Test Report

(FCC Rules 47 CFR,
2.1046, 2.1047, 2.1049, 2.1051, 2.1053, 2.1055, and 80.217)

For

Trade name: Furuno
Model: Transceiver for Marine Radar
Type: RTR-088B

Report no.: FLI 12-14-019
Date of issue: 4 April 2014

Furuno Labotech International Co., Ltd.
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Report Summary

FLI project number:	FLI 04-13-0521		
Test report number of initial issue:	FLI 12-14-019	Date of Initial Issue:	4 April 2014
Test report number of revised/replaced issue:	---	Date of revised/replaced Issue:	---
Test report revision/ replacement history:	---		
Test standard(s)/ Test specifications:	FCC 47 CFR, Sections: 2.1046 - RF Power Output, 2.1047 - Modulation Characteristics, 2.1049 - Occupied Bandwidth, 2.1051 - Spurious Emissions at Antenna Terminal, 2.1055 - Frequency Stability, 2.1053 - Field Strength of Spurious Radiation, 80.217 - Suppression of Interference Aboard Ships. (Date of issue: 1 October 2013)		
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:	Transceiver for Marine Radar FR-8045		
Type:	RTR-088B		
Product function and intended use:	For Maritime Safety Navigation		
Number of samples tested:	One		
Serial number:	R00011-000051		
Power rating:	24 VDC, 3.7 A (for Display Unit) (The EUT was powered through the Display unit, not directly from DC mains)		
Product status:	Pre-production model		
Modifications made to samples during testing:	None.		
Date of receipt of samples:	22 January 2014		
Test period:	From 22 January 2014 to 31 January 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 firm Designation Number: JP2007, Test firm Registration #: 838049 - Nishinomiya Lab. 9-52 Ashihara-cho, Nishinomiya-shi, Hyogo, 662-8580 Japan		
Test results/ Compliance:	Passed. The test results of this report relate only to the samples tested.		
Tested by:	Katsumi Imamura		
Written by:	Akiko Inoue		
Verified by:	Yoshihiro Ishii		
Approved by:	Date: 4 April 2014 Name: Yoshihiro Ishii Title: Title: Senior Manager, Technical Department 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, 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, 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:
  Elecrtrical 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 Resister (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)
- Recogintion 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, interfave and safety testing.

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: Transceiver for Marine Radar

	Type	Serial Number	Note
Antenna Unit			
Scanner	RSB-0073	R00011-000051	Antenna rotation rate: 48 rpm.
Transceiver	RTR-088B	---	
Antenna	XN13A XN12A	---	One (1) selectable.

(d) FCC ID: ADB9ZWRTR088B

(e) Primary Function: Search, Navigation and anticollison

(f) Frequency Range: Fixed frequency, X-band (9410 MHz)

Type of Emission: P0N

(g) Power Supply: 24 VDC (*) 3.7A with Display unit RDP-154.

(*): Antenna unit was powered through the Display Unit, not directly from the external DC mains.

1.1.2 Radar Sensor

1.1.2.1 Transceiver

Type: RTR-088B

(Contained in the Scanner)

(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: E3571

Peak Output Power: 4 kW nominal

(c) Magnetron Ratings

Center frequency of Magnetron: 9410 MHz

Tolerances

Manufacturing: ±30 MHz

Pulling: 27 MHz

Tolerance for 20°C temperature variation: -5 MHz

(d) Pulse Characteristics:

Pulse type	S	M	L
Pulselength (μs)	0.08	0.30	0.80
P.R.R.(Hz)	2100	1200	600

(2) Modulator

(a) FET Type: 2SK1450

Trigger Voltage: Approx. +10 VDC positive

(3) Receiver

(a) Passband

RF Stage: 100 MHz

IF Stage:

Pulse type	S	M	L
Passband (MHz)	40	2.5	2.5

(b) Gain (overall): approximately 130 dB

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

(d) Video Output Voltage: ±4 V Negative across 75 Ω

(e) Features Provided: Sensitivity Time Controls (Anti-clutter Sea),

Fast Time Constant (Anti-clutter Rain)

(f) If receiver is tunable, describe method for adjusting frequency:
by adjustment of tuning voltage of receiver local oscillator (Automatic and manual)

1.1.2.2 Antenna and Scanner

(a) Antenna Rotation ON-OFF Switch: Not Provided.
(b) Antenna structure: Slotted array

(c) Antenna size:

Antenna type	XN12A	XN13A
Length (cm)	126	180

(d) Type of Beam: Vertical fan

(e) Beam Width (3 dB):

Antenna type	XN12A	XN13A
Horizontal (°)	1.9	1.4
Vertical (°)	22	22

(f) Polarization: Horizontal

(g) Antenna Gain:

Antenna type	XN12A	XN13A
Gain (dB)	28.5	30.0

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

Antenna type	XN12A	XN13A
Within ±10° (dB)	-24	-28
Outside ±10° (dB)	-30	-35

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

(j) Antenna Rotation Rate: 48 rpm

(k) Number of Degrees Scanned: 360°
(l) Sector Scan: Not Provided.

(m) Rated Loss of Transmission line per hundred feet:

Negligible. (Transmission path is only in the scanner unit.)

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:

Yes (Receiver tuning indicator)

(b) Is the equipment for continuous operation: Yes

(c) Is provision made for operation with shore based radar beacons (RACONS):

Yes (RACONS)

1.1.4 Line Power Supply Requirements

(a) Input Voltage: 24 VDC (*)

(*): The Antenna Unit was powered through the voltage regulator built in the RDP-154, not directly from the external DC mains.

(b) Power consumption: 89 W

1.1.5 Construction Features

(a) Does equipment embody replacement units with chassis type assembly: Yes

(b) Are fuse alarms provided: Yes

(c) State units that are weatherproof: Antenna Unit (IEC 60529 – IP26)

(d) If all units are not housed in a single container, indicate number and give description of individual units:

1 × Antenna Unit

Scanner	Type: RSB-0073
Transceiver	Type: RTR-088B (contained in the Scanner)
Antenna	Type: XN12A or XN13A

(e) Approximate Weight of Complete Installation:

Antenna Unit:	25 kg (with XN12A)
	27 kg (with XN13A)

(f) Approximate space required for installation excluding scanner: not applicable.

1.2 Observation and comments

None.

2 Test Results Summary

Clause no. of this report	47 CFR Section	Item	Result	Test Engineer
3.1	2.1046	RF Power Output	Passed.	K. Imamura
3.2	2.1047	Modulation Characteristics	Passed.	K. Imamura
3.3	2.1049	Occupied Bandwidth	Passed.	K. Imamura
3.4	2.1055	Frequency Stability	Passed.	K. Imamura
3.5	---	Spurious Emissions	---	---
3.5.1	2.1051	- Spurious Emissions at Antenna Terminal	Passed.	K. Imamura
3.5.2	2.1053	- Field Strength of Spurious Radiation	Passed.	K. Imamura
3.6	80.217	Suppression of Interference Aboard Ships	Passed.	K. Imamura

3 Test Results

3.1 RF Power Output (FCC Rule 47 CFR, 2.1046)

(1) Test conditions:

For all TX (S/ M/ L) Pulses, the transmitter output power was measured at the antenna port with Antenna replaced with the Non-reflective load.

(2) Test setup:

See Clause 4.

(3) Test Results:

Pulse type	S	M	L
Magnetron Output, mean P_m (W)	0.582	1.939	2.492
Magnetron Output, peak P_p (kW) (*1)	4.33	5.53	5.40
Pulselength T (µs) (-3 dB points) (*2)	0.064	0.292	0.769
PRR (Hz)	2100	1200	600

(*1) P_p (kW) = (P_m (W) / (T (µs) × PRR (Hz))) × 1000

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

Environmental conditions observed: On 30 January 2014, 24°C to 24°C, 60%RH to 60%RH

Power supply voltage measured (*): 24.0 VDC to 24.0 VDC.

(*): Power input voltages to the external equipment (Display Unit RDP-154) measured. Antenna unit was powered through the voltage regulator built in the RDP-154, not directly from the external DC mains.

3.2 Modulation Characteristics (FCC Rule 47 CFR, 2.1047)

(1) Test Conditions:

The RF envelope of the magnetron output pulse was measured using an envelope detector and an oscilloscope.
Each pulse spectrum was measured using a spectrum analyzer.

(2) Test setup:

See Clause 4.

(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): 9410 MHz
Authorized bandwidth (f(AUBW)): 110 MHz

(4) Test Results:

Complied.

Pulse type	S	M	L	Result
Pulselength T (μs) (-3 dB points) (*1)	0.064	0.292	0.769	Not applicable
Rise time t_r (μs) (10 - 90 % amplitude)	0.015	0.051	0.044	Not applicable
Decay time t_f (μs) (90 - 10 % amplitude)	0.036	0.055	0.102	Not applicable
PRR (Hz)	2100	1200	600	Not applicable
Guard Band f(1.5/T) (MHz) (*2)	23.4	5.1	2.0	Not applicable
f(U) (MHz)	9436.6	9454.9	9458.0	Not applicable
f(L) (MHz)	9383.4	9365.1	9362.0	Not applicable
Frequency at maximum emission (MHz)	9411.5	9408.0	9407.0	Complied

(*1): Measured at -3 dB points of the RF envelope of the magnetron output pulse instead of at 50% points of the current of the magnetron, 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 7.

Environmental conditions observed: On 30 January 2014, 24°C to 24°C, 60%RH to 60%RH
On 31 January 2014, 22°C to 22°C, 58%RH to 58%RH

Power supply voltage measured (*): 24.0 VDC to 24.0 VDC.
(*): Power input voltages to the external equipment (Display Unit RDP-154) measured. Antenna unit was powered through the voltage regulator built in the RDP-154, not directly from the external DC mains.

3.3 Occupied Bandwidth (FCC Rule 47 CFR, 2.1049)

(1) Test conditions:

For all TX (S/M/L) Pulses, the transmitter occupied bandwidth was measured at the antenna port with Antenna replaced with the Non-reflective load.

(2) Test setup:

See Clause 4.

(3) Test Results:

Pulse type	S	M	L
Occupied bandwidth (MHz)	48.9	17.3	10.1

Environmental conditions observed: On 30 January 2014, 24°C to 24°C, 60%RH to 60%RH

Power supply voltage measured (*): 24.0 VDC to 24.0 VDC.

(*): Power input voltages to the external equipment (Display Unit RDP-154) measured. Antenna unit was powered through the voltage regulator built in the RDP-154, not directly from the external DC mains.

3.4 Frequency Stability (FCC Rule 47 CFR, 2.1055)

(1) Test Conditions:

1) Radar Transmitter settings: All TX (S/ M/ L) Pulses
2) Ambient Temperature settings: - 20°C to + 50°C (10°C interval)
3) Power Supply Voltage settings: 85 /115 % of nominal voltage (20.4 VDC/27.6 VDC)

(2) Test setup:

See Clause 4.

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

Pulse type	S	M	L
f(U) (MHz)	9436.6	9454.9	9458.0
f(L) (MHz)	9383.4	9365.1	9362.0

See Clause 3.2 for details.

(4) Test Results:

Complied.

Power Supply Voltage setting (*): 20.4 VDC

Pulse type		S	M	L	Result
Frequency at maximum emission (MHz)	-30°C	9421.0	9418.0	9418.0	Complied
	-20°C	9419.5	9416.5	9416.0	Complied
	-10°C	9417.0	9414.0	9413.6	Complied
	0°C	9415.0	9412.0	9411.4	Complied
	+10°C	9413.0	9410.0	9409.2	Complied
	+20°C	9411.0	9408.0	9407.0	Complied
	+30°C	9409.3	9406.2	9405.3	Complied
	+40°C	9407.7	9404.3	9403.7	Complied
	+50°C	9406.0	9402.5	9402.0	Complied

Power Supply Voltage setting (*): 24.0 VDC

Pulse type		S	M	L	Result
Frequency at maximum emission (MHz)	-30°C	9421.5	9418.0	9417.5	Complied
	-20°C	9419.5	9416.5	9416.0	Complied
	-10°C	9417.5	9414.0	9413.3	Complied
	0°C	9415.5	9412.0	9411.2	Complied
	+10°C	9413.5	9410.0	9409.1	Complied
	+20°C	9411.5	9408.0	9407.0	Complied
	+30°C	9409.8	9406.3	9405.5	Complied
	+40°C	9408.2	9404.7	9404.0	Complied
	+50°C	9406.5	9403.0	9402.5	Complied

Power Supply Voltage setting (*): 27.6 VDC

Pulse type		S	M	L	Result
Frequency at maximum emission (MHz)	-30°C	9421.0	9417.5	9417.5	Complied
	-20°C	9419.5	9416.5	9416.0	Complied
	-10°C	9417.0	9413.5	9413.3	Complied
	0°C	9415.0	9411.6	9411.2	Complied
	+10°C	9413.0	9409.6	9409.1	Complied
	+20°C	9411.0	9407.6	9407.0	Complied
	+30°C	9409.3	9405.9	9405.3	Complied
	+40°C	9407.7	9404.2	9403.7	Complied
	+50°C	9406.0	9402.5	9402.0	Complied

Environmental conditions observed: On 30 January 2014, 24°C to 24°C, 60%RH to 60%RH
On 31 January 2014, 22°C to 22°C, 58%RH to 58%RH

(*): Power input voltages to the external equipment (Display Unit RDP-154) measured. Antenna unit was powered through the voltage regulator built in the RDP-154, not directly from the external DC mains.

3.5 Spurious Emissions
3.5.1 Spurious Emissions at Antenna Terminal (FCC Rule 47 CFR, 2.1051)

(1) Test Conditions:

For all TX (S/M/L) Pulses, the transmitter output power will be measured at the antenna port with Antenna replaced with the Non-reflective load.

(2) Test setup:

See Clause 4.

(3) Emission Limits (FCC Rule 47 CFR, 80.211 (f)):

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 $\log_{10}$ (mean power in watts)

Note: (1) Authorized bandwidth = 110 MHz

(*) - for the relevant frequency bands, tests were performed according to FCC Rule, 2.1053. See Clause 3.5.2.

(4) Test Results:

Complied.

From the results of the pre-tests, the EUT emission level was found to be the maximum with S pulse. Consequently, the test was performed only with S pulse.

Spectrum Plots: See Clause 8.

Environmental conditions observed: On 30 January 2014, 24°C to 24°C, 60%RH to 60%RH

Power supply voltage measured (*): 24.0 VDC to 24.0 VDC.

(*): Power input voltages to the external equipment (Display Unit RDP-154) measured. Antenna unit was powered through the voltage regulator built in the RDP-154, not directly from the external DC mains.

3.5.2 Field Strength of Spurious Radiation (FCC Rule 47 CFR, 2.1053)

(1) Test Conditions:

Tests were performed with all (S/M/L) Pulses.

(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 so as to detect the maximum spurious radiation.

(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, 80.211 (f)):

Frequency removed from the assigned frequency	Frequency (MHz) (for X-band)	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 %	0.009 - 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 = 110 MHz
(*) - for the relevant frequency bands, tests were performed according to FCC Rule 47 CFR, 2.1051. See Clause 3.5.1.

(6) Test Results:

Complied.

From the results of the pre-tests, the spurious emission level was found to be the maximum with S pulse. Consequently, the test was performed only with S pulse.

[Limit] = 43 + 10 $\log_{10}$ (mean power in watts)
= 43 + 10 $\log_{10}$ (0.582)
= 40.6 dB
where, [mean power in watts] = 0.582 W for S pulse. See 3.1.

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

The electric field strength of the maximum power radiation was 153.1 dBμV/m with S pulse. Consequently, the allowable emission limit was set to 93.1 dBμV/m (= 153.1 dBμV/m - 60 dB).

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

Spectrum plots: See Clause 9.

Spurious Emission Frequency and Electric Field Strength of which the limit margin was less than 20 dB are listed in the following table:

Frequency (GHz)	Antenna Polarization	Pulse type	Electric Field Strength measured (dBμV/m)	Limit (dBμV/m)	Margin (dB)
18.836	Horizontal	S	77.8	93.1	15.3

Environmental conditions observed: On 25 February 2014, 21°C to 22°C, 49%RH to 47%RH
Power supply voltage measured (*): 24.0 VDC to 24.0 VDC.
(*): Power input voltages to the external equipment (Display Unit RDP-154) measured. Antenna unit was powered through the voltage regulator built in the RDP-154, not directly from the external DC mains.

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

(1) Test Conditions:

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

(2) Test Setup:

See Clause 4.

(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
	(μW)	(dBm)	
9 kHz - 150 kHz	400	-4	1 kHz
150 kHz - 30 MHz			10 kHz
30 MHz - 100 MHz	4,000	6	100 kHz
100 MHz to 300 MHz	40,000	16	
300 MHz - 1 GHz	400,000	26	
1 GHz - 40 GHz			1 MHz

(5) Test Results:

Complied.

Spurious emission components: Not found.

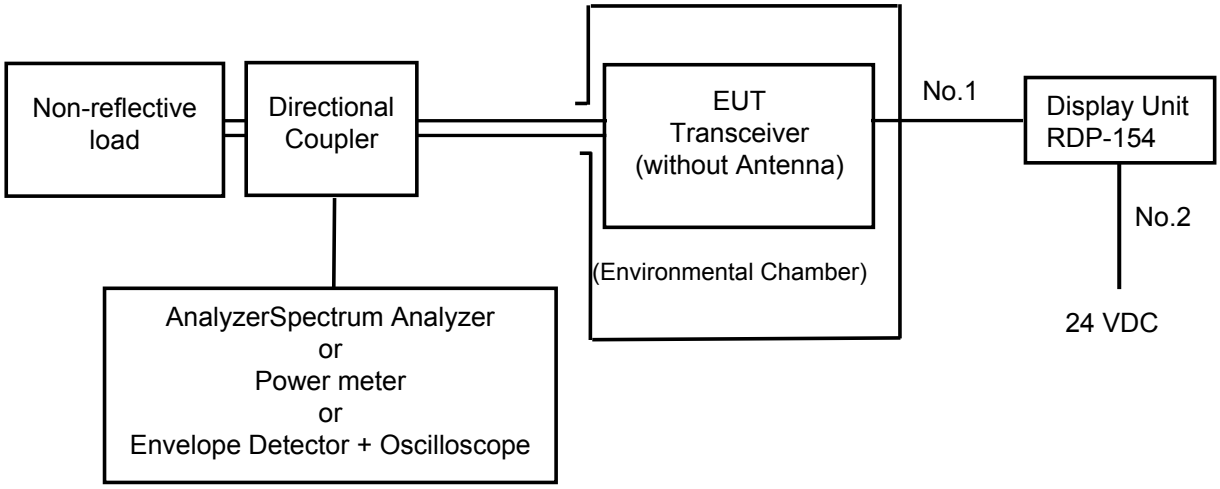
Spectrum plots: See Clause 10.

Environmental conditions observed: On 31 January 2014, 22°C to 23°C, 58%RH to 59 %RH
Power supply voltage measured (*): 24.0 VDC to 24.0 VDC.

(*): Power input voltages to the external equipment (Display Unit RDP-154) measured. Antenna unit was powered through the voltage regulator built in the RDP-154, not directly from the external DC mains.

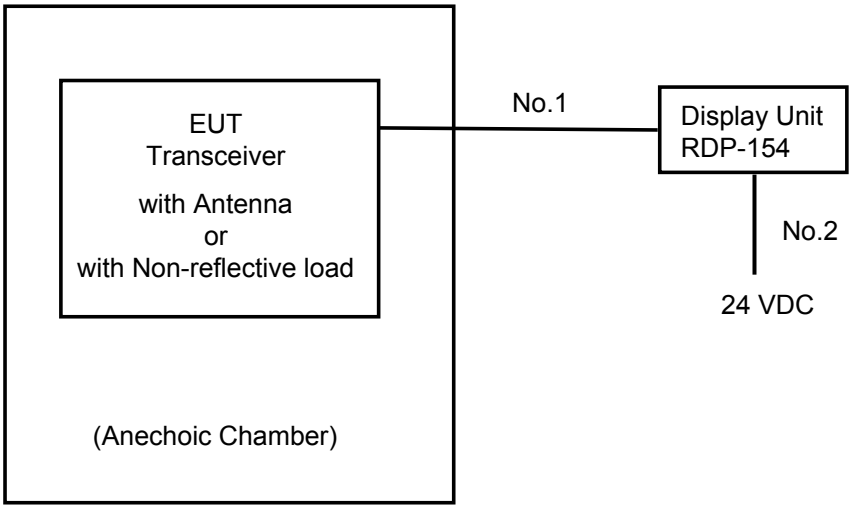
4 Test Setup for Measurement:

(1) Test Setup for Clauses 3.1, 3.2, 3.3, 3.4, and 3.5.1.

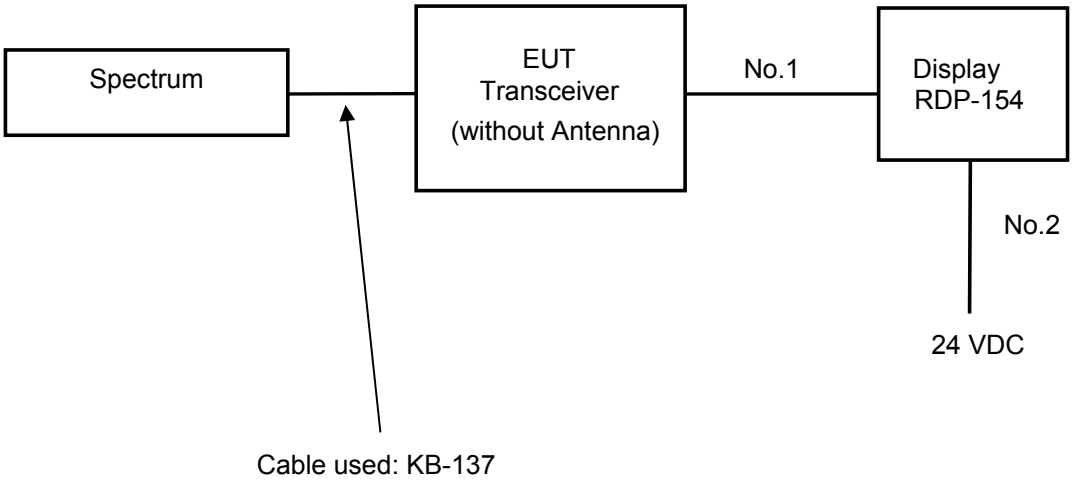


Wave Guide designation: WRJ-10 (length: 60 cm)

(2) Test Setup for Clause 3.5.2.



(3) Test Setup for Clause 3.6.



Cable designations:

No.	Name	Length (m)
1	MJ-B24LPF0005-200+R	20
2	MJ-A3SPF0017-050ZC	5

5 List of Measuring Equipment

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 RF Power Output,

C/N	Instrument	Type	S/N	Manufacturer	Date of last calibration
HT552	Power meter	E4418B	GB43315050	Agilent	23 October 2013
HT926	Power Sensor	E9304A-H18	MY53100039	Agilent	1 August 2013
RT125-3	Crystal Detector	432B	MY42244692	Agilent	1 May 2013
8411096	Directional Coupler (X-band)	5D364S	R05762	Shimada	23 May 2013
8411057	Dummy Load (X-band)	4D376	R05763	Shimada	---
----	Waveguide (for X-band)	WRJ-10 (l = 60 cm)	----	Furuno	---
HT553	Frequency Counter	53150A	US40501919	Agilent	23 October 2013
RT125-1	Attenuator	8494B	MY42150509	Agilent	24 October 2013
RT125-2	Attenuator	8495B	MY42146372	Agilent	14 June 2013
HT594	Oscilloscope	DSO6102A	MY44001501	Agilent	28 October 2013
-----	Coaxial cable	SUCOFLEX 104 - 2m	-----	SUHNER	--
HT432	DC power supply	PAN55-20	AK003307	Kikusui	--

(2) For 3.2 Modulation Characteristics,

C/N	Instrument	Type	S/N	Manufacturer	Date of last calibration
8411096	Directional Coupler (X-band)	5D364S	R05762	Shimada	23 May 2013
8411057	Dummy Load (X-band)	4D376	R05763	Shimada	---
----	Waveguide (for X-band)	WRJ-10 (l = 60 cm)	----	Furuno	---
RT125-1	Attenuator	8494B	MY42150509	Agilent	24 October 2013
RT125-2	Attenuator	8495B	MY42146372	Agilent	14 June 2013
RT125-3	Crystal Detector	432B	MY42244692	Agilent	1 May 2013
HT553	Frequency Counter	53150A	US40501919	Agilent	23 October 2013
HT594	Oscilloscope	DSO6102A	MY44001501	Agilent	28 October 2013
HT432	DC power supply	PAN55-20	AK003307	Kikusui	---

(3) For 3.3 Occupied Bandwidth and for 3.5.1 Spurious Emissions at Antenna Terminal,

C/N	Instrument	Type	S/N	Manufacturer	Date of last calibration
8411096	Directional Coupler (X-band)	5D364S	R05762	Shimada	23 May 2013
8411057	Dummy Load (X-band)	4D376	R05763	Shimada	---
----	Waveguide (for X-band)	WRJ-10 (l = 60 cm)	----	Furuno	---
RT125-1	Attenuator	8494B	MY42150509	Agilent	24 October 2013
RT125-2	Attenuator	8495B	MY42146372	Agilent	14 June 2013
RT124	Spectrum Analyzer	N9030A	US51350170	Agilent	25 January 2013
HT432	DC power supply	PAN55-20	AK003307	Kikusui	---

(4) For 3.4 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
HT725	Paperless recorder/Dual communication logger DAQSTATION FX100	FX106-4-1	S5JA01447	Yokogawa	7 September 2013
8411096	Directional Coupler (X-band)	5D364S	R05762	Shimada	23 May 2013
8411057	Dummy Load (X-band)	4D376	R05763	Shimada	---
----	Waveguide (for X-band)	WRJ-10 (l = 60 cm)	----	Furuno	---
RT124	Spectrum Analyzer	N9030A	US51350170	Agilent	25 January 2013
RT125-1	Attenuator	8494B	MY42150509	Agilent	24 October 2013
RT125-2	Attenuator	8495B	MY42146372	Agilent	14 June 2013
-----	Coaxial cable	SUCOFLEX 104 - 2m	-----	SUHNER	---
-----	Coaxial cable	SUCOFLEX 104 - 5m	250497	SUHNER	---
HT432	DC power supply	PAN55-20	AK003307	Kikusui	---

(5) For 3.5.2 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
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
HT365	Semi-anechoic Chamber	3mSAC	D-002	Riken	31 October 2012
HT676	Spectrum Analyzer	8564EC	4103A00440	Agilent	15 April 2013
740060501	Horn antenna (18 GHz to 26.5 GHz)	42-442-6	E414109-01	A. H. Systems	---
0511041	Low-noise amplifier	JSWV4-18002600-30-8P	1058348	MITEQ	---
----	DC power supply for Low-noise amplifier	EX-375L2	405650060347	Takasago	---
740060502	Horn antenna (26.5 GHZ to 40 GHz)	28-442-6	E414209-01	A. H. Systems	---
----	Notch Filter (X-band)	CBR-X7-3A	R9865001	Shimada	---
----	Coaxial cable	SUCOFLEX 104 - 2m	-----	SUHNER	---
----	Coaxial cable	SUCOFLEX 104 - 5m	250497	SUHNER	---
----	Coaxial cable	SUCOFLEX 102 - 5m	265055	SUHNER	---

(6) For 3.6 Spurious Emission Limits for Receivers:

C/N	Instrument	Type	S/N	Manufacturer	Date of last calibration
RT124	Spectrum Analyzer	N9030A	US51350170	Agilent	25 January 2013
KB-137	3.5 mm cable	MWX221-2m	0804S167	Junkosha	---

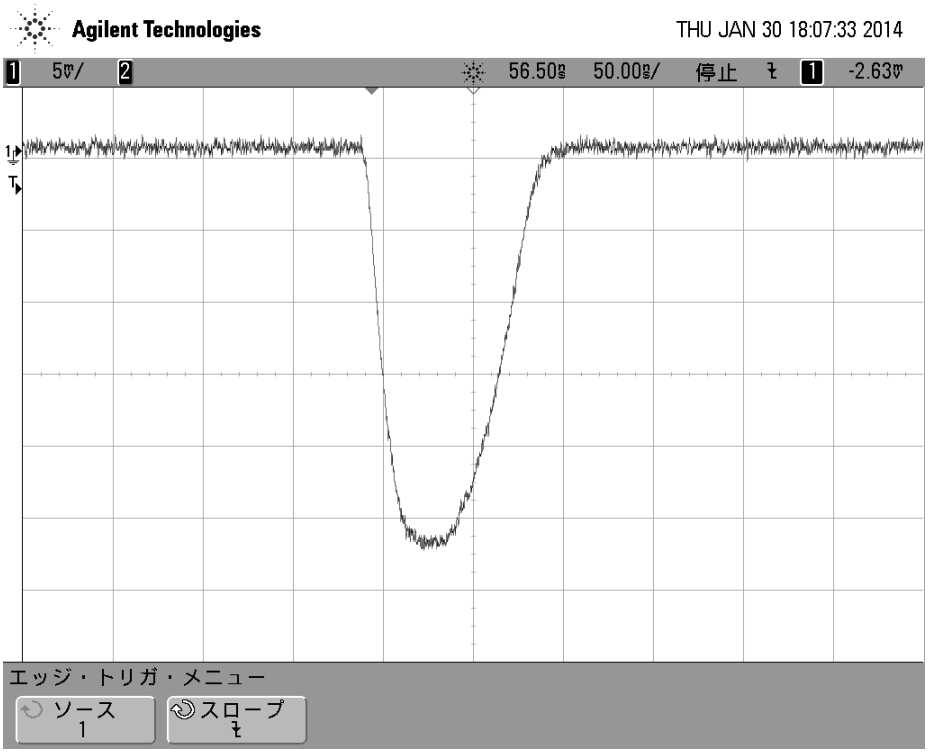
6 Photograph of Test Setup/Arrangement

(1) For Frequency Stability tests,

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

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

7 RF Envelope and Spectrum of the output pulse



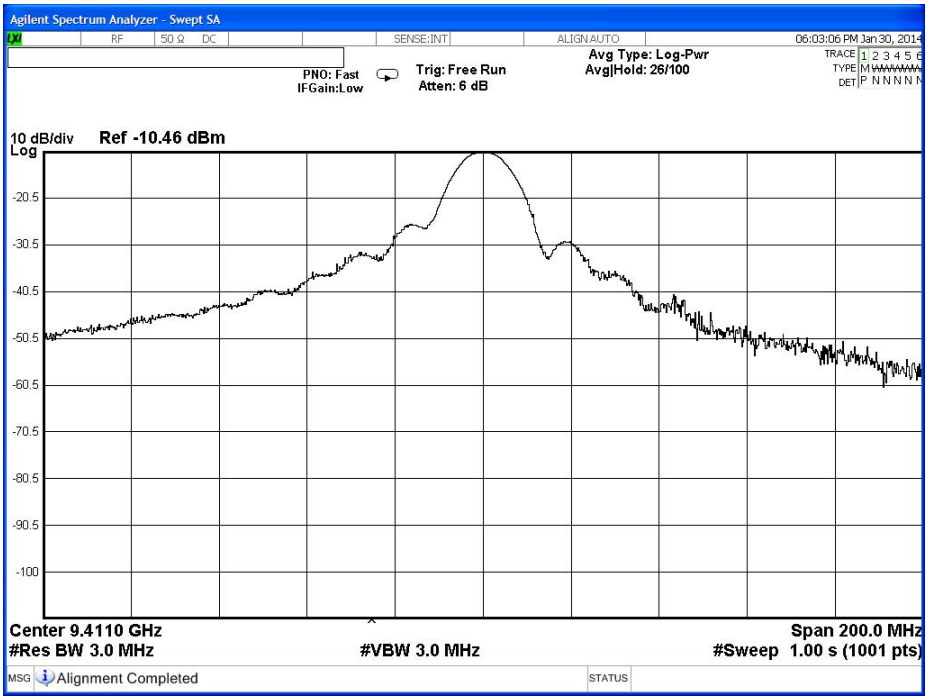
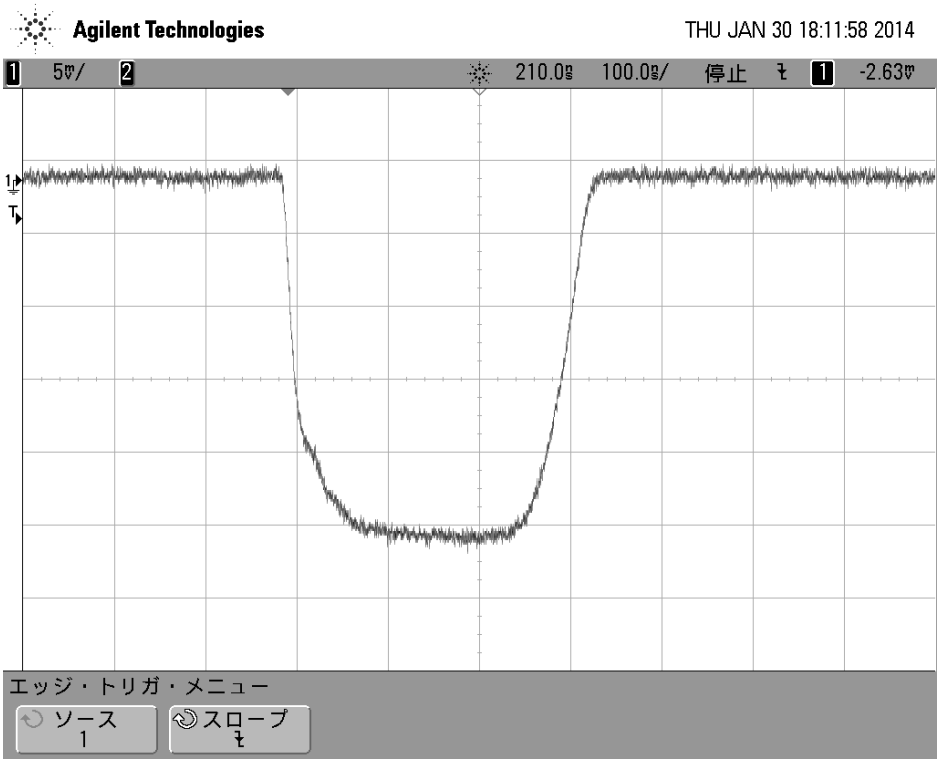


Fig. 7.1 S Pulse Envelope and Spectrum



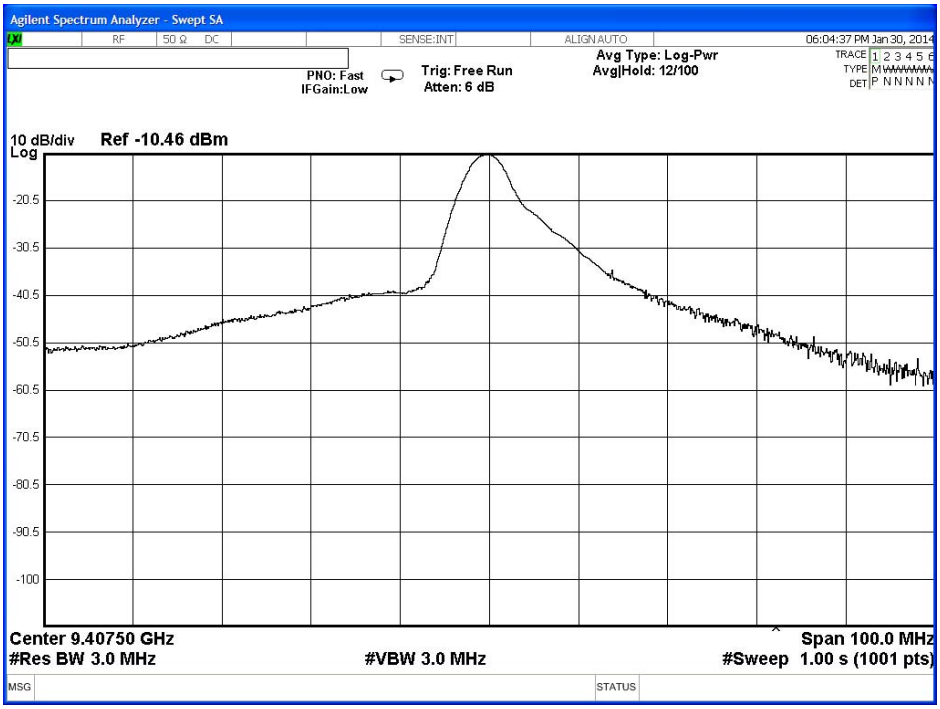
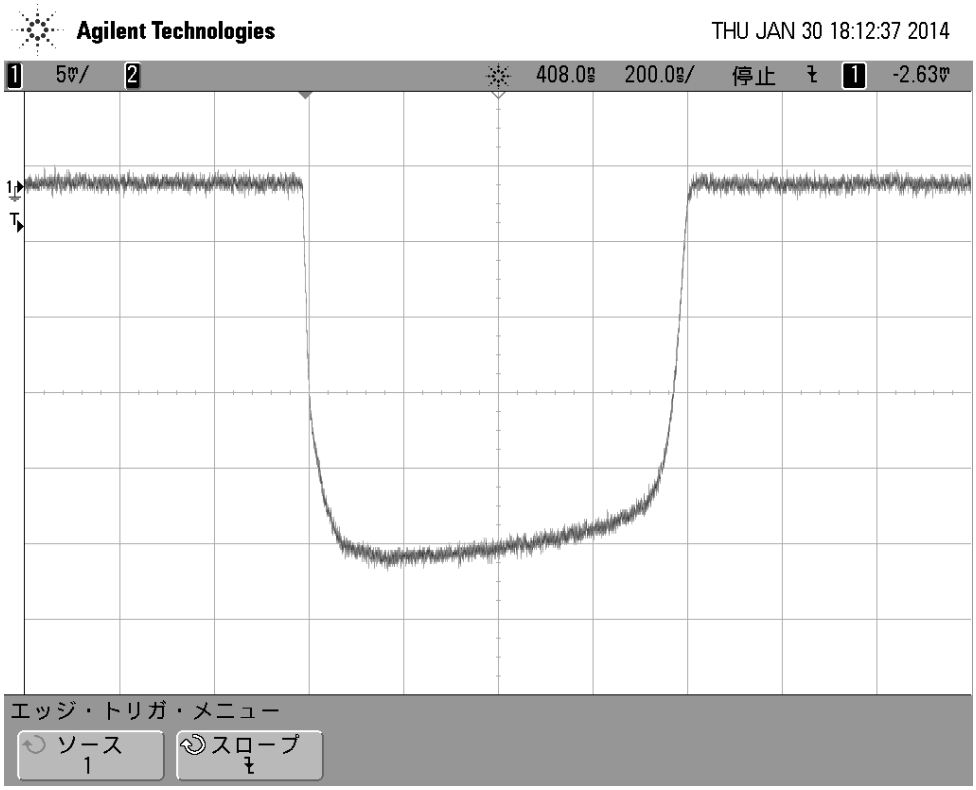


Fig. 7.2 M Pulse Envelope and Spectrum



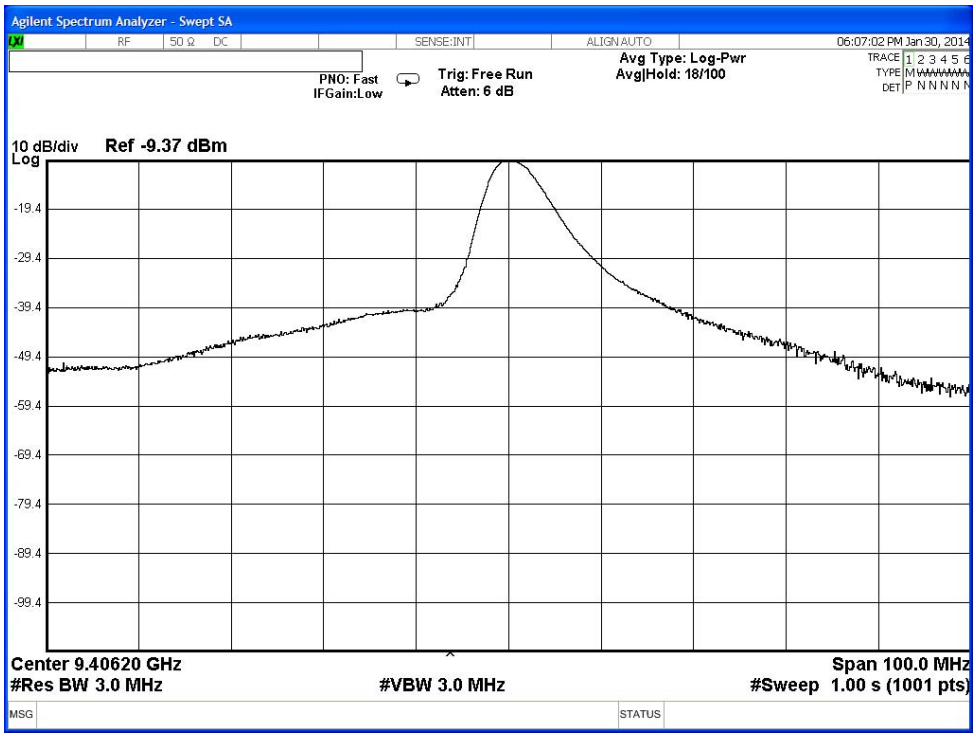
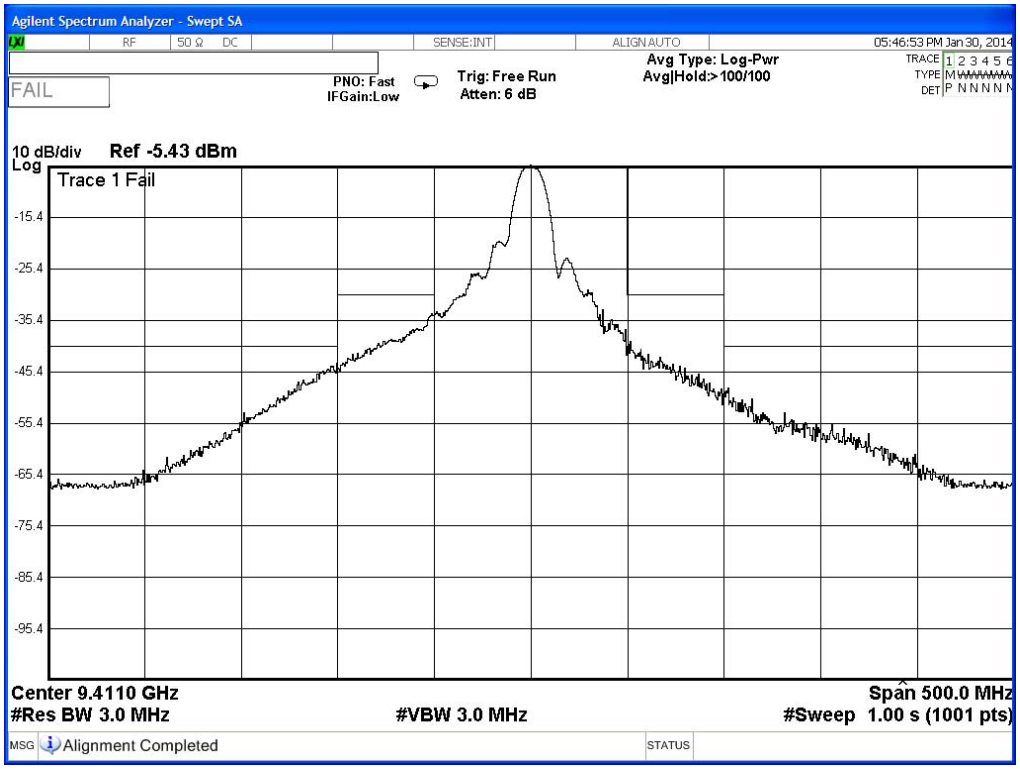


Fig. 7.3 L Pulse Envelope and Spectrum

8 Spurious Emission Plots measured at Antenna Terminal

for S pulse

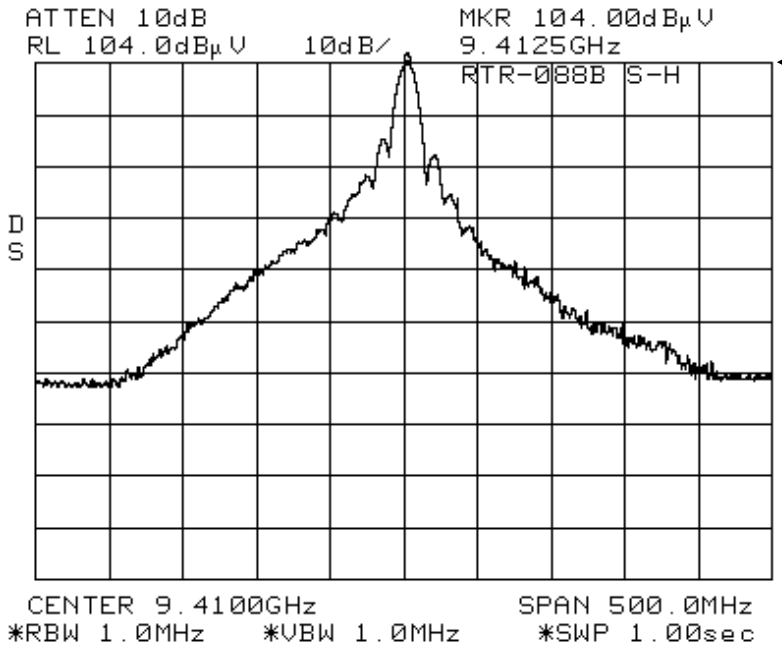


Limit

9 Field Strength Plots of Spurious Radiation

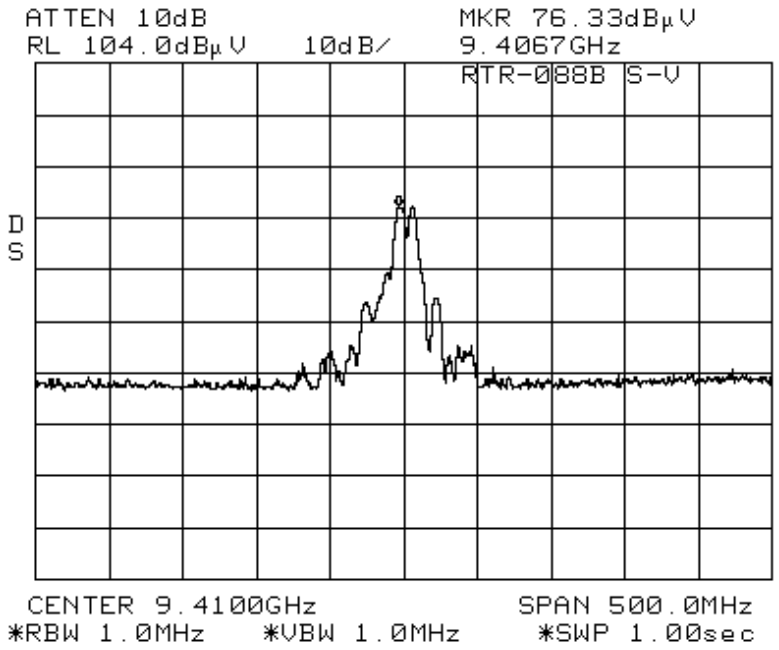
9.1 Maximum power radiation level (for S Pulse)

- Horizontal



Maximum radiation level
(Equals to Reference level)

- for Vertical



Maximum radiation level
(Equals to Reference level)

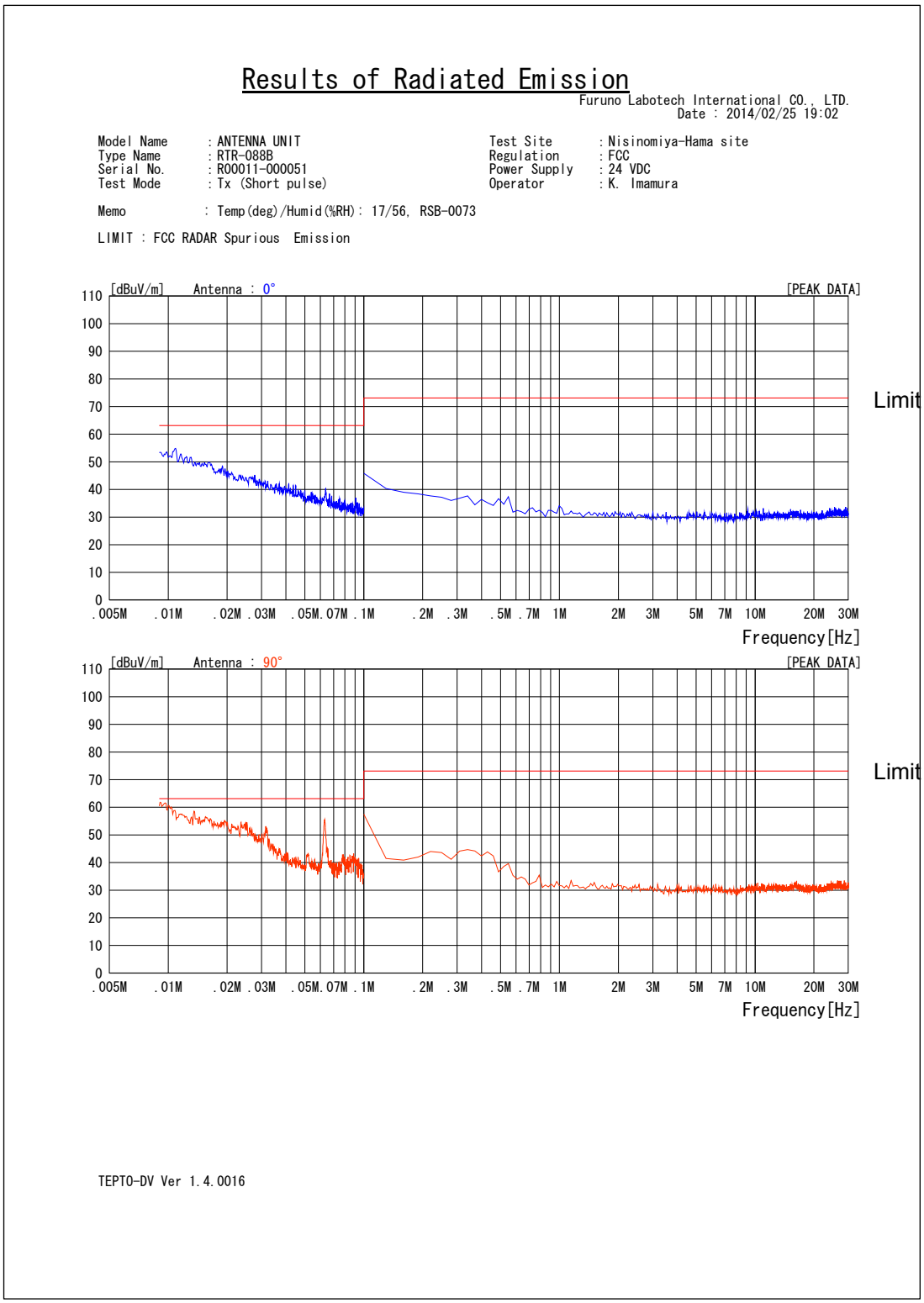
For the maximum power radiation level, the voltage value measured by the spectrum analyzer was converted into the electric field strength with the measuring antenna factor, Cable loss and Amp. gain.

Maximum power radiation level = 153.1 dBµV/m

Therefore, Emission Limit = 153.1 dBµV/m - 60 dB = 93.1 dBµV/m

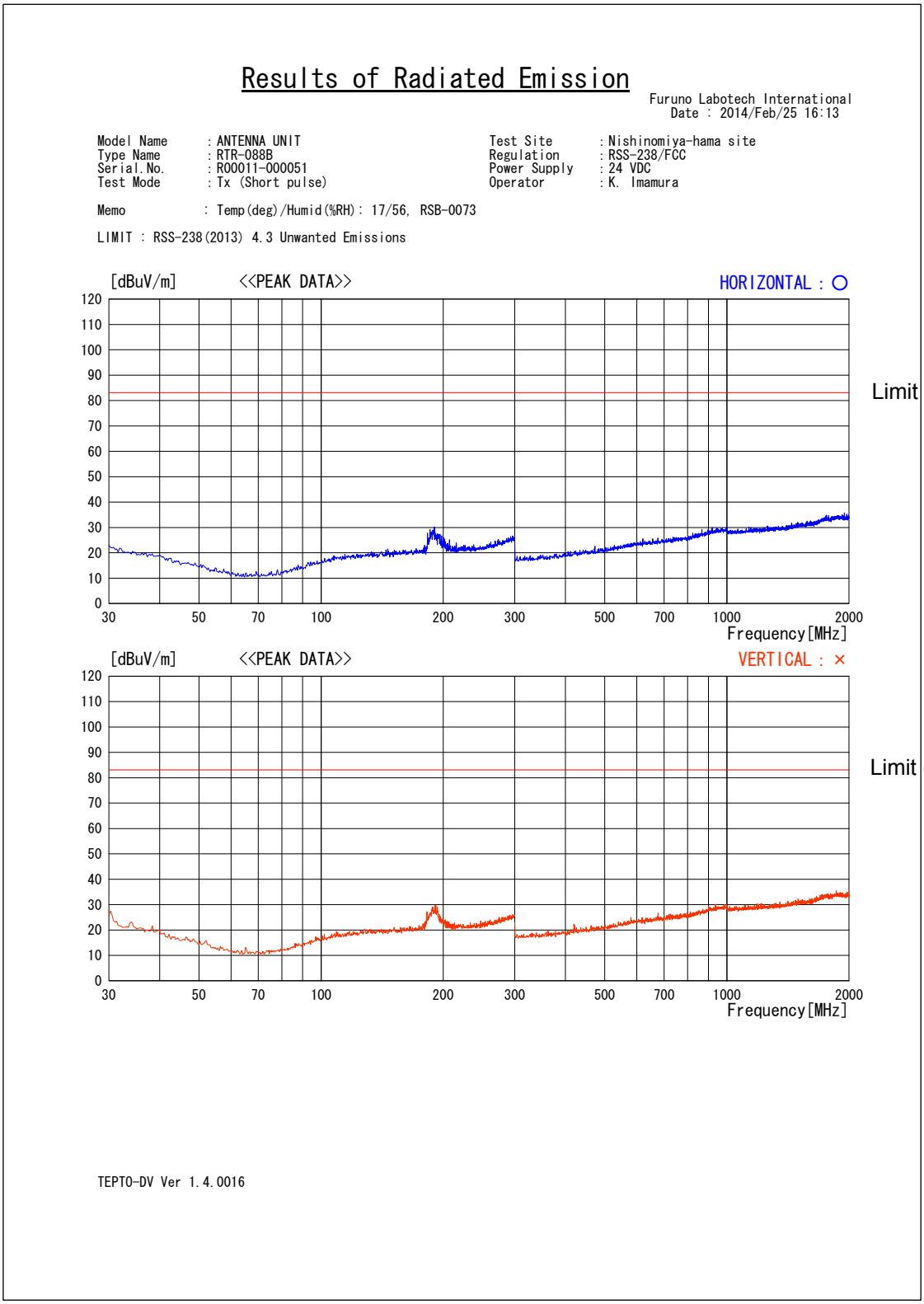
9.2 Spurious emissions (S pulse)

(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.

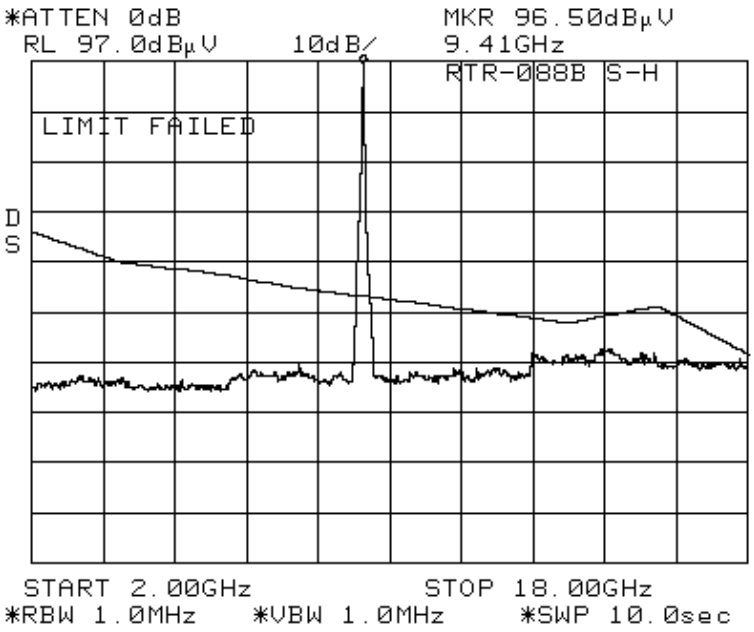
(2) for 30 MHz to 2000 MHz



(*) 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.

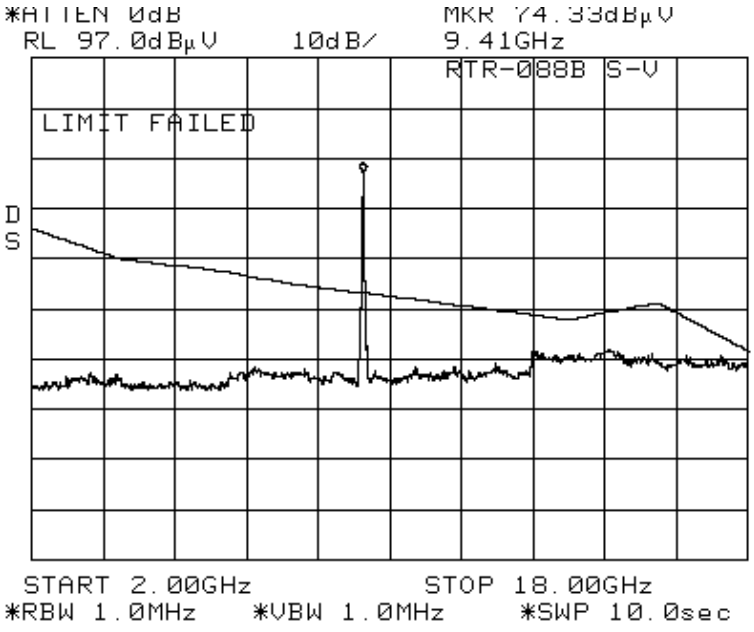
(3) for 2 GHz to 18 GHz (with Notch Filter used)

- for Horizontal



Limit (*)

- for Vertical



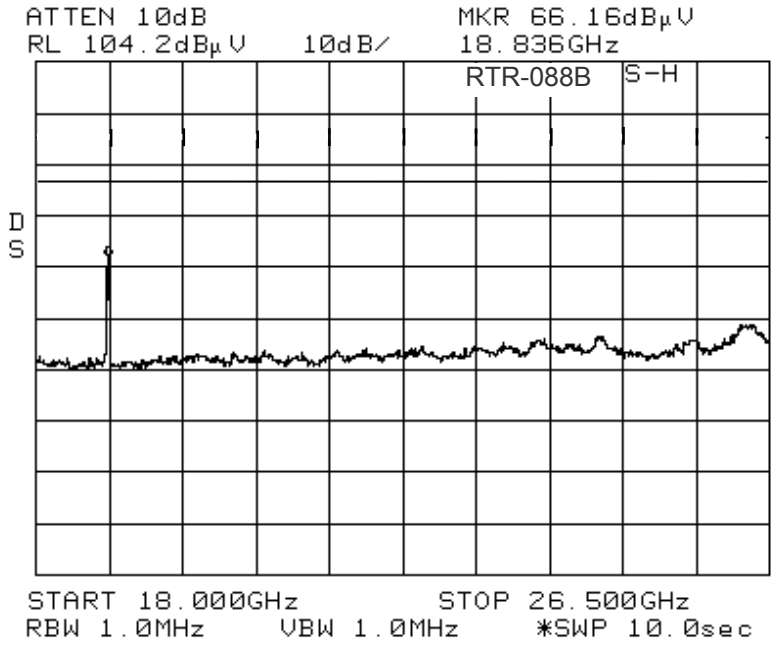
Limit (*)

The notch filer (Pass band: 9410 ± 150 MHz) 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.

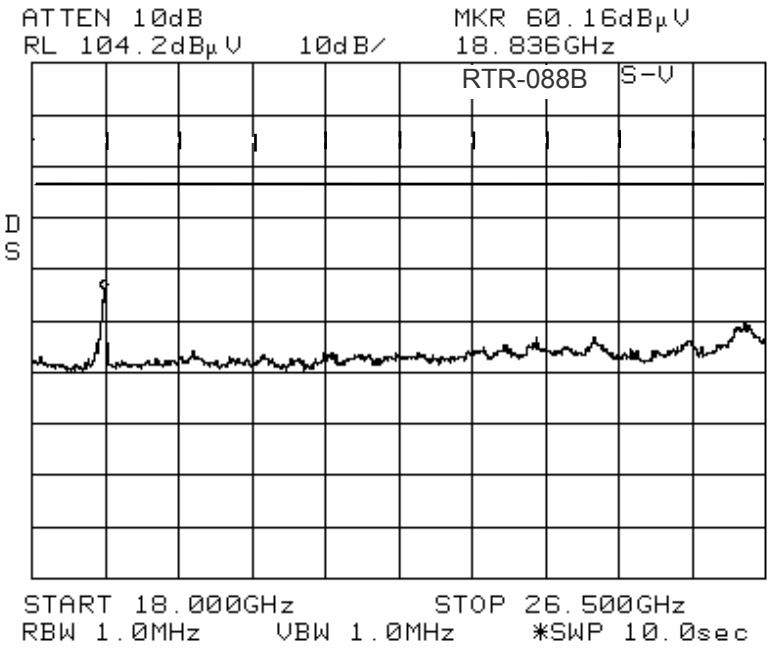
(4) for 18 GHz to 26.5 GHz

- for Horizontal



Limit (*)

- for Vertical



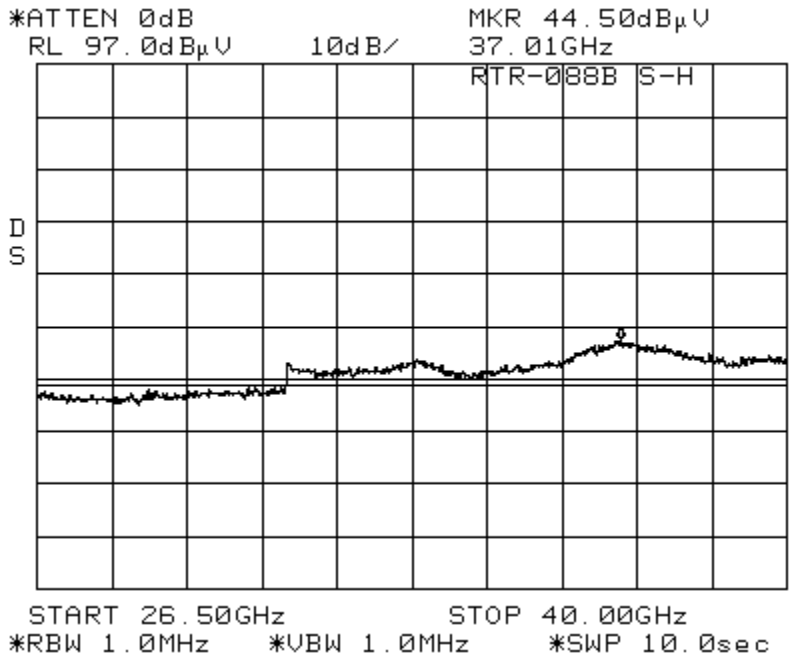
Limit (*)

(*) 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.

Minimum limit line for the frequency range of 18 GHz to 26.5 GHz is indicated in the above plots.

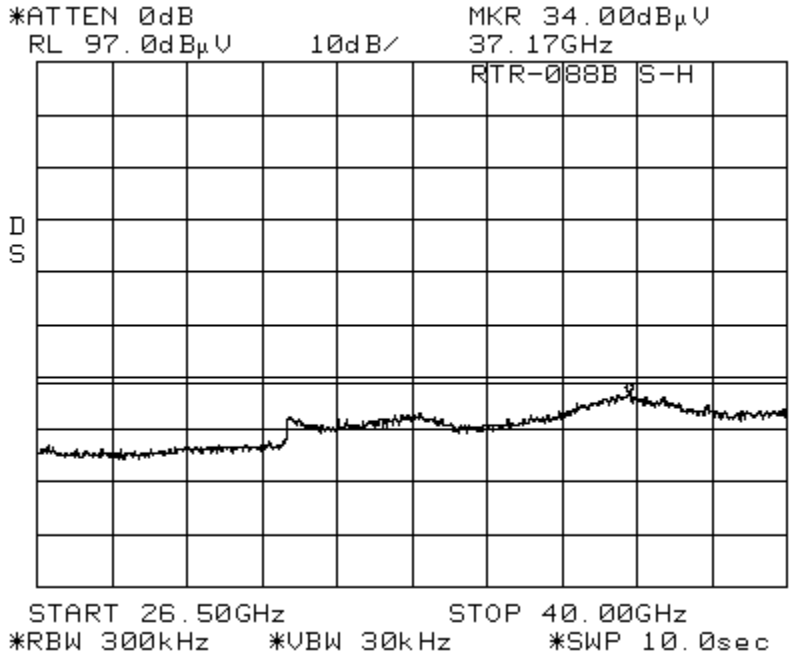
(5) for 26.5 GHz to 40 GHz

- for Horizontal



Limit (*)

The floor noise level (background noise) exceeded the limit with RBW and VBW settings of 1 MHz. So, with changed to 300 kHz of RBW and 30 kHz of VBW settings, the emission level was observed whether the spurious emission components occurred or not.

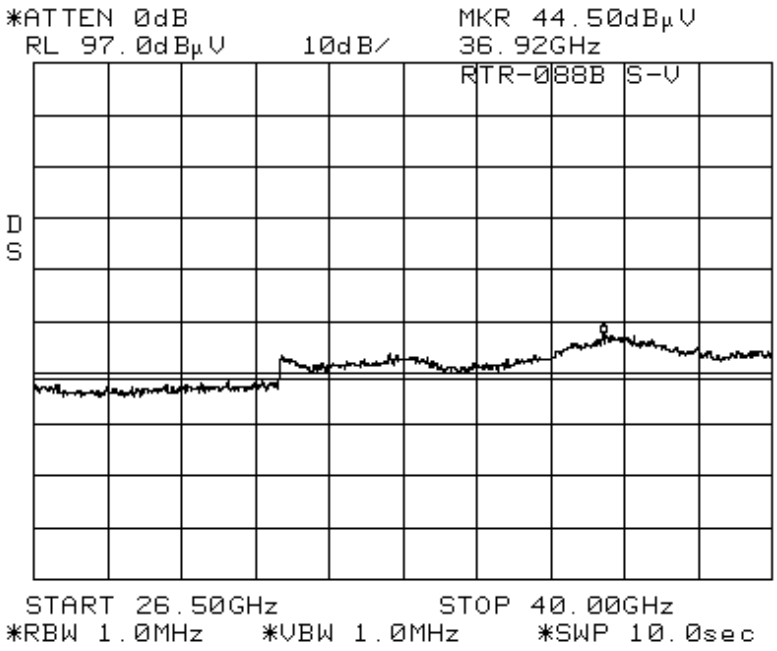


Limit (*)

(*) Emission limit was converted from the electric field strength into the voltage values with Antenna factor, Cable loss and Amp. gain added to the calculation.

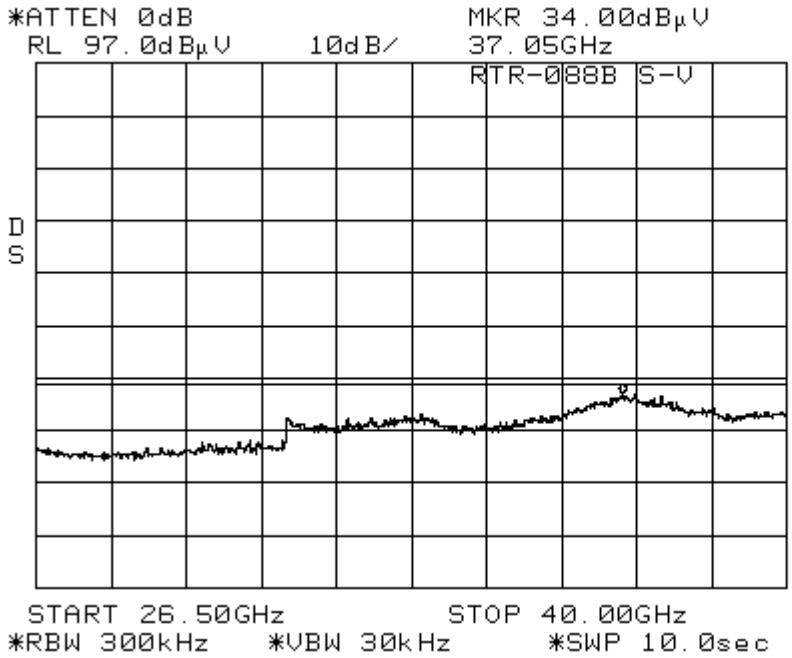
Minimum limit line for the frequency range of 26.5 GHz to 40 GHz is indicated in the above plots.

- for Vertical



Limit (*)

The floor noise level (background noise) exceeded the limit with RBW and VBW settings of 1 MHz. So, with changed to 300 kHz of RBW and 30 kHz of VBW settings, the emission level was observed whether the spurious emission components occurred or not.



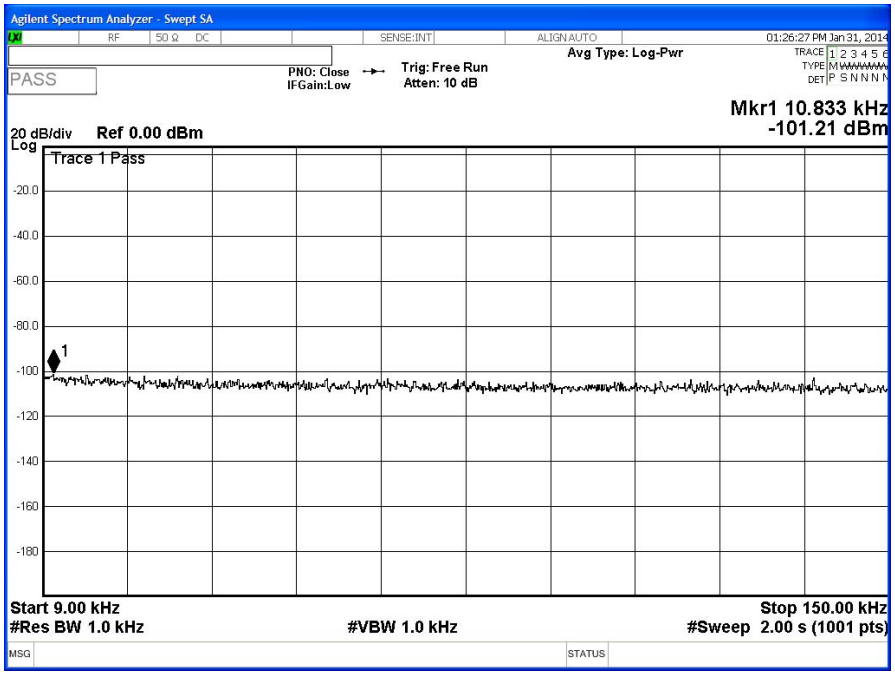
Limit (*)

(*) Emission limit was converted from the electric field strength into the voltage values with Antenna factor, Cable loss and Amp. gain added to the calculation.

Minimum limit line for the frequency range of 26.5 GHz to 40 GHz is indicated in the above plots.

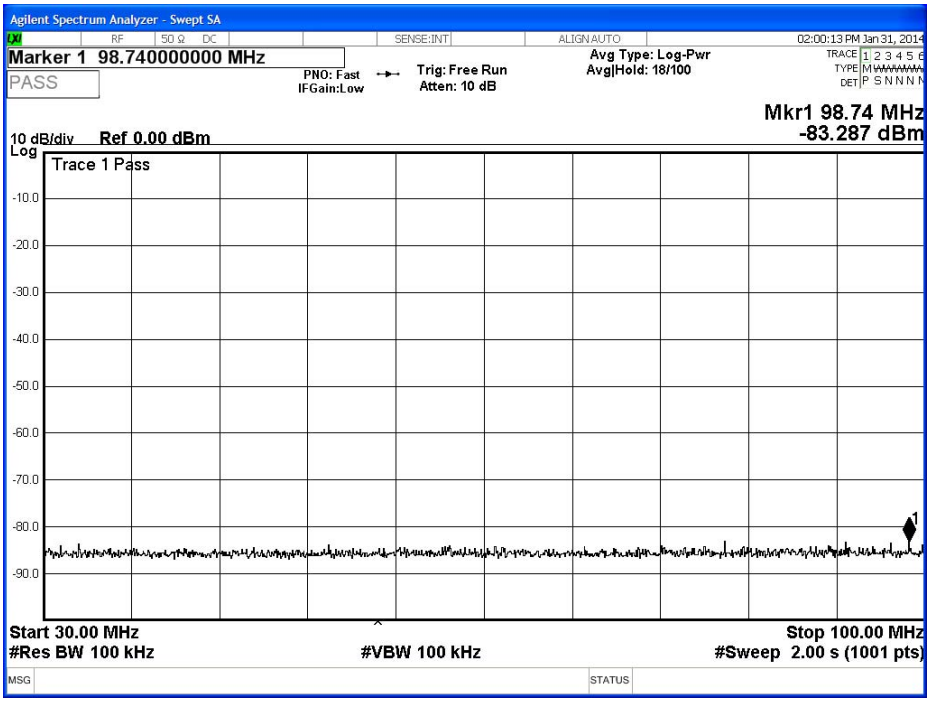
10 Field Strength Plots for Suppression of Interference Aboard Ships

(1) 9 kHz – 150 kHz: Limit = 400 µW (-4 dBm)

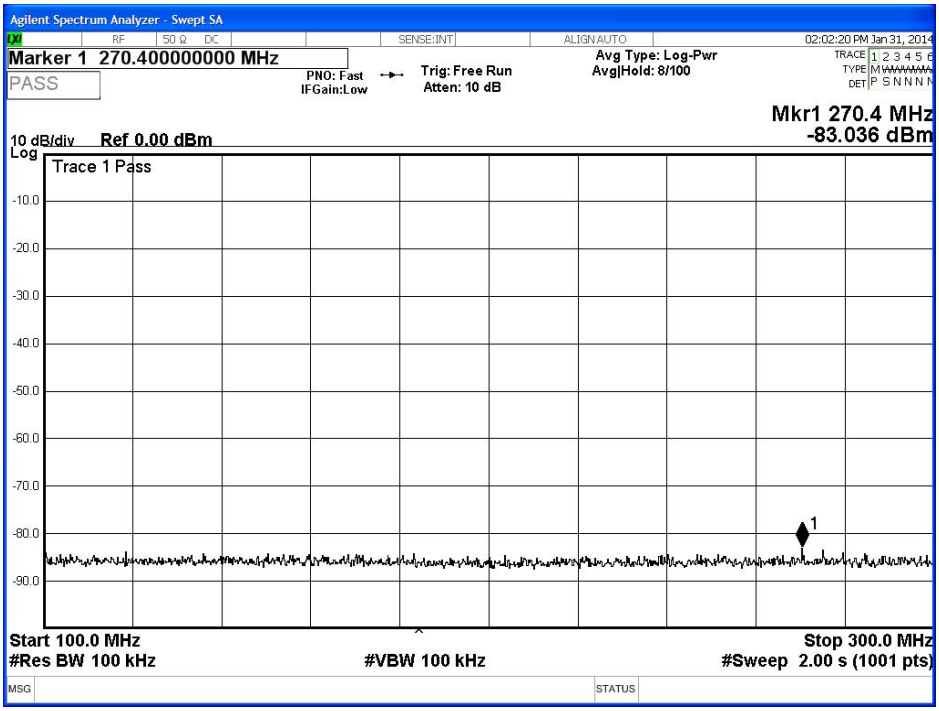


(2) 150 kHz – 30 MHz: Limit = 400 µW (-4 dBm)

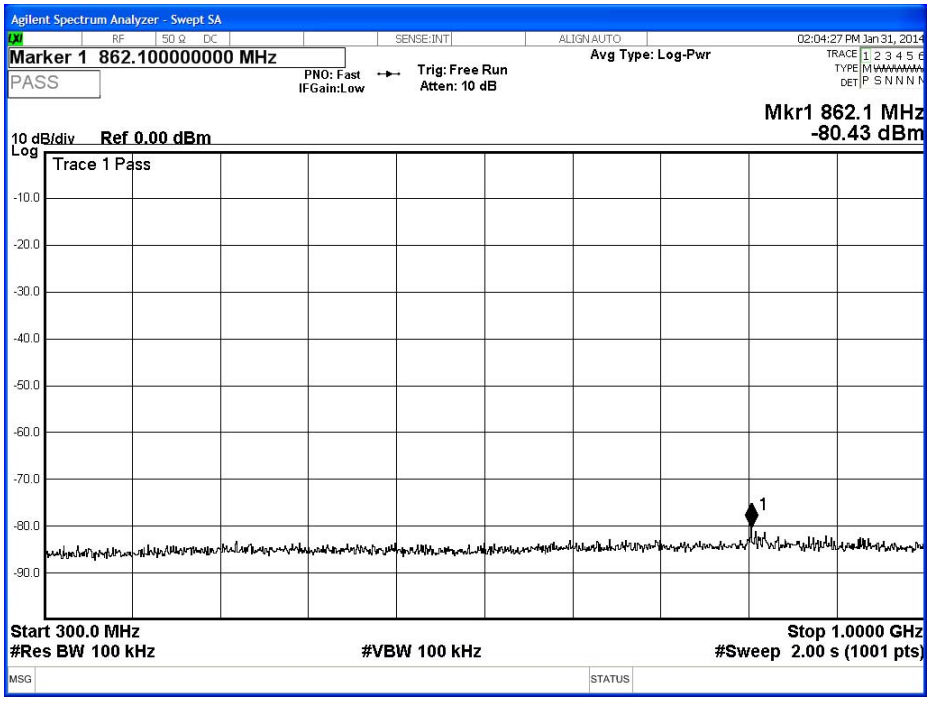
(3) 30 MHz – 100 MHz: Llimit = 4000 µW (+6 dBm)



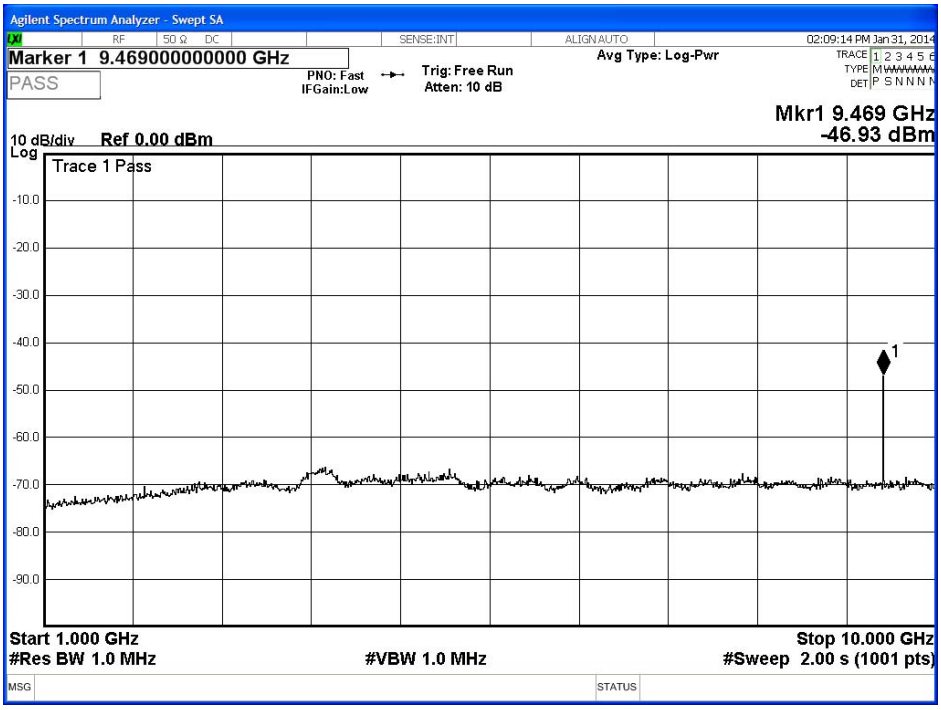
(4) 100 MHz – 300 MHz: Limit = 40000 µW (+16 dBm)



(5) 300 MHz – 1 GHz: Limit = 400000 µW (+26 dBm)



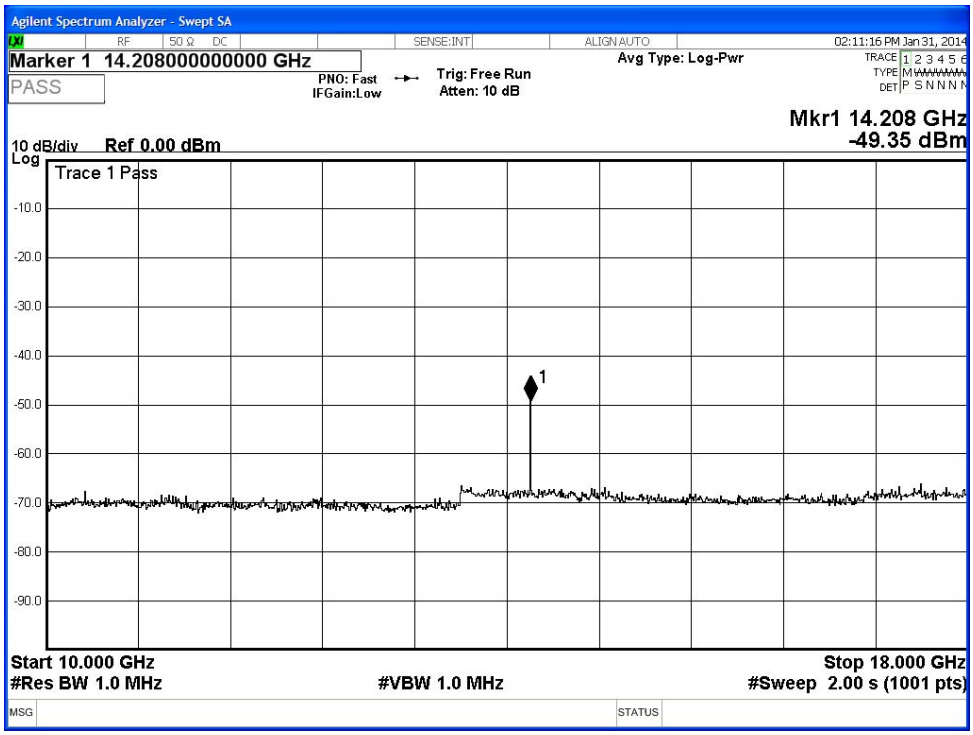
(6) 1 GHz – 10 GHz: Limit = 400000 µW (+26 dBm)



Spurious frequency: 9.469 GHz, Cable loss: 1.8 dB

Spurious strength = 10^((-46.93+1.8)/10) mW = 0.00003 mW = 0.03 µW

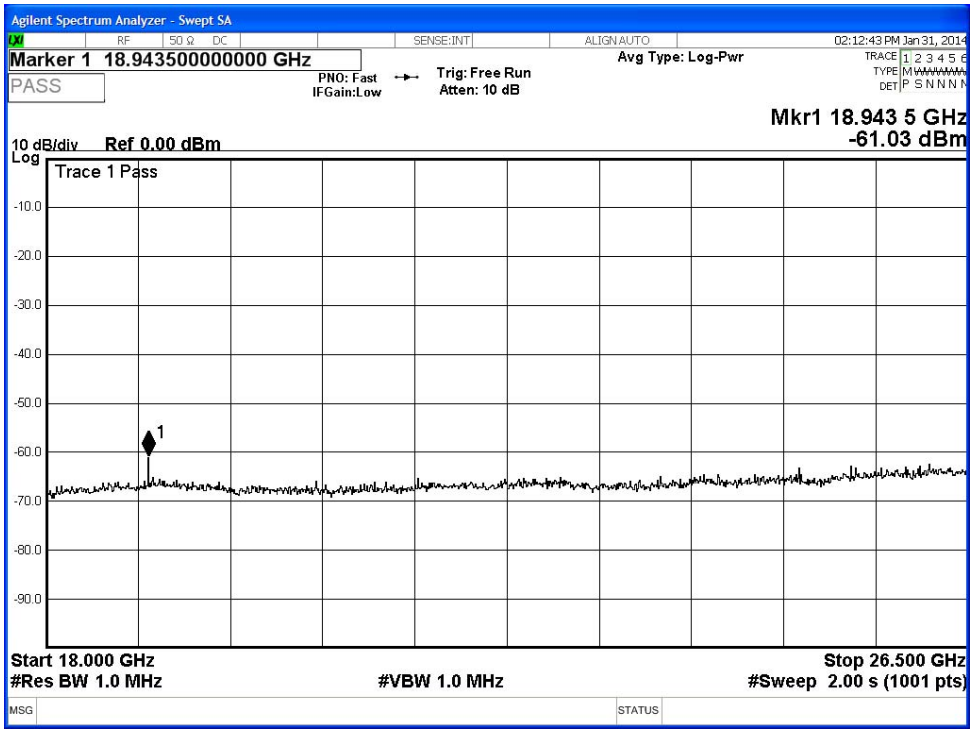
(7) 10 GHz – 18 GHz: Limit = 400000 μW (+26 dBm)



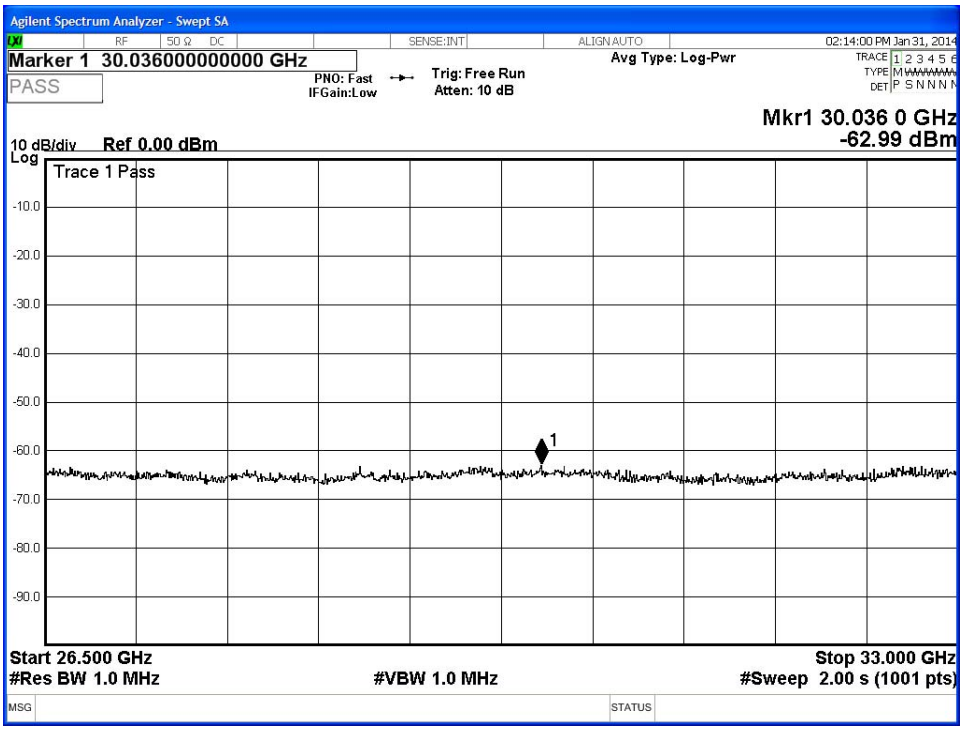
Spurious frequency: 9.469 GHz, Cable loss: 2.2 dB

Spurious strength = 10^((-49.35+2.2)/10) mW = 0.00002 mW = 0.02 μW

(8) 18 GHz – 26.5 GHz: Limit = 400000 μW (+26 dBm)



(9) 26.5 GHz – 33 GHz: Limit = 400000 µW (+26 dBm)



(10) 33 GHz – 40 GHz: Limit = 400000 µW (+26 dBm)