

TECHNICAL INFORMATION

TEST REPORT ON THE PERFORMANCE OF RADAR/PLOTTER/SOUNDER

Trade Mark : FURUNO

Model : FRS-1000A

Report no. : FLI 12-98-024
Date of issue: Nov. 25, 1998

Furuno Labotech International Co., Ltd.
9-52 Ashihara-cho, Nishinomiya City, Hyogo 662-8580, Japan
Tel. : +81-798-63-1094 Fax. : +81-798-63-1098

LABOTECH

Furuno Labotech International

Report no. : FLI 12-98-024

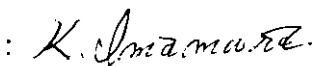
All tests were performed in Furuno Labotech International Co., Ltd.

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

All tests were performed by:

name : Katsumi Imamura

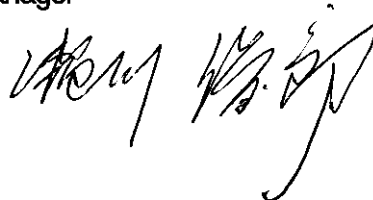
function : Test engineer

signature : 

Review and report by:

name : Toshiro Segawa

function : QA manager


signature : 

This report has been verified and approved by:

date : November 25, 1998

name : Sadatomo Kuwahara

function : Manager Engineering Section

signature : 



*** * * * * C O N T E N T S * * * * ***

1	General Information	4
2	Identification of Equipment (FCC Rule §2.925)	10
3	RF Power Output (FCC Rule §2.985)	11
4	Modulation Characteristics (FCC Rule §2.987)	14
5	Occupied Bandwidth (FCC Rule §2.989)	19
6	Spurious Emissions at Antenna Terminal (FCC Rule §2.991)	21
7	Field Strength of Spurious Radiation (FCC Rule §2.993)	25
8	Frequency Stability (FCC Rule §2.995)	27
9	Suppression of Interference Aboard Ships (FCC Rule § 80.217)	30
10	Photographs to Reveal Equipment Construction and Layout (FCC Rule §2.983)	34
11	Technical Description of Equipment (FCC Rule §2.983)	48
11.1	Function of Each Semiconductor or Active Device (FCC Rule §2.983 (d)(6)).....	48
11.2	Description of the Circuits Employed for Suppression of Spurious Radiation, for Limiting or Shaping the Control Pulse, and for Limiting or Controlling Power	50
12	Operator's Manual Incl. Circuit Diagrams (FCC Rule §2.983)	53
Attachment 1	[Test data for <u>6. Spurious Emissions at Antenna Terminal</u>]	A1
Attachment 2	[Test data for <u>7. Field Strength of Spurious Radiation</u>]	A2
Attachment 3	[Test data for <u>9. Suppression of Interference Aboard Ships</u>]	A3
Attachment 4	[List of Test/Measuring Equipment]	A4

1 GENERAL INFORMATION

1.0 General

- (a) Manufacturer: Furuno Electric Co., Ltd.
Ashihara-cho 9-52, Nishinomiya-city, 662-8580 Japan
- (b) Model: FRS-1000A
Serial no.: 3381-0001
- (c) Primary Function: Marine Radar, GPS, Echo Sounder
(c-1) Marine Radar: (see subclause 1.1 for details)
(c-2) GPS: Position fixing.
RX frequency: 1575.42 MHz
(c-3) Echo Sounder: TX frequency: 50/200 kHz
TX power: 600 W (1 kW: option)
- (d) Power Supply: 12 - 24 VDC

1.1 Marine Radar

1.1.0 General

- (a) Function: Search, navigation and anticollision
- (b) Discrimination
Range Discrimination: 20 meters on a range scale of 1.5 nm
Bearing Discrimination: 1.90° on a range scale of 1.5 nm
- (c) Minimum Range: 25 meters on a range scale of 0.25 nm
- (d) Range Scale: 0.125/0.25/0.5/0.75/1.5/2/3/4/6/12/16/24/36 nm
- (e) Frequency Range: Fixed frequency, X-band
- (f) Type of Emission: P0N

1.1.1 Transceiver

Type: RTR-057
(contained in the Radar Antenna Unit)

(1) 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: MG5223E E3571 MAF1421B
Peak Output Power: 4 kW nominal

(c)

Magnetron Ratings

Center frequency of Magnetron: 9410 MHz

Tolerances

Manufacturing: ±30 MHz ±30 MHz ±30 MHz

Pulling: 23 MHz 18 MHz 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:

Range Scale (nm)	Pulselength (µs)	P.R.R. (Hz)	Duty cycle	Guard Band (MHz)
(Short)	0.125 0.25 0.5 0.75 1.5	2100	1.68×10^{-4}	18.75
(Middle)	1.5 2 3	1200	3.60×10^{-4}	5.00
(Long)	3 4 6 12 16 24 36	600	4.80×10^{-4}	1.88

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

(2)

Modulator

(a)

FET Type:

ZSK1449

Trigger Voltage: Approx. +20 VDC positive

(3) Receiver

(a) Passband

RF Stage: 100 MHz

IF Stage:

Pulselength	Short	Middle	Long
(MHz)	25	25	3

Video Amp. : 10 MHz

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

(c) Overall Noise Figure (dB): 9 (typical)

(d) Video Output Voltage (V): 3.6 V positive across 400 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)

1.1.2 Antenna

(a) Antenna Rotation ON-OFF Switch:

Not Provided.

(b) Reflector: Printed array, 60 cm long

Radiator Type	M1832
Length (cm)	60
Length (ft)	2

(c) Type of Beam: Vertical fan

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

Radiator Type	M1832
Horizontal	4.0 °
Vertical	20 °

(e) Polarization: Horizontal

(f) Antenna Gain:

Radiator Type	M1832
(dB)	24.7

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

Radiator Type	M1832
---------------	-------

Within $\pm 20^\circ$	-18 dB or less
Outside $\pm 20^\circ$	-23 dB or less

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

(i) Antenna Rotation Rate: 24 rpm

(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.

1.1.3 Display

(a) Type: 10.4 (in.) TFT-color LCD, 640 X 480 pixels

(b) Size of Indicator Tube: 10.4 in. diagonal CRT

effective dia. 130 mm

(c) Sweep Linearity: 2 % on all ranges

(d) Range Scales:

Range (nm)	Number of Range Rings	Range Ring Interval (nm)
0.125	2	0.0625
0.25	2	0.125
0.5	4	0.125
0.75	3	0.25
1	4	0.25
1.5	3	0.25
2	4	0.5
3	3	1.0
4	4	1
6	3	2
8	4	2
12	4	3
16	4	4
24	4	6

<u>Range (nm)</u>	<u>Number of Range Rings</u>	<u>Range Ring Interval (nm)</u>
36	3	12

- (e) Range Ring Accuracy: Better than 0.9 % of maximum scale in use or 8 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

1.1.4 Functional Controls

Range selector	Tune (manual)	EBL offset
A/C Sea control	Anti-clutter auto	Power Switch
Heading line off	Gain control	Panel dimmer
Guard zone set/Audio alarm off	Echo stretch	MENU
Interference rejector	STBY/TX	Noise rejector on/off
VRM on/off	Off-center (SHIFT)	Trackball (VRM,EBL,GUARD)
Range set	Zoom	A/C Rain control
Target trail	Brilliance (screen)	EBL on/off
Navigation on/off	Mark Brilliance	TRU/REL/HU/CU/NU/TM
Range ring on/off	Text Brilliance	
ARPA function (option)	Range ring brilliance	

1.1.5 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)

1.2 Line Power Supply Requirements
(a) Input Voltage: 12 - 24 VDC
(b) Power Drain: 100 W

1.3 Construction Features
(a) Does equipment embody replacement units with chassis type assembly: Yes
(b) Are fuse alarms provided: Fuses are provided.
(c) State units that are weatherproof: Scanner Unit (IEC 60529 - IPX6)
(d) If all units are not housed in a single container, indicate number and give description of individual units:

1 × Processor Unit	Type:	RSM-001
1 × LCD Monitor	Type:	RSD-001
1 × Radar Antenna Unit	Type:	RSB-0071
Transceiver	Type:	RTR-057 (contained in the Antenna unit)
1 × GPS Antenna	Type:	GPA-016

(e) Approximate Weight of Complete Installation:

Processor Unit:	6 kg	(RSM-001)
LCD Monitor:	3.5 kg	(RSD-001)
Radar Antenna Unit	8 kg	(RSB-0071)
GPS Antenna	0.1 kg	(GPA-016)

(f) Approximate space required for installation excluding Radar Antenna Unit and GPS antenna.

Processor Unit:	357 mm (W) X 252 mm (H) X 380 mm (D)
LCD Monitor:	491 mm (W) X 277 mm (H) X 185 mm (D)

Magnetron input pulse current

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

Pulselength	Short	Middle	Long
Magnetron input current (A)	3.0	3.7	3.7
Pulselength (μ s) (50 % amplitude)	0.072	0.263	0.746
Rise time (μ s) (10-90 % amplitude)	0.065	0.120	0.150
Decay time (μ s) (90-10 % amplitude)	0.060	0.060	0.060

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:

Pulselength	Short	Middle	Long
Pulselength (μ s) (-3 dB points)	0.079	0.265	0.746
Rise time (μ s) (10-90 % amplitude)	0.016	0.040	0.042
Decay time (μ s) (90-10 % amplitude)	0.064	0.060	0.060

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.

Pulselength	Short	Middle	Long
Range scale (nm)	0.125	1.5	36
P.R.R (Hz)	2234.7	1257.0	566.5
Duty cycle	1.76×10^{-4}	3.33×10^{-4}	4.22×10^{-4}
Magnetron input, av. (W)	2.07	4.81	6.10
Magnetron input, peak (kW)	11.70	14.43	14.16
Power meter reading	0.0475	0.1118	0.1470

Pulselength	Short	Middle	Long	(mW)
Magnetron output, av. (W)	0.538	1.266	1.665	
Spurious response limits (dB)	40.31	44.02	45.21	
Magnetron Output, peak (kW)	3.05	3.80	3.94	
Magnetron efficiency (%)	26.0	26.3	27.3	

Peak Power Input to RF Generator : 13.5 kW
Estimated Efficiency of RF Generator : 26.6 %

4 MODULATION CHARACTERISTICS (FCC Rule § 2.987)

4.1 FET Trigger Pulse

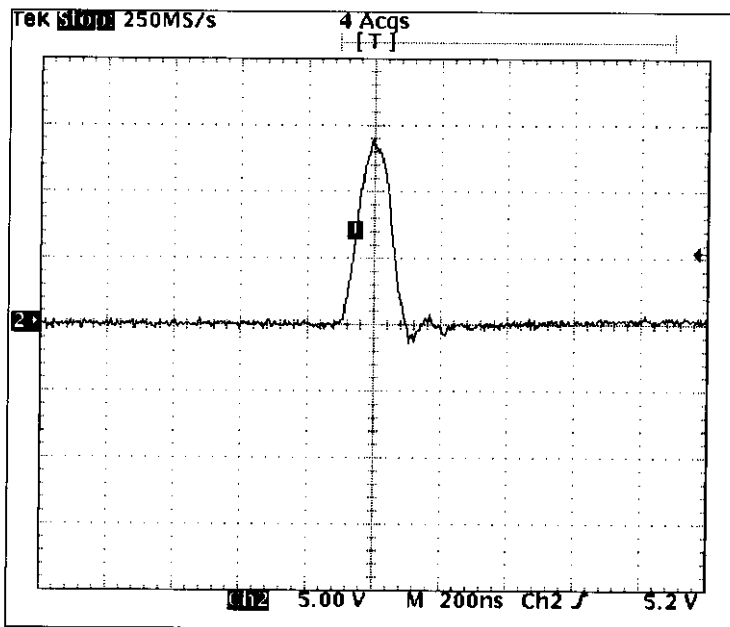


Fig. 4.1.1 Typical waveform of Trigger Pulse Scale: 5 V/div., 200 ns/div.

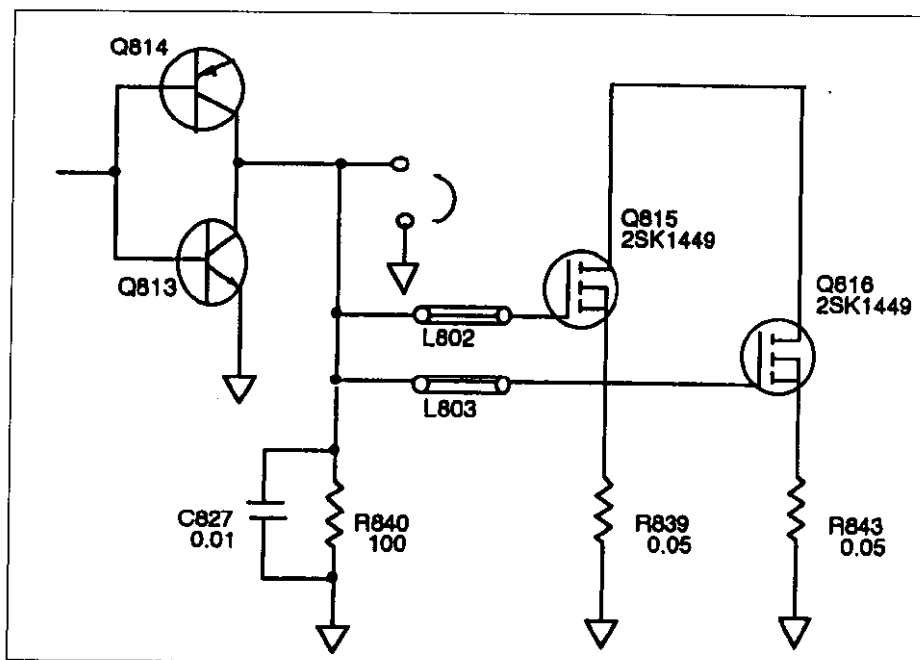
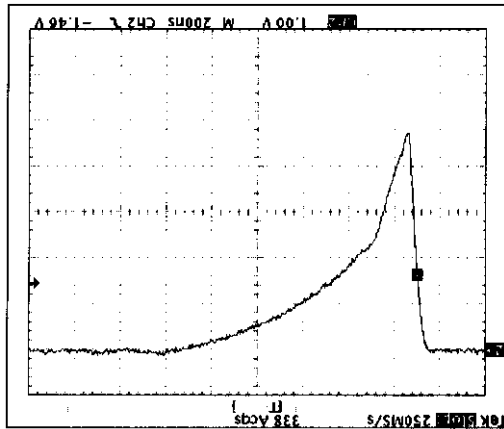


Fig. 4.1.2 Test Point for Trigger Pulse
(in MD board (MD-9208) of Radar Antenna Unit)

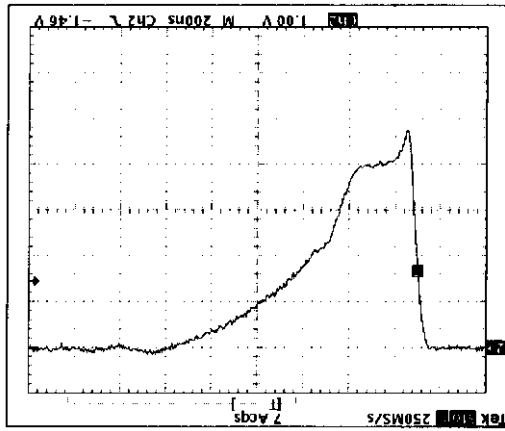
4.2 Trigger Pulse at Magnetron Cathode



Scale: 1 kV/div. 200 ns/div.

Short Pulse (0.125 nm Range)

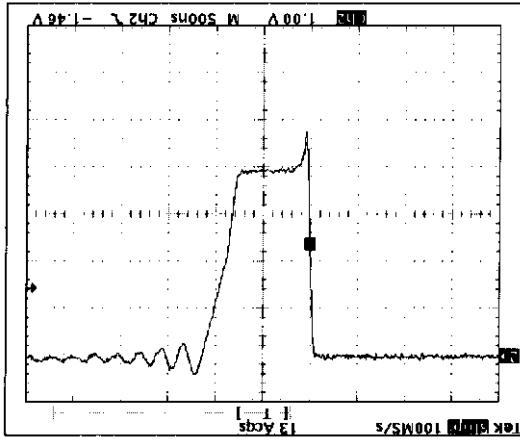
Fig. 4.2.1



Scale: 1 kV/div. 200 ns/div.

Middle Pulse (1.5 nm Range)

Fig. 4.2.2



Scale: 1 kV/div. 500 ns/div.

Long Pulse (36 nm Range)

Fig. 4.2.3

4.3 Magnetron Output (detected):

4.3.1 Setup for Measurement:

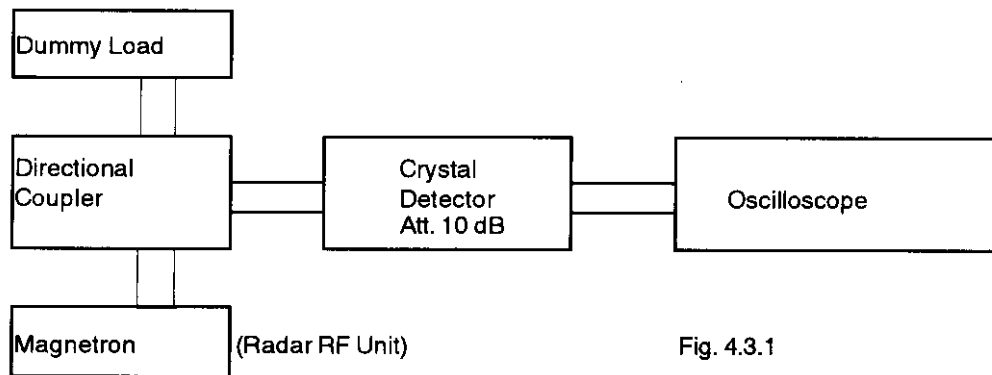


Fig. 4.3.1

4.3.2 Measuring Equipment List:

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

4.3.3 Measured Data:

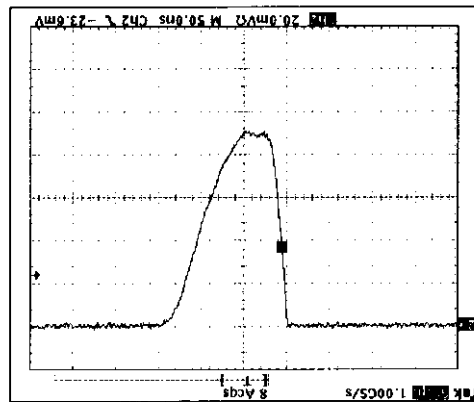


Fig. 4.3.2

Short Pulse (0.125 nm Range)

Scale: 20 mV/div. 50 ns/div.

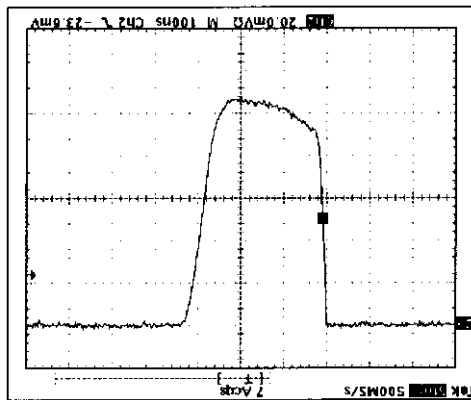


Fig. 4.3.3

Middle Pulse (1.5 nm Range)

Scale: 20 mV/div. 100 ns/div.

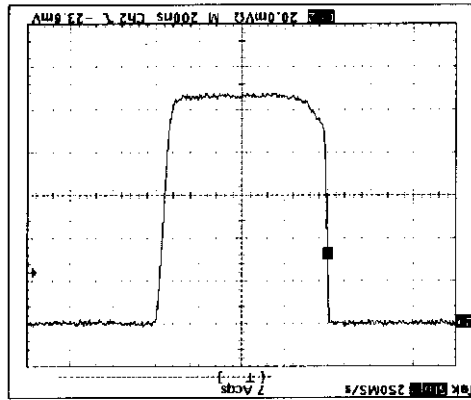


Fig. 4.3.4

Long Pulse (36 nm Range)

Scale: 20 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.)

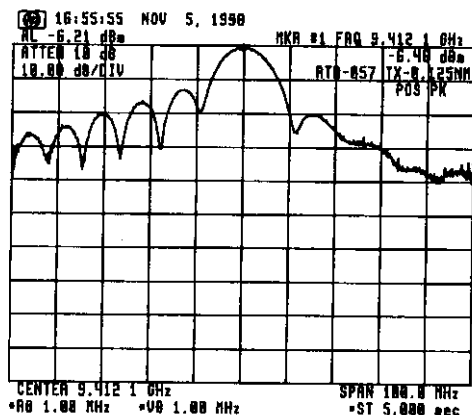


Fig. 4.4.1 For Short Pulse (0.125 nm Rang)

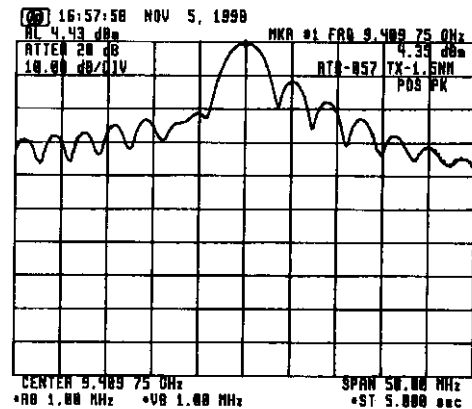


Fig. 4.4.2 For Middle Pulse (1.5 nm Rang)

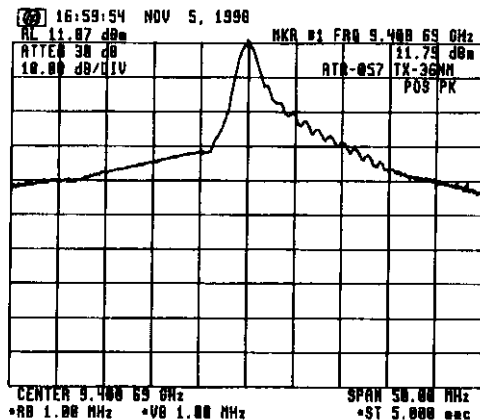


Fig. 4.4.3 For Long Pulse (36 nm Range)

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 T18
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:FUNCDDEF D_LP,1;"
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:1%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:ELSI K_ey,EQ,2;THEN;PWR_BW;"
280 | OUTPUT @Sa:ELSI K_ey,EQ,14;THEN;ABORT;"
290 | OUTPUT @Sa:ENDIF;"
300 | OUTPUT @Sa:UNTIL K_ey,EQ,14;"
310 | OUTPUT @Sa:IF: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:FUNCDDEF D_LP;"
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:FUNCDDEF LIMIT LINE;"
480 | OUTPUT @Sa:"PU;PA 0.654;"
490 | OUTPUT @Sa:UNNET 1;"
490 |
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:UNNET 1;"
590 | OUTPUT @Sa:"PD;PA 400.743;"
600 | OUTPUT @Sa:"PU;PA 601.743;"
610 | OUTPUT @Sa:UNNET 1;"
620 | OUTPUT @Sa:"PD;PA 700.743;"
630 | OUTPUT @Sa:"PU;PA 701.654;"
640 | OUTPUT @Sa:UNNET 1;"
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:FUNCDDEF PWR_BW;"
730 | OUTPUT @Sa:CLRW TRA;"
740 | OUTPUT @Sa:CLRDSP;"
750 | OUTPUT @Sa:SNGLS;"
760 | OUTPUT @Sa:MXMH TRA;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

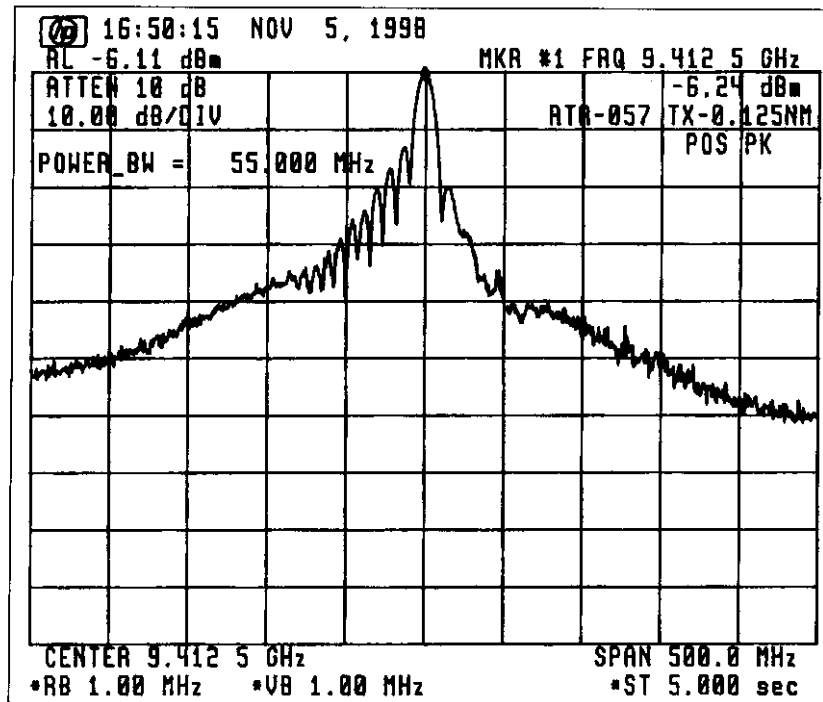
5.2 Test Equipment Setup:

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 = 55.000 MHz

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

6.1 Test Equipment Setup:

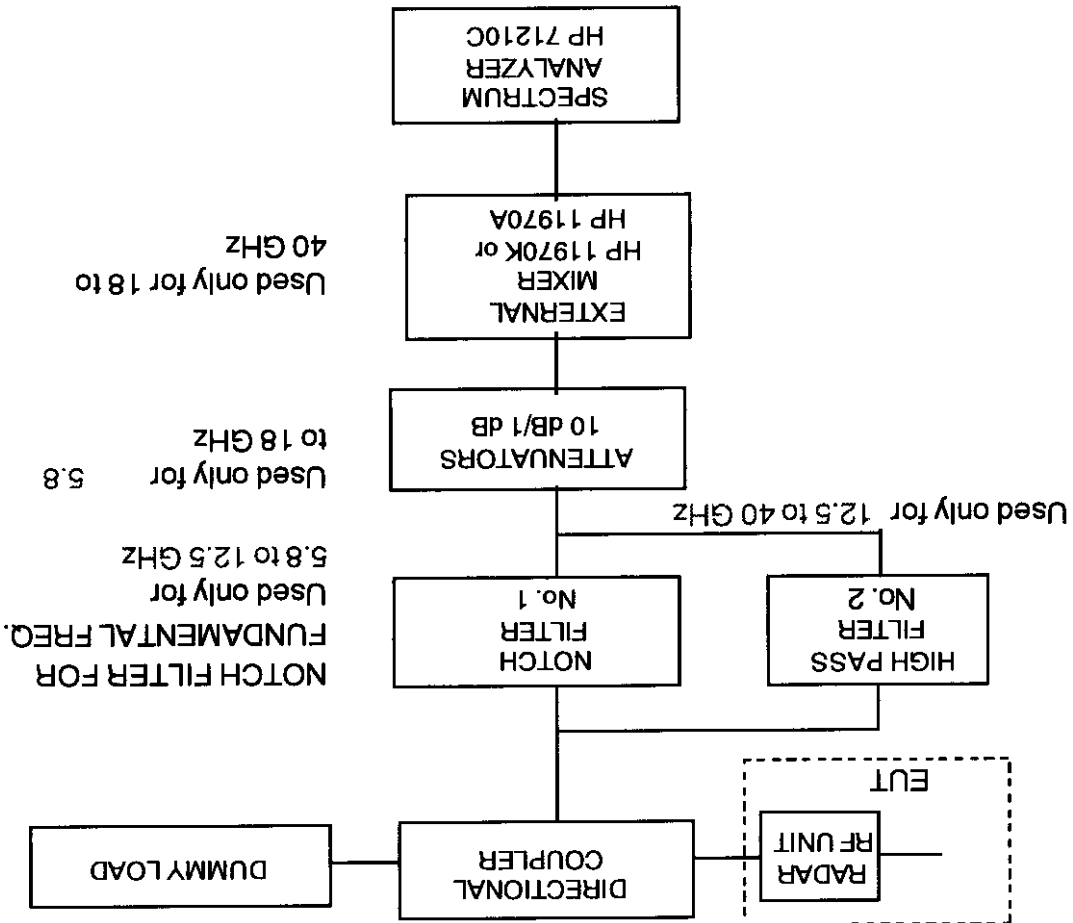


Fig. 6.1

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 (Short)/1.5 nm (Middle)/ 36 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	At least 25
	9460 - 9510 M	
100 - 250 %	9160 - 9310 M	At least 35
	9510 - 9660 M	
more than 250 %	10 k - 9160 M	At least $43 + 10 \log_{10}$ (mean power in watts)
	9660 - 40,000 M	

- 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)).

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

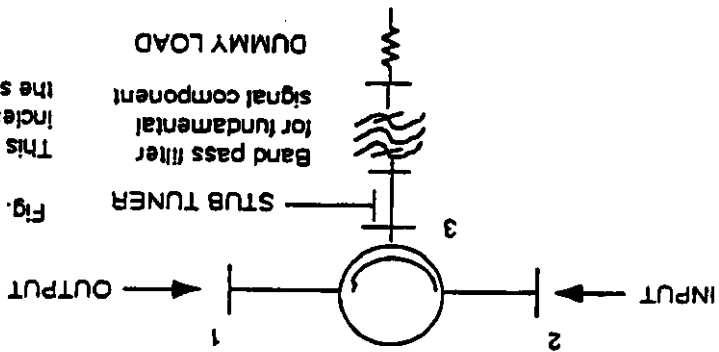


Fig. 6.2 Setup of Notch Filter No.1
 This notch filter is used to increase the dynamic range of the spectrum analyzer

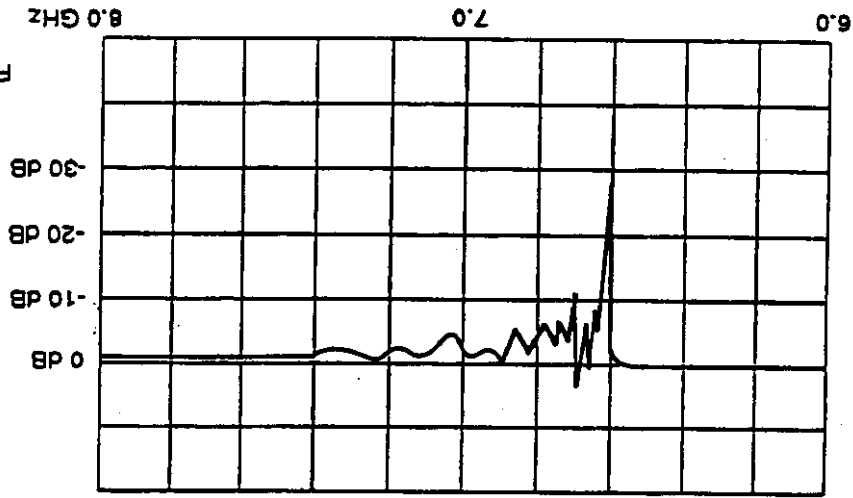


Fig. 6.3

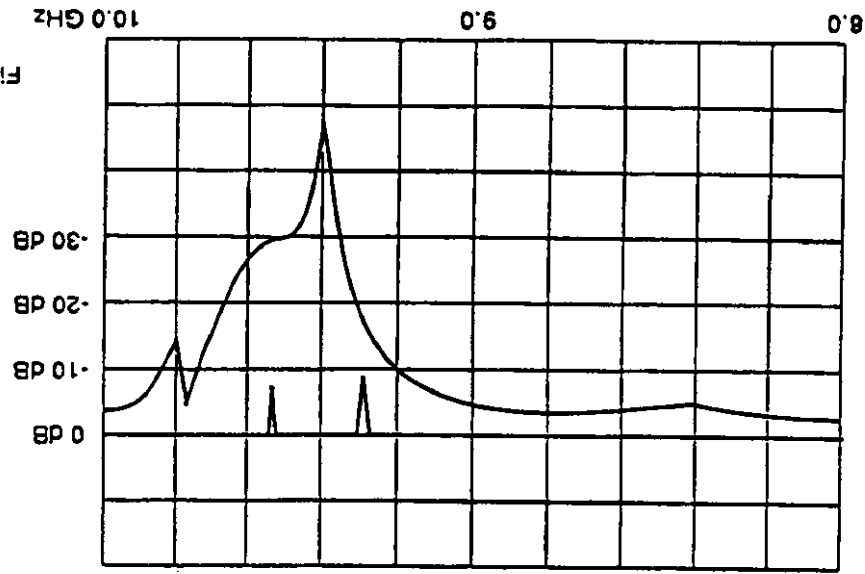


Fig. 6.4

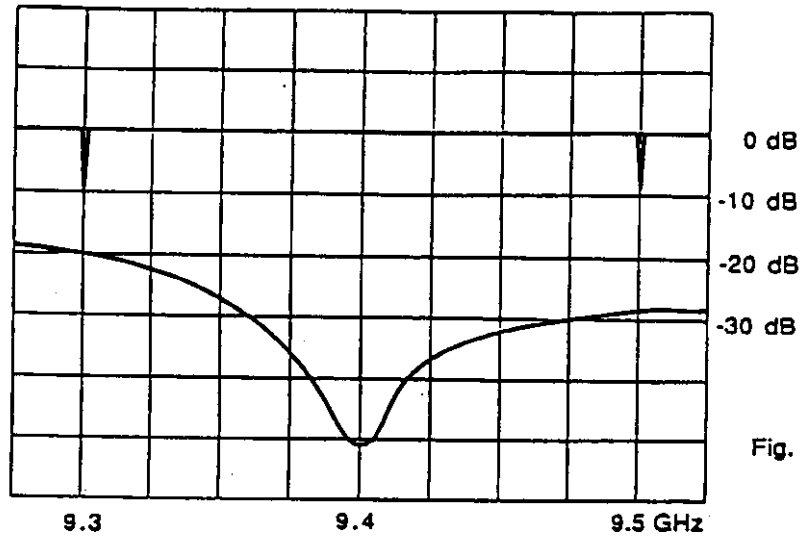
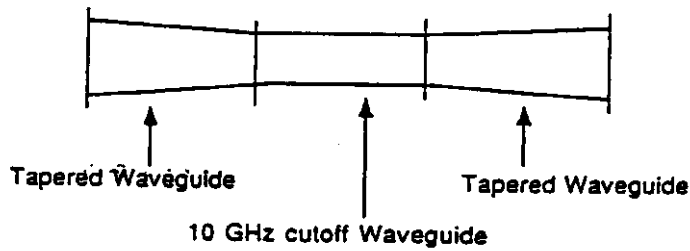


Fig. 6.5

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

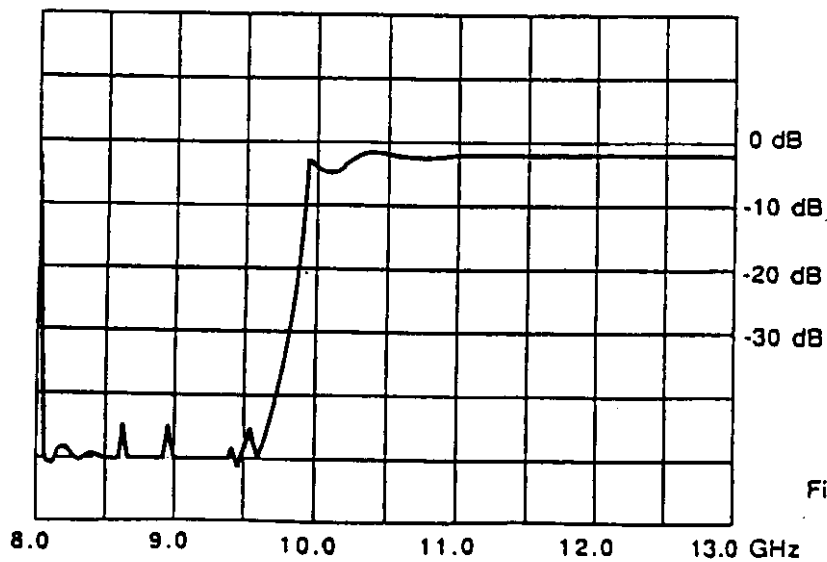


Fig. 6.6

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: Nov., 1998

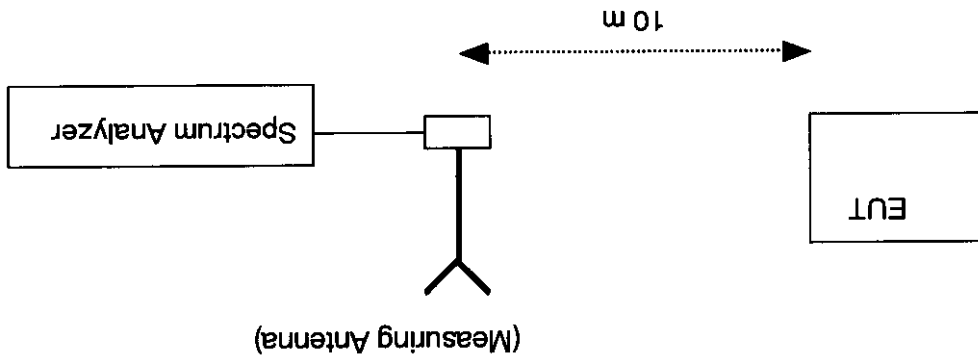
7.3 Distance between the radar set and measuring antenna: 10 m

7.4 Radar Range settings: 0.125 nm (Short)/1.5 nm (Middle)/36 nm (Long)

7.5 Measuring Equipment List:

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

7.6 Test settings:



7.7 Field Strength Limits:

- (a) Frequency Range (FCC Rule § 2.997) : 10 KHZ - 40 GHZ
- (b) Emission Limits (FCC Rule § 80.211) :

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

Frequency removed from the assigned frequency	Frequency (Hz)	Emission attenuation (mean power, dB)
	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.

8 FREQUENCY STABILITY (FCC Rule §2.995)

8.1 Setup for Measurement

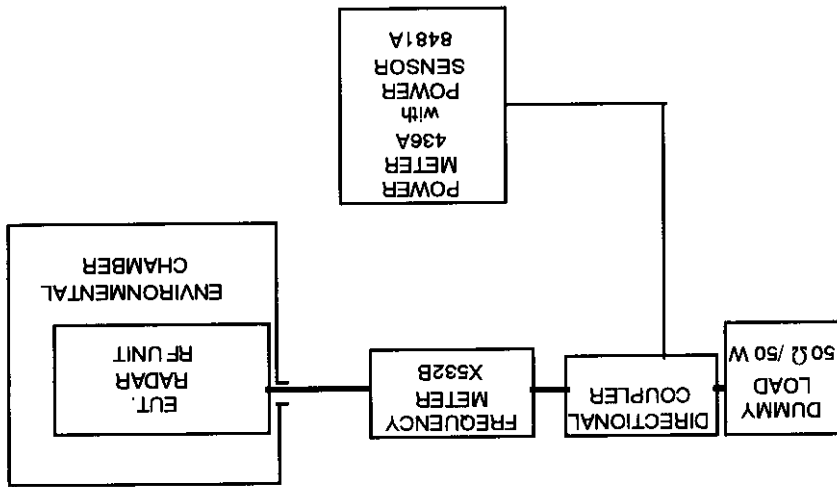


Fig. 8.1

8.2 Test Conditions:

- 1) Radar Range settings : 0.125 nm (Short)/1.5 nm (Middle)/36 nm (Long)
- 2) Ambient Temperature settings: - 20 to +50 °C (10 °C step)
- 3) Power Supply Voltage settings: 85 /115 % of nominal voltage (20.4 to 27.6 VDC)

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", $f(UAUBW) = f_0 + f(AUBW)/2 = 9465$ MHz

"Lower limit frequency of the authorized band", $f(LAUBW) = f_0 - f(AUBW)/2 = 9365$ MHz

3) Assignable 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	Middle	Long
Range Scale (nm)	0.125	1.5	36
Pulselength (μ sec)	0.08	0.30	0.80
Guard Band $f(1.5/T)$ (MHz)	18.75	5.00	1.88

8.5 Test Results:

Shown on Fig. 8.2.

(1) "Upper Tolerance Frequency measured (at -20 °C)", $f(U) = 9414.0$ MHz

(2) "Lower Tolerance Frequency measured (at $+50$ °C)", $f(L) = 9408.5$ MHz

(3)-(a)

$f(U) + \max. f(1.5/T) = 9432.75$ MHz $< f(UAUBW) = 9460$ MHz $\leq f(UASB) = 9500$ MHz

(3) - (b)

$f(L) - \max. f(1.5/T) = 9389.75$ MHz $> f(LAUBW) = 9360$ MHz $\geq f(LASB) = 9300$ 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 (20.4 to 27.6 VDC for nominal 24 VDC).

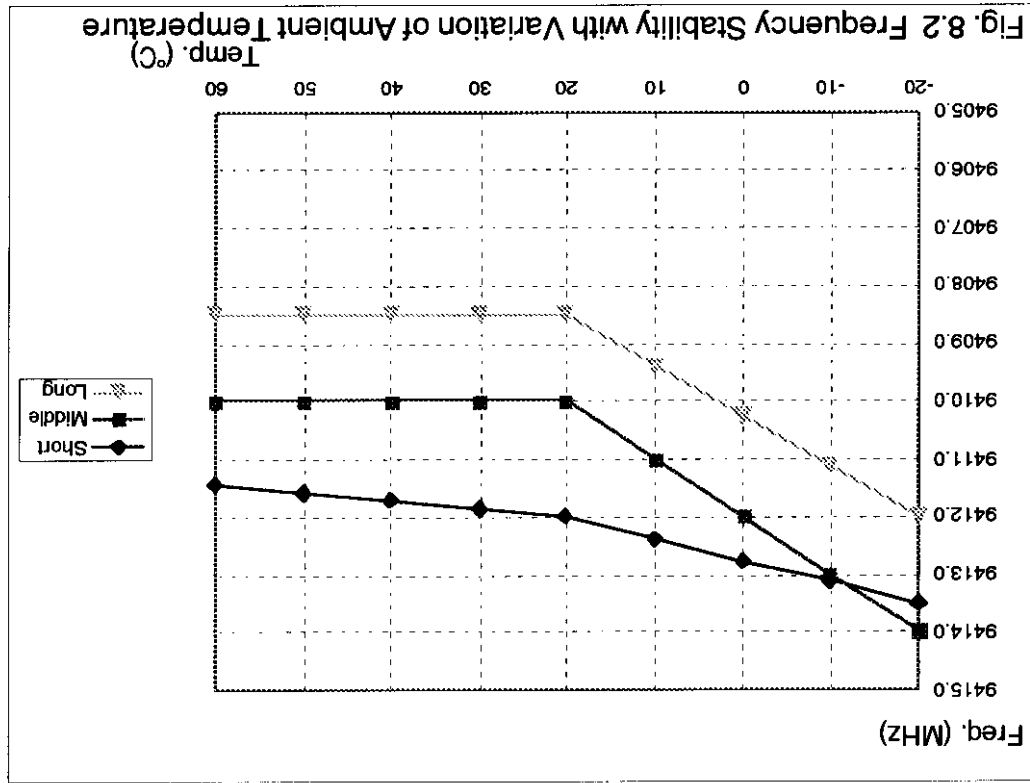


Fig. 8.2 Frequency Stability with Variation of Ambient Temperature

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 Instrument List:

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

(Instruments for measuring antenna characteristics are listed below.)

- (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 dBµV/m)
for 30 to 100 MHz, 0.3 µV/m at 1 nm (-10.5 dBµV/m)
for 100 to 300 MHz, 1.0 µV/m at 1 nm (0 dBµV/m)
for over 300 MHz, 3.0 µV/m at 1 nm (9.5 dBµV/m)

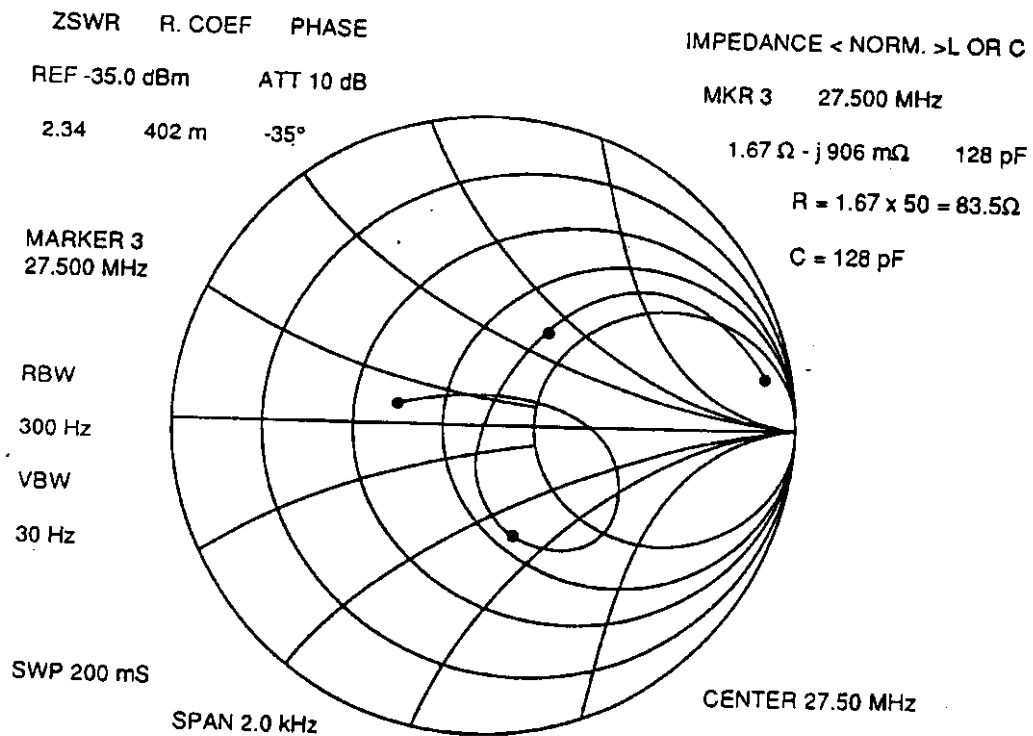
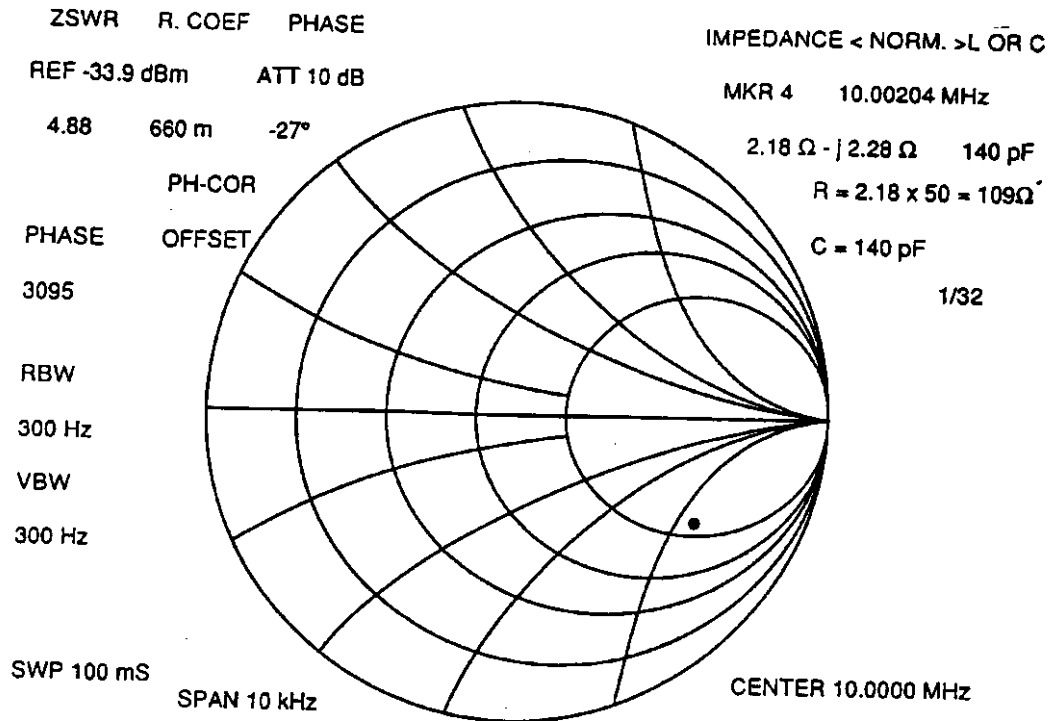
Results: Interference was measured with the antenna located 2 m from the radar and converted to levels at 1 nm. There is no spurious component exceeding the limits. (Test data are shown in ATTACHMENT 3)

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

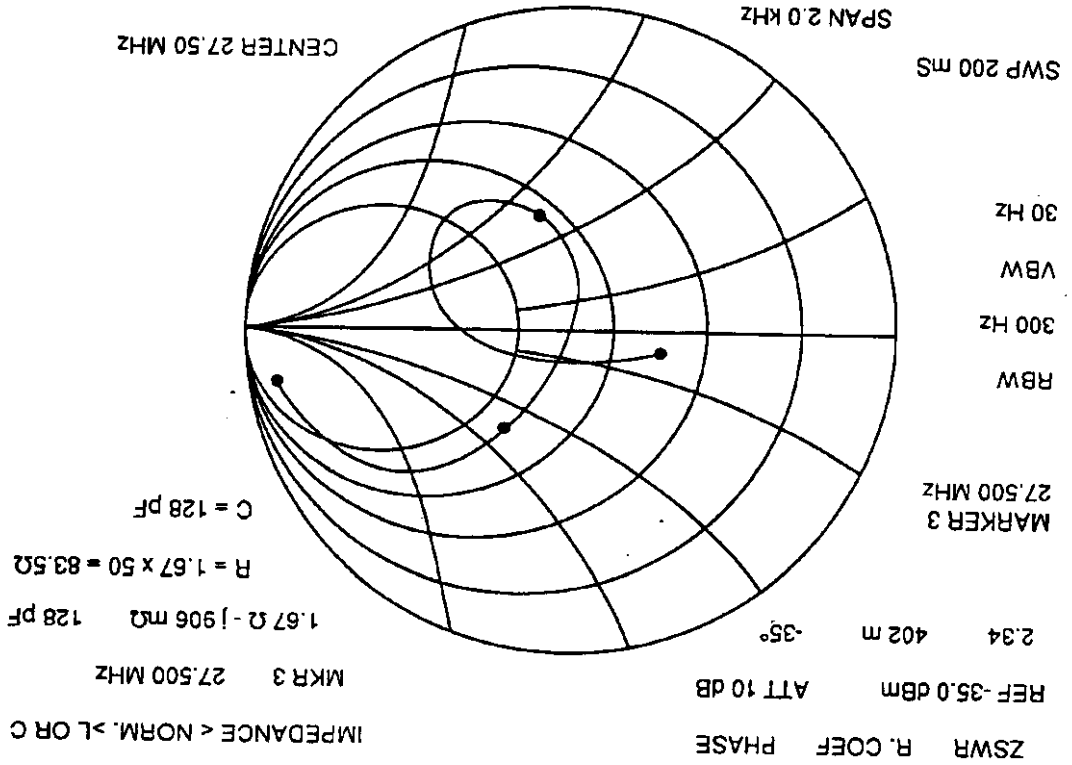
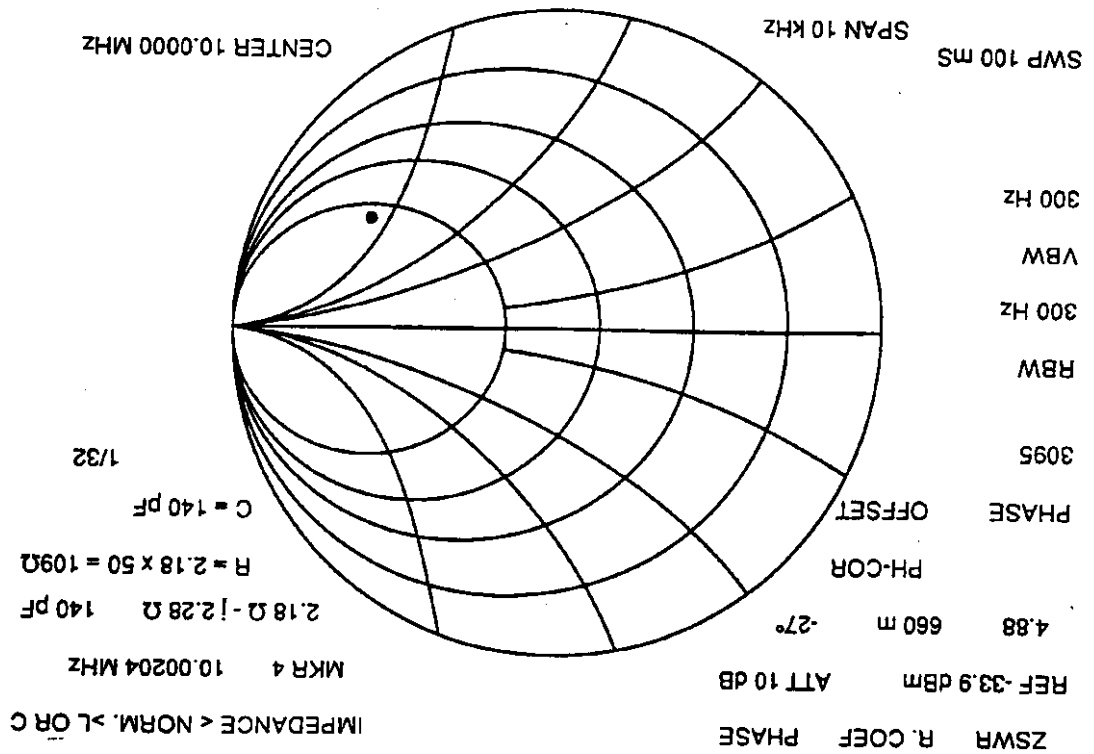
Limits: for below 30 MHz, 400 µW
for 30 to 100 MHz, 4,000 µW
for 100 to 300 MHz, 40,000 µW
for over 300 MHz, 400,000 µW

Results: There is no spurious component exceeding the limits. (Test data are shown in ATTACHMENT 3)

MEASUREMENT OF IMPEDANCE OF TEST ANTENNAS



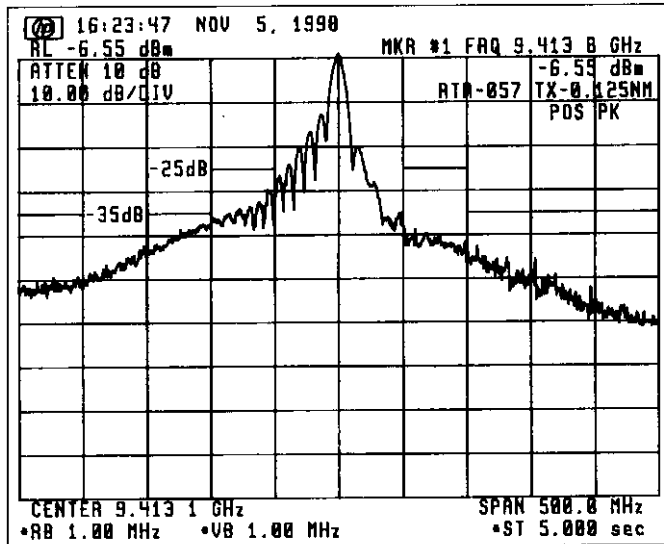
MEASUREMENT OF IMPEDANCE OF TEST ANTENNAS



ATTACHMENT 1

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

1. Spurious emissions for 0.125 nm Range:

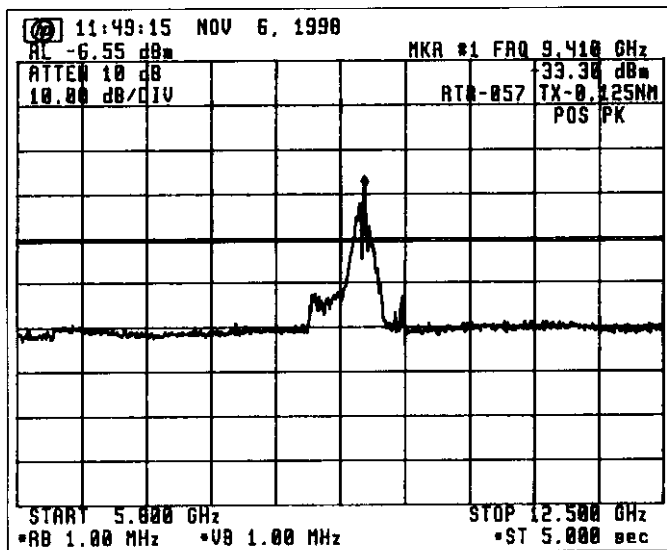


Ref. level: -6.55 dBm

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)

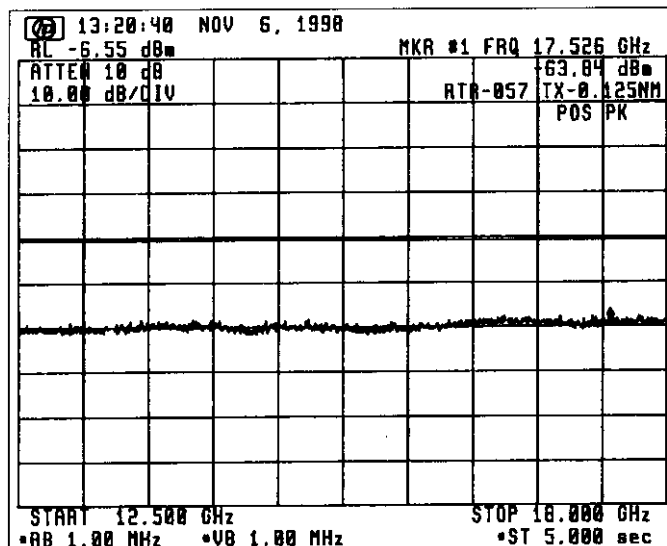
Fig. 1.1 Without Filter



Emission limitations:

- (c) $43 + 10 \log P_m = 40.31 \text{ dB}$ for more than 250 % of the authorized BW (100 MHz)

Fig. 1.2 With Filter No.1



Emission limitations:

- (c) $43 + 10 \log P_m = 40.31 \text{ dB}$ for more than 250 % of the authorized BW (100 MHz)

Fig. 1.3 With Filter No. 2

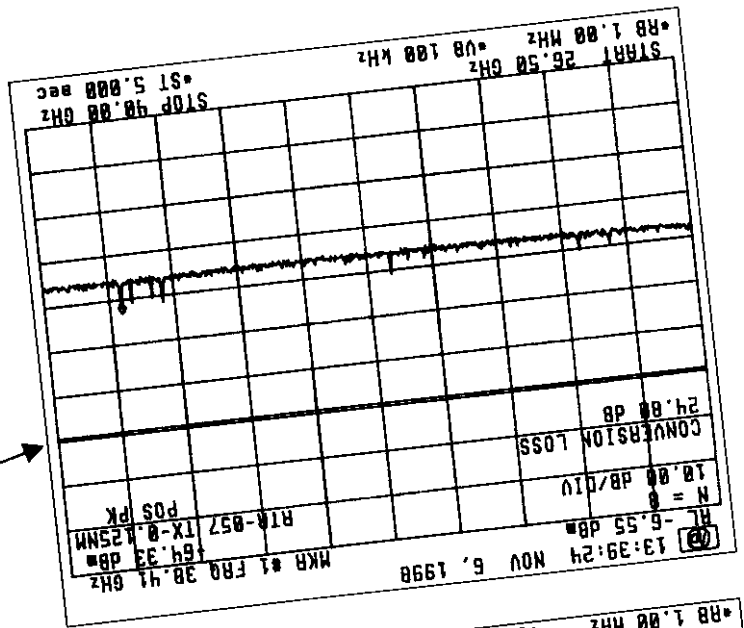


Fig. 1.5 With Filter No. 2

(c) Emission limitations:
 $43 + 10 \log P_m = 40.31 \text{ dB}$
 for more than 250% of
 the authorized BW (100 MHz)

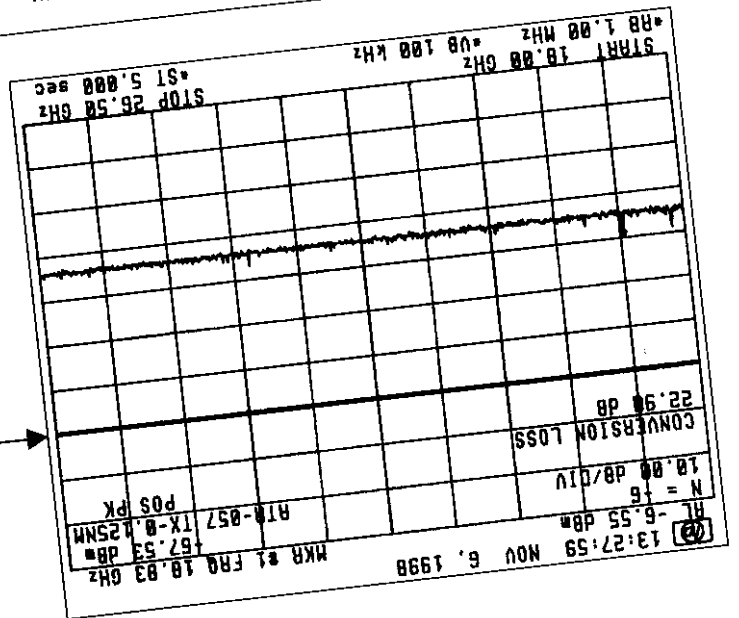
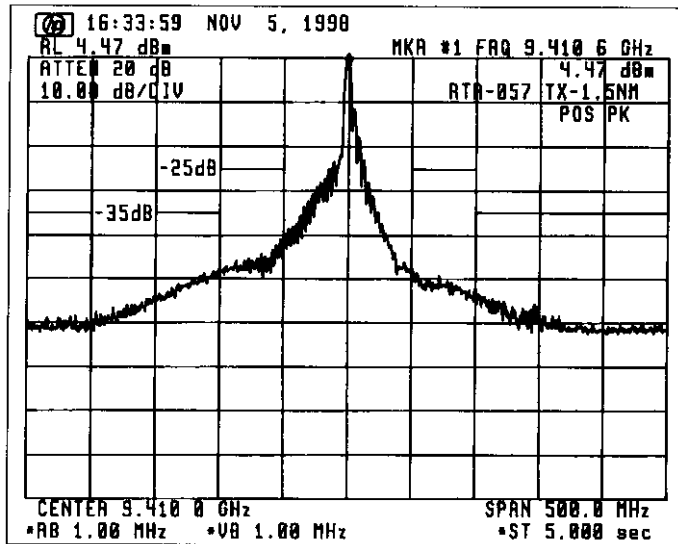


Fig. 1.4 With Filter No. 2

(c) Emission limitations:
 $43 + 10 \log P_m = 40.31 \text{ dB}$
 for more than 250% of
 the authorized BW (100 MHz)

2. Spurious emissions for 1.5 nm Range:

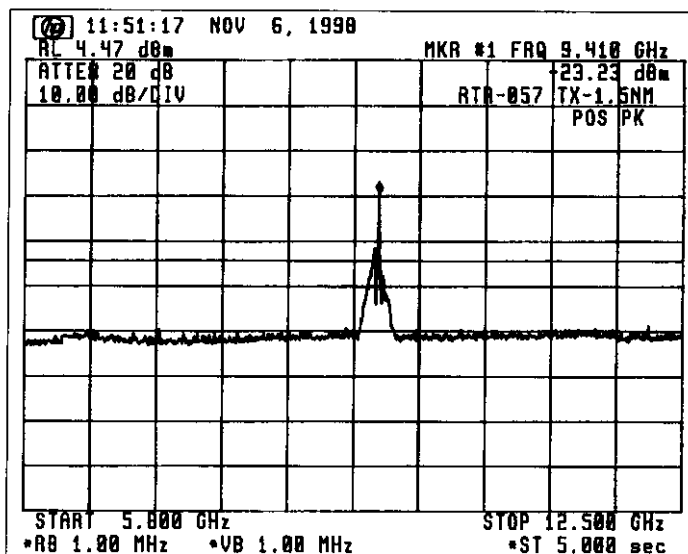


Ref. level: 4.47 dBm

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)

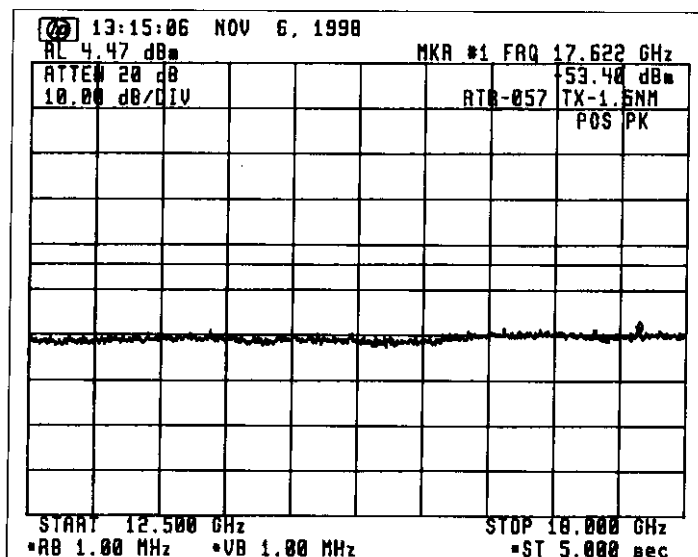
Fig. 2.1 Without Filter



Emission limitations:

- (c) $43 + 10 \log P_m = 44.02 \text{ dB}$ for more than 250 % of the authorized BW (100 MHz)

Fig. 2.2 With Filter No.1



Emission limitations:

- (c) $43 + 10 \log P_m = 44.02 \text{ dB}$ for more than 250 % of the authorized BW (100 MHz)

Fig. 2.3 With Filter No. 2

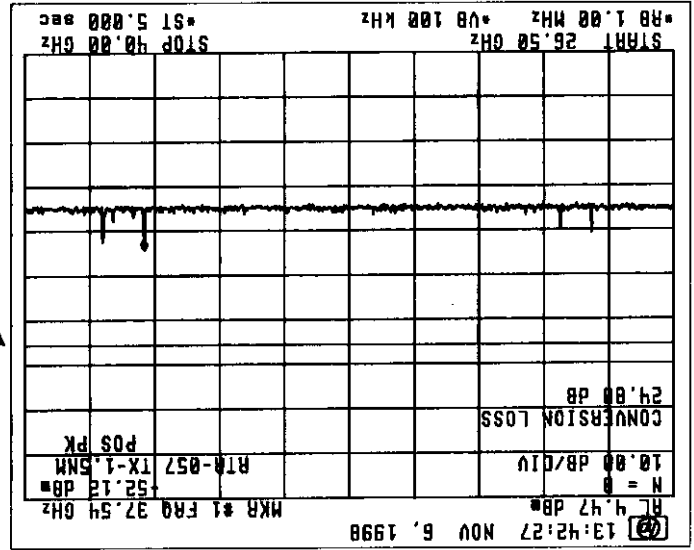


Fig. 2.5 With Filter No. 2

(c) Emission limitations:
 $43 + 10 \log P_m = 44.02 \text{ dB}$
 for more than 250 % of
 the authorized BW (100 MHz)

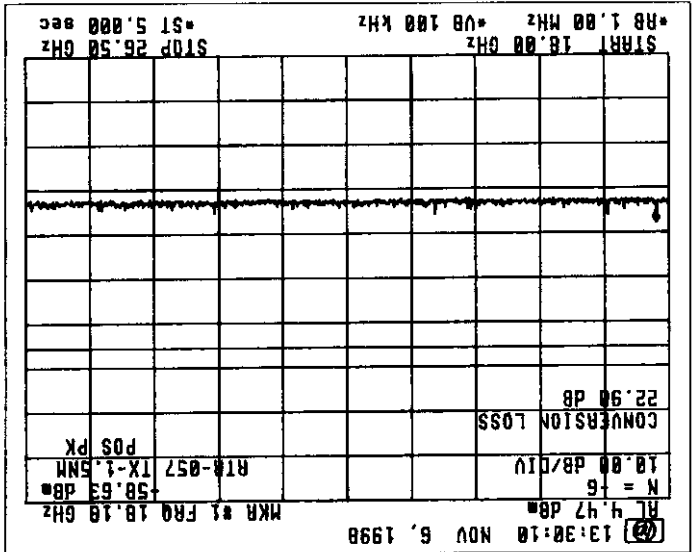
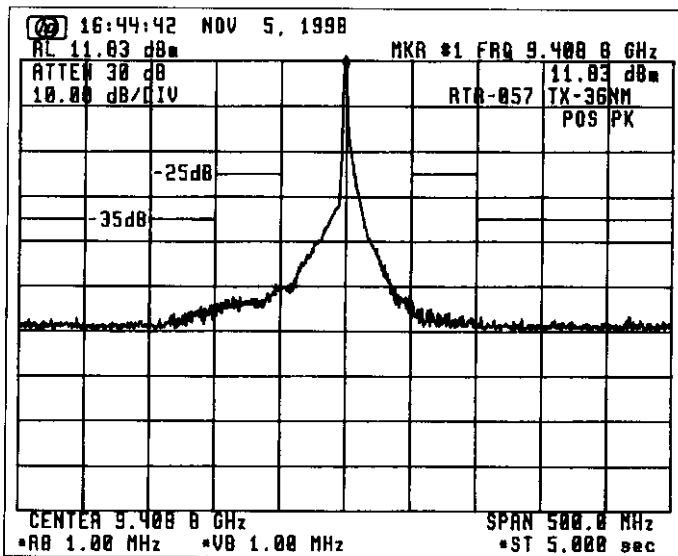


Fig. 2.4 With Filter No. 2

(c) Emission limitations:
 $43 + 10 \log P_m = 44.02 \text{ dB}$
 for more than 250 % of
 the authorized BW (100 MHz)

3. Spurious emissions for 36 nm Range:

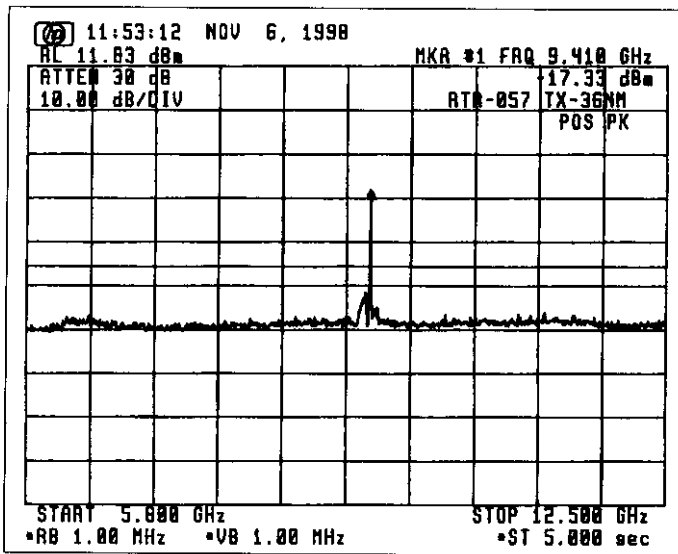


Ref. level: 11.83 dBm

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)

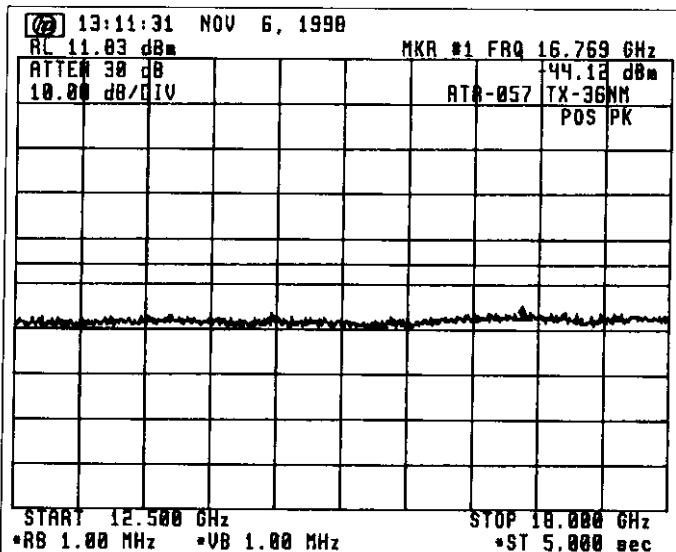
Fig. 3.1 Without Filter



Emission limitations:

- (c) $43 + 10 \log P_m = 45.21 \text{ dB}$ for more than 250 % of the authorized BW (100 MHz)

Fig. 3.2 With Filter No.1



Emission limitations:

- (c) $43 + 10 \log P_m = 45.21 \text{ dB}$ for more than 250 % of the authorized BW (100 MHz)

Fig. 3.3 With Filter No. 2

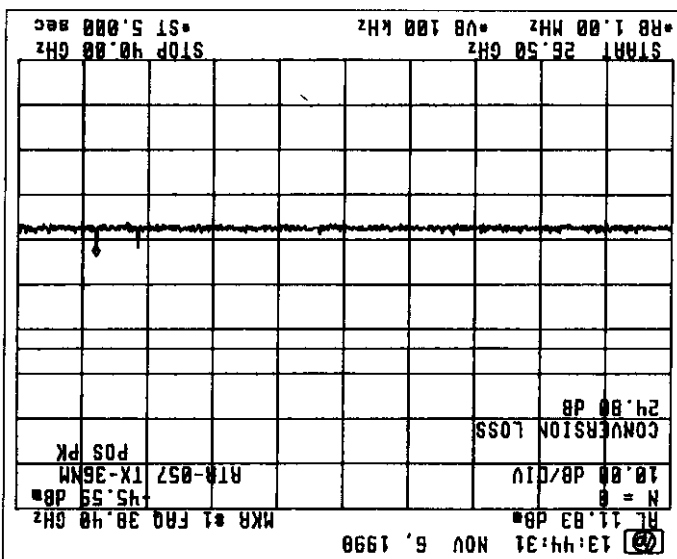


Fig. 3.5 With Filter No. 2

(c) Emission limitations:
 $43 + 10 \log P_m = 45.21 \text{ dB}$
 for more than 250 % of
 the authorized BW (100 MHz)

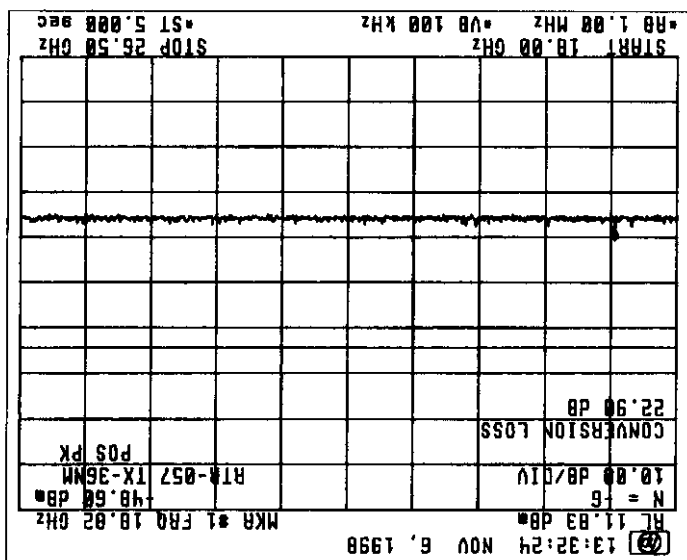
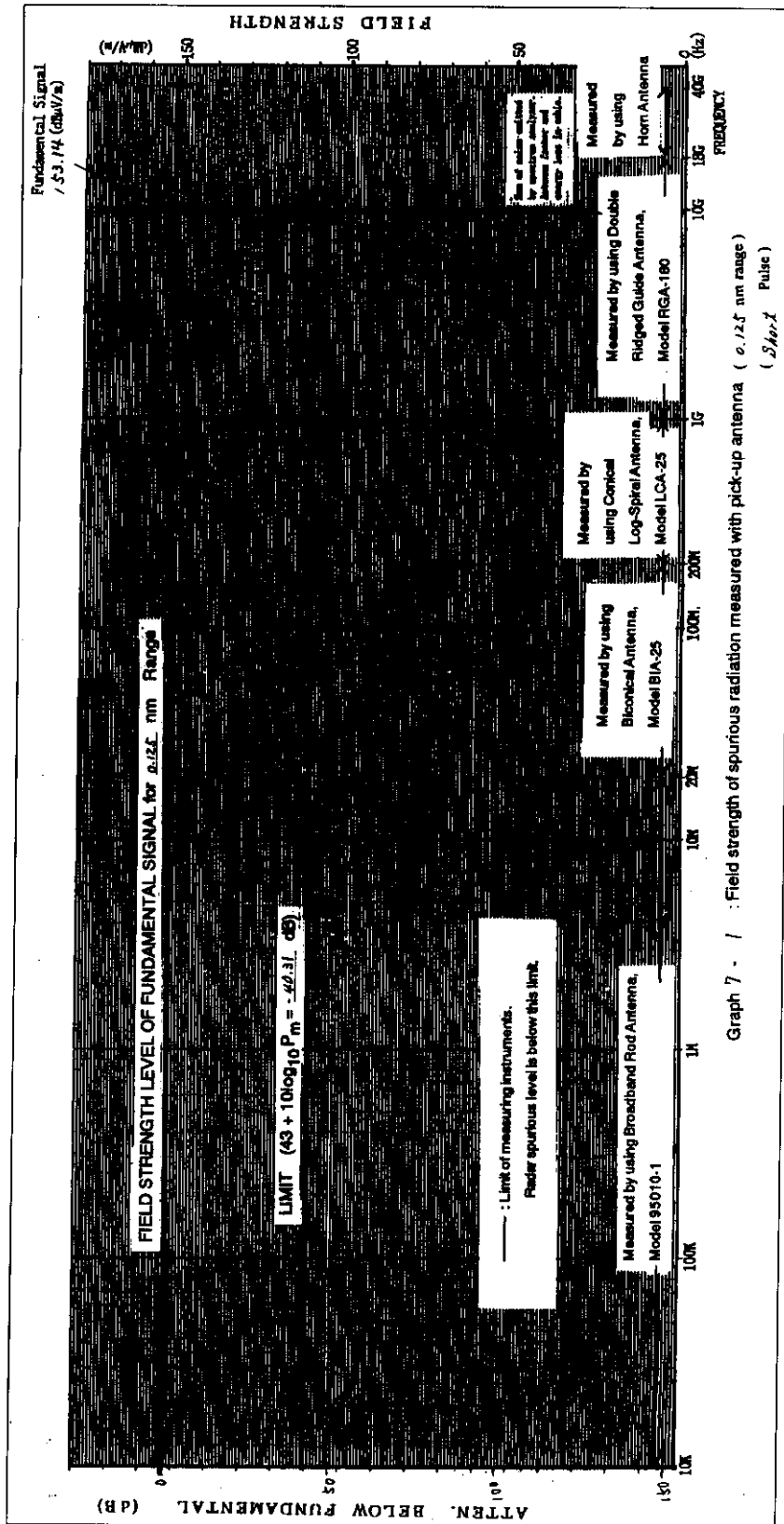
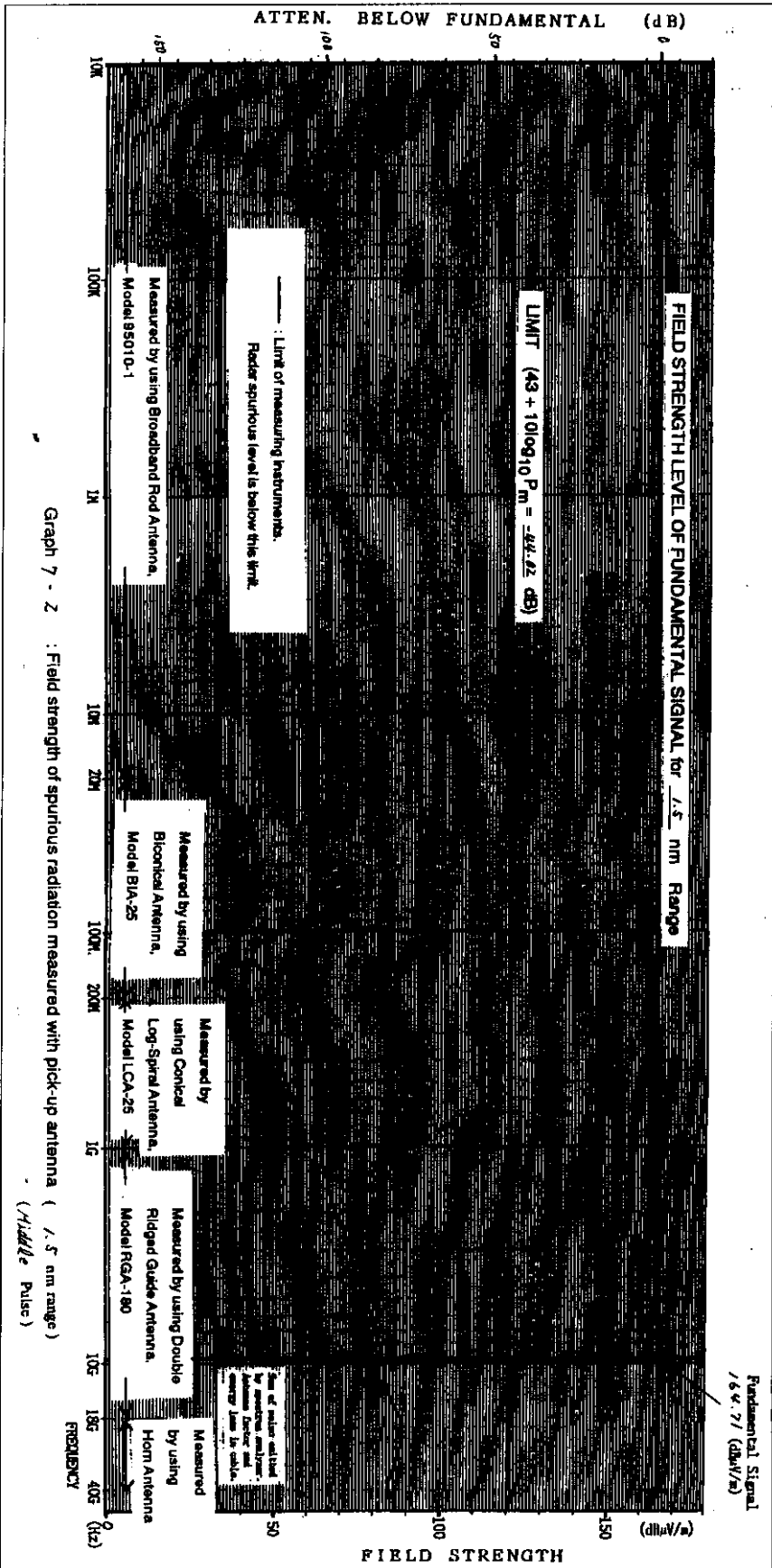


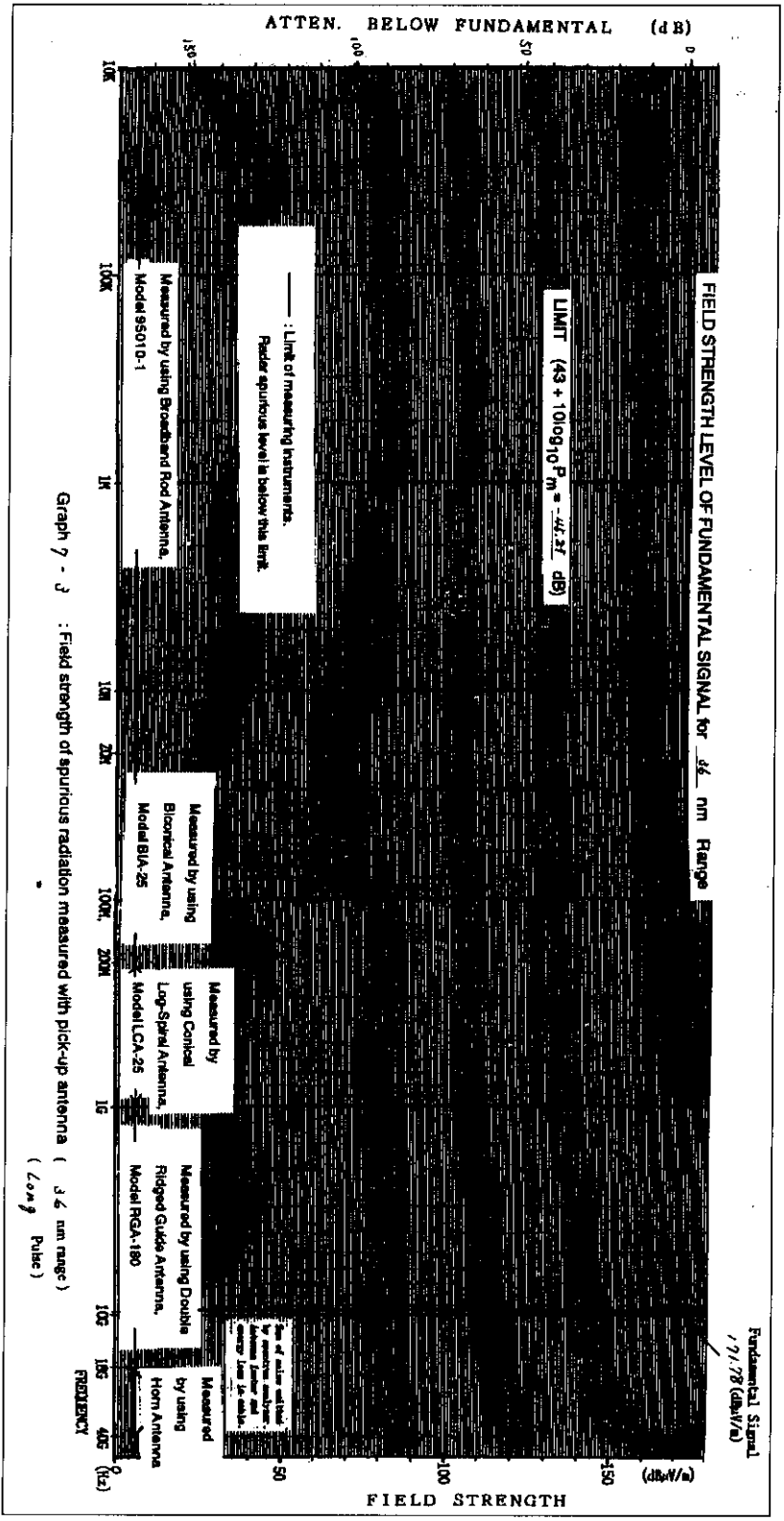
Fig. 3.4 With Filter No. 2

(c) Emission limitations:
 $43 + 10 \log P_m = 45.21 \text{ dB}$
 for more than 250 % of
 the authorized BW (100 MHz)

ATTACHMENT 2 [TEST DATA FOR 7. FIELD STRENGTH OF SPURIOUS RADIATION]





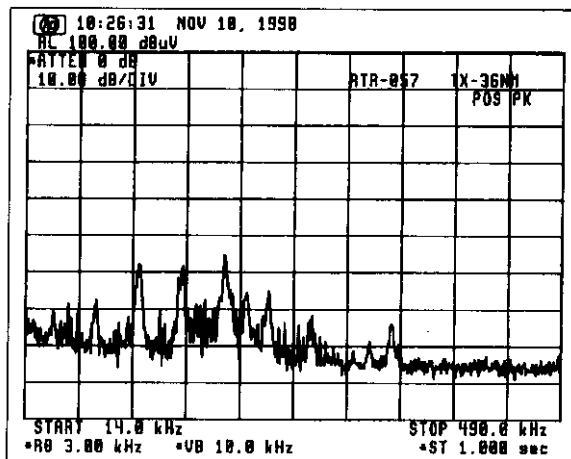
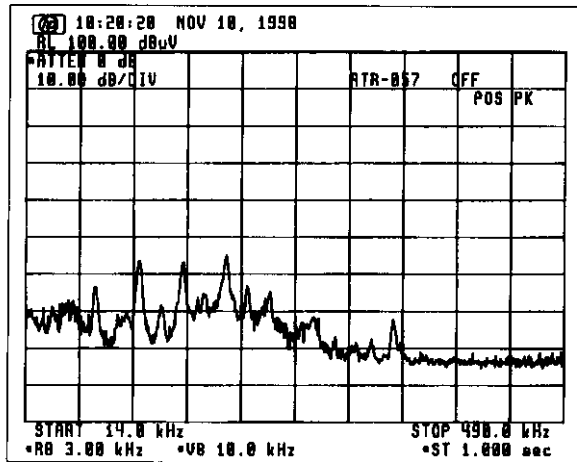


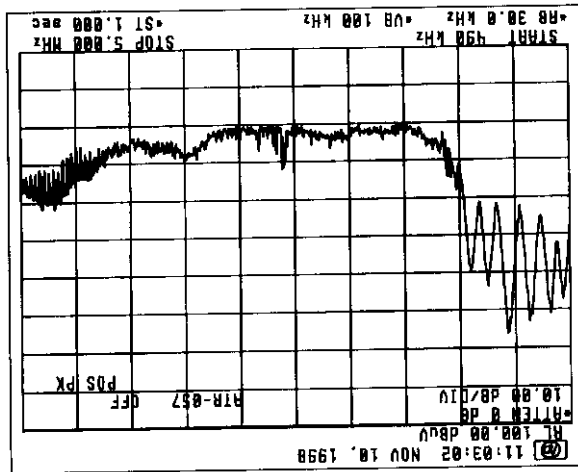
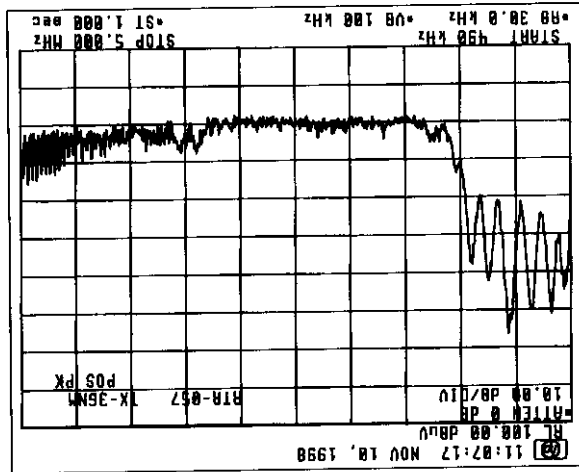
ATTACHMENT 3

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

1. Harmful Interference to Receiver

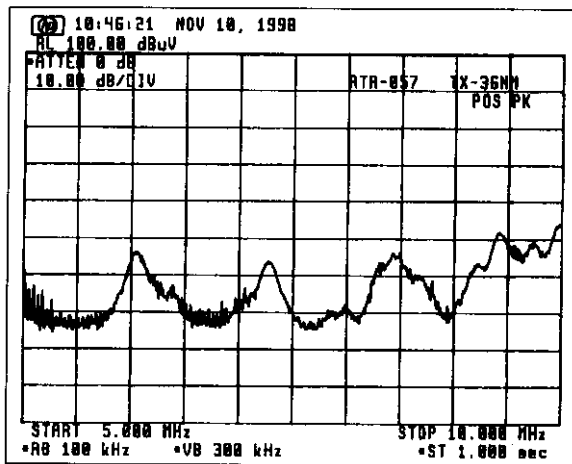
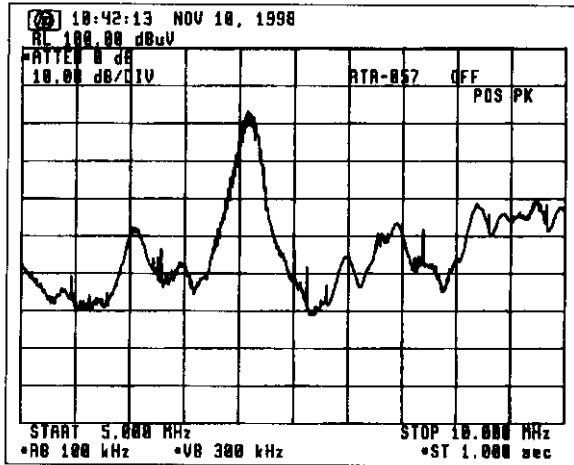
(Band : 14 kHz - 490 kHz)

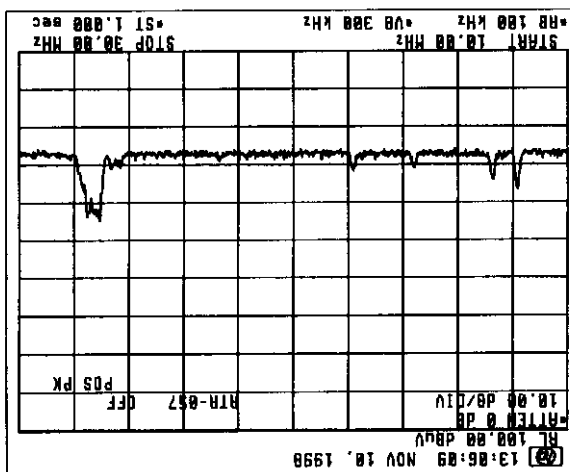
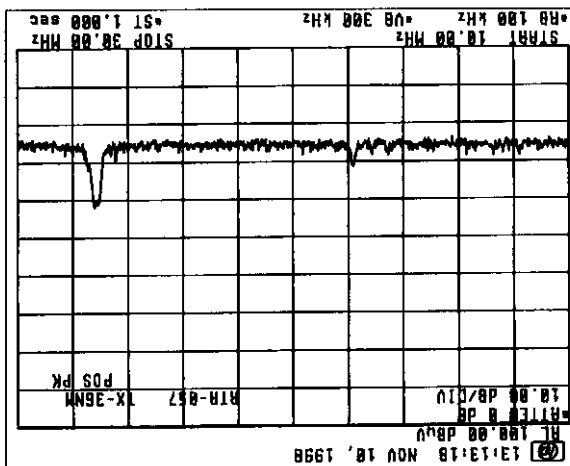




(Band : 490 KHZ - 5 MHz)

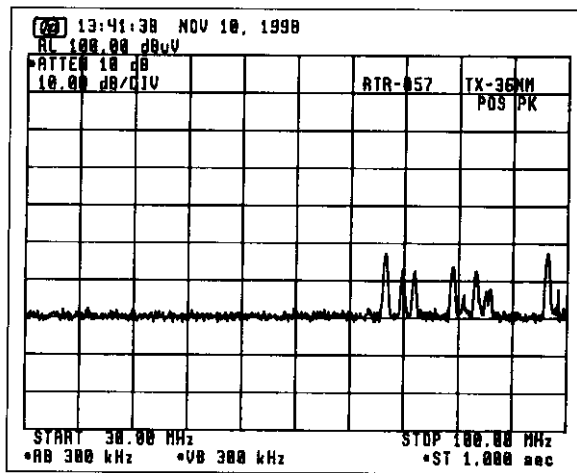
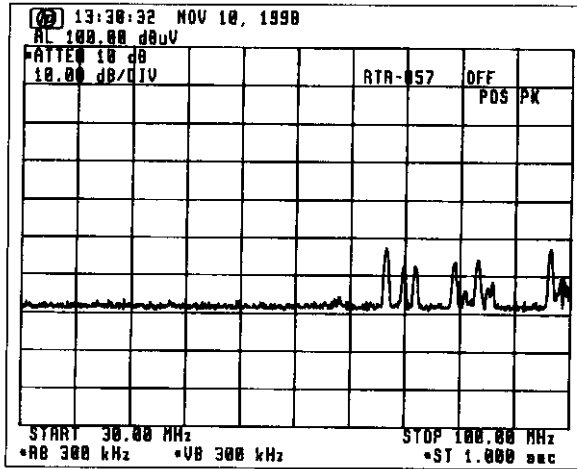
(Band : 5 MHz - 10 MHz)

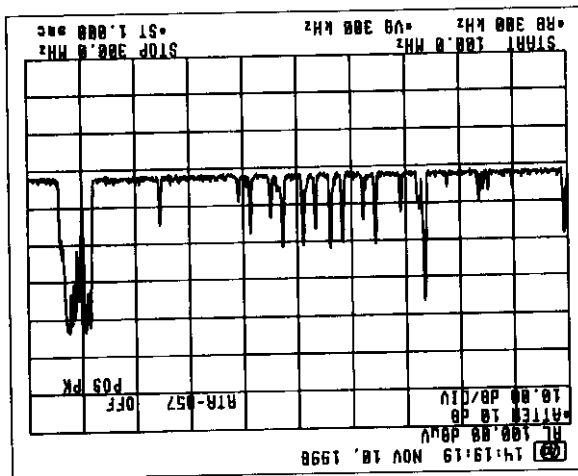
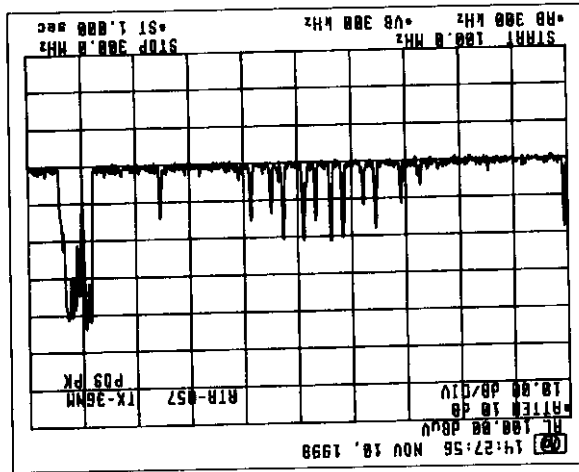




(Band : 10 MHz - 30 MHz)

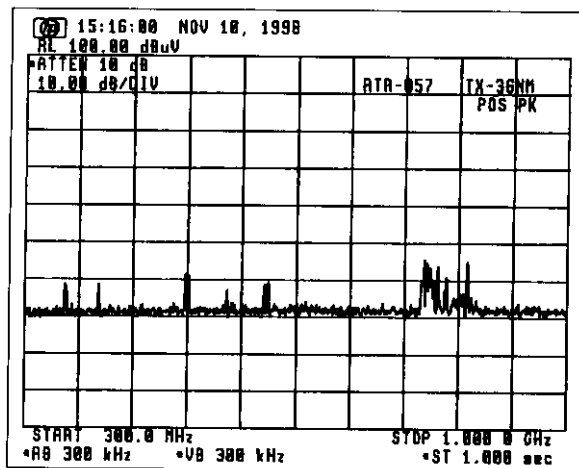
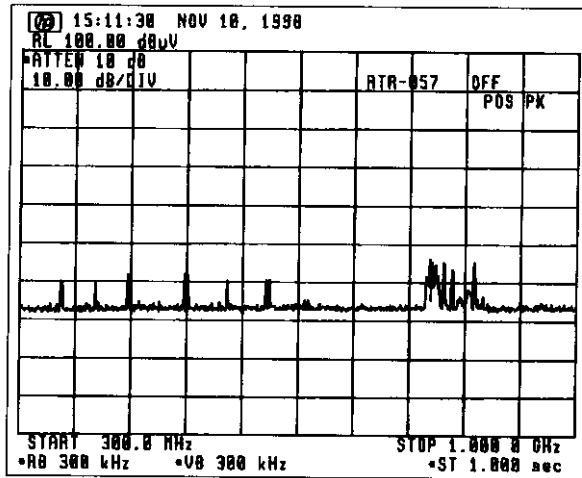
(Band : 30 MHz - 100 MHz)





(Band : 100 MHz - 300 MHz)

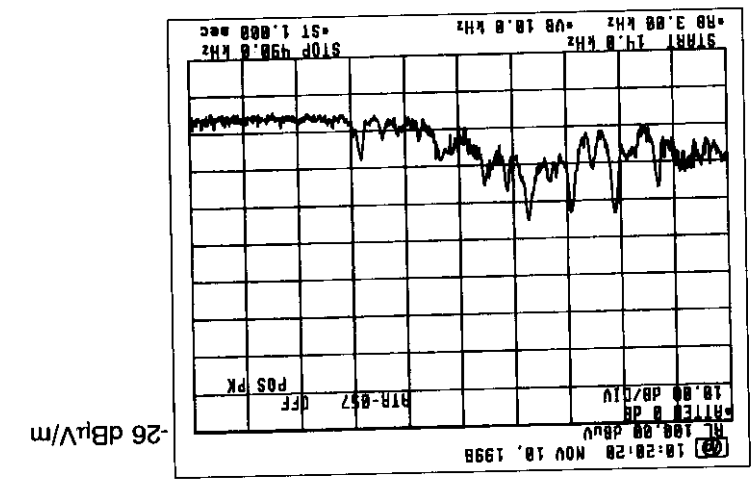
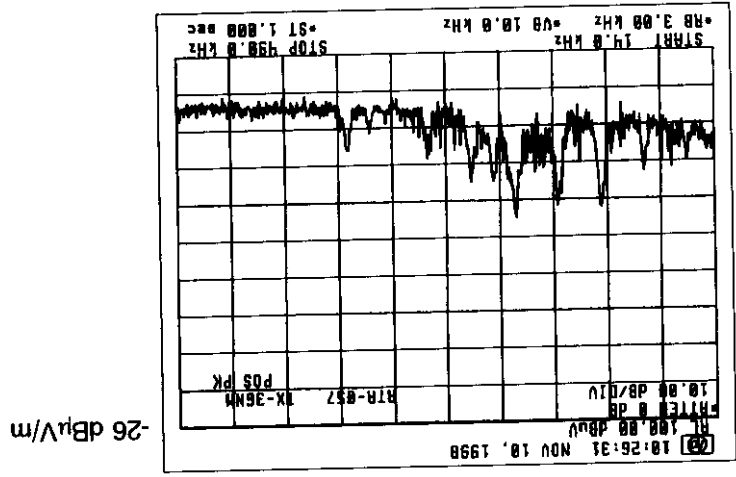
(Band : 300 MHz - 1 GHz)



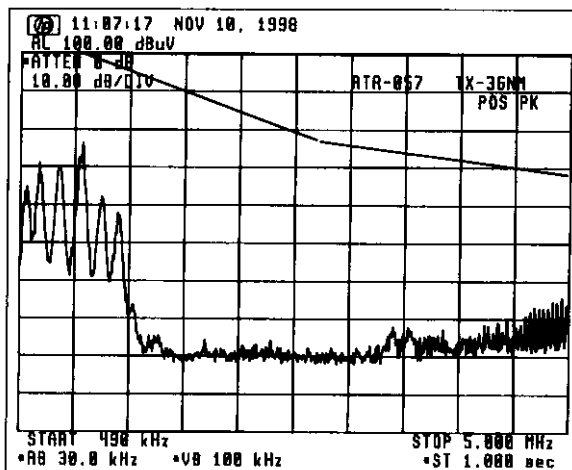
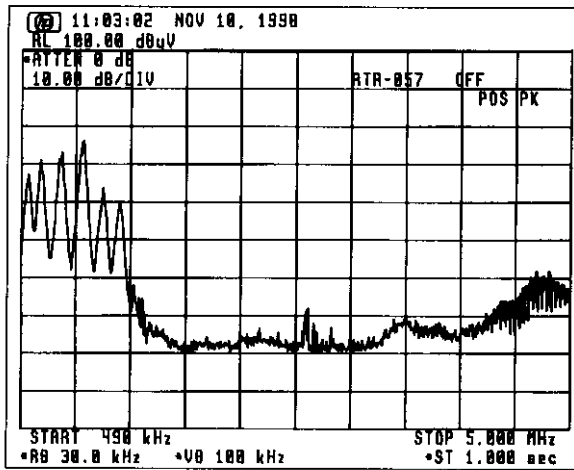
2. Electromagnetic Field

(Band : 14 KHz - 490 KHz, Limit at 1 nm = 0.1 μ V/m = -20 dB μ V/m)

LABOTECH



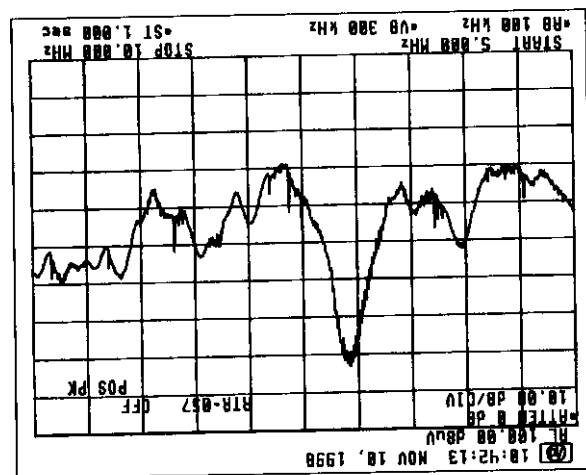
(Band : 490 kHz - 5 MHz, Limit at 1 nm = 0.1 $\mu\text{V}/\text{m}$ = -20 dB $\mu\text{V}/\text{m}$)



Ref. level (dB $\mu\text{V}/\text{m}$)
 = 126 - 100 = 26 (at 0.5 MHz)
 = 100 - 96 = 4 (at 3 MHz)
 = 100 - 88 = 12 (at 5 MHz)

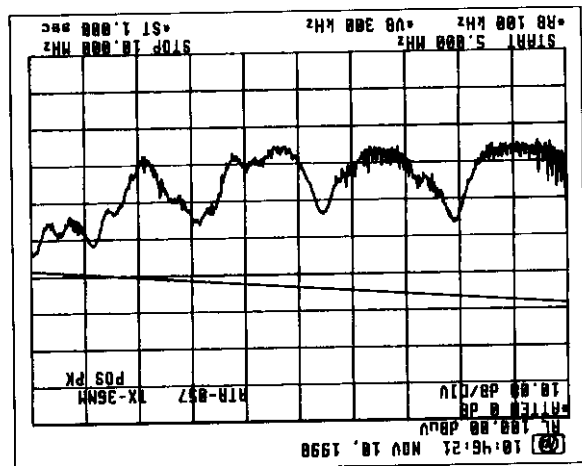
-20 dBmV/m limit line

Band : 5 MHz - 10 MHz, Limit at 1 nm = 0.1 μ V/m = -20 dB μ V/m)

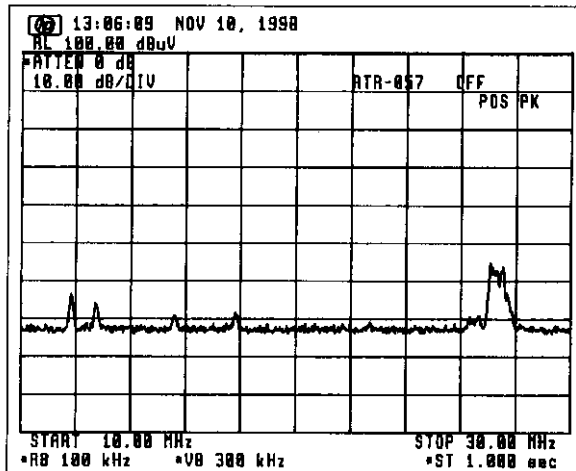


Ref. level (dB μ V/m)
 = 100 - 88 = 12 (at 5 MHz)
 = 100 - 83 = 17 (at 7 MHz)
 = 100 - 78 = 22 (at 10 MHz)

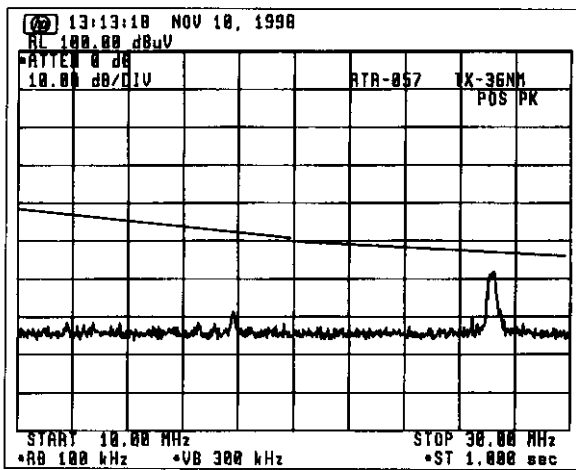
-20 dBmV/m limit line



(Band : 10 MHz - 30 MHz, Limit at 1 nm = 0.1 $\mu\text{V}/\text{m}$ = -20 dB $\mu\text{V}/\text{m}$)



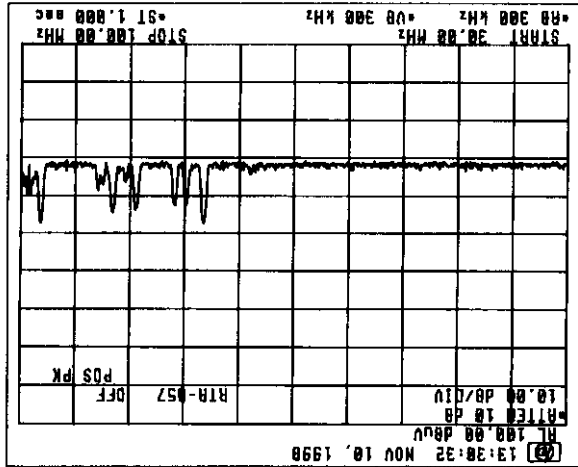
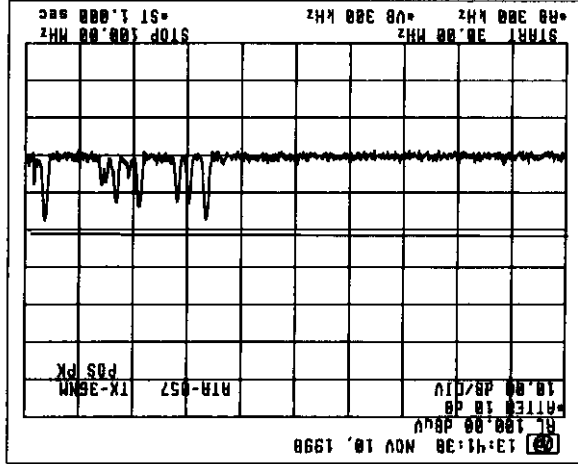
Ref. level (dB $\mu\text{V}/\text{m}$)
 = 100 - 78 = 22 (at 10 MHz)
 = 100 - 70 = 30 (at 20 MHz)
 = 100 - 67 = 33 (at 30 MHz)



-20 dBmV/m limit line

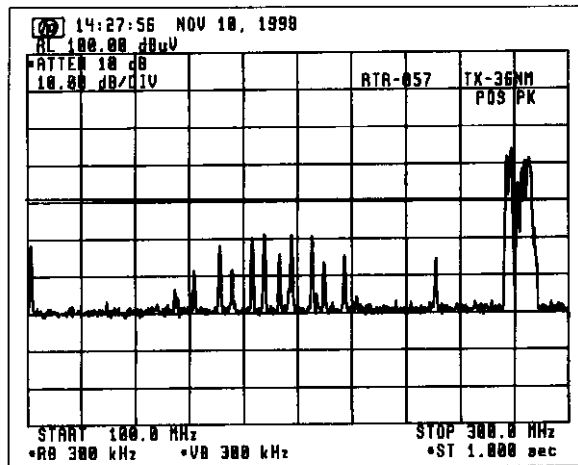
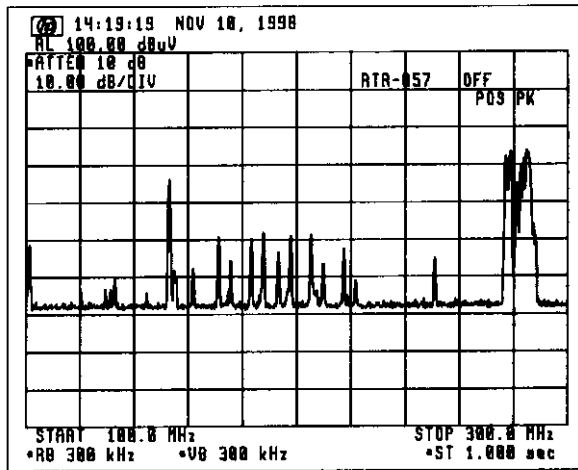
- 10.5 dBmV/m limit line

Ref. level (dBμV/m) = 100 - 61 = 39



(Band : 30 MHz - 100 MHz, Limit at 1 nm = 0.1 μV/m = -10.5 dBμV/m)

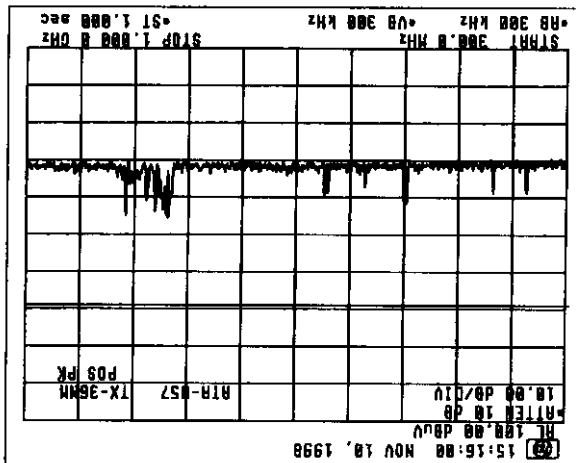
(Band : 100 MHz - 300 MHz, Limit at 1 nm = 0.1 $\mu\text{V}/\text{m}$ = -0 dB $\mu\text{V}/\text{m}$)



Ref. level (dB $\mu\text{V}/\text{m}$)
= 100 - 60 = 40

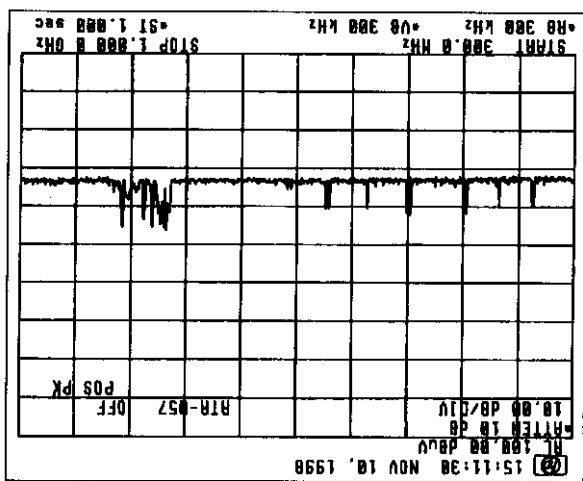
0 dB $\mu\text{V}/\text{m}$ limit line

All components above the limit
are from external noise or
signals, not from RADAR.



9.5 dBµV/m limit line

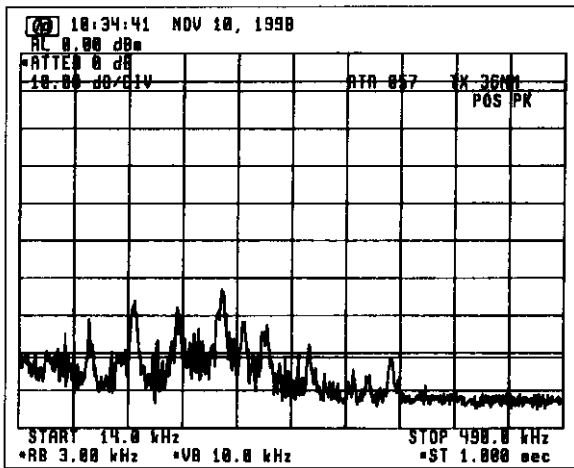
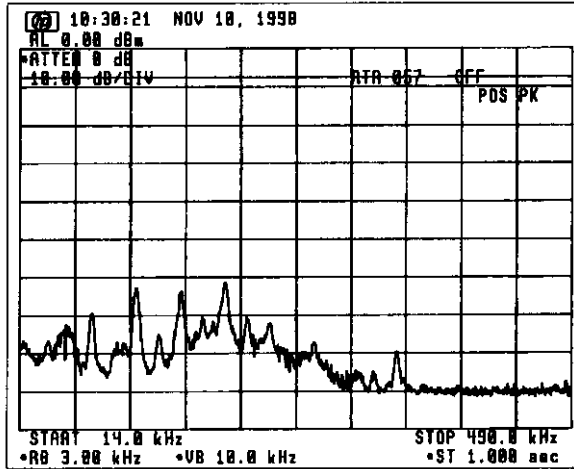
Ref. level (dBµV/m) = 100 - 59.5 = 40.5



(Band : 300 MHz - 1 GHz, Limit at 1 nm = 3 µV/m = -9.5 dBµV/m)

3. Power Input to an Artificial Antenna

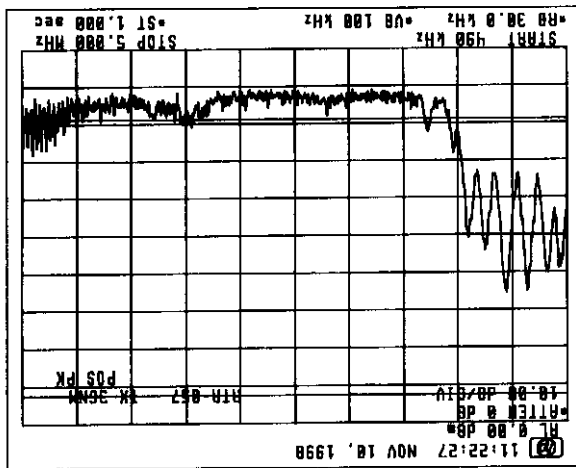
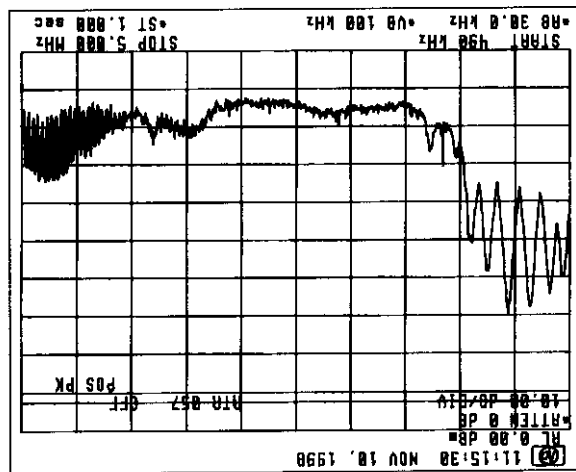
(Band : 14 kHz - 490 kHz, Limit at 2 m = -81 dBm)



-81 dBm limit line

All components above the limit
are from external noise or
signals, not from RADAR.

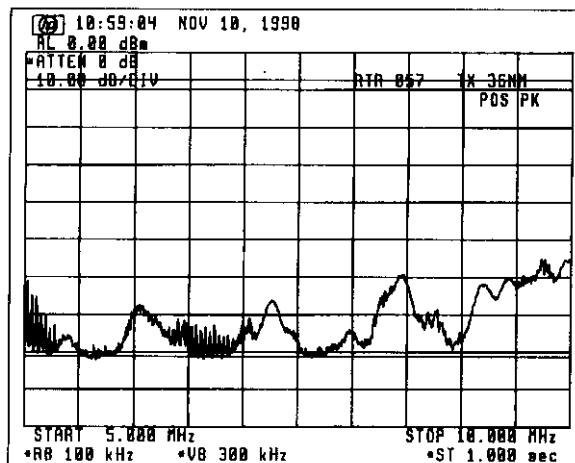
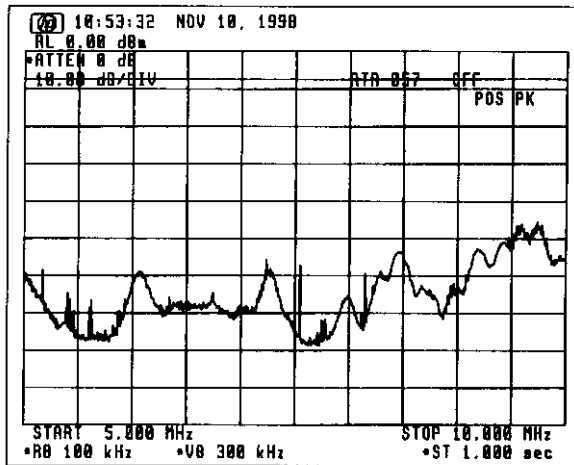
(Band : 490 KHz - 5 MHz, Limit at 2 m = -81 dBm)



-81 dBm limit line

All components above the limit are from external noise or signals, not from RADAR.

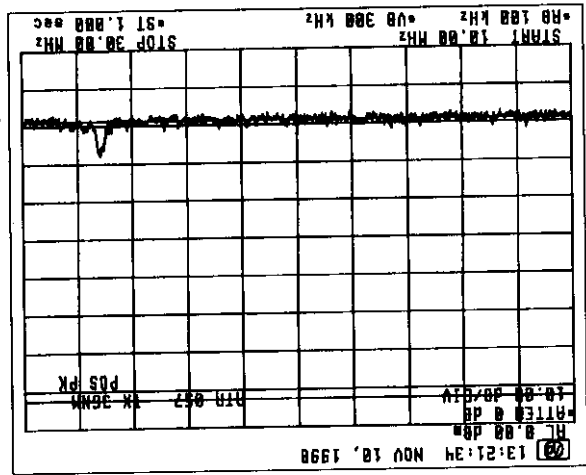
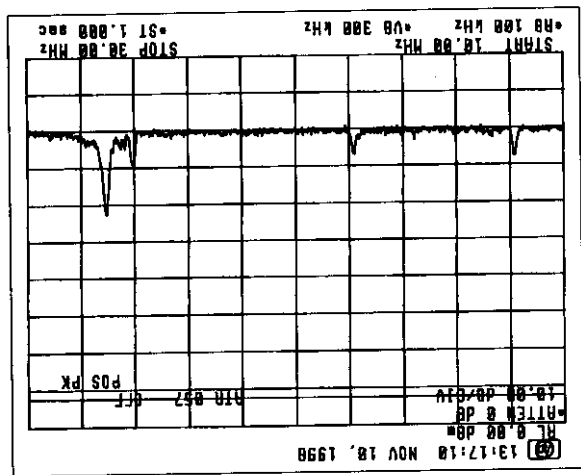
(Band : 5 MHz - 10 MHz, Limit at 2 m = -81 dBm)



-81 dBm limit line

All components above the limit
are from external noise or
signals, not from RADAR.

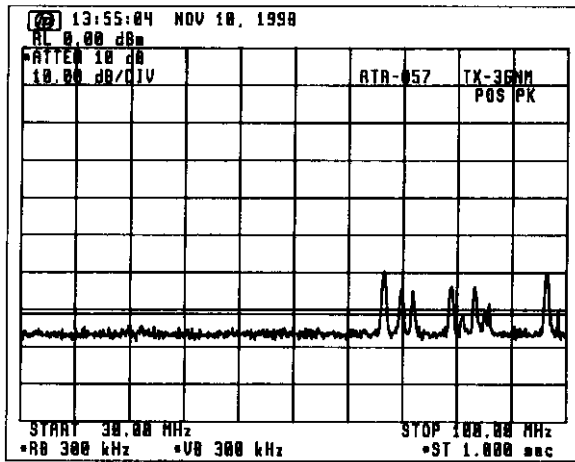
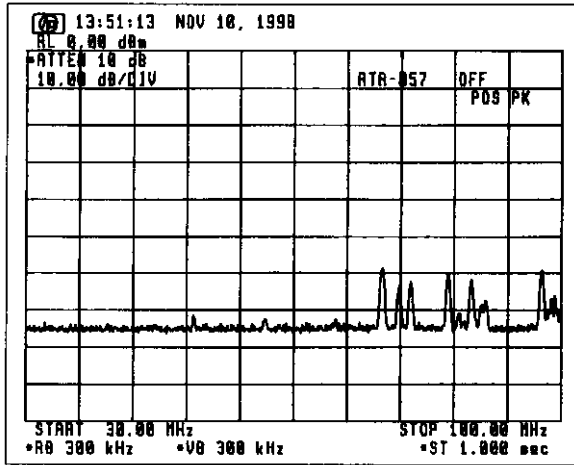
(Band : 10 MHz - 30 MHz, Limit at 2 m = -81 dBm)



-81 dBm limit line

All components above the limit are from external noise or signals, not from RADAR.

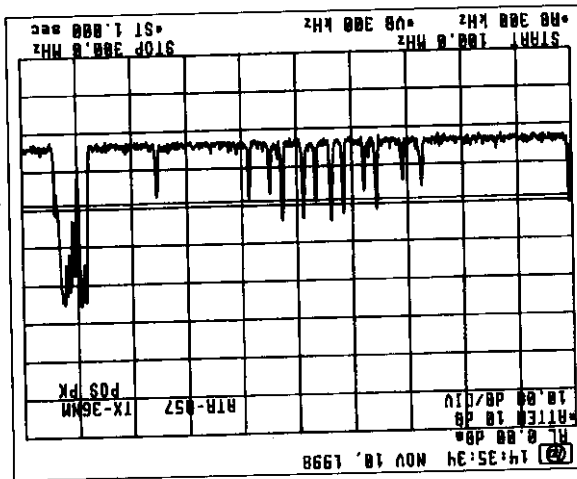
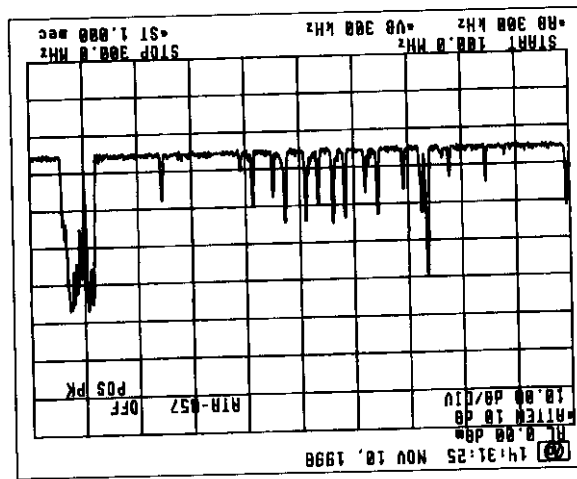
(Band : 30 MHz - 100 MHz, Limit at 2 m = -71 dBm)



-71 dBm limit line

All components above the limit
are from external noise or
signals, not from RADAR.

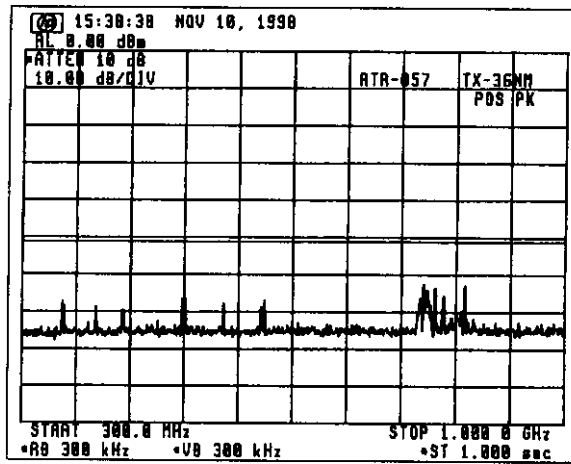
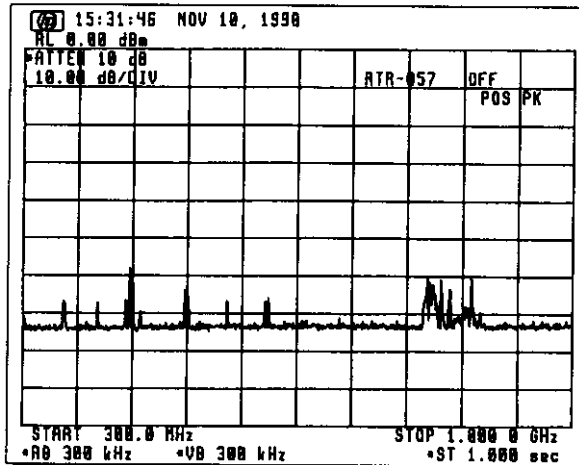
(Band : 100 MHz - 300 MHz, Limit at 2 m = -61 dBm)



-61 dBm limit line

All components above the limit are from external noise or signals, not from RADAR.

(Band : 300 MHz - 1 GHz, Limit at 2 m = -51 dBm)



-51 dBm limit line

ATTACHMENT 4 [List of Test/Measuring Equipment]**3. RF Power Output**

<u>Model</u>	<u>Type</u>	<u>Serial no.</u>	<u>Mfr.</u>
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	8481A	2349A39603	HP
Frequency Counter	TR5824A	41940036	Advantest
Frequency Meter	X532B	1441A00523	HP
Crystal Detector	423B	1822A24214	HP
Step Attenuator	8494B	1510A07310	HP
Step Attenuator	8495B	1350A04754	HP
Dummy Load	----	8411057	Shimada

4. Modulation Characteristics

<u>Model</u>	<u>Type</u>	<u>Serial no.</u>	<u>Mfr.</u>
Oscilloscope	TDS680B	B030202	Tektronix
Step Attenuator	8494B	1510A07310	HP
Step Attenuator	8495B	1350A04754	HP
Crystal Detector	423B	1822A24214	HP
Directional Coupler	5D364S	R94471	Shimada
Dummy Load	-----	8411057	Shimada
Voltage Divider	P6015	----	Tektronix
Spectrum Analyzer	71210C	2927A02847	HP

6. Spurious Emissions at Antenna Terminal

Model	Type	Serial no.	Mfr.
Spectrum Analyzer	71210C	2927A02847	HP
Attenuator (10 dB)	8491A	36122	HP
External Mixer:	11970K	2332A00589	HP
External Mixer:	11970A	2332A01187	HP
Directional Coupler	5D364S	R05762	Shimada
Dummy Load	-----	8411057	Shimada
Notch Filter	-----	-----	-----
Circulator	MA8L32#82	-----	Microwave Associates
Bandpass filter	-----	R9904	Shimada
High Pass Filter	-----	-----	Furuno

7. Field Strength of Spurious Radiation

Model	Type	Serial no.	Mfr.
Broadband Rod Antenna	95010-1	-----	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	2248	Electro Metrics
Horn Antenna:	-----	-----	Toshiba
Spectrum Analyzer:	71210C	2927A02847	HP
External Mixer:	11970K	2332A00589	HP
External Mixer:	11970A	2332A01187	HP
Notch Filter	-----	-----	-----
Circulator	MA8L32#82	-----	Microwave Associates
Bandpass filter	-----	R9904	Shimada
Attenuator (10 dB)	8491A	36122	HP
Attenuator (20 dB)	8491A	40072	HP

8. Frequency Stability

<u>Model</u>	<u>Type</u>	<u>Serial no.</u>	<u>Mfr.</u>
Power Meter:	436A	2410A19137	HP
Power Sensor:	8481A	2349A39603	HP
Frequency Meter:	X532B	1441A00523	HP
Directional Coupler:	5D364S	R5762	Shimada
Dummy Load:	----	8411057	Shimada
Environmental Chamber:	PL-4E	1632712	Tabai Espec

9. Suppression of Interference Aboard Ships

<u>Model</u>	<u>Type</u>	<u>Serial no.</u>	<u>Mfr.</u>
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
Attenuator (10 dB)	8491A	36122	HP

