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 Radar Sensor DRS4DL
Type: RTR-104

Report no.: FLI 12-14-111
Rev.1

Date of Revised issue: 30 January 2015

Furuno Labotech International Co., Ltd.
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Report Summary

FLI project number:	FLI 04-14-0548			
Test report number of initial issue:	FLI 12-14-111		Date of initial issue	26 December 2014
Test report number of revised/replaced issue:	FLI 12-14-111, Rev.1		Date of revised/replaced issue	30 January 2015
Test report revision/ replacement history:	Rev. no. / Date / Page / Item / Description of change/reason			
	1 / 30 Jan. 2015 / 5 / 1.1.1General, (d) / Certification number was changed from "ADB9ZWRTR104" to "FCC ID: ADB9ZWRTR104".			
Test standard(s)/ Test specifications:	FCC Rules 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 2014)			
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 Radar Sensor DRS4DL			
Type:	RTR-104			
Product function and intended use:	For Maritime Safety Navigation			
Number of samples tested:	One			
Serial number:	1000-3200-0011			
Power rating:	12 - 24 VDC, 2.1 - 1.0 A			
Product status:	Pre-production model			
Modifications made to samples during testing:	None.			
Date of receipt of samples:	4 November 2014			
Test period:	From 4 November 2014 to 7 November 2014			
Place of test:	Furuno Labotech International Co., Ltd. - Nishinomiya-Hama Lab. 2-20, Nishinomiya-Hama, Nishinomiya-shi, Hyogo, 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			
Test results/ Compliance:	Passed. The test results of this report relate only to the samples tested.			
Tested by:	Koji Kawai			
Written by:	Akiko Inoue			
Verified by:	Yoshihiro Ishii			
Approved by:	Date: 30 January 2015 Name: Yoshihiro Ishii 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, 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: 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 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)
- 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, 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: Radar Sensor DRS4DL

	Type	Serial number	Note
Radar Sensor	DRS4DL	1000-3200-0011	
Scanner	RSB-127	---	Antenna rotation rate: 24 rpm
Transceiver	RTR-104	---	Contained in the Radome.
Antenna	03P9306-8N	---	Microstrip patch array antenna

(d) Certification number: FCC ID: ADB9ZWRTR104

(e) Primary Function: Search, Navigation and Anti-collision

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

Type of Emission: (Emission designator) P0N

(g) Size and mass: Radar Sensor: 488 mm (dia) X 220 mm (H), 5.7 kg

(h) Power Supply: 12 - 24 VDC, 2.1 - 1.0 A.

1.1.2 Transceiver

Type: RTR-104 (Contained in the Radome)

1.1.2.1 Transmitter

(a) Assignable Frequency for Shipborne Radar:

Between 9300 and 9500 MHz (for X-band radars) (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 nominal

Tolerances:

Manufacturing: ± 30 MHz

Pulling: ±1.5 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
PRR(Hz)	360	360	360

1.1.2.2 Modulator

(a) FET Type: FMC20N50E

Trigger Voltage: Approx. +20 VDC positive

1.1.2.3 Receiver

(a) Passband

RF Stage: 60 MHz

IF Stage:

Pulse type	S	M	L
Passband (MHz)	20	4.5	4.5

(b) Intermediate Frequency: 60 MHz

(c) Gain (overall): approximately 70 dB

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

(e) Video Output Voltage: 5V

(f) Features Provided: Sensitivity Time Controls (Anti-clutter Sea),
Fast Time Constant (Anti-clutter Rain)

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

(h) Frequency adjustable range: 9410 MHz (center) ± 30 MHz min.

1.1.3 Antenna and Scanner

(a) Antenna Rotation ON-OFF Switch: Not Provided.

(b) Construction: Microstrip patch array antenna (installed on the Scanner)

(c) Length:

Antenna type	03P9306
Length (cm)	41.5

(d) Type of Beam: Vertical fan

(e) Beam Width (3 dB):

Antenna type	03P9306
Horizontal (°)	5.7
Vertical (°)	25

(f) Polarization: Horizontal

(g) Antenna Gain:

Antenna type	03P9306
Gain (dBi)	21

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

Antenna type	03P9306
Within ±20° (dB)	-20
Outside ±20° (dB)	-25

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

(j) Antenna Rotation Rate: 24 rpm

(k) Sector Scan: Available. (Start: 0-359°, Angle: 135°)

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

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

1.1.4 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)

1.1.5 Construction Features

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

(b) Are fuse alarms provided: No

(c) State units that are weatherproof: Radar Sensor (IEC 60529 – IP26)

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

(e) Approximate space required for installation excluding scanner: Not applicable.

1.2 Observation and comments

None.

1.3 Modification made to the EUT

No modifications were made to the EUT during testing.

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. Kawai
3.2	2.1047	Modulation Characteristics	Passed.	K. Kawai
3.3	2.1049	Occupied Bandwidth	Passed.	K. Kawai
3.4	2.1055	Frequency Stability	Passed.	K. Kawai
3.5		Spurious Emissions	---	
3.5.1	2.1051	- Spurious Emissions at Antenna Terminal	Passed.	K. Kawai
3.5.2	2.1053	- Field Strength of Spurious Radiation	Passed.	K. Kawai
3.6	80.217	Suppression of Interference Aboard Ships	Passed.	K. Kawai

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)	0.101	0.324	0.782
Magnetron Output, peak P_p (kW) (*1)	3.17	2.96	2.88
Pulselength T (µs) (-3 dB points) (*2)	0.089	0.304	0.754
PRR (Hz)	360	360	360

(*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 4 November 2014, 24°C to 24°C, 53% to 53%RH
Power supply voltage measured: 24.0 VDC to 24.0 VDC.

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 (for X-band radars)
Authorized bandwidth (f(AUBW)): 110 MHz (for X-band radars)

(4) Test Results:

Complied.

Pulse type	S	M	L	Result
Pulselength T (µs) (-3 dB points) (*1)	0.089	0.304	0.754	Not applicable
Rise time t_r (µs) (10 - 90 % amplitude)	0.026	0.024	0.025	Not applicable
Decay time t_f (µs) (90 - 10 % amplitude)	0.084	0.079	0.089	Not applicable
PRR (Hz)	360	360	360	Not applicable
Guard Band f(1.5/T) (MHz) (*2)	16.9	4.9	2.0	Not applicable
f(U) (MHz)	9448.1	9460.1	9463.0	Not applicable
f(L) (MHz)	9371.9	9359.9	9357.0	Not applicable
Frequency at maximum emission (MHz)	9409.3	9408.0	9407.8	Complied

(*1): Measured at -3 dB points of the RF envelope of the magnetron output pulse instead of at 50% points of the voltage/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 4 November 2014, 24°C to 24°C, 53% to 53%RH
Power supply voltage measured: 24.0 VDC to 24.0 VDC.

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)	55.9	32.1	11.0

Environmental conditions observed: On 4 November 2014, 24°C to 24°C, 53% to 53%RH
Power supply voltage measured: 24.0 VDC to 24.0 VDC.

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 /100/115 % of nominal voltage (10.2/12.0/24.0/27.6 VDC)

(2) Test setup:

See Clause 4.

(3) Frequency Tolerance Limits (FCC Rule 47 CFR, 80.209(b)):

Pulse type	S	M	L
f(U) (MHz)	9448.1	9460.1	9463.0
f(L) (MHz)	9371.9	9359.9	9357.0

See Clause 3.2 for details.

(4) Test Results:

Complied.

Power Supply Voltage setting: 10.2 VDC

Pulse type		S	M	L	Result
Frequency at maximum emission (MHz)	-30°C	9417.5	9415.2	9414.8	Complied.
	-20°C	9416.0	9413.6	9412.8	Complied.
	-10°C	9413.5	9412.3	9411.7	Complied.
	0°C	9412.3	9411.5	9411.4	Complied.
	+10°C	9411.7	9410.8	9410.5	Complied.
	+20°C	9409.3	9408.4	9408.2	Complied.
	+30°C	9407.0	9406.5	9406.6	Complied.
	+40°C	9405.0	9404.7	9405.0	Complied.
	+50°C	9404.2	9403.5	9403.8	Complied.

Power Supply Voltage setting: 12.0 VDC

Pulse type		S	M	L	Result
Frequency at maximum emission (MHz)	-30°C	9416.8	9415.2	9414.6	Complied.
	-20°C	9416.2	9413.5	9412.7	Complied.
	-10°C	9413.5	9412.0	9411.8	Complied.
	0°C	9412.6	9411.4	9411.2	Complied.
	+10°C	9411.3	9410.6	9410.4	Complied.
	+20°C	9409.5	9408.7	9408.0	Complied.
	+30°C	9407.4	9406.5	9406.6	Complied.
	+40°C	9405.2	9404.7	9404.9	Complied.
	+50°C	9403.7	9403.6	9403.7	Complied.

Power Supply Voltage setting: 24.0 VDC

Pulse type		S	M	L	Result
Frequency at maximum emission (MHz)	-30°C	9416.7	9414.8	9414.4	Complied.
	-20°C	9416.2	9413.2	9412.2	Complied.
	-10°C	9413.9	9411.8	9411.5	Complied.
	0°C	9413.1	9411.4	9411.0	Complied.
	+10°C	9411.5	9410.2	9410.1	Complied.
	+20°C	9409.3	9408.0	9407.8	Complied.
	+30°C	9407.3	9406.3	9406.4	Complied.
	+40°C	9405.5	9404.7	9404.6	Complied.
	+50°C	9404.8	9403.5	9403.2	Complied.

Power Supply Voltage setting: 27.6 VDC

Pulse type		S	M	L	Result
Frequency at maximum emission (MHz)	-30°C	9417.3	9414.9	9414.1	Complied.
	-20°C	9416.8	9413.3	9412.1	Complied.
	-10°C	9413.4	9412.0	9411.2	Complied
	0°C	9412.7	9411.6	9410.9	Complied.
	+10°C	9411.3	9410.9	9409.9	Complied.
	+20°C	9409.7	9408.5	9407.7	Complied.
	+30°C	9406.7	9406.8	9406.4	Complied.
	+40°C	9405.2	9404.8	9404.7	Complied.
	+50°C	9404.0	9403.5	9403.4	Complied.

Environmental conditions observed: On 5 November 2014, 22°C to 22°C, 54% to 54%RH
On 6 November 2014, 24°C to 25°C, 60% to 61%RH
Power supply voltage measured: 24.0 VDC to 24.0 VDC.

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 X-band radars)
(*) - 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 4 November 2014, 24°C to 24°C, 53% to 53%RH
Power supply voltage measured: 24.0 VDC to 24.0 VDC.

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

(1) Test Conditions:

For all TX (S/M/L) Pulses, the Radiated Emission test was 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 rotating mode.

(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 × 3.6 m × 0.3 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) 2.0 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) 2.0 m for the test frequency range of 2 GHz to 40 GHz.

See Clauses 4 and 6.

(5) Field Strength 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) Assigned frequency (center frequency) = 9410 MHz (for X-band radars)
(2) Authorized bandwidth = 110 MHz (for X-band radars)
(*) - 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 $\log_{10}$ (0.101)
= 33.0 dB
where, [mean power in watts] = 0.101 W for S pulse. See 3.1.

For this time, Limit of 60 dB was applied for the test.

From the results of the pre-tests, the spurious emission level was found to be the maximum with S pulse. Consequently, the final test was performed only with S.
The electric field strength of the maximum power radiation was 162.4 dBμV/m with S pulse.
Consequently, the allowable emission limit was set to 102.4 dBμV/m (= 162.4 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)
18.822	Horizontal	S	83.7	102.4	18.7
18.808	Vertical	S	82.6	102.4	19.8

Environmental conditions observed: On 7 November 2014, 20°C to 20°C, 60% to 60%RH
Power supply voltage measured: 24.0 VDC to 24.0 VDC.

3.6 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 (Receive) mode.

(2) Test frequency range: 9 kHz to 40 GHz

(3) Spurious Emission Limits for Receivers:

for delivered power to artificial antenna,

Frequency	Power to artificial antenna (µW)	Resolution bandwidth of Spectrum analyzer
9 kHz - 150 kHz	400	1 kHz
150 kHz - 30 MHz		10 kHz
30 MHz - 100 MHz	4,000	100 kHz
100 MHz - 300 MHz	40,000	
300 MHz - 1 GHz	400,000	
1 GHz - 40 GHz		1 MHz

(4) Test Results:

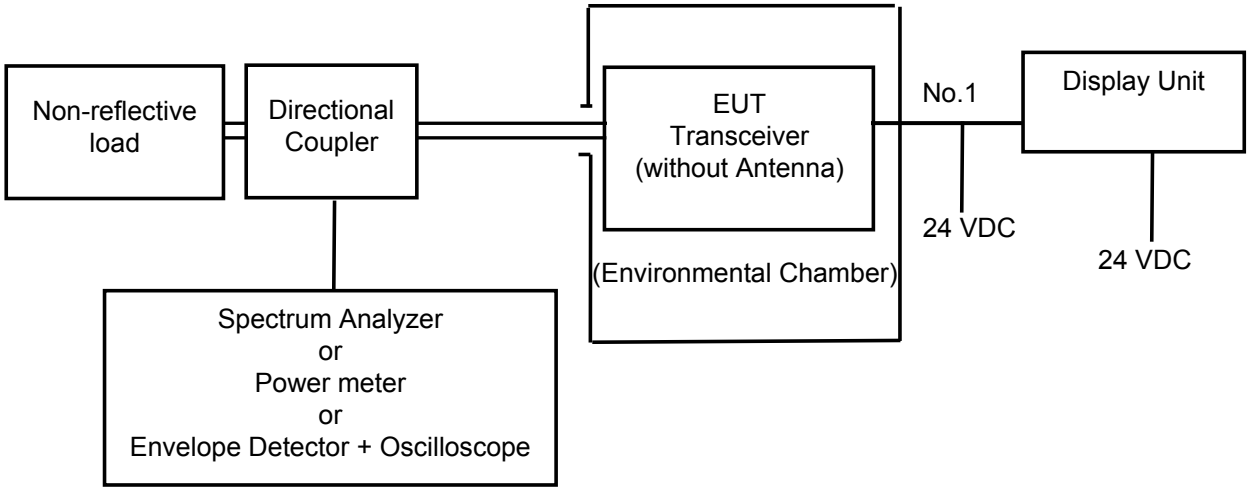
Complied.

Spectrum plots: See Clause 10.

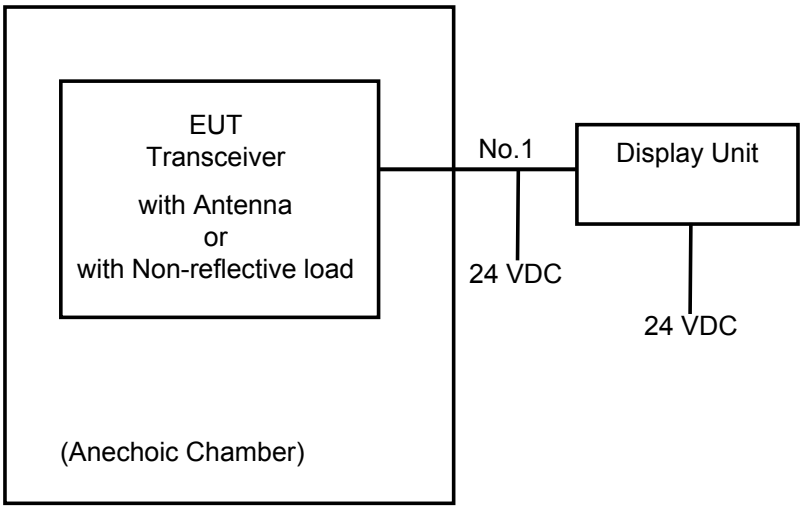
Environmental conditions observed: On 5 November 2014, 22°C to 22°C, 54% to 54%RH
Power supply voltage measured: 24.0 VDC to 24.0 VDC.

4 Test Setup for Measurements

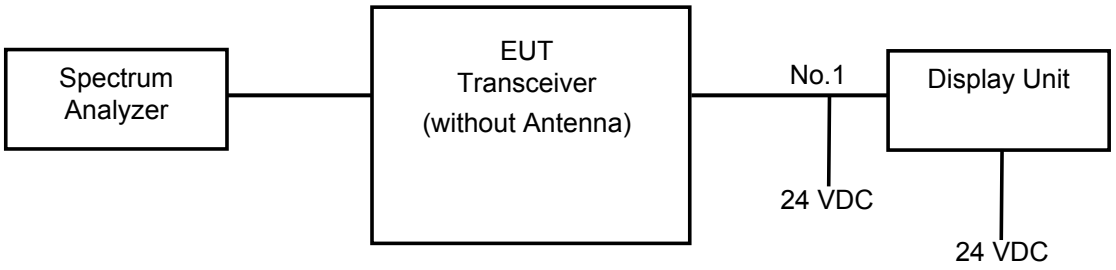
(1) Test Setup for Clauses 3.1, 3.2, 3.3, 3.4, and 3.5.1.



(2) Test Setup for Clause 3.5.2.



(3) Test Setup for Clause 3.6.



Cable designations

No.	Name	Length (m)
1	Power/Signal cable	20

5 Measuring Equipment List

(1) For 3.1 RF Power Output:

C/N	Instrument	Type	S/N	Manufacturer	Date of last calibration	Calibration interval
HT552	Power meter	E4418B	E4418B	AGILENT	17 October 2014	1 year
HT926	Power Sensor	E9304A-H18	MY53100039	AGILENT	22 July 2014	1 year
120121202	Directional Coupler (X-band)	5D364S	R05762	Shimada	10 April 2014	1 year
120121202	Dummy Load (X-band)	4D376	R4535004	Shimada	10 April 2014	1 year
HT431	DC Power Supply	PAN55-20	AK003303	KIKUSUI	---	---

(2) For 3.2 Modulation Characteristics:

C/N	Instrument	Type	S/N	Manufacturer	Date of last calibration	Calibration interval
120121202	Directional Coupler (X-band)	5D364S	R05762	Shimada	10 April 2014	1 year
120121202	Dummy Load (X-band)	4D376	R4535004	Shimada	10 April 2014	1 year
HT654	Step Attenuator	8494B	MY42148134	Agilent	31 March 2014	1 year
HT655	Step Attenuator	8495B	MY42144403	Agilent	31 March 2014	1 year
HT913	Crystal Detector	423B	MY51340543	Agilent	27 February 2014	1 year
HT676	Spectrum Analyzer	8564EC	4103A00440	Agilent	11 April 2014	1 year
HT553	Frequency Counter	53150A	US40501919	AGILENT	17 October 3014	1 year
HT972	Oscilloscope	MSO4054B	C030483	Tektronix	6 May 2014	1 year
HT431	DC Power Supply	PAN55-20	AK003303	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	Calibration interval
120121202	Directional Coupler (X-band)	5D364S	R05762	Shimada	10 April 2014	1 year
120121202	Dummy Load (X-band)	4D376	R4535004	Shimada	10 April 2014	1 year
HT654	Step Attenuator	8494B	MY42148134	Agilent	31 March 2014	1 year
HT655	Step Attenuator	8495B	MY42144403	Agilent	31 March 2014	1 year
HT676	Spectrum Analyzer	8564EC	4103A00440	Agilent	11 April 2014	1 year
HT972	Oscilloscope	MSO4054B	C030483	Tektronix	6 May 2014	1 year
HT431	DC Power Supply	PAN55-20	AK003303	KIKUSUI	---	---

(4) For 3.4 Frequency Stability:

C/N	Instrument	Type	S/N	Manufacturer	Date of last calibration	Calibration interval
HT510	Climatic Chamber (Large)	TBE-3HW4PE2F	3013002540	Espec	9 September 2014	1 year
HT725	Paperless recorder/Dual communication logger DAQSTATIOM FX100	FX106-4-1	S5JA01447	Yokogawa	9 September 2014	1 year
120121202	Directional Coupler (X-band)	5D364S	R05762	Shimada	10 April 2014	1 year
120121202	Dummy Load (X-band)	4D376	R4535004	Shimada	10 April 2014	1 year
----	Waveguide (for X-band)	WRJ-10 (l = 60 cm)	----	Furuno	---	---
HT676	Spectrum Analyzer	8564EC	4103A00440	Agilent	11 April 2014	1 year
HT654	Step Attenuator	8494B	MY42148134	Agilent	31 March 2014	1 year
HT655	Step Attenuator	8495B	MY42144403	Agilent	31 March 2014	1 year
HT431	DC Power Supply	PAN55-20	AK003303	KIKUSUI	---	---

(5) For 3.5.2 Field Strength of Spurious Radiation:

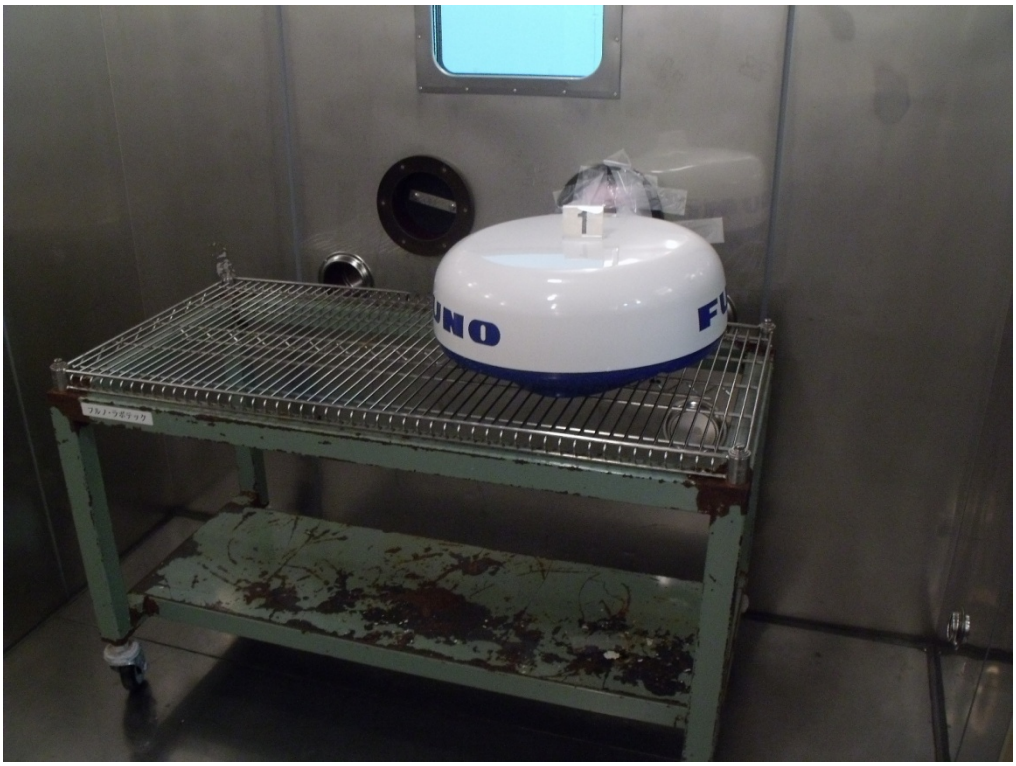
C/N	Instrument	Type	S/N	Manufacturer	Date of last calibration	Calibration interval
HT676	Spectrum Analyzer	8564EC	4103A00440	Agilent	11 April 2014	1 year
HT459	Biconical antenna (30 MHz to 300 MHz)	VBA6106A	1296	Schaffner	13 August 2014	1 year
HT331	Log periodic antenna (300 MHz to 1000 MHz)	UHALP9107	8411059	Schwarzbeck	13 August 2014	1 year
HT467	Double-ridged waveguide horn antenna (1 GHz to 18 GHz)	3115	6520	EMCO	12 August 2014	1 year
HT761	Double rigged horn antenna & amp.	HAP18-26N	00000017	TOYO	28 December 2013	1 year
HT762	Double rigged horn antenna & amp.	HAP26-40N	00000010	TOYO	28 December 2013	1 year
HT518	Pre-amplifier (30 MHz to 2 GHz)	87405A	3207A01643	Agilent	23 June 2014	1 year
HT365	Semi-anechoic Chamber	3mSAC	D-002	Riken	---	---
HT446	Programmable AC power supply	4420/4471	306043	NF	---	---
30-0021	Notch Filter (X-band)	CBR-X7-3A	R986500	Shimada	17 September 2014	1 year
---	Dummy Load (X-band)	---	---	---	---	---
KB137	Coaxial cable	MWX221-2m	0804S167	JUNKOSHA	19 September 2014	1 year
KB138	Coaxial cable	MWX221-5m	0804S166	JUNKOSHA	19 September 2014	1 year
KB179	Coaxial Cable for Radiated Emission Measurement	SUCOFLEX 104A	48932/4A	HUBER+SUHNER	9 August 2014	1 year
KB180	Coaxial Cable for Radiated Emission Measurement	SUCOFLEX 104A	48933/4A	HUBER+SUHNER	9 August 2014	1 year
KB181	Coaxial Cable for Radiated Emission Measurement	SUCOFLEX 102A	1261/2A	HUBER+SUHNER	9 August 2014	1 year

(6) For 3.6 Suppression of Interference Aboard Ships:

C/N	Instrument	Type	S/N	Manufacturer	Date of last calibration	Calibration interval
HT676	Spectrum Analyzer	8564EC	4103A00440	Agilent	11 April 2014	1 year
HT431	DC Power Supply	PAN55-20	AK003303	KIKUSUI	---	---

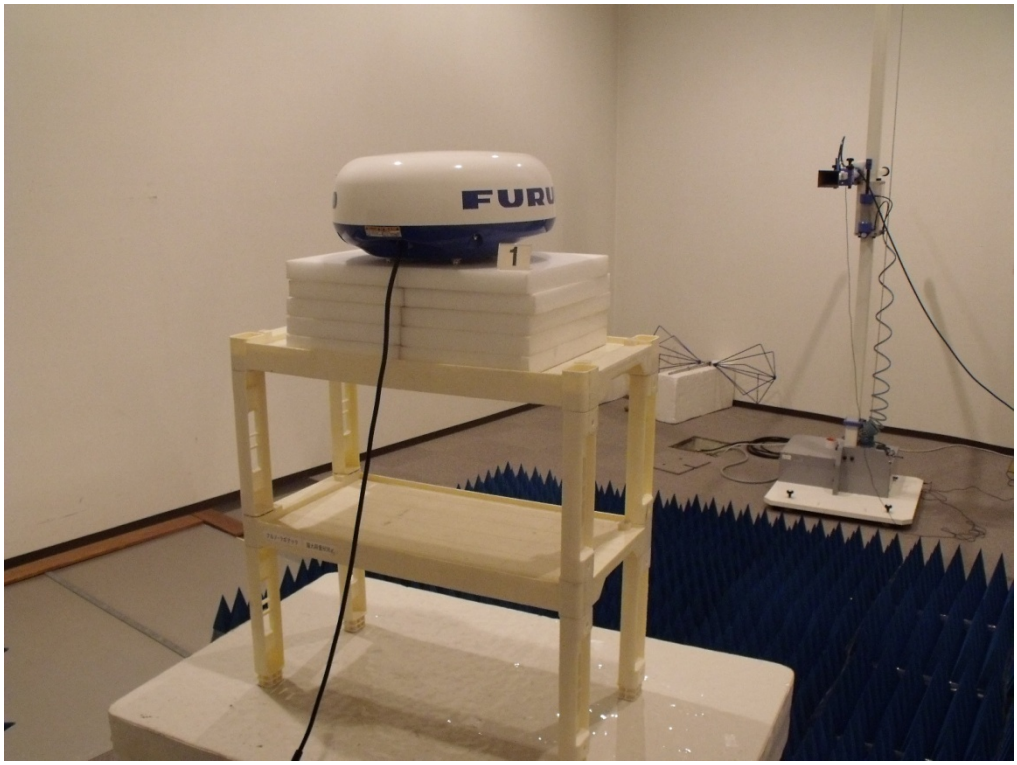
6 Photograph of Test Setup/Arrangement

(1) For Temperature (TX frequency stability) tests,



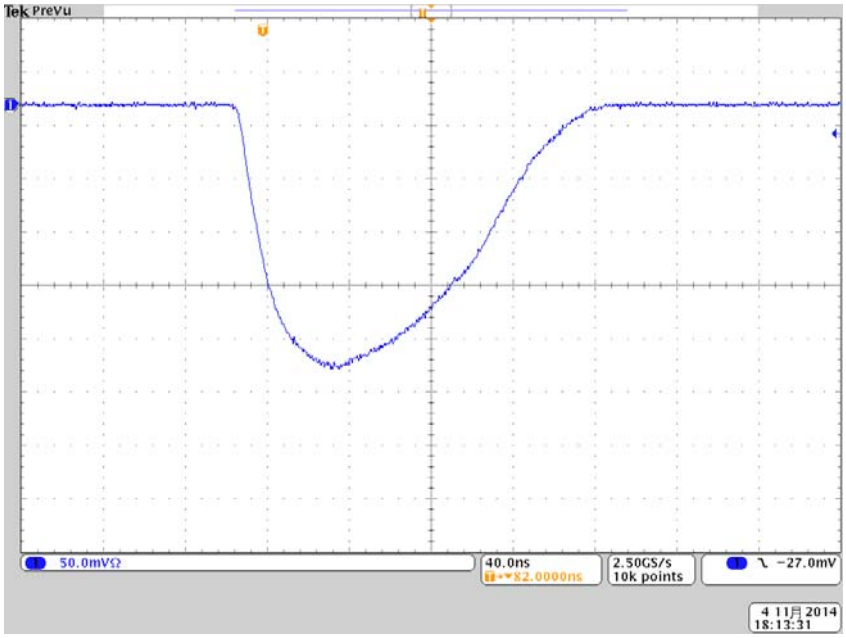
(2) For Spurious Emission measurements,

for 9 kHz to 2000 MHz



for 2 GHz to 40 GHz

7 RF Envelope and Spectrum of the output pulse



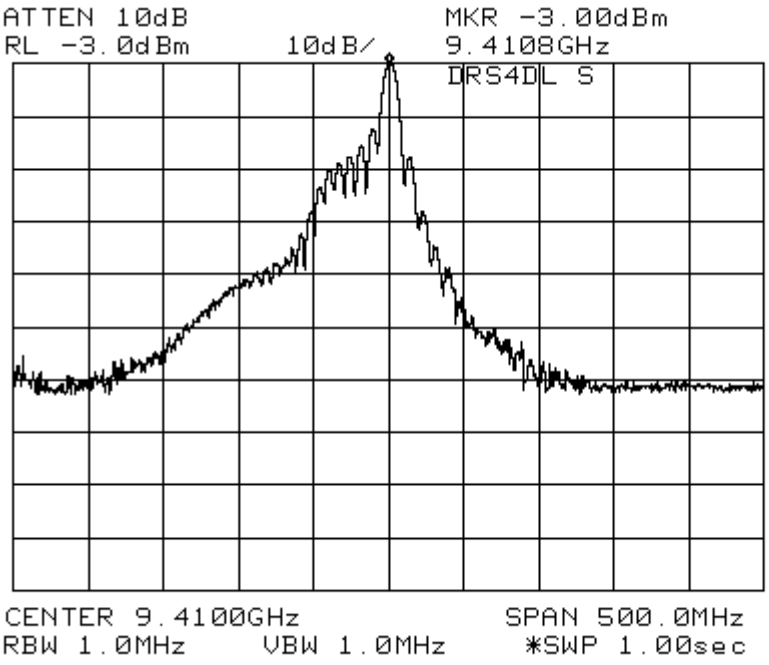
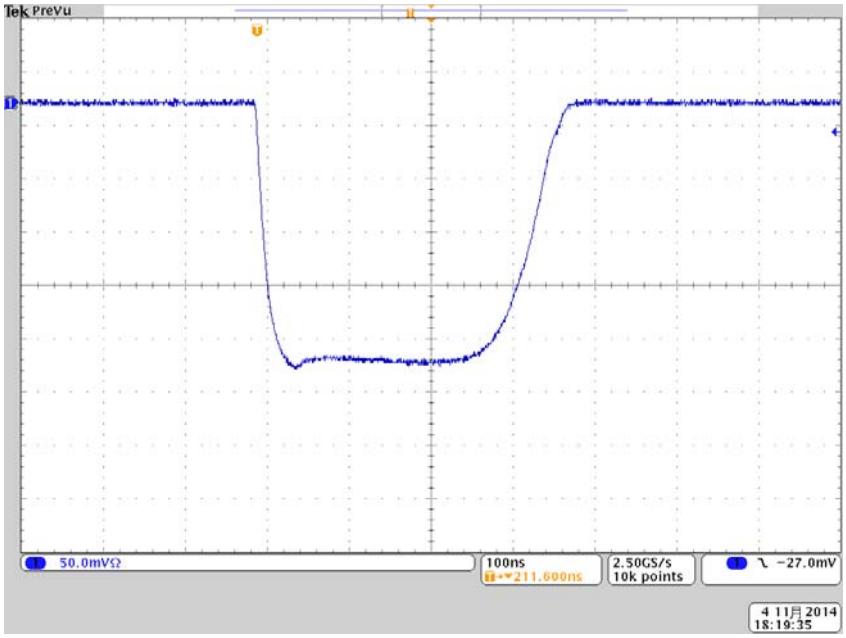


Fig. 7.1 S Pulse Envelope and Spectrum



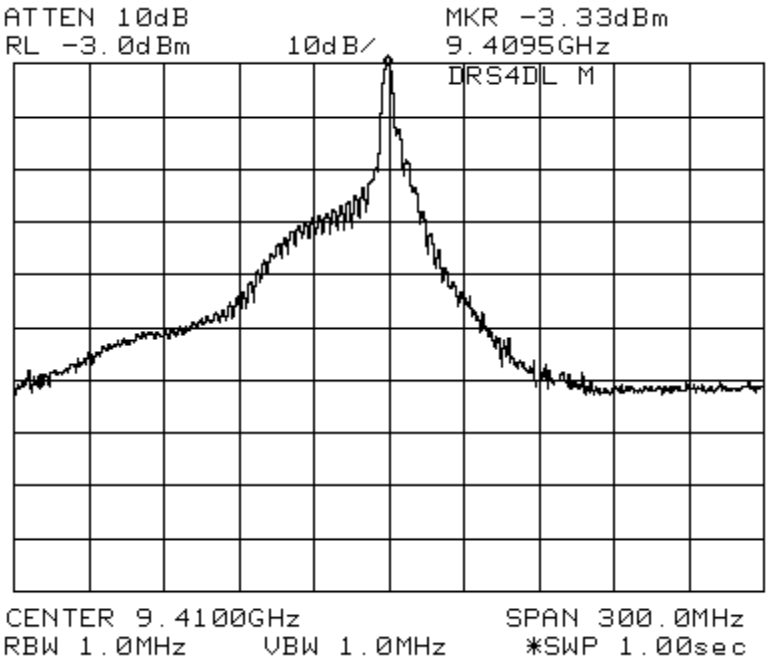
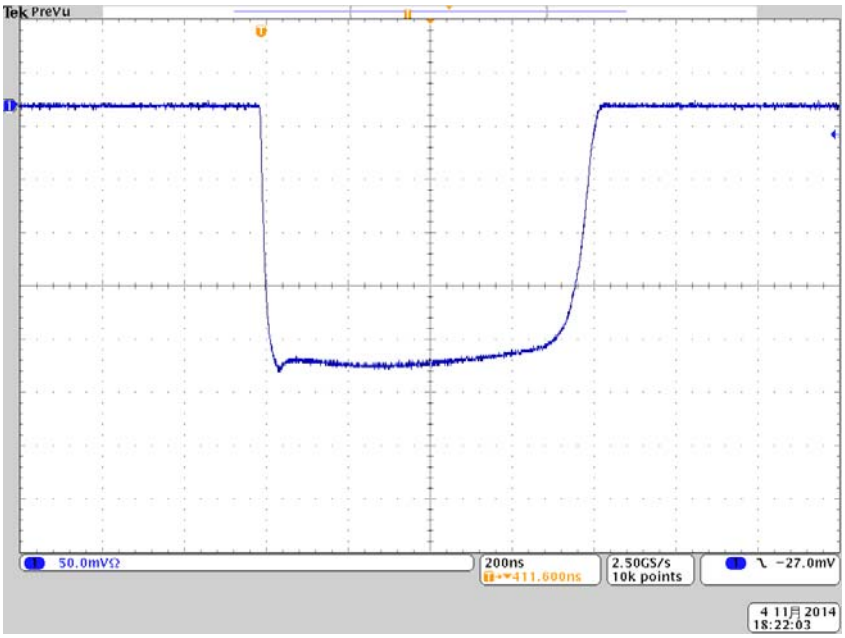


Fig. 7.2 M Pulse Envelope and Spectrum



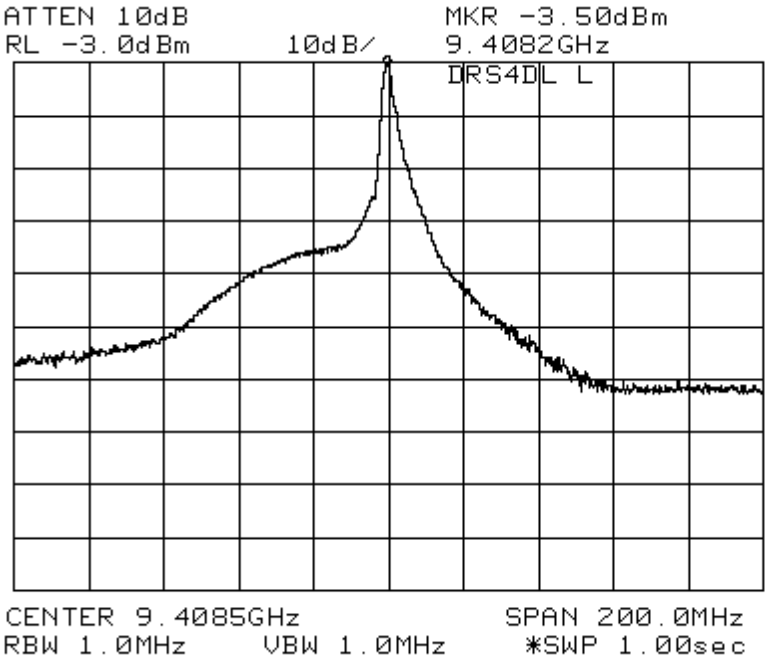
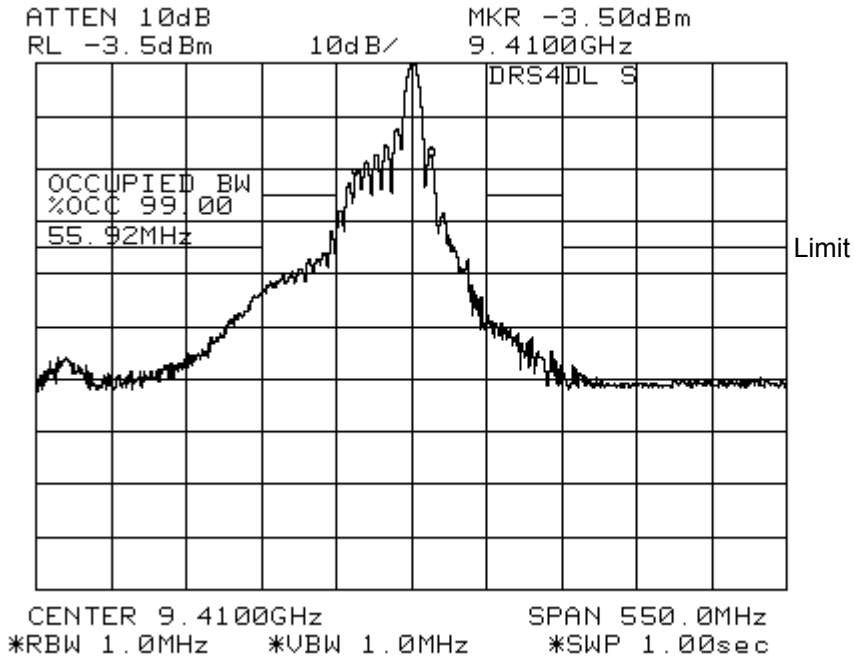


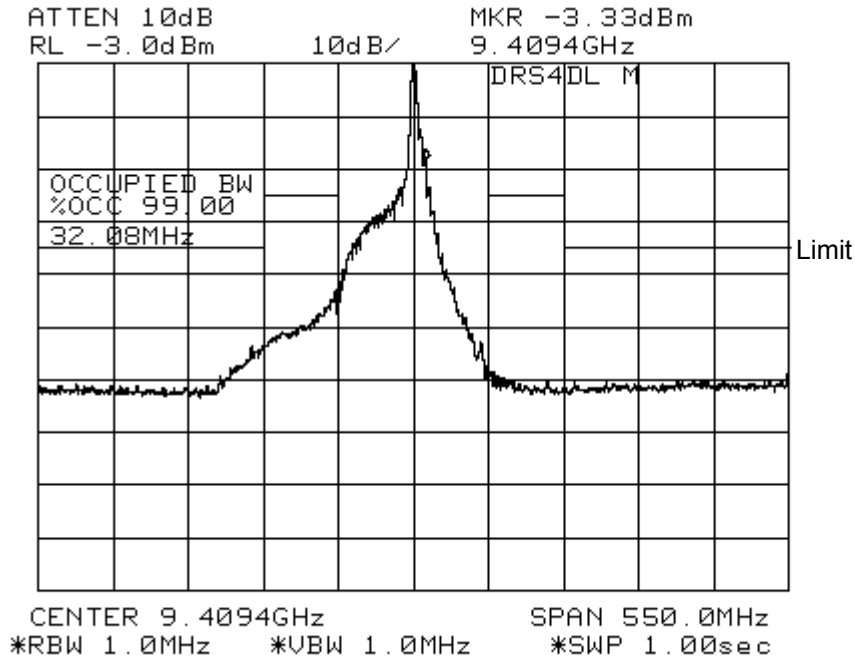
Fig. 7.3 L Pulse Envelope and Spectrum

8 Spurious Emission Plots measured at Antenna Terminal

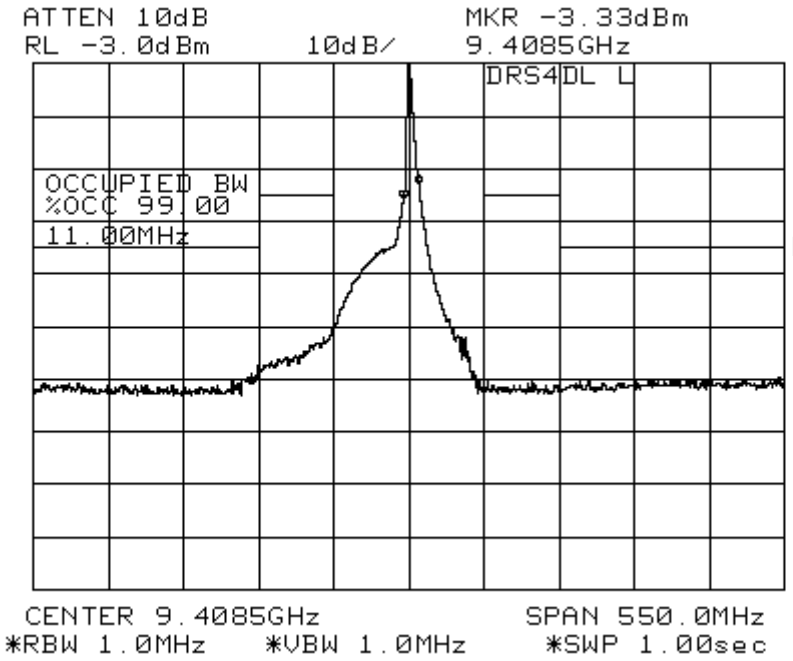
for S pulse



for M pulse



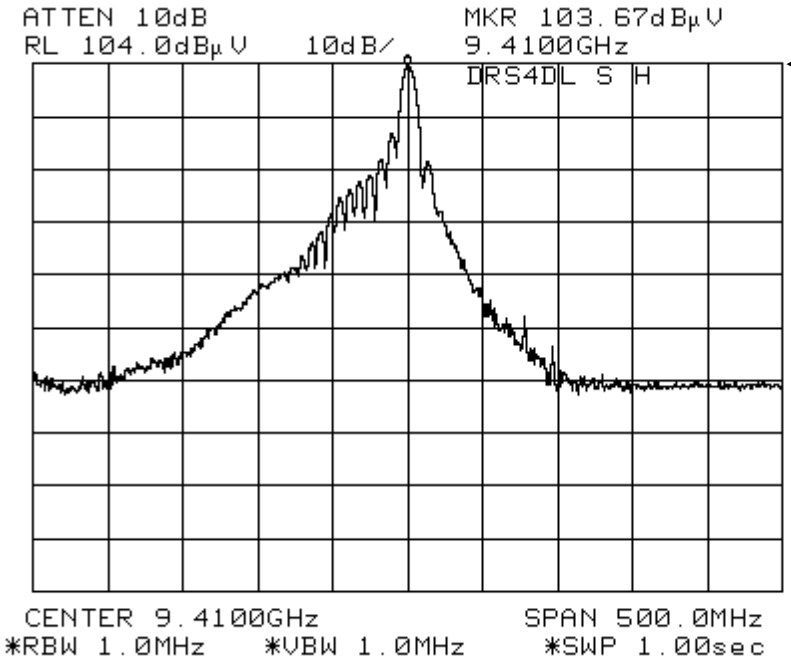
for L pulse


ATTEN 10dB
RL -3.0dBm
10dB/
MKR -3.33dBm
9.4085GHz
DRS4DL L
OCCUPIED BW
%OCC 99.00
11.00MHz
Limit
CENTER 9.4085GHz
SPAN 550.0MHz
*RBW 1.0MHz
*VBW 1.0MHz
*SWP 1.00sec

9 Field Strength Plots of Spurious Radiation

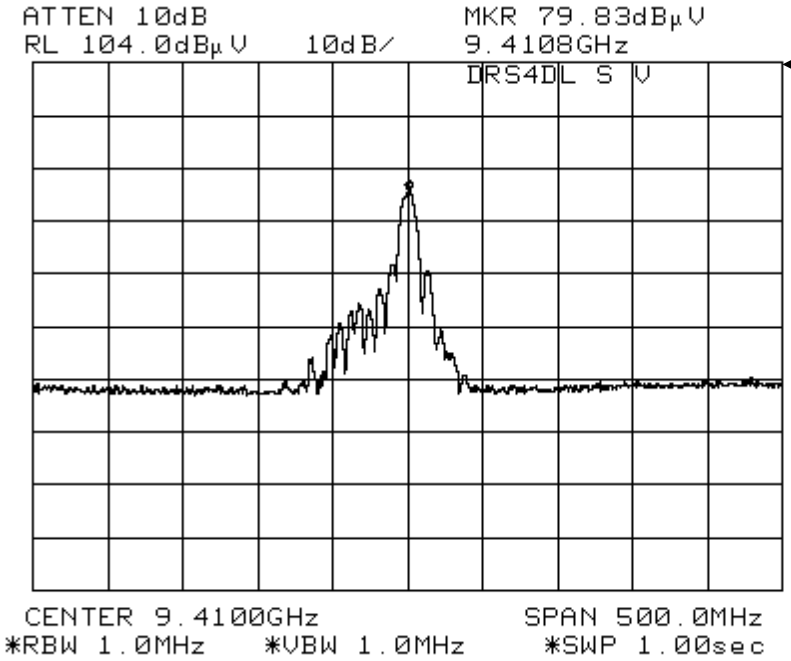
9.1 Maximum power radiation level (for Short Pulse)

- Horizontal



Maximum radiation level
(Equals to Reference level)

- Vertical



Maximum radiation level
(Equals to Reference level)

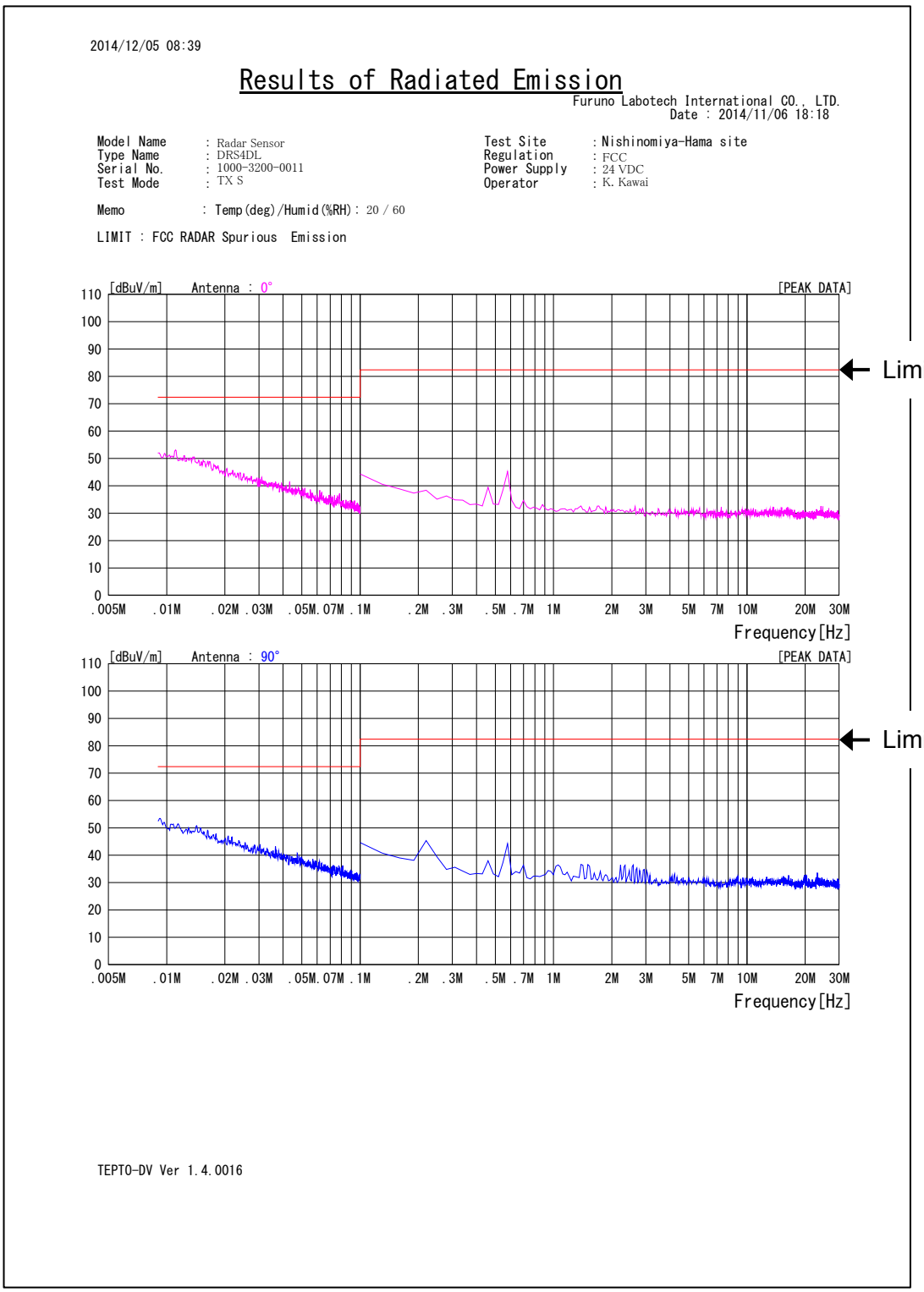
For the maximum power radiation level, the voltage value measured by the spectrum analyzer was converted into the electric field strength with the measuring antenna factor, Cable loss and Amp. gain.

Maximum power radiation level = 162.4 dBµV/m

Therefore, Emission Limit = 162.4 dBµV/m - 60 dB = 102.4 dBµV/m

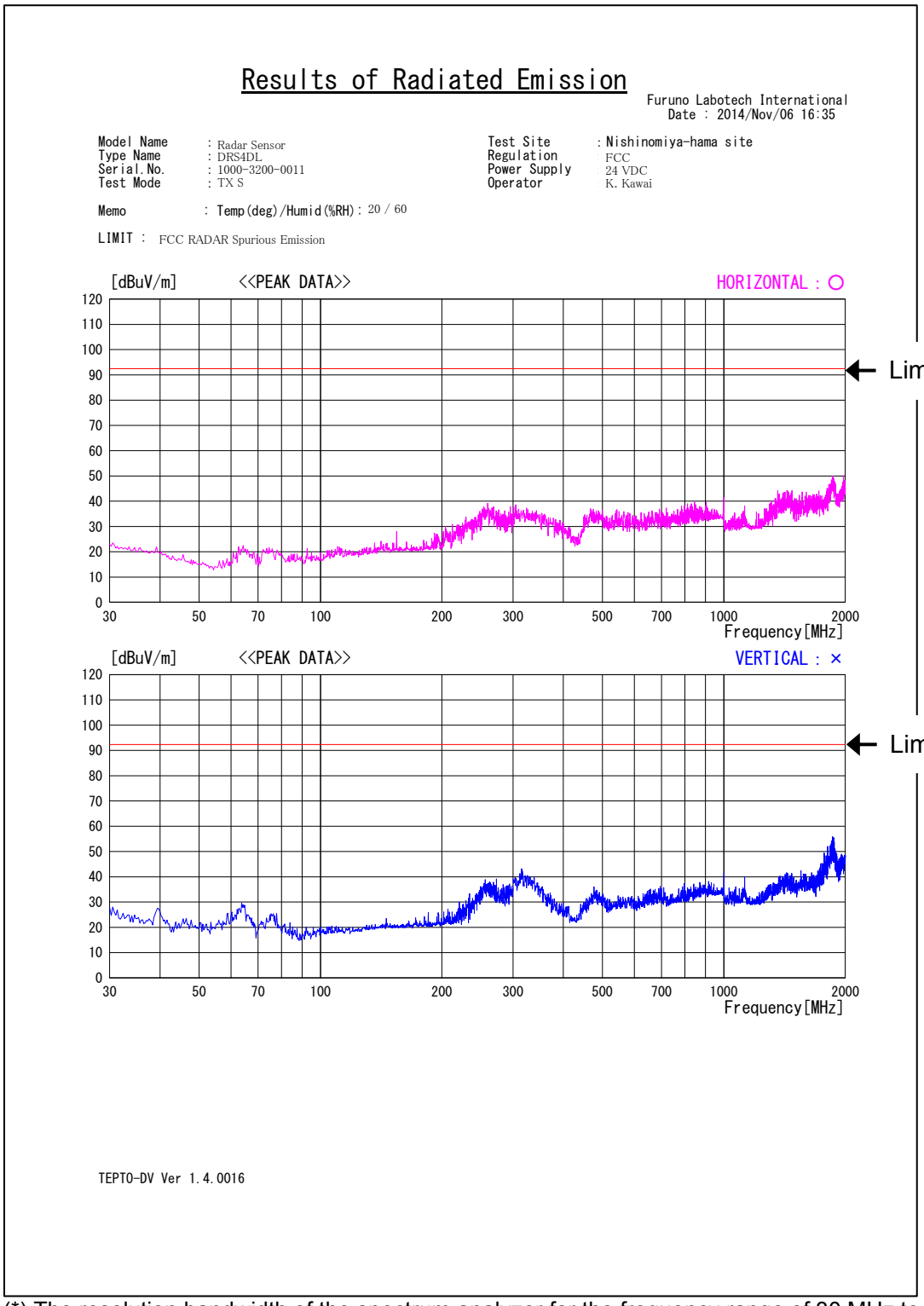
9.2 Spurious emissions (S pulse)

(1) for 9 kHz to 30 MHz



(*) The resolution bandwidth of the spectrum analyzer for the frequency range of 9 kHz to 100 kHz was set to 1 kHz, and to 10 kHz for 100 kHz to 30 MHz, instead of 1 MHz for the frequency range of 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.

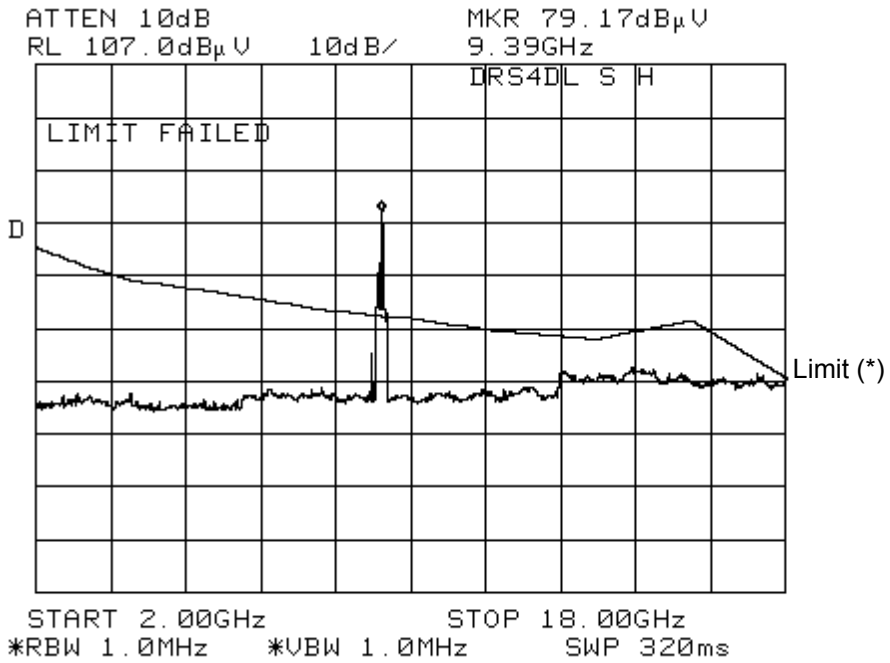
(2) for 30 MHz to 2000 MHz



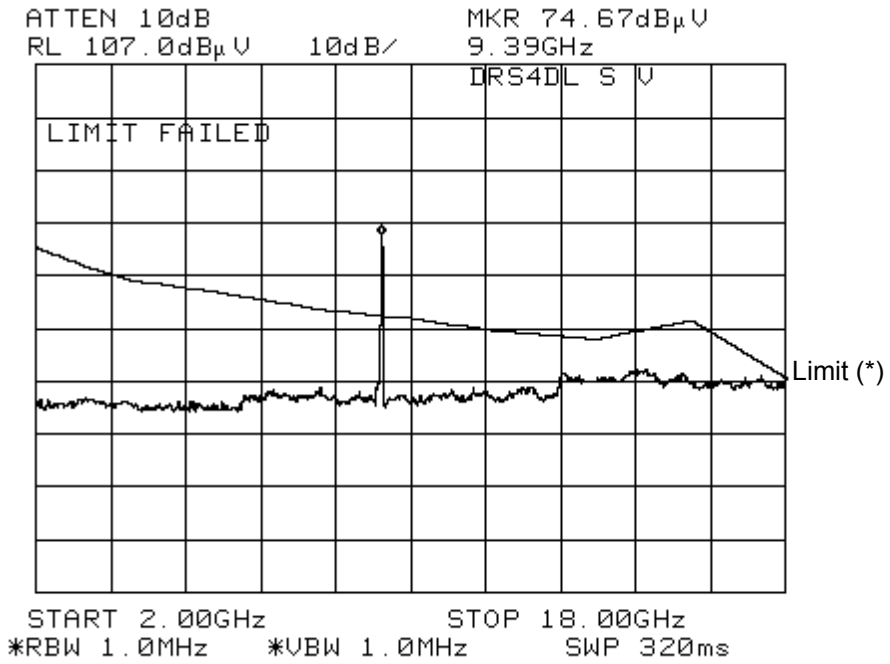
(*) The resolution bandwidth of the spectrum analyzer for the frequency range of 30 MHz to 2000 MHz was set to 100 kHz instead of 1 MHz for the frequency range of 2 GHz to 40 GHz. The applicable limit was set at 10 dB lower than that computed in Clause 9.1.

(3) for 2 GHz to 18 GHz

- for Horizontal



- for Vertical



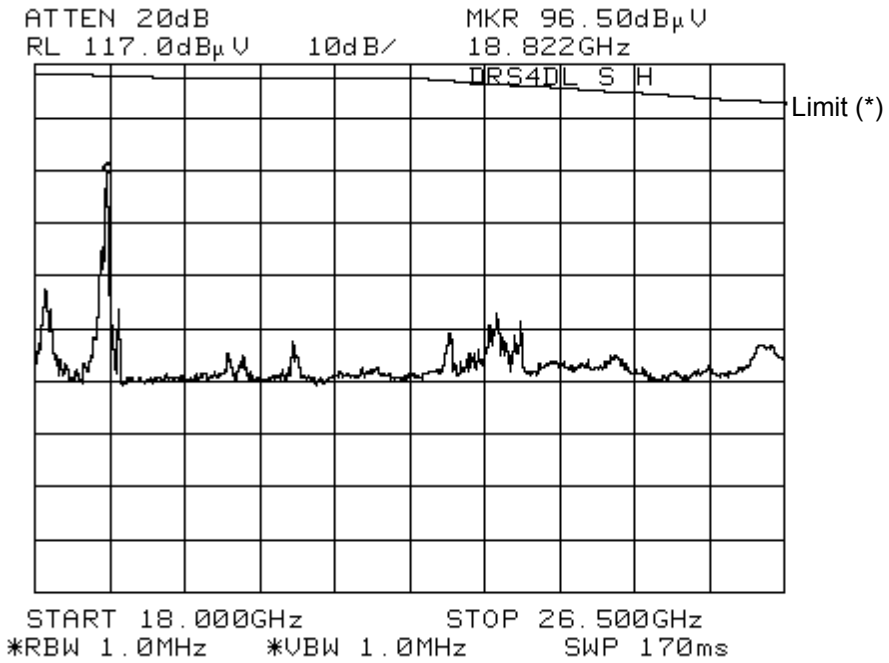
The notch filer (Pass band: 9410 ± 150 MHz) was inserted between the measuring antenna and Spectrum Analyzer to prevent the excessive input to Spectrum Analyzer only for the test frequency range of 2 GHz to 18 GHz.

(*) 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 included.

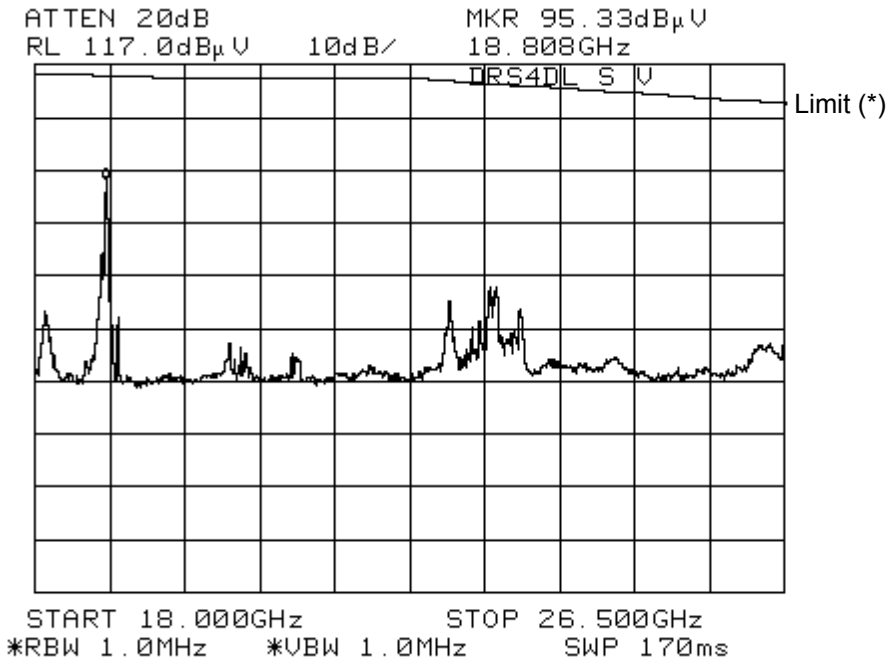
Limit (*)

(4) for 18 GHz to 26.5 GHz

- for Horizontal



- for Vertical

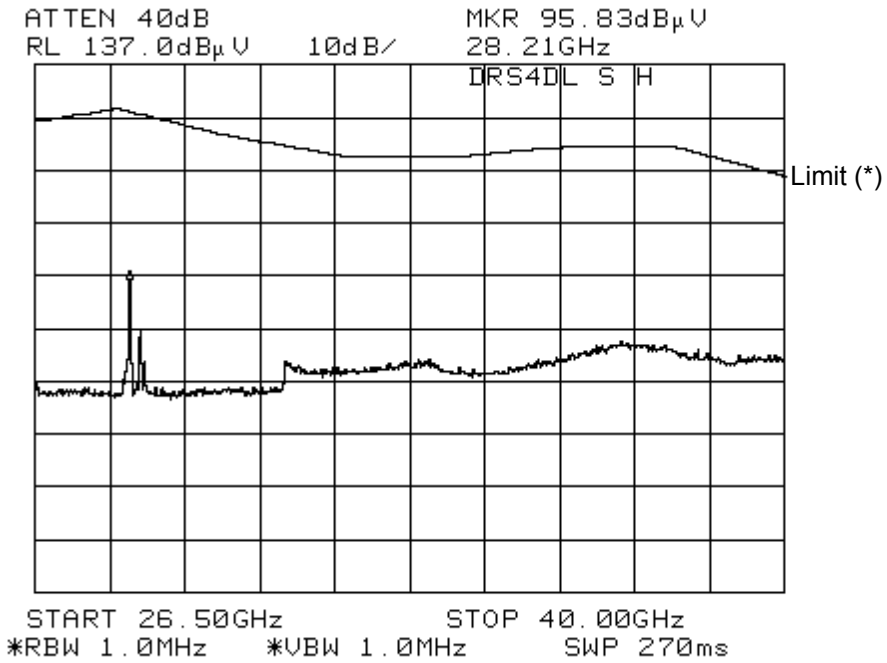


(*) The Limit is represented by the voltage value, which was derived from the electric field strength value with Antenna factor, Cable loss and Amp. gain included.

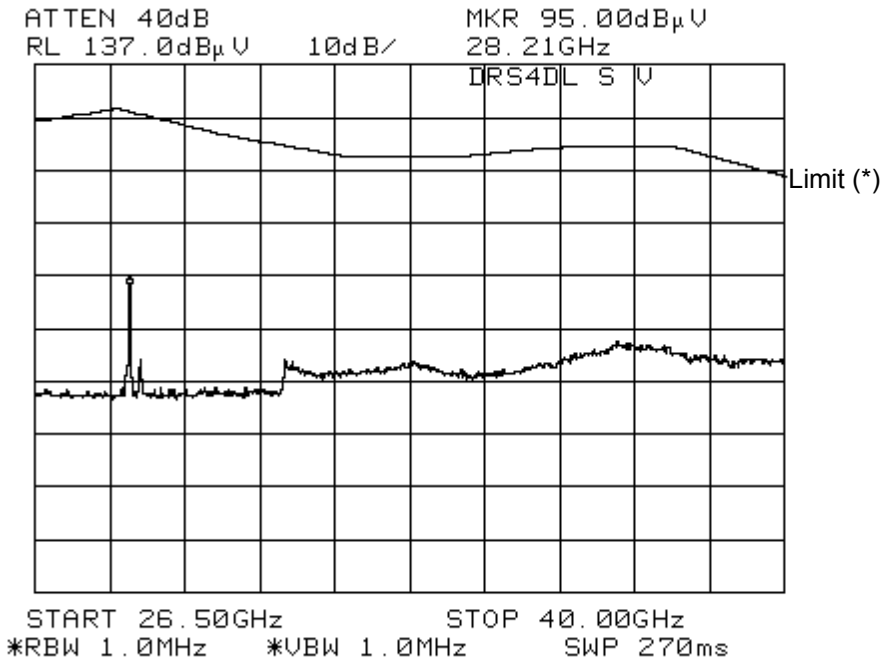
Minimum limit line for the frequency range of 18 GHz to 26.5 GHz is indicated in the above plots.

(5) for 26.5 GHz to 40 GHz

- for Horizontal



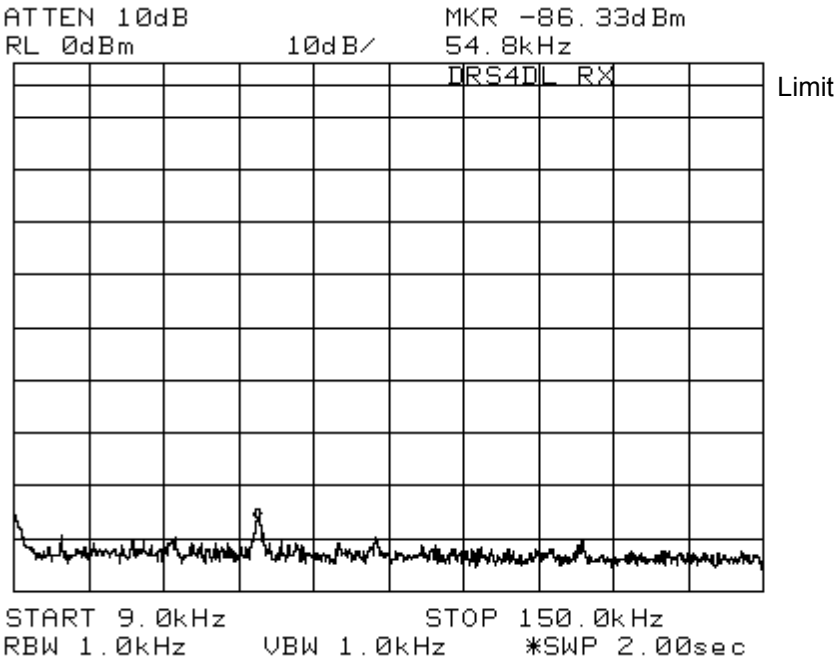
- for Vertical



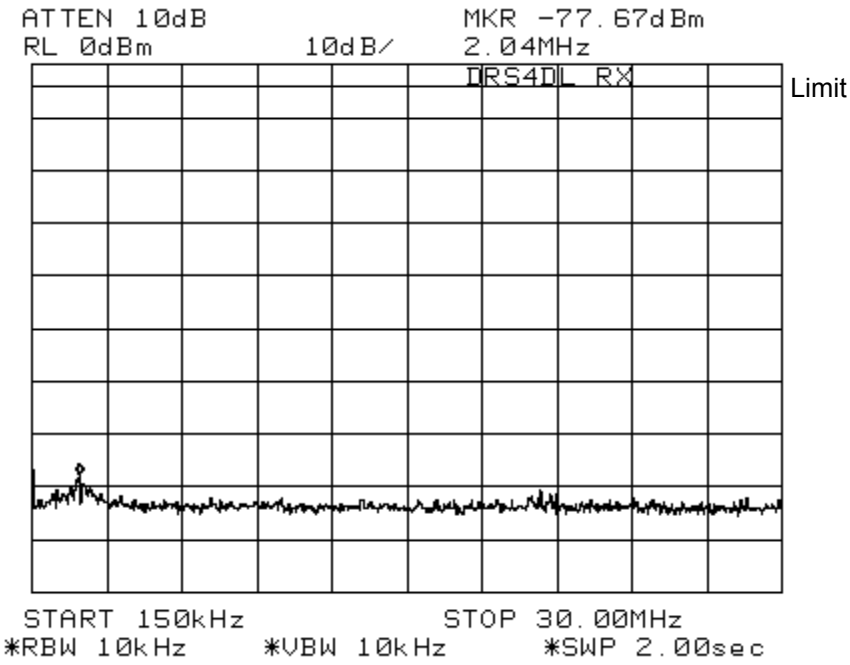
(*) Emission limit was converted from the electric field strength into the voltage values with Antenna factor, Cable loss and Amp. gain added to the calculation.
Minimum limit line for the frequency range of 26.5 GHz to 40 GHz is indicated in the above plots.

10 Field Strength Plots for Suppression of Interference Aboard Ships

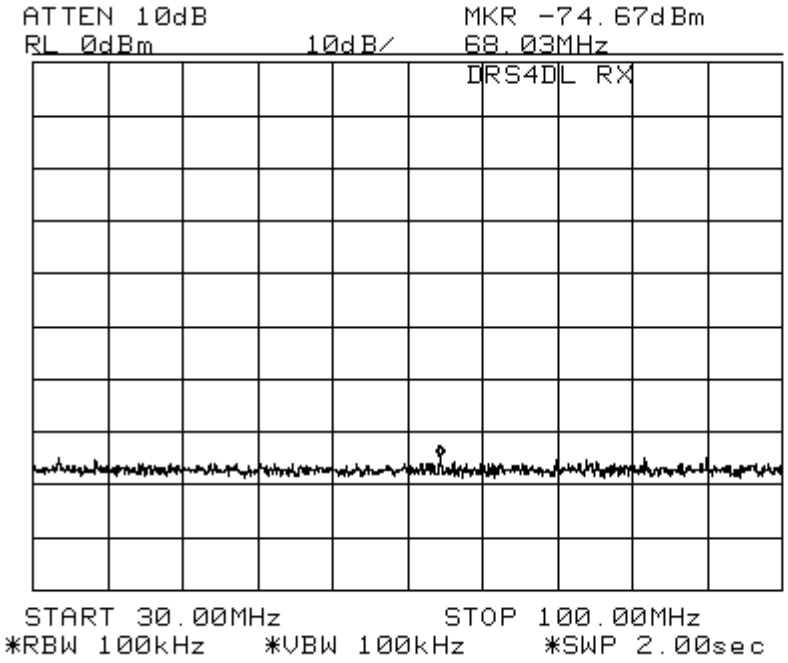
(1) 9 kHz – 150 kHz: Limit = 400 µW (-4 dBm)



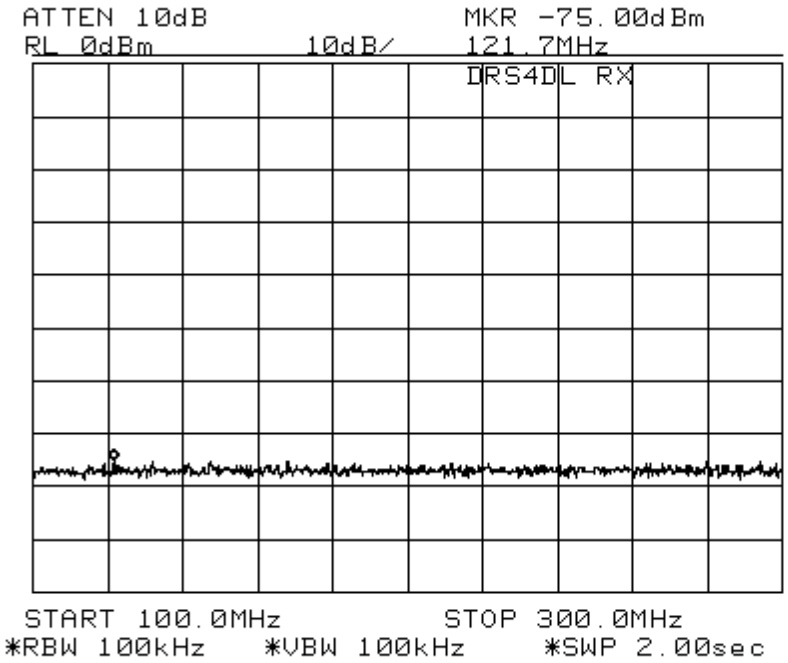
(2) 150 kHz – 30 MHz: Limit = 400 µW (-4 dBm)



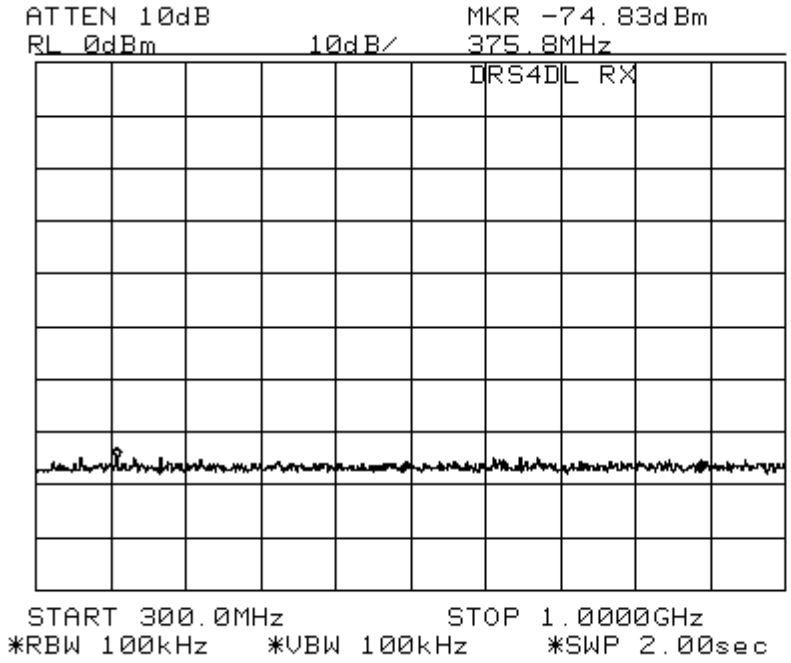
(3) 30 MHz – 100 MHz: Limit = 4000 µW (+6 dBm)



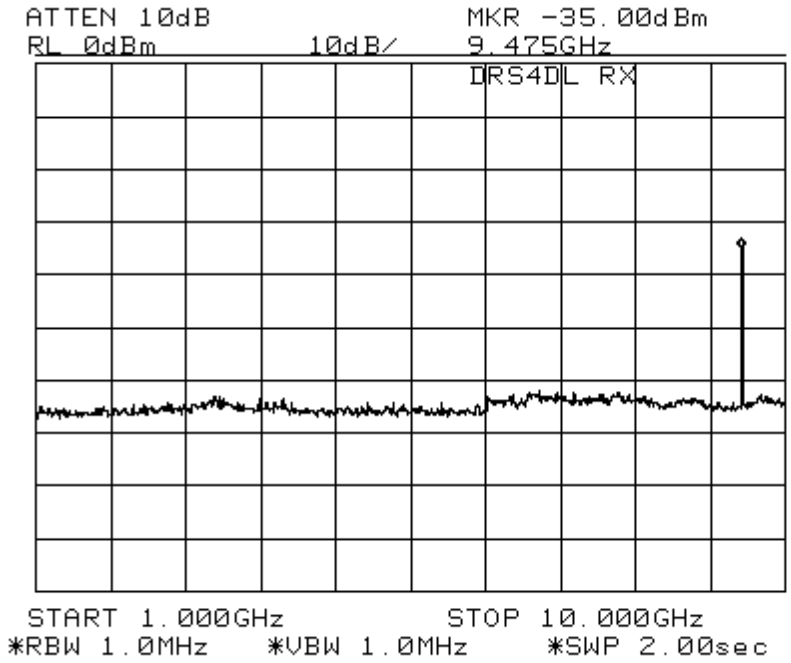
(4) 100 MHz – 300 MHz: Limit = 40000 µW (+16 dBm)



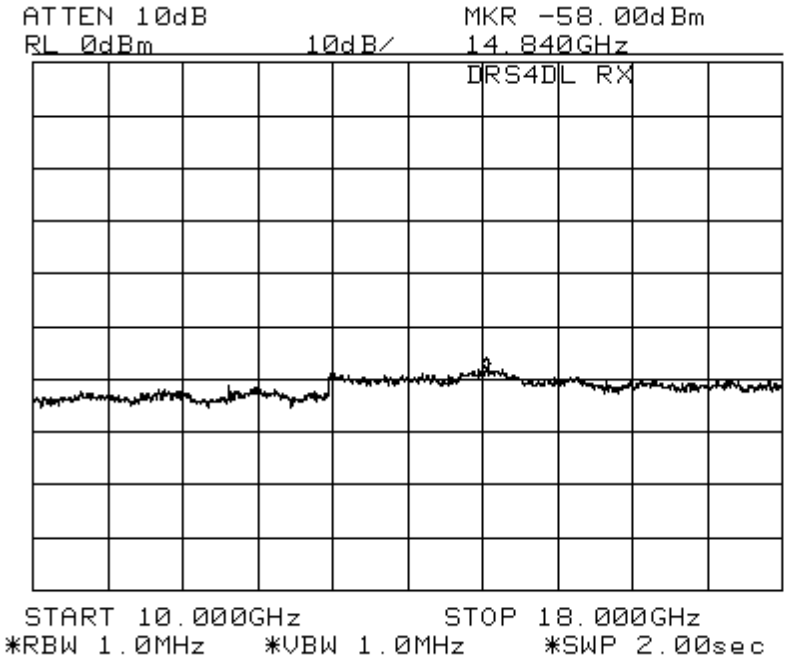
(5) 300 MHz – 1 GHz: Limit = 400000 µW (+26 dBm)



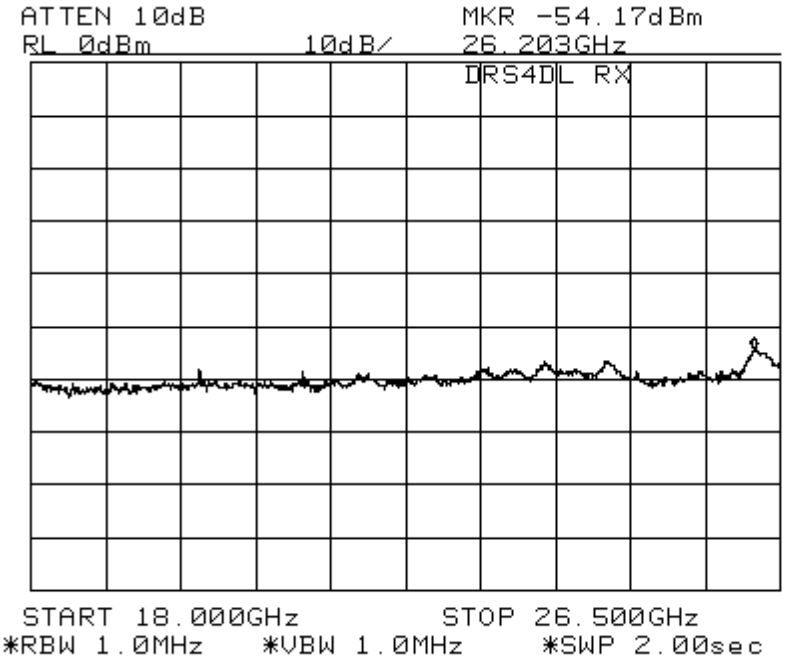
(6) 1 GHz – 10 GHz: Limit = 400000 µW (+26 dBm)



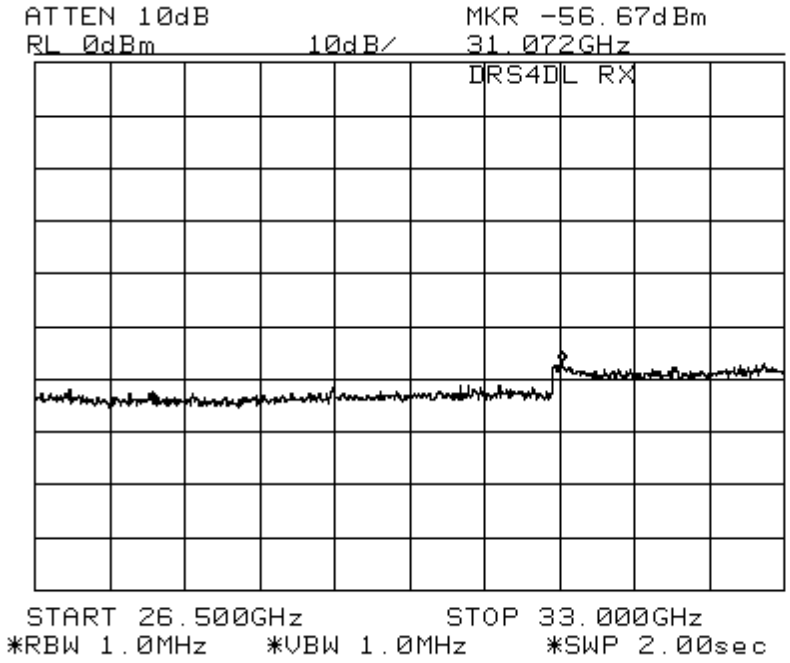
(7) 10 GHz – 18 GHz: Limit = 400000 µW (+26 dBm)



(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)