**LABOTECH**



# TECHNICAL INFORMATION

## TEST REPORT ON THE PERFORMANCE OF RADAR/PLOTTER/SOUNDER

## Trade Mark : FURUNO

## Model : FRS-1000C

Report no. : FLI 12-98-029

Date of issue: Dec. 25, 1998

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All tests were performed in Furuno Labotech International Co., Ltd.
All data herein contained is true and correct to our best knowledge.

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date : December 25, 1998

name : Sadatomo Kuwahara

function : Manager Engineering Section

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# 1 GENERAL INFORMATION

## 1.0 General

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

(b) Model: FRS-1000C
Serial no.: 3383-0001

(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: Radiator Type, XN12A XN13A
1.9° 1.2°
on a range scale of 1.5 nm

(c) Minimum Range: 25 meters on a range scale of 0.25 nm

(d) Range Scale: 0.125/0.25/0.5/0.75/1/1.5/2/3/4/6/8/12/16/24/36/48/64 nm

(e) Frequency Range: Fixed frequency, X-band

(f) Type of Emission: P0N

### 1.1.1 Transceiver

Type: RTR-059
(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: MG5389 E3560

Peak Output Power: 6 kW nominal

(c) Magnetron Ratings

Center frequency of Magnetron: 9410 MHz

Tolerances

| | MG5389 | E3560 |
|---|---|---|
| Manufacturing: | ±30 MHz | ±30 MHz |
| Pulling: | 23 MHz | 18 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) | (Short ) | (Middle) | (Long ) |
|---|---|---|---|
| | 0.125 | | |
| | 0.25 | | |
| | 0.5 | | |
| | 0.75 | | |
| | 1 | | |
| | 1.5 | 1.5 | |
| | | 2 | |
| | | 3 | 3 |
| | | | 4 |
| | | | 6 |
| | | | 8 |
| | | | 12 |
| | | | 16 |
| | | | 24 |
| | | | 36 |
| | | | 48 |
| | | | 64 |
| Pulselength ($\mu$s) | 0.08 | 0.30 | 0.80 |
| P.R.R.(Hz) | 2100 | 1200 | 600 |
| Duty cycle | $1.68X10^{-4}$ | $3.60X10^{-4}$ | $4.80X10^{-4}$ |
| Guard Band (MHz) | 18.75 | 5.00 | 1.88 |

Note 1: Tests were carried out for the underlined Range Scales.

**(2) Modulator**

(a) FET Type: 2SK1450

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): 6 (typical)

(d) Video Output Voltage (V): 0.7 V 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)

**1.1.2 Antenna**

(a) Antenna Rotation ON-OFF Switch:

Not Provided.

(b) Reflector: Slotted waveguide array

| Radiator Type | XN12A | XN13A |
|---|---|---|
| Length (cm) | 120 | 180 |
| Length (ft) | 4 | 6 |

(c) Type of Beam: Vertical fan

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

| Radiator Type | XN12A | XN13A |
|---|---|---|
| Horizontal | 1.9 ° | 1.2 ° |
| Vertical | 22 ° | 22 ° |

(e) Polarization: Horizontal

(f) Antenna Gain:

| Radiator Type | XN12A | XN13A |
|---|---|---|
| (dB) | 28.0 | 30.0 |

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

| Radiator Type | XN12A | XN13A |
|---|---|---|
| Within ±20 ° (±10 ° for (*)) | -24 dB or less | -24 dB or less (*) |
| Outside ±20 ° (±10 ° for (*)) | -30 dB or less | -30 dB or less (*) |

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

(i) Antenna Rotation Rate: 24 rpm (for RSB-0070-XN12A/13A)
48 rpm (for RSB-0073-XN12A)

(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 : 10.4 in. diagonal
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 | 0.5 |
| 2 | 4 | 0.5 |
| 3 | 3 | 1 |

| Range (nm) | Number of Range Rings | Range Ring Interval (nm) |
|---|---|---|
| 4 | 4 | 1 |
| 6 | 3 | 2 |
| 8 | 4 | 2 |
| 12 | 4 | 3 |
| 16 | 4 | 4 |
| 24 | 4 | 6 |
| 36 | 3 | 12 |
| 48 | 4 | 12 |
| 64 | 4 | 16 |

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

### 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: Antenna 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-0070 (24 rpm) |
| | Type: | RSB-0073 (48 rpm) |
| Transceiver | Type: | RTR-059 (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: | 4 kg (RSD-001) |
| Radar Antenna Unit: | 23 kg (RSB-0070/RSB-0073) |
| 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) |

## 2 IDENTIFICATION OF EQUIPMENT (FCC Rule §2.925)

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

FCC ID: ADB9ZWRTR059

Material of nameplate: Polyester film, 0.1 mm thick

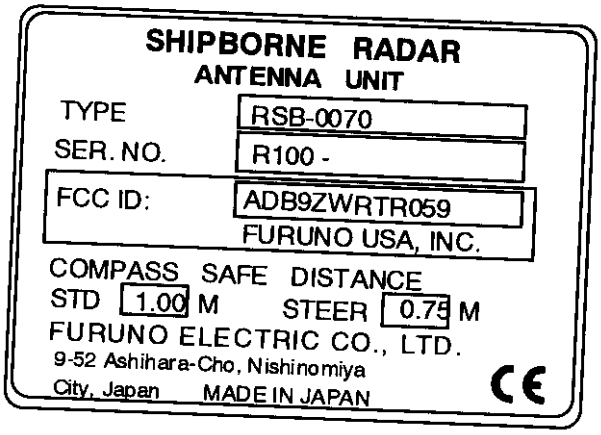



**Fig. 2.1 Nameplate for Antenna Unit (RSB-0070 ) Note:TYPE and SER. NO. change to RSB-0073 and R101 incase of 48 rpm set.**

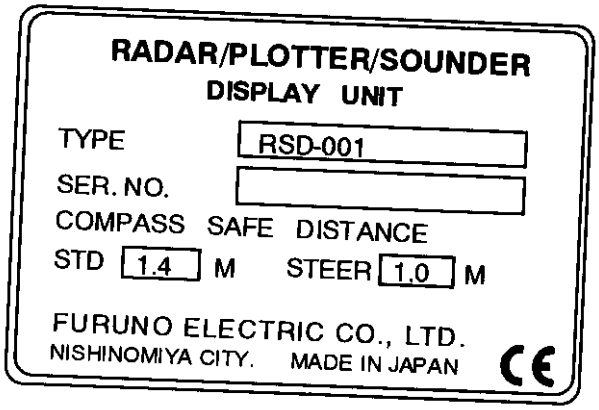



**Fig. 2.2 Nameplate for Display Unit**

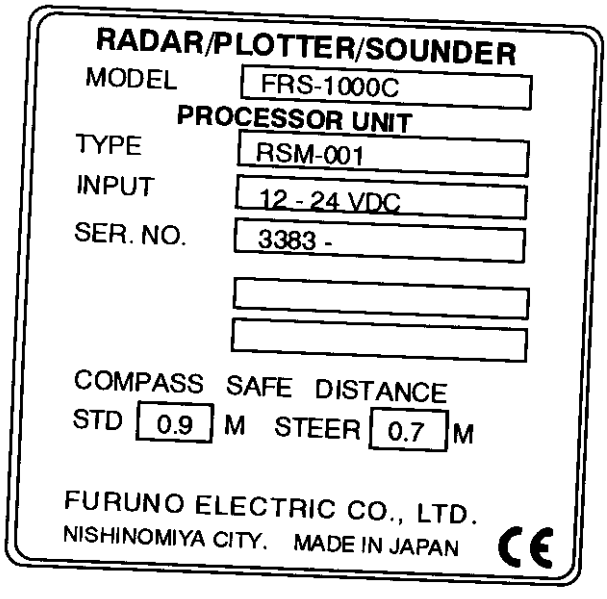



**Fig. 2.3 Nameplate for Processor Unit**

## 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.

#### (1) Nominal values

| Pulselength | Short | Middle | Long |
|---|---|---|---|
| Range scale (nm) | 0.125 | 1.5 | 64 |
| Pulselength (μs) | 0.08 | 0.30 | 0.80 |
| PRR (Hz) | 2100 | 1200 | 600 |
| Duty cycle | $1.68 \times 10^{-4}$ | $3.60 \times 10^{-4}$ | $4.80 \times 10^{-4}$ |
| Guard band (MHz) | 18.75 | 5.00 | 1.88 |

#### (2) Measured values

**Magnetron input pulse voltage**

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

| Pulselength | Short | Middle | Long |
|---|---|---|---|
| Directional coupler attenuation (dB) | 40.54 | 40.54 | 40.54 |
| Magnetron input voltage (kV) | 4.6 | 4.3 | 4.3 |
| Pulselength (μs) (50 % amplitude) | 0.410 | 0.600 | 0.1.064 |
| Rise time (μs) (10-90 % amplitude) | 0.052 | 0.052 | 0.052 |
| Decay time (μs) (90-10 % amplitude) | 0.920 | 0.844 | 0.576 |

**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) | 3.2 | 3.4 | 3.6 |
| Pulselength (µs) (50 % amplitude) | 0.105 | 0.298 | 0.808 |
| Rise time (µs) (10-90 % amplitude) | 0.070 | 0.070 | 0.070 |
| Decay time (µs) (90-10 % amplitude) | 0.060 | 0.060 | 0.065 |

**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 (µs) (-3 dB points) | 0.108 | 0.295 | 0.788 |
| Rise time (µs) (10-90 % amplitude) | 0.020 | 0.020 | 0.020 |
| Decay time (µs) (90-10 % amplitude) | 0.062 | 0.070 | 0.070 |

**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 | 64 |
| P.R.R (Hz) | 2234.7 | 1257.0 | 566.5 |
| Duty cycle | $2.41 \times 10^{-4}$ | $3.70 \times 10^{-4}$ | $4.46 \times 10^{-4}$ |
| Magnetron input, av. (W) | 3.55 | 5.42 | 6.91 |
| Magnetron input, peak (kW) | 14.72 | 14.62 | 15.48 |
| Power meter reading (mW) | 0.0962 | 0.1540 | 0.1920 |

| Pulselength | Short | Middle | Long |
|---|---|---|---|
| Magnetron output, av. (W) | 1.089 | 1.744 | 2.174 |
| Spurious response limits (dB) | 43.37 | 45.42 | 46.37 |
| Magnetron Output, peak (kW): | 4.51 | 4.70 | 4.87 |
| Magnetron efficiency (%): | 30.7 | 32.2 | 31.5 |

Peak Power Input to RF Generator : 14.9 kW

Estimated Efficiency of RF Generator : 31.4 %

# 4 MODULATION CHARACTERISTICS (FCC Rule § 2.987)

## 4.1 FET Trigger Pulse

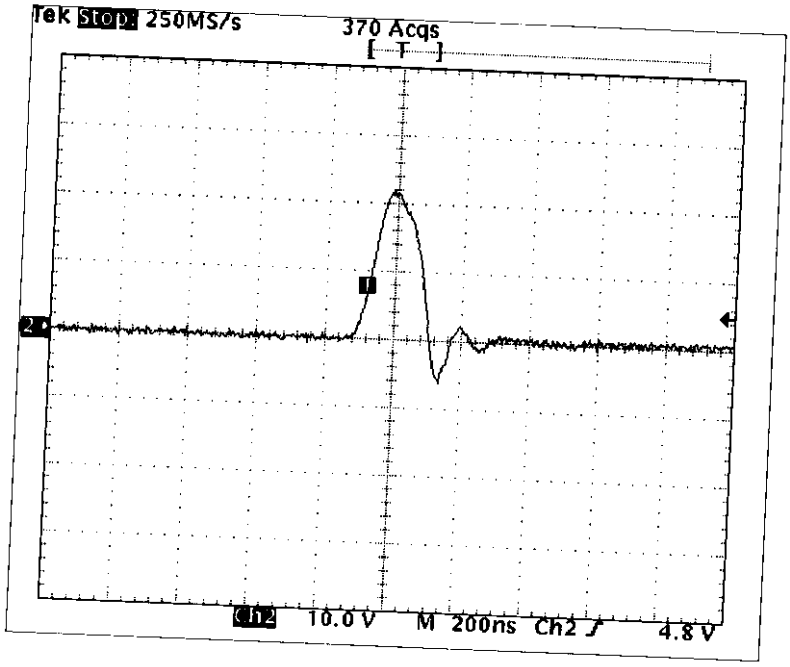



Fig. 4.1.1 Typical waveform of Trigger Pulse Scale: 10 V/div., 200 ns/div.

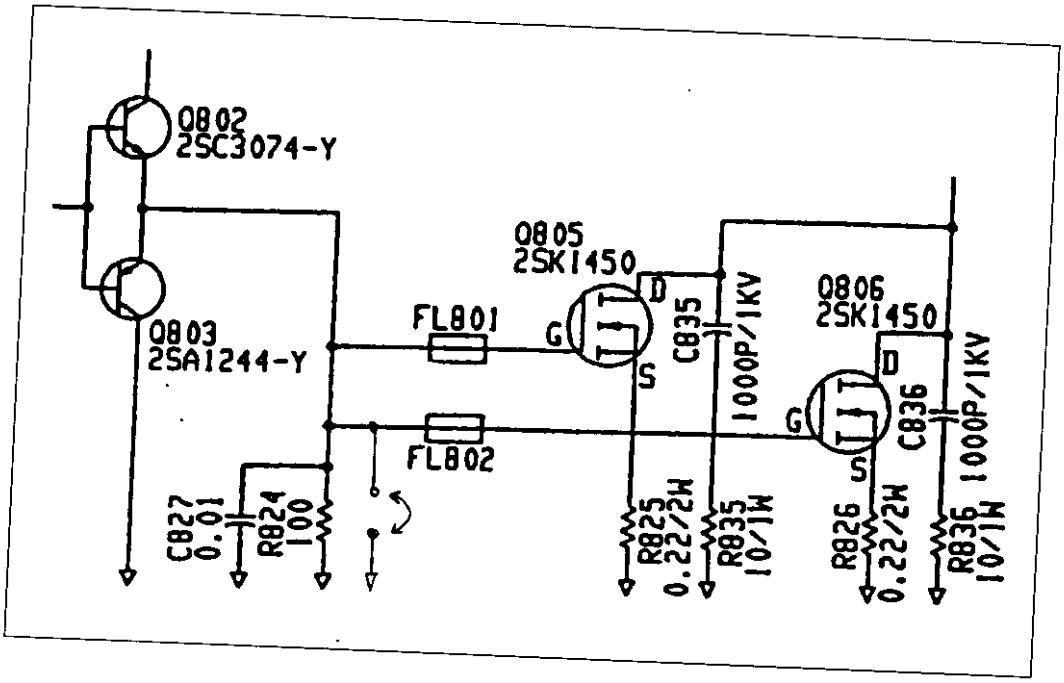



Fig. 4.1.2 Test Point for Trigger Pulse
(in MD board (03P9235) of Radar Antenna Unit)

### 4.2 Trigger Pulse at Magnetron Cathode

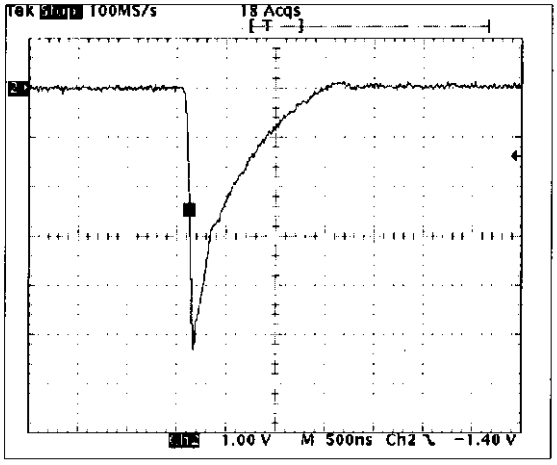



Fig. 4.2.1 Short Pulse (0.125 nm Range) Scale: 1 kV/div. 500 ns/div.

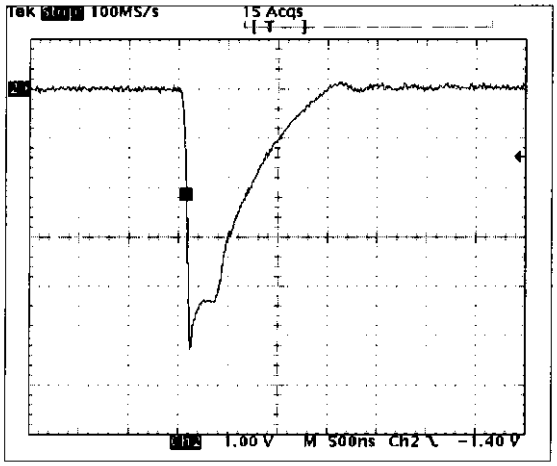



Fig. 4.2.2 Middle Pulse (1.5 nm Range) Scale: 1 kV/div. 500 ns/div.

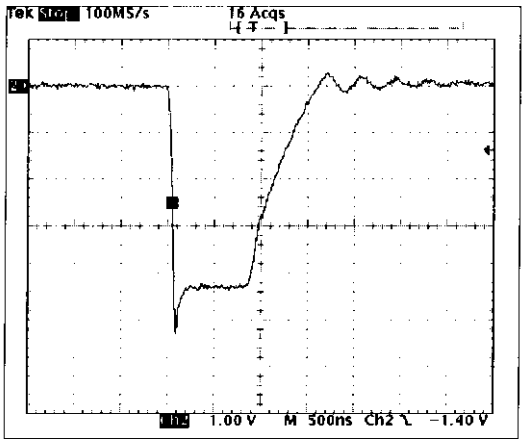



Fig. 4.2.3 Long Pulse (64 nm Range) Scale: 1 kV/div. 500 ns/div.

## 4.3 **Magnetron Output** (detected):

### 4.3.1 Setup for Measurement:

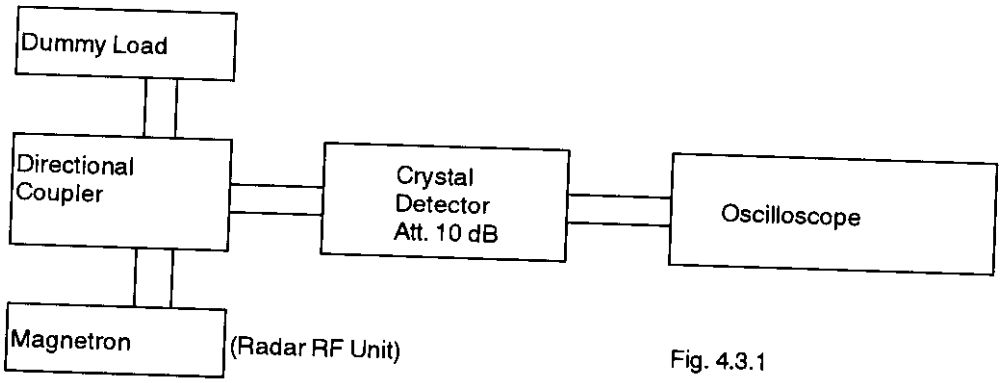



Fig. 4.3.1

### 4.3.2 Measuring Equipment List:

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

4.3.3 Measured Data:

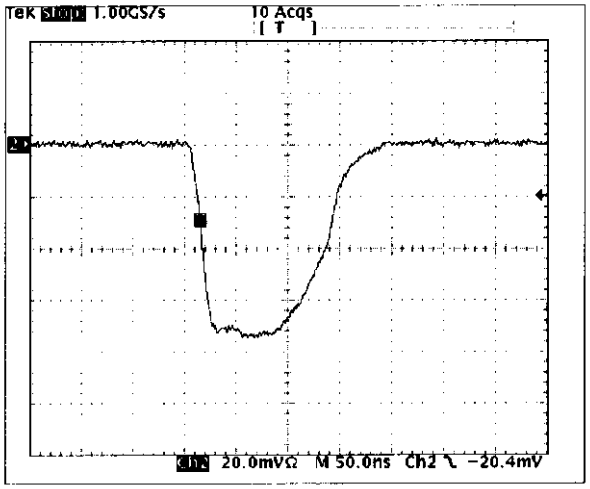



Fig. 4.3.2 Short Pulse (0.125 nm Range) Scale: 20 mV/div. 50 ns/div.

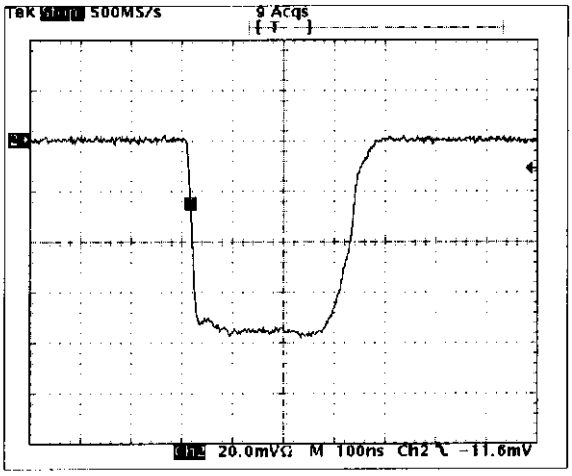



Fig. 4.3.3 Middle Pulse (1.5 nm Range) Scale: 20 mV/div. 100 ns/div.

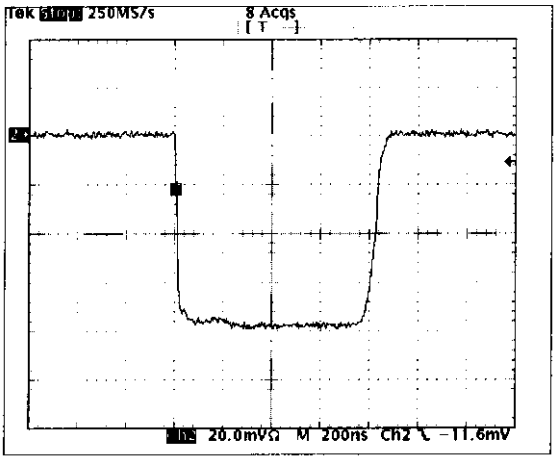



Fig. 4.3.4 Long Pulse (64 nm Range) Scale: 20 mV/div. 200 ns/div.

## 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.)

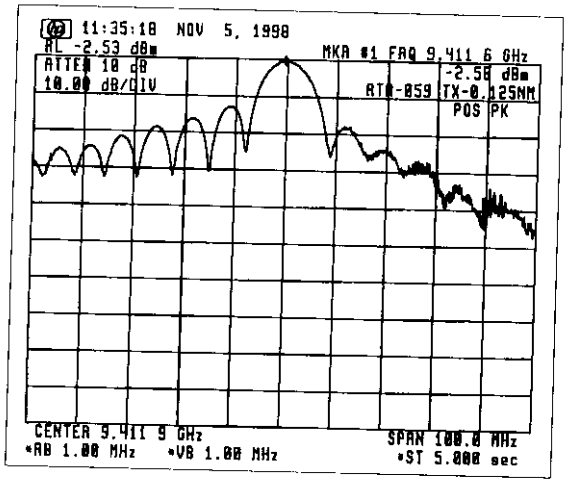



Fig. 4.4.1 For Short Pulse (0.125 nm Range)

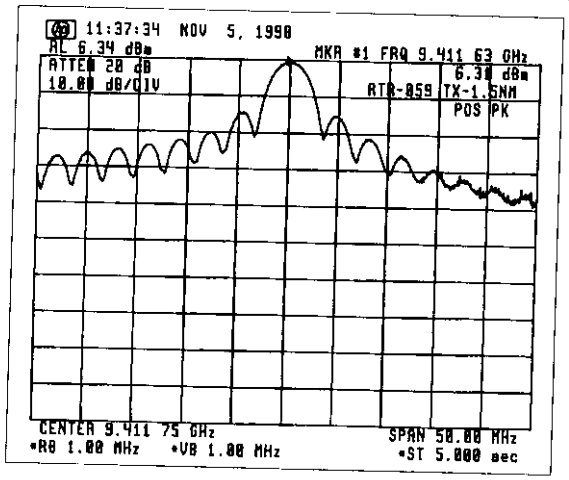



Fig. 4.4.2 For Middle Pulse (1.5 nm Range)

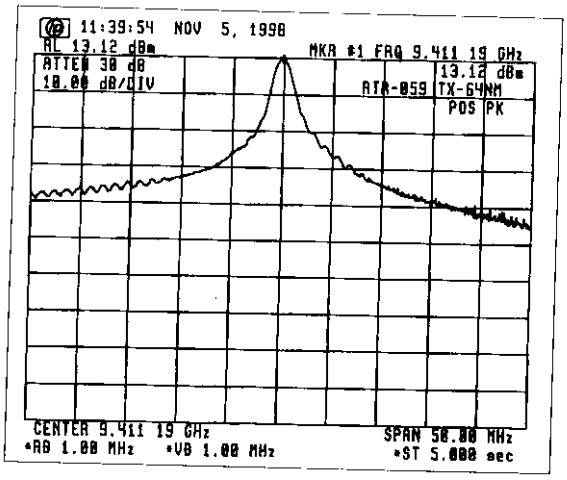



Fig. 4.4.3 For Long Pulse (64 nm Range)

## 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,I4;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 I;";
620  OUTPUT   @Sa;"PD;PA 700,743;";
630  OUTPUT   @Sa;"PU;PA 701,654;";
640  OUTPUT   @Sa;"LINET I;";
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.

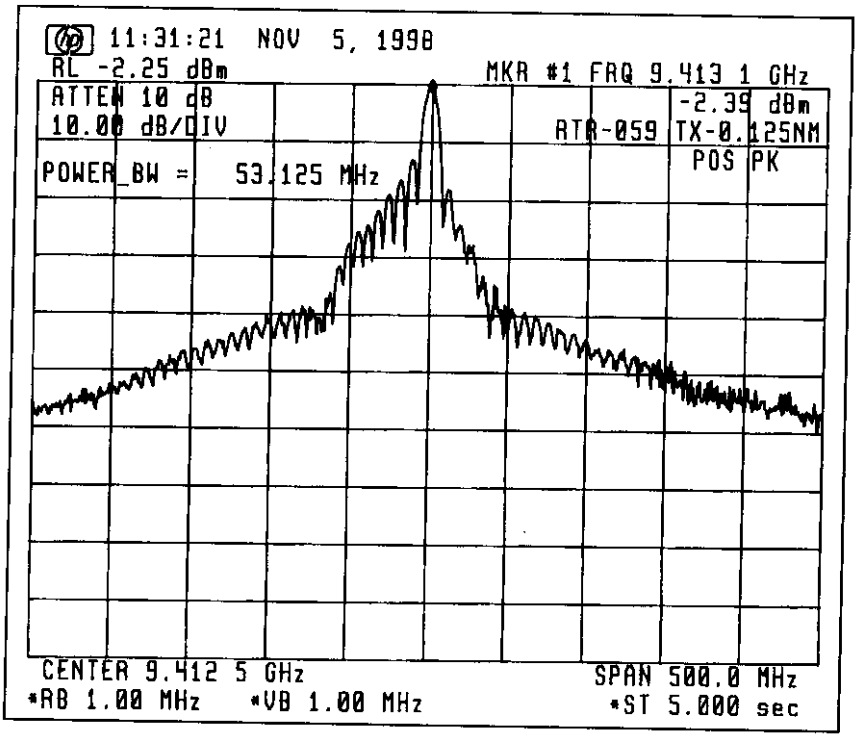



Fig. 5.2 Measurement of Occupied Bandwidth

**Occupied bandwidth = 53.125 MHz**

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

### 6.1 Test Equipment Setup:

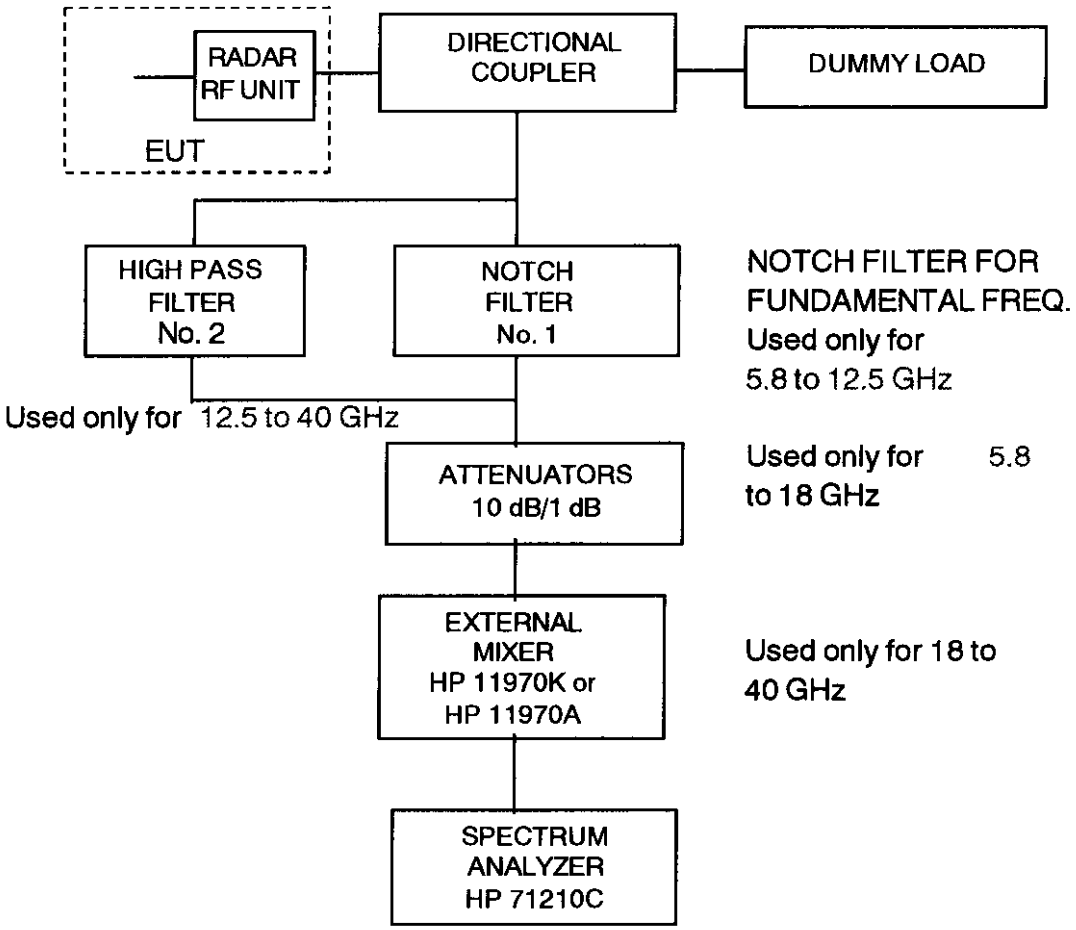



Fig. 6.1

### 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)/ 64 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<br>9460 - 9510 M | At least 25 |
| 100 - 250 % | 9160 - 9310 M<br>9510 - 9660 M | At least 35 |
| more than 250 % | 10 k - 9160 M<br>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)).

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

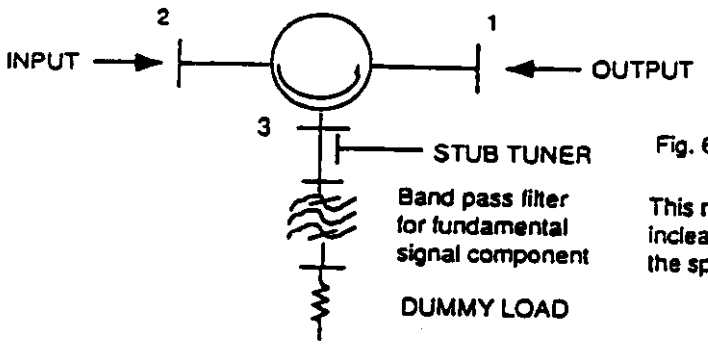



Fig. 6.2 Setup of Notch Filter No.1

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

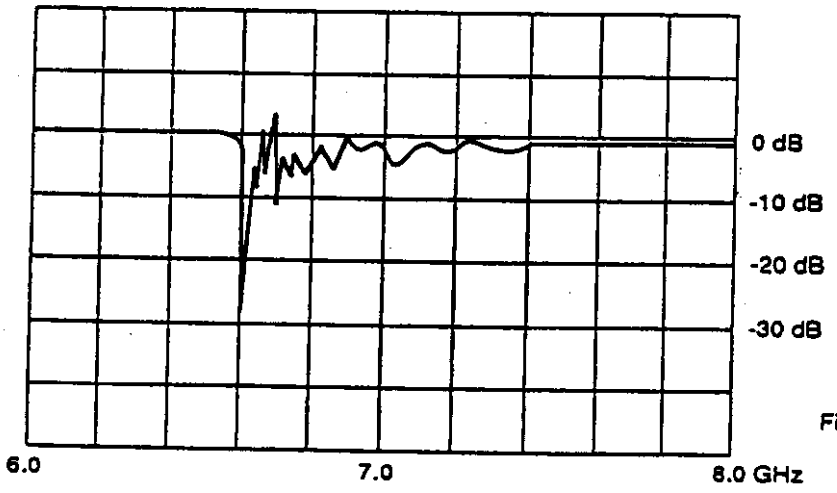



Fig. 6.3

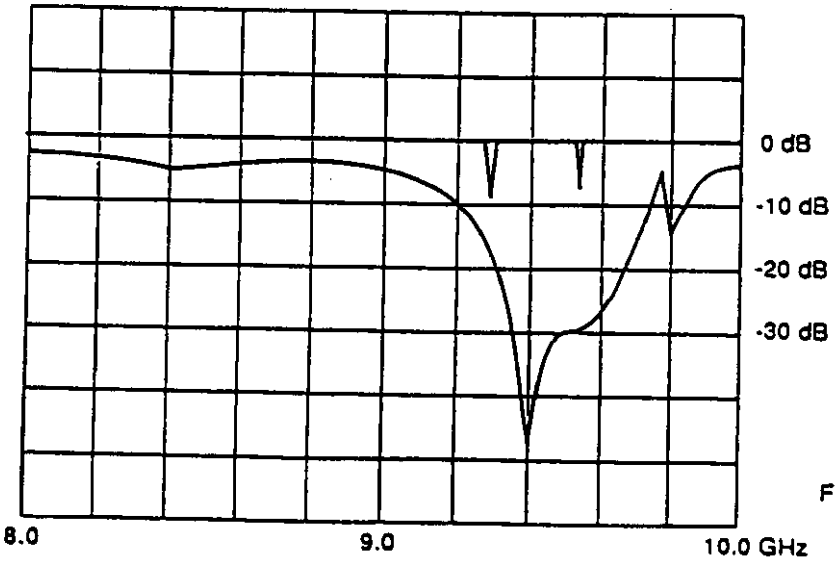



Fig. 6.4

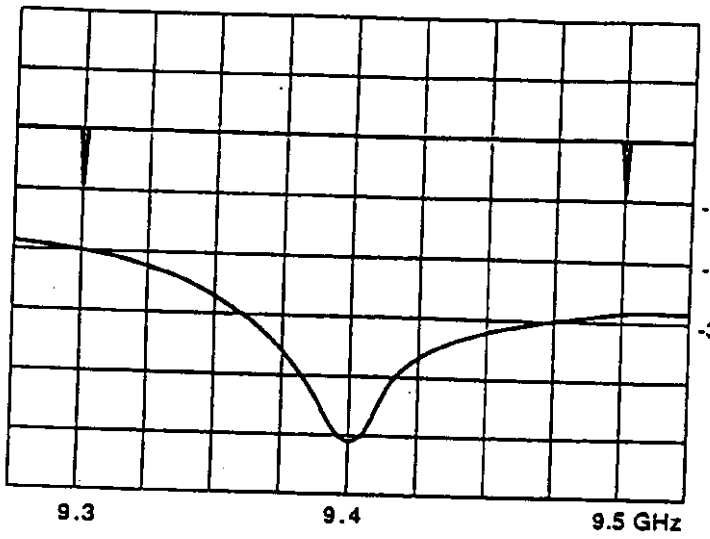
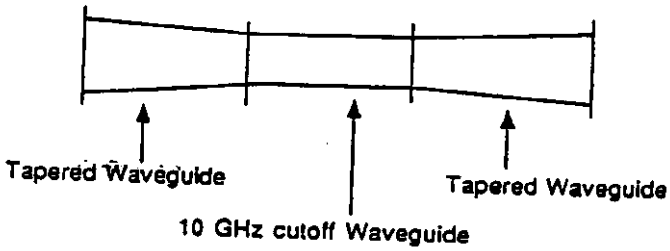



Fig. 6.5

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

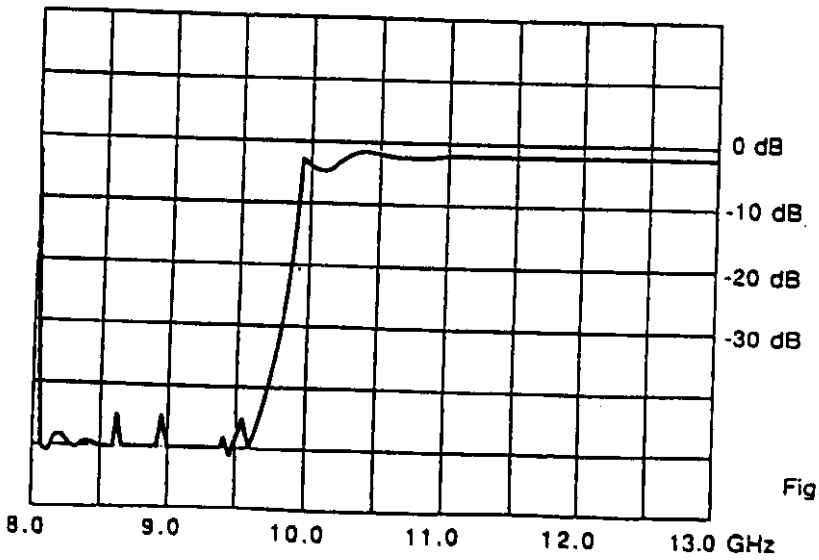



Fig.6.6

## 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

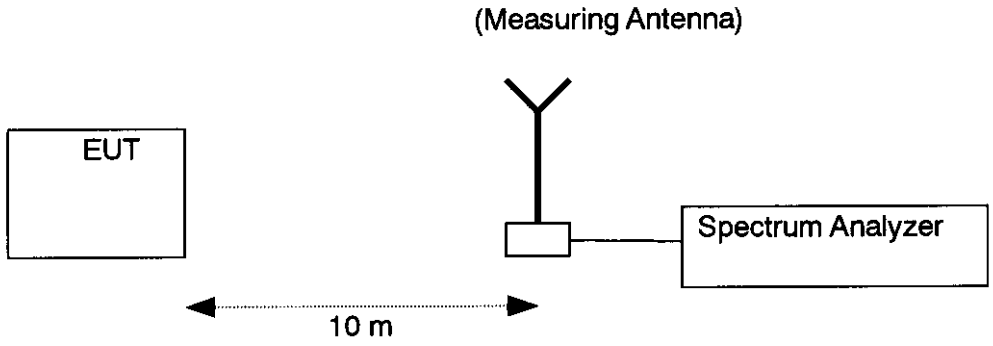
**7.2 Date:** Nov., 1998

**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)/ 64 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 - 4GHz

(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<br>9460 - 9510 M | At least 25 |
| 100 - 250 % | 9160 - 9310 M<br>9510 - 9660 M | At least 35 |
| more than 250 % | 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

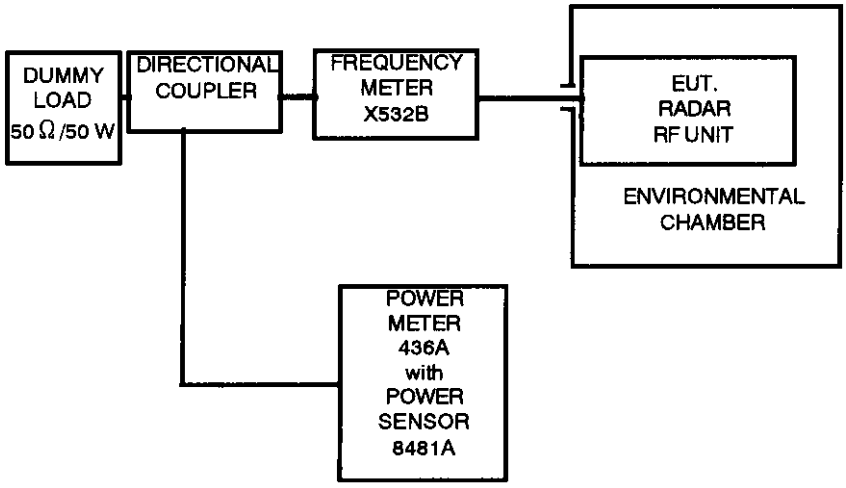



Fig. 8.1

### 8.2 Test Conditions:

1) Radar Range settings : 0.125 nm (Short)/1.5 nm (Middle)/ 64 nm (Long)
2) Ambient Temperature settings: - 20 to + 50 ℃ (10 ℃ 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 = 9460 MHz

"Lower limit frequency of the authorized band", f(LAUBW) = $f_0$ - f(AUBW)/2 = 9360 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)) :

| Pulselength | Short | Middle | Long |
|---|---|---|---|
| Range Scale (nm) | 0.125 | 1.5 | 64 |
| Pulselength ($\mu$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 ℃)", f(U) = 9413.0 MHz
(2) "Lower Tolerance Frequency measured (at + 50 ℃)", f(L) = 9407.8 MHz
(3)-(a)
f(U) + max. f(1.5/T) = 9431.75 MHz < f(UAUBW) = 9460 MHz ≦ f(UASB) = 9500 MHz
(3) - (b)
f(L) - max. f(1.5/T) =9389.0 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 (20.4 to 27.6 VDC for nominal 24 VDC).

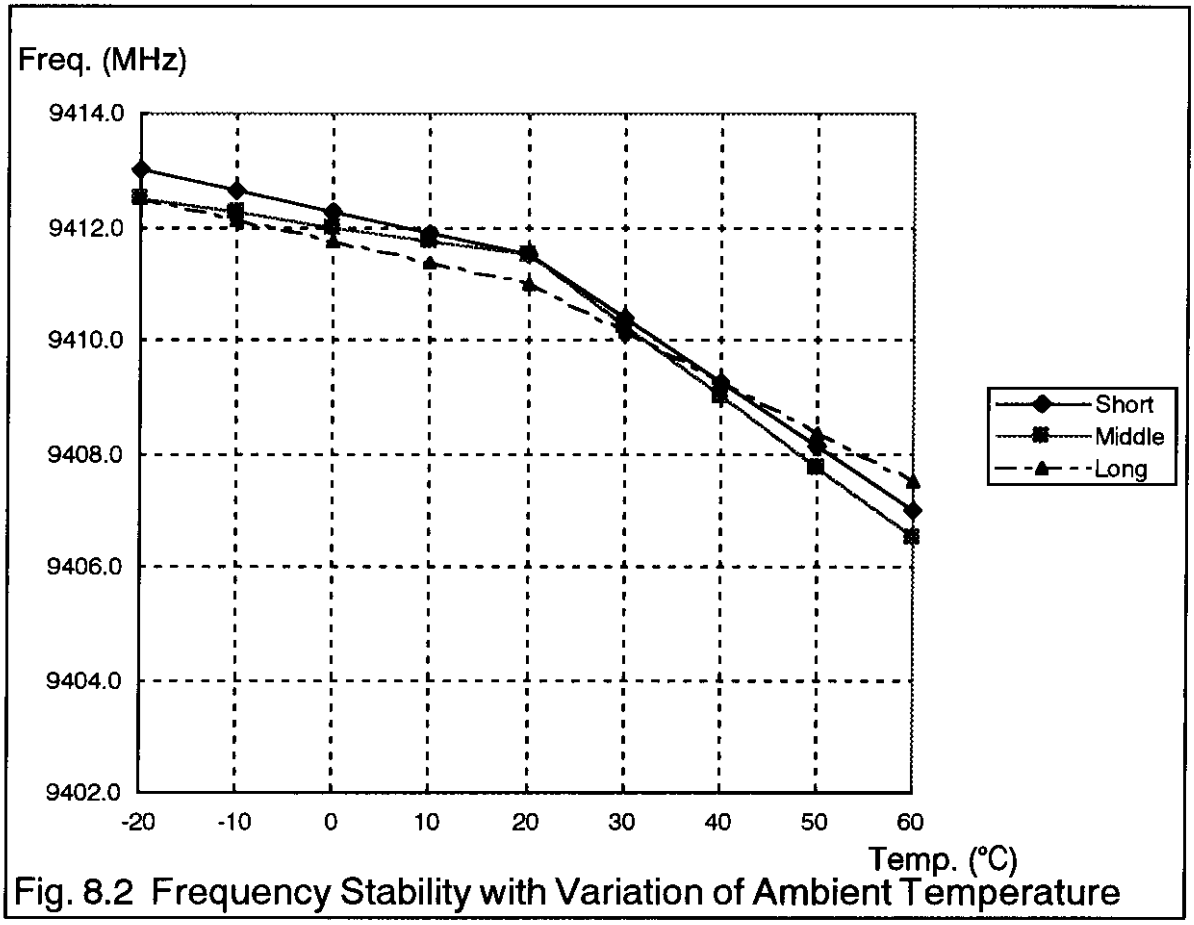



Fig. 8.2 Frequency Stability with Variation of Ambient Temperature

## 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 mesuring 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)

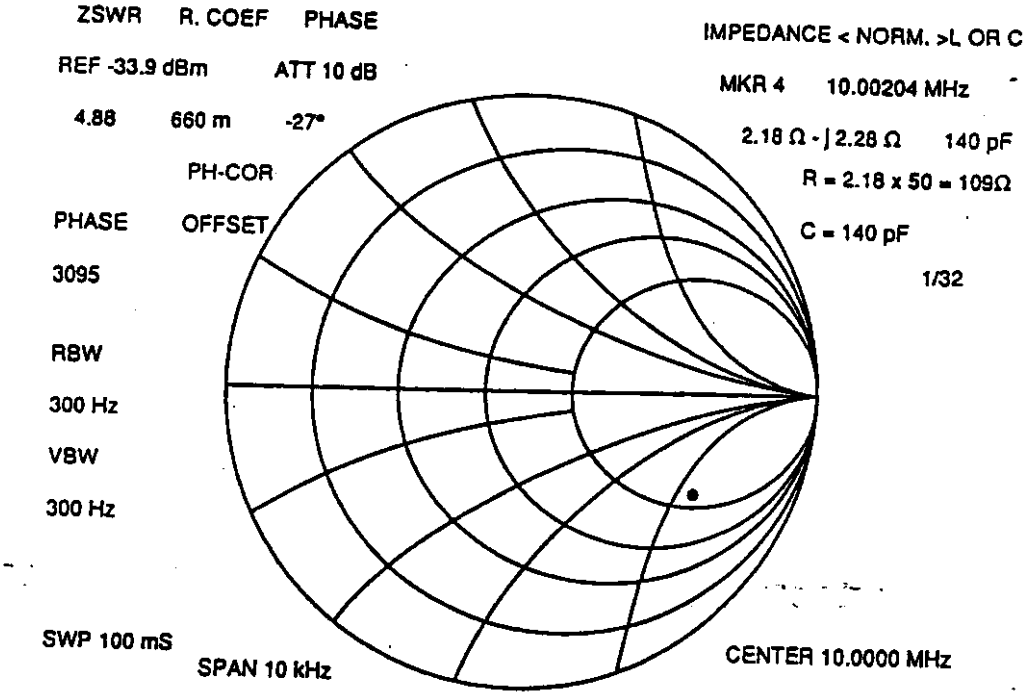
Results: Interference was measured with the antenna located 2 m from the radar and converted to levels at 1 nm. There is no spurious component exceeding the limits.
(Test data are shown in ATTACHMENT 3 )

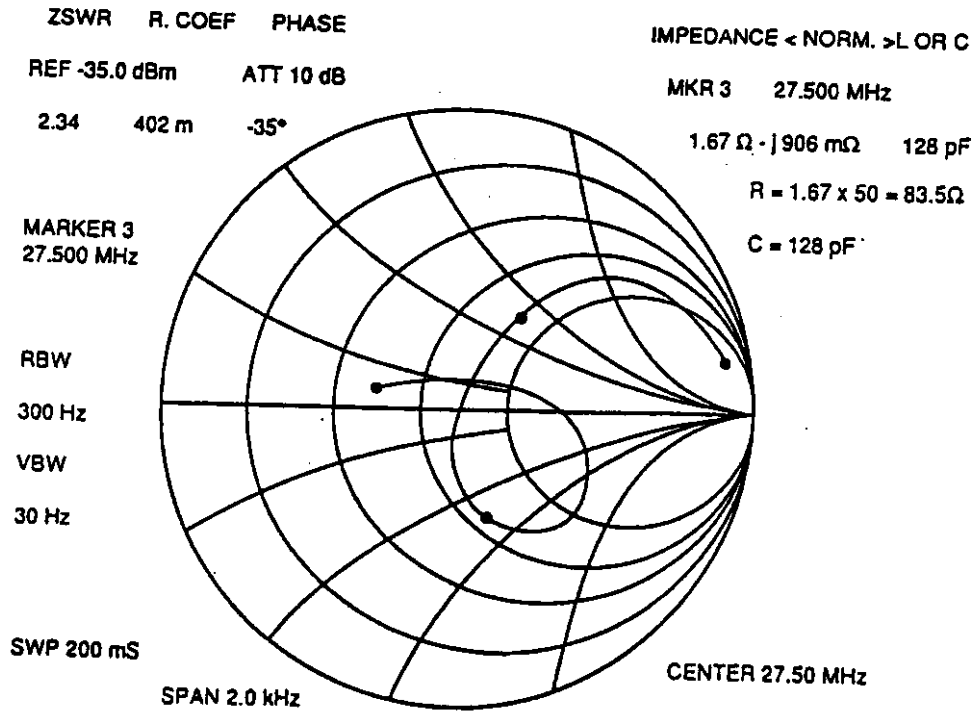
**9.4.3 Power Input to an Artificial Antenna** (FCC Rule § 80.217 (b) - 2)

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

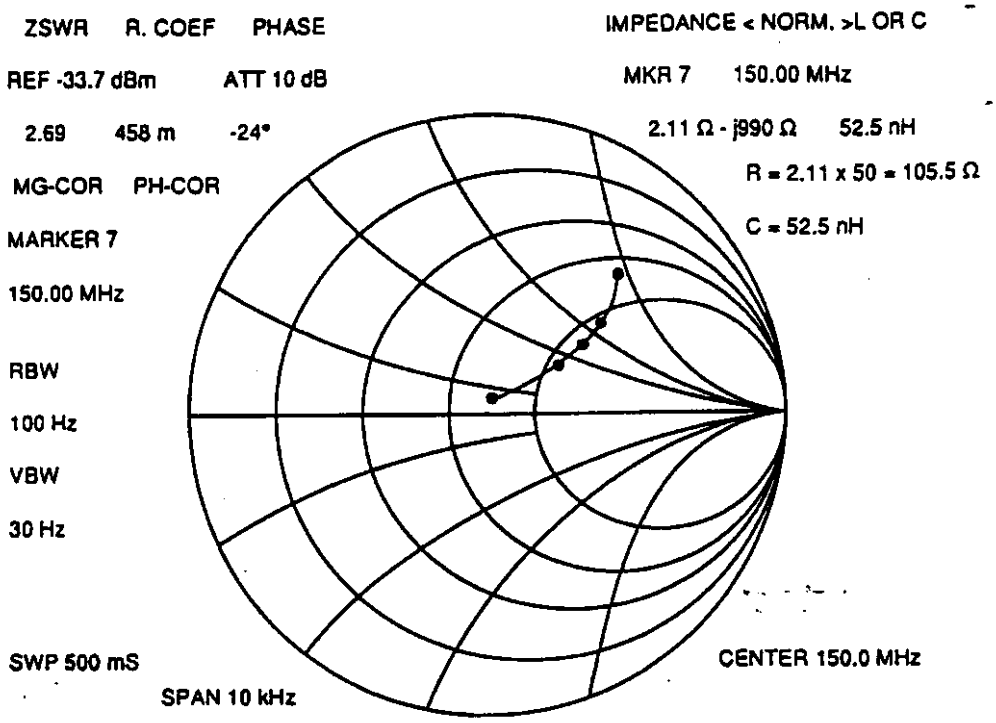
Results: There is no spurious component exceeding the limits.
(Test data are shown in ATTACHMENT 3 )

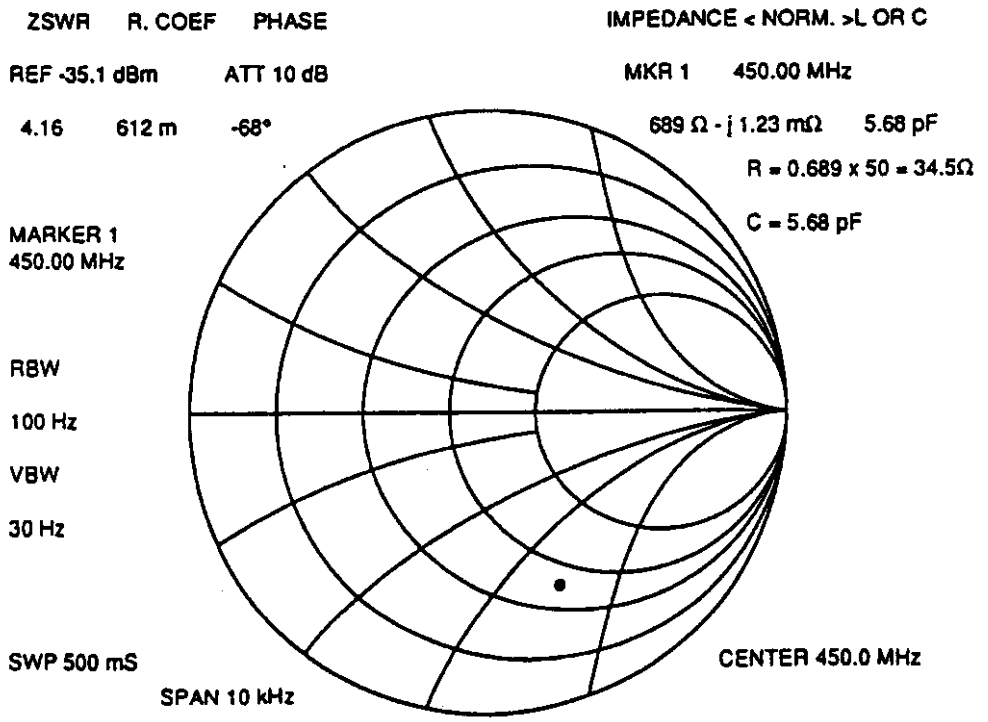
MEASUREMENT OF IMPEDANCE OF TEST ANTENNAS



MEASUREMENT OF IMPEDANCE OF TEST ANTENNAS



# 11 TECHNICAL DESCRIPTION OF EQUIPMENT (FCC Rules § 2.983)

## 11.1 Function of Each Semiconductor or Active Device (FCC Rule § 2.983 (d)(6))

ANTENNA UNIT

TRANSCEIVER MODULE (RTR-059)

Modulator PCB 03P9235

| | |
|---|---|
| CR801: | Rectifier |
| CR802: | Rectifier |
| CR803: | Rectifier |
| CR804: | Transient Suppression |
| CR805: | Rectifier |
| CR806: | Detector (Magnetron Current) |
| CR807: | Pulse width Select |
| CR809: | Reverse Voltage Protection |
| L801: | Noise Reject |
| L802: | Noise Reject |
| L804: | Noise Reject |
| Q801: | 45 kHz PWM Output MOS FET |
| Q802: | Pulse Amplifier |
| Q803: | Pulse Amplifier |
| Q804: | Pulse width Select |
| Q805: | Pulse Amplifier |
| Q806: | Pulse Amplifier |
| Q807: | IF Bandwidth Select |
| Q808: | Pulse Amplifier |
| Q809: | Pulse Amplifier |
| Q810: | Protective Circuit Monitor |
| Q811: | Switching |
| Q812: | Switching |
| T801: | Transformer |
| T802: | Pulse Transformer |
| U802: | Voltage Detector |
| U803: | Voltage Detector |
| U804: | Voltage Detector |
| U805: | Pulse Forming Network |
| U806: | 45 kHz PWM Inverter |

Chassis Mounted Parts

| | |
|---|---|
| HY801: | 3 Ports Circulator |
| U801: | MIC Frequency Converter with Limiter |
| V801: | Magnetron |

IF Amplifier PCB IF-9214

| | |
|---|---|
| CR1 to CR6: | Switching |
| CR8: | Level Shifter |
| CR10: | DC Restoring |
| CR11: | Over Voltage Protection |
| CR12-CR13: | Reverse Voltage Protection |
| CR14-CR16: | Over Voltage Protection |
| | |
| Q1 to Q4: | Video Amplifier |
| Q5: | Inverter |
| Q6: | DC Amplifier |
| Q7: | Switching |
| Q8-Q9: | I.F. Amplifier in Cascade Connection |
| Q10: | Bias Setting |
| Q11: | Detector |
| Q12: | Current Buffer |
| Q13-Q14: | Tuning Indication Amplifier |
| Q15: | Switching |
| Q16: | MBS Pulse Amplifier |
| Q17: | Tuning Gate Amplifier |
| U1 to U4: | I.F. Amplifier |
| U5: | Inverter |
| U6 to U9: | DC Regulator |

Motor Soft Starter PCB 03P9249

| | |
|---|---|
| CR1: | Reverse Voltage Protection |
| CR2: | C3 discharger |
| CR3: | Level Shifter |
| CR4: | Soft starter switch |
| CR5: | Reverse Voltage Protection |
| Q1-Q2: | Buffer for bearing pulse |
| Q3: | Trigger switch for CR4 |

## 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

(FCC Rule § 2.983 (d)-(11))

ANTENNA UNIT

TRANSCEIVER MODULE (RTR-059)

Modulator PCB 03P9235

The primary function of the modulator is to produce narrow high tension pulses to drive the magnetron. To produce such pulses, the modulator board incorporates a modulator trigger circuit, a modulating pulse generator and a booster pulse transformer.

The modulator trigger circuit is composed of U805 and associated components. It generates pulses that fire modulator FET Q805, Q806. Normally, the circuit is stable with U805 off. The pulse to fire the modulator FET is produced when U805 turns on upon receiving the TX trigger pulse from the display unit. When U805 turns on at the positive-going edge of the TX trigger pulse, it produces a narrow pulse. This narrow pulse is boosted by pulse transformer T802 by the ratio 1:21. The resultant pulse, its level being 4.5 kV, is provided to limit the magnetron current.

C820 decouples the pulse energy that is liable to occur across the magnetron heater when T802's secondary windings are unbalanced or the load is asymmetric.

Also incorporated in the modulator board are the TX HV circuit and magnetron heater power supply circuit. The TX HV circuit provides a high tension of about 330 V to the pulse forming network through CR802,CR805. A DC voltage of 7.6 V is supplied to the magnetron heater through CR801.

Duplexer and Frequency Converter

The microwave energy produced by the magnetron enters the circulator from port 2. It is fed to port 3 with a negligible loss of energy; port 1 at this time is isolated. In the same manner, the received signal entering into port 3 is transferred to port 1, isolating port 2. This operation of the circulator protects the receiver during transmission and minimizes the loss of the received signal. Thus, the circulator allows a single antenna radiator to be used for transmission and reception of radar signals.

A diode limiter, made up of a pair of PIN diodes, is incorporated in the first stage of the MIC (microwave IC, U801). It is a passive switching device which allows the

low-level RF signal to pass through and prohibits relatively strong microwave energy, such as the leak from the magnetron. It also protects the sensitive amplifier from pulses received direct from other radars operating in the proximity.

When a low-level signal is received, the PIN diodes remain in the cutoff state, and the limiter's input impedance matches the characteristic impedance of the receiver allowing the signal to be delivered to the frequency converter of U801. When strong microwave energy is received, the PIN diodes are put in the conductive state (or short-circuited) causing the input energy to be attenuated. The strong input is further reduced to about 150 mW by the varacter diode.

The MIC converts 9 GHz RF signal into an intermediate frequency of 60 MHz. It is achieved by mixing the received signal with the local oscillator signal in the frequency converter of the MIC. The built-in local oscillator oscillates at a frequency 60 MHz higher than the magnetron frequency of 9410 MHz.

IF Amplifier IF9214

The IF signal of 60 MHz coming from the MIC is amplified and converted into a video signal, which is delivered to the display unit.

The IF amplifier is composed of five major circuits; Logarithmic Amplifier (U1/U2, U3/U4), Video Amplifier(Q1/Q2/Q3/Q4), Bandwidth Selector (Q5/Q6, CR1 to CR6), Tuning Indicator Circuit (Q8 to Q14) and Main Bang Suppression Circuit (U5, Q15/Q16/Q17, CR11 to CR15)

The IF signal from the MIC ("IF" TERMINAL) is applied to the bandwidth selector.

The IF amplifier operates in narrow or wide bandwidth mode depending on the setting of the RANGE switch and TX touchpad. For short and middle ranges, a wide bandwidth (25 MHz) is selected, since the levels at the base of Q5 and the collector of Q6 go high, thus CR2, CR4, CR5 and CR6 are conductive and CR1/CR3 are cut off, causing the signal to pass through CR5/CR6. On the contrary, CR2, CR4, CR5 and CR6 are cut off and CR1/CR3 are conductive, which causes the signal to pass through C5/C6, selecting a narrow bandwidth (3 MHz) on long ranges.

The signal through the bandwidth selector is coupled to the logarithmic amplifier and amplified and detected by U1/U2/U3. The detected signals are fed to Q1/Q2 to be amplified further, and then sent to the display unit via buffer Q3/Q4.

The other IF signal from the MIC ("IF TUN" TERMINAL) of 60 MHz is amplified by U4, Q8/Q9 and detected by Q10/Q11. Then the detected signal (Tuning Indicator Signal) is sent to the display unit via Q13 to Q14.

On the other hand, U4 is additional amplifier circuits to make the dynamic range of the IF signal wider, causing the discrimination of the target echoes to get better. The attenuated IF signal from the MIC ("IF TUN" TERMINAL) is fed to U4. Therefore, U4 amplifies even a strong signal which may be saturated in U1/U2/U3 and sent to logarithmic amplifier U4. This signal is added to the saturated signal in U1/U2/U3, causing the saturation level of the IF signal to become high.

The purpose of main bang suppression circuit is to minimize transmission leakage near the center spot on the screen.

When the Magnetron Current pulse generated in Modulator PCB 03P9235 is fed to the inverter U5, it produces a rectangular pulse which is controlled by Q6. This pulse is fed to "MBS" TERMINAL of the MIC through Q15/CR12 as a main bang suppression waveform, then IF Amplifier incorporated in the MIC turns off during transmission to eliminate direct reception of the strong TX energy (main bang).

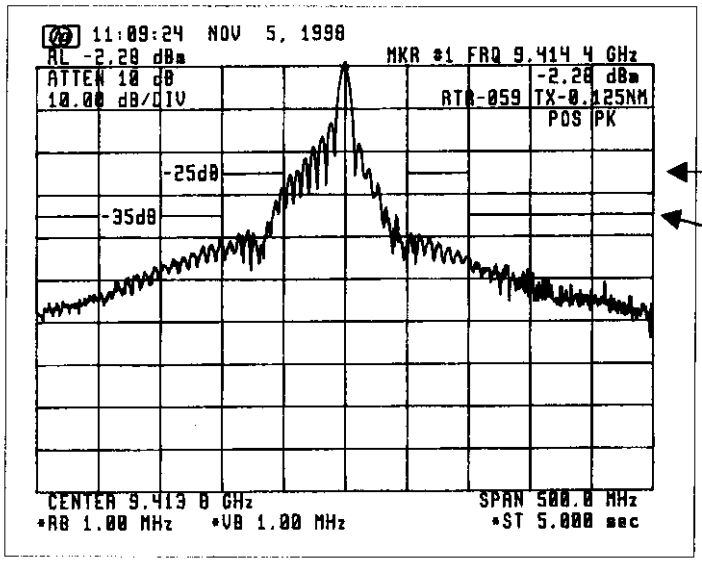
## 12 OPERATOR'S MANUAL INCL. CIRCUIT DIAGRAMS (FCC Rule § 2.983)

(See separate covers)

# ATTACHMENT 1

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

1. Spurious emissions for 0.125 nm Range:



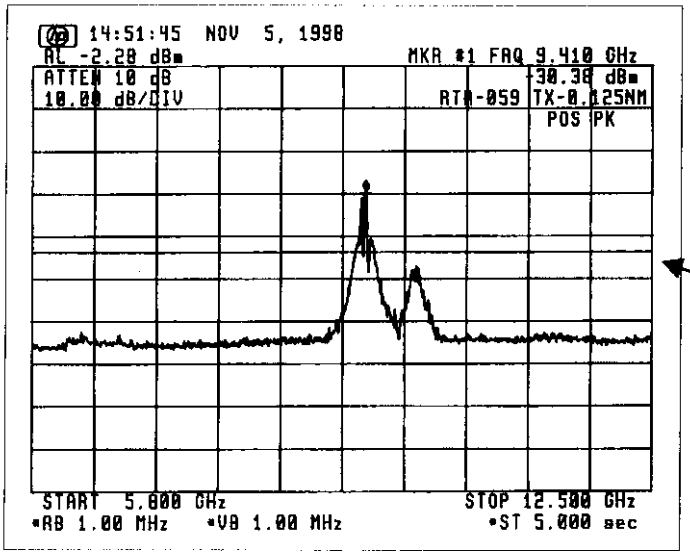

Ref. level: -2.28 dBm

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)

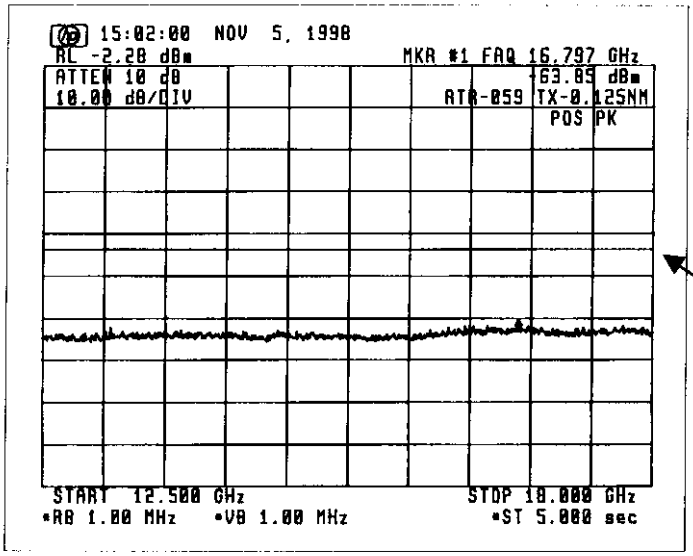
Fig. 1.1 Without Filter




Emission limitations:

(c) 43 + 10 log Pm = 43.37 dB for more than 250 % of the authorized BW (100 MHz)

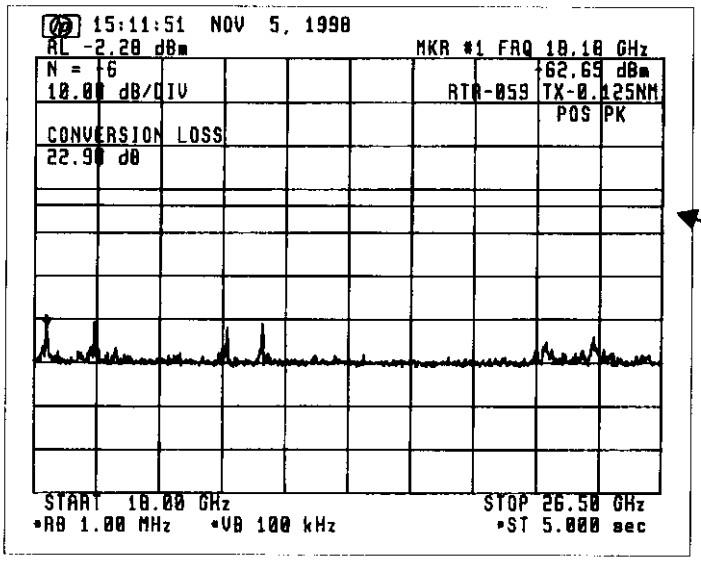
Fig. 1.2 With Filter No.1




Emission limitations:

(c) 43 + 10 log Pm = 43.37 dB for more than 250 % of the authorized BW (100 MHz)

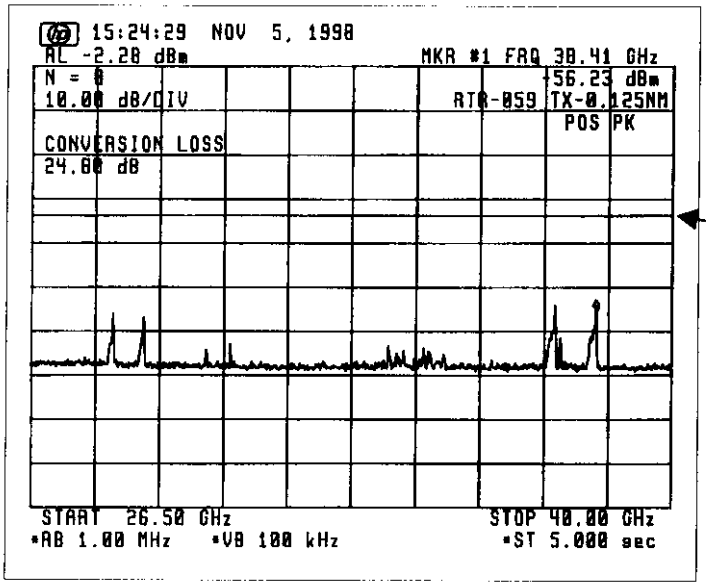
Fig. 1.3 With Filter No. 2




Emission limitations:

(c) 43 + 10 log Pm = 43.37 dB
for more than 250 % of
the authorized BW (100 MHz)

Fig. 1.4 With Filter No. 2

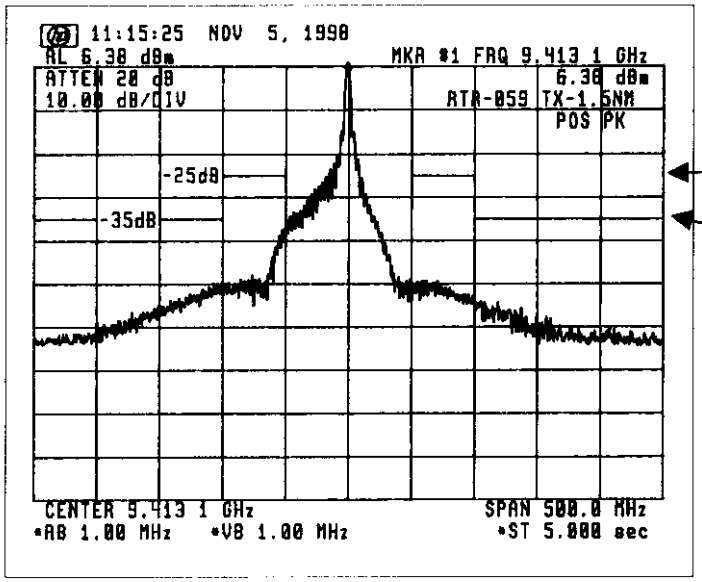



Emission limitations:

(c) 43 + 10 log Pm = 43.37 dB
for more than 250 % of
the authorized BW (100 MHz)

Fig. 1.5 With Filter No. 2

2. Spurious emissions for 1.5 nm Range:



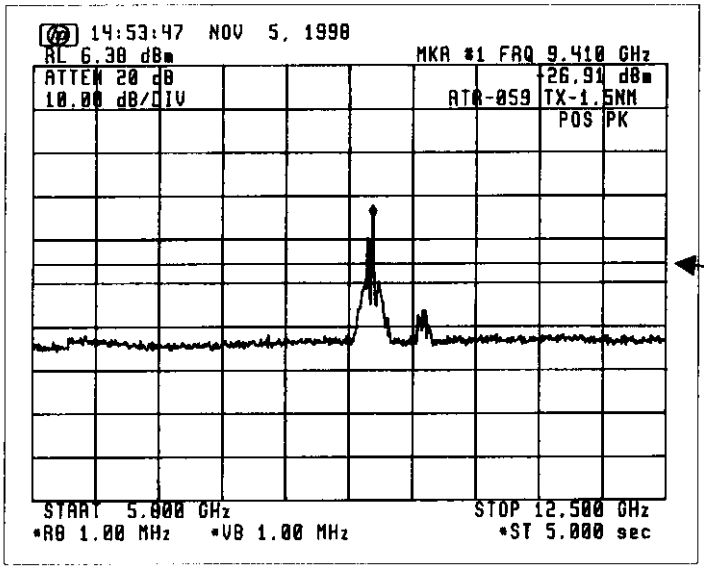

Ref. level: 6.38 dBm

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)

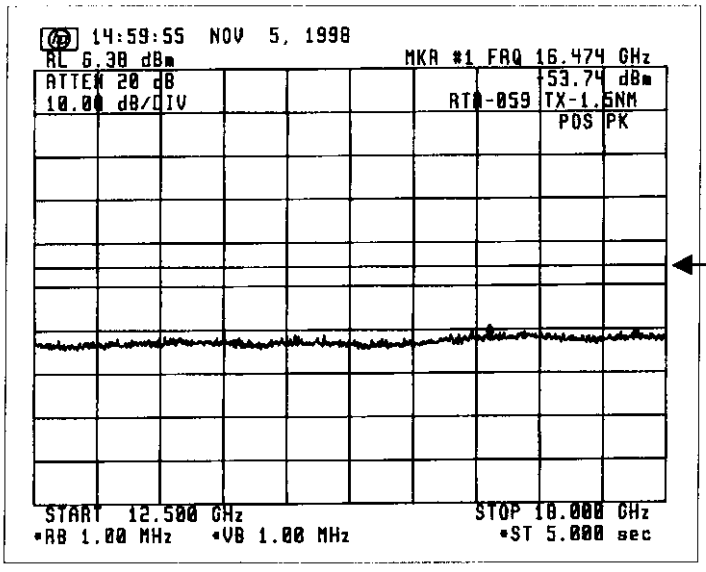
Fig. 2.1 Without Filter




Emission limitations:

(c) 43 + 10 log Pm = 45.42 dB for more than 250 % of the authorized BW (100 MHz)

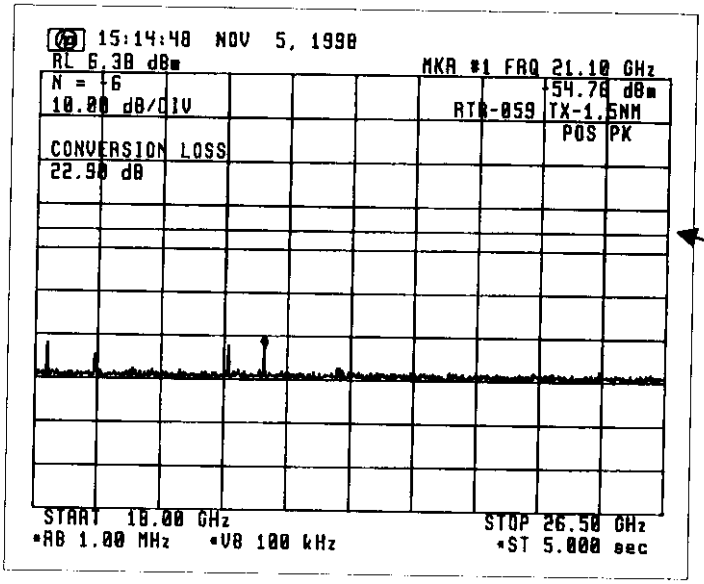
Fig. 2.2 With Filter No.1




Emission limitations:

(c) 43 + 10 log Pm = 45.42 dB for more than 250 % of the authorized BW (100 MHz)

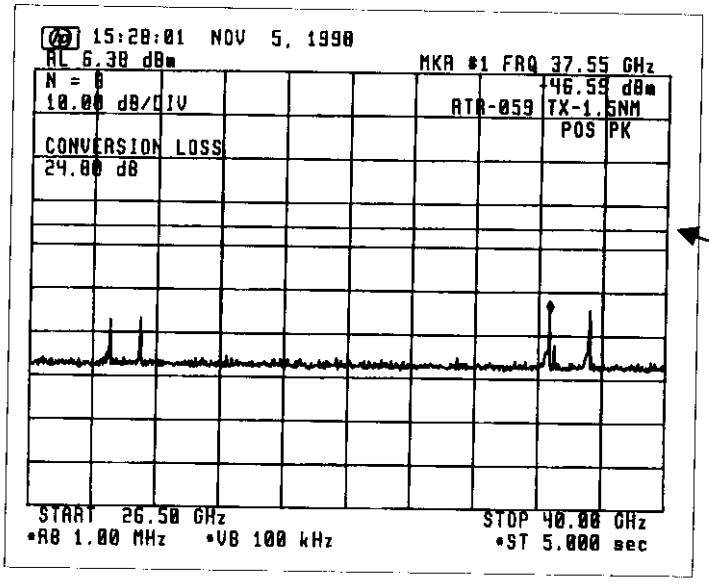
Fig. 2.3 With Filter No. 2




Emission limitations:

(c) 43 + 10 log Pm = 45.42 dB
for more than 250 % of
the authorized BW (100 MHz)

Fig. 2.4 With Filter No. 2

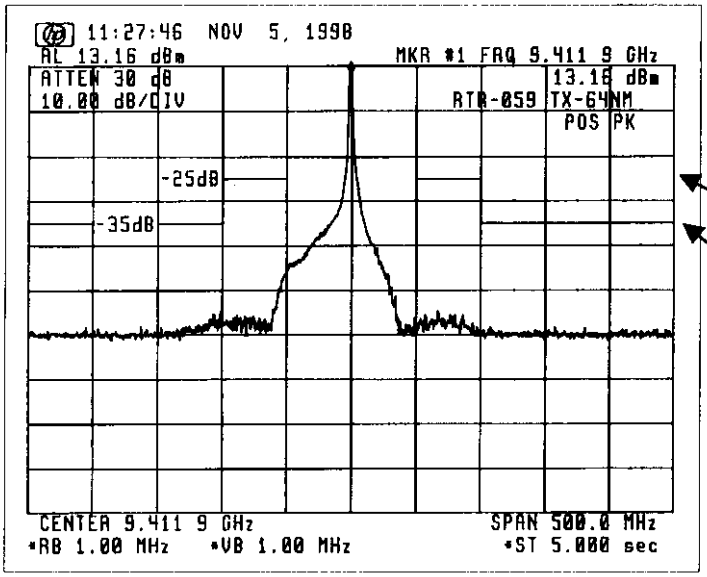



Emission limitations:

(c) 43 + 10 log Pm = 45.42 dB
for more than 250 % of
the authorized BW (100 MHz)

Fig. 2.5 With Filter No. 2

3. Spurious emissions for 64 nm Range:



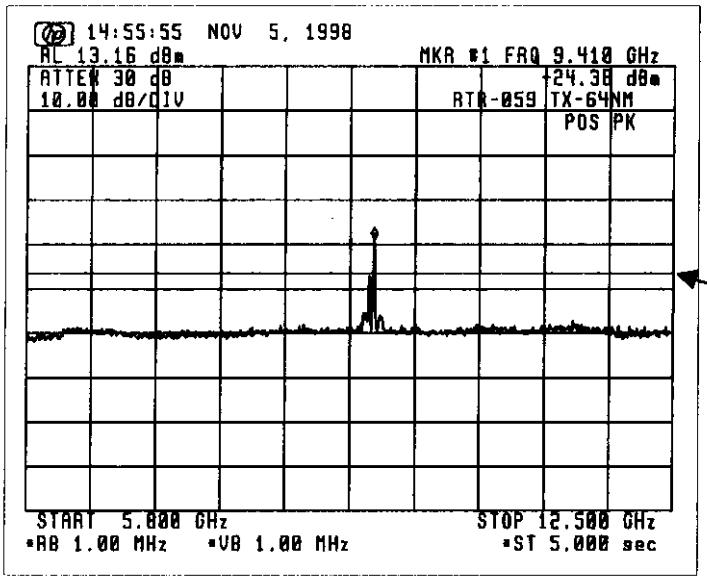

Ref. level: 13.16 dBm

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)

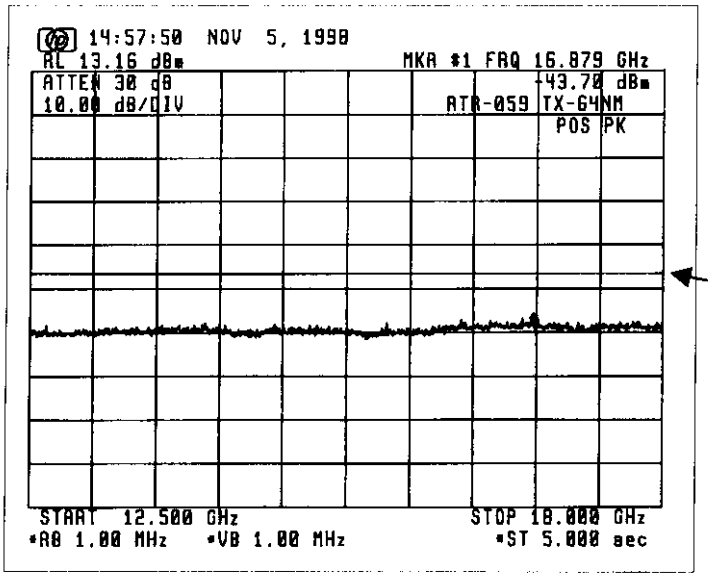
Fig. 3.1 Without Filter




Emission limitations:

(c) 43 + 10 log Pm = 46.37 dB for more than 250 % of the authorized BW (100 MHz)

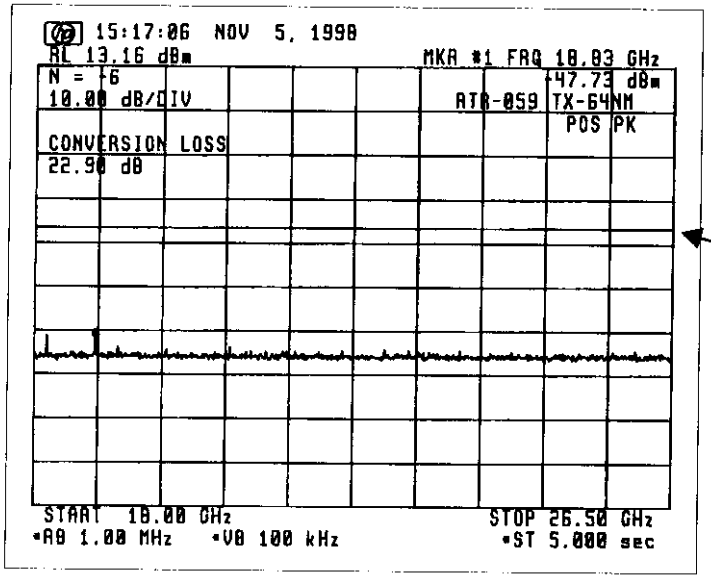
Fig. 3.2 With Filter No.1




Emission limitations:

(c) 43 + 10 log Pm = 46.37 dB for more than 250 % of the authorized BW (100 MHz)

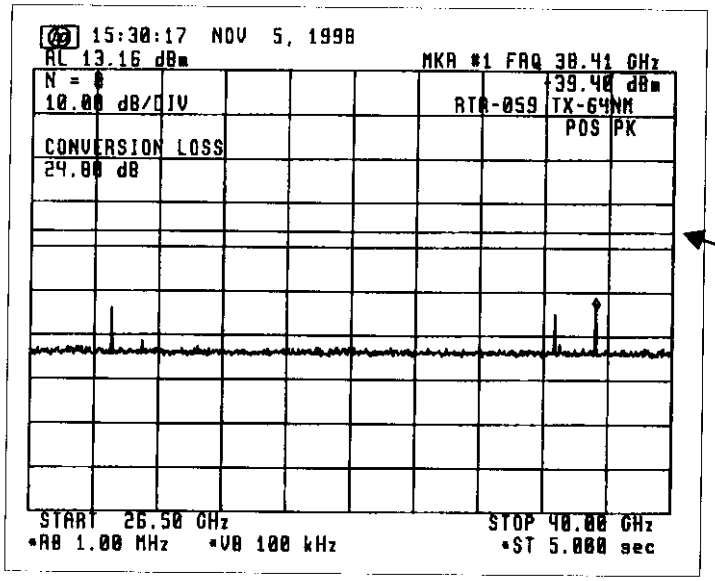
Fig. 3.3 With Filter No. 2




Emission limitations:

(c) 43 + 10 log Pm = 46.37 dB
for more than 250 % of
the authorized BW (100 MHz)

Fig. 3.4 With Filter No. 2

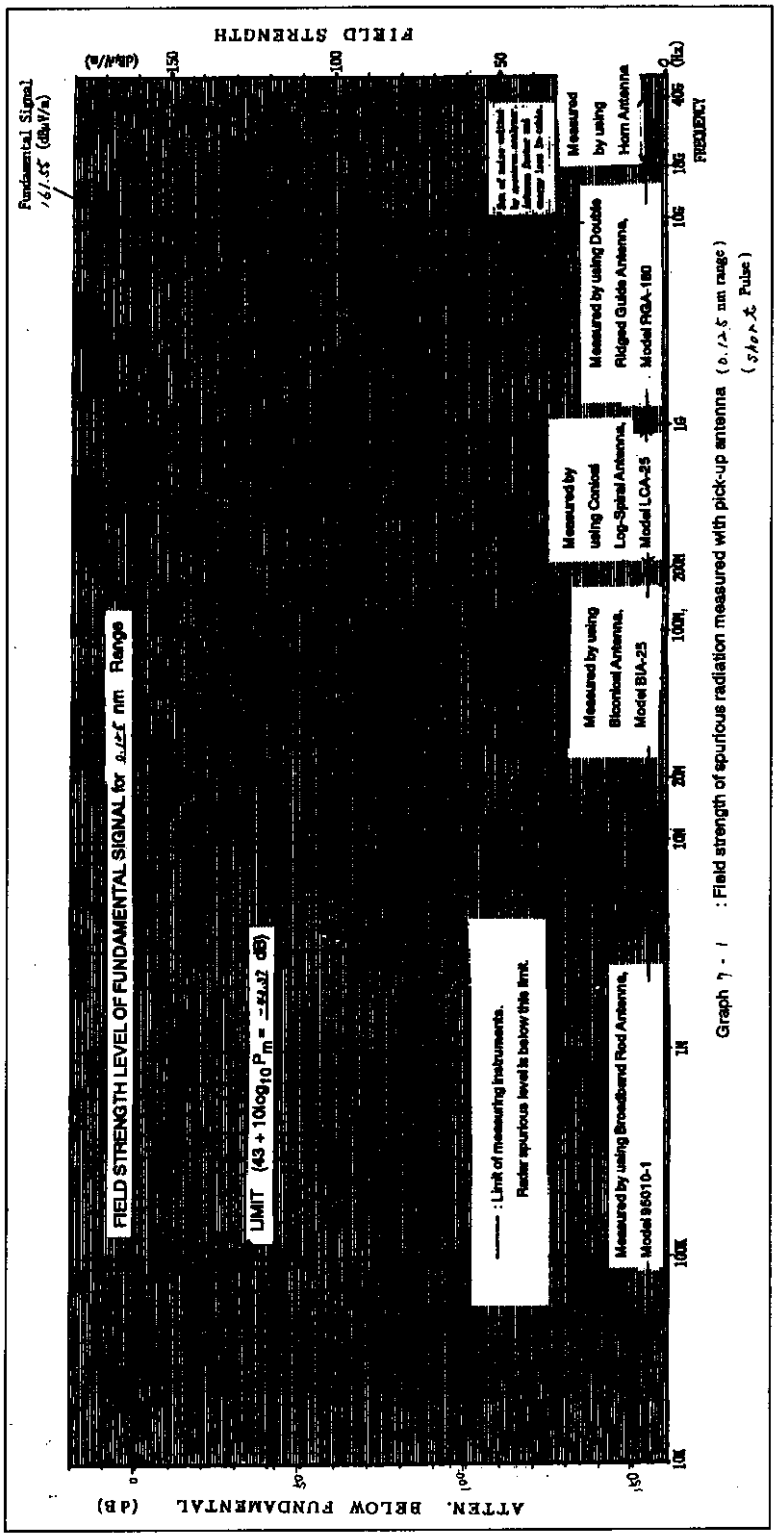



Emission limitations:

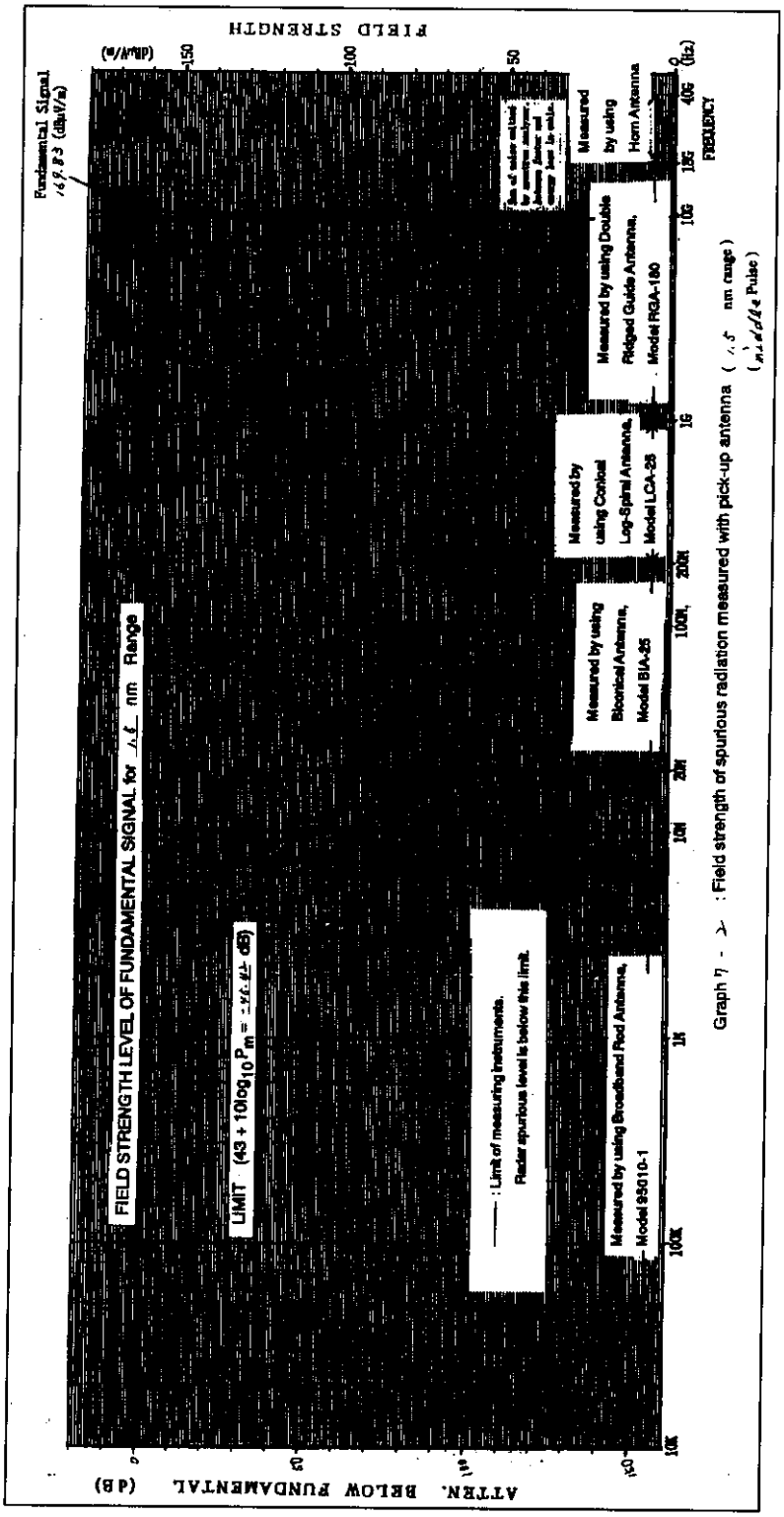
(c) 43 + 10 log Pm = 46.37 dB
for more than 250 % of
the authorized BW (100 MHz)

Fig. 3.5 With Filter No. 2

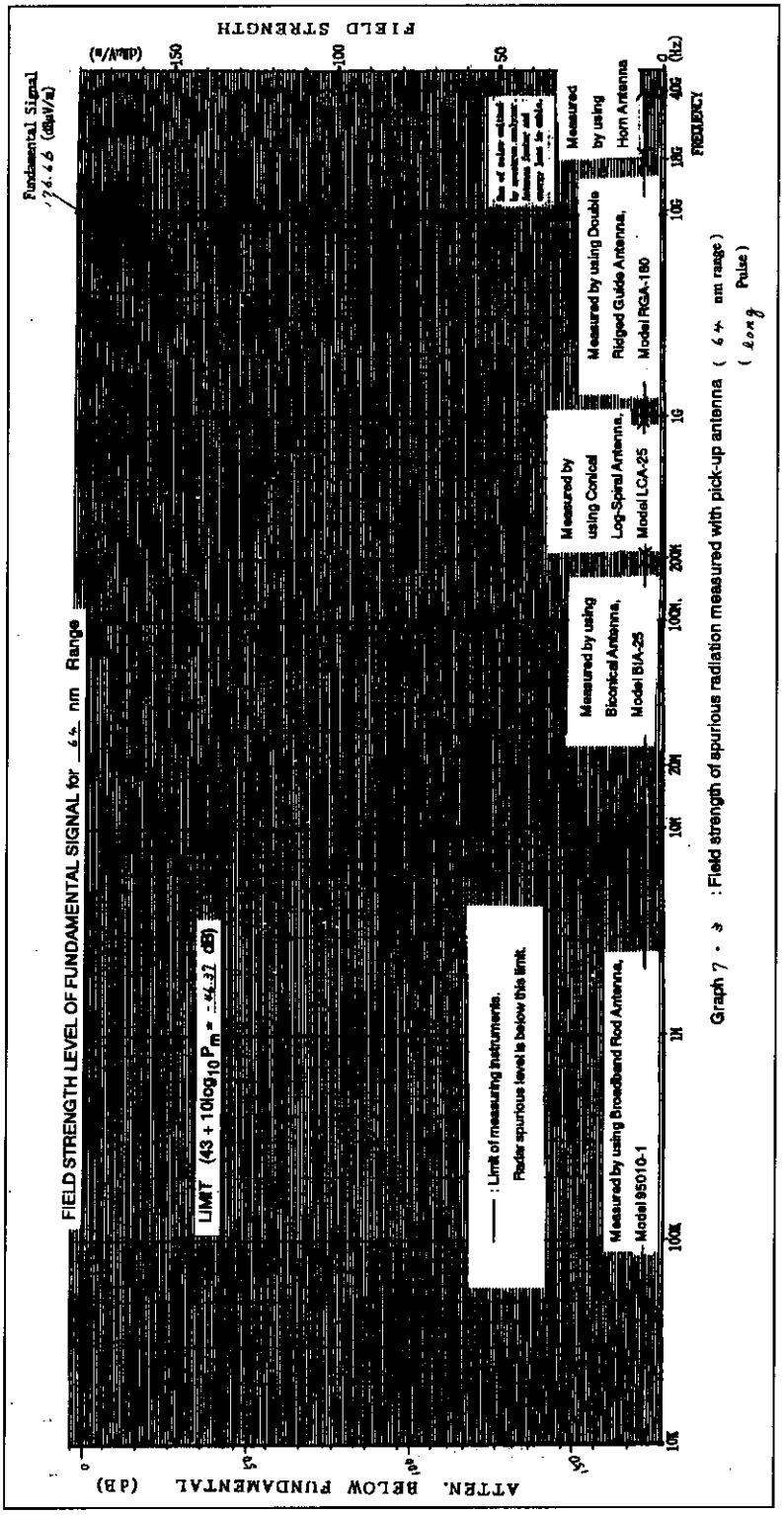
ATTACHMENT 2 [TEST DATA FOR 7. FIELD STRENGTH OF SPURIOUS RADIATION]




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




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



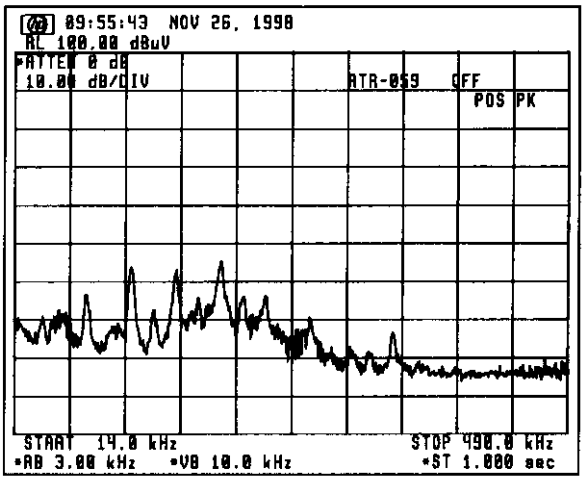

Graph 7 - 3 : Field strength of spurious radiation measured with pick-up antenna ( 4λ nm range )
( Long Pulse )

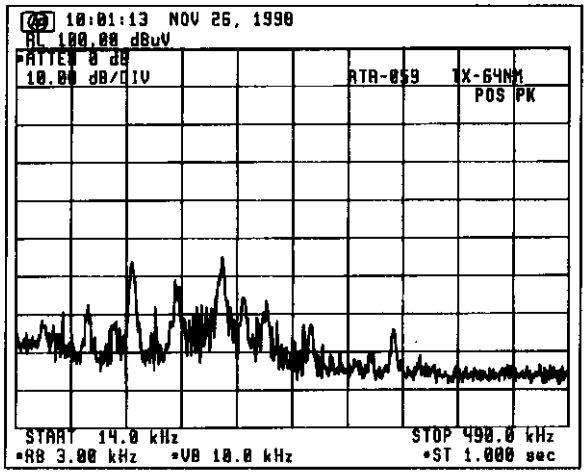
# ATTACHMENT 3

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

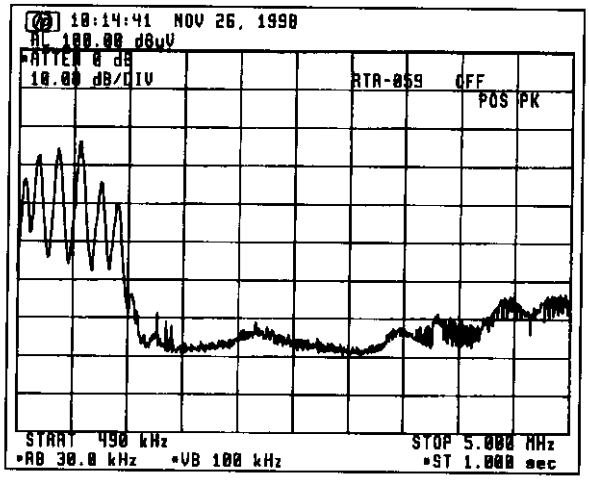
1. Harmful Interference to Receiver

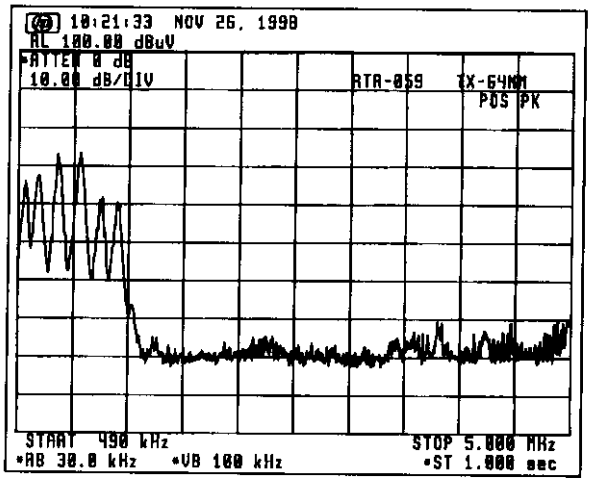
(Band : 14 kHz - 490 kHz)



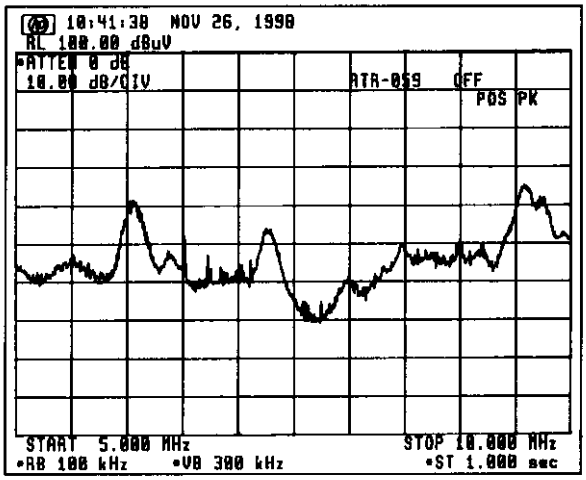



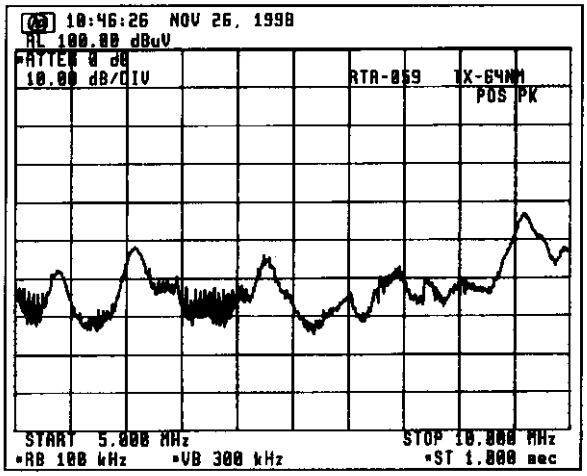
(Band : 490 kHz - 5 MHz)



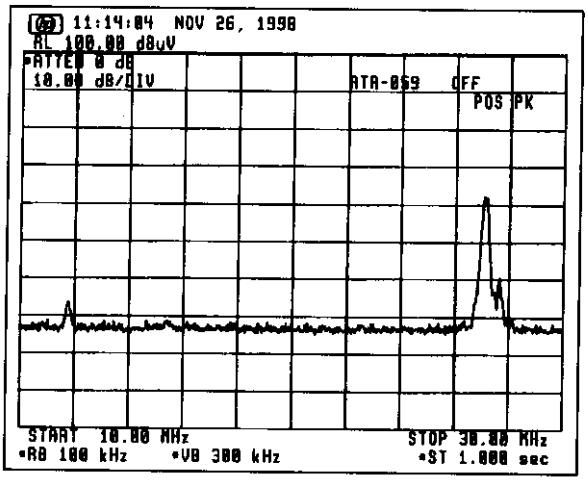



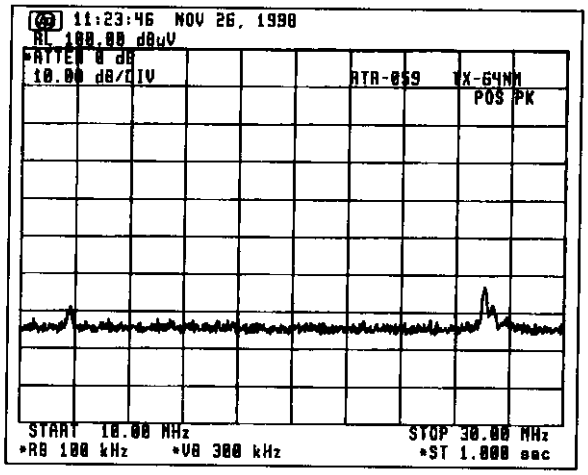
(Band : 5 MHz - 10 MHz)



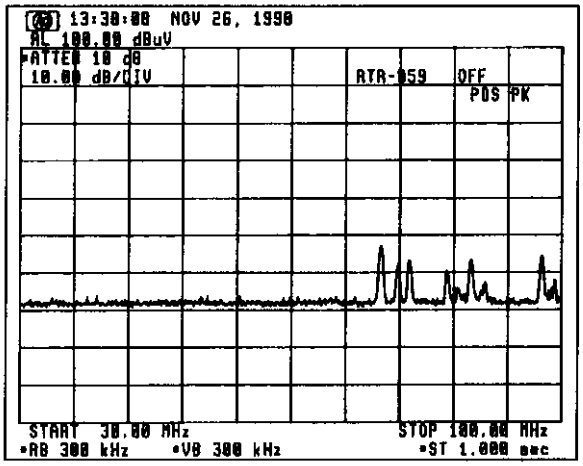



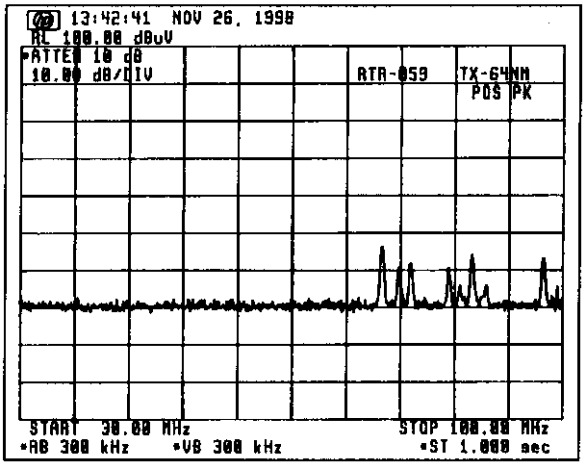
(Band : 10 MHz - 30 MHz)



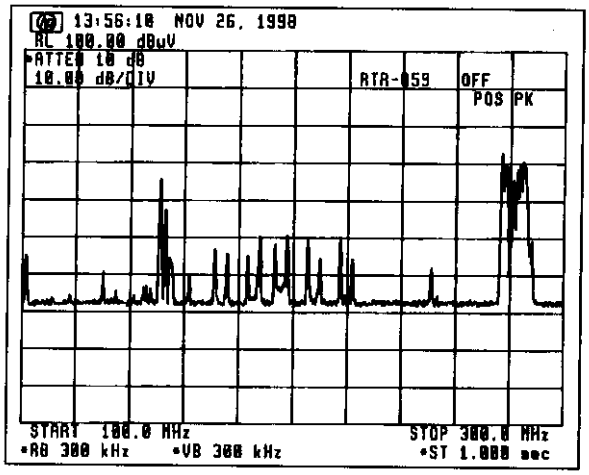



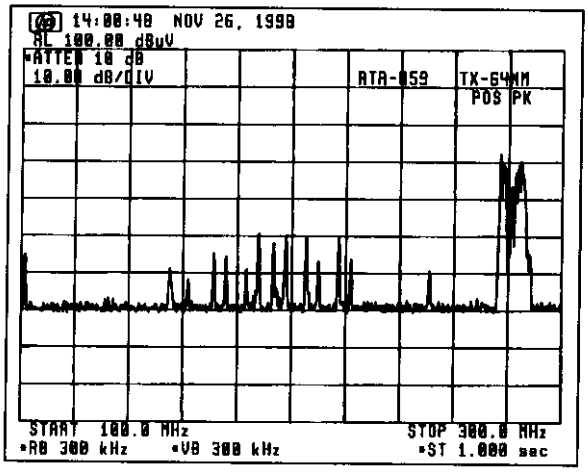
(Band : 30 MHz - 100 MHz)



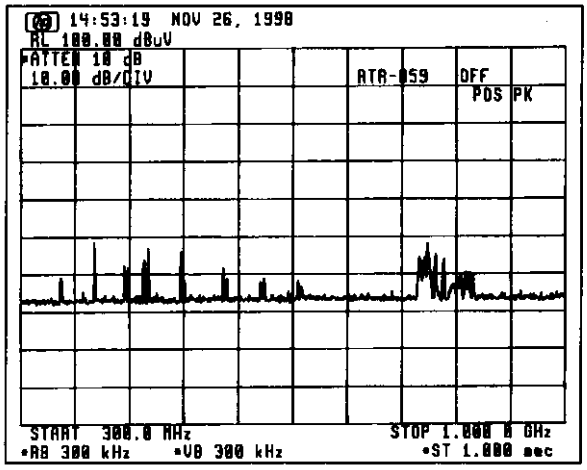



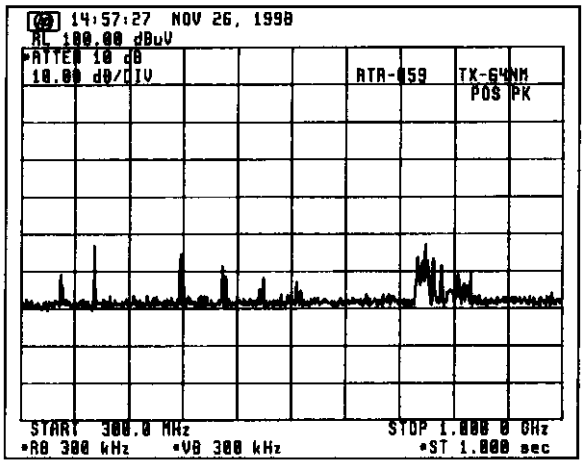
(Band : 100 MHz - 300 MHz)



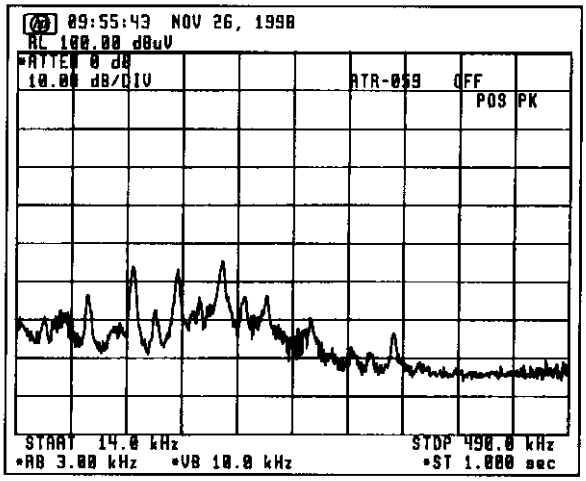
(Band : 300 MHz - 1 GHz)



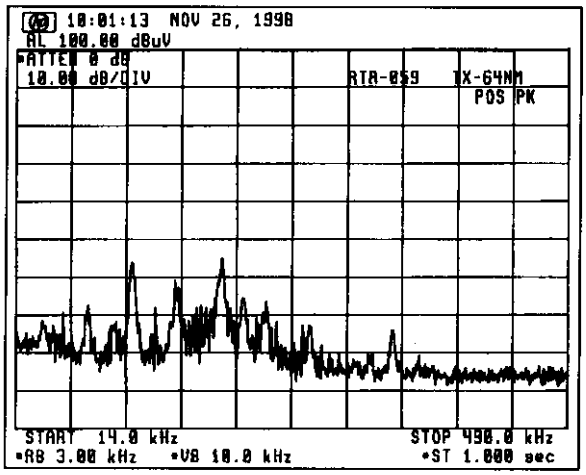



2. Electromagnetic Field

(Band : 14 kHz - 490 kHz, Limit at 1 nm = 0.1 μV/m = -20 dBμV/m)

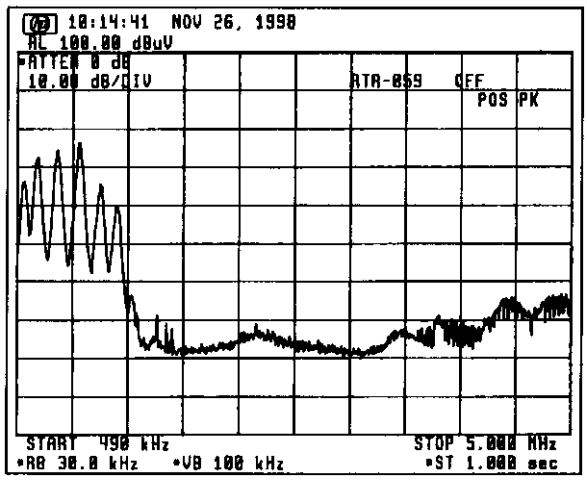


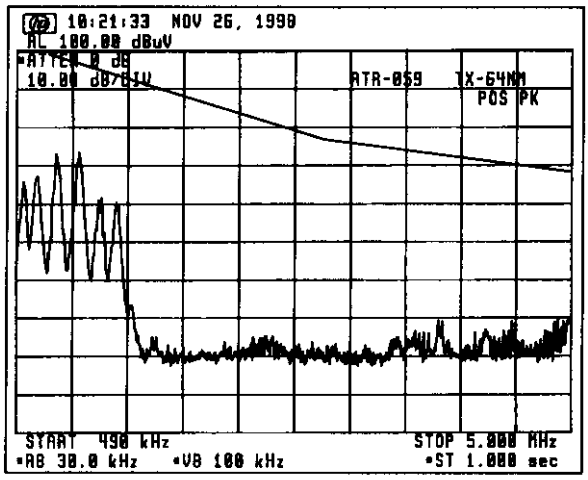

-26 dBμV/m




-26 dBμV/m

(Band : 490 kHz - 5 MHz, Limit at 1 nm = 0.1 μV/m = -20 dBμV/m)

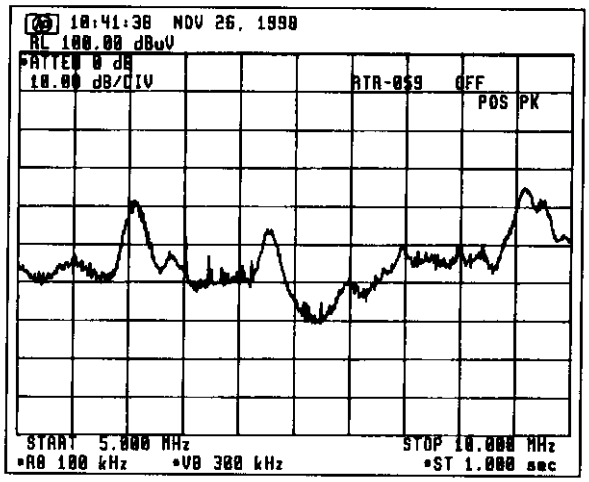


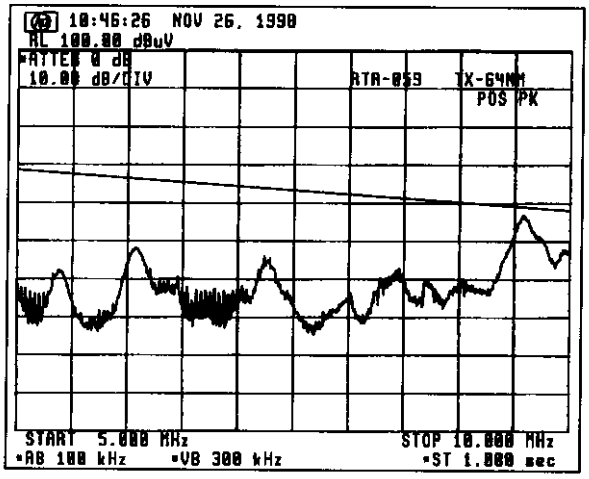




Ref. level (dBμV/m)
= 126 - 100 = 26 (at 0.5 MHz)
= 100 - 96 = 4 (at 3 MHz)
= 100 - 88 = 12 (at 5 MHz)

-20 dBμV/m limit line

(Band : 5 MHz - 10 MHz, Limit at 1 nm = 0.1 μV/m = -20 dBμV/m)

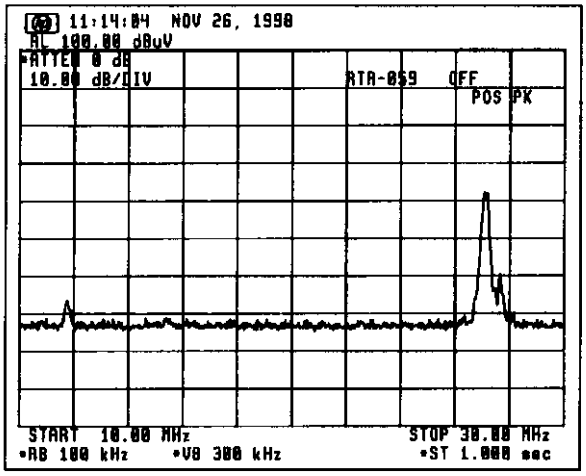


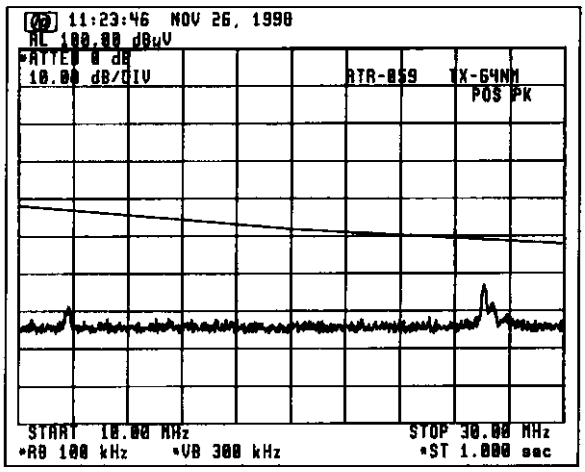




Ref. level (dBμV/m)
= 100 - 88 = 12 (at 5 MHz)
= 100 - 83 = 17 (at 7 MHz)
= 100 - 78 = 22 (at 10 MHz)

-20 dBμV/m limit line

(Band : 10 MHz - 30 MHz, Limit at 1 nm = 0.1 μV/m = -20 dBμV/m)

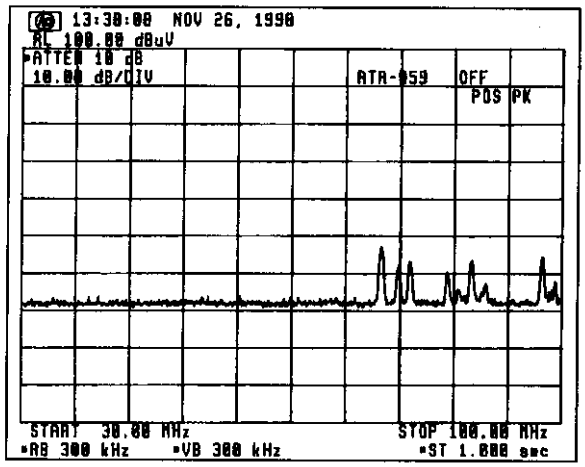


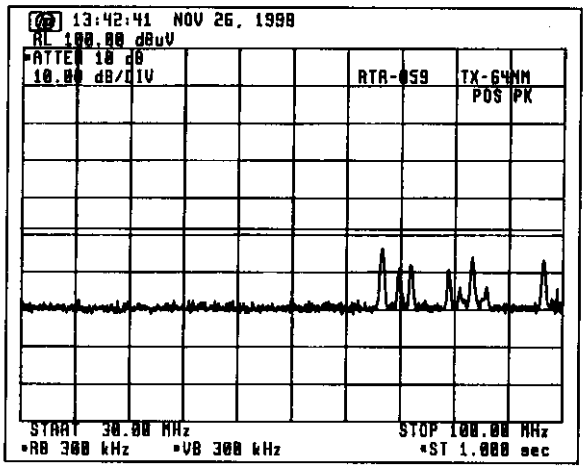




Ref. level (dBμV/m)
= 100 - 78 = 22 (at 10 MHz)
= 100 - 70 = 30 (at 20 MHz)
= 100 - 67 = 33 (at 30 MHz)

-20 dBμV/m limit line

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

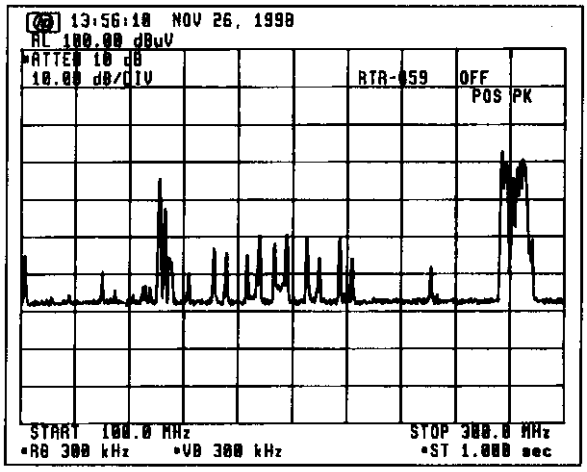


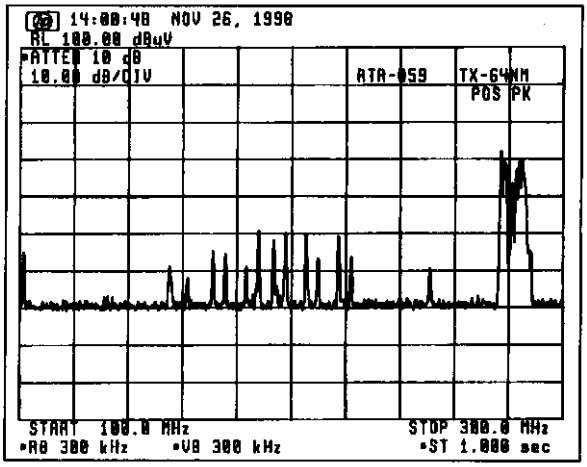




Ref. level (dBμV/m)
= 100 - 61 = 39

- 10.5 dBμV/m limit line

(Band : 100 MHz - 300 MHz, Limit at 1 nm = 0.1 μV/m = -0 dBμV/m)



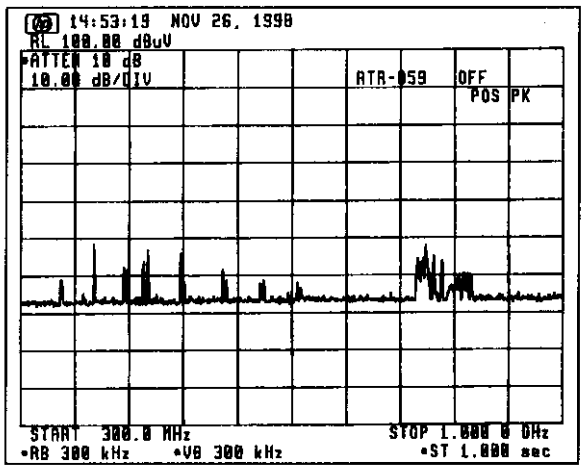



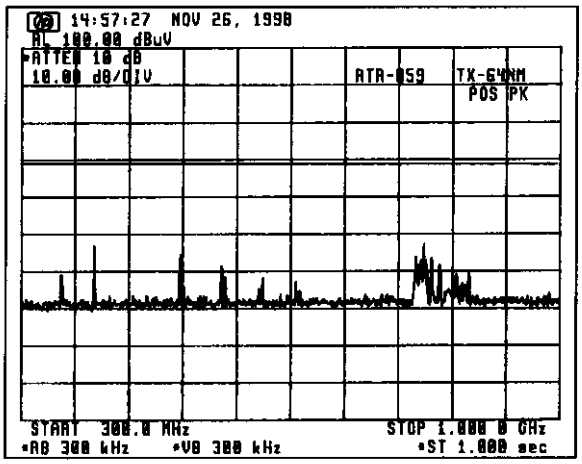

Ref. level (dBμV/m)
= 100 - 60 = 40

0 dBμV/m limit line

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

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



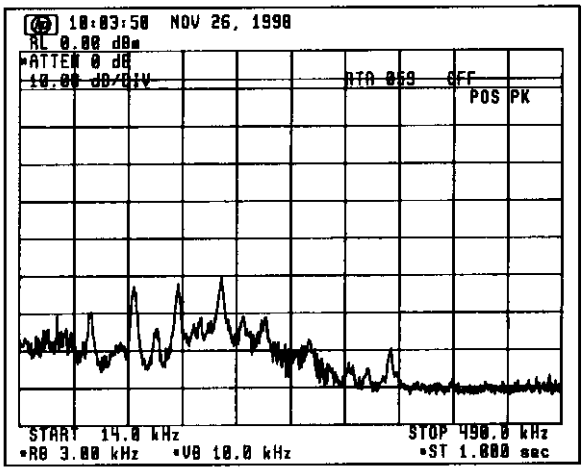



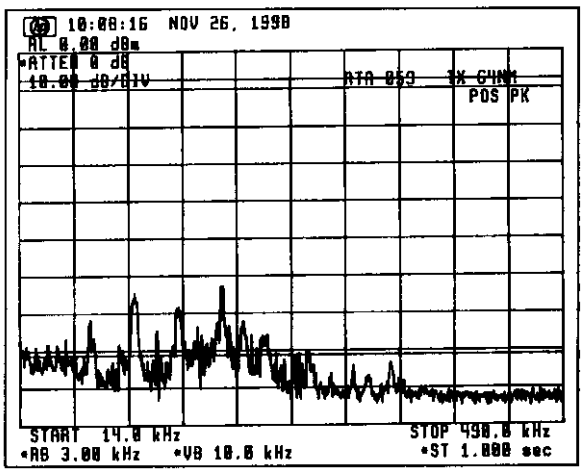

Ref. level (dBμV/m)
= 100 - 59.5 = 40.5

9.5 dBμV/m limit line

3. Power Input to an Artificial Antenna

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

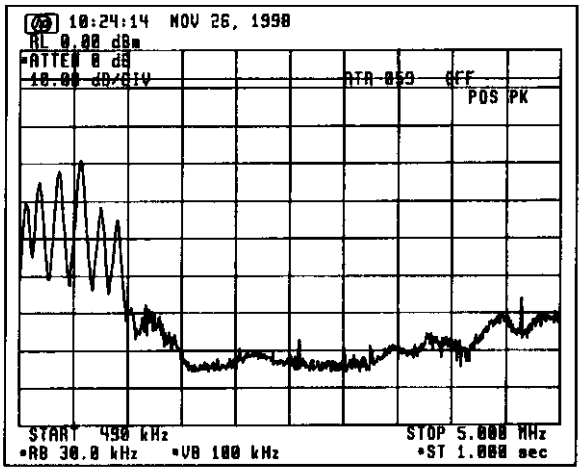


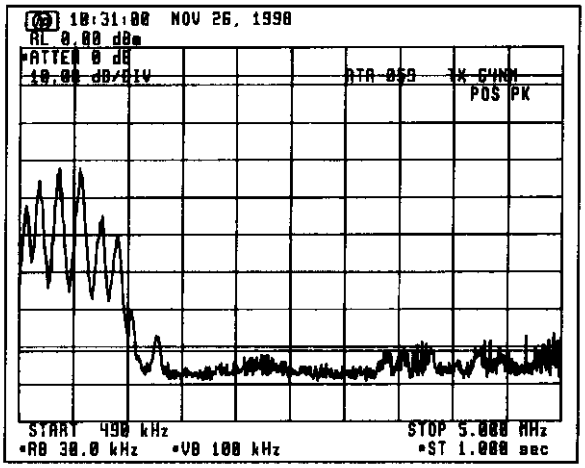




-81 dBm limit line

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)

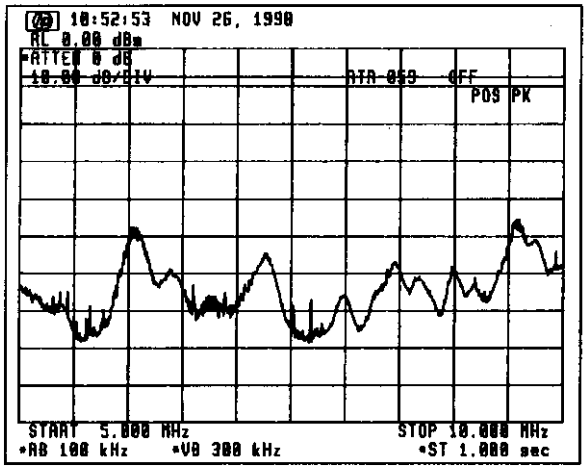


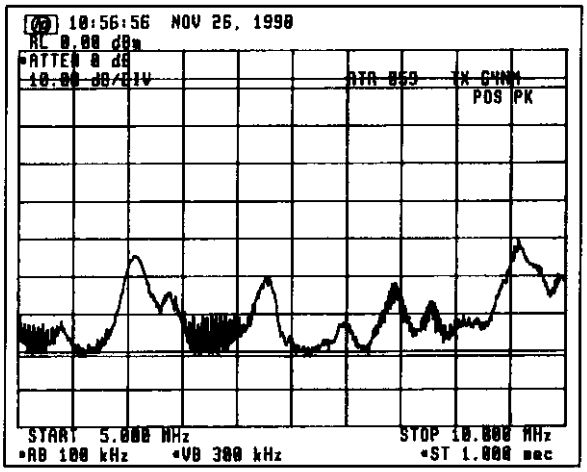




-81 dBm limit line

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)

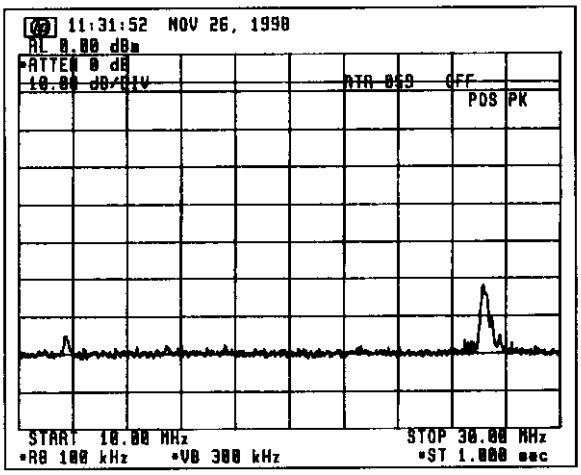


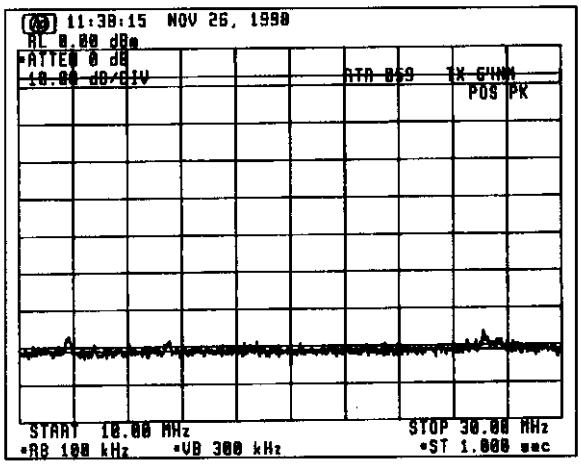




-81 dBm limit line

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)

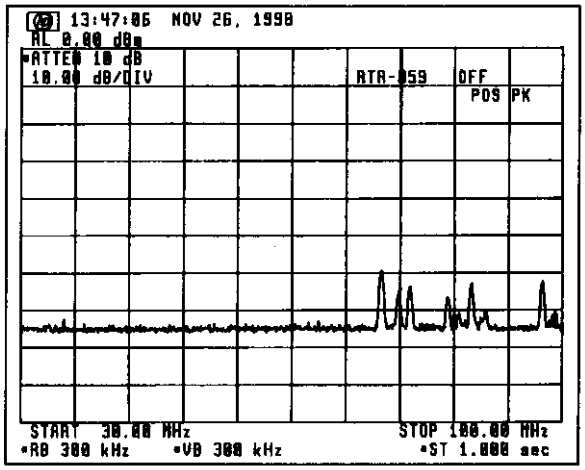


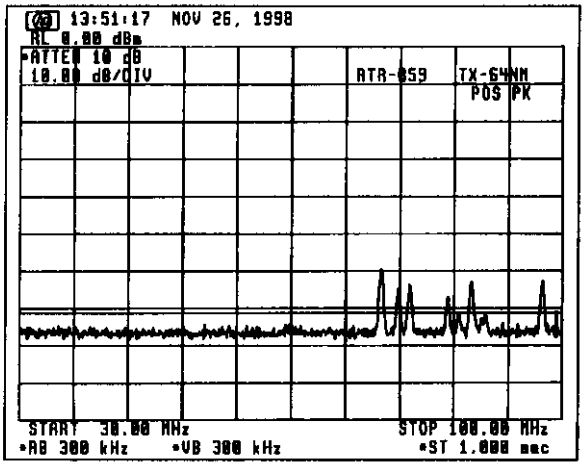




-81 dBm limit line

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)

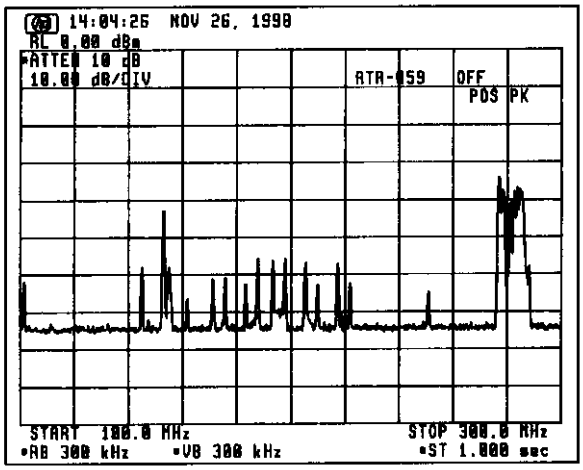


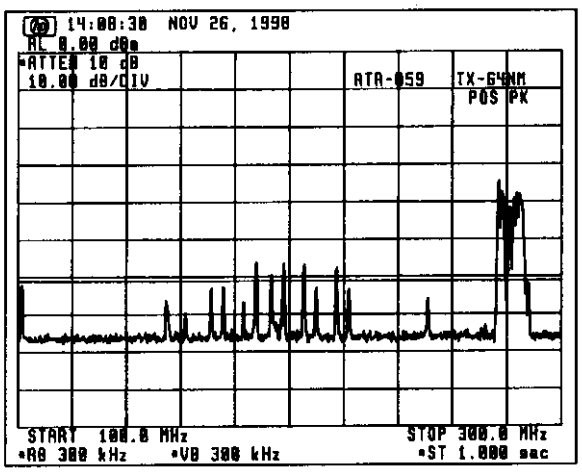




-71 dBm limit line

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)

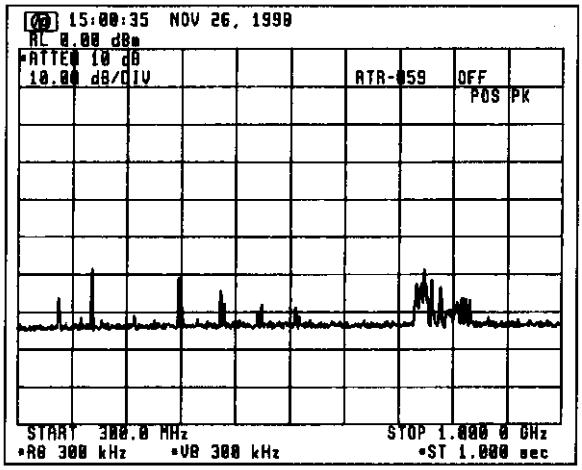


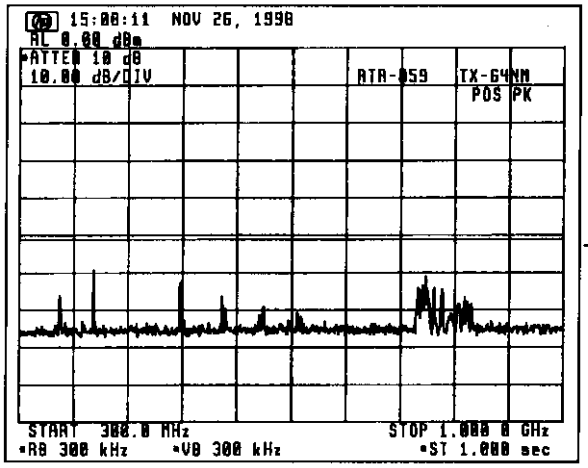




-61 dBm limit line

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 ] (for X-band radar)

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 | 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

| 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 | 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 |
| Atten uator (10 dB) | 8491A | 36122 | HP |
| Atten uator (20 dB) | 8491A | 40072 | 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 | R5762 | Shimada |
| Dummy Load: | ---- | 8411057 | Shimada |
| Environmental Chamber: | PL-4E | 1632712 | Tabai Espec |

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 |
| Atten uator (10 dB) | 8491A | 36122 | HP |