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)
Part 90 (90.205, 90.207, 90.209, 90.210, 90.213, 90.215, 90.248)

for

Trade name: FURUNO
Model: Transceiver
for MARINE RADAR
FAR-2018-MARK-2, FAR-3015
Type: RTR-131

Report no.: LIC 12-22-119

Date of issue: 31 August 2022

Labotech International Co., Ltd.
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Report Summary

LIC project number:	LIC 04-22-0061		
Test report number of initial issue:	LIC 12-22-119	Date of initial issue	31 August 2022
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 90.205 - Power and antenna height limits 90.207 - Types of emissions 90.209 - Bandwidth limitations 90.210 - Emission masks 90.213 - Frequency stability 90.215 - Transmitter measurement 90.248 - Wildlife and ocean buoy tracking (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 MARINE RADAR FAR-2018-MARK-2, FAR-3015		
Type:	RTR-131		
Product function and intended use:	Marine radar: CAT 1C, 2C/ 1HC, 2HC		
Serial number:	See Clause 1.1 of this report.		
Power rating:	Powered via MARINE RADAR PROCESSOR UNIT (AU).		
Modifications made to samples during testing:	None		
Date of receipt of samples:	8 March 2022		
Test period:	4 May 2022 and from 1 June 2022 to 22 June 2022		

Place of test:	Labotech International Co., Ltd. - LABOTECH EMC Center FCC Test firm Designation Number: JP2007 FCC Test firm Registration Number: 838049 1-16, Fukazu-cho, Nishinomiya-shi, Hyogo, 663-8203 Japan - Nishinomiya Lab. FCC Test firm Designation Number: JP2010 FCC Test firm Registration Number: 696248 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. (*) For the test result in Clause 3.5 of this report, the measurement results for the frequency below 6.54 GHz were not taken into account as the final result of this test with the consent of the customer.
Approved by:	Date: 31 August 2022 Name: Tadayuki Ekawa Title: Manager, Testing & Facilities Control Section, 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 and the 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 Recognized Environmental Test Laboratory:
- recognized by Det Norske Veritas AS
- 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 accredited Testing Laboratory:
- accredited by American Association of Laboratory Accreditation (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/).

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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.
9-52, Ashihara-cho, Nishinomiya-city, Hyogo, 662-8580 Japan

(c) Model:

Transceiver for MARINE RADAR FAR-2018-MARK-2, FAR-2028-MARK-2, FAR-3015, FAR-3025

Name	Type	Serial number	Note
MARINE RADAR ANTENNA UNIT	RSB-146-131	R000-3000-0001	--
Transceiver	RTR-131	--	--
Scanner	RSB-146	--	Antenna rotation rate: 24/36/42 rpm
Performance monitor	PM-32A	--	--
ANTENNA RADIATOR	XN12AF	A010-6102	One (1) selectable. (*)
	XN20AF	A024-3942	
	XN24AF	A031-2690	

(*) Test was performed with ANTENNA RADIATOR XN12AF.

Associated units (AU)

Name	Type	Serial number	Note
MARINE RADAR PROCESSOR UNIT	RPU-025	1000-7910-0105	--
CONTROL UNIT	RCU-014	100068	--
MONITOR UNIT	MU-190	001436	--

Auxiliary Equipment (AE)

Name	Type	Serial number	Note
PC	PR6DNTC4447FD1	XK194109H	--
CONTROL UNIT	RCU-029	101216	--
MARINE RADAR DISPLAY UNIT	RDP-155	1000-5900-0004	--
AC/DC POWER SUPPLY UNIT	PR-241	999924	--
Dummy load	4D376	R4535001	--

(d) FCC ID: ADB9ZWRTR131

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

(f) Frequency range: Fixed frequency, X-band (9380–9440 MHz)

(g) Type of emission: P0N

(h) Occupied bandwidth:

Pulse type		S1	S2	M1	M2	M3	L
Occupied bandwidth (MHz)	TT24NM	47.55	30.30	23.68	12.51	8.94	8.06
	TT32NM	49.38	30.48	23.77	11.97	9.27	7.93
	2nd trace	48.89	29.95	22.10	13.01	9.09	7.84

Note: measured data

(i) Size and mass: MARINE RADAR ANTENNA UNIT
1260 mm (W) × 570 mm (H) × 449 mm (D), 39 kg (*1)
2040 mm (W) × 570 mm (H) × 449 mm (D), 44 kg (*2)
2550 mm (W) × 570 mm (H) × 449 mm (D), 46 kg (*3)
(*1) with ANTENNA RADIATOR (Type: XN12AF) installed.
(*2) with ANTENNA RADIATOR (Type: XN20AF) installed.
(*3) with ANTENNA RADIATOR (Type: XN24AF) installed.

(j) Power supply: 100-230 VAC, 50-60 Hz (*)
(*) Powered from MARINE RADAR PROCESSOR UNIT (AU), not directly from AC mains.

1.1.2 Transceiver module

Type: RTR-131 (Contained in MARINE RADAR ANTENNA UNIT)

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:
- Magnetron type: FNE1201
- Peak output power: 12 kW nominal
- Fundamental frequency: 9410 MHz
- Manufacturing: ±30 MHz
- Pulling: 25 MHz
- Tolerance for 20°C temperature variation: -5 MHz

(c) Pulse characteristics:

Pulse type		S1	S2	M1	M2	M3	L
Pulse length (μs)	P0N	0.07	0.15	0.30	0.50	0.70	1.2
PRF(Hz)	TT24NM	3000	3000	1500	1200	1000	600
	TT32NM	2200	2200	1200	1000	1000	600
	2nd trace	3000	3000	500	500	500	500

1.1.2.2 Modulator

(a) FET Type: 2SK4207
Trigger Voltage: Approx. +14.0 VDC positive

1.1.2.3 Receiver

(a) Passband

RF Stage: 300 MHz

IF Stage:

Pulse type	S1	S2	M1	M2	M3	L
Pass band (MHz)	18	11	11	4	4	1.7

(b) Intermediate Frequency: 60 MHz

(c) Gain (overall): Approximately 25.5 dB

(d) Overall Noise Figure: 4 dB (typical)

(e) Video Output Voltage: ±1 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 adjustment of tuning voltage of receiver local oscillator (Automatic and manual)

1.1.3 Antenna and Scanner

(a) Antenna specifications

Antenna model		XN12AF	XN20AF	XN24AF
Length (mm)		1260	2040	2550
Rotation diameter (mm)		1400	2200	2700
Transmission frequency		9410±30 MHz		
Horizontal beam width (-3 dB)		1.9°	1.23°	0.95°
Vertical beam width (-3 dB)		20°		
Side lobe (max.)	Less than ±10°	-24 dB	-28 dB	-28 dB
	Outside ±10°	-30 dB	-32 dB	-32 dB
Gain		27.5 dBi	30.0 dBi	31.5 dBi
Radiator		Slot array		
Polarization		Horizontal		
Type of beam		Vertical fan		

(b) Antenna Rotation ON-OFF Switch: Provided

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

(d) Antenna Rotation Rate: 24/36/42 rpm

(e) Sector Scan: Provided

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

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 (Hardware alarms)

(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: Antenna Unit (IEC 60529 – IP56)

(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 Antenna Unit: Not applicable

1.2 Observation and comments

For Spurious Emissions at Antenna Terminals in Clause 3.5 of this report, the measurement for the frequency below 6.54 GHz were unmeasurable due to the large path loss. The measurement results for the frequency below 6.54 GHz were not taken into account as the final result of this test with the consent of the customer.

2 Test Results Summary

Clause number of this report	CFR Title 47 Sections	Item	Result	Test engineer
3.1	2.1046 (a) 80.215 90.205 (s)	RF Power Output	Passed.	Y. Hijiri
3.2	2.201 2.1047 (d) 90.207	Modulation Characteristics	Passed.	Y. Hijiri
3.3	2.1055 (a)(2),(d)(1),(d)(3) 80.209 (b) 90.213 90.248	Frequency Stability –temperature & voltage	Passed.	Y. Hijiri
3.4	2.202 (a) 2.1049 (c)(1) 80.209 (b) 80.211 (f) 90.210 (b)	Occupied Bandwidth	Passed.	Y. Hijiri
3.5	2.1051 80.211 (f) 80.273 90.210 90.215	Spurious Emissions at Antenna Terminals	Passed. (*)	Y. Hijiri
3.6	2.1053 80.211 (f) 90.210 90.215	Field Strength of Spurious Radiation	Passed.	Y. Katoh and N. Yasuda

(*) The measurement results for the frequency below 6.54 GHz were not taken into account as the final result of this test with the consent of the customer.

3 Test Results

3.1 RF Power Output

3.1.1 Test conditions:

For all TX (S1/S2/M1/M2/M3/L) pulses, the transmitter output power was measured at the antenna port with a non-reflective load as a substitute for ANTENNA RADIATOR.

3.1.2 Test setup:

See Clause 4.

3.1.3 Test Results:

Complied.

TT24NM mode (Normal mode)

Pulse type	S1	S2	M1	M2	M3	L
Transmission mean power Pm (W)	1.7	3.4	4.3	5.8	6.9	7.1
Pulse length *T* (μs) (50% points)	0.073	0.137	0.297	0.485	0.700	1.192
Pulse Repetition Frequency (Hz)	3000.0	3000.0	1500.0	1200.0	999.8	600.0
Transmission pulse power Pp (kW) (*)	8.0	8.3	9.6	9.9	9.9	9.9

TT32NM mode

Pulse type	S1	S2	M1	M2	M3	L
Transmission mean power Pm (W)	1.3	2.5	4.3	5.8	6.9	7.1
Pulse length *T* (μs) (50% points)	0.075	0.138	0.299	0.485	0.698	1.192
Pulse Repetition Frequency (Hz)	2199.0	2199.0	1500.0	1200.0	999.8	600.0
Transmission pulse power Pp (kW) (*)	7.8	8.4	9.6	9.9	10.0	10.0

2nd trace mode

Pulse type	S1	S2	M1	M2	M3	L
Transmission mean power Pm (W)	1.7	3.4	1.4	2.5	3.6	6.0
Pulse length *T* (μs) (50% points)	0.074	0.137	0.298	0.487	0.700	1.188
Pulse Repetition Frequency (Hz)	3000.0	3000.0	500.0	500.0	500.0	500.0
Transmission pulse power Pp (kW) (*)	7.9	8.3	9.7	10.1	10.2	10.1

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

Environmental conditions observed: On 15 June 2022, 22°C to 22°C, 74%RH to 74%RH

Power supply voltage measured: 100 VAC, 60 Hz to 100 VAC, 60 Hz （*）

(*) The power supplied to MARINE RADAR PROCESSOR UNIT (AU).

3.2 Modulation Characteristics

3.2.1 Test Conditions:

The RF envelope of the 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:

Complied.

TT24NM mode (Normal mode)

Pulse type	S1	S2	M1	M2	M3	L
Pulse length T (μs) (50% points)	0.073	0.137	0.297	0.485	0.700	1.192
Rise time t_r (μs) (10 to 90 % amplitude)	0.023	0.028	0.073	0.074	0.077	0.076
Fall time t_f (μs) (90 to 10 % amplitude)	0.061	0.065	0.114	0.121	0.120	0.121
Pulse Repetition Frequency (Hz)	3000	3000	1500	1200	1000	600

TT32NM mode

Pulse type	S1	S2	M1	M2	M3	L
Pulse length T (μs) (50% points)	0.075	0.138	0.299	0.485	0.698	1.192
Rise time t_r (μs) (10 to 90 % amplitude)	0.023	0.029	0.074	0.074	0.078	0.077
Fall time t_f (μs) (90 to 10 % amplitude)	0.060	0.065	0.118	0.118	0.121	0.120
Pulse Repetition Frequency (Hz)	2199	2199	1500	1200	1000	600

2nd trace mode

Pulse type	S1	S2	M1	M2	M3	L
Pulse length T (μs) (50% points)	0.074	0.137	0.298	0.487	0.700	1.188
Rise time t_r (μs) (10 to 90 % amplitude)	0.022	0.029	0.073	0.076	0.077	0.076
Fall time t_f (μs) (90 to 10 % amplitude)	0.062	0.066	0.120	0.128	0.116	0.119
Pulse Repetition Frequency (Hz)	3000	3000	500	500	500	500

Measured Plots: See Clause 6.

Environmental conditions observed: On 14 June 2022, 22°C to 22°C, 74%RH to 74%RH
Power supply voltage measured: 100 VAC, 60 Hz to 100 VAC, 60 Hz (*)
(*) The power supplied to MARINE RADAR PROCESSOR UNIT (AU).

3.3 Frequency Stability –temperature & voltage

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

MARINE RADAR PROCESSOR UNIT: 100 VAC – 230 VAC

V_L: 85 VAC / V_{nom}: 100 VAC / V_H: 264.5 VAC

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) and 90.213(a)):

TT24NM mode

Pulse type	S1	S2	M1	M2	M3	L
Guard Band f(1.5/T) (MHz) (*1)	20.6	10.9	5.1	3.1	2.1	1.3
Upper limit (MHz) (*2)	9479.4	9489.1	9494.9	9496.9	9497.9	9498.7
Lower limit (MHz) (*2)	9320.6	9310.9	9305.1	9303.1	9302.1	9301.3

TT32NM mode

Pulse type	S1	S2	M1	M2	M3	L
Guard Band f(1.5/T) (MHz) (*1)	20.1	10.9	5.0	3.1	2.1	1.3
Upper limit (MHz) (*2)	9479.9	9489.1	9495.0	9496.9	9497.9	9498.7
Lower limit (MHz) (*2)	9320.1	9310.9	9305.0	9303.1	9302.1	9301.3

2nd trace mode

Pulse type	S1	S2	M1	M2	M3	L
Guard Band f(1.5/T) (MHz) (*1)	20.4	10.9	5.0	3.1	2.1	1.3
Upper limit (MHz) (*2)	9479.6	9489.1	9495.0	9496.9	9497.9	9498.7
Lower limit (MHz) (*2)	9320.4	9310.9	9305.0	9303.1	9302.1	9301.3

(*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 100 VAC, 60 Hz:

TT24NM mode

Pulse type		S1	S2	M1	M2	M3	L	Result
Frequency at maximum emission (MHz)	-30°C	9426.1	9424.9	9424.2	9422.3	9421.1	9420.9	Complied.
	-20°C	9424.5	9423.4	9422.9	9421.0	9420.0	9420.1	Complied.
	-10°C	9422.6	9420.8	9420.3	9418.4	9417.3	9417.3	Complied.
	0°C	9420.6	9419.3	9418.5	9416.4	9415.2	9415.2	Complied.
	+10°C	9418.6	9417.1	9416.3	9414.4	9413.1	9413.2	Complied.
	+20°C	9416.3	9414.7	9413.7	9411.9	9410.8	9411.1	Complied.
	+30°C	9415.0	9413.6	9412.7	9410.6	9409.0	9408.6	Complied.
	+40°C	9412.7	9410.8	9409.9	9407.8	9406.8	9406.7	Complied.
	+50°C	9410.4	9408.9	9407.8	9405.9	9404.9	9405.0	Complied.

TT32NM mode

Pulse type		S1	S2	M1	M2	M3	L	Result
Frequency at maximum emission (MHz)	-30°C	9426.5	9425.8	9424.8	9422.8	9421.8	9421.6	Complied.
	-20°C	9425.2	9423.7	9422.6	9420.7	9419.6	9419.5	Complied.
	-10°C	9423.1	9421.8	9420.3	9418.5	9417.4	9417.3	Complied.
	0°C	9420.3	9419.6	9418.1	9416.2	9414.9	9415.0	Complied.
	+10°C	9419.3	9417.9	9416.6	9414.6	9413.5	9413.4	Complied.
	+20°C	9417.3	9416.7	9414.7	9412.4	9411.1	9410.8	Complied.
	+30°C	9415.0	9413.3	9411.8	9409.7	9408.7	9408.6	Complied.
	+40°C	9412.3	9410.9	9409.4	9407.6	9406.6	9406.5	Complied.
	+50°C	9410.7	9409.0	9407.3	9405.3	9404.2	9404.0	Complied.

2nd trace mode

Pulse type		S1	S2	M1	M2	M3	L	Result
Frequency at maximum emission (MHz)	-30°C	9426.9	9426.0	9427.7	9427.1	9424.5	9422.4	Complied.
	-20°C	9425.0	9423.9	9425.4	9424.1	9422.9	9420.8	Complied.
	-10°C	9422.8	9421.7	9423.1	9421.9	9420.8	9418.6	Complied.
	0°C	9420.6	9419.3	9420.8	9419.4	9418.3	9416.2	Complied.
	+10°C	9418.9	9417.5	9419.0	9417.6	9416.1	9414.0	Complied.
	+20°C	9417.3	9416.3	9417.5	9416.2	9415.2	9411.6	Complied.
	+30°C	9415.3	9414.0	9415.1	9413.6	9412.4	9410.4	Complied.
	+40°C	9413.3	9411.5	9412.4	9410.7	9409.6	9407.7	Complied.
	+50°C	9411.1	9409.5	9410.6	9408.8	9407.7	9405.5	Complied.

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

TT24NM mode

Pulse type		S1	S2	M1	M2	M3	L	Result
Frequency at maximum emission (MHz)	V_L	9416.5	9415.5	9414.3	9412.6	9411.5	9411.0	Complied.
	V_{nom}	9416.3	9414.7	9413.7	9411.9	9410.8	9411.1	Complied.
	V_H	9416.3	9414.5	9413.5	9411.9	9410.7	9411.0	Complied.

TT32NM mode

Pulse type		S1	S2	M1	M2	M3	L	Result
Frequency at maximum emission (MHz)	V_L	9417.3	9415.6	9413.8	9412.1	9410.8	9410.8	Complied.
	V_{nom}	9417.3	9416.7	9414.7	9412.4	9411.1	9410.8	Complied.
	V_H	9416.6	9415.4	9413.5	9411.8	9410.8	9410.9	Complied.

2nd trace mode

Pulse type		S1	S2	M1	M2	M3	L	Result
Frequency at maximum emission (MHz)	V_L	9417.2	9415.8	9416.8	9415.6	9414.7	9411.6	Complied.
	V_{nom}	9417.3	9416.3	9417.5	9416.2	9415.2	9411.6	Complied.
	V_H	9417.0	9415.9	9416.8	9415.8	9414.7	9411.6	Complied.

Environmental conditions observed: On 1 June 2022, 23°C to 23°C, 55%RH to 55%RH
On 2 June 2022, 23°C to 23°C, 59%RH to 52%RH
On 9 June 2022, 23°C to 23°C, 59%RH to 59%RH
On 10 June 2022, 23°C to 23°C, 55%RH to 55%RH

Power supply voltage measured: 100 VAC, 60 Hz to 100 VAC, 60 Hz (*)

(*) The power supplied to MARINE RADAR PROCESSOR UNIT (AU).

3.4 Occupied Bandwidth

3.4.1 Test conditions:

For all TX (S1/S2/M1/M2/M3/L) pulses, the transmitter output power was measured at the antenna port with a non-reflective load as a substitute for 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 = 200 MHz (for X-band radars)

3.4.4 Test Results:

Complied.

Spectrum plots: See Clause 7.1.

Environmental conditions observed: On 16 June 2022, 24°C to 24°C, 75%RH to 75%RH

Power supply voltage measured: 100 VAC, 60 Hz to 100 VAC, 60 Hz (*)

(*) The power supplied to MARINE RADAR PROCESSOR UNIT (AU).

3.5 Spurious Emissions at Antenna Terminals

3.5.1 Test Conditions:

(a) For S1 pulse, the transmitter output power was measured at the antenna port with a non-reflective load converter as a substitute for 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 (*1) to the lower OoB boundary	From the upper OoB boundary to 40 GHz

(*1) 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 = 200 MHz (for X-band radars)
(*3) Spurious measurement range for X-band radar (WRJ-10): 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. (*)

(*) The measurement results for the frequency below 6.54 GHz were not taken into account as the final result of this test with the consent of the customer.

Measured maximum emission value

Frequency (GHz)	Level (dBm)	Limit (dBm)	Margin (dB)
18.8329	-48.21	-13	35.21

Spectrum plots: See Clause 7.2.

Environmental conditions observed: On 22 June 2022, 24°C to 24°C, 56%RH to 56%RH
Power supply voltage measured: 100 VAC, 60 Hz to 100 VAC, 60 Hz (*)
(*) The power supplied to MARINE RADAR PROCESSOR UNIT (AU).

3.6 Field Strength of Spurious Radiation

3.6.1 Test Conditions:

(a) For S1 pulse, the transmitter output power was measured at the antenna port with a non-reflective load as a substitute for 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 (*1) to the lower OoB boundary	From the upper OoB boundary to 40 GHz

(*1) 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 (2.01 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 = 200 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.

Measured maximum emission value

Frequency (GHz)	Level (dBμV/m)	Limit (dBμV/m) (*1)	Margin (dB)
17.663	55.65	82.2	26.5

(*1) -13 dBm = 82.2 dBμV/m (3 m) (Refer to ITU-R SM.329-12/ Annex 1, Section 3.)

Spectrum plots: See Clause 8.

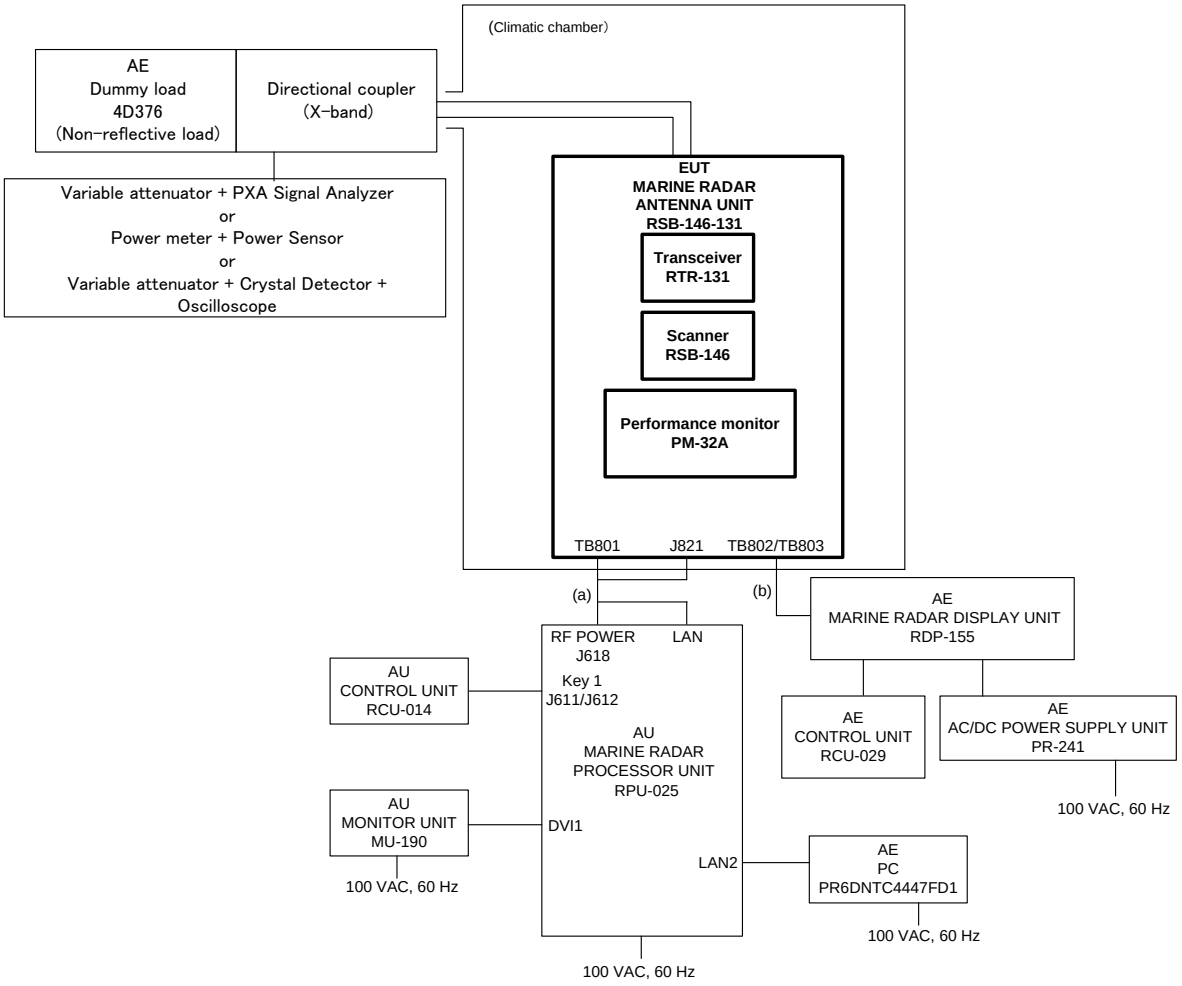
Environmental conditions observed: On 4 May 2022, 20°C to 20°C, 56%RH to 56%RH

Power supply voltage measured: 100 VAC, 60 Hz to 100 VAC, 60 Hz (*)

(*) The power supplied to MARINE RADAR PROCESSOR UNIT (AU).

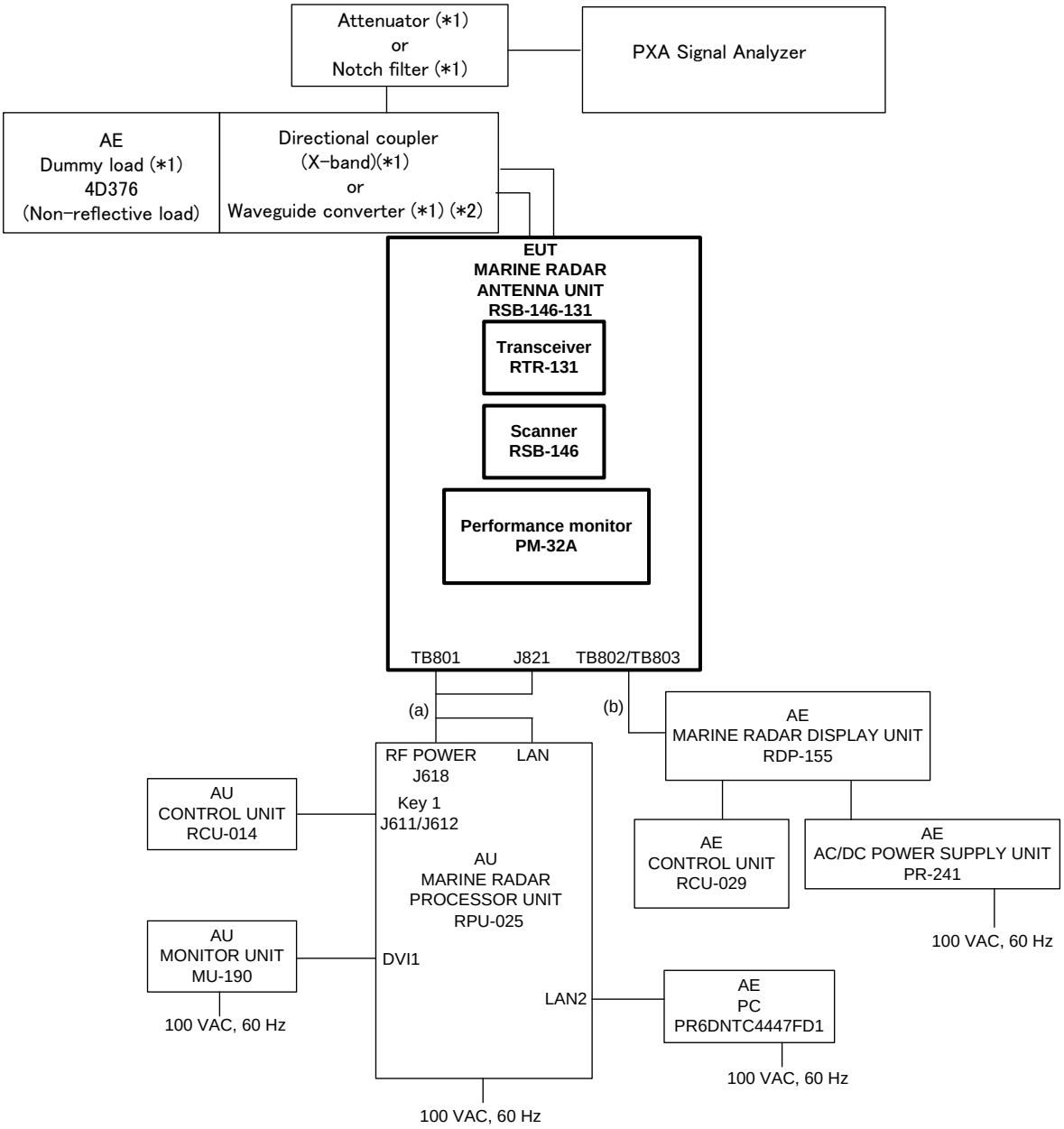
4 Test Setup for Measurements

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



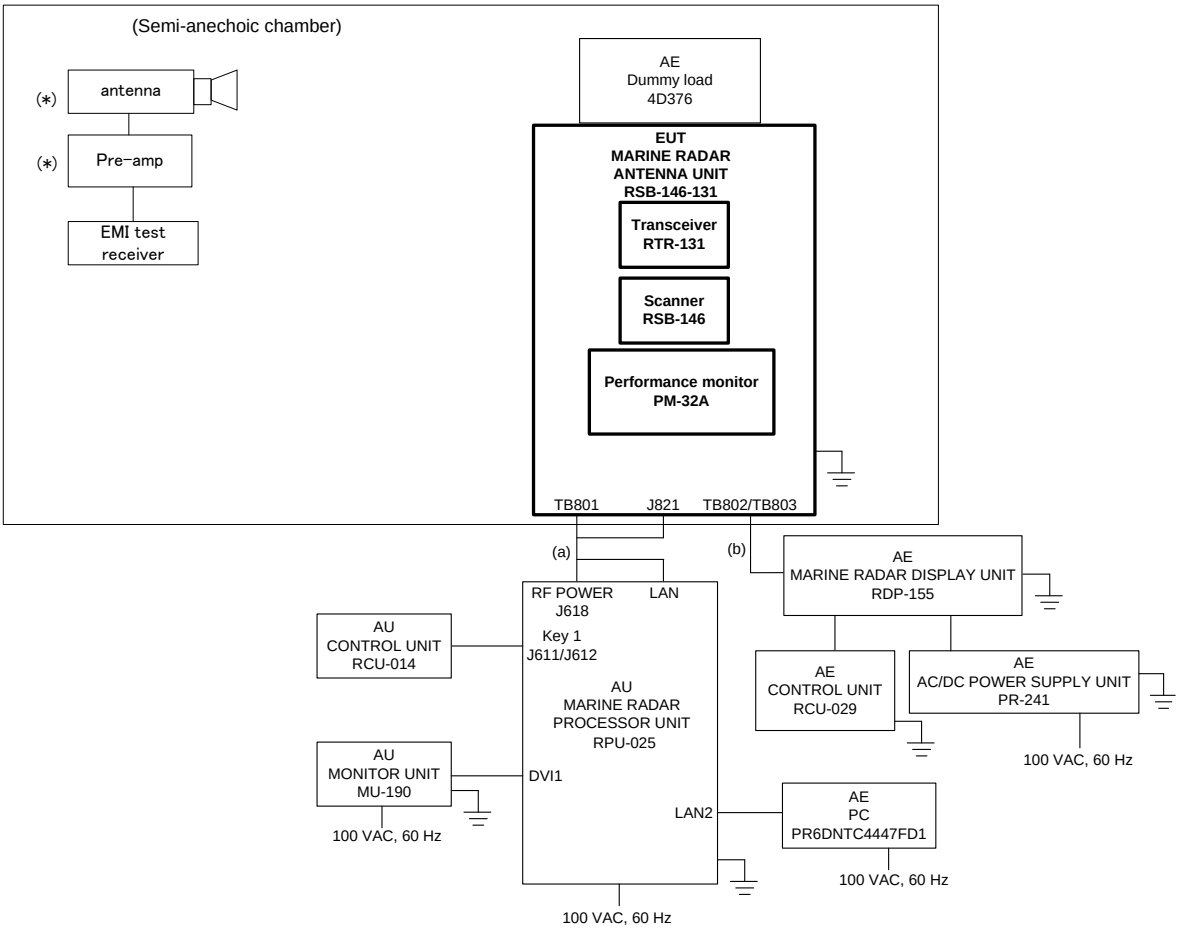
Note: For the test of “Spurious Emissions at Antenna Port”, the test was conducted with the EUT outside the climatic chamber.

4.2 Test Setup for Clause 3.5



(*1) Used depending on measurement frequency bandwidth.
(*2) Submitted by the customer.

4.3 Test Setup for Clause 3.6



(*) Used depending on measurement frequency bandwidth.

Cable designations

No.	Category	Name	Type	Length (m)	Number of cables used	Cable shielded
a	Signal/control	Multicore cable	RW-00135	20	1	Yes
b	Signal/control	Multicore cable	RW-00136	20	1	Yes

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	8 April 2022	1 year
RT200	Power meter	E4419B	MY45101375	ANRITSU	3 March 2022	1 year
RT201	Power sensor	8481A	2349A39603	Agilent	7 March 2022	1 year
RT213	Waveguide	WRJ-10	--	Furuno	13 July 2021	1 year
HT654	Attenuator	8494B	MY42148134	Agilent	7 March 2022	1 year
HT1223	Attenuator	8495B	MY42148137	Agilent	7 March 2022	1 year
HT972	Oscilloscope	MSO4054B	C030483	TEKTRONIX	11 March 2022	1 year
HT415	Climatic chamber (Small)	PL-4KP	14004204	Espec	21 July 2021	1 year
HT724	Paperless recorder/ Dual communication logger	FX106-4-1	S5JA01450	Yokogawa	Not applicable.	--
HT461	Digital multi-meter	111	78410077	Fluke	6 January 2022	1 year

(2) For Clause 3.2 Modulation Characteristics

C/N	Instrument	Type	S/N	Manufacturer	Date of last calibration	Calibration interval
RT198	Directional coupler (X-band)	5D364S	R05762	Shimada	8 April 2022	1 year
RT213	Waveguide	WRJ-10	--	Furuno	13 July 2021	1 year
HT654	Attenuator	8494B	MY42148134	Agilent	7 March 2022	1 year
HT1223	Attenuator	8495B	MY42148137	Agilent	7 March 2022	1 year
HT1317	PXA Signal Analyzer	N9030B	SG57142024	KEYSIGHT	9 March 2022	1 year
HT415	Climatic chamber (Small)	PL-4KP	14004204	Espec	21 July 2021	1 year
HT724	Paperless recorder/ Dual communication logger	FX106-4-1	S5JA01450	Yokogawa	Not applicable.	--
HT1204	Programmable AC power source	DP045M	9158465	NF	Not applicable.	--
HT461	Digital multi-meter	111	78410077	Fluke	6 January 2022	1 year
HT1221	Crystal detector	423B	MY51342422	Agilent	5 March 2022	1 year
HT972	Oscilloscope	MSO4054B	C030483	TEKTRONIX	11 March 2022	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	8 April 2022	1 year
RT213	Waveguide	WRJ-10	--	Furuno	13 July 2021	1 year
HT654	Attenuator	8494B	MY42148134	Agilent	7 March 2022	1 year
HT1223	Attenuator	8495B	MY42148137	Agilent	7 March 2022	1 year
HT1317	PXA Signal Analyzer	N9030B	SG57142024	KEYSIGHT	9 March 2022	1 year
HT415	Climatic chamber (Small)	PL-4KP	14004204	Espec	21 July 2021	1 year
HT724	Paperless recorder/ Dual communication logger	FX106-4-1	S5JA01450	Yokogawa	Not applicable.	--
HT1204	Programmable AC power source	DP045M	9158465	NF	Not applicable.	--
HT461	Digital multi-meter	111	78410077	Fluke	6 January 2022	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	SPC Electronics	8 April 2022	1 year
HT654	Attenuator	8494B	MY42148134	Agilent	7 March 2022	1 year
HT1223	Attenuator	8495B	MY42148137	Agilent	7 March 2022	1 year
HT1317	PXA Signal Analyzer	N9030B	SG57142024	KEYSIGHT	9 March 2022	1 year
HT1204	Programmable AC power source	DP045M	9158465	NF	Not applicable.	--
HT461	Digital multi-meter	111	78410077	Fluke	6 January 2022	1 year

(5) For Clause 3.5 Spurious Emissions at Antenna Terminals

C/N	Instrument	Type	S/N	Manufacturer	Date of last calibration	Calibration interval
RT198	Directional coupler (X-band)	5D364S	R05762	Aeroflex/ Weinschel	8 April 2022	1 year
--	Adapter	X281A	--	HEWLETT PACKARD	Not applicable.	--
--	Adapter	K281C	--	Agilent	Not applicable.	--
--	Adapter	R281B	00472	HEWLETT PACKARD	Not applicable.	--
--	Isolator	OMC FX0157	--	--	Not applicable.	--
HT1328	Notch filter	BRC20663	001	MICRO-TRONICS	18.August 2021	1 year
HT1317	PXA Signal Analyzer	N9030B	SG57142024	KEYSIGHT	9 March 2022	1 year
HT1204	Programmable AC power source	DP045M	9158465	NF	Not applicable.	--
HT461	Digital multi-meter	111	78410077	Fluke	6 January 2022	1 year
KB289	Coaxial cable	SF104A/11PC35/11 PC35/5500MM	800048/4A	HUBER+ SUHNER	7 August 2021	1 year
KB181	Coaxial cable	SUCOFLEX 102A	1261/2A	HUBER+ SUHNER	7 August 2021	1 year
HT1223	Attenuator	8495B	MY42148137	Agilent	7 March 2022	1 year
HT654	Attenuator	8494B	MY42148134	Agilent	7 March 2022	1 year

(6) For Clause 3.6 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: 9 December 2019	3 years
HT1277	Test software	EP5/RE	Ver.6.0.112	Toyo	--	--
HT1270	EMI test receiver (2 Hz to 44 GHz)	ESW44	101841	Rohde & Schwarz	7 August 2021	1 year
NK004	Double rigged horn antenna (1 GHz to 18 GHz)	TR17206	93370015	Advantest	7 August 2021	1 year
HT761	Double rigged horn antenna & amp. (18 GHz to 26 GHz)	HAP18-26N	00000017	Toyo	11 August 2021	1 year
HT762	Double rigged horn antenna & amp. (26 GHz to 40 GHz)	HAP26-40N	00000010	Toyo	1 December 2021	1 year
HT866	Digital multimeter	115	19170029	Fluke	1 February 2022	1 year
HT780	Programmable AC/DC power supply	ES18000W	9128767-1 +9128767-2	NF	Not applicable.	--

6 RF Envelope and Spectrum of the Output Pulse

TT24NM mode

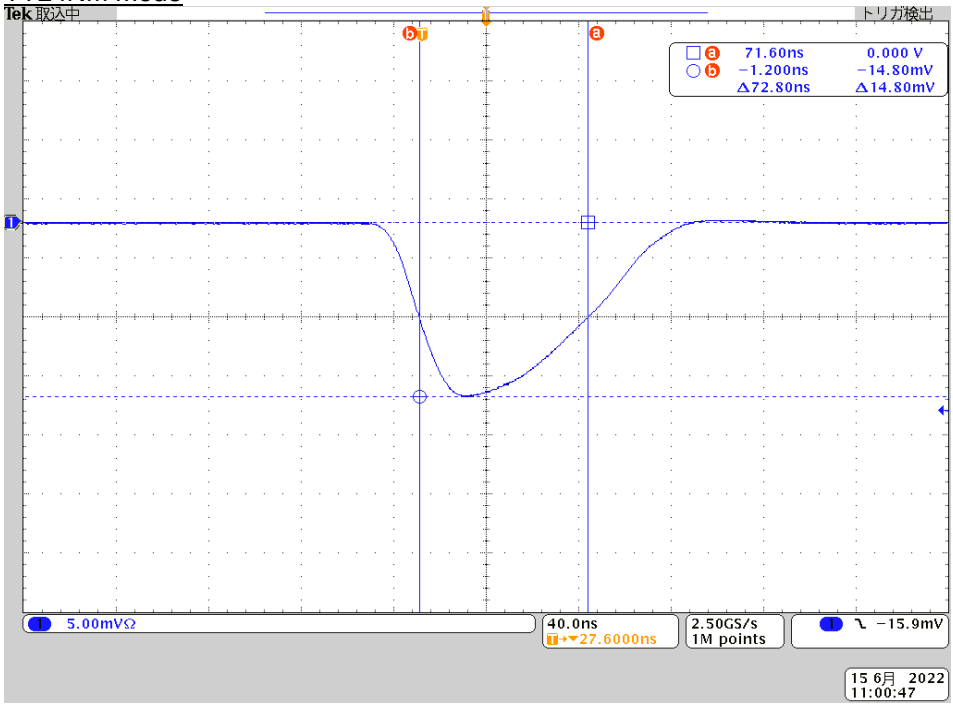


Fig. 6.1 S1 pulse envelope

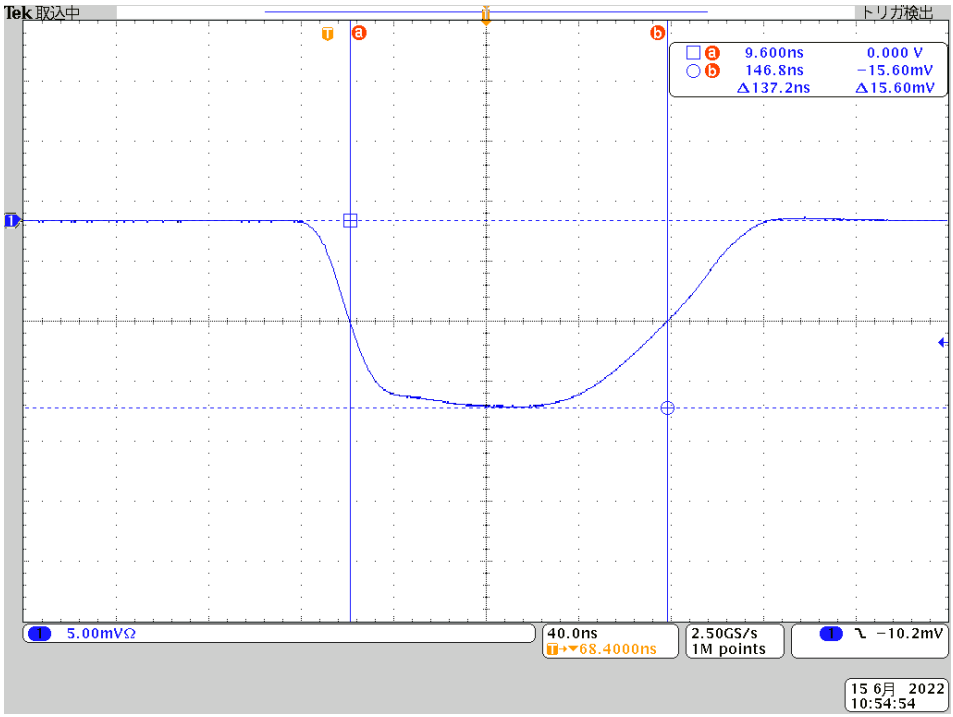


Fig. 6.2 S2 pulse envelope

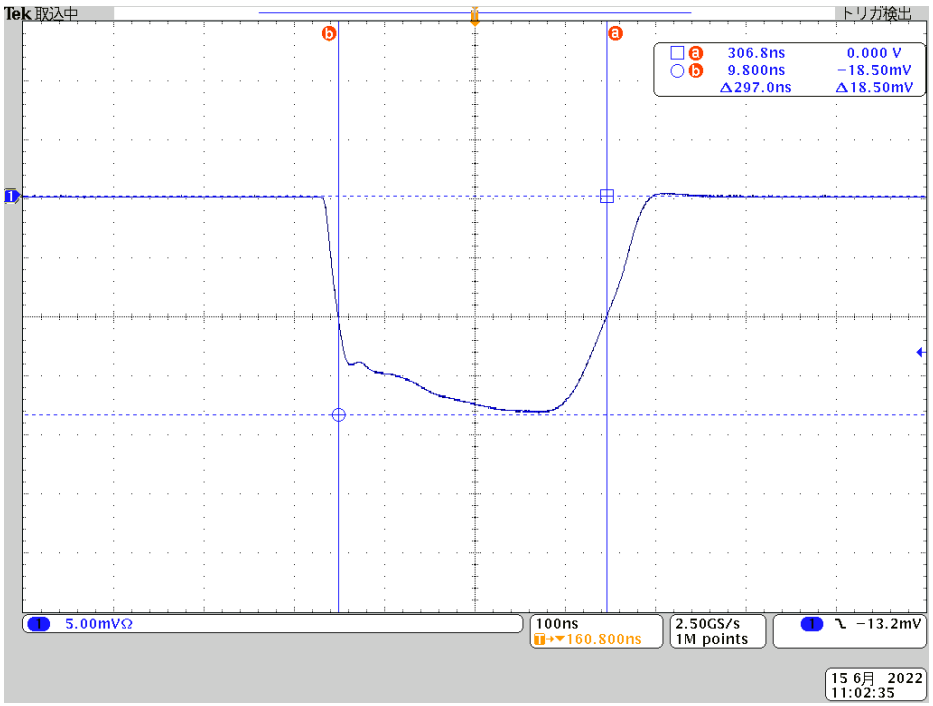


Fig. 6.3 M1 pulse envelope

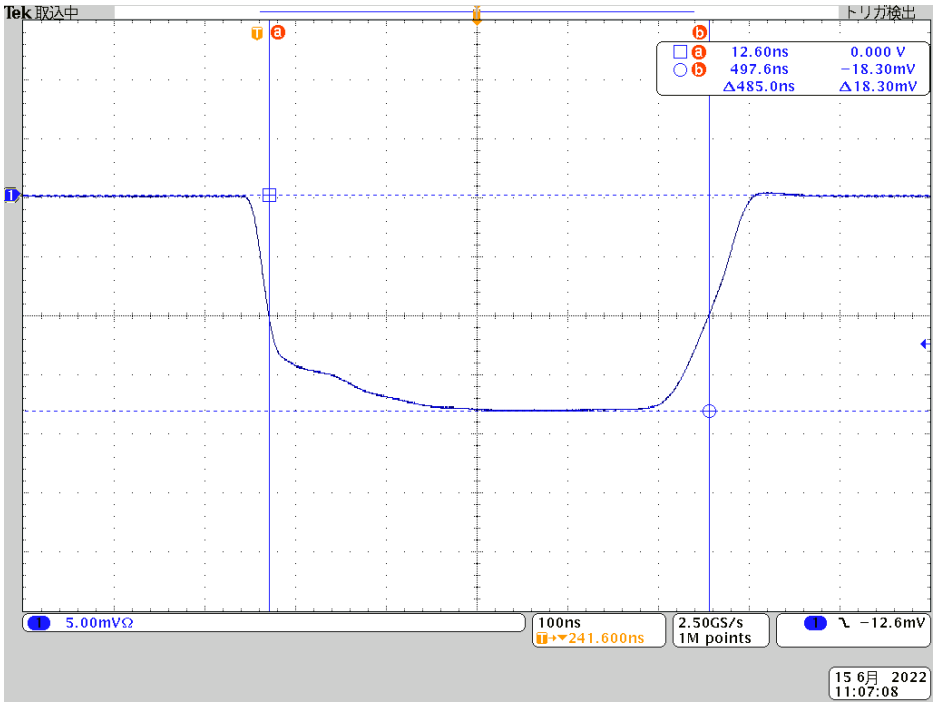


Fig. 6.4 M2 pulse envelope

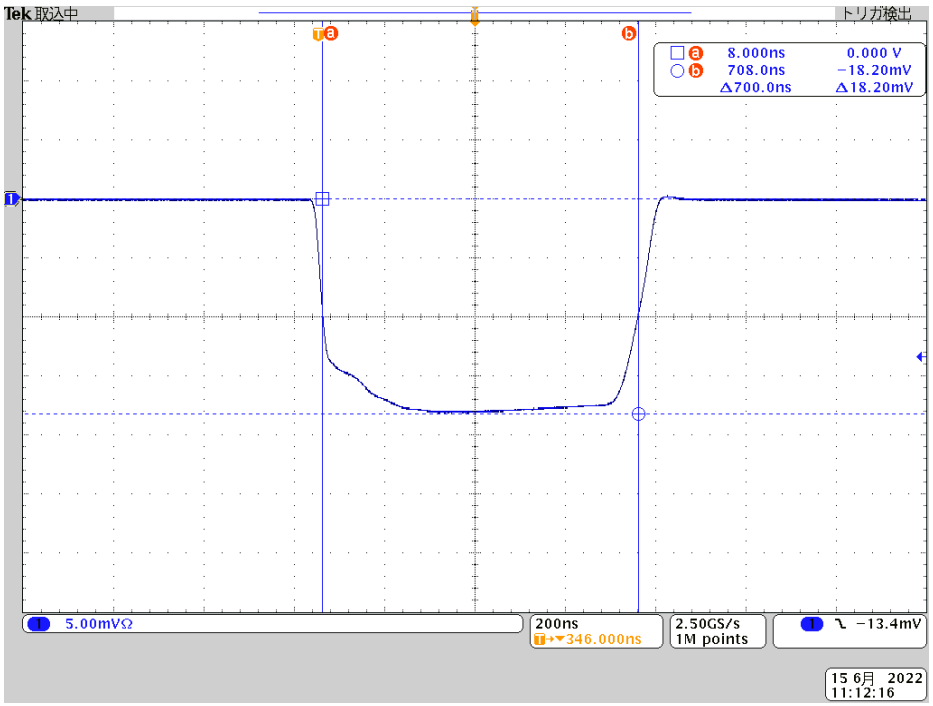


Fig. 6.5 M3 pulse envelope

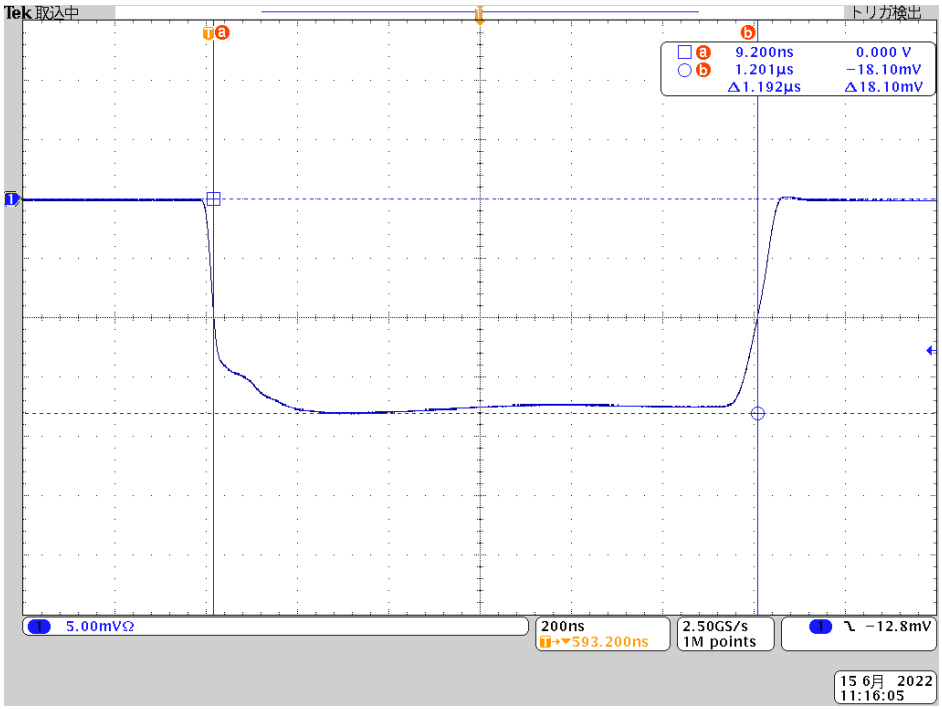


Fig. 6.6 L pulse envelope

TT32NM mode

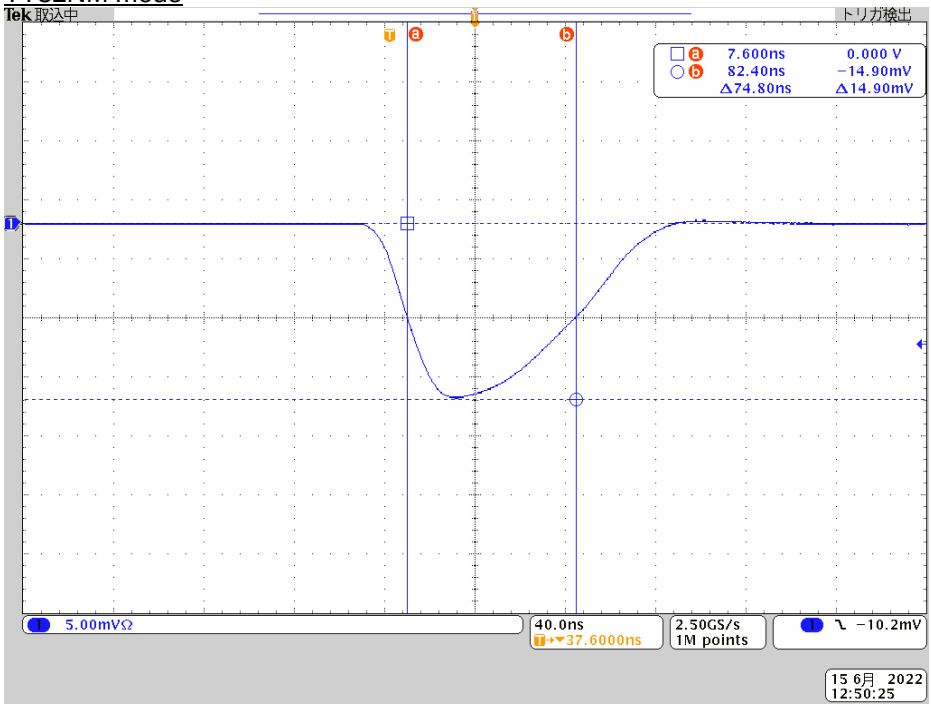


Fig. 6.7 S1 pulse envelope

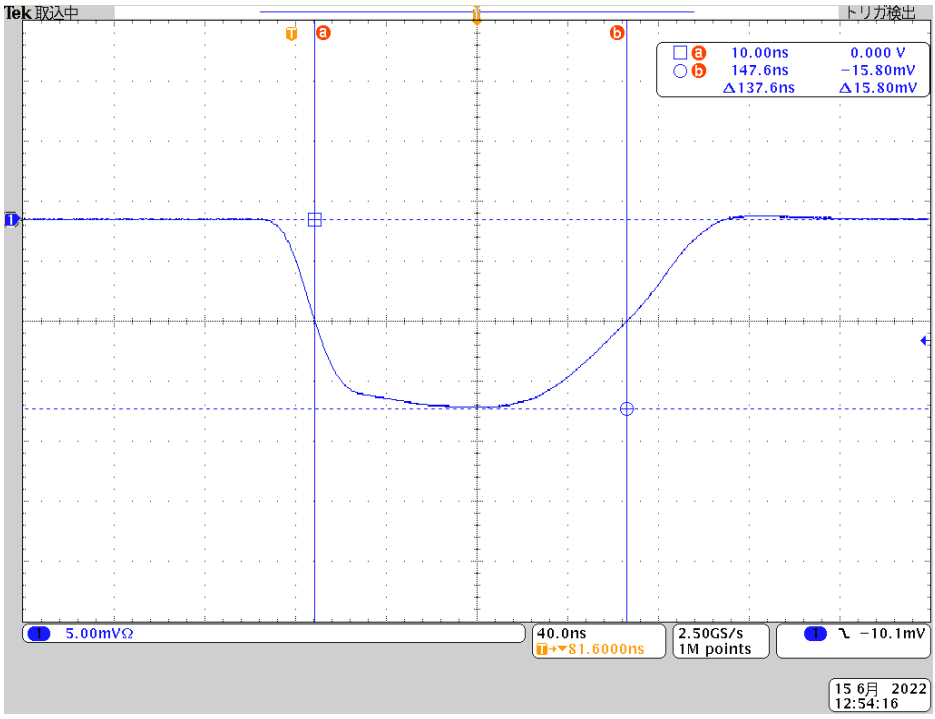


Fig. 6.8 S2 pulse envelope

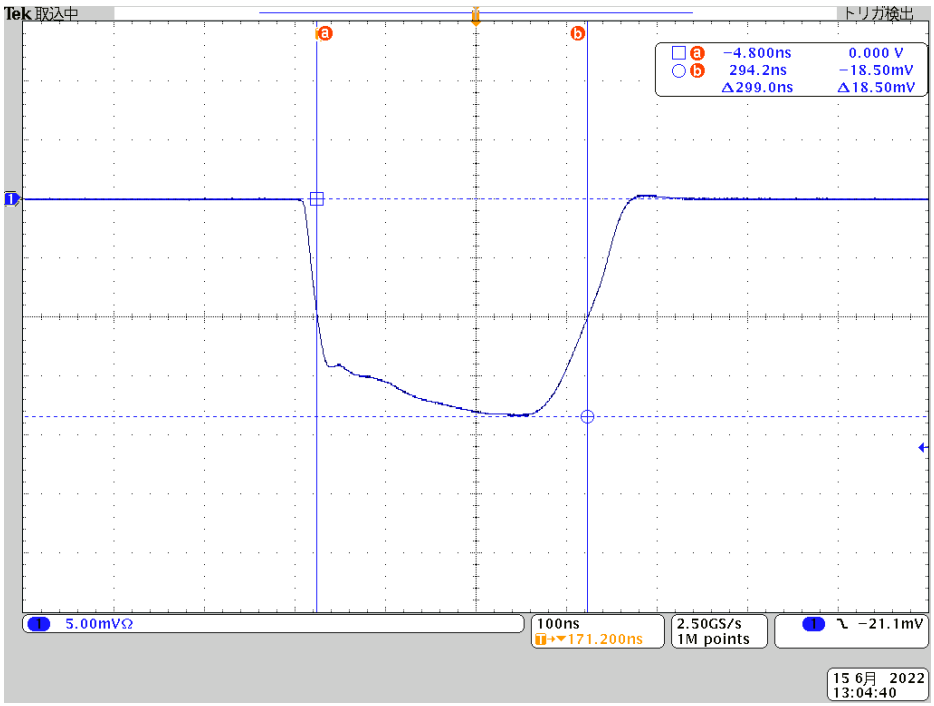


Fig. 6.9 M1 pulse envelope

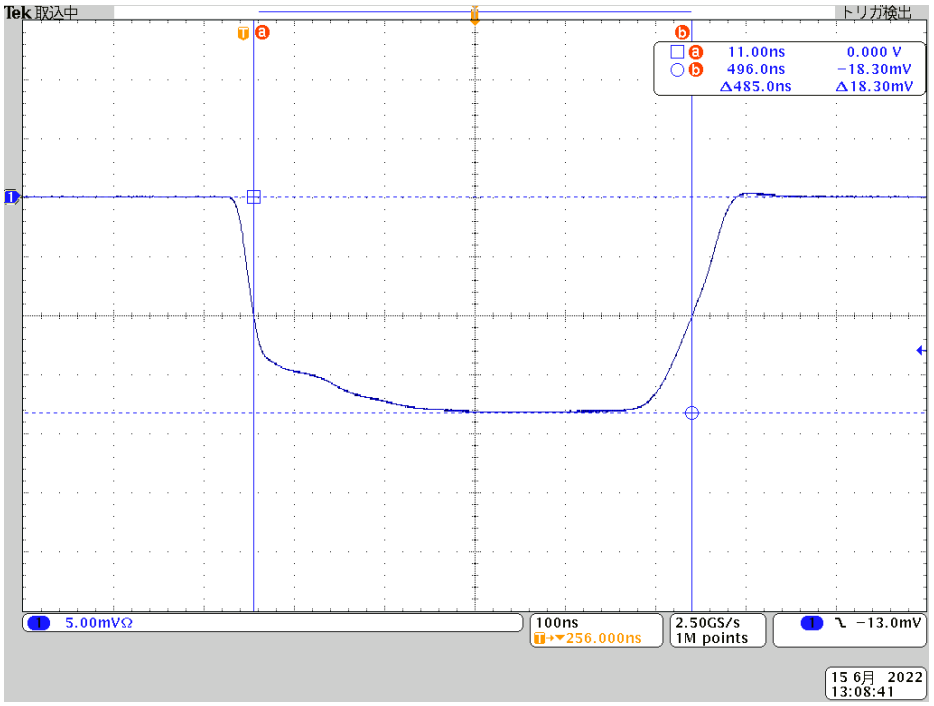


Fig. 6.10 M2 pulse envelope

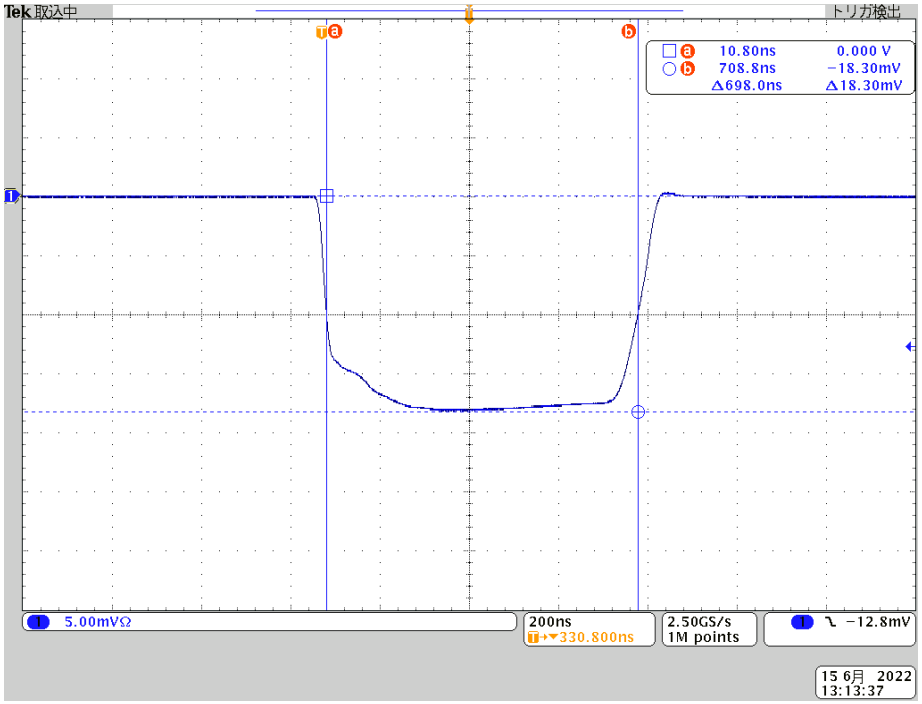


Fig. 6.11 M3 pulse envelope

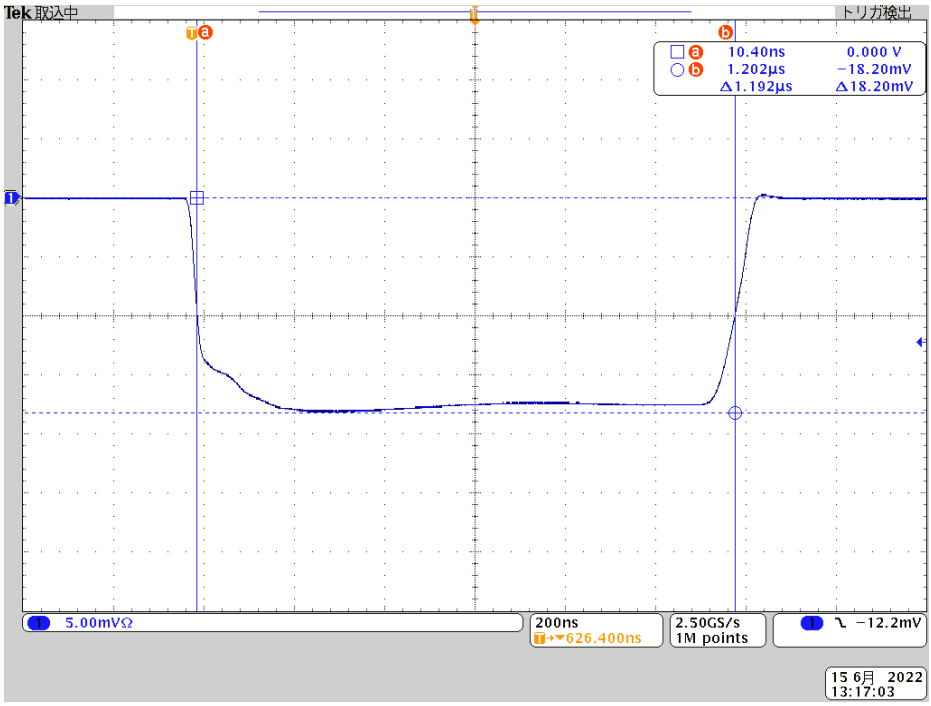


Fig. 6.12 L pulse envelope

2nd trace mode

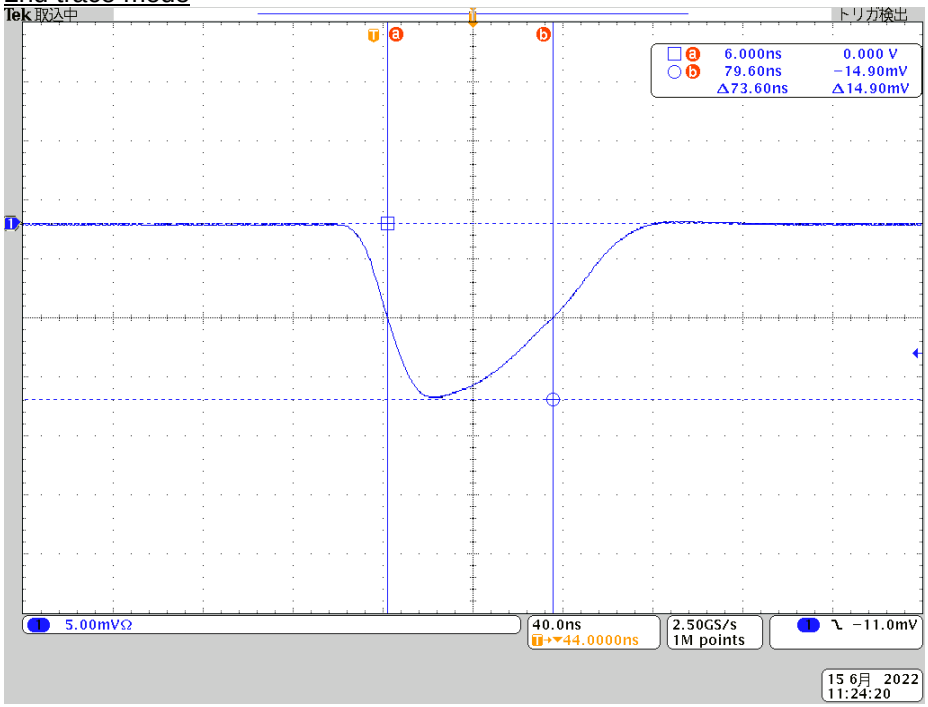


Fig. 6.13 S1 pulse envelope

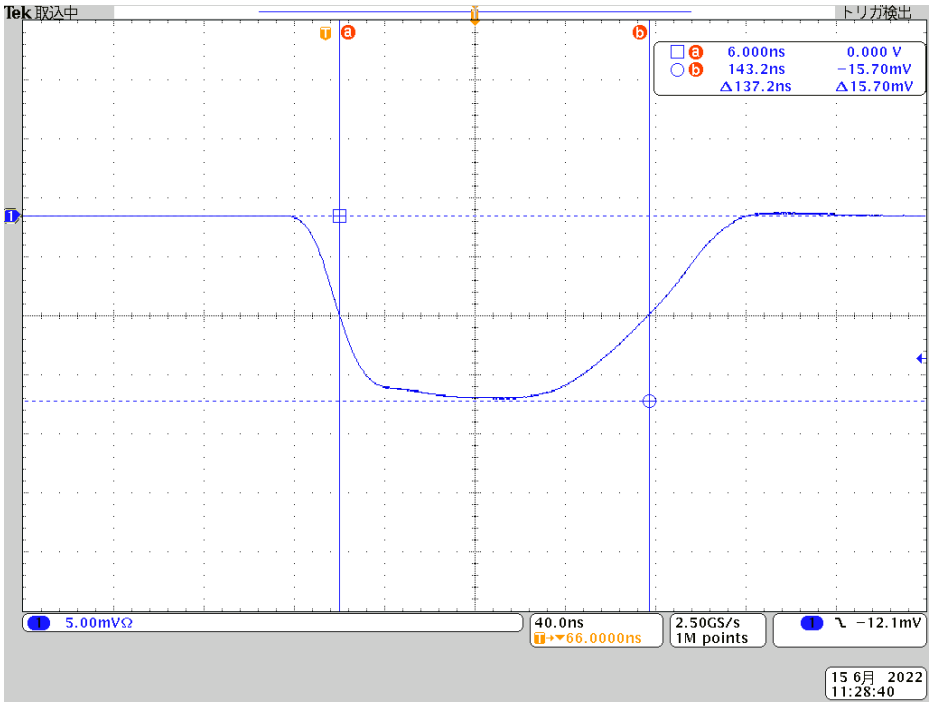


Fig. 6.14 S2 pulse envelope

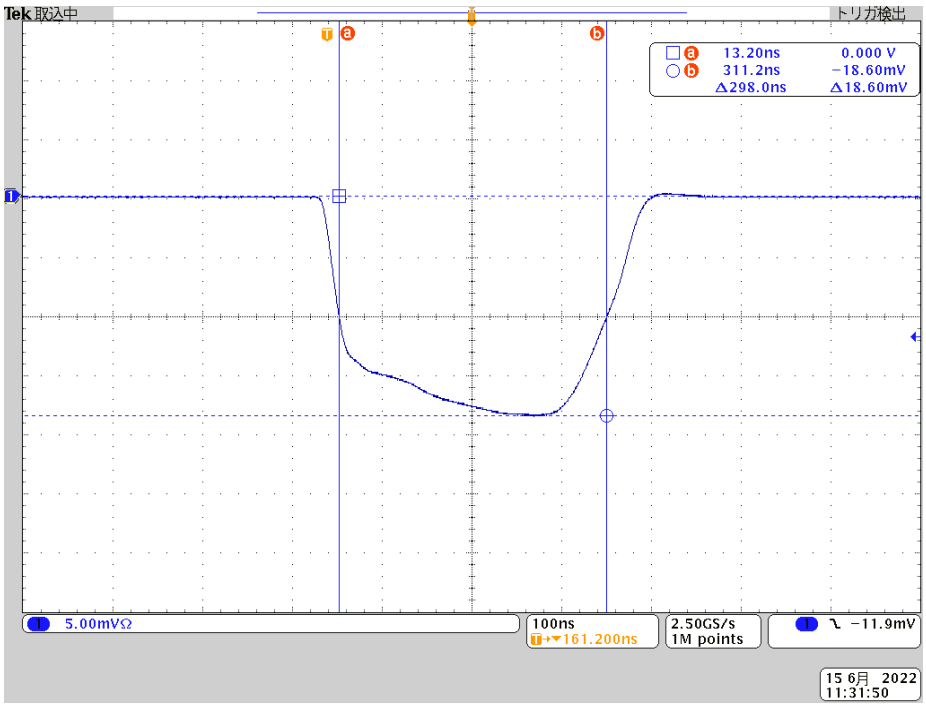


Fig. 6.15 M1 pulse envelope

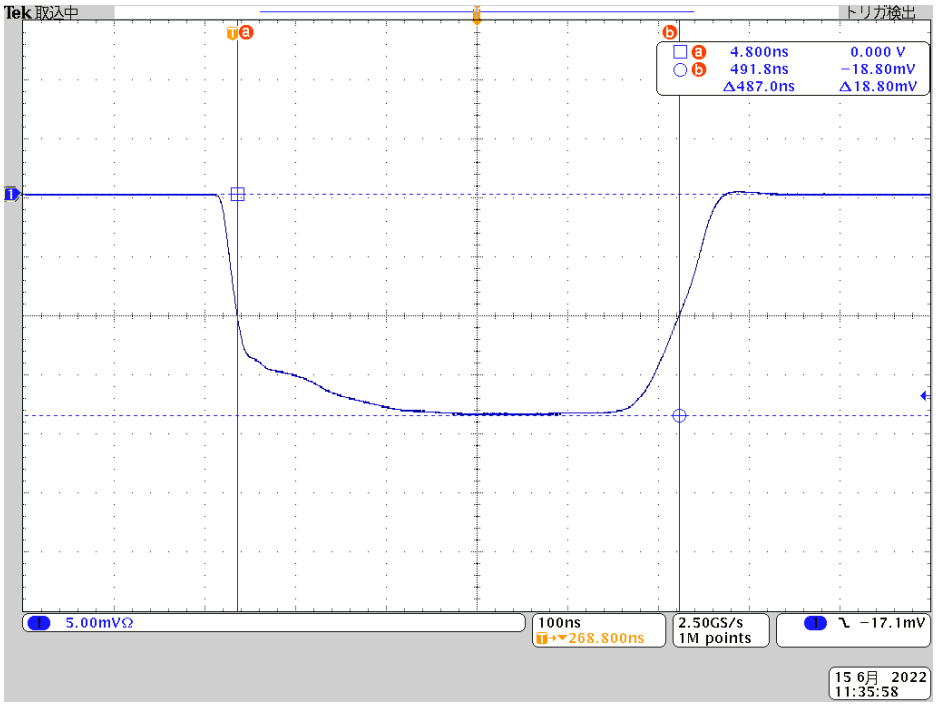


Fig. 6.16 M2 pulse envelope

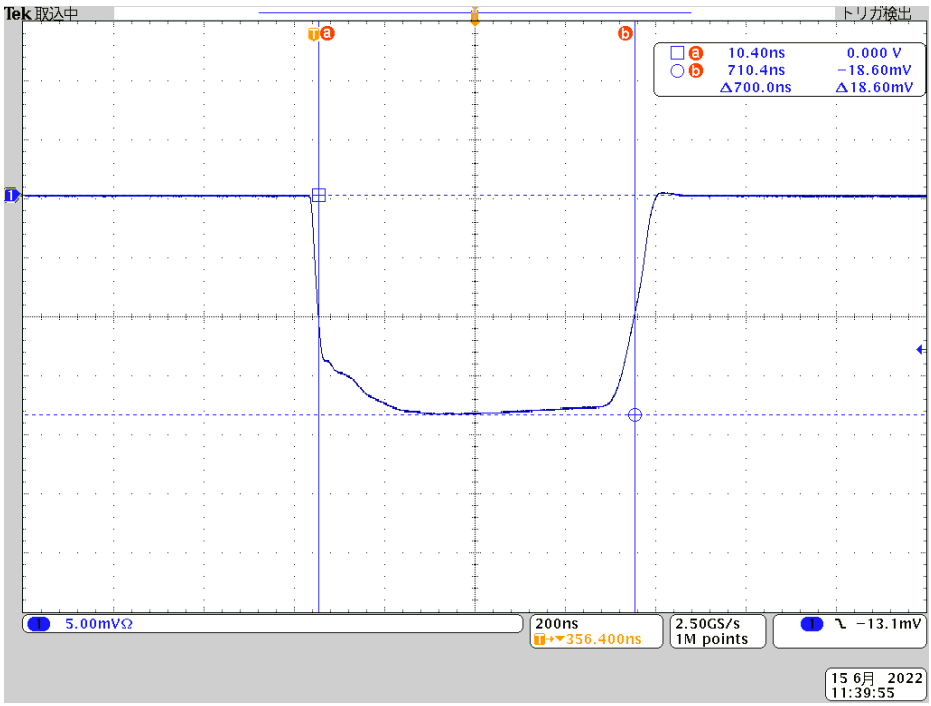


Fig. 6.17 M3 pulse envelope

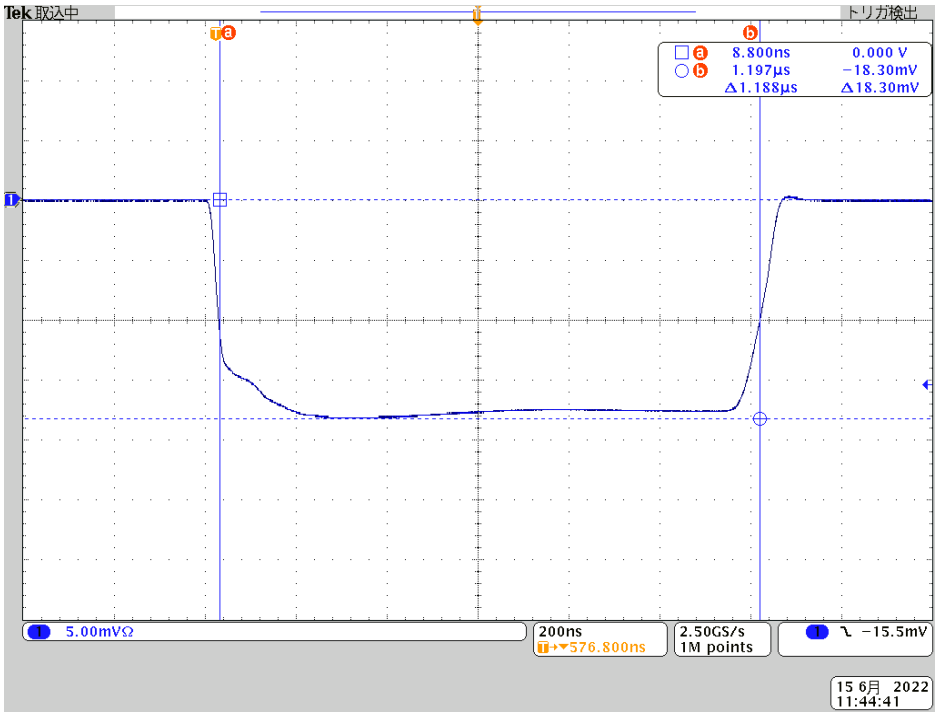


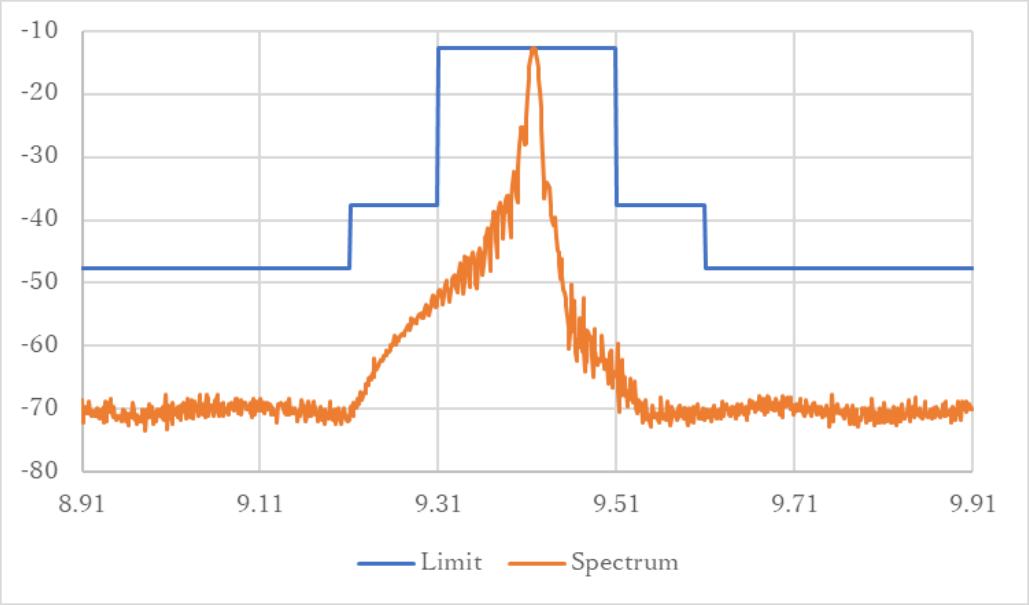
Fig. 6.18 L pulse envelope

7 Spurious Emission Plots measured at Antenna Terminal

7.1 Occupied Bandwidth

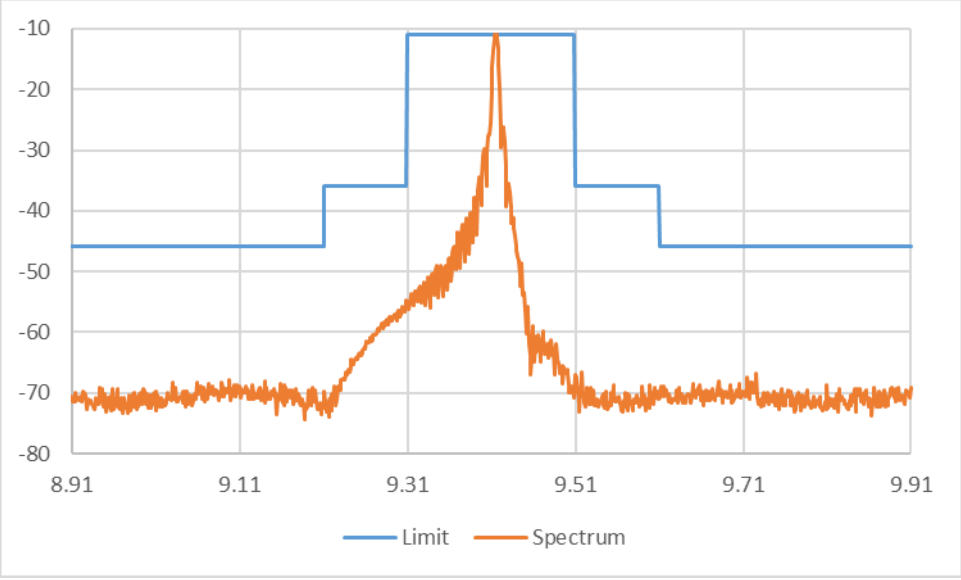
TT24NM mode

ch1, P0N



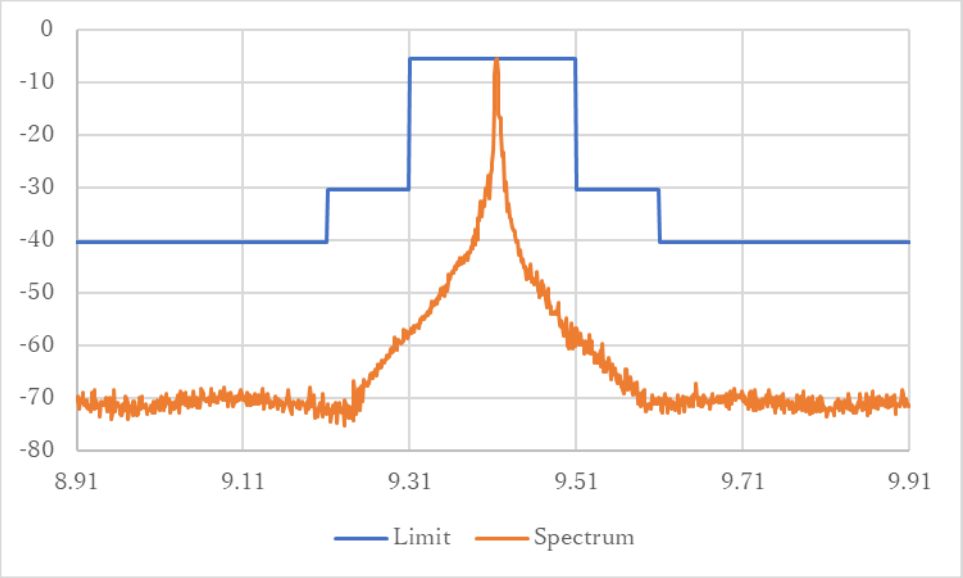
Occupied bandwidth: 47.551 MHz

Fig. 7.1 S1 pulse



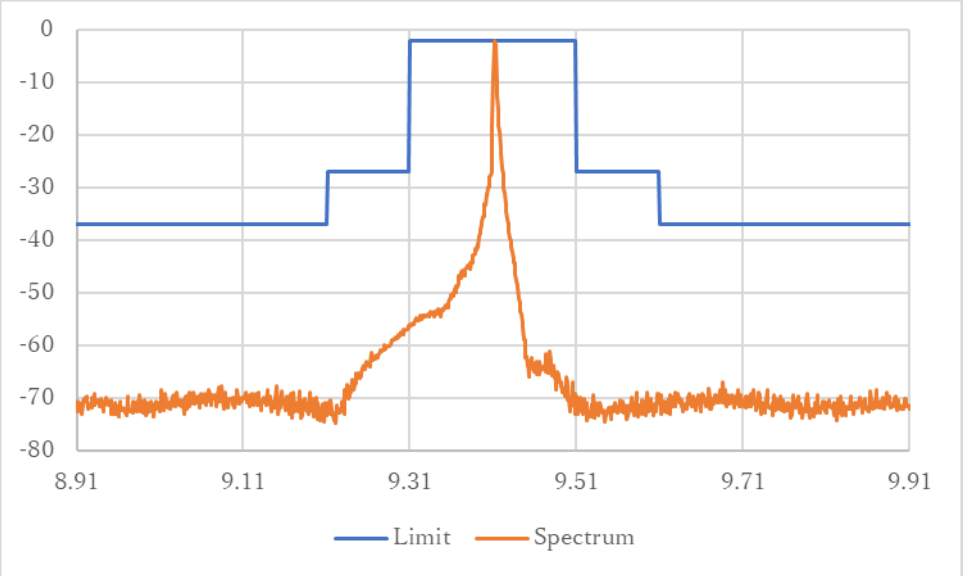
Occupied bandwidth: 30.295 MHz

Fig. 7.2 S2 pulse



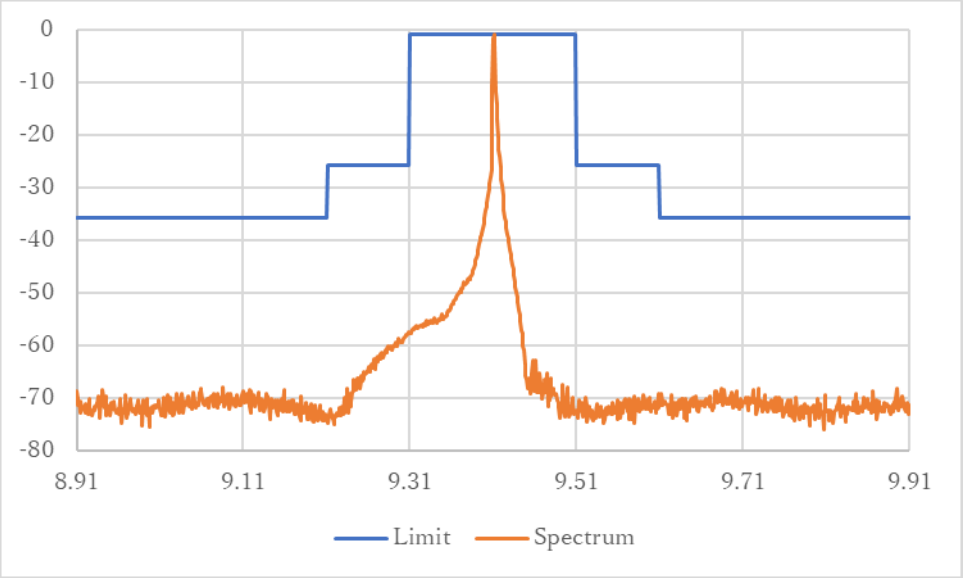
Occupied bandwidth: 23.675 MHz

Fig. 7.3 M1 pulse



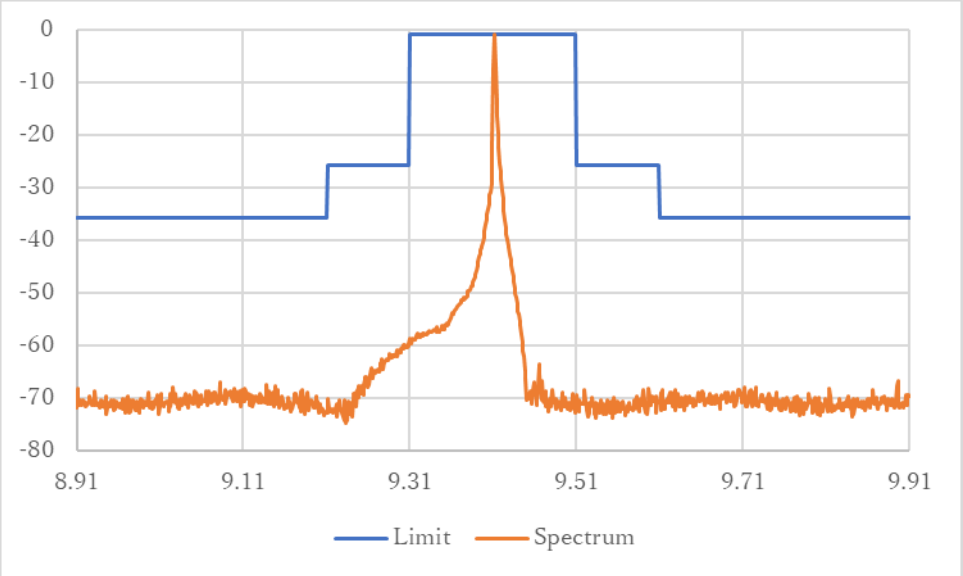
Occupied bandwidth: 12.511 MHz

Fig. 7.4 M2 pulse



Occupied bandwidth: 8.9409 MHz

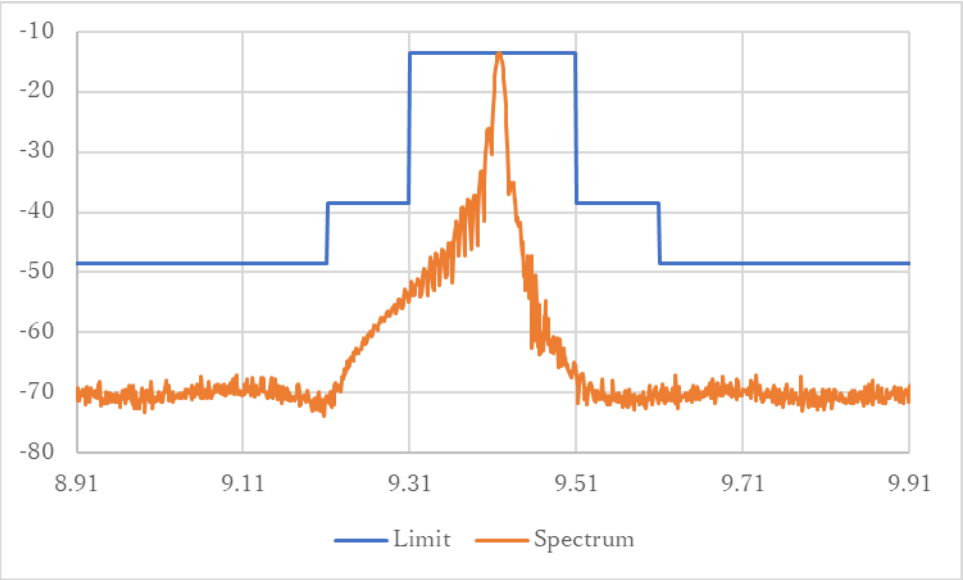
Fig. 7.5 M3 pulse



Occupied bandwidth: 8.0606 MHz

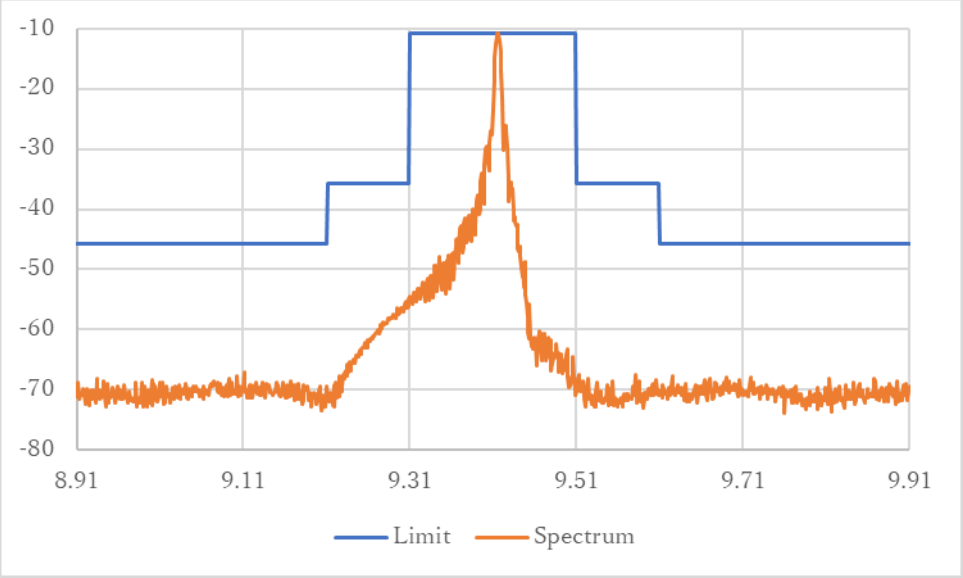
Fig. 7.6 L pulse

TT32NM mode



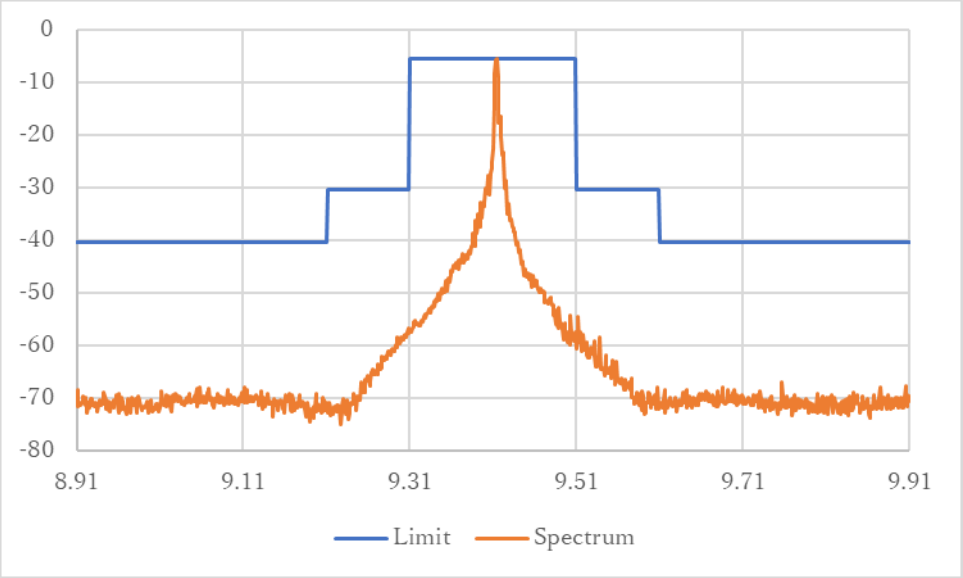
Occupied bandwidth: 49.363 MHz

Fig. 7.7 S1 pulse



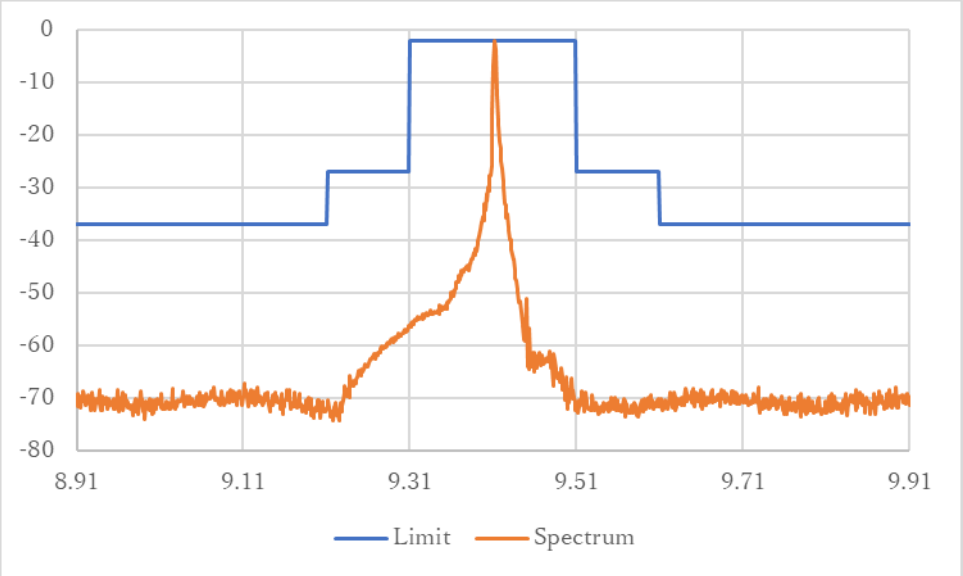
Occupied bandwidth: 30.480 MHz

Fig. 7.8 S2 pulse



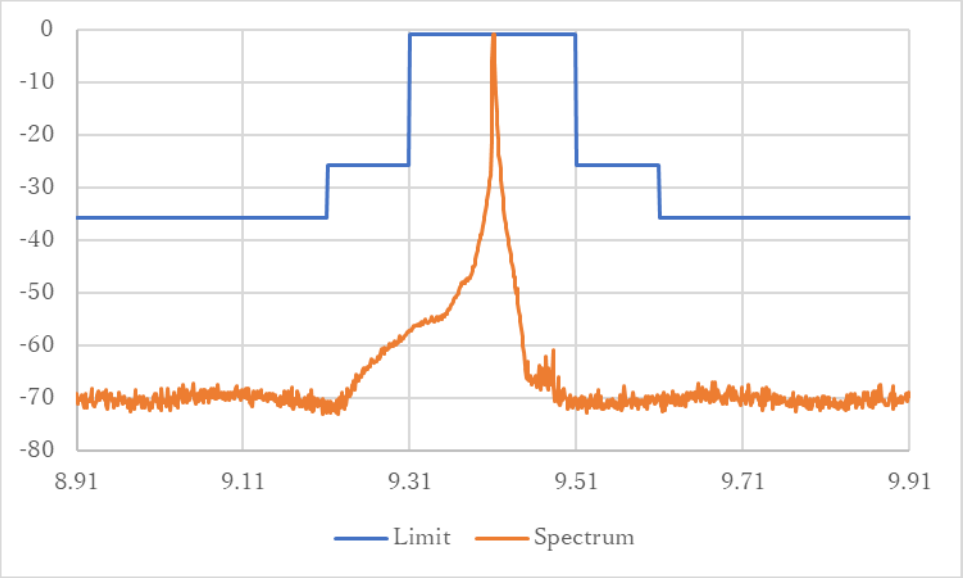
Occupied bandwidth: 23.766 MHz

Fig. 7.9 M1 pulse



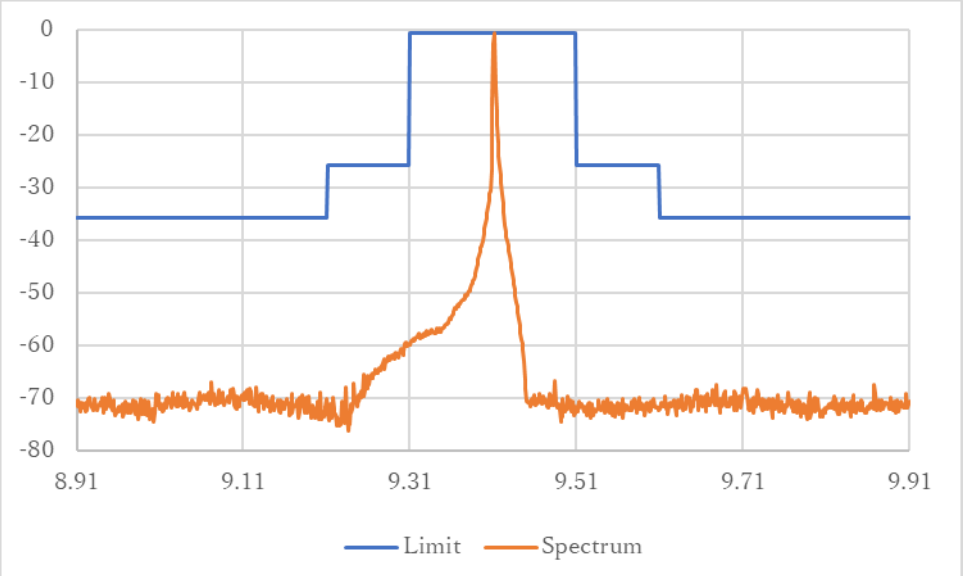
Occupied bandwidth: 11.968 MHz

Fig. 7.10 M2 pulse



Occupied bandwidth: 9.2741 MHz

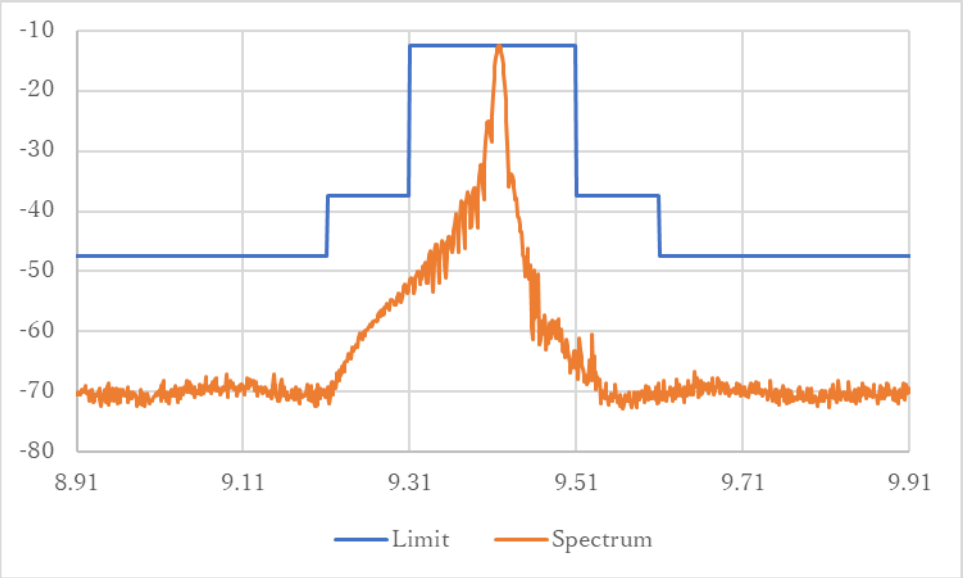
Fig. 7.11 M3 pulse



Occupied bandwidth: 7.9328 MHz

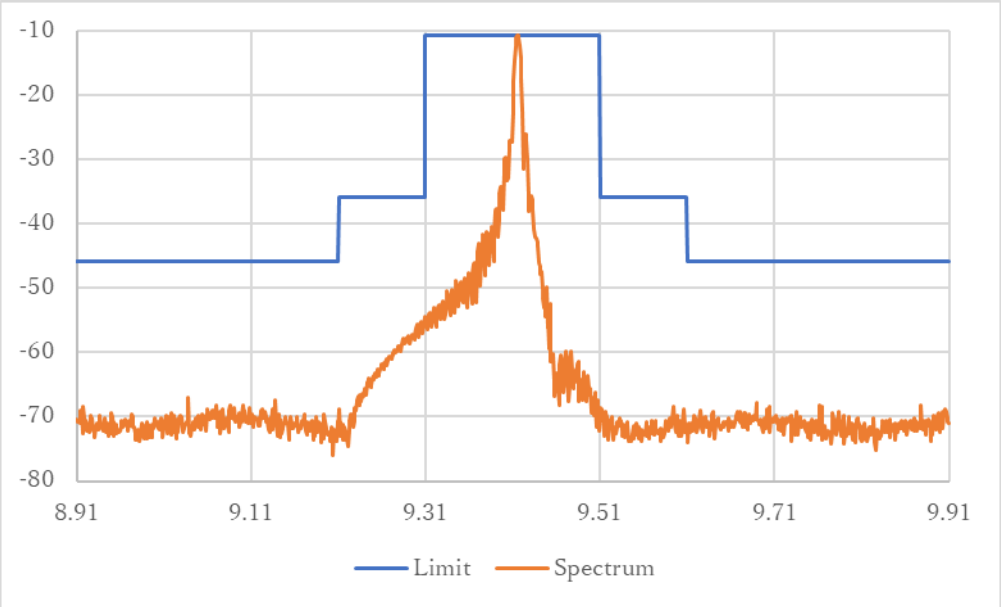
Fig. 7.12 L pulse

2nd trace mode



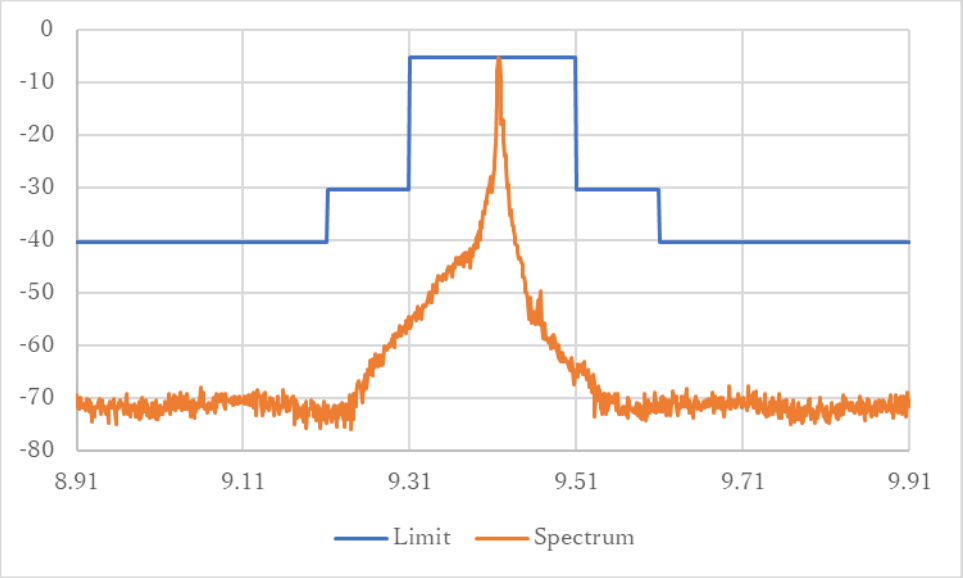
Occupied bandwidth: 48.878 MHz

Fig. 7.13 S1 pulse



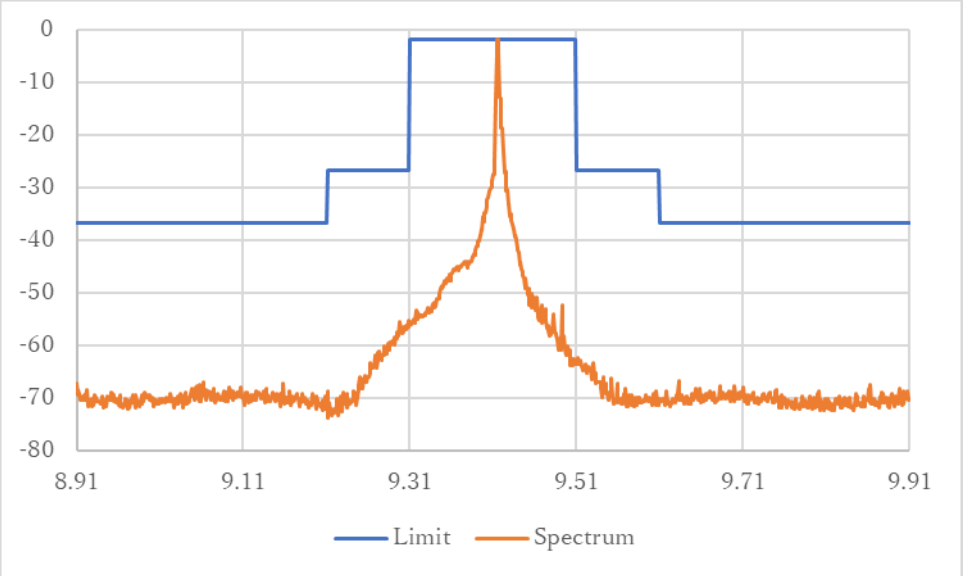
Occupied bandwidth: 29.948 MHz

Fig. 7.14 S2 pulse



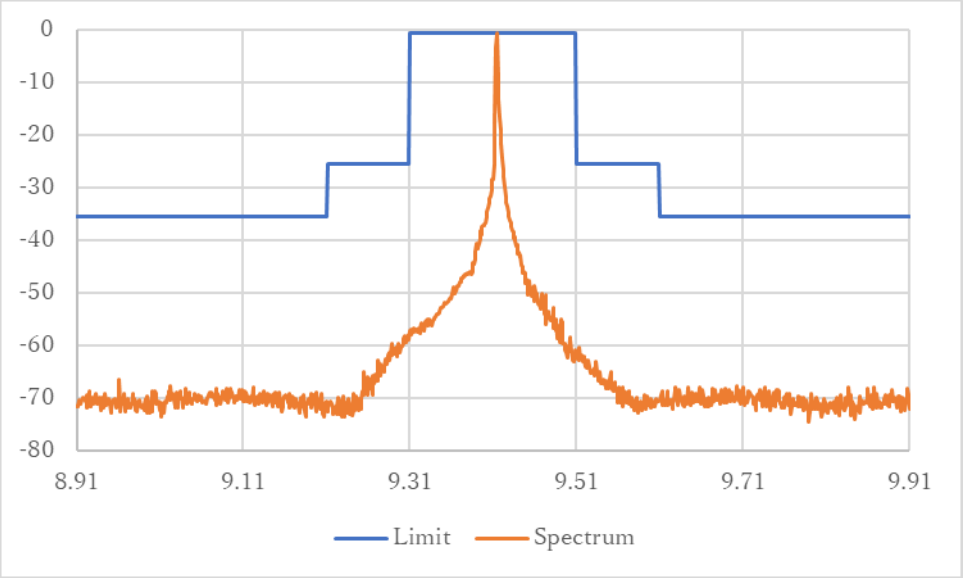
Occupied bandwidth: 22.102 MHz

Fig. 7.15 M1 pulse



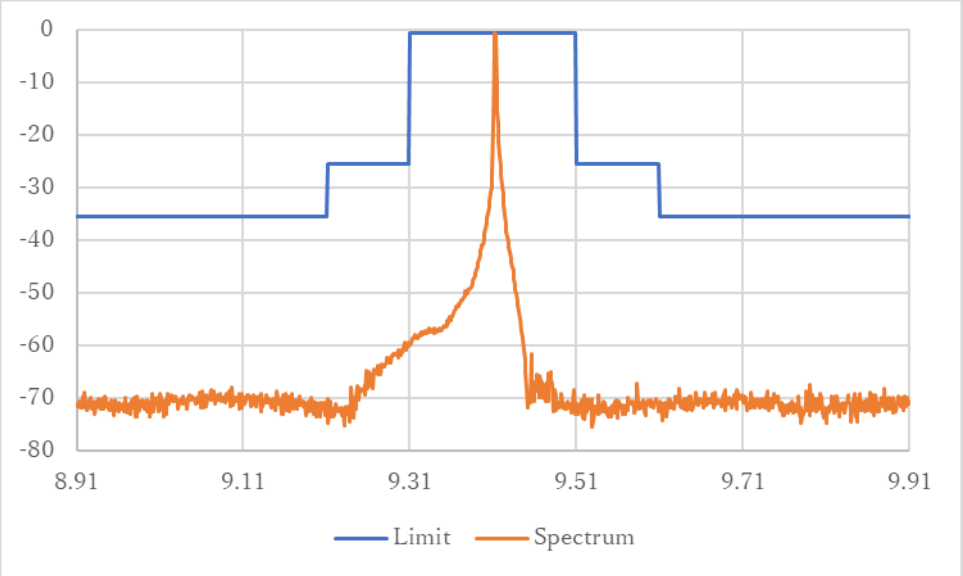
Occupied bandwidth: 13.009 MHz

Fig. 7.16 M2 pulse



Occupied bandwidth: 9.0926 MHz

Fig. 7.17 M3 pulse



Occupied bandwidth: 7.8402 MHz

Fig. 7.18 L pulse

7.2 Spurious Emissions

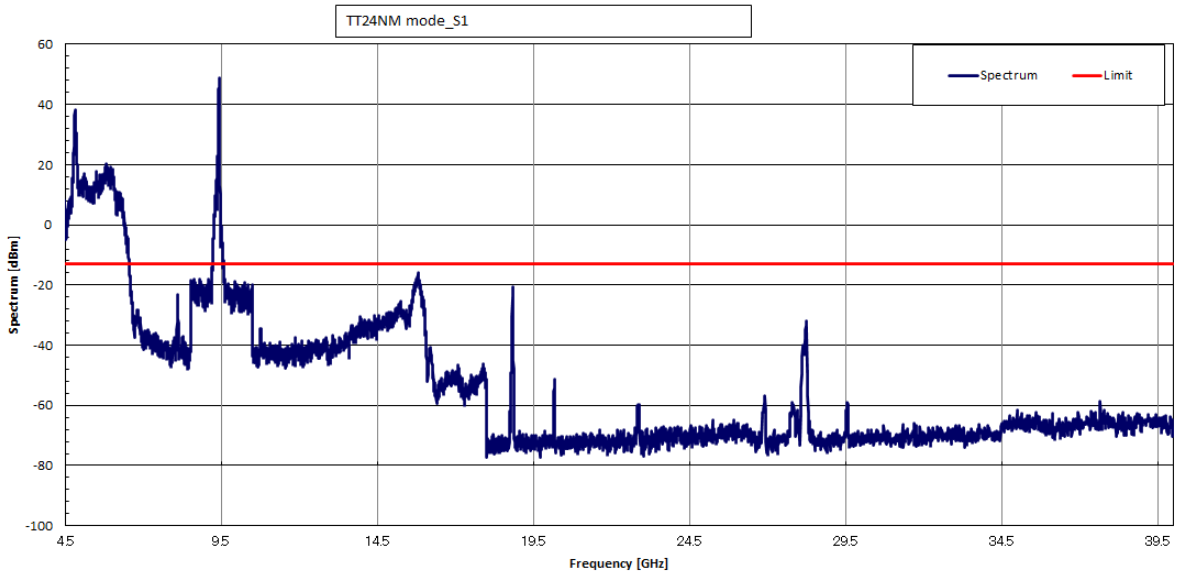


Fig 7.19 Peak, 4.5 GHz to 40 GHz

Note: The measurement for the frequency below 6.54 GHz were unmeasurable due to the large path loss even though the EUT operation was OFF.

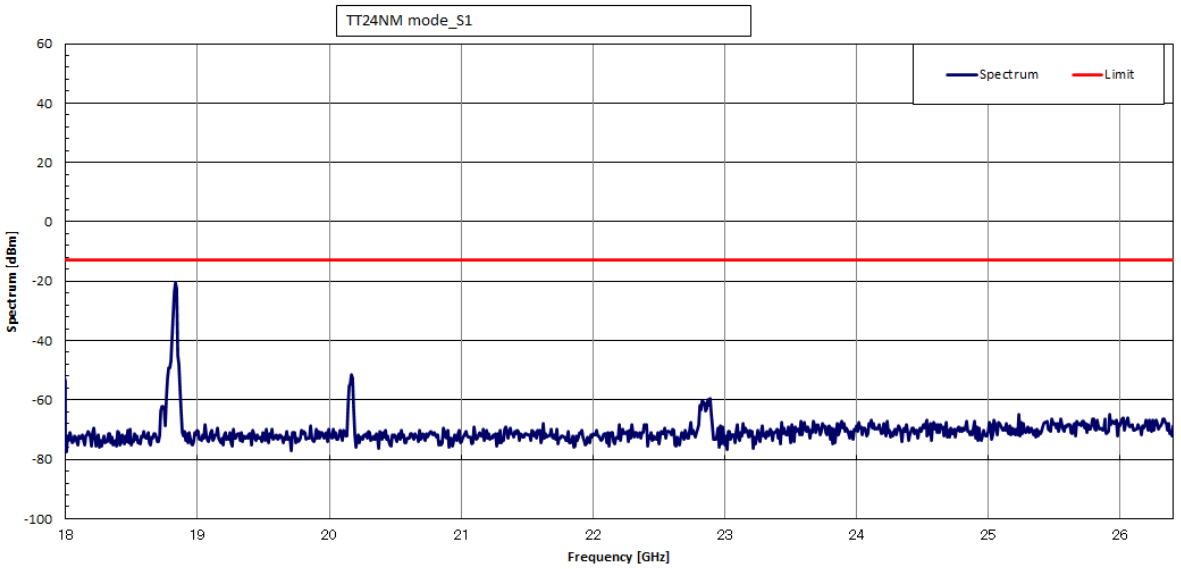
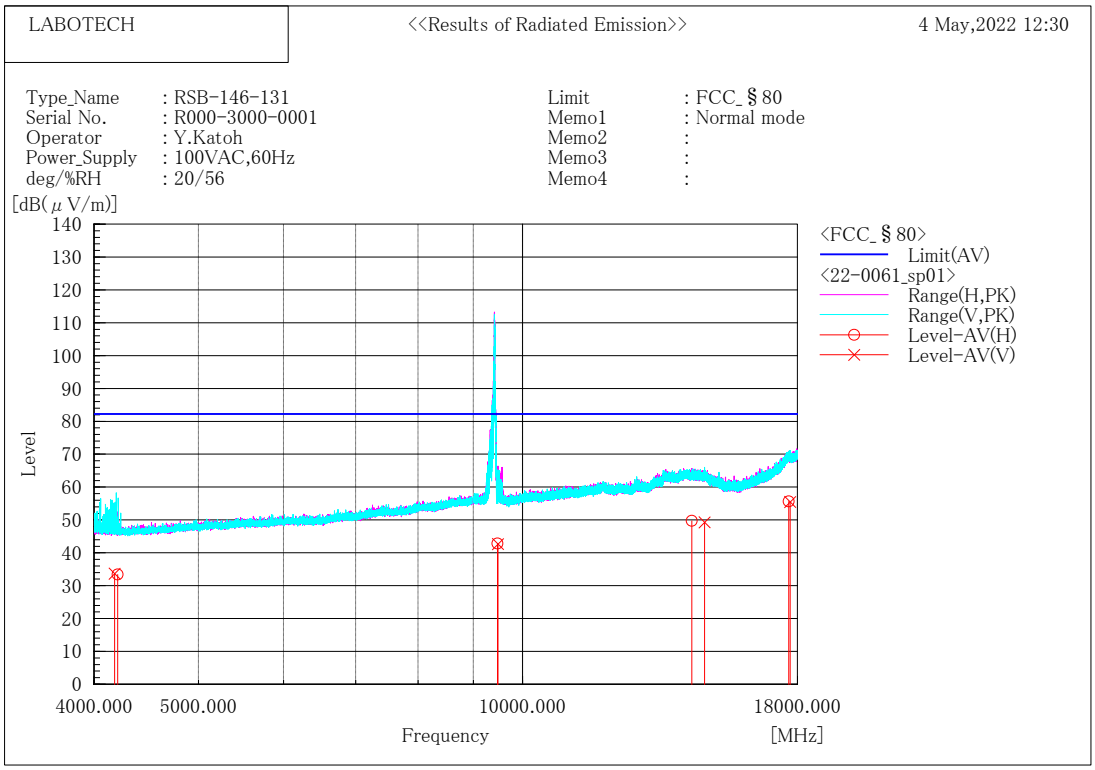


Fig 7.20 Peak, 18 GHz to 26.5 GHz (maximum peak value)

Fig 7.21 Average of the maximum peak value

8 Field Strength of Spurious Radiation Plots measured in the Spurious domain

8.1 Measured maximum emission value



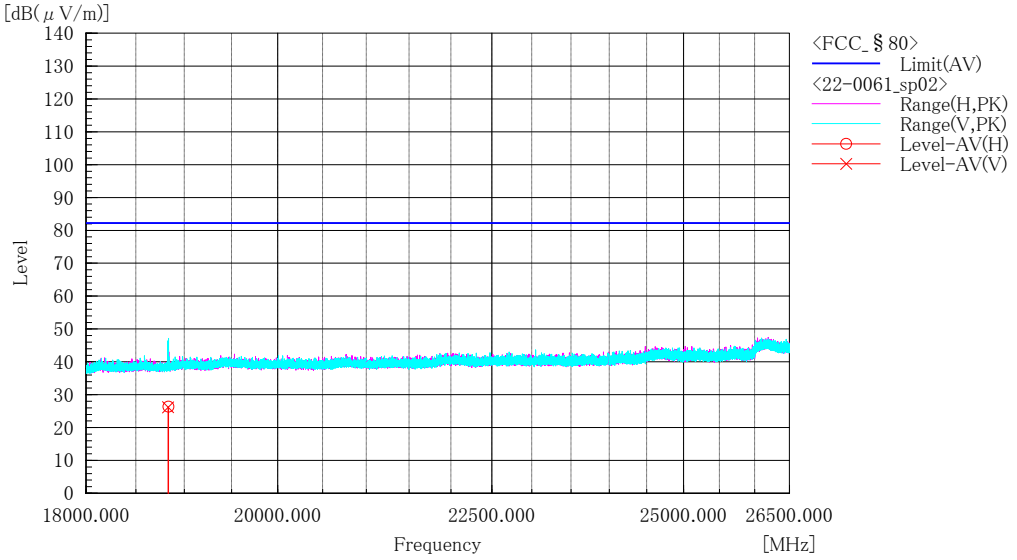
Final Result

No.	Frequency [MHz]	(P)	Reading AV [dB(μV)]	c.f [dB(1/m)]	Result AV [dB(μV/m)]	Limit AV [dB(μV/m)]	Margin AV [dB]	Height [cm]	Angle [°]
1	4179.111	V	32.22	1.48	33.70	82.2	48.5	257.0	224.0
2	4206.419	H	31.93	1.46	33.39	82.2	48.8	258.0	40.0
3	9480.148	H	33.28	9.53	42.81	82.2	39.4	225.0	165.0
4	9486.380	V	33.19	9.52	42.71	82.2	39.5	260.0	342.0
5	14360.050	H	32.01	17.76	49.77	82.2	32.4	150.0	75.0
6	14757.400	V	32.45	16.87	49.32	82.2	32.9	150.0	106.0
7	17663.090	H	33.24	22.41	55.65	82.2	26.5	150.0	84.0
8	17717.100	V	32.82	22.66	55.48	82.2	26.7	150.0	74.0

Note: Result AV (dBμV/m) = Reading (dBμV) + Antenna Factor (dB(1/m)) + Path Loss (dB).

LABOTECH <<Results of Radiated Emission>> 4 May,2022 14:33

Type_Name	: RSB-146-131	Limit	: FCC_§80
Serial No.	: R000-3000-0001	Memo1	: Normal mode
Operator	: Y.Katoh	Memo2	:
Power_Supply	: 100VAC,60Hz	Memo3	:
deg/%RH	: 20/56	Memo4	:



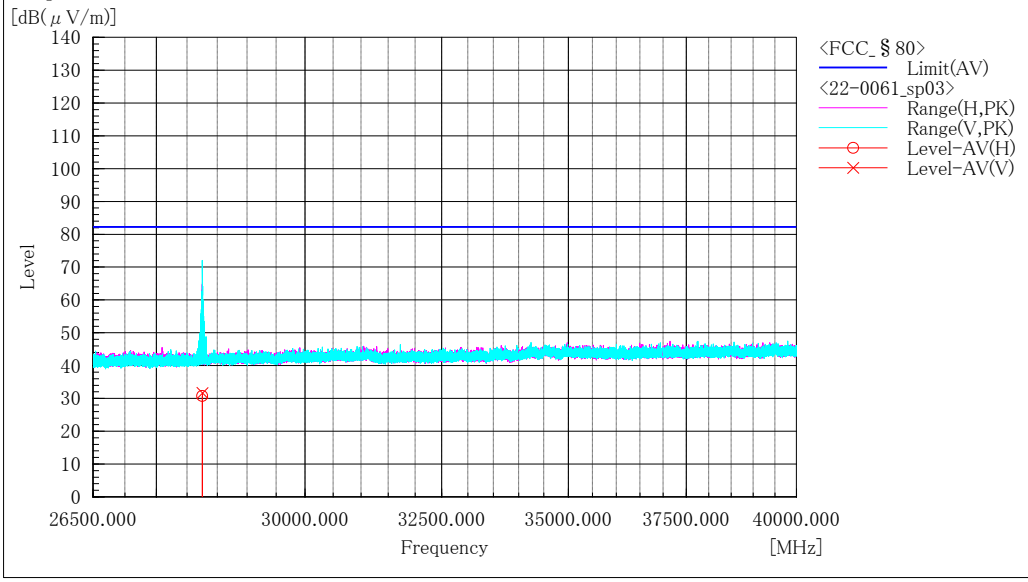
Final Result

No.	Frequency [MHz]	(P)	Reading AV [dB(μV)]	c.f [dB(1/m)]	Result AV [dB(μV/m)]	Limit AV [dB(μV/m)]	Margin AV [dB]	Height [cm]	Angle [°]
1	18834.120	H	34.18	-7.84	26.34	82.2	55.9	154.0	128.0
2	18830.960	V	34.06	-7.84	26.22	82.2	56.0	146.0	171.0

Note: Result AV (dBμV/m) = Reading (dBμV) + Antenna Factor (dB(1/m)) + Path Loss (dB).

LABOTECH <<Results of Radiated Emission>> 4 May,2022 15:22

Type_Name	: RSB-146-131	Limit	: FCC_§80
Serial No.	: R000-3000-0001	Memo1	: Normal mode
Operator	: Y.Katoh	Memo2	:
Power_Supply	: 100VAC,60Hz	Memo3	:
deg/%RH	: 20/56	Memo4	:



Final Result

No.	Frequency [MHz]	(P)	Reading AV [dB(μV)]	c.f [dB(1/m)]	Result AV [dB(μV/m)]	Limit AV [dB(μV/m)]	Margin AV [dB]	Height [cm]	Angle [°]
1	28250.510	H	45.89	-15.13	30.76	82.2	51.4	153.0	66.0
2	28251.190	V	46.81	-15.13	31.68	82.2	50.5	196.0	150.0

Note: Result AV (dBμV/m) = Reading (dBμV) + Antenna Factor (dB(1/m)) + Path Loss (dB).

End of text