LABOTECH

TECHNICAL INFORMATION

TEST REPORT ON THE PERFORMANCE OF MARINE RADAR

Trade Mark : FURUNO

Transceiver Type : RTR-069

Report no.: FLI 12-01-056
Date of issue: December 12, 2001

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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.

All tests were performed by:

Name : Katsumi Imamura

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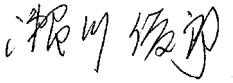
Name : Toshiro Segawa

Function : Manager, QA

Signature : 

This report has been verified and approved by:

Date : December 12, 2001

Name : Mitsuyoshi Komori

Function : Manager, Technical Section

Signature : 

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1 General Information

1.1 General

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

(b) Models: MODEL 1752

	MODEL 1752
Display unit	RDP-130 (S/N: 4305-0030)
Antenna unit:	RSB-0091 (S/N: R124-0004)
Transceiver:	RTR-069 (contained in Antenna unit)
Radiator:	XN065BF

(c) Primary Function: Search, Navigation and anticollison

(d) Discrimination

Range Discrimination: 20 meters on a range scale of 0.25 nm
Bearing Discrimination:3.5 ° on a range scale of 0.25 nm

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

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

(g) Power Supply: 12 - 24 VDC

1.2 Antenna Unit

1.2.1 Transceiver

Type: RTR-069

(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: E3571A/E3571 MG5388/MG4004
Peak Output Power: 4 kW nominal

(c) Magnetron Ratings
Center frequency of Magnetron: 9410 MHz
Tolerances

	E3571A/E3571	MG5388/MG4004
Manufacturing:	±30 MHz,	±30 MHz
Pulling:	27 MHz,	27 MHz

Tolerance for 20°C temperature variation: -5 MHz, -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 (b))

(e) Pulse Characteristics:

Range Scale (nm)	(Short)	(Middle)	(Long)
	<u>0.125</u>		
	0.25		
	0.5		
	0.75		
	1		
	1.5	1.5	
		2	
		<u>3</u>	3
			4
			6
			8
			12
			16
			24
			<u>36</u>
Pulselength (µs)	0.08	0.30	0.80
P. R. R. (Hz)	2100	1200	600
Duty cycle	1.68×10^{-4}	3.60×10^{-4}	4.80×10^{-4}
Guard Band (MHz)	18.75	5.00	1.88

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

(2) Modulator

(a) FET Type: 2SK1449

Trigger Voltage: Approx. +20 VDC positive

(3) Receiver

(a) Passband (MHz)

RF Stage: 100 MHz

IF Stage:

Pulselength	Short	Middle	Long
(MHz) (typ.)	10	3	3

Video Amp.:

Pulselength	Short	Middle	Long
(MHz) (typ.)	30	2.6	1.0

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

Pulselength	Short	Middle	Long
(MHz) (typ.)	90	98	98

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

(d) Video Output Voltage (V): 4 V positive

(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)

1.2.2 Antenna

(a) Antenna Rotation ON-OFF Switch:

Not Provided.

(b) Reflector: Type: XN065BF

Slotted waveguide array, 65 cm long

(c) Type of Beam: Vertical fan

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

Horizontal	3.4°
Vertical	30°

(e) Polarization: Horizontal

(f) Antenna Gain: 22.5 dB

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

Within ±20°	-20 dB or less
Outside ±20°	-25 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.

(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.

1.3 Display Unit

(a) Type: 7 (in.) monochrome LCD
240 X 320 pixels

(b) Size of Indicator: 7 in. diagonal
effective dia. 96 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
4	4	1
6	3	2
8	4	2
12	4	3
16	4	4
24	4	6
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: Not provided

1.4 Functional Controls

Range selector	Power Switch	FTC switch 2)
A/C Rain control 2)	STC control 2)	Gain control 2)
Panel dimmer 2)	Heading line off	Echo stretch 2)
MENU	Guard zone 2)	Range ring on/off 2)
Interference rejecter 2)	ST-BY/TX 2)	Arrow keys (VRM/EBL/GUARD)
VRM on/off 2)	SHIFT	Range set 2)
Zoom 2)	EBL on/off 2)	Echo Trail 2)
Contrast 2)	PLOT brilliance 2)	Navigation on/off 1),2)
Anchor watch 2)	Display brilliance 2)	TRU/REL 2) 3)
Mode 2) 3)	TLL 1) 2) 3)	Offcenter 2)
Chart display [2)]	Waypoint [2)]	Date box [1) 2)]

Note: [1)] Valid when interfaced with navaid

[2)] Selected on menu

[3)] Valid when interfaced with gyrocompass

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:

Yes (Magnetron/X'tal 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)

1.6 Line Power Supply Requirements

(a) Input Voltage: 12 - 24 VDC

(b) Power Drain: 55 W

1.7 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 × Display Unit	Type:	RDP-130
1 × Antenna Unit	Type:	RSB-0091
Transceiver	Type:	RTR-069 (contained in the Antenna unit)

(e) Approximate Weight of Complete Installation:

Display Unit:	3.5 kg
Antenna Unit:	15 kg

(f) Approximate space required for installation excluding scanner

Display Unit:

RDP-130	416 mm (W) X 253 mm (H) X 306 mm (D)

2 Identification of Equipment (FCC Rule § 2.925)

The following nameplates are permanently fixed on the corresponding equipment units.
FCC ID: ADB9ZWRTR069
Material of nameplate: Polyester film, 0.1 mm thick

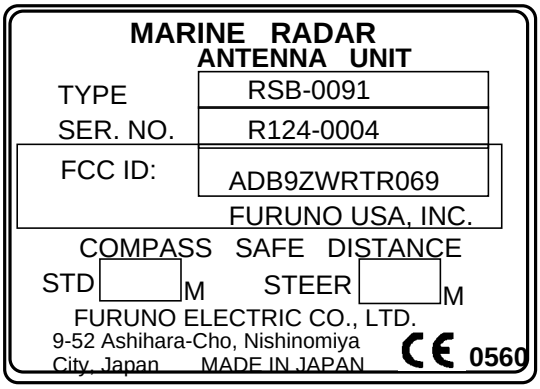


Fig. 2.1 Nameplate for Antenna Unit

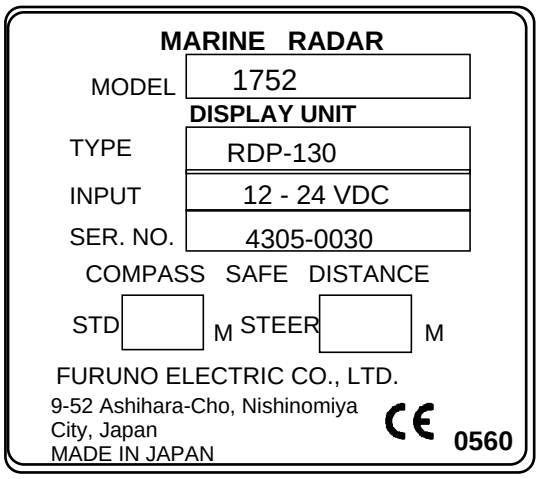


Fig. 2.2 Nameplate for Display Unit RDP-130

3 Test data

3.1 RF Power Output (FCC Rule § 2.1046)

3.1.1 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	3	36
Pulselength (µs)	0.08	0.30	0.8
PRR (Hz)	2100	1200	600
Duty cycle	1.68×10^{-4}	3.60×10^{-4}	4.80×10^{-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)	40.44	40.44	40.44
Magnetron input voltage (kV)	3.7	3.7	3.8
Pulselength (µs) (50 % amplitude)	0.172	0.510	0.120
Rise time (µs) (10-90 % amplitude)	0.052	0.110	0.120
Decay time (µs) (90-10 % amplitude)	0.160	0.184	0.060

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)	3.3	3.2	3.5
Pulselength (µs) (50 % amplitude)	0.050	0.318	0.785
Rise time (µs) (10-90 % amplitude)	0.045	0.204	0.320
Decay time (µs) (90-10 % amplitude)	0.060	0.060	0.076

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)	0.070	0.335	0.800
Rise time (µs) (10-90 % amplitude)	0.015	0.080	0.140
Decay time (µs) (90-10 % amplitude)	0.046	0.057	0.052

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	3	36
P.R.R (Hz)	2129.9	1226.3	622.6
Duty cycle	1.49×10^{-4}	4.10×10^{-4}	4.98×10^{-4}
Magnetron input, av. (W)	1.82	4.86	6.62

Pulselength	Short	Middle	Long
Magnetron input, peak (kW)	12.21	11.84	13.30
Power meter reading (mW)	0.0362	0.1145	0.1530
Magnetron output, av. (W)	0.401	1.267	1.693
Spurious response limits (dB)	39.03	44.03	45.29
Magnetron Output, peak (kW):	2.69	3.08	3.40
Magnetron efficiency (%):	22.0	26.1	25.6

Peak Power Input to RF Generator : 12.5 kW
Estimated Efficiency of RF Generator : 24.5 %

3.2 Modulation Characteristics (FCC Rule § 2.1047)

3.2.1 FET Trigger Pulse

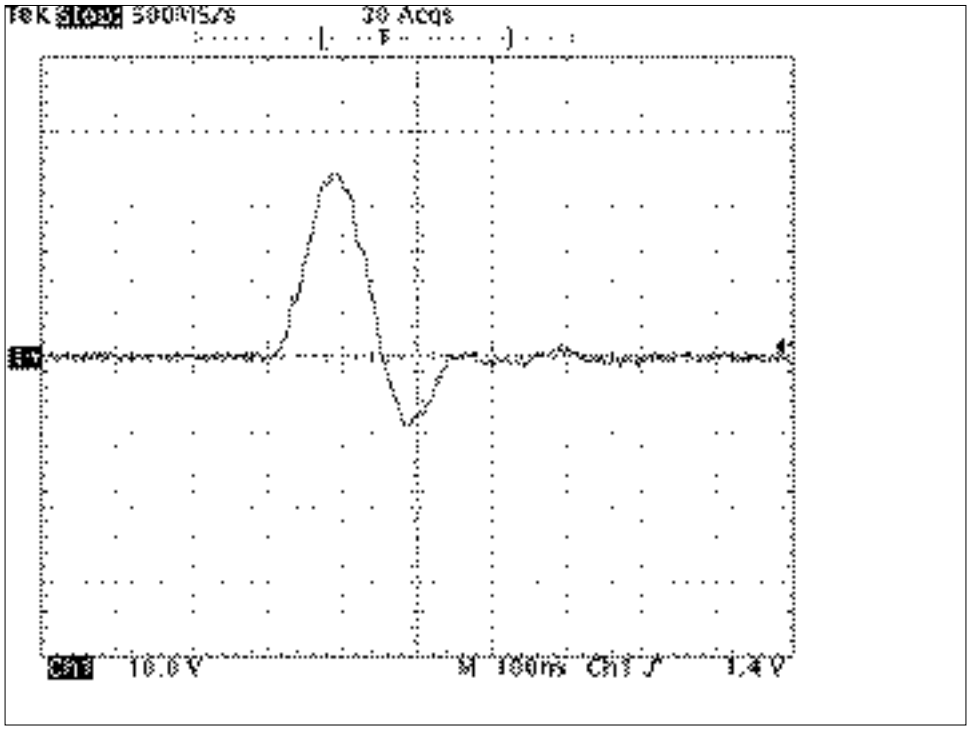


Fig. 3.2.1.1 Typical waveform of Trigger Pulse Scale: 10 V/div., 100 ns/div.

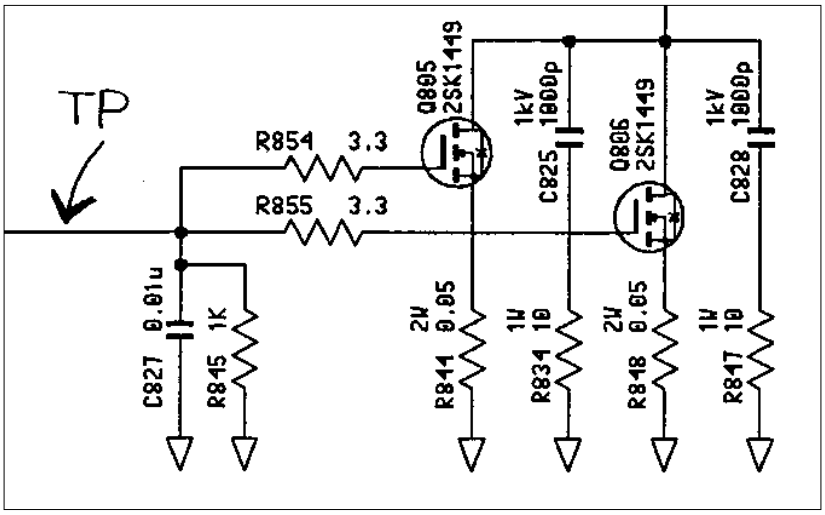


Fig. 3.2.1.2 Test Point for Trigger Pulse
(in MD board (03P9309) of Radar Antenna Unit)

3.2.2 Trigger Pulse at Magnetron Cathode

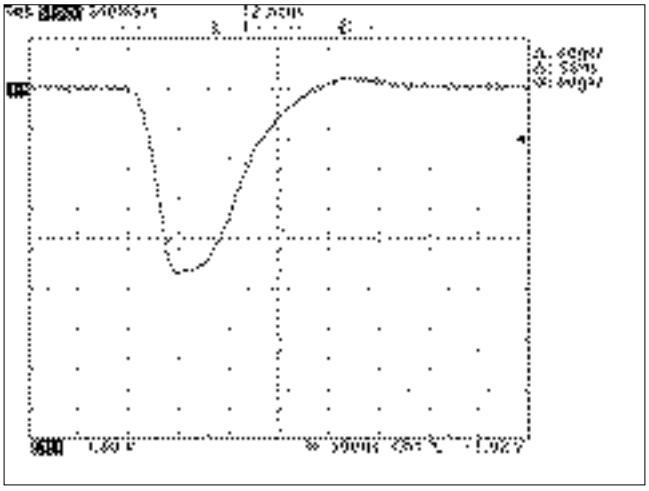


Fig. 3.2.2.1 Short Pulse (0.125 nm Range) Scale: 1 kV/div. 100 ns/div.

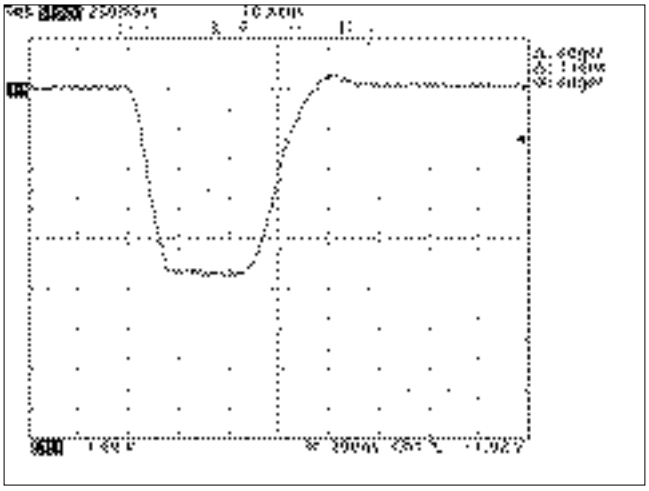


Fig. 3.2.2.2 Middle Pulse (3 nm Range) Scale: 1 kV/div. 200 ns/div.

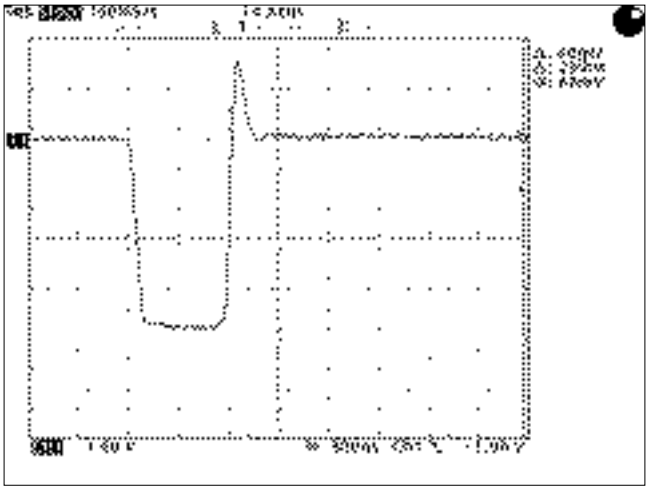


Fig. 3.2.2.3 Long Pulse (36 nm Range) Scale: 1 kV/div. 500 ns/div.

3.2.3 **Magnetron Output** (detected):

3.2.3.1 Setup for Measurement:

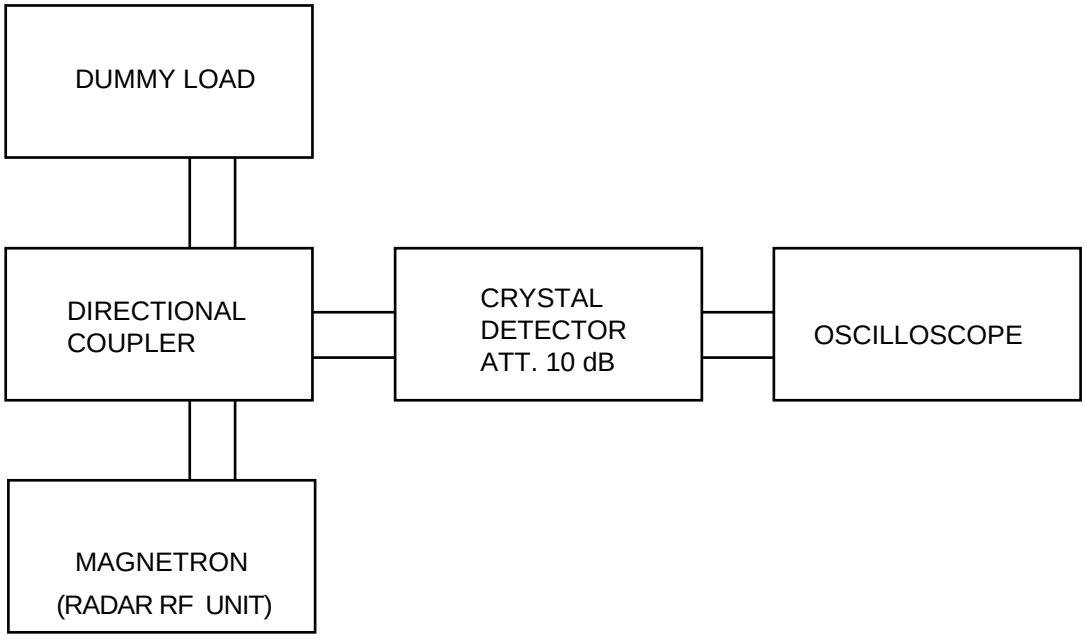


Fig. 3.2.3.1

3.2.3.2 Measuring Equipment List:

See Attachment D [List of Test/Measuring Equipment].

3.2.3.3 Measured Data:

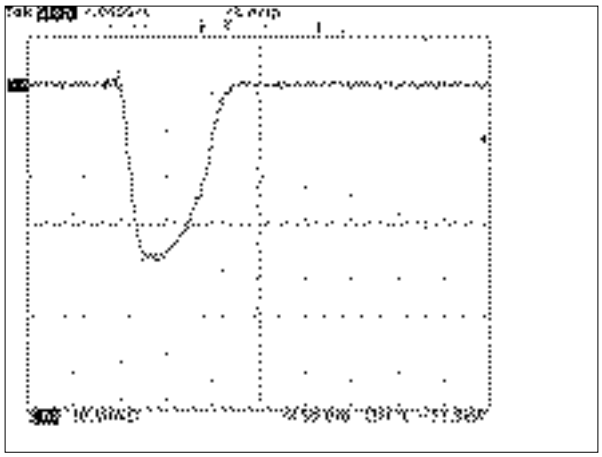


Fig. 3.2.3.2 Short Pulse (0.125 nm Range) Scale: 10 mV/div. 50 ns/div.

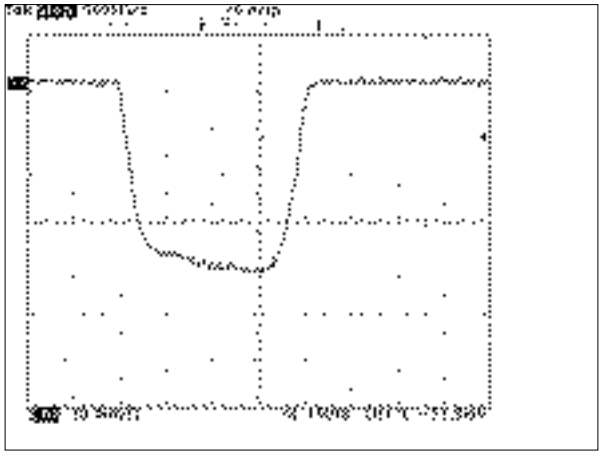


Fig. 3.2.3.3 Middle Pulse (3 nm Range) Scale: 10 mV/div. 100 ns/div.

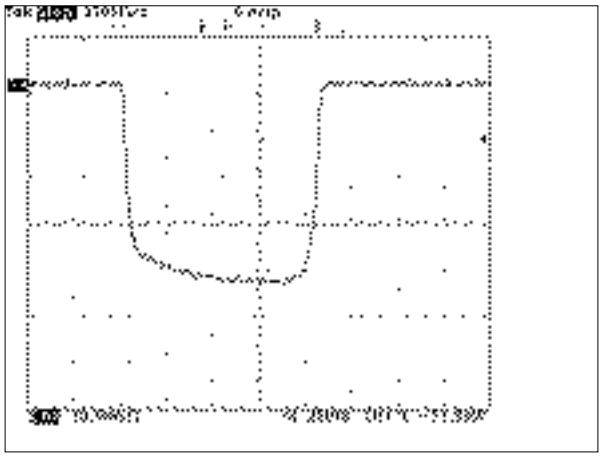


Fig. 3.2.3.4 Long Pulse (36 nm Range) Scale: 10 mV/div. 200 ns/div.

3.2.4 Radar Pulse Spectrum:

Measured by the spectrum analyzer.

(Test Equipment Setup and Measuring Equipment List are same as Clause 3.4.1 and 3.4.2.)

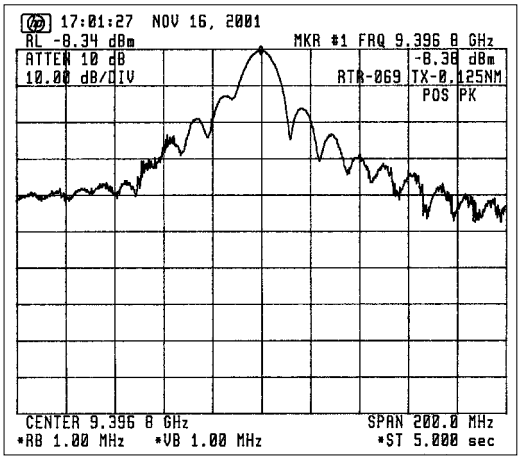


Fig. 3.2.4.1 For Short Pulse (0.125 nm Range)

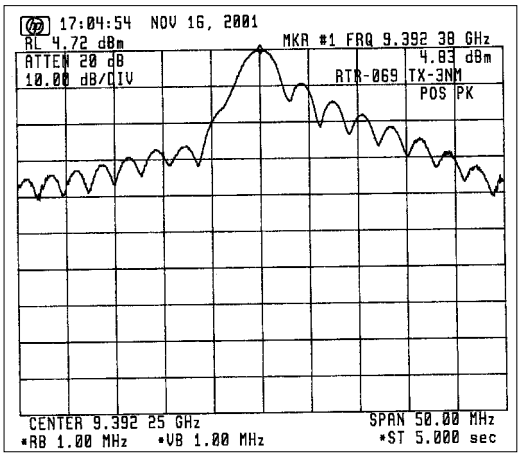


Fig. 3.2.4.2 For Middle Pulse (3 nm Range)

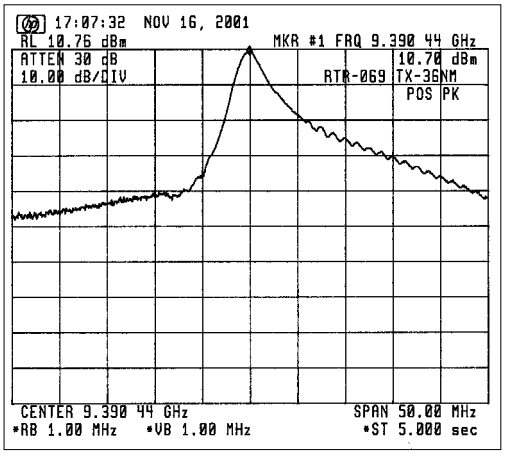


Fig. 3.2.4.3 For Long Pulse (36 nm Range)

3.3 Occupied Bandwidth (FCC Rule § 2.1049)

3.3.1 Measuring Method

FCC rule 47 CFR 2.1049 requires measurements of the occupied bandwidth which is defined in the same section as "the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission." To obtain the occupied bandwidth of the radar transmitter, a special program (program list shown below) was loaded to the Hewlett-Packard spectrum analyzer and run by entering the HP-provided POWER BANDWIDTH calculation command [PWRBW].

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

POWER_BW=----- MHz

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

Fig. 3.3.1 Program for Calculation of Occupied Bandwidth

3.3.2 Test Equipment Setup:

Same as Clause 3.4.1.

3.3.3 Measuring Equipment List:

Same as Clause 3.4.2.

3.3.4 Test Result:

The test result is shown below.

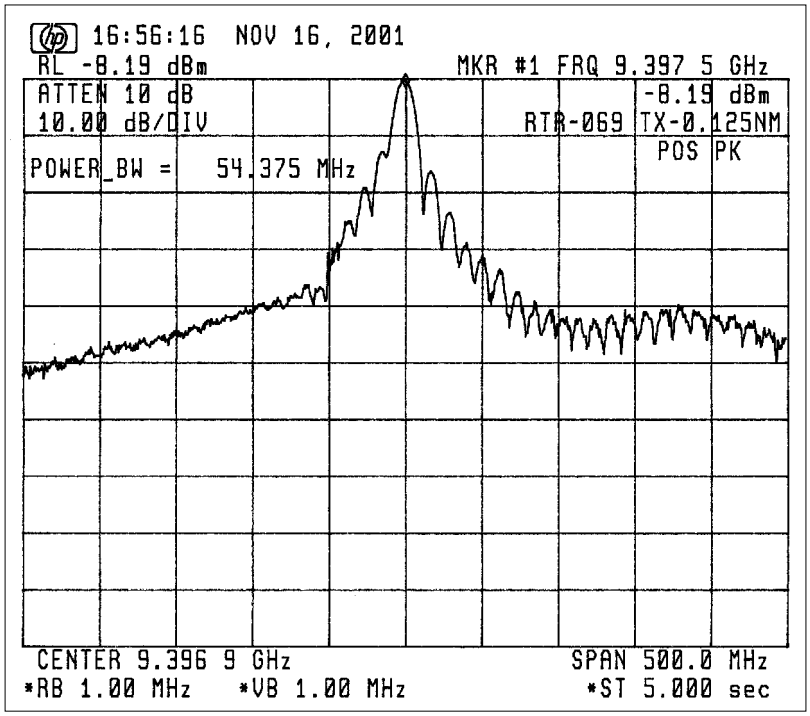


Fig. 3.3.2 Measurement of Occupied Bandwidth

Occupied bandwidth = 54.375 MHz

3.4 Spurious Emissions at Antenna Terminal (FCC Rule § 2.1051)

3.4.1 Test Equipment Setup:

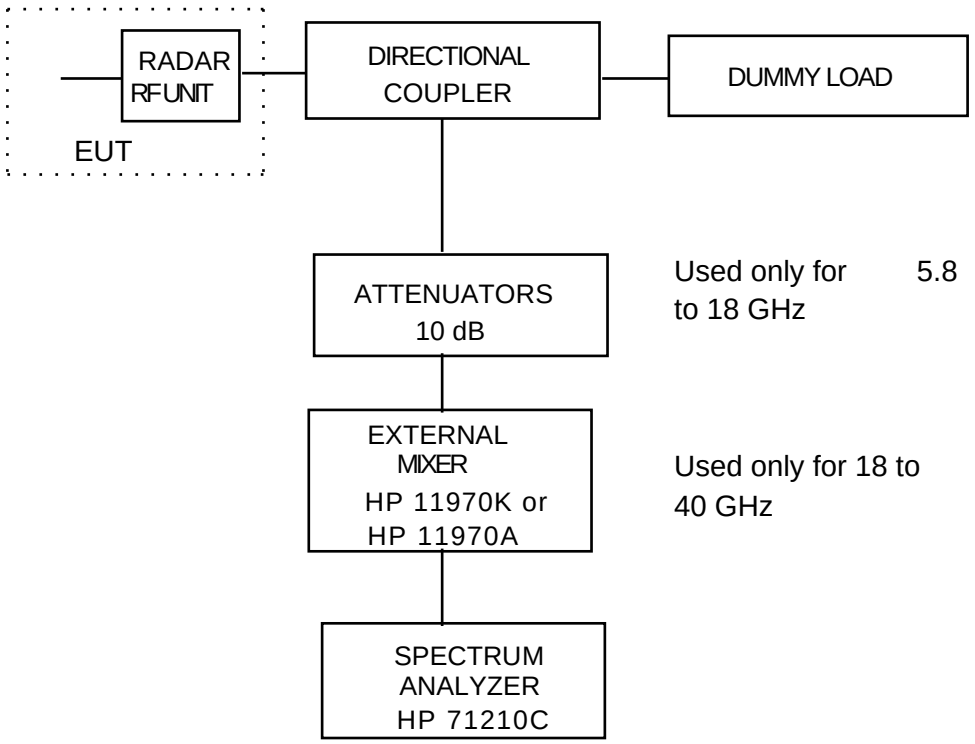


Fig. 3.4.1

3.4.2 Measuring Equipment List:

See Attachment D [List of Test/Measuring Equipment].

3.4.3 Test Conditions:

Radar Range Settings: 0.125 nm (Short)/3 nm (Middle)/ 36 nm (Long)

3.4.4 Emission Limits:

(a) Frequency Range (FCC Rule §2.1057(1)) : 10 kHz - 40 GHz

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

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

3.4.5 Test Results:

As shown in Attachment A, 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. (Waveguide tube)).

3.5 Field Strength of Spurious Radiation (FCC Rule § 2.1053)

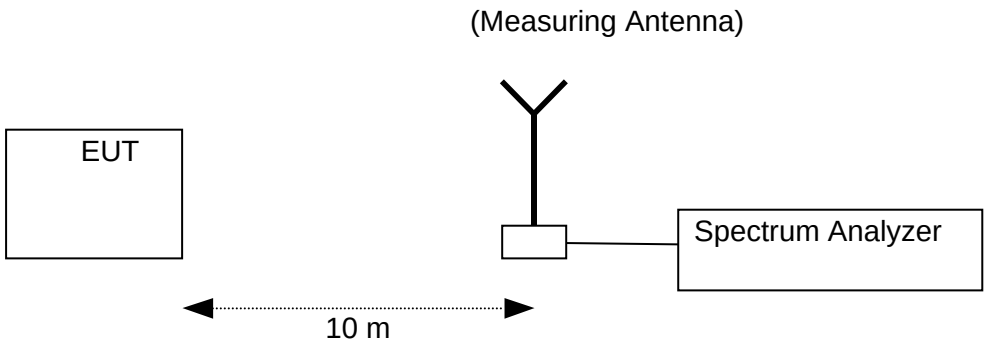
3.5.1 Test Site: Rooftop of 6-story building,
FURUNO ELECTRIC CO., LTD.
Ashihara-cho 9-52, Nishinomiya-city, 662-8580 Japan

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

3.5.3 Radar Range settings: 0.125 nm (Short)/3 nm (Middle)/ 36 nm (Long)

3.5.4 Measuring Equipment List:
See Attachment D [List of Test/Measuring Equipment].

3.5.5 Test settings:



3.5.6 Field Strength Limits:

(a) Frequency Range (FCC Rule § 2.1057(1)) : 10 kHz - 4 GHz

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

Frequency removed from the assigned frequency	Frequency (MHz)	Emission attenuation (mean power, dB)
50 - 100 % (of the authorized bandwidth)	9,310 – 9,360 9,460 – 9,510	At least 25
100 - 250 %	9,160 – 9,310 9,510 – 9,660	At least 35

Frequency removed from the assigned frequency	Frequency (MHz)	Emission attenuation (mean power, dB)
more than 250 %	0.01 – 9,160 9,660 - 40,000	At least 43 + 10 log $_{10}$ (mean power in watts)

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

3.5.7 Test Results:

As shown in Attachment B, the field strengths of spurious radiation generated by EUT are found lower than the specified limits.

3.6 Frequency Stability (FCC Rule § 2.1055)

3.6.1 Setup for Measurement

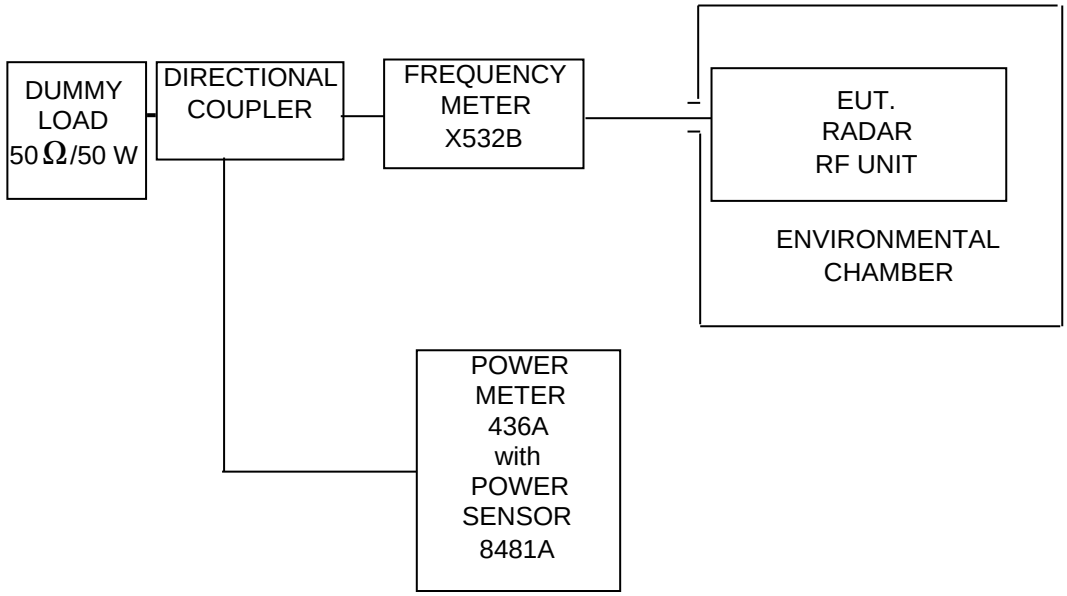


Fig. 3.6.1

3.6.2 Test Conditions:

1) Radar Range settings : 0.125 nm (Short)/3 nm (Middle)/ 36 nm (Long)
2) Ambient Temperature settings: - 30, +25, +40 and +70°C
3) Power Supply Voltage settings: 85 /115 % of nominal voltage (20.4 to 27.6 VDC)

3.6.3 Measuring Equipment List:

See Attachment D [List of Test/Measuring Equipment].

3.6.4 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 (b))

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)) :

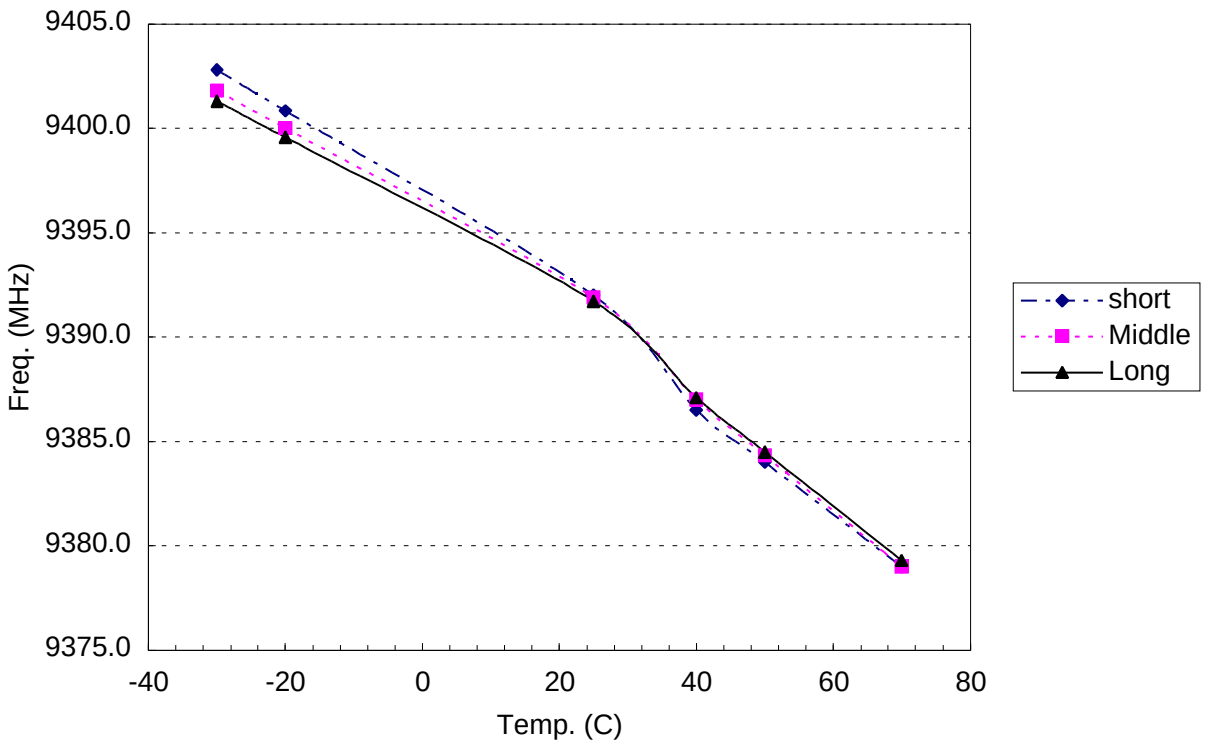
Pulselength	Short	Middle	Long
Range Scale (nm)	0.125	3	36
Pulselength (μsec)	0.08	0.30	0.80
Guard Band f(1.5/T) (MHz)	18.75	5.00	1.88

3.6.5 Test Results:

Shown on Fig. 3.6.2.
(1) "Upper Tolerance Frequency measured (at - 20 °C)", f(U) = 9400.8 MHz
(2) "Lower Tolerance Frequency measured (at + 50 °C)", f(L) = 9384.0 MHz
(3)-(a)
f(U) + max. f(1.5/T) = 9419.55 MHz < f(UAUBW) = 9460 MHz $\leqq$ f(UASB) = 9500 MHz
(3) - (b)
f(L) - max. f(1.5/T) = 9365.25 MHz > f(LAUBW) = 9360 MHz $\geqq$ 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. 3.6.2 Frequency Stability with Variation of Ambient Temperature



3.7 Suppression of Interference Aboard Ships (FCC Rule § 80.217)

3.7.1 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 l	150 M	116.5		105.5	52.5 nH
1/4 l	450 M	70.5		34.5	5.68 pF

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

3.7.3 Measuring Instrument List:

See Attachment D [List of Test/Measuring Equipment].
(Instruments for measuring antenna characteristics are listed below.)

(1) Network Analyzer, HP 8753C
(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

3.7.4 Test Results:

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

3.7.4.1 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 C.)

3.7.4.2 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)

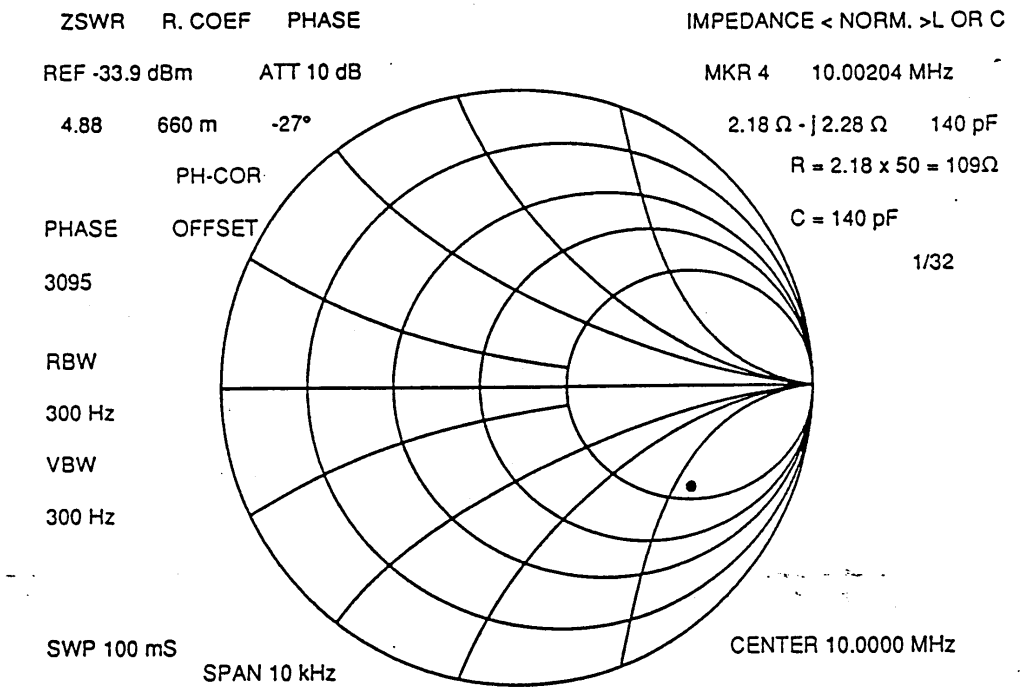
Results: Interference was measured with the antenna located 2 m from the radar and converted to levels at 1 nm. There is no spurious component exceeding the limits.
(Test data are shown in Attachment C.)

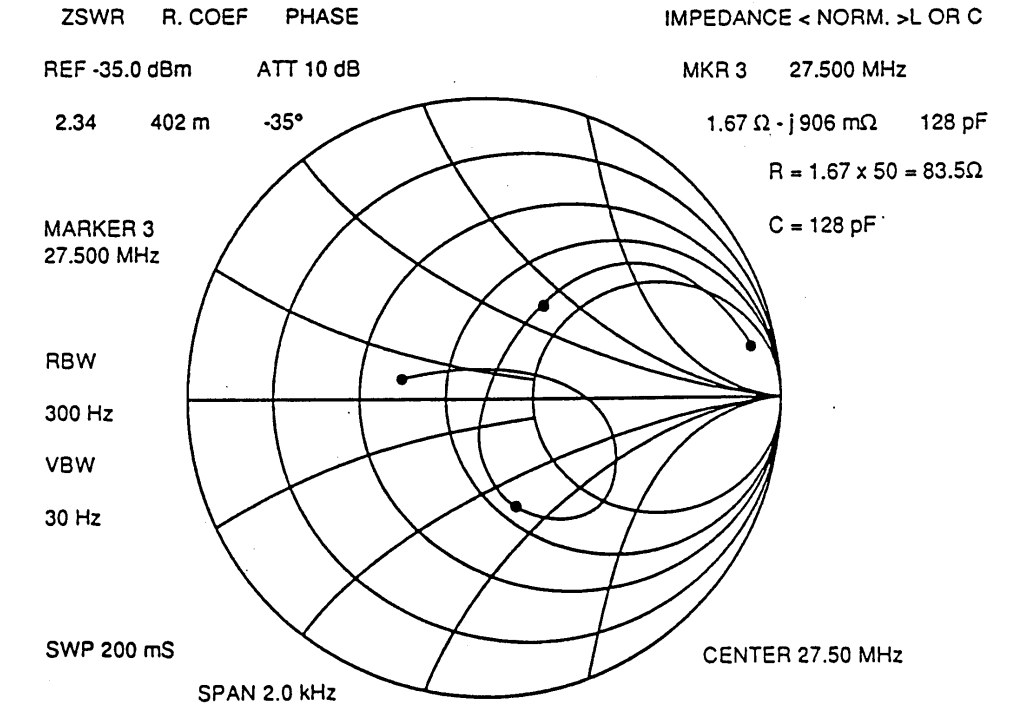
3.7.4.3 Power Input to an Artificial Antenna (FCC Rule § 80.217 (b) - 2)

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

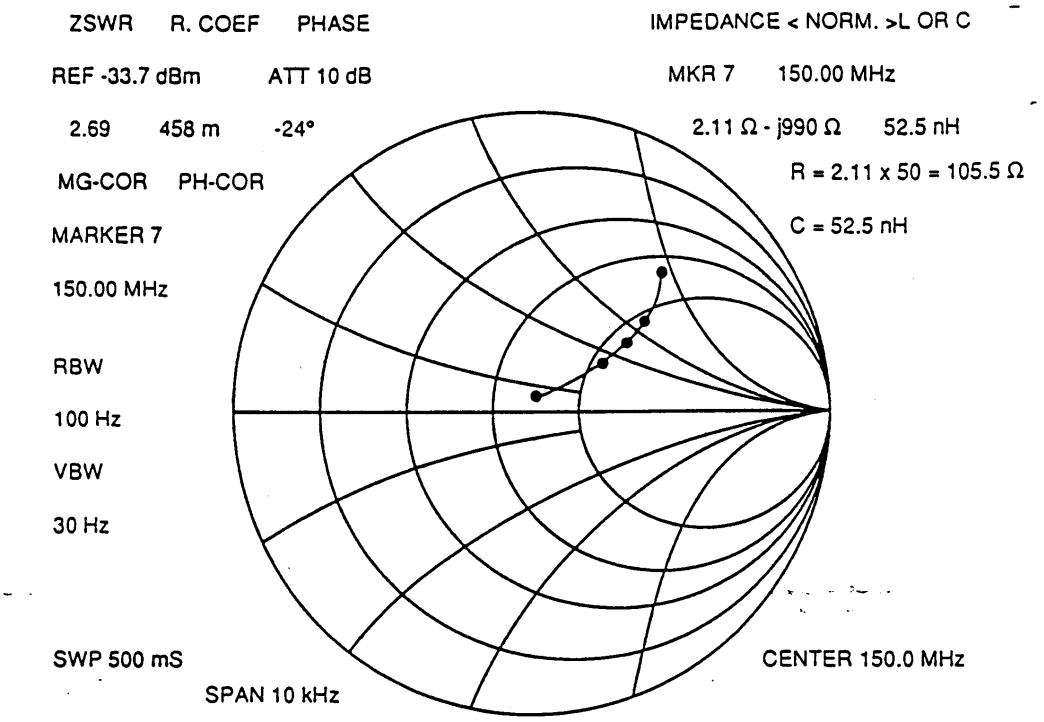
Results: There is no spurious component exceeding the limits.
(Test data are shown in Attachment C.)

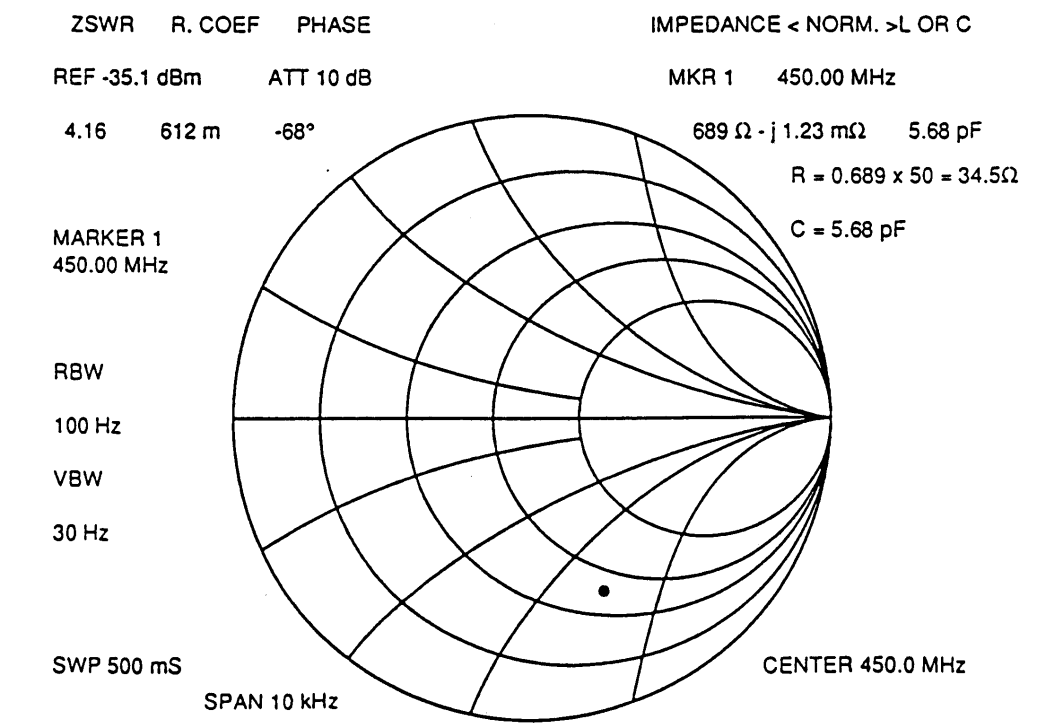
MEASUREMENT OF IMPEDANCE OF TEST ANTENNAS





MEASUREMENT OF IMPEDANCE OF TEST ANTENNAS





4 Photographs to Reveal Equipment Construction and Layout (FCC Rule § 2.1033)

(See Attachment E Photos of the equipment under test (EUT))

5 Description of Circuitry and Devices (FCC Rules § 2.1033)

5.1 Function of Each Semiconductor or Active Device

ANTENNA UNIT

TRANSCEIVER MODULE (RTR-069)

Modulator PCBs (MD & RRV, 03P9309 & 03P9317)

Parts No.	Function	
CR2	Rise-up voltage control	(located in 03P9317)
CR3	Rise-up voltage control	(located in 03P9317)
CR4	Reverse Voltage Protection	(located in 03P9317)
CR5	Reverse Voltage Protection	(located in 03P9317)
CR801	Reverse Voltage Protection	
CR802	TX HV Rectifier	
CR803	TX Trigger Pulse Voltage Rectifier	
CR804	Detector (Magnetron Current)	
CR805	Power Supply Rectifier for Magnetron Heater	
CR806	TX-HV Rectifier	
CR809	Zener diode	
CR810	Pulse width Select	
CR811	Reverse Voltage Protection	
L801 - L803	Noise Rejection	
Q801	Overcurrent Protection	
Q802	PWM Switching	
Q803, Q804	Overcurrent Protection	
Q805, Q806	Pulse Amplifier	
Q807	IF Bandwidth Select	
Q813 - Q816	Pulse width Select	
Q817	TX Trigger Pulse Voltage Buffer	
Q818	Pulse Amplifier	
T801	Switching Regulator Transformer	
T802	Pulse Transformer	

U801	Overcurrent Protection
U802	Switching Regulator Controller
U803	Shunt Regulator
U804	Heater Voltage Feedback
U806	Overcurrent Protection
U807	DC Regulator
U808	Dual Monostable Multivibrator
U809	Pulse width Select
U810 - U812	Pulse Amplifier

Chassis Mounted Parts

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

IF Amplifier PCB (IF, 03P9310)

CR1 - CR5	Band Width Switching
CR6	Voltage Slicer (Overvoltage Protector)
CR7	Voltage Slicer
CR11	DC Restoring
CR12	Voltage Slicer (Overvoltage Protector)
CR13	DC Restoring
CR18	DC Restoring (A/C SEA)
CR19	DC Restoring (GAIN)
CR20	Thermal Compensator
CR21	DC Restoring (A/C RAIN)
CR22	Voltage Slicer (Overvoltage Protector)
Q1 - Q3	Video Amplifier
Q5	IF Amplifier
Q6	DC Bias
Q7 - Q8	Video Amplifier
Q10 - Q12	Voltage Buffer
Q14	Transistor Switch (Tuning Amplifier Gate)
U1	IF Amplifier
U2	IF Amplifier/ Video Amplifier
U3	OP Amplifier (Band Width Switching)
U4	Inverter
U5 - U7	Voltage Regulator

Antenna Motor Power Supply PCB (PWR, 03P9315)

CR1	Antenna Motor Power Supply Rectifier
CR2	Reverse Voltage Protection
CR3	Zener diode
CR4	Switching
CR7	Switching
CR8	Switching
CR9	Zener diode
L1, L2	Noise Rejection
L3	Choke coil
Q1	Soft starter switch
Q2	Transistor switch
Q3	PWM Switching
Q4 - Q10	Transistor switch
Q11	Overcurrent Protection
Q12, Q13	Transistor switch
U1	Switching Regulator Controller
U2	Pulse Amplifier
U3	Output Voltage Feedback

I/O Interface PCB (RTB, 03P9311)

Q1	Transistor switch
Q2	Pulse Amplifier

5.2 Description of the circuits employed for suppression of spurious radiation, for limiting or shaping the control pulse, and for limiting or controlling power

ANTENNA UNIT

TRANSCEIVER MODULE (RTR-069)

Modulator PCBs (MD & RRV, 03P9309 & 03P9317)

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 power supply circuit, a modulator trigger circuit, a modulating pulse generator and a booster pulse transformer.

The modulator trigger circuit is composed of U808 and associated components. It generates pulses that fire modulator FET Q805, Q806. Normally. the circuit is stable with U808 off. The pulse to fire the modulator FET is produced when U808 turns on upon receiving the TX trigger pulse from the display unit. When U808 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 of 1 :16. The resultant pulse, its level being 3.5 kV, is provided to oscillate the magnetron.

The power supply block incorporates the TX HV circuit and magnetron heater power supply circuit. The TX HV circuit provides a high tension of about 300 V to the pulse forming network. A DC voltage of 7.5 V is supplied to the magnetron heater.

Duplexer and Frequency Converter in Scanner unit

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 directly 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 PIN 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 PCB (IF, 03P9310)

The received 60 MHz IF signal is amplified by the IF amplifier, the output of which is delivered to the display unit Digital Signal Processor. The 60MHz IF signal from the MIC is fed to the IF Amplifier U1.

The output of U1 is conductively coupled to the second-stage IF amplifier U2.

GAIN/STC signals are applied respectively to U1 pin 5 and pin U2 pin 14 via the STC circuit. The output of U2 is then coupled to video amplifier Q4. The video signal is taken from the emitter of Q2/Q3 through C25, and sent to the display via the video cable.

The IF amplifier PCB also incorporates an STC circuit. The STC circuit made up of Q10, Q11 changes the gain of the IF amplifier in the function of time so that the gain is minimum at the time of transmission and increases gradually to maximum gain with time (range).

The amount of current flowing into Q11 is determined by the time constant of the parallel-series capacitor/resistor network consisting of C50 - C52, R67 - R69. It gradually decreases as the capacitors are discharged. The rate of discharge is inversely proportional to "t", the elapsed time after transmission. The current flowing into Ql11 is also controlled by the base potential in addition to the time constant of the capacitor/ resistor network.

The time-varying waveform produced at capacitor/ resistor network is restored via CR18 by the STC control potentiometer (located in the display) and applied to U1 pin 5 and U2 pin14.

Antenna Motor Power Supply PCB (PWR, 03P9315)

Provides the power supply voltage of 25 VDC to drive the antenna motor.

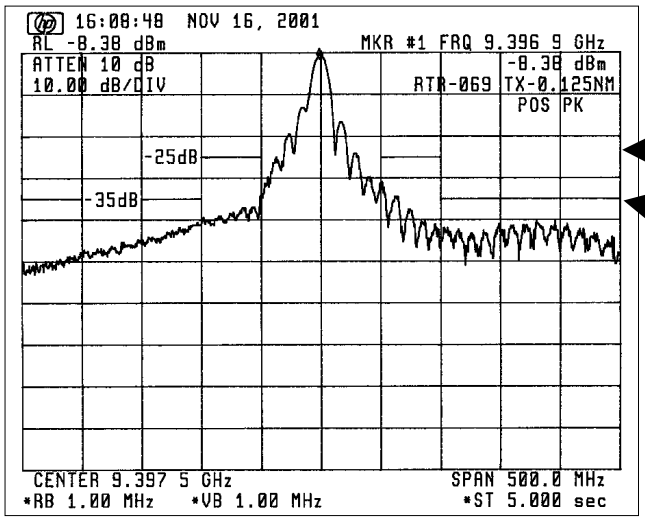
6 Operator's Manual Incl. Circuit Diagrams (FCC Rule § 2.1033)

(See separate covers)

Attachment A

[TEST DATA for Clause 3.4. SPURIOUS EMISSIONS AT ANTENNA TERMINALS]

1. Spurious emissions for 0.125 nm Range:



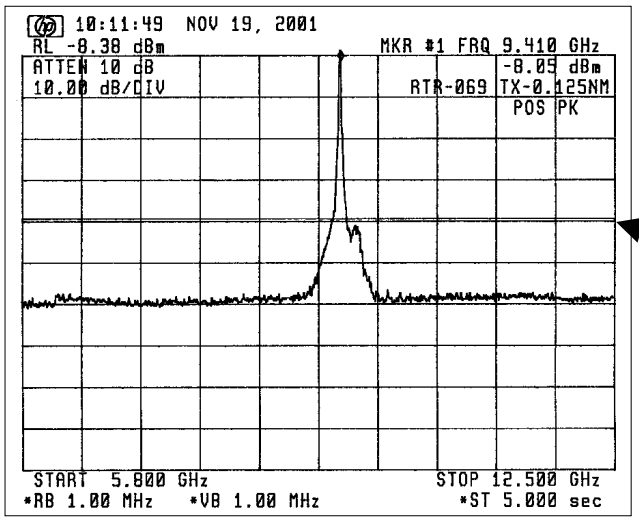
Ref. level: -8.38 dBm

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)

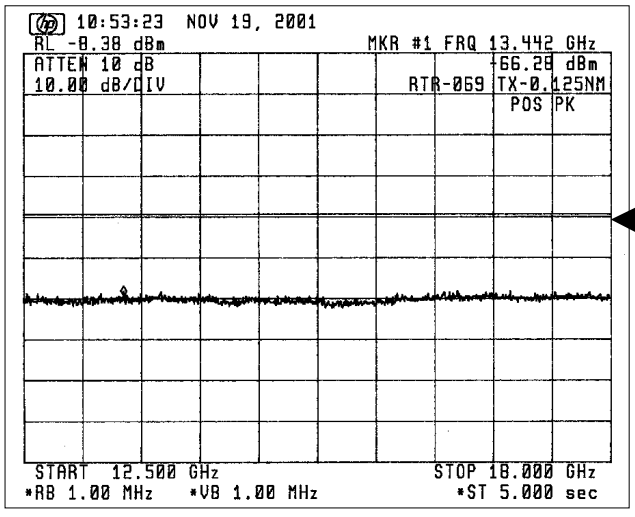
Fig. 1.1



Emission limitations:

(c) 43 + 10 log Pm = 39.03 dB for more than 250 % of the authorized BW (100 MHz)

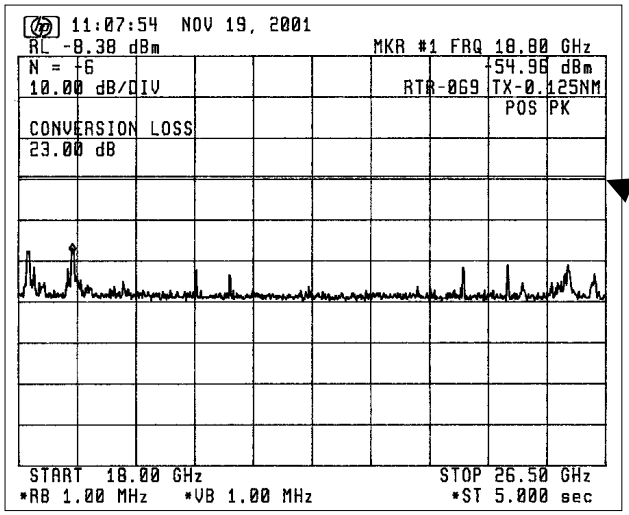
Fig. 1.2



Emission limitations:

(c) 43 + 10 log Pm = 39.03 dB for more than 250 % of the authorized BW (100 MHz)

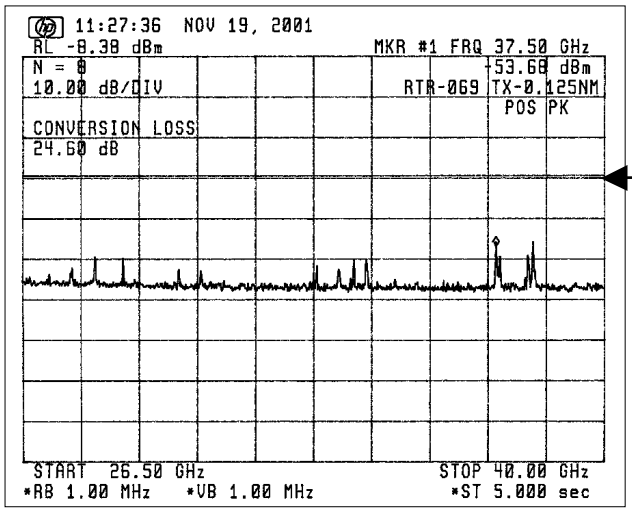
Fig. 1.3



Emission limitations:

(c) 43 + 10 log Pm = 39.03 dB
for more than 250 % of
the authorized BW (100 MHz)

Fig. 1.4

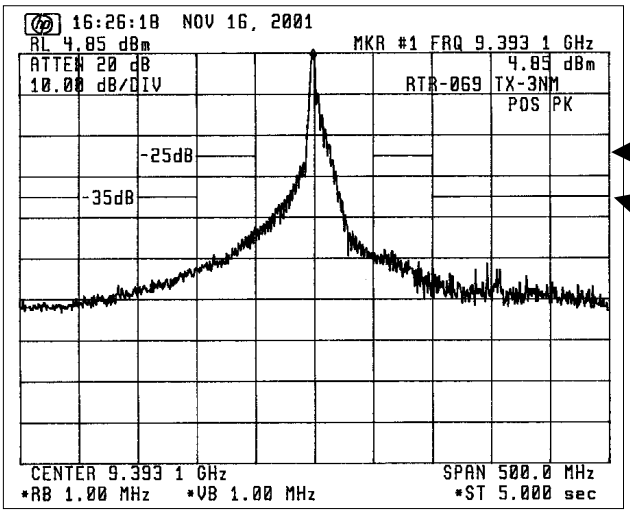


Emission limitations:

(c) 43 + 10 log Pm = 39.03 dB
for more than 250 % of
the authorized BW (100 MHz)

Fig. 1.5

2. Spurious emissions for 3 nm Range:



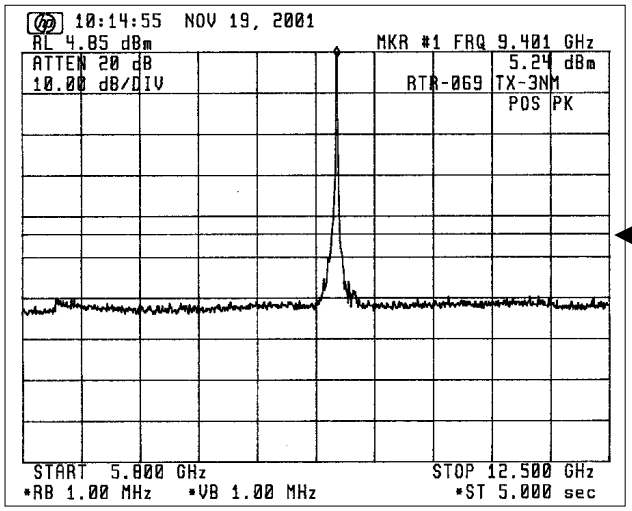
Ref. level: 4.85 dBm

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)

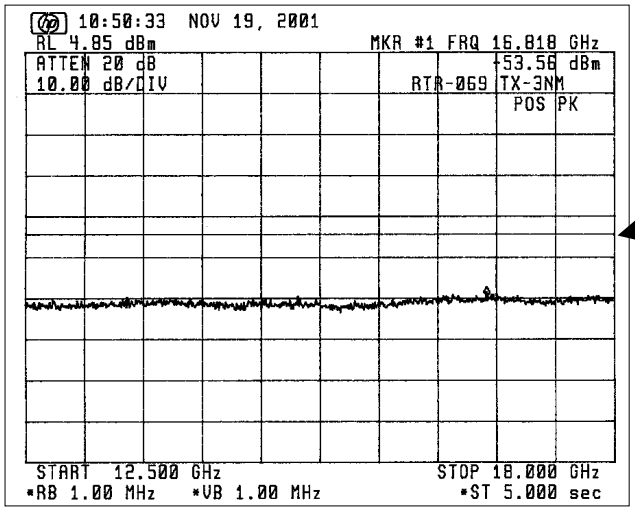
Fig. 2.1



Emission limitations:

(c) 43 + 10 log Pm = 44.03 dB for more than 250 % of the authorized BW (100 MHz)

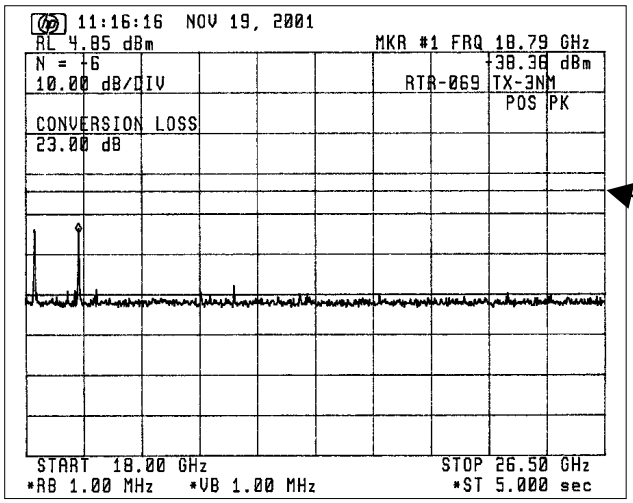
Fig. 2.2



Emission limitations:

(c) 43 + 10 log Pm = 44.03 dB for more than 250 % of the authorized BW (100 MHz)

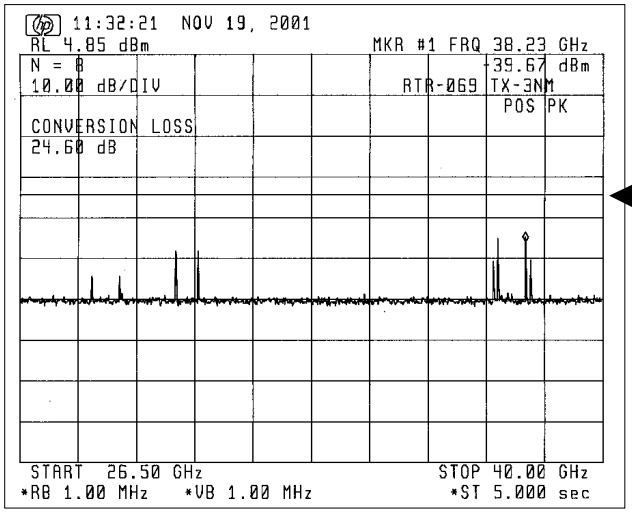
Fig. 2.3



Emission limitations:

(c) 43 + 10 log Pm = 44.03 dB
for more than 250 % of
the authorized BW (100 MHz)

Fig. 2.4

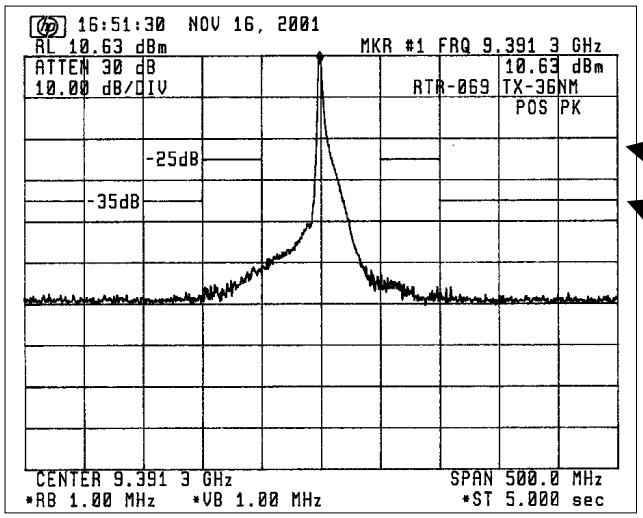


Emission limitations:

(c) 43 + 10 log Pm = 44.03 dB
for more than 250 % of
the authorized BW (100 MHz)

Fig. 2.5

3. Spurious emissions for 36 nm Range:



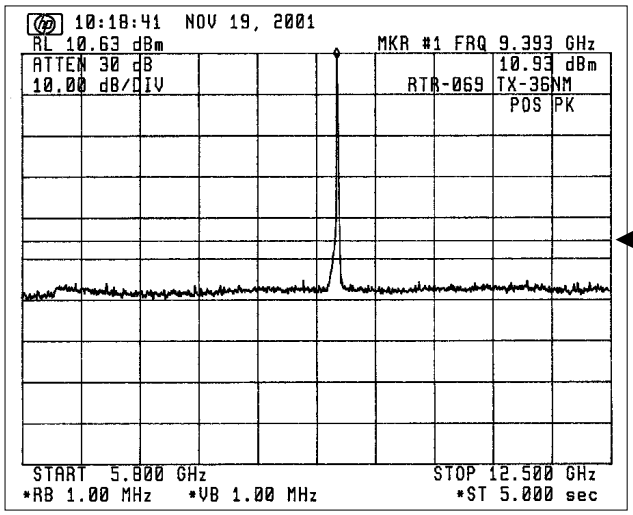
Ref. level: 10.63 dBm

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)

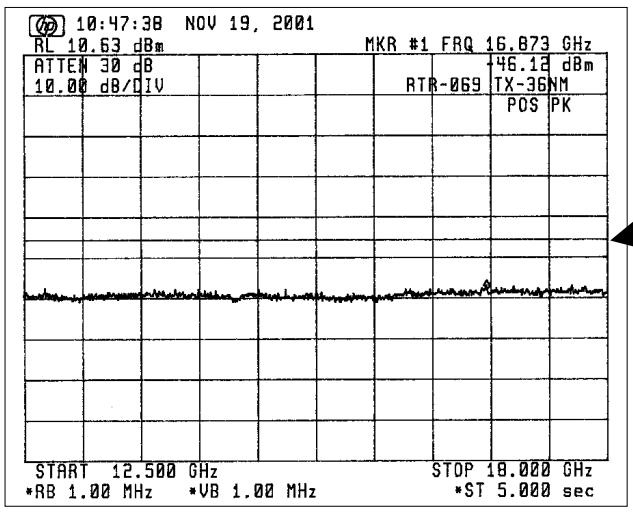
Fig. 3.1



Emission limitations:

(c) 43 + 10 log Pm = 45.29 dB for more than 250 % of the authorized BW (100 MHz)

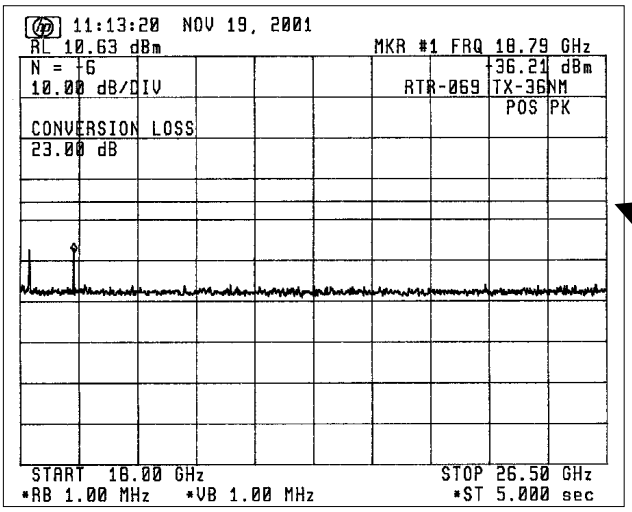
Fig. 3.2



Emission limitations:

(c) 43 + 10 log Pm = 45.29 dB for more than 250 % of the authorized BW (100 MHz)

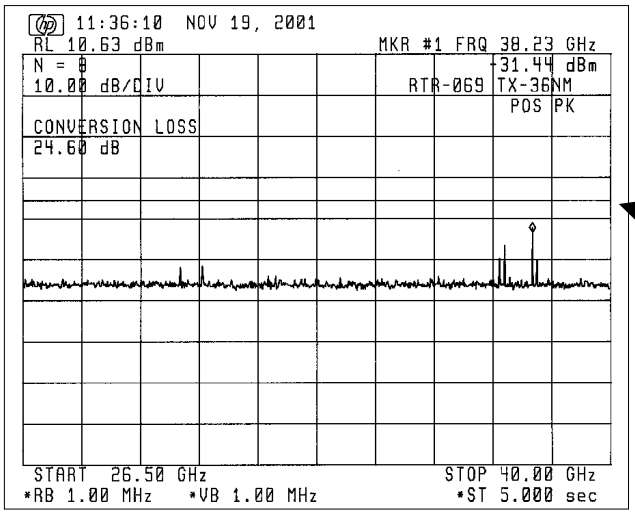
Fig. 3.3



Emission limitations:

(c) 43 + 10 log Pm = 45.29 dB
for more than 250 % of
the authorized BW (100 MHz)

Fig. 3.4



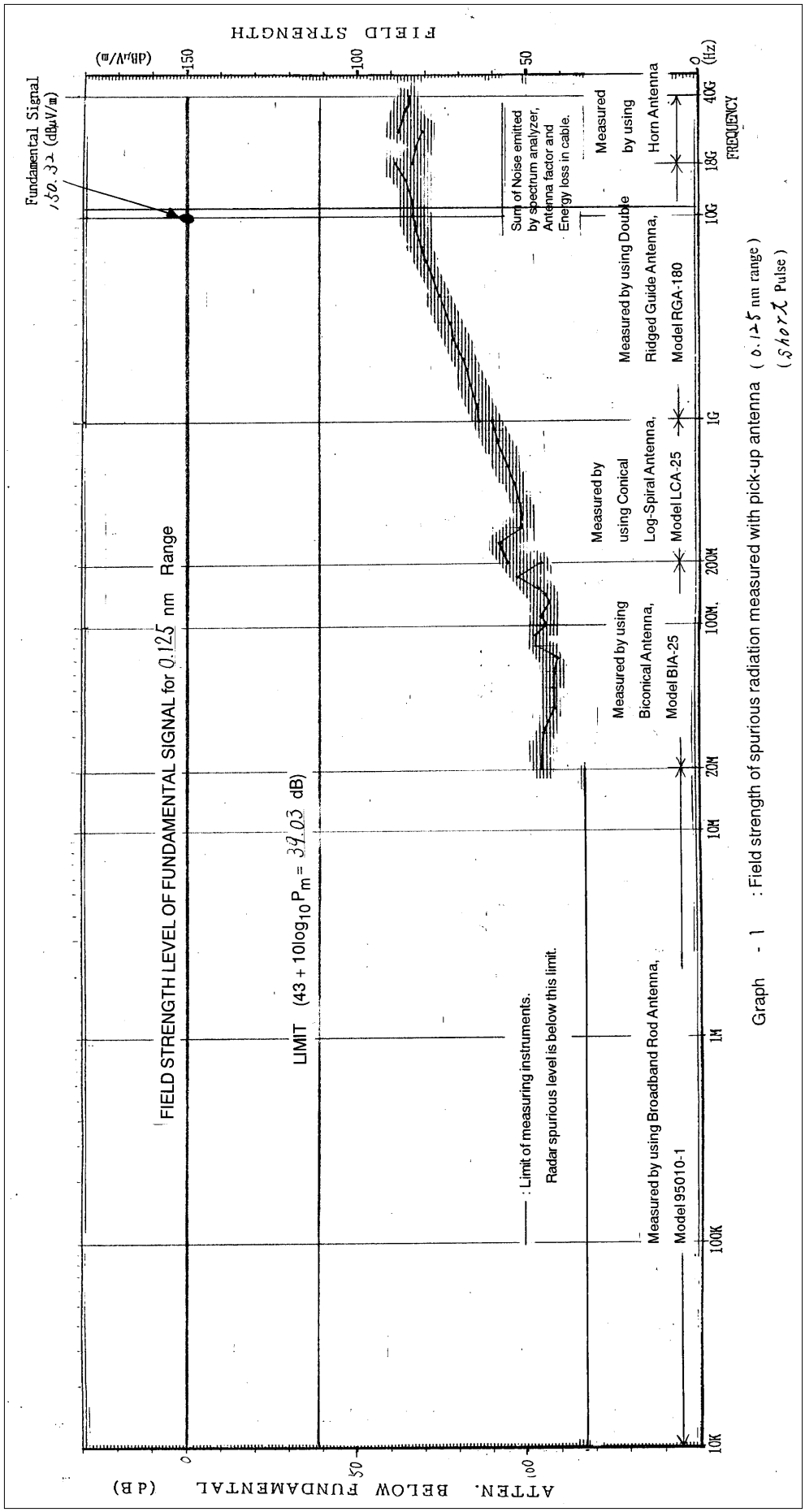
Emission limitations:

(c) 43 + 10 log Pm = 45.29 dB
for more than 250 % of
the authorized BW (100 MHz)

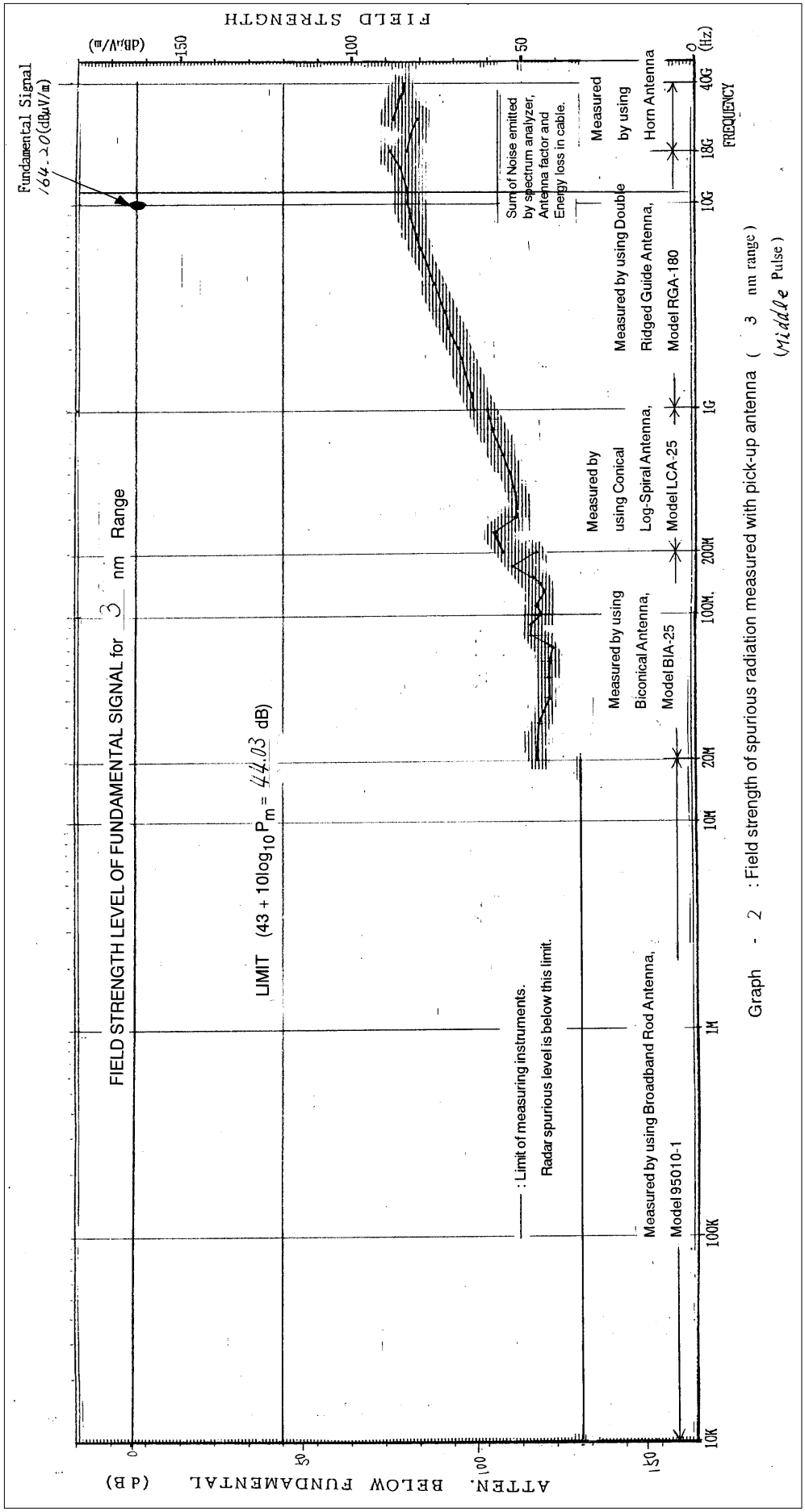
Fig. 3.5

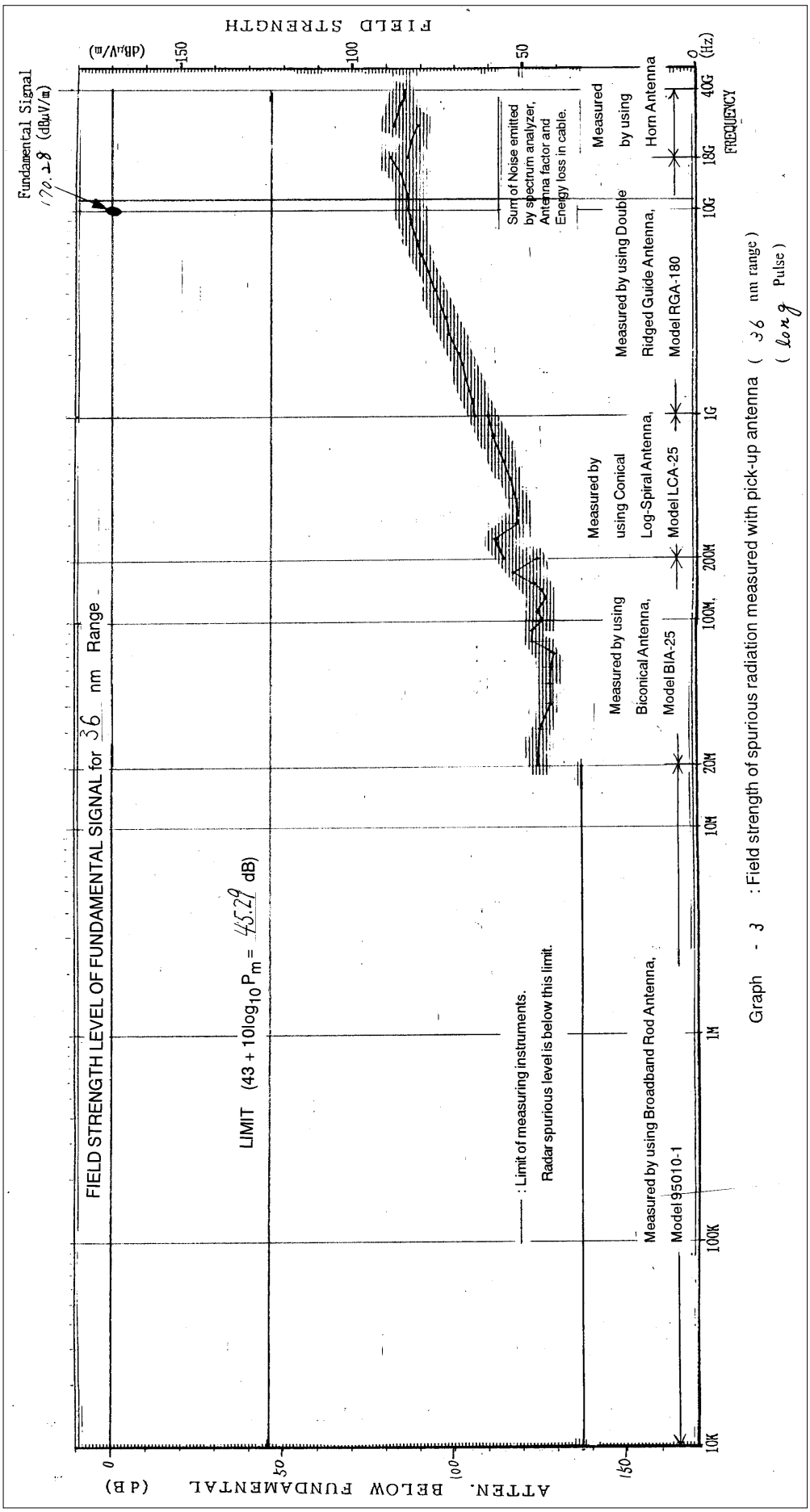
Attachment B

TEST DATA for Clause 3.5 FIELD STRENGTH OF SPURIOUS RADIATION



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


FIELD STRENGTH
(dBμV/m)
150
100
50
0 (Hz)
Fundamental Signal
164.20(dBμV/m)
FREQUENCY
Sum of Noise emitted by spectrum analyzer, Antenna factor and Energy loss in cable.
Measured by using Double Ridged Guide Antenna, Model RGA-180
Measured by using Horn Antenna
10G
18G
40G
Measured by using Conical Log-Spiral Antenna, Model LCA-25
1G
FIELD STRENGTH LEVEL OF FUNDAMENTAL SIGNAL for 3 m Range
LIMIT (43 + 10log10 Pm = 44.03 dB)
Measured by using Biconical Antenna, Model BIA-25
100M
200M
10M
20M
1M
: Limit of measuring instruments.
Radar spurious level is below this limit.
Measured by using Broadband Rod Antenna, Model 95010-1
100K
10K
ATTEN. BELOW FUNDAMENTAL (dB)
0
50
100
150
Graph - 2 : Field strength of spurious radiation measured with pick-up antenna (3 m range)
(Middle Pulse)

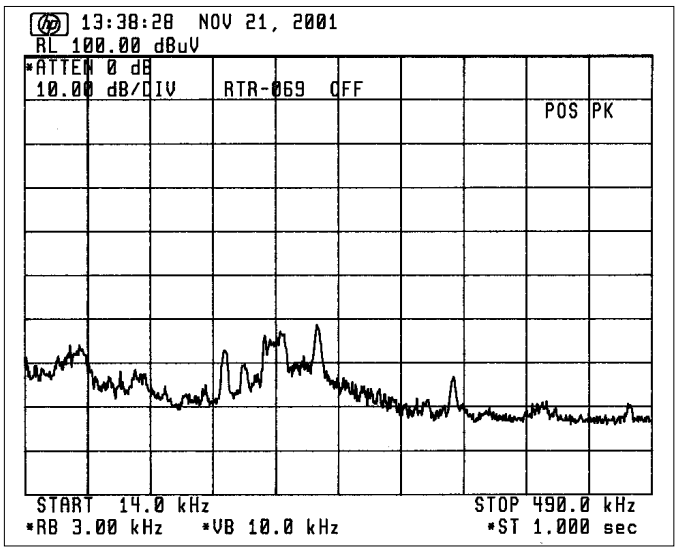

FIELD STRENGTH
(dBμV/m)
150
100
50
0 (Hz)
FREQUENCY
Fundamental Signal
120.28 (dBμV/m)
Sum of Noise emitted by spectrum analyzer, Antenna factor and Energy loss in cable.
Measured by using Double Ridged Guide Antenna, Model RGA-180
Measured by using Horn Antenna
Measured by using Conical Log-Spiral Antenna, Model LCA-25
Measured by using Biconical Antenna, Model BIA-25
Measured by using Broadband Rod Antenna, Model 95010-1
: Limit of measuring instruments.
Radar spurious level is below this limit.
LIMIT (43 + 10log10 Pm = 45.29 dB)
FIELD STRENGTH LEVEL OF FUNDAMENTAL SIGNAL for 36 nm Range
ATTEN. BELOW FUNDAMENTAL (dB)
0
30
100
150
10K
100K
1M
10M
20M
100M
200M
1G
10G
18G
40G
Graph - 3 : Field strength of spurious radiation measured with pick-up antenna (36 nm range)
(Long Pulse)

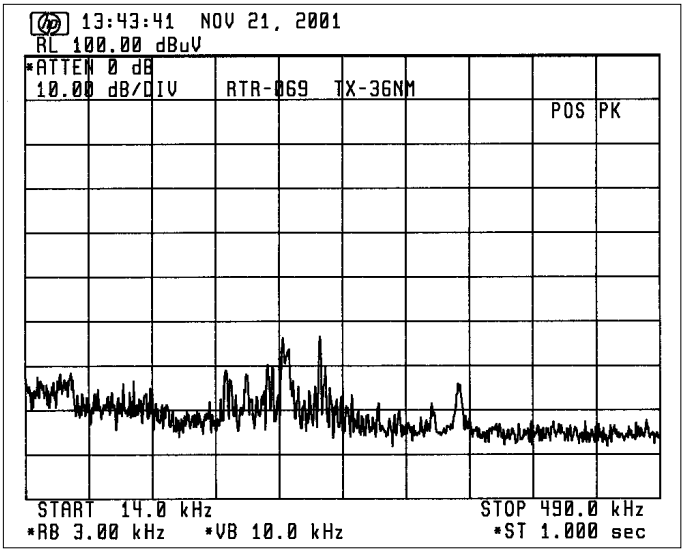
Attachment C

[TEST DATA for Clause 3.7 SUPPRESSION OF INTERFERENCE ABOARD SHIPS]

1. Harmful Interference to Receiver

(Band : 14 kHz - 490 kHz)





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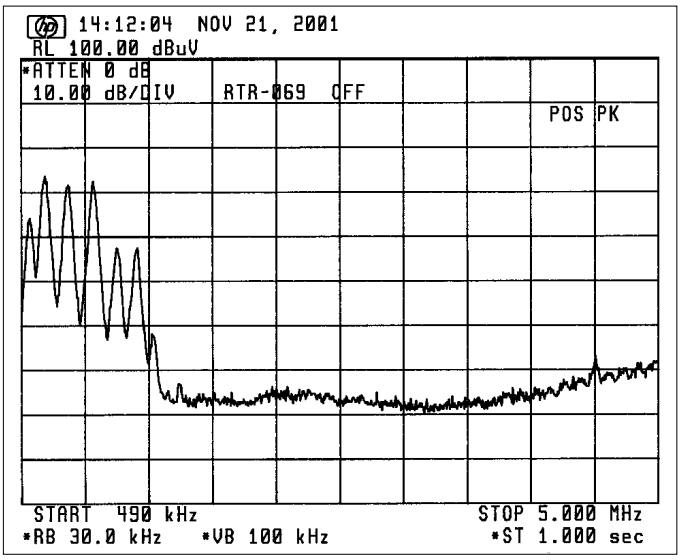
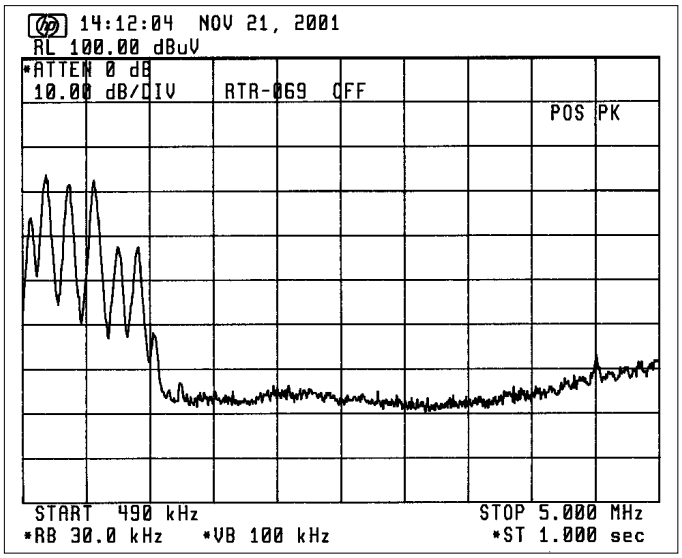
(Band : 490 kHz - 5 MHz)





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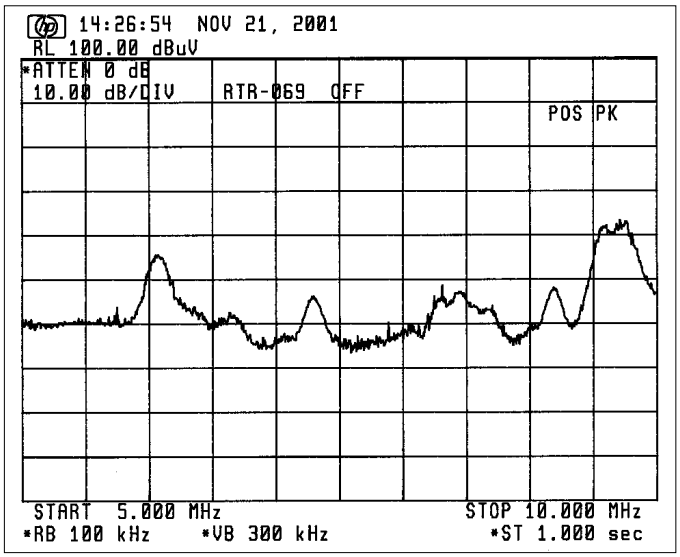
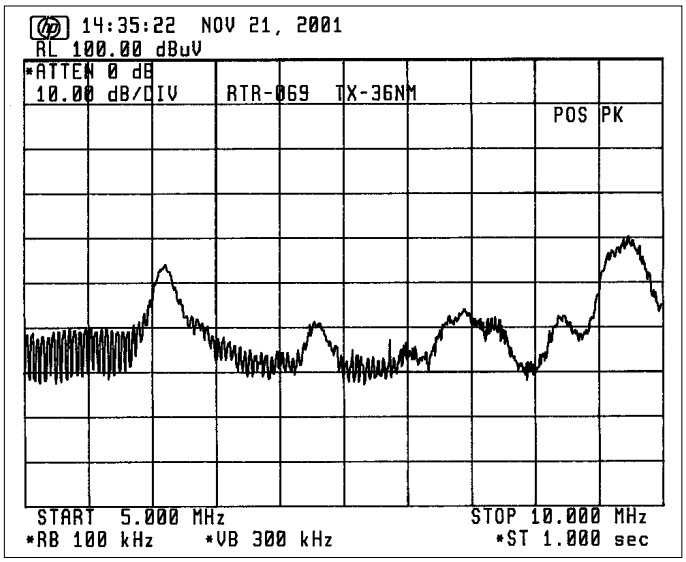
(Band : 5 MHz - 10 MHz)





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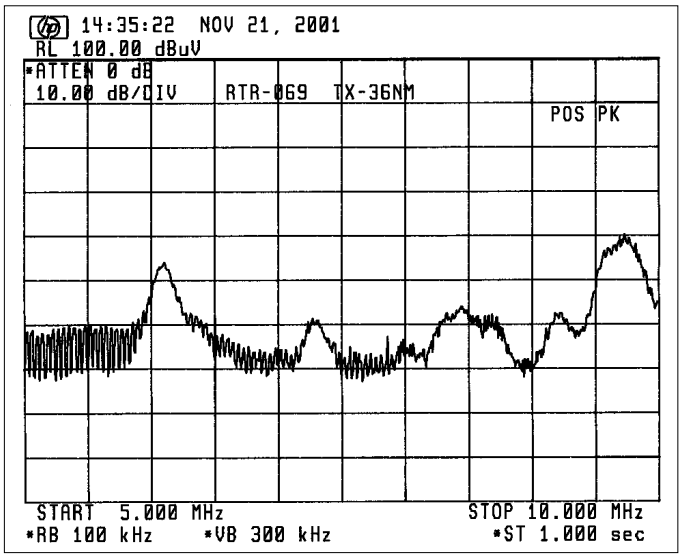
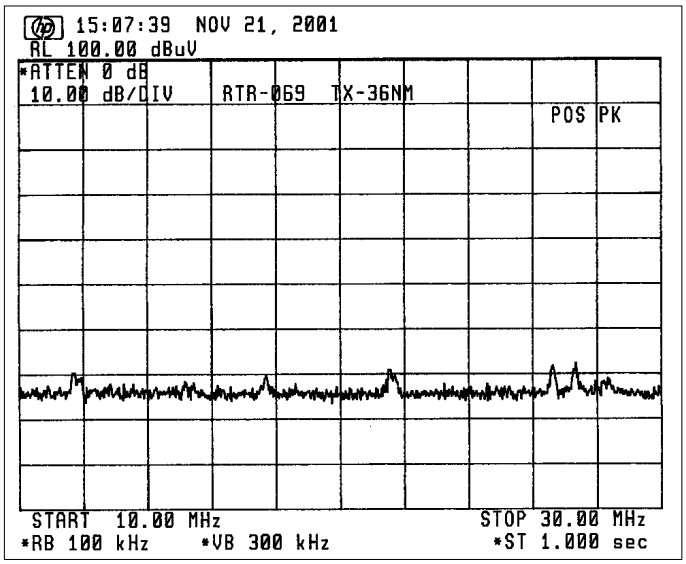
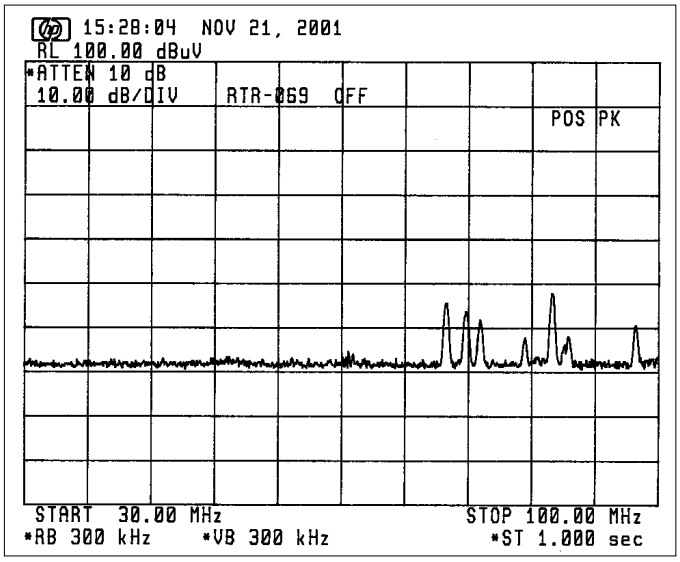
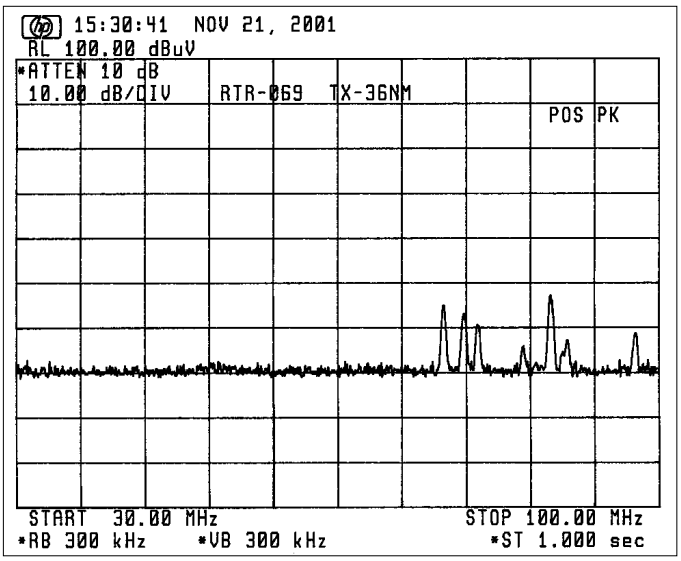
(Band : 10 MHz - 30 MHz)





(Band : 30 MHz - 100 MHz)





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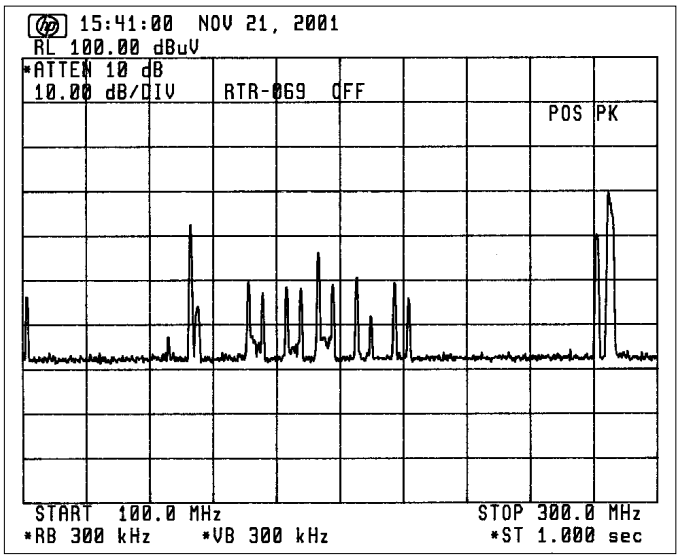
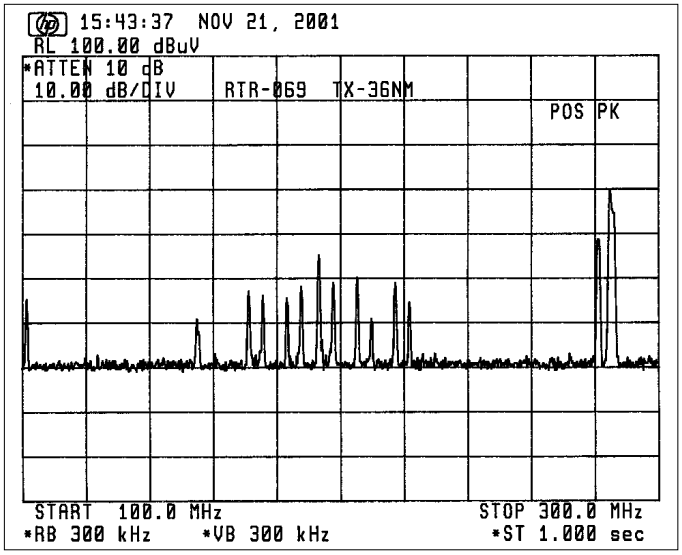
(Band : 100 MHz - 300 MHz)





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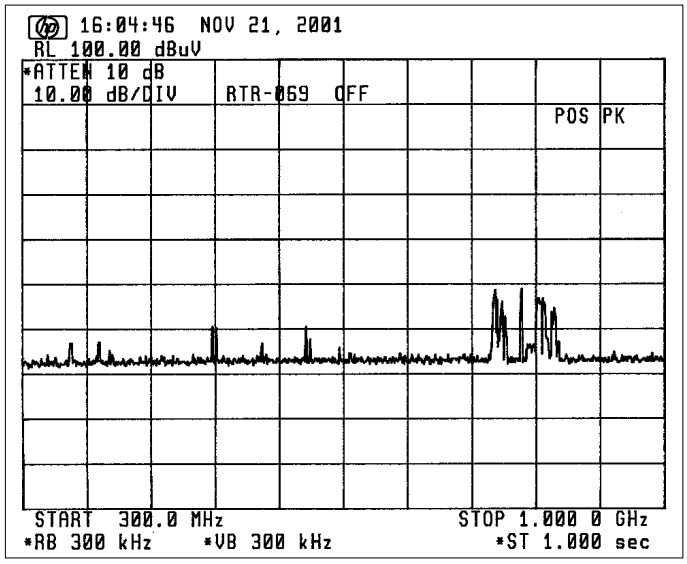
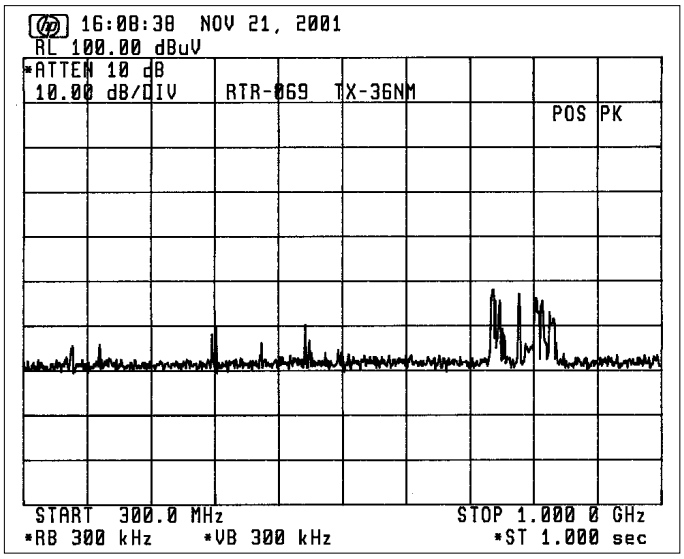
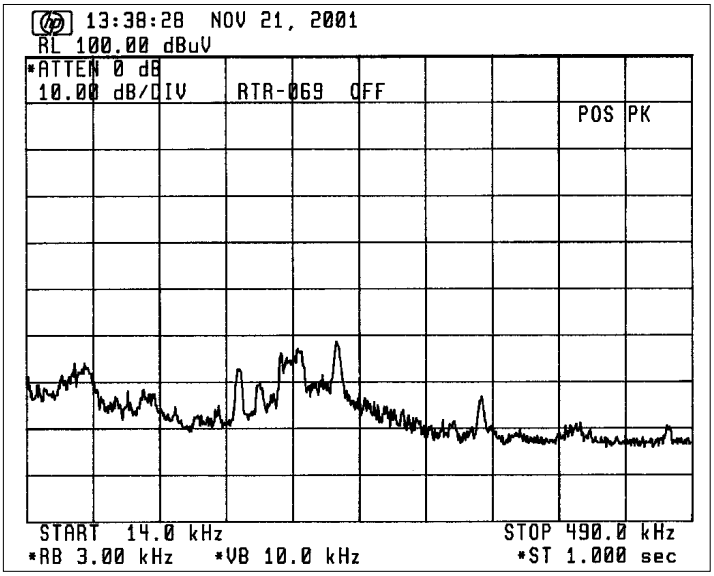
(Band : 300 MHz - 1 GHz)



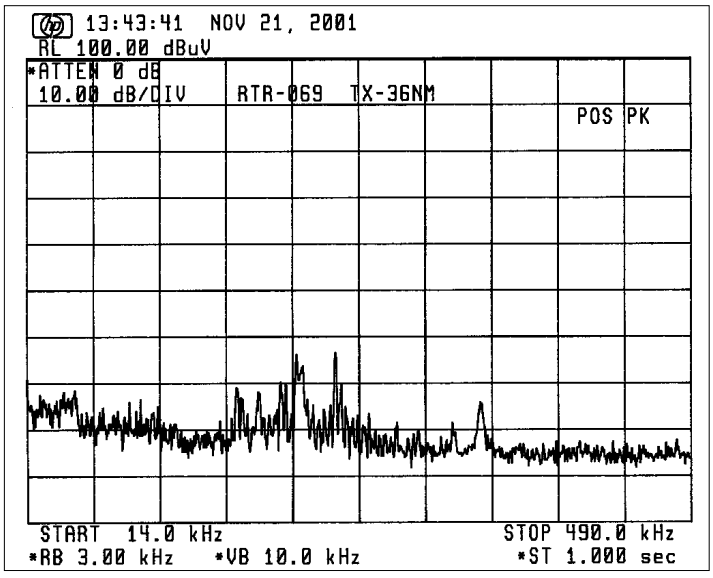


2. Electromagnetic Field

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



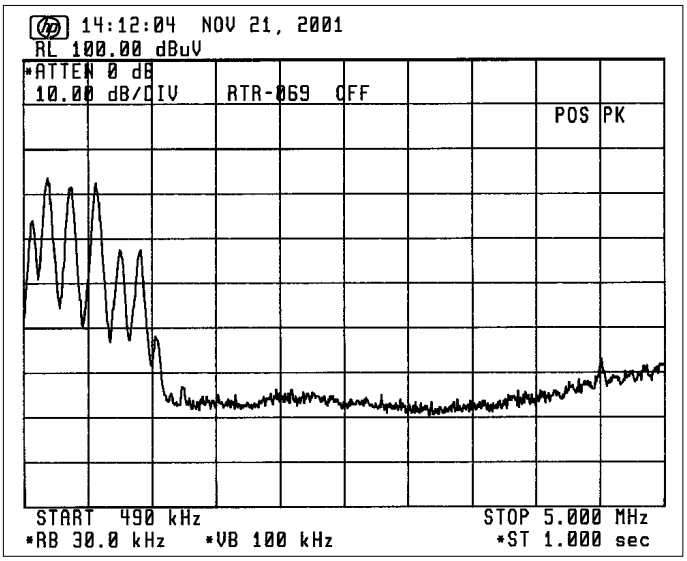
-26 dBµV/m

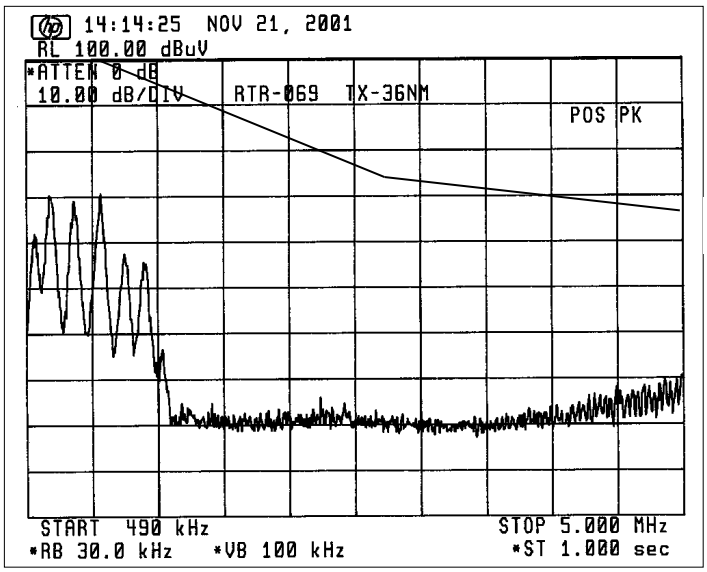


-26 dBµV/m

.

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



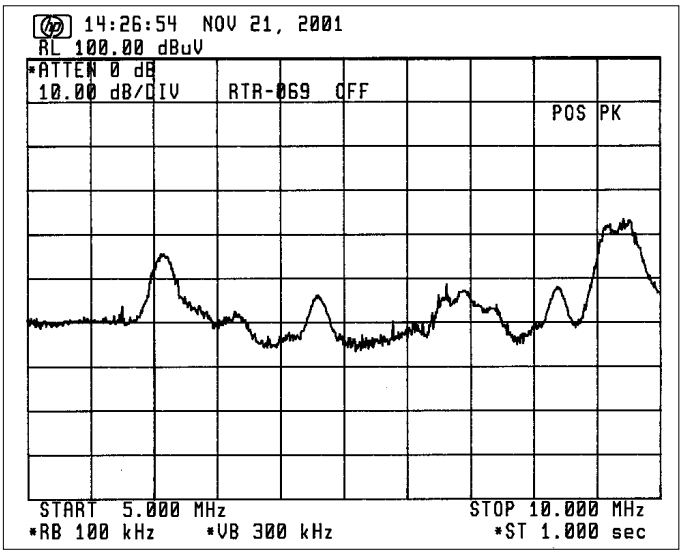


Ref. level (dBµV/m)
= 100 - 126 = -26 (at 0.5 MHz)
= 100 - 96 = 4 (at 3 MHz)
= 100 - 88 = 12 (at 5 MHz)

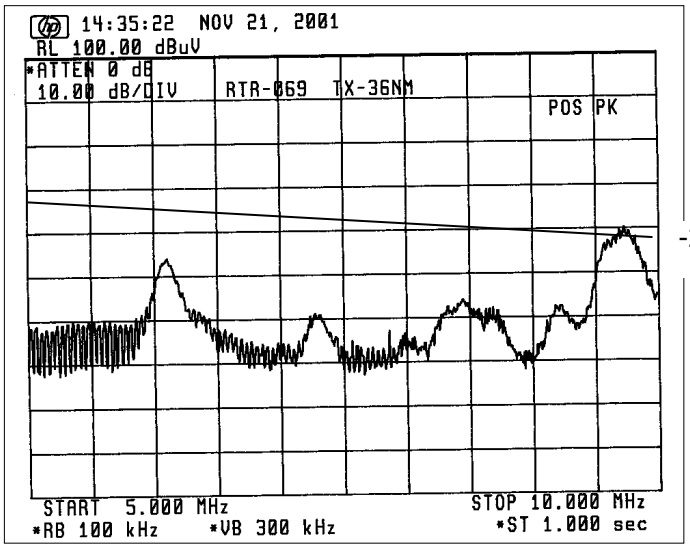
-20 dBµV/m limit line

.

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



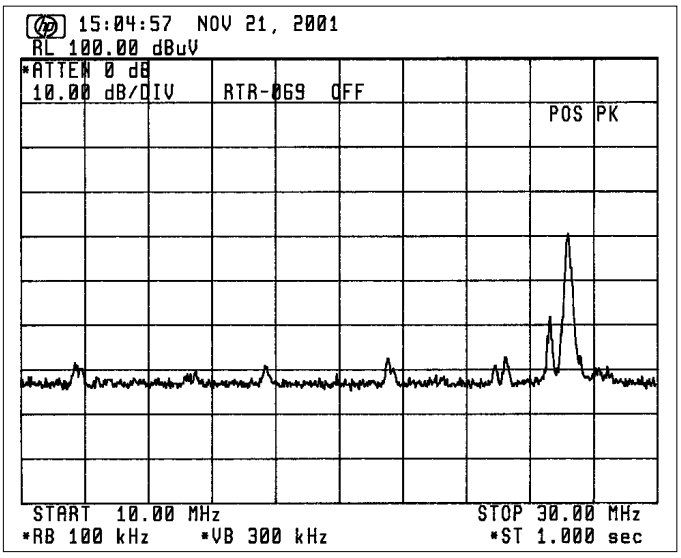
Ref. level (dBµV/m)
= 100 - 88 = 12 (at 5 MHz)
= 100 - 83 = 17 (at 7 MHz)
= 100 - 78 = 22 (at 10 MHz)

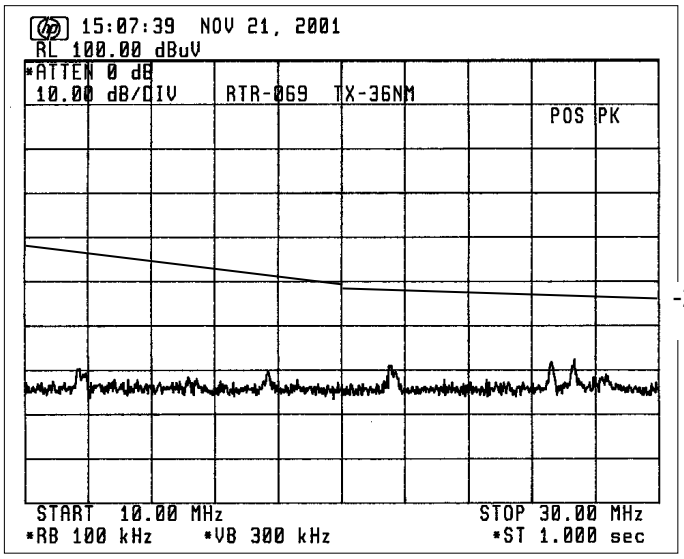


-20 dBµV/m limit line

.

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



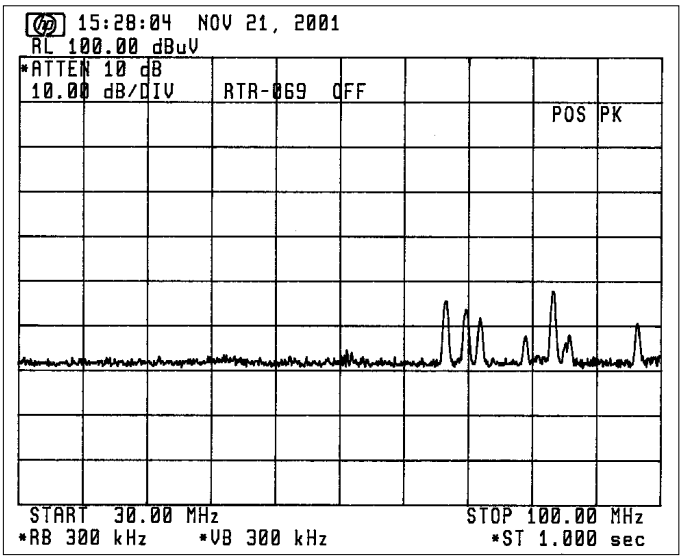


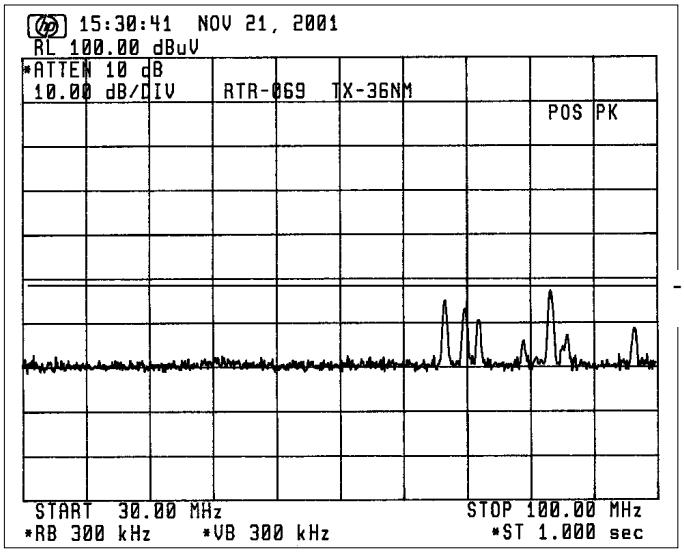
Ref. level (dBµV/m)
= 100 - 78 = 22 (at 10 MHz)
= 100 - 70 = 30 (at 20 MHz)
= 100 - 67 = 33 (at 30 MHz)

-20 dBµV/m limit line

.

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





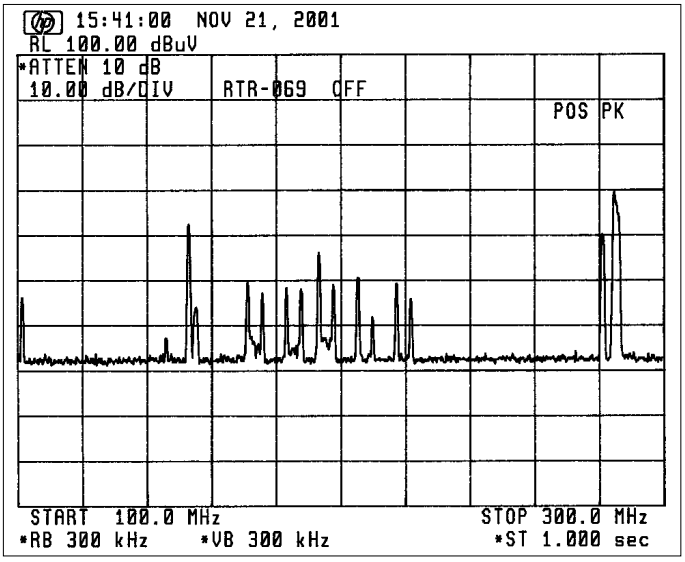
Ref. level (dBµV/m)
= 100 - 61 = 39

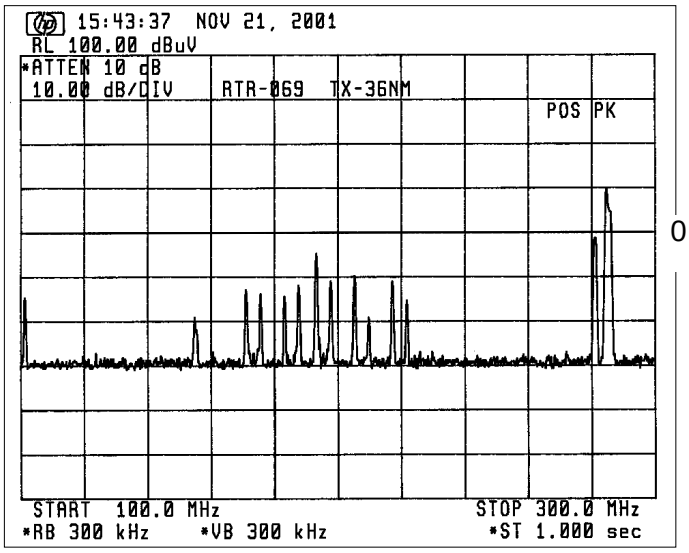
- 10.5 dBµV/m limit line

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

.

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





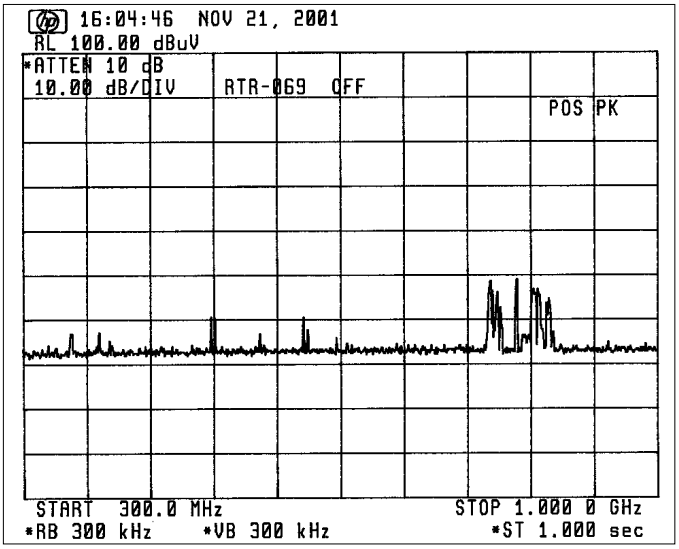
Ref. level (dBµV/m)
= 100 - 60 = 40

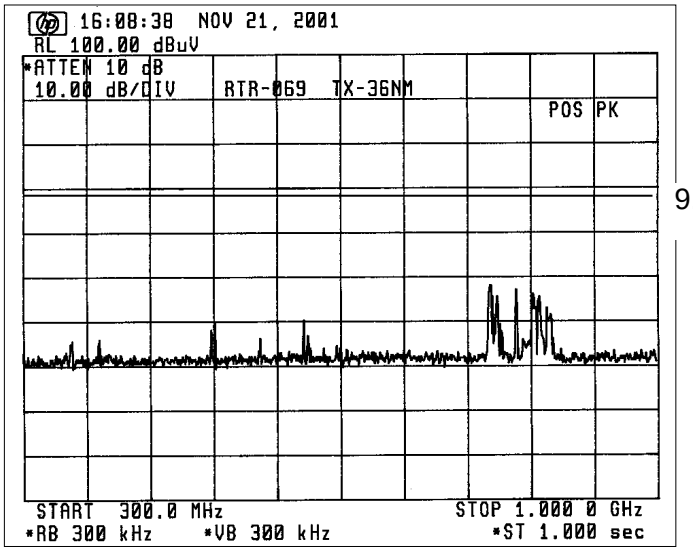
0 dBµV/m limit line

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)



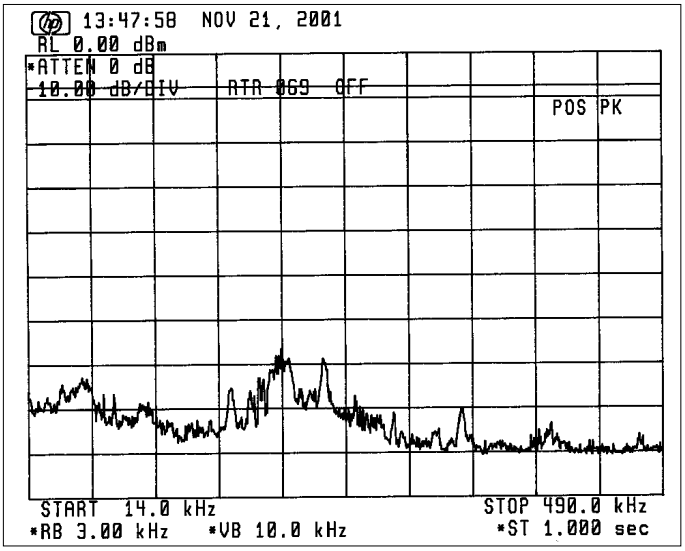


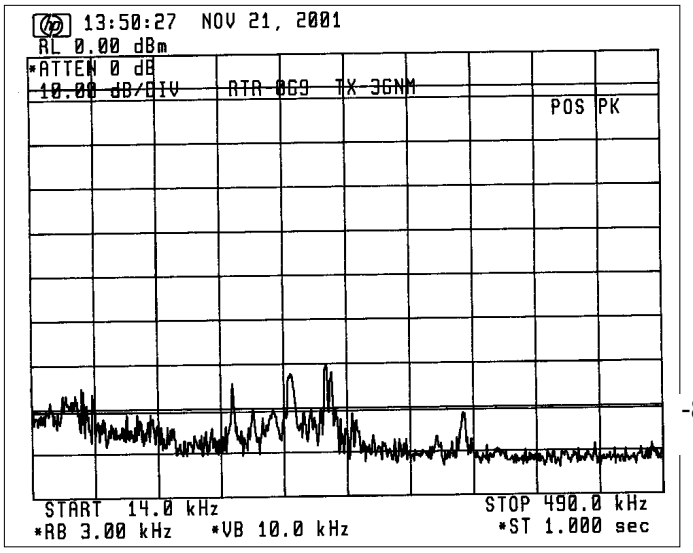
Ref. level (dBµV/m)
= 100 - 59.5 = 40.5

9.5 dBµV/m limit line

3. Power Input to an Artificial Antenna

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



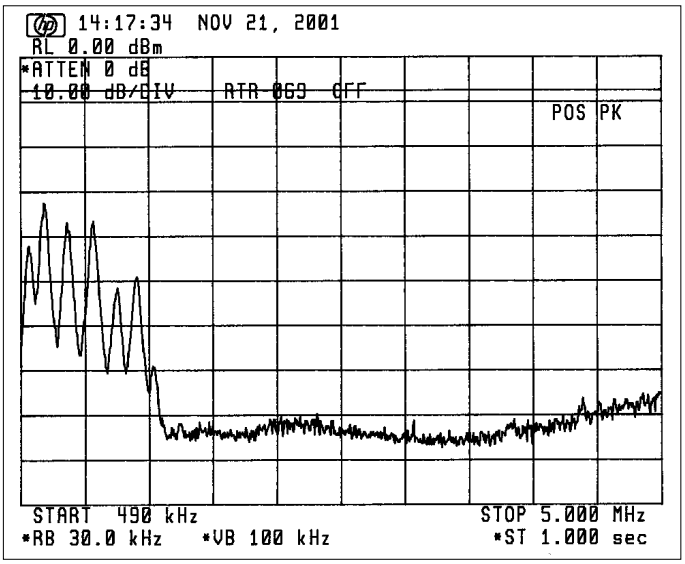


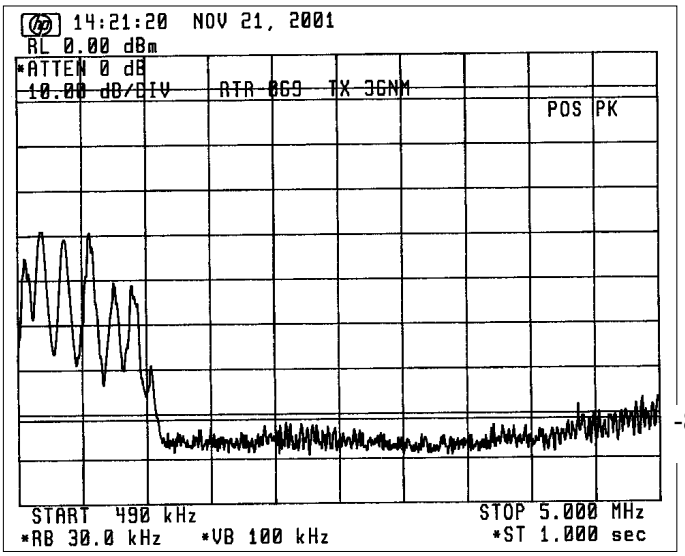
-81 dBm limit line

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)



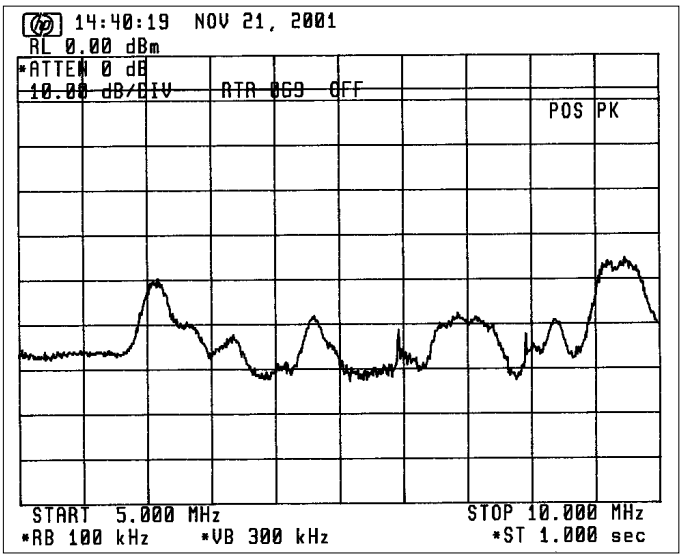


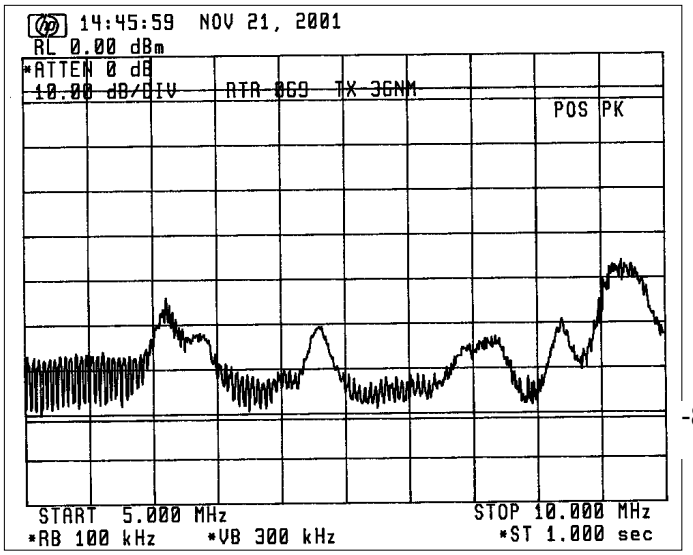
-81 dBm limit line

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)



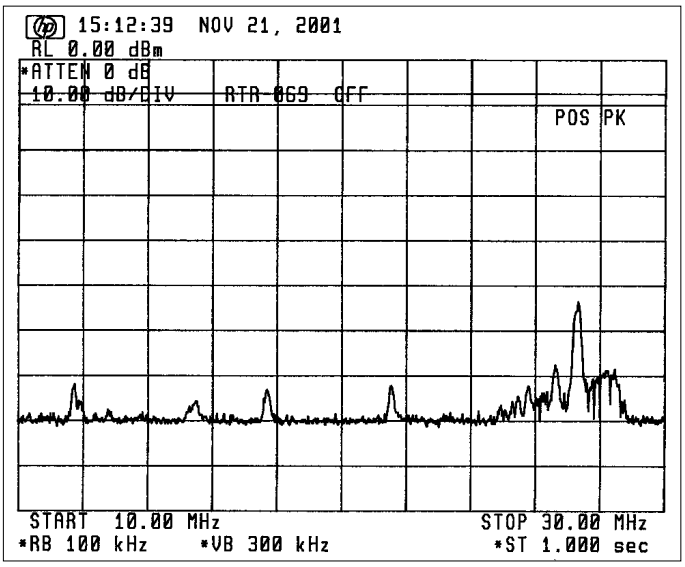


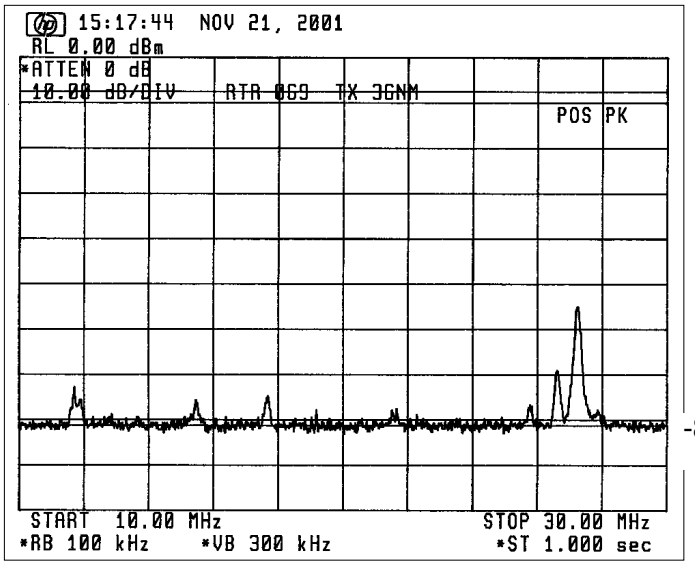
-81 dBm limit line

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)



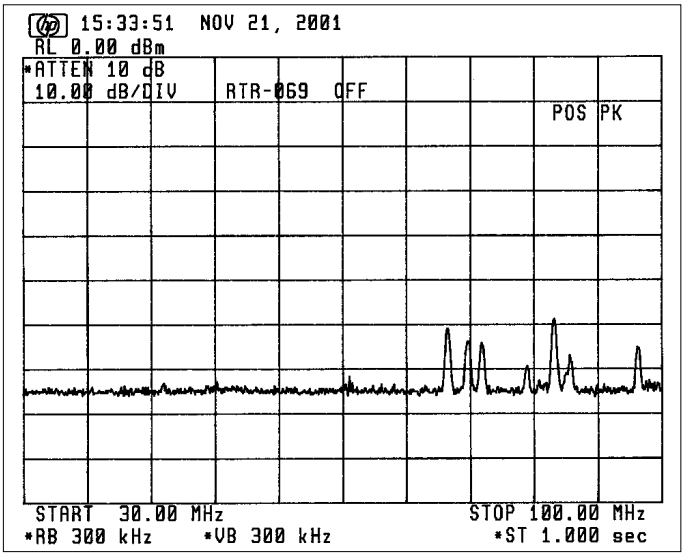


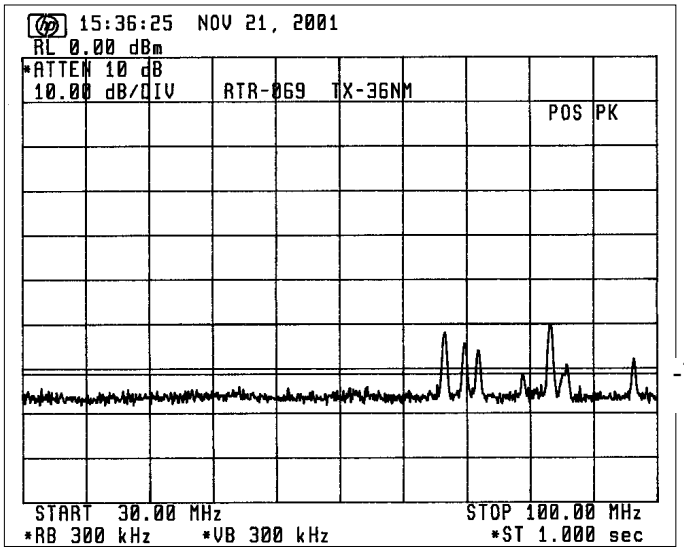
-81 dBm limit line

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)



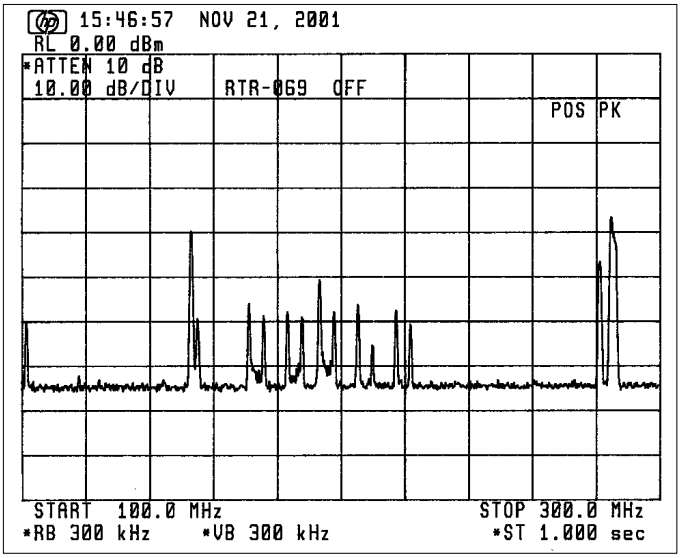


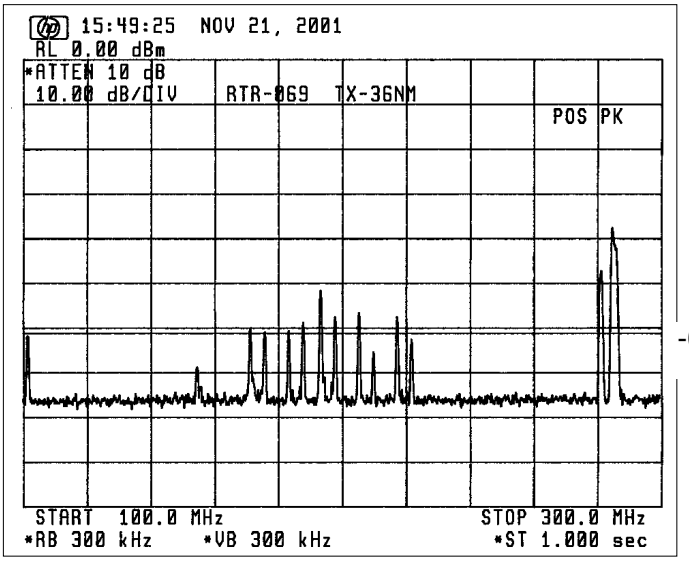
-71 dBm limit line

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)



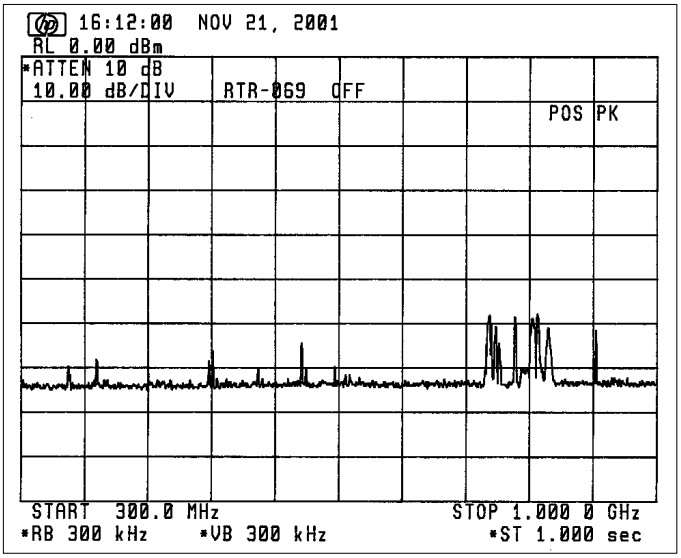


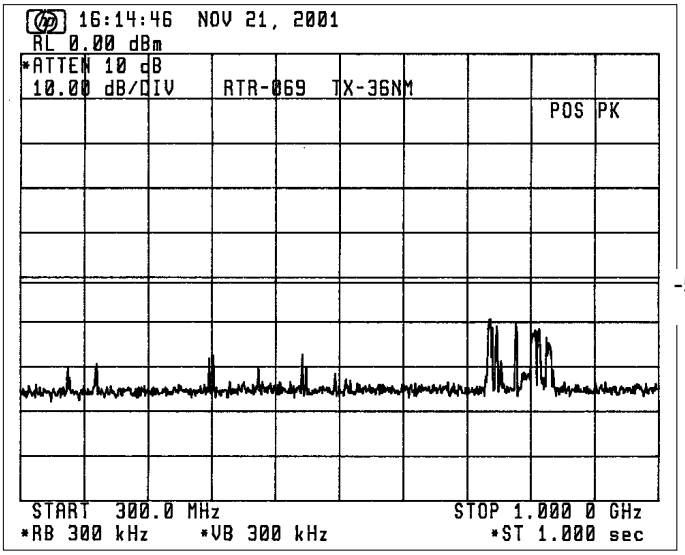
-61 dBm limit line

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 D [List of Test/Measuring Equipment] (for X-band radar)

For Clause 3.1 RF Power Output

Model	Type	Serial no.	Mfr.
Spectrum Analyzer	71210C	2927A02847	HP (Agilent)
Oscilloscope	TDS680B	B030202	Tektronix
Directional Coupler	5D364S	R05762	Shimada
Voltage Divider	HV-P30	2780	Iwatsu
Current Transformer	2100	----	Pearson Electronics
Power Meter	436A	2410A19137	HP (Agilent)
Power Sensor	8481A	2349A39603	HP (Agilent)
Frequency Counter	TR5824A	41940036	Advantest
Frequency Meter	X532B	1441A00523	HP (Agilent)
Crystal Detector	423B	1822A24228	HP (Agilent)
Dummy Load	----	8411057	Shimada
Coax. Attenuator (10 dB)	8491B	28845	HP (Agilent)
Rotary Attenuator (10 dB)	8494B	US00430229	HP (Agilent)
Rotary Attenuator (1 dB)	8495B	3308A22026	HP (Agilent)

For Clause 3.2 Modulation Characteristics and Clause 3.3 Occupied Bandwidth

Model	Type	Serial no.	Mfr.
Oscilloscope	TDS680B	B030202	Tektronix
Crystal Detector	423B	1822A24228	HP (Agilent)
Directional Coupler	5D364S	R05762	Shimada
Dummy Load	-----	8411057	Shimada
Voltage Divider	HV-P30	2780	Iwatsu
Spectrum Analyzer	71210C	2927A02847	HP (Agilent)
Coax. Attenuator (10 dB)	8491B	28845	HP (Agilent)

For Clause 3.4 Spurious Emissions at Antenna Terminal

Model	Type	Serial no.	Mfr.
Spectrum Analyzer	71210C	2927A02847	HP (Agilent)
Coax. Attenuator (10 dB)	8491B	28845	HP (Agilent)
External Mixer	11970K	3003A05695	HP (Agilent)
External Mixer	11970A	2332A00905	HP (Agilent)
Directional Coupler	5D364S	R05762	Shimada
Dummy Load	-----	8411057	Shimada

For Clause 3.5 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 (Agilent)
External Mixer	11970K	3003A05695	HP (Agilent)
External Mixer	11970A	2332A00905	HP (Agilent)
Coax. Attenuator (10 dB)	8491B	28845	HP (Agilent)

For Clause 3.6 Frequency Stability

Model	Type	Serial no.	Mfr.
Power Meter	436A	2410A19137	HP (Agilent)
Power Sensor	8481A	2349A39603	HP (Agilent)
Frequency Meter	X532B	1441A00523	HP (Agilent)
Directional Coupler	5D364S	R5762	Shimada
Dummy Load	----	8411057	Shimada
Environmental Chamber	PL-4KP	14004204	Tabai Espec

For Clause 3.7 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
Network Analyzer	8753C	3214J01067	HP (Agilent)
Spectrum Analyzer	TR4172	30690116	Advantest
Spectrum Analyzer	8566B	2637A03642	HP (Agilent)
Coax. Attenuator (10 dB)	8491B	28845	HP (Agilent)