

# Test Report

FCC Rules 47 CFR,  
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**  
**Type: RTR-124**

Report no.: LIC 12-18-089

Date of issue: 19 September 2018

**Labotech International Co., Ltd.**


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## Report Summary

LIC project number:	LIC 04-18-0423		
Test report number of initial issue:	LIC 12-18-089	Date of initial issue	19 September 2018
Test report number of revised/replaced issue:	--	Date of revised/replaced issue	--
Test report revision/replacement history:	--		
Test standard(s)/ Test specifications:	FCC Rules 47 CFR, 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		
Type:	RTR-124		
Product function and intended use:	Object-detection for safety navigation		
Number of samples tested:	One		
Serial number:	R000-2300-0001		
Power rating:	24 VDC, 5.0 A (for Processor Unit)		
Product status:	Engineering model		
Modifications made to samples during testing:	None		
Date of receipt of samples:	4 August 2018		
Test period:	From 4 August 2018 to 24 August 2018		
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 - Nishinomiya-Hama Lab. 2-20, Nishinomiya-Hama, Nishinomiya-shi, Hyogo, 662-0934 Japan		
Test results/Compliance:	Passed. The test results of this report relate only to the samples tested.		

Tested by:	Atsushi Takagi, Osamu Araki and Koji Kawai
Written by:	Arisa Ogino
Verified by:	Atsushi Takagi
Approved by:	19 September 2018 Name: Tadayuki Ekawa Title: Chief engineer, Technical Department, Labotech International Co., Ltd. Signature: 

## 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 and IEC 62288

(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:  
EN 55011, CISPR 11, EN 55012, CISPR 12, EN 55022, CISPR 22, EN 55024, CISPR 24, EN 55025, CISPR 25, EN/IEC 61000-3-2/-3, EN/IEC 61000-4-2/-3/-4/-5/-6/-8/-11, EN/IEC 61000-6-1/-2/-3/-4, EN/IEC 60945, EN/IEC 61326-1, EN/IEC 61326-2-6, EN/IEC 60601-1-2, JIS T 0601-1-2, JIS C 1806-1, ISO 11452-1/-2/-4, EN ISO 14982, IEC 62236-3-2 and EN 50121-3-2

(4) RMRS Recognized Testing Laboratory:

- recognized by Russian Maritime Register of Shipping (RMRS) (Russia)
- Laboratory recognition number: 11.02594.011
- Date of initial recognition: 27 January 2009 (\*)
- for carrying out testing in the field of:  
Electrical measurements and tests, EMC tests, Mechanical measurements and tests, Equipment protection degree tests, and Climatic tests for Ship's radio and navigational equipment and IEC 60945: 2002

(5) RRR Recognized Test Laboratory:

- recognized by Russian River Register (RRR) (Russia)
- Recognition 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 (DNV GL) (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

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

## TABLE OF CONTENTS

Report Summary.....	2
Testing Laboratory Status.....	4
1 Principal Information .....	6
1.1 Equipment under test (EUT).....	6
1.2 Observation and Comments.....	8
2 Test Results Summary.....	8
3 Test Results .....	9
3.1 RF Power Output (FCC Rule 47 CFR, 2.1046(a) and 80.215).....	9
3.2 Modulation Characteristics (FCC Rule 47 CFR, 2.201, 2.1047(d) and 80.213) .....	9
3.3 Frequency Stability –temperature & voltage (FCC Rule 47 CFR, 2.1055(a)(2)/(d)(1)/(d)(3) and 80.209(b)) .....	10
3.4 Occupied Bandwidth (FCC Rule 47 CFR, 2.202(a), 2.1049(c)(1), 80.209(b) and 80.211(f)) .....	11
3.5 Spurious Emissions at Antenna Port (FCC Rule 47 CFR, 2.1051, 80.211(f), 80.273 and ITU-R SM.329-12).....	12
3.6 Field Strength of Spurious Radiation (FCC Rule 47 CFR, 2.1053, 80.211(f) and ITU-R SM.329-12).....	13
4 Test Setup for Measurements.....	14
4.1 Test Setup for Clauses 3.1, 3.2 and 3.3 .....	14
4.2 Test Setup for Clauses 3.4 and 3.5 .....	14
4.3 Test Setup for Clause 3.6.....	15
5 Measuring Equipment List .....	16
5.1 RF Power Output.....	16
5.2 Modulation Characteristics .....	16
5.3 Frequency Stability –temperature & voltage.....	16
5.4 Occupied Bandwidth.....	17
5.5 Spurious Emissions at Antenna Port.....	17
5.6 Field Strength of Spurious Radiation.....	17
6 RF Envelope and Spectrum of the Output Pulse .....	18
7 Spurious Emission Plots measured at Antenna Terminal.....	20

# 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:
- |                    | Type          | Serial Number  | Note                       |
|--------------------|---------------|----------------|----------------------------|
| Transceiver module | RTR-124       | R000-2300-0001 | Contained in Antenna Unit. |
| Scanner module     | RSB-120       |                | --                         |
| Antenna radiator   | XN20AF/XN24AF | --             | Selectable                 |
- (d) FCC ID: ADB9ZWRTR124
- (e) Primary function: Search, navigation and anti-collision
- (f) Frequency range: Fixed frequency, X-band (9410 MHz)
- (g) Type of emission: P0N  
(Emission designator)
- (h) Occupied bandwidth:
- | Pulse type               | S    | M1   | M2   | L    |
|--------------------------|------|------|------|------|
| Occupied bandwidth (MHz) | 77.0 | 54.1 | 33.0 | 13.8 |
- Note: measured data.
- (i) Size and mass: Antenna Unit: 2040 mm x 570 mm (H), 37 kg with the antenna XN20AF installed.  
Antenna Unit: 2550 mm x 570 mm (H), 39 kg with the antenna XN24AF installed.
- (j) Power supply: 24 VDC (for Processor unit) or 100 to 115/220 to 230 VAC (\*) (for Processor unit)  
(\*): Fed through the specified external equipment, not directly from AC/DC mains.

### 1.1.2 Transceiver

Type: RTR-124 (contained in the Antenna Unit)

#### 1.1.2.1 Transmitter

- (a) Assignable frequency for shipborne radar: Between 9300 and 9500 MHz (FCC Rule, 80.375 (d)-(1))
- (b) Type of RF generator:  
Type: MAF1615B  
Peak output power: 12 kW nominal
- (c) Magnetron ratings:  
Center frequency of magnetron: 9410 MHz nominal  
Tolerances:  
Manufacturing:  $\pm 30$  MHz  
Pulling: 23 MHz  
Tolerance for 20°C temperature variation: -5 MHz

(d) Pulse characteristics:

Pulse type	S	M1	M2	L
Pulse length ( $\mu$ s)	0.039	0.097	0.265	0.584
PRF (Hz)	3994	1998	1998	1000

### 1.1.2.2 Modulator

FET Type: TK20J50D  
Trigger Voltage: Approximately +12 VDC

### 1.1.2.3 Receiver

(a) Passband

RF Stage: 100 MHz

IF Stage:

Pulse type	S	M1	M2	L
Passband (MHz)	38	10	4.0	4.0

(b) Intermediate Frequency: 60 MHz

(c) Gain (overall): Approximately 100 dB

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

(e) Video Output Voltage: 4 V Negative

(f) Features Provided: Superheterodyne

(g) Method for adjusting frequency: By adjusting tuning voltage of receiver local oscillator (automatically and manually)

(h) Frequency adjustable range: 9410 MHz (center)  $\pm$ 30 MHz

### 1.1.3 Antenna and Scanner

(a) Antenna Rotation ON-OFF Switch: Provided.

(b) Construction: Slotted array antenna

(c) Length:

Antenna type	XN20AF	XN24AF
Length (cm)	204	255

(d) Type of Beam: Vertical fan

(e) Beam Width (3 dB):

Antenna type	XN20AF	XN24AF
Horizontal (°)	1.23	0.95
Vertical (°)	20	20

(f) Polarization: Horizontal

(g) Antenna Gain:

Antenna type	XN20AF	XN24AF
Gain (dBi)	30.0	31.0

(h) Attenuation of Major Side and Back Lobes with respect to Main Beam:

Antenna type	XN20AF	XN24AF
Within $\pm$ 20° (dB)	-28	-28
Outside $\pm$ 20° (dB)	-32	-32

(i) Scanning (rotating or oscillating): Rotating

(j) Antenna Rotation Rate: 26 rpm

(k) Sector Scan: Not provided.

(l) Rated Loss of Transmission Line per 100 Feet: Negligible

(Transmission path is only in the Antenna 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: 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

None

## 2 Test Results Summary

Clause number of this report	47 CFR Section	Item	Result	Test engineer
3.1	2.1046 (a), 80.215	RF Power Output	Passed.	K. Kawai
3.2	2.201, 2.1047 (d), 80.213	Modulation Characteristics	Passed.	K. Kawai
3.3	2.1055 (a)(2),(d)(1),(d)(3), 80.209 (b)	Frequency Stability	Passed.	K. Kawai
3.4	2.202 (a), 2.1049 (c)(1), 80.209 (b), 80.211 (f)	Occupied Bandwidth	Passed.	K. Kawai
3.5	2.1051, 80.211 (f), 80.273	Spurious Emissions at Antenna Terminals	Passed.	K. Kawai
3.6	2.1053, 80.211 (f)	Field Strength of Spurious Radiation	Passed.	A. Takagi and O. Araki



### 3 Test Results

#### 3.1 RF Power Output (FCC Rule 47 CFR, 2.1046(a) and 80.215)

##### 3.1.1 Test conditions:

For all TX (S /M1/M2/ 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:

Pulse type	S	M1	M2	L
Transmission mean power P <sub>m</sub> (W)	1.4	1.6	4.0	4.7
Pulse length T (μs) (-3 dB points)	0.039	0.097	0.265	0.584
PRF (Hz)	3994	1998	1998	1000
Transmission pulse power P <sub>p</sub> (kW) (*1)	8.9	8.5	7.6	8.1

$$(*1) P_p \text{ (kW)} = (P_m \text{ (W)} / (T \text{ (}\mu\text{s)} \times PRF \text{ (Hz)})) \times 1000$$

Environmental conditions observed: On 20 August 2018, 24°C to 23°C, 60%RH to 52%RH

On 22 August 2018, 24°C to 23°C, 60%RH to 59%RH

Power supply voltage measured: 24.0 VDC to 24.0 VDC

#### 3.2 Modulation Characteristics (FCC Rule 47 CFR, 2.201, 2.1047(d) and 80.213)

##### 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:

Pulse type	S	M1	M2	L
Pulse length T (μs) (-3 dB points)	0.039	0.097	0.265	0.584
Rise time t <sub>r</sub> (μs) (10 to 90 % amplitude)	0.017	0.017	0.020	0.027
Fall time t <sub>f</sub> (μs) (90 to 10 % amplitude)	0.060	0.077	0.069	0.077
Pulse Repetition Frequency (Hz)	3994	1998	1998	1000

Measured plots: See Clause 6.

Environmental conditions observed: On 20 August 2018, 24°C to 23°C, 60%RH to 52%RH

On 22 August 2018, 24°C to 23°C, 60%RH to 59%RH

Power supply voltage measured: 24.0 VDC to 24.0 VDC

### 3.3 Frequency Stability –temperature & voltage (FCC Rule 47 CFR, 2.1055(a)(2)/(d)(1)/(d)(3) and 80.209(b))

#### 3.3.1 Test Conditions:

- (1) Radar transmitter settings: All TX (S /M1/M2/ 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  
DC Processor unit (24 VDC): 20.4/24.0/27.6 VDC

#### 3.3.2 Test setup:

See Clause 4.

#### 3.3.3 Frequency Tolerance Limits (FCC Rule 47 CFR, 2.1055(a)(2)/(d)(1)/(d)(3), 80.209(b)):

Pulse type	S	M1	M2	L
Guard Band f(1.5/T) (MHz) (*1)	38.4	15.4	5.7	2.6
Upper limit (MHz) (*2)	9461.6	9484.6	9494.3	9497.4
Lower limit (MHz) (*2)	9338.4	9315.4	9305.7	9302.6

(\*1) Guard Band is specified to be equal to 1.5/T MHz, where "T" is the pulse length in microseconds.  
(FCC Rule 47 CFR, 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 24.0 VDC:

Pulse type		S	M1	M2	L	Result
Frequency at maximum emission (MHz)	-20°C	9433.7	9433.7	9432.7	9432.0	Complied.
	-10°C	9431.7	9431.3	9430.3	9429.0	Complied.
	0°C	9428.7	9429.3	9428.3	9427.3	Complied.
	+10°C	9427.3	9427.3	9425.7	9424.7	Complied.
	+20°C	9425.0	9425.0	9423.3	9421.7	Complied.
	+30°C	9422.0	9422.0	9420.7	9419.7	Complied.
	+40°C	9420.7	9420.0	9418.7	9416.7	Complied.
	+50°C	9418.7	9418.0	9416.7	9415.0	Complied.

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

Pulse type		S	M1	M2	L	Result
Frequency at maximum emission (MHz)	20.4 VDC	9425.0	9425.0	9423.3	9421.7	Complied.
	24.0 VDC	9425.0	9425.0	9423.3	9421.7	Complied.
	27.6 VDC	9425.0	9425.0	9423.3	9421.0	Complied.

Environmental conditions observed: On 20 August 2018, 24°C to 23°C, 60%RH to 52%RH  
On 21 August 2018, 23°C to 23°C, 52%RH to 52%RH  
On 22 August 2018, 24°C to 23°C, 60%RH to 59%RH

Power supply voltage measured: 24.0 VDC to 24.0 VDC

### 3.4 Occupied Bandwidth

(FCC Rule 47 CFR, 2.202(a), 2.1049(c)(1), 80.209(b) and 80.211(f))

#### 3.4.1 Test conditions:

For all TX (S /M1/M2/ 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 (FCC Rule 47 CFR, 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 22 August 2018, 23°C to 23°C, 59%RH to 59%RH

Power supply voltage measured: 24.0 VDC to 24.0 VDC

### 3.5 Spurious Emissions at Antenna Port (FCC Rule 47 CFR, 2.1051, 80.211(f), 80.273 and ITU-R SM.329-12)

#### 3.5.1 Test Conditions:

- (a) For S 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 (*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 (FCC Rule 47 CFR, 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 frequency and levels measured of which margins were below 20 dB were listed in the following table.

Frequency (GHz)	Level (dBm)	Limit (dBm)	Margin (dB)
18.850	-31.15	-13.00	18.15

Environmental conditions observed: On 23 August 2018, 23°C to 23°C, 59%RH to 59%RH

On 24 August 2018, 23°C to 23°C, 59%RH to 59%RH

Power supply voltage measured: 24.0 VDC to 24.0 VDC

### 3.6 Field Strength of Spurious Radiation (FCC Rule 47 CFR, 2.1053, 80.211(f) and ITU-R SM.329-12)

#### 3.6.1 Test Conditions:

(a) For S 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 (*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) Antenna Height and Polarization:

(a) Antenna height: EUT center (1.75 m)

(b) Antenna polarization: vertical and horizontal.

EUT height: 1.5 m

#### 3.6.5 Field Strength Limits (FCC Rule 47 CFR, 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.

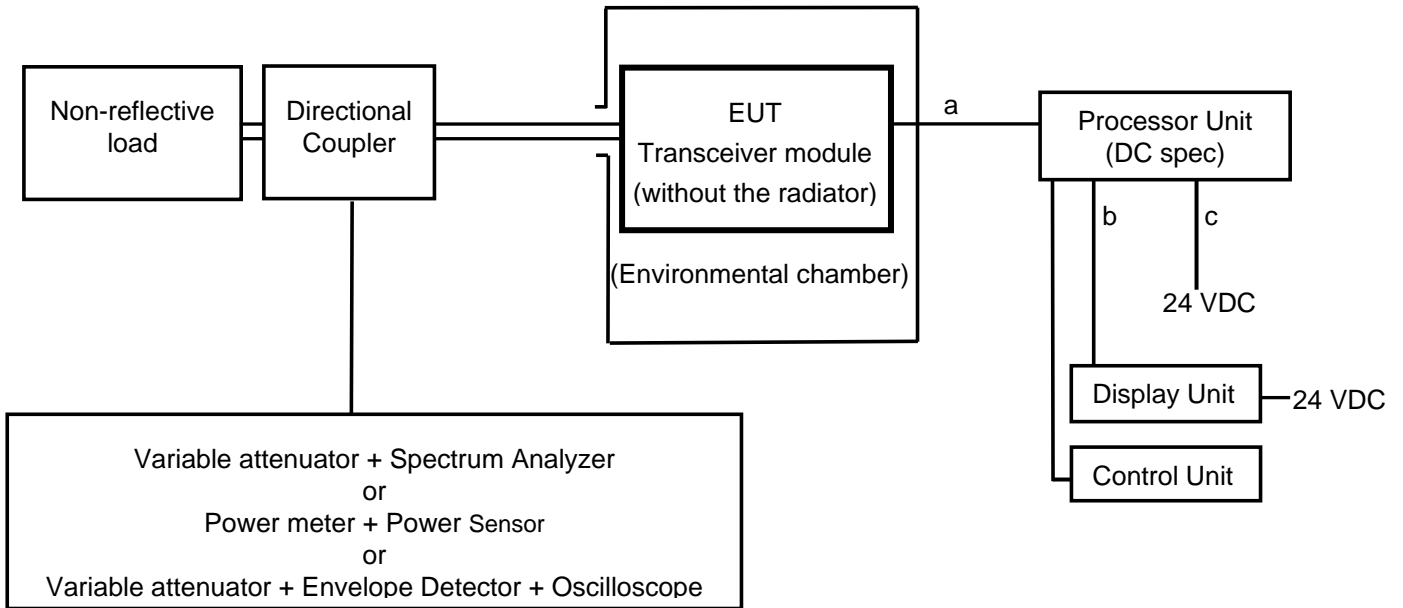
Spurious emission levels measured were found to be attenuated more than 20 dB below the limits.

Environmental conditions observed: On 4 August 2018, 21°C to 21°C, 57%RH to 57%RH

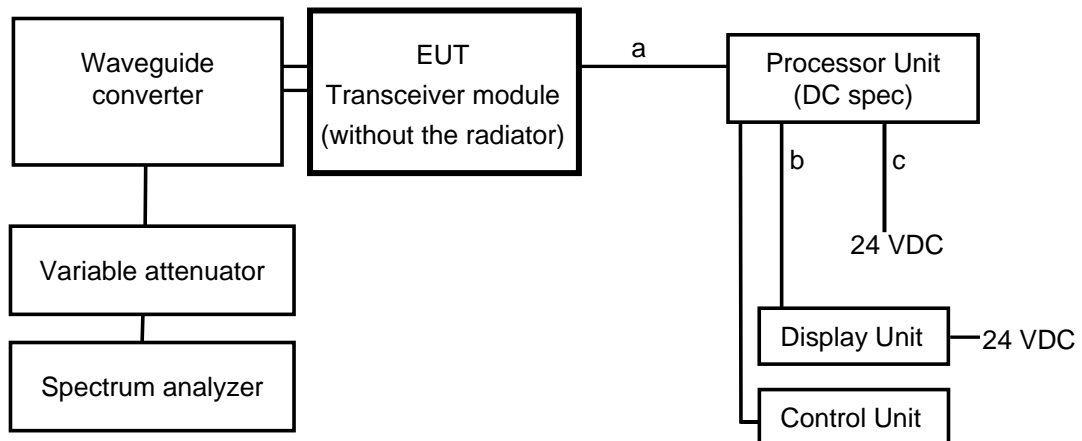
Power supply voltage measured: 24.0 VDC to 24.0 VDC

## 4 Test Setup for Measurements

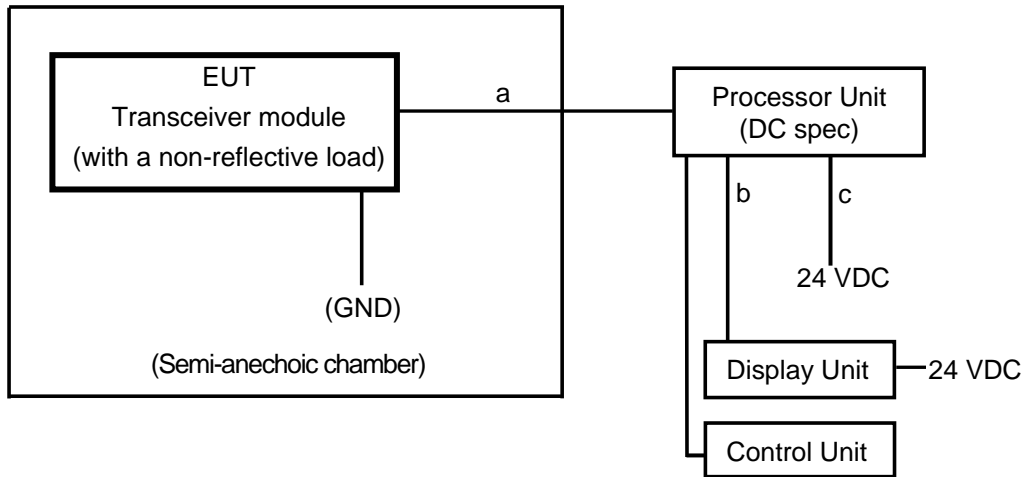
### 4.1 Test Setup for Clauses 3.1, 3.2 and 3.3



### 4.2 Test Setup for Clauses 3.4 and 3.5



**4.3 Test Setup for Clause 3.6**



**Cable designations**

No.	Category (*)	Cable name	Type	Length (m)	Number of cables	Cable Shielding
a	S	Signal cable	RW-0013	15	1	Yes
b	S	DVI cable	DVI-D/D S-LINK	10	1	Yes
c	P	JIS cable	DPYC-6	5	1	No

(\*) 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.

### 5.1 RF Power Output

C/N	Instrument	Type	S/N	Manufacturer	Date of last calibration	Calibration interval
RT198	Directional coupler (X-band)	5D364S	R05762	Shimada	6 March 2018	1 year
--	Dummy load (X-band)	4D376	R25510002	Shimada	Not applicable.	--
RT200	Power meter	E4419B	MY45101375	Agilent	16 March 2018	1 year
RT201	Power sensor	8481A	2349A39603	Agilent	16 March 2018	1 year
RT213	Waveguide	WRJ-10	--	Furuno	19 July 2018	1 year
HT431	DC power supply	PAN55-20	AK003303	Kikusui	--	--
HT414	Climatic chamber (Small)	PL-4KP	14004203	Espec	27 September 2017	1 year
HT726	Paperless recorder/ Dual communication logger	FX106-4-1	S5JA01448	Yokogawa	--	--
HT1024	Digital multi-meter	233	27230019	Fluke	26 February 2018	1 year

### 5.2 Modulation Characteristics

C/N	Instrument	Type	S/N	Manufacturer	Date of last calibration	Calibration interval
RT198	Directional coupler (X-band)	5D364S	R05762	Shimada	6 March 2018	1 year
--	Dummy load (X-band)	4D376	R25510002	Shimada	Not applicable.	--
RT213	Waveguide	WRJ-10	--	Furuno	19 July 2018	1 year
HT654	Attenuator	8494B	MY42148134	Agilent	21 February 2018	1 year
HT1223	Attenuator	8495B	MY42148137	Agilent	15 May 2018	1 year
HT1221	Crystal detector	423B	MY51342422	Agilent	8 March 2018	1 year
0808052	Frequency counter	MF2414C	6200769857	ANRITSU	20 July 2018	1 year
HT972	Oscilloscope	MSO4054B	C030483	TEKTRONIX	5 March 2018	1 year
HT431	DC power supply	PAN55-20	AK003303	Kikusui	Not applicable.	--
HT414	Climatic chamber (Small)	PL-4KP	14004203	Espec	27 September 2017	1 year
HT726	Paperless recorder/ Dual communication logger	FX106-4-1	S5JA01448	Yokogawa	Not applicable.	--
HT1024	Digital multi-meter	233	27230019	Fluke	26 February 2018	1 year

### 5.3 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	6 March 2018	1 year
--	Dummy load (X-band)	4D376	R25510002	Shimada	Not applicable.	--
HT414	Climatic chamber (Small)	PL-4KP	14004203	Espec	27 September 2017	1 year
HT726	Paperless recorder/ Dual communication logger	FX106-4-1	S5JA01448	Yokogawa	Not applicable.	--
RT213	Waveguide	WRJ-10	--	Furuno	19 July 2018	1 year
HT654	Attenuator	8494B	MY42148134	Agilent	21 February 2018	1 year
HT1223	Attenuator	8495B	MY42148137	Agilent	15 May 2018	1 year
HT676	Spectrum analyzer	8564EC	4103A00440	Agilent	18 April 2018	1 year
HT431	DC power supply	PAN55-20	AK003303	Kikusui	Not applicable.	--
HT1024	Digital multi-meter	233	27230019	Fluke	26 February 2018	1 year



### 5.4 Occupied Bandwidth

C/N	Instrument	Type	S/N	Manufacturer	Date of last calibration	Calibration interval
RT198	Directional coupler (X-band)	5D364S	R05762	Shimada	6 March 2018	1 year
--	Dummy load (X-band)	4D376	R25510002	Shimada	Not applicable.	--
HT654	Attenuator	8494B	MY42148134	Agilent	21 February 2018	1 year
HT1223	Attenuator	8495B	MY42148137	Agilent	15 May 2018	1 year
HT676	Spectrum analyzer	8564EC	4103A00440	Agilent	18 April 2018	1 year
HT431	DC power supply	PAN55-20	AK003303	Kikusui	Not applicable.	--
HT1024	Digital multi-meter	233	27230019	Fluke	26 February 2018	1 year

### 5.5 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	6 March 2018	1 year
--	Dummy load (X-band)	4D376	R25510002	Shimada	Not applicable.	--
--	Adapter	BL00-6254-00	--	Orient Microwave	Not applicable.	--
--	Adapter	PE9803	---	Pasternack	Not applicable.	--
--	Adapter	BL00-6256-00	--	Orient Microwave	Not applicable.	--
--	Adapter	PE9826	---	Pasternack	Not applicable.	--
--	Isolator	OMC FX0157	8H0028	--	Not applicable.	--
HT676	Spectrum analyzer	8564EC	4103A00440	Agilent	18 April 2018	1 year
HT431	DC power supply	PAN55-20	AK003303	Kikusui	Not applicable.	--
HT1024	Digital multi-meter	233	27230019	Fluke	26 February 2018	1 year
KB181	Coaxial cable for radiated emission measurement	SUCOFLEX 102A	1261/2A	HUBER+SUHNER	11 August 2018	1 year
KB289	Coaxial cable for radiated emission measurement	SF104A/11PC 35/11PC35/55 00MM	800048/4A	HUBER+SUHNER	11 August 2018	1 year

### 5.6 Field Strength of Spurious Radiation

C/N	Instrument	Type	S/N	Manufacturer	Date of last calibration	Calibration interval
HT744	Radiated emission measurement Software	EP5/RE	Ver. 6.0.10	TOYO	Not applicable.	--
HT745	EMI test receiver (20 Hz to 40 GHz)	ESU40	110243	Rohde & Schwarz	29 December 2017	1 year
HT758	Broadband horn antenna (1 GHz to 6 GHz)	9120B	522	Schwarzbeck	3 January 2018	1 year
NK004	Double rigged horn antenna	TR17206	93370015	ADVANTEST	15 December 2017	1 year
HT761	Double rigged horn antenna & amp.	HAP18-26N	00000017	TOYO	7 December 2017	1 year
HT762	Double rigged horn antenna & amp.	HAP26-40N	00000010	TOYO	7 December 2017	1 year
HT755	Pre-amplifier	TPA0108-40	1017	TOYO	19 July 2018	1 year
HT779	Semi-anechoic chamber	10mSAC	90984	TOKIN	Not applicable.	--
HT781	Programmable DC power supply	PAN60-20A	QM003356	Kikusui	Not applicable.	--

### 6 RF Envelope and Spectrum of the Output Pulse

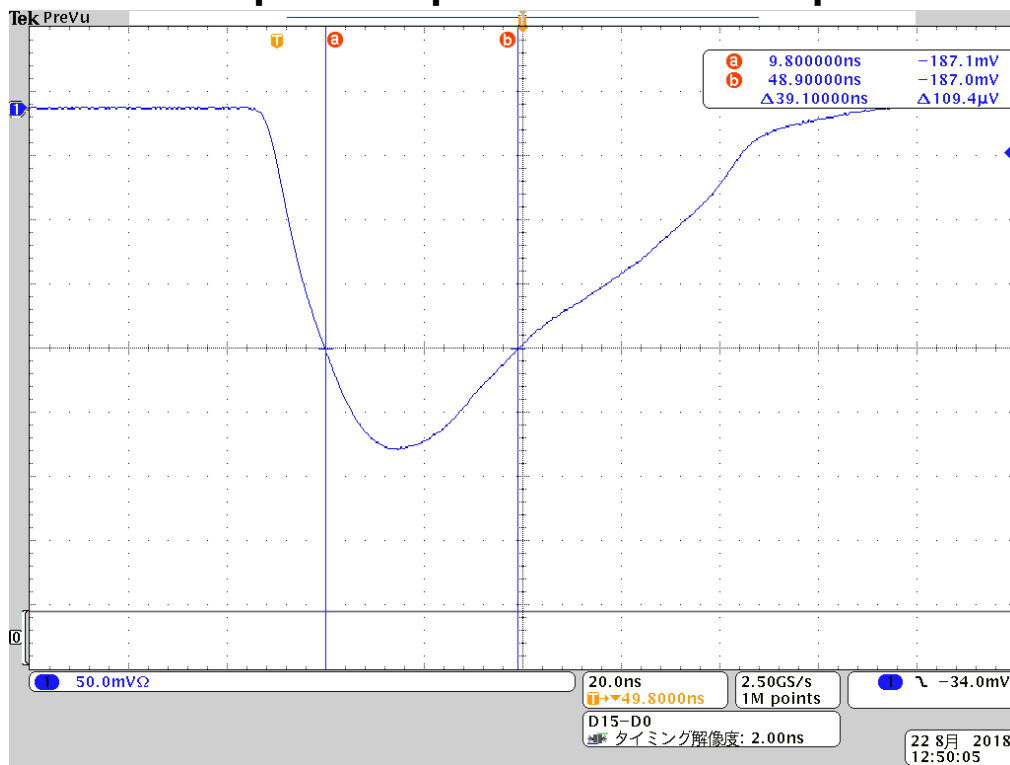


Fig. 6.1 S pulse envelope

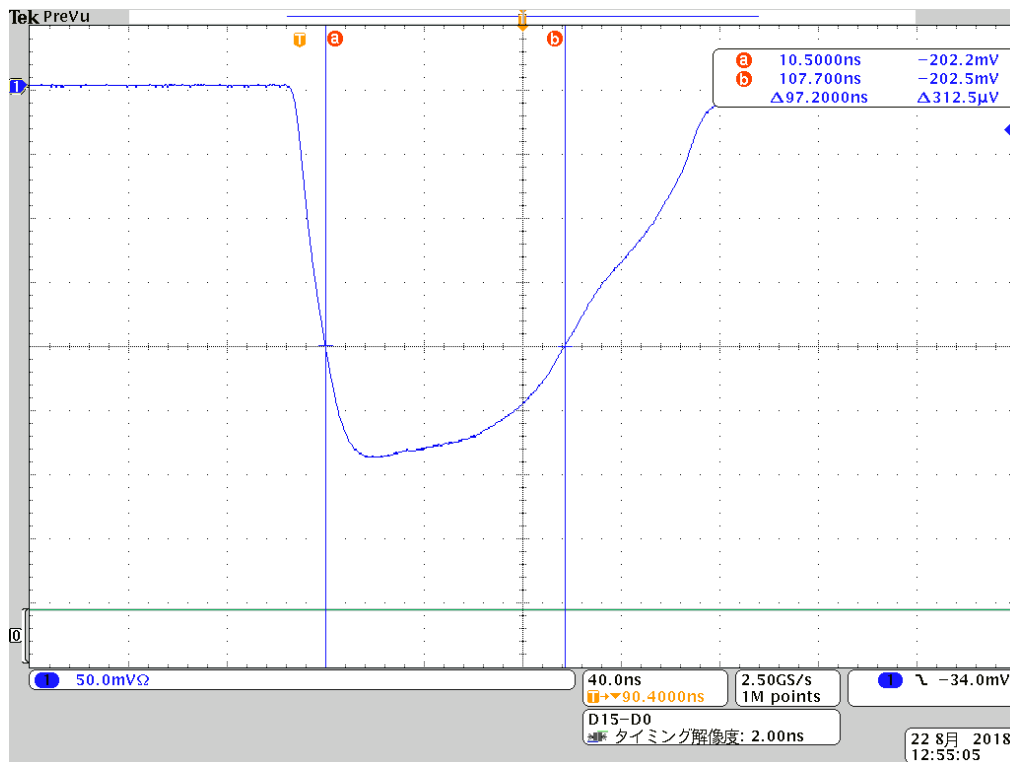


Fig. 6.2 M1 pulse envelope

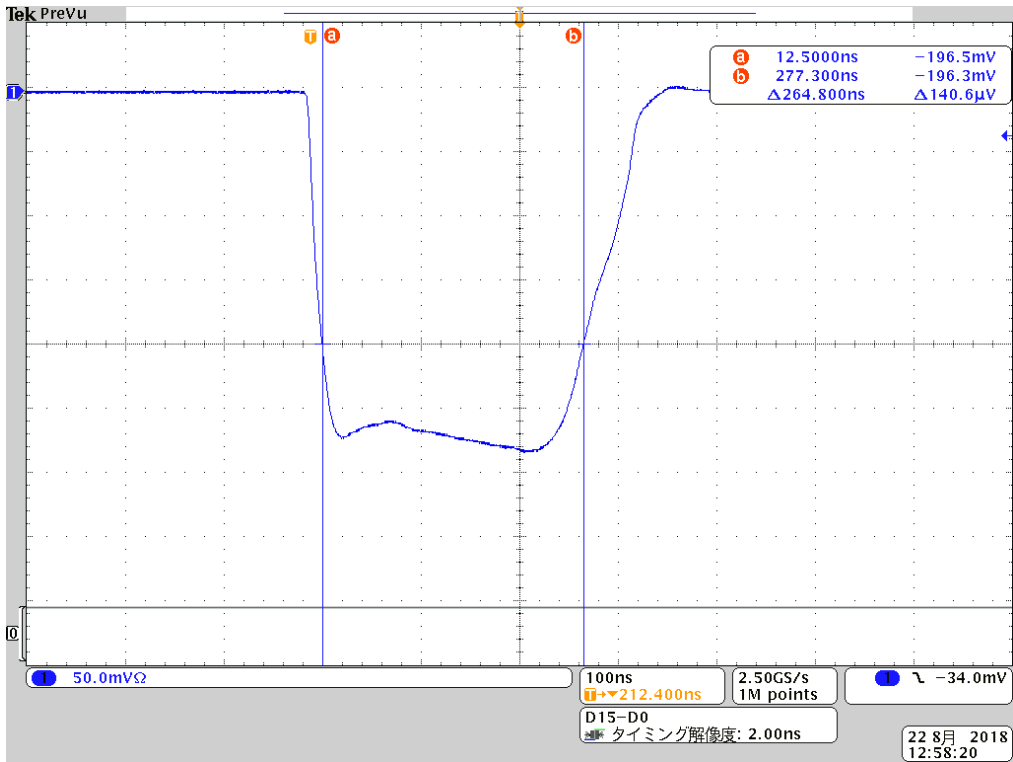


Fig. 6.3 M2 pulse envelope

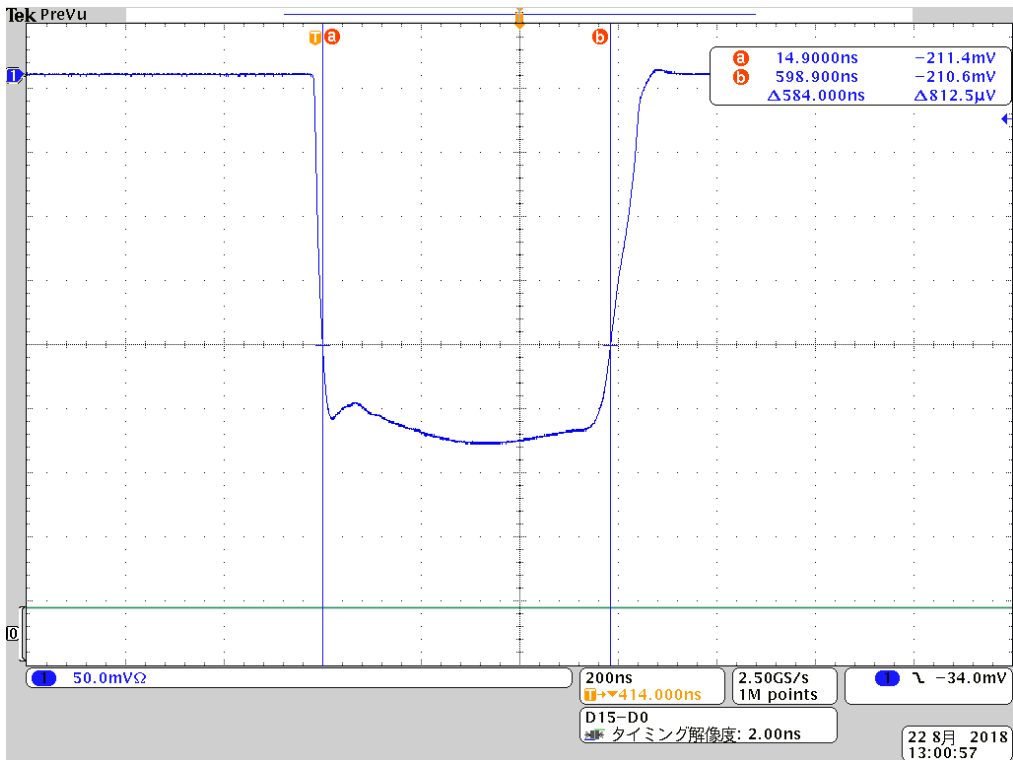


Fig. 6.4 L pulse envelope

## 7 Spurious Emission Plots measured at Antenna Terminal

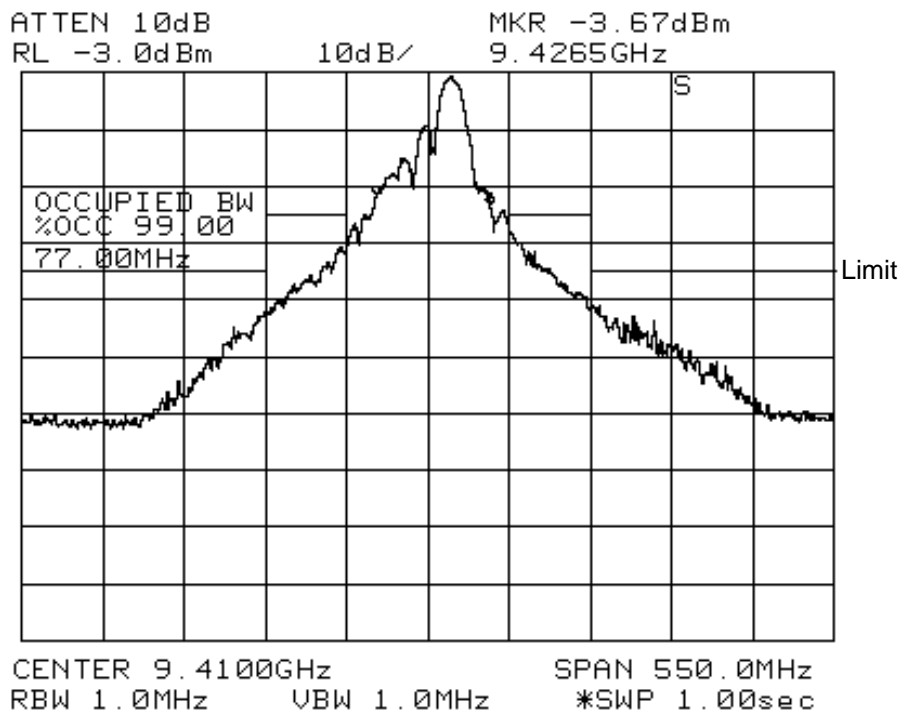


Fig. 7.1 for S pulse

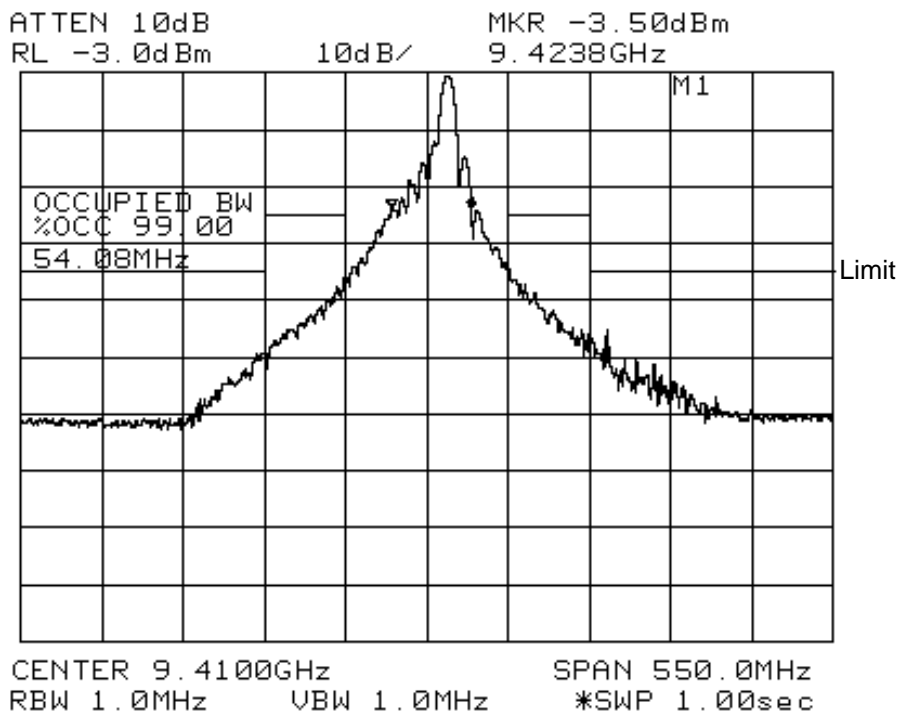


Fig. 7.2 for M1 pulse

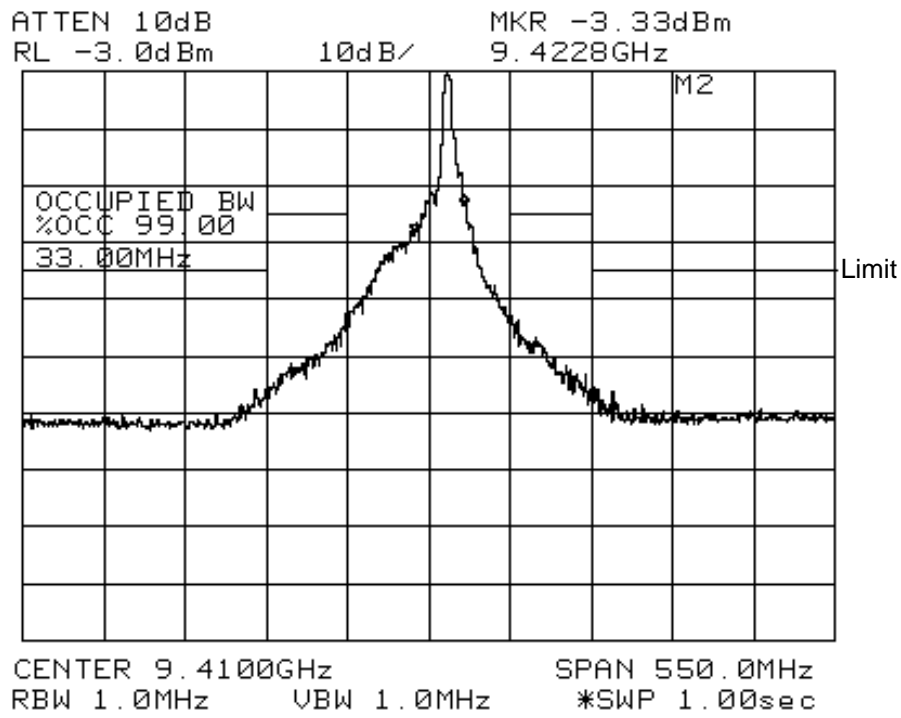


Fig. 7.3 for M2 pulse

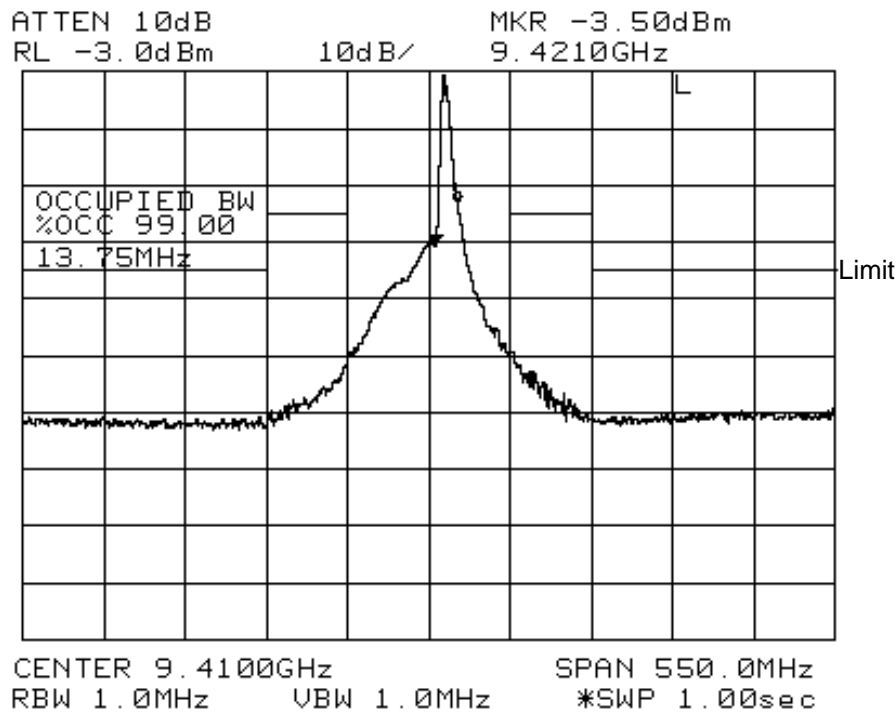


Fig. 7.4 for L pulse

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