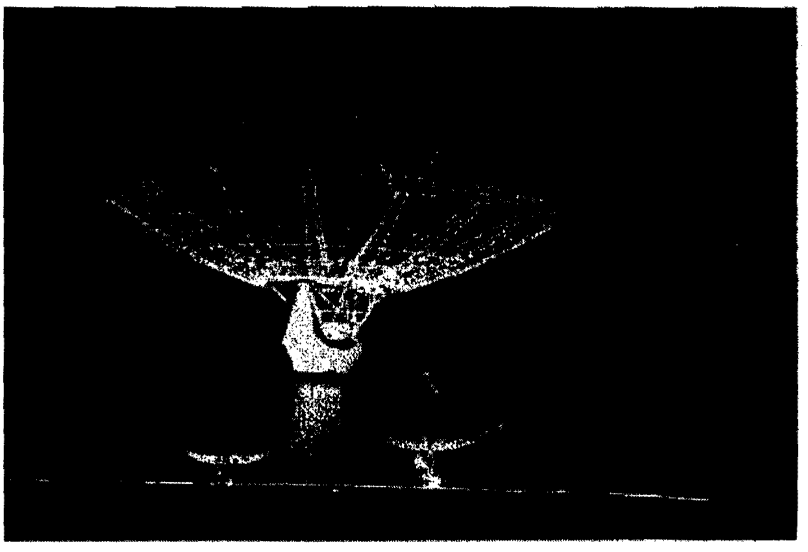
PROJECT REPORT

Developement of green PC



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STP 2003.

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I sincerely thank ***Prof. S. Ananthakrishnan,*** *observatory director, GMRT and* ***Mr.A.B.Joshi,****P.A. To Centre Director, for giving me an opportunity to work at GMRT project site.*

I am indebted to my project guide ***Mr. Ajith Kumar B.*** *& subguide* ***Mr.Pravin Raybole*** *for giving their full support and their immense help during the project.*

I would like to express sincere gratitude towards, Mr. Sandeep Parkhi, Mr. Prakash Hande, Mr.Ramdas, Mr. Sateesh lokhande and other Baseband lab members for keenly following up my progress in the project work. I am thankful to GMRT staff for giving their full co-operation during the project.

Submitted by:-

Himanshu choudhary

INTRODUCTION

Radio astronomy is defined as the astronomy based on the reception of radio waves of cosmic origin. The radiation measured in radio astronomy has in almost all cases a Gaussian probability distribution in amplitude. Generally it cannot be distinguished from thermal noise radiation of the earth or its atmosphere, or from the noise generated in a receiver.

In radio astronomy observation the signal to noise ratio in the radio frequency(RF) and intermediate frequency (IF) parts of the receiver is typically in the range –20 dB to -60 dB, i.e. the power contributed by the source under study is a factor of 10^{-2} to 10^{-6} of the unwanted noise power from the atmosphere, the ground and the receiver circuits.

Because radio astronomy signals are so weak in comparison to those of other services, radio astronomy observations are highly vulnerable to radio interference, and to exacerbate the problem cosmic signals generally have no characteristic modulation that would help to distinguish them from noise or from many forms of interfering signals.

The main observing instrument at NCRA is the Giant Meterwave Radio Telescope (GMRT), comprising of 30 different parabolic antenna making observations at frequencies ranging from 50 MHz to 1500 MHz.

The personal computer and the workstation in the main observatory building and offices are a source of Electromagnetic interference with the astronomical observations. The central square antennas of the telescope are situated near to the observatory control building making it even more susceptible to low level interference.

The aim of this project is to limit the RF emission from personal computers to an acceptable level. This is achieved by shielding PC unit with a conductive material to reduce EMI reflections or absorption i.e. the design of a Faraday cage. According to the measurement that is available in GMRT virtually all the emissions appeared to be generated by the main processor unit with the very little contributions from monitor, key board and other peripherals.

PROJECT DEFINITION

The setup for development of green PC consist of:

- Permanent portable measuring setup with whip aerials.
- Measurements of mesh type shielding cage.
- New aluminium enclosure as a improvement to mesh type.

MEASURING SETUP

Initially a measuring setup is configured to check the shielding efficiency. To cover the frequency range of 100 MHz to 1GHz, we require voltage controlled oscillator (VCO) working at different range of frequencies in which the output frequency of oscillator changes according to the input voltage, the frequency can be varied using variable potentiometer. .The potentiometer is 10 Kohm. A switch mechanism is provide to select the desired VCO. The circuit diagram of the VCO is shown in fig. 1.

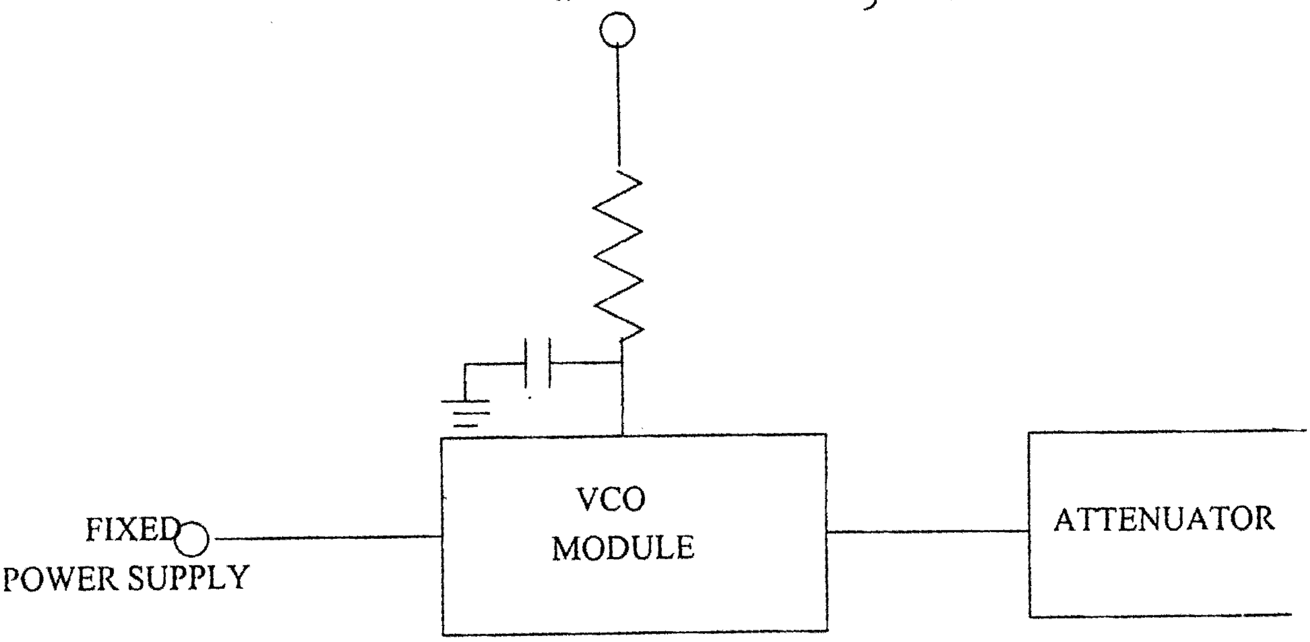


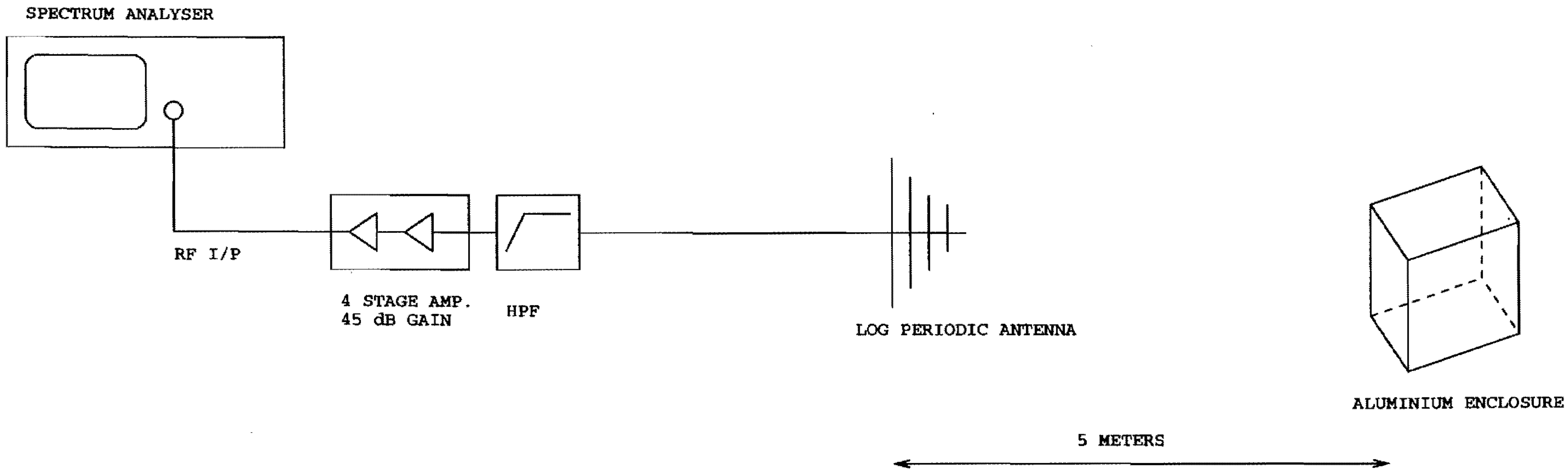
Fig. 1

The whole setup consist of:-

1. VCO 1 (100 MHz to 200 MHz)
2. VCO 2 (200 MHz to 350 MHz)
3. VCO 3 (400 MHz to 620 MHz)
4. VCO 4 (900 MHz to 1600 MHz)
5. 4 way combiner
6. 12 volt battery
7. Whip aerials

The block diagram of the measuring setup is shown in fig. 2. Fig 3-6 show the frequency vs voltage graph of all 4 VCOs. Fig 7-10 represent the power vs frequency graph.

TEST SETUP FOR " SHIELDED CAGE PROTO TYPE– II " FOR EMI RFI MEASUREMENT



TEST SETUP FOR MEASURING RADIATION LOSS USING OMNI DIRECTIONAL ANTENNAS.

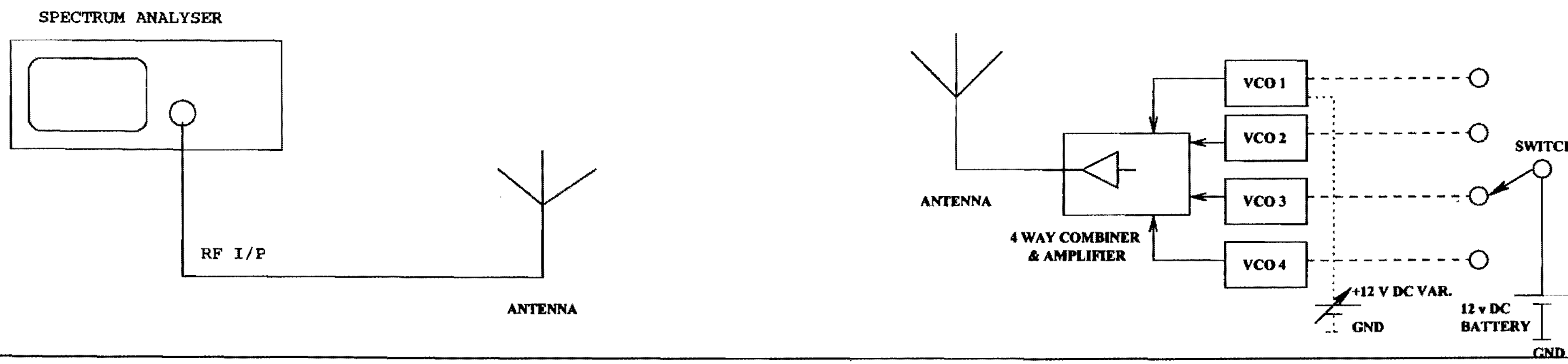


FIG. 2

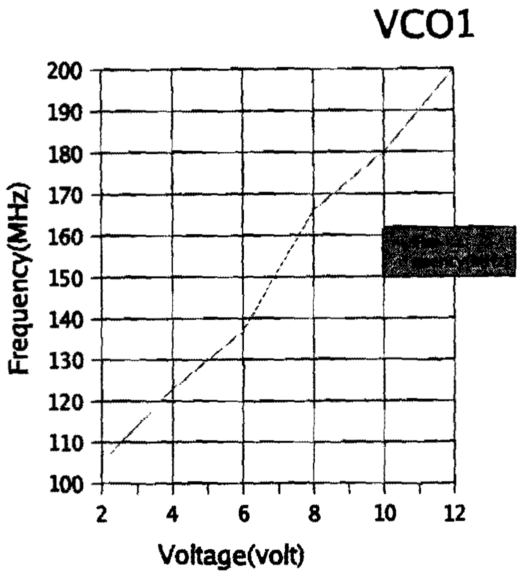


Fig. 3

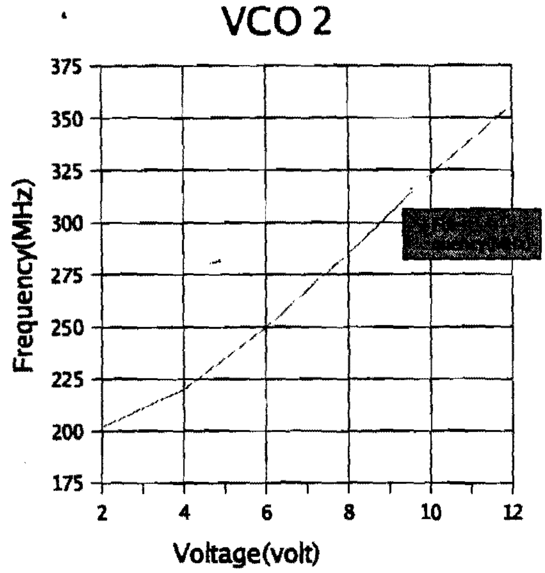


Fig.4

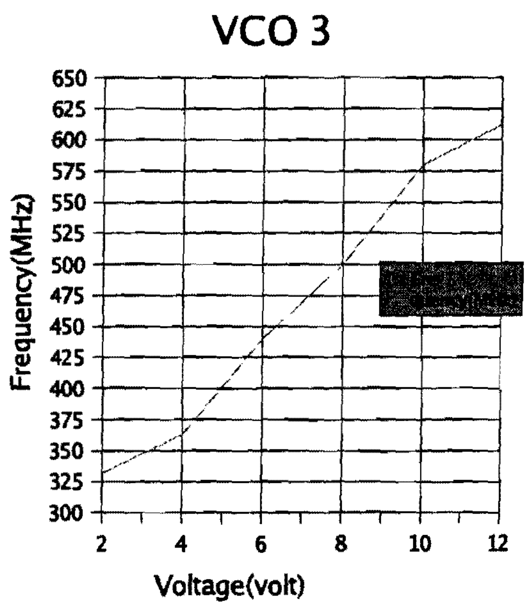


Fig. 5

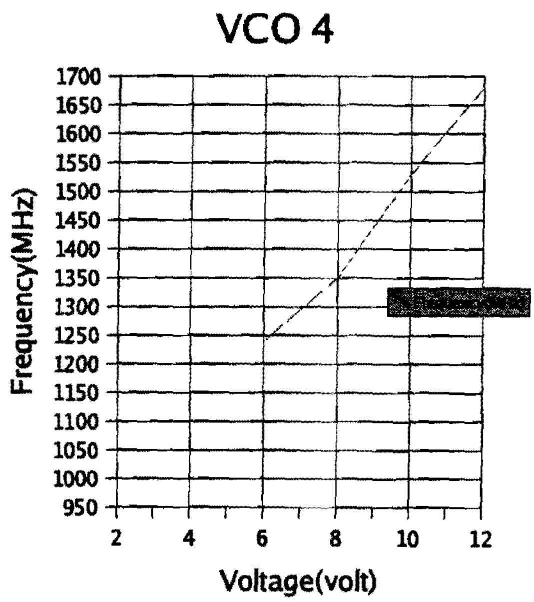


Fig. 6

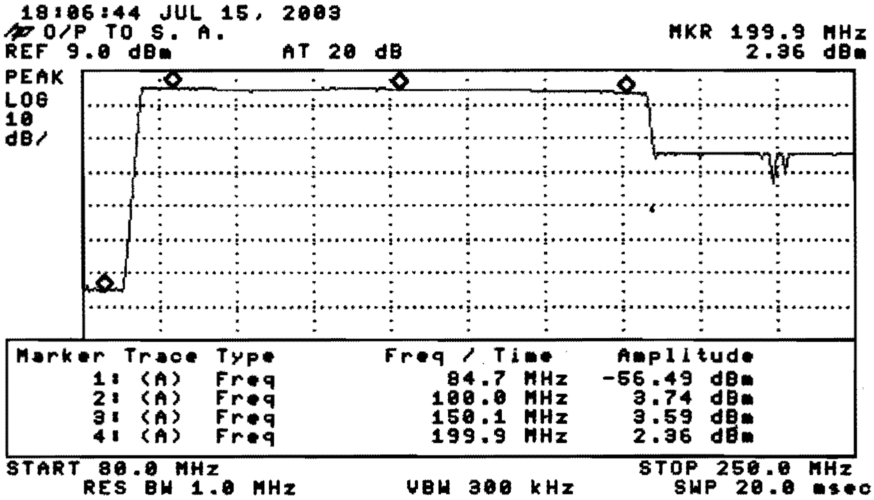


Fig. 7 (VCO1)

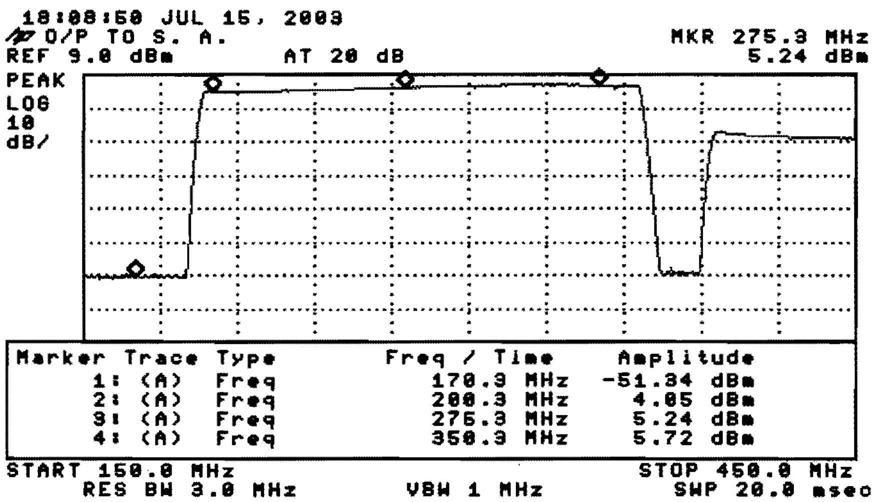


Fig. 8 (VCO2)

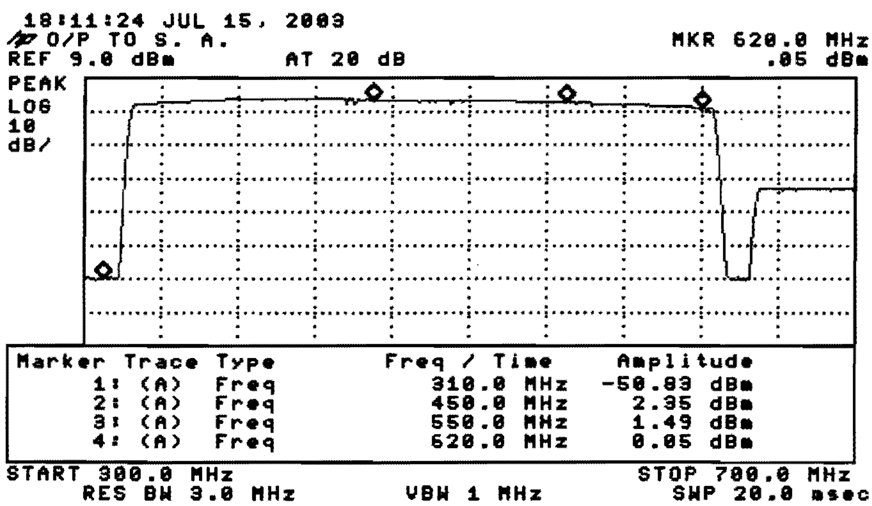


Fig. 9 (VCO3)

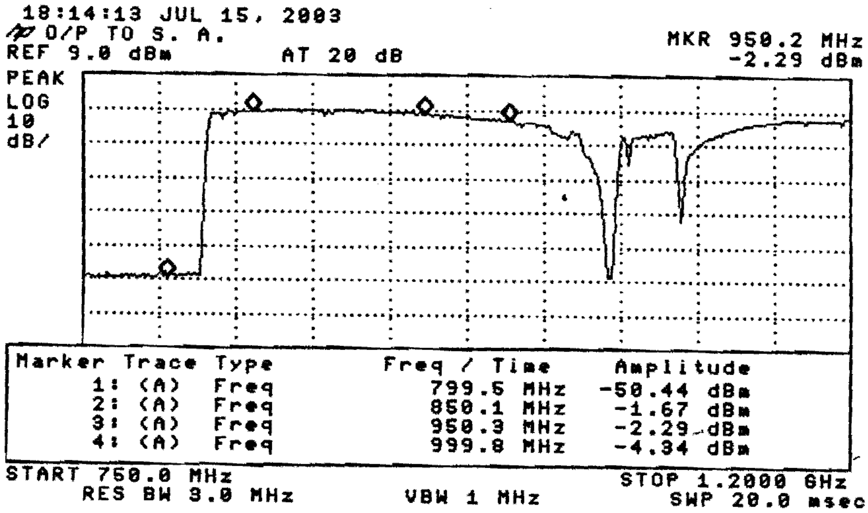


Fig. 10

4 way combiner: To Compensate loss of 4 way com

All VCOs output go to 4 way combiner. It is a resistive circuit which combines the outputs of 4 VCO. Due to loss in the combiner we use a MAR 3 amplifier so that overall output of the 4 way combiner is 0 db. Circuit diagram and response of the combiner is shown in fig 11 and fig 12-15 respectively.

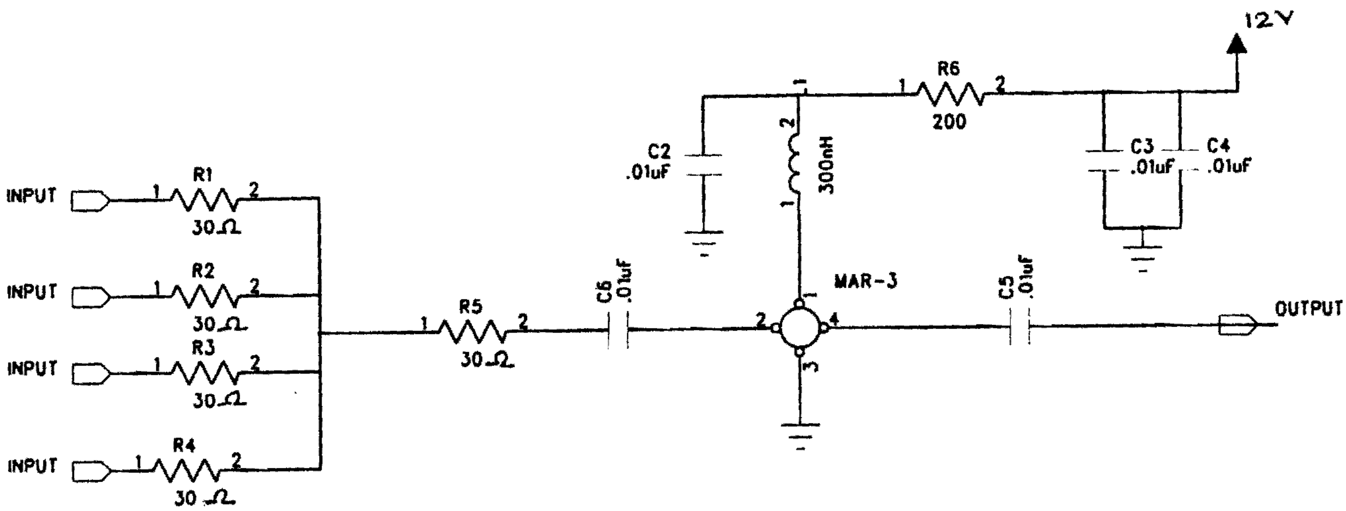


Fig 11

The output of 4 way combiner, fed to a whip aerial. It is a monopole antenna with a ground plane. The length of the antenna depends on the wavelength which is inversely proportional to frequency. We use the frequency range from 100 MHz to 1 GHz. So we choose the frequencies in logarithmic form, like 125 MHz, 250 MHz, 500 MHz, 1000 MHz, for whip aerials.

1. INTRODUCTION

Radio astronomy is defined as the astronomy based on the reception of radio waves of cosmic origin. The radiation measured in radio astronomy has in almost all cases a Gaussian probability distribution in amplitude. Generally it cannot be distinguished from thermal noise radiation of the earth or its atmosphere, or from the noise generated in a receiver.

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2. EMI SHIELDING PRINCIPLE

The importance of wave impedance is shown by electromagnetic wave encountering an obtrude such as a metal shield. If the impedance of the wave differ greatly from the natural impedance of the shield much of the energy is reflected and the

<u>Port -1 Response of 4way comb.+ Mar Amp.</u>

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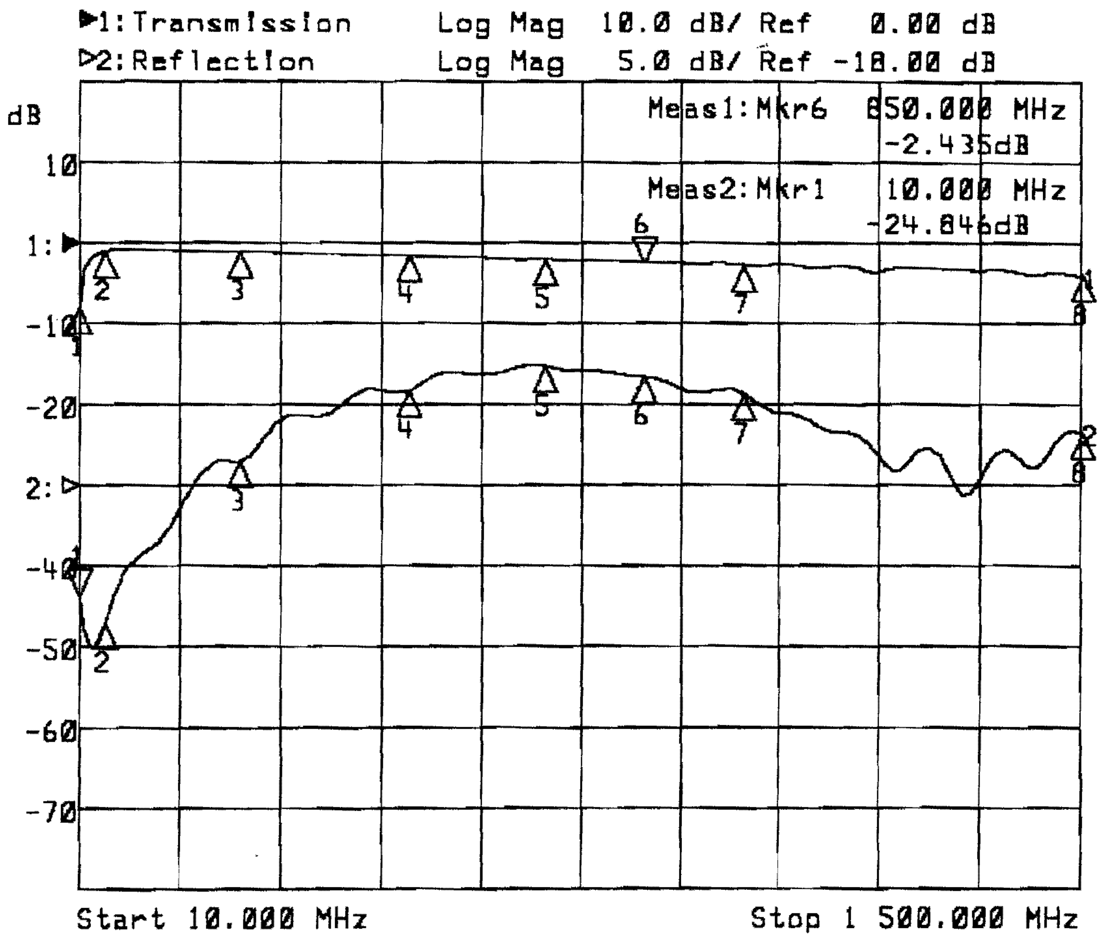


1:Mkr (MHz)	dB	2:Mkr (MHz)	dB
1: 10.0000	-8.090	1› 10.0000	-24.846
2: 50.0000	-1.028	2: 50.0000	-26.451
3: 250.0000	-1.106	3: 250.0000	-16.499
4: 500.0000	-1.608	4: 500.0000	-12.113
5: 700.0000	-1.995	5: 700.0000	-10.653
6› 850.0000	-2.435	6: 850.0000	-11.276
7: 1000.0000	-2.701	7: 1000.0000	-12.335
8: 1500.0000	-4.044	8: 1500.0000	-14.802

Fig. 12

From these frequencies calculated length of whip aerials are,

1. 60 cm for 125 MHz.
2. 30 cm for 250 MHz
3. 15 cm for 500 MHz
4. 7.5 cm for 1 GHz

TESTING FOR ISOLATION

The most widely used method for determining a large enclosure's shielding effectiveness is :-

By using the measuring setup a reference field strength is measured in free space (outside the enclosure) by varying the potentiometer. The free space loss can be calculated as,

Free Space Loss=32.4+20logF(MHz)+20log R(Km)

F is the frequency expressed in the MHz.

R is the distance between the transmitting and receiving antennas.

AT 2.4 GHz, this formula is :100+20 Log R(Km)

A transmitting antenna is then placed inside the enclosure(shielding cage).we use two type of enclosure.

1. Mesh type enclosure
2. Aluminium enclosure

Mesh type cage

This shielding cage was available. The cage consists of a metal frame with removable top. The design is that of stainless steel wire mesh (5 mm *5 mm : grid). The dimension of the box is 50cm in length, 35 cm in width and 66 cm in height. These was chosen to be more wider and higher then the CPU. The extra depth is required for the interconnecting cables, power lines filters etc.. adequately small mesh size was chosen to ensure shielding effectiveness at higher frequencies.

After putting the transmitting antenna in to the enclosure the drop in field strength is determined. This drop is the measure of shielding effectiveness. When a spectrum analyzer is connected to the receiving antenna, field strength can be measured at any point inside the enclosure.

Spectrum analyzer gives a measurement of a signal in the freq. domain and plots the amplitude in dBm vs. freq of each sine wave in the spectrum of that signal.

compliance testing of commercial equipment is typically conducted in open field sites to avoid reflections that could interfere with the measurements of emission from the equipment, placed on a turn table. A receiving antenna is located at 3, 5 and10 meter away from the transmitting antenna. The measurements are taken in all four directions.

Advantage:-

1. No need of additional ventilation.
2. It is cheaper due to stainless steel mesh.

Disadvantage:-

1. It gives poor isolation at higher frequencies.
2. Usage of floppy drive and CD drive are tedious.

Result:-

The shielding effectiveness of the cage is above 30 dB up to 350MHz but above 350MHz the isolation reduce to 12dB. So we put the EMC tape at all corners and take the measurements again. This time the isolation hardly improve 4-5dB. The measurements of isolation (without tape and with tape) is shown in table 1.

COMPARISION BETWEEN WIHTOUT EMC TAPE AND WITH TAPE

FREQ.	ISOLATION (dbm)									
Mhz.	EAST 3 Mtr.		EAST 5 Mtr.		EAST 10 Mtr.		WEST 3 Mtr.		WEST 5 Mtr.	
	WITHOUT TAPE	WITH TAPE	WITHOUT TAPE	WITH TAPE	WITHOUT TAPE	WITH TAPE	WITHOUT TAPE	WITH TAPE	WITHOUT TAPE	WITH TAPE
170	29	29	30	29	22	22	17	21	9	14
200	27	41	27	40	24	34	23	36	12	26
275	29	26	26	25	25	21	22	14	22	15
350	43	37	36	32	32	28	35	33	25	20
310	22	23	22	22	12	13	18	17	14	14
450	29	43	30	36	13	29	24	39	12	33
550	10	12	24	12	12	12	3	2	4	4
620	30	30	31	27	21	20	24	24	20	24
800	23	22	23	22	12	12	16	16	13	13
850	25	26	26	26	14	15	24	24	22	21
950	20	33	22	24	18	22	12	23	17	16
1000	18	27	8	32	16	23	15	23	4	14

	NORTH 3 Mtr.		NORTH 5 Mtr.		NORTH 10 Mtr.		SOUTH 3 Mtr.		SOUTH 5 Mtr.	
FREQ.	WITHOUT TAPE	WITH TAPE	WITHOUT TAPE	WITH TAPE	WITHOUT TAPE	WITH TAPE	WITHOUT TAPE	WITH TAPE	WITHOUT TAPE	WITH TAPE
170	11	16	15	20	23	28	19	18	16	16
200	23	44	29	45	23	37	25	52	32	49
275	32	34	30	26	32	34	29	30	29	29
350	47	52	39	41	29	28	41	53	41	41
310	15	14	14	14	16	16	18	17	19	19
450	18	34	16	29	6	14	23	34	21	36
550	21	26	45	17	19	15	21	24	23	24
620	26	32	34	35	23	24	30	28	48	46
800	13	12	8	12	8	13	12	12	15	16
850	16	17	18	12	25	23	27	24	26	23
950	7	0	8	-3	27	21	15	15	21	19
1000	-2	-2	-6	-4	12	8	15	13	25	23

Table 1

Aluminium Enclosure

A new aluminium enclosure is proposed , to overcome the disadvantages of mesh type cage. The enclosure has continuous welding, with a door type mechanism at the front and rear side. So it's easy to handle the CPU. The dimension of the box is 21 inch in height, 11 inch in width, 26 inch in length more wider and higher then the CPU. The extra depth is required for the interconnecting cables, and fans for cooling. On both door a shielding gasket is fixed to provide extra shielding. The box is shown in fig. 12.

The measurement process is repeated, using measuring setup, for selected frequencies from 100 MHz to 1 GHz. This time the potentiometer is fixed for a particular frequency then readings are noted. The measurements are shown in table 2

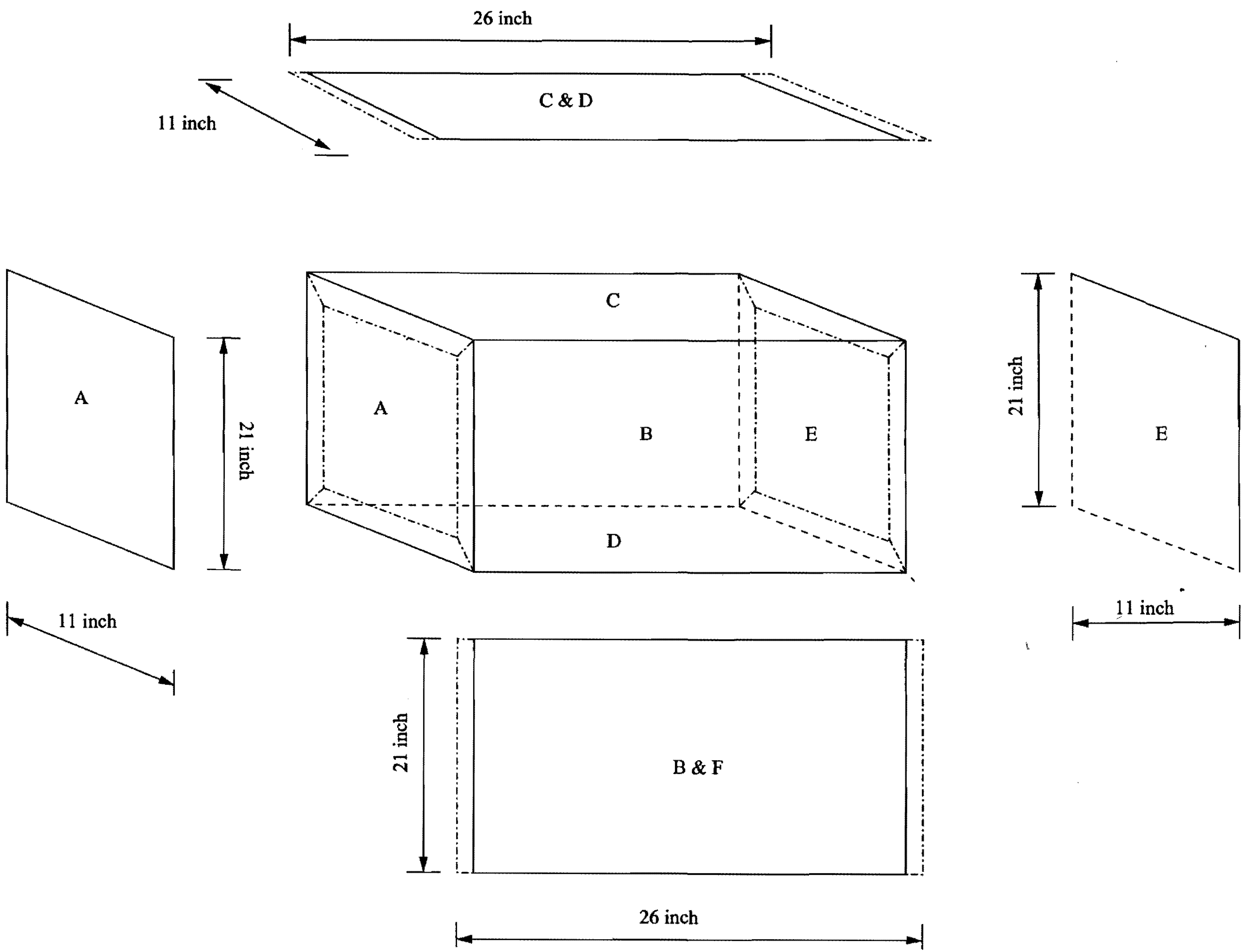
ISOLATION OF ALUMINIUM ENCLOSURE

Freq(MHz)	East 3 m	East 5m	East 10 m	West 3m	West 5m	West 10 m
250	68	74	73	74	79	71
500	65	53	61	64	53	56
1000	27	55	56	63	59	41

Freq.(MHz)	North 3m	North 5m	North 10m	South 3m	South 5m	South 10m
250	69	72	72	72	69	71
500	70	56	60	71	65	61
1000	68	66	58	50	67	56

Table 2

The comparision between mesh type cage and aluminium enclosure is shown in table 3.



Note :– 1.6mm thick Aluminium sheet with continues welding on all sides except A and E side.
Side A and side E are the doors of the rectangular box with continues SS Hing on one side.

Prep. By : Himanshu Jain

ISOLATION OF MESH TYPE SHIELDING CAGE & ALUMINIUM ENCLOSURE

FREQ.	ISOLATION (dbm)								
Mhz.	EAST 3 Mtr.			EAST 5 Mtr.			EAST 10 Mtr.		
	WITHOUT TAPE	WITH TAPE	WITH AL. EN.	WITHOUT TAPE	WITH TAPE	WITH AL. EN.	WITHOUT TAPE	WITH TAPE	WITH AL. EN.
275	29	26	68	26	25	74	25	21	73
550	10	12	65	24	12	53	12	12	61
1000	18	27		8	32	55	16	23	56

	WEST 3 Mtr.			WEST 5 Mtr.			WEST 10 Mtr.		
FREQ. Mhz.	WITHOUT TAPE	WITH TAPE	WITH AL. EN.	WITHOUT TAPE	WITH TAPE	WITH AL. EN.	WITHOUT TAPE	WITH TAPE	WITH AL. EN.
275	22	14	74	22	15	79			71
550	3	2	64	4	4	53			56
1000	15	23	63	4	14	59			41

	NORTH 3 Mtr.			NORTH 5 Mtr.			NORTH 10 Mtr.		
FREQ. Mhz.	WITHOUT TAPE	WITH TAPE	WITH AL. EN.	WITHOUT TAPE	WITH TAPE	WITH AL. EN.	WITHOUT TAPE	WITH TAPE	WITH AL. EN.
275	32	34	69	30	26	72	32	34	72
550	21	26	70	45	17	56	19	15	60

Table 3

CPU measurements:-

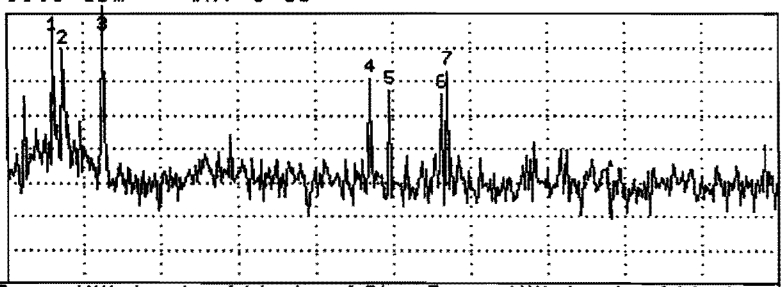
First the free space radiation of different PCs (monitor,CPU,keyboard) are measured in open field sites, in two directions at 5 meter. Measurements are taken in such a manner that it cover the frequency range (100MHz to 1GHz). To cover this whole frequency range Log periodic antenna is used at the receiver side. Same process is repeated to measure the radiation from CPU after placing it in aluminium enclosure. The drop in field strength gives the shielding efficiency of the enclosure. The Graphs are shown in fig. 13. Refer to annexure 2 for reamining graphs.

Result:-

The isolation of the aluminium enclosure is around 65 dB at all frequency range.

at East direction

15:48:02 AUG 14, 2003
FREE SPACE WITH AMP. EAST
REF -68.3 dBm #AT 0 dB
SMPL
LOG
2
dB/



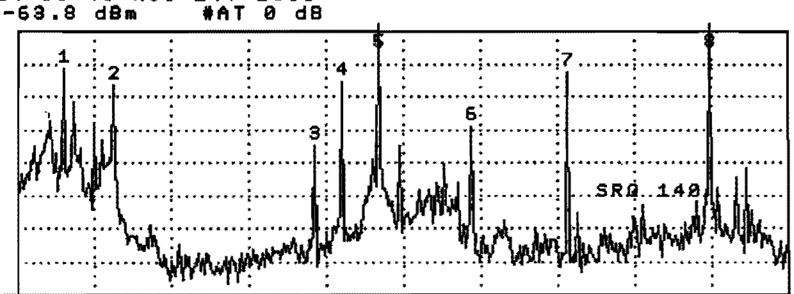
Pk	Freq (MHz)	Amplitude	Pk	Freq (MHz)	Amplitude
1	162.0	-68.58 dBm	6	262.5	-73.08 dBm
2	164.5	-70.48 dBm	7	264.0	-71.75 dBm
3	175.0	-67.46 dBm	8		
4	244.0	-72.20 dBm	9		
5	249.0	-72.82 dBm	10		

CENTER 250.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

A1

Free Space

15:40:59 AUG 15, 2003
14:09:45 AUG 14, 2003
REF -63.8 dBm #AT 0 dB
SMPL
LOG
2
dB/



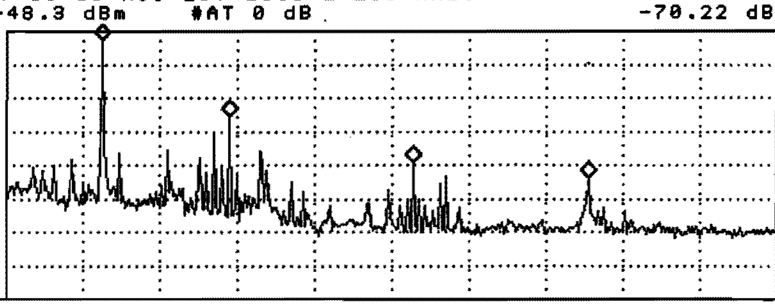
Pk	Freq (MHz)	Amplitude	Pk	Freq (MHz)	Amplitude
1	162.0	-66.04 dBm	6	267.5	-69.65 dBm
2	175.0	-67.08 dBm	7	292.5	-66.29 dBm
3	227.0	-70.75 dBm	8	329.5	-60.85 dBm
4	234.0	-66.94 dBm	9		
5	243.5	-53.56 dBm	10		

CENTER 250.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

(37)

Without Shielding

19:11:34 AUG 13, 2003
17:35:03 AUG 13, 2003 E 166 MHZ.
REF -48.3 dBm #AT 0 dB -70.22 dBm
SMPL
LOG
5
dB/



Marker	Trace	Type	Freq / Time	Amplitude
1:	(A)	Freq	175.0 MHz	-49.65 dBm
2:	(A)	Freq	208.0 MHz	-61.04 dBm
3:	(A)	Freq	255.5 MHz	-68.08 dBm
4:	(A)	Freq	301.0 MHz	-70.22 dBm

CENTER 250.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

With Shielding

FIG. 13

Future scope:-

1. For ventilation fans should be placed at both sides.
2. To connect the peripherals from the box, the shielded connectors and cables should be used. Refer to annexure 4
3. Aluminium enclosure can be replaced by Flectron metallised materials . As it gives shielding effectiveness up to 85 dB at 1 GHz. Refer to annexure 5.

References:-

1. Antennas by J.D. Kraus
2. EMI/RFI shielding magzines of Chomerics.

ANNEXURE 1

EMI SHIELDING PRINCIPLE

The importance of wave impedance is shown by electromagnetic wave encountering an obtrude such as a metal shield. If the impedance of the wave differ greatly from the natural impedance of the shield much of the energy is reflected and the rest is transmitted across the surface boundary, where absorption and the shield further attenuates it. Because most metals have an intrinsic impedance of only milliohms less low impedance H field energy is reflected and more is absorbed, this is because the metal is more closely matched to the impedance of the field this is also why it is difficult to shield against magnetic fields. On the other hand the wave impedance of electric field is high so most of the energy is reflected for this case.

At frequencies over 10 Mhz, EMI shielding is governed mostly by absorption. Shielding effectiveness of metallic enclosure is not infinite, because the conductivity of all metal is finite. They can however approach very large value because metallic shields have less than infinite conductivity, part of the field is transmitted across the boundary and supports a current in the metal. The amount of current flow at any depth in the shield ,and the rate of decay is governed by the conductivity of the metal, its permeability, and the frequency and amplitude of the field source. The residual current appearing on the opposite face is the one responsible for generating the field which exists on the other side.

The current density in the metal shield is not affected by the shield's thickness the only difference with their shield is that a large part of the re-reflected wave may appear on the front surface. This wave can add to or subtract from the primary reflected wave depending upon the phase relationship between them. For this reason a correction factor appears in the shielding equation to account for reflection from the far surface of a thin shield.

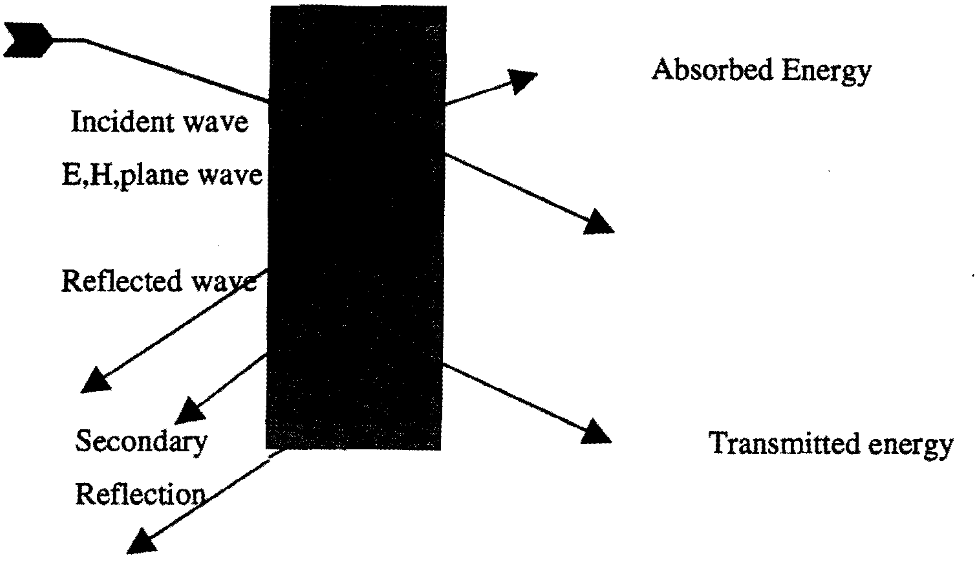


Fig 1. Attenuation of EMI by shield

EMI SHIELDING EQUATION

As described above, electromagnetic waves incident upon a discontinuity will be partially reflected and partly absorbed by the material. The effectiveness of the shield is the sum total of these two effects ,plus a correction factor to account for reflections from the back surfaces of the shield.

Reduction in the field strength are determined by the frequency ,the shielding material conductivity, thickness and permeability, and by the distance between the radiating source and the EMI shield.

how well a shield reduces the energy of (attenuates)a radiate electromagnetic field is referred to as its shielding effectiveness or SE .The standard unit of SE measurement is the decibel or dB. The decibel value is the ratio of two measurement of electromagnetic field strength taken before and after shielding in place. Every 20 dB increase in SE represent a tenfold reduction in EMI leakage through a shield .A 60 dB shield reduces field strength by a factor of 1000 times (e.g. from 5 volts per meter to 5 millivolts/meter)

The overall expression for shielding effectiveness is written as:-

$$SE=A+B+R$$

where

SE is shielding effectiveness ,

R is the reflection factor,

A is the absorption factor.

B is the correction factor to account for reflections from the far boundary

(All values are expressed in dB(decibel))

Reflection loss includes reflections at both surfaces of the shield and is dependent upon the relative mismatch between the incoming wave impedance and the frequency of the impinging wave ,as well as upon the electrical parameters of the shielding material itself .

The correction factor (B)can be mathematically positive or negative (in practice it is always negative)and becomes insignificant when A>6 dB. It is always only important when (i.e. below approximately 20 Khz)

WHERE EMI SHIELDING IS NEEDED

Requirements for EMI shielding abound in computers ,medical devices ,and many other types of electronic equipment ,as new emission and immunity requirements are placed on these device, the importance of shielding grows .

GROUNDING ISSUES

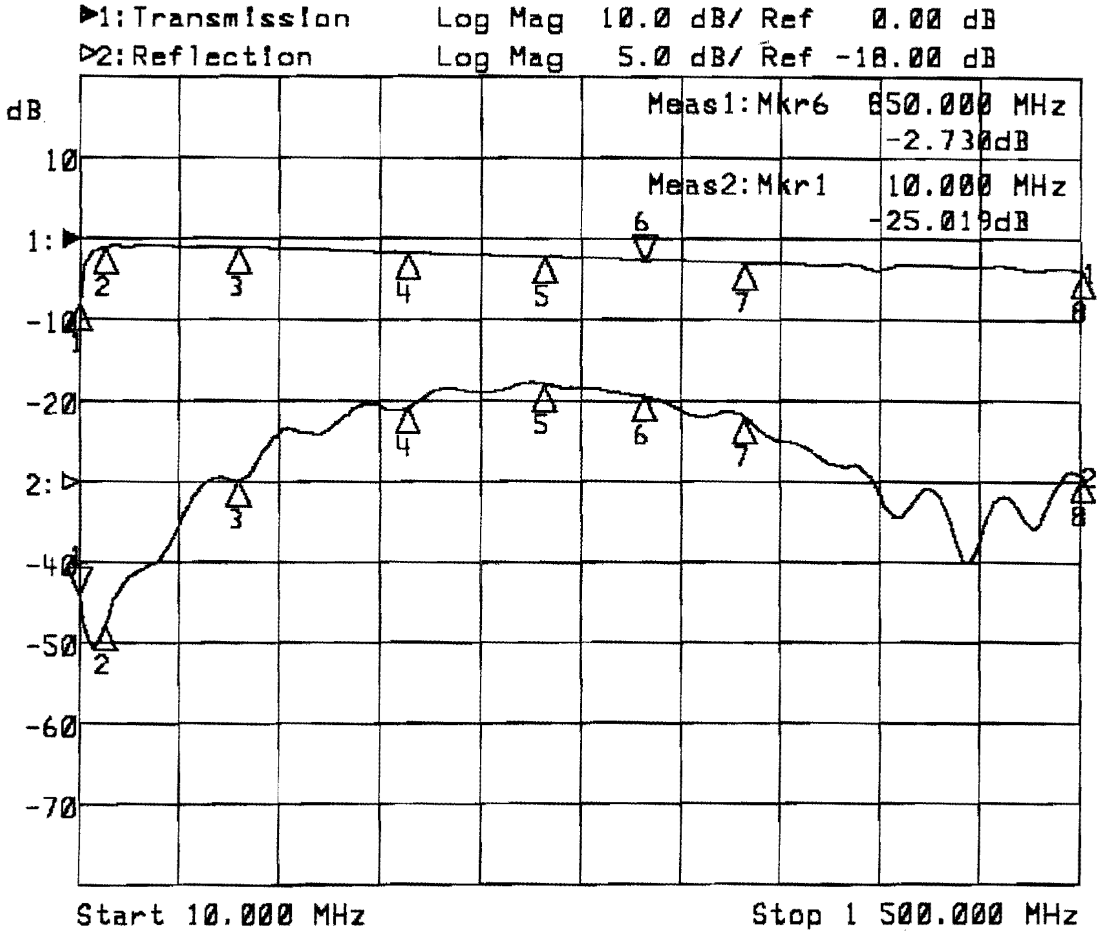
shielding against EMI emissions is commonly provided by a conductive enclosure.

the separate parts of the enclosure must be electrically bonded together and grounded for the shielding to work .disruption in the electrical continuity between parts adversely effect. Shielding performance proper grounding of PCB ,and shielding enclosure component is also a method for reducing board generated EMI. however improper or ineffective grounding may actually increase EMI emission levels ,with the ground itself become a major radiating source.

ANNEXURE - 2

Port -2 Response of 4way comb.+ Mar Amp.

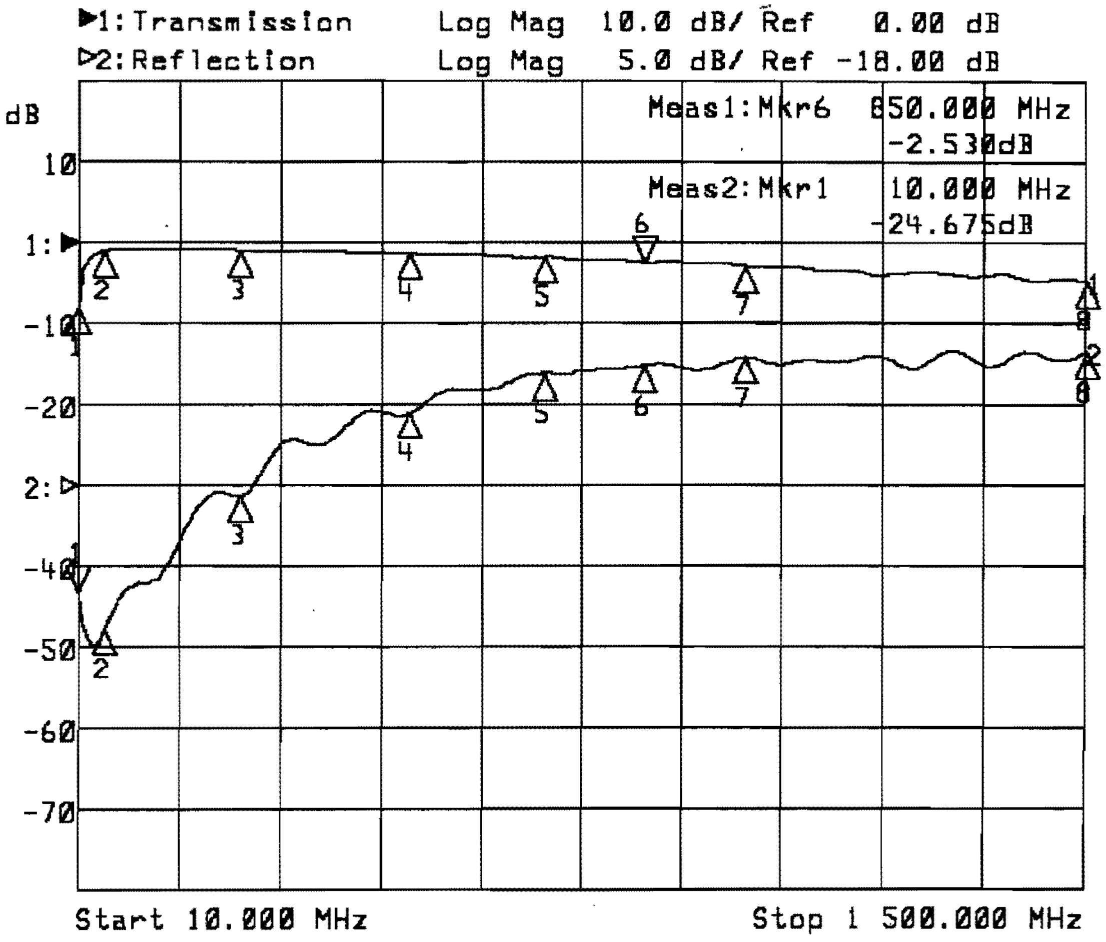
Date : 01.07.2003



1:Mkr (MHz)	dB	2:Mkr (MHz)	dB
1: 10.0000	-8.037	1> 10.0000	-25.019
2: 50.0000	-1.001	2: 50.0000	-26.831
3: 250.0000	-1.122	3: 250.0000	-17.926
4: 500.0000	-1.683	4: 500.0000	-13.434
5: 700.0000	-2.189	5: 700.0000	-11.951
6> 850.0000	-2.730	6: 850.0000	-12.679
7: 1000.0000	-2.962	7: 1000.0000	-13.938
8: 1500.0000	-3.934	8: 1500.0000	-17.634

Port -3 Response of 4way comb.+ Mar Amp.

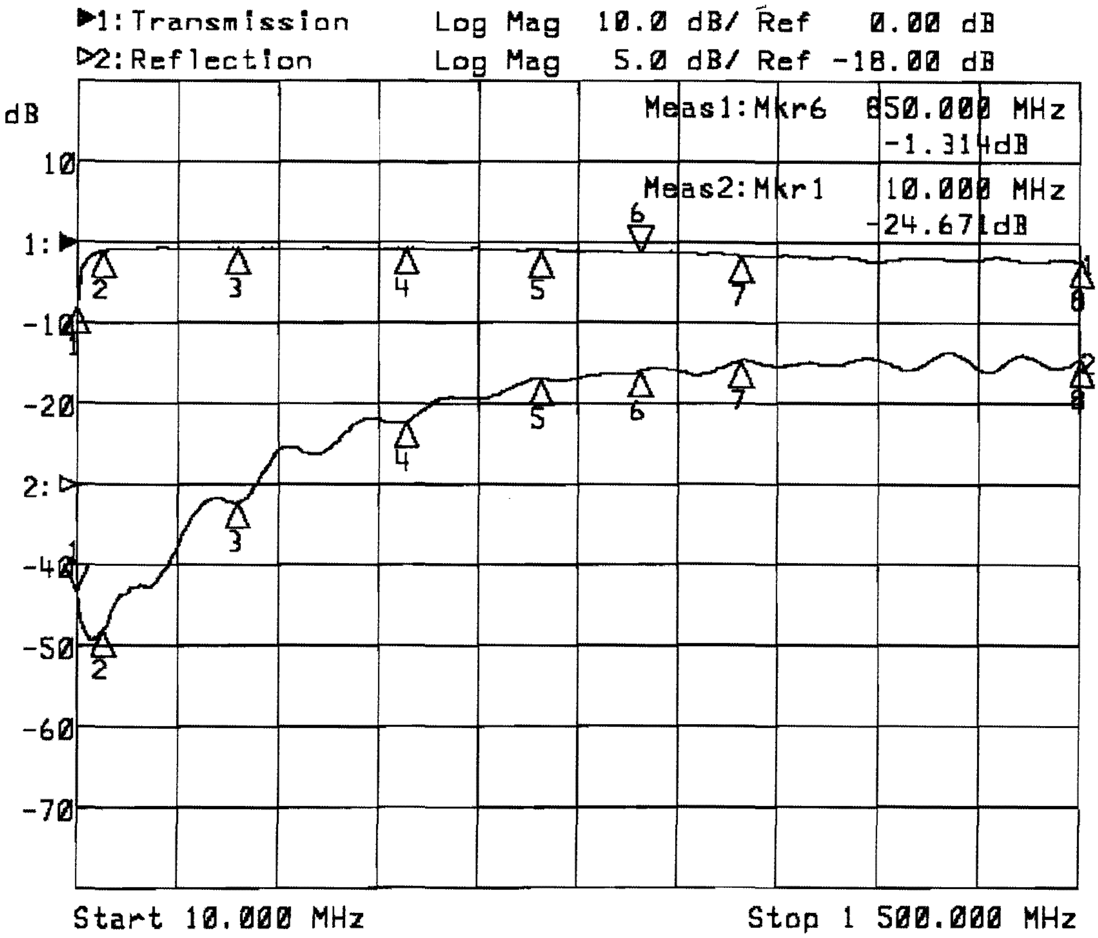
Date : 01.07.2003



1: Mkr (MHz)	dB	2: Mkr (MHz)	dB
1: 10.0000	-8.001	1> 10.0000	-24.675
2: 50.0000	-0.984	2: 50.0000	-26.884
3: 250.0000	-1.004	3: 250.0000	-18.673
4: 500.0000	-1.366	4: 500.0000	-13.499
5: 700.0000	-1.820	5: 700.0000	-11.072
6> 850.0000	-2.530	6: 850.0000	-10.656
7: 1000.0000	-2.887	7: 1000.0000	-10.176
8: 1500.0000	-4.839	8: 1500.0000	-9.742

Port -4 Response of 4way comb.+ Mar Amp.

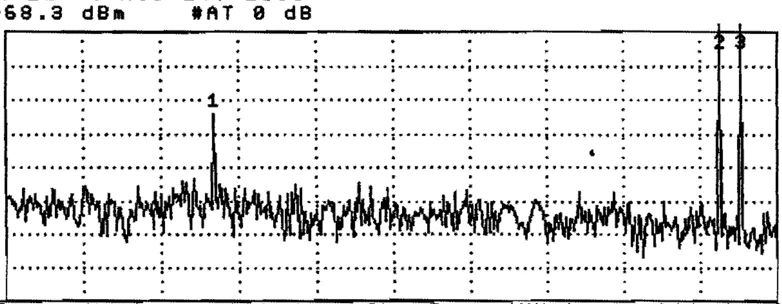
Date : 01.07.2003



1: Mkr (MHz)		dB	2: Mkr (MHz)		dB
1:	10.0000	-8.036	1>	10.0000	-24.671
2:	50.0000	-0.990	2:	50.0000	-26.940
3:	250.0000	-0.792	3:	250.0000	-19.151
4:	500.0000	-0.776	4:	500.0000	-14.143
5:	700.0000	-0.882	5:	700.0000	-11.485
6>	850.0000	-1.314	6:	850.0000	-10.987
7:	1000.0000	-1.674	7:	1000.0000	-10.346
8:	1500.0000	-2.333	8:	1500.0000	-10.258

WEST

15:49:55 AUG 14, 2003
14:21:48 AUG 14, 2003
REF -68.3 dBm #AT 0 dB
SMPL
LOG
2
dB/



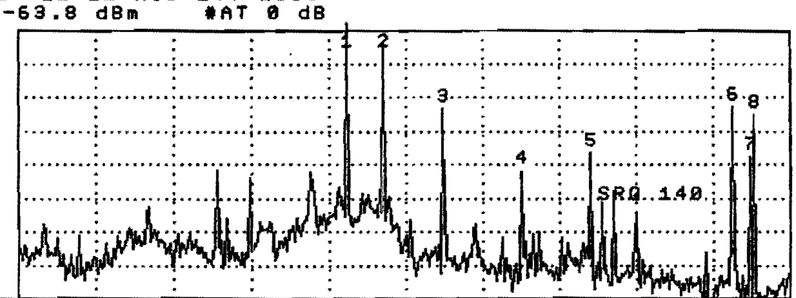
B1

Pk	Freq (MHz)	Amplitude	Pk	Freq (MHz)	Amplitude
1	403.5	-73.14 dBm	6		
2	535.0	-55.16 dBm	7		
3	540.5	-53.44 dBm	8		
4			9		
5			10		

CENTER 450.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

Free Space

15:42:49 AUG 15, 2003
14:11:11 AUG 14, 2003
REF -63.8 dBm #AT 0 dB
SMPL
LOG
2
dB/



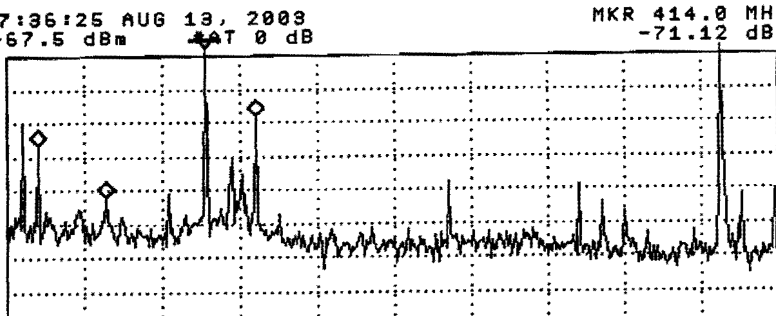
(38)

Pk	Freq (MHz)	Amplitude	Pk	Freq (MHz)	Amplitude
1	434.5	-49.63 dBm	6	535.0	-69.38 dBm
2	444.0	-64.45 dBm	7	539.5	-71.37 dBm
3	459.5	-68.52 dBm	8	540.5	-68.84 dBm
4	480.0	-72.20 dBm	9		
5	498.0	-71.06 dBm	10		

CENTER 450.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

Without Shielding

17:36:25 AUG 13, 2003 MKR 414.0 MHz
REF -67.5 dBm #AT 0 dB -71.12 dBm
SMPL
LOG
2
dB/



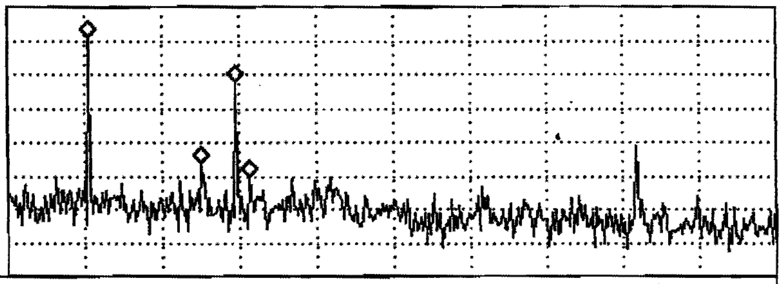
Marker	Trace	Type	Freq / Time	Amplitude
1:	(A)	Freq	358.0 MHz	-72.82 dBm
2:	(A)	Freq	375.5 MHz	-75.91 dBm
3:	(A)	Freq	401.0 MHz	-53.30 dBm
4:	(A)	Freq	414.0 MHz	-71.12 dBm

CENTER 450.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

With Shielding

NORTH

15:51:59 AUG 14, 2003
F S WITH AMP. E
REF -68.3 dBm #AT 0 dB -72.73 dBm
SMPL
LOG
2
dB/

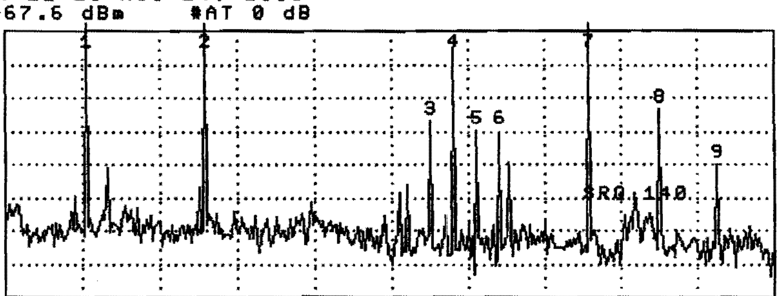


C1

Marker	Trace	Type	Freq / Time	Amplitude
1:	(A)	Freq	571.0 MHz	-70.16 dBm
2:	(A)	Freq	600.0 MHz	-77.51 dBm
3:	(A)	Freq	609.0 MHz	-72.73 dBm
4:	(A)	Freq	612.5 MHz	-78.38 dBm

CENTER 650.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

15:43:12 AUG 15, 2003
14:12:28 AUG 14, 2003
REF -67.6 dBm #AT 0 dB
SMPL
LOG
2
dB/

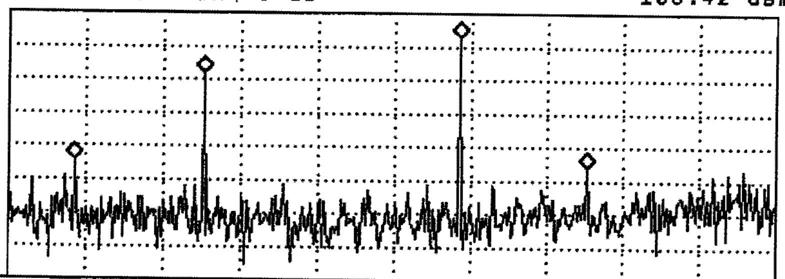


(30)

Pk	Freq (MHz)	Amplitude	Pk	Freq (MHz)	Amplitude
1	571.0	-67.03 dBm	6	678.0	-73.60 dBm
2	601.5	-57.28 dBm	7	701.5	-65.68 dBm
3	660.0	-72.97 dBm	8	720.0	-72.34 dBm
4	666.0	-68.64 dBm	9	735.0	-75.56 dBm
5	672.0	-73.54 dBm	10		

CENTER 650.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

19:14:53 AUG 13, 2003
13:40:11 AUG 13, 2003 MKR 700.5 MHz
REF -101.8 dBm #AT 0 dB -106.42 dBm
SMPL
LOG
1
dB/

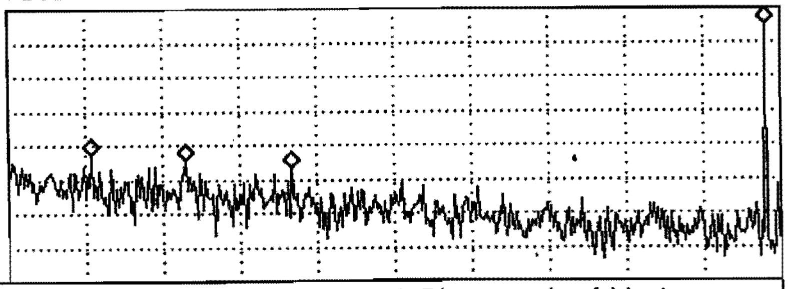


Marker	Trace	Type	Freq / Time	Amplitude
1:	(A)	Freq	567.0 MHz	-106.27 dBm
2:	(A)	Freq	600.5 MHz	-103.65 dBm
3:	(A)	Freq	667.0 MHz	-102.57 dBm
4:	(A)	Freq	700.5 MHz	-106.42 dBm

CENTER 650.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

SOUTH

15:53:31 AUG 14, 2003
14:23:29 AUG 14, 2003 MKR 946.0 MHz
REF -71.5 dBm #AT 0 dB -72.56 dBm
SMPL
LOG
2
dB/

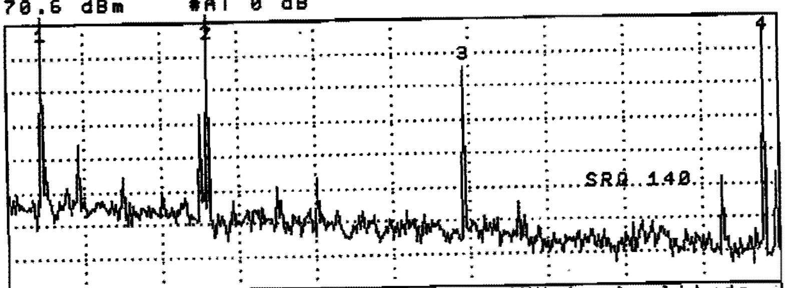


D1

Marker	Trace	Type	Freq / Time	Amplitude
1:	(A)	Freq	771.5 MHz	-80.12 dBm
2:	(A)	Freq	796.0 MHz	-80.39 dBm
3:	(A)	Freq	823.5 MHz	-80.85 dBm
4:	(A)	Freq	946.0 MHz	-72.56 dBm

CENTER 850.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

15:43:39 AUG 15, 2003
14:13:47 AUG 14, 2003
REF -70.6 dBm #AT 0 dB
SMPL
LOG
2
dB/

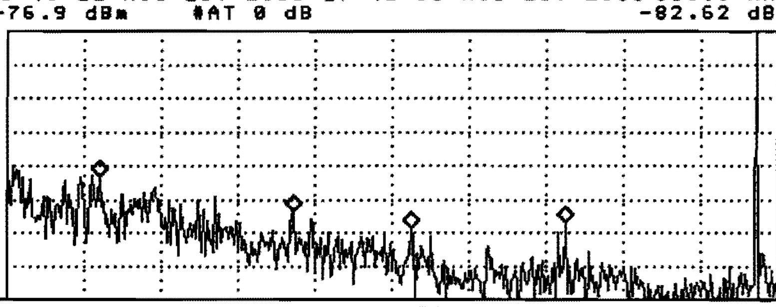


40

Pk	Freq (MHz)	Amplitude	Pk	Freq (MHz)	Amplitude
1	759.0	-67.19 dBm	6		
2	802.0	-68.94 dBm	7		
3	868.5	-73.51 dBm	8		
4	946.0	-71.41 dBm	9		
5			10		

CENTER 850.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

13:40:11 AUG 13, 2003 17:41:08 AUG 13, 2003 895.0 MHz
REF -76.9 dBm #AT 0 dB -82.62 dBm
SMPL
LOG
1
dB/

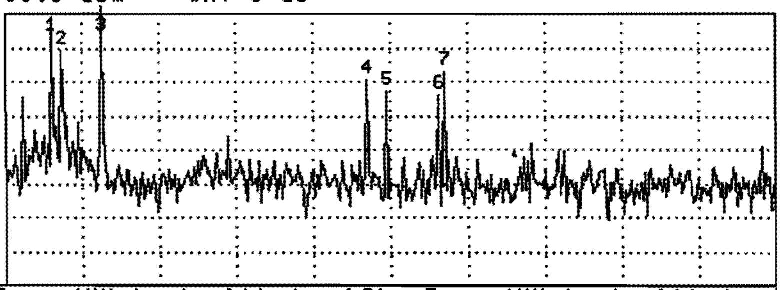


Marker	Trace	Type	Freq / Time	Amplitude
1:	(A)	Freq	774.0 MHz	-81.22 dBm
2:	(A)	Freq	824.5 MHz	-82.28 dBm
3:	(A)	Freq	855.0 MHz	-82.77 dBm
4:	(A)	Freq	895.0 MHz	-82.62 dBm

CENTER 850.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

D7

15:48:02 AUG 14, 2003
FREE SPACE WITH AMP. EAST
REF -68.3 dBm #AT 0 dB
SMPL
LOG
2
dB/

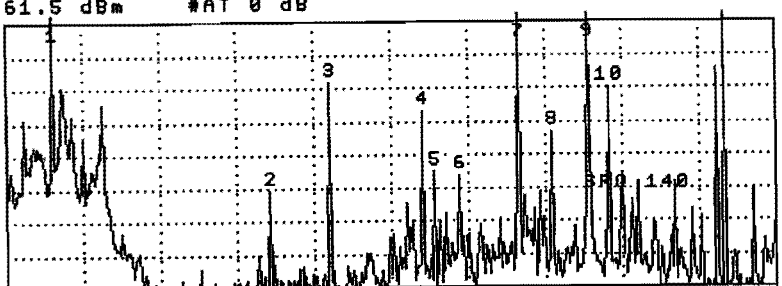


A1

Pk	Freq (MHz)	Amplitude	Pk	Freq (MHz)	Amplitude
1	162.0	-68.58 dBm	6	262.5	-73.08 dBm
2	164.5	-70.48 dBm	7	264.0	-71.75 dBm
3	175.0	-67.46 dBm	8		
4	244.0	-72.20 dBm	9		
5	249.0	-72.82 dBm	10		

CENTER 250.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

15:18:48 AUG 15, 2003
EAST 533 MHZ. W\O SHILD
REF -61.5 dBm #AT 0 dB
SMPL
LOG
2
dB/

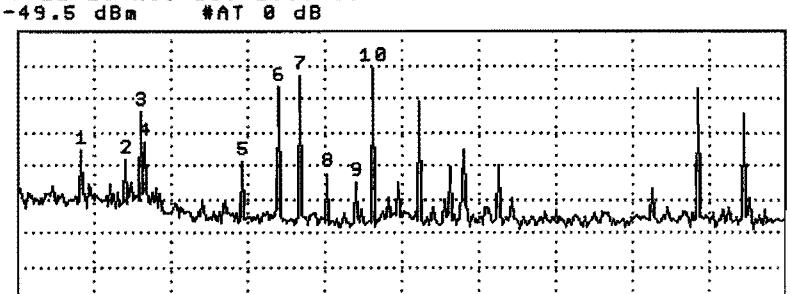


A2

Pk	Freq (MHz)	Amplitude	Pk	Freq (MHz)	Amplitude
1	162.0	-60.80 dBm	6	267.5	-70.80 dBm
2	218.5	-71.62 dBm	7	283.0	-60.06 dBm
3	234.0	-65.14 dBm	8	291.5	-68.18 dBm
4	258.0	-66.92 dBm	9	301.0	-52.55 dBm
5	261.0	-70.50 dBm	10	306.5	-65.54 dBm

CENTER 250.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

19:01:19 AUG 13, 2003
17:12:20 AUG 13, 2003 533 MHZ E
REF -49.5 dBm #AT 0 dB
SMPL
LOG
5
dB/

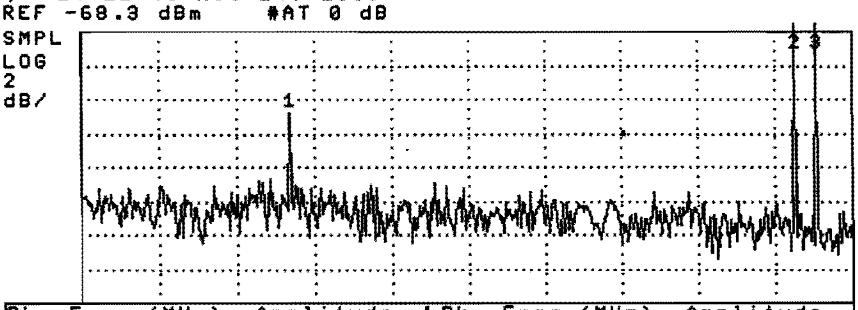


A3

Pk	Freq (MHz)	Amplitude	Pk	Freq (MHz)	Amplitude
1	208.3	-67.22 dBm	6	234.0	-57.66 dBm
2	214.0	-68.62 dBm	7	236.8	-56.16 dBm
3	216.0	-61.61 dBm	8	240.3	-70.78 dBm
4	216.5	-66.12 dBm	9	244.0	-72.15 dBm
5	229.3	-69.02 dBm	10	246.3	-54.93 dBm

CENTER 250.0 MHz SPAN 100.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 333 msec

15:49:55 AUG 14, 2003
14:21:48 AUG 14, 2003
REF -68.3 dBm #AT 0 dB

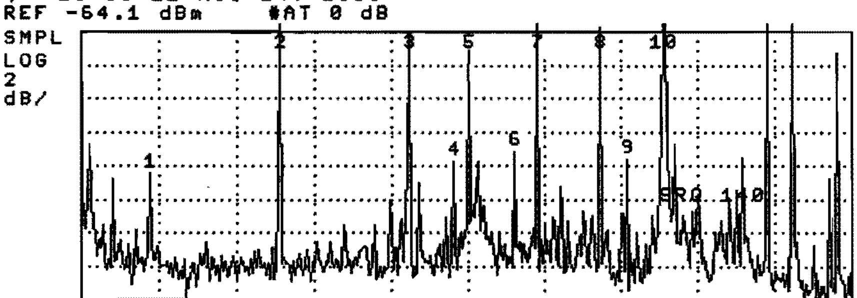


B1

Pk	Freq (MHz)	Amplitude	Pk	Freq (MHz)	Amplitude
1	403.5	-73.14 dBm	6		
2	535.0	-55.16 dBm	7		
3	540.5	-53.44 dBm	8		
4			9		
5			10		

CENTER 450.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

15:19:36 AUG 15, 2003
13:06:22 AUG 14, 2003
REF -64.1 dBm #AT 0 dB



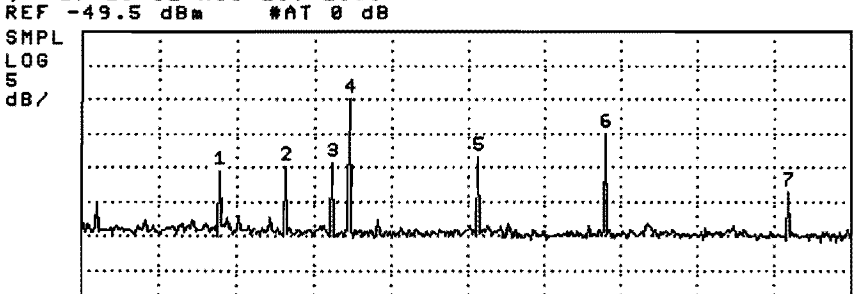
B2

②

Pk	Freq (MHz)	Amplitude	Pk	Freq (MHz)	Amplitude
1	367.5	-72.55 dBm	6	462.0	-71.25 dBm
2	401.0	-50.33 dBm	7	468.0	-63.50 dBm
3	434.5	-64.24 dBm	8	484.5	-63.83 dBm
4	446.0	-71.83 dBm	9	491.5	-71.75 dBm
5	450.0	-65.27 dBm	10	501.0	-56.87 dBm

CENTER 450.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

19:02:05 AUG 13, 2003
17:13:51 AUG 13, 2003
REF -49.5 dBm #AT 0 dB

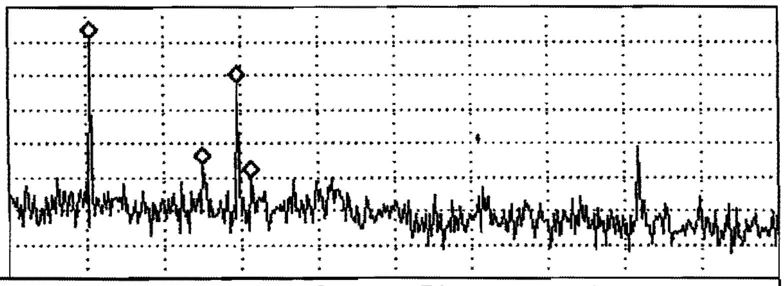


B3

Pk	Freq (MHz)	Amplitude	Pk	Freq (MHz)	Amplitude
1	417.8	-70.19 dBm	6	468.0	-64.61 dBm
2	426.3	-69.61 dBm	7	491.8	-73.11 dBm
3	432.3	-68.80 dBm	8		
4	434.5	-59.44 dBm	9		
5	451.3	-68.00 dBm	10		

CENTER 450.0 MHz SPAN 100.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 333 msec

15:51:59 AUG 14, 2003
F S WITH AMP. E
REF -68.3 dBm #AT 0 dB -72.73 dBm
SMPL
LOG
2
dB/

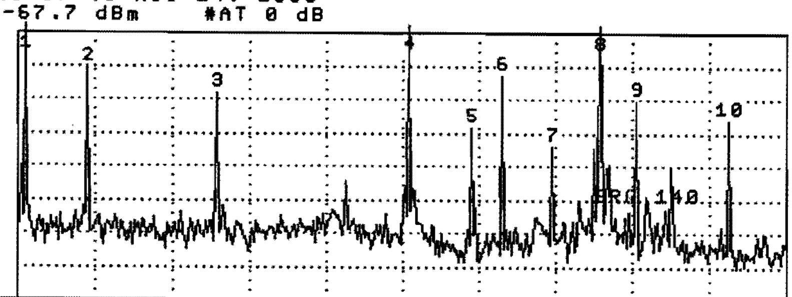


C1

Marker	Trace	Type	Freq / Time	Amplitude
1:	(A)	Freq	571.0 MHz	-70.16 dBm
2:	(A)	Freq	600.0 MHz	-77.51 dBm
3:	(A)	Freq	609.0 MHz	-72.73 dBm
4:	(A)	Freq	612.5 MHz	-78.38 dBm

CENTER 650.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

15:20:06 AUG 15, 2003
13:07:48 AUG 14, 2003
REF -67.7 dBm #AT 0 dB
SMPL
LOG
2
dB/



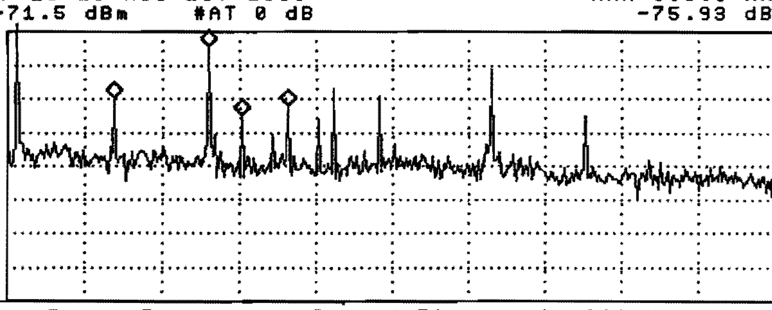
(3)

C2

Pk	Freq (MHz)	Amplitude	Pk	Freq (MHz)	Amplitude
1	552.0	-59.52 dBm	6	676.0	-70.34 dBm
2	568.0	-69.82 dBm	7	689.0	-74.55 dBm
3	601.5	-71.37 dBm	8	701.5	-63.00 dBm
4	651.5	-64.17 dBm	9	711.0	-71.82 dBm
5	668.0	-73.41 dBm	10	735.0	-72.92 dBm

CENTER 650.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

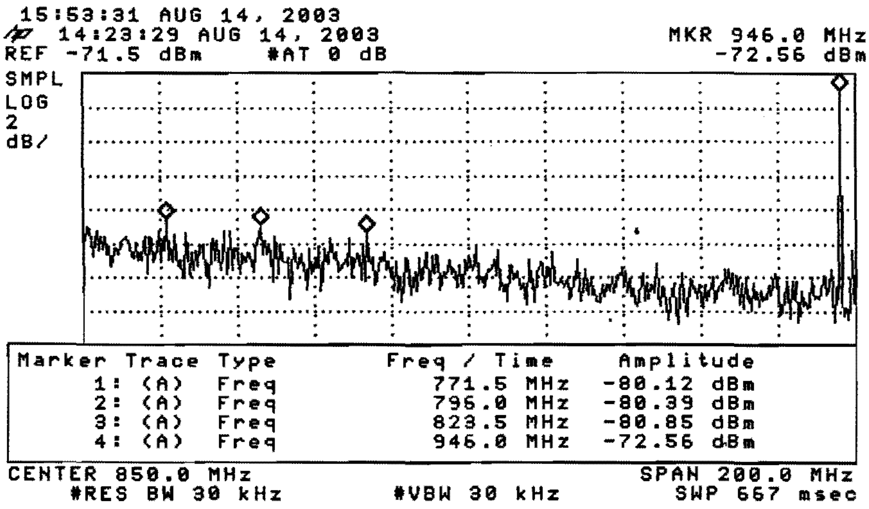
17:15:18 AUG 13, 2003 MKR 636.3 MHz
REF -71.5 dBm #AT 0 dB -75.93 dBm
SMPL
LOG
2
dB/



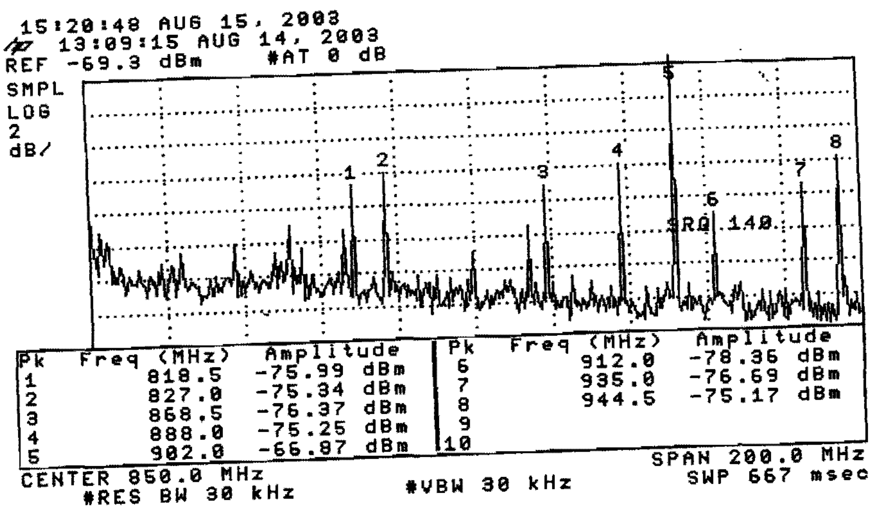
C3

Marker	Trace	Type	Freq / Time	Amplitude
1:	(A)	Freq	613.7 MHz	-75.55 dBm
2:	(A)	Freq	626.0 MHz	-72.44 dBm
3:	(A)	Freq	630.2 MHz	-76.58 dBm
4:	(A)	Freq	636.2 MHz	-75.93 dBm

CENTER 650.0 MHz SPAN 100.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 333 msec

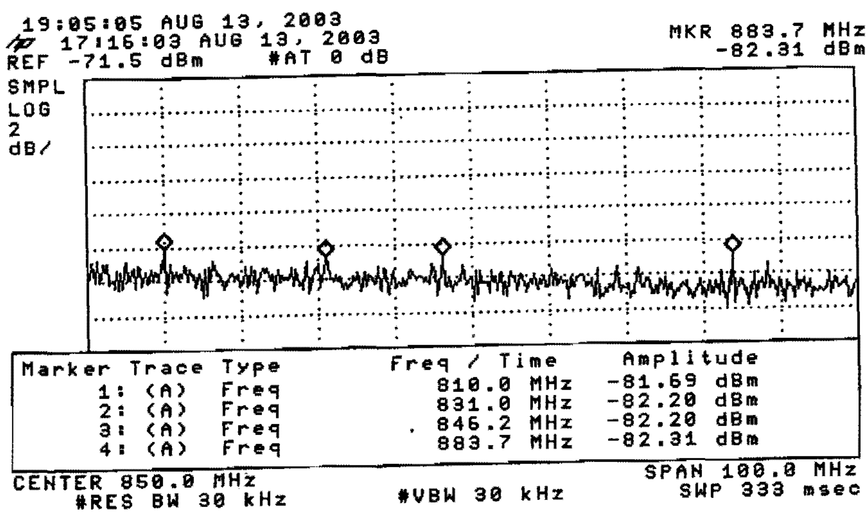

15:53:31 AUG 14, 2003
14:23:29 AUG 14, 2003
REF -71.5 dBm #AT 0 dB
MKR 946.0 MHz
-72.56 dBm
SMPL
LOG
2
dB/
Marker Trace Type Freq / Time Amplitude
1: (A) Freq 771.5 MHz -80.12 dBm
2: (A) Freq 796.0 MHz -80.39 dBm
3: (A) Freq 823.5 MHz -80.85 dBm
4: (A) Freq 946.0 MHz -72.56 dBm
CENTER 850.0 MHz
#RES BW 30 kHz
#VBW 30 kHz
SPAN 200.0 MHz
SWP 667 msec

D1


15:20:48 AUG 15, 2003
13:09:15 AUG 14, 2003
REF -69.3 dBm #AT 0 dB
SMPL
LOG
2
dB/
Pk Freq (MHz) Amplitude
1 818.5 -75.99 dBm
2 827.0 -75.34 dBm
3 868.5 -76.37 dBm
4 888.0 -75.25 dBm
5 902.0 -66.87 dBm
6 912.0 -78.36 dBm
7 935.0 -76.69 dBm
8 944.5 -75.17 dBm
9
10
CENTER 850.0 MHz
#RES BW 30 kHz
#VBW 30 kHz
SPAN 200.0 MHz
SWP 667 msec

(u)

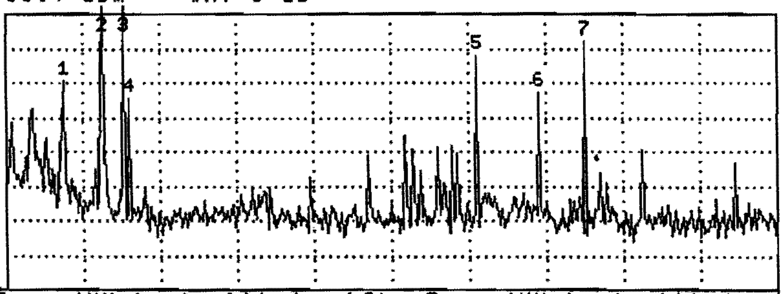
D2


19:05:05 AUG 13, 2003
17:16:03 AUG 13, 2003
REF -71.5 dBm #AT 0 dB
MKR 883.7 MHz
-82.31 dBm
SMPL
LOG
2
dB/
Marker Trace Type Freq / Time Amplitude
1: (A) Freq 810.0 MHz -81.69 dBm
2: (A) Freq 831.0 MHz -82.20 dBm
3: (A) Freq 846.2 MHz -82.20 dBm
4: (A) Freq 883.7 MHz -82.31 dBm
CENTER 850.0 MHz
#RES BW 30 kHz
#VBW 30 kHz
SPAN 100.0 MHz
SWP 333 msec

D3

15:40:09 AUG 14, 2003
FREE SPACE WITH AMP. WEST
REF -66.4 dBm #AT 0 dB
SMPL
LOG
2
dB/

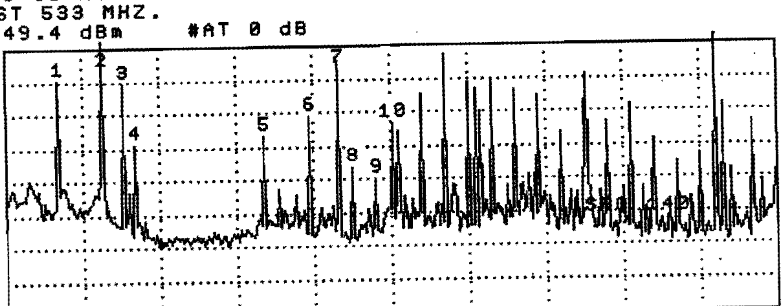
21



Pk	Freq (MHz)	Amplitude	Pk	Freq (MHz)	Amplitude
1	165.0	-70.23 dBm	6	288.0	-70.95 dBm
2	175.0	-52.04 dBm	7	300.0	-68.04 dBm
3	180.5	-55.46 dBm	8		
4	182.0	-71.33 dBm	9		
5	272.0	-68.85 dBm	10		

CENTER 250.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

15:26:55 AUG 15, 2003
WEST 533 MHZ.
REF -49.4 dBm #AT 0 dB
SMPL
LOG
5
dB/



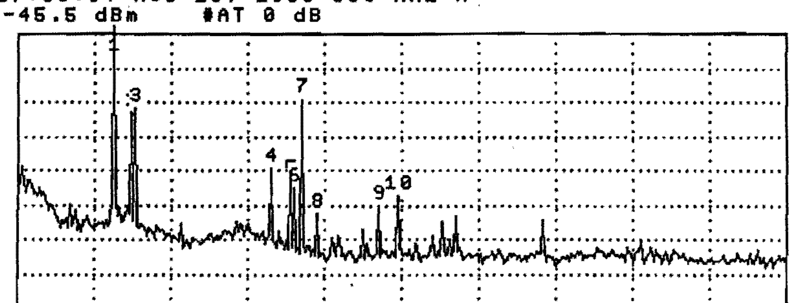
(3)
(17)

Pk	Freq (MHz)	Amplitude	Pk	Freq (MHz)	Amplitude
1	163.5	-54.32 dBm	6	229.0	-60.09 dBm
2	175.0	-34.48 dBm	7	236.5	-51.64 dBm
3	180.5	-54.87 dBm	8	240.0	-67.73 dBm
4	183.5	-63.94 dBm	9	246.0	-69.36 dBm
5	217.0	-62.71 dBm	10	250.5	-61.14 dBm

CENTER 250.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

18:55:11 AUG 13, 2003
17:00:04 AUG 13, 2003 533 MHZ W
REF -45.5 dBm #AT 0 dB
SMPL
LOG
5
dB/

A3



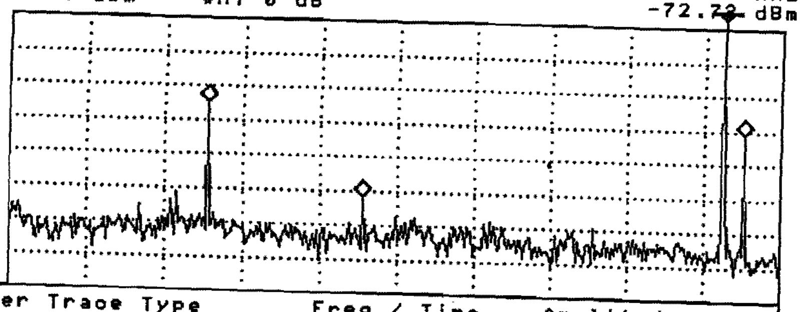
Pk	Freq (MHz)	Amplitude	Pk	Freq (MHz)	Amplitude
1	175.0	-43.20 dBm	6	222.0	-68.13 dBm
2	179.5	-56.80 dBm	7	224.0	-55.07 dBm
3	180.5	-56.25 dBm	8	228.0	-71.78 dBm
4	216.0	-65.30 dBm	9	244.0	-70.77 dBm
5	221.0	-66.92 dBm	10	249.0	-69.14 dBm

CENTER 250.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

Free Space with amp. West Wisconsin

Y1

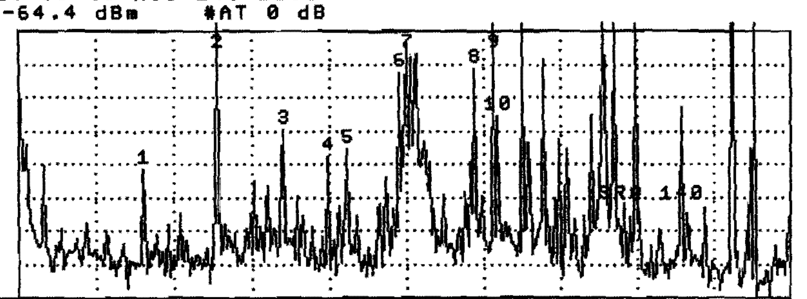
15:43:05 AUG 14, 2003
13:41:08 AUG 14, 2003
REF -66.4 dBm #AT 0 dB
MKR 540.5 MHz -72.73 dBm
SMPL LOG 2 dB/



Marker	Trace	Type	Freq / Time	Amplitude
1:	(A)	Freq	401.0 MHz	-71.40 dBm
2:	(A)	Freq	441.0 MHz	-76.81 dBm
3:	(A)	Freq	535.0 MHz	-55.86 dBm
4:	(A)	Freq	540.5 MHz	-72.73 dBm

CENTER 450.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

15:27:48 AUG 15, 2003
13:36:20 AUG 14, 2003
REF -64.4 dBm #AT 0 dB
SMPL LOG 2 dB/

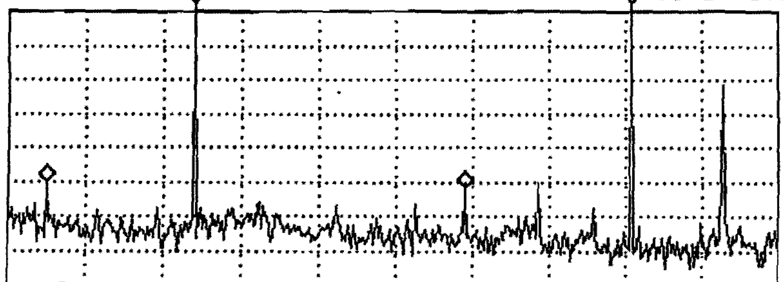


Pk	Freq (MHz)	Amplitude	Pk	Freq (MHz)	Amplitude
1	382.0	-72.77 dBm	6	448.0	-66.96 dBm
2	401.0	-57.81 dBm	7	450.0	-65.09 dBm
3	418.0	-70.37 dBm	8	467.5	-66.71 dBm
4	429.5	-71.97 dBm	9	472.5	-62.21 dBm
5	434.5	-71.48 dBm	10	473.5	-69.56 dBm

CENTER 450.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

(18)

18:57:17 AUG 13, 2003
17:01:29 AUG 13, 2003
REF -65.7 dBm #AT 0 dB
MKR 511.5 MHz -63.16 dBm
SMPL LOG 2 dB/



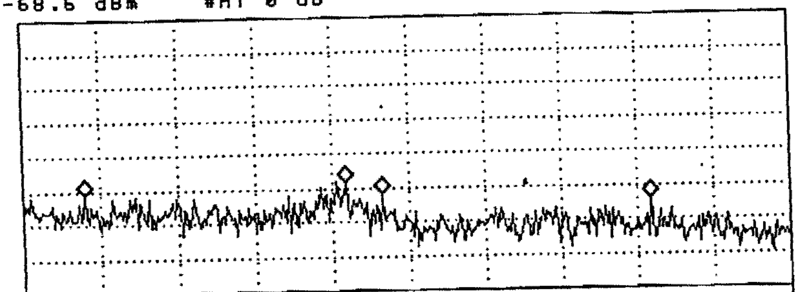
Marker	Trace	Type	Freq / Time	Amplitude
1:	(A)	Freq	360.0 MHz	-75.71 dBm
2:	(A)	Freq	398.0 MHz	-61.87 dBm
3:	(A)	Freq	468.0 MHz	-76.11 dBm
4:	(A)	Freq	511.5 MHz	-63.16 dBm

CENTER 450.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

15:44:22 AUG 14, 2003
hp 13:42:30 AUG 14, 2003
REF -68.6 dBm #AT 0 dB

MKR 643.0 MHz
-79.04 dBm

SMPL
LOG
2
dB/

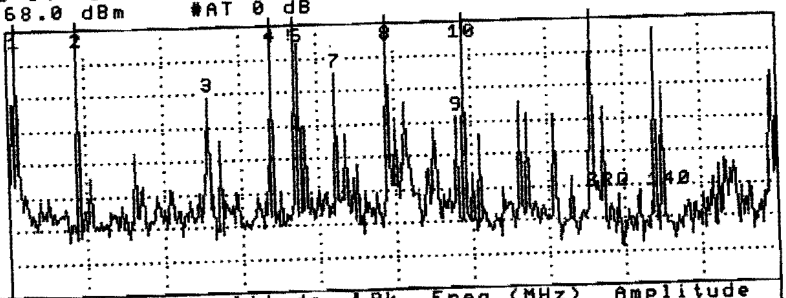


Marker	Trace	Type	Freq / Time	Amplitude
1:	(A)	Freq	566.0 MHz	-78.88 dBm
2:	(A)	Freq	633.5 MHz	-78.30 dBm
3:	(A)	Freq	643.0 MHz	-79.04 dBm
4:	(A)	Freq	713.5 MHz	-79.40 dBm

CENTER 650.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

15:28:15 AUG 15, 2003
hp 13:34:45 AUG 14, 2003
REF -68.0 dBm #AT 0 dB

SMPL
LOG
2
dB/



Pk	Freq (MHz)	Amplitude	Pk	Freq (MHz)	Amplitude
1	552.0	-55.58 dBm	6	625.0	-69.18 dBm
2	568.0	-55.50 dBm	7	634.5	-70.94 dBm
3	601.5	-72.21 dBm	8	648.0	-55.96 dBm
4	618.0	-56.32 dBm	9	666.0	-73.70 dBm
5	624.0	-67.10 dBm	10	668.0	-58.99 dBm

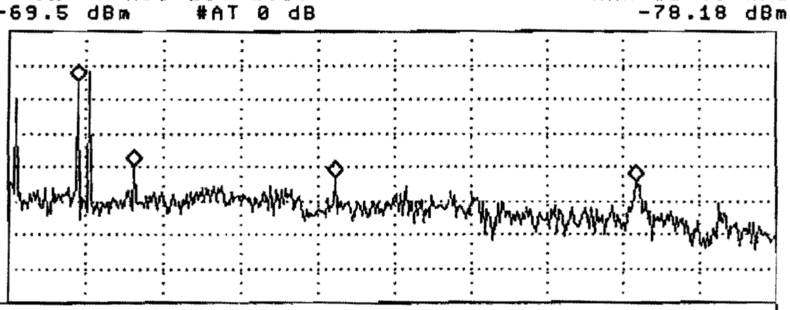
CENTER 650.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

(19)

18:58:17 AUG 13, 2003
hp 17:02:47 AUG 13, 2003
REF -69.5 dBm #AT 0 dB

MKR 634.5 MHz
-78.18 dBm

SMPL
LOG
2
dB/

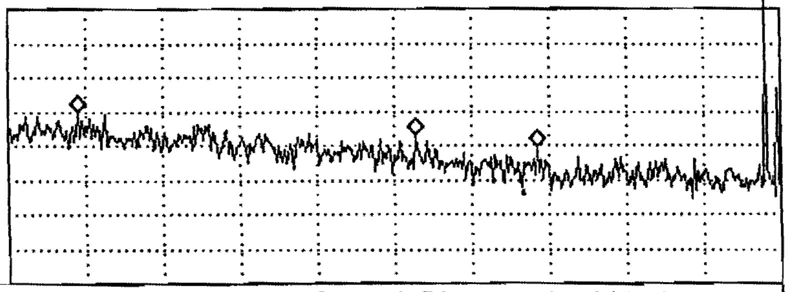


Marker	Trace	Type	Freq / Time	Amplitude
1:	(A)	Freq	568.0 MHz	-72.42 dBm
2:	(A)	Freq	582.5 MHz	-77.47 dBm
3:	(A)	Freq	634.5 MHz	-78.18 dBm
4:	(A)	Freq	713.5 MHz	-78.44 dBm

CENTER 650.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

①

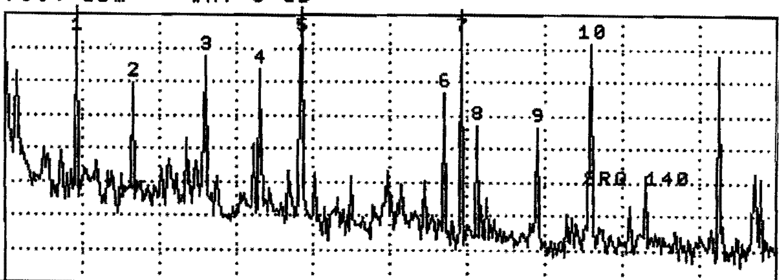
15:45:30 AUG 14, 2003
13:43:57 AUG 14, 2003 MKR 946.0 MHz
REF -74.6 dBm #AT 0 dB -63.36 dBm
SMPL
LOG
2
dB/



Marker	Trace	Type	Freq / Time	Amplitude
1:	(A)	Freq	768.0 MHz	-80.67 dBm
2:	(A)	Freq	855.5 MHz	-82.08 dBm
3:	(A)	Freq	887.0 MHz	-82.70 dBm
4:	(A)	Freq	946.0 MHz	-63.36 dBm

CENTER 850.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

15:29:00 AUG 15, 2003
13:33:23 AUG 14, 2003
REF -70.4 dBm #AT 0 dB
SMPL
LOG
2
dB/

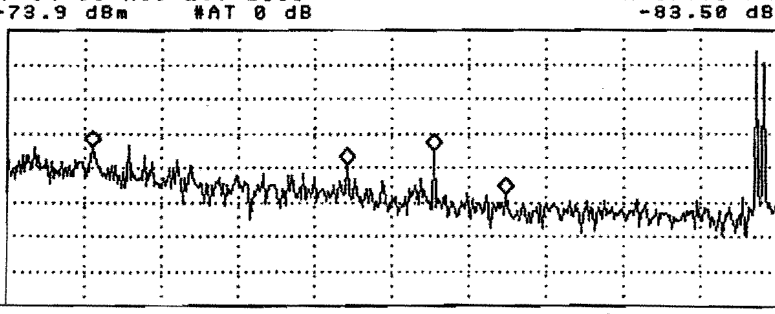


②

Pk	Freq (MHz)	Amplitude	Pk	Freq (MHz)	Amplitude
1	768.5	-57.18 dBm	6	864.0	-75.06 dBm
2	789.0	-74.50 dBm	7	869.5	-70.10 dBm
3	802.0	-72.86 dBm	8	872.5	-77.02 dBm
4	816.0	-73.77 dBm	9	888.0	-77.18 dBm
5	827.0	-69.69 dBm	10	902.0	-72.11 dBm

CENTER 850.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

18:59:33 AUG 13, 2003
17:04:08 AUG 13, 2003 MKR 879.5 MHz
REF -73.9 dBm #AT 0 dB -83.50 dBm
SMPL
LOG
2
dB/

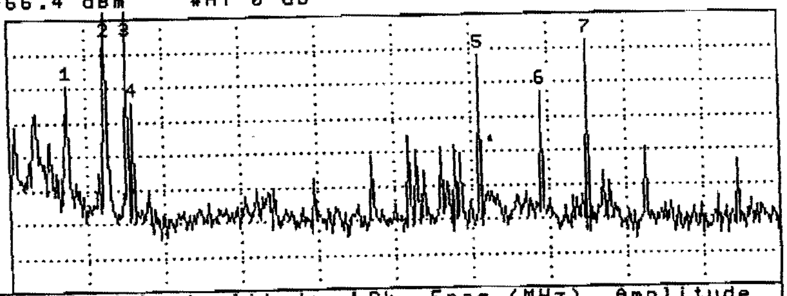


Marker	Trace	Type	Freq / Time	Amplitude
1:	(A)	Freq	772.0 MHz	-80.75 dBm
2:	(A)	Freq	838.5 MHz	-81.80 dBm
3:	(A)	Freq	861.0 MHz	-80.99 dBm
4:	(A)	Freq	879.5 MHz	-83.50 dBm

CENTER 850.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

15:40:09 AUG 14, 2003
FREE SPACE WITH AMP. WEST
REF -66.4 dBm #AT 0 dB
SMPL
LOG
2
dB/

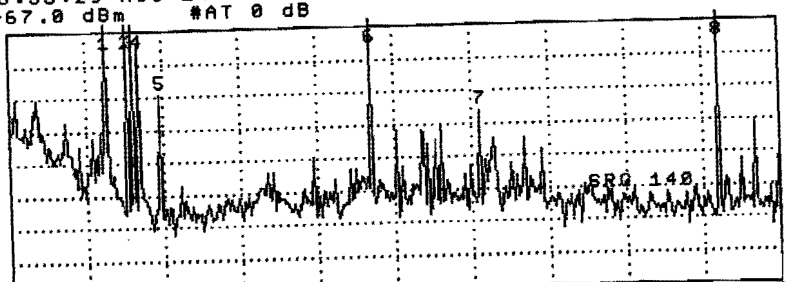
Z1



Pk	Freq (MHz)	Amplitude	Pk	Freq (MHz)	Amplitude
1	165.0	-70.23 dBm	6	288.0	-70.95 dBm
2	175.0	-52.04 dBm	7	300.0	-68.04 dBm
3	180.5	-55.46 dBm	8		
4	182.0	-71.33 dBm	9		
5	272.0	-68.85 dBm	10		

CENTER 250.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

15:36:48 AUG 15, 2003
13:53:29 AUG 14, 2003
REF -67.0 dBm #AT 0 dB
SMPL
LOG
2
dB/



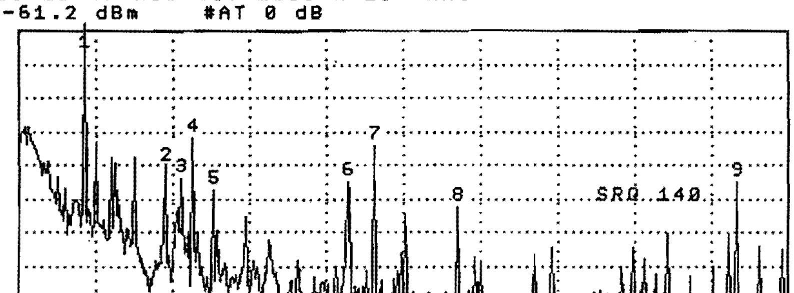
(25)

Pk	Freq (MHz)	Amplitude	Pk	Freq (MHz)	Amplitude
1	175.0	-58.69 dBm	6	244.0	-66.59 dBm
2	180.5	-60.05 dBm	7	272.0	-72.30 dBm
3	182.0	-66.44 dBm	8	334.0	-66.23 dBm
4	183.5	-67.69 dBm	9		
5	189.0	-70.84 dBm	10		

CENTER 250.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

19:48:35 AUG 13, 2003
18:16:47 AUG 13, 2003 W 166 MHZ
REF -61.2 dBm #AT 0 dB
SMPL
LOG
2
dB/

Z3



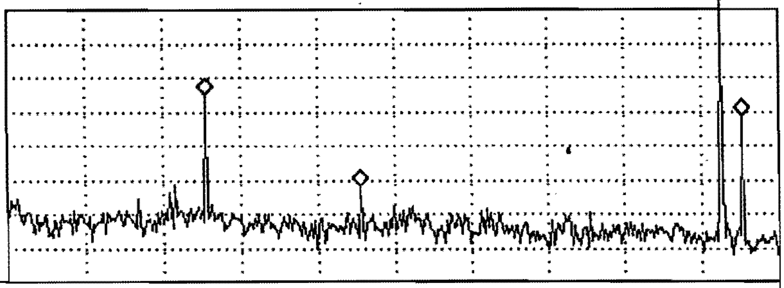
Pk	Freq (MHz)	Amplitude	Pk	Freq (MHz)	Amplitude
1	167.0	-51.04 dBm	6	235.5	-70.26 dBm
2	188.0	-69.36 dBm	7	242.5	-68.02 dBm
3	192.0	-70.05 dBm	8	264.0	-71.66 dBm
4	195.0	-67.56 dBm	9	336.5	-70.27 dBm
5	200.5	-70.64 dBm	10		

CENTER 250.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

Free Space with amp. West Direction

15:43:05 AUG 14, 2003
13:41:08 AUG 14, 2003 MKR 540.5 MHz
REF -66.4 dBm #AT 0 dB -72.73 dBm
SMPL
LOG
2
dB/

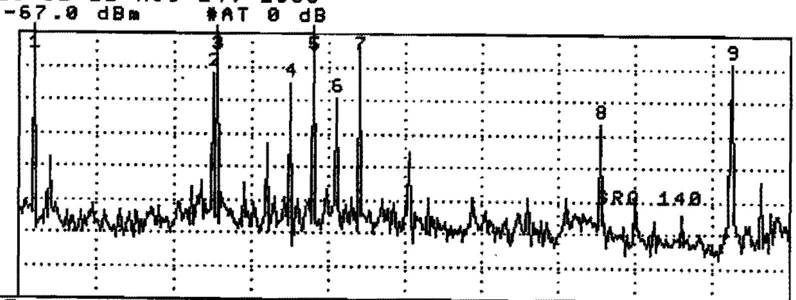
Y1



Marker	Trace	Type	Freq / Time	Amplitude
1:	(A)	Freq	401.0 MHz	-71.40 dBm
2:	(A)	Freq	441.0 MHz	-76.81 dBm
3:	(A)	Freq	535.0 MHz	-55.86 dBm
4:	(A)	Freq	540.5 MHz	-72.73 dBm

CENTER 450.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

15:37:58 AUG 15, 2003
13:52:11 AUG 14, 2003
REF -67.0 dBm #AT 0 dB
SMPL
LOG
2
dB/



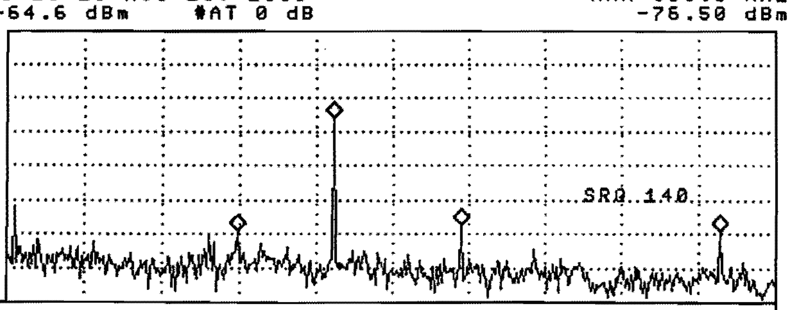
(26)

Pk	Freq (MHz)	Amplitude	Pk	Freq (MHz)	Amplitude
1	354.0	-65.40 dBm	6	432.0	-70.86 dBm
2	400.0	-69.38 dBm	7	438.0	-67.58 dBm
3	401.0	-54.27 dBm	8	501.0	-72.32 dBm
4	420.0	-70.00 dBm	9	535.0	-68.76 dBm
5	426.0	-65.81 dBm	10		

CENTER 450.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec

19:50:30 AUG 13, 2003
18:15:20 AUG 13, 2003 MKR 535.5 MHz
REF -64.6 dBm #AT 0 dB -76.50 dBm
SMPL
LOG
2
dB/

Y3



Marker	Trace	Type	Freq / Time	Amplitude
1:	(A)	Freq	409.5 MHz	-76.49 dBm
2:	(A)	Freq	434.5 MHz	-69.88 dBm
3:	(A)	Freq	468.0 MHz	-76.12 dBm
4:	(A)	Freq	535.5 MHz	-76.50 dBm

CENTER 450.0 MHz SPAN 200.0 MHz
#RES BW 30 kHz #VBW 30 kHz SWP 667 msec