Test Report

CFR Title 47 Sections:
Part 2 (2.201, 2.202, 2.1046, 2.1047, 2.1049, 2.1051, 2.1053, 2.1055),
Part 80 (80.209, 80.211, 80.213, 80.215, 80.273)

for

Trade name: Furuno
Model: Transceiver
for RADAR SENSOR DRS4D X-Class
Type: RTR-128

Report no.: LIC 12-21-059

Date of issue: 4 June 2021

Labotech International Co., Ltd.
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Report Summary

LIC project number:	LIC 04-20-0698		
Test report number of initial issue:	LIC 12-21-059	Date of initial issue	4 June 2021
Test report number of revised/replaced issue:	--	Date of revised/replaced issue	--
Test report revision/ replacement history:	--		
Test standard(s)/ Test specifications:	CFR Title 47 Sections: 2.201 - Emission, modulation, and transmission characteristics 2.202 - Bandwidths 2.1046 - RF Power output 2.1047 - Measurements required: Modulation characteristics 2.1049 - Occupied Bandwidth 2.1051 - Spurious Emissions at antenna terminals 2.1053 - Field Strength of Spurious Radiation 2.1055 - Measurements required: Frequency Stability 80.209 - Transmitter frequency tolerances 80.211 - Emission limitations 80.213 - Modulation requirements 80.215 - Transmitter power 80.273 - Radar standards (the latest version on the first day of the testing period)		
Customer:	Furuno Electric Co., Ltd. 9-52, Ashihara-cho, Nishinomiya city, Hyogo, 662-8580 Japan		
Manufacturer:	Furuno Electric Co., Ltd. 9-52, Ashihara-cho, Nishinomiya city, Hyogo, 662-8580 Japan		
Trade name:	Furuno		
Model:	Transceiver for RADAR SENSOR DRS4D X-Class		
Type:	RTR-128		
Product function and intended use:	Radio detection and ranging		
Number of samples tested:	One		
Serial number:	1001-3110-0003		
Power rating:	12–24 VDC, 2.3–1.1 A		
Modifications made to samples during testing:	None		
Date of receipt of samples:	27 January 2021		
Test period:	From 3 February 2021 to 5 April 2021		
Place of test:	Labotech International Co., Ltd. FCC Test firm Designation Number: JP2007 FCC Test firm Registration Number: 838049 - LABOTECH EMC Center 1-16, Fukazu-cho, Nishinomiya-shi, Hyogo, 663-8203 Japan - Kishu Lab. 579-1 Umehara, Wakayama-shi, Wakayama, 640-8452 Japan		
Test results/Compliance:	Passed. The test results of this report relate only to the samples tested.		

Tested by:	Atsushi Takagi, Akihiro Sakai and Yukihiro Hijiri
Written by:	Arisa Ogino
Verified by:	Tadayuki Ekawa
Approved by:	Date: 4 June 2021 Name: Tadayuki Ekawa Title: Head engineer, Technical Department, Labotech International Co., Ltd. Signature: 

Disclaimer:

The test results of this report relate only to the samples tested.

LIC has no responsibility for the followings except for the requirements of test standards.

– The thing(s) in association with the test and information pertaining to it/them, which are provided by the customer; information described in Clause 1 (except for Clause 1.1.1, (h)) of this report and information of the cable(s) used.

– The matter(s) specified by the customer; Test standard(s) applied, test item(s), test conditions, criteria, object(s) to be tested or excluded, operation mode(s) and connection/configuration.

Testing Laboratory Status

Labotech International Co., Ltd. (hereafter called “LIC”) 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, Climatic, Vibration and Radio tests

(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, IEC 62288, ETSI EN 301 843-1 / -2, ETSI EN 301 489-1 / -3 / -17

(3) 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 EMC emission and immunity

(4) RMRS Recognized Testing Laboratory:
- recognized by Russian Maritime Register of Shipping (Russia)
- Laboratory recognition number: 17.13259.170 (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

(5) RRR Recognized Test Laboratory:
- recognized by Russian River Register (Russia)
- Certificate number: 131927 (- Date of initial recognition: 31 May 2013 (*))
- for carrying out of tests of ships radio and navigation equipment

(6) DNV GL Recognized Environmental Test Laboratory:
- recognized by Det Norske Veritas AS, Germanischer Lloyd (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.

(7) 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

(8) SABS EMC A-Lab program Laboratory:
- recognized by South African Bureau of Standards
- Assigned Lab number: SABS/A-LAB/0042/2018 (Date of initial recognition: 5 July 2018 (*))
- Approved List of EMC Standards : SANS 211 / 214-1 / 214-2 / 222 / 2332 / 2335, CISPR 11 / 14-1 / 14-2 / 22 / 32 / 35, SANS/IEC 60601-1-2, SANS/IEC 61326-1, IEC 61326-2-6, SANS/IEC 61000-3-2 / -3-3 / -4-2 / -4-3 / -4-4 / -4-5 / -4-6 / -4-8 / -4-11 / -6-1 / -6-2 / -6-3 / -6-4

(9) A2LA accreditted Testing Laboratory:
- accredited by American Association of Laboratory (A2LA)
- Certificate number: 5241.01 (Date of initial accreditation: 17 Jul 2019 (*))
- Scope of accreditation: Electrical testing - Emissions - Radiated and Conducted, Radio - Maritime Radio Systems, Stations in the maritime services, Private land mobile radio service, Radio / Intentional radiators, RF Exposure and EMC - Automotive Electronic Devices (AED), Machine and Vehicle

(*) The latest certification status may be found on the LIC website (https://www.labotech-intl.co.jp/).

TABLE OF CONTENTS

1 Principal Information

1.1 Equipment under test (EUT)

1.1.1 General

(a) Trade name: Furuno

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

(c) Model:

Transceiver for RADAR SENSOR DRS4D X-Class

Name	Type	Serial number	Note
RADAR SENSOR	DRS4D X-Class (RSB-143-128)	1001-3110-0003	--
Transceiver module	RTR-128	--	--
Scanner module	RSB-143	--	Antenna rotation rate: 24/36/48 rpm

Associated units (AU)

Name	Type	Serial number	Manufacturer
ETHERNET HUB	HUB-101	010057	Furuno
INTEGRATED HEADING SENSOR	PG-700	6406-4142	Furuno
DISPLAY UNIT	FR-12 (RDP-161)	1001-3010-0002	Furuno
TRACKBALL CONTROL UNIT	RCU-030	101633	Furuno
DISPLAY	B2282HS-B1	1165393461304	iiyama

Ancillary equipment (AE)

Name	Type	Serial number	Manufacturer
PC	Latitude 7390	2017AP6389	DELL
USB-Serial converter	Uport 1650-8	TAAI01041296	MOXA
SWITCH-MODE POWER SUPPLY	3A-165DA12	--	ENG SHENG
NMEA Connector 1	FRU-MM1MF1MF1001	--	Furuno
NMEA Connector 2	FRU-MM1MF1MF1001	--	Furuno
NMEA Connector 3	FRU-MM1MF1MF1001	--	Furuno
Termination	FRU-MM1000000001	--	Furuno
DC POWER SUPPLY	ASP030-12-C	--	COSEL
LED jig	--	--	Furuno

(d) FCC ID: ADB9ZWRTR128

(e) Primary function: Ship radar station operating in the band 9300–9500 MHz

(f) Frequency range: Fixed frequency, 9410 MHz±30 MHz

(g) Type of emission: P0N
(Emission designator)

(h) Occupied bandwidth:

Pulse type	S1	S2	M1	M2	M3	L
Occupied bandwidth (MHz)	53.17	38.50	24.75	14.67	11.00	9.17

Note: measured data

(i) Size and mass: RADAR SENSOR: 610 mm (ϕ) × 220 mm (H), 7.2 kg

(j) Power supply: 12–24 VDC

1.1.2 Transceiver module

Type: RTR-128 (Contained in RADAR SENSOR)

1.1.2.1 Transmitter

(a) Assignable frequency band: Between 9300 and 9500 MHz (CFR Title 47 Sections: 80.375 (d)-(1))

(b) Type of RF generator:

- Type: M1653
- Peak output power: 4 kW nominal
- Fundamental frequency: 9410 MHz nominal
- Tolerances:
  - Manufacturing: ±30 MHz
  - Pulling: 1.5 MHz
  - Tolerance for 20°C temperature variation: -5 MHz

(c) Pulse characteristics:

Pulse type		S1	S2	M1	M2	M3	L
Pulse length (μs)		0.08	0.15	0.30	0.50	0.80	1.0
PRF(Hz)	Normal mode	3000	3000	1500	1000	600	600

1.1.2.2 Modulator

FET Type: FMC20N50E

Trigger Voltage: Approx. +9.8 VDC positive

1.1.2.3 Receiver

(a) Passband

RF Stage: 300 MHz

IF Stage:

Pulse type	S1-S2	M1-M2	M3-L
Passband (MHz)	18	6	2.6

(b) Intermediate Frequency: 60 MHz

(c) Gain (overall): Approximately 15 dB

(d) Overall Noise Figure: 5.5 dB (typical)

(e) Video Output Voltage: ±2 V

(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 adjusting tuning voltage of receiver local oscillator (automatically and manually)

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

1.1.3 Antenna and Scanner

(a) Antenna specifications

Antenna model		03P9459-1NLF
Length (mm)		555
Rotation diameter (mm)		610
Transmission frequency		9410±30 MHz
Horizontal beam width (-3 dB)		4.0°
Vertical beam width		25°
Side lobe (max.)	Less than ±20°	-24 dB
	Outside ±20°	-26 dB
Gain		23.0 dBi
Radiator		Patch array
Polarization		Horizontal
Type of beam		Vertical fan

(b) Antenna Rotation ON-OFF Switch: Not provided.

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

(d) Antenna Rotation Rate: 24/36/48 rpm

(e) Sector Scan: Provided

(f) Rated Loss of Transmission Line per 100 Feet: Negligible
(Transmission path is only in RADAR SENSOR.)

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:
See Clause 1.1.1 (c) of this report.

(e) Approximate space required for installation excluding RADAR SENSOR: Not applicable

1.2 Observation and comments

None.

2 Test Results Summary

Clause number of this report	CFR Title 47 Sections	Item	Result	Test engineer
3.1	2.1046 (a), 80.215	RF Power Output	Passed.	Y. Hijiri
3.2	2.201, 2.1047 (d)	Modulation Characteristics	Passed.	Y. Hijiri
3.3	2.1055 (a)(2),(d)(1),(d)(3), 80.209 (b)	Frequency Stability –temperature & voltage	Passed.	Y. Hijiri
3.4	2.202 (a), 2.1049 (c)(1), 80.209 (b), 80.211 (f)	Occupied Bandwidth	Passed.	Y. Hijiri
3.5	2.1051, 80.211 (f), 80.273	Spurious Emissions at Antenna Port	Passed.	Y. Hijiri
3.6	2.1053, 80.211 (f)	Field Strength of Spurious Radiation	Passed.	A. Sakai and A. Takagi

3 Test Results

3.1 RF Power Output (CFR Title 47 Sections: 2.1046 (a) and 80.215)

3.1.1 Test conditions:

For all TX (S1/S2/M1/M2/M3/L) pulses, the transmitter output power was measured with a non-reflective load and a directional coupler as a substitute for the antenna radiator.

3.1.2 Test setup:

See Clause 4.

3.1.3 Test Results:

Normal mode

Pulse type	S1	S2	M1	M2	M3	L
Transmission mean power Pm (W)	0.6	1.1	1.2	1.4	1.3	1.6
Pulse length *T* (μs) (50% points)	0.077	0.153	0.316	0.524	0.832	1.024
Pulse Repetition Frequency (Hz)	3002	3001	1501	1000	600	600
Transmission pulse power Pp (kW) (*)	2.7	2.5	2.5	2.6	2.6	2.6

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

Environmental conditions observed: On 23 March 2021, 21°C to 21°C, 39%RH to 39%RH
Power supply voltage measured: 24 VDC to 24 VDC

3.2 Modulation Characteristics (CFR Title 47 Sections: 2.201, 2.1047 (d))

3.2.1 Test Conditions:

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

3.2.2 Test setup:

See Clause 4.

3.2.3 Test Results:

Normal mode

Pulse type	S1	S2	M1	M2	M3	L
Pulse length T (μs) (-3 dB points)	0.077	0.153	0.316	0.524	0.832	1.024
Rise time t_r (μs) (10 to 90 % amplitude)	0.016	0.014	0.015	0.016	0.016	0.015
Fall time t_f (μs) (90 to 10 % amplitude)	0.063	0.062	0.061	0.063	0.065	0.068
Pulse Repetition Frequency (Hz)	3002	3001	1501	1000	600	600

Measured Plots: See Clause 6.

Environmental conditions observed: On 23 March 2021, 21°C to 21°C, 39%RH to 39%RH
Power supply voltage measured: 24 VDC to 24 VDC

3.3 Frequency Stability –temperature & voltage (CFR Title 47 Sections: 2.1055 (a)(2)/(d)(1)/(d)(3), 80.209(b))

3.3.1 Test Conditions:

(1) Radar transmitter settings: All TX (S1/S2/M1/M2/M3/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

DRS4D X-Class: 12–24 VDC V_L: 10.2 VDC / V_{nom}: 24.0 VDC / V_H: 27.6 VDC

3.3.2 Test setup:

See Clause 4.

3.3.3 Frequency Tolerance Limits (CFR Title 47 Sections: 2.1055 (a)(2)/(d)(1)/(d)(3),80.209(b)):

Pulse type	S1	S2	M1	M2	M3	L
Guard Band f(1.5/T) (MHz) (*1)	19.4	9.8	4.7	2.9	1.8	1.5
Upper limit (MHz) (*2)	9480.6	9490.2	9495.3	9497.1	9498.2	9498.5
Lower limit (MHz) (*2)	9319.4	9309.8	9304.7	9302.9	9301.8	9301.5

(*1) Guard Band is specified to be equal to 1.5/T MHz, where "T" is the pulse length in microseconds.
(CFR Title 47 Sections: 80.209 (b))

(*2) Upper limit frequency, f(U) =9500 -1.5/T
Lower limit frequency, f(L) = 9300 +1.5/T

3.3.4 Test Results:

Complied.

(1) Temperature test at the rated supply voltage of 24 VDC:

Pulse type		S1	S2	M1	M2	M3	L	Result
Frequency at maximum emission (MHz)	-20°C	9411.5	9412.0	9412.5	9413.0	9413.5	9413.5	Complied.
	-10°C	9410.0	9410.5	9411.5	9412.0	9412.5	9413.0	Complied.
	0°C	9409.0	9409.0	9410.0	9410.0	9410.5	9411.0	Complied.
	+10°C	9407.0	9407.0	9407.5	9408.0	9407.5	9407.5	Complied.
	+20°C	9405.0	9405.5	9405.5	9405.0	9405.0	9405.0	Complied.
	+30°C	9404.0	9404.5	9404.0	9403.5	9403.5	9403.5	Complied.
	+40°C	9402.5	9402.5	9402.0	9401.5	9401.5	9401.5	Complied.
	+50°C	9400.5	9400.0	9399.5	9399.0	9398.5	9398.5	Complied.

(2) Voltage variation test at the temperature of +20°C:

Pulse type		S1	S2	M1	M2	M3	L	Result
Frequency at maximum emission (MHz)	V_L	9405.5	9405.5	9405.5	9405.0	9405.0	9405.5	Complied.
	V_{nom}	9405.0	9405.5	9405.5	9405.0	9405.0	9405.0	Complied.
	V_H	9405.0	9405.0	9405.5	9405.0	9405.0	9405.0	Complied.

Environmental conditions observed: On 16 March 2021, 24°C to 23°C, 48%RH to 50%RH
On 17 March 2021, 22°C to 22°C, 46%RH to 39%RH
On 18 March 2021, 23°C to 23°C, 38%RH to 38%RH

Power supply voltage measured: 24 VDC to 24 VDC

3.4 Occupied Bandwidth
(CFR Title 47 Sections: 2.202 (a), 2.1049 (c)(1), 80.209 (b), 80.211 (f))

3.4.1 Test conditions:

For all TX (S1/S2/M1/M2/M3/L) pulses, the transmitter output power was measured with a non-reflective load and a directional coupler as a substitute for the antenna radiator.

3.4.2 Test setup:

See Clause 4.

3.4.3 Emission Limits (CFR Title 47 Sections: 80.211 (f)):

Frequency removed from the assigned frequency (*1)	Emission attenuation (mean power, dB)
50 to 100 % (of the authorized bandwidth) (*2)	At least 25
100 to 250 % (of the authorized bandwidth) (*2)	At least 35
more than 250 % (of the authorized bandwidth) (*2)	At least 43 + 10 $\log_{10}$ (mean power in watts) = -13 dBm

(*1) Assigned frequency (center frequency) = 9410 MHz (for X-band radars)
(*2) Authorized band width = 110 MHz (for X-band radars)

3.4.4 Test Results:

Complied.
Spectrum plots: See Clause 7.

Environmental conditions observed: On 24 March 2021, 24°C to 24°C, 41%RH to 41%RH
Power supply voltage measured: 24 VDC to 24 VDC

3.5 Spurious Emissions at Antenna Port (CFR Title 47 Sections: 2.1051, 80.211 (f), 80.273 and ITU-R SM.329-12)

3.5.1 Test Conditions:

(a) For S1 pulse, the transmitter output power was measured with a waveguide converter as a substitute for the antenna radiator. (*1)

(*1) Emission measurements only need to be carried out for the pulse length setting producing the widest calculated B–40 bandwidth. (IEC 62388 Ed.2/ Annex B.4.2 part)

(b) Spurious measurement range for X-band radar: 4.59 GHz to 40 GHz

Lower measurement band	Upper measurement band
From 4.59 GHz (*2) to the lower OoB boundary	From the upper OoB boundary to 40 GHz

(*2) 0.7 times of the waveguide cut-off frequency for WRJ-10 (ITU-R SM.329-12, Section 2.5)

3.5.2 Test setup:

See Clause 4.

3.5.3 Emission Limits (CFR Title 47 Sections: 80.211 (f)):

Frequency removed from the assigned frequency (*1)	Emission attenuation (mean power, dB)
More than 250% (*3) (of the authorized bandwidth) (*2)	At least 43 + 10 $\log_{10}$ (mean power in watts) = -13 dBm

(*1) Assigned frequency (center frequency) = 9410 MHz (for X-band radars)
(*2) Authorized bandwidth = 110 MHz (for X-band radars)
(*3) Spurious measurement range for X-band radar: 4.59 GHz to 40 GHz

3.5.4 Harmonics Frequencies:

f_0 (GHz)	$1/2f_0$	$2f_0$	$3f_0$	$4f_0$
9.410	4.705	18.820	28.23	37.64

3.5.5 Test Results:

Complied.

Spurious emission levels measured were found to be attenuated more than 20 dB below the limits.

Environmental conditions observed: On 1 April 2021, 24°C to 24°C, 36%RH to36%RH
On 5 April 2021, 22°C to 23°C, 47%RH to34%RH

Power supply voltage measured: 24 VDC to 24 VDC

3.6 Field Strength of Spurious Radiation (CFR Title 47 Sections: 2.1053, 80.211 (f) and ITU-R SM.329-12)

3.6.1 Test Conditions:

(a) For S1 pulse, the transmitter output power was measured with the non-reflective load as a substitute for the antenna radiator. (*1)

(*1) Emission measurements only need to be carried out for the pulse length setting producing the widest calculated B–40 bandwidth. (IEC 62388 Ed.2/ Annex B.4.2 part)

(b) Spurious measurement range for X-Band RADAR: 4.59 GHz to 40 GHz

Lower measurement band	Upper measurement band
From 4.59 GHz (*2) to the lower OoB boundary	From the upper OoB boundary to 40 GHz

(*2) 0.7 times of the waveguide cut-off frequency for WRJ-10 (ITU-R SM.329-12, Section 2.5)

(c) Antenna port was terminated with dummy load.

3.6.2 Test Site: LIC EMC Center, Semi-anechoic chamber

3.6.3 Distance between the Radar and Measuring Antenna: 3 m

3.6.4 Test setup:

See Clause 4.

The GRP (Ground reference plane, metal floor) between the EUT and the measuring (receiving) antenna was lined with the radio absorbers (3.0 m × 2.4 m × 0.3 m) to reduce the influences of the reflections of the RF waves from the floor.

Measuring (receiving) the antenna height and polarization:

(a) Antenna height: EUT center (1.61 m)

(b) Antenna polarization: vertical and horizontal.

EUT height: 1.5 m

3.6.5 Field Strength Limits (CFR Title 47 Sections: 80.211 (f)):

Frequency removed from the assigned frequency (*1)	Emission attenuation (mean power, dB)
More than 250% (*3) (of the authorized bandwidth) (*2)	At least 43 + 10 $\log_{10}$ (mean power in watts) = -13 dBm

(*1) Assigned frequency (center frequency) = 9410 MHz (for X-band radars)

(*2) Authorized bandwidth = 110 MHz (for X-band radars)

(*3) Spurious measurement range for X-band radar: 4.59 GHz to 40 GHz

3.6.6 Harmonics Frequencies:

f_0 (GHz)	$1/2f_0$	$2f_0$	$3f_0$	$4f_0$
9.410	4.705	18.820	28.23	37.64

3.6.7 Test Results:

Complied.

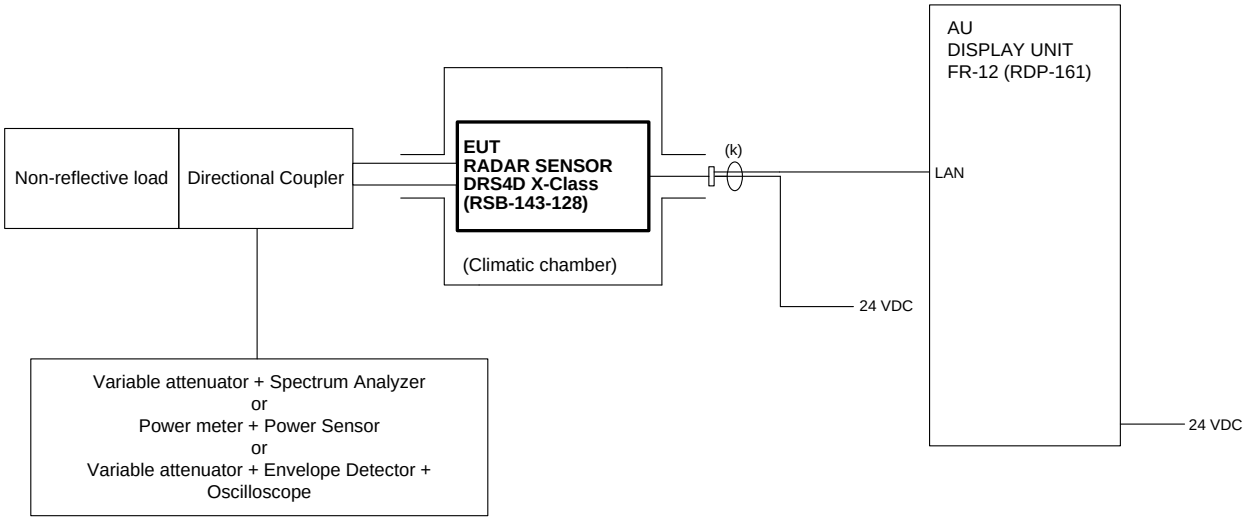
Spurious emission frequency and levels measured of which margins were below 20 dB were listed in the following table.

Frequency (GHz)	Antenna polarization	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)
9.464	horizontal	71.97	82.2	10.2
9.464	vertical	67.74	82.2	14.5
18.928	horizontal	75.74	82.2	6.5
18.928	vertical	78.50	82.2	3.7
28.387	vertical	65.49	82.2	16.7

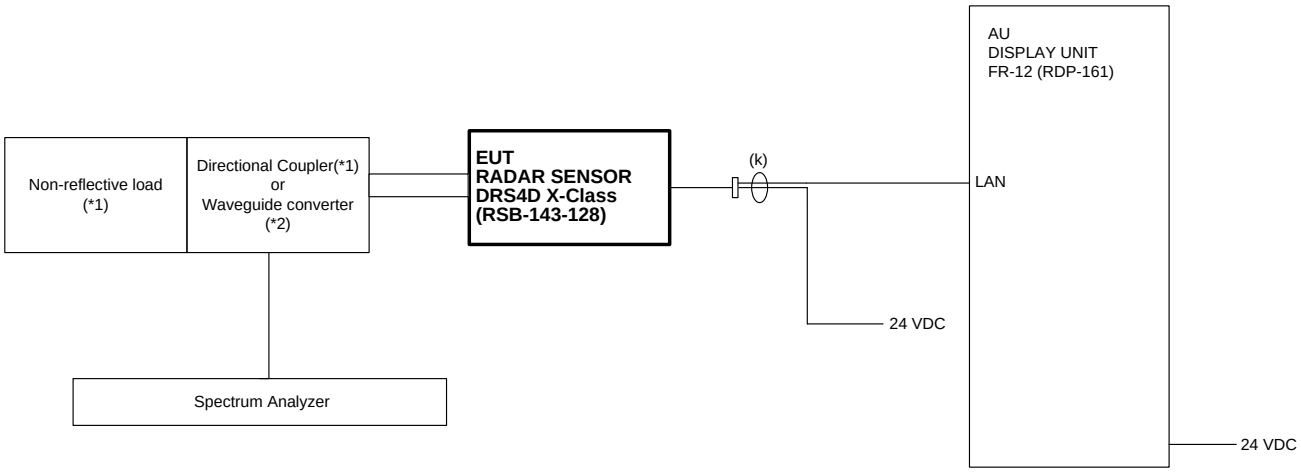
Environmental conditions observed: On 3 February 2021, 22°C to 22°C, 36%RH to 36%RH
On 4 February 2021, 22°C to 22°C, 36%RH to 36%RH
Power supply voltage measured: 24 VDC to 24 VDC

4 Test Setup for Measurements

4.1 Test Setup for Clause 3.1, 3.2, 3.3 and 3.4

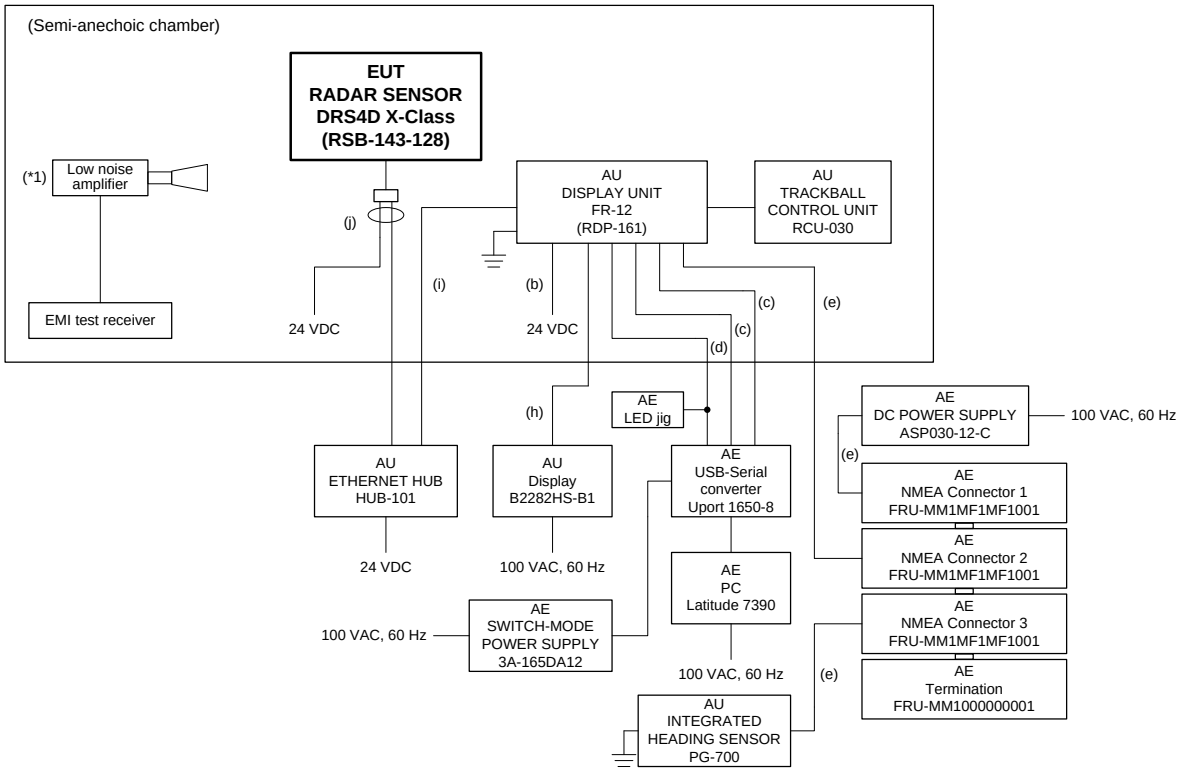


4.2 Test Setup for Clause 3.5



(*1) Used for the measurement up to 18 GHz.
(*2) Used for the measurement above 18 GHz.

4.3 Test Setup for Clause 3.6



(*1) Used depending on measurement frequency bandwidth.

Cable designations

No.	Category (*2)	Cable name	Type	Length (m)	Number of cables	Cable Shielded
b	P	Cable (for FR-12)	MJ-A3SPF0013-035C	3.5	1	Yes
c	S	Cable (for NMEA0183)	MJ-A6SPF0003-150C	15	2	Yes
d	S	Cable (for NMEA0183 and External contacts)	MJ-A7SPF0003-050C	5	1	Yes
e	S	Cable (for NMEA2000)	FRU-NMEA-PMMFF-060	6	3	Yes
h	S	HDMI cable	HDMI-TO-DVI-L=10.3M	10	1	Yes
i	S	LAN cable	MOD-Z7072-100+	10	1	Yes
j	P/S	Antenna unit Cable	FRU-2P5S-FF-30M-A	30	1	Yes
k	P/S	Antenna unit Cable	FRU-2P5S-FF-20M-A	20	1	Yes

(*2) P – Power cable, S – Signal/control cable

5 Measuring Equipment List

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

(1) For Clause 3.1 RF Power Output

C/N	Instrument	Type	S/N	Manufacturer	Date of last calibration	Calibration interval
RT198	Directional coupler (X-band)	5D364S	R05762	Shimada	12 March 2021	1 year
RT200	Power meter	E4419B	MY45101375	Agilent	25 February 2021	1 year
RT201	Power sensor	8481A	2349A39603	Agilent	25 February 2021	1 year
RT213	Waveguide	WRJ-10	--	Furuno	6 July 2020	1 year
HT1039	DC power supply	EX-1500H2	405410050099	Takasago	Not applicable.	--
HT1165	Climatic chamber (Extra-Large)	TBE-6E20W0P3T	3015006336	Espec	20 August 2020	1 year
HT167	Digital multimeter	E2377A	3651J18668	Agilent	3 February 2021	1 year

(2) For Clause3.2 Modulation Characteristics

C/N	Instrument	Type	S/N	Manufacturer	Date of last calibration	Calibration interval
RT198	Directional coupler (X-band)	5D364S	R05762	Shimada	12 March 2021	1 year
RT213	Waveguide	WRJ-10	--	Furuno	6 July 2020	1 year
HT654	Attenuator	8494B	MY42148134	Agilent	5 February 2021	1 year
HT1223	Attenuator	8495B	MY42148137	Agilent	3 March 2021	1 year
HT1221	Crystal detector	423B	MY51342422	Agilent	24 February 2021	1 year
HT972	Oscilloscope	MSO4054B	C030483	TEKTRONIX	28 February 2021	1 year
HT1039	DC power supply	EX-1500H2	405410050099	Takasago	Not applicable.	--
HT1165	Climatic chamber (Extra-Large)	TBE-6E20W0P3T	3015006336	Espec	20 August 2020	1 year
HT167	Digital multimeter	E2377A	3651J18668	Agilent	3 February 2021	1 year

(3) For Clause 3.3 Frequency Stability –temperature & voltage

C/N	Instrument	Type	S/N	Manufacturer	Date of last calibration	Calibration interval
RT198	Directional coupler (X-band)	5D364S	R05762	Shimada	12 March 2021	1 year
RT213	Waveguide	WRJ-10	--	Furuno	6 July 2020	1 year
HT654	Attenuator	8494B	MY42148134	Agilent	5 February 2021	1 year
HT1223	Attenuator	8495B	MY42148137	Agilent	3 March 2021	1 year
HT676	Spectrum analyzer	8564EC	4103A00440	Agilent	1 May 2020	1 year
HT1039	DC power supply	EX-1500H2	405410050099	Takasago	Not applicable.	--
HT1165	Climatic chamber (Extra-Large)	TBE-6E20W0P3T	3015006336	Espec	20 August 2020	1 year
HT167	Digital multimeter	E2377A	3651J18668	Agilent	3 February 2021	1 year

(4) For Clause 3.4 Occupied Bandwidth

C/N	Instrument	Type	S/N	Manufacturer	Date of last calibration	Calibration interval
RT198	Directional coupler (X-band)	5D364S	R05762	Shimada	12 March 2021	1 year
HT654	Attenuator	8494B	MY42148134	Agilent	5 February 2021	1 year
HT1223	Attenuator	8495B	MY42148137	Agilent	3 March 2021	1 year
HT676	Spectrum analyzer	8564EC	4103A00440	Agilent	1 May 2020	1 year
HT1039	DC power supply	EX-1500H2	405410050099	Takasago	Not applicable.	--
HT167	Digital multimeter	E2377A	3651J18668	Agilent	3 February 2021	1 year

(5) For Clause 3.5 Spurious Emissions at Antenna Port

C/N	Instrument	Type	S/N	Manufacturer	Date of last calibration	Calibration interval
RT198	Directional coupler (X-band)	5D364S	R05762	Shimada	12 March 2021	1 year
--	Adapter	X281A	--	HEWLETT PACKARD	Not applicable.	--
--	Adapter	BL00-6256-00	--	Orient Microwave	Not applicable.	--
--	Adapter	R281B	--	HEWLETT PACKARD	Not applicable.	--
HT676	Spectrum analyzer	8564EC	4103A00440	Agilent	1 May 2020	1 year
HT1039	DC power supply	EX-1500H2	405410050099	Takasago	Not applicable.	--
HT167	Digital multimeter	E2377A	3651J18668	Agilent	3 February 2021	1 year
KB289	Coaxial cable for radiated emission measurement	SF104A/11PC35/11PC35/5500MM	800048/4A	HUBER+ SUHNER	8 August 2020	1 year
KB181	Coaxial cable	SUCOFLEX 102A	1261/2A	HUBER+ SUHNER	8 August 2020	1 year

(6) For Clause 5.6 Field Strength of Spurious Radiation

C/N	Instrument	Type	S/N	Manufacturer	Date of last calibration	Calibration interval
HT779	Semi-anechoic chamber	10mSAC	90984	Tokin	SVSWR: 7 December 2020	3 years
HT1277	Test Software	EP5/RE	Ver.6.0.112	Toyo	Not applicable.	--
HT1270	EMI test receiver (2 Hz to 44 GHz)	ESW44	101841	Rohde & Schwarz	8 August 2020	1 year
HT758	Broadband horn antenna (1 GHz to 6 GHz)	BBHA9120B	522	Schwarzbeck	13 August 2020	1 year
HT759	Double ridged horn antenna & amp. (6 GHz to 18 GHz)	HAP06-18W	00000065	TOYO	13 August 2020	1 year
HT761	Double rigged horn antenna & amp. (18 GHz to 26 GHz)	HAP18-26N	00000017	TOYO	14 August 2020	1 year
HT762	Double rigged horn antenna & amp. (26 GHz to 40 GHz)	HAP26-40N	00000010	TOYO	14 August 2020	1 year
HT883	Test table	W1500-D1000-H800	No.01	JSE	Not applicable.	--
HT780	AC/DC power supply	ES18000W	9128767-1+9128767-2	NF	Not applicable.	--
HT866	Digital multimeter	115	19170029	Fluke	2 February 2020	1 year

6 RF Envelope and Spectrum of the Output Pulse

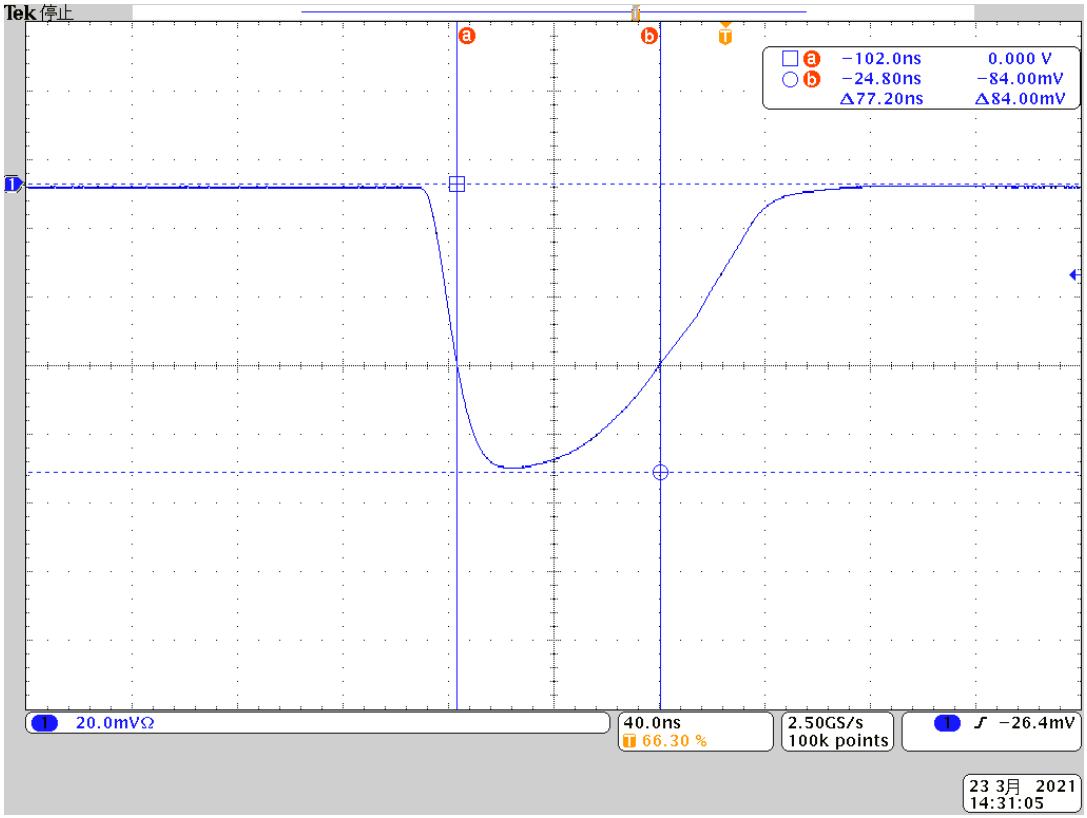


Fig. 6.1 S1 pulse envelope

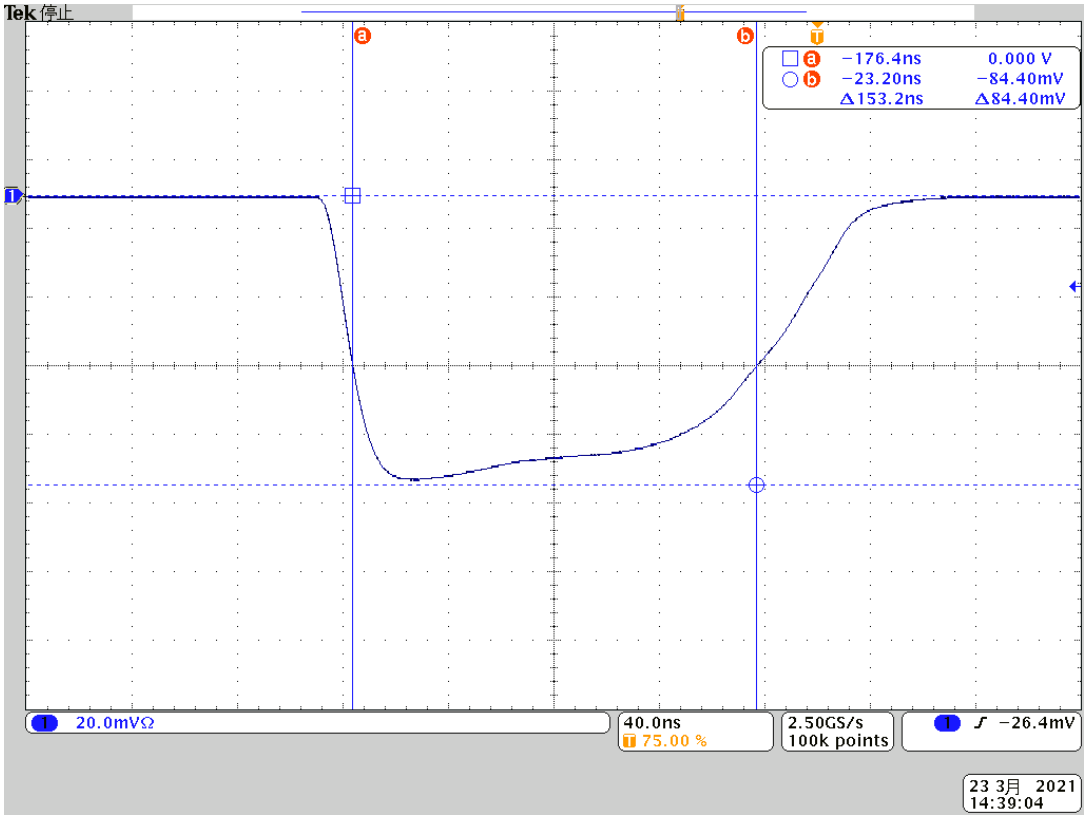


Fig. 6.2 S2 pulse envelope

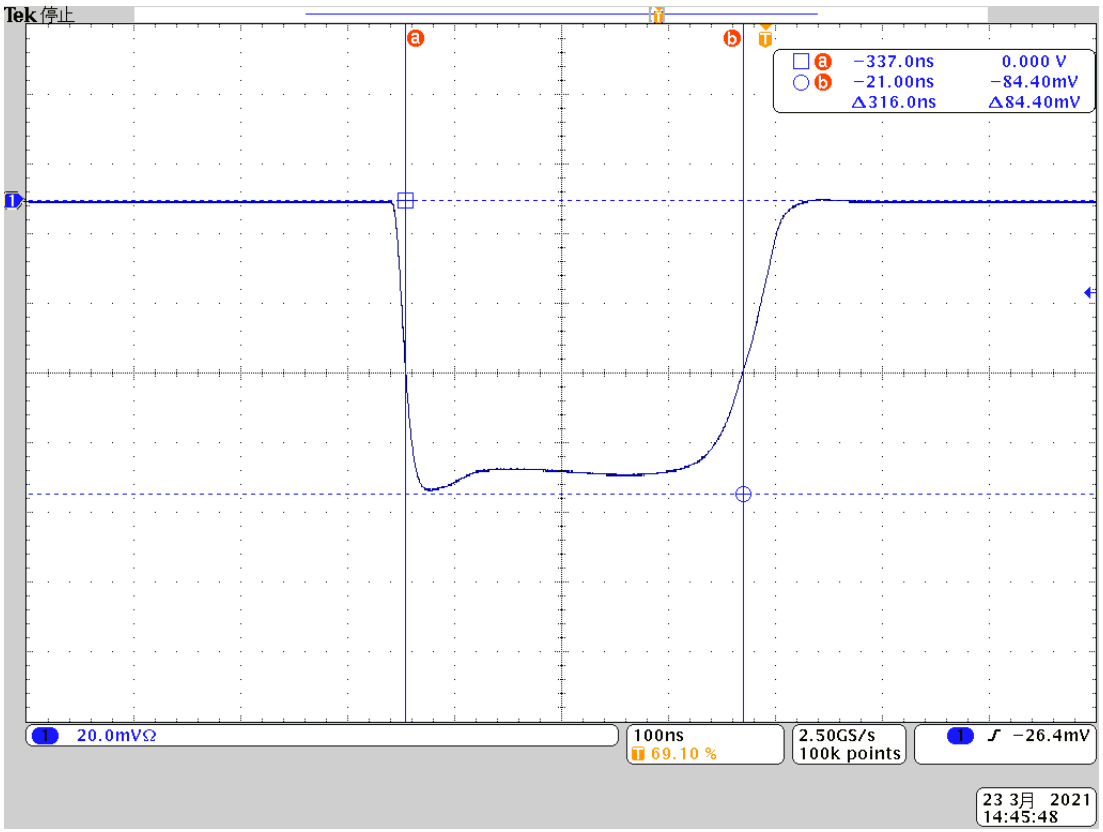


Fig. 6.3 M1 pulse envelope

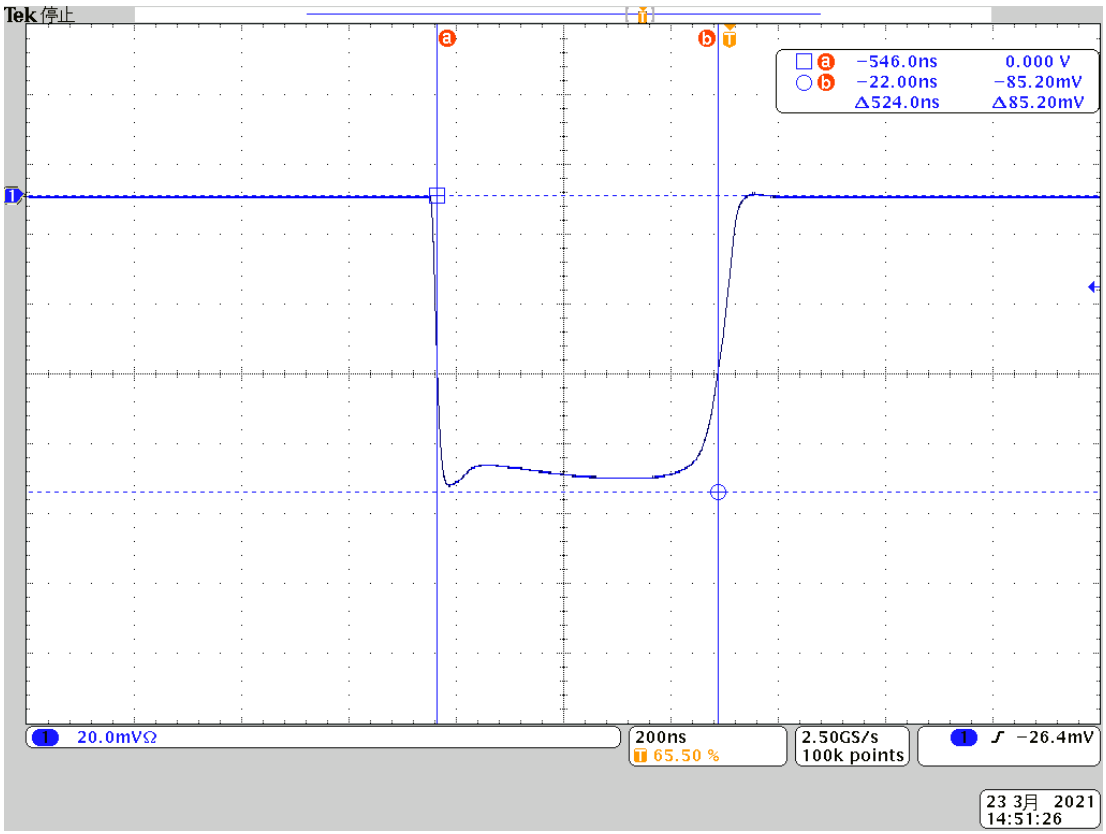


Fig. 6.4 M2 pulse envelope

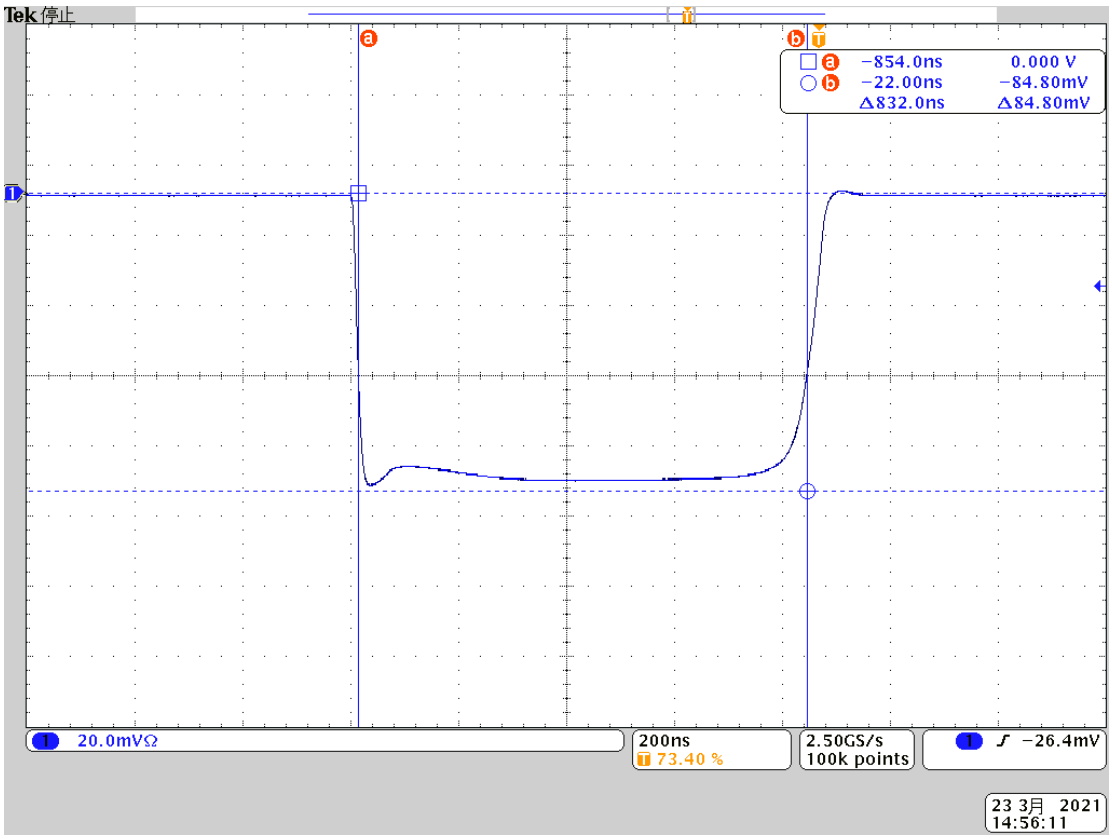


Fig. 6.5 M3 pulse envelope

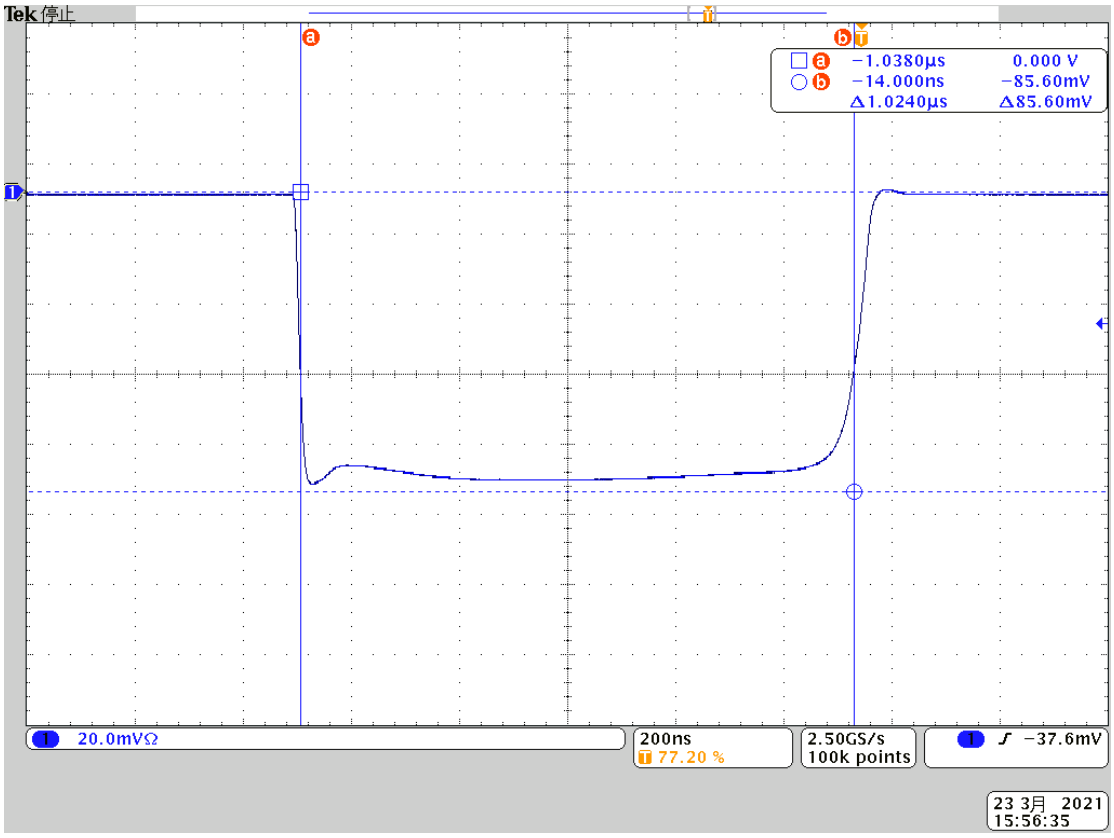
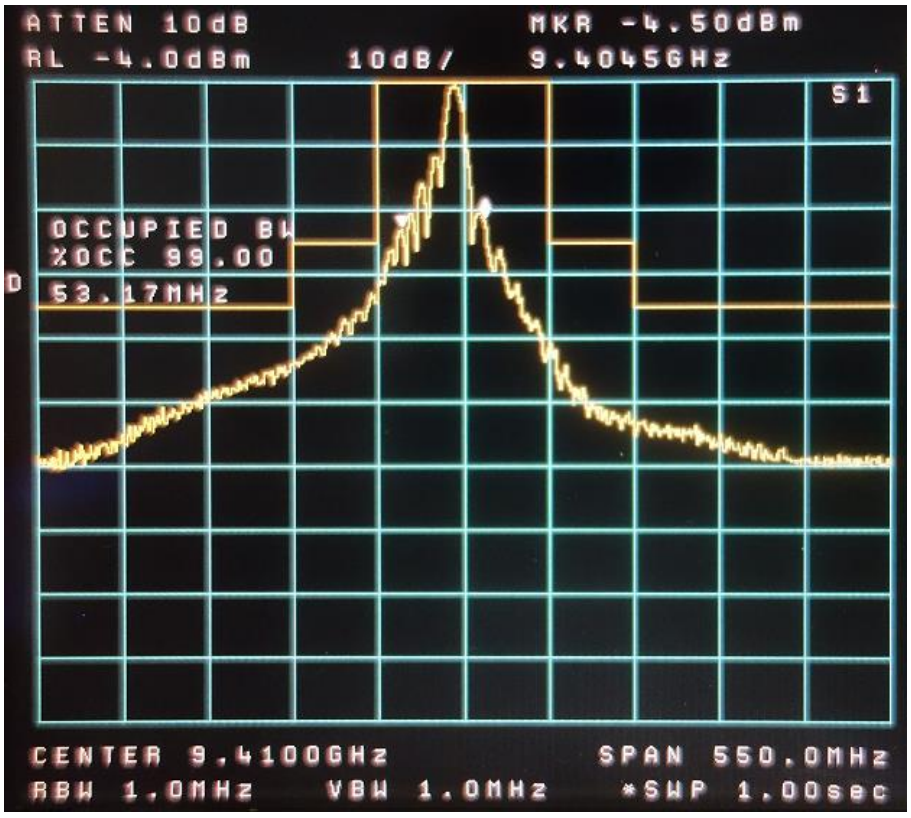


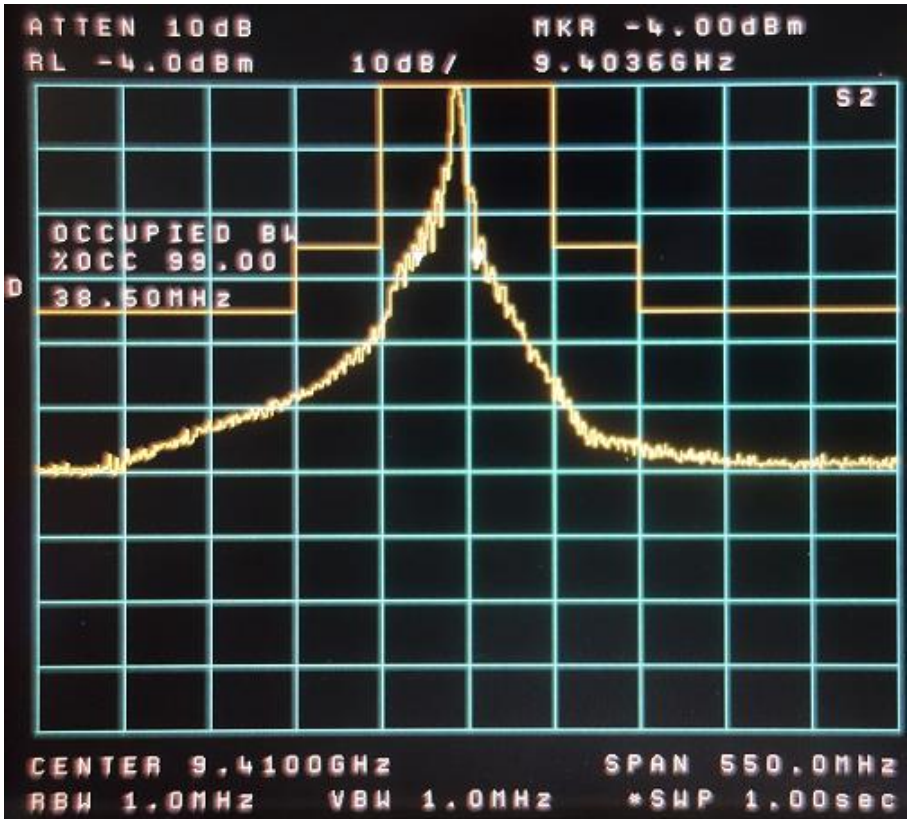
Fig. 6.6 L pulse envelope

7 Spurious Emission Plots measured at Antenna Terminal



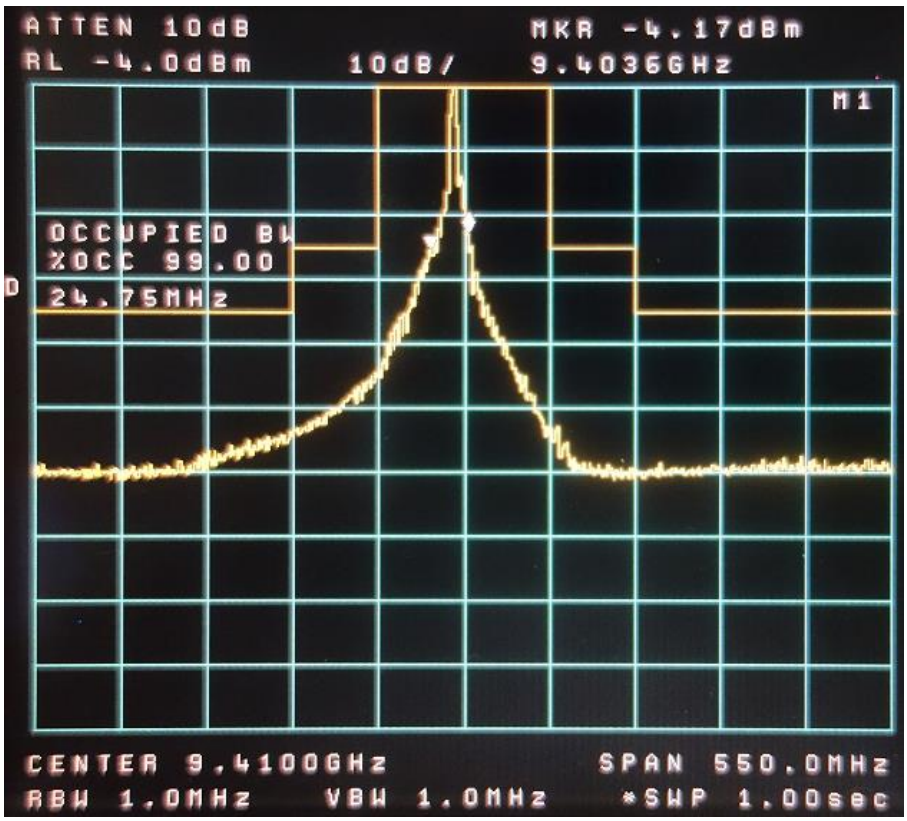
Limit

Fig. 7.1 for S1 pulse



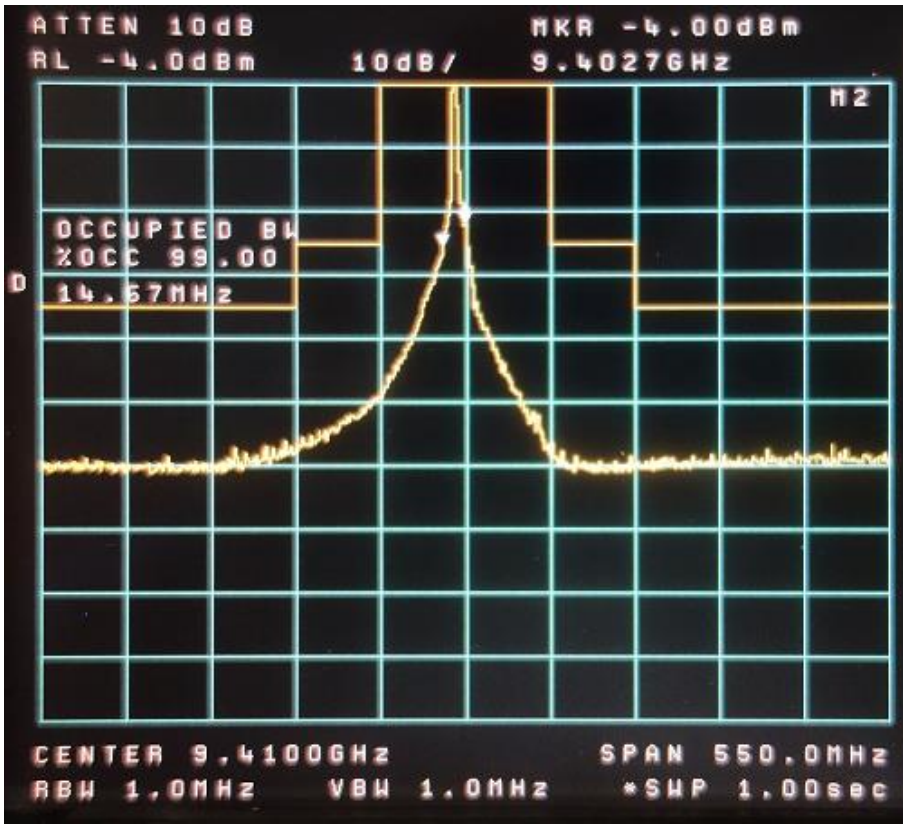
Limit

Fig. 7.2 for S2 pulse



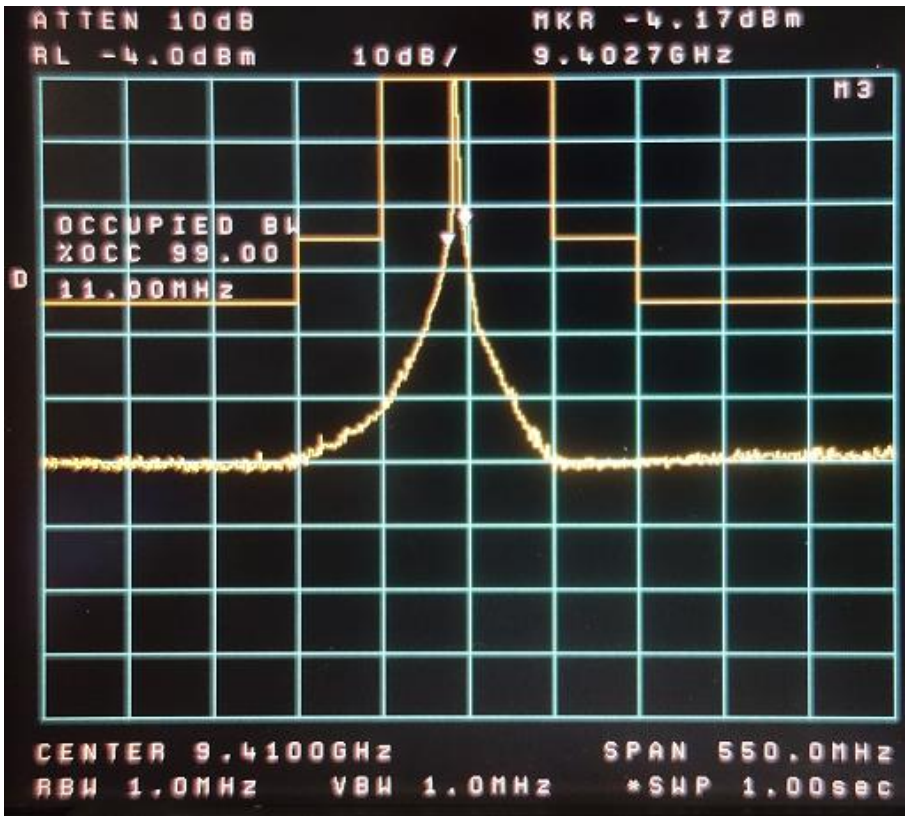
Limit

Fig. 7.3 for M1 pulse



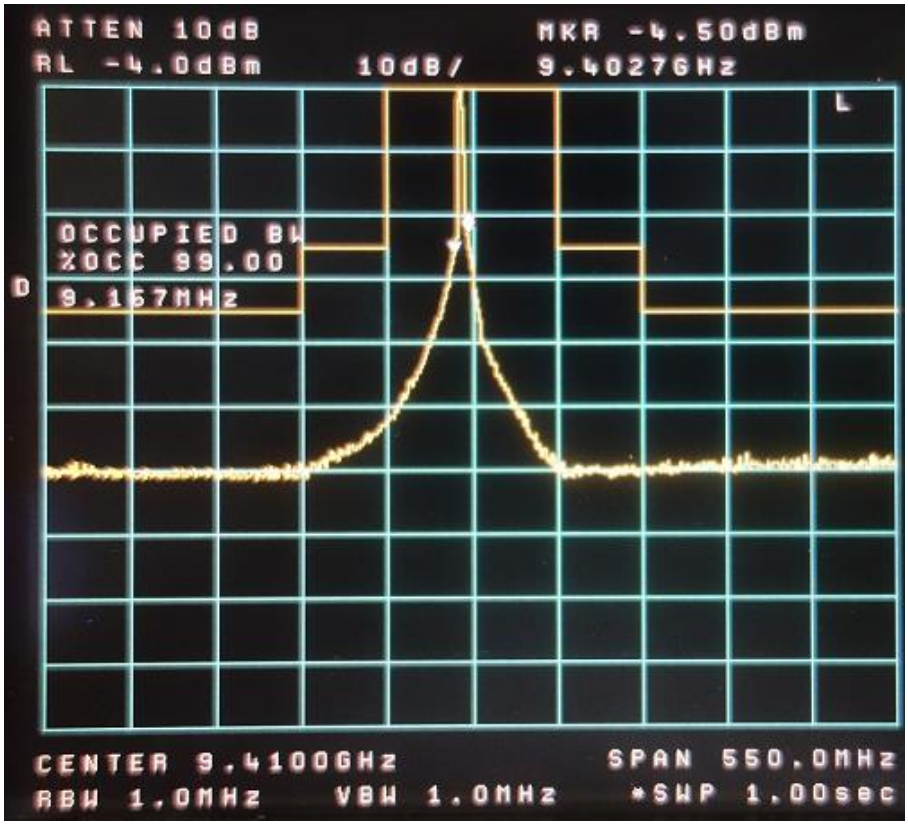
Limit

Fig. 7.4 for M2 pulse



Limit

Fig. 7.5 for M3 pulse



Limit

Fig. 7.6 for L pulse

End of text