

# Test Report

(FCC Rules 47 CFR, 2.1051, 2.1053, 90.210)

**For**

**Trade name: Furuno**

**Model: Compact Dual Polarimetric X-band**

**Doppler Weather Radar**

**Type: WR-2100**

**Report no.: FLI 12-14-047**


**Date of issue: 28 November 2014**

**Furuno Labotech International Co., Ltd.**

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## Report Summary

FLI project number:	FLI 04-13-0663		
Test report number:	FLI 12-14-047	Date of Initial Issue:	28 November 2014
Revision number:	---	Date of Revised Issue:	---
Test report revision made:	---		
Test standard(s)/ Test specifications:	FCC 47 CFR, Sections: 2.1051 - Spurious Emissions at Antenna Terminal, 2.1053 - Field Strength of Spurious Radiation, 90.210 – Emission masks.		
Customer:	Furuno Electric Co., Ltd. 9-52 Ashihara-Cho, Nishinomiya-City, 662-8580 Japan		
Manufacturer:	Furuno Electric Co., Ltd. 9-52 Ashihara-Cho, Nishinomiya-City, 662-8580 Japan		
Trade name:	FURUNO		
Model:	Compact Dual Polarimetric X-band Doppler Weather Radar		
Type:	WR-2100		
Product function and intended use:	Weather Radar		
Number of samples tested:	One		
Serial number:	Antenna unit: 0001 Signal Processing unit: 0001		
Power rating:	100 - 240 VAC, 50 - 60 Hz, 2.7 - 6.5 A		
Product status:	Pre-production model		
Modifications made to samples during testing:	None.		
Date of receipt of samples:	3 March 2014		
Test period:	From 4 March 2014 to 25 March 2014		
Place of test:	Furuno Labotech International Co., Ltd. - Nishinomiya-Hama Lab. 2-20 Nishinomiya-Hama, Nishinomiya City, Hyogo Prefecture, 662-0934 Japan Anechoic Chamber used for the test has been registered by FCC. (File number: 90607)		
Test results/ Compliance:	Passed.		
Tested by:	Koji Kawai and Katsumi Imamura		
Written by:	Akiko Inoue		
Verified by:	Yoshihiro Ishii		
Approved by:	Date: 28 November 2014 Name: Yoshihiro Ishii Title: Manager, Technical Section, Furuno Labotech International Co., Ltd. Signature: 		

## Testing Laboratory Status

Furuno Labotech International Co., Ltd. (hereafter called "FLI") has been holding the following status after having been assessed according to the provisions of ISO/IEC 17025 and/or the relevant rules:

- (1) JAB Accredited Testing Laboratory:
  - accredited by Japan Accreditation Board (JAB),
  - Laboratory accreditation number: RTL03220
  - Date of initial accreditation: 14 January 2011
  - Scope of accreditation: Electrical testing - EMC testing (\*)
- (2) Telefication Listed Testing Laboratory:
  - listed by Telefication B. V., (The Netherlands)
  - Laboratory assignment number: L116
  - Date of initial listing: 26 July 1999 (\*)
  - for testing the following product categories/ test standards: EN 60945, IEC 61162-1/-2, IEC/EN 61162-450 and IEC 62288
- (3) BSH Recognized Testing Laboratory:
  - recognized by Bundesamt für Seeschifffahrt und Hydrographie (BSH), (Germany)
  - Recognition certificate number: BSH/4613/06202/1864/11
  - Date of initial recognition: 4 April 2003 (\*)
  - for testing the following product categories/ test standards: IEC/EN 60945, IEC 62388, IEC 61162-1/-2, and IEC 62288
- (4) TÜV Appointed EMC Test Laboratory:
  - appointed by TÜV Rheinland Japan Ltd.,
  - Laboratory assignment number: UA 50046428
  - Date of initial appointment: 21 December 1998 (\*)
  - for carrying out the tests of: - EN 55011, CISPR 11, EN 55022, CISPR 22, EN 55024, CISPR 24, EN 55025, CISPR 25, EN/IEC 61000-3-2/-3, EN/IEC 61000-4-2/-3/-4/-5/-6/-8/-11, EN/IEC 61000-6-1/-2/-3/-4, EN/IEC 60945, EN/IEC 61326-1, EN/IEC 61326-2-6, EN/IEC 60601-1-2, JIS T 0601-1-2, JIS C 1806-1, and ISO 11452-1/-2/-4.
- (5) RMRS Recognized Testing Laboratory:
  - recognized by Russian Maritime Register of Shipping (RMRS), (Russia)
  - Laboratory recognition number: 11.02594.011
  - Date of initial recognition: 27 January 2009 (\*)
  - for carrying out testing in the field of: Electrical measurements and tests, EMC tests, Mechanical measurements and tests, Equipment protection degree tests, and Climatic tests for Ship's radio and navigational equipment and IEC 60945: 2002
- (6) RRR Recognized Test Laboratory:
  - recognized by Russian River Register (RRR), (Russia)
  - Recognition certificate number: 154262
  - Date of initial recognition: 31 May 2013
  - for carrying out of tests of ships radio and navigation equipment
- (7) DNV Recognized Environmental Test Laboratory:
  - recognized by Det Norske Veritas AS (DNV), (Norway)
  - Recognition certificate number: 262.1-015854-J-12
  - Date of initial recognition: 12 July 2013
  - Scope of recognition: Testing according to the standards IEC 60945, IEC 61162-1/-2/-450, IEC 62288, IEC 62388 and IEC 62252 Annex E
  - Application: Provisions of Environmental, interface and safety testing.
- (8) CCS Recognized Test Agency :
  - recognized by China Classification Society
  - Recognition certificate number : DB13A00001
  - Date of initial recognition : 29 January 2014
  - Scope of recognition : Performance/Environmental/EMC/Special purpose/Safety precautions tests for Electrical & Electronic Product including Maritime Navigation and Radio-communication Equipment & Systems

Note: (\*) – The current certificates may be found in the FLI web site (<http://www.furuno-labotech.co.jp>).

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# 1 Principal Information

## 1.1 Equipment under test (EUT)

### 1.1.1 General

- (a) Trade name: Furuno
- (b) Manufacturer: Furuno Electric Co., Ltd.  
Ashihara-cho 9-52, Nishinomiya-city, 662-8580 Japan
- (c) Model: WR-2100

No. (*)	Name	Type	Serial Number	Note
1	Antenna unit	WR-2100-ATU	0001	
2	Signal processing unit	WR-2100-SPU	0001	

(\*): Item number(s) is(are) corresponding to the unit(s) shown in Clause 6 "Photographs of Test Setup/Arrangement" of this report.

- (d) Primary Function: WEATHER RADAR
- (e) FCC ID: ADB9ZWWR2100
- (f) Frequency Range: Tunable frequency, X-band (9460 to 9500 MHz)
- Type of Emission: P0N, Q0N, P0N+Q0N
- (g) Power Supply: 1  $\phi$ , 100 - 240 VAC, 50/60 Hz (\*), 650 W.  
(\*): Antenna unit was powered through the Signal processing Unit, not directly from the external power supply.

- (h) Size and weight:

Name	Type	Size (mm)	Weight (kg)
Antenna unit	WR-2100-ATU	$\phi$ 1086 x H1024	65
Signal processing unit	WR-2100-SPU	W725 x D300 x H750	50

### 1.1.2 Radar Sensor

#### 1.1.2.1 Transceiver

**Type:** WR-2100-ATU  
(Contained in the radome)

#### (1) Transmitter

- (a) Assignable Frequency: Between 9300 and 9500 MHz (for X-band radars)  
(FCC Rule, 90.103 (18))
- (b) Type of RF Generator  
Power Amplifier Type: 52P0173  
Peak Output Power: 100 W nominal (Horizontal and Vertical each)
- (c) Transmitter Ratings  
Center frequency of Magnetron: 9470 MHz  
Tolerances:  $\pm$ 12.5 MHz  
Pulling: 1 MHz  
Tolerance for 20°C temperature variation: 1 MHz

- (d) Pulse Characteristics:

Type of Emission	P0N	Q0N	P0N + Q0N
Pulselength ( $\mu$ s)	0.1	5.0	5.0

**(2) Final Amplifier**

- (a) FET Type: TGI9098-100P
- Drain Voltage: Approx. 34 VDC positive
- Drain Current: Approx. 12 A

**(3) Receiver**

- (a) Passband
- RF Stage: 145 MHz
- IF Stage:

Type of Emission	P0N	Q0N	P0N + Q0N
Passband (MHz)	145	145	145

- (b) Intermediate Frequency: 93.75 MHz
- (c) Gain (overall): approximately 63 dB
- (d) Overall Noise Figure: 5.0 dB (typical)
- (e) IF Output Power: -8 dBm single ended
- (f) If receiver is tunable, describe method for adjusting frequency: Tuned automatically.

**1.1.2.2 Antenna and Scanner**

- (a) Antenna Rotation ON-OFF Switch: Exist inside for maintenance.
- (b) Antenna structure: Cassegrain antenna  
(installed in the Scanner)
- (c) Antenna size:  $\phi$  75 cm (  $\phi$  2.5 ft.)
- (d) Type of Beam: Pencil beam
- (e) Beam Width (3 dB):

Horizontal (°)	3.0
Vertical (°)	3.0

- (f) Polarization: Horizontal and Vertical
- (g) Antenna Gain:

Gain (dBi)	33.0
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- (h) Attenuation of Major Side Lobes with respect to main beam:

Within $\pm 10^\circ$ (dB)	-27
Outside $\pm 10^\circ$ (dB)	-34

- (i) Scanning (rotating or oscillating): Azimuth rotation over 360° continuously clockwise/counter clockwise  
Elevation scan: -2° to +182°  
This radar can search hemisphere over ground plane using these scan capability.
- (j) Antenna Rotation Rate: 0 to 48 rpm
- (k) Number of Degrees Scanned: 360°
- (l) Sector Scan: It is provided as RHI (Range Height Indicator) mode.
- (m) Rated Loss of Transmission line per hundred feet:  
Negligible. (Transmission path is only between the ATU and SPU.)

### 1.1.3 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: No.
- (b) Is the equipment for continuous operation: Yes.

### 1.2 Observation and comments

- (1) Test standard and test items were specified by the customer.  
Following tests were performed and reported as reference data at the customer's request.

FCC 47 CFR, Sections:  
 2.1046 - RF Power Output,  
 2.1047 – Output Pulse Characteristics,  
 2.1049 - Occupied Bandwidth,  
 2.1055 - Frequency Stability,  
 80.217 - Suppression of Interference Aboard Ships.

## 2 Test Results Summary

Clause no. of this report	47 CFR Section	Item	Result	Test Engineer
3.1	2.1051	- Spurious Emissions at Antenna Terminal	Passed.	K. Kawai and K. Imamura
3.2	2.1053	- Field Strength of Spurious Radiation	Passed.	K. Kawai and K. Imamura

### 3 Test Results

#### 3.1 Spurious emissions at Antenna Terminal (FCC Rule 47 CFR,2.1051/90.210 (b))

**(1) Test Conditions:**

For all TX (P0N/Q0N) types, the tests were performed.  
The Antenna was set to the stop mode.

**(2) Test setup:**

See Clause 4.

**(3) Emission Limits (FCC Rule 47 CFR, 90.210 (b)):**

Emission Mask B was applied based on Part 90.210 (n) at the customer's request.

Frequency removed from the assigned frequency	Emission attenuation (mean power, dB)
50 - 100 % (of the authorized bandwidth)	At least 25
100 - 250 % (of the authorized bandwidth)	At least 35
more than 250 % (*) (of the authorized bandwidth)	At least 43 + 10 log <sub>10</sub> (mean power in watts)

Note: Authorized bandwidth = 110 MHz

(\*) - for the relevant frequency bands, tests were performed according to FCC Rule, 2.1053.

**(4) Test Results:**

Complied.

Spectrum Plots: See Clause 7.

Environmental conditions observed: On 19 March 2014, 23°C to 23°C, 48%RH to 48%RH  
On 20 March 2014, 22°C to 25°C, 54%RH to 47%RH

Power supply voltage measured (\*): 100.0 VAC/60Hz to 100.0 VAC/60Hz.

(\*): measured at the power input terminal of Signal processing unit WR-2100-SPU.

Antenna Unit was powered through WR-2100-SPU, not directly from the AC mains.

#### 3.2 Field Strength of Spurious Radiation (FCC Rule 47 CFR, 2.1053/90.210 (b))

**(1) Test Conditions:**

For TX (P0N + Q0N) type (\*), the tests were performed.

(a) For the test frequency range of 9 kHz to 2000 MHz, the Antenna for Transceiver was replaced with the rotating non-reflective load. Spurious emissions for 9 kHz to 2000 MHz are not found at the antenna terminal due to its structure (Waveguide tube). The EUT cabinet radiation was measured with the EUT rotated 360°.

(b) For 2 GHz to 40 GHz, the Antenna was set to the Transceiver with the stop mode.

(\*): Test was performed with P0N + Q0N modulation wave, which is for normal use, representing all conditions.

**(2) Test Site:** FLI Nishinomiya-Hama Laboratory, Semi-Anechoic Chamber  
(FCC file number: 90607)

**(3) Distance between the radar set and measuring antenna:** 3 m

**(4) Test setup:**

For the test frequency range of 2 GHz to 40 GHz, the GRP (Ground reference plane, metal floor) between the EUT and the measuring (receiving) antenna was lined with the Radio Absorbers (2.4 m × 3.0 m × 0.5 m) to reduce the influences of the reflections of the RF waves from the floor.

**Measuring (Receiving) Antenna height and polarization:**

(a1) 1.5 m for the test frequency range of 9 kHz to 30 MHz,

(a2) 1 m to 4 m for the test frequency range of 30 MHz to 2000 MHz,

(b) 2.1 m that was same as those for the EUT for the test frequency range of 2 GHz to 40 GHz.

(c) Antenna polarization: vertical and horizontal.



**EUT height:**

- (a) 0.8 m for the test frequency range of 9 kHz to 2000 MHz,
- (b) 2.1 m for the test frequency range of 2 GHz to 40 GHz (To reduce the influences of the reflections from GRP).

See Clauses 4 and 6.

**(5) Field Strength Limits (FCC Rule 47 CFR, 90.210(b)):**

Frequency removed from the assigned frequency	Frequency (MHz)	Emission attenuation (mean power, dB)
50 - 100 % (*) (of the authorized bandwidth)	9,370 - 9,420 9,520 - 9,570	At least 25
100 - 250 % (*) (of the authorized bandwidth)	9,220 - 9,370 9,570 - 9,720	At least 35
more than 250 % (of the authorized bandwidth)	0.009 - 9,220 9,720 - 40,000	At least 43 + 10 log <sub>10</sub> (mean power in watts)

Note (1): Assigned frequency (center frequency) = 9470 MHz

(2): Authorized bandwidth = 110 MHz

(\*) - for the relevant frequency bands, tests were performed according to FCC Rule 47 CFR, 2.1051.

**(6) Test Results:**

Complied.

[ Limit ] = 43 + 10 log<sub>10</sub> (mean power in watts)

at P<sub>0N</sub>+Q<sub>0N</sub> = 43 + 10 log<sub>10</sub> (0.0316) = 28.0 dB

where, [ mean power in watts ]=0.0316 W for P<sub>0N</sub>+Q<sub>0N</sub>. See 9.2.1.

For this time, Limit of 60 dB was applied for the test at the customer's request.

The electric field strength of the maximum power radiation was 159.7 dB<sub>μ</sub>V/m.

Consequently, the allowable emission limit was set to 99.7 dB<sub>μ</sub>V/m (= 159.7 dB<sub>μ</sub>V/m - 60 dB).

As a result, the minimum emission attenuation was found to be more than 60 dB.

Spectrum plots: See Clause 8.

Spurious emission frequency and Electric field strength of which margins were below 20 dB were listed in the following table.

Frequency (MHz)	Loop Antenna Angle (°)	Electric Field Strength measured (dB <sub>μ</sub> V/m)	Limit (dB <sub>μ</sub> V/m) (*)	Margin (dB)
0.012	0	66.3	69.7	3.4
0.036	0	55.4	69.7	14.3
0.085	0	69.3	69.7	0.4
0.339	0	63.3	79.7	16.4
0.010	90	62.1	69.7	7.6
0.063	90	55.6	69.7	14.1
0.084	90	68.1	69.7	1.6
0.339	90	59.9	79.7	19.8

(\*): Limit for the test frequencies from 9 kHz to 30 MHz, see Clause 9.2 (1).

Frequency (GHz)	Polarization	Electric Field Strength measured (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)
2.43	Horizontal	80.0	99.7	19.7
2.43	Vertical	83.5	99.7	16.2

Environmental conditions observed: On 25 March 2014, 24°C to 25°C, 49%RH to 47%RH

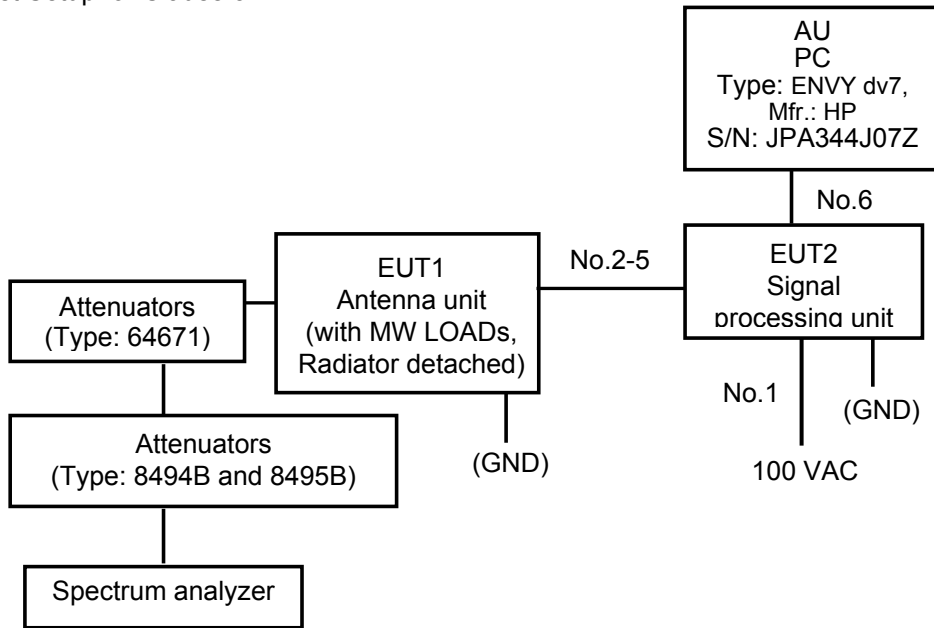
Power supply voltage measured (\*): 100.0 VAC/60 Hz to 100.0 VAC/60 Hz

(\*): measured at the power input terminal of Signal processing unit WR-2100-SPU.

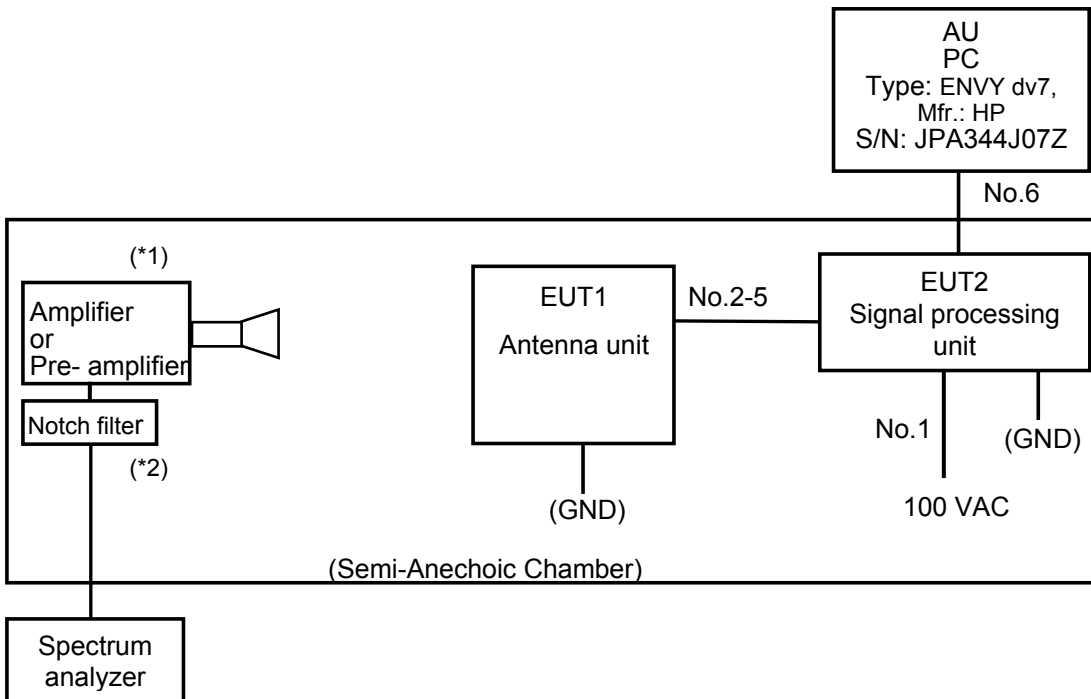
Antenna Unit was powered through WR-2100-SPU, not directly from the AC mains.

### 4 Test Setup for Measurement:

(1) Test Setup for Clause 3.1.



(2) Test Setup for Clause 3.2.



Note: AU - Auxiliary Unit.

(\*1): Pre-amplifier (Type: 87405A), (Type: 83051A) or Amplifier (Type: 310N) was used depending on test frequency.

(\*2): Used only for test frequency from 2 GHz to 18 GHz.

**Cable designations**

No.	Name	Length (m)
1	VCT 2.0sq, 3C	20
2	3D-2W	5
3	AWG28, UL, 26C	5
4	AWG28, UL, 10C	5
5	VCT 1.25sq, 3C	5
6	Ethernet CAT.5e	20

## 5 Measuring Equipment List:

Measuring/Test instruments have been appropriately calibrated/maintained according to the FLI programs/procedures and ISO/IEC 17025. Measuring/Test instruments used for the tests are listed below.

### (1) For 3.1 Spurious Emissions at Antenna Terminal:

C/N	Instrument	Type	S/N	Manufacturer	Date of last calibration
----	Attenuator	64671	----	INMET	4 March 2014
----	Attenuator	64671	----	INMET	4 March 2014
----	MW LOAD (10dB)	1310-6209-21	006	VXL TECNOLOCIES LTD	4 March 2014
----	MW LOAD (10dB)	1310-6209-21	007	VXL TECNOLOCIES LTD	4 March 2014
HT676	Spectrum Analyzer	8564EC	4103A00440	Agilent	15 April 2013
HT654	Attenuator	8494B	MY42148134	Agilent	8 March 2013
HT655	Attenuator	8495B	MY42144403	Agilent	8 March 2013
KB-137	Coaxial cable	MWX221 - 2m	0804S167	Junkosha	----

### (2) For 3.2 Field Strength of Spurious Radiation:

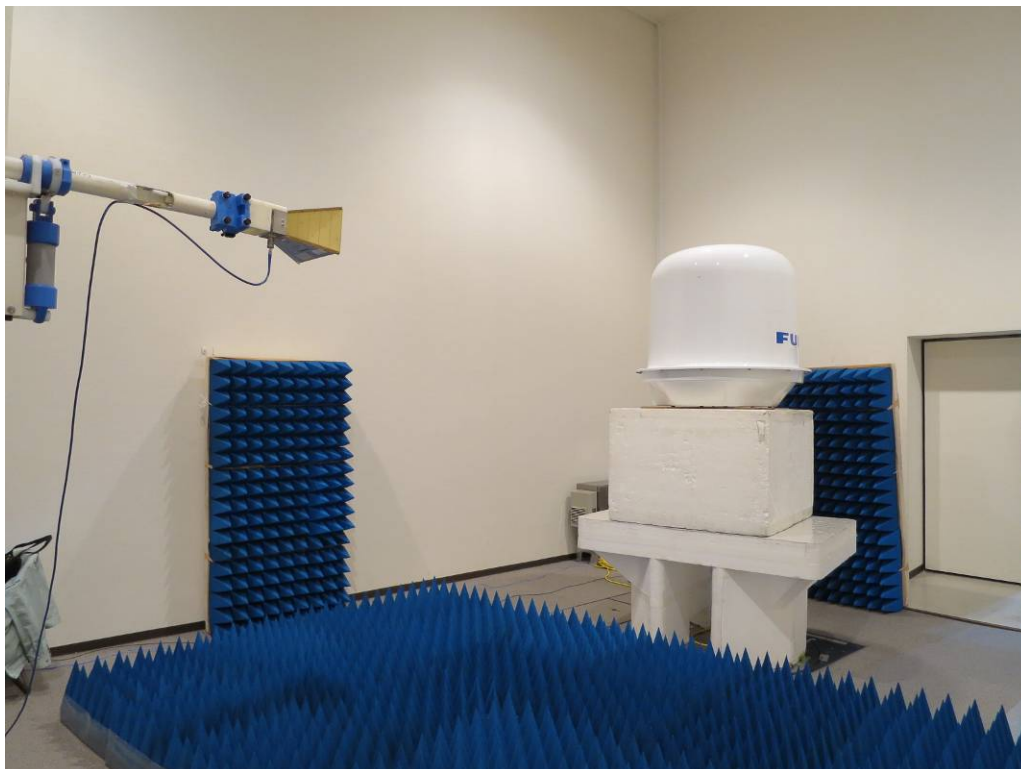
C/N	Instrument	Type	S/N	Manufacturer	Date of last calibration
HT463	Spectrum analyzer (9 kHz to 3 GHz)	R3132	110401654	Advantest	26 July 2013
HT565	Loop antenna (0.15 MHz to 30 MHz)	HFH2-Z2	100093	Rohde & Schwarz	19 August 2013
HT568	Amplifier (for Loop antenna)	310N	250607	Sonoma Instrument	24 June 2013
HT459	Biconical antenna (30 MHz to 300 MHz)	VBA6106A	1296	Schaffner	19 August 2013
HT331	Log periodic antenna (300 MHz to 1000 MHz)	UHALP9107	91071214	Schwarzbeck	19 August 2013
HT467	Double-ridged waveguide horn antenna (1 GHz to 18 GHz)	3115	6520	EMCO	19 August 2013
HT518	Pre-amplifier (30 MHz to 2 GHz)	87405A	3207A01643	Agilent	24 June 2013
RT133	Broadband Horn Antenna (15 GHz to 40 GHz)	BBHA9170	366	Schwarzbeck	24 June 2013
RT135	Pre- amplifier	83051A	3332A00329	Agilent	14 March 2014
HT365	Semi-anechoic Chamber	3mSAC	D-002	Riken	10 October 2012
----	9470MHz Notch filter	SF00T2915	130805759	Almotech	----
KB-137	Coaxial cable	MWX221 - 2m	0804S167	Junkosha	----
KB-138	Coaxial cable	MWX221 - 5m	0804S166	Junkosha	----
KB-139	Coaxial cable	SF102-40- 5m	30823/2	HUBER+SUHNER	----

## 6 Photograph of Test Setup/Arrangement

(1) For Spurious Emission measurements (9 kHz to 2 GHz),



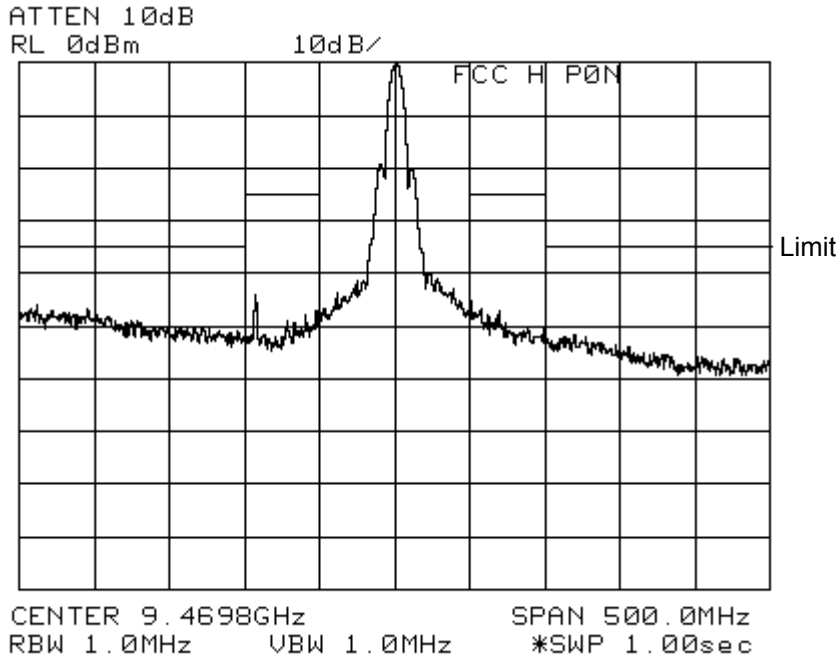
(2) For Spurious Emission measurements (2 GHz to 40 GHz),



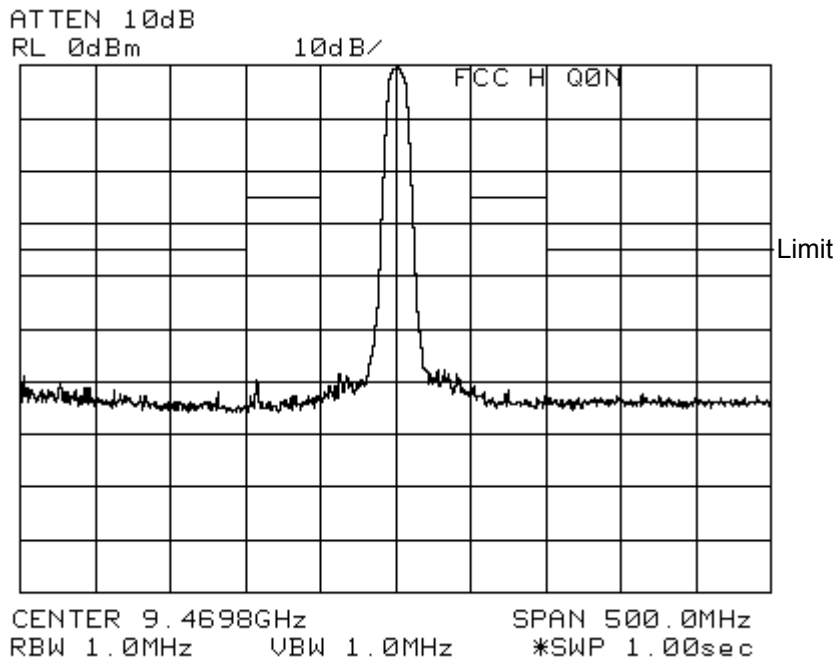
## 7 Spurious Emission Plots measured at Antenna Terminal

### 7.1 Tx output of Amplifier for horizontal fan

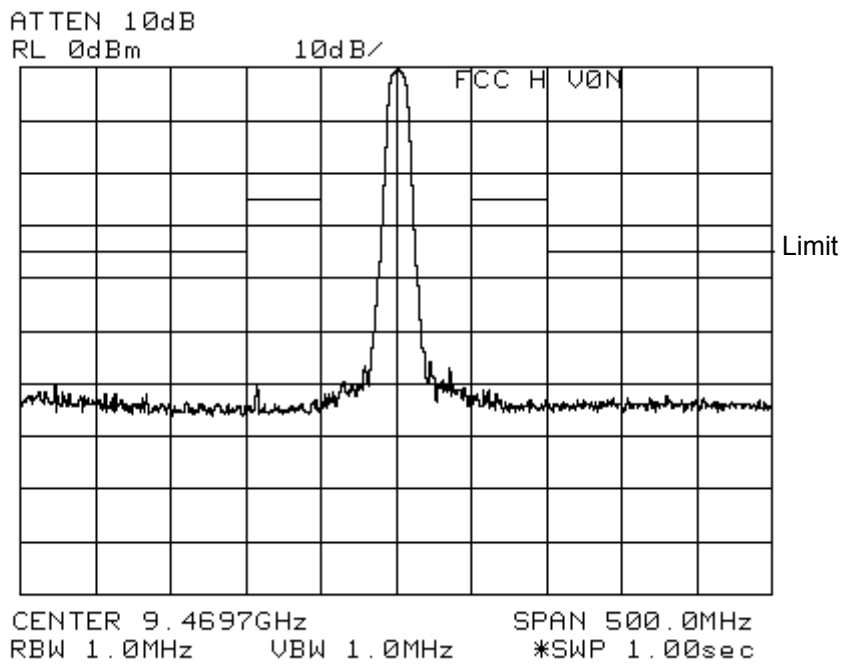
For P0N type



For Q0N type

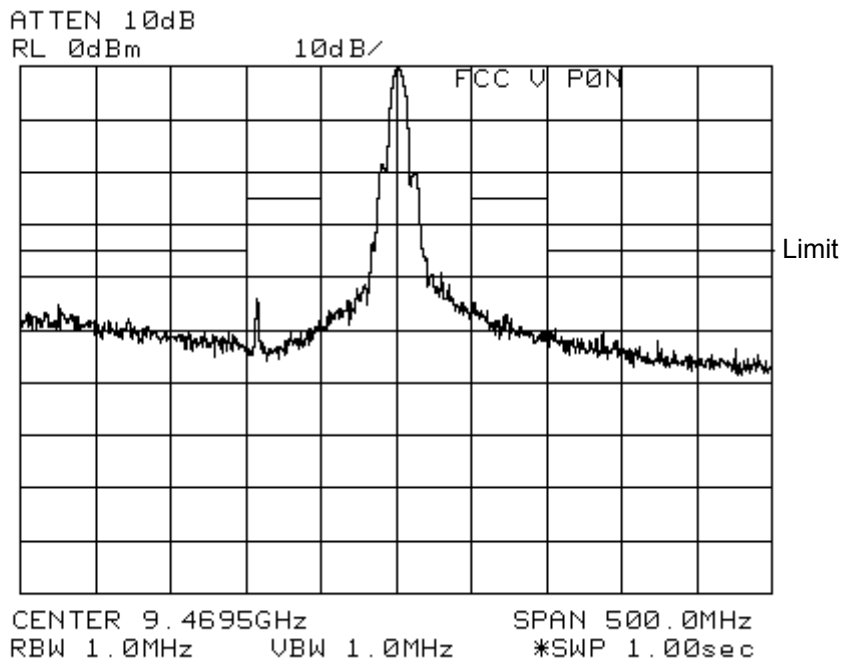


For P0N + Q0N type

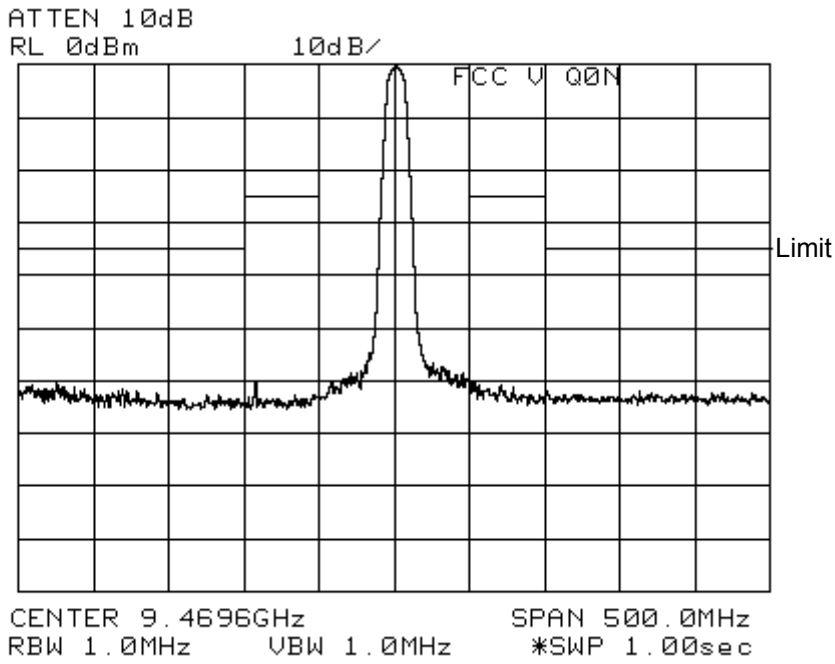


7.2 Tx output of Amplifier for vertical fan

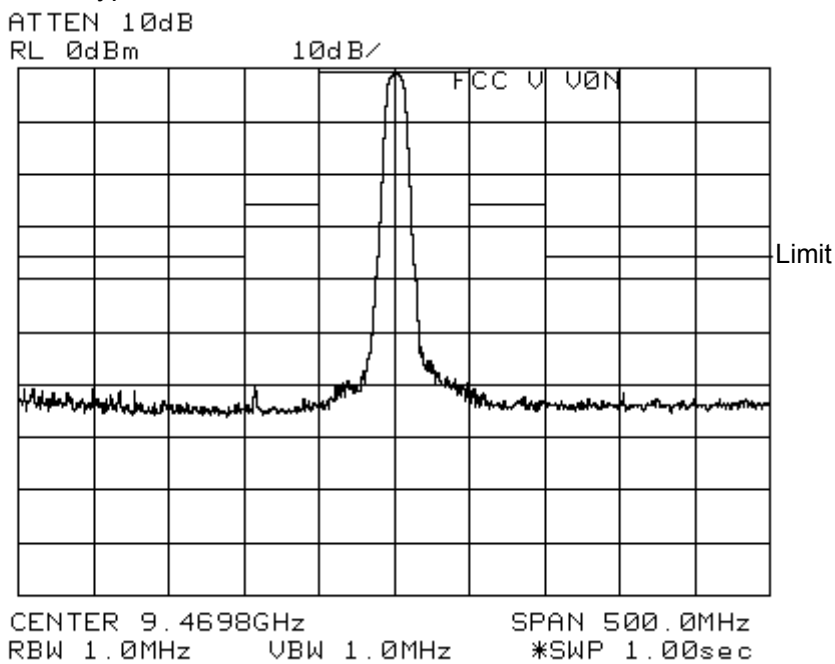
For P0N type



For Q0N type



For P0N + Q0N type

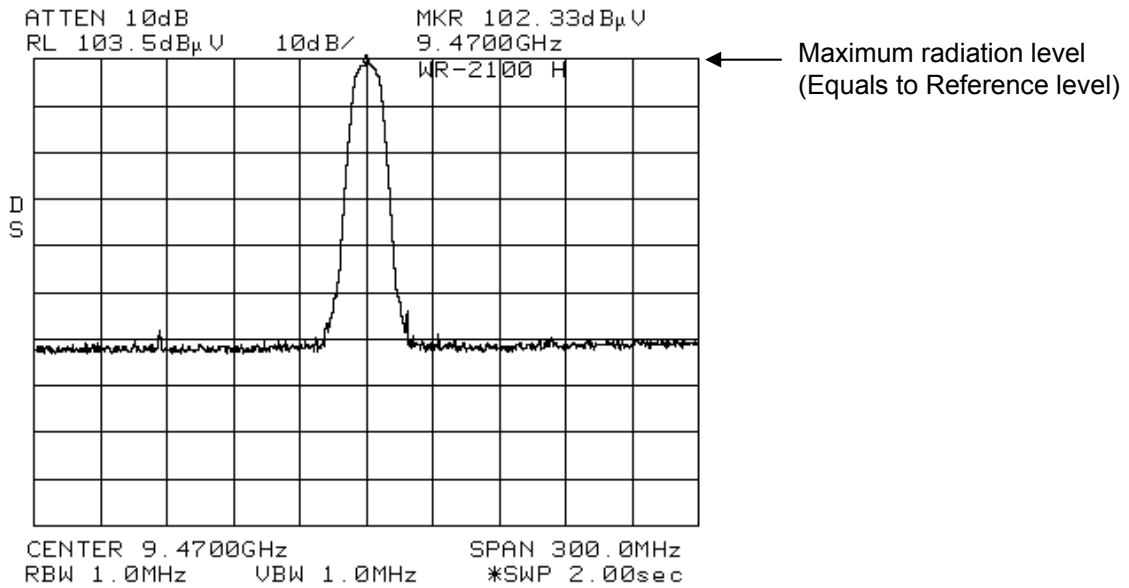




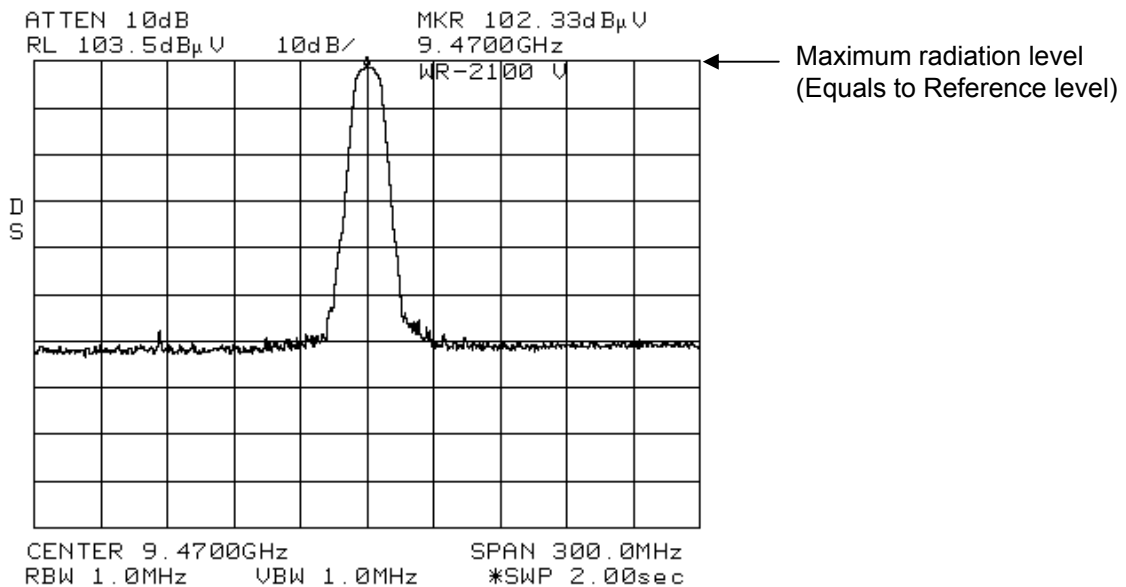
## 8 Field Strength Plots of Spurious Radiation

### 8.1 Maximum power radiation level (For P0N + Q0N type)

- Horizontal



- Vertical



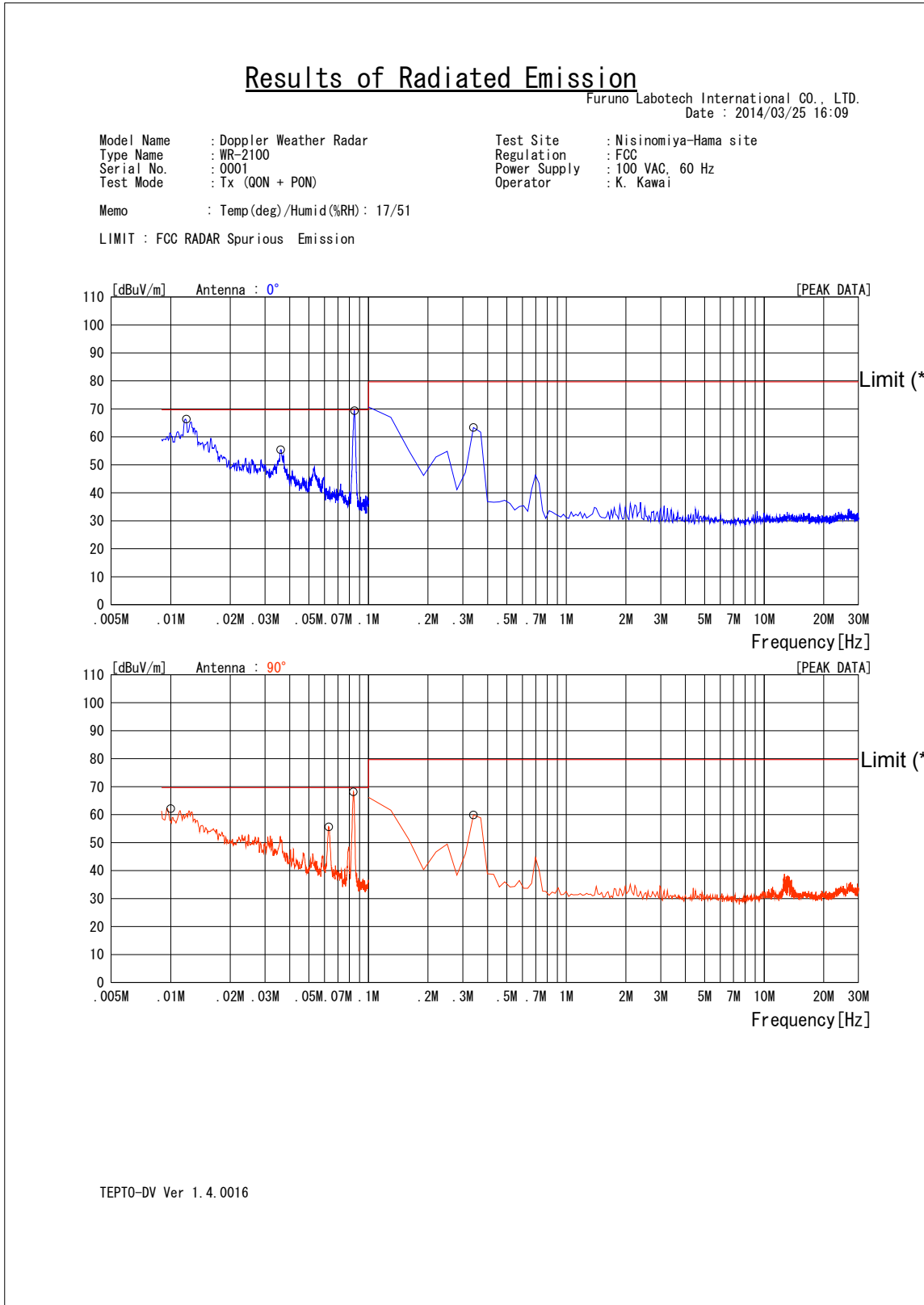
For the maximum power radiation level, the voltage value measured by the spectrum analyzer was converted into the electric field strength with the measuring antenna factor, Cable loss and Amp. gain.

Maximum power radiation level = 159.7 dBμV/m

Therefore, Emission Limit = 159.7 dBμV/m - 60 dB = 99.7 dBμV/m

**8.2 Spurious emissions (For P0N + Q0N type)**

(1) for 9 kHz to 30 MHz



(\*) The resolution bandwidth of the spectrum analyzer in the frequency range of 9 kHz to 100 kHz was set to 1 kHz, and 100 kHz to 30 MHz, to 10 kHz, instead of 1 MHz at the frequency range from 2 GHz to 40 GHz. The applicable limit was set at 30 dB lower than that computed in Clause 9.1 for the former frequency range, and 20 dB lower for the latter frequency range.

(2) for 30 MHz to 2000 MHz

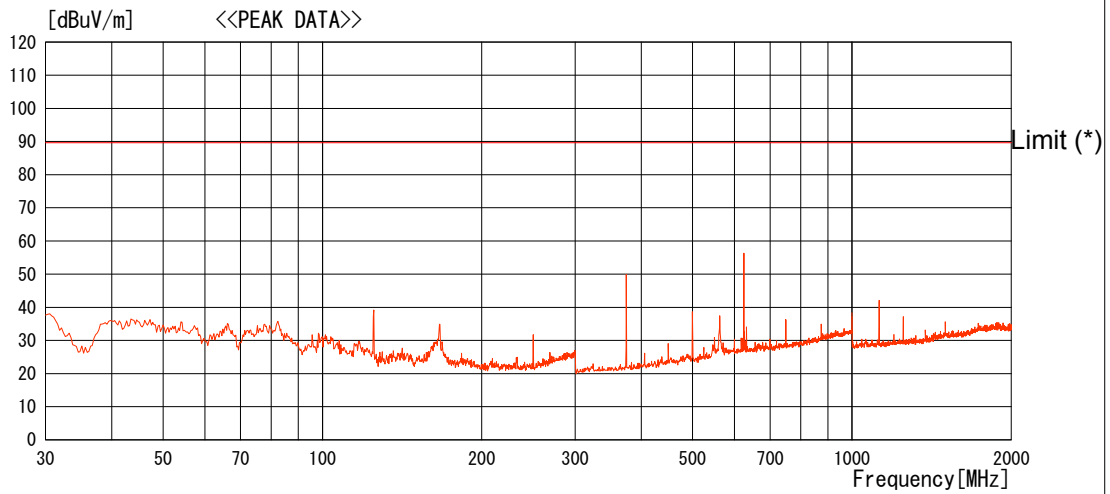
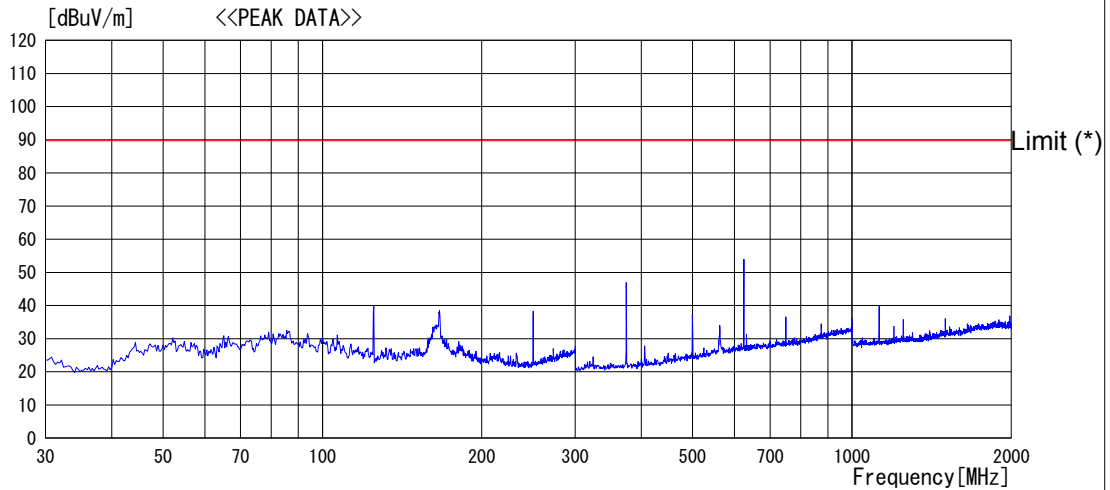
### Results of Radiated Emission

Furuno Labotech International  
Date : 2014/Mar/25 15:43

Model Name : Doppler Weather Radar	Test Site : Nishinomiya-hama site
Type Name : WR-2100	Regulation : RSS-238/FCC
Serial No. : 0001	Power Supply : 100 VAC, 60 Hz
Test Mode : TX (QON + PON)	Operator : K. Kawai

Memo : Temp(deg)/Humid(%RH) : 17/51

LIMIT : RSS-238 (2013) 4.3 Unwanted Emissions

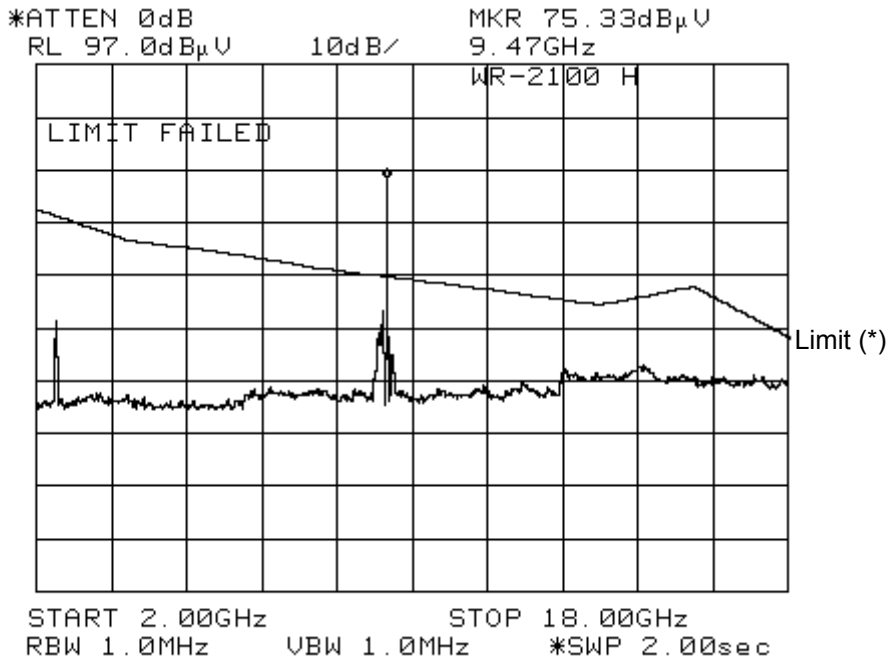


TEPT0-DV Ver 1.4.0016

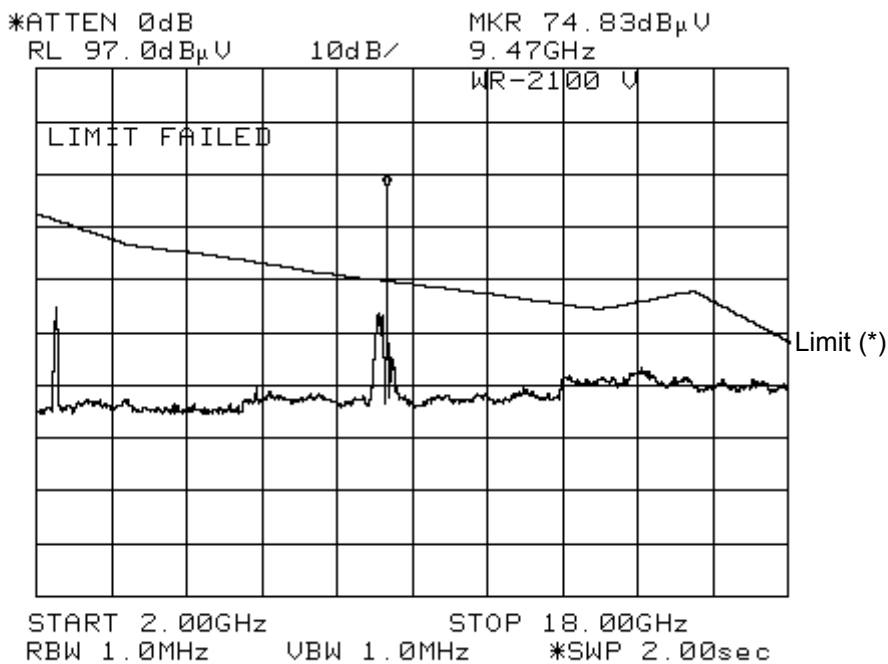
(\*) The resolution bandwidth of the spectrum analyzer in the frequency range of 30 MHz to 2000 MHz was set to 100 kHz instead of 1 MHz at the frequency range from 2 GHz to 40 GHz. The applicable limit was set at 10 dB lower than that computed in Clause 9.1.

(3) for 2 GHz to 18 GHz (For P0N + Q0N type)

- for Horizontal



- for Vertical



The notch filter was inserted between the measuring antenna and Spectrum Analyzer to prevent the excessive input to Spectrum Analyzer only for the test frequency range of 2 GHz to 18 GHz.

(\*) The Limit is represented by the voltage value, which was derived from the electric field strength value with Antenna factor, Cable loss and Amp. gain.





## 9 Additional Test Results

### 9.1 Test Results Summary

47 CFR Section	Item	Result	Test Engineer
2.1046	RF Power Output	Passed.	K. Kawai and K. Imamura
2.1047	Output Pulse Characteristics	Passed.	K. Kawai and K. Imamura
2.1049	Occupied Bandwidth	Passed.	K. Kawai and K. Imamura
2.1055	Frequency Stability	Passed.	K. Kawai and K. Imamura
80.217	Suppression of Interference Aboard Ships	Passed.	K. Kawai and K. Imamura

### 9.2 Test Results

#### 9.2.1 RF Power Output (FCC Rule 47 CFR, 2.1046)

##### (1) Test conditions:

For all TX (P0N/Q0N/V0N) types, the transmitter output power was measured at the antenna port with Antenna replaced with the Non-reflective load.

##### (2) Test setup:

See Clause 9.5.

##### (3) Test Results:

Pulse type	P0N		Q0N		V0N (P0N +Q0N)	
	H	V	H	V	H	V
Amplifier (H: for horizontal, V:for vertical)						
Magnetron Output, mean $P_m$ (W)	0.018	0.017	0.617	0.592	0.464	0.451
Magnetron Output, peak $P_p$ (W) (*1)	79.0	74.9	68.5	65.8	68.8	66.8
Pulselength T ( $\mu$ s) (-3 dB points) (*2)	0.100	0.102	5.00	5.00	5.00	5.00
PRR (Hz)	2250.0	2250.0	1800.0	1800.0	1350.0	1350.0

(\*1)  $P_p$  (W) =  $(P_m$  (W) / (T ( $\mu$ s)  $\times$  PRR (Hz)))  $\times$  1000

(\*2): Measured at -3 dB points of the RF envelope of the semiconductor output pulse instead of at 50% points of the current of the semiconductor, which are equivalent.

Environmental conditions observed: On 8 March 2014, 23°C to 22°C, 45%RH to 54%RH

Power supply voltage measured (\*): 100.0 VAC/60 Hz to 100.0 VAC/60 Hz.

(\*) : measured at the power input terminal of Signal processing unit WR-2100-SPU.

Antenna Unit was powered through WR-2100-SPU, not directly from the AC mains.

#### 9.2.2 Output Pulse Characteristics (FCC Rule 47 CFR, 2.1047)

##### (1) Test Conditions:

For all TX (P0N/Q0N/V0N) types, the transmitter output power was measured at the antenna port with Antenna replaced with the Non-reflective load.

##### (2) Test setup:

See Clause 9.5.

**(3) Limits (FCC Rule, 80.213 (g)/80.209(b)):**

Upper limit frequency,  $f(U) = f_0 + f(AUBW)/2 - 1.5/T$

Lower limit frequency,  $f(L) = f_0 - f(AUBW)/2 + 1.5/T$

Note: Assigned frequency ( $f_0$ ): 9470 MHz

Authorized bandwidth ( $f(AUBW)$ ): 110 MHz

**(4) Test Results:**

Pulse type	P0N		Q0N		V0N (P0N +Q0N)	
	H	V	H	V	H	V
Amplifier (H: for horizontal, V:for vertical)						
Pulselength T ( $\mu$ s) (-3 dB points) (*1)	0.100	0.102	5.00	5.00	5.00	5.00
Rise time $t_r$ ( $\mu$ s) (10 - 90 % amplitude)	0.0396	0.0392	0.130	0.120	0.124	0.128
Decay time $t_f$ ( $\mu$ s) (90 - 10 % amplitude)	0.0412	0.0400	0.132	0.134	0.132	0.132
PRR (Hz)	2250.0	2250.0	1800.0	1800.0	1350.0	1350.0
Guard Band $f(1.5/T)$ (MHz) (*2)	15.0	14.7	0.3	0.3	0.3	0.3
f(U) (MHz)	9505.0	9505.3	9519.7	9519.7	9519.7	9519.7
f(L) (MHz)	9435.0	9434.7	9420.3	9420.3	9420.3	9420.3
Frequency at maximum emission (MHz)	9469.8	9469.5	9469.8	9469.6	9469.7	9469.8

(\*1): Measured at -3 dB points of the RF envelope of the semiconductor output pulse instead of at 50% points of the voltage/current of the semiconductor, which are equivalent.

(\*2): Guard Band is specified to be equal to  $1.5/T$  MHz, where "T" is the pulselength in microseconds. (FCC Rule 47 CFR, 80.209(b))

Measured Plots: See Clause 9.3.

Environmental conditions observed: On 4 March 2014, 24°C to 25°C, 49%RH to 47%RH

On 5 March 2014, 22°C to 23°C, 47%RH to 48%RH

On 6 March 2014, 23°C to 23°C, 45%RH to 48%RH

On 7 March 2014, 22°C to 24°C, 50%RH to 49%RH

Power supply voltage measured (\*): 100.0 VAC/60 Hz to 100.0 VAC/60 Hz.

(\*) measured at the power input terminal of Signal processing unit WR-2100-SPU.

Antenna Unit was powered through WR-2100-SPU, not directly from the AC mains.



### 9.2.3. Occupied Bandwidth (FCC Rule 47 CFR, 2.1049)

#### (1) Test conditions:

For all TX (P0N/Q0N/V0N) types, the Out-of-Band emission was measured at the antenna port with Antenna replaced with the Non-reflective load.

#### (2) Test setup:

See Clause 9.5.

#### (3) Test Results:

Pulse type	P0N		Q0N		V0N (P0N +Q0N)	
	H	V	H	V	H	V
Amplifier (H: for horizontal, V:for vertical)						
Occupied bandwidth (MHz)	17.50	17.17	14.17	14.83	14.67	14.83

Environmental conditions observed: On 8 March 2014, 23°C to 22°C, 45%RH to 54%RH

Power supply voltage measured (\*):100.0 VAC/60 Hz to 100.0 VAC/60 Hz.

(\*): measured at the power input terminal of Signal processing unit WR-2100-SPU.

Antenna Unit was powered through WR-2100-SPU, not directly from the AC mains.

### 9.2.4. Frequency Stability (FCC Rule 47 CFR, 2.1055)

#### (1) Test Conditions:

- 1) Radar Transmitter settings: All TX (P0N/Q0N/V0N) types
- 2) Power Supply Voltage settings: 85%/115% of nominal voltage (85 VAC/276 VAC)  
Power Supply Frequency settings: -5%/+5% of nominal frequency (47.5 Hz/63 Hz)
- 3) Ambient Temperature settings: Antenna unit (Outdoor unit): - 30°C to + 50°C (10°C interval) and + 55°C

#### (2) Test setup:

See Clause 9.5.

#### (3) Frequency Tolerance Limits (FCC Rule 47 CFR, 80.213 (g)):

Pulse type	P0N		Q0N		V0N (P0N +Q0N)	
	H	V	H	V	H	V
Amplifier (H: for horizontal, V:for vertical)						
f(U) (MHz)	9505.0	9505.3	9519.7	9519.7	9519.7	9519.7
f(L) (MHz)	9435.0	9434.7	9420.3	9420.3	9420.3	9420.3

See Clause 9.2.2 for details.

#### (4) Test Results:

Power Supply Voltage setting (\*): 85.0 VAC/47.5 Hz

Pulse type		P0N		Q0N		V0N (P0N +Q0N)	
		H	V	H	V	H	V
Frequency at maximum emission (MHz)	-30°C	9469.83	9469.33	9469.58	9469.58	9469.75	9469.83
	-20°C	9469.83	9469.33	9469.58	9469.58	9469.75	9469.83
	-10°C	9469.83	9469.33	9469.58	9469.58	9469.75	9469.83
	0°C	9469.83	9469.33	9469.58	9469.58	9469.75	9469.83
	+10°C	9469.83	9469.33	9469.58	9469.58	9469.75	9469.83
	+20°C	9469.83	9469.33	9469.58	9469.58	9469.75	9469.83
	+30°C	9469.67	9469.42	9469.75	9469.75	9469.67	9469.83
	+40°C	9469.67	9469.42	9469.75	9469.75	9469.67	9469.83
	+50°C	9469.67	9469.42	9469.75	9469.75	9469.67	9469.83

Power Supply Voltage setting (\*): 100.0 VAC/60.0 Hz

Pulse type		P0N		Q0N		V0N (P0N +Q0N)	
Amplifier (H: for horizontal, V:for vertical)		H	V	H	V	H	V
Frequency at maximum emission (MHz)	-30°C	9469.67	9469.42	9469.58	9469.67	9469.67	9469.75
	-20°C	9469.67	9469.50	9469.42	9469.75	9469.83	9469.92
	-10°C	9470.00	9469.75	9469.75	9470.00	9469.75	9469.58
	0°C	9469.58	9469.58	9469.50	9469.67	9469.75	9469.67
	+10°C	9469.83	9470.00	9469.58	9469.58	9469.67	9469.42
	+20°C	9469.83	9469.50	9469.83	9469.58	9469.67	9469.75
	+30°C	9469.83	9469.58	9469.50	9469.75	9469.42	9470.00
	+40°C	9469.50	9470.08	9469.75	9469.50	9469.50	9469.67
	+50°C	9469.50	9469.67	9469.67	9469.58	9469.83	9469.58

Power Supply Voltage setting (\*): 240.0 VAC/50.0 Hz

Pulse type		P0N		Q0N		V0N (P0N +Q0N)	
Amplifier (H: for horizontal, V:for vertical)		H	V	H	V	H	V
Frequency at maximum emission (MHz)	-30°C	9469.67	9469.58	9469.83	9470.00	9469.50	9469.67
	-20°C	9470.17	9469.50	9469.58	9469.08	9469.83	9469.58
	-10°C	9470.58	9469.75	9469.75	9469.67	9469.83	9469.58
	0°C	9469.83	9469.58	9469.58	9469.58	9469.42	9469.83
	+10°C	9469.75	9469.75	9469.25	9469.58	9469.33	9469.58
	+20°C	9469.75	9469.25	9469.67	9469.67	9469.33	9468.58
	+30°C	9469.58	9469.83	9469.42	9470.00	9469.92	9469.92
	+40°C	9469.83	9469.67	9469.75	9470.00	9469.92	9469.58
	+50°C	9469.75	9469.75	9469.75	9469.75	9469.83	9469.58

Power Supply Voltage setting (\*): 276.0 VAC/63.0 Hz

Pulse type		P0N		Q0N		V0N (P0N +Q0N)	
Amplifier (H: for horizontal, V:for vertical)		H	V	H	V	H	V
Frequency at maximum emission (MHz)	-30°C	9469.75	9469.58	9469.58	9469.33	9469.50	9469.75
	-20°C	9469.75	9469.58	9469.58	9469.33	9469.50	9469.75
	-10°C	9469.75	9469.58	9469.58	9469.33	9469.50	9469.75
	0°C	9469.75	9469.58	9469.58	9469.33	9469.50	9469.75
	+10°C	9469.75	9469.58	9469.58	9469.33	9469.50	9469.75
	+20°C	9469.75	9469.58	9469.58	9469.33	9469.50	9469.75
	+30°C	9469.42	9470.08	9469.75	9469.75	9469.33	9469.75
	+40°C	9469.42	9470.08	9469.75	9469.75	9469.33	9469.75
	+50°C	9469.42	9470.08	9469.75	9469.75	9469.33	9469.75

Environmental conditions observed: On 4 March 2014, 24°C to 25°C, 49%RH to 47%RH  
 On 5 March 2014, 22°C to 23°C, 47%RH to 48%RH  
 On 6 March 2014, 23°C to 23°C, 45%RH to 48%RH

(\*): measured at the power input terminal of Signal processing unit WR-2100-SPU.

Antenna Unit was powered through WR-2100-SPU, not directly from the AC mains.

### 9.2.5 Suppression of Interference Aboard Ships (FCC Rule 47 CFR, 80.217)

#### (1) Test Conditions/Test Setup:

The test was performed at the antenna port with the Standby mode.

#### (2) Test Setup:

See Clause 9.5.

#### (3) Test frequency range: 9 kHz to 40 GHz

#### (4) Spurious Emission Limits for Receivers:

for delivered power to artificial antenna,

Frequency	Power to artificial antenna		Resolution bandwidth of Spectrum analyzer
	( $\mu$ W)	(dBm)	
9 kHz to 150 kHz	400	-4	1 kHz
150 kHz to 30 MHz			10 kHz
30 MHz to 100 MHz	4,000	6	100 kHz
100 MHz to 300 MHz	40,000	16	
300 MHz to 1 GHz	400,000	26	
1 GHz to 40 GHz			1 MHz

#### (5) Test Results:

Spurious emission components: Not found.

Spectrum plots: See Clause 9.4.

Environmental conditions observed: On 20 March 2014, 22°C to 25°C, 54%RH to 47%RH

Power supply voltage measured (\*): 100.0 VAC/60 Hz to 100.0 VAC/60 Hz.

(\*): measured at the power input terminal of Signal processing unit WR-2100-SPU.

Antenna Unit was powered through WR-2100-SPU, not directly from the AC mains.

**9.3. RF Envelope and Spectrum of the output pulse**

**9.3.1 Tx output of Amplifier for horizontal fan**

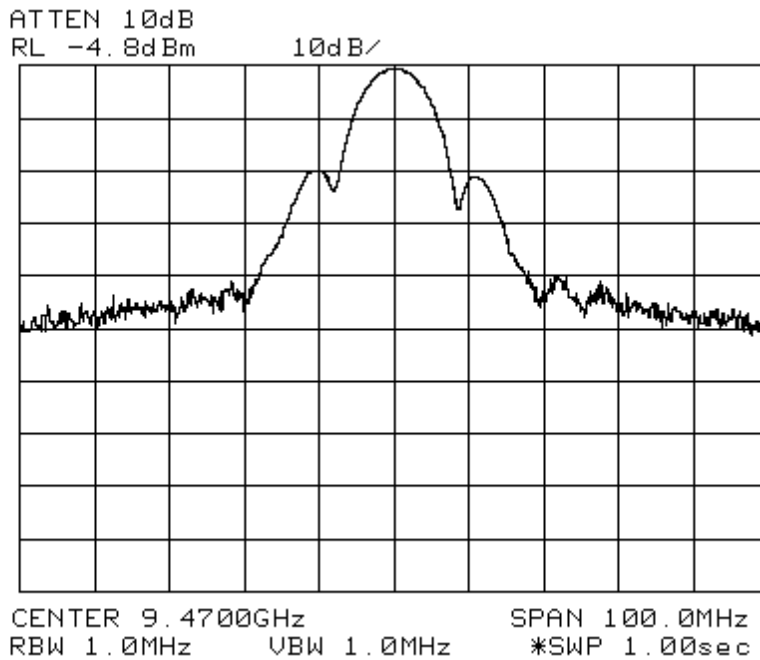
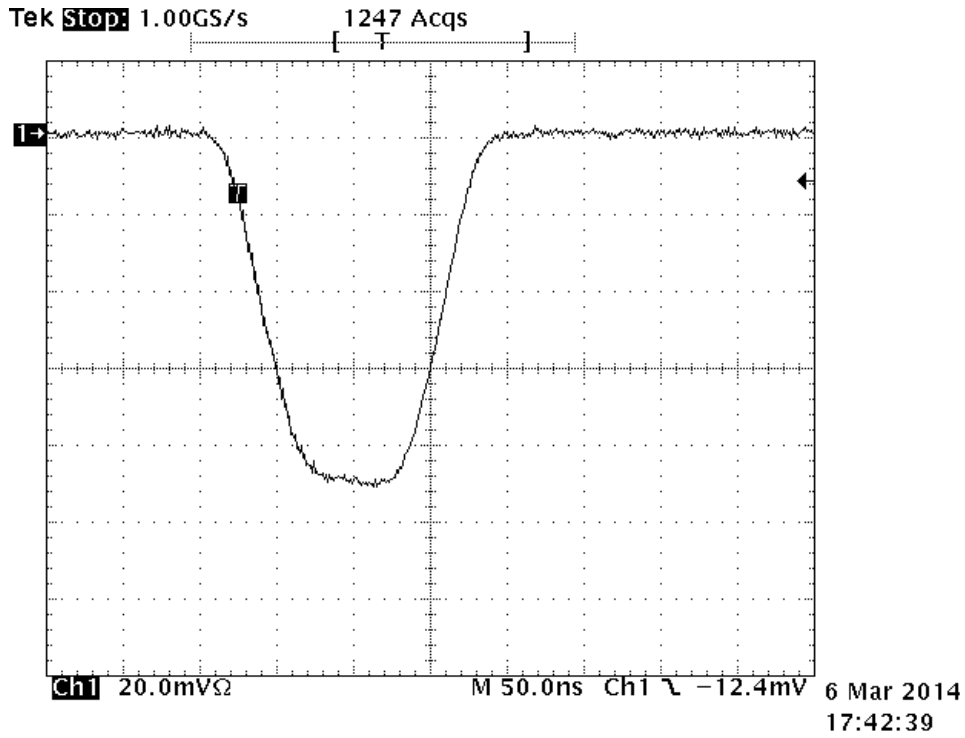


Fig. 3.1.1 Envelope and Spectrum of P0N type

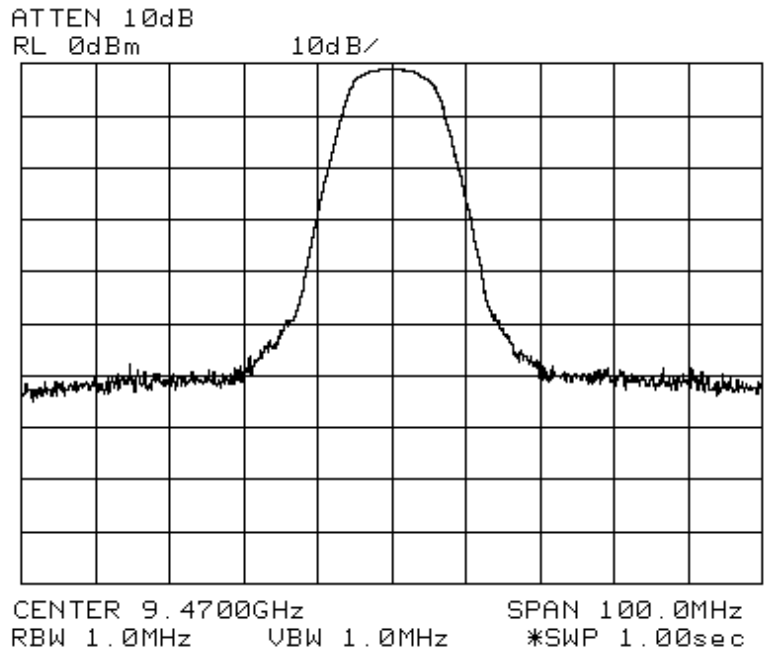
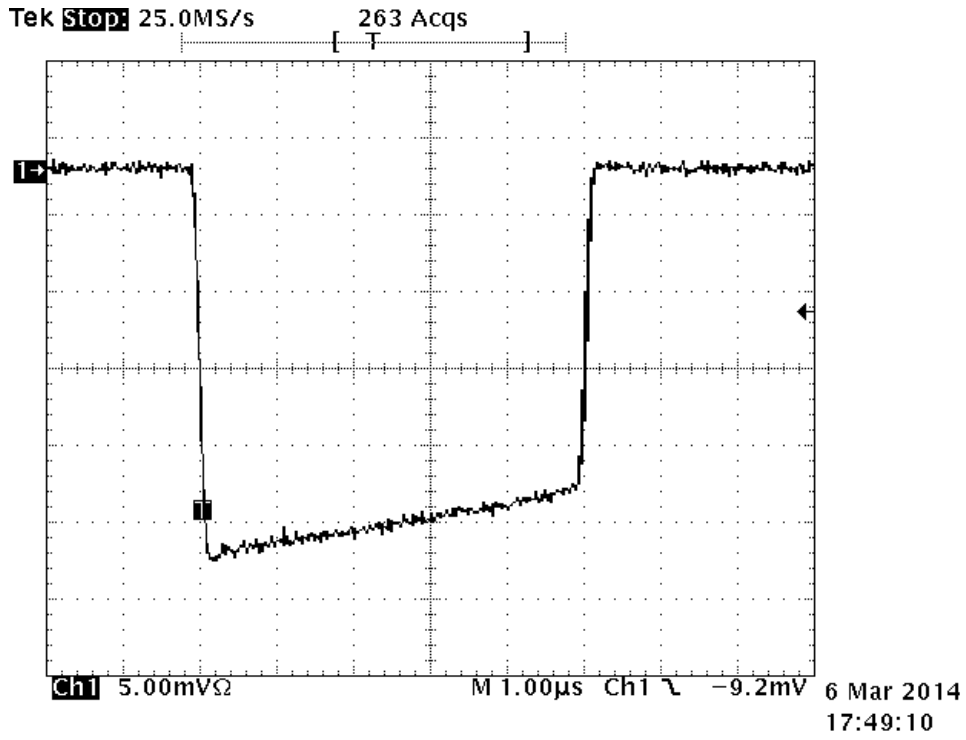


Fig. 3.1.2 Envelope and Spectrum of Q0N type

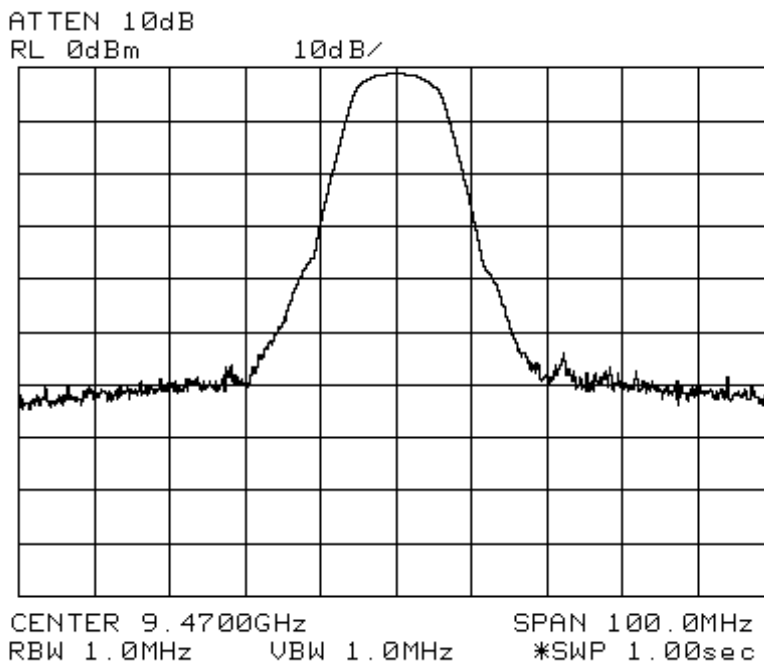
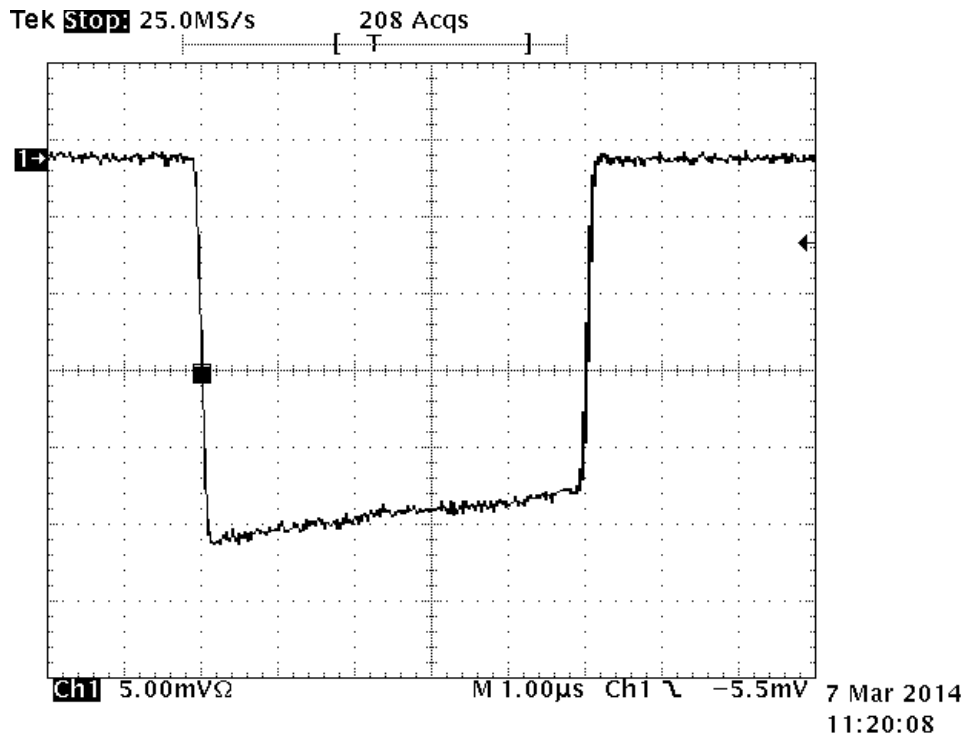


Fig. 3.1.3 Envelope and Spectrum of P0N + Q0N type

**9.3.2 Tx output of Amplifier for vertical fan**

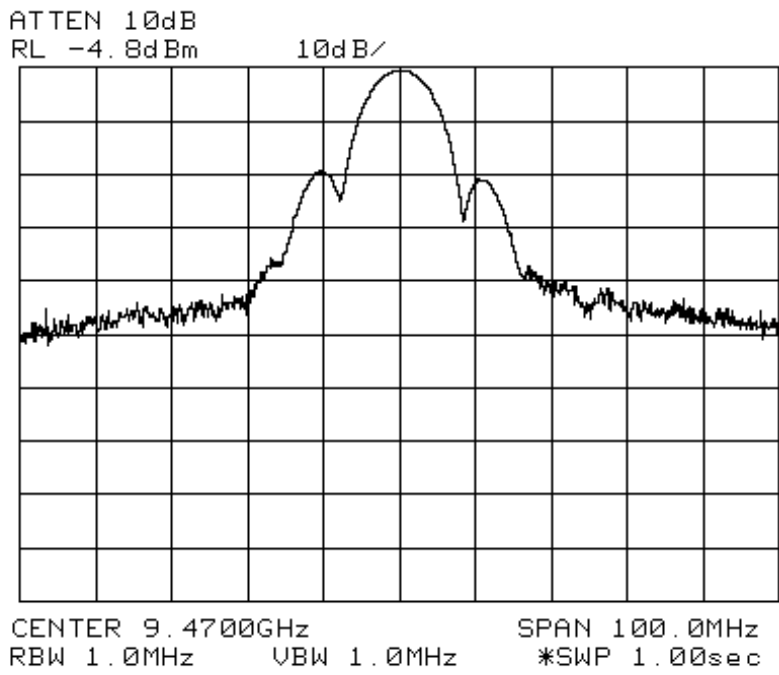
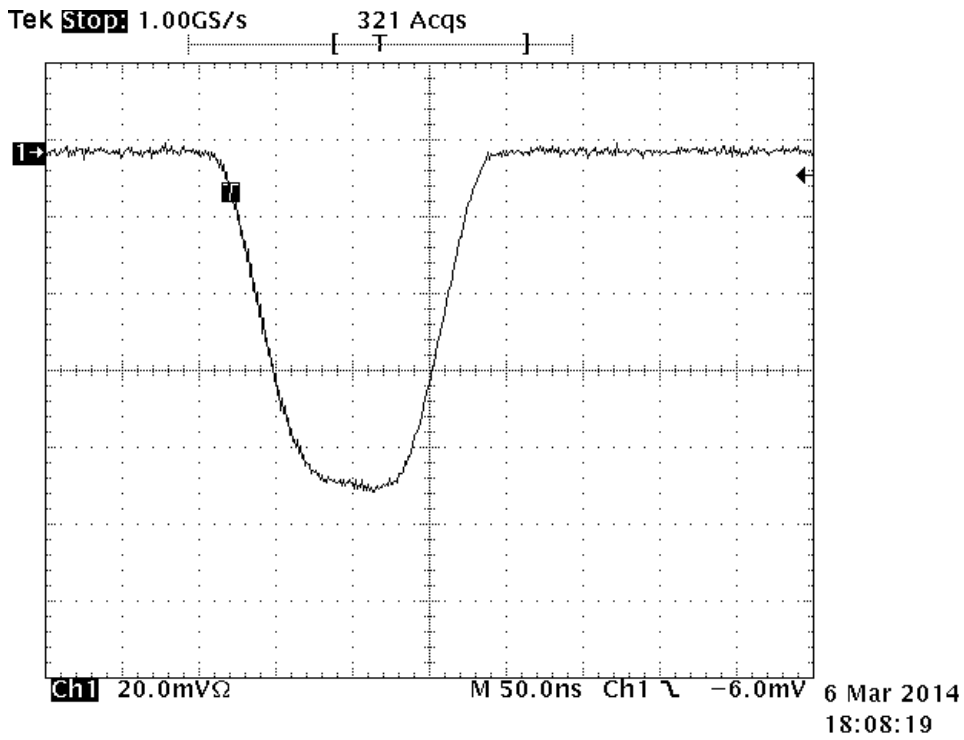


Fig. 3.2.1 Envelope and Spectrum of P0N type

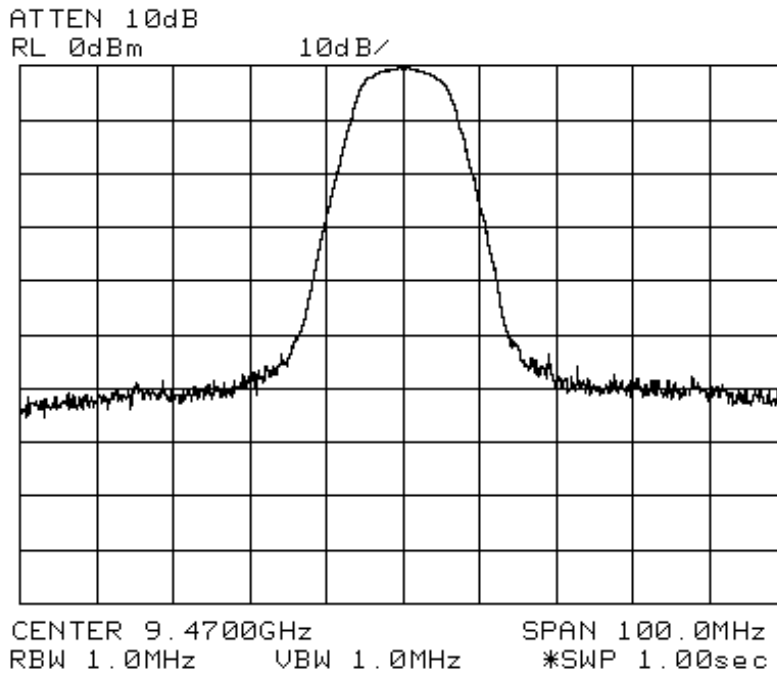
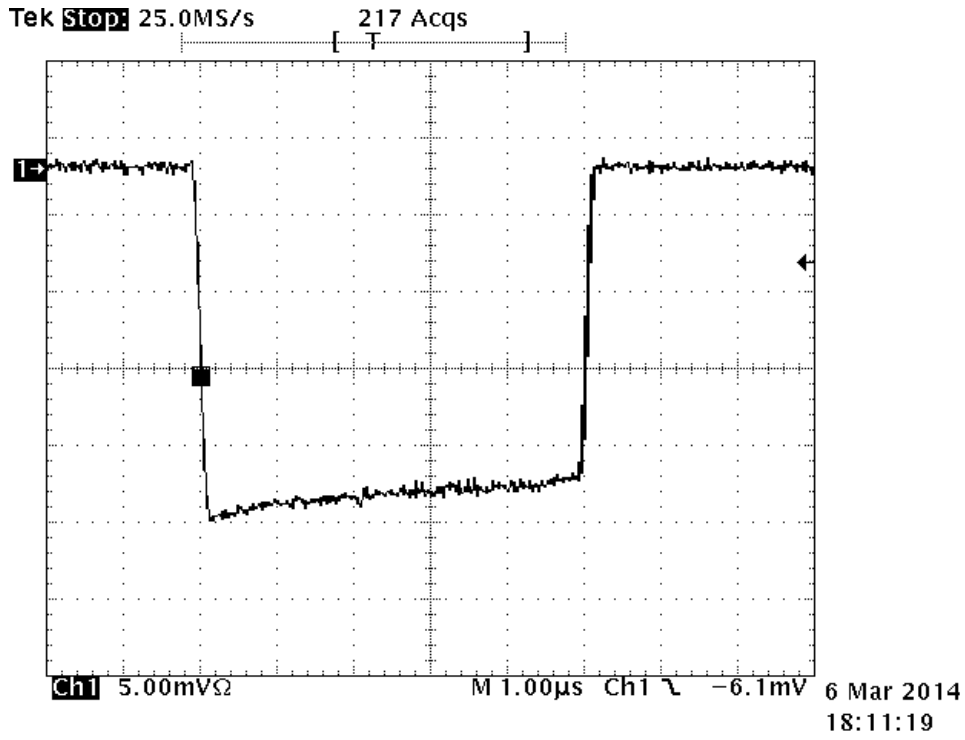


Fig. 3.2.2 Envelope and Spectrum of Q0N type



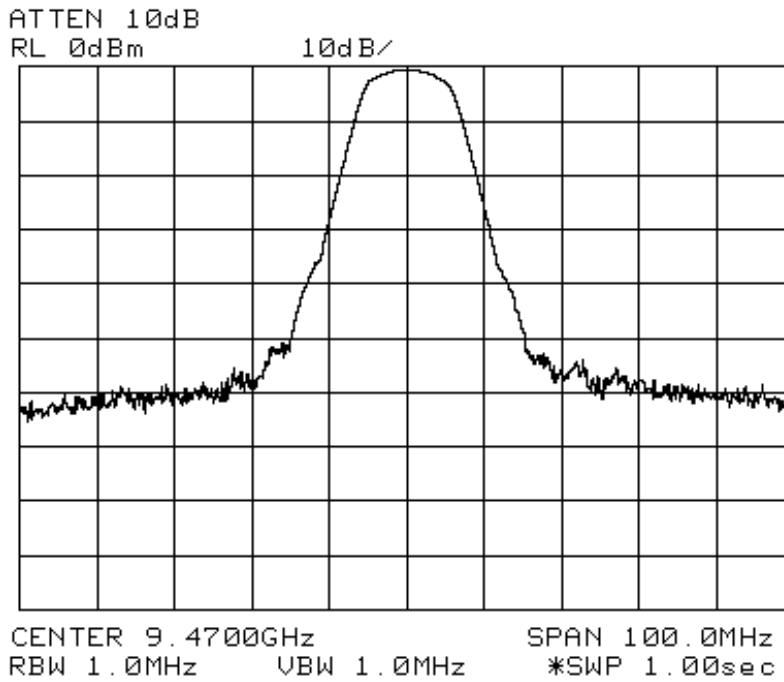
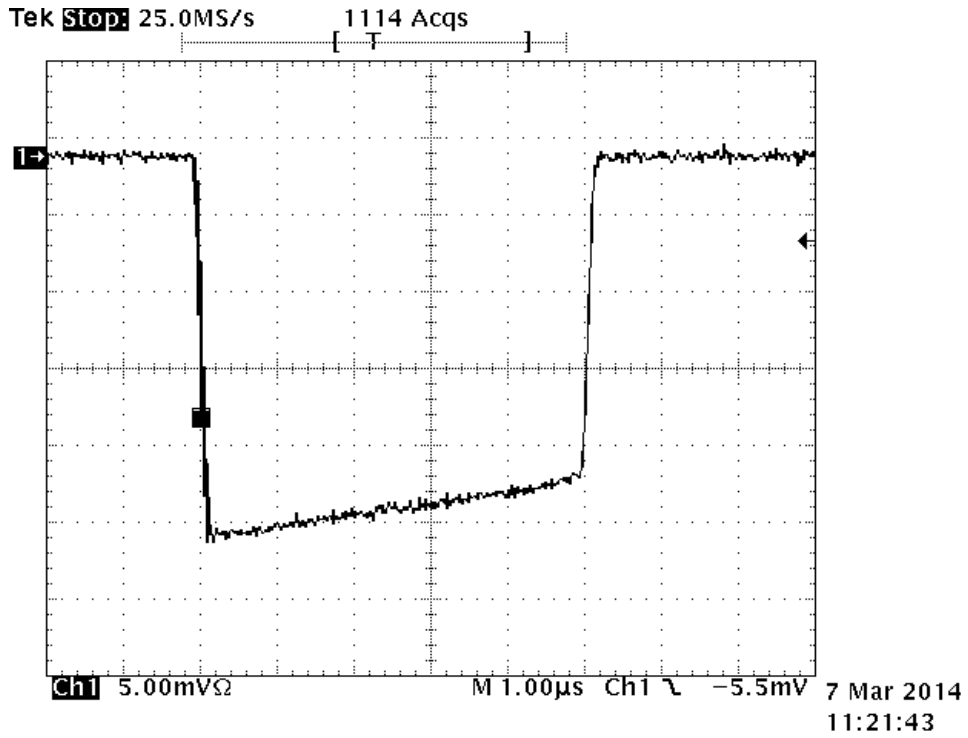


Fig. 3.2.3 Envelope and Spectrum of P0N + Q0N type

















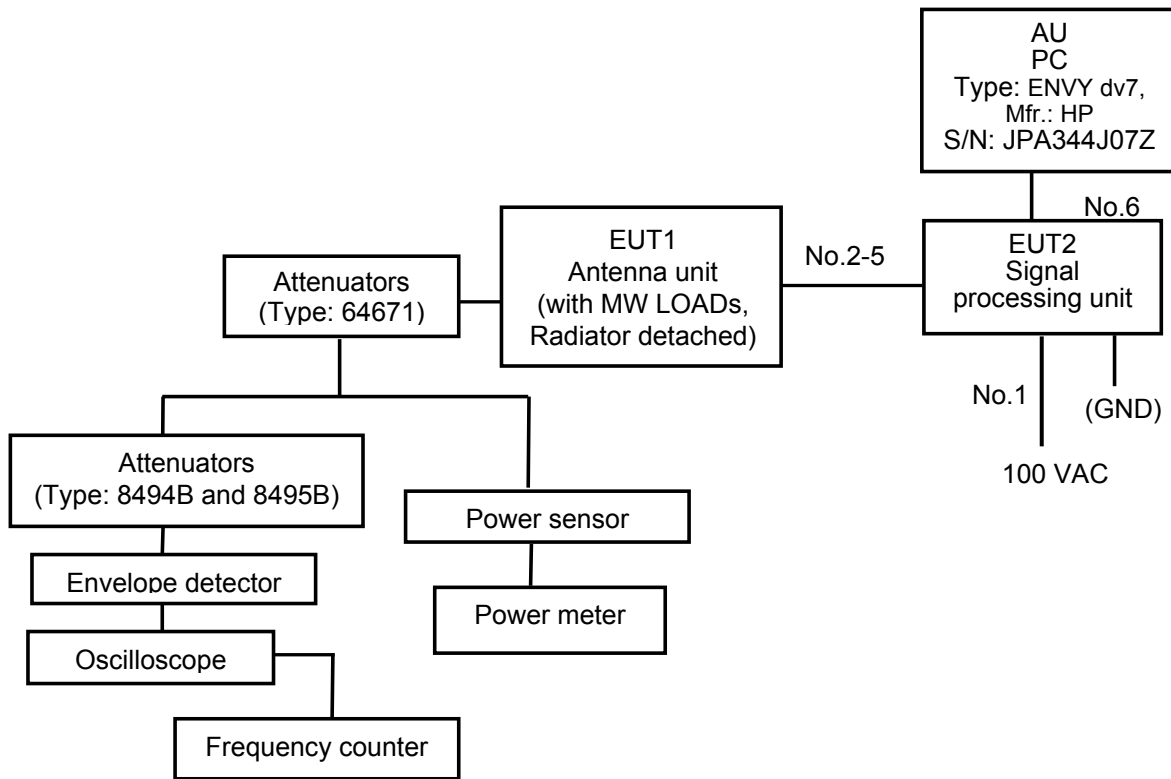




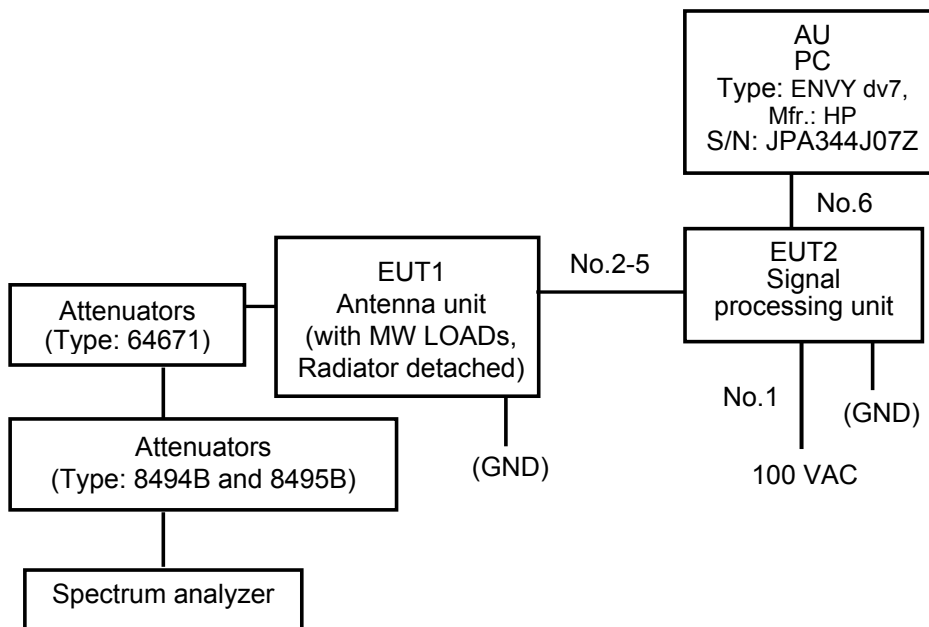


**9.5. Test Setup for Measurement:**

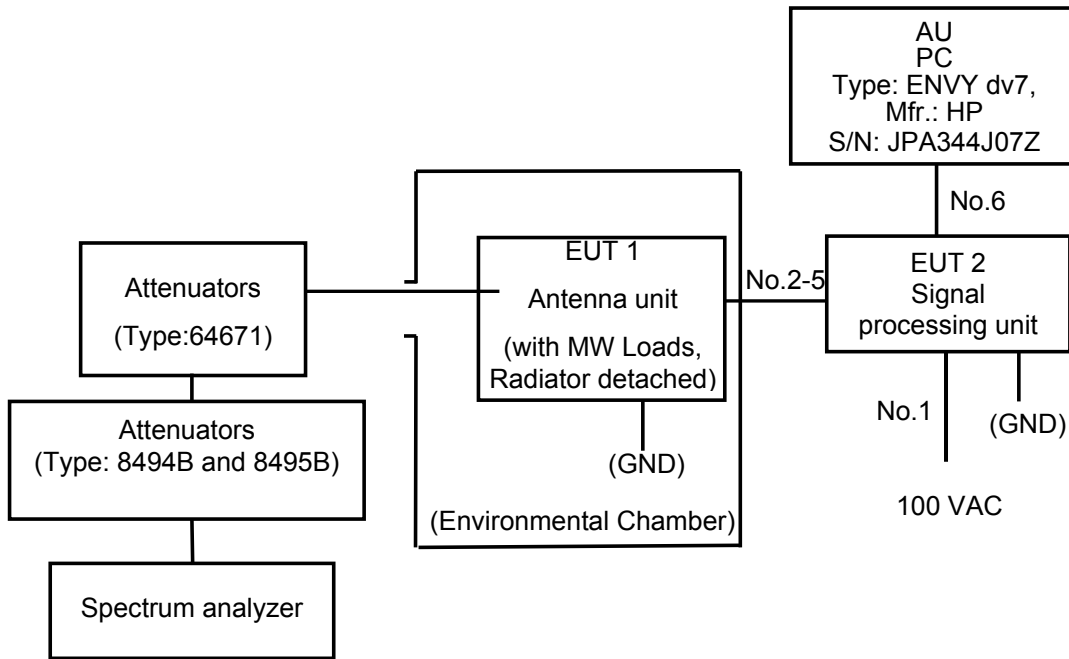
(1) Test Setup for Clause 9.2.1 and 9.2.2.



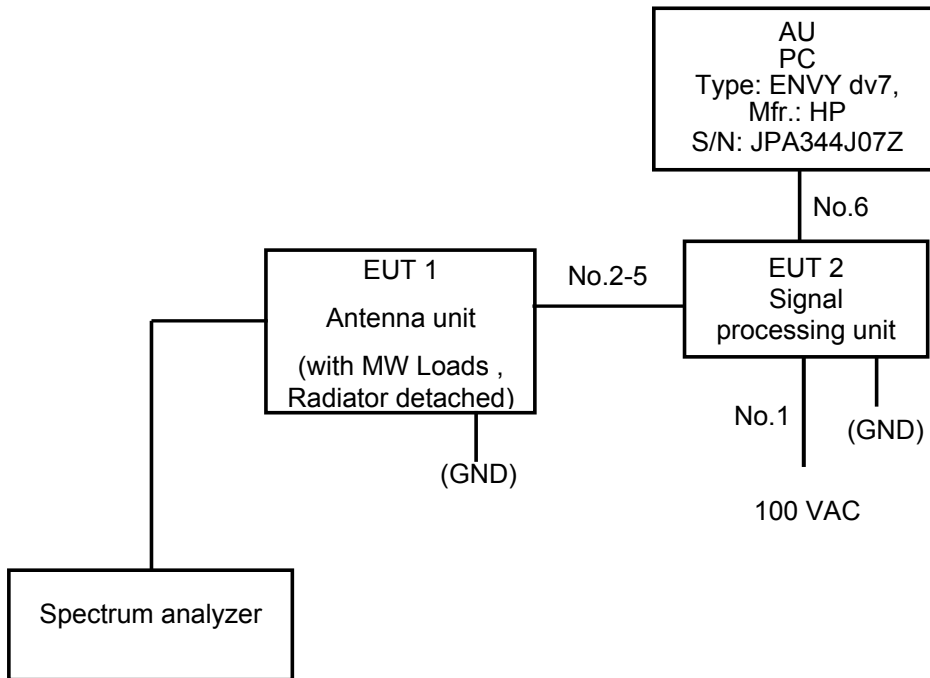
(2) Test Setup for Clause 9.2.3.



(3) Test Setup for Clause 9.2.4.



(5) Test Setup for Clause 9.2.5.



Cable designations;

No.	Name	Length (m)
1	VCT 2.0sq, 3C	20
2	3D-2W	5
3	AWG28, UL, 26C	5
4	AWG28, UL, 10C	5
5	VCT 1.25sq, 3C	5
6	Ethernet CAT.5e	20

## 9.6. Measuring Equipment List:

Measuring/Test instruments have been appropriately calibrated/maintained according to the FLI programs/procedures and ISO/IEC 17025. Measuring/Test instruments used for the tests are listed below.

### (1) For 9.2.1 Transmitter Output Power and for 2.2 Type Characteristics

C/N	Instrument	Type	S/N	Manufacturer	Date of last calibration
HT552	Power meter	E4418B	GB43315050	Agilent	21 October 2013
HT926	Power Sensor	E9304A-H18	MY53100039	Agilent	1 August 2013
HT913	Crystal Detector	423B	MY51340543	Agilent	27 February 2014
----	Attenuator	64671	----	INMET	4 March 2014
----	Attenuator	64671	----	INMET	4 March 2014
----	MW LOAD (10dB)	1310-6209-21	006	VXL TECNOLOCIES LTD	4 March 2014
----	MW LOAD (10dB)	1310-6209-21	007	VXL TECNOLOCIES LTD	4 March 2014
HT938	Frequency Counter	53181A	KR91200825	AGILENT	8 January 2014
HT654	Attenuator	8494B	MY42148134	Agilent	8 March 2013
HT655	Attenuator	8495B	MY42144403	Agilent	8 March 2013
HT168	Oscilloscope	TDS680B	B030202	Agilent	13 August 2013

### (2) For 9.2.3 Occupied Bandwidth

C/N	Instrument	Type	S/N	Manufacturer	Date of last calibration
----	Attenuator	64671	----	INMET	4 March 2014
----	Attenuator	64671	----	INMET	4 March 2014
----	MW LOAD (10dB)	1310-6209-21	006	VXL TECNOLOCIES LTD	4 March 2014
----	MW LOAD (10dB)	1310-6209-21	007	VXL TECNOLOCIES LTD	4 March 2014
HT676	Spectrum Analyzer	8564EC	4103A00440	Agilent	15 April 2013
HT654	Attenuator	8494B	MY42148134	Agilent	8 March 2013
HT655	Attenuator	8495B	MY42144403	Agilent	8 March 2013
KB-137	Coaxial cable	MWX221 - 2m	0804S167	Junkosha	----

### (3) For 9.2.4 Frequency Stability

C/N	Instrument	Type	S/N	Manufacturer	Date of last calibration
HT510	Climatic chamber (Hama-L)	TBE-3HW4PE2F	3013002540	Tabai Espec	7 September 2013
-----	Attenuator	64671	----	INMET	4 March 2014
-----	Attenuator	64671	----	INMET	4 March 2014
----	MW LOAD (10dB)	1310-6209-21	006	VXL TECNOLOCIES LTD	4 March 2014
----	MW LOAD (10dB)	1310-6209-21	007	VXL TECNOLOCIES LTD	4 March 2014
HT676	Spectrum Analyzer	8564EC	4103A00440	Agilent	15 April 2013
HT654	Attenuator	8494B	MY42148134	Agilent	8 March 2013
HT655	Attenuator	8495B	MY42144403	Agilent	8 March 2013
KB-137	Coaxial cable	MWX221 - 2m	0804S167	Junkosha	----

### (4) For 9.2.5 Suppression of Interference Aboard Ships

C/N	Instrument	Type	S/N	Manufacturer	Date of last calibration
-----	Attenuator	64671	----	INMET	4 March 2014
-----	Attenuator	64671	----	INMET	4 March 2014
----	MW LOAD (10dB)	1310-6209-21	006	VXL TECNOLOCIES LTD	4 March 2014
----	MW LOAD (10dB)	1310-6209-21	007	VXL TECNOLOCIES LTD	4 March 2014
HT676	Spectrum Analyzer	8564EC	4103A00440	Agilent	15 April 2013
KB-137	Coaxial cable	MWX221 - 2m	0804S167	Junkosha	----