Pub. No. : TI-1692
Date : June, 1998

FURUNO®

TECHNICAL INFORMATION

TEST REPORT ON THE PERFORMANCE OF MARINE RADAR

MODEL: FR-2125

FURUNO ELECTRIC CO., LTD.
NISHINOMIYA CITY, JAPAN

Pub. No. : TI-1692
Date : June, 1998

June 25, 1998

All data herein contained is true and correct to my best knowledge.

T. Yoshihara
Manager
Radio Navigation & Communication Section 2
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Marine Product Division
FURUNO ELECTRIC CO., LTD.

Personal History

Born:	January 29, 1944
Graduated:	Osaka University Electric Engineering Faculty
Occupation:	Joined FURUNO ELECTRIC CO., LTD. in April 1967, since then engaged in the development of radar equipment.

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1 GENERAL INFORMATION

1.1 General

(a) Manufacturer: Furuno Electric Co., Ltd.
Ashihara-cho 9-52, Nishinomiya-city, 662-8580 Japan

(b) Model: FR-2125
Serial no.: 3377-0004

(c) Primary Function: Search, navigation and anticollision

(d) Maximum Range Scale: 96 nm

(e) Discrimination
Range Discrimination: 35 meters on a range scale of 1.5 nm
Bearing Discrimination: Better than 2.5 ° on a range scale of 1.5 nm

(e) Minimum Range: 35 meters on a range scale of 0.25 nm

(f) Frequency Range: Fixed frequency, X-band
Type of Emission: P0N

(g) Power Supply: 24/32 VDC
100/110/115/220/230 VAC, 50/60 Hz, 1φ

1.2 Transmitter

(a) Assignable Frequency for Shipborne Radar:
Between 9300 and 9500 MHz (FCC Rule § 80.375 (d)-(1))

(b) Type of RF Generator
Magnetron Type: MG5436
Peak Output Power: 25 kW nominal

(c) Magnetron Ratings
Center frequency of Magnetron: 9410 MHz
Tolerances
Manufacturing: ±30 MHz
Pulling: 23 MHz
Tolerance for 20°C temperature variation: 5 MHz

(d) Guard Band:
Guard Band is specified to be equal to 1.5/T MHz, where "T" is the pulselength in microseconds. See para (e). (FCC Rule § 80.209)

(e) Pulse Characteristics:

Pulse Type	Short 1	Short 2	Middle 1	Middle 2	Middle 3	Long
Range Scale (nm)	0.125 0.25 0.5 0.75 (*) 1.5 (*)	0.5 0.75 (*) 1.5 (*) 3 (*)	0.75 (*) 1.5 (*) 3 (*) 6 (*)	3 (*) 6 (*) 12 (*) 24 (*)	3 (*) 6 (*) 12 (*) 24 (*)	6 (*) 12 (*) 24 (*) 48 96
Output pulselength (μs)	0.07	0.15	0.30	0.50	0.70	1.20
P.R.R. (Hz)	3000	3000	1500	1000	1000	600
Duty cycle	2.10E-4	4.50E-4	4.50E-4	5.00E-4	7.00E-4	7.20E-4
Guard Band (MHz)	21.43	10.00	5.00	3.00	2.14	1.25

Note 1:(*) Two (2) pulse types are selectable for each Range Scale.
2: Tests were carried out for the underlined Range Scales.

1.3 Modulator

(a) FET Type: 2SK1450

1.4 Receiver

(a) Passband

IF Stage:

Pulse Type	Short 1	Short 2	Middle 1	Middle 2	Middle 3	Long
(MHz)	27	27	27	3	3	3

(b) Gain (overall) (dB): Sufficient to cause limiting, approximately 130

(c) Overall Noise Figure (dB): 6 (typical)

(d) Video Output Voltage (V): 0.7 positive across 75 ohms

(e) Features Provided: Sensitivity Time Controls (Anti-clutter Sea),
Fast Time Constant (Anti-clutter Rain)

(f) If receiver is tunable, describe method of adjusting frequency:

Adjustment of tuning voltage of receiver local oscillator (Automatic and manual)

1.5 Display

(a) Type: 21 (in.) multi-color, 1280X1024 pixels
Rasterscan, non-interlace

(b) Size of Indicator Tube: 21 in. diagonal CRT
effective dia. 275 mm

(c) Sweep Linearity: 2 % on all ranges

(d) Range Scales:

Range (nm)	Number of Range Rings	Range Ring Interval (nm)
0.125	5	0.025
0.25	5	0.05
0.5	5	0.1
0.75	3	0.25
1.5	6	0.25
3	6	0.5
6	6	1
12	6	2
24	6	4
48	6	8
96	6	16

(e) Range Ring Accuracy: Better than 1 % of maximum scale in use
or 15 m, whichever is the greater

(f) Overall Bearing Accuracy from Scanner to Display:
Better than 1°

(g) Target Plot Facility: Simulated afterglow in low shade

(h) Heading Indicator: Provided, automatic alignment. Heading Line and Heading Marker

(i) True Bearing Indicator: Provided

1.6 Antenna

(a) Antenna Rotation ON-OFF Switch:
Provided, interlocked with the Power Switch and Transmitter Circuits.

(b) Reflector: Slotted waveguide array,

Radiator Type	XN12AF	XN20AF	XN24AF
Length (cm)	120	200	240
Length (ft)	4	6.6	8

(c) Type of Beam: Vertical fan

(d) Beam Width (between half-Radiator power points)

Radiator Type	XN12AF	XN20AF	XN24AF
Horizontal	1.80 °	1.23 °	0.95 °
Vertical	20 °	20 °	20 °

(e) Polarization: Horizontal

(f) Antenna Gain:

Radiator Type	XN12AF	XN20AF	XN24AF
(dB)	27.9	30.7	31.6

(g) Attenuation of Major Side Lobes with respect to main beam:

Within ±10° , -28 dB or less for all radiators

Outside ±10° , -32 dB or less for all radiators

(h) Scanning (rotating or Rotating over 360° continuously oscillating):

clockwise

(i) Antenna Rotation Rate (rpm): 24 rpm (for RSB-0074)

42 rpm (for RSB-0075)

(j) Number of Degrees Scanned: 360°

(k) Sector Scan: Not provided. Sector blanking available.

(l) Type of Transmission System: Contained in scanner unit

(m) Rated Loss of Transmission System per hundred feet::

None. Transmission path is only in the antenna scanner unit.

1.7 Line Power Supply Requirements

(a) Input Voltage: 24/32 VDC

100/110/115/220/230 VAC, 50/60 Hz, 1φ

(b) Power Drain: 260 W

410 VA

1.8 Functional Controls

Range selector	Tune (manual)	EBL offset
INDEX LINE	Anti-clutter auto	Power Switch
A/C Sea control	Gain control	Panel dimmer
Heading line off	Echo stretch	MENU
Guard zone set/Audio alarm off	Range ring brilliance	Noise rejector on/off
Interference rejector	STBY/TX	Trackball (VRM,EBL,GUARD)
VRM on/off	Off-center (SHIFT)	A/C Rain control

Range set	Zoom	EBL on/off
Target trail	Brilliance (screen)	TRU/REL
Navigation on/off	Mark Brilliance	Function #1- #4
Range ring on/off	Text Brilliance	
ARPA function (option)		

1.9 Construction Features

(a) Does equipment embody replacement units with chassis type assembly:

Yes

(b) Are fuse alarms provided: Fuses are provided.

(c) State units which are weatherproof: Scanner Unit (IEC IPX6)

(d) If all units are not housed in a single container, indicate number and give description of individual units:

1 × Display Unit	Type:	RDP-124	
1× Scanner Unit	Type:	RSB-0074	(24 V, 24 rpm)
		RSB-0075	(24 V, 42 rpm)
(Transceiver	Type:	RTR-063	(contained in the Scanner unit))

(e) Approximate Weight of Complete Installation:

Display Unit (Optional):	55 kg	
Scanner Unit:	31 kg	(XN12AF-RSB-0074/75)
	34 kg	(XN20AF-RSB-0074/75)
	36 kg	(XN24AF-RSB-0074/75)

(f) Approximate space required for installation excluding scanner:

Display Unit: 588 mm (W) X 573 mm (H) X 720 mm (D)

1.10 Operational Features

(a) Is positive means provided to indicate whether or not the overall operation of the equipment is such that it may be relied upon to provide effective operation in accordance with its primary function:

Magnetron/Xtal checker

(b) Is the equipment for continuous operation:

Yes

(c) Is provision made for operation with shore based radar beacons (RACONS):

Yes (RACONS and SART)

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2 IDENTIFICATION OF EQUIPMENT (FCC Rule § 2.925)

The following nameplates are permanently fixed on the corresponding equipment units.

FCC ID: ADB9ZWFR2125

Material of nameplate: Aluminum, 0.5 mm thick

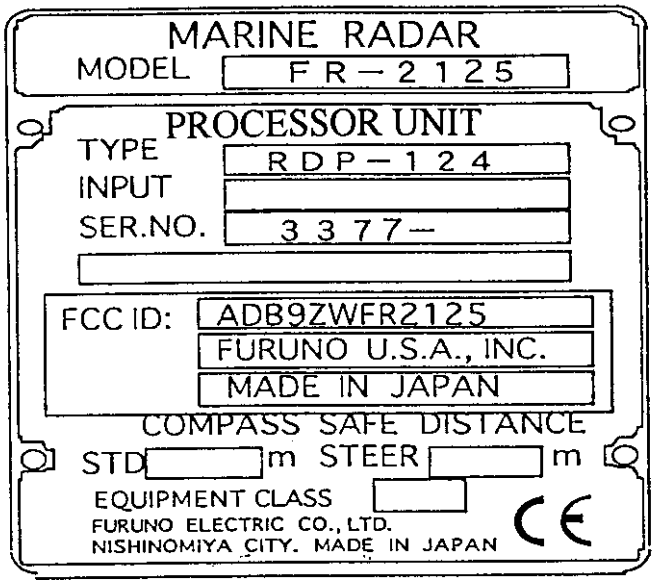

Fig.2.1
Nameplate for Processor Unit
(RDP-0124)

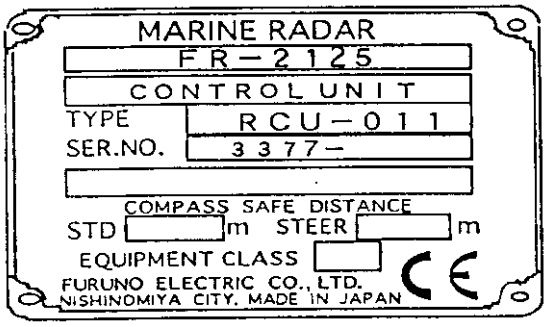

Fig.2.2
Nameplate for Control unit
(RCU-011)
(Display unit consists of
Control and Processor units.)

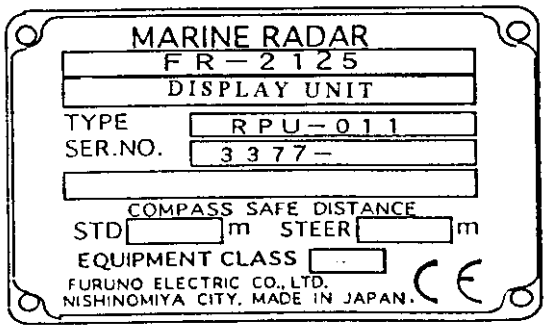

Fig.2.3
Nameplate for Display Unit
(RPU-011)

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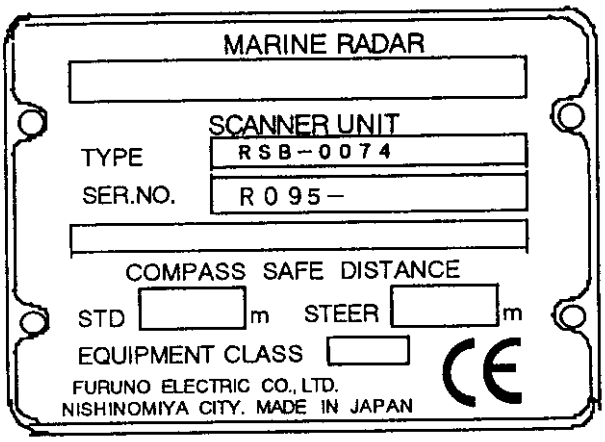

Fig.2.4
Nameplate for Scanner unit
(RSB-0074)

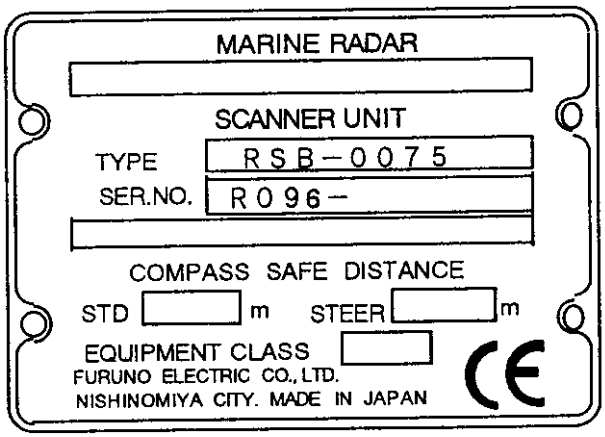

Fig.2.5
Nameplate for Scanner unit
(RSB-0075)

3 RF POWER OUTPUT (FCC Rule §2.985)

3.1 Microwave characteristics

The peak voltage was determined using the divider having a ratio of 1000 to 1 and the oscilloscope. Current pulse was viewed across the wideband current transformer with output voltage per ampere 1.00.

Nominal values

Pulse Type	Short 1	Short 2	Middle 1	Middle 2	Middle 3	Long
Range scale (nm)	0.125	3	6	12	24	48
Pulselength (µs)	0.07	0.15	0.30	0.50	0.70	1.20
PRR (Hz)	3000	3000	1500	1000	1000	600
Duty cycle	2.10E-4	4.50E-4	4.50E-4	5.00E-4	7.00E-4	7.20E-4
Guard band (MHz)	21.43	10.00	5.00	3.00	2.14	1.25

Measured values

Magnetron input pulse voltage was measured at its cathode using the oscilloscope and divider with ratio 1000 to 1.

Pulse Type	Short 1	Short 2	Middle 1	Middle 2	Middle 3	Long
Directional coupler attenuation (dB)	40.67	40.67	40.67	40.67	40.67	40.67
Magnetron input voltage (kV)	8.40	8.40	8.30	8.40	8.40	8.40
Pulselength (µs) (50 % amplitude)	0.245	0.750	1.200	1.300	0.930	1.370
Rise time (µs) (10-90 % amplitude)	0.070	0.070	0.070	0.070	0.070	0.070
Decay time (µs) (90-10 % amplitude)	0.160	1.550	1.550	1.350	1.080	0.560

Magnetron input pulse current

Magnetron input pulse current was observed across the wideband current transformer with output voltage per ampere 1.00.

Pulse Type	Short 1	Short 2	Middle 1	Middle 2	Middle 3	Long
Magnetron input current (A)	7.0	7.0	7.0	8.4	8. 8	8.8

Pulse Type	Short 1	Short 2	Middle 1	Middle 2	Middle 3	Long
Pulselength (μs) (50 % amplitude)	0.074	0.150	0.320	0.504	0.710	1.150
Rise time (μs) (10-90 % amplitude)	0.090	0.090	0.090	0.255	0.330	0.330
Decay time (μs) (90-10 % amplitude)	0.100	0.130	0.180	0.180	0.125	0.125

RF envelope of the magnetron output pulse

The RF envelope of the magnetron output pulse was measured using a diode and the oscilloscope with the following results:

Pulse Type	Short 1	Short 2	Middle 1	Middle 2	Middle 3	Long
Pulselength (μs) (-3 dB points)	0.073	0.166	0.317	0.505	0.710	1.160
Rise time (μs) (10-90 % amplitude)	0.008	0.008	0.008	0.008	0.190	0.245
Decay time (μs) (90-10 % amplitude)	0.102	0.109	0.186	0.200	0.132	0.135

Estimated efficiency

The estimated efficiency of the RF generator (magnetron) was determined by the following measurements and calculation. Power output from magnetron was measured using the directional coupler, power meter and the oscilloscope.

Pulse Type	Short 1	Short 2	Middle 1	Middle 2	Middle 3	Long
Range scale (nm)	0.125	3	6	12	24	48
PRR (Hz)	3212	2982.1	1605.8	1043.7	1043.7	623.1
Duty cycle	2.34E-4	4.95E-4	5.09E-4	5.27E-4	7.41E-4	7.22E-4
Magnetron input, av. (W)	13.79	29.11	29.58	37.19	54.78	53.43
Magnetron input, peak (kW)	58.800	58.800	58.100	70.560	73.920	73.920
Power meter reading (mW)	0.333	0.673	0.825	0.913	1.330	1.320
Magnetron output, av. (W)	3.885	7.853	9.626	10.653	15.519	15.402
Spurious response limits (dB)	48.9	52.0	52.8	53.3	54.9	54.9
Magnetron Output, peak (kW):	16.573	15.863	18.911	20.212	20.942	21.309
Magnetron efficiency (%):	28.2	27.0	32.5	28.6	28.3	28.8

Peak Power Input to RF Generator : 64.04 kW
Estimated Efficiency of RF Generator : 28.9 %

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4 MODULATION CHARACTERISTICS (FCC Rule § 2.987)

4.1 FET Trigger Pulse

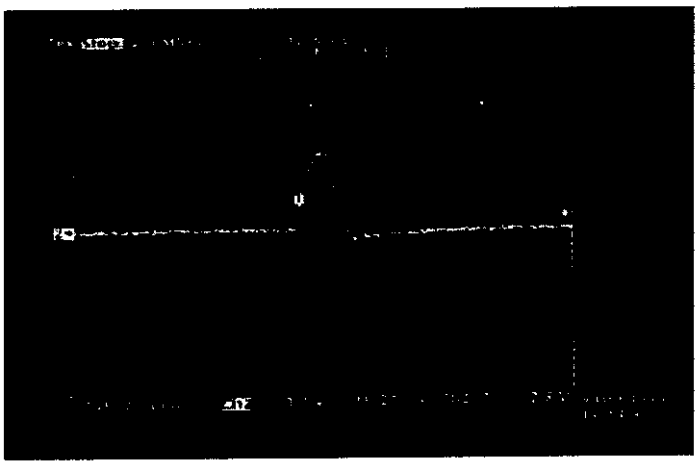
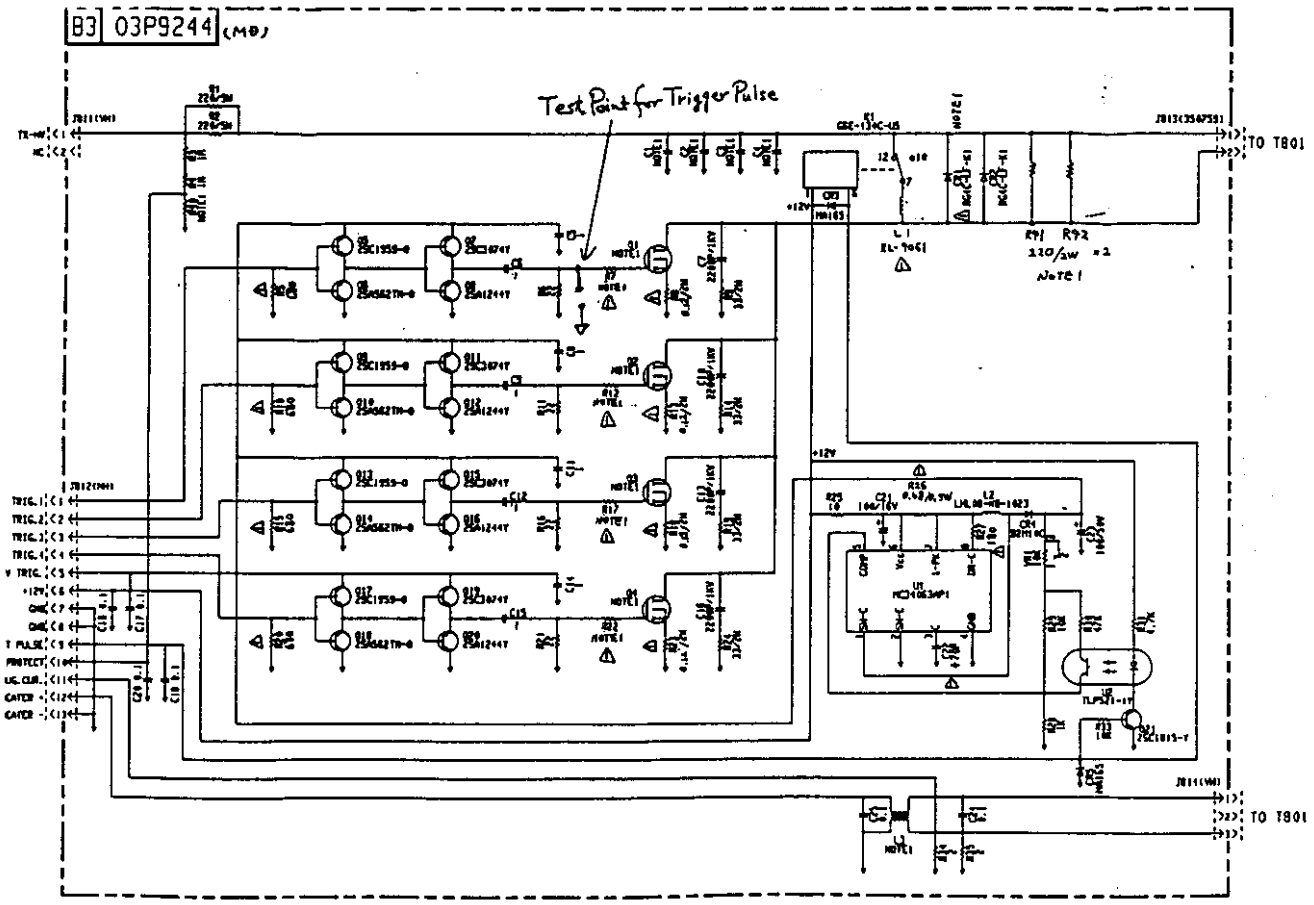


Fig. 4.1 (Typical wave form of Trigger Pulse) Scale: 10 V/div.

Short 1 Pulse (0.125 nm Range) 200 ns/div.



4.2 Trigger Pulse at Magnetron Cathode

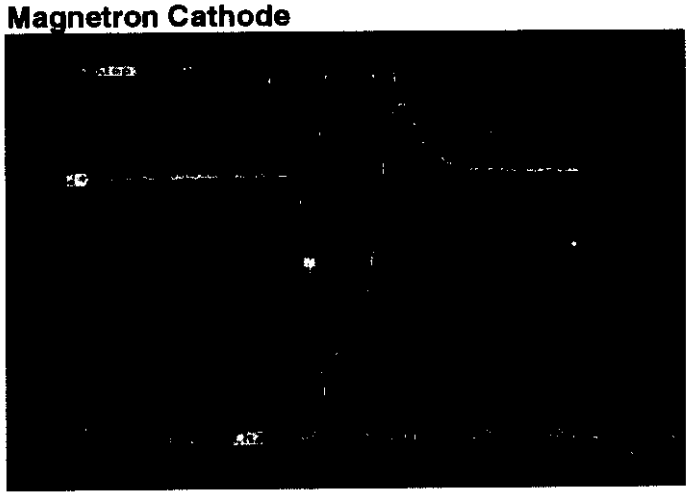


Fig. 4.2.1 Short 1 Pulse (0.125 nm Range) Scale: 2 kV/div. 200 ns/div.

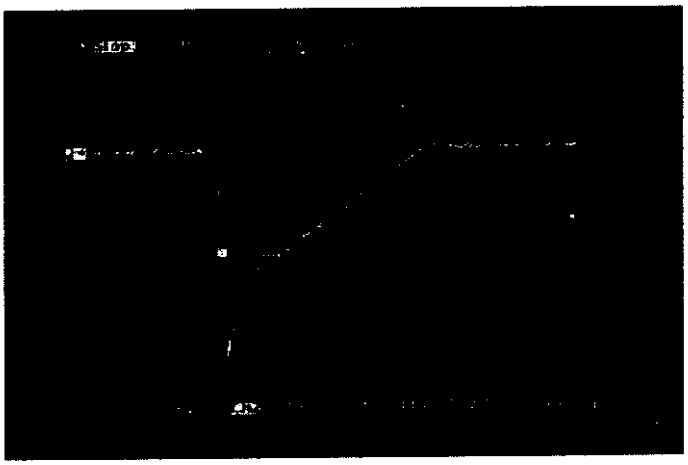


Fig. 4.2.2 Short 2 Pulse (3 nm Range) Scale: 2 kV/div. 500 ns/div.

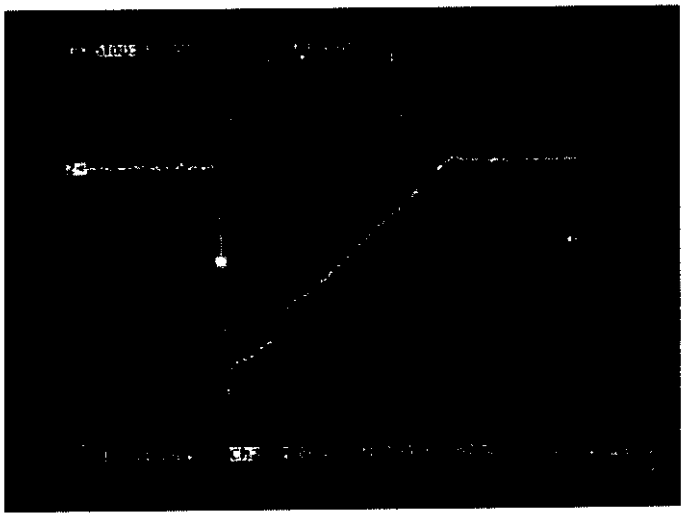


Fig. 4.2.3 Middle 1 Pulse (6 nm Range) Scale: 2 kV/div. 500 ns/div.

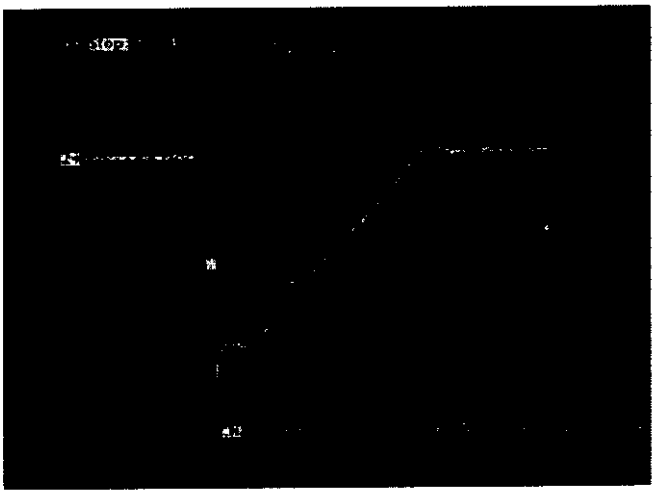


Fig. 4.2.4 Middle 2 Pulse (12 nm Range) Scale: 2 kV/div. 500 ns/div.

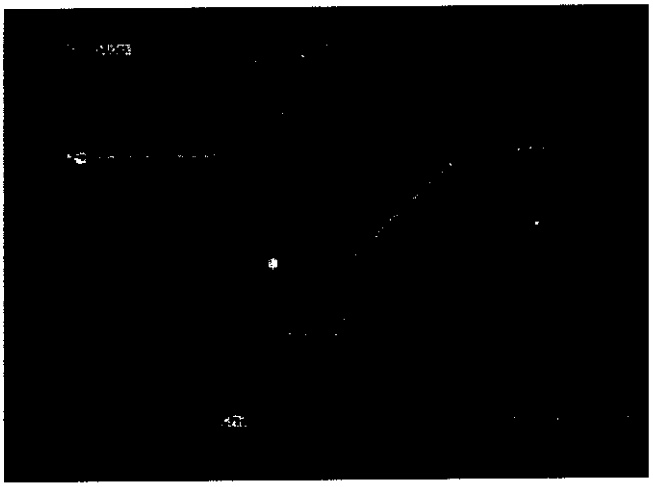


Fig. 4.2.5 Middle 3 Pulse (24 nm Range) Scale: 2 kV/div. 500 ns/div.

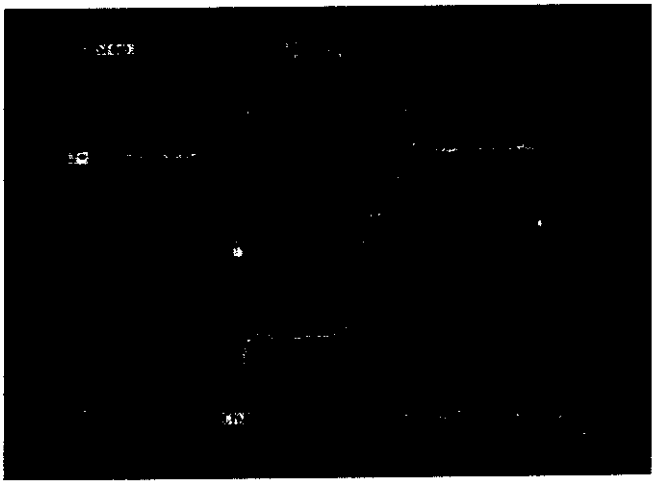


Fig. 4.2.6 Long Pulse (48 nm Range) Scale: 2 kV/div. 500 ns/div.

4.3 **Magnetron Output** (detected):

4.3.1 Setup for **Measurement:**

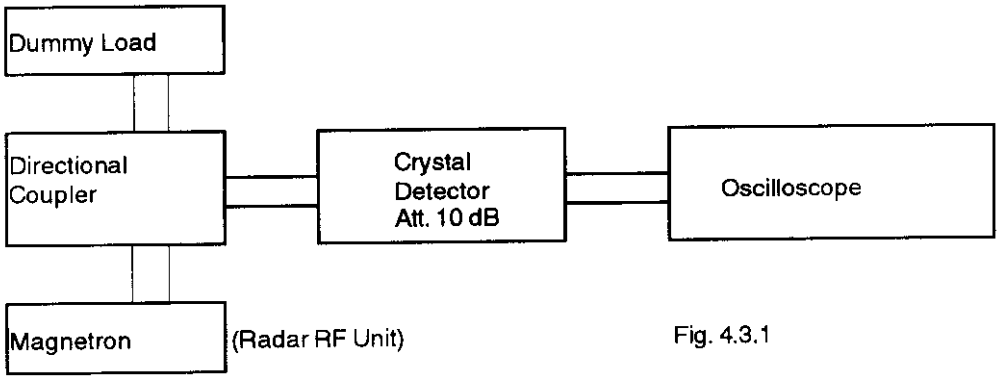


Fig. 4.3.1

4.3.2 Measuring Equipment List:

See ATTACHMENT 4 [LIST OF TEST/MEASURING EQUIPMENT].

4.3.3 Measured Data:

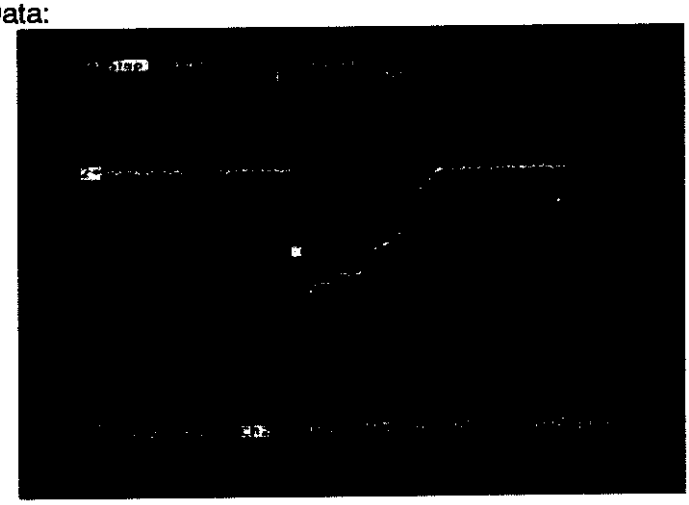


Fig. 4.3.2 Short 1 Pulse (0.125 nm Range) Scale: 100 mV/div. 50 ns/div.

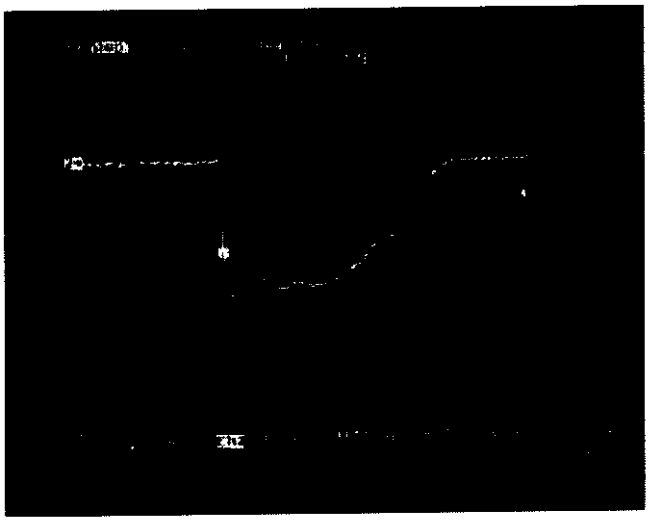


Fig. 4.3.3 Short 2 Pulse (3 nm Range) Scale: 100 mV/div. 50 ns/div.

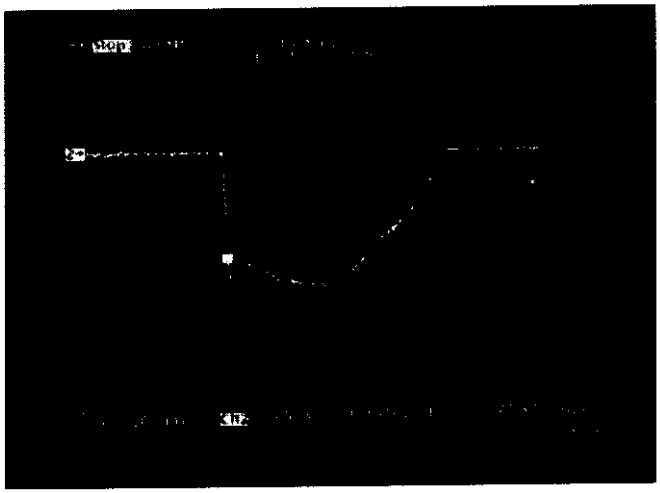


Fig. 4.3.4 Middle 1 Pulse (6 nm Range) Scale: 100 mV/div. 100 ns/div.

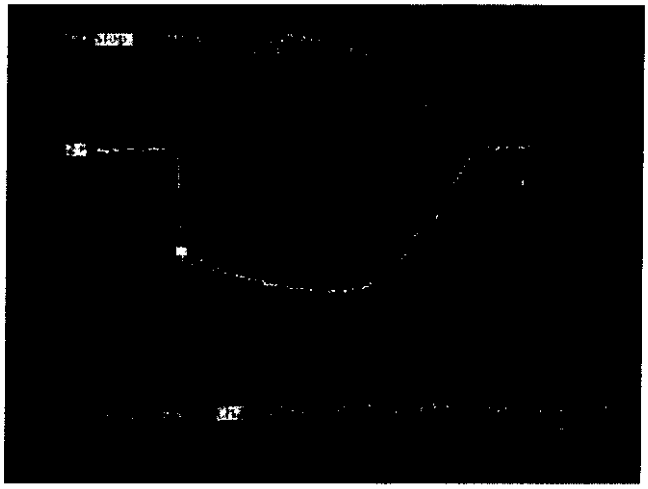


Fig. 4.3.5 Middle 2 Pulse (12 nm Range) Scale: 100 mV/div. 100 ns/div.

Fig. 4.3.6 Middle 3 Pulse (24 nm Range) Scale: 100 mV/div. 200 ns/div.

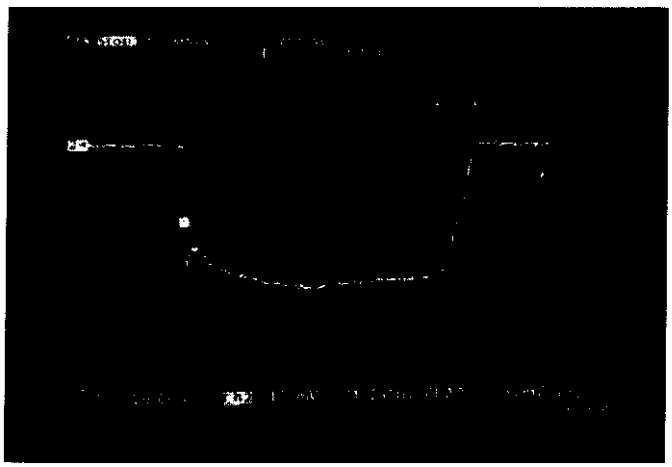


Fig. 4.3.7 Long Pulse (48 nm Range) Scale: 100 mV/div. 200 ns/div.

4.4 Radar Pulse Spectrum:

Measured by the spectrum analyzer.

(Test Equipment Setup and Measuring Equipment List are same as Clause 6.1 and 6.2.)

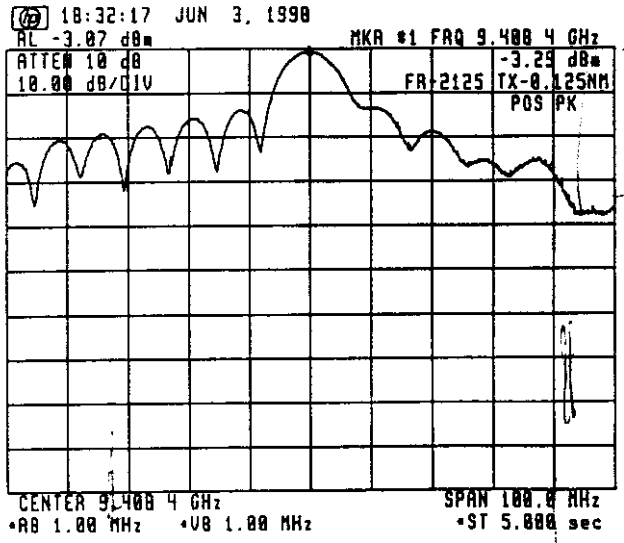


Fig. 4.4.1

Short 1 Pulse (0.125 nm Range)

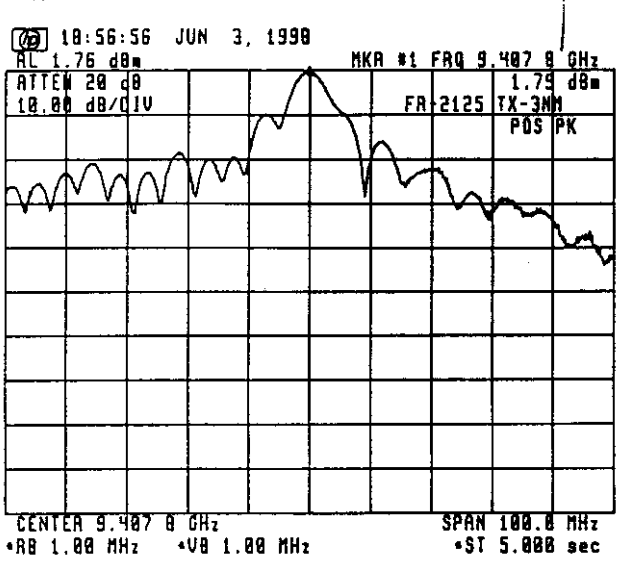


Fig. 4.4.2

Short 2 Pulse (3 nm Range)

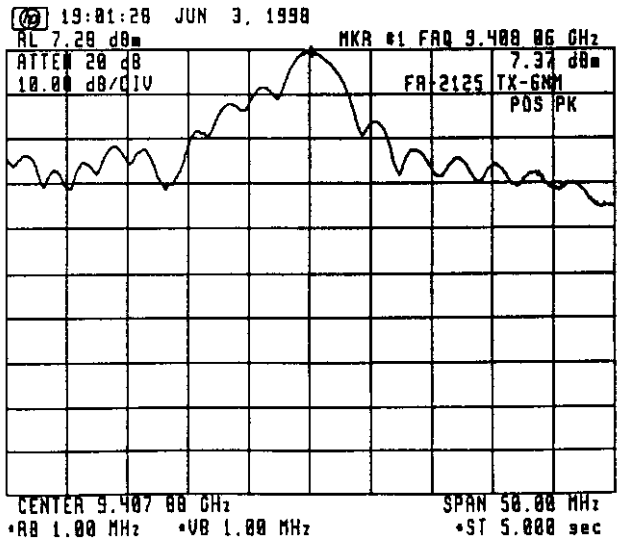


Fig. 4.4.3

Middle 1 Pulse (6 nm Range)

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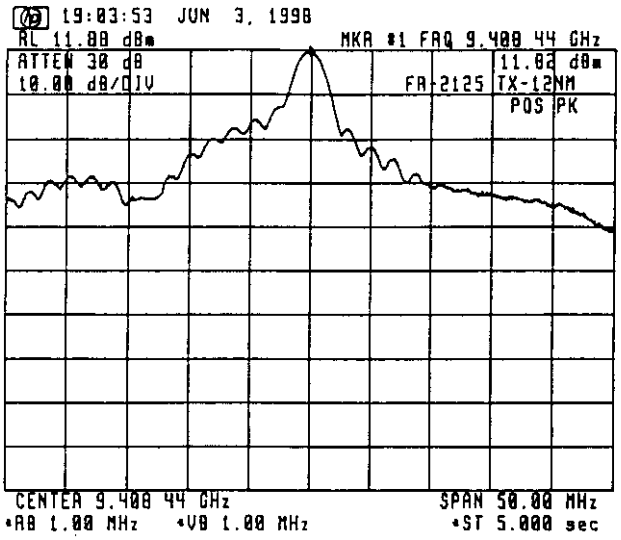


Fig. 4.4.4

Middle 2 Pulse (12 nm Range)

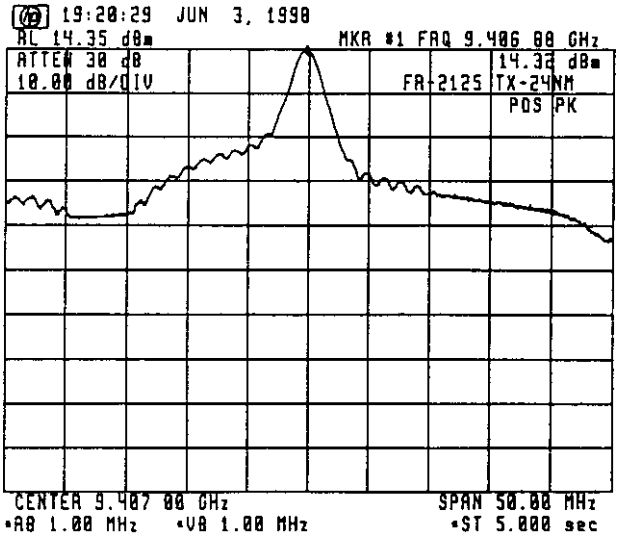


Fig. 4.4.5

Middle 3 Pulse (24 nm Range)

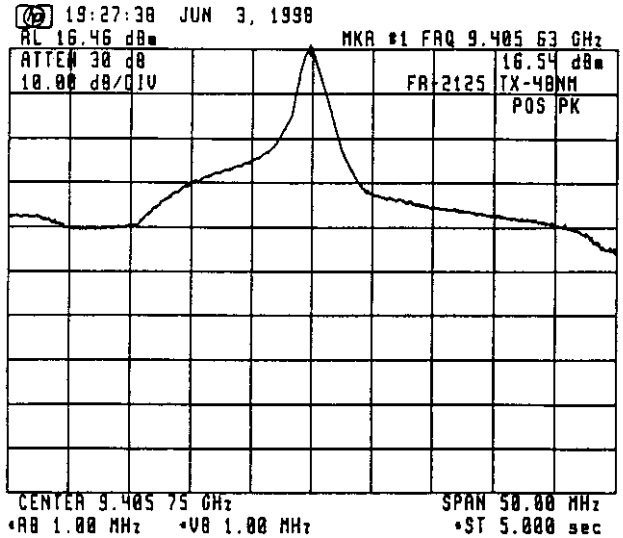


Fig. 4.4.6

Long Pulse (48 nm Range)

5 OCCUPIED BANDWIDTH (FCC Rule §2.989)

5.1 Measuring Method

FCC rule 47 CFR 2.989 requires measurements of the occupied bandwidth which is defined in the same section as "the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission."

To obtain the occupied bandwidth of the radar transmitter, a special program (program list shown below) was loaded to the Hewlett-Packard spectrum analyzer and run by entering the HP-provided POWER BANDWIDTH calculation command [PWRBW].

The result was automatically displayed on the screen on the spectrum analyzer as:

POWER_BW=----- MHz

```
10    ! HP_71000 DOWNLOAD PROGRAM
20    ASSIGN @Sa TO 718
30    CLEAR @Sa
40    CALL M_ain(@Sa)
50    LOCAL @Sa
60    END
70    !
80    SUB M_ain(@Sa)
90 M_ain:     !
100   CALL Pwr_bw(@Sa)
110   CALL Limit_line(@Sa)
120   !
130   OUTPUT @Sa;"VARDEF K_ey,0;";
140   !
150   OUTPUT @Sa;"FUNCDEF D_LP,^";
160   OUTPUT @Sa;"MOV K_ey,0;";
170   !
180 Main_menu:   !
190   OUTPUT @Sa;"REPEAT;";
200   OUTPUT @Sa;"READMENU K_ey,";
210   !  location: %Top----Bottom-%
220   OUTPUT @Sa;" l,%Limit  line  %,";
230   OUTPUT @Sa;" 2,%Power  bw     %,";
240   OUTPUT @Sa;"14,%    Exit%;";
250   !
260   OUTPUT @Sa;"IF K_ey,EQ,1;THEN;LIMIT_LINE;";
270   OUTPUT @Sa;"ELSIF K_ey,EQ,2;THEN;PWR_BW;";
280   OUTPUT @Sa;"ELSIF K_ey,EQ,l4;THEN;ABORT;";
290   OUTPUT @Sa;"ENDIF;";
300   OUTPUT @Sa;"UNTIL K_ey,EQ,14;";
310   OUTPUT @Sa;"IP;TS;";
320   OUTPUT @Sa;"ADORT;";
330   OUTPUT @Sa;"^"
340   !
350 Define_keydef:   !
360   OUTPUT @Sa;"KEYDEF 7,D_LP, %DLP      TEST%;";
370   !
380   OUTPUT   @Sa;"FUNCDEF D,^";
390   OUTPUT   @Sa;"KEYPST;";
400   OUTPUT   @Sa;"^"
410   !
420   SUBEND
430   !
440   SUB Limit_line(@Sa)
450 Limit_line:    !
460   OUTPUT @Sa;"CLRDSP;";
470   OUTPUT@Sa;"FUNCDEF LIMIT_LINE,^";
480   OUTPUT   @Sa;"PU;PA   0,654;";
490   OUTPUT   @Sa;"LINET 1;";
500   OUTPUT   @Sa;"PD;PA 100,654;";
510   OUTPUT   @Sa;"PU;PA 201,654;";
520   OUTPUT   @Sa;"PD;PA 300,654;";
530   OUTPUT   @Sa;"PU;PA 105,630;";
540   OUTPUT   @Sa;"TEXT @-35dB@;";
550   OUTPUT   @Sa;"PU;PA 205,720;";
560   OUTPUT   @Sa;"TEXT @-25dB@;";
570   OUTPUT   @Sa;"PU;PA 301,743;";
580   OUTPUT   @Sa;"LINET 1;";
590   OUTPUT   @Sa;"PD;PA 400,743;";
600   OUTPUT   @Sa;"PU;PA 601,743;";
610   OUTPUT   @Sa;"LINET l;";
620   OUTPUT   @Sa;"PD;PA 700,743;";
630   OUTPUT   @Sa;"PU;PA 701,654;";
640   OUTPUT   @Sa;"LINET l;";
650   OUTPUT@Sa;"PD;PA 1000,654;HD;";
660   OUTPUT   @Sa;"^"
670   SUBEND
680   SUB Pwr_bw(@Sa)
690 Pwr_bw:     !
700   !     Calculating Power band width
710   OUTPUT @Sa;   "VARDEF P_bw,0;";
720   OUTPUT @Sa;"FUNCDEF PWR_BW,^";
730   OUTPUT @Sa;"CLRW TRA;";
740   OUTPUT @Sa;"CLRDSP;";
750   OUTPUT @Sa;"SNGLS;";
760   OUTPUT @Sa;"MXMH   TRA;TS;TS;TS;";
770   OUTPUT @Sa;"MOV   P_bw,PWRBW   TRA,99.0;";
780   OUTPUT@Sa;"DIV P__bw,P_bw,1000000;";
790   OUTPUT @Sa;"PU;PA 10,800;HD;";
800   OUTPUT @Sa;"TEXT @POWER_BW = @;";
810   OUTPUT @Sa;"DSPLY P_bw,8,3;";
820   OUTPUT @Sa;"TEXT @ MHz @;";
830   OUTPUT @Sa;"^"
840   SUBEND
```

Fig. 5.1 Program for Calculation of Occupied Bandwidth

5.2 Test Equipment Setup:

Same as Clause 6.1.

5.3 Measuring Equipment List:

Same as Clause 6.2.

5.4 Test Result:

The test result is shown below.

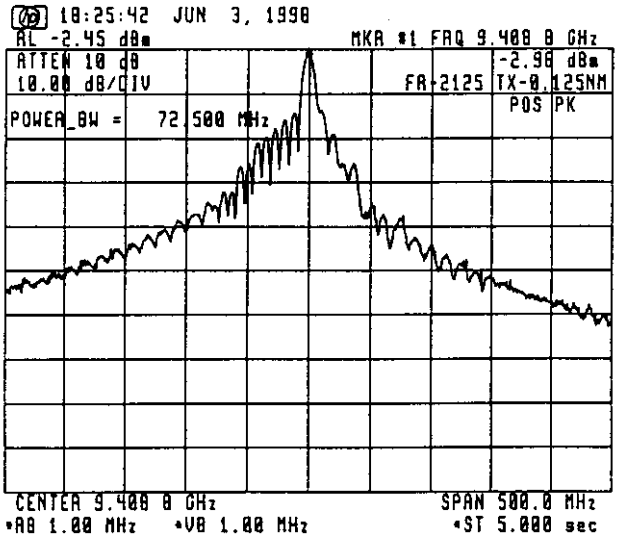


Fig. 5.2 Measurement of Occupied Bandwidth

Occupied bandwidth = 72.500 MHz

6 SPURIOUS EMISSIONS AT ANTENNA TERMINAL (FCC Rule §2.991)

6.1 Test Equipment Setup:

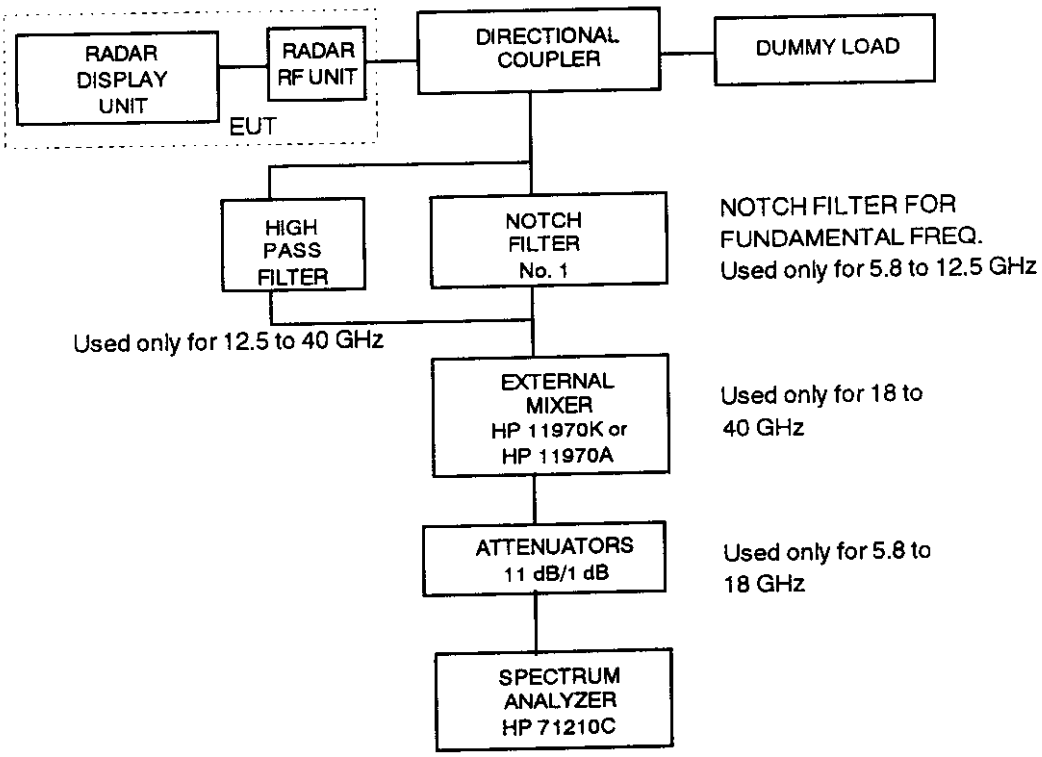


Fig. 6.1

6.2 Measuring Equipment List:

See ATTACHMENT 4 [LIST OF TEST/MEASURING EQUIPMENT].

Note : (1) The characteristics of Notch Filter (No. 1) are described in Fig. 6.2 to Fig. 6.5.
(2) The characteristic of High Pass Filter (No. 2) is described in Fig. 6.6.

6.3 Test Conditions:

Radar Range Settings: 0.125 nm (Short1)/3 nm (Short2)/6 nm (Middle1)/
12 nm (Middle2)/24 nm (Middle3)/48 nm (Long)

6.4 Emission Limits:

(a) Frequency Range (FCC Rule §2.997) : 10 kHz - 40 GHz

(b) Emission Limits (FCC Rule §80.211) :

Frequency removed from the assigned frequency	Frequency (Hz)	Emission attenuation (mean power ,dB)
50 - 100 % (of the authorized bandwidth)	9310 - 9360 M 9460 - 9510 M	At least 25
100 - 250 %	9160 - 9310 M 9510 - 9660 M	At least 35
more than 250 %	10 k - 9160 M 9660 - 40,000 M	At least 43 + 10 log 10 (mean power in watts)

Note : (1) Assigned frequency (center frequency) = 9410 MHz

(2) Authorized bandwidth = 100 MHz

6.5 Test Results:

As shown in ATTACHMENT 1 , the spurious emissions at antenna terminal of EUT are found lower than the specified limits.

(Note: Spurious emissions for 10 kHz to 5 GHz are not found due to the antenna terminal structure. (wave guide tube)).

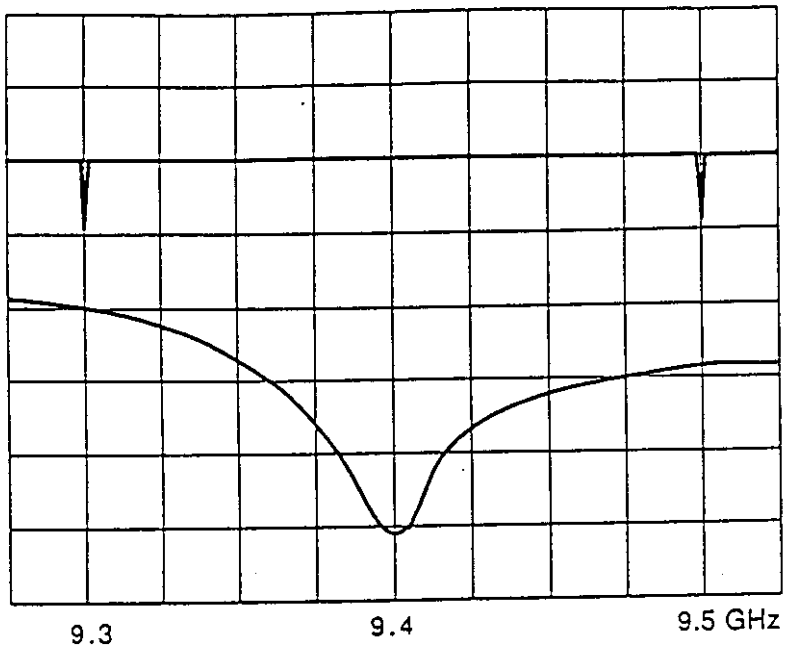
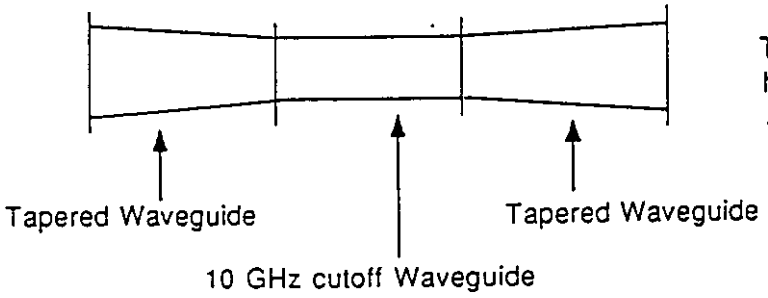


Fig. 6.5

Characteristic of Filter No. 2 (for X-band)



This filter is used to filter out the high level fundamental signal to avoid damage to the analyzer.

High Pass Filter Construction

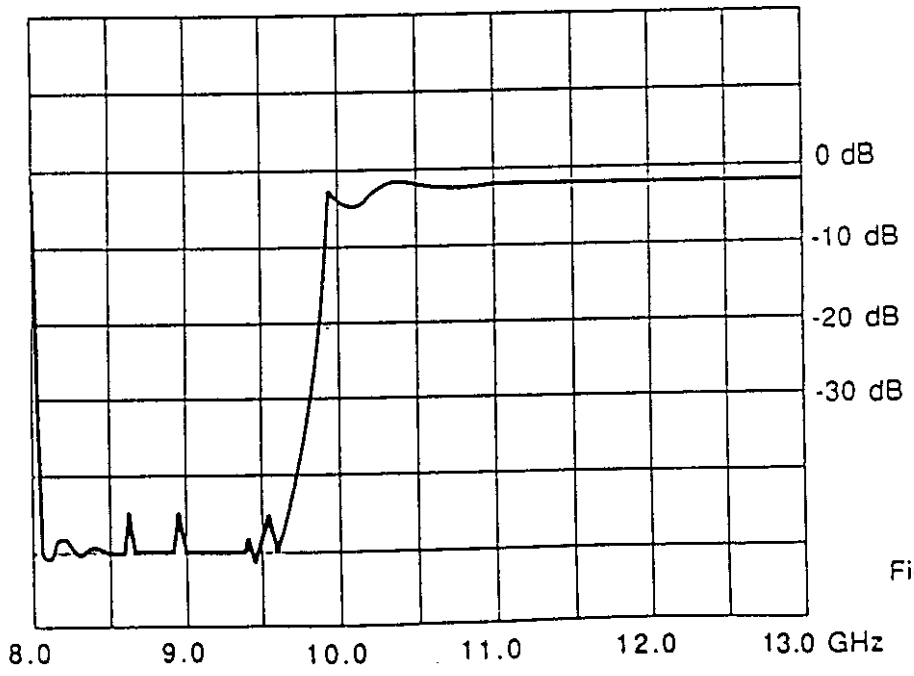


Fig.6.6

Characteristic of Filter No. 1 (for X-band)

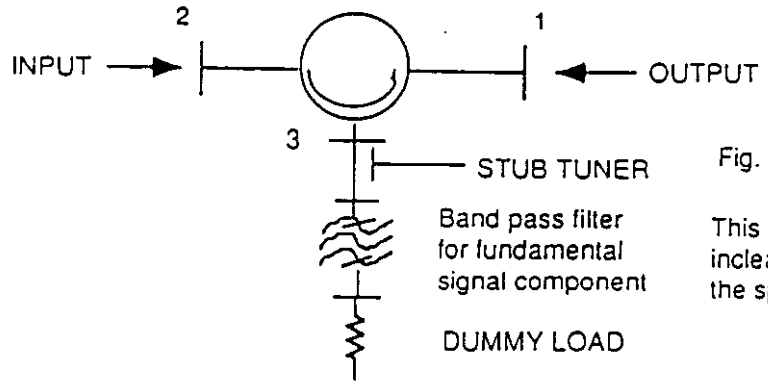


Fig. 6.2 Setup of Notch Filter No.1

This notch filter is used to inclease the dynamic range of the spectrum analyzer

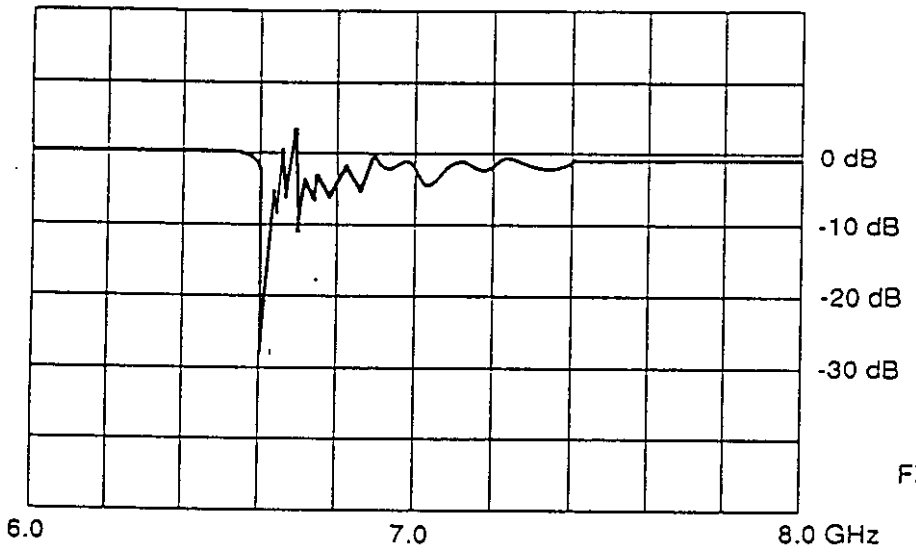


Fig. 6.3

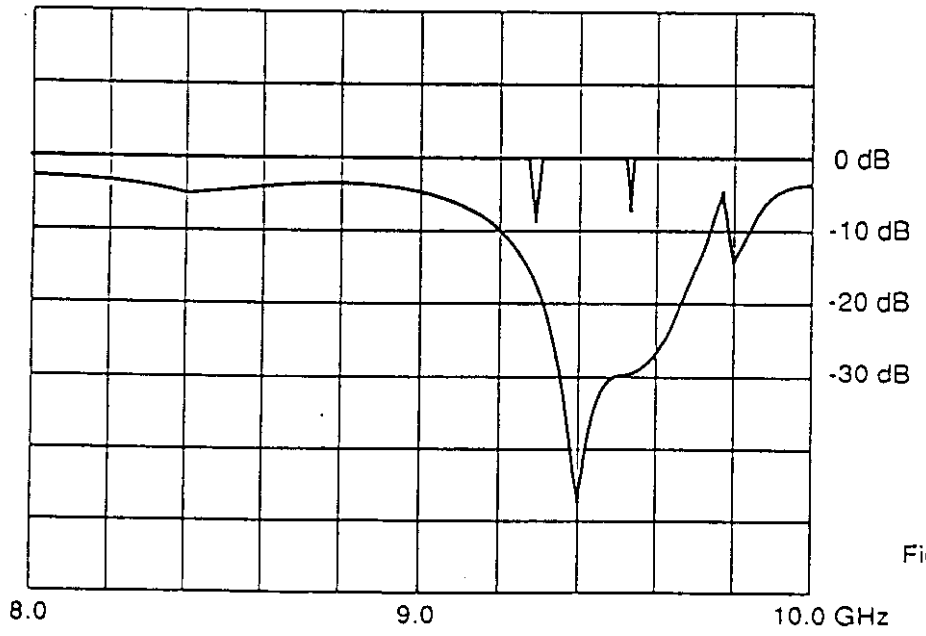


Fig. 6.4

7 FIELD STRENGTH OF SPURIOUS RADIATION (FCC Rule §2.993)

7.1 Test Site: Rooftop of 6-story building,
FURUNO ELECTRIC CO., LTD.
Ashihara- cho 9-52, Nishinomiya-city, 662-8580 Japan

7.2 Date: June, 1998

7.3 Distance between the radar set and measuring antenna: 10 m

7.4 Radar Range settings: 0.125 nm (Short1)/3 nm (Short2)/6 nm (Middle1)/
12 nm (Middle2)/24 nm (Middle3)/48 nm (Long)

7.5 Measuring Equipment List:
See ATTACHMENT 4 [LIST OF TEST/MEASURING EQUIPMENT].

7.6 Test settings:
See Fig. 7.1 - Fig. 7.5.

7.7 Field Strength Limits:
(a) Frequency Range (FCC Rule §2.997) : 10 kHz - 40 GHz
(b) Emission Limits (FCC Rule §80.211) :

Frequency removed from the assigned frequency	Frequency (Hz)	Emission attenuation (mean power ,dB)
50 - 100 % (of the authorized bandwidth)	9310 - 9360 M 9460 - 9510 M	At least 25
100 - 250 %	9160 - 9310 M 9510 - 9660 M	At least 35
more than 250 %	10 k - 9160 M 9660 - 40,000 M	At least 43 + 10 log 10 (mean power in watts)

Note : (1) Assigned frequency (center frequency) = 9410 MHz
(2) Authorized bandwidth = 100 MHz

7.8 Test Results:
As shown in ATTACHMENT 2 , the field strengths of spurious radiation generated by EUT are found lower than the specified limits.

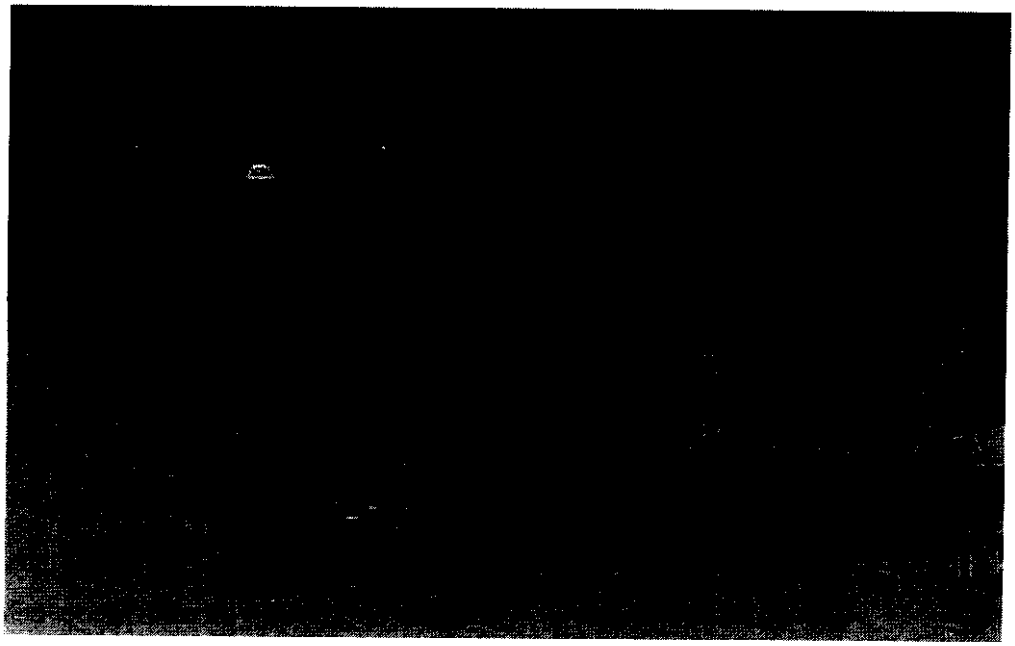


Fig. 7.1 Measuring Antenna: Broadband Rod Antenna Model 95010-1 of Advanced Electronics
Frequency Range: 10 kHz - 20 MHz

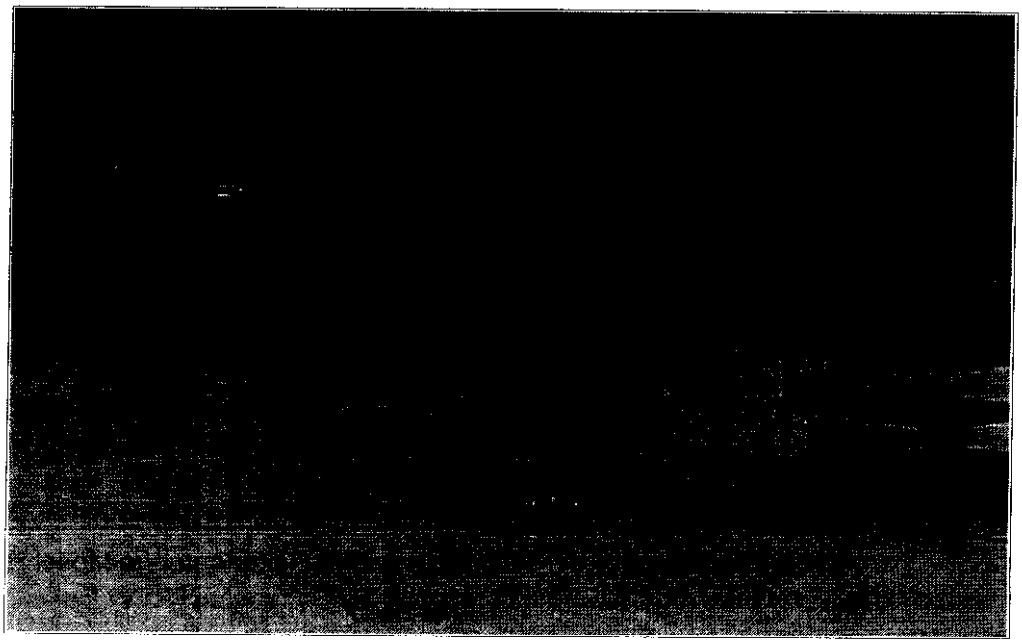


Fig. 7.2 Measuring Antenna: Biconical Antenna Model BIA-25 of Electro Metrics
Frequency Range: 20 MHz - 200 MHz

Fig. 7.3 Measuring Antenna: Conical Log-Spiral Antenna Model LCA-25 of Electro Metrics

Frequency Range: 200 MHz - 1 GHz

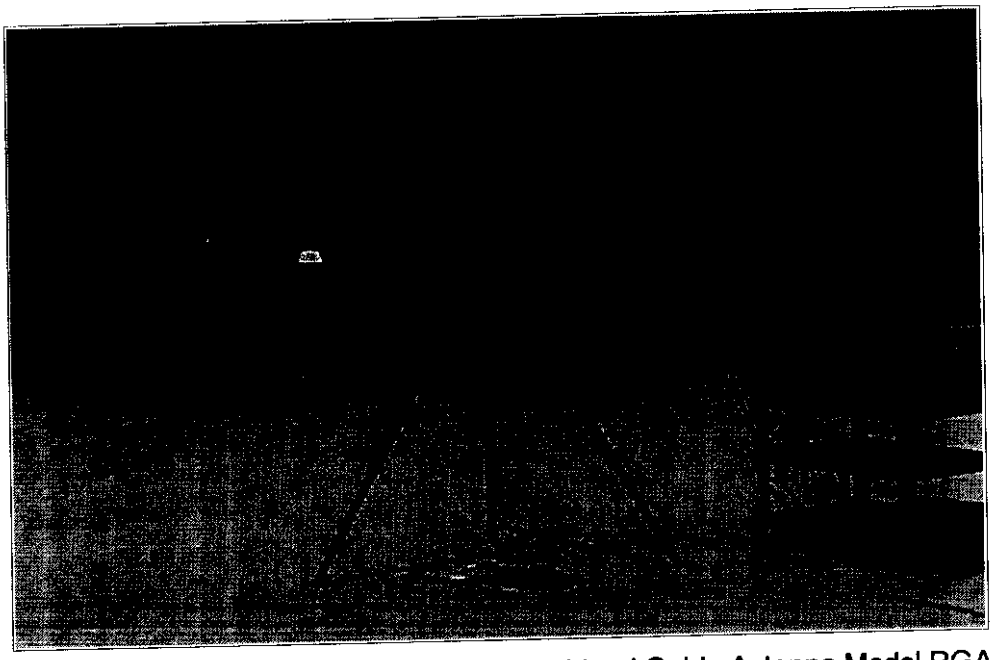


Fig. 7.4 Measuring Antenna: Double-ridged Guide Antenna Model RGA-180 of EMD
(Notch filter was connected between 9.3 and 9.5 GHz to ensure sufficient dynamic range of spectrum analyzer.)

Frequency Range: 1 GHz - 18 GHz

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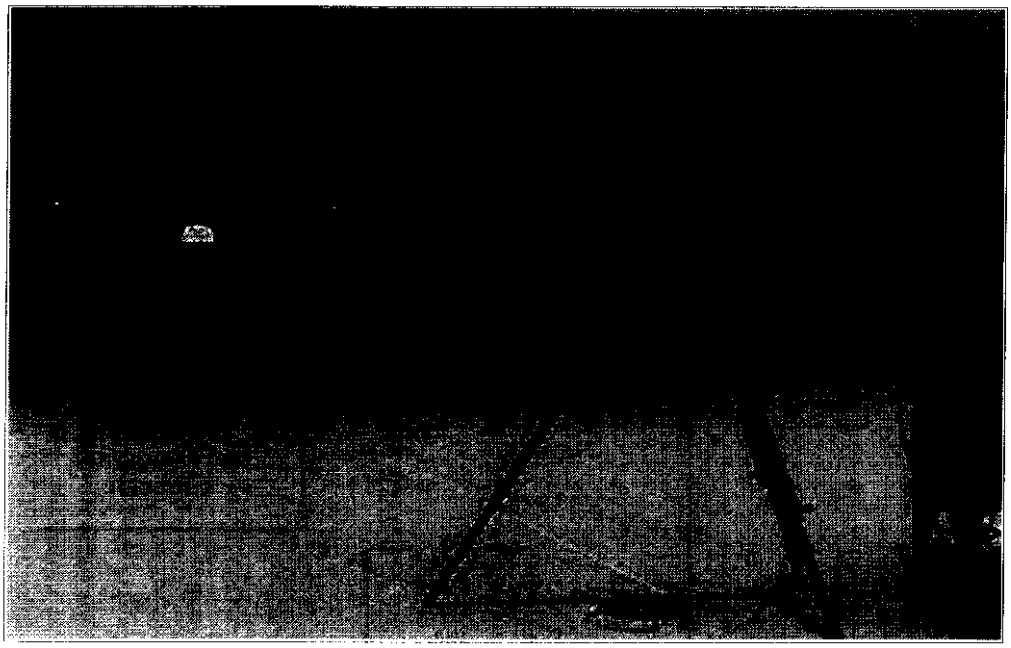

Fig. 7.5 Measuring Antenna: Toshiba Horn Antenna
Frequency Range: 18 GHz - 40 GHz

8 FREQUENCY STABILITY (FCC Rule §2.995)

8.1 Setup for Measurement

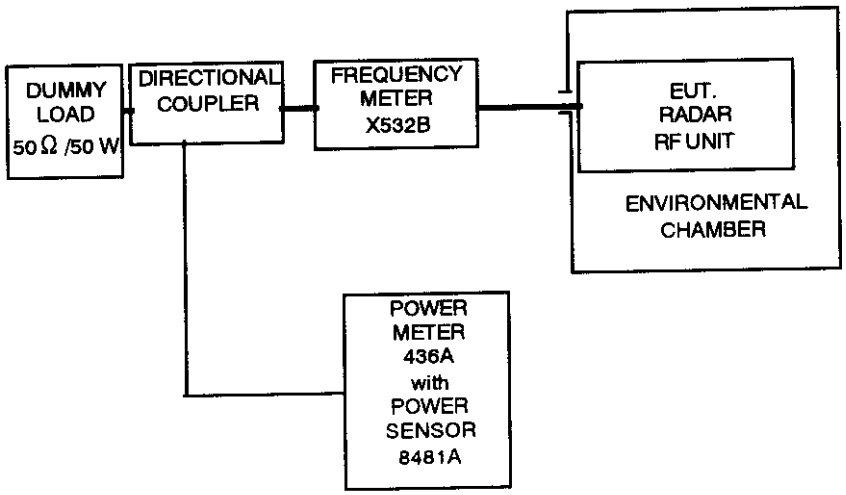

Fig. 8.1

8.2 Test Conditions:

1) Radar Range settings : 0.125 nm (Short1)/3 nm (Short2)/6 nm (Middle1)/
12 nm (Middle2)/24 nm (Middle3)/48 nm (Long)
2) Ambient Temperature settings: - 20 to + 50 ℃ (10 ℃ step)
3) Power Supply Voltage settings: 85 /115 % of nominal voltage (85 to 115 VAC)

8.3 Measuring Equipment List:

See ATTACHMENT 4 [LIST OF TEST/MEASURING EQUIPMENT].

8.4 Frequency Tolerance Limits:

"The frequency at which maximum emission occurs must be within the authorized bandwidth and must not be closer than 1.5/T MHz to the upper and lower limits of the authorized band width, where "T" is the pulse duration in microseconds. " (FCC Rule § 80.209)

1) Center frequency (f_0): 9410 MHz
2) Authorized bandwidth (f(AUBW)): 100 MHz

"Upper limit frequency of the authorized band", f(UAUBW) = f_0 + f(AUBW)/2 = 9460 Mhz
"Lower limit frequency of the authorized band", f(LAUBW) = f_0 - f(AUBW)/2 = 9360 Mhz

3) Assignanble frequency bandwidth : 200 MHz (between 9300 MHz and 9500 MHz)
(FCC Rule § 80.375 (d)-(1))

"Upper limit frequency of the assignable band", f(UASB) = 9500 MHz
"Lower limit frequency of the assignable band", f(LASB) = 9300 MHz

4) Guard Band (f(1.5/T)) :

Pulse Type	Short 1	Short 2	Middle 1	Middle 2	Middle 3	Long
Range Scale (nm)	0.125	3	6	12	24	48
Pulselength (μ sec)	0.07	0.15	0.30	0.50	0.70	1.20
Guard Band f(1.5/T) (MHz)	21.43	10.00	5.00	3.00	2.14	1.25

8.5 Test Results:

Shown on Fig. 8.2.

(1) "Upper Tolerance Frequency measured (at - 20 ℃)", f(U) = 9418.0 MHz
(2) "Lower Tolerance Frequency measured (at + 50 ℃)", f(L) = 9403.6 MHz
(3)-(a)
f(U) + max. f(1.5/T) = 9439.43 MHz < f(UAUBW) = 9460 MHz < f(UASB) = 9500 MHz
(b)
f(L) - max. f(1.5/T) = 9382.17 MHz > f(LAUBW) = 9360 MHz > f(LASB) = 9300 MHz
So, both are found within the specified limits.

FREQUENCY STABILITY WITH VARIATION OF PRIMARY SUPPLY VOLTAGE:

The built-in voltage regulator allows no frequency variation against variations of ±15 % of nominal power supply voltage (85 to 115 VAC for nominal 100 VAC).

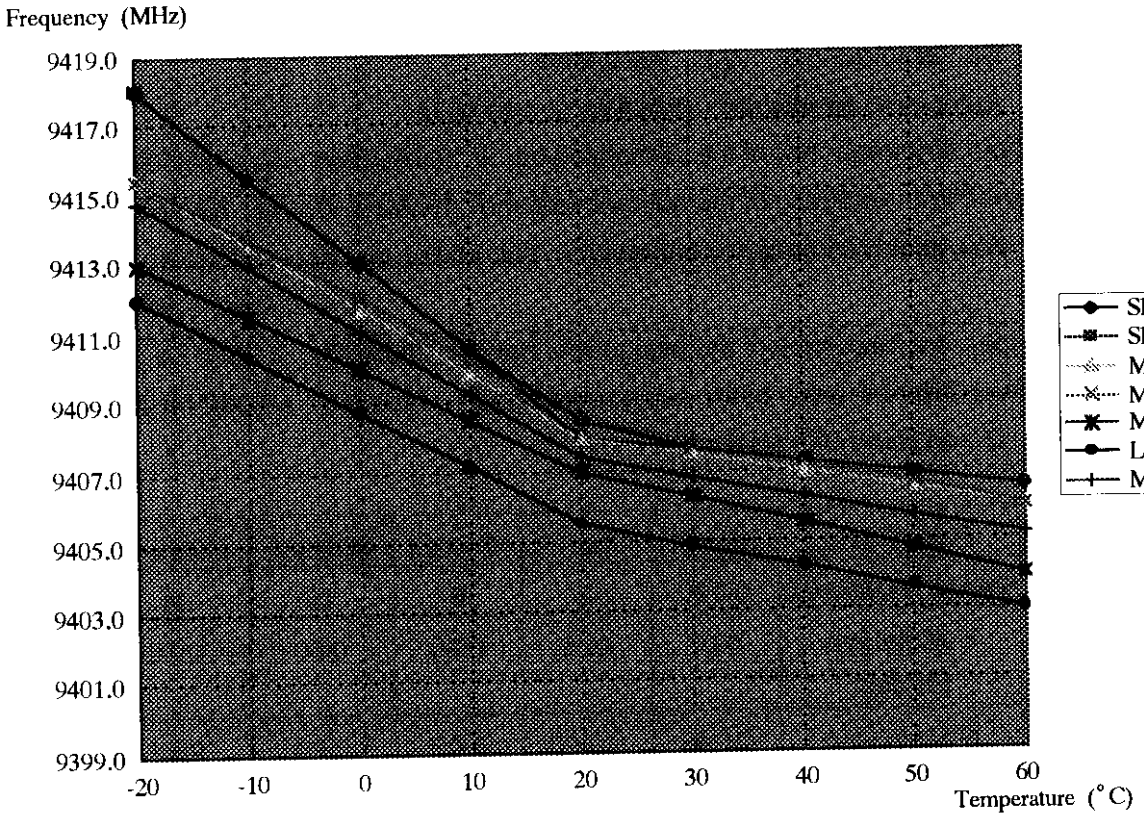

Fig.8.2 Frequency Stability with Variation of Ambient Temperature

9 SUPPRESSION OF INTERFERENCE ABOARD SHIPS

(FCC Rule § 80.217)

9.1 Measuring Antenna Characteristics at Representative Frequencies:

Whip antennas are used to determine the level of interference caused by the radar to shipboard receivers. These antennas have the following characteristics (refer to impedance charts attached):

Length	Test Frequency (Hz)	Impedance (Ω)	θ	R (Ω)	C or L
6 m	500.5 k	1 k	-90°	0	80 pF
6 m	1.992 M	1.25 k	-86°	87.2	64 pF
6 m	10.00204 M	158		109	140 pF
4 m	27.5 M	95		83.5	128 pF
5/8 λ	150 M	116.5		105.5	52.5 nH
1/4 λ	450 M	70.5		34.5	5.68 pF

9.2 Test Site:

Rooftop of 6-story building,
Furuno Electric Company, Ltd.
Ashihara-cho 9-52, Nishinomiya-city, 662-8580 JAPAN

9.3 Measuring Instruments:

(1) RF Vector Impedance Meter, HP 4815A
(2) Spectrum Analyzer, ADVANTEST TR4172
(3) Spectrum Analyzer, HP 8566B
(4) Antennas,
for 14 k - 10 MHz, 6 m whip
for 10 - 30 MHz, 4 m whip
for 30 - 300 MHz, VHF whip
for 300 - 1000 MHz, UHF whip

9.4 Test Results:

Interference levels to the respective antenna were measured at 2 m from the radar which was put in OFF, STANDBY, TRANSMIT conditions., and found within the specified limits.

9.4.1 **Harmful Interference to Receiver** (FCC Rule § 80.217 (a))

Limits:	for 14 - 490 kHz, 5 μV/m for 490 kHz - 1 GHz, 1 μV/m
Results:	There is no spurious component which is deemed harmful interference. (Test data are shown in ATTACHMENT 3)

9.4.2 **Electromagnetic Field** (FCC Rule § 80.217 (b) - 1)

Limits:	for below 30 MHz, 0.1 μV/m at 1 nm (-20 dBmV/m) for 30 to 100 MHz, 0.3 μV/m at 1 nm (-10.5 dBmV/m) for 100 to 300 MHz, 1.0 μV/m at 1 nm (0 dBmV/m) for over 300 MHz, 3.0 μV/m at 1 nm (9.5 dBmV/m)
Results:	Interference was measured with the antenna located 2 m from the radar and converted to levels at 1 nm. There is no spurious component exceeding the limits. (Test data are shown in ATTACHMENT 3)

9.4.3 **Power Input to an Artificial Antenna** (FCC Rule § 80.217 (b) - 2)

Limits:	for below 30 MHz, 400 μW for 30 to 100 MHz, 4,000 μW for 100 to 300 MHz, 40,000 μW for over 300 MHz, 400,000 μW
Results:	There is no spurious component exceeding the limits. (Test data are shown in ATTACHMENT 3)

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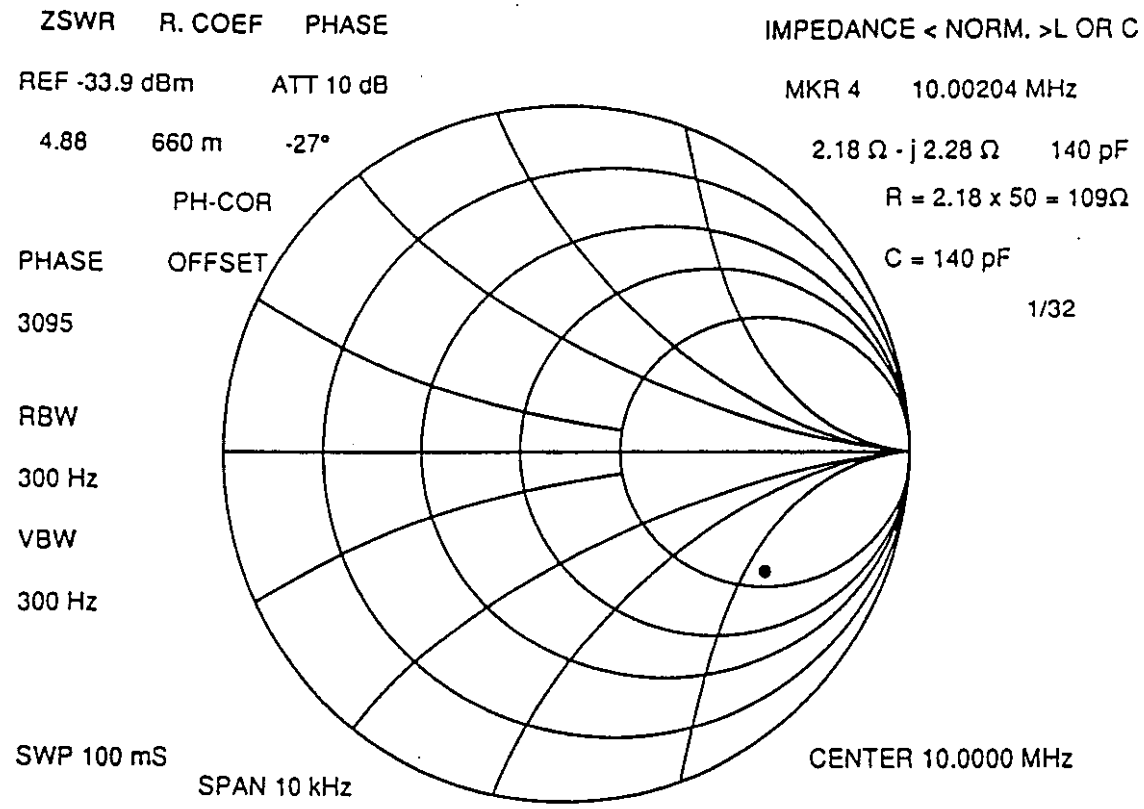
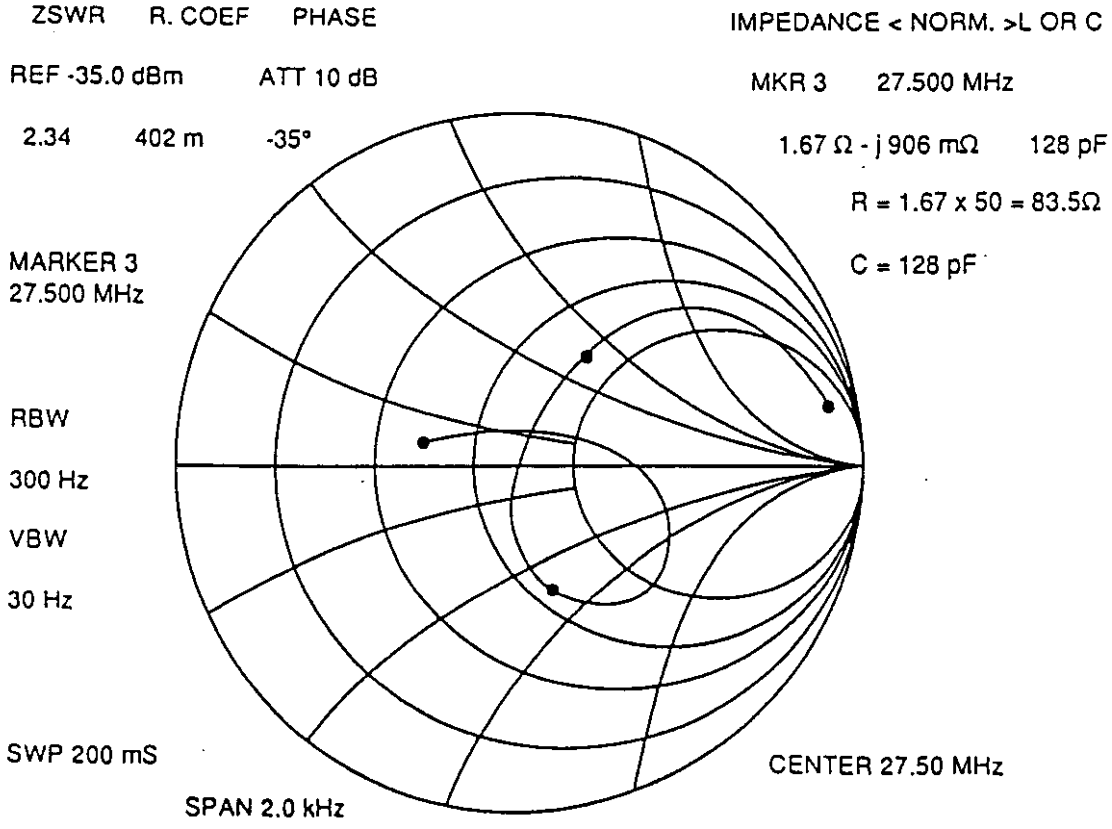
MEASUREMENT OF IMPEDANCE OF TEST ANTENNAS





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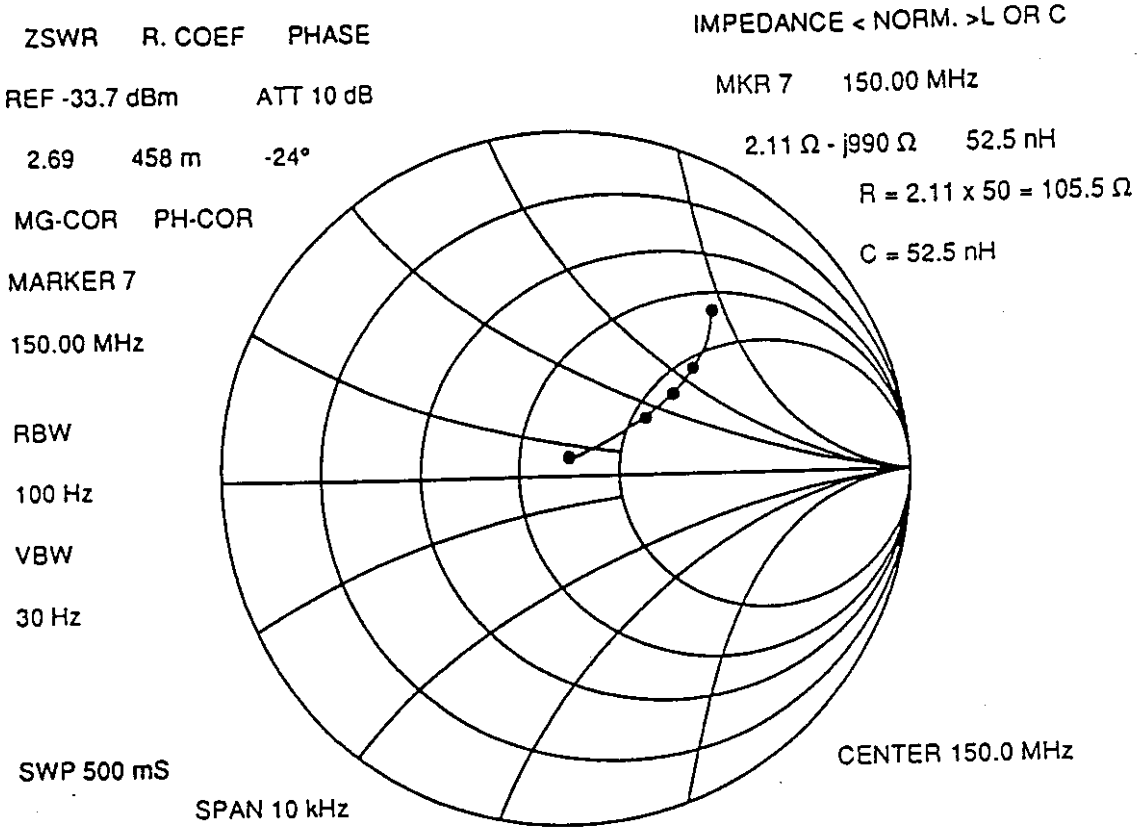
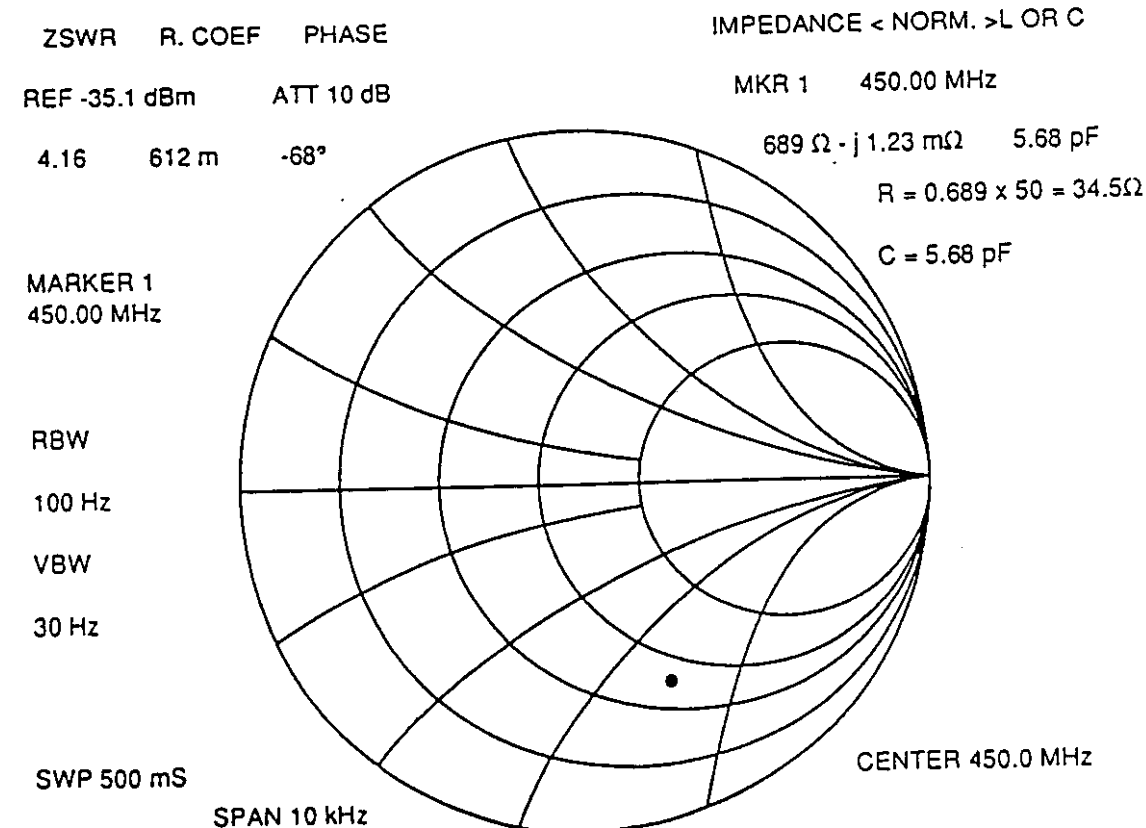
Date : June, 1998

MEASUREMENT OF IMPEDANCE OF TEST ANTENNAS





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Date : June, 1998

12 OPERATOR'S MANUAL INCL. CIRCUIT DIAGRAMS (FCC Rule § 2.983)

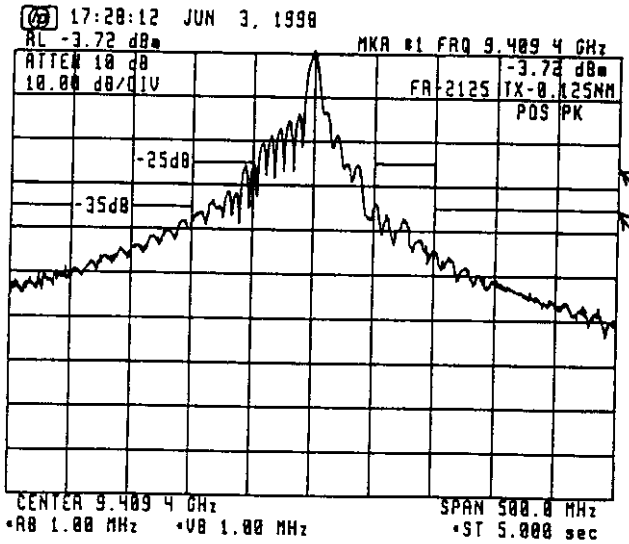
(See separate covers)

ATTACHMENT 1

[TEST DATA FOR 6. SPURIOUS EMISSIONS AT ANTENNA TERMINALS]

1. Spurious emissions for 0.125 nm Range:

Ref. level: -3.72 dBm

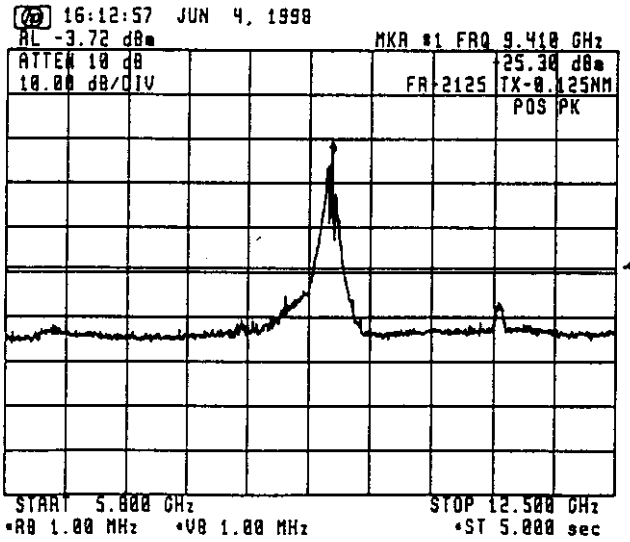


Emission limitations:

(a) 25 dB for 50 to 100 % of the authorized BW (100 MHz)

(b) 35 dB for 100 to 250 % of the authorized BW (100 MHz)

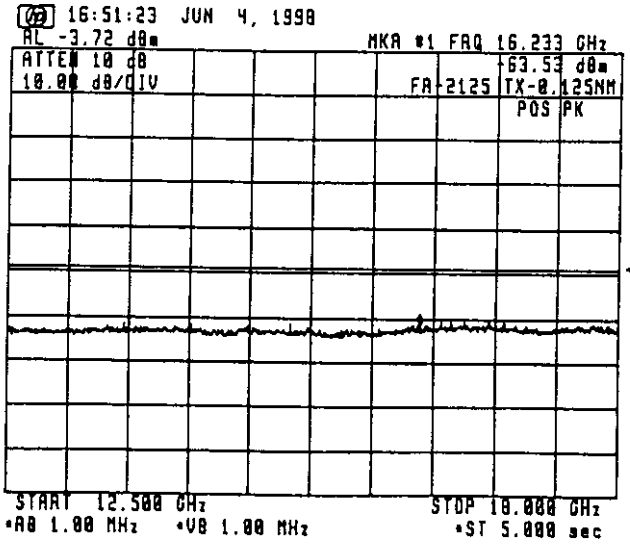
Fig. 1.1 Without Filter



Emission limitations:

(c) 43 + 10 log Pm = 48.89 dB for more than 250 % of the authorized BW (100 MHz)

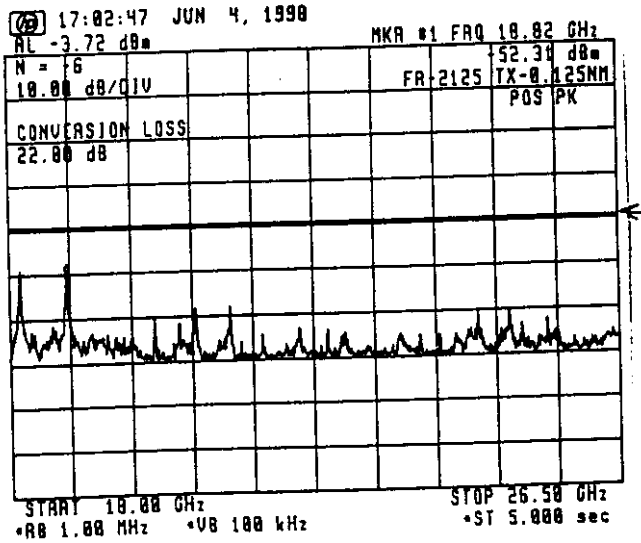
Fig. 1.2 With Filter No.1



Emission limitations:

(c) 43 + 10 log Pm = 48.89 dB for more than 250 % of the authorized BW (100 MHz)

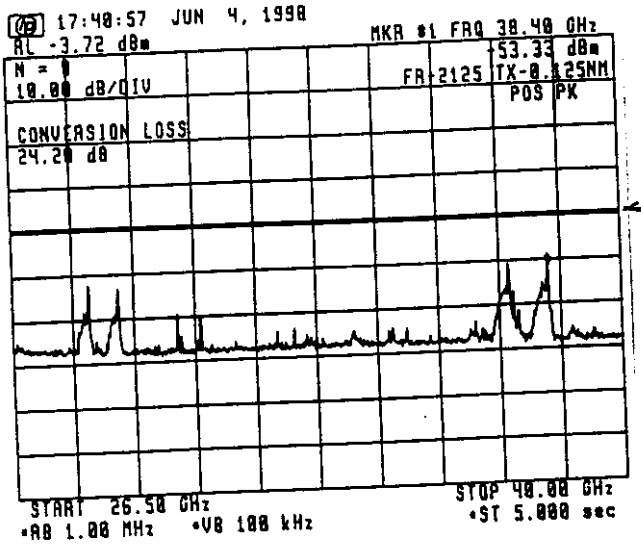
Fig. 1.3 With Filter No. 2



Emission limitations:

(c) 43 + 10 log Pm = 48.89 dB
for more than 250 % of
the authorized BW (100 MHz)

Fig. 1.4 With Filter No. 2

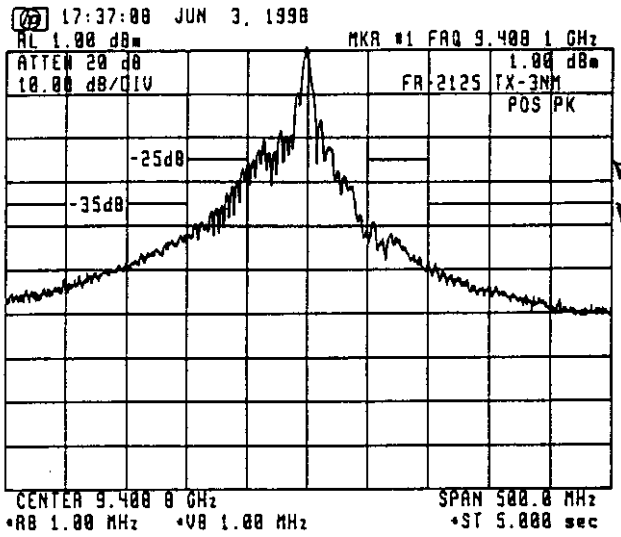


Emission limitations:

(c) 43 + 10 log Pm = 48.89 dB
for more than 250 % of
the authorized BW (100 MHz)

Fig. 1.5 With Filter No. 2

2. Spurious emissions for 3 nm Range:



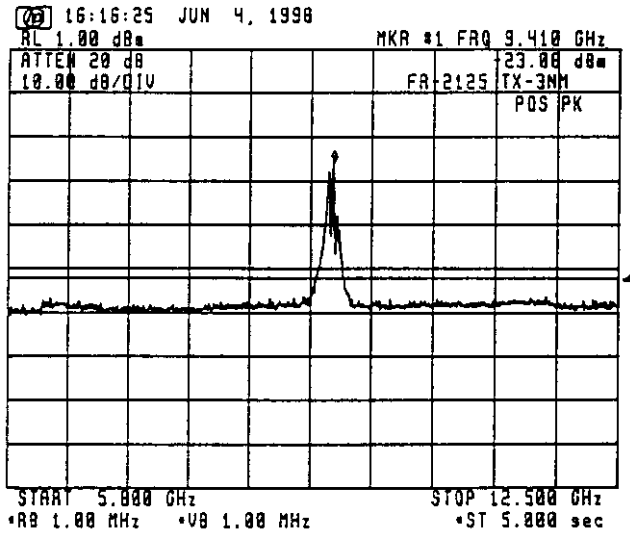
Ref. level: 1 dBm

Emission limitations:

(a) 25 dB for 50 to 100 % of the authorized BW (100 MHz)

(b) 35 dB for 100 to 250 % of the authorized BW (100 MHz)

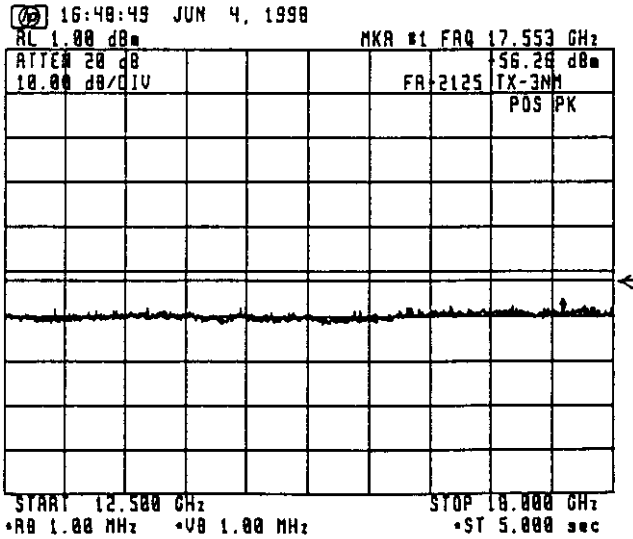
Fig. 2.1 Without Filter



Emission limitations:

(c) 43 + 10 log Pm = 51.95 dB for more than 250 % of the authorized BW (100 MHz)

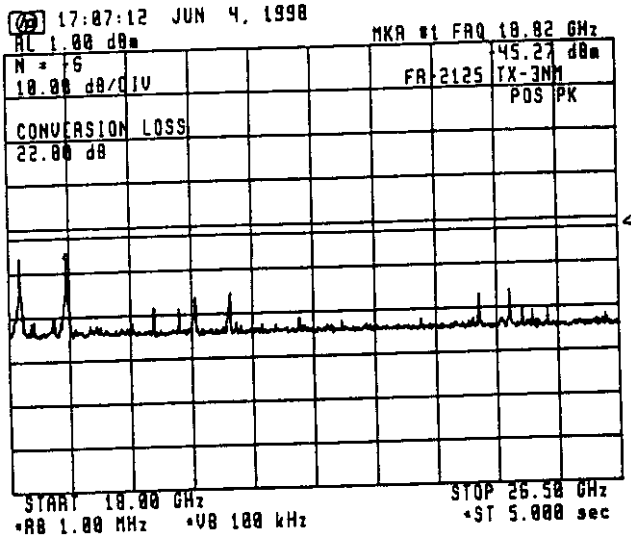
Fig. 2.2 With Filter No.1



Emission limitations:

(c) 43 + 10 log Pm = 51.95 dB for more than 250 % of the authorized BW (100 MHz)

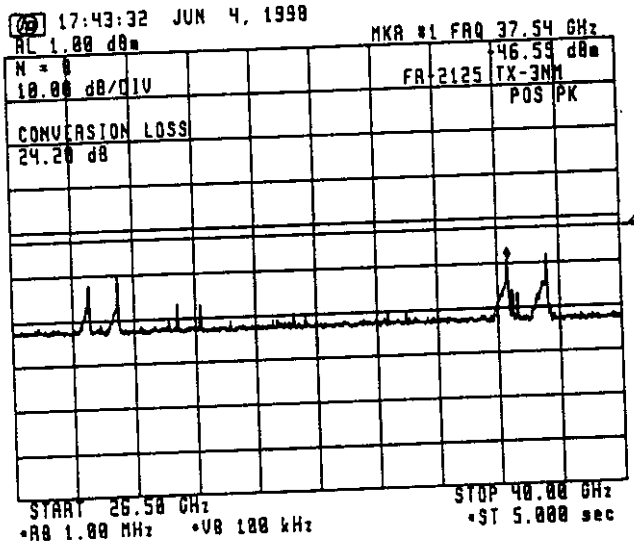
Fig. 2.3 With Filter No. 2



Emission limitations:

(c) 43 + 10 log Pm = 51.95 dB
for more than 250 % of
the authorized BW (100 MHz)

Fig. 2.4 With Filter No. 2

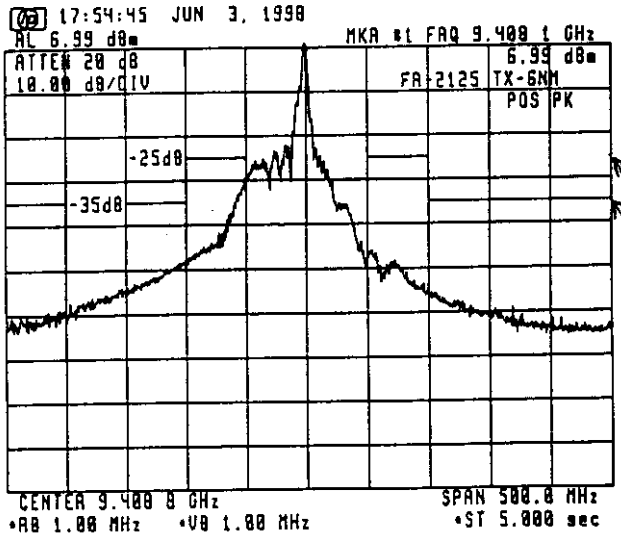


Emission limitations:

(c) 43 + 10 log Pm = 51.95 dB
for more than 250 % of
the authorized BW (100 MHz)

Fig. 2.5 With Filter No. 2

3. Spurious emissions for 6 nm Range:



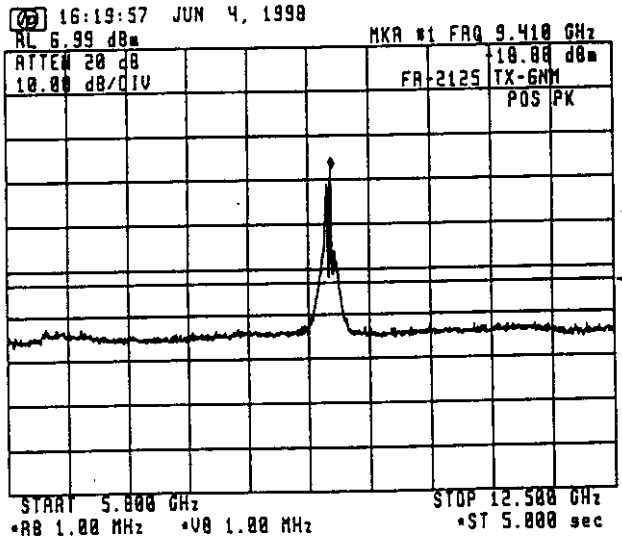
Ref. level: 6.99 dBm

Emission limitations:

(a) 25 dB for 50 to 100 % of the authorized BW (100 MHz)

(b) 35 dB for 100 to 250 % of the authorized BW (100 MHz)

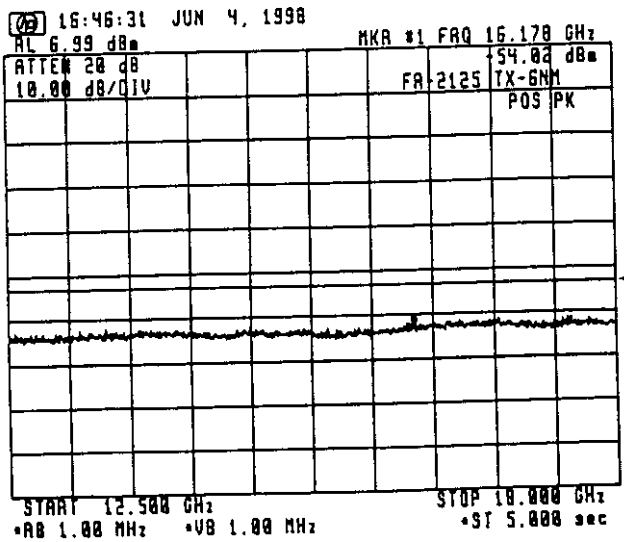
Fig. 3.1 Without Filter



Emission limitations:

(c) 43 + 10 log Pm = 52.83 dB for more than 250 % of the authorized BW (100 MHz)

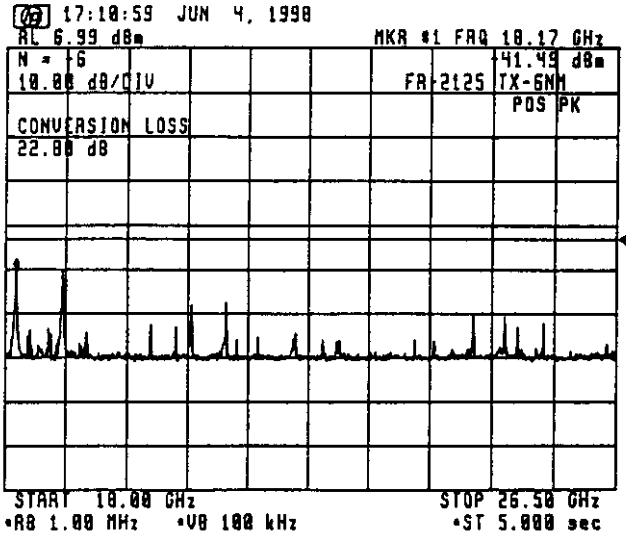
Fig. 3.2 With Filter No.1



Emission limitations:

(c) 43 + 10 log Pm = 52.83 dB for more than 250 % of the authorized BW (100 MHz)

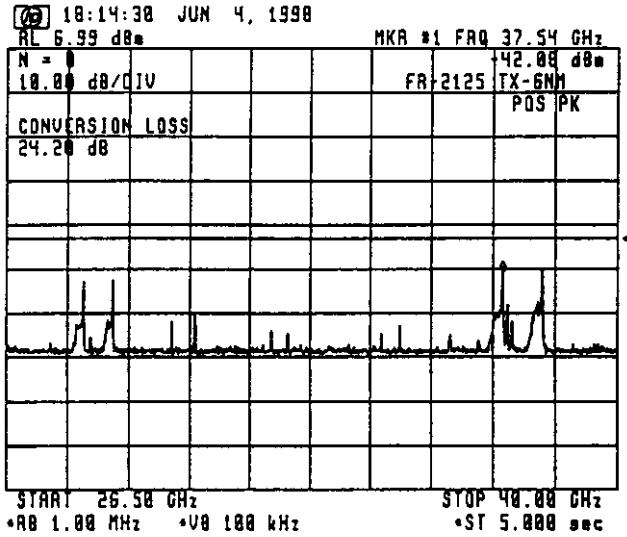
Fig. 3.3 With Filter No. 2



Emission limitations:

(c) 43 + 10 log Pm = 52.83 dB
for more than 250 % of
the authorized BW (100 MHz)

Fig. 3.4 With Filter No. 2

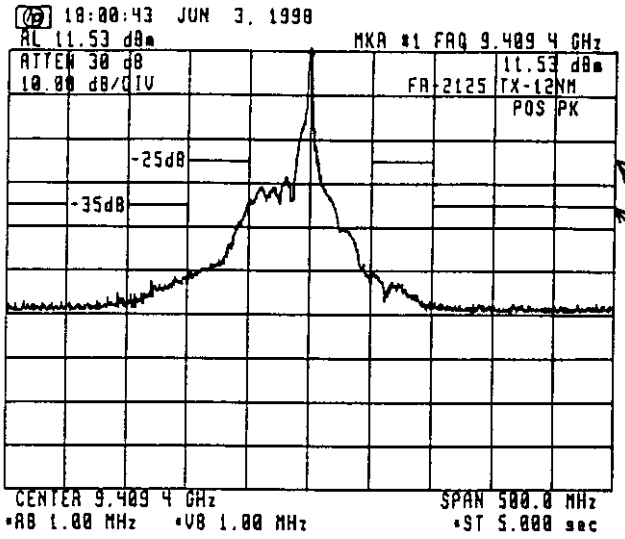


Emission limitations:

(c) 43 + 10 log Pm = 52.83 dB
for more than 250 % of
the authorized BW (100 MHz)

Fig. 3.5 With Filter No. 2

4. Spurious emissions for 12 nm Range:



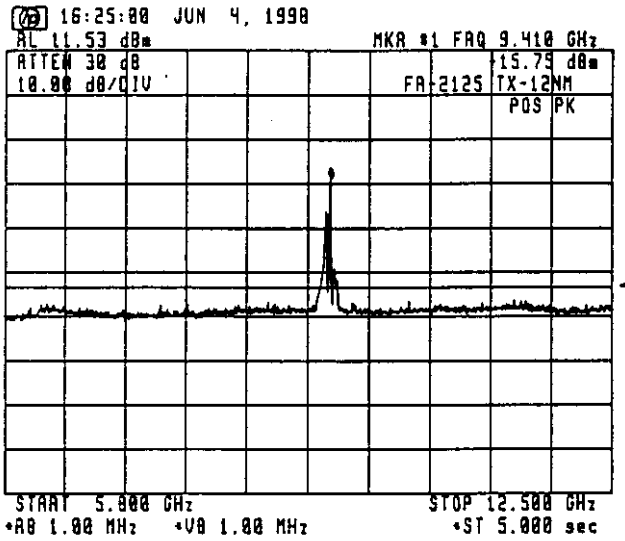
Ref. level: 11.53 dBm

Emission limitations:

(a) 25 dB for 50 to 100 % of the authorized BW (100 MHz)

(b) 35 dB for 100 to 250 % of the authorized BW (100 MHz)

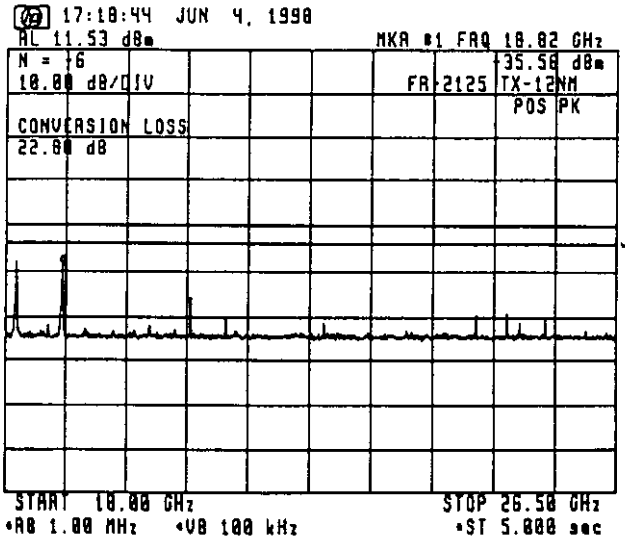
Fig. 4.1 Without Filter



Emission limitations:

(c) 43 + 10 log Pm = 53.27 dB for more than 250 % of the authorized BW (100 MHz)

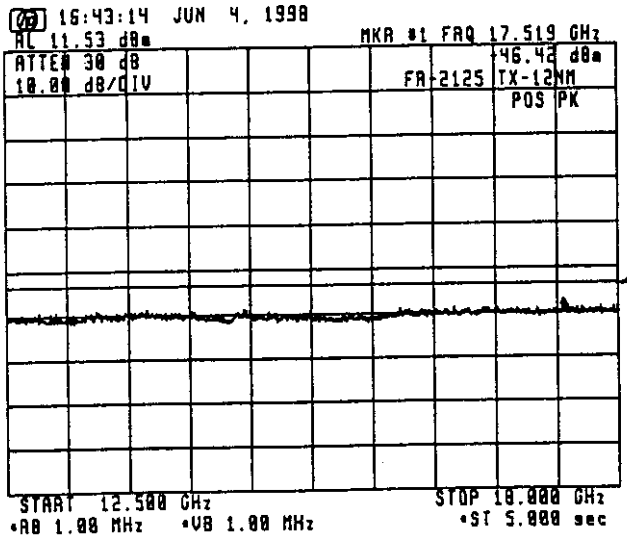
Fig. 4.2 With Filter No.1



Emission limitations:

(c) 43 + 10 log Pm = 53.27 dB for more than 250 % of the authorized BW (100 MHz)

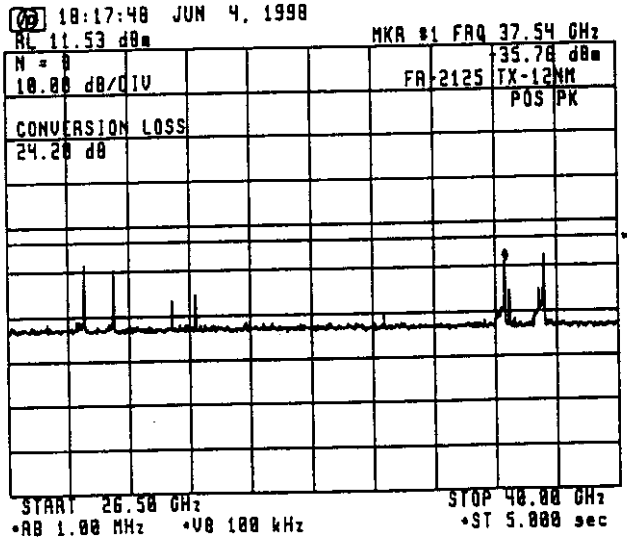
Fig. 4.3 With Filter No. 2



Emission limitations:

(c) 43 + 10 log Pm = 53.27 dB
for more than 250 % of
the authorized BW (100 MHz)

Fig. 4.4 With Filter No. 2



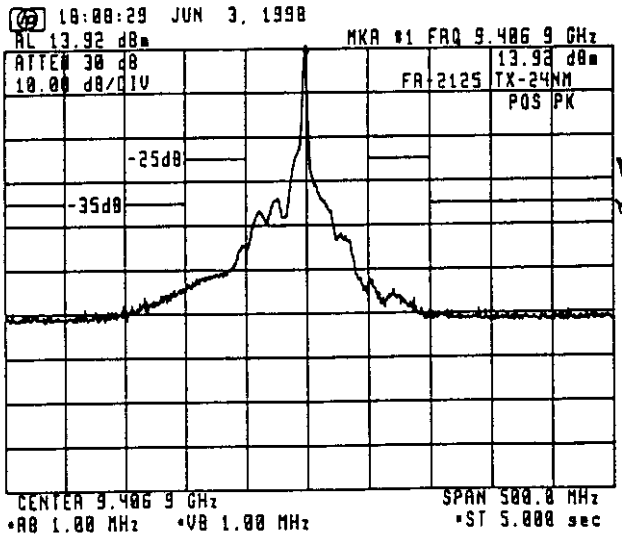
Emission limitations:

(c) 43 + 10 log Pm = 53.27 dB
for more than 250 % of
the authorized BW (100 MHz)

Fig. 4.5 With Filter No. 2

5. Spurious emissions for 24 nm Range:

Ref. level: 13.92 dBm

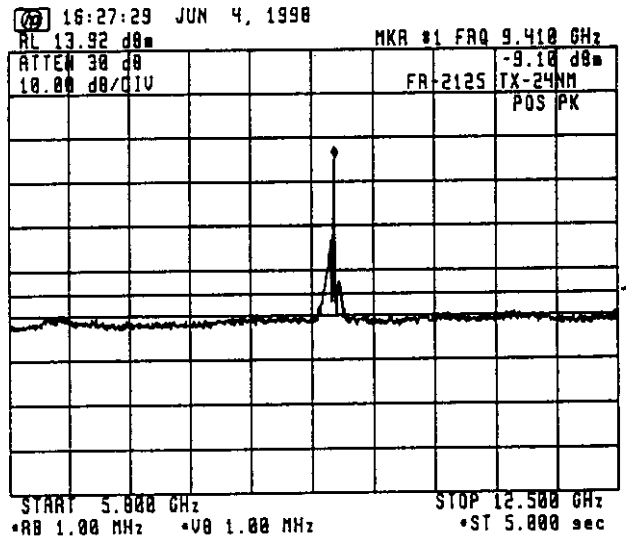


Emission limitations:

(a) 25 dB for 50 to 100 % of the authorized BW (100 MHz)

(b) 35 dB for 100 to 250 % of the authorized BW (100 MHz)

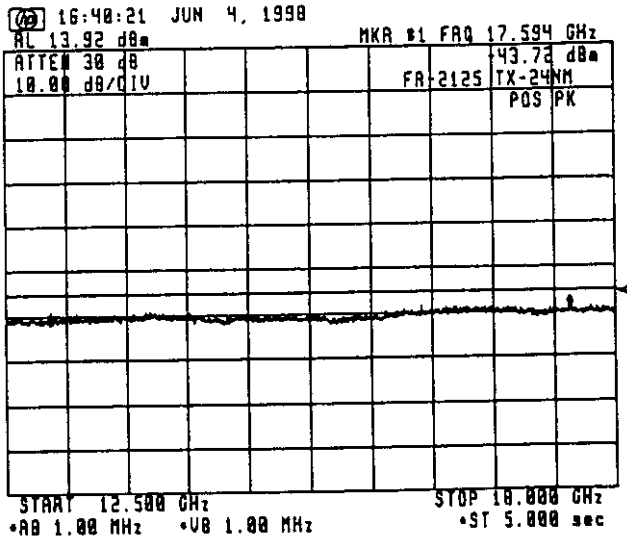
Fig. 5.1 Without Filter



Emission limitations:

(c) 43 + 10 log Pm = 54.91 dB for more than 250 % of the authorized BW (100 MHz)

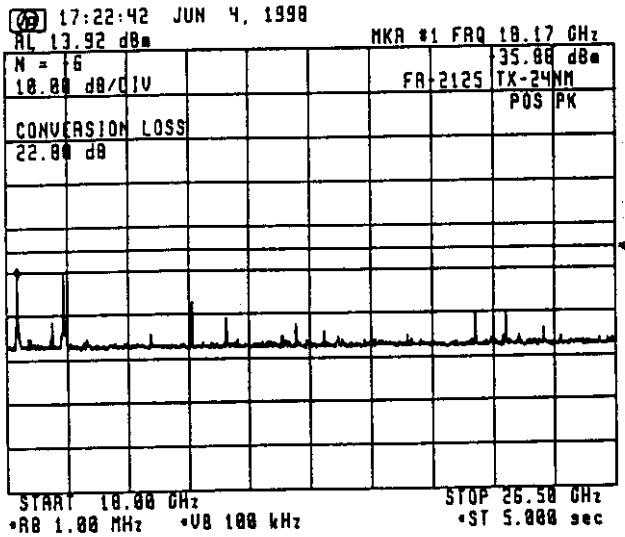
Fig. 5.2 With Filter No.1



Emission limitations:

(c) 43 + 10 log Pm = 54.91 dB for more than 250 % of the authorized BW (100 MHz)

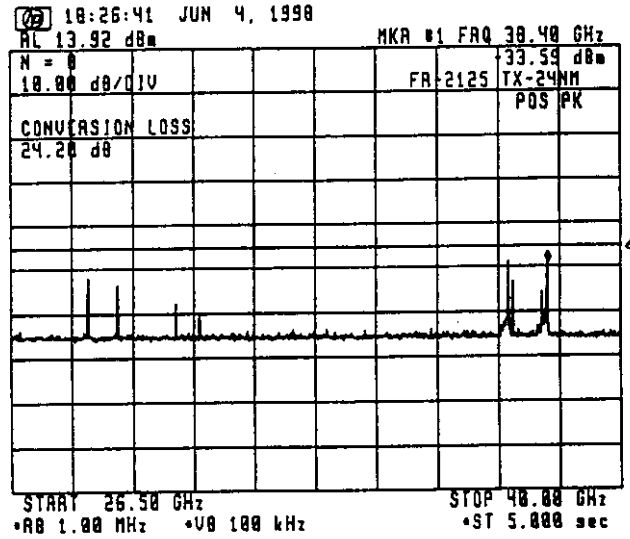
Fig. 5.3 With Filter No. 2



Emission limitations:

(c) 43 + 10 log Pm = 54.91 dB
for more than 250 % of
the authorized BW (100 MHz)

Fig. 5.4 With Filter No. 2

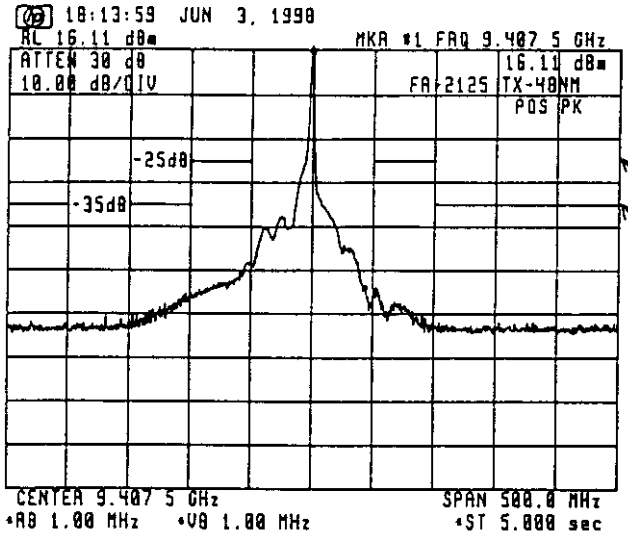


Emission limitations:

(c) 43 + 10 log Pm = 54.91 dB
for more than 250 % of
the authorized BW (100 MHz)

Fig. 5.5 With Filter No. 2

6. Spurious emissions for 48 nm Range:



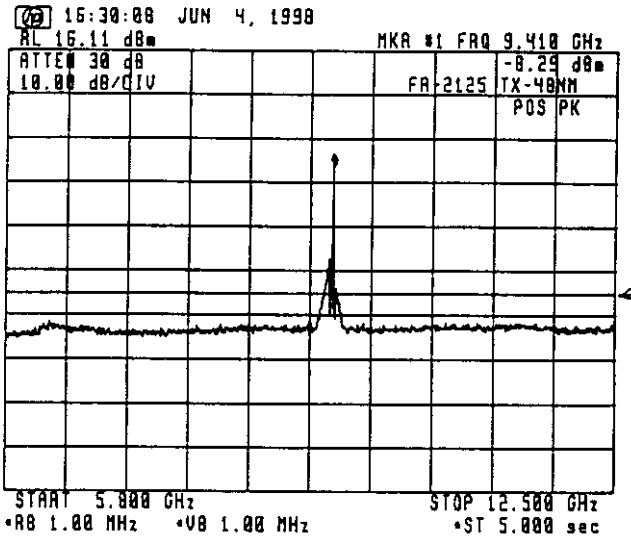
Ref. level: 16.11 dBm

Emission limitations:

(a) 25 dB for 50 to 100 % of the authorized BW (100 MHz)

(b) 35 dB for 100 to 250 % of the authorized BW (100 MHz)

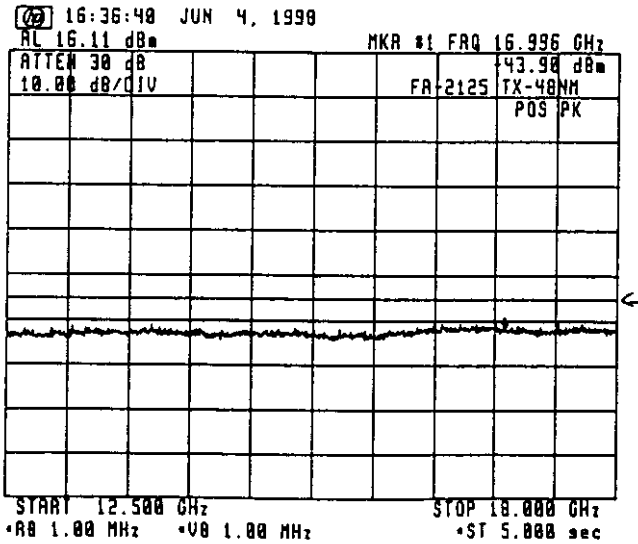
Fig. 6.1 Without Filter



Emission limitations:

(c) 43 + 10 log Pm = 54.88 dB for more than 250 % of the authorized BW (100 MHz)

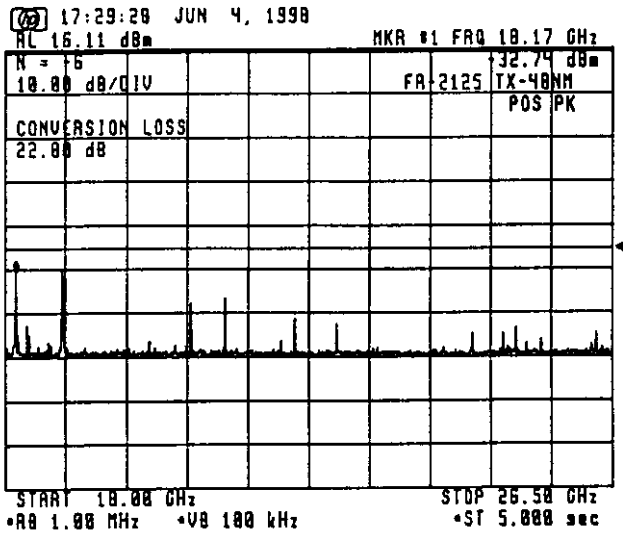
Fig. 6.2 With Filter No.1



Emission limitations:

(c) 43 + 10 log Pm = 54.88 dB for more than 250 % of the authorized BW (100 MHz)

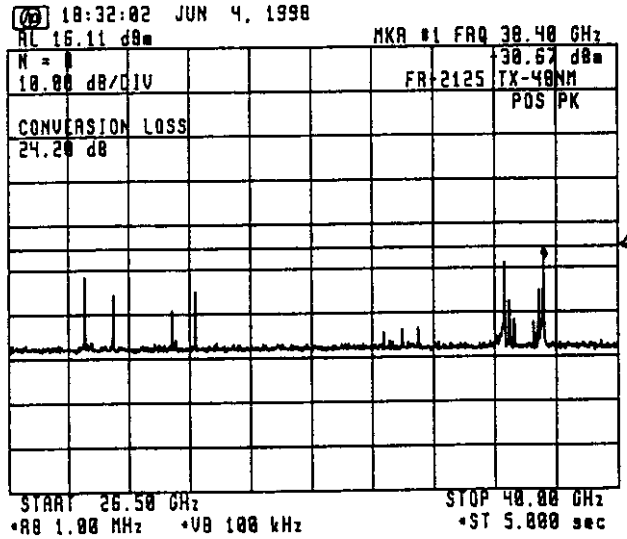
Fig. 6.3 With Filter No. 2



Emission limitations:

(c) 43 + 10 log Pm = 54.88 dB
for more than 250 % of
the authorized BW (100 MHz)

Fig. 6.4 With Filter No. 2



Emission limitations:

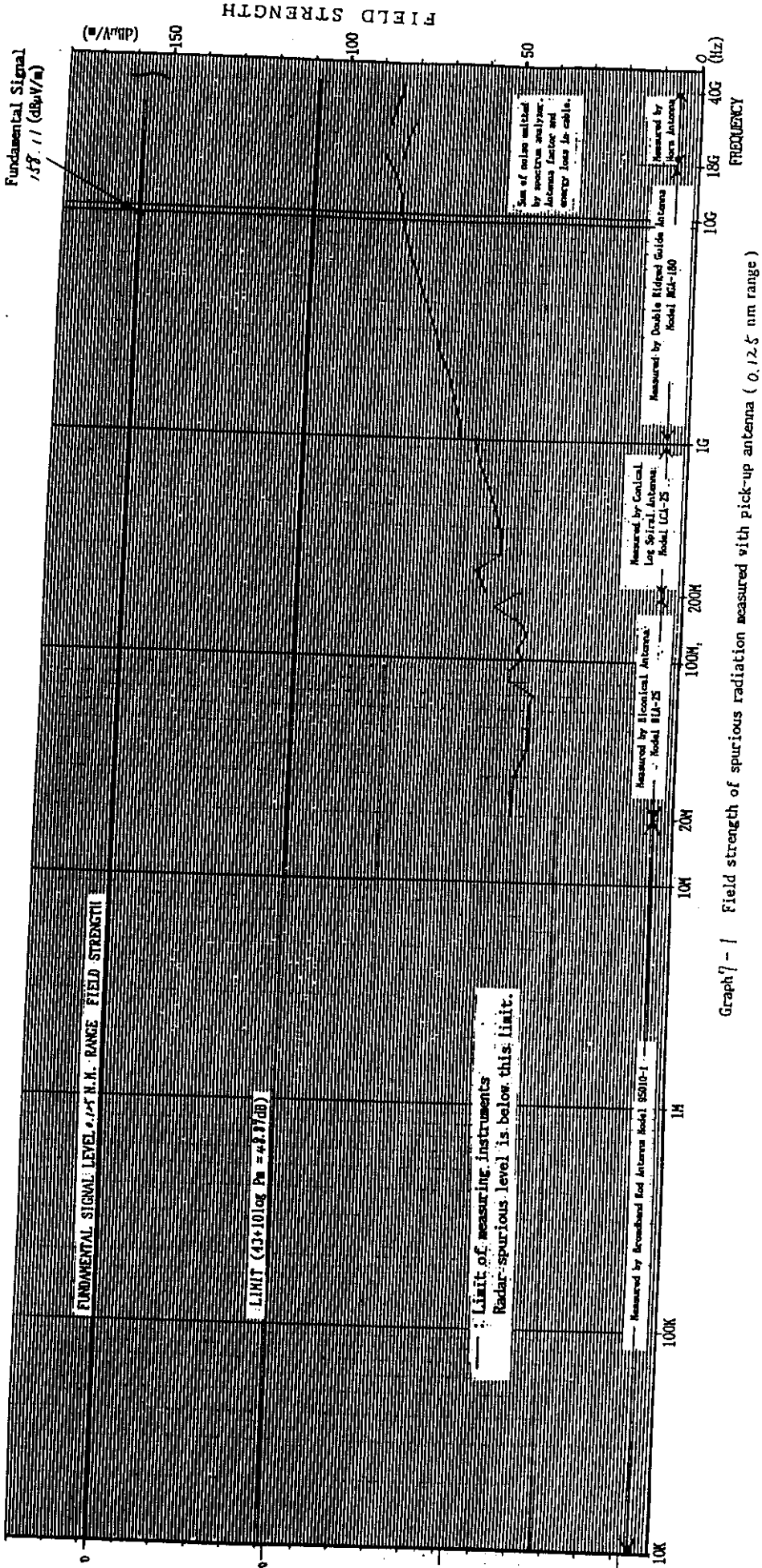
(c) 43 + 10 log Pm = 54.88 dB
for more than 250 % of
the authorized BW (100 MHz)

Fig. 6.5 With Filter No. 2

Pub. No. : TI-1692
Date : June. 1998

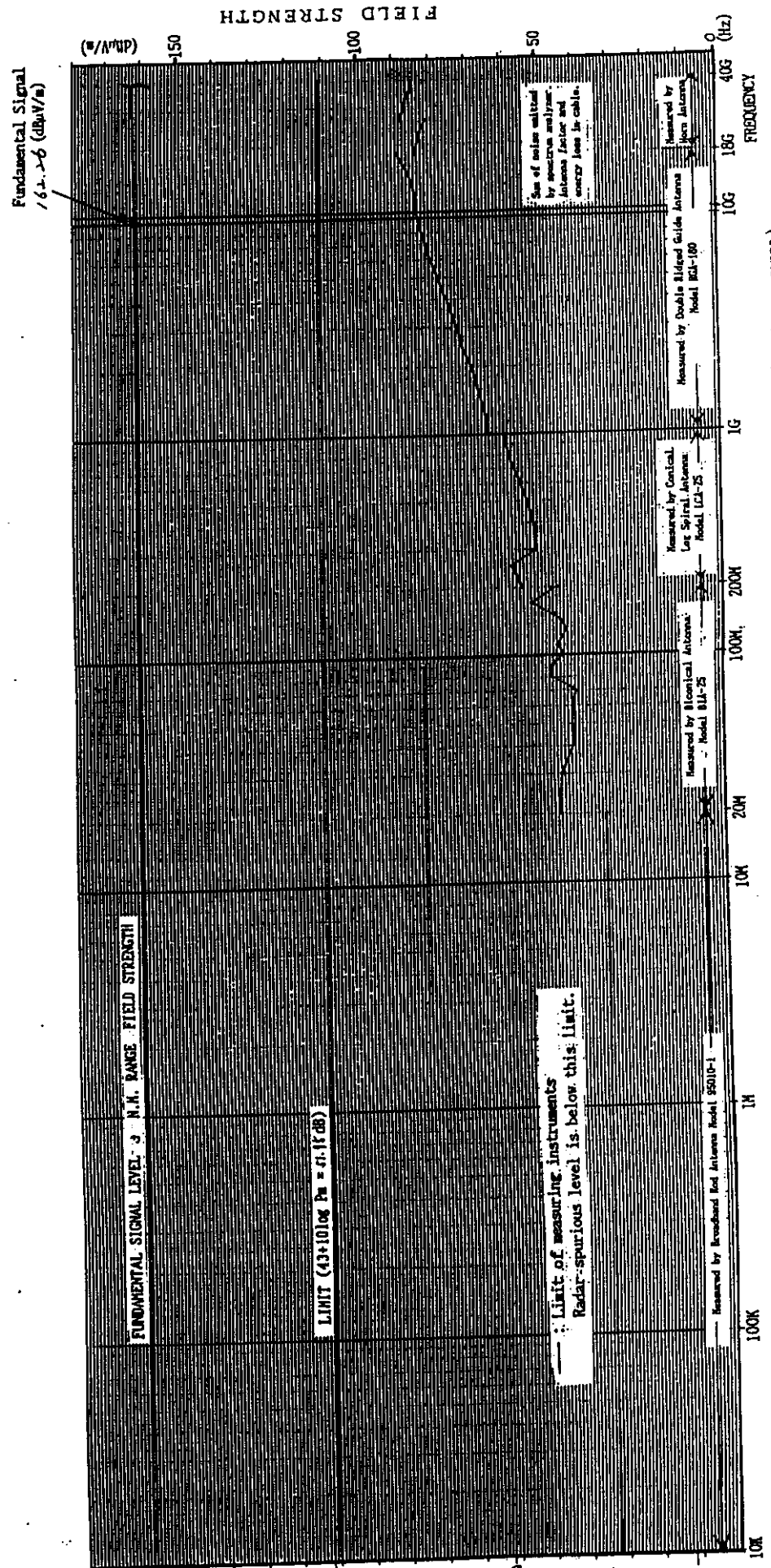
ATTACHMENT 2

[TEST DATA FOR 7. FIELD STRENGTH OF SPURIOUS RADIATION]



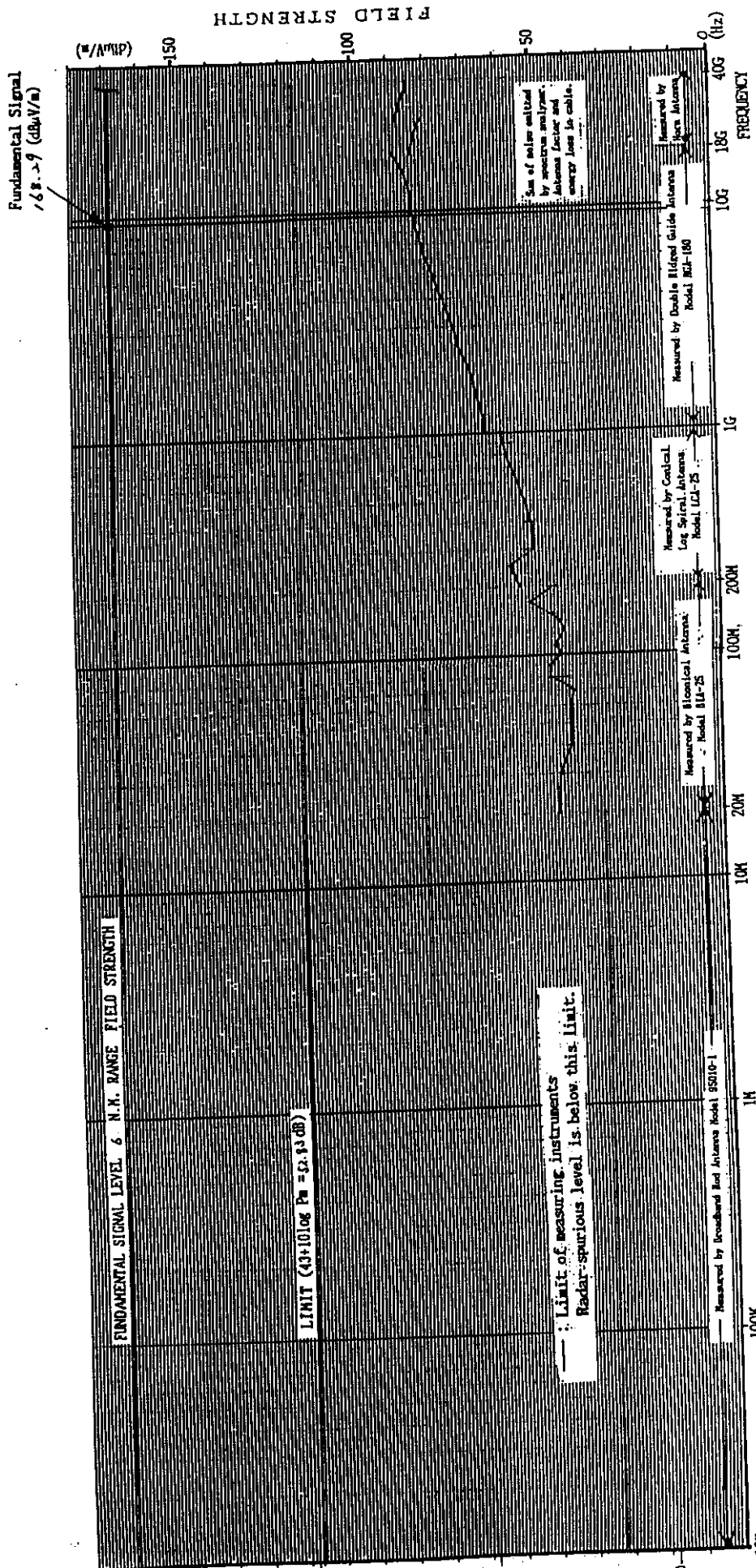
Graph 7 - 1 Field strength of spurious radiation measured with pick-up antenna (0.125 nm range)
(Short / Pulse)

Pub. No. : TI-1692
Date : June, 1998



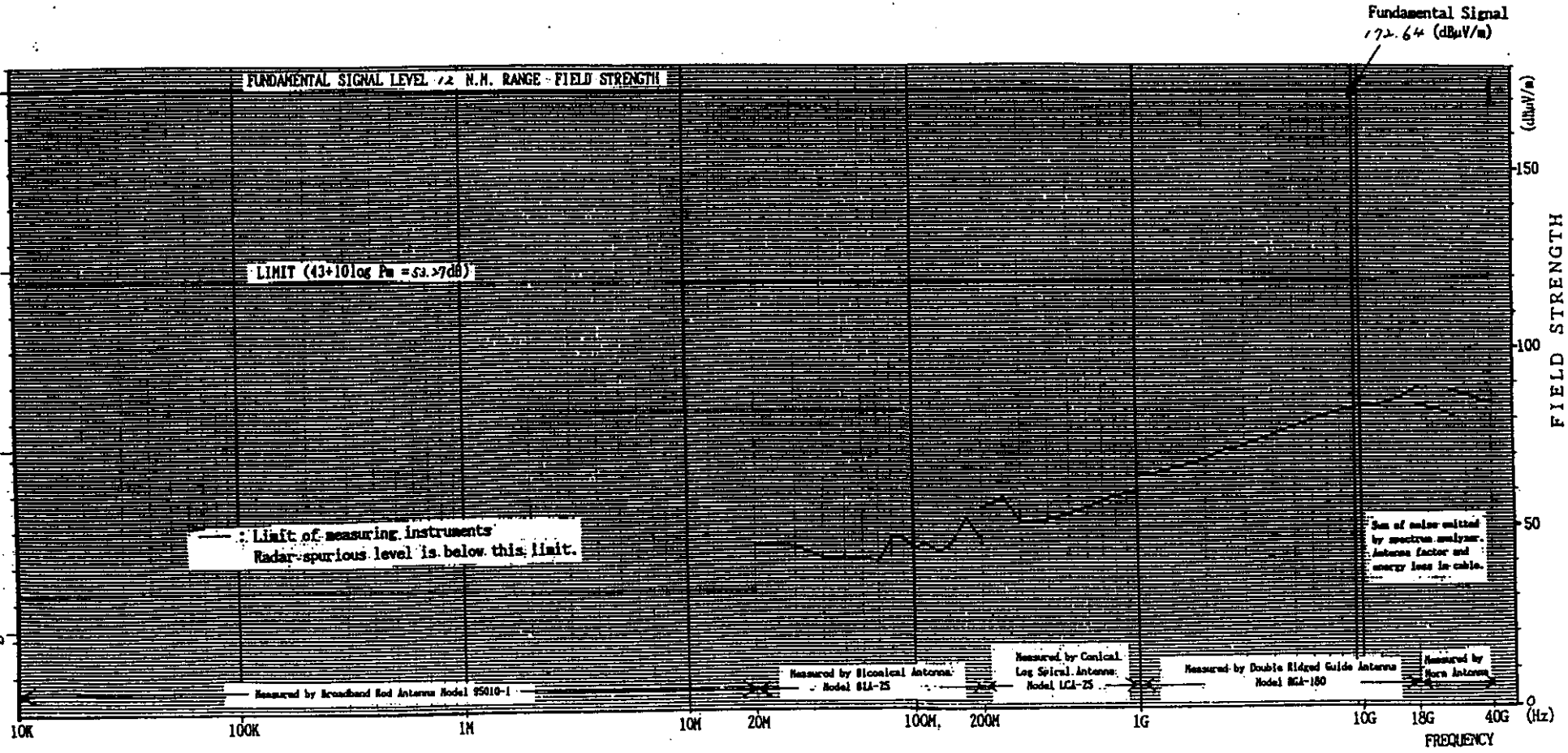
Graph 7-1 Field strength of spurious radiation measured with pick-up antenna (3 nm range)
(short Pulse)

Pub. No. : TI-1692
Date : June, 1998



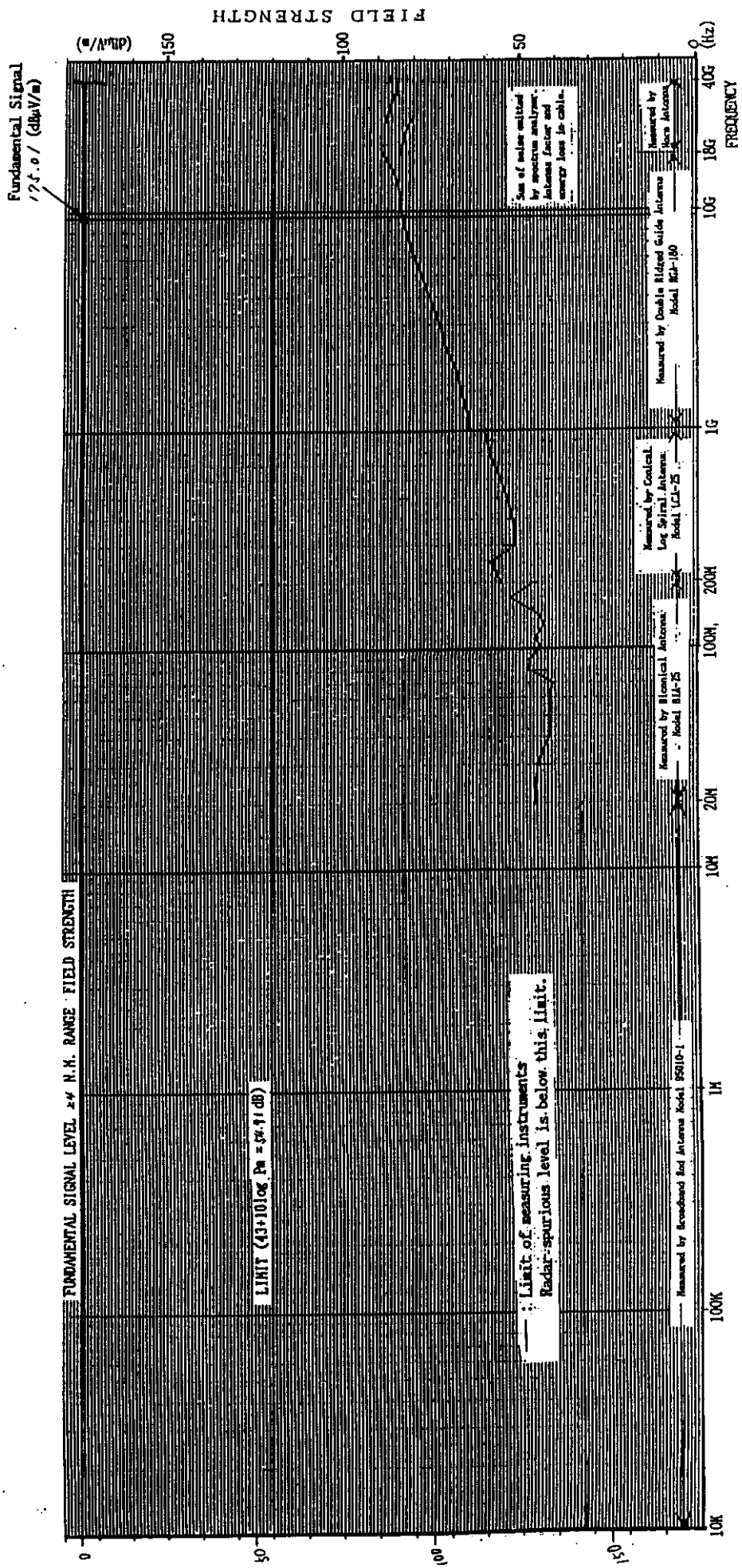
Graph 7 - 3 Field strength of spurious radiation measured with pick-up antenna (6 nm range)
(Pulse)

Pub.No.: TI-1692
Date: June 1998



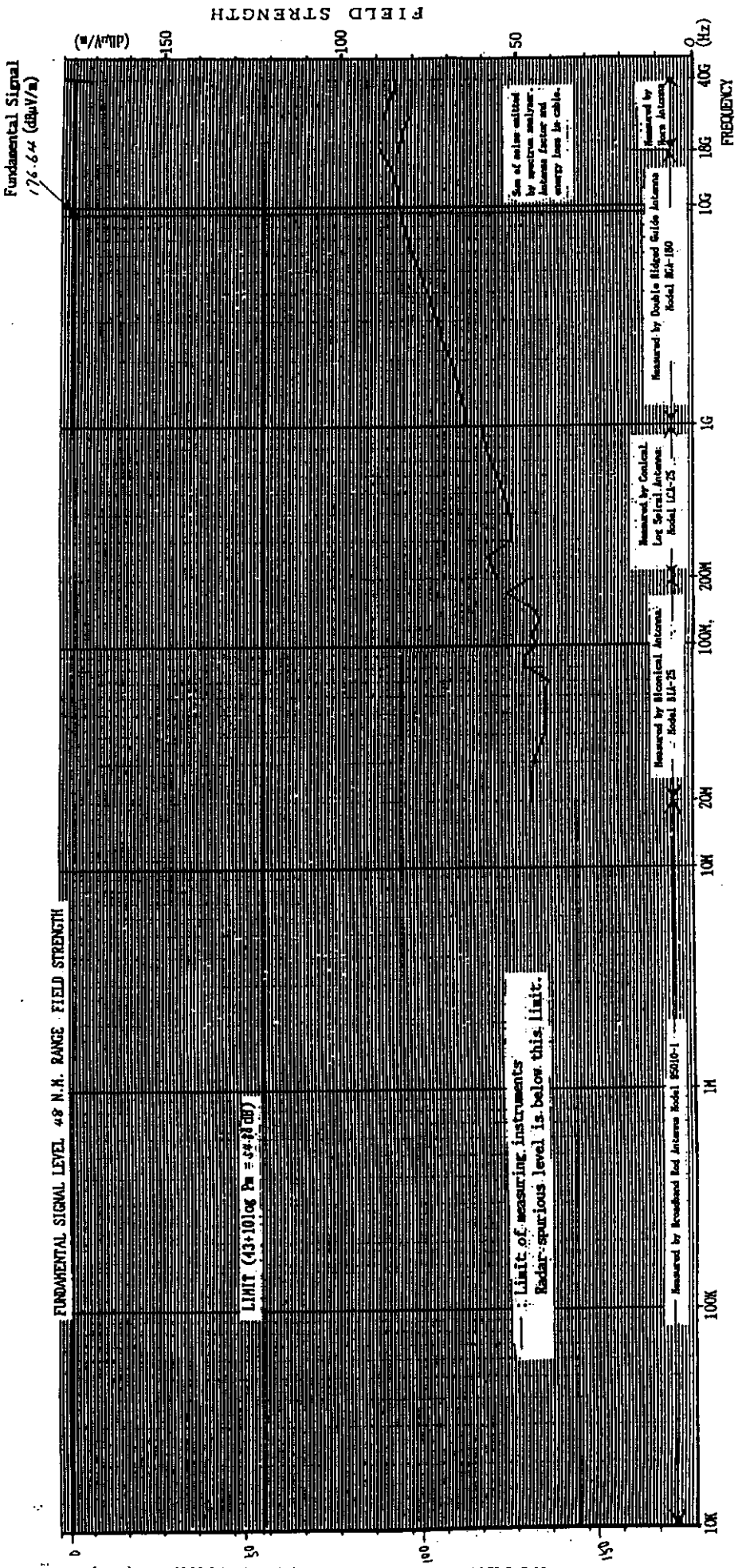
Graph 7 - 4 Field strength of spurious radiation measured with pick-up antenna (12 nm range)
(middle Pulse)

Pub. No. : TI-1692
Date : June, 1998



Graph 7- 5 Field strength of spurious radiation measured with pick-up antenna (3m nm range)
(middle 3 Pulse)

Pub. No. : TI-1692
Date : June. 1998

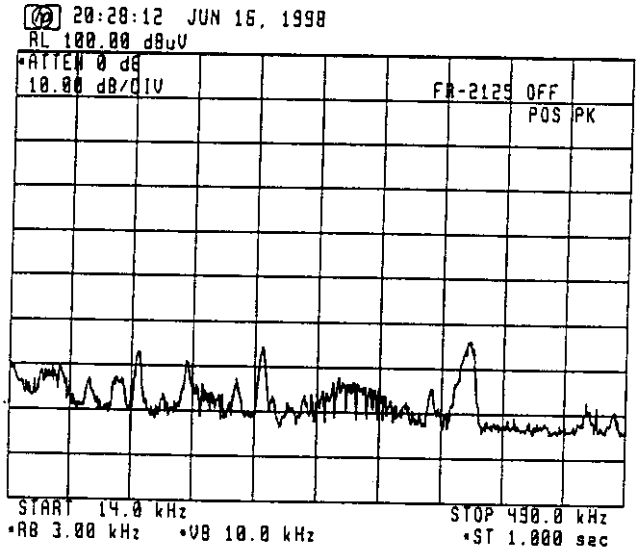


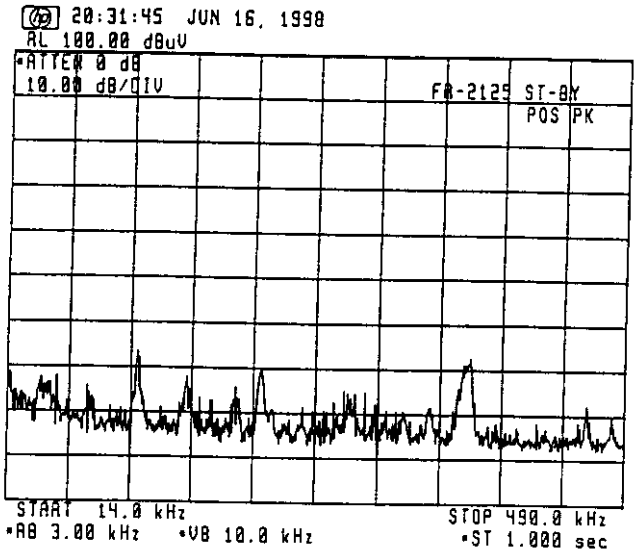
Graph 7-6 Field strength of spurious radiation measured with pick-up antenna (48 nm range)
(Long Pulse)

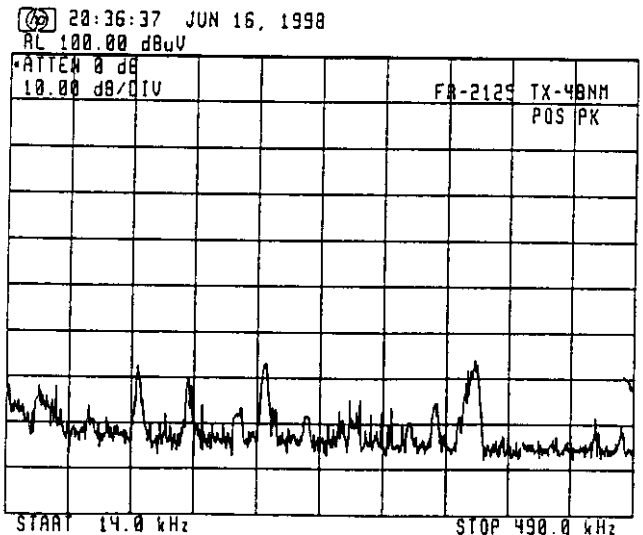
ATTACHMENT 3

[TEST DATA FOR 9. SUPPRESSION OF INTERFERENCE ABOARD SHIP]

1. Harmful Interference to Receiver Band : 14kHz ~ 490kHz

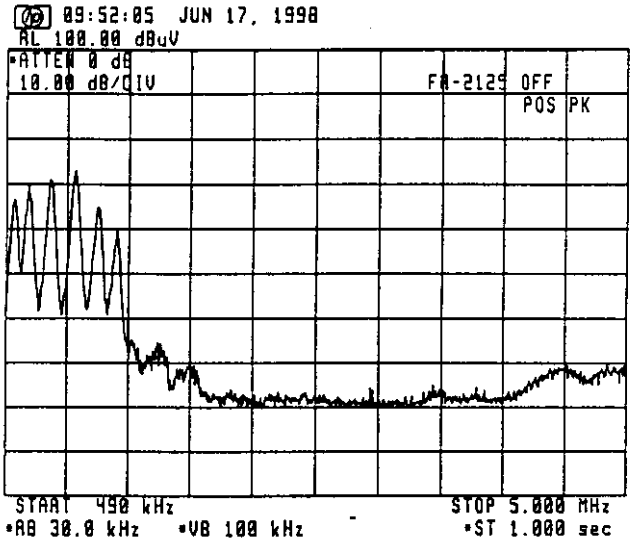


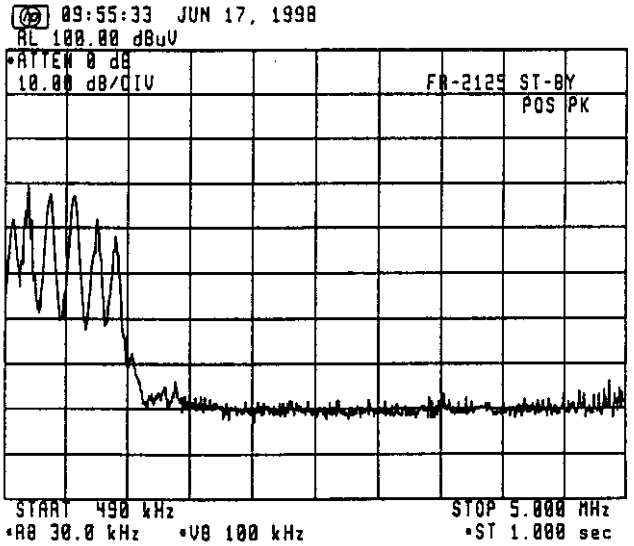


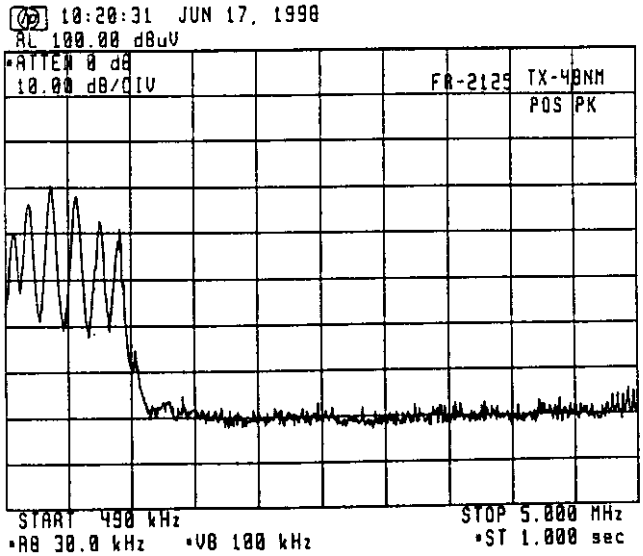


Pub. No. : TI-1692
Date : June, 1998

Band: 490kHz ~ 5MHz

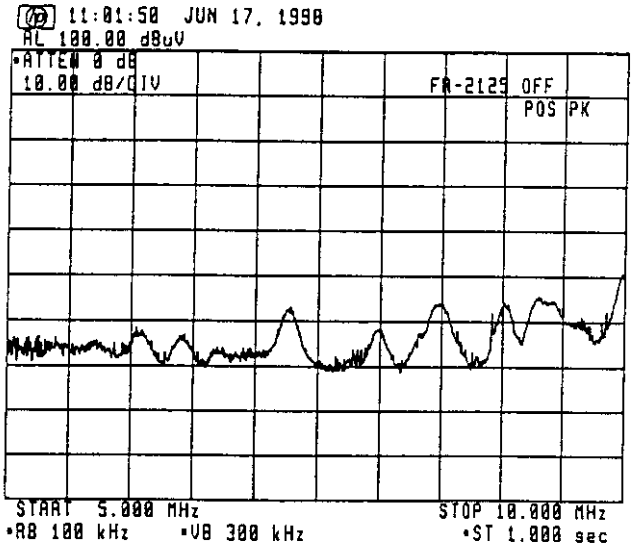


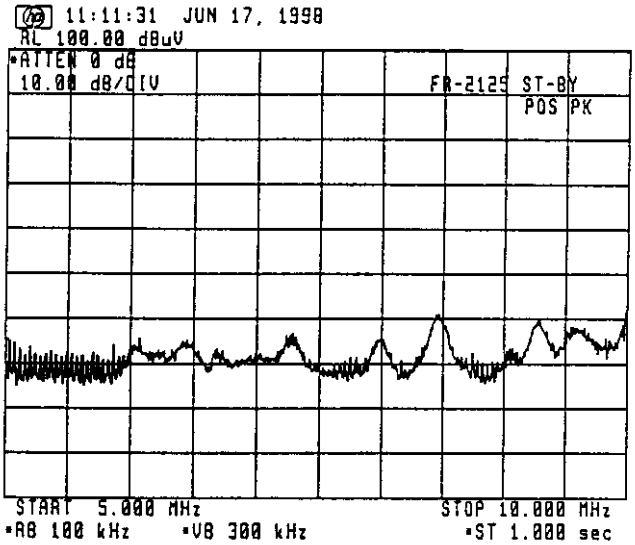


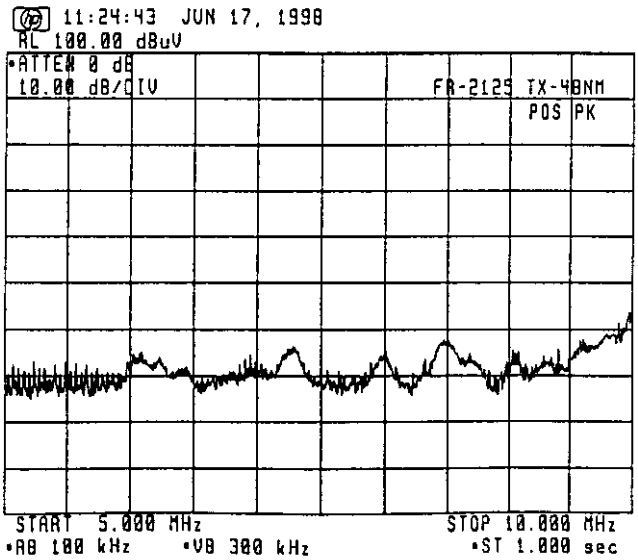


Pub. No. : TI-1692
Date : June, 1998

Band : 5MHz ~ 10MHz

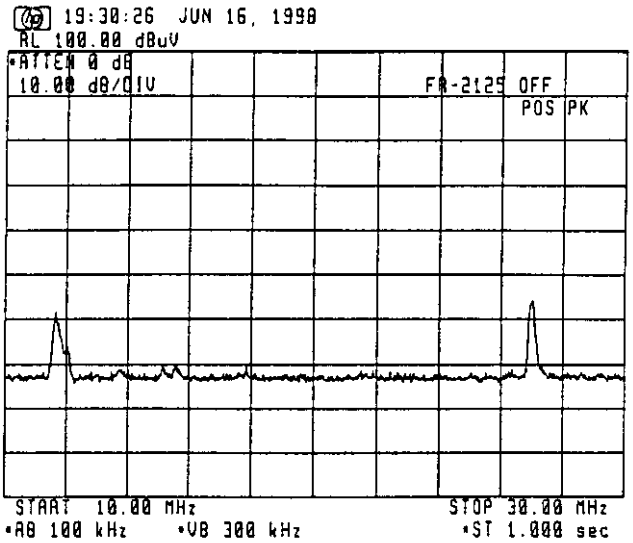


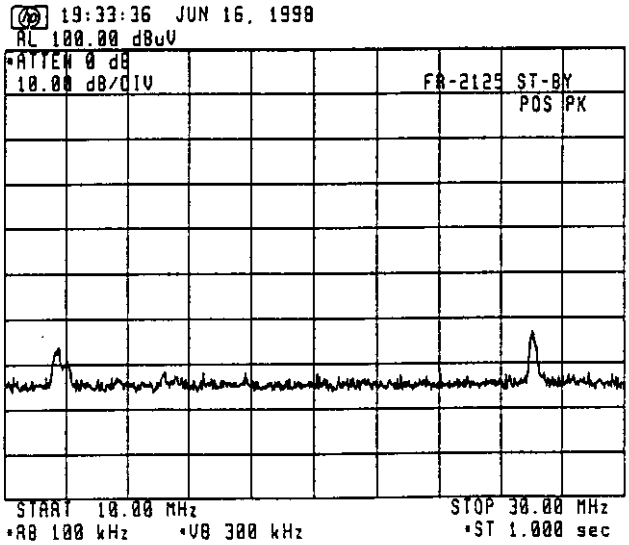


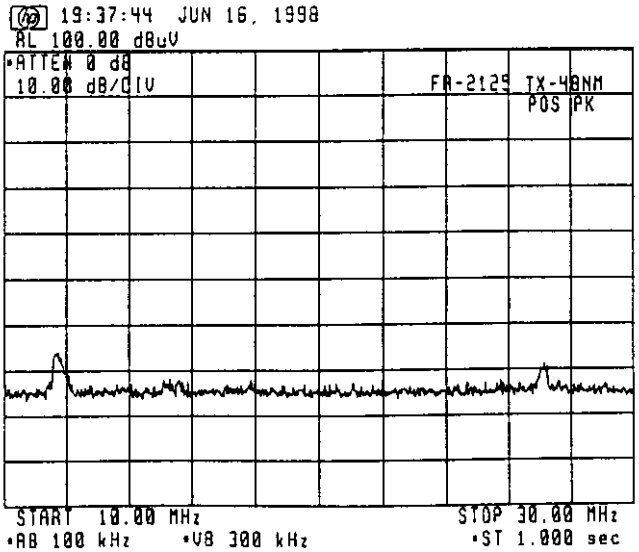


Pub. No. : TI-1692
Date : June, 1998

Band : 10MHz ~ 30MHz

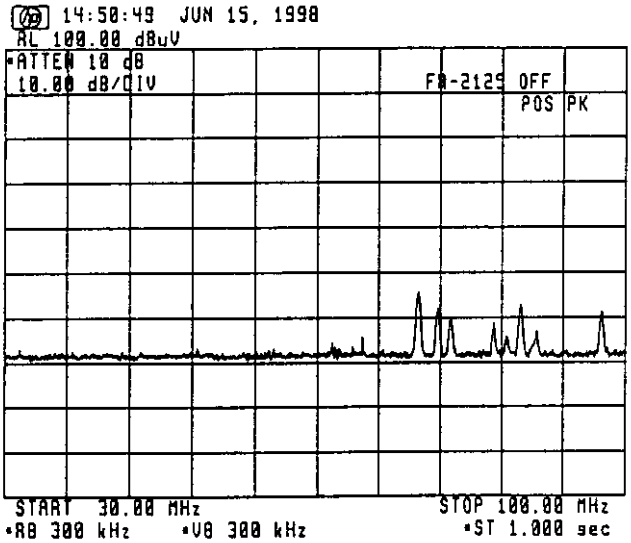


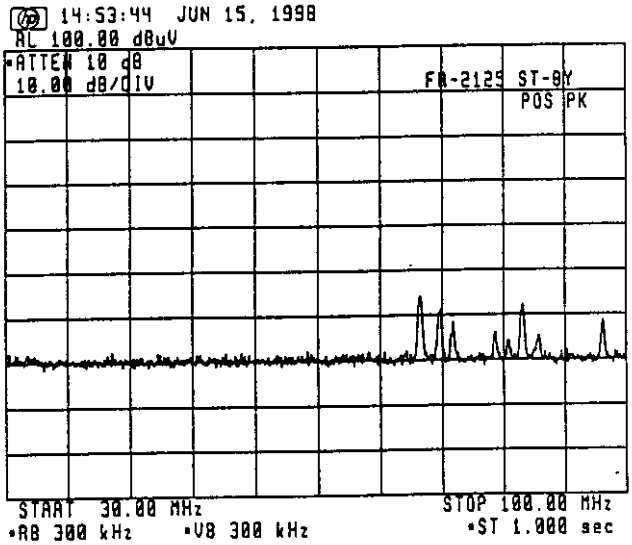


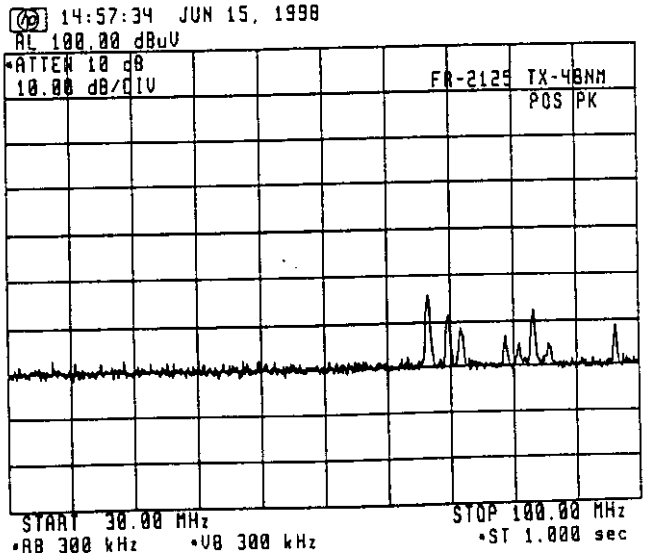


Pub. No. : TI-1692
Date : June, 1998

Band : 30MHz ~ 100MHz

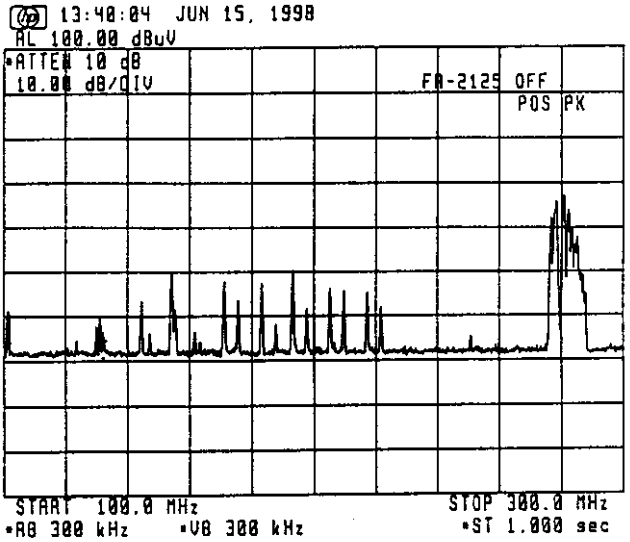


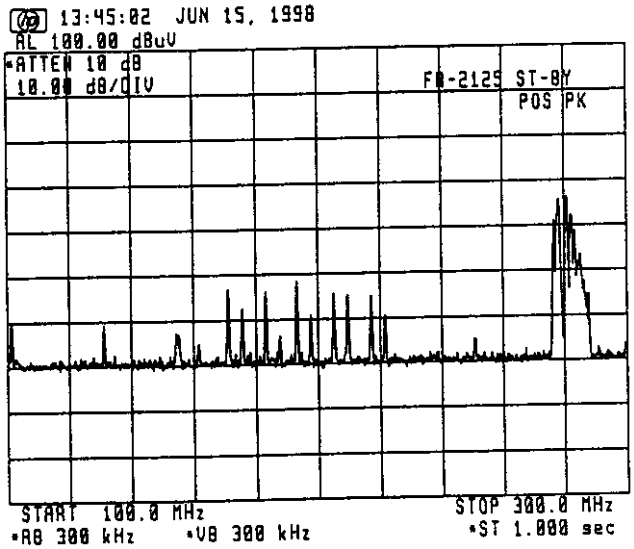


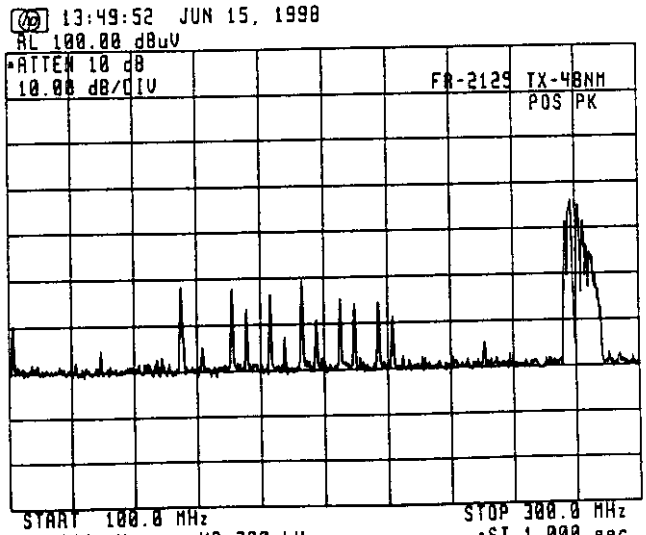


Pub. No. : TI-1692
Date : June. 1998

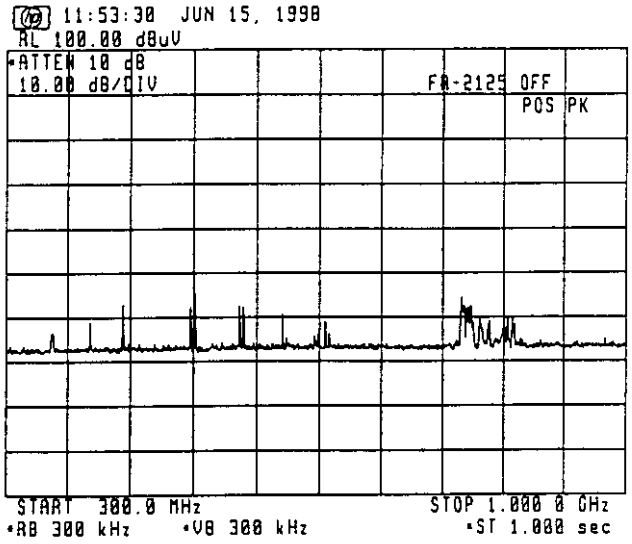
Band: 100MHz ~ 300MHz

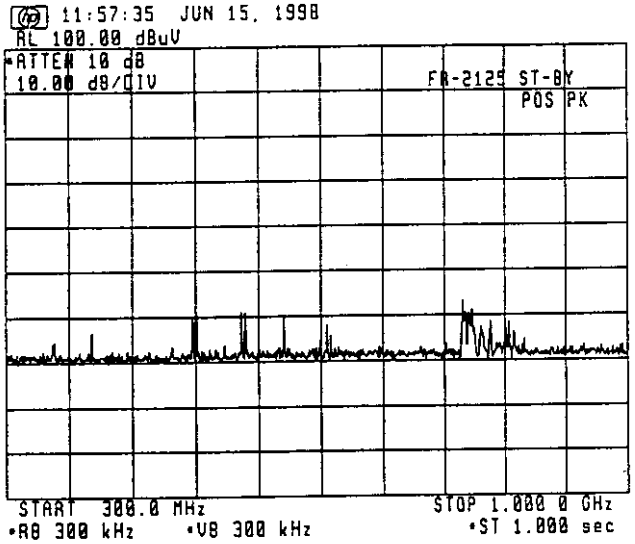


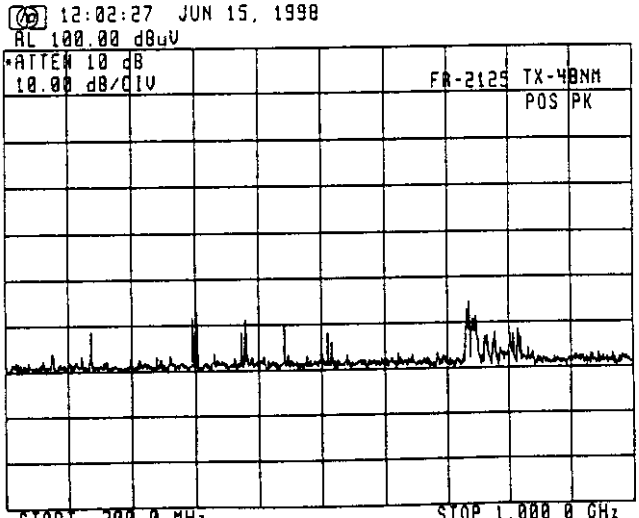




Band: 300MHz ~ 1GHz

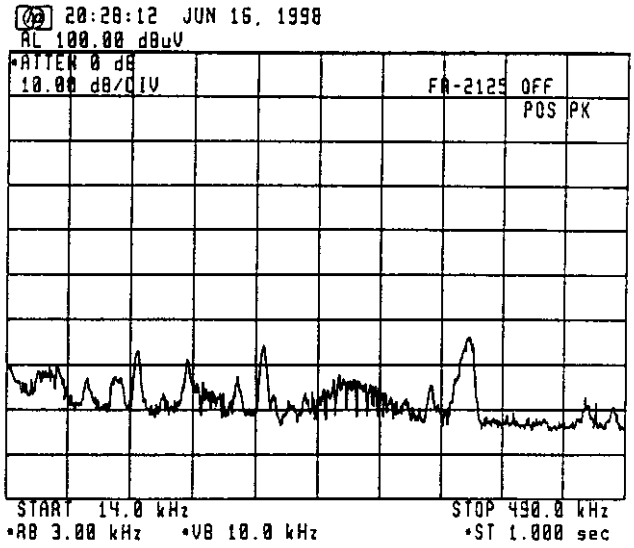


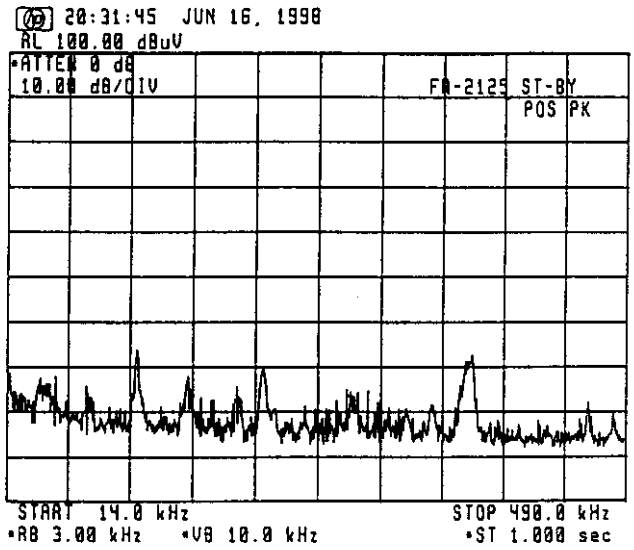




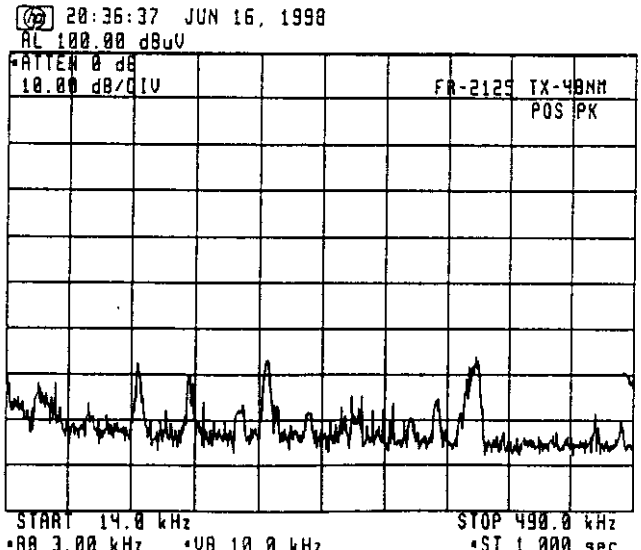
2. Electromagnetic Field

Band: 14kHz ~ 490kHz (Limit at 1N.M. = 0.1μV/m = -20 dBμV/m)



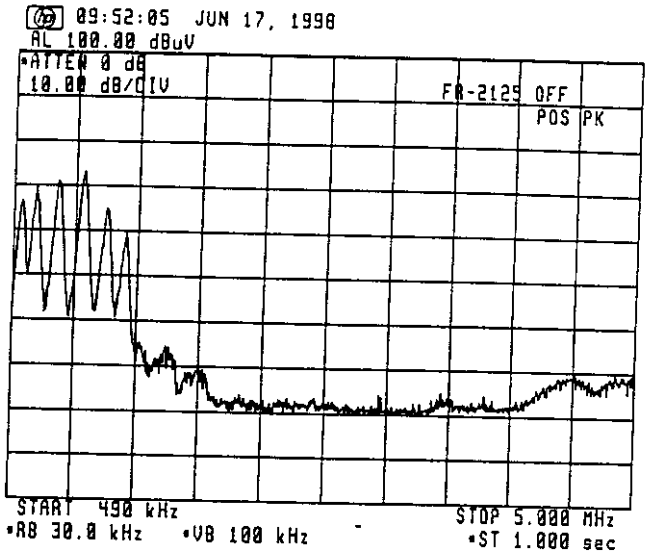


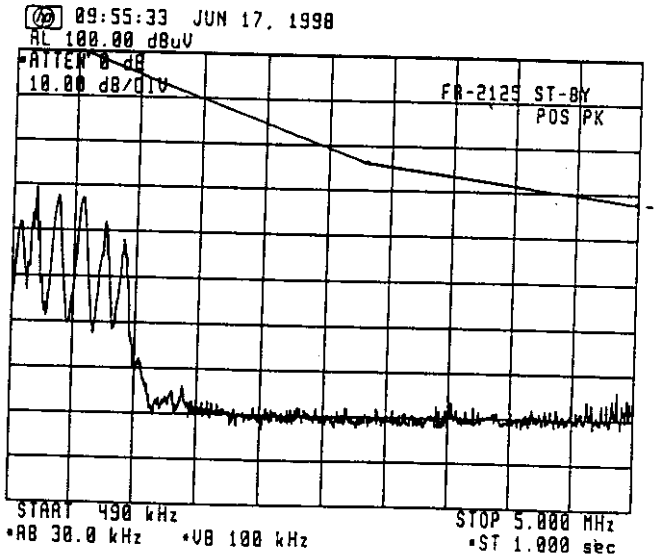
R.E.F
-26 dBμV/m



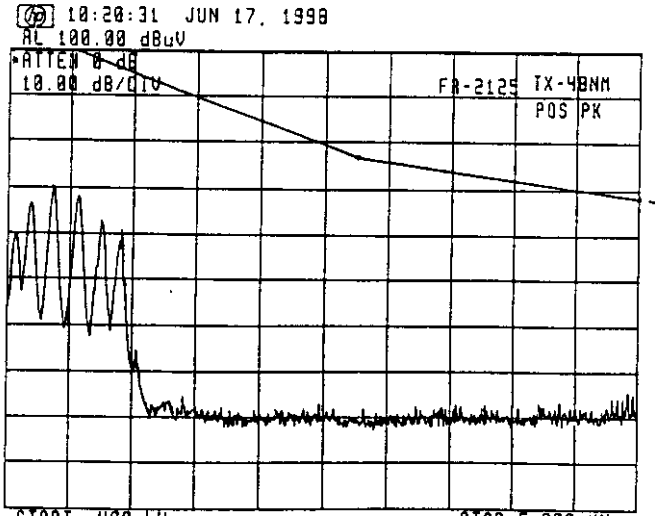
REF
-26 dBμV/m

Band: 490kHz ~ 5MHz (Limit at 1 N.M. = 0.1 μV/m = -20dBμV/m)



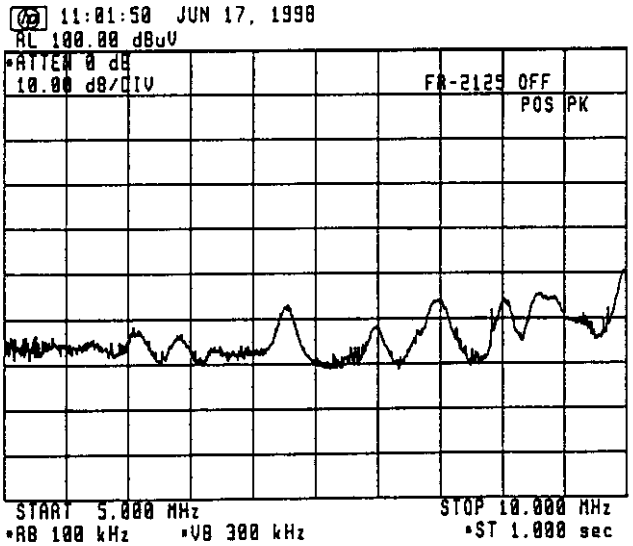


REF (dBμV/m)
100 - 126 = -26 (0.5MHz)
100 - 96 = 4 (3MHz)
100 - 88 = 12 (5MHz)
-20dBμV/m

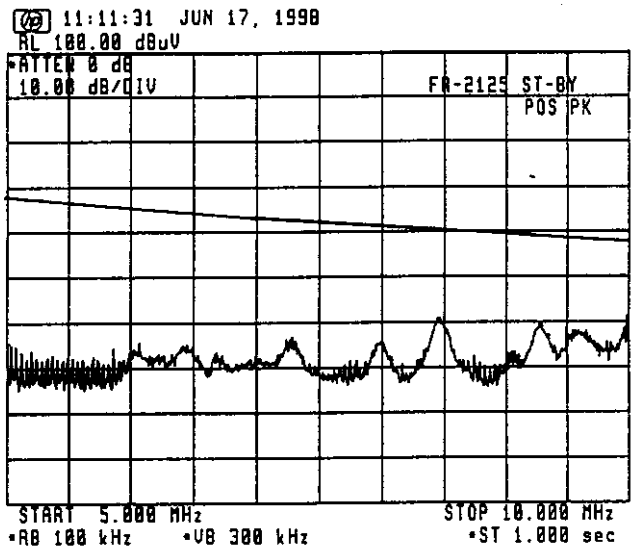


REF (dBμV/m)
100 - 126 = -26 (0.5MHz)
100 - 96 = 4 (3MHz)
100 - 88 = 12 (5MHz)
-20 dBμV/m

Band: 5MHz ~ 10MHz (Limit at 1 N.M. = 0.1μV/m = -20dBμV/m)

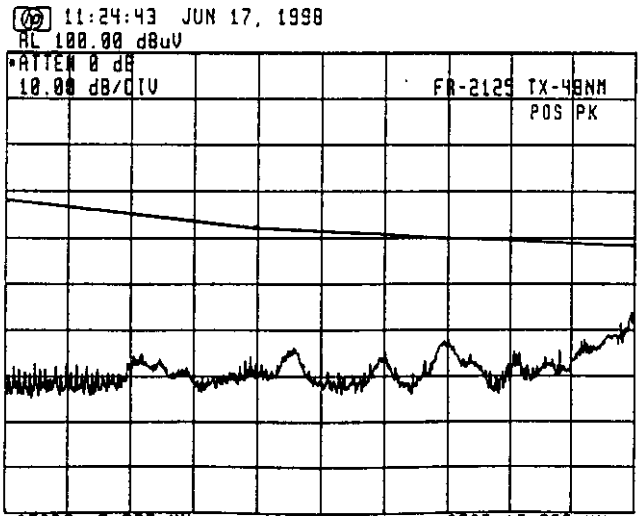


R.E.F (dBμV/m)
100 - 88 = 12 (5MHz)
100 - 83 = 17 (7MHz)
100 - 78 = 22 (10MHz)



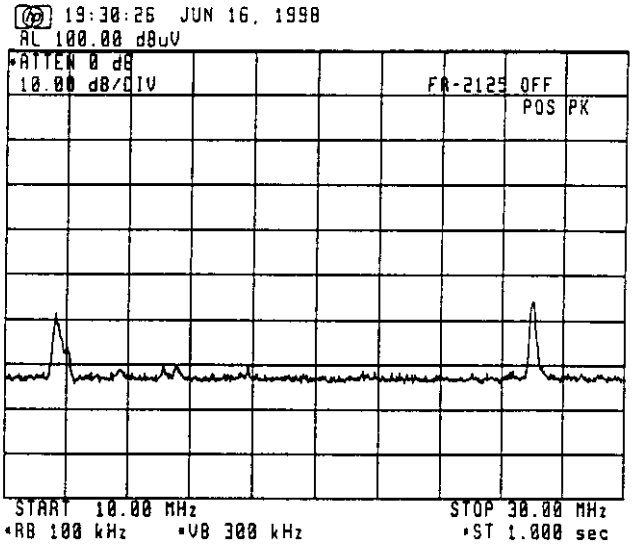
-20 dBμV/m

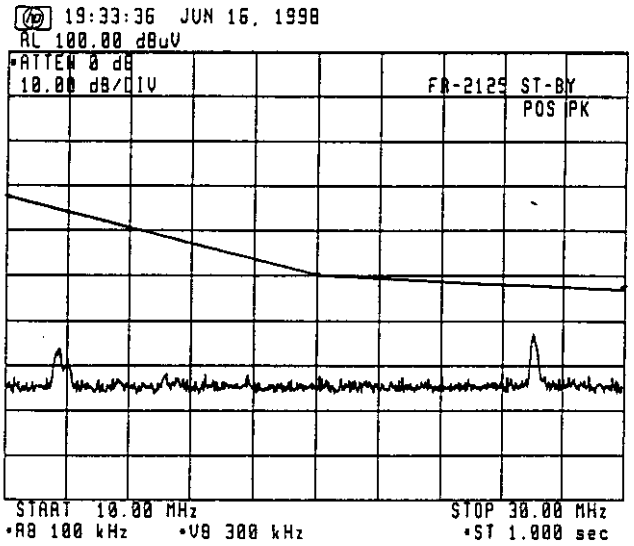
R.E.F (dBμV/m)
100 - 88 = 12 (5MHz)
100 - 83 = 17 (7MHz)
100 - 78 = 22 (10MHz)



-20 dBμV/m

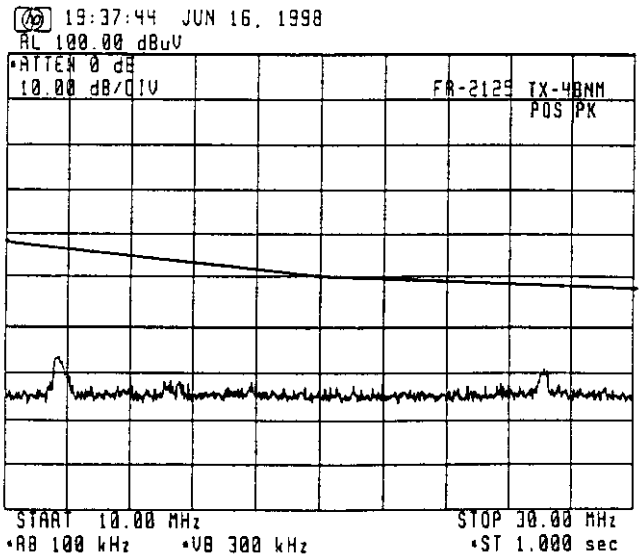
Band : 10MHz ~ 30MHz (Limit at 1N.M.= 0.1μV/m = -20 dBμV/m)





R.E.F (dBμV/m)
100 - 78 = 22 (10MHz)
100 - 70 = 30 (20MHz)
100 - 67 = 33 (30MHz)

-20 dBμV/m

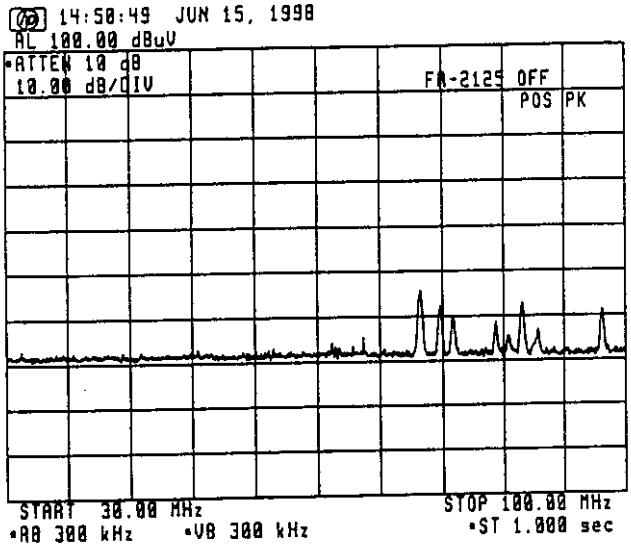


R.E.F (dBμV/m)
100 - 78 = 22 (10 MHz)
100 - 70 = 30 (20MHz)
100 - 67 = 33 (30MHz)

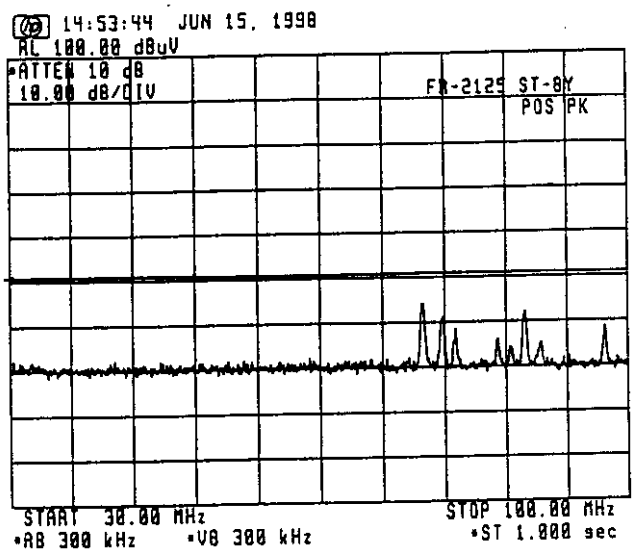
-20 dBμV/m

Pub. No. : TI-1692
Date : June. 1998

Band: 30MHz ~ 100MHz (Limit at 1 N.M. = 0.1 μV/m = -10.5 dBμV/m)

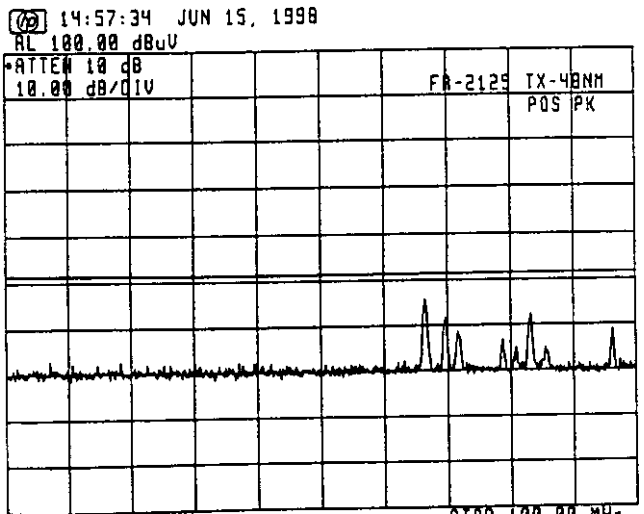


REF (dBμV/m)
100 - 61 = 39



-10 dBμV/m

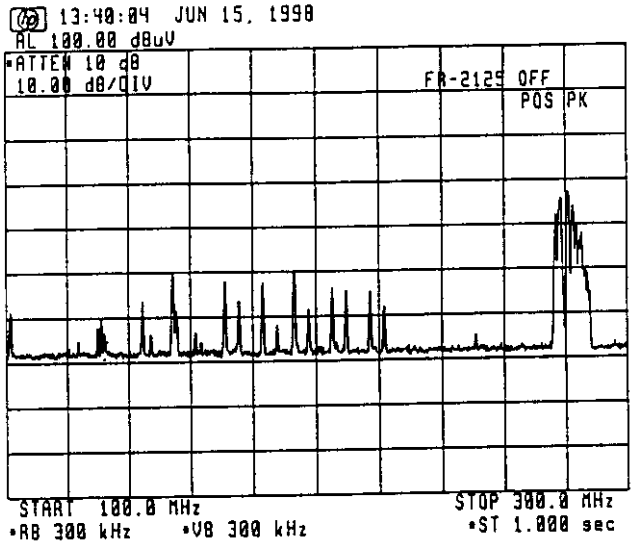
REF. (dBμV/m)
100 - 61 = 39



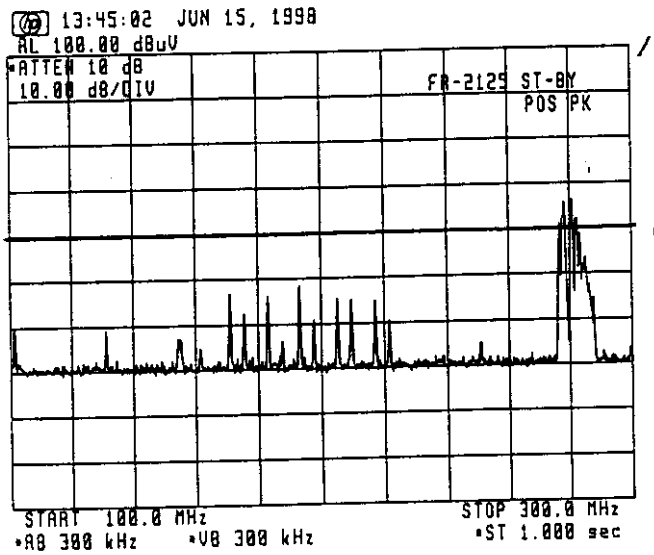
-10 dBμV/m

Pub. No. : TI-1692
Date : June, 1998

Band: 100MHz ~ 300MHz (Limit at 1 N.M. = 1μV/m = 0 dBμV/m)



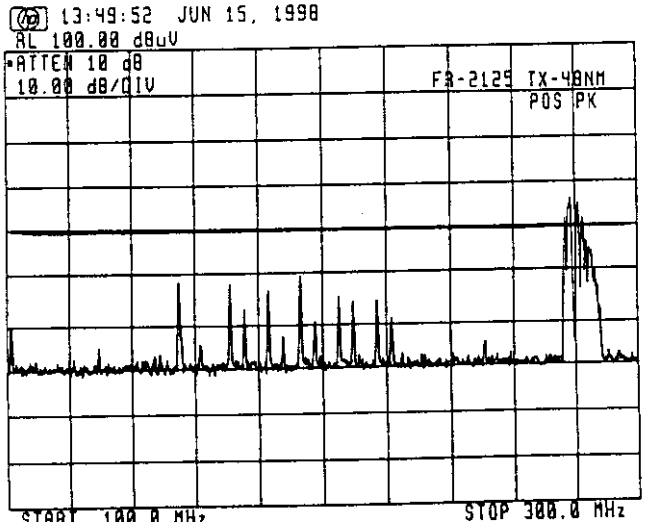
REF. (dBμV/m)
100 - 60 = 40



0dBμV/m

ALL COMPONENTS ABOVE THE LIMIT ARE FROM EXTERNAL NOISE OR SIGNALS, NOT FROM RADAR

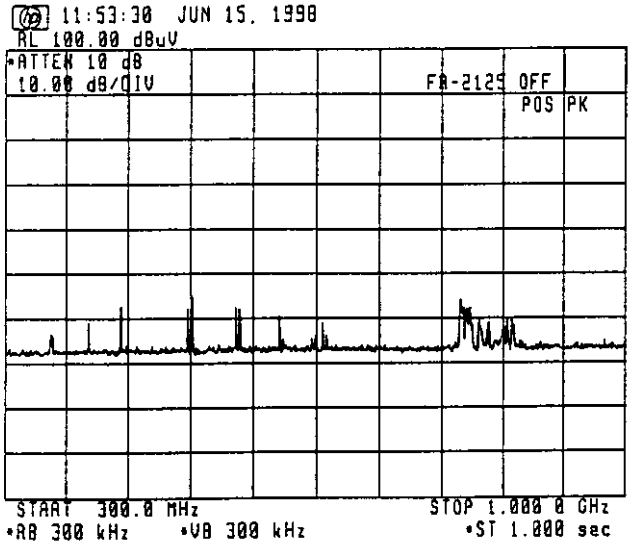
REF. (dBμV/m)
100 - 61 = 40



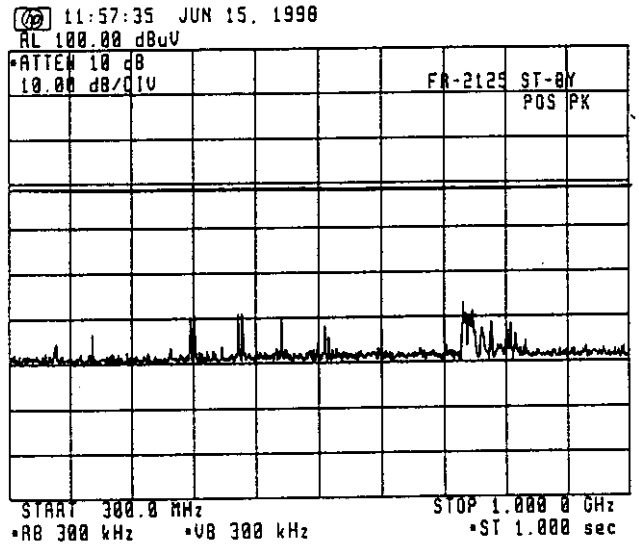
0dBμV/m

Pub. No. : TI-1692
Date : June, 1998

Band: 300MHz ~ 1GHz (Limit at 1N.M. = 3μV/m = 9.5dBμV/m)

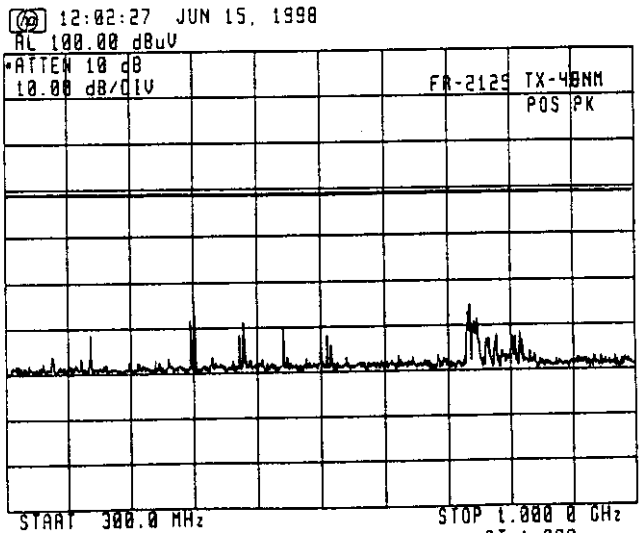


REF. (dBμV/m)
100 - 59.5 = 40.5



9.5dBμV/m

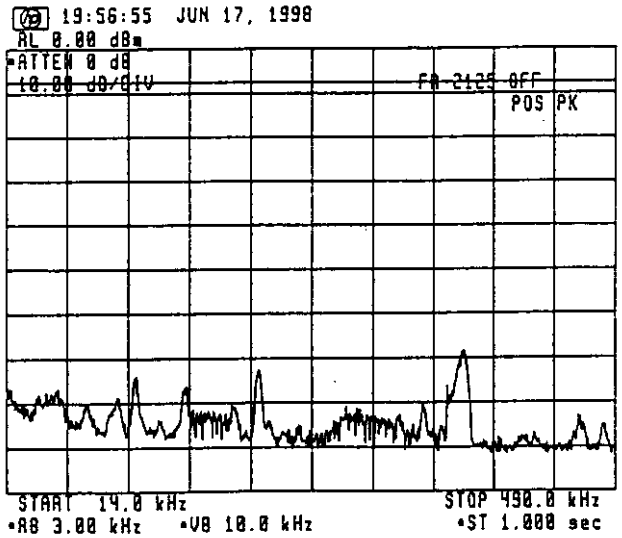
REF. (dBμV/m)
100 - 59.5 = 40.5

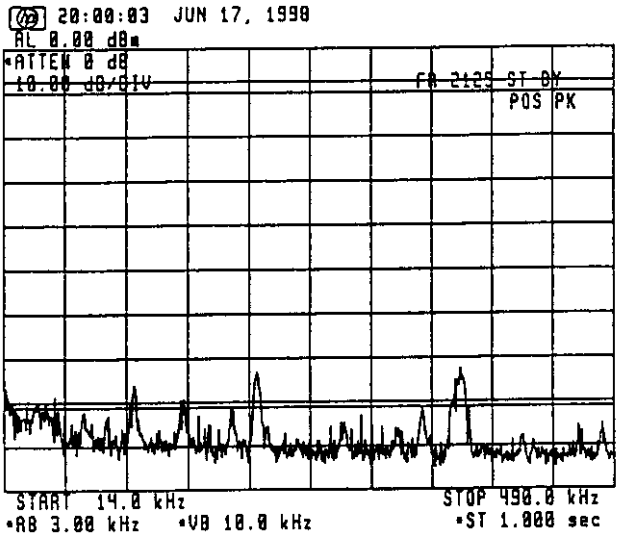


9.5 dBμV/m

3. Power Input to an Artificial Antenna

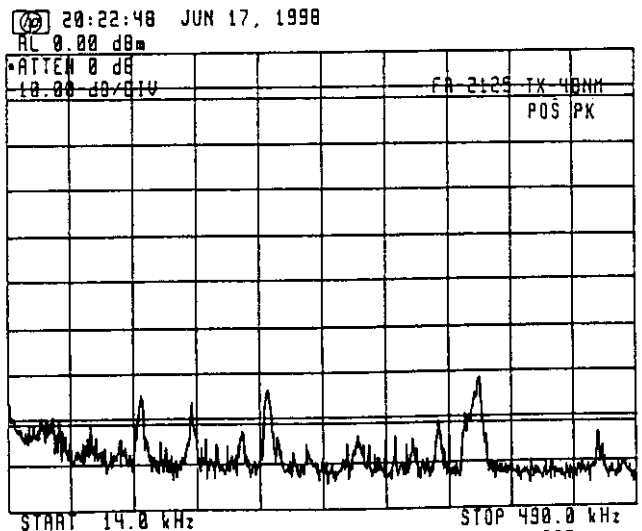
Band = 14kHz ~ 490kHz (Limit at 2meter = -81dBm)





-81dBm

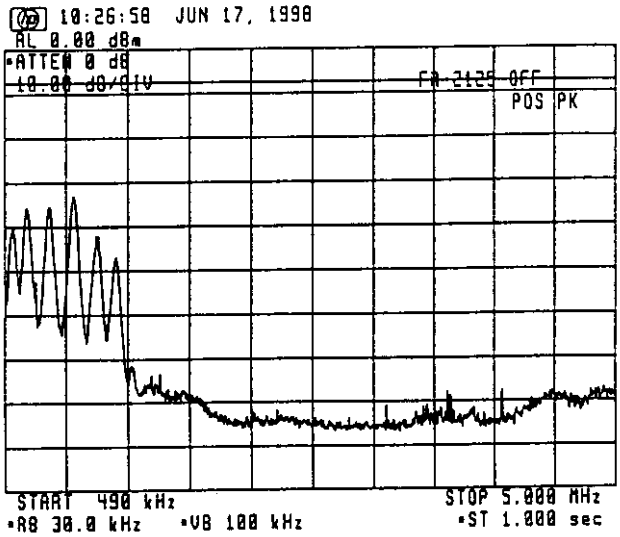
ALL COMPONENTS ABOVE THE LIMIT ARE FROM EXTERNAL NOISE OR SIGNALS, NOT FROM RADAR.

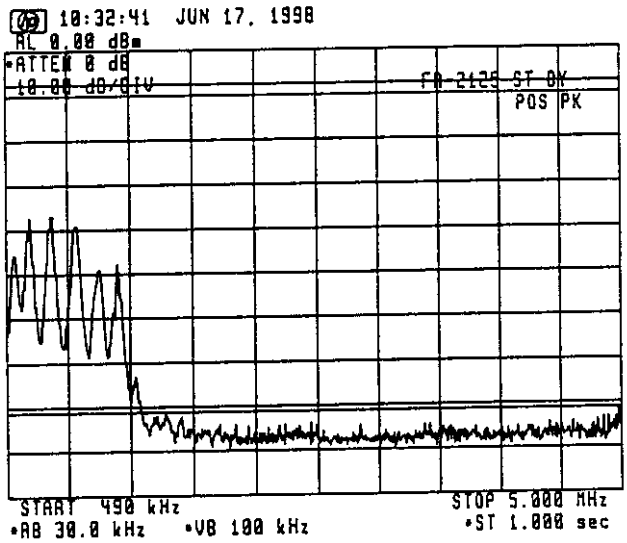


-81 dBm

Pub. No. : TI-1692
Date : June, 1998

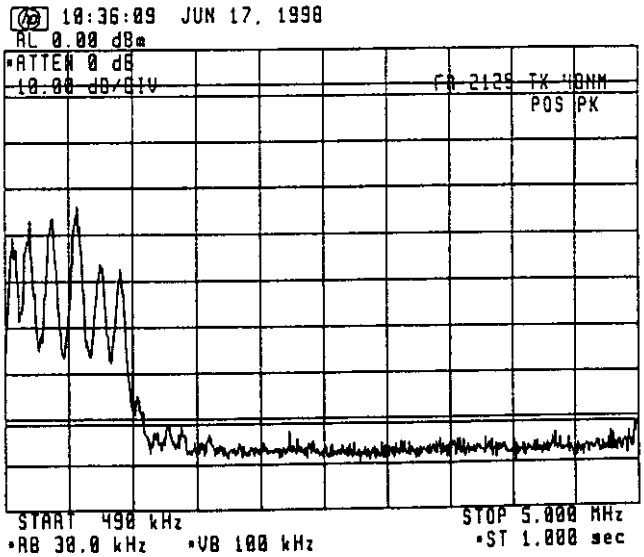
Band = 490kHz ~ 5MHz (Limit at 2meter = -81 dBm)





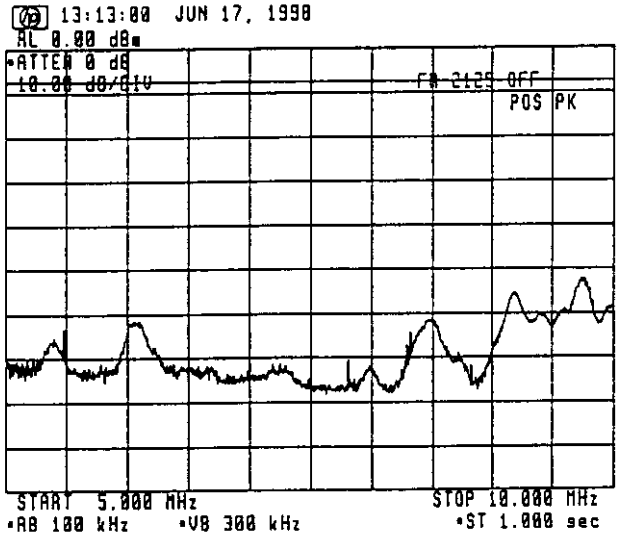
-81dBm

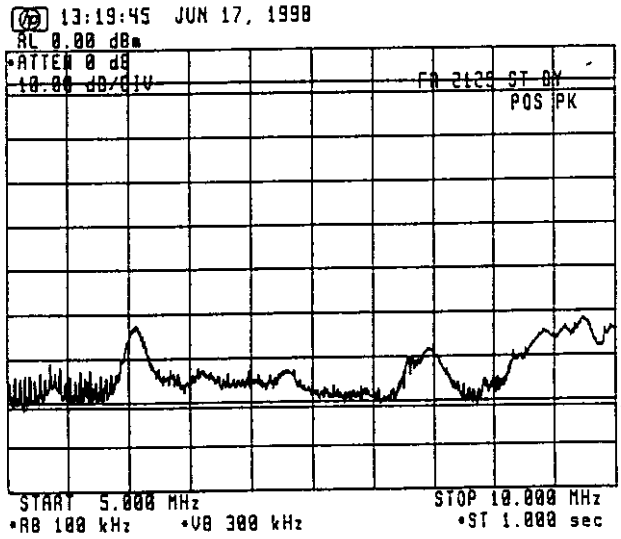
ALL COMPONENTS ABOVE THE LIMIT ARE FROM EXTERNAL NOISE OR SIGN. NOT FROM RADAR.



-81dBm

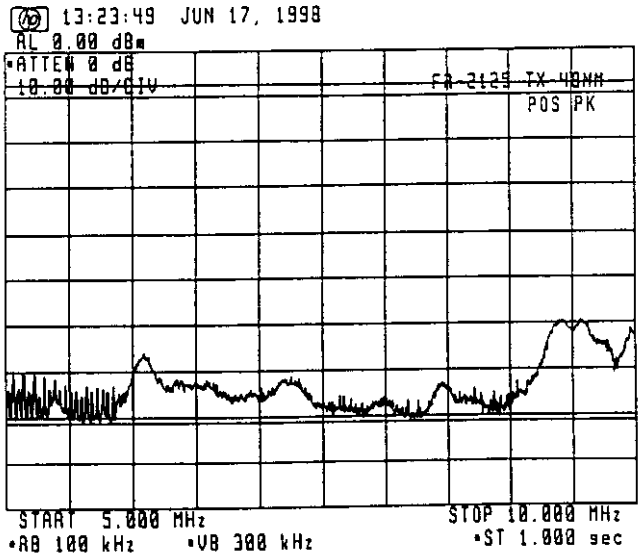
Band: 5MHz ~ 10MHz (Limit at 3meter = -81dBm)





-81dBm

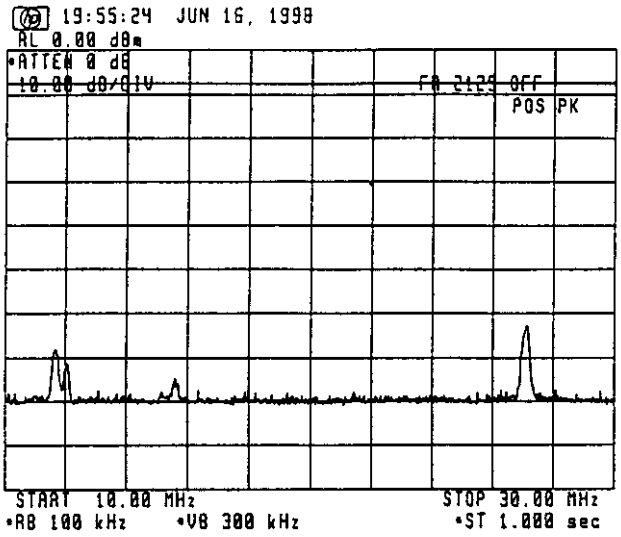
ALL COMPONENTS ABOVE THE LIMIT ARE FROM EXTERNAL NOISE OR SIGNALS, NOT FROM RADAR.

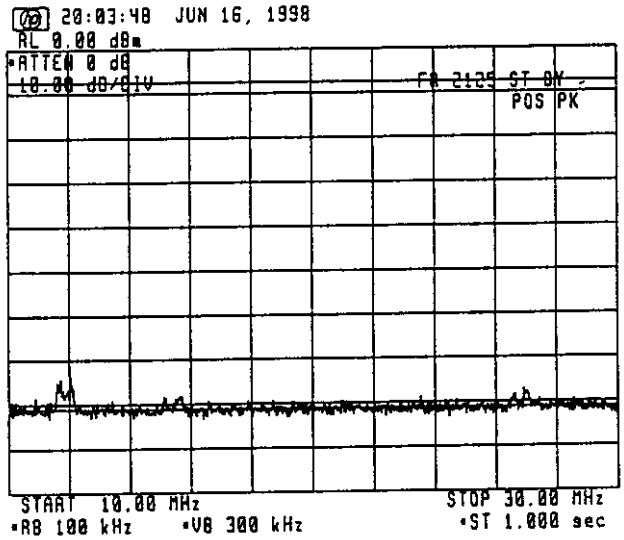


-81 dBm

Pub. No. : TI-1692
Date : June, 1998

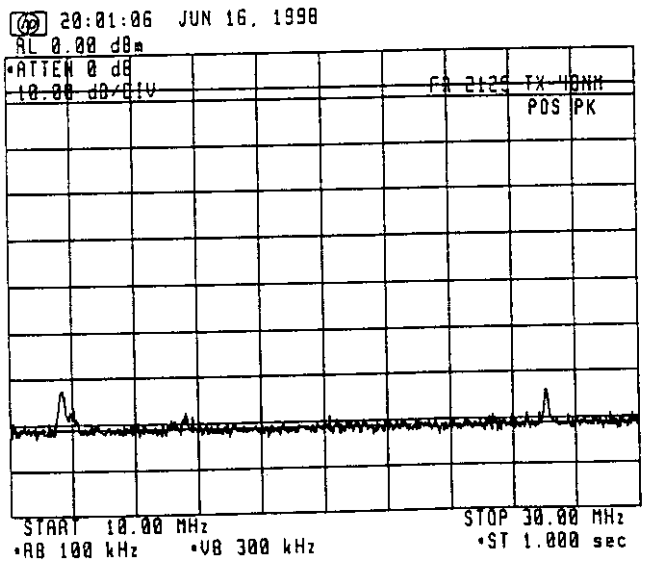
Band : 10MHz ~ 30MHz (Limit at 2meter = -81dBm)





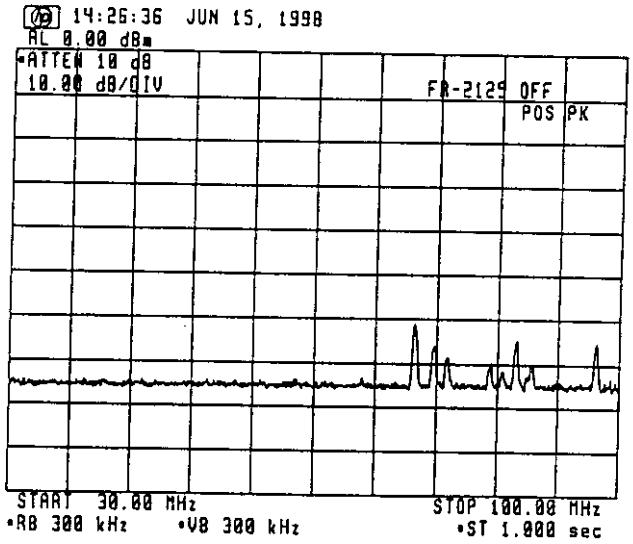
-81dBm

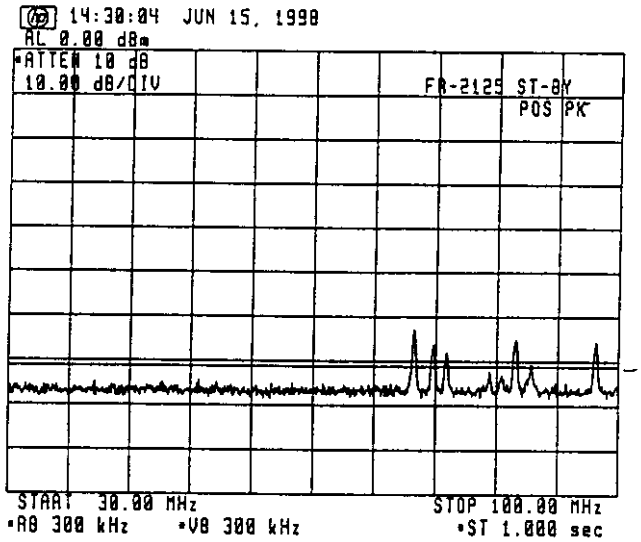
ALL COMPONENTS ABOVE THE LIMIT ARE FROM EXTERNAL NOISE OR SIGNALS, NOT FROM RADAR.



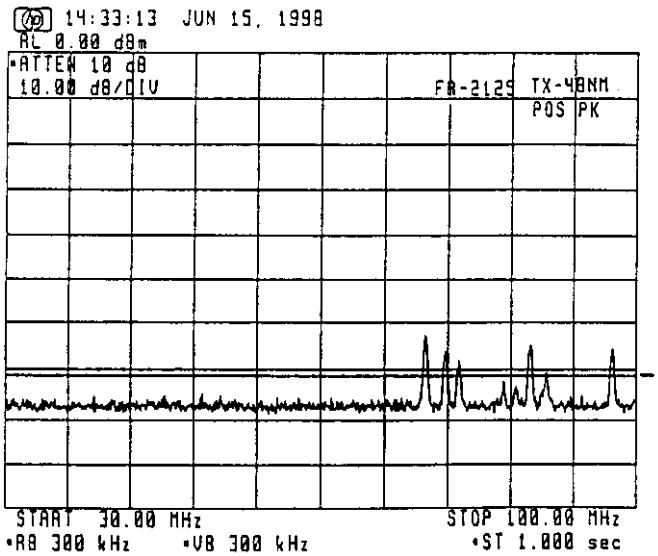
-81 dBm

Band: 30MHz ~ 100MHz (Limit at 3meter = -81dBm)





ALL COMPONENTS ABOVE THE LIMIT ARE FROM EXTERNAL NOISE OR SIGNALS, NOT FROM RADAR.



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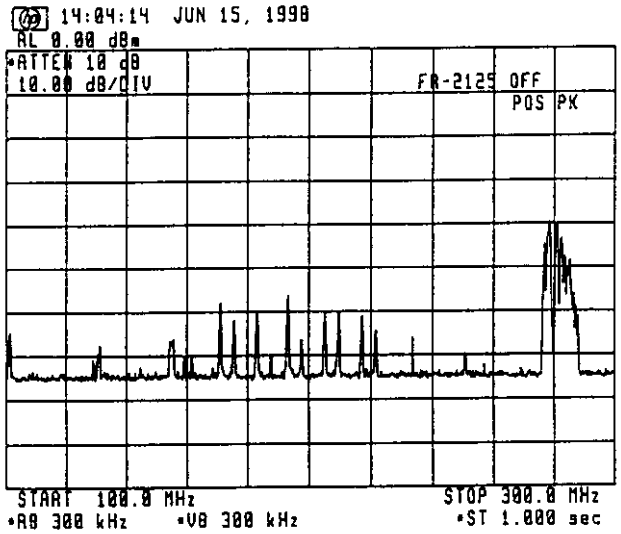
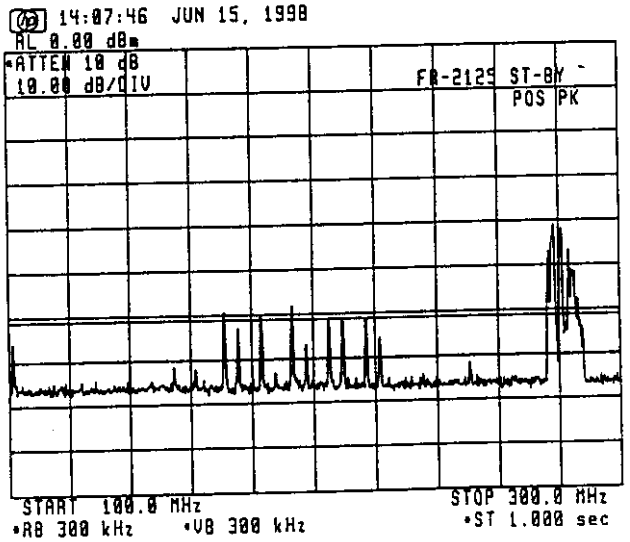
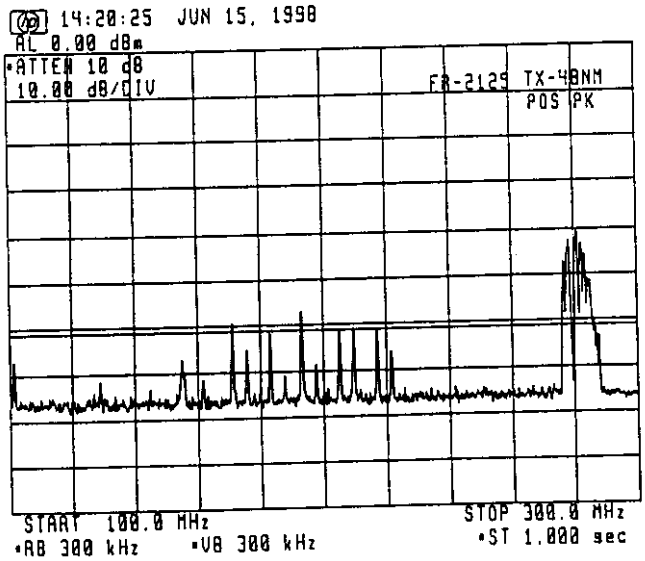
Band: 100MHz ~ 300MHz (Limit at 3meter = -81dBm)





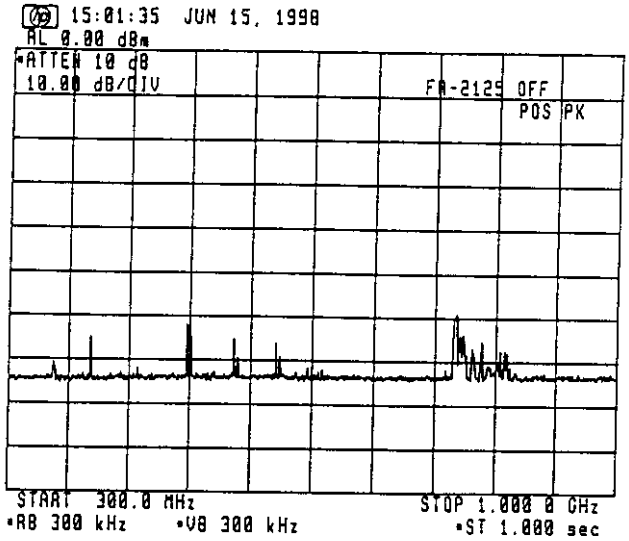
- 81 dBm

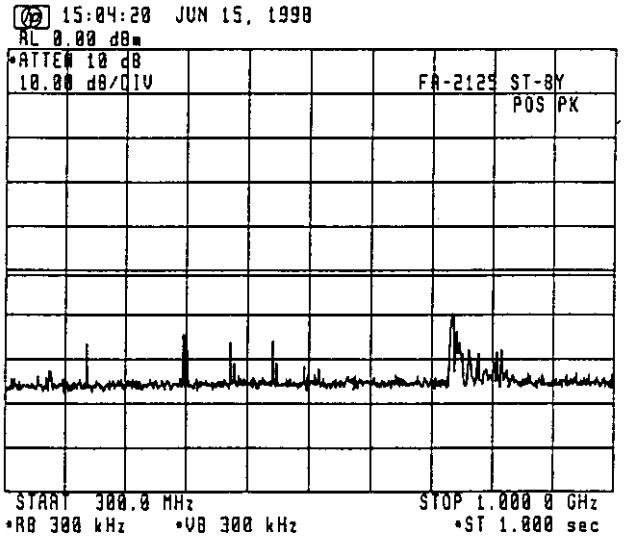
ALL COMPONENTS ABOVE THE LIMIT ARE FROM EXTERNAL NOISE OR SIGNALS, NOT FROM RADAR.



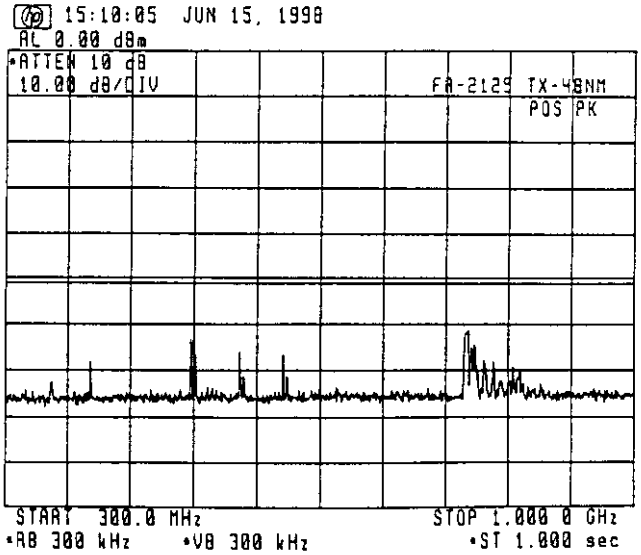
- 81 dBm

Band: 300MHz ~ 1GHz (Limit at 3meter = -81dBm)





-81 dBm



-81 dBm

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ATTACHMENT 4 [List of Test/Measuring Equipment]

3. RF Power Output

Model	Type	Serial no.	Mfr.
Spectrum Analyzer	71210C	2927A02847	HP
Oscilloscope	TDS680B	B030202	Tektronix
Directional Coupler	----	R94471	Shimada
Directional Coupler	5D364S	R05762	Shimada
Voltage Divider	P6015	----	Tektronix
Current Transformer	2100	----	Pearson Electronics
Power Meter	436A	2410A19137	HP
Power Sensor	9481A	2349A39603	HP
Frequency Counter	TR5824A	41940036	Advantest
Frequency Meter	X532B	1441A00523	HP
Crystal Detector	423B	03696	HP
Step Attenuator	8494B	1510A07310	HP
Step Attenuator	8495B	1350A04754	HP
Dummy Load	----	8411057	Shimada

4. Modulation Characteristics

Model	Type	Serial no.	Mfr.
Oscilloscope	TDS680B	B030202	Tektronix
Step Attenuator	8494B	1510A07310	HP
Step Attenuator	8495B	1350A04754	HP
Crystal Detector	423B	1822A24214	HP
Directional Coupler	5D364S	R9425	Shimada
Dummy Load	-----	8411057	Shimada
Voltage Divider	P6015	----	Tektronix
Spectrum Analyzer	71210C	2927A02847	HP
External Mixer:	11970K	----	HP
External Mixer:	11970A	----	HP
Directional Coupler	5D364S	R9425	Shimada

6. Spurious Emissions at Antenna Terminal

Model	Type	Serial no.	Mfr.
Spectrum Analyzer	71210C	2927A0847	HP
Attenuator (11dB/1dB)	8494B	1510A07310	HP
External Mixer:	11970K	----	HP
External Mixer:	11970A	----	HP
Directional Coupler	5D364S	R0576	Shimada
Dummy Load	-----	8411057	Shimada
Notch Filter	MA8L32#8	----	Microwave
High Pass Filter	MAS15905004	R9904	Shimada

7. Field Strength of Spurious Radiation

Model	Type	Serial no.	Mfr.
Broadband Rod Antenna	M 95010-1	0496	Advanced Electronics
Biconical Antenna	BIA-25	2650	Electro Metrics
Conical Log-Spiral Antenna	LCA-25	2886	Electro Metrics
Double Ridged Guide Horn Antenna:	RGA-180	----	EMD
Horn Antenna:	----	----	Toshiba
Spectrum Analyzer:	71210C	2927A0287	HP
External Mixer:	11970K	----	HP
External Mixer:	11970A	----	HP

8. Frequency Stability

Model	Type	Serial no.	Mfr.
Power Meter:	436A	2410A19137	HP
Power Sensor:	8481A	2349A39603	HP
Frequency Meter:	X532B	1441A00523	HP
Directional Coupler:	5D364S	R9425	Shimada
Dummy Load:	----	8411057	Shimada
Environmental Chamber:	PL-4E	1632712	Tabai Espec

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9. Suppression of Interference Aboard Ships

Model	Type	Serial no.	Mfr.
Spectrum Analyzer:	71210C	2927A02847	HP
6 m Whip Antenna	14 k - 10 MHz	----	Furuno
4 m Whip Antenna	10 - 30 MHz	----	Furuno
VHF Whip Antenna	30 - 300 MHz	150M-W2UM	Anten
UHF Whip Antenna	300 - 1000 MHz	----	Anten
RF Vector Impedance Meter:	4815A	2048A03354	HP
Spectrum Analyzer	TR4172	30690116	Advantest
Spectrum Analyzer	8566B	2637A03642	HP