TECHNICAL INFORMATION

TEST REPORT ON THE PERFORMANCE OF MARINE RADAR

Trade Name : FURUNO

Transceiver Type : RTR-076

Report no.: FLI 12-03-031

Date of issue: July 3, 2003

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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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1 General Information

1.1 General

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

(b) Model: MODEL 1715

	Type	Serial Number
Antenna unit	RSB-0095	R133-0002
Transceiver:	RTR-076	Contained in Antenna unit
Radiator:	RSB-0095	
Display unit	RDP-142	4316-0002

(c) Primary Function: Search, Navigation and anticollison

(d) Discrimination

Range Discrimination: 41 meters on a range scale of 1.5 nm

Bearing Discrimination: 5.7° on a range scale of 1.5 nm,

(e) Minimum Range: 34 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-076

(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: E3588

Peak Output Power: 2.2 kW nominal

(c) Magnetron Ratings

Center frequency of Magnetron: 9410 MHz

Tolerances

	E3588
Manufacturing:	±30 MHz
Pulling:	27 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(b))

(e) Pulse Characteristics:

Range Scale (nm)	(Short)	(Middle)	(Long)
	0.125 (*1)		
	0.25		
	0.5		
	0.75		
		1	
		1.5 (*1)	
		2	
			3
			4
			6
			8
			12
			16
			24 (*1)
Pulselength (µs)	0.08	0.30	0.80
P.R.R.(Hz)	3000	1200	600
Duty cycle	$2.40X10^{-4}$	$3.60X10^{-4}$	$4.80X10^{-4}$
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: 2SK1449

Trigger Voltage: Approx. +10 VDC positive

(3) Receiver

(a) Passband (MHz)

RF Stage: 100 MHz

IF Stage:

Pulselength	Short	Middle	Long
(MHz)	15	5	5

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

(c) Overall Noise Figure (dB): 10 (typical)

(d) Video Output Voltage (V): 5 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: Microstrip antenna

(contained in Radome)

(c) Type of Beam: Vertical fan

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

Horizontal (°):	5.2
Vertical (°):	25

(e) Polarization: Horizontal

(f) Antenna Gain:

Ant. gain (dB):	≥ 20

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

Within ±20°	-20 dB
Outside ±20°	-25 dB

(h) Scanning (rotating or oscillating):

Rotating over 360° continuously clockwise

(i) Antenna Rotation Rate: 24, 31 or 41 rpm (corresponding to the range scale setting)

(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:

Monitor type	RDP-142
Size (in. diagonal) and Color:	7, Monochrome LCD,
Pixels:	240 x 320
Effective diameter (mm):	86

(b) Size of Indicator: See above.

(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	1	3
4	1	4
6	2	3
8	2	4
12	3	4
16	4	4
24	6	4

(e) Range Ring Accuracy: Better than 1% 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 control
A/C Rain control [2)]		
A/C sea	Gain control	Panel dimmer [2)]
Heading line off	Echo stretch [2)]	MENU
Guard zone set/Audio alarm off		Range ring on/off
Interference rejector [2)]	ST-BY/TX	
Trackball (VRM/EBL/GUARD)		
VRM on/off	SHIFT (Offcenter)	Range set [2)]
Zoom	EBL on/off	Echo Trail
Contrast	Off-center	Navigation on/off [1),2)]
Anchor watch [2)]	Display brilliance	
TLL [1), 2), 3)]	Waypoint [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/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)

1.6 Line Power Supply Requirements

(a) Input Voltage: 12 - 24 VDC

(b) Power Drain: 38 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 × Antenna Unit	Type:	RSB-0095
Transceiver	Type:	RTR-076 (contained in the Antenna unit)
1 × Display Unit	Type:	RDP-142

(e) Approximate Weight of Complete Installation:

Antenna Unit:	4.9 kg
Display Unit:	1.5 kg

(f) Approximate space required for installation excluding scanner:

Display Unit: 400 (W) X 240 (H) X 264 (D) mm

2 Identification of Equipment (FCC Rule, 2.925)

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

FCC ID: ADB9ZWRTR076

Material of nameplate: Polyester film, 0.1 mm thick

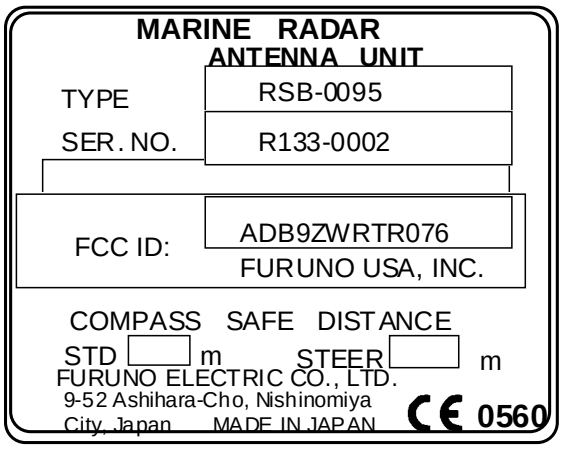


Fig. 2.1 Nameplate forAntenna Unit

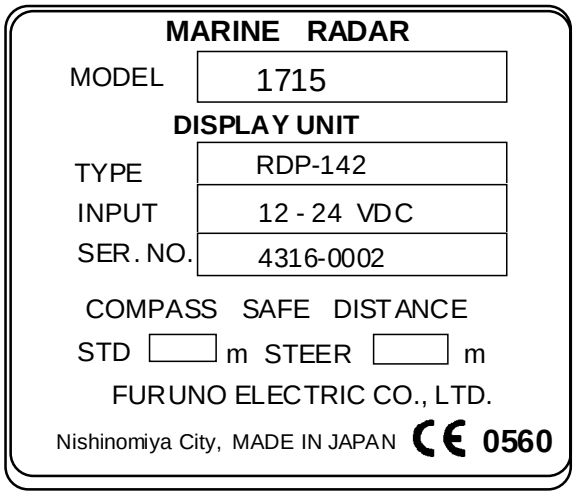


Fig. 2.2 Nameplate for Display Unit

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	1.5	24
Pulselength (µs)	0.08	0.30	0.80
PRR (Hz)	3000	1200	600
Duty cycle	2.40E-04	3.60E-04	4.80E-04
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)	2.4	2.5	2.5
Pulselength (µs) (50 % amplitude)	0.250	0.500	0.956
Rise time (µs) (10 - 90 % amplitude)	0.088	0.128	0.132
Decay time (µs) (90 - 10 % amplitude)	0.310	0.312	0.300

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)	2.2	2.2	2.4
Pulselength (µs) (50 % amplitude)	0.057	0.276	0.736
Rise time (µs) (10 - 90 % amplitude)	0.028	0.102	0.154
Decay time (µs) (90 - 10 % amplitude)	0.045	0.040	0.042

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)	0.063	0.282	0.748
Rise time (ns) (10 - 90 % amplitude)	22.4	71.0	86.0
Decay time (ns) (90 - 10 % amplitude)	47.6	47.0	46.0

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	24
P.R.R (Hz)	3113.0	1226.3	622.6
Duty cycle	1.97E-4	3.46E-4	4.66E-4
Magnetron input, av. (W)	1.02	1.87	2.69
Magnetron input, peak (kW)	5.20	5.41	5.78
Power meter reading (mW)	0.0241	0.0420	0.0612
Magnetron output, av. (W)	0.267	0.465	0.677

Pulselength	Short	Middle	Long
Magnetron Output, peak (kW):	1.36	1.34	1.45
Magnetron efficiency (%):	26.05	24.83	25.16
Spurious response limits (dB)	37.26	39.67	41.31

Peak Power Input to RF Generator : 5.5 kW
Estimated Efficiency of RF Generator : 25.3 %

3.2 Modulation Characteristics (FCC Rule, 2.1047)

3.2.1 FET Trigger Pulse

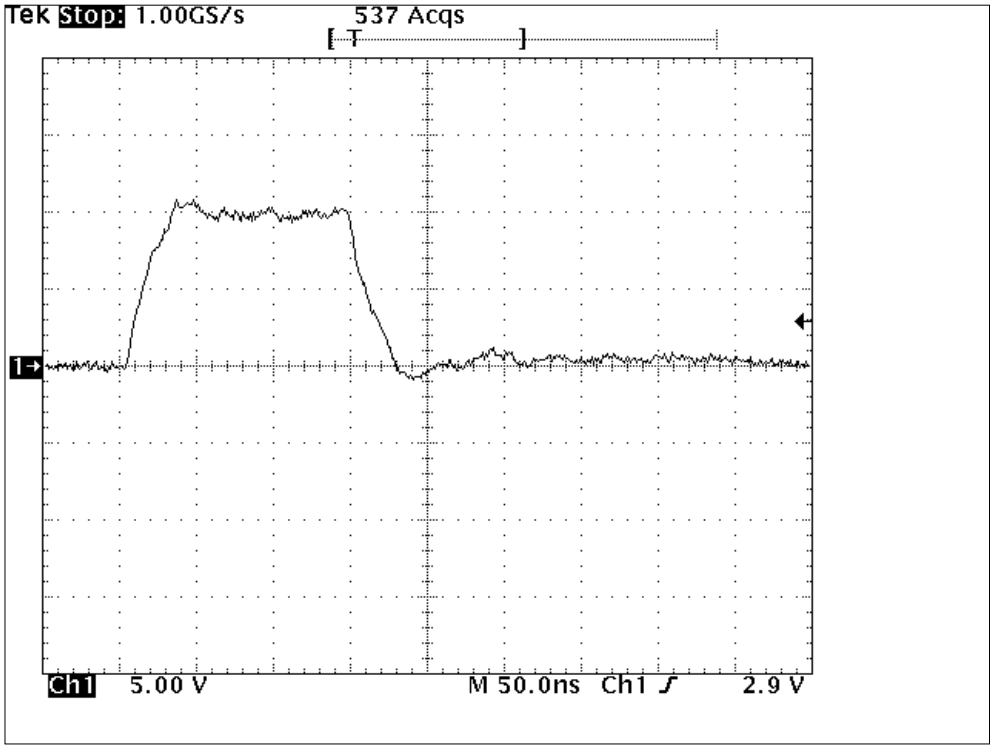


Fig. 3.2.1.1 Typical waveform of Trigger Pulse Scale: 5 V/div., 50 ns/div.

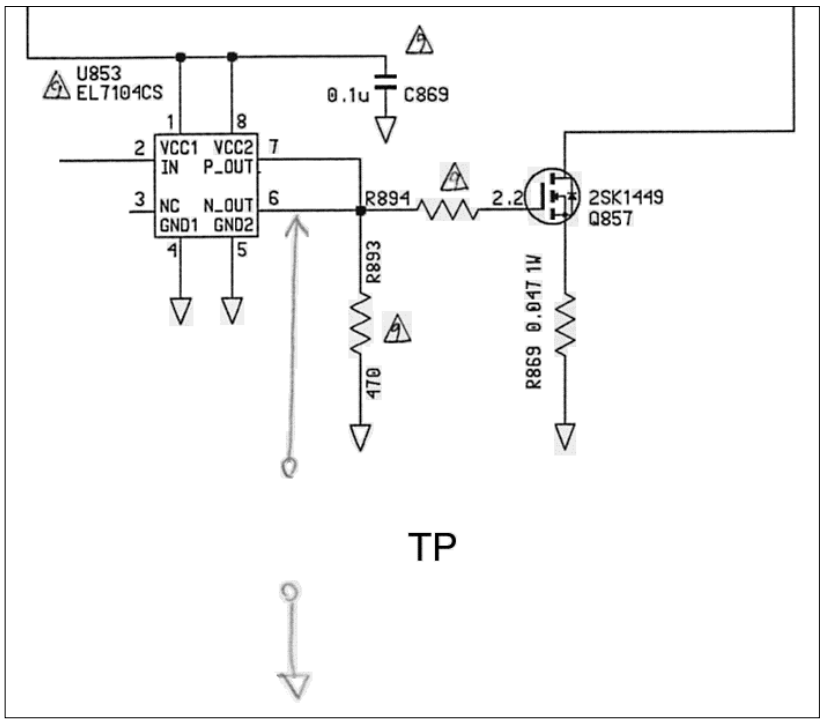


Fig. 3.2.1.2 Test Point for Trigger Pulse
(in MD board (03P9270) of Radar Antenna Unit)

3.2.2 Trigger Pulse at Magnetron Cathode

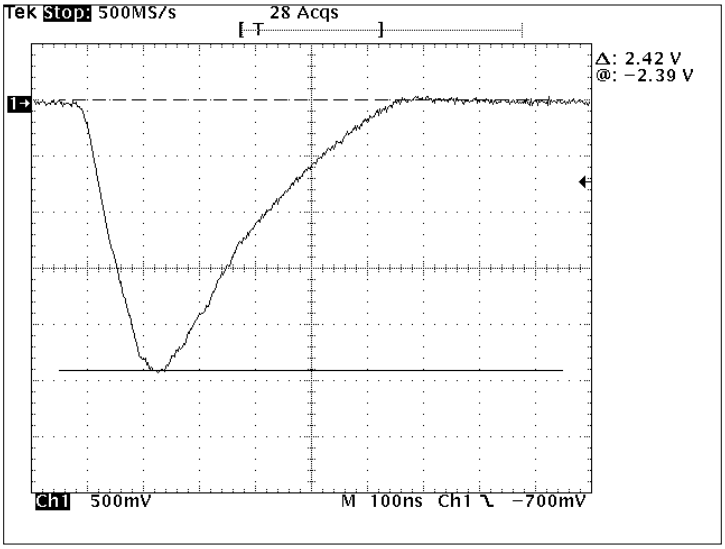


Fig. 3.2.2.1 Short Pulse (0.125 nm Range) Scale: 500 V/div. 100 ns/div.

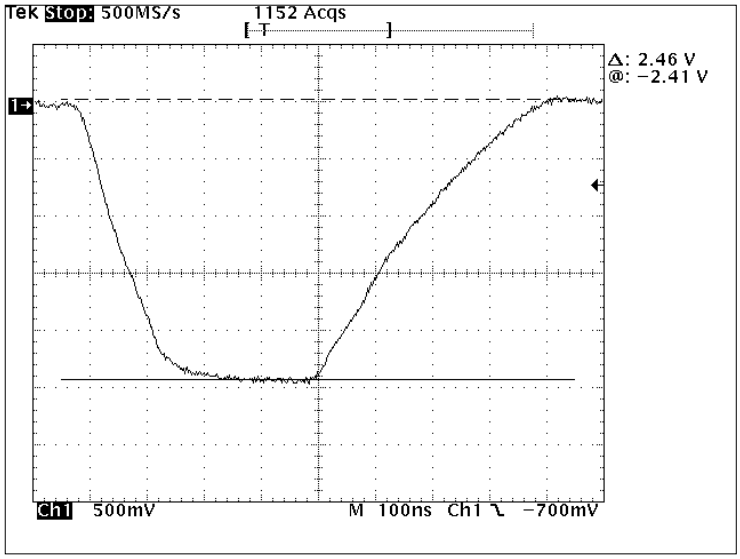


Fig. 3.2.2.2 Middle Pulse (1.5 nm Range) Scale: 500 V/div. 100 ns/div.

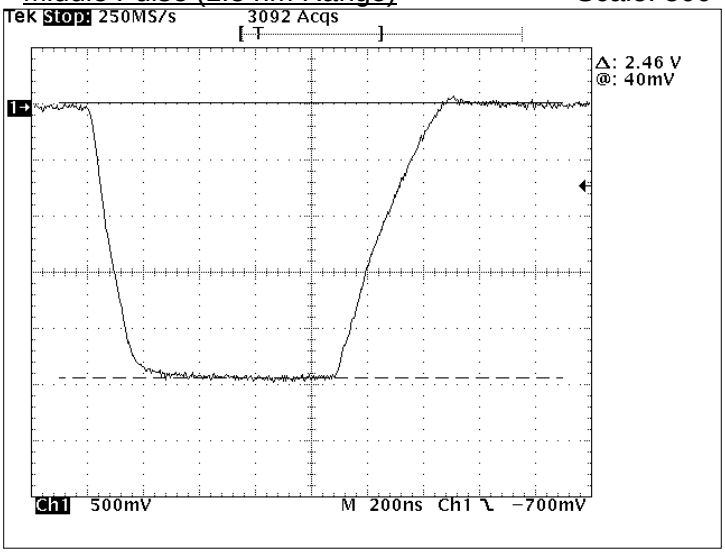


Fig. 3.2.2.3 Long Pulse (24 nm Range) Scale: 500 V/div. 200 ns/div.

3.2.3 **Magnetron Output** (detected):

3.2.3.1 Setup for Measurement:

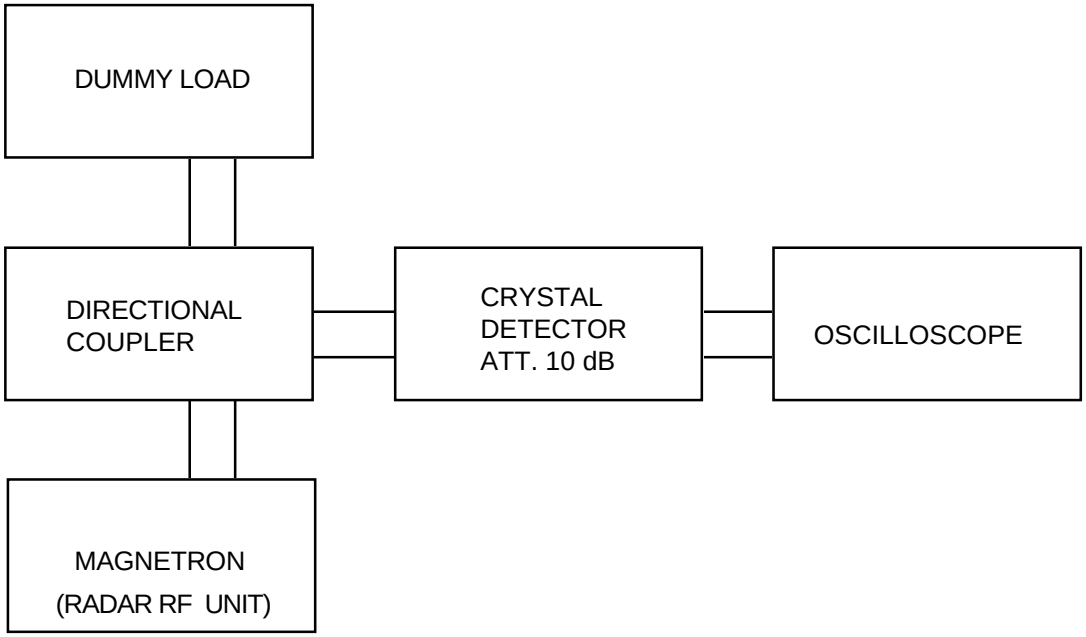


Fig. 3.2.3.1

3.2.3.2 Measuring Equipment List:

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

3.2.3.3 Measured Data:

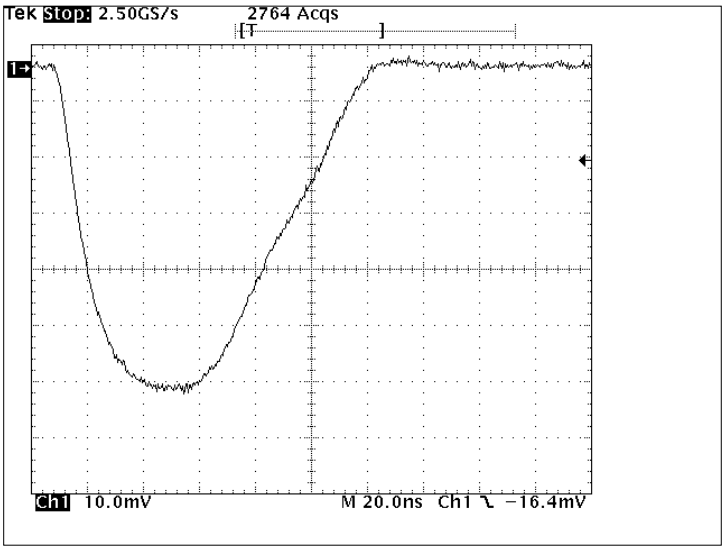


Fig. 3.2.3.2 Short Pulse (0.125 nm Range) Scale: 10 mV/div. 20 ns/div.

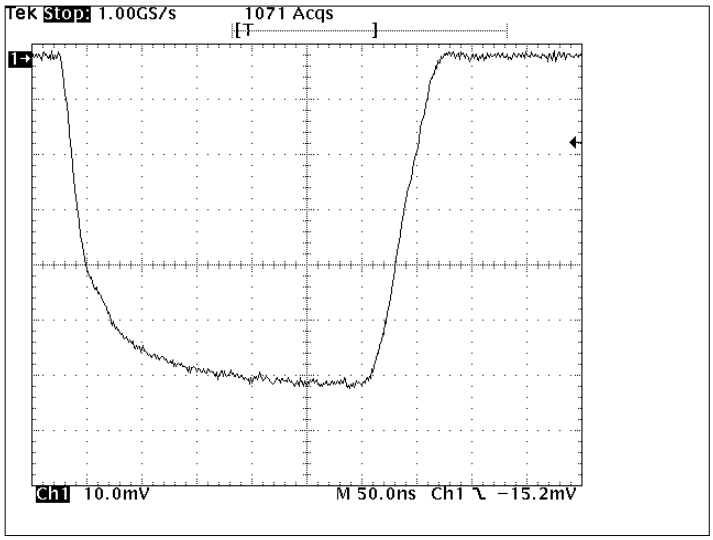


Fig. 3.2.3.3 Middle Pulse (1.5 nm Range) Scale: 10 mV/div. 50 ns/div.

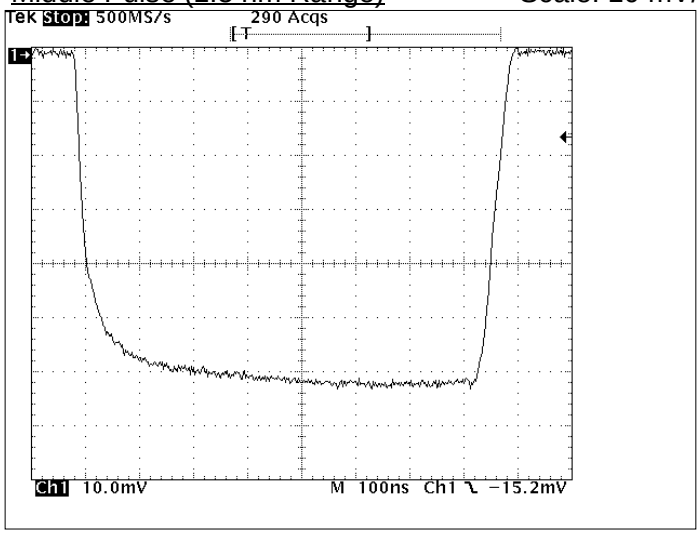


Fig. 3.2.3.4 Long Pulse (24 nm Range) Scale: 10 mV/div. 100 ns/div.

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.)

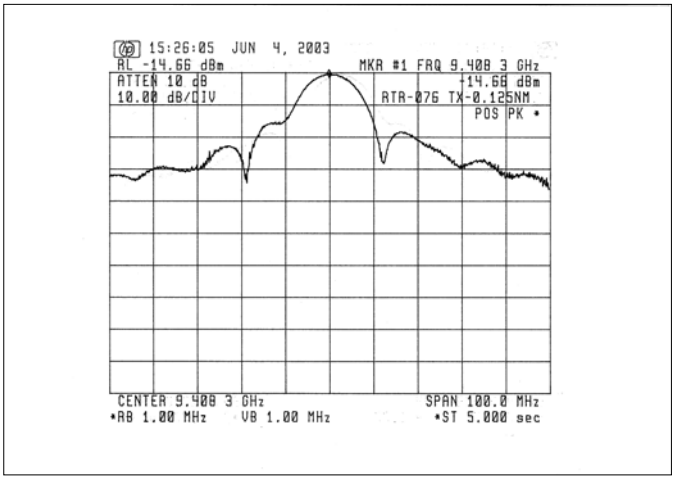


Fig. 3.2.4.1 For Short Pulse (0.125 nm Range)

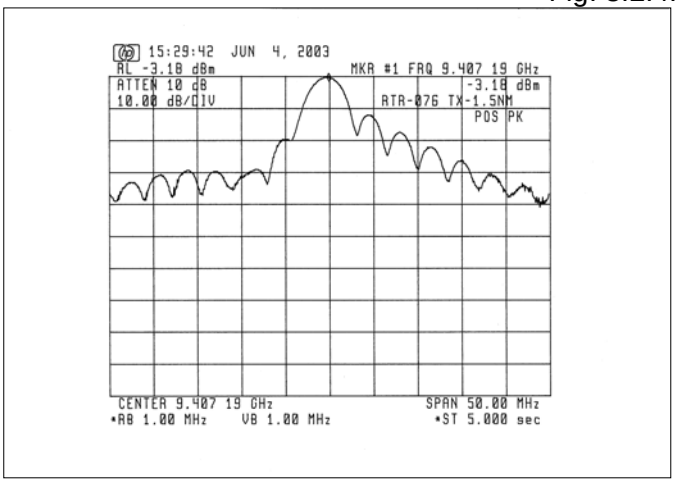


Fig. 3.2.4.2 For Middle Pulse (1.5 nm Range)

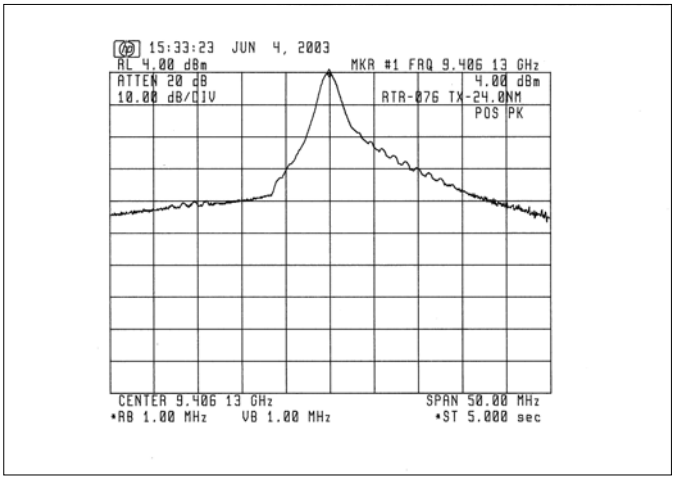


Fig. 3.2.4.3 For Long Pulse (24 nm Range)

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.

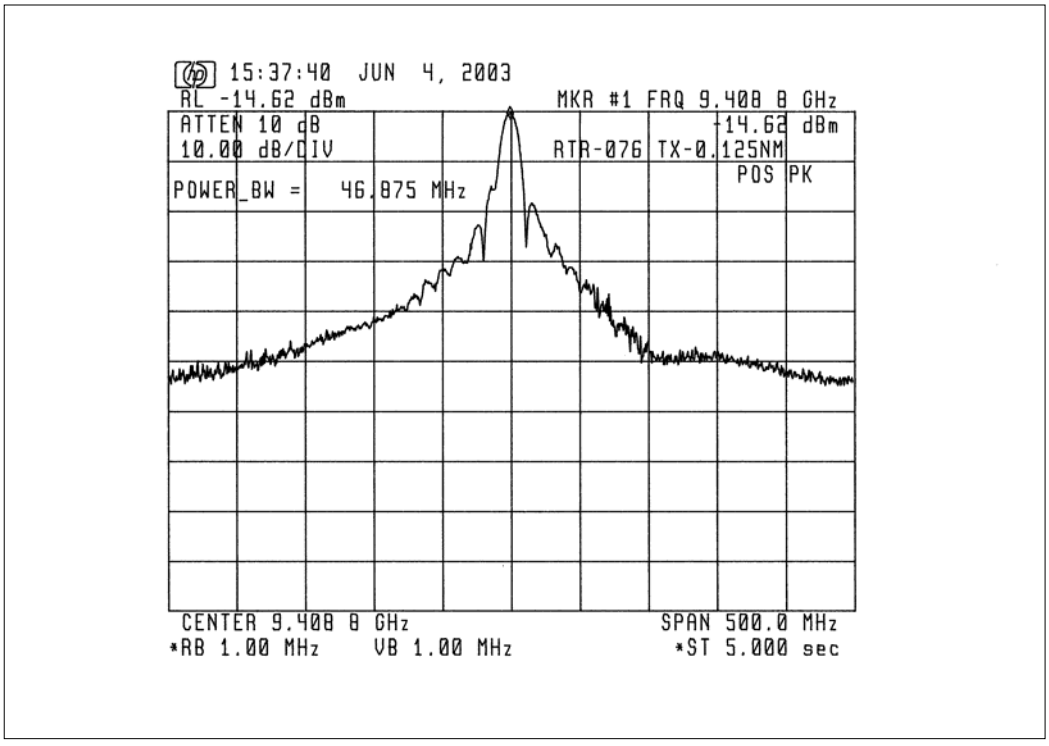
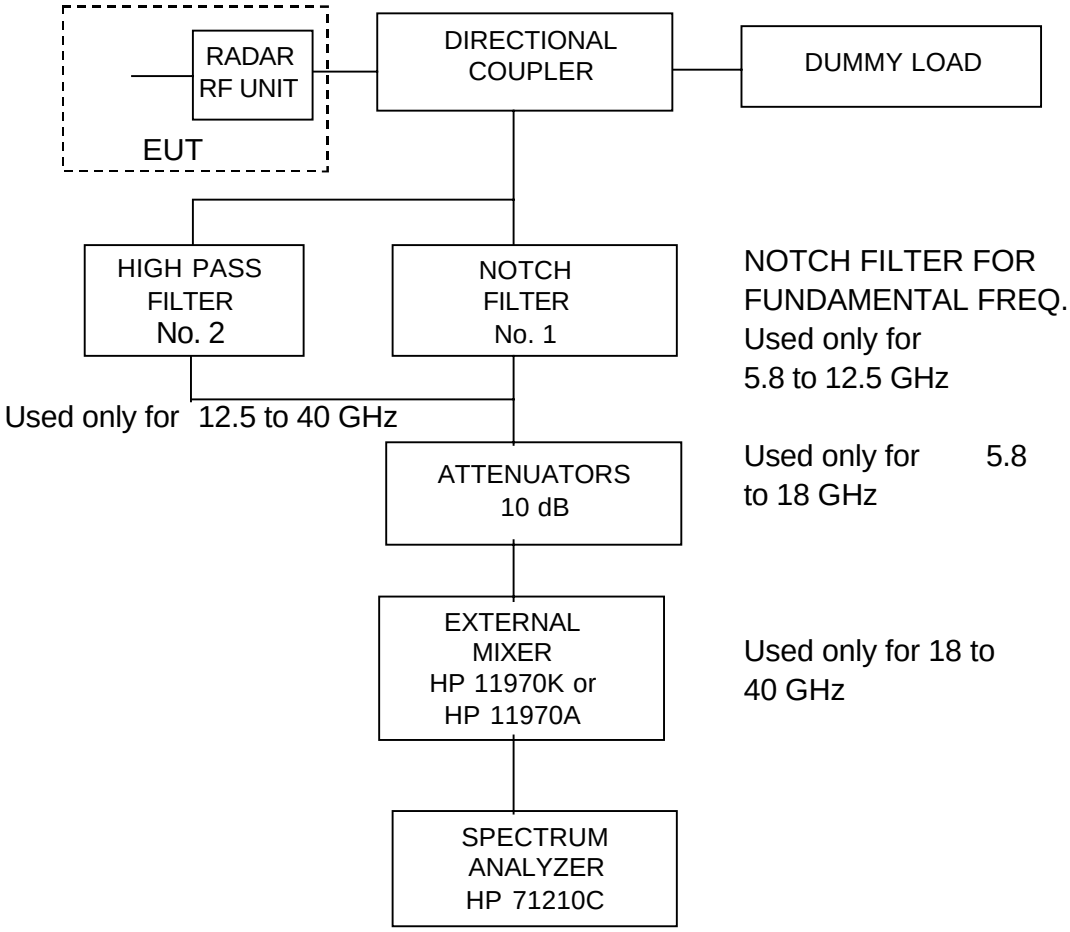


Fig. 3.3.2 Measurement of Occupied Bandwidth

Occupied bandwidth = 46.875 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].

Note : (1) The characteristics of Notch Filter (No. 1) are described in Fig. 3.4.2 to Fig. 3.4.5.
(2) The characteristic of High Pass Filter (No. 2) is described in Fig. 3.4.6.

3.4.3 Test Conditions:

Radar Range Settings: 0.125 nm (Short)/)/ 1.5 nm (Middle)/ 24 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 - 9660 M	At least 35
more than 250 %	10 k - 9160 M 9660- 40,000 M	At least 43 + 10 $\log_{10}$ (mean power in watts)

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

(2) Authorized bandwidth = 100 MHz

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)).

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

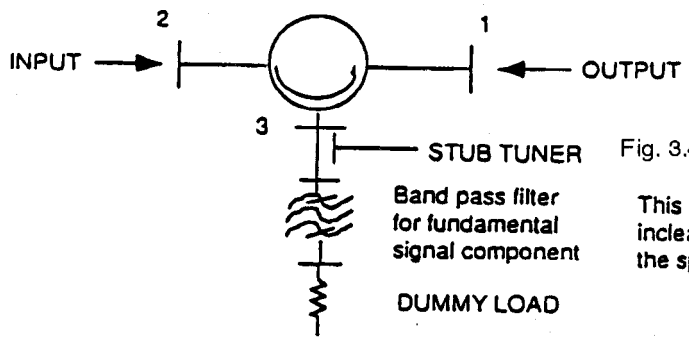


Fig. 3.4.2 Setup of Notch Filter No.1

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

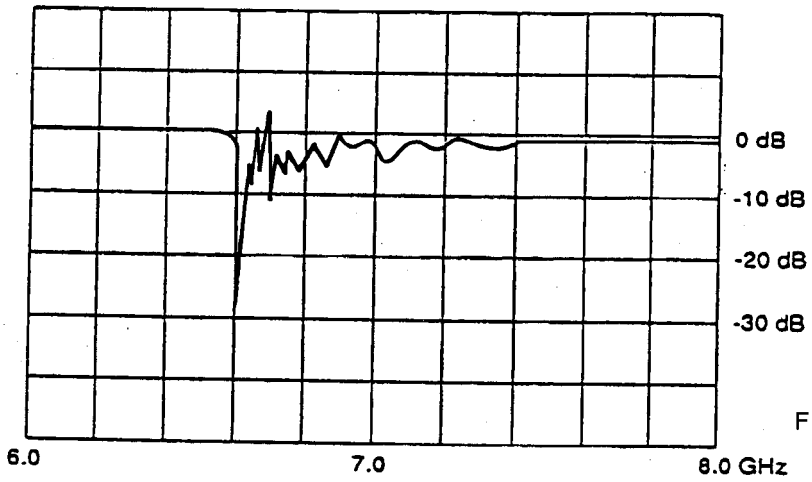


Fig. 3.4.3

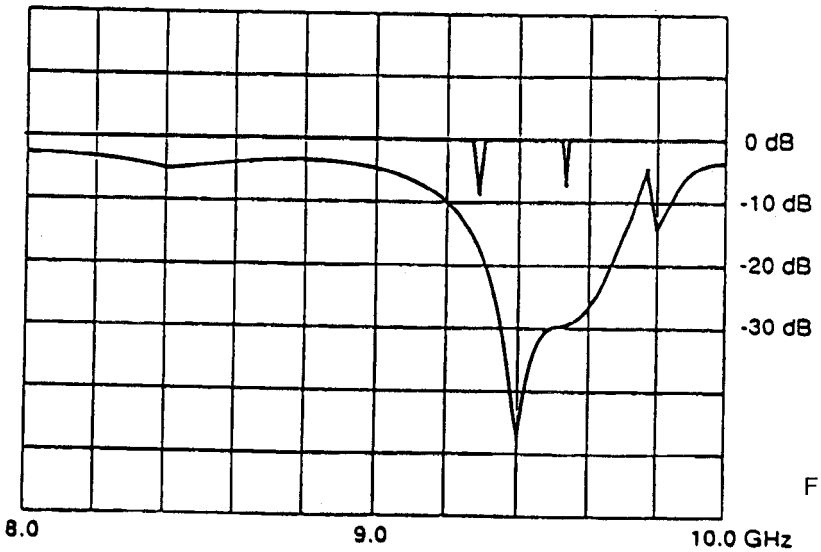


Fig. 3.4.4

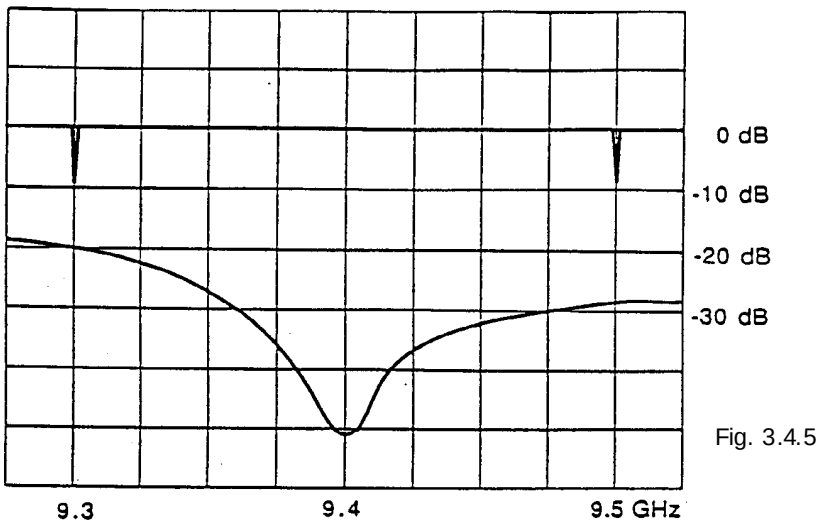
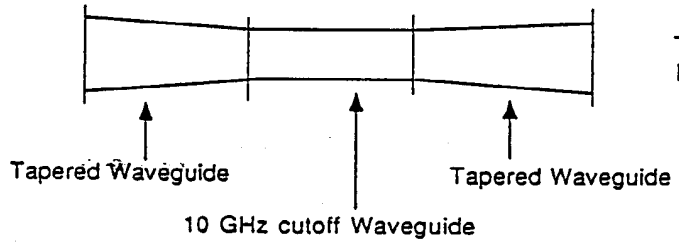


Fig. 3.4.5

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

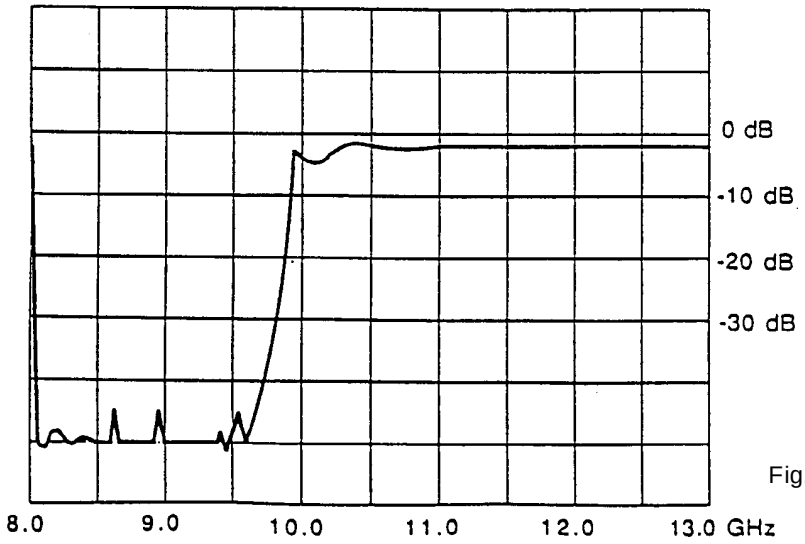


Fig. 3.4.6

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

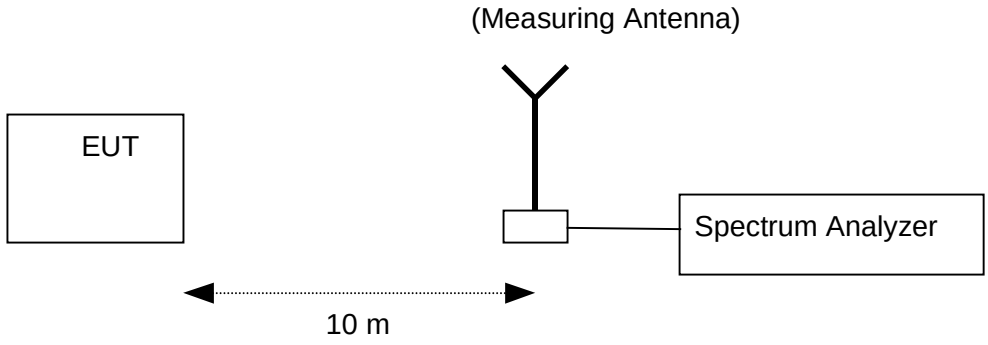
3.5.1 Test Site: Rooftop of 6-story building,
FURUNO ELECTRIC CO., LTD.
Ashihara-cho 9-52, Nishinomiya-city, 662-8580 Japan

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

3.5.3 Radar Range settings: 0.125 nm (Short)/)/ 1.5 nm (Middle)/ 24 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
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

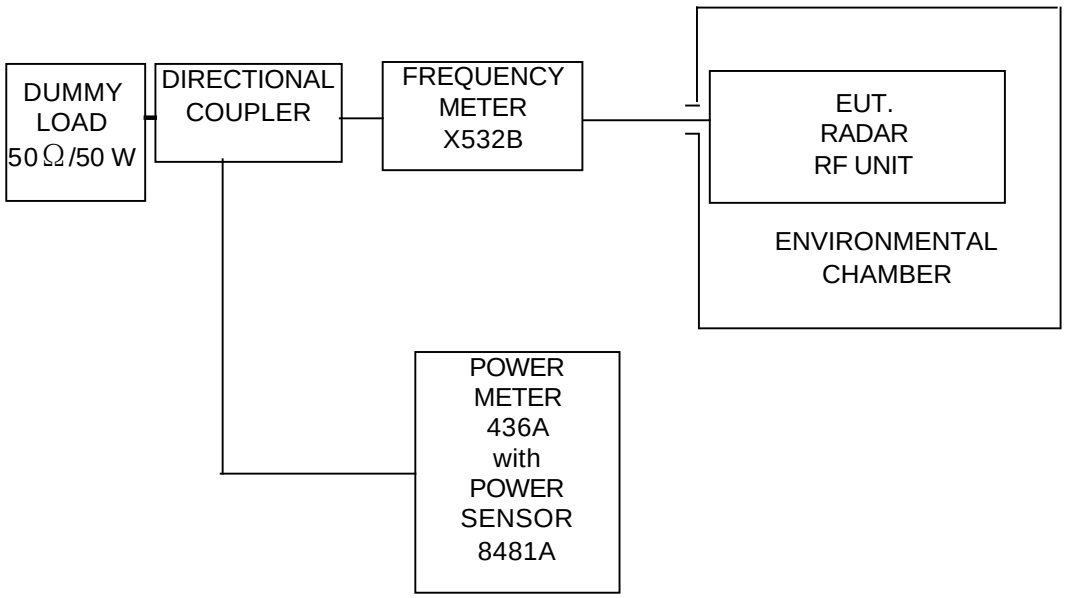


Fig. 3.6.1

3.6.2 Test Conditions:

1) Radar Range settings : 0.125 nm (Short)/)/ 1.5 nm (Middle)/ 24 nm (Long)
2) Ambient Temperature settings: - 20°C to + 50°C (10°C step)
3) Power Supply Voltage settings: 85 /115% of nominal voltage (20.4 VDC 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	1.5	24
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) = 9420.7 MHz
(2) "Lower Tolerance Frequency measured (at + 50°C)", f(L) = 9406.9 MHz
(3)-(a)
f(U) + max. f(1.5/T) = 9439.4 MHz < f(UAUBW) = 9460 MHz ≤ f(UASB) = 9500 MHz
(3)-(b)
f(L) - max. f(1.5/T) =9388.2 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 VDC to 27.6 VDC).

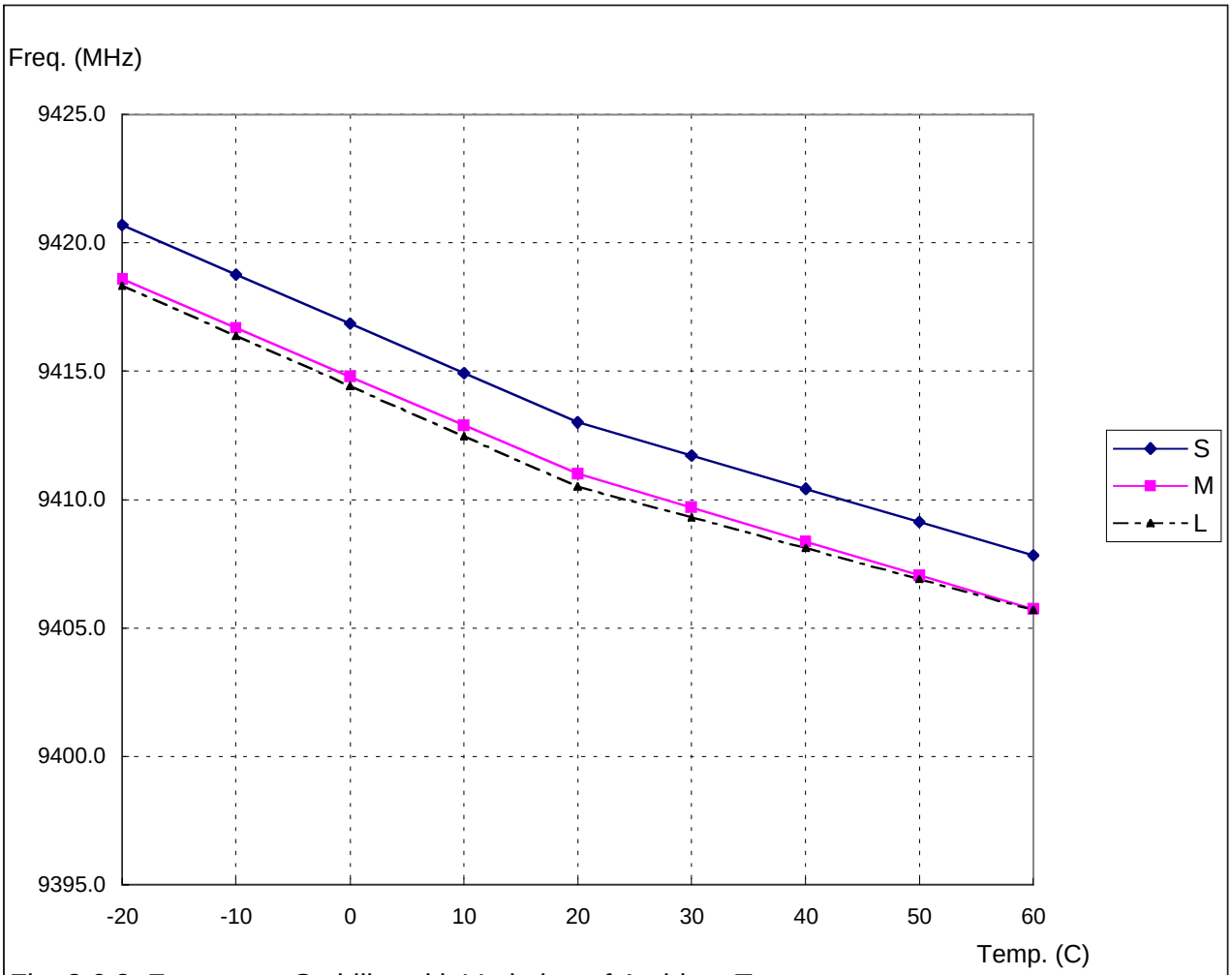


Fig. 3.6.2 Frequency Stability with Variation of Ambient Temperature

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 (W)	θ	R (W)	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

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.)

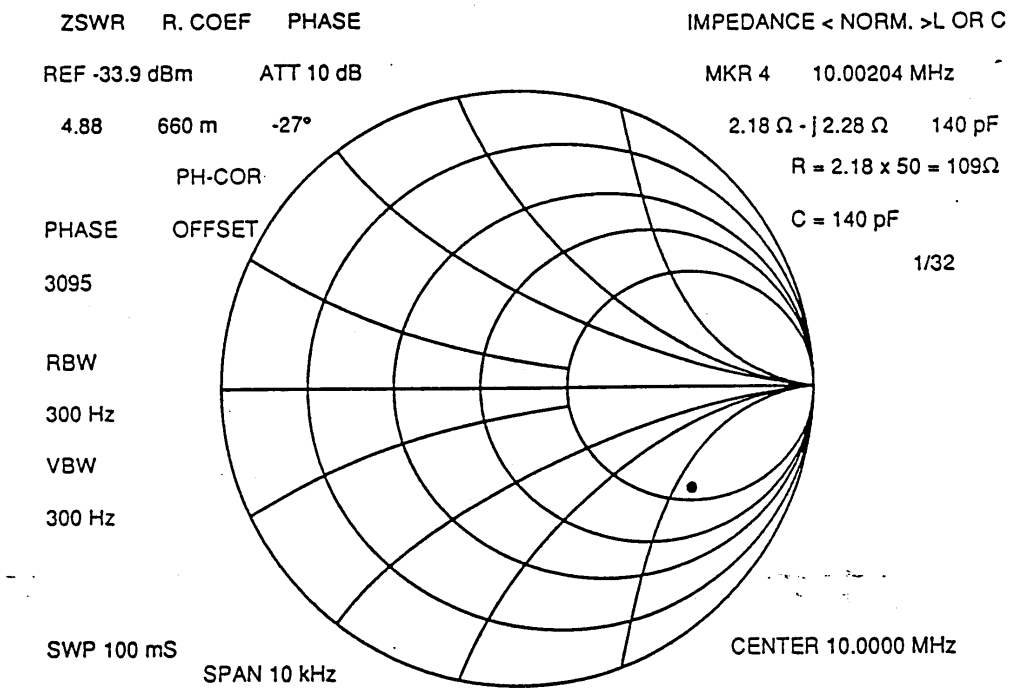
3.7.4.2 **Electromagnetic Field** (FCC Rule, 80.217 (b) - 1)

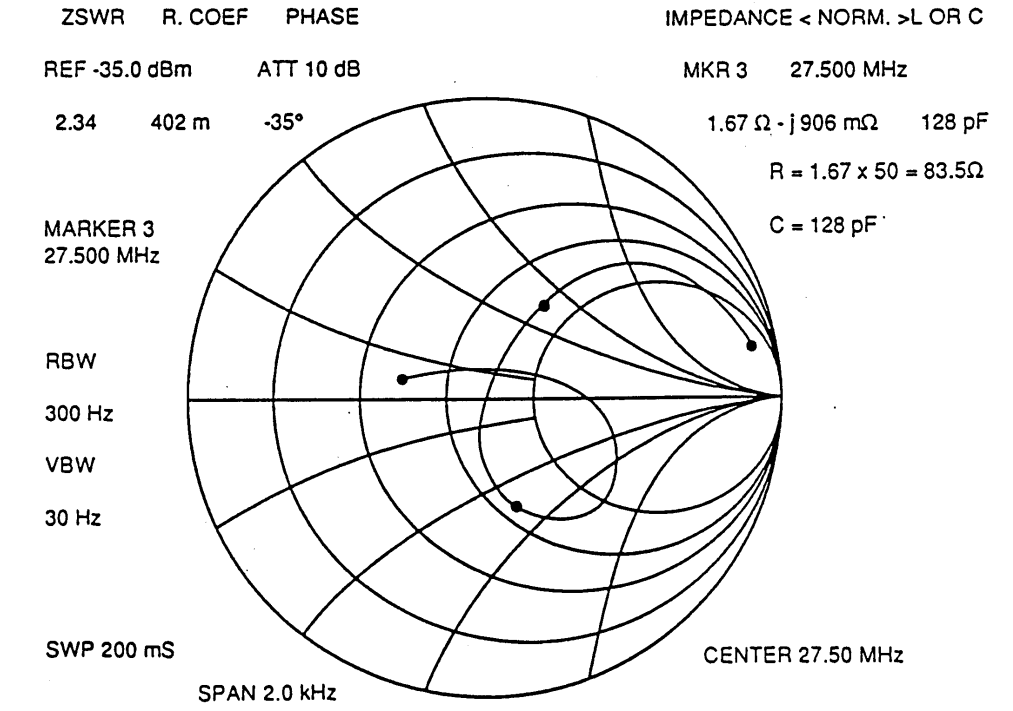
Limits:	for below 30 MHz, 0.1 µV/m at 1 nm (-20 dBµV/m) for 30 to 100 MHz, 0.3 µV/m at 1 nm (-10.5 dBµV/m) for 100 to 300 MHz, 1.0 µV/m at 1 nm (0 dBµV/m) for over 300 MHz, 3.0 µV/m at 1 nm (9.5 dBµV/m)
Results:	Interference was measured with the antenna located 2 m from the radar and converted to levels 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)

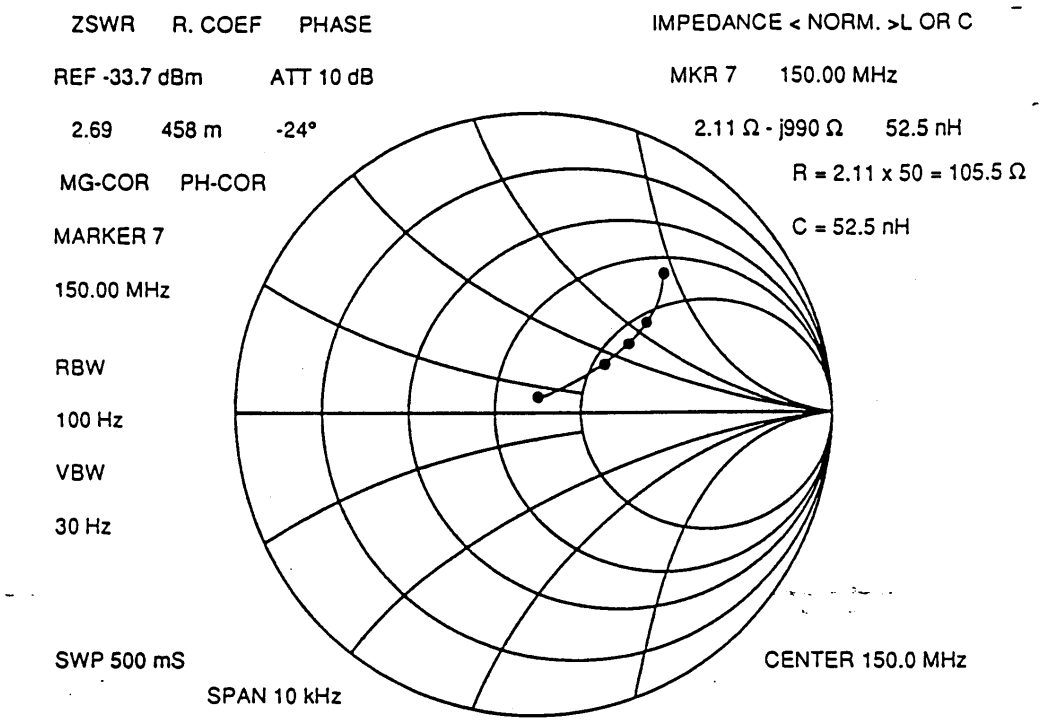
Limits:	for below 30 MHz, 400 µW for 30 to 100 MHz, 4,000 µW for 100 to 300 MHz, 40,000 µW for over 300 MHz, 400,000 µW
Results:	There is no spurious component exceeding the limits. (Test data are shown in Attachment C.)

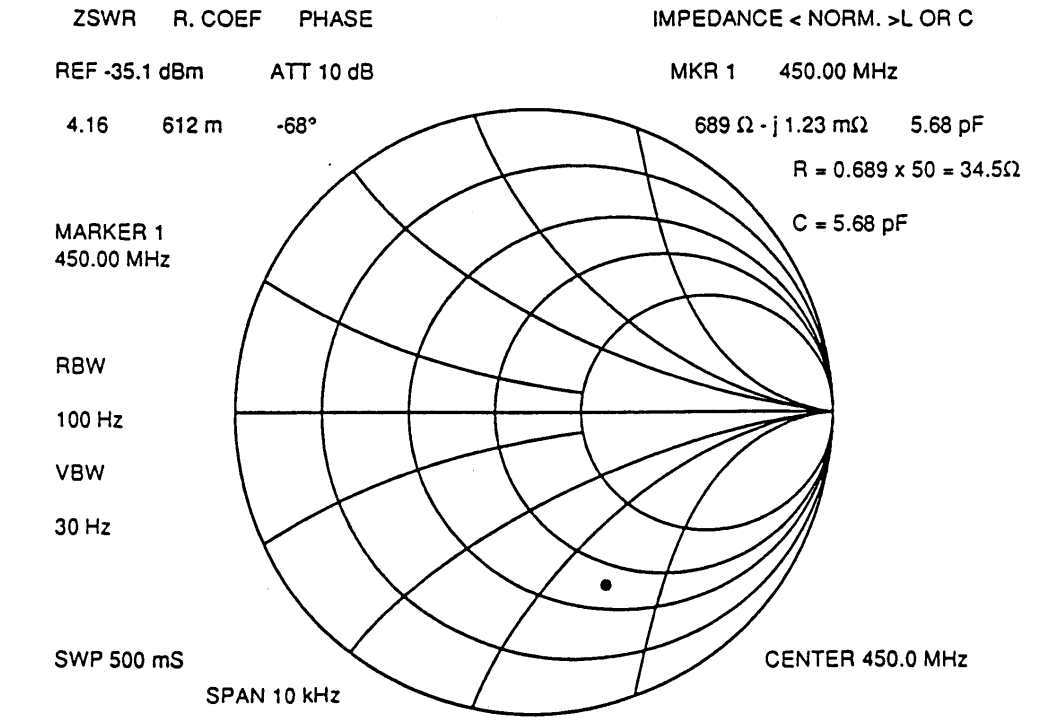
MEASUREMENT OF IMPEDANCE OF TEST ANTENNAS





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-076)

MD PCB 03P9270

CR802:	Voltage Regulator
CR803 & CR834:	Power Switch Control
CR804:	Over Current Protection
CR805 & CR835	Snubber Diode
CR831 & CR832:	Rectifier
CR836-CR838:	Rectifier
CR851:	Pulse Width Select
CR853:	Reverse Voltage Protection
CR855:	Detector (Magnetron Current)
CR856 & CR857:	Reverse Voltage Protection
CR858 & CR859:	Rise-up Voltage Control
Q801:	9V Regulator
Q802:	Power Switch Control
Q803:	45 kHz PWM Inverter and Output MOS FET
Q804:	Current Detector
Q805:	Pulse Amplifier
Q831:	Power Switch Control
Q832:	45 kHz Inverter and Output MOS FET
Q851 & Q852:	Pulse Width Select
Q857:	Pulse Amplifier
Q858 & Q859:	Pulse Width Select
Q860:	TX Trigger Pulse Voltage Buffer
Q861:	Pulse Amplifier
U801:	45 kHz PWM Inverter Control
U802 & U803:	Voltage Detector
U804:	DC Voltage Regulator
U805:	45 kHz Inverter Control
U851:	Dual Monostable Multivibrator
U852:	Pulse Width Select
U853 & U854:	Pulse Amplifier

IF PCB 03P9321

CR1:	Voltage Limiter
CR3:	Voltage Limiter
CR4:	Voltage Limiter
CR12:	Detector
CR13:	Voltage Shifter
Q1 & Q2:	IF Amplifier
Q4:	FET Switch
Q6:	FET Switch
Q10:	Tuning Amplifier
U1:	IF Amplifier
U2:	Voltage Buffer
U3 & U4:	Voltage Regulator
U5:	Analog Switch
U6:	Voltage Buffer
U7:	Comparator
U8:	Multivibrator
U9 & U10:	Logics

INT PCB 03P9322

CR1:	D.C. Blocking
CR2:	Voltage Slicer
CR3:	Signal Mixer
CR5-CR8:	Transient Suppression
Q1-Q3:	Video Amplifier
Q1-Q13:	Transistor Switch
U1:	Reset IC
U2:	D/A Converter
U3:	Voltage Amplifier
U4:	CPU
U5:	Line Driver
Y1:	Resonator

Chassis-mounted parts

B801:	Scanner Motor
U801:	Circulator & MIC
V801:	Magnetron
W801:	Lead-switch

5.2 Description of the circuitry and devices provided for determining and stabilizing frequency, for suppression of spurious radiation, for limiting modulation, and for limiting power

ANTENNA UNIT

TRANSCEIVER MODULE (RTR-076)

Modulator/Block PCB 03P9270

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

The modulator trigger circuit is composed of U851 and associated components. It generates pulses that fire modulator FET Q857. Normally, the circuit is stable with U851 off. The pulse to fire the modulator FET is produced when U851 turns on upon receiving the TX trigger pulse from the display unit. When U851 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 T851 by the ratio 1:9. The resultant pulse, its level being 2.2 kV, is provided to oscillate the magnetron.

CR856 and CR857 absorb the ringing in the secondary side of T851 while C862 decouples the pulse energy that is liable to occur across the magnetron heater when T851's secondary windings are unbalanced or the load is asymmetric.

Also incorporated in the PCB 03P9270 are 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 through CR837, CR838. A DC voltage of 8.0 V is supplied to the magnetron heater through CR836.

Duplexer and Frequency Converter

Since this radar uses a patch array antenna for transmission and reception, an efficient device is required for switching the transmission and receiver. This radar employs circulator U801 (Composed of the circulator and the MIC) for this purpose. It is a passive directional coupler with three ports.

The microwave energy produced by the magnetron enters the circulator from port RF1. It is fed to port RF2 with little loss of energy; port MIC-INPUT at this is isolated. In the same manner, the received signal entering into RF2 is transferred to port MIC-INPUT, isolating port RF1. This

operation of the circulator protects the receiver during transmission and minimizes the loss of the received signal.

A diode limiter, made up of a pair of PIN diodes, is incorporated in the first stage of the MIC (microwave IC). 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 circulator during each TX cycle or the TX pulses received directly from other radars operating in the proximity, to enter the sensitive receiver circuit.

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 the MIC. 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 limiter 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 Block PCB 03P9321

The converted 60 MHz IF signal from MIC is amplified in the IF amplifier block.
The signal detected at the final stage is delivered to the display unit video amplifier.

The 60 MHz IF signal is divided into the tuning block and the amplifier block through C1 and C2.

In the tuning block, IF signal is amplified at Q5 and tuned at T2.
CR3 detects IF signal. And its detected voltage is amplified and buffered by U8. The output voltage is used for the tuning indicator and the tuning control.

In the amplifier block, Q1/Q2 is the first amplifier. Q3 is the attenuator switch.
The signal from Q3 is fed to the detector/broadband-amplifier U1.
The output of U1 is coupled to the video amplifier U2.

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

(See separate covers)