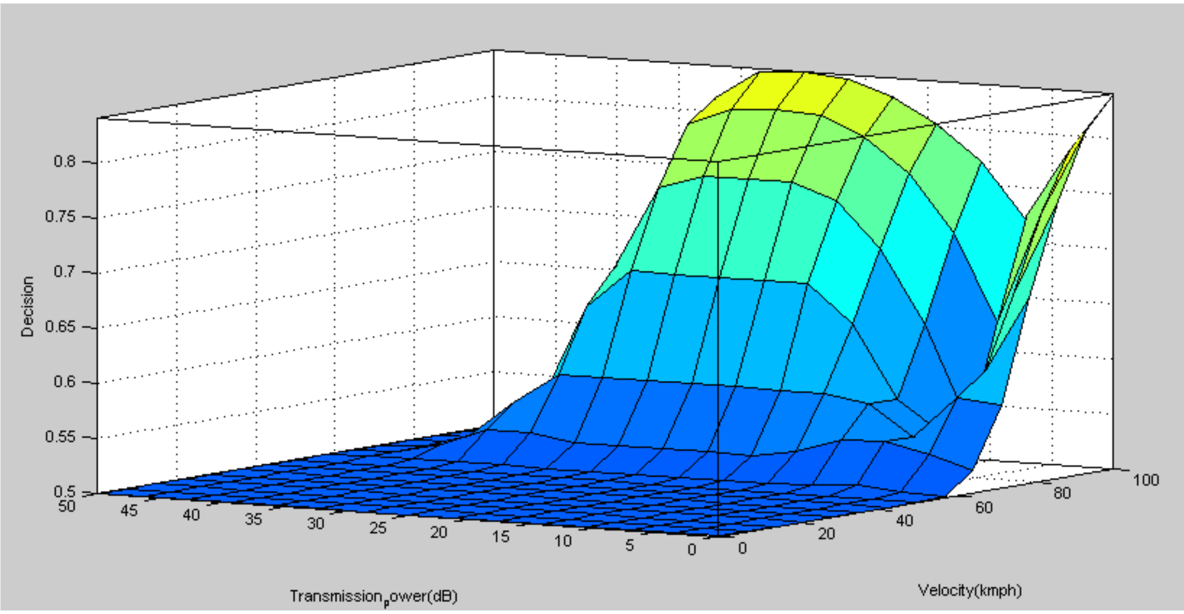

Fig. 36. Transmission Power vs Velocity vs Decision

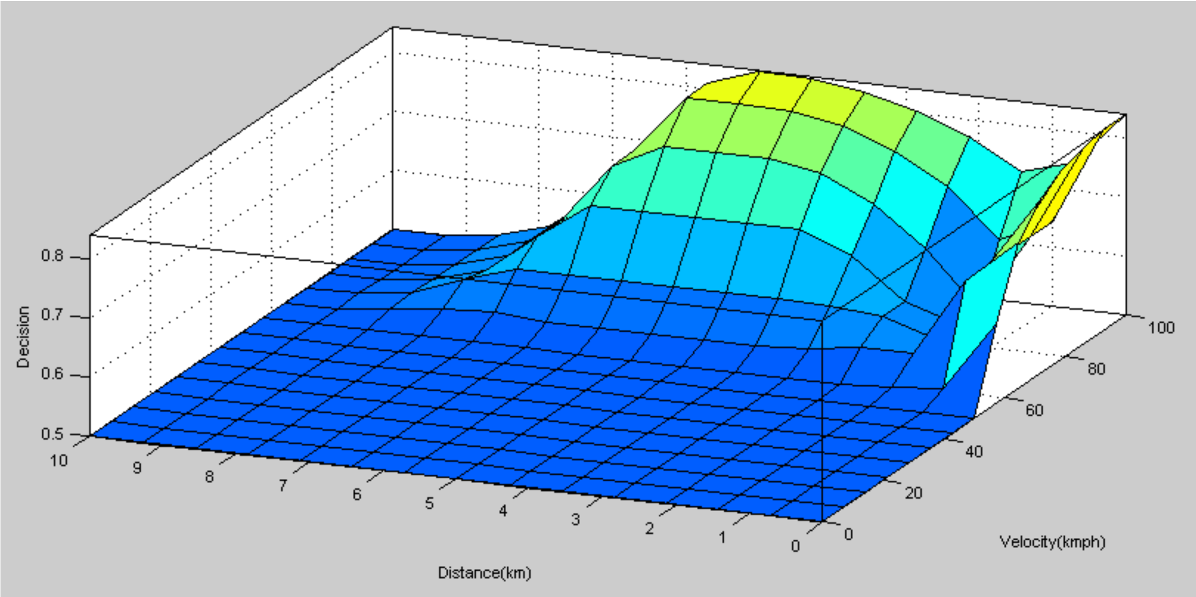

Fig. 37. Distance vs Velocity vs Decision

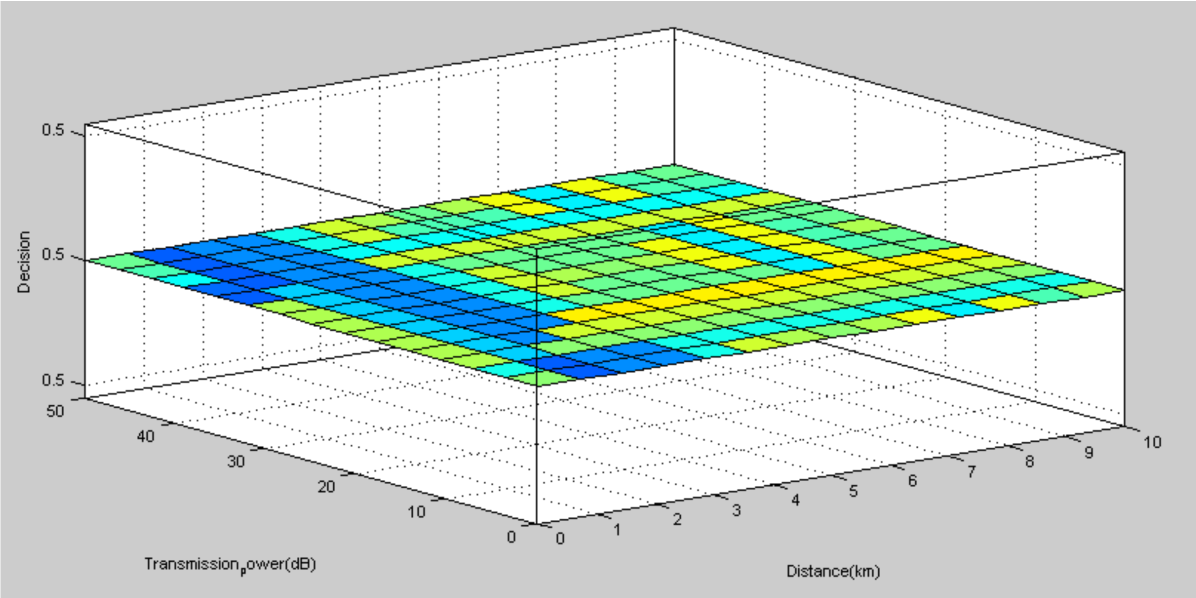

Fig. 38. Transmission Power vs Distance vs Decision

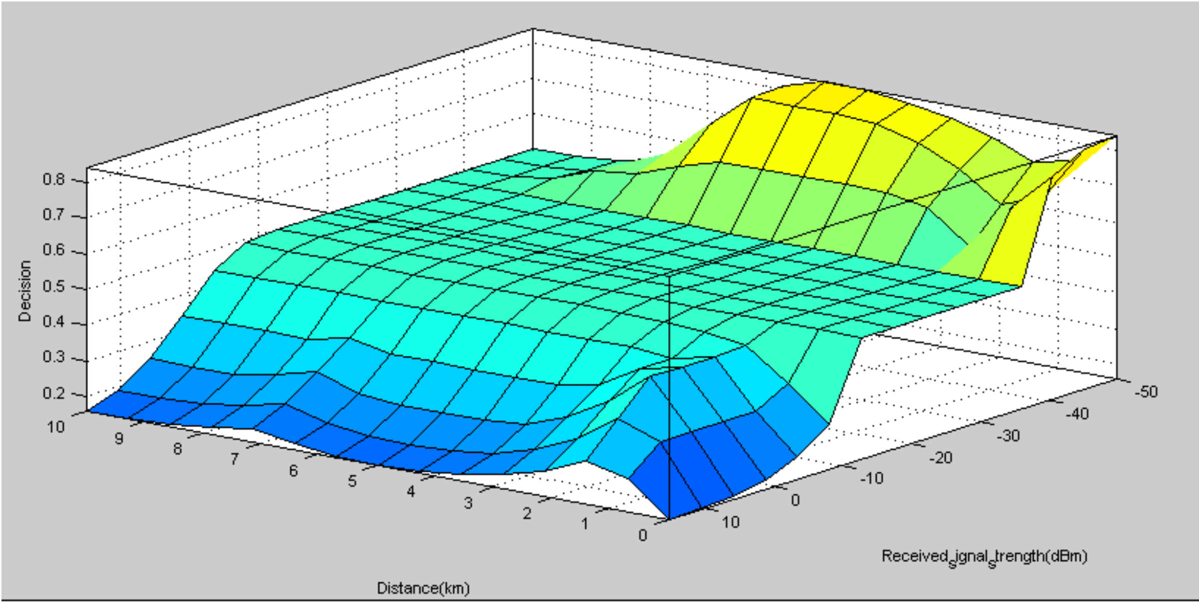

Fig. 39. Received Power vs Distance vs Decision

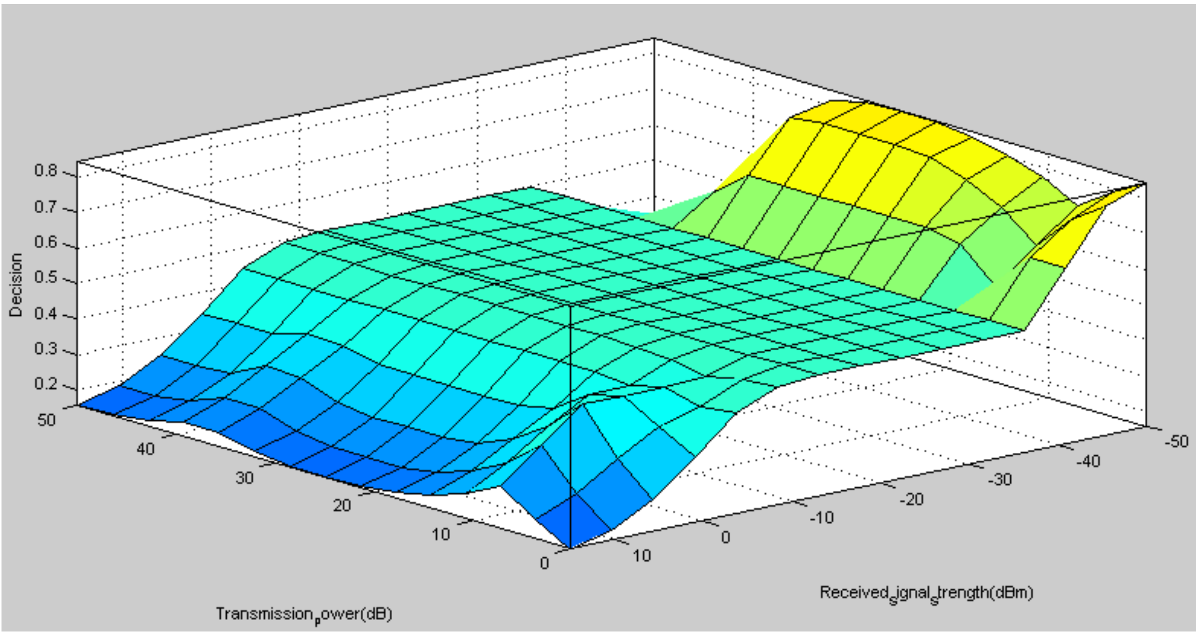

Fig. 40. Received Power vs Transmission Power vs Decision

Chapter-5

Conclusions

The analysis of the spectrum shows that the RF spectrum from 80 MHz to 500 MHz is utilized less than 15% on average. Also the frequency range from 220 MHz to 460 MHz is almost always empty i.e. unoccupied.

The employment of fuzzy logic might be helpful, for very complex processes, when there is no mathematical model for highly non-linear processes or if the processing of expert knowledge is to be performed. The decision-making operation enables better decision making by CR and more efficient spectrum utilization. The proposed system does not require either complex or time-consuming software. Therefore it can be implemented easily in real systems.

APPENDIX

Appendix-A

Table showing the readings that we used to calibrate the spectrum analyzer scale.

Divisions	Voltage (mV)	Power (dBm)	Divisions	Voltage (mV)	Power (dBm)
0.8	4	-34.94	3.6	136	-4.31
1	5	-33.01	3.8	180	-1.88
1.2	7	-30.08	4	212	-0.462
1.4	9	-27.9	4.2	280	1.95
1.6	12	-25.4	4.4	370	4.37
1.8	15	-23.4	4.6	470	6.45
2	19	-21.41	4.8	590	8.42
2.2	24	-19.38	5	680	9.66
2.4	31	-17.16	5.2	850	11.59
2.6	41	-14.73	5.4	1100	13.83
2.8	54	-12.34	5.6	1400	15.93
3	70	-10.08	5.8	1800	18.11
3.2	89	-8.001	6	2400	20.61
3.4	110	-6.16			

Appendix-B

Day-wise Readings of Power Levels for Various Bands

B.1 80 MHz – 130 MHz

Day 1

	11:00	12:00	13:00	14:00	15:00	16:00	
Freq (MHz)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power Avg. (dBm)
80	-41	-41	-41	-41	-41	-41	-41
82.5	-41	-41	-40	-41	-41	-41	-40.83333333
85	-41	-41	-41	-41	-41	-41	-41
87.5	-41	-40	-41	-40	-41	-41	-40.66666667
90	-41	-41	-40	-41	-41	-40	-40.66666667
92.5	-34.94	-19.38	-34.94	-19.38	-34.94	-33.01	-29.43166667
95	-14.73	-10.08	-10.08	-14.73	-14.73	-14.73	-13.18
97.5	-38	-39	-38	-40	-38	-38.5	-38.58333333
100	-30.08	-30.08	-30.08	-30.08	-27.9	-23.4	-28.60333333
102.5	-23.4	-23.4	-23.4	-23.4	-23.4	-21.41	-23.06833333
105	-10.08	-10.08	-10.08	-10.08	-8.001	-10.08	-9.7335
107.5	-6.16	-8.01	1.95	-0.462	1.95	-8.01	-3.123666667
110	-38	-38	-38	-39	-38	-38	-38.16666667
112.5	-38	-38	-39	-38	-39	-38	-38.33333333
115	-38	-38	-38	-38	-39	-38	-38.16666667
117.5	-38	-38	-39	-38	-38	-38	-38.16666667
120	-38	-38	-38	-38	-38	-39	-38.16666667
122.5	-33.01	-41	-41	-33.01	-38	-30.08	-36.01666667
125	-38	-39	-38	-38	-38	-38	-38.16666667
127.5	-38	-38	-39	-38	-38	-38	-38.16666667
130	-38	-38	-38	-38	-39	-38	-38.16666667

Day 2

	11:00	**12:00**	**13:00**	**14:00**	**15:00**	**16:00**	
Freq (MHz)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power Avg. (dBm)
80	-41	-41	-41	-41	-41	-41	-41
82.5	-41	-41	-40	-41	-41	-41	-40.83333333
85	-41	-41	-41	-41	-41	-41	-41
87.5	-41	-40	-38	-41	-41	-40	-40.16666667
90	-41	-41	-40	-41	-41	-41	-40.83333333
92.5	-30.08	-27.9	-30.08	-30.08	-30.08	-27.9	-29.35333333
95	-14.73	-19.38	-14.73	-19.38	-19.38	-10.08	-16.28
97.5	-41	-39	-38	-41	-41	-39	-39.83333333
100	-34.94	-19.38	-19.38	-34.94	-34.94	-19.38	-27.16
102.5	-34.94	-19.38	-21.41	-34.94	-34.94	-19.38	-27.49833333
105	-27.9	-10.08	-14.73	-10.08	-14.73	-10.08	-14.6
107.5	-1.88	1.95	6.45	-1.88	-1.88	1.95	0.785
110	-41	-38	-38	-41	-41	-38	-39.5
112.5	-41	-38	-34.94	-41	-41	-38	-38.99
115	-40	-38	-34.94	-40	-40	-38	-38.49
117.5	-40	-39	-39	-40	-40	-39	-39.5
120	-39	-38	-38	-39	-39	-38	-38.5
122.5	-39	-40	-38	-39	-39	-40	-39.16666667
125	-40	-34.94	-34.94	-40	-40	-34.94	-37.47
127.5	-40	-38	-39	-40	-40	-38	-39.16666667
130	-41	-38	-38	-41	-41	-38	-39.5

Day 3

	11:00	**12:00**	**13:00**	**14:00**	**15:00**	**16:00**	
Freq (MHz)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power Avg. (dBm)
80	-41	-41	-38	-41	-41	-41	-40.5
82.5	-41	-38	-38	-41	-38	-41	-39.5
85	-40	-38	-38	-40	-38	-40	-39
87.5	-41	-38	-38	-41	-38	-41	-39.5
90	-38	-41	-38	-38	-41	-38	-39
92.5	-10.08	-10.08	-14.73	-10.08	-10.08	-12.34	-11.23166667
95	-1.88	0.46	-1.88	-1.88	-1.88	-1.88	-1.49
97.5	-41	-41	-41	-41	-41	-41	-41
100	-38	-40	-40	-40	-40	-40	-39.66666667
102.5	-19.38	-33.01	-19.38	12.34	-19.38	12.34	-11.07833333
105	-8.001	-10.08	-14.73	-10.08	-8.001	-10.08	-10.162
107.5	-41	-41	-38	-41	-38	-41	-40
110	-40	-40	-38	-40	-38	-40	-39.33333333
112.5	-41	-41	-38	-41	-38	-41	-40
115	-33.01	-33.01	-34.94	-33.01	-33.01	-33.01	-33.33166667
117.5	-38	-38	-40	-38	-40	-40	-39
120	-38	-38	-41	-38	-41	-41	-39.5
122.5	-34.94	-34.94	-34.94	-34.94	-34.94	-33.01	-34.61833333
125	-39	-41	-38	-41	-38	-41	-39.66666667
127.5	-38	-40	-38	-40	-38	-40	-39
130	-39	-41	-38	-41	-38	-41	-39.66666667

B.2 130 MHz – 180 MHz

Day 1

	11:05	**12:05**	**13:05**	**14:05**	**15:05**	**16:05**	
Freq (MHz)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power Avg. (dBm)
130	-38	-38	-38	-38	-39	-38	-38.16666667
132.5	-38	-34.94	-34.94	-38	-38	-34.94	-36.47
135	-38	-38	-38	-39	-38	-38	-38.16666667
137.5	-38	-38	-39	-38	-39	-38	-38.33333333
140	-38	-38	-38	-38	-39	-38	-38.16666667
142.5	-38	-38	-39	-38	-38	-38	-38.16666667
145	-38	-38	-38	-38	-38	-39	-38.16666667
147.5	-38	-38	-39	-38	-38	-38	-38.16666667
150	-38	-38	-38	-38	-39	-38	-38.16666667
152.5	-34.94	-34.94	-34.94	-34.94	-34.94	-34.94	-34.94
155	-38	-38	-38	-38	-38	-38	-38
157.5	-38	-38	-38	-38	-38	-38	-38
160	-38	-38	-38	-38	-38	-38	-38
162.5	-38	-38	-39	-38	-38	-38	-38.16666667
165	-38	-38	-38	-38	-39	-38	-38.16666667
167.5	-34.94	-34.94	-34.94	-34.94	-34.94	-34.94	-34.94
170	-38	-38	-38	-38	-38	-38	-38
172.5	-38	-38	-38	-38	-38	-38	-38
175	-38	-38	-38	-38	-38	-38	-38
177.5	-34.94	-34.94	-34.94	-34.94	-34.94	-34.94	-34.94
180	-38	-38	-38	-38	-38	-38	-38

Day 2

	11:05	**12:05**	**13:05**	**14:05**	**15:05**	**16:05**	
Freq (MHz)	Power (dBm)	Powe r (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power Avg. (dBm)
130	-41	-38	-38	-41	-41	-38	-39.5
132.5	-40	-40	-40	-40	-40	-40	-40
135	-40	-41	-40	-40	-40	-41	-40.33333333
137.5	-39	-40	-39	-39	-39	-40	-39.33333333
140	-39	-38	-38	-39	-39	-38	-38.5
142.5	-40	-38	-39	-40	-40	-38	-39.16666667
145	-40	-38	-38	-40	-40	-38	-39
147.5	-41	-38	-39	-41	-41	-38	-39.66666667
150	-41	-38	-38	-41	-41	-38	-39.5
152.5	-40	-34.94	-34.94	-40	-40	-34.94	-37.47
155	-40	-38	-38	-40	-40	-38	-39
157.5	-40	-38	-38	-40	-40	-38	-39
160	-39	-38	-38	-39	-39	-38	-38.5
162.5	-39	-38	-39	-39	-39	-38	-38.66666667
165	-40	-38	-38	-40	-40	-38	-39
167.5	-40	-38	-39	-40	-40	-38	-39.16666667
170	-38	-34.94	-33.01	-38	-38	-34.94	-36.14833333
172.5	-40	-38	-38	-40	-40	-38	-39
175	-41	-38	-38	-41	-41	-38	-39.5
177.5	-34.94	-34.94	-34.94	-34.94	-34.94	-34.94	-34.94
180	-38	-38	-38	-38	-38	-38	-38

Day 3

	11:05	12:05	13:05	14:05	15:05	16:05	
Freq (MHz)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power Avg. (dBm)
130	-39	-41	-38	-41	-38	-41	-39.66666667
132.5	-40	-41	-41	-41	-41	-41	-40.83333333
135	-41	-38	-38	-38	-38	-38	-38.5
137.5	-41	-38	-38	-38	-38	-38	-38.5
140	-41	-38	-38	-38	-38	-38	-38.5
142.5	-41	-41	-41	-41	-41	-41	-41
145	-33.01	-34.94	-33.01	-33.01	-33.01	-33.01	-33.33166667
147.5	-38	-38	-38	-38	-38	-38	-38
150	-39	-38	-38	-38	-38	-38	-38.16666667
152.5	-34.94	-33.01	-34.94	-34.94	-33.01	-34.94	-34.29666667
155	-38	-38	-41	-41	-38	-41	-39.5
157.5	-38	-38	-38	-38	-38	-38	-38
160	-38	-38	-38	-38	-38	-38	-38
162.5	-38	-38	-38	-38	-38	-38	-38
165	-38	-38	-41	-41	-38	-41	-39.5
167.5	-38	-41	-38	-38	-41	-38	-39
170	-34.94	-33.01	-33.01	-34.94	-33.01	-33.01	-33.65333333
172.5	-38	-38	-41	-38	-41	-38	-39
175	-39	-41	-38	-41	-38	-41	-39.66666667
177.5	-34.94	-33.01	-33.01	-34.94	-33.01	-33.01	-33.65333333
180	13.83	11.59	13.83	13.83	11.59	13.83	13.08333333

B.3 180 MHz – 230 MHz

Day 1

	11:10	12:10	13:10	14:10	15:10	16:10	
Freq (MHz)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power Avg. (dBm)
180	-38	-38	-38	-38	-38	-38	-38
182.5	-6.16	-1.88	-4.31	-6.16	-6.16	-6.16	-5.138333333
185	-38	-34.94	-34.94	-38	-33.01	-33.01	-35.31666667
187.5	-12.34	-17.16	-17.16	-12.34	-10.08	-10.08	-13.19333333
190	-38	-38	-38	-38	-38	-38	-38
192.5	-40	-40	-40	-40	-40	-40	-40
195	-38	-38	-38	-38	-38	-38	-38
197.5	-30.08	-30.08	-27.9	-30.08	-34.94	-34.94	-31.33666667
200	-38	-38	-38	-38	-38	-38	-38
202.5	-27.9	-30.08	-27.9	-21.41	-17.16	-17.16	-23.60166667
205	-38	-38	-38	-38	-38	-38	-38
207.5	-34.94	-34.94	-34.94	-30.08	-25.4	-25.4	-30.95
210	-38	-38	-38	-38	-38	-38	-38
212.5	-39	-39	-39	-39	-39	-39	-39
215	-38	-38	-38	-38	-38	-38	-38
217.5	-34.94	-33.01	-34.94	-34.94	-34.94	-34.94	-34.61833333
220	-38	-38	-38	-38	-38	-38	-38
222.5	-34.94	-34.94	-34.94	-34.94	-34.94	-34.94	-34.94
225	-38	-38	-38	-38	-38	-38	-38
227.5	-40	-40	-40	-38	-38	-38	-39
230	-38	-38	-38	-38	-38	-38	-38

Day 2

	11:10	**12:10**	**13:10**	**14:10**	**15:10**	**16:10**	
Freq (MHz)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power Avg. (dBm)
180	-38	-38	-38	-38	-38	-38	-38
182.5	-0.462	1.95	6.45	-0.462	-0.462	1.95	1.494
185	-21.41	-25.4	-23.4	-21.41	-21.41	-25.4	-23.07166667
187.5	-10.08	-6.16	-4.31	-10.08	-10.08	-6.16	-7.811666667
190	-41	-38	-38	-41	-41	-38	-39.5
192.5	-40	-38	-39	-40	-40	-38	-39.16666667
195	-34.94	-38	-34.94	-34.94	-34.94	-38	-35.96
197.5	-41	-38	-38	-41	-41	-38	-39.5
200	-38	-34.94	-34.94	-38	-38	-34.94	-36.47
202.5	-27.9	-25.4	-38	-27.9	-27.9	-25.4	-28.75
205	-40	-38	-38	-40	-40	-38	-39
207.5	-40	-30.08	-34.94	-40	-40	-30.08	-35.85
210	-34.94	-33.01	-38	-34.94	-34.94	-33.01	-34.80666667
212.5	-41	-38	-39	-41	-41	-38	-39.66666667
215	-40	-38	-38	-40	-40	-38	-39
217.5	-38	-38	-34.94	-38	-38	-38	-37.49
220	-40	-38	-38	-40	-40	-38	-39
222.5	-38	-34.94	-34.94	-38	-38	-34.94	-36.47
225	-38	-34.94	-38	-38	-38	-34.94	-36.98
227.5	-39	-38	-39	-39	-39	-38	-38.66666667
230	-41	-39	-38	-41	-41	-39	-39.83333333

Day 3

	11:10	**12:10**	**13:10**	**14:10**	**15:10**	**16:10**	
Freq (MHz)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power Avg. (dBm)
180	13.83	11.59	13.83	13.83	11.59	13.83	13.08333333
182.5	-30.08	-27.9	-30.08	-27.9	-30.08	-30.08	-29.35333333
185	-14.73	-14.73	-14.73	-14.73	-19.38	-19.38	-16.28
187.5	-27.9	-27.9	-30.08	-27.9	-27.9	-27.9	-28.26333333
190	-39	-38	-41	-38	-38	-38	-38.66666667
192.5	-38	-38	-38	-38	-38	-38	-38
195	-30.08	-27.9	-30.08	-30.08	-30.08	-30.08	-29.71666667
197.5	-39	-40	-38	-38	-38	-38	-38.5
200	-33.01	-30.08	-33.01	-30.08	-33.01	-33.01	-32.03333333
202.5	-19.38	-14.73	-19.38	-14.73	-19.38	-19.38	-17.83
205	-39	-39	-38	-39	-38	-39	-38.66666667
207.5	-21.41	-19.38	-14.73	-19.38	-14.73	-19.38	-18.16833333
210	-25.4	-25.4	-27.9	-25.4	-25.4	-30.08	-26.59666667
212.5	-39	-38	-39	-38	-39	-38	-38.5
215	-39	-38	-39	-38	-39	-38	-38.5
217.5	-30.08	-27.9	-30.08	-30.08	-30.08	-30.08	-29.71666667
220	-40	-41	-38	-41	-38	-41	-39.83333333
222.5	-38	-38	-38	-38	-38	-38	-38
225	-39	-38	-38	-38	-38	-38	-38.16666667
227.5	-40	-38	-38	-38	-38	-38	-38.33333333
230	-40	-41	-38	-41	-38	-41	-39.83333333

B.4 230 MHz – 280 MHz

Day 1

	11:15	**12:15**	**13:15**	**14:15**	**15:15**	**16:15**	
Freq (MHz)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power Avg. (dBm)
230	-38	-38	-38	-38	-38	-38	-38
232.5	-41	-41	-41	-41	-41	-41	-41
235	-38	-38	-38	-38	-38	-38	-38
237.5	-41	-41	-41	-41	-41	-41	-41
240	-38	-38	-38	-38	-38	-38	-38
242.5	-41	-41	-41	-41	-41	-41	-41
245	-38	-38	-38	-38	-38	-38	-38
247.5	-41	-41	-41	-41	-41	-41	-41
250	-38	-38	-38	-38	-38	-38	-38
252.5	-41	-41	-41	-41	-41	-41	-41
255	-38	-38	-38	-38	-38	-38	-38
257.5	-41	-41	-41	-41	-41	-41	-41
260	-38	-38	-38	-38	-38	-38	-38
262.5	-41	-41	-41	-41	-41	-41	-41
265	-38	-38	-38	-38	-38	-38	-38
267.5	-41	-41	-41	-41	-41	-41	-41
270	-38	-38	-38	-38	-38	-38	-38
272.5	-40	-40	-40	-40	-40	-40	-40
275	-38	-38	-38	-38	-38	-38	-38
277.5	-39	-39	-39	-39	-39	-39	-39
280	-40	-40	-40	-40	-40	-40	-40

Day 2

	11:15	**12:15**	**13:15**	**14:15**	**15:15**	**16:15**	
Freq (MHz)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power Avg. (dBm)
230	-41	-39	-38	-41	-41	-39	-39.83333333
232.5	-41	-40	-41	-41	-41	-40	-40.66666667
235	-40	-41	-40	-40	-40	-41	-40.33333333
237.5	-40	-40	-41	-40	-40	-40	-40.16666667
240	-41	-41	-38	-41	-41	-41	-40.5
242.5	-41	-38	-39	-41	-41	-38	-39.66666667
245	-40	-41	-38	-40	-40	-41	-40
247.5	-41	-40	-38	-41	-41	-40	-40.16666667
250	-40	-38	-38	-40	-40	-38	-39
252.5	-41	-38	-41	-41	-41	-38	-40
255	-38	-41	-38	-38	-38	-41	-39
257.5	-38	-38	-41	-38	-38	-38	-38.5
260	-39	-41	-38	-39	-39	-41	-39.5
262.5	-39	-38	-41	-39	-39	-38	-39
265	-38	-41	-38	-38	-38	-41	-39
267.5	-41	-38	-41	-41	-41	-38	-40
270	-38	-40	-38	-38	-38	-40	-38.66666667
272.5	-40	-38	-40	-40	-40	-38	-39.33333333
275	-38	-39	-38	-38	-38	-39	-38.33333333
277.5	-39	-40	-39	-39	-39	-40	-39.33333333
280	-41	-38	-40	-41	-41	-38	-39.83333333

Day 3

	11:15	**12:15**	**13:15**	**14:15**	**15:15**	**16:15**	
Freq (MHz)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power Avg. (dBm)
230	-40	-41	-38	-41	-38	-41	-39.83333333
232.5	-40	-41	-41	-41	-39	-38	-40
235	-41	-38	-38	-38	-38	-38	-38.5
237.5	-41	-38	-38	-38	-38	-38	-38.5
240	-41	-38	-38	-38	-38	-38	-38.5
242.5	-38	-41	-41	-41	-38	-38	-39.5
245	-38	-38	-38	-38	-38	-38	-38
247.5	-38	-38	-38	-38	-38	-38	-38
250	-41	-38	-38	-38	-38	-38	-38.5
252.5	-38	-38	-38	-38	-38	-38	-38
255	-38	-38	-38	-38	-38	-38	-38
257.5	-38	-38	-38	-38	-38	-38	-38
260	-38	-38	-38	-38	-38	-38	-38
262.5	-38	-41	-41	-41	-41	-41	-40.5
265	-38	-38	-38	-38	-38	-38	-38
267.5	-38	-38	-38	-38	-38	-38	-38
270	-41	-38	-38	-38	-38	-38	-38.5
272.5	-38	-38	-38	-38	-41	-41	-39
275	-38	-38	-38	-38	-38	-38	-38
277.5	-38	-38	-38	-38	-38	-38	-38
280	-38	-38	-38	-38	-38	-38	-38

B.5 280 MHz – 330 MHz

Day 1

	11:20	**12:20**	**13:20**	**14:20**	**15:20**	**16:20**	
Freq (MHz)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power Avg. (dBm)
280	-40	-40	-40	-40	-40	-40	-40
282.5	-38	-38	-38	-38	-38	-38	-38
285	-39	-39	-39	-39	-39	-39	-39
287.5	-38	-38	-38	-38	-38	-38	-38
290	-39	-39	-39	-39	-39	-39	-39
292.5	-38	-38	-38	-38	-38	-38	-38
295	-40	-40	-40	-40	-40	-40	-40
297.5	-38	-38	-38	-38	-38	-38	-38
300	-40	-40	-40	-40	-40	-40	-40
302.5	-34.94	-34.94	-34.94	-34.94	-34.94	-34.94	-34.94
305	-40	-40	-40	-40	-40	-40	-40
307.5	-38	-38	-38	-38	-38	-38	-38
310	-40	-40	-40	-40	-40	-40	-40
312.5	-38	-38	-38	-38	-38	-38	-38
315	-38	-34.94	-38	-34.94	-38	-34.94	-36.47
317.5	-34.94	-34.94	-34.94	-34.94	-34.94	-34.94	-34.94
320	-38	-38	-38	-38	-38	-38	-38
322.5	-40	-40	-40	-40	-40	-40	-40
325	-38	-38	-38	-38	-38	-38	-38
327.5	-39	-39	-39	-39	-39	-39	-39
330	-40	-40	-40	-40	-40	-40	-40

Day 2

	11:20	**12:20**	**13:20**	**14:20**	**15:20**	**16:20**	
Freq (MHz)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power Avg. (dBm)
280	-41	-38	-40	-41	-41	-38	-39.83333333
282.5	-41	-38	-38	-41	-41	-38	-39.5
285	-40	-38	-39	-40	-40	-38	-39.16666667
287.5	-41	-39	-38	-41	-41	-39	-39.83333333
290	-41	-38	-39	-41	-41	-38	-39.66666667
292.5	-38	-40	-38	-38	-38	-40	-38.66666667
295	-40	-38	-40	-40	-40	-38	-39.33333333
297.5	-41	-40	-38	-41	-41	-40	-40.16666667
300	-40	-40	-40	-40	-40	-40	-40
302.5	-38	-40	-40	-38	-38	-40	-39
305	-40	-38	-40	-40	-40	-38	-39.33333333
307.5	-38	-40	-38	-38	-38	-40	-38.66666667
310	-40	-38	-40	-40	-40	-38	-39.33333333
312.5	-38	-40	-38	-38	-38	-40	-38.66666667
315	-38	-40	-38	-38	-38	-40	-38.66666667
317.5	-38	-38	-39	-38	-38	-38	-38.16666667
320	-38	-40	-38	-38	-38	-40	-38.66666667
322.5	-40	-34.94	-34.94	-40	-40	-34.94	-37.47
325	-38	-39	-38	-38	-38	-39	-38.33333333
327.5	-39	-40	-34.94	-39	-39	-40	-38.65666667
330	-40	-38	-40	-40	-40	-38	-39.33333333

Day 3

	11:20	**12:20**	**13:20**	**14:20**	**15:20**	**16:20**	
Freq (MHz)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power Avg. (dBm)
280	-38	-38	-38	-38	-38	-38	-38
282.5	-41	-38	-39	-40	-41	-38	-39.5
285	-38	-38	-38	-41	-38	-38	-38.5
287.5	-38	-38	-38	-41	-38	-38	-38.5
290	-38	-41	-38	-41	-38	-38	-39
292.5	-41	-38	-41	-38	-41	-38	-39.5
295	-38	-38	-38	-38	-38	-38	-38
297.5	-38	-38	-38	-38	-38	-38	-38
300	-38	-41	-38	-41	-38	-38	-39
302.5	-38	-38	-38	-38	-38	-38	-38
305	-38	-38	-38	-38	-38	-38	-38
307.5	-38	-38	-38	-38	-38	-38	-38
310	-38	-38	-38	-38	-38	-38	-38
312.5	-41	-38	-41	-38	-41	-41	-40
315	-38	-38	-38	-38	-38	-38	-38
317.5	-38	-38	-38	-38	-38	-38	-38
320	-38	-41	-38	-41	-38	-38	-39
322.5	-38	-38	-38	-38	-38	-41	-38.5
325	-38	-38	-38	-38	-38	-38	-38
327.5	-38	-38	-38	-38	-38	-38	-38
330	-38	-41	-38	-38	-38	-38	-38.5

B.6 330 MHz – 380 MHz

Day 1

	11:25	**12:25**	**13:25**	**14:25**	**15:25**	**16:25**	
Freq (MHz)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power Avg. (dBm)
330	-40	-40	-40	-40	-40	-40	-40
332.5	-38	-38	-38	-38	-38	-38	-38
335	-40	-40	-40	-40	-40	-40	-40
337.5	-38	-38	-38	-38	-38	-38	-38
340	-39	-39	-39	-39	-39	-39	-39
342.5	-40	-38	-40	-38	-40	-40	-39.33333333
345	-38	-38	-38	-38	-38	-38	-38
347.5	-40	-40	-40	-40	-40	-40	-40
350	-38	-38	-38	-38	-38	-38	-38
352.5	-39	-39	-39	-39	-39	-39	-39
355	-40	-38	-40	-38	-40	-40	-39.33333333
357.5	-38	-38	-38	-38	-38	-38	-38
360	-40	-40	-40	-40	-40	-40	-40
362.5	-38	-38	-38	-38	-38	-38	-38
365	-39	-39	-39	-39	-39	-39	-39
367.5	-40	-38	-40	-38	-40	-40	-39.33333333
370	-38	-38	-38	-38	-38	-38	-38
372.5	-40	-40	-40	-40	-40	-40	-40
375	-38	-38	-38	-38	-38	-38	-38
377.5	-40	-40	-40	-40	-40	-40	-40
380	-38	-38	-38	-38	-38	-38	-38

Day 2

	11:25	**12:25**	**13:25**	**14:25**	**15:25**	**16:25**	
Freq (MHz)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power Avg. (dBm)
330	-40	-38	-40	-40	-40	-38	-39.33333333
332.5	-40	-40	-38	-40	-40	-40	-39.66666667
335	-40	-38	-40	-40	-40	-38	-39.33333333
337.5	-40	-39	-38	-40	-40	-39	-39.33333333
340	-41	-38	-39	-41	-41	-38	-39.66666667
342.5	-40	-38	-40	-40	-40	-38	-39.33333333
345	-40	-40	-38	-40	-40	-40	-39.66666667
347.5	-40	-38	-40	-40	-40	-38	-39.33333333
350	-38	-39	-38	-38	-38	-39	-38.33333333
352.5	-39	-38	-39	-39	-39	-38	-38.66666667
355	-38	-38	-40	-38	-38	-38	-38.33333333
357.5	-39	-40	-38	-39	-39	-40	-39.16666667
360	-40	-38	-40	-40	-40	-38	-39.33333333
362.5	-38	-39	-38	-38	-38	-39	-38.33333333
365	-39	-38	-39	-39	-39	-38	-38.66666667
367.5	-40	-38	-40	-40	-40	-38	-39.33333333
370	-38	-40	-38	-38	-38	-40	-38.66666667
372.5	-40	-38	-40	-40	-40	-38	-39.33333333
375	-38	-40	-38	-38	-38	-40	-38.66666667
377.5	-40	-38	-40	-40	-40	-38	-39.33333333
380	-41	-38	-38	-41	-41	-38	-39.5

Day 3

	11:25	12:25	13:25	14:25	15:25	16:25	
Freq (MHz)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power Avg. (dBm)
330	-38	-41	-38	-38	-38	-38	-38.5
332.5	-38	-41	-41	-39	-38	-38	-39.16666667
335	-38	-38	-38	-41	-38	-38	-38.5
337.5	-38	-38	-38	-41	-38	-38	-38.5
340	-41	-38	-38	-41	-38	-38	-39
342.5	-38	-41	-41	-38	-41	-38	-39.5
345	-38	-38	-38	-38	-38	-38	-38
347.5	-38	-38	-38	-38	-38	-38	-38
350	-41	-38	-38	-41	-38	-38	-39
352.5	-38	-38	-38	-38	-38	-38	-38
355	-38	-38	-38	-38	-38	-38	-38
357.5	-38	-38	-38	-38	-38	-38	-38
360	-38	-38	-38	-38	-38	-38	-38
362.5	-38	-41	-41	-38	-41	-41	-40
365	-38	-38	-38	-38	-38	-38	-38
367.5	-38	-38	-38	-38	-38	-38	-38
370	-41	-38	-38	-41	-38	-38	-39
372.5	-38	-38	-38	-38	-38	-41	-38.5
375	-38	-38	-38	-38	-38	-38	-38
377.5	-38	-38	-38	-38	-38	-38	-38
380	-41	-38	-38	-38	-38	-38	-38.5

B.7 380 MHz – 430 MHz

Day 1

	11:30	12:30	13:30	14:30	15:30	16:30	
Freq (MHz)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power Avg. (dBm)
380	-38	-38	-38	-38	-38	-38	-38
382.5	-38	-38	-38	-38	-38	-38	-38
385	-40	-40	-40	-40	-40	-40	-40
387.5	-38	-38	-38	-38	-38	-38	-38
390	-39	-39	-39	-39	-39	-39	-39
392.5	-40	-38	-40	-38	-40	-40	-39.33333333
395	-38	-38	-38	-38	-38	-38	-38
397.5	-40	-40	-40	-40	-40	-40	-40
400	-38	-38	-38	-38	-38	-38	-38
402.5	-39	-39	-39	-39	-39	-39	-39
405	-40	-38	-40	-38	-40	-40	-39.33333333
407.5	-38	-38	-38	-38	-38	-38	-38
410	-40	-40	-40	-40	-40	-40	-40
412.5	-38	-38	-38	-38	-38	-38	-38
415	-39	-39	-39	-39	-39	-39	-39
417.5	-40	-38	-40	-38	-40	-40	-39.33333333
420	-38	-38	-38	-38	-38	-38	-38
422.5	-40	-40	-40	-40	-40	-40	-40
425	-38	-38	-38	-38	-38	-38	-38
427.5	-40	-40	-40	-40	-40	-40	-40
430	-38	-38	-38	-38	-38	-38	-38

Day 2

	11:30	**12:30**	**13:30**	**14:30**	**15:30**	**16:30**	
Freq (MHz)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power Avg. (dBm)
380	-41	-38	-38	-41	-41	-38	-39.5
382.5	-41	-40	-38	-41	-41	-40	-40.16666667
385	-40	-38	-40	-40	-40	-38	-39.33333333
387.5	-40	-39	-38	-40	-40	-39	-39.33333333
390	-41	-38	-39	-41	-41	-38	-39.66666667
392.5	-40	-38	-40	-40	-40	-38	-39.33333333
395	-40	-40	-38	-40	-40	-40	-39.66666667
397.5	-40	-38	-40	-40	-40	-38	-39.33333333
400	-40	-39	-38	-40	-40	-39	-39.33333333
402.5	-39	-38	-39	-39	-39	-38	-38.66666667
405	-38	-38	-40	-38	-38	-38	-38.33333333
407.5	-38	-40	-38	-38	-38	-40	-38.66666667
410	-39	-38	-40	-39	-39	-38	-38.83333333
412.5	-38	-39	-38	-38	-38	-39	-38.33333333
415	-39	-38	-39	-39	-39	-38	-38.66666667
417.5	-38	-38	-40	-38	-38	-38	-38.33333333
420	-38	-40	-38	-38	-38	-40	-38.66666667
422.5	-39	-38	-40	-39	-39	-38	-38.83333333
425	-38	-40	-38	-38	-38	-40	-38.66666667
427.5	-38	-38	-40	-38	-38	-38	-38.33333333
430	-40	-40	-38	-40	-40	-40	-39.66666667

Day 3

	11:30	**12:30**	**13:30**	**14:30**	**15:30**	**16:30**	
Freq (MHz)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power Avg. (dBm)
380	-41	-38	-38	-38	-38	-38	-38.5
382.5	-38	-41	-40	-41	-41	-38	-39.83333333
385	-38	-38	-41	-38	-38	-38	-38.5
387.5	-38	-38	-41	-38	-38	-38	-38.5
390	-38	-38	-41	-38	-38	-38	-38.5
392.5	-38	-41	-38	-41	-41	-38	-39.5
395	-38	-38	-38	-38	-38	-38	-38
397.5	-38	-38	-38	-38	-38	-38	-38
400	-38	-38	-41	-38	-38	-38	-38.5
402.5	-38	-38	-38	-38	-38	-38	-38
405	-38	-38	-38	-38	-38	-38	-38
407.5	-38	-38	-38	-38	-38	-38	-38
410	-38	-38	-38	-38	-38	-38	-38
412.5	-41	-41	-38	-41	-41	-41	-40.5
415	-38	-38	-38	-38	-38	-38	-38
417.5	-38	-38	-38	-38	-38	-38	-38
420	-38	-38	-41	-38	-38	-38	-38.5
422.5	-41	-38	-38	-38	-38	-41	-39
425	-38	-38	-38	-38	-38	-38	-38
427.5	-38	-38	-38	-38	-38	-38	-38
430	-38	-38	-38	-38	-38	-38	-38

B.8 430 MHz – 480 MHz

Day 1

	11:35	12:35	13:35	14:35	15:35	16:35	
Freq (MHz)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power Avg. (dBm)
430	-38	-38	-38	-38	-38	-38	-38
432.5	-40	-39	-39	-39	-39	-39	-39.16666667
435	-38	-38	-40	-38	-40	-40	-39
437.5	-39	-38	-38	-38	-38	-38	-38.16666667
440	-40	-40	-40	-40	-40	-40	-40
442.5	-38	-38	-38	-38	-38	-38	-38
445	-40	-39	-39	-39	-39	-39	-39.16666667
447.5	-38	-38	-40	-38	-40	-40	-39
450	-39	-38	-38	-38	-38	-38	-38.16666667
452.5	-40	-39	-39	-39	-39	-39	-39.16666667
455	-38	-38	-40	-38	-40	-40	-39
457.5	-40	-38	-38	-38	-38	-38	-38.33333333
460	-38	-40	-40	-40	-40	-40	-39.66666667
462.5	-40	-38	-38	-38	-38	-38	-38.33333333
465	-38	-39	-39	-39	-39	-39	-38.83333333
467.5	-38	-38	-40	-38	-40	-40	-39
470	-4.31	-4.31	-4.31	-4.31	-4.31	-4.31	-4.31
472.5	-34.94	-34.94	-34.94	-34.94	-34.94	-34.94	-34.94
475	-34.94	-34.94	-34.94	-34.94	-34.94	-34.94	-34.94
477.5	-14.73	-14.73	-14.73	-14.73	-14.73	-14.73	-14.73
480	-33.01	-33.01	-34.94	-39	-34.94	-34.94	-34.97333333

Day 2

	11:35	12:35	13:35	14:35	15:35	16:35	
Freq (MHz)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power Avg. (dBm)
430	-40	-40	-38	-40	-40	-40	-39.66666667
432.5	-40	-38	-39	-40	-40	-38	-39.16666667
435	-41	-38	-40	-41	-41	-38	-39.83333333
437.5	-39	-40	-38	-39	-39	-40	-39.16666667
440	-40	-38	-40	-40	-40	-38	-39.33333333
442.5	-40	-39	-38	-40	-40	-39	-39.33333333
445	-40	-38	-39	-40	-40	-38	-39.16666667
447.5	-38	-38	-40	-38	-38	-38	-38.33333333
450	-39	-39	-38	-39	-39	-39	-38.83333333
452.5	-39	-38	-39	-39	-39	-38	-38.66666667
455	-38	-38	-40	-38	-38	-38	-38.33333333
457.5	-39	-40	-38	-39	-39	-40	-39.16666667
460	-38	-38	-40	-38	-38	-38	-38.33333333
462.5	-39	-39	-38	-39	-39	-39	-38.83333333
465	-39	-38	-39	-39	-39	-38	-38.66666667
467.5	-38	-39	-40	-38	-38	-39	-38.66666667
470	-10.08	-8.001	-1.88	-10.08	-10.08	-8.001	-8.020333333
472.5	-39	-34.94	-30.08	-33.01	-39	-34.94	-35.16166667
475	-27.9	-30.08	-27.9	-27.9	-27.9	-30.08	-28.62666667
477.5	-10.08	-8.001	-8.001	-10.08	-10.08	-8.001	-9.0405
480	-33.01	-34.94	-33.01	-33.01	-33.01	-34.94	-33.65333333

Day 3

	11:35	**12:35**	**13:35**	**14:35**	**15:35**	**16:35**	
Freq (MHz)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power Avg. (dBm)
430	-38	-38	-38	-38	-38	-38	-38
432.5	-38	-41	-41	-40	-41	-41	-40.33333333
435	-38	-38	-38	-41	-38	-38	-38.5
437.5	-38	-38	-38	-41	-38	-38	-38.5
440	-38	-38	-38	-41	-38	-38	-38.5
442.5	-38	-41	-41	-38	-41	-41	-40
445	-41	-38	-38	-38	-38	-38	-38.5
447.5	-38	-38	-38	-38	-38	-38	-38
450	-38	-38	-38	-41	-38	-38	-38.5
452.5	-38	-38	-38	-38	-38	-38	-38
455	-41	-38	-38	-38	-38	-38	-38.5
457.5	-38	-38	-38	-38	-38	-38	-38
460	-38	-38	-38	-38	-38	-38	-38
462.5	-38	-41	-41	-38	-41	-41	-40
465	-39	-38	-38	-38	-38	-38	-38.16666667
467.5	-40	-38	-38	-38	-38	-38	-38.33333333
470	-10.008	-8.001	-10.008	-12.34	-10.008	-10.008	-10.06216667
472.5	-23.4	-23.4	-23.4	-25.4	-23.4	-23.4	-23.73333333
475	-10.008	-10.008	-10.008	-12.34	-10.008	-10.008	-10.39666667
477.5	9.66	11.59	9.66	9.66	9.66	9.66	9.981666667
480	-10.008	-10.008	-10.008	-8.001	-10.008	-10.008	-9.6735

B.9 480 MHz – 500 MHz

Day 1

	11:40	12:40	13:40	14:40	15:40	16:40	
Freq (MHz)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power Avg. (dBm)
480	-33.01	-33.01	-34.94	-39	-34.94	-34.94	-34.97333333
482.5	-38	-41	-38	-34.94	-34.94	-34.94	-36.97
485	-38	-38	-38	-38	-38	-38	-38
487.5	-38	-38	-40	-38	-40	-40	-39
490	-38	-38	-40	-38	-40	-40	-39
492.5	-38	-38	-38	-38	-38	-38	-38
495	-38	-40	-40	-40	-40	-40	-39.66666667
497.5	-38	-38	-38	-38	-38	-38	-38
500	-38	-39	-39	-39	-39	-39	-38.83333333

Day 2

	11:40	12:40	13:40	14:40	15:40	16:40	
Freq (MHz)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power Avg. (dBm)
480	-33.01	-34.94	-33.01	-33.01	-33.01	-34.94	-33.65333333
482.5	-38	-41	-38	-38	-38	-41	-39
485	-34.94	-34.94	-34.94	-34.94	-34.94	-34.94	-34.94
487.5	-38	-38	-38	-38	-38	-38	-38
490	-39	-38	-40	-39	-39	-38	-38.83333333
492.5	-38	-40	-38	-38	-38	-40	-38.66666667
495	-38	-38	-40	-38	-38	-38	-38.33333333
497.5	-39	-39	-38	-39	-39	-39	-38.83333333
500	-38	-38	-39	-38	-38	-38	-38.16666667

Day 3

	11:40	**12:40**	**13:40**	**14:40**	**15:40**	**16:40**	
Freq (MHz)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power Avg. (dBm)
480	-10.008	-10.008	-10.008	-8.001	-10.008	-10.008	-9.6735
482.5	-41	-41	-41	-38	-41	-41	-40.5
485	-30.08	-30.08	-30.08	-38	-30.08	-30.08	-31.4
487.5	-38	-38	-38	-38	-38	-38	-38
490	-38	-38	-38	-38	-38	-38	-38
492.5	-38	-38	-38	-38	-41	-41	-39
495	-38	-41	-41	-38	-38	-38	-39
497.5	-38	-38	-38	-38	-38	-38	-38
500	-38	-38	-38	-38	-38	-38	-38

Appendix-C

Readings for Bands analyzed specifically

C.1 85 MHz - 112 MHz

Frequency (MHz)	Power (dBm)		Frequency (MHz)	Power (dBm)		Frequency (MHz)	Power (dBm)
85	-39		94.3	-10.08		103.16	-25.4
85.1	-38		94.35	-33.01		103.2	-38
85.2	-39		94.4	-38		103.3	-39
85.3	-38		94.5	-40		103.4	-33.01
85.4	-39		94.6	-41		103.45	-40
85.5	-39		94.7	-39		103.5	-33.01
85.6	-39		94.8	-40		103.6	-33.01
85.7	-38		94.9	-38		103.65	-0.462
85.8	-38		95	-10.08		103.7	-14.73
85.9	-39		95.1	-0.462		103.8	-40
86	-38		95.15	-38		103.9	-41
86.1	-38		95.2	-38		103.95	-34.94
86.2	-38		95.3	-38		104	-38
86.3	-38		95.4	-39		104.06	-34.94
86.4	-39		95.5	-38		104.1	-40
86.5	-39		95.6	-39		104.2	-40
86.6	-38		95.7	-38		104.3	-40
86.7	-39		95.8	-39		104.4	-40
86.8	-34.94		95.9	-40		104.5	-40
86.9	-34.94		96	-41		104.6	-40
87	-34.94		96.02	-27.9		104.7	-39
87.1	-38		96.1	-38		104.75	-25.4
87.2	-39		96.2	-38		104.8	-1.88
87.3	-39		96.3	-39		104.9	-38
87.4	-39		96.4	-38		105	-39
87.5	-39		96.5	-39		105.1	-40
87.6	-38		96.6	-38		105.2	-40
87.7	-37		96.7	-39		105.3	-40
87.8	-38		96.8	-40		105.4	-40
87.9	-38		96.9	-41		105.5	-40
87.95	-30.08		97	-40		105.55	-1.88
88	-34.94		97.1	-38		105.6	-0.462
88.1	-38		97.2	-38		105.65	-39
88.2	-38		97.3	-39		105.7	-39

88.3	-39		97.4	-38		105.8	-40
88.4	-39		97.5	-39		105.9	-40
88.5	-39		97.6	-38		106	-39
88.6	-39		97.7	-39		106.1	-39
88.7	-38		97.8	-40		106.2	-40
88.8	-37		97.9	-41		106.3	-40
88.9	-38		98	-40		106.4	-21.41
89	-38		98.1	-39		106.45	-6.16
89.1	-38		98.2	-38		106.5	-38
89.2	-38		98.33	-8.01		106.6	-39
89.3	-39		98.3	-21.41		106.7	-40
89.4	-39		98.4	-39		106.8	-40
89.5	-39		98.5	-38		106.9	-40
89.6	-39		98.6	-39		107	-40
89.7	-38		98.7	-40		107.1	-40
89.8	-37		98.8	-41		107.15	-6.16
89.9	-38		98.9	-39		107.2	-0.462
90	-38		99	-40		107.3	11.4
90.1	-37		99.1	-39		107.4	-38
90.2	-38		99.2	-38		107.5	-40
90.3	-38		99.3	-39		107.6	-40
90.35	-37.02		99.4	-40		107.7	-40
90.4	-38		99.5	-41		107.8	-30.08
90.45	-23.4		99.6	-39		107.85	-25.4
90.5	-38		99.7	-40		107.9	-40
90.6	-39		99.8	-39		108	-30.08
90.7	-38		99.9	-40		108.1	-38
90.8	-39		99.96	-33.01		108.2	-39
90.9	-38		100	-27.9		108.3	-40
91	-39		100.02	-41		108.4	-40
91.1	-38		100.1	-12.34		108.5	-40
91.2	-38		100.15	-41		108.6	-40
91.3	-41		100.2	-30.08		108.7	-40
91.4	-38		100.3	-40		108.8	-38
91.5	-41		100.4	-40		108.9	-39
91.6	-38		100.5	-34.93		109	-40
91.7	-40		100.55	1.95		109.1	-40
91.8	-40		100.6	-34.93		109.2	-40
91.85	-33.01		100.7	-40		109.3	-40
91.9	-15		100.8	-39		109.4	-40
91.95	-38		100.9	-40		109.5	-38
92	-33.01		101	-41		109.6	-39
92.1	-41		101.1	-40		109.7	-40
92.12	-33.01		101.2	-38		109.8	-40
92.2	-40		101.3	-40		109.9	-40
92.3	-39		101.35	-33.01		110	-40
92.4	-39		101.4	-12.34		110.1	-40
92.5	-39		101.45	-4.31		110.2	-38
92.6	-38		101.5	-38		110.3	-39

92.65	-25.4		101.6	-40		110.4	-40
92.7	-10.08		101.78	-38		110.5	-40
92.75	-30.08		101.7	-39		110.6	-40
92.8	-38		101.8	-33.01		110.7	-40
92.9	-39		101.9	-39		110.8	-40
93	-38		102	-40		110.9	-38
93.1	-37		102.1	-40		111	-39
93.2	-38		102.2	-40		111.1	-40
93.3	-38		102.3	-40		111.2	-40
93.4	-38		102.4	-40		111.3	-40
93.5	-38		102.5	-40		111.4	-40
93.6	-39		102.6	-40		111.5	-40
93.7	-38		102.7	-27.9		111.6	-38
93.8	-39		102.75	-10.08		111.7	-39
93.9	-38		102.8	-27.9		111.8	-40
94	-39		102.9	-40		111.9	-40
94.1	-41		103	-39		112	-40
94.2	-41		103.1	-25.4			
94.25	-19.38		103.12	-12.34			

C.2 174 MHz- 230 MHz

Frequency (MHz)	Power (dBm)		Frequency (MHz)	Power (dBm)		Frequency (MHz)	Power (dBm)
174	-40		193.5	-38		212.5	-38
174.5	-41		194	-38		213	-38
175	-41		194.5	-40		213.5	-38
175.5	-41		195	-40		214	-38
176	-38		195.5	-41		214.5	-40
176.5	-38		196	-34.94		215	-41
177	-38		196.25	-23.4		215.5	-41
177.5	-38		196.5	-34.94		216	-39
178	-38		197	-39		216.5	-38
178.5	-38		197.5	-38		217	-38
179	-38		198	-38		217.5	-33.01
179.5	-40		198.5	-38		218	-39
180	-40		199	-38		218.5	-38
180.5	-40		199.5	-40		219	-39
181	-40		200	-38		219.5	-38
181.5	-25.4		200.5	-38		220	-40
182	4.37		201	-38		220.5	-38
182.225	15.93		201.5	-38		221	-39
182.5	4.37		202	-38		221.5	-41
183	-21.41		202.5	-33.01		222	-41
183.5	-27.22		203	-33.01		222.5	-39
184	-33.01		203.5	-19.38		222.75	-33.01
184.5	-21.41		204	-38		223	-39
185	-21.41		204.5	-39		223.5	-39
185.5	-38		205	-39		224	-39
186	-38		205.5	-39		224.5	-38
186.5	-19.38		206	-39		225	-40
187	-34.94		206.5	-39		225.5	-38
187.5	2.49		207	-39		226	-39
188	-0.462		207.5	-39		226.5	-41
188.5	-34.94		208	-38		227	-41
189	-40		208.5	-33.01		227.5	-39
189.5	-40		208.75	-19.38		228	-39
190	-40		209	-38		228.5	-39
190.5	-40		209.5	-38		229	-38
191	-40		210	-38		229.5	-40
191.5	-38		210.5	-38		230	-38
192	-38		211	-38			
192.5	-38		211.5	-38			
193	-38		212	-38			

C.3 470 MHz to 486 MHz

Frequency (MHz)	Power (dBm)		Frequency (MHz)	Power (dBm)		Frequency (MHz)	Power (dBm)
470	-38		475.4	-21.41		480.8	-68.08
470.1	-27.9		475.5	-14.73		480.9	-68.08
470.2	-21.41		475.6	-21.41		481	-68.08
470.3	-19.38		475.7	-23.4		481.1	-61.4
470.4	-19.38		475.8	-27.9		481.2	-61.4
470.5	-17.16		475.9	-33.01		481.3	-61.4
470.6	-12.34		476	-27.9		481.4	-61.4
470.7	-10.08		476.1	-21.41		481.5	-61.4
470.8	-8.04		476.2	-14.73		481.6	-61.4
470.9	-0.462		476.3	-8.001		481.7	-61.4
471	4.37		476.4	1.95		481.8	-61.4
471.1	11.59		476.5	6.45		481.9	-61.4
471.2	13.83		476.6	11.59		482	-61.4
471.3	15.93		476.7	13.83		482.1	-55.16
471.4	9.66		476.8	9.66		482.2	-55.16
471.5	1.95		476.9	4.37		482.3	-55.16
471.6	-4.31		477	-1.88		482.4	-55.16
471.7	-10.08		477.1	-1.88		482.5	-55.16
471.8	-12.34		477.2	-10.08		482.6	-55.16
471.9	-14.73		477.3	-17.16		482.7	-55.16
472	-23.4		477.4	-23.4		482.8	-55.16
472.1	-25.4		477.5	-30.08		482.9	-55.16
472.2	-27.9		477.6	-34.94		483	-55.16
472.3	-30.08		477.7	-38		483.1	-38
472.4	-33.01		477.8	-38		483.2	-39
472.5	-33.01		477.9	-38		483.3	-40
472.6	-33.01		478	-38		483.4	-34.94
472.7	-33.01		478.1	-38		483.5	-33.01
472.8	-33.01		478.2	-38		483.6	-27.9
472.9	-33.01		478.3	-38		483.7	-21.41
473	-33.01		478.4	-38		483.8	-25.4
473.1	-49.67		478.5	-38		483.9	-34.94
473.2	-49.67		478.6	-38		484	-38
473.3	-49.67		478.7	-33.01		484.1	-38
473.4	-49.67		478.8	-21.41		484.2	-38
473.5	-49.67		478.9	-14.73		484.3	-34.94

473.6	-49.67		479	-8.001		484.4	-30.08
473.7	-49.67		479.1	-0.462		484.5	-19.38
473.8	-49.67		479.2	-1.88		484.6	-12.34
473.9	-49.67		479.3	-4.31		484.7	-8.001
474	-49.67		479.4	-12.34		484.8	-6.16
474.1	-73.48		479.5	-17.16		484.9	-12.34
474.2	-73.48		479.6	-21.41		485	-19.38
474.3	-73.48		479.7	-30.08		485.1	-27.9
474.4	-73.48		479.8	-34.94		485.2	-34.94
474.5	-73.48		479.9	-38		485.3	-39
474.6	-73.48		480	-38		485.4	-38
474.7	-73.48		480.1	-68.08		485.5	-39
474.8	-73.48		480.2	-68.08		485.6	-39
474.9	-73.48		480.3	-68.08		485.7	-39
475	-73.48		480.4	-68.08		485.8	-39
475.1	-33.01		480.5	-68.08		485.9	-39
475.2	-30.08		480.6	-68.08		486	-39
475.3	-25.4		480.7	-68.08			

Appendix-D

MATLAB commands used

xlsread: To read Microsoft Excel spreadsheet file.

Syntax:

```
num = xlsread(filename)
num = xlsread(filename,sheet)
num = xlsread(filename,xlRange)
num = xlsread(filename,sheet,xlRange)
```

mesh: mesh(X,Y,Z) draws a wireframe mesh with color determined by Z, so color is proportional to surface height.

Syntax:

```
mesh (X,Y,Z)
```

plot: Graph 2D with linear scales for both axes.

Syntax:

```
plot(X,Y)
plot(X,Y,LineSpec)
plot(Y,LineSpec)
plot(axes_handle,___)
```

Appendix-E

Table of rules used to arrive at Decision

S.No.	Received Signal Strength	Velocity	Transmission Power	Distance	Decision
1	Low	Low	Low	Low	High
2	Low	Low	Low	Medium	High
3	Low	Low	Low	High	Medium
4	Low	Low	Medium	Low	High
5	Low	Low	Medium	Medium	High
6	Low	Low	Medium	High	Medium
7	Low	Low	High	Low	Medium
8	Low	Low	High	Medium	Medium
9	Low	Low	High	High	Low
10	Low	Medium	Low	Low	High
11	Low	Medium	Low	Medium	High
12	Low	Medium	Low	High	Low
13	Low	Medium	Medium	Low	High
14	Low	Medium	Medium	Medium	High
15	Low	Medium	Medium	High	Medium
16	Low	Medium	High	Low	Medium
17	Low	Medium	High	Medium	Low
18	Low	Medium	High	High	Low
19	Low	High	Low	Low	High
20	Low	High	Low	Medium	High
21	Low	High	Low	High	High
22	Low	High	Medium	Low	High
23	Low	High	Medium	Medium	High
24	Low	High	Medium	High	High
25	Low	High	High	Low	Medium
26	Low	High	High	Medium	Medium
27	Low	High	High	High	High
28	Medium	Low	Low	Low	Medium
29	Medium	Low	Low	Medium	Medium
30	Medium	Low	Low	High	Medium
31	Medium	Low	Medium	Low	Medium
32	Medium	Low	Medium	Medium	Medium
33	Medium	Low	Medium	High	Medium
34	Medium	Low	High	Low	Medium
35	Medium	Low	High	Medium	Medium
36	Medium	Low	High	High	Medium
37	Medium	Medium	Low	Low	Medium
38	Medium	Medium	Low	Medium	Medium

39	Medium	Medium	Low	High	Medium
40	Medium	Medium	Medium	Low	Medium
41	Medium	Medium	Medium	Medium	Medium
42	Medium	Medium	Medium	High	Medium
43	Medium	Medium	High	Low	Medium
44	Medium	Medium	High	Medium	Medium
45	Medium	Medium	High	High	High
46	Medium	High	Low	Low	High
47	Medium	High	Low	Medium	Medium
48	Medium	High	Low	High	High
49	Medium	High	Medium	Low	High
50	Medium	High	Medium	Medium	Medium
51	Medium	High	Medium	High	Medium
52	Medium	High	High	Low	Medium
53	Medium	High	High	Medium	Medium
54	Medium	High	High	High	Low
55	High	Low	Low	Low	Low
56	High	Low	Low	Medium	Low
57	High	Low	Low	High	Low
58	High	Low	Medium	Low	Low
59	High	Low	Medium	Medium	Low
60	High	Low	Medium	High	Low
61	High	Low	High	Low	Low
62	High	Low	High	Medium	Low
63	High	Low	High	High	Low
64	High	Medium	Low	Low	Low
65	High	Medium	Low	Medium	Low
66	High	Medium	Low	High	Low
67	High	Medium	Medium	Low	Low
68	High	Medium	Medium	Medium	Low
69	High	Medium	Medium	High	Low
70	High	Medium	High	Low	Low
71	High	Medium	High	Medium	Low
72	High	Medium	High	High	Low
73	High	High	Low	Low	Low
74	High	High	Low	Medium	Low
75	High	High	Low	High	Low
76	High	High	Medium	Low	Low
77	High	High	Medium	Medium	Low
78	High	High	Medium	High	Low
79	High	High	High	Low	Low
80	High	High	High	Medium	Low
81	High	High	High	High	Low

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