LABOTECH

TECHNICAL INFORMATION

TEST REPORT ON THE PERFORMANCE OF MARINE RADAR

Trade Mark : FURUNO

Model : MODEL 851 MARK 2

Report no.: FLI 12-00-018

Date of issue: 16 June 2000

Furuno Labotech International Co., Ltd.

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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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This report has been verified and approved by:

Date : 16 June 2000

Name : Mitsuyoshi Komori

Function : Manager, Technical Section

Signature :

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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 851 MARK 2
Serial no.: 4302-0002

(c) Primary Function: Search, Navigation and anticollison

(d) Discrimination
Range Discrimination: 20 meters on a range scale of 0.25 nm
Bearing Discrimination:2.4 ° on a range scale of 1.5 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-065**

(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:	MG5248	E3571	E3571A

Peak Output Power: 4 kW nominal

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

	MG5248	E3571	E3571A
Manufacturing:	±30 MHz	±30 MHz	±30 MHz
Pulling:	23 MHz	27 MHz	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		
	0.25		
	0.5		
	0.75		
	1		
	1.5	1.5	
		2	
		3	3
			4
			6
			8
			12
			16
			24
			48
Pulselength (μs)	0.08	0.30	0.80
P.R.R.(Hz)	2100	1200	600
Duty cycle	$1.68X10^{-4}$	$3.60X10^{-4}$	$4.80X10^{-4}$
Guard Band (MHz)	18.75	5.00	1.88

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

(2) Modulator

(a) FET Type: 2SK1450

Trigger Voltage: Approx. +10 VDC positive

(3) Receiver

(a) Passband (MHz)

RF Stage: 100 MHz

IF Stage:

Pulselength	Short	Middle	Long
(MHz)	7	7	7

Video Amp.:

Pulselength	Short	Middle	Long
(MHz)	14	14	3

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

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

(d) Video Output Voltage (V): 3.8 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: Slotted waveguide antenna

Radiator type	XN8
Length (cm)	100

(c) Type of Beam: Vertical fan

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

Horizontal	2.4°
Vertical	25°

(e) Polarization: Horizontal

(f) Antenna Gain: 26 dB

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

Within ±20°	-24 dB or less
Outside ±20°	-30 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: 8 (in.) monochrome LCD,
481 X 640 pixels

(b) Size of Indicator: 8 in. diagonal
effective dia. 122 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
48	4	12

(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 switch
STC control	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	Omini Pad keys
A/C Rain control	Noise cancell ON/OFF [2]	(VRM/EBL/GUARD)
VRM on/off	Off-center (SHIFT)	Range set [2]
Zoom/Wide [2]	EBL on/off	Echo Trail
Contrast	PLOT brilliance [2]	Navigation on/off [1),2)]
Watchman [2]	Display brilliance	NODE (HU/CU/WU/NU/TM) [1),2)]
TRU/REL [2),3)]		

Note: [1)] Valid when interfaced with navaid.
[2)] Selected on menu.
[3)] Valid when interface 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: 60 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-117
1 × Antenna Unit	Type:	RSB-0082 (24 rpm)
Transceiver	Type:	RTR-065 (contained in the Antenna unit)

(e) Approximate Weight of Complete Installation:

Display Unit:	3.5 kg
Antenna Unit:	23 kg

(f) Approximate space required for installation excluding scanner

Display Unit: 426 mm (W) X 275 mm (H) X 337 mm (D)

2 Identification of Equipment (FCC Rule §2.925)

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

FCC ID: ADB9ZWRTR065

Material of nameplate: Polyester film, 0.1 mm thick

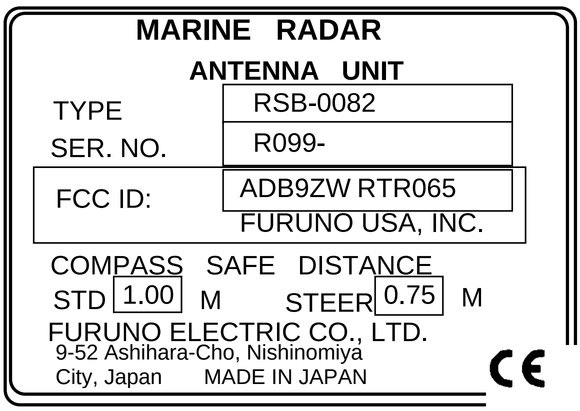


Fig. 2.1 Nameplate for Antenna Unit

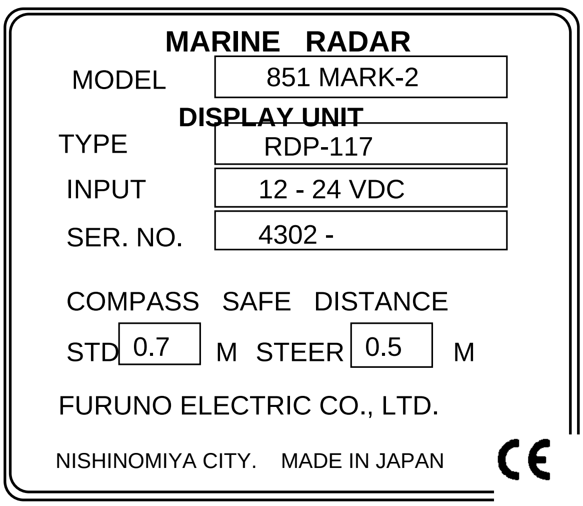


Fig. 2.2 Nameplate for Display Unit

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	3	48
Pulselength (µs)	0.08	0.30	0.80
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)	3.6	3.6	3.7
Pulselength (µs) (50 % amplitude)	0.384	0.560	1.010
Rise time (µs) (10-90 % amplitude)	0.024	0.026	0.020
Decay time (µs) (90-10 % amplitude)	0.700	0.610	0.320

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)	3.1	3.2	3.2
Pulselength (µs) (50 % amplitude)	0.103	0.288	0.805
Rise time (µs) (10-90 % amplitude)	0.047	0.050	0.050
Decay time (µs) (90-10 % amplitude)	0.059	0.060	0.064

RF envelope of the magnetron output pulse

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

Pulselength	Short	Middle	Long
Pulselength (µs) (-3 dB points)	0.108	0.290	0.800
Rise time (µs) (10-90 % amplitude)	0.012	0.013	0.013
Decay time (µs) (90-10 % amplitude)	0.054	0.062	0.084

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	48
P.R.R (Hz)	2083.4	1190.3	606.6
Duty cycle	2.25×10^{-4}	3.45×10^{-4}	4.85×10^{-4}
Magnetron input, av. (W)	2.51	3.98	5.75

Pulselength	Short	Middle	Long
Magnetron input, peak (kW)	11.16	11.52	11.84
Power meter reading (mW)	0.0702	0.1116	0.1540
Magnetron output, av. (W)	0.777	1.235	1.704
Spurious response limits (dB)	41.90	43.92	45.32
Magnetron Output, peak (kW):	3.45	3.58	3.51
Magnetron efficiency (%):	30.9	31.1	29.7

Peak Power Input to RF Generator : 11.5 kW
Estimated Efficiency of RF Generator : 30.5 %

3.2 Modulation Characteristics (FCC Rule § 2.1047)

3.2.1 FET Trigger Pulse

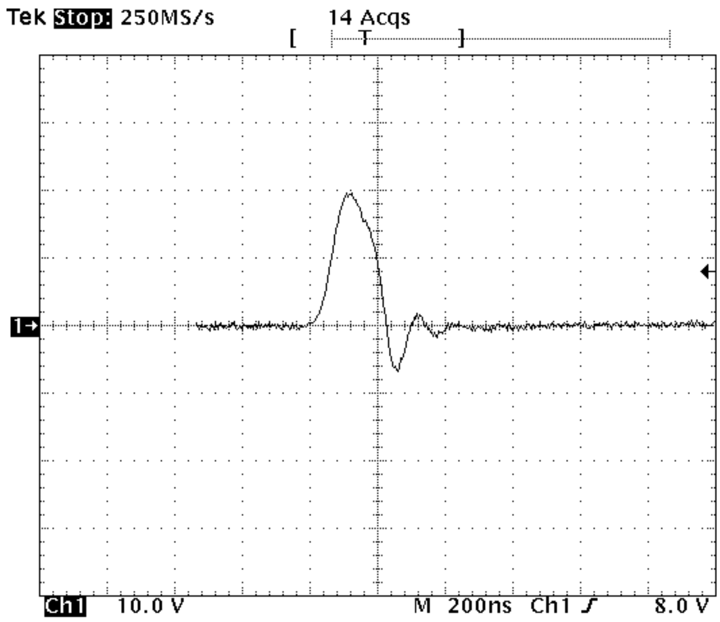


Fig. 3.2.1.1 Typical waveform of Trigger Pulse Scale: 10 V/div., 200 ns/div.

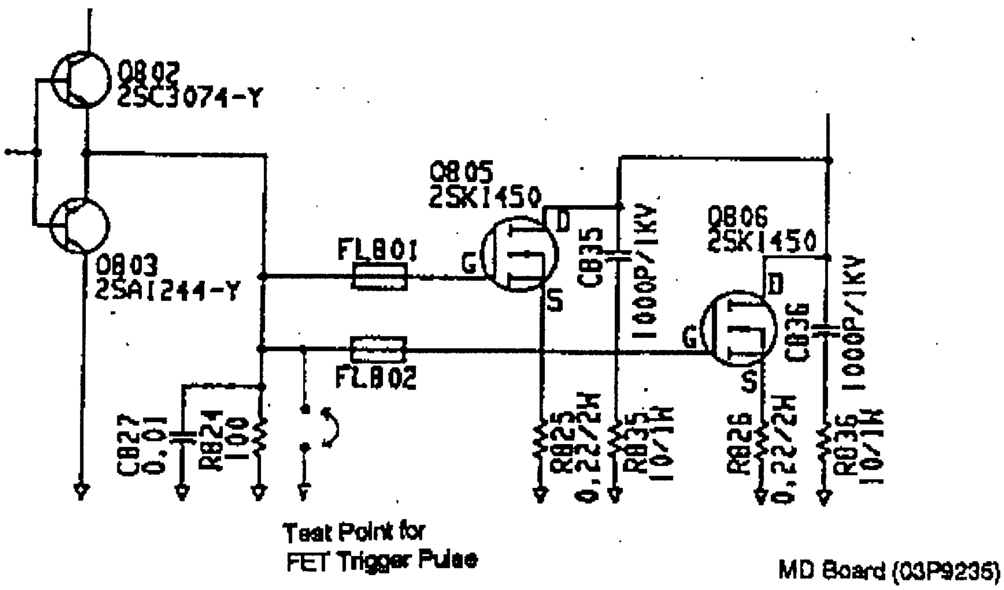


Fig. 3.2.1.2 Test Point for Trigger Pulse
(in MD board (03P9235) of Radar Antenna Unit)

3.2.2 Trigger Pulse at Magnetron Cathode

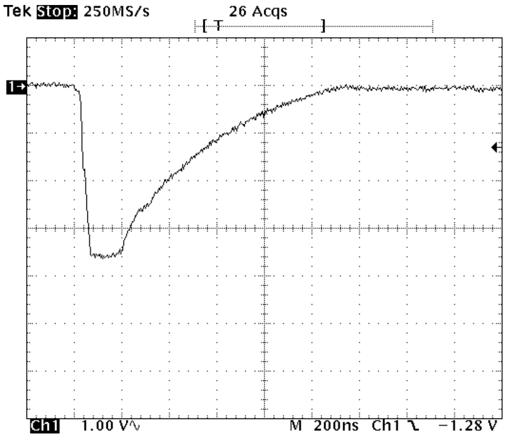


Fig. 3.2.2.1 Short Pulse (0.125 nm Range) Scale: 1 kV/div. 200 ns/div.

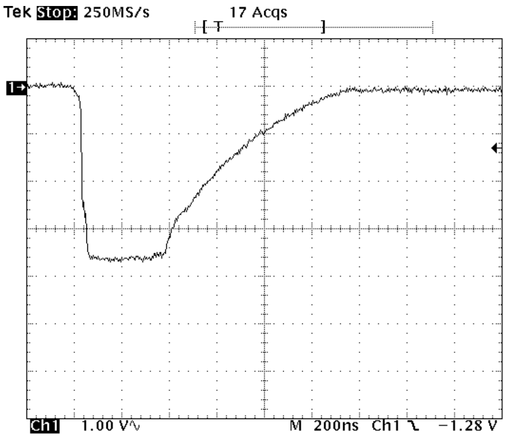


Fig. 3.2.2.2 Middle Pulse (3 nm Range) Scale: 1 kV/div. 200 ns/div.

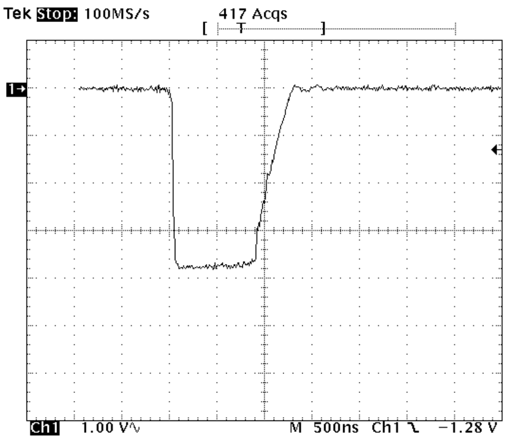


Fig. 3.2.2.3 Long Pulse (48 nm Range) Scale: 1 kV/div. 500 ns/div.

3.2.3 **Magnetron Output** (detected):

3.2.3.1 Setup for Measurement:

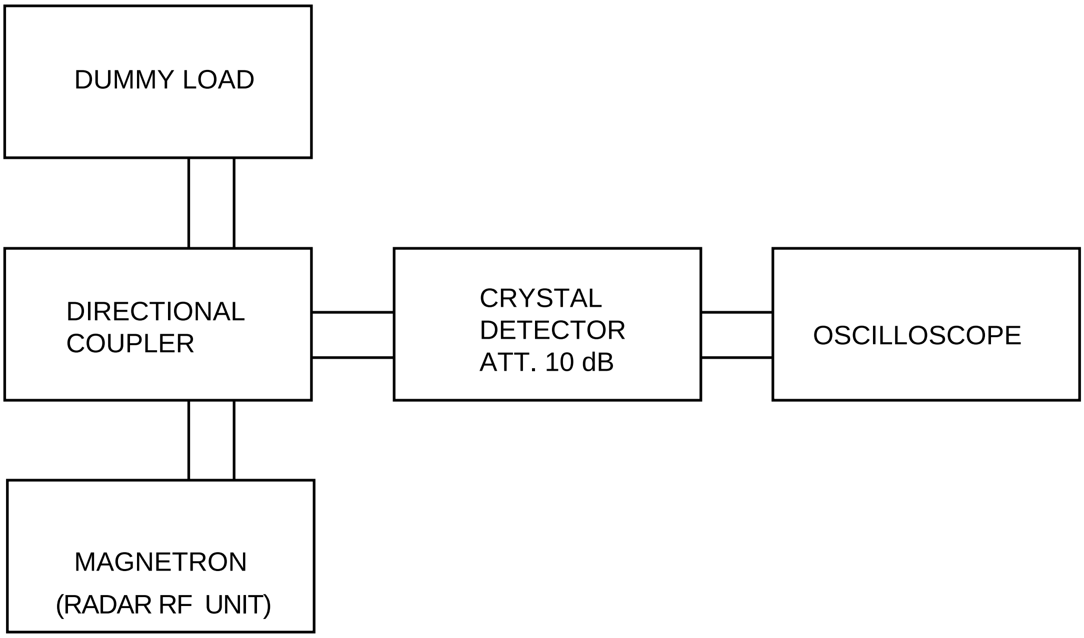


Fig. 3.2.3.1

3.2.3.2 Measuring Equipment List:

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

3.2.3.3 Measured Data:

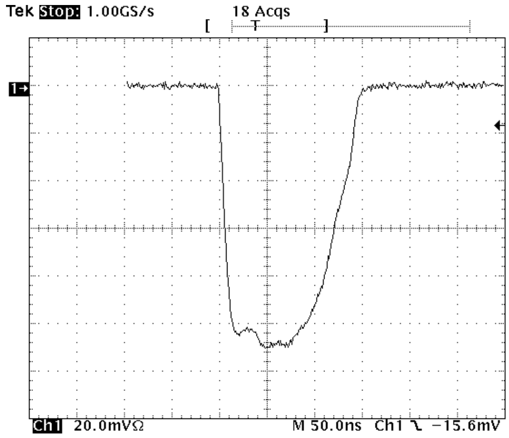


Fig. 3.2.3.2 Short Pulse (0.125 nm Range) Scale: 20 mV/div. 50 ns/div.

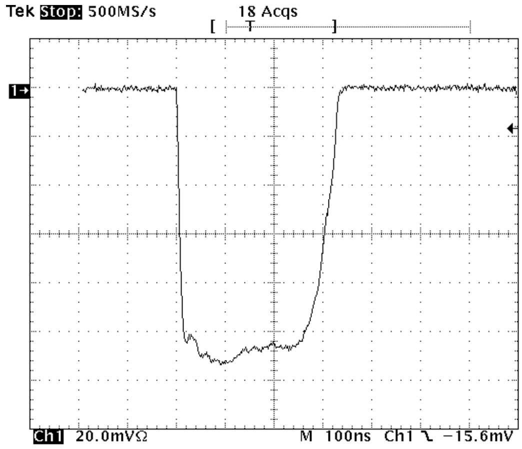


Fig. 3.2.3.3 Middle Pulse (3 nm Range) Scale: 20 mV/div. 100 ns/div.

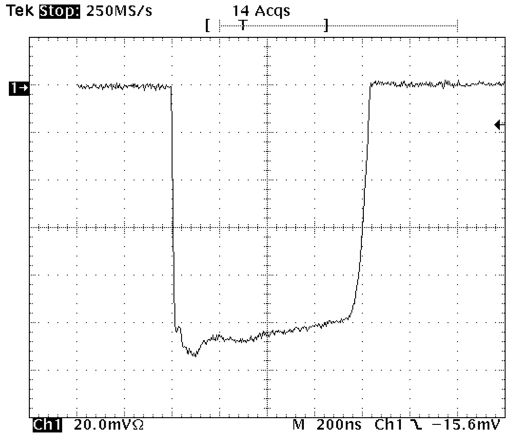


Fig. 3.2.3.4 Long Pulse (48 nm Range) Scale: 20 mV/div. 200 ns/div.

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.)

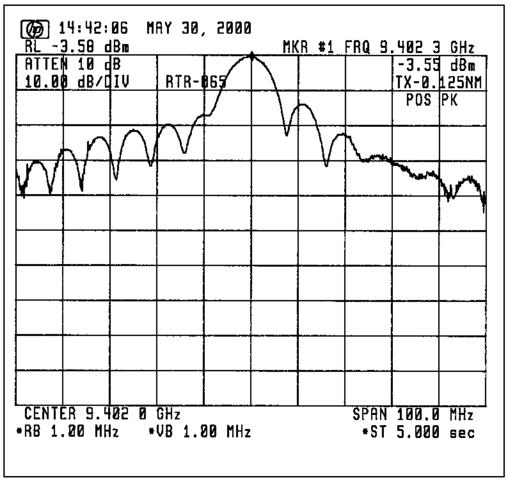


Fig. 3.2.4.1 For Short Pulse (0.125 nm Range)

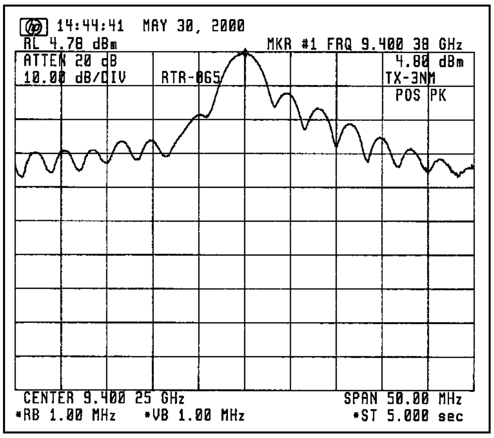


Fig. 3.2.4.2 For Middle Pulse (3 nm Range)

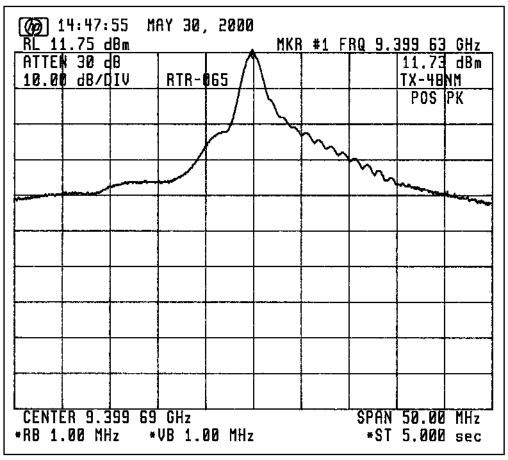


Fig. 3.2.4.3 For Long Pulse (48 nm Range)

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.

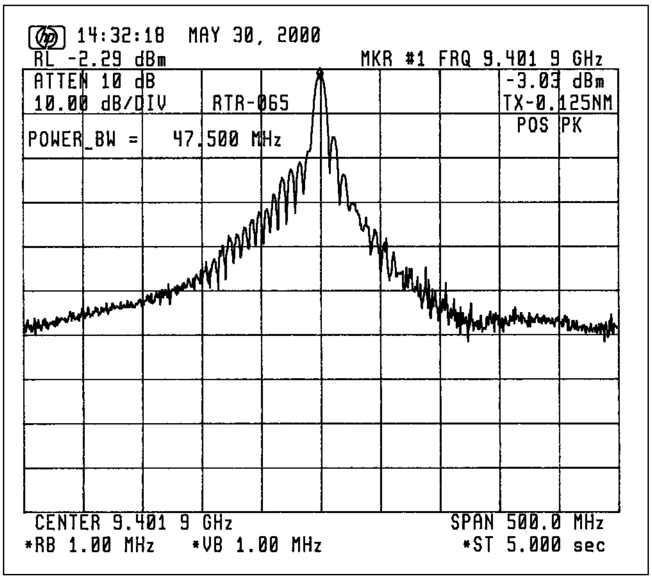


Fig. 3.3.2 Measurement of Occupied Bandwidth

Occupied bandwidth = 47.500 MHz

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

3.4.1 Test Equipment Setup:

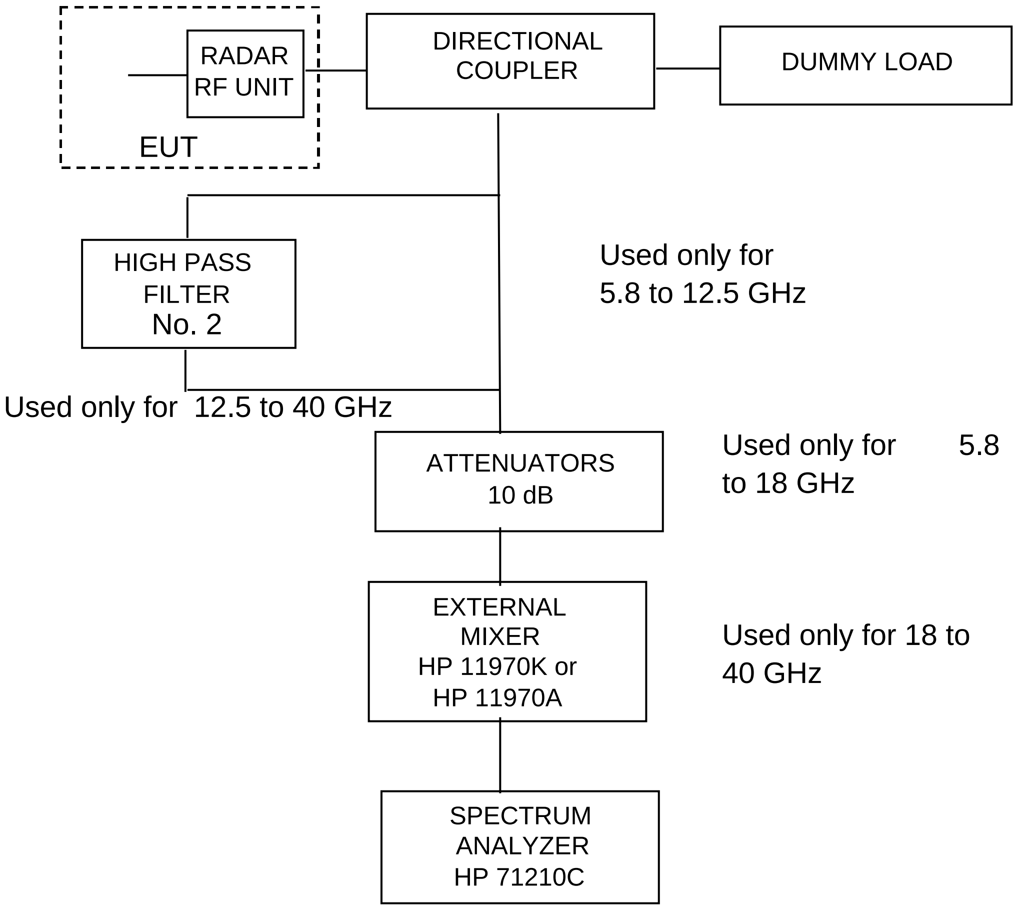


Fig. 3.4.1

3.4.2 Measuring Equipment List:

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

Note :

(1) The 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)/3 nm (Middle)/ 48 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)).

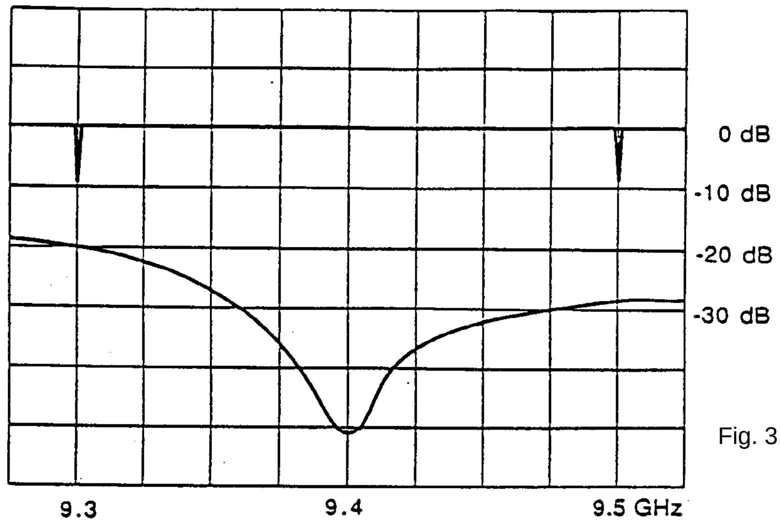
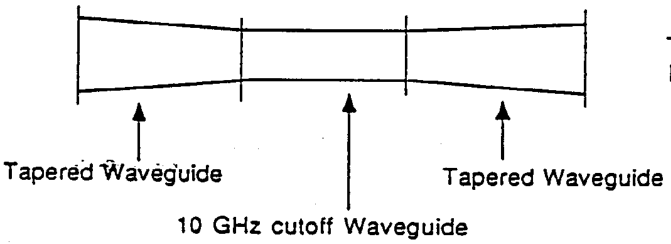


Fig. 3.4.5

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

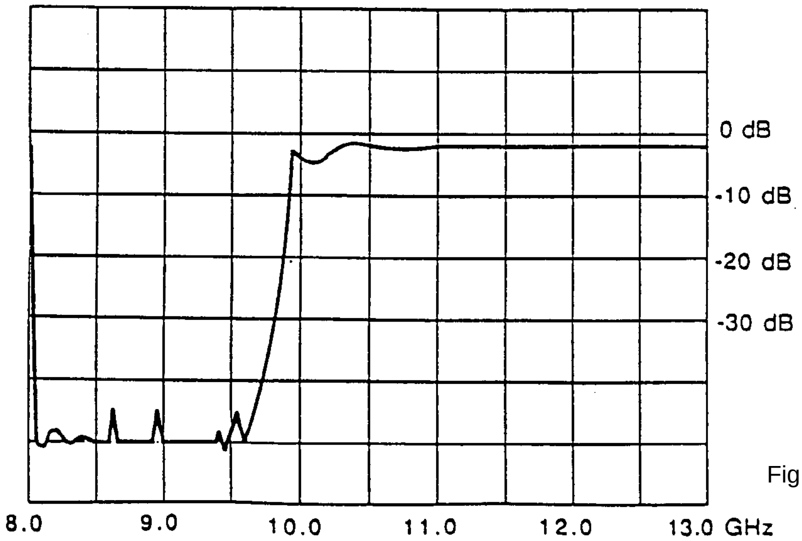


Fig. 3.4.6

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

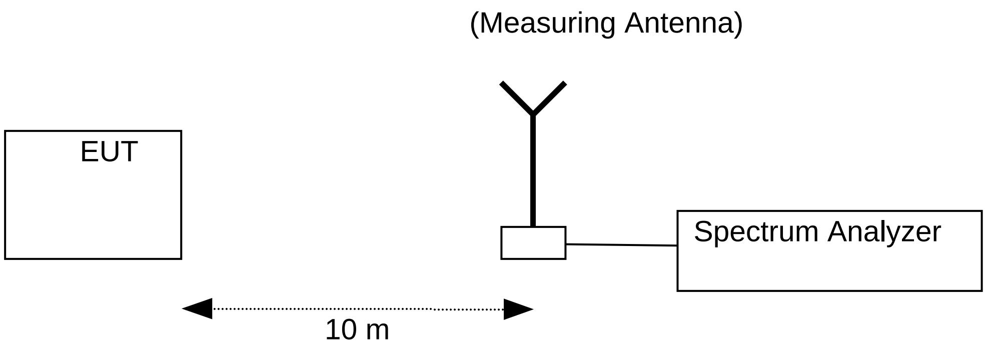
3.5.1 Test Site: Rooftop of 6-story building,
FURUNO ELECTRIC CO., LTD.
Ashihara-cho 9-52, Nishinomiya-city, 662-8580 Japan

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

3.5.3 Radar Range settings: 0.125 nm (Short)/3 nm (Middle)/ 48 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 - 4GHz

(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

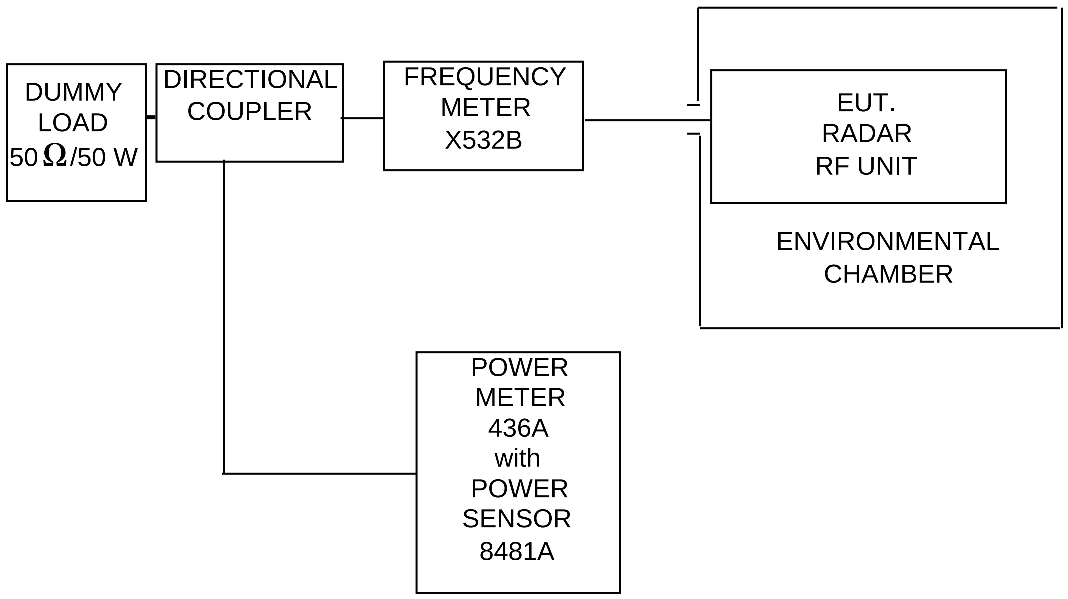


Fig. 3.6.1

3.6.2 Test Conditions:

1) Radar Range settings : 0.125 nm (Short)/3 nm (Middle)/ 48 nm (Long)
2) Ambient Temperature settings: - 20 to + 50 °C (10 °C step)
3) Power Supply Voltage settings: 85 /115 % of nominal voltage (20.4 to 27.6 VDC)

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	48
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) = 9413.0 MHz
(2) "Lower Tolerance Frequency measured (at + 50 °C)", f(L) = 9395.4 MHz
(3)-(a)
f(U) + max. f(1.5/T) = 9431.75 MHz < f(UAUBW) = 9460 MHz ≦ f(UASB) = 9500 MHz
(3) - (b)
f(L) - max. f(1.5/T) =9376.61 MHz > f(LAUBW) = 9360 MHz ≧ f(LASB) = 9300 MHz
So, both are found within the specified limits.

FREQUENCY STABILITY WITH VARIATION OF PRIMARY SUPPLY VOLTAGE:
The built-in voltage regulator allows no frequency variation against variations of ±15 % of nominal power supply voltage (20.4 to 27.6 VDC for nominal 24 VDC).

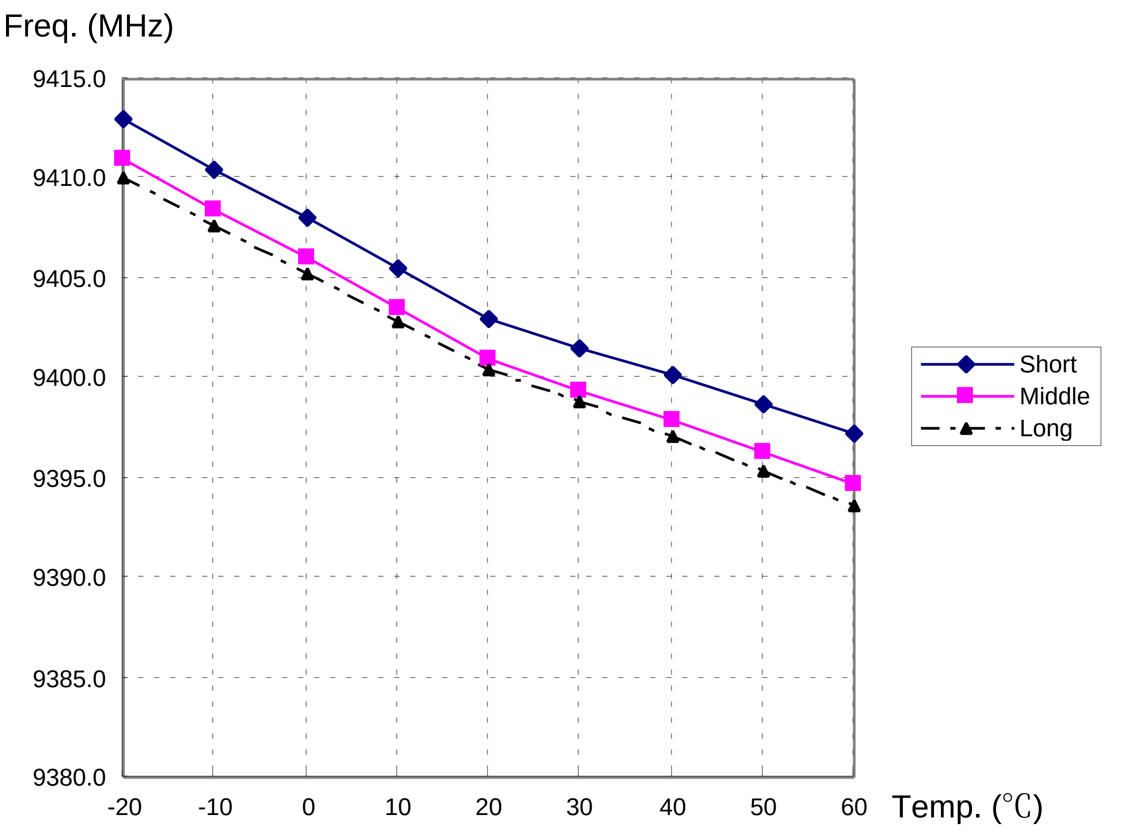


Fig. 3.6.2 Frequency Stability with Variation of Ambient Temperature

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

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.)

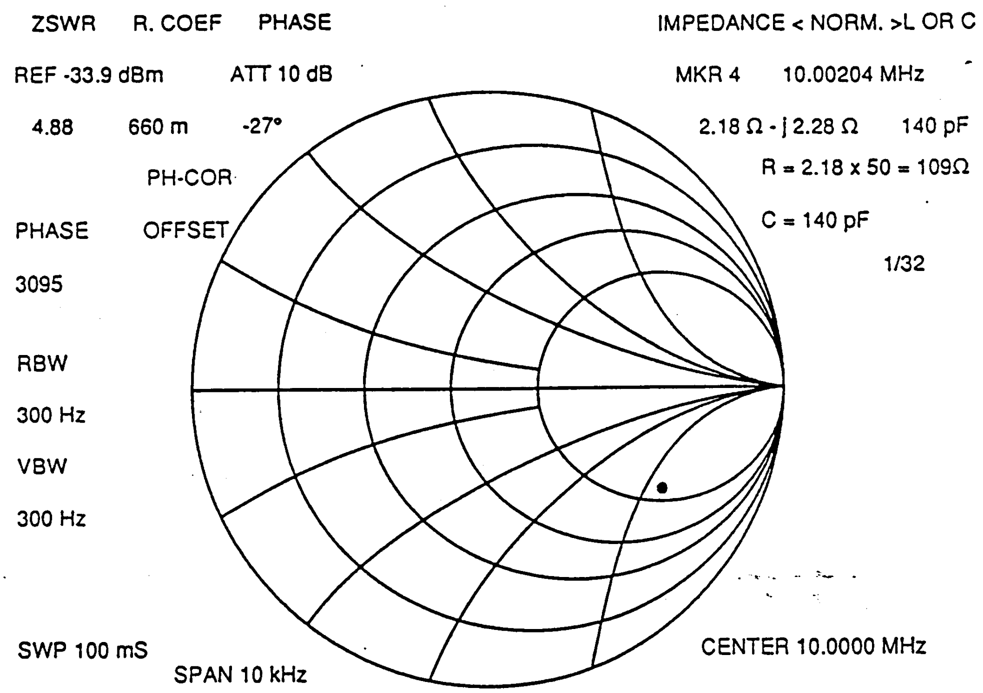
3.7.4.2 Electromagnetic Field (FCC Rule §80.217 (b) - 1)

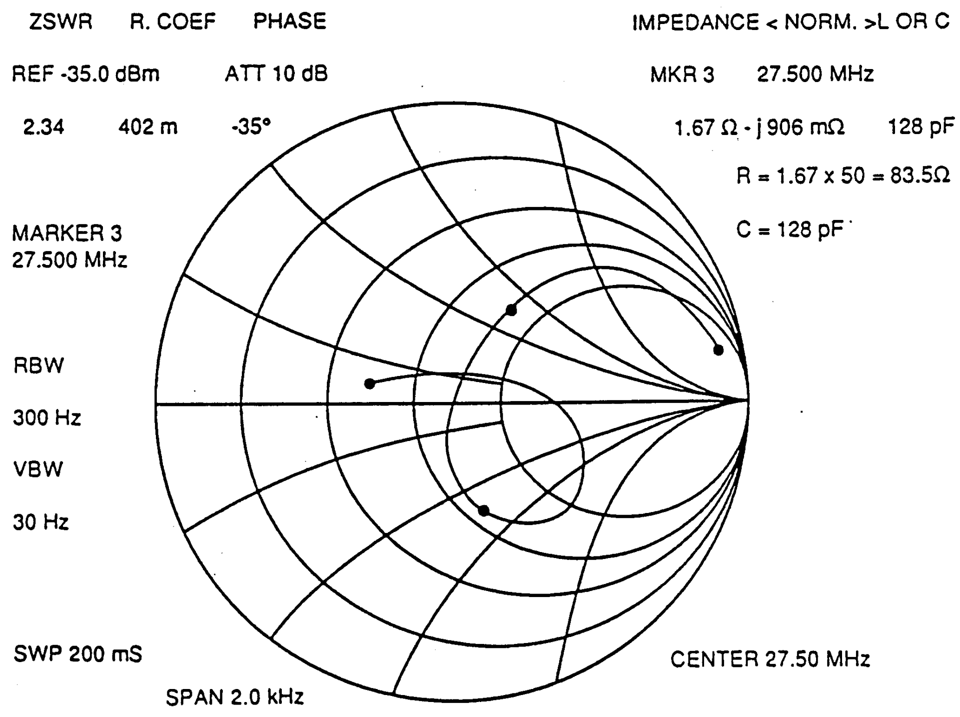
Limits:	for below 30 MHz, 0.1 μV/m at 1 nm (-20 dBμV/m) for 30 to 100 MHz, 0.3 μV/m at 1 nm (-10.5 dBμV/m) for 100 to 300 MHz, 1.0 μV/m at 1 nm (0 dBμV/m) for over 300 MHz, 3.0 μV/m at 1 nm (9.5 dBμV/m)
Results:	Interference was measured with the antenna located 2 m from the radar and converted to levels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

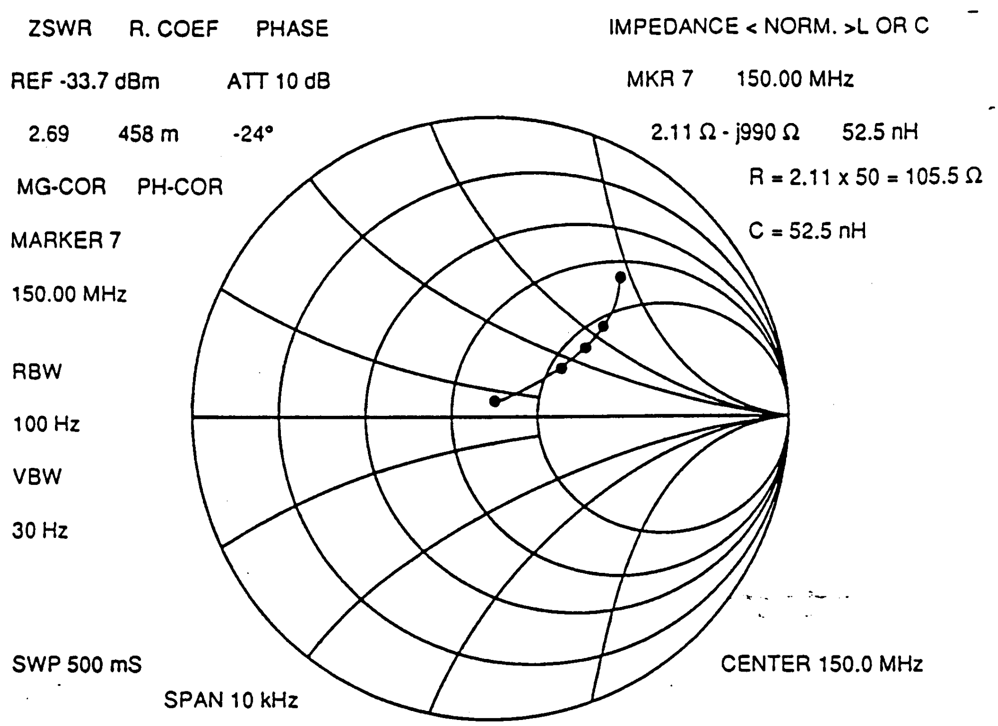
Limits:	for below 30 MHz, 400 μW for 30 to 100 MHz, 4,000 μW for 100 to 300 MHz, 40,000 μW for over 300 MHz, 400,000 μW
Results:	There is no spurious component exceeding the limits. (Test data are shown in Attachment C.)

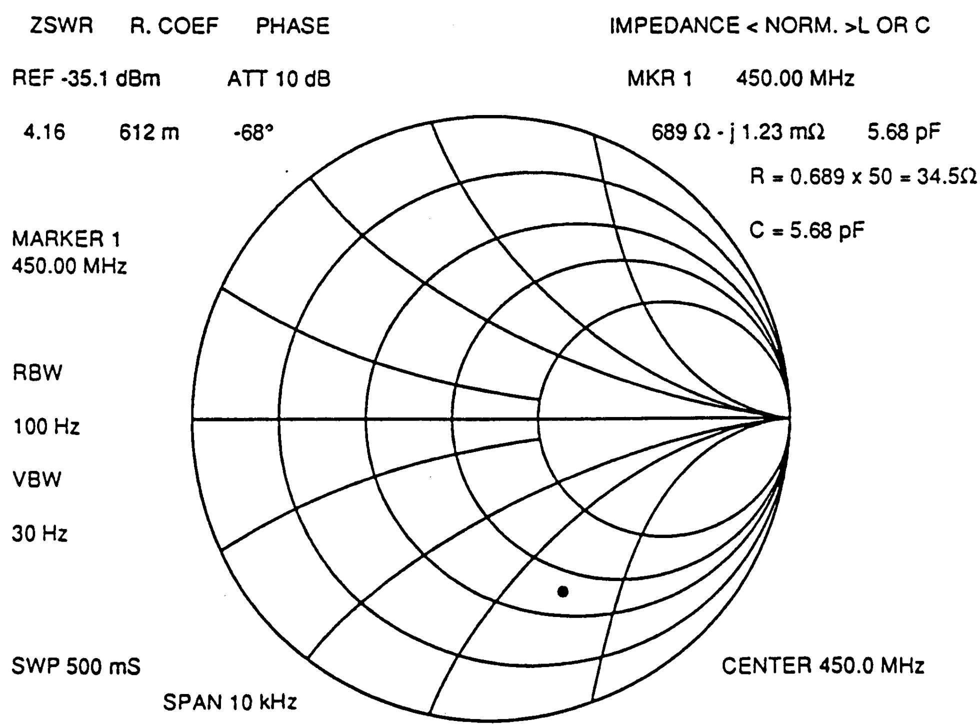
MEASUREMENT OF IMPEDANCE OF TEST ANTENNAS





MEASUREMENT OF IMPEDANCE OF TEST ANTENNAS





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

(See Attachment E　Photos of MODEL 851 MARK 2.)

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

5.1 Function of Each Semiconductor or Active Device

ANTENNA UNIT
TRANSCEIVER MODULE (RTR-065)

Modulator PCB 03P9235

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

Chassis Mounted Parts

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

IF Amplifire PCB 03P9215

CR1 to CR5:	Band Width Switching
CR6:	Voltage SIicer (Overvoltage Protector)
CR7:	Voltage Slicer
CR11:	DC Restoring
CR12:	Voltage SIicer (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 to Q3:	Video Amplifier
Q5:	I.F. Amplifier
Q6:	DC Bias
Q7 to Q8:	Video Amplifier
Q10 to Q12:	Voltage Buffer
Q14:	Transistor Switch (Tuning Amplifier Gate)
U1:	I. F. Amplifier
U2:	I. F. Amplifier/Video Amplifier
U3:	OP Amplifier (Band Width Switching)
U4:	Inverter
U5 to U7:	Voltage Regulator

TB & Motor Soft Starter   PCB 03P9249

CR1:	Reverse Voltage Protection
CR2:	C703 discharger
CR3:	Level Shifter

CR4:	Soft starter switch
CR5:	Reverse Voltage Protection
Q1:	Buffer for bearing pulse
Q2:	Buffer for bearing pulse
Q3:	Trigger switch for CR4

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-065)

<u>Modulator PCB 03P9235</u>

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

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

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

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

<u>Duplexer and Frequency Converter</u>

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

A diode limiter, made up of a pair of PIN diodes, is incorporated in the first stage of the MIC (microwave IC, U801). It is a passive switching device which allows the low-level RF signal to pass through and prohibits relatively strong microwave energy, such as the leak from the magnetron. It also protects the sensitive amplifier from pulses received direct from other radars operating in the proximity.

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

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

IF Amplifier 03P9215

The received 60 MHz IF signal is amplified by the IF amplifier, the output of which is delivered to the Digital Signal Processor of the Display Unit. The 60 MHz 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’s pin 5 and U2’s pin 14 via the STC circuit. The output of U2 is then coupled to video amplifier Q1. 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 to C52, R67 to 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 Q11 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’s pin 5 and U2’s pin14.

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

(See separate covers)