

Test Report

CFR Title 47 Sections:

**Part 2 (2.1046, 2.1049, 2.1051, 2.1053, 2.1055, 2.1057),
Part 80 (80.209, 80.211, 80.215, 80.217)**

for

**Trade name: Furuno
Model: CLASS B AIS TRANSPONDER
Type: FA-70**

Report No.: LIC 12-19-199

Date of Issue: 31 October 2019

Labotech International Co., Ltd.

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Report Summary

LIC project number:	LIC 04-19-0293		
Test report number of initial issue:	LIC 12-19-199	Date of initial issue	31 October 2019
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: 2.1046 - RF Power Output 2.1049 - Occupied Bandwidth 2.1051 - Spurious Emissions at Antenna Terminals 2.1053 - Field Strength of Spurious Radiation 2.1055 - Measurements required: Frequency Stability 2.1057 - Frequency spectrum to be investigated 80.209 - Transmitter frequency tolerances 80.211 - Emission limitations 80.215 - Transmitter power 80.217 - Suppression of Interference Aboard Ships (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:	CLASS B AIS TRANSPONDER		
Type:	FA-70		
Product function and intended use:	Class B AIS transponder		
Number of samples tested:	One		
Serial number:	1001-0610-0006		
Power rating:	12–24 VDC, 1.8–0.9 A		
Product status:	Pre-production model		
Modifications made to samples during testing:	See Clause 1.3 of this report.		
Date of receipt of samples:	17 July 2019 and 3 September 2019		
Test period:	From 22 July 2019 to 8 October 2019		
Place of test:	Labotech International Co., Ltd. FCC Test firm Designation Number: JP2007 FCC Test firm Registration #: 838049 - Nishinomiya Lab. 9-52, Ashihara-cho, Nishinomiya-shi, Hyogo, 662-8580 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:	Koji Kawai
Written by:	Arisa Ogino
Verified by:	Atsushi Takagi
Approved by:	Date: 31 October 2019 Name: Atsushi Takagi Title: Manager, 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, 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 accredited 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/>).

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1 Principal Information

1.1 Equipment under test (EUT)

1.1.1 General

- (a) Trade name: Furuno
- (b) Manufacturer: Furuno Electric Co., Ltd.
Ashihara-cho 9-52, Nishinomiya-city, Hyogo, 662-8580 Japan
- (c) Model: FA-70
- (d) EUT configuration:
- | Unit | Type | Serial number | Remarks |
|-------------------------|-----------|----------------|--------------------|
| CLASS B AIS TRANSPONDER | FA-70 | 1001-0610-0006 | -- |
| GPS Antenna | GPA-017S | 021871 | One (1) selectable |
| GPS Antenna | GPA-017 | - | |
| GPS Antenna | GPA-C01 | - | |
| VHF Antenna | CX4-3/FEC | 20160215S0001 | -- |
- (e) Certification number: FCC ID: ADB9ZWFA70
- (f) Classification: Class B SO/CS AIS equipment
- (g) Equipment designator: CLASS B AIS TRANSPONDER
- (h) Communication capacity: 2250 reports/min/1 channel
4500 reports/min/2 channels
- (i) Communication system: Self-Organized Time Division Multiple Access (SOTDMA),
Carrier Sense Time Division Multiple Access (CSTDMA),
Simultaneous reception of 2 channels
- (j) Occupied bandwidth: 25 kHz (depending on Channel spacing setting)
- (k) Frame synchronization: UTC Direct synchronization by built-in GPS receiver or
UTC Indirect synchronization by using other station
- (l) Operating mode: Autonomous, Assigned and Polled/interrogation response
- (m) Channel selection: Automatically
- (n) Prevention of abnormal TDMAX-transmitting: Automatic transmission stops when detecting 1 second or more
continuous transmission
- (o) ANT Impedance: 50 ohm
- (p) Regulations/Standards: IMO MSC.140 (76)
ITU-R M.1371-5, DSC: ITU-R M.825-3, ITU-R M.1084-5
IEC 62287-1 Ed.3.0, IEC 62287-2 Ed.2.0, EN 303 413 V1.1.1
EN 301 843-1 V2.2.1
IEC 60945 Ed.4+CORR.1, IEC 62368-1 Ed.3, IEC 62311 Ed.1+Ed.2

1.1.2 TRANSPONDER UNIT

TDMA TX

- (a) Frequency range: 156.025 MHz to 162.025 MHz
- (b) Output Power: 1 W / 5 W (SOTDMA), 2 W (CSTDMA)
- (c) Type of emission: F1D
- (d) Emission designator: 25K0F1D
- (e) Type of modulation: GMSK
- (f) Channel interval: 25 kHz
- (g) Frequency deviation: within ± 500 Hz
- (h) Transmit speed: within 9600 bps $\pm$ 50 ppm
- (i) Spurious emissions: 9 kHz to 1 GHz, less than -36 dBm (0.25 μ W)
1 GHz to 4 GHz, less than -30 dBm (1 μ W)

TDMA RX

- (a) Frequency range: 156.025 MHz to 162.025 MHz
- (b) Oscillator frequency: 1st LO: $f_0 + (46.35 \text{ MHz}/58.05 \text{ MHz})$
2nd LO: 45.9 MHz/57.6 MHz
Note: f_0 : TDMA frequency
- (c) Intermediate frequency: 1st IF: 46.35 MHz/58.05 MHz
2nd IF: 450 kHz
- (d) RX System: Double super-heterodyne
- (e) Sensitivity: < -107 dBm (PER < 20%)
- (f) Error at high input level: -7 dBm (PER < 10%)
-77 dBm (PER < 2%)
- (g) Co-channel rejection: > -10 dB (PER < 20%)
- (h) Adjacent channel selectivity: > 70 dB (PER < 20%)
- (i) Spurious response rejection: > 70 dB (PER < 20%)
- (j) Intermodulation response: Wanted Signal: -101 dBm
Unwanted Signal1: ± 50 kHz, -36 dBm, unmodulated
Unwanted Signal2: ± 100 kHz, -36 dBm, Mod 400 Hz/Dev ± 3 kHz
PER < 20%
- (k) Spurious emissions: 9 kHz to 1 GHz, less than -57 dBm (2 nW)
1 GHz to 4 GHz, less than -47 dBm (20 nW)

DSC RX (TIMESHARING SYSTEM)

- (a) Receiving Frequency: CH 70 (fixed), 156.525 MHz
- (b) Sensitivity: < -107 dBm (BER < 1%)
- (c) Error at high input level: -7 dBm (BER < 1%)
- (d) Co-channel rejection: >-10 dB (BER < 1%)
- (e) Adjacent channel selectivity: >70 dB (BER < 1%)
- (f) Spurious response rejection: >70 dB (BER < 1%)
- (g) Intermodulation response:
 - Wanted Signal: -104 dBm
 - Unwanted Signal1: ± 50 kHz, -39 dBm, unmodulated
 - Unwanted Signal2: ± 100 kHz, -39 dBm, Mod 400 Hz/Dev ± 3 kHz
 - BER < 1%
- (h) Blocking or desensitization:
 - Wanted Signal: -104 dBm
 - Unwanted Signal: -20 dBm, unmodulated
 - BER < 1%
- (i) Spurious emissions:
 - 9 kHz to 1 GHz, less than -57 dBm (2 nW)
 - 1 GHz to 4 GHz, less than -47 dBm (20 nW)

1.1.3 GPS RECEIVER

- (a) Receiving frequency: 1575.42 MHz
- (b) Tracking code: C/A code
- (c) Number of channel: 14 channels parallel, 14 satellites
- (d) Position fixing method: All in view, 8-state Kalman filter
- (e) Position accuracy:
 - GPS: 13 m max. (2DRMS, HDOP < 4)
 - DGPS: 5 m max. (2DRMS, HDOP < 4)
- (f) Tracking velocity: 1000 kn
- (g) Position fixing time: Cold start: 90 seconds typical
- (h) Geoids: WGS-84
- (i) Position update interval: 1 second (Typ.)
- (j) DGPS data receiving: RTCM SC104 Ver 2.1 formatted by AIS information

1.1.4 POWER SUPPLY

- (a) Transponder Unit: 12–24 VDC, 1.8–0.9 A

1.1.5 ENVIRONMENTAL CONDITIONS

- (a) Ambient Temperature:
- | | |
|--------------|----------------|
| FA-70: | -15°C to +55°C |
| GPS Antenna: | -25°C to +70°C |
- (b) Relative Humidity: 93% at +40°C
- (c) Degree of protection (IEC 60529):
- | | |
|--------------|------|
| FA-70: | IP55 |
| GPS Antenna: | IP56 |
- (d) Bearing vibration: IEC 60945 edition 4

1.1.6 DIMENSIONS AND MASS

- (a) Transponder unit: 190 (W) × 131 (H) × 55 (D) mm, 0.5 kg

1.1.7 Identification of Equipment (FCC Rule 2.925)

The following nameplate is permanently fixed on the corresponding equipment unit.

FCC ID: ADB9ZWFA70

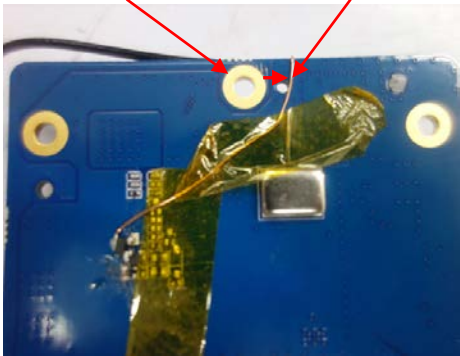
Material of nameplate: Polycarbonate film, 0.25 mm thick

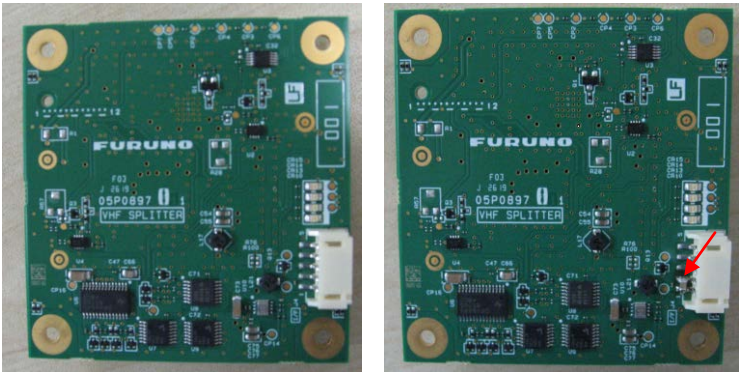
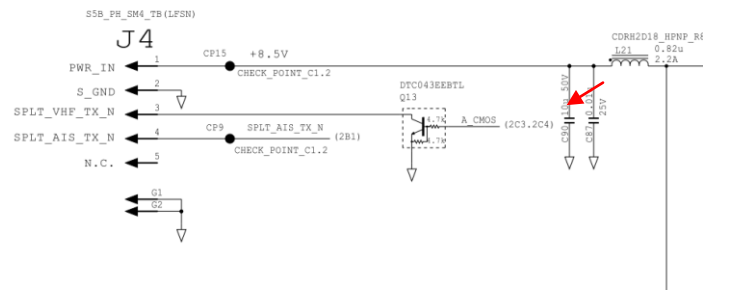
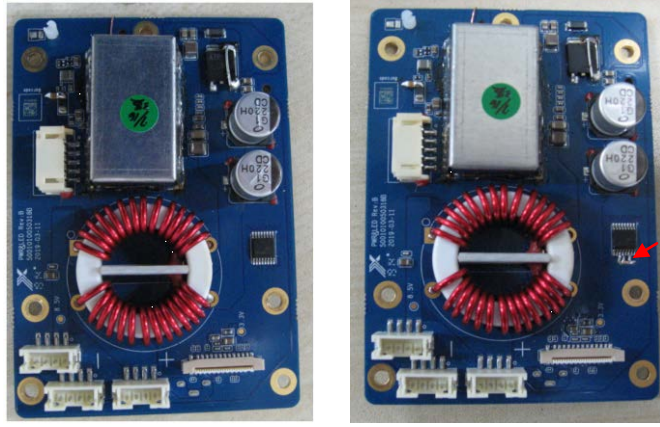
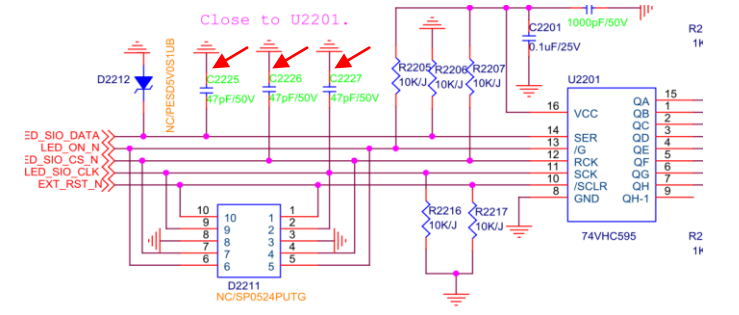
1.2 Observation and comments

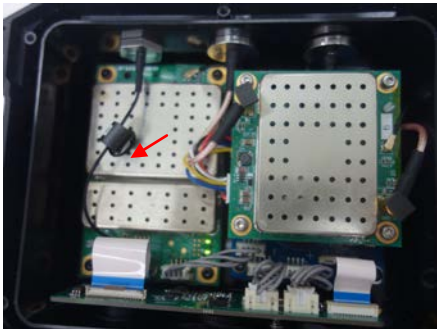
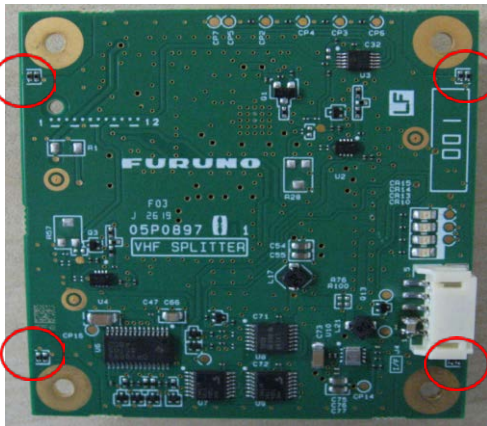
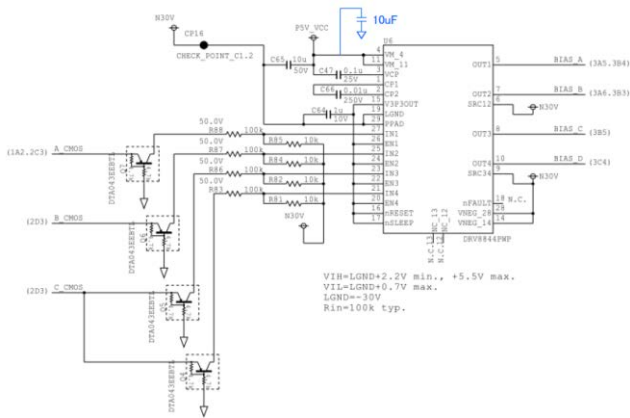
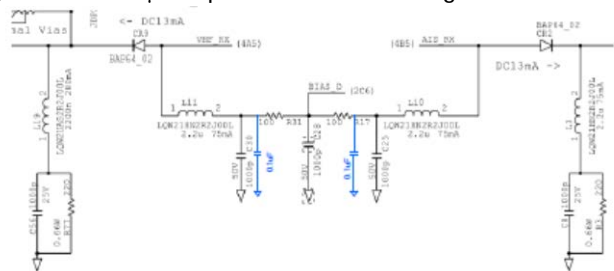
None.

1.3 Modification made to the EUT

Following modifications were made to the EUT during testing:

State	Description	Made by	Date
0	As supplied by the customer.	--	--
1	Moved the jumper wire on PWR&LED board to keep away from the grounding pattern. Grounding pattern Jumper wire 	Customer	21 August 2019

State	Description	Made by	Date
2	(1) Changed the threshold value of VHF SPLITTER board, from 28 to 65. (2) Added a capacitor of 10 μF on VHF SPLITTER board. Before the modification After the modification   (3) Added three capacitors of 47 pF on PWR&LED board. Before the modification After the modification  	Customer	3 September 2019

State	Description	Made by	Date
3	(1) Added a 2-turn ferrite core (Manufacturer: TKK, Type: SCN-10-5-10) on GPS port line.  (2) Changed the eight pieces of 0 Ω resistance on VHF SPLITTER board, which were the ground connections to PWR&LED board, to four pieces of 1000 pF capacitors. 	Customer	1 October 2019
4	(1) Added a 10 μF capacitor on the power line of U6 on VHF SPLITTER.  (2) Added a 0.1 μF capacitor on the receiving line of VHF SPLITTER. 	Customer	2 October 2019

2 Test Results Summary

Clause No. of this report	47 CFR Section	Item	Result	Test engineer
3.1	2.1046 80.215	RF Power Output	Passed.	K. Kawai
3.2	2.1049 80.209(b) 80.211(f)	Occupied Bandwidth	Passed.	K. Kawai
3.3	2.1055 80.209(b)	Frequency Stability	Passed.	K. Kawai
3.4	--	Spurious Emissions	--	--
3.4.1	2.1051 2.1057 80.211(f)	- Spurious Emissions at Antenna Terminal	Passed.	K. Kawai
3.4.2	2.1053 2.1057 80.211(f)	- Field Strength of Spurious Radiation	Passed.	K. Kawai
3.5	80.217	Suppression of Interference Aboard Ships	Passed.	K. Kawai

3 Test Results

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

(1) Test conditions:

AIS Transmitter Setting: 156.025 MHz (CH 1060) and 162.025 MHz (CH 2088)
5 W, 2 W and 1 W

For the transmitter, output power was measured at the antenna port with unmodulated.

(2) Test setup:

See Clause 4.

(3) Test Results:

RF Power Output (Temperature) (Modification status: 0)

Test conditions		RF Power Output (dBm)					
		156.025 MHz (CH1060)			162.025 MHz (CH 2088)		
Temperature	Voltage	5 W	2 W	1 W	5 W	2 W	1 W
Tmin (-20°C)	Vnom (12 V)	37.1	33.0	29.8	37.0	32.8	29.6
(-10°C)	Vnom (12 V)	37.1	33.0	29.8	37.0	32.8	29.6
(0°C)	Vnom (12 V)	37.1	33.0	29.8	37.0	32.8	29.6
(+10°C)	Vnom (12 V)	37.1	33.0	29.8	36.9	32.7	29.5
Tnom (+20°C)	Vnom (12 V)	37.1	32.9	29.7	36.9	32.7	29.4
(+30°C)	Vnom (12 V)	37.0	32.9	29.6	36.8	32.6	29.4
(+40°C)	Vnom (12 V)	37.0	32.8	29.5	36.8	32.5	29.3
Tmax (+50°C)	Vnom (12 V)	36.9	32.7	29.5	36.7	32.4	29.2
Limits		1 W: 1 W or less					

Output carrier power set at its nominal: 37 dBm (5 W)

Output carrier power set at its nominal: 33 dBm (2 W)

Output carrier power set at its nominal: 30 dBm (1 W)

RF Power Output (Voltage) (Modification status: 0)

Test conditions		RF Power Output (dBm)					
		156.025 MHz			162.025 MHz		
Temperature	Voltage	5 W	2 W	1 W	5 W	2 W	1 W
Tnom (+20°C)	Vnom-10% (10.2 V)	37.1	33.0	29.7	36.9	32.7	29.4
Tnom (+20°C)	Vnom (12 V)	37.1	32.9	29.7	36.9	32.7	29.4
Tnom (+20°C)	Vnom+15% (27.6 V)	37.1	32.9	29.7	36.9	32.7	29.4
Limits		1 W: 1 W or less					

Output carrier power set at its nominal: 37 dBm (5 W)

Output carrier power set at its nominal: 33 dBm (2 W)

Output carrier power set at its nominal: 30 dBm (1 W)

Current and Voltage measurements (Modification status: 4)

Test conditions		Current and Voltage measurements					
		156.025 MHz			162.025 MHz		
Temperature	Voltage	5 W	2 W	1 W	5 W	2 W	1 W
Tnom (+20°C)	Vnom-10% (10.2 V)	7.32 VDC	7.40 VDC	7.42 VDC	7.36 VDC	7.41 VDC	7.43 VDC
		1.33 A	0.62 A	0.36 A	1.11 A	0.52 A	0.30 A
Tnom (+20°C)	Vnom (12 V)	7.32 VDC	7.39 VDC	7.42 VDC	7.35 VDC	7.40 VDC	7.42 VDC
		1.33 A	0.62 A	0.36 A	1.11 A	0.52 A	0.30 A
Tnom (+20°C)	Vnom+15% (27.6 V)	7.32 VDC	7.39 VDC	7.41 VDC	7.34 VDC	7.40 VDC	7.42 VDC
		1.33 A	0.63 A	0.36 A	1.11 A	0.52 A	0.30 A

Output carrier power set at its nominal: 37 dBm (5 W)

Output carrier power set at its nominal: 33 dBm (2 W)

Output carrier power set at its nominal: 30 dBm (1 W)

The DC voltage applied to and DC current into the several elements of the final radio frequency amplifying device for normal operation over the power range.

Environmental conditions observed: On 23 July 2019, 23°C to 23°C, 59%RH to 59%RH
On 24 July 2019, 23°C to 23°C, 59%RH to 59%RH
On 25 July 2019, 23°C to 23°C, 59%RH to 59%RH
On 8 October 2019, 22°C to 22°C, 62%RH to 62%RH

Power supply voltage measured: 12.0 VDC to 12.0 VDC, 10.2 VDC to 10.2 VDC, 27.6 VDC to 27.6 VDC

3.2 Occupied Bandwidth (FCC Rule 47 CFR, 2.1049, 80.209 (b), 80.211 (f))

(1) Test conditions:

AIS Transmitter Setting: 156.025 MHz (CH 1060) and 162.025 MHz (CH 2088)

5 W, 2 W and 1 W

Occupied bandwidth was measured at the antenna port with AIS message 18 and maximum symbol rate (2 sec).

(2) Test setup:

See Clause 4.

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

Frequency removed from the carrier frequency	Emission limits (output power)
50 - 100% (of the authorized bandwidth)	At least 25 dBc
100 - 250% (of the authorized bandwidth)	At least 35 dBc
more than 250% (of the authorized bandwidth)	At least $43 + 10 \log_{10} p(\text{watts})$ = At least 50 dBc for 5 W setting = At least 46 dBc for 2 W setting = At least 43 dBc for 1 W setting

Authorized bandwidth = 25 kHz

Reference level = RF Power Output (Mean Power, in dBW)

(4) Test Results:

Complied. (Modification status: 0)

Spectrum plots: See Clause 6.

Environmental conditions observed: On 5 August 2019, 22°C to 22°C, 66%RH to 66%RH

Power supply voltage measured: 12.0 VDC to 12.0 VDC.

3.3 Frequency Stability (FCC Rule 47 CFR, 2.1055, 80.209 (a))

(1) Test Conditions:

- (1) AIS Transmitter Setting: 156.025 MHz (CH 1060) and 162.025 MHz (CH 2088)
5 W, 2 W and 1 W
- (2) Ambient Temperature settings: -20°C to +50°C (10°C interval)
- (3) Power Supply Voltage settings: 85 /100/115 % of nominal voltage (10.2/12.0/27.6 VDC)

Frequency Stability was measured at the antenna port with unmodulated.

(2) Test setup:

See Clause 4.

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

±10 ppm

(4) Test Results:

Complied. (Modification status: 0)

Frequency Stability (Temperature)

Test conditions		Frequency Stability (MHz)					
		156.025 MHz (CH1060)			162.025 MHz (CH 2088)		
Temperature	Voltage	5 W	2 W	1 W	5 W	2 W	1 W
Tmin (-20°C)	Vnom (12 V)	156024957 (-43 Hz)	156024956 (-44 Hz)	156024955 (-45 Hz)	162024955 (-45 Hz)	162024955 (-45 Hz)	162024953 (-47 Hz)
(-10°C)	Vnom (12 V)	156024941 (-59 Hz)	156024941 (-59 Hz)	156024942 (-58 Hz)	162024939 (-61 Hz)	162024939 (-61 Hz)	162024940 (-60 Hz)
(0°C)	Vnom (12 V)	156024940 (-60 Hz)	156024941 (-59 Hz)	156024941 (-59 Hz)	162024939 (-61 Hz)	162024940 (-60 Hz)	162024940 (-60 Hz)
(+10°C)	Vnom (12 V)	156024949 (-51 Hz)	156024949 (-51 Hz)	156024949 (-52 Hz)	162024947 (-53 Hz)	162024947 (-53 Hz)	162024947 (-53 Hz)
Tnom (+20°C)	Vnom (12 V)	156024925 (-75 Hz)	156024925 (-75 Hz)	156024925 (-75 Hz)	162024922 (-78 Hz)	162024922 (-78 Hz)	162024922 (-78 Hz)
(+30°C)	Vnom (12 V)	156024923 (-77 Hz)	156024923 (-77 Hz)	156024923 (-77 Hz)	162024920 (-80 Hz)	162024920 (-80 Hz)	162024920 (-80 Hz)
(+40°C)	Vnom (12 V)	156024921 (-79 Hz)	156024922 (-78 Hz)	156024921 (-79 Hz)	162024919 (-81 Hz)	162024919 (-81 Hz)	162024919 (-81 Hz)
Tmax (+50°C)	Vnom (12 V)	156024877 (-123 Hz)	156024877 (-123 Hz)	156024877 (-123 Hz)	162024875 (-125 Hz)	162024873 (-127 Hz)	162024873 (-127 Hz)
Deviation max.		-123 Hz	-123 Hz	-123 Hz	-125 Hz	-127 Hz	-127 Hz
Limits		±1620 Hz for CH2088 (162.025 MHz) ±1560 Hz for CH1060 (156.025 MHz)					

Output carrier power set at its nominal: 37 dBm (5 W)

Output carrier power set at its nominal: 33 dBm (2 W)

Output carrier power set at its nominal: 30 dBm (1 W)

Frequency Stability (Voltage)

Test conditions		Frequency Stability (MHz)					
		156.025 MHz (CH1060)			162.025 MHz (CH 2088)		
Temperature	Voltage	5 W	2 W	1 W	5 W	2 W	1 W
Tnom (+20°C)	Vnom-15% (10.2 V)	156024932 (-68 Hz)	156024932 (-68 Hz)	156024931 (-69 Hz)	162024922 (-78 Hz)	162024921 (-79 Hz)	162024921 (-79 Hz)
Tnom (+20°C)	Vnom (12 V)	156024925 (-75 Hz)	156024925 (-75 Hz)	156024925 (-75 Hz)	162024922 (-78 Hz)	162024922 (-78 Hz)	162024922 (-78 Hz)
Tnom (+20°C)	Vnom+15% (27.6 V)	156024929 (-71 Hz)	156024929 (-71 Hz)	156024929 (-71 Hz)	162024928 (-72 Hz)	162024929 (-71 Hz)	162024929 (-71 Hz)
Deviation max.		-75 Hz	-75 Hz	-75 Hz	-78 Hz	-79 Hz	-79 Hz
Limits		± 1620 Hz for CH2088 (162.025 MHz) ± 1560 Hz for CH1060 (156.025 MHz)					

Output carrier power set at its nominal: 37 dBm (5 W)

Output carrier power set at its nominal: 33 dBm (2 W)

Output carrier power set at its nominal: 30 dBm (1 W)

Environmental conditions observed: On 22 July 2019, 23°C to 23°C, 59%RH to 59%RH

On 23 July 2019, 23°C to 23°C, 59%RH to 59%RH

On 24 July 2019, 23°C to 23°C, 59%RH to 59%RH

On 25 July 2019, 23°C to 23°C, 59%RH to 59%RH

Power supply voltage measured: 12.0 VDC to 12.0 VDC, 10.2 VDC to 10.2 VDC, 27.6 VDC to 27.6 VDC

3.4 Spurious Emissions

3.4.1 Spurious Emissions at Antenna Terminal (FCC Rule 47 CFR, 2.1051, 2.1057, 80.211 (f))

(1) Test Conditions:

AIS Transmitter Setting: 156.025 MHz (CH 1060) and 162.025 MHz (CH 2088)

5 W, 2 W and 1 W

Spurious Emissions at Antenna Terminal was measured at the antenna port with AIS message 18 and maximum symbol rate (2 sec)

(2) Test setup:

See Clause 4.

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

Frequency	Emission limits
9 kHz to the 10th harmonic of the highest fundamental frequency (Except OoB)	At least $43 + 10 \log_{10} p$ (watts) dB= -13dBm

Note: Reference level = Transmit output power (P, in dBW)

(4) Test Results:

Complied. (Modification status: 0)

Spectrum Plots: See Clause 7.

Spurious emissions at Antenna Terminal of 156.025 MHz (*1) (CH 1060), 5 W

Spurious frequency	Spurious Emissions power (dBm)	Emission limits (dBm)	Margin (dB)
$1/2 \times F_c$ (*1)	-53.18	-13	40.18
$2 \times F_c$	-48.80	-13	35.80
$3 \times F_c$	-48.60	-13	35.60
$4 \times F_c$	-51.75	-13	38.75
$5 \times F_c$	-50.27	-13	37.27
$6 \times F_c$	-49.50	-13	36.50
$7 \times F_c$	-53.21	-13	40.21
$8 \times F_c$	-51.66	-13	38.66
$9 \times F_c$	-50.80	-13	37.80
$10 \times F_c$	-50.10	-13	37.10

Spurious emissions at Antenna Terminal of 156.025 MHz (*1) (CH 1060), 2 W

Spurious frequency	Spurious Emissions power (dBm)	Emission limits (dBm)	Margin (dB)
$1/2 \times F_c$ (*1)	-52.38	-13	39.38
$2 \times F_c$	-50.93	-13	37.93
$3 \times F_c$	-51.81	-13	38.81
$4 \times F_c$	-51.41	-13	38.41
$5 \times F_c$	-51.08	-13	38.08
$6 \times F_c$	-50.51	-13	37.51
$7 \times F_c$	-52.01	-13	39.01
$8 \times F_c$	-51.51	-13	38.51
$9 \times F_c$	-52.17	-13	39.17
$10 \times F_c$	-51.51	-13	38.51

Spurious emissions at Antenna Terminal of 156.025 MHz (*1) (CH 1060), 1 W

Spurious frequency	Spurious Emissions power (dBm)	Emission limits (dBm)	Margin (dB)
$1/2 \times F_c$ (*1)	-51.60	-13	38.60
$2 \times F_c$	-53.56	-13	40.56
$3 \times F_c$	-50.89	-13	37.89
$4 \times F_c$	-51.66	-13	38.66
$5 \times F_c$	-51.79	-13	38.79
$6 \times F_c$	-49.93	-13	36.93
$7 \times F_c$	-54.09	-13	41.09
$8 \times F_c$	-52.81	-13	39.81
$9 \times F_c$	-50.36	-13	37.36
$10 \times F_c$	-50.44	-13	37.44

Spurious emissions at Antenna Terminal of 162.025 MHz (*2) (CH 2088), 5 W

Spurious frequency	Spurious Emissions power (dBm)	Emission limits (dBm)	Margin (dB)
$1/2 \times F_c$ (*2)	-52.03	-13	39.03
$2 \times F_c$	-49.56	-13	36.56
$3 \times F_c$	-51.59	-13	38.59
$4 \times F_c$	-51.99	-13	38.99
$5 \times F_c$	-49.04	-13	36.04
$6 \times F_c$	-49.33	-13	36.33
$7 \times F_c$	-52.27	-13	39.27
$8 \times F_c$	-53.22	-13	40.22
$9 \times F_c$	-50.13	-13	37.13
$10 \times F_c$	-49.87	-13	36.87

Spurious emissions at Antenna Terminal of 162.025 MHz (*2) (CH 2088), 2 W

Spurious frequency	Spurious Emissions power (dBm)	Emission limits (dBm)	Margin (dB)
$1/2 \times F_c$ (*2)	-51.29	-13	38.29
$2 \times F_c$	-53.06	-13	40.06
$3 \times F_c$	-52.87	-13	39.87
$4 \times F_c$	-51.54	-13	38.54
$5 \times F_c$	-50.08	-13	37.08
$6 \times F_c$	-49.65	-13	36.65
$7 \times F_c$	-53.81	-13	40.81
$8 \times F_c$	-52.76	-13	39.76
$9 \times F_c$	-49.81	-13	36.81
$10 \times F_c$	-49.67	-13	36.67

Spurious emissions at Antenna Terminal of 162.025 MHz (*2) (CH 2088), 1 W

Spurious frequency	Spurious Emissions power (dBm)	Emission limits (dBm)	Margin (dB)
$1/2 \times F_c$ (*2)	-52.55	-13	39.55
$2 \times F_c$	-54.75	-13	41.75
$3 \times F_c$	-52.19	-13	39.19
$4 \times F_c$	-53.25	-13	40.25
$5 \times F_c$	-48.67	-13	35.67
$6 \times F_c$	-50.48	-13	37.48
$7 \times F_c$	-52.08	-13	39.08
$8 \times F_c$	-52.48	-13	39.48
$9 \times F_c$	-49.87	-13	36.87
$10 \times F_c$	-50.29	-13	37.29

Environmental conditions observed: On 5 August 2019, 26°C to 26°C, 62%RH to 62%RH
Power supply voltage measured: 12.0 VDC to 12.0 VDC

3.4.2 Field Strength of Spurious Radiation (FCC Rule 47 CFR, 2.1053, 2.1057, 80.211 (f))**(1) Test Conditions:**

AIS Transmitter Setting: 156.025 MHz (CH 1060) and 162.025 MHz (CH 2088)
5 W, 2 W and 1 W

Spurious Emissions at Antenna Terminal was measured at the antenna port with AIS message 18 and maximum symbol rate (2 sec).

(2) Test Site: LIC Nishinomiya-Hama Laboratory, Semi-Anechoic Chamber

(3) Distance between the radar set and measuring antenna: 3 m

(4) Test setup:**Measuring (Receiving) Antenna height and polarization:**

- (a) 1 m to 4 m for the test frequency range of 30 MHz to 1700 MHz
- (b) Antenna polarization: vertical and horizontal.

EUT height:

- (a) 1.5 m for the test frequency range of 30 MHz to 1700 MHz

See Clauses 4 and 6.

(5) Field Strength Limits (FCC Rule 47 CFR, 80.211 (f)):

Radiation limit: ≤ 86.2 dBμV/m (at 3 m : 30 MHz to 1000 MHz)
≤ 82.2 dBμV/m (at 3 m : 1000 MHz to 1700 MHz)

(6) Test Results:

Complied. (Modification status: 0)

Spectrum plots: See Clause 8.

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

Environmental conditions observed: On 1 August 2019, 25°C to 26°C, 54%RH to 52%RH
On 2 August 2019, 23°C to 25°C, 67%RH to 61%RH

Power supply voltage measured: 12.0 VDC to 12.0 VDC

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

(1) Test Conditions:

AIS Receiver Setting: 156.025 MHz, 162.025 MHz

Receiver conducted emissions was measured with the antenna disconnected and with receiver antenna terminals connected to a measuring instrument.

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

(3) Test setup: See Clause 4

(4) Receiver Conducted Emissions Limits:

Frequency	Power to artificial antenna in		Resolution bandwidth of Spectrum analyzer
	(μ W)	(dBm)	
9 kHz - 150 kHz	400	-4	1 kHz
150 kHz - 30 MHz			10 kHz
30 MHz - 100 MHz	4,000	6	100 kHz
100 MHz - 300 MHz	40,000	16	
300 MHz - 1 GHz	400,000	26	
1 GHz - 2 GHz			1 MHz

(5) Test Results:

Complied. (Modification status: 0)

Tests were performed with the EUT receive only mode.

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

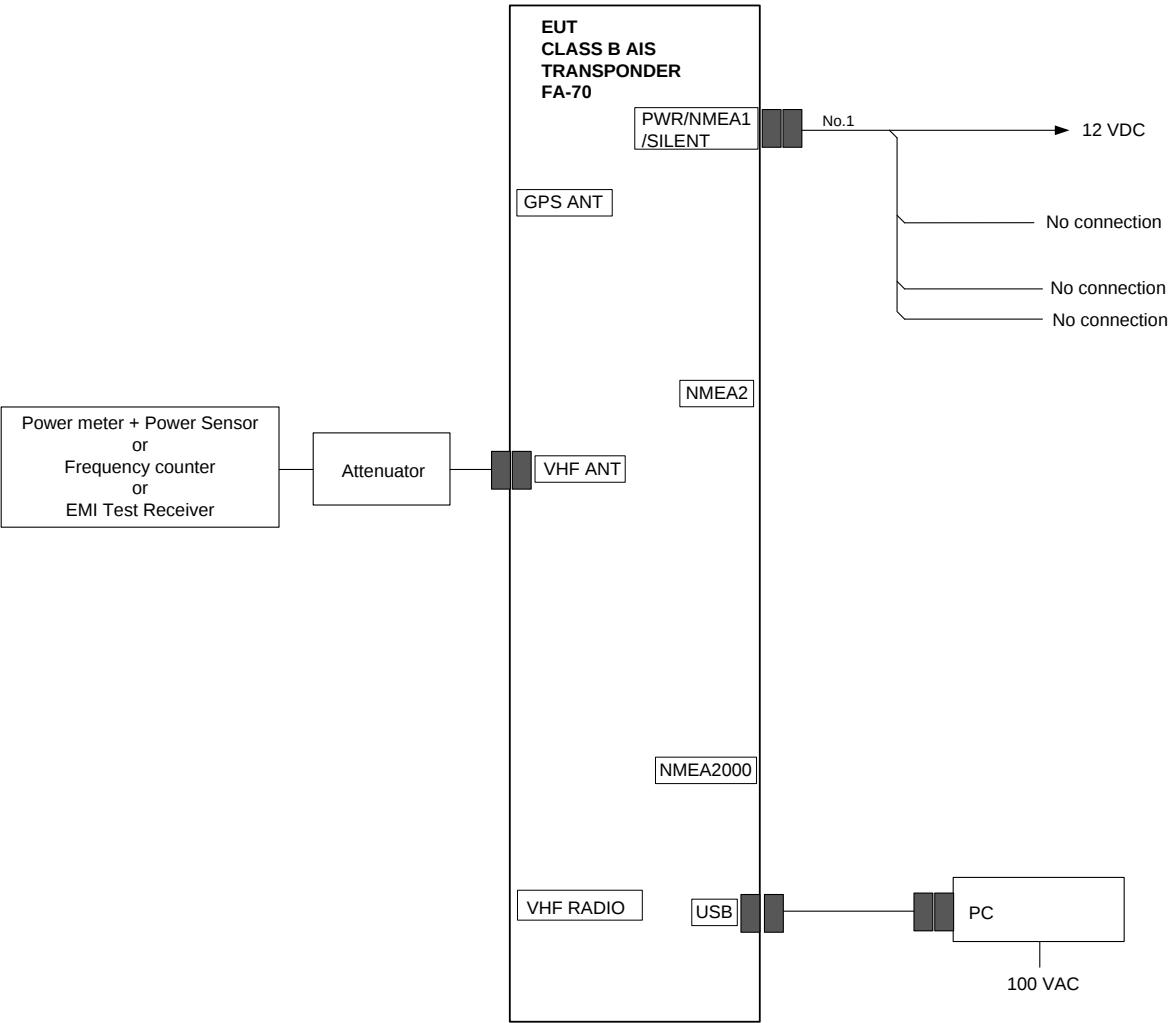
Spectrum plots: See Clause 9.

Environmental conditions observed: On 6 August 2019, 25°C to 25°C, 61%RH to 68%RH

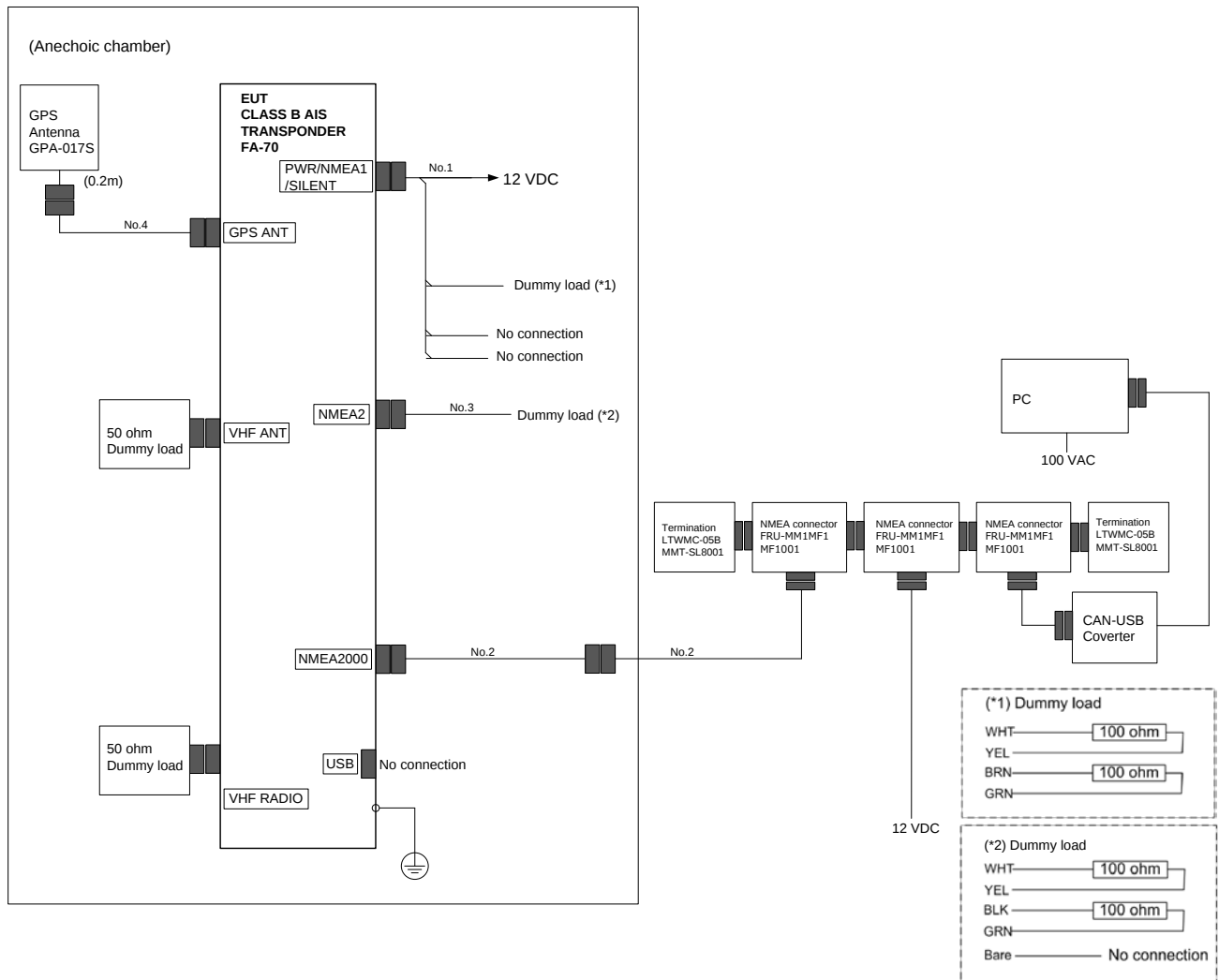
Power supply voltage measured: 12.0 VDC to 12.0 VDC

4 Test Setup for Measurements

4.1 Test Setup for Clauses 3.1, 3.2, 3.3, 3.4.1, and 3.5



4.2 Test Setup for Clause 3.4.2



List of cables used

No.	Category (*)	Cable name	Type	Length (m)	Number of cables	Cable Shielded
1	P/S	PWR/NMEA1/SILENT cable	61110000000101	2	1	P: No S: Yes
2	S	NMEA2000 cable	FRU-NMEA-PMMFF-060	6	2	Yes
3	S	NMEA0183 cable	MJ-A6SPF0003-150C	15	1	Yes
4	S	Coaxial cable (GPS)	TNC-PS/PS-3D-L15M-R	15	1	Yes

(*): 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 calibration	Calibration interval
HT552	Power meter	E4418B	GB43315050	Agilent	28 May 2019	1 year
HT325	Power Sensor	8481A	2702A70235	Agilent	2 July 2019	1 year
HT1254	Attenuator	50HF-020-50/18 N	20190304	JFW	12 March 2019	1 year
RT255-4	DC power supply	PWR1600M	PD000705	Kikusui	Not applicable.	--
HT1024	Digital multimeter	233	27230019	Fluke	15 February 2019	1 year

(2) For Clause 3.2 Occupied Bandwidth, Clause 3.4.1 Spurious Emissions at Antenna Terminal and Clause 3.5 Suppression of Interference Aboard Ships

C/N	Instrument	Type	S/N	Manufacturer	Date of calibration	Calibration interval
HT1270	EMI Test Receiver	ESW44	101841	Rohde & Schwarz	9 May 2019	1 year
HT1254	Attenuator	50HF-020-50/18 N	20190304	JFW	12 March 2019	1 year
RT255-4	DC power supply	PWR1600M	PD000705	Kikusui	Not applicable.	--
HT1024	Digital multimeter	233	27230019	Fluke	15 February 2019	1 year

(3) For Clause 3.3 Frequency Stability

C/N	Instrument	Type	S/N	Manufacturer	Date of calibration	Calibration interval
HT938	Frequency counter	53181A	KR91200825	Agilent	24 October 2018	1 year
HT1254	Attenuator	50HF-020-50/18 N	20190304	JFW	12 March 2019	1 year
RT255-4	DC power supply	PWR1600M	PD000705	Kikusui	Not applicable.	--
HT1024	Digital multimeter	233	27230019	Fluke	15 February 2019	1 year

(4) For Clause 3.4.2 Field Strength of Spurious Radiation

C/N	Instrument	Type	S/N	Manufacturer	Date of calibration	Calibration interval
HT745	EMI Test receiver	ESU40	100243	Rohde & Schwarz	11 August 2018	1 year
HT568	Amplifier	310N	250607	Sonoma Instrument	21 June 2019	1 year
RT286	Biconical antenna (30 MHz to 300 MHz)	VHA9103/BBA 9106	None	Schwarzbeck	14 April 2019	1 year
HT331	Log.-Per. antenna (300 MHz to 1000 MHz)	UHALP9107	91071214	Schwarzbeck	14 August 2018	1 year
HT467	Double-ridged waveguide horn antenna (1 GHz to 2 GHz)	3115	6520	ETS-Lindgren (EMCO)	11 August 2018	1 year
HT1267	Pre Amplifier	00-T1885	BBB1952285	NoiseKen	4 June 2019	1 year
HT1193	Radiated Emission Measurement Software	EP5/RE	Ver.6.0.112	Toyo	Not applicable.	--
HT365	Semi-anechoic chamber	3mSAC	D-002	Riken	Not applicable.	--
HT156	DC power supply	GP035-30	1014396080	Takasago	Not applicable.	--
HT885	Test table	W1500-D1000-H800	No.03	JSE	Not applicable.	--
HT688	Digital multimeter	115	10821184	Fluke	12 November 2018	1 year

6 Occupied Bandwidth Plots

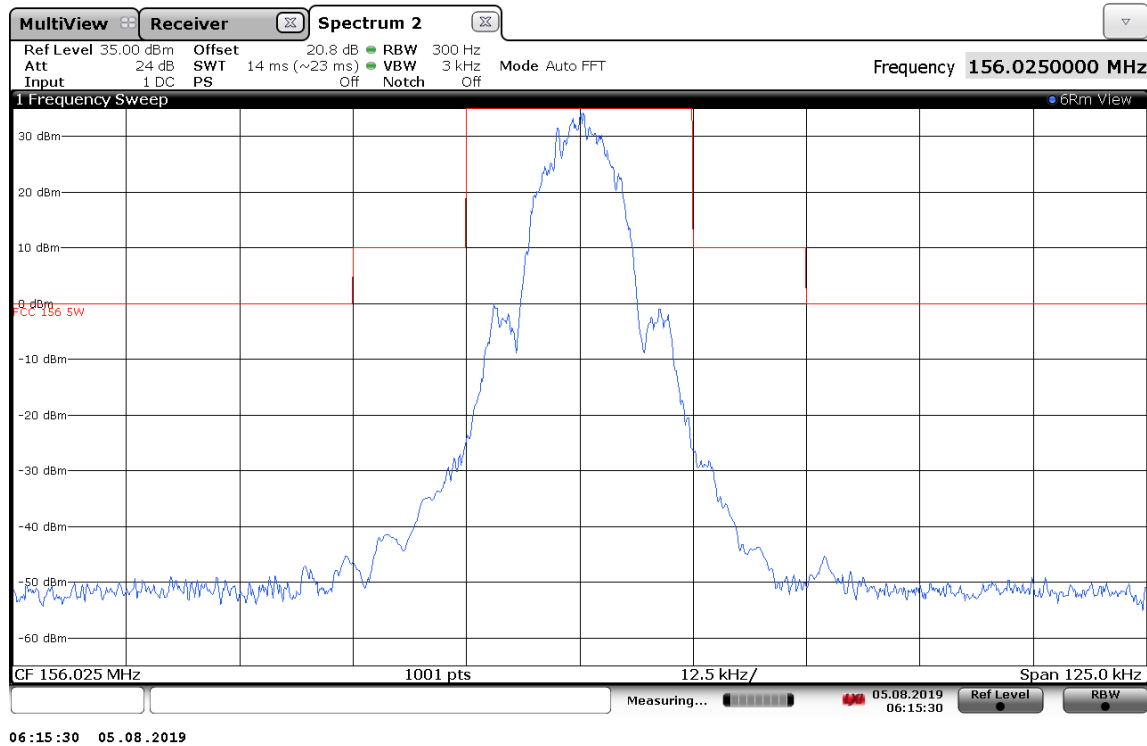


Fig. 6.1 156.025 MHz (CH 1060), 5 W Occupied Band Width

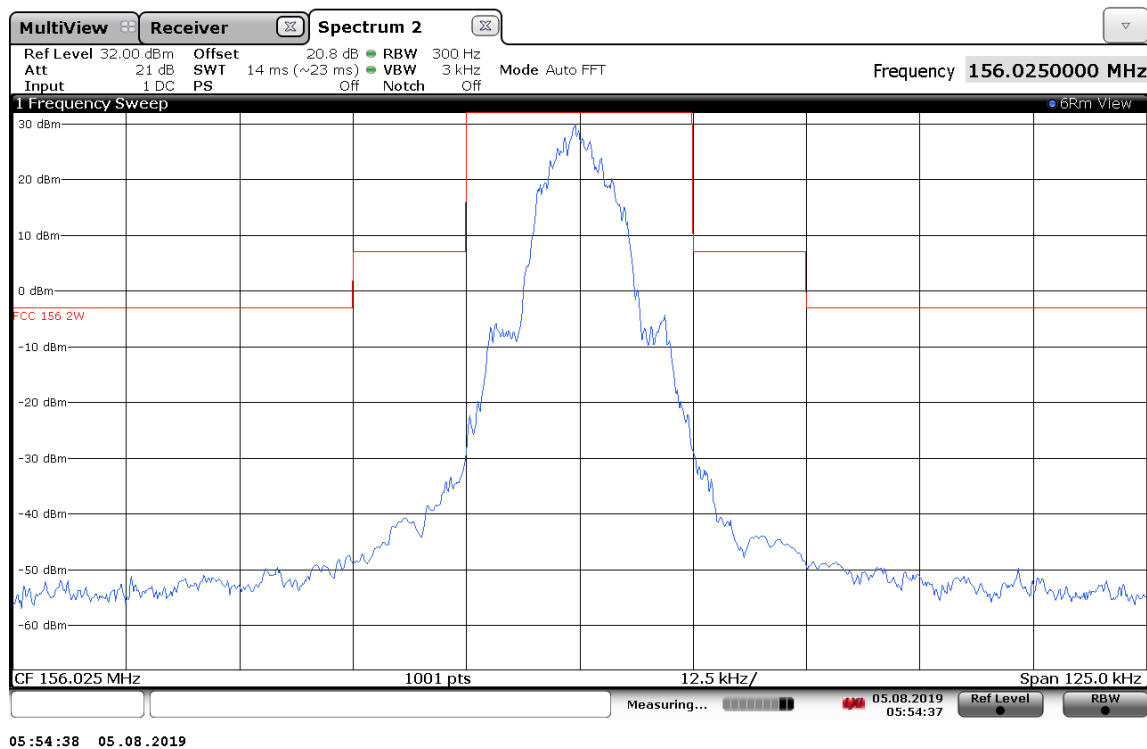


Fig. 6.2 156.025 MHz (CH 1060), 2 W Occupied Band Width

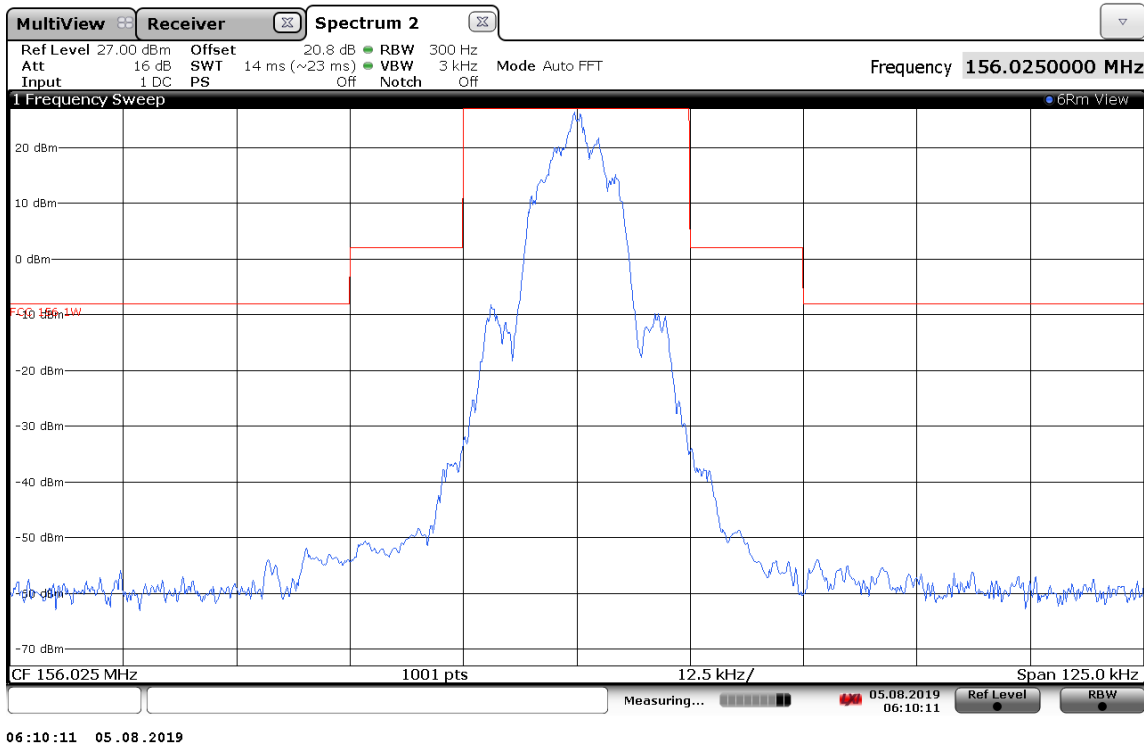


Fig. 6.3 156.025 MHz (CH 1060), 1 W Occupied Band Width

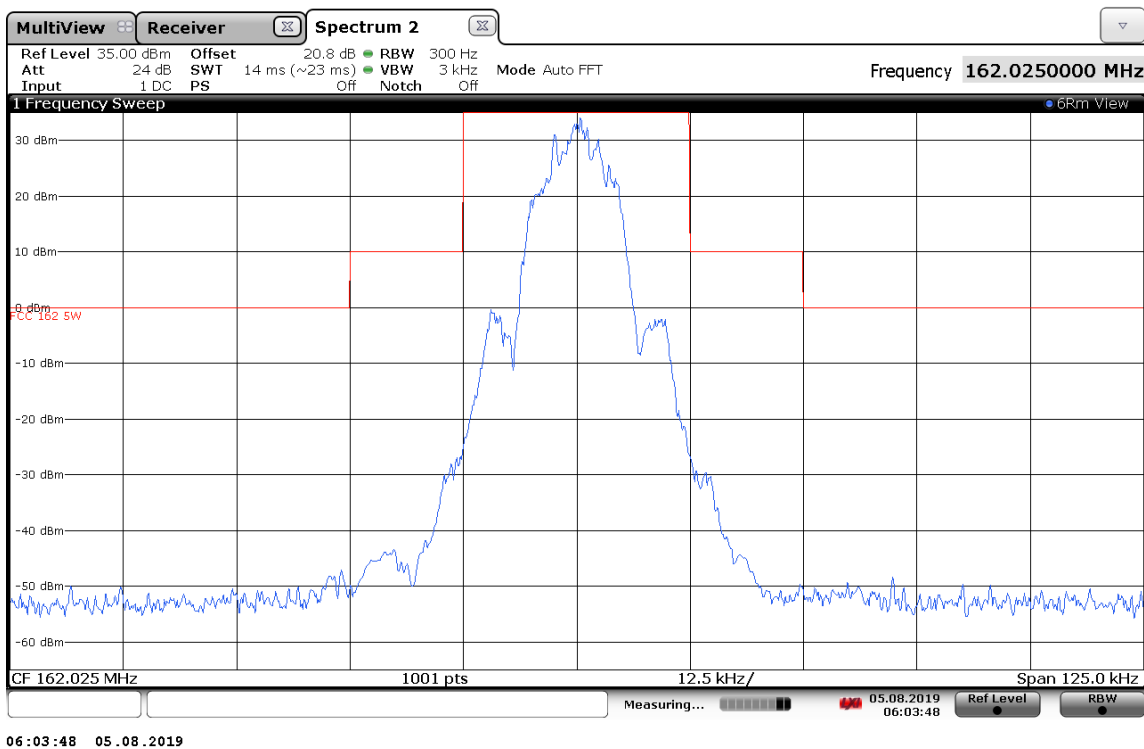


Fig. 6.4 162.025 MHz (CH 2088), 5 W Occupied Band Width

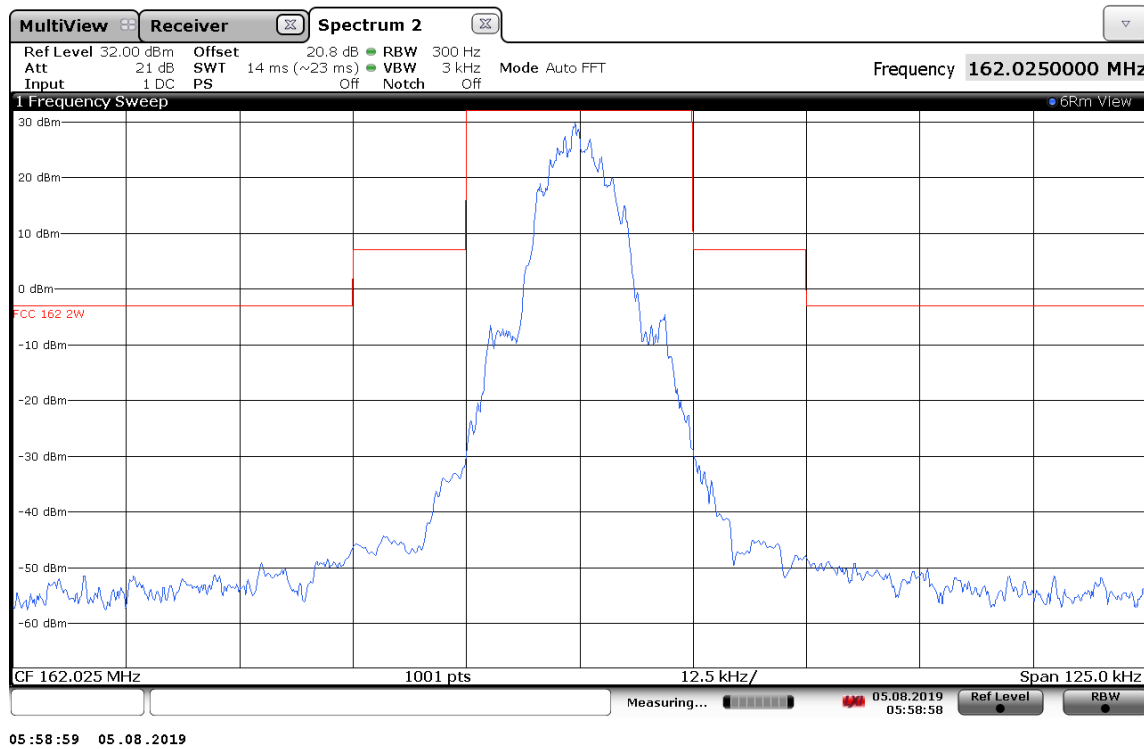


Fig. 6.5 162.025 MHz (CH 2088), 2 W Occupied Band Width

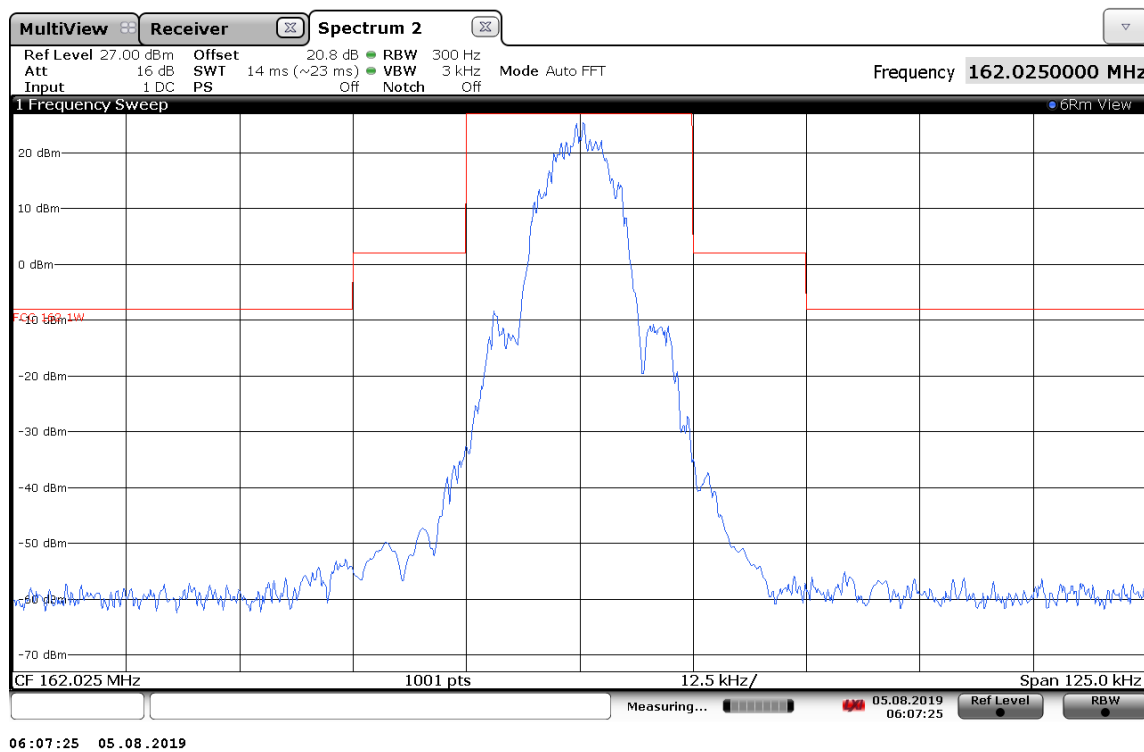


Fig. 6.6 162.025 MHz (CH 2088), 1 W Occupied Band Width

7 Spurious Emission Plots measured at Antenna Terminal

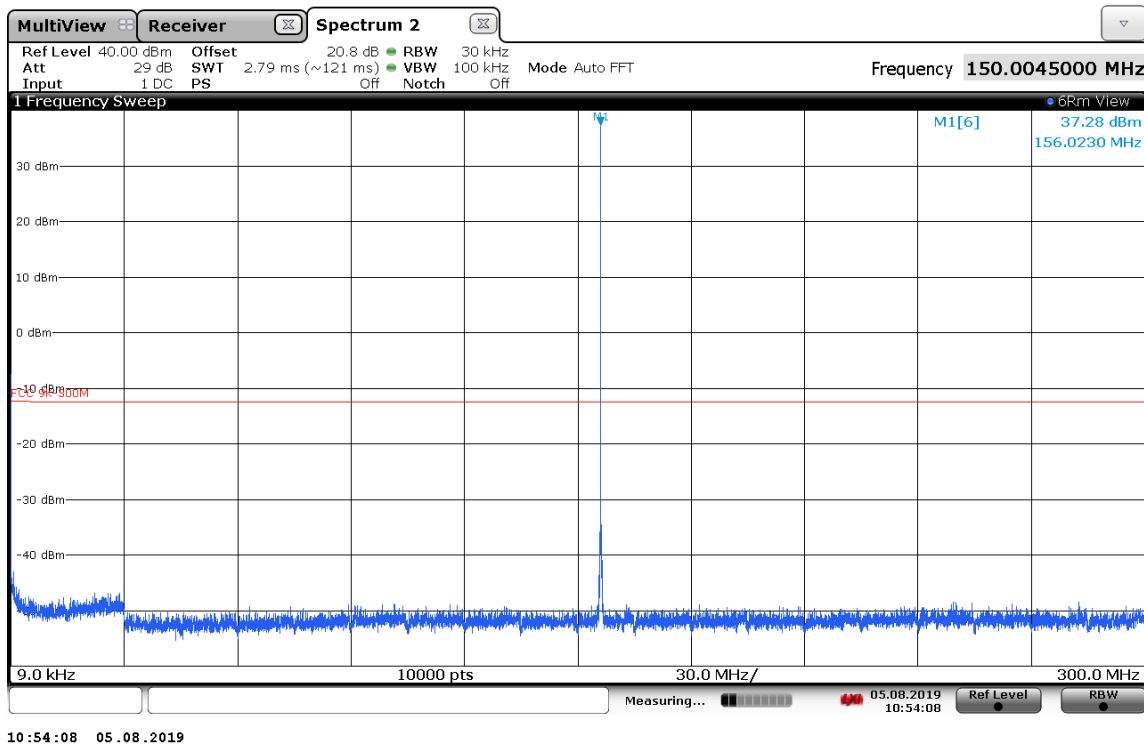


Fig. 7.1 156.025 MHz, 5 W Spurious Emission at Antenna Terminal (9 kHz to 300 MHz)

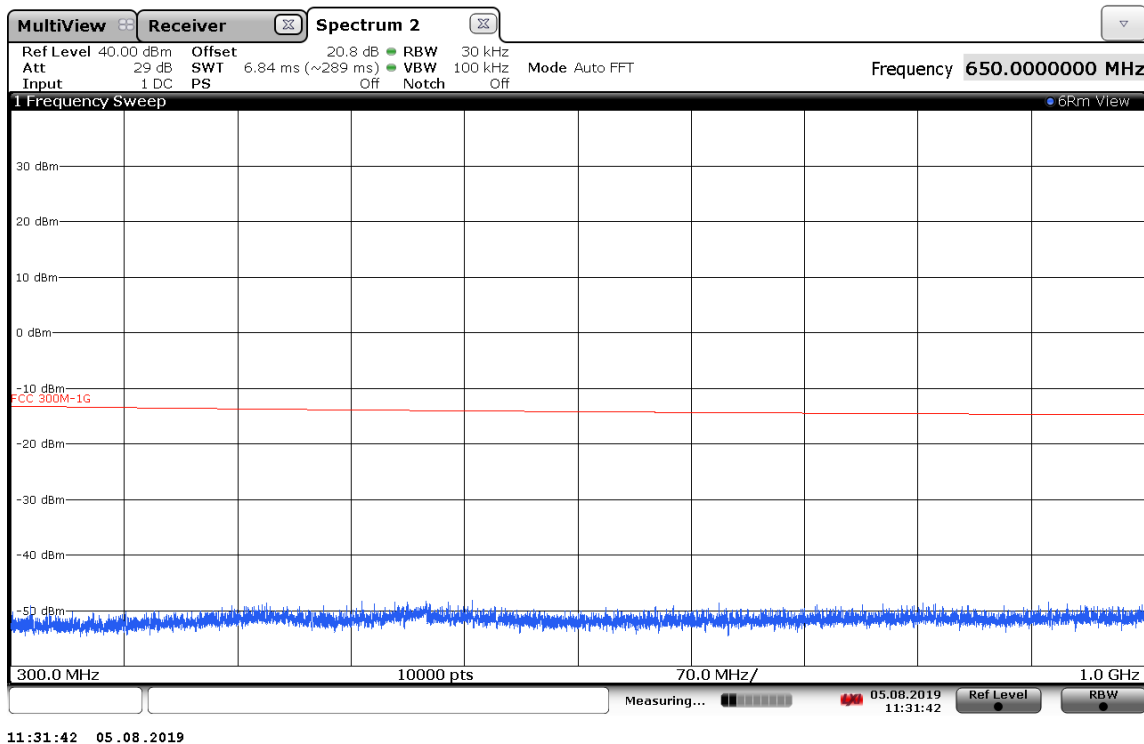


Fig. 7.2 156.025 MHz, 5 W Spurious Emission at Antenna Terminal (300 MHz to 1 GHz)

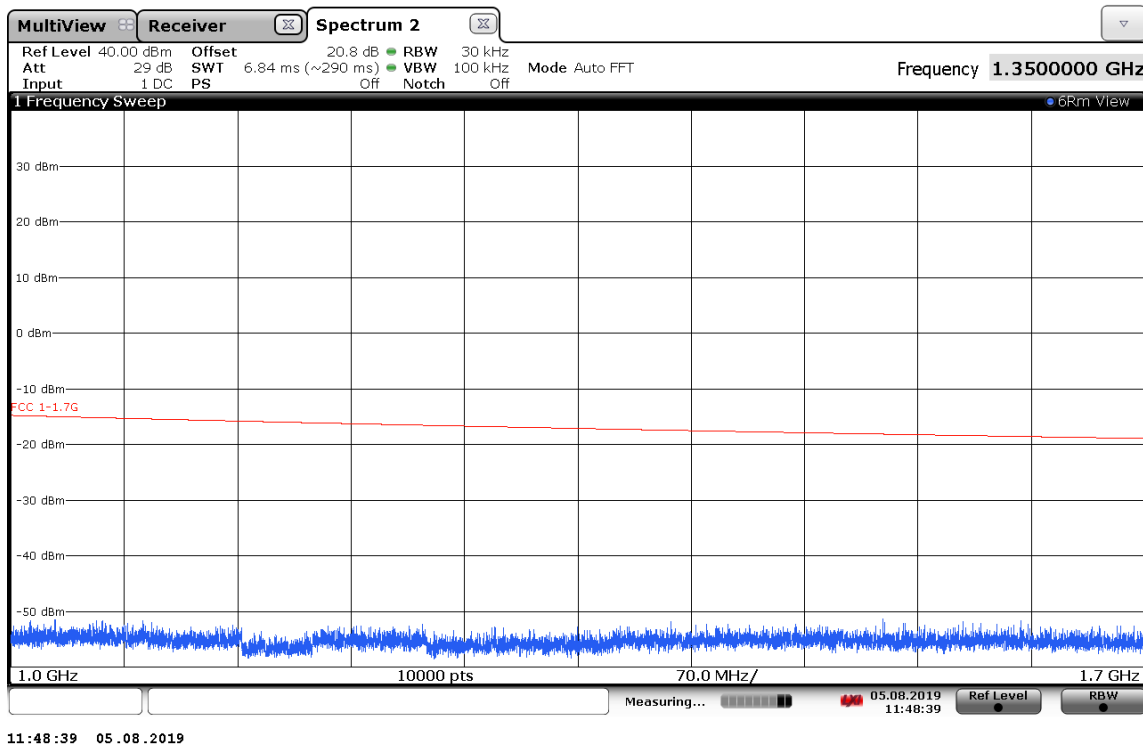


Fig. 7.3 156.025 MHz, 5 W Spurious Emission at Antenna Terminal (1 GHz to 1.7 GHz)

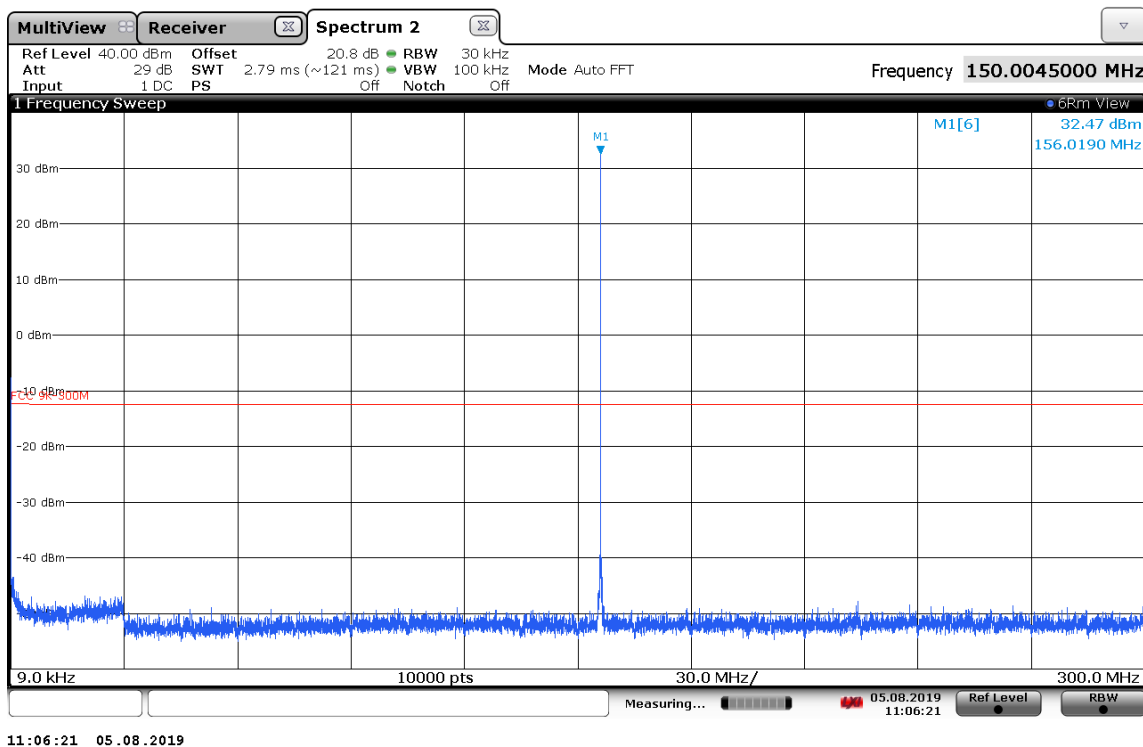


Fig. 7.4 156.025 MHz, 2 W Spurious Emission at Antenna Terminal (9 kHz to 300 MHz)

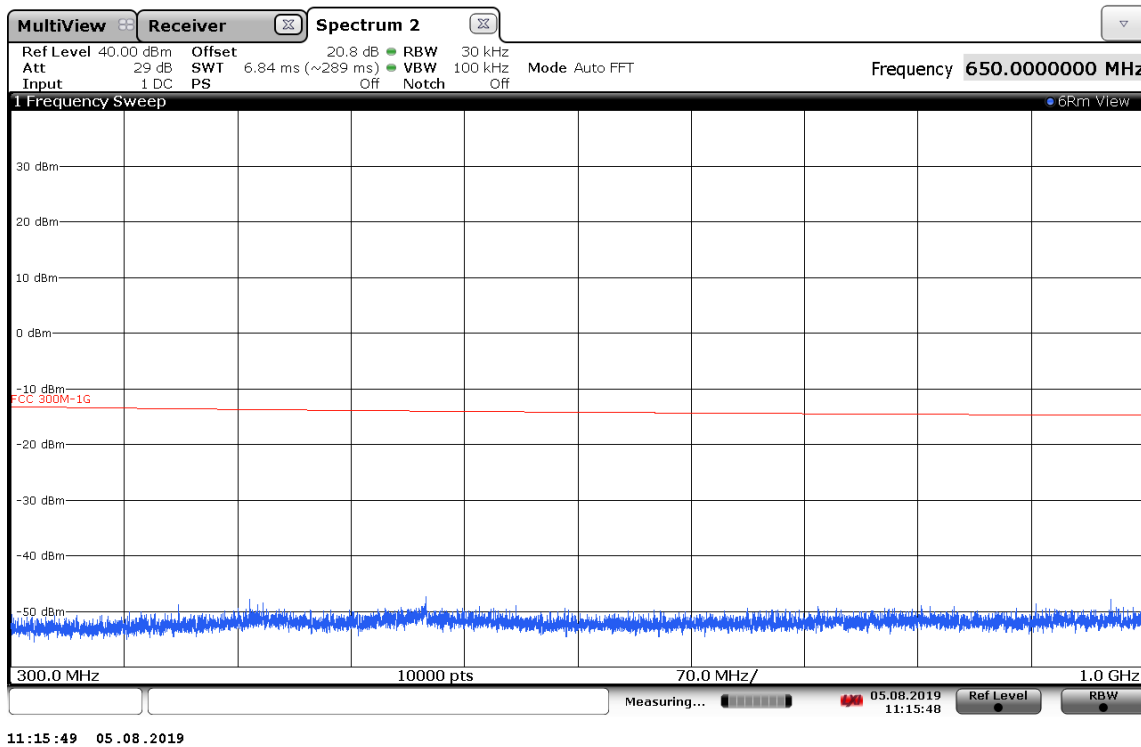


Fig. 7.5 156.025 MHz, 2 W Spurious Emission at Antenna Terminal (300 MHz to 1 GHz)

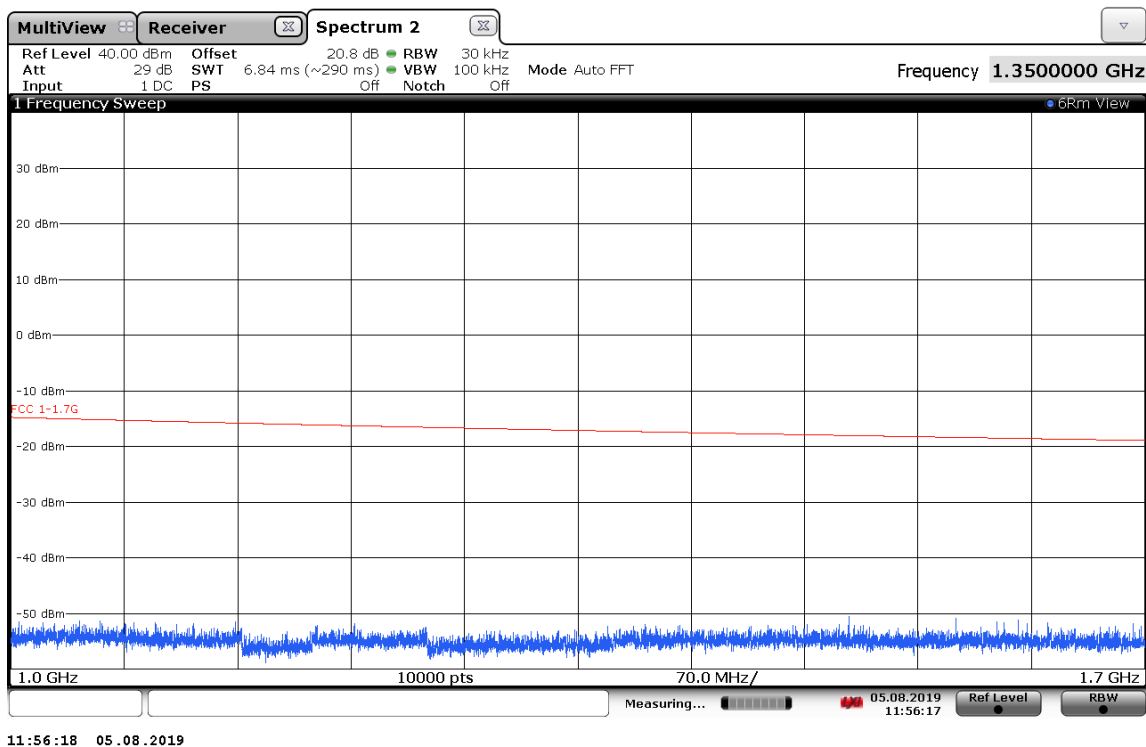


Fig. 7.6 156.025 MHz, 2 W Spurious Emission at Antenna Terminal (1 GHz to 1.7 GHz)

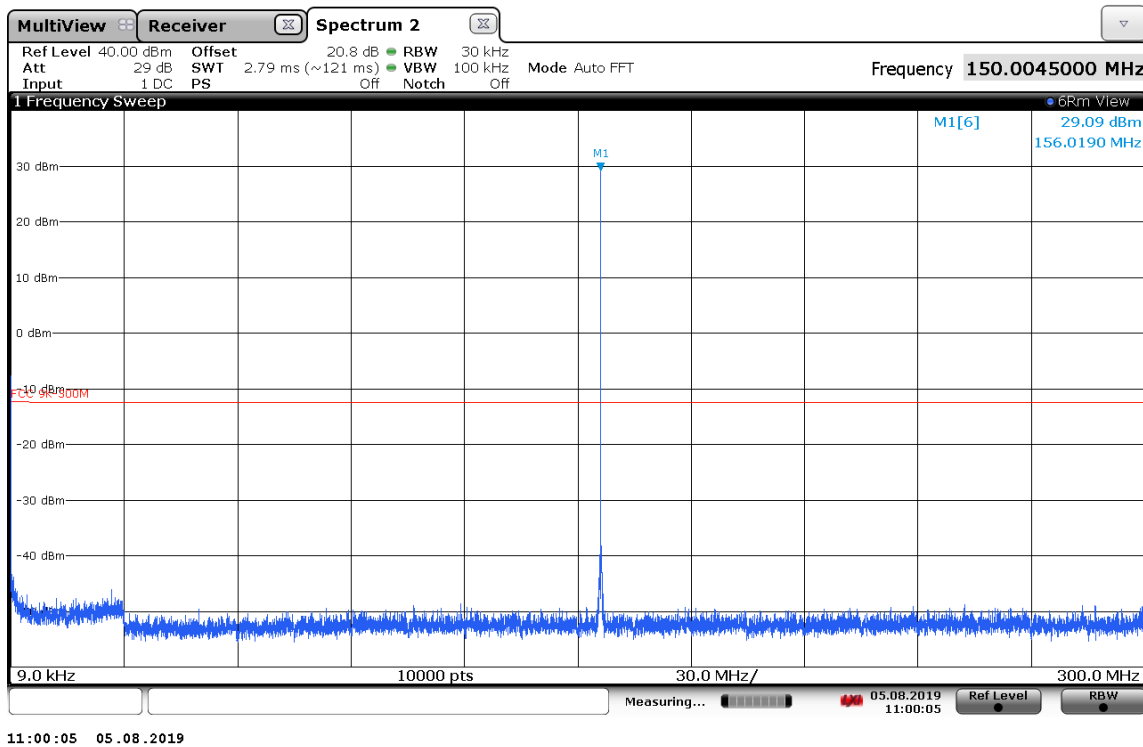


Fig. 7.7 156.025 MHz, 1 W Spurious Emission at Antenna Terminal (9 kHz to 300 MHz)

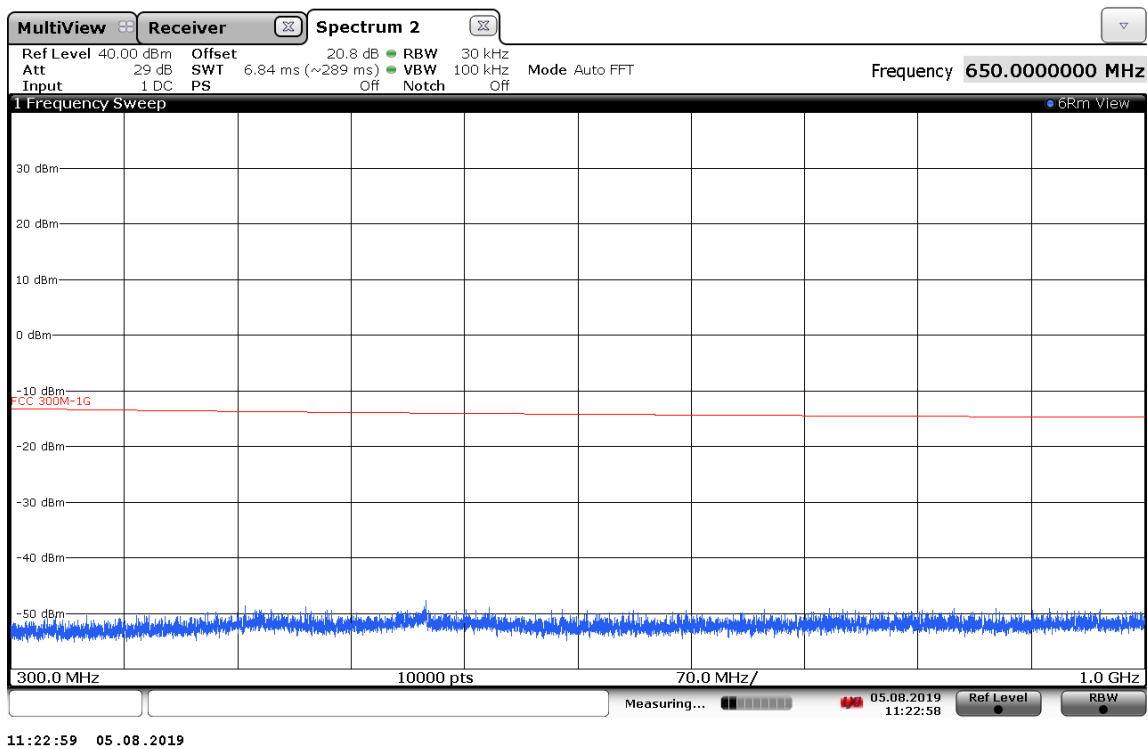


Fig. 7.8 156.025 MHz, 1 W Spurious Emission at Antenna Terminal (300 MHz to 1 GHz)

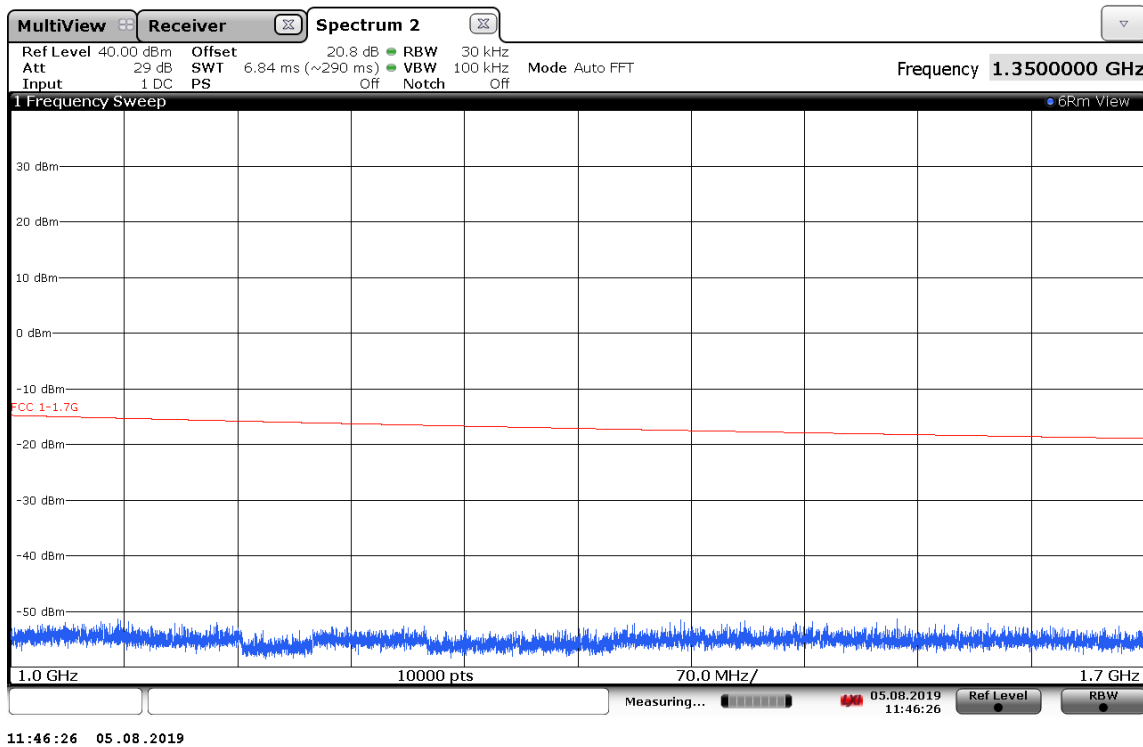


Fig. 7.9 156.025 MHz, 1 W Spurious Emission at Antenna Terminal (1 GHz to 1.7 GHz)

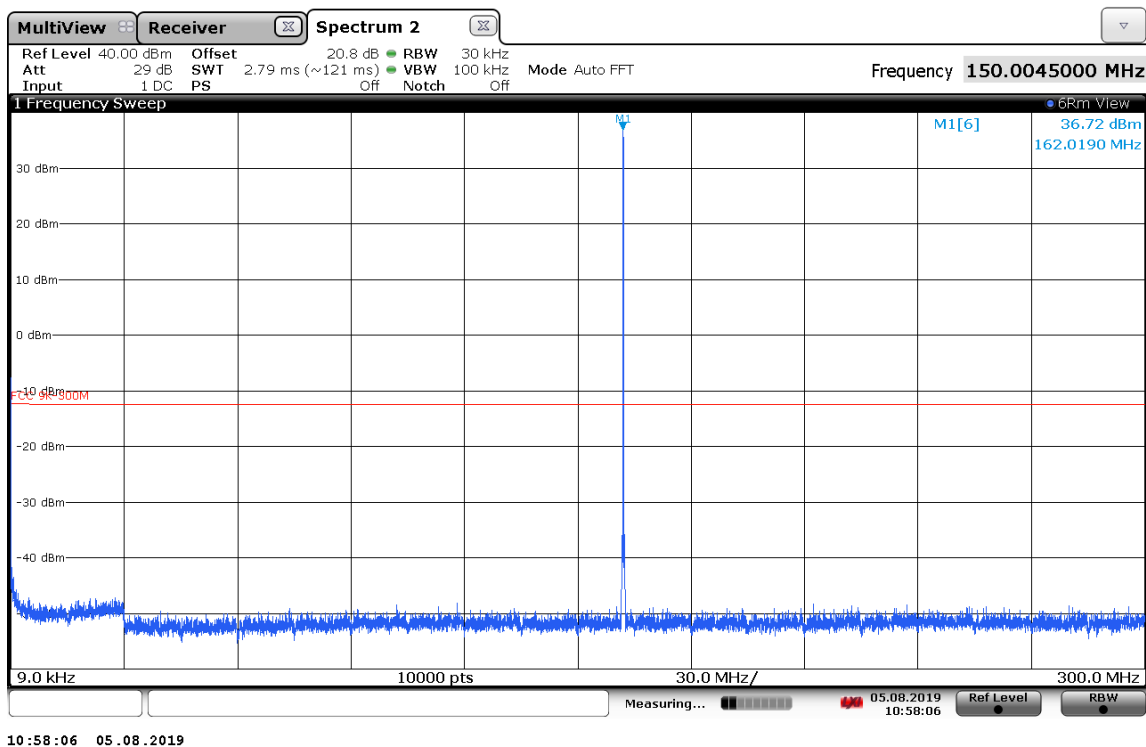


Fig. 7.10 162.025 MHz, 5 W Spurious Emission at Antenna Terminal (9 kHz to 300 MHz)

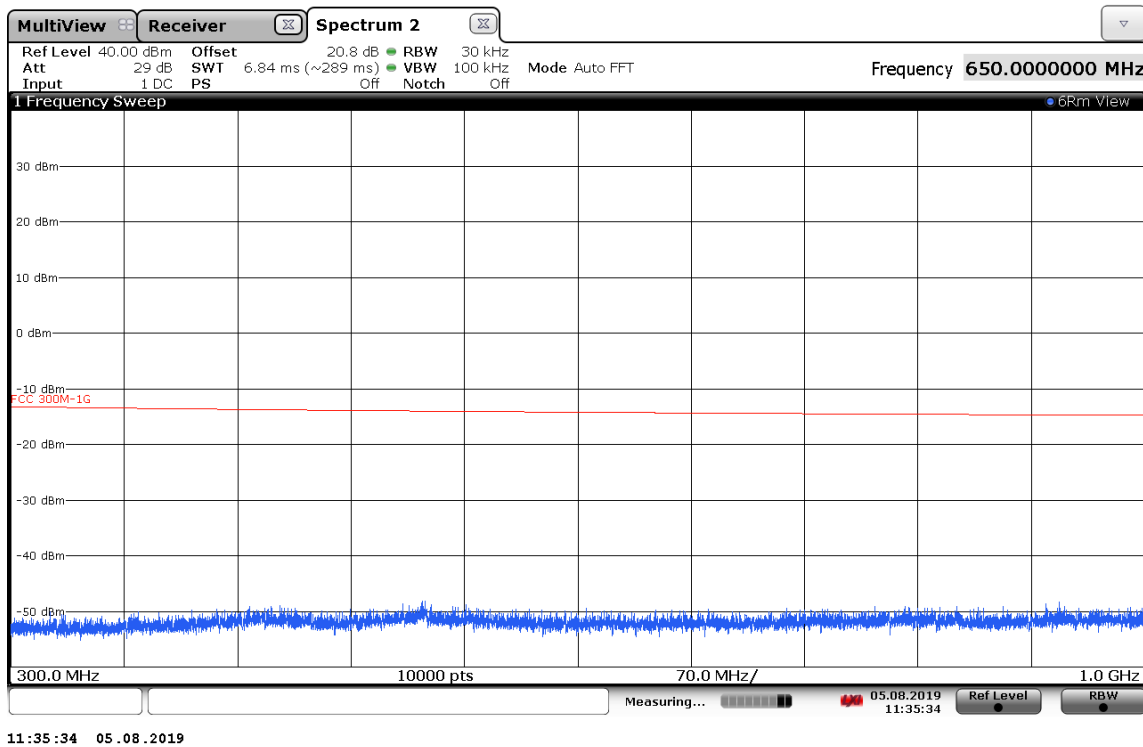


Fig. 7.11 162.025 MHz, 5 W Spurious Emission at Antenna Terminal (300 MHz to 1 GHz)

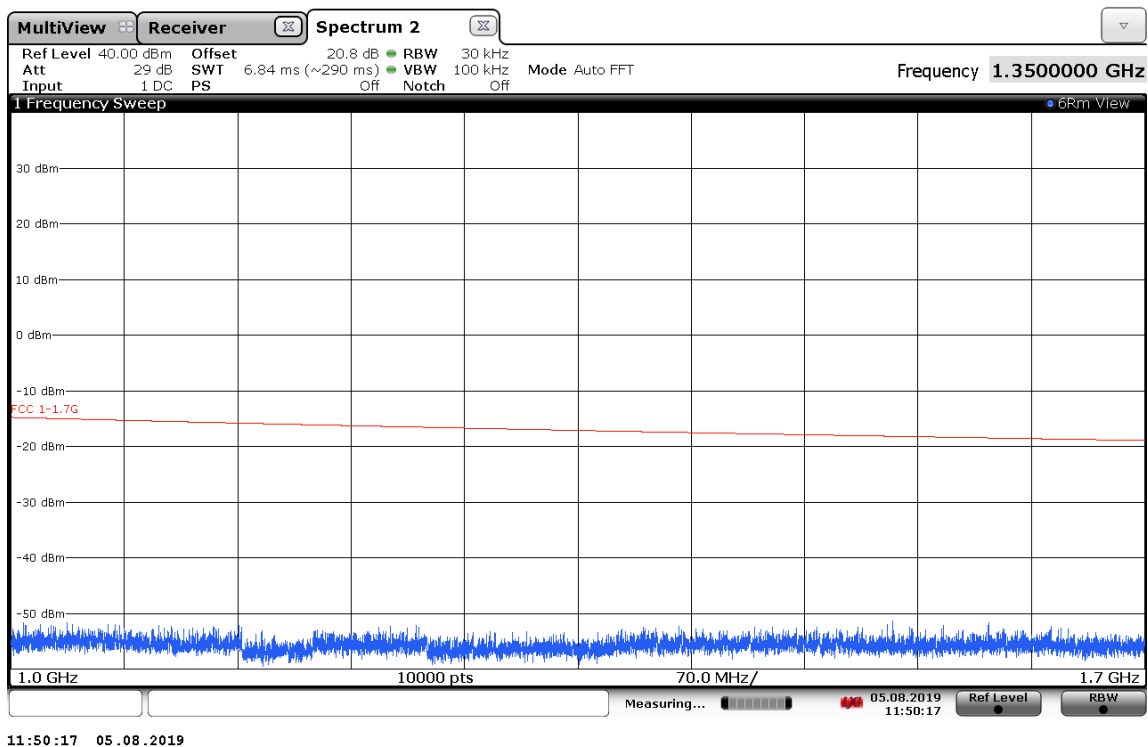


Fig. 7.12 162.025 MHz, 5 W Spurious Emission at Antenna Terminal (1 GHz to 1.7 GHz)

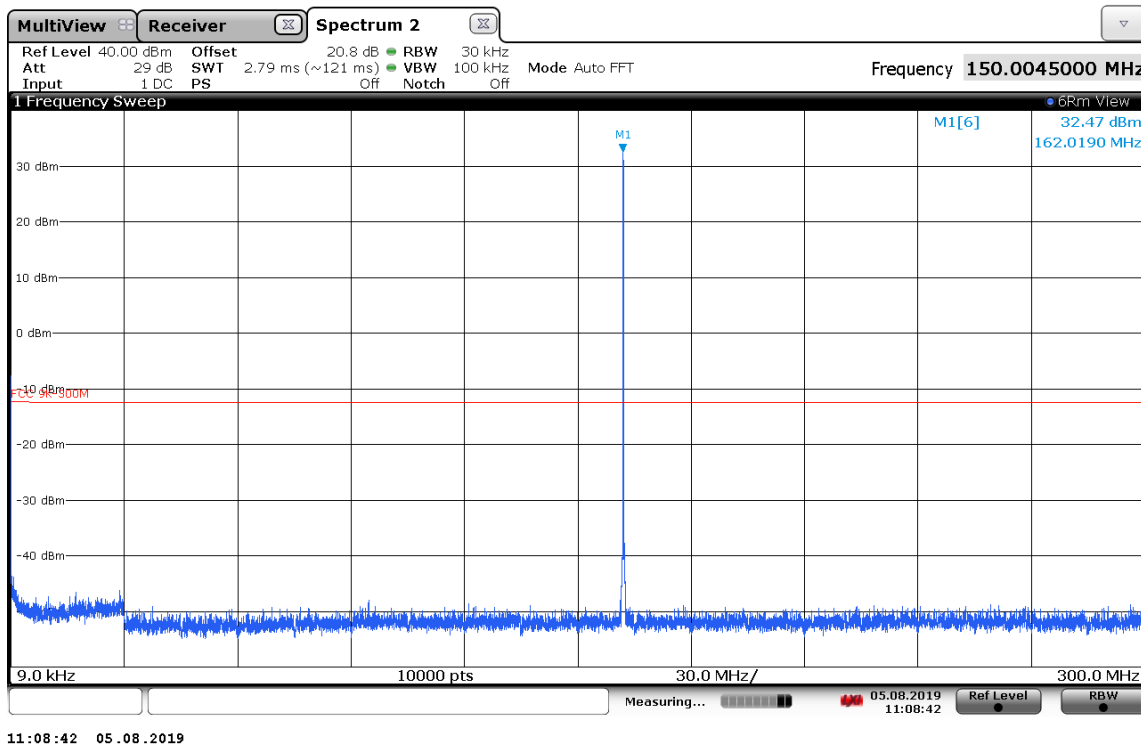


Fig. 7.13 162.025 MHz, 2 W Spurious Emission at Antenna Terminal (9 kHz to 300 MHz)

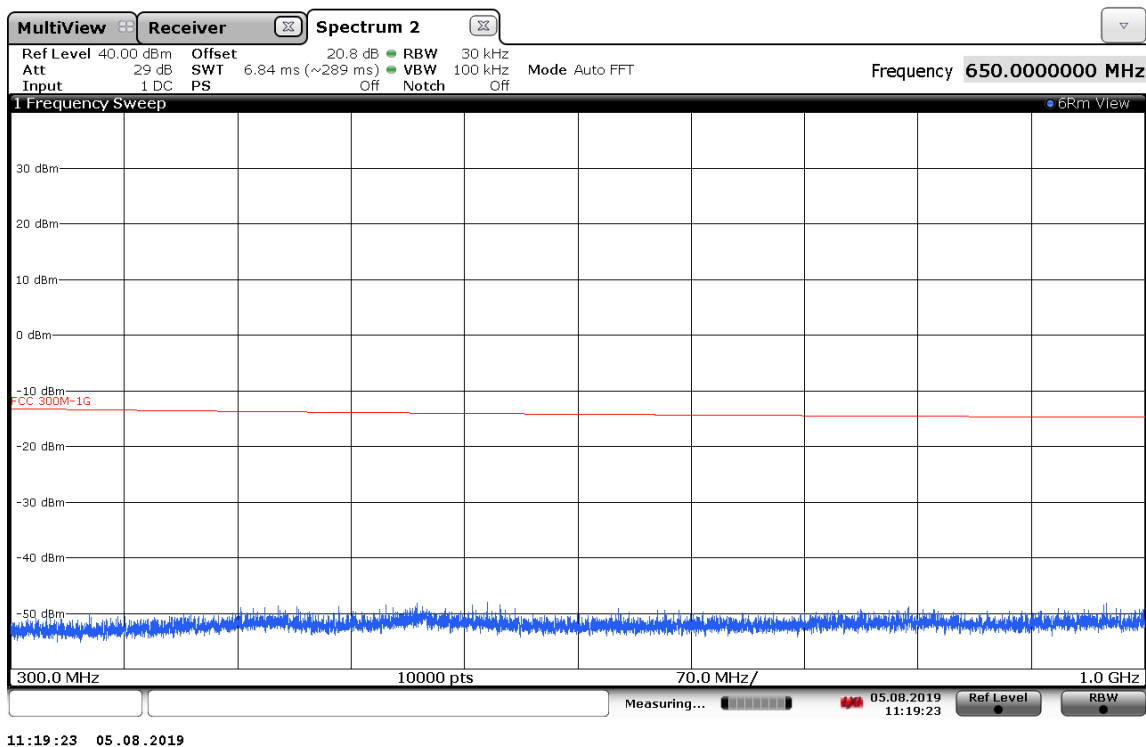


Fig. 7.14 162.025 MHz, 2 W Spurious Emission at Antenna Terminal (300 MHz to 1 GHz)

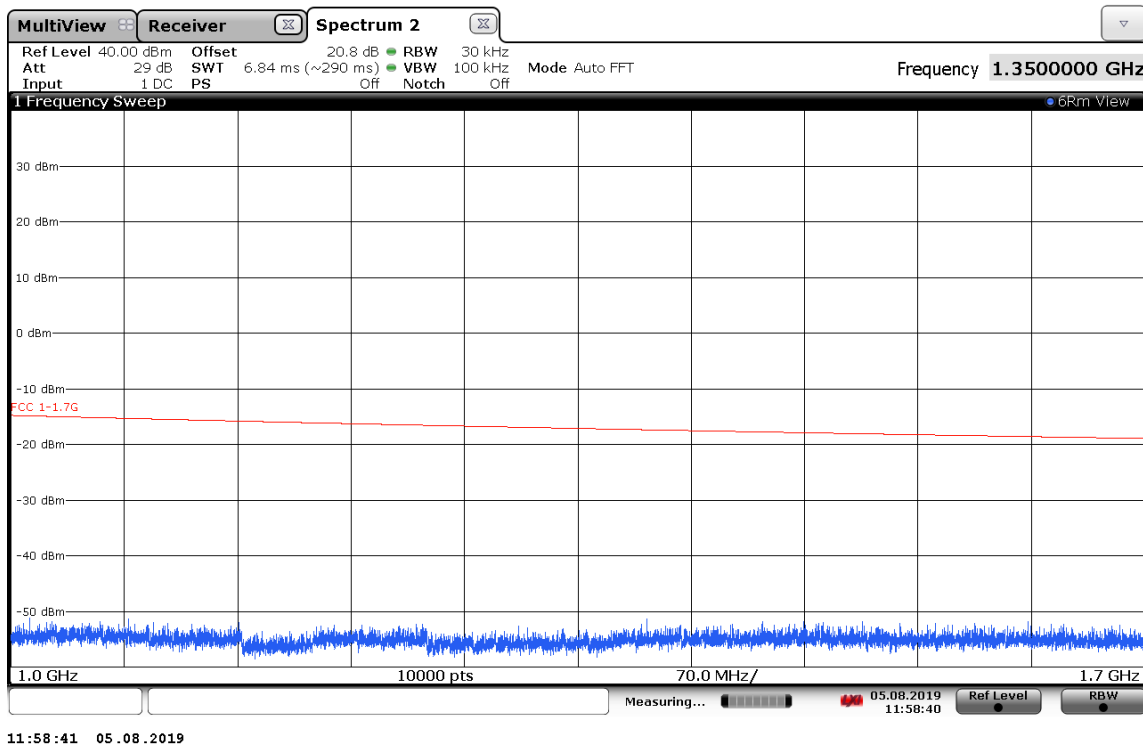


Fig. 7.15 162.025 MHz, 2 W Spurious Emission at Antenna Terminal (1 GHz to 1.7 GHz)

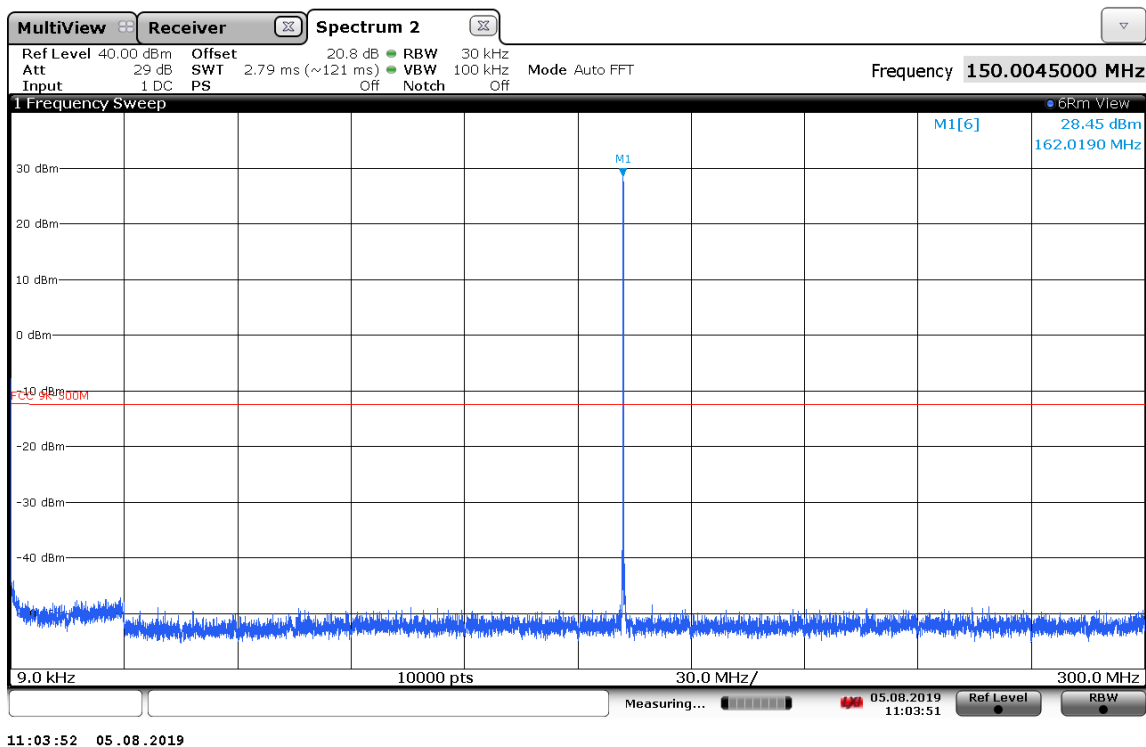


Fig. 7.16 162.025 MHz, 1 W Spurious Emission at Antenna Terminal (9 kHz to 300 MHz)

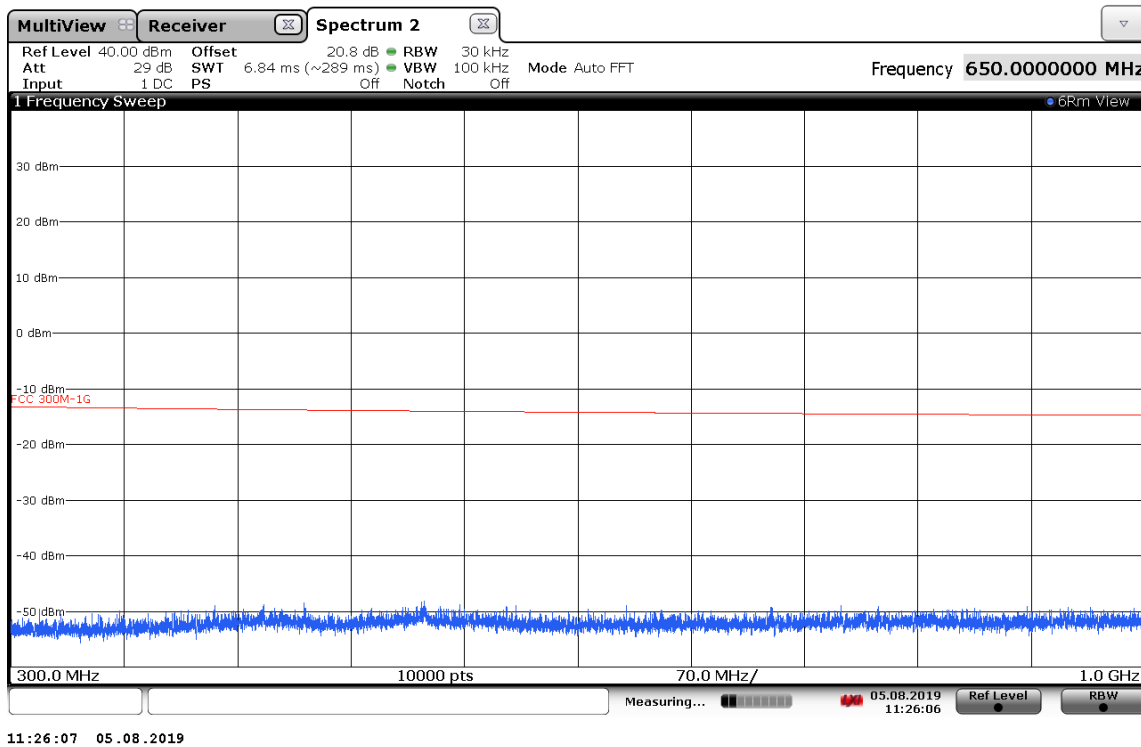


Fig. 7.17 162.025 MHz, 1 W Spurious Emission at Antenna Terminal (300 MHz to 1 GHz)

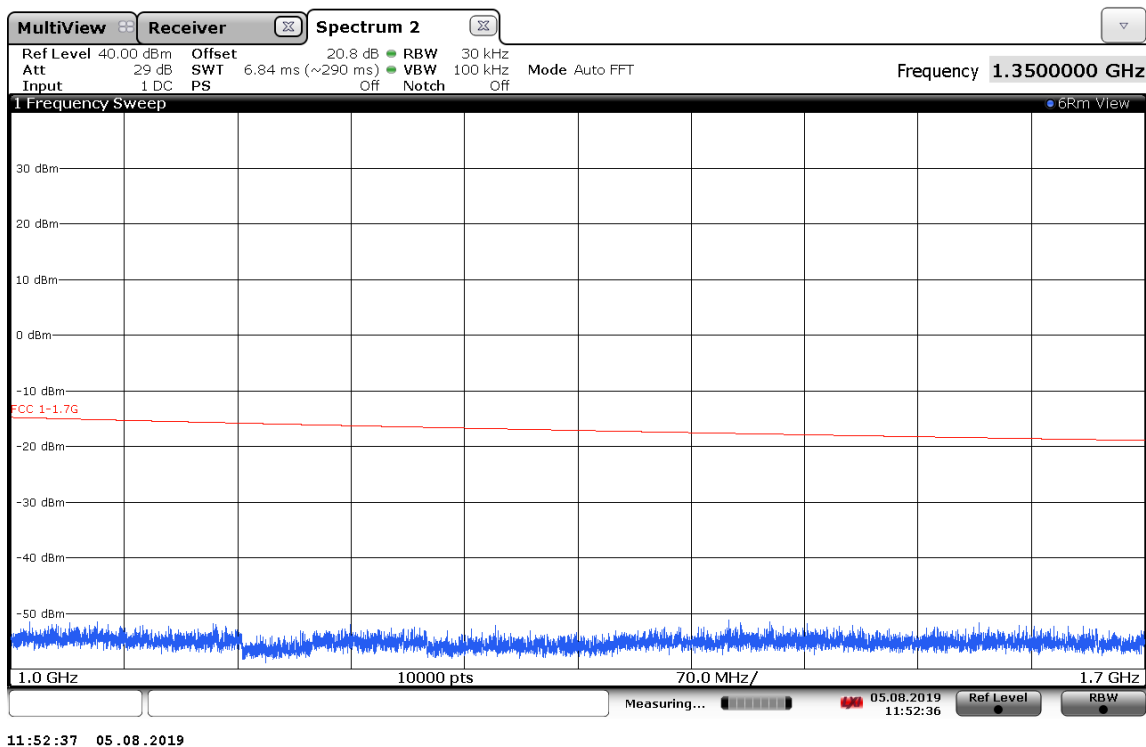


Fig. 7.18 162.025 MHz, 1 W Spurious Emission at Antenna Terminal (1 GHz to 1.7 GHz)

8 Field Strength Plots of Spurious Radiation

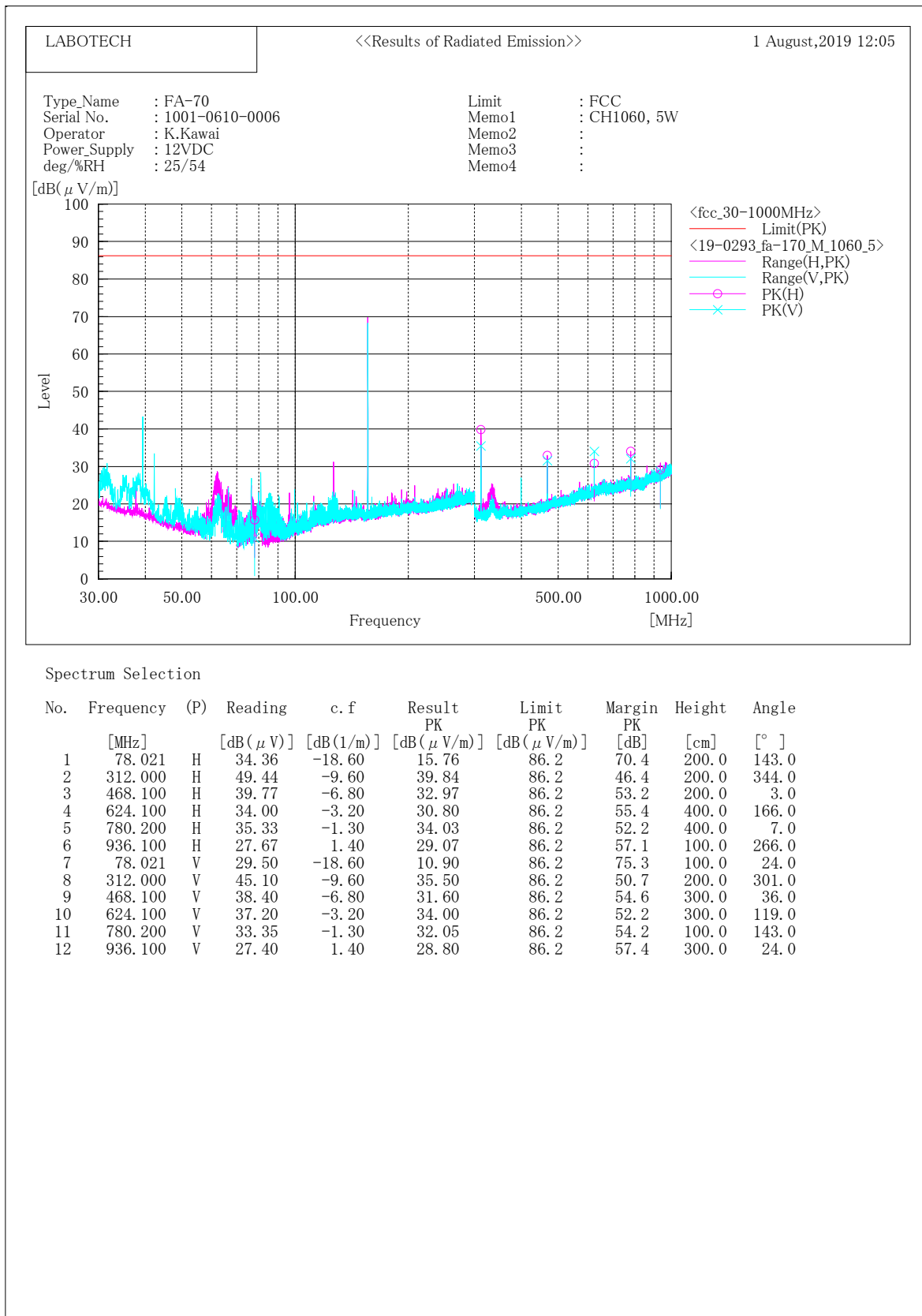


Fig. 8.1 156.025 MHz, 5 W Field Strength of Spurious Radiation (30 MHz to 1 GHz)

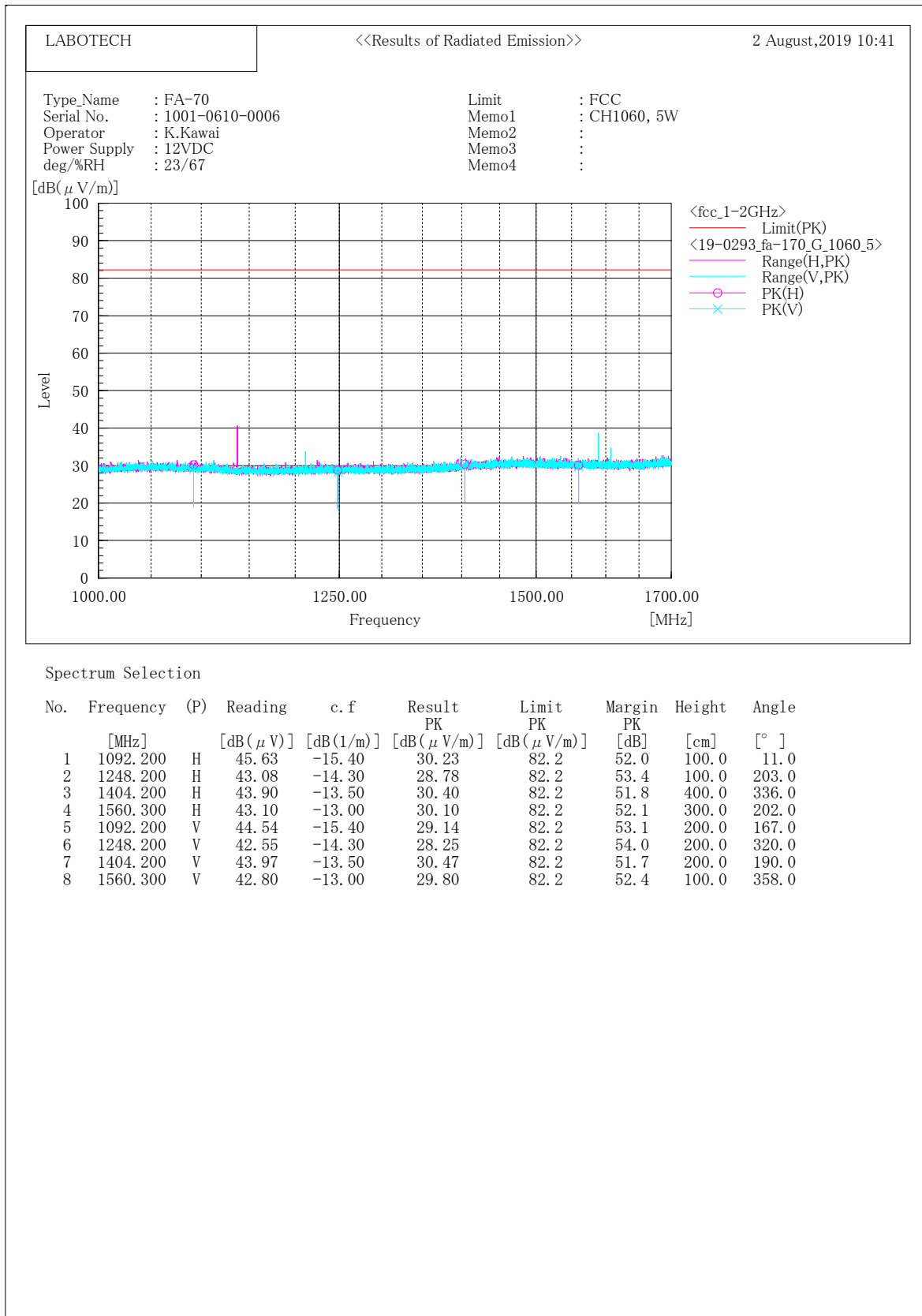


Fig. 8.2 156.025 MHz, 5 W Field Strength of Spurious Radiation (1 GHz to 1.7 GHz)

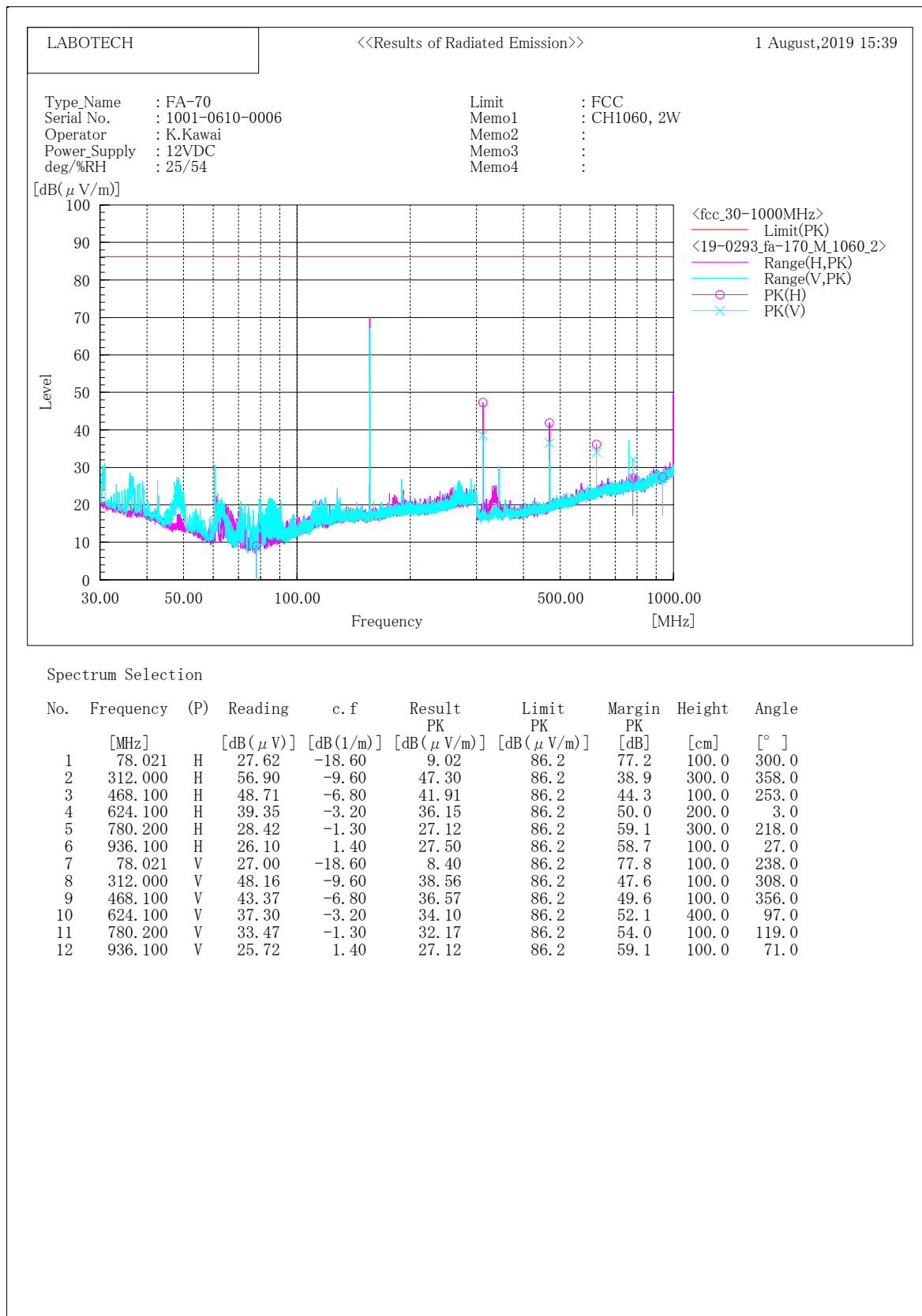


Fig. 8.3 156.025 MHz, 2 W Field Strength of Spurious Radiation (30 MHz to 1 GHz)

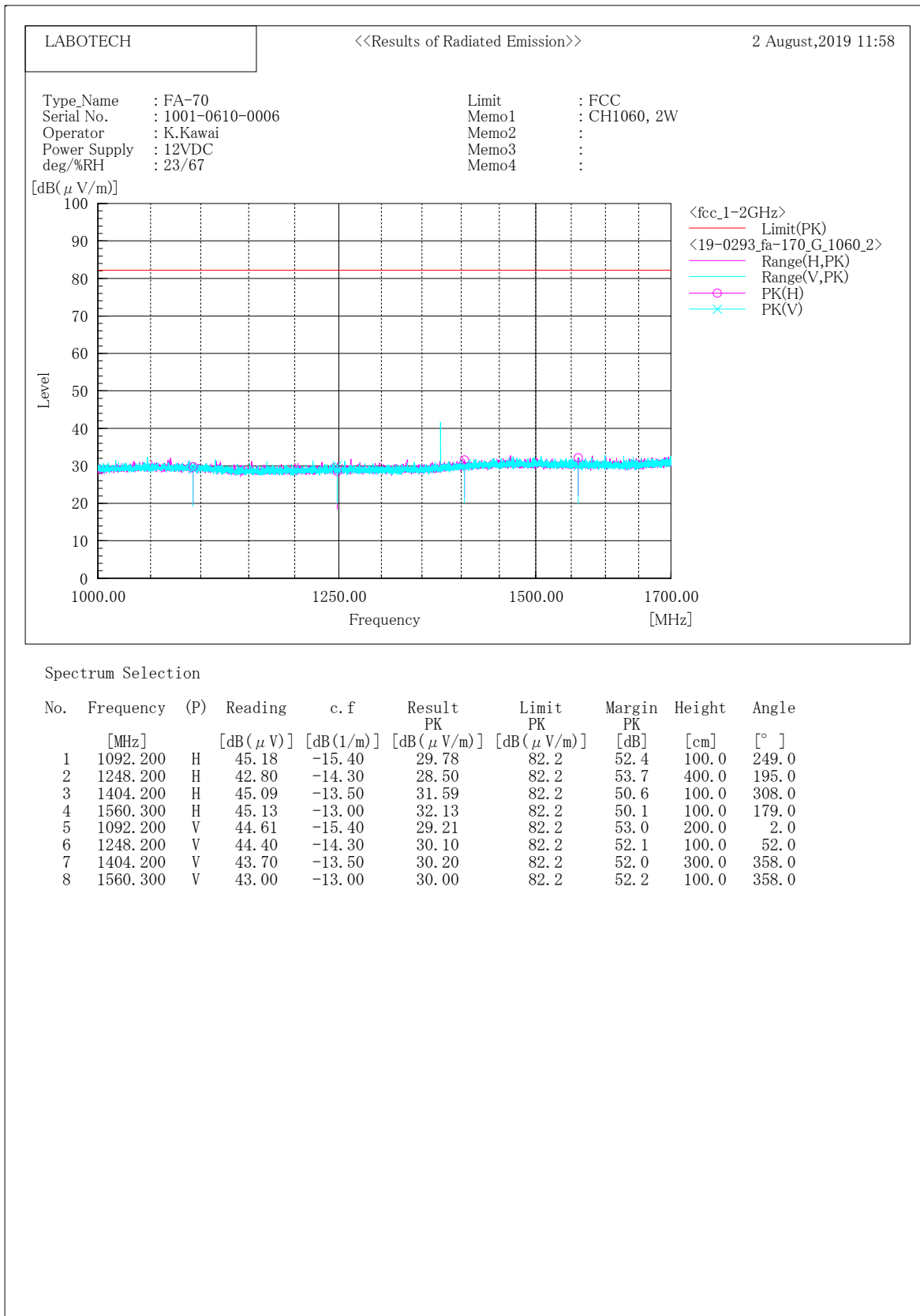


Fig. 8.4 156.025 MHz, 2 W Field Strength of Spurious Radiation (1 GHz to 1.7 GHz)

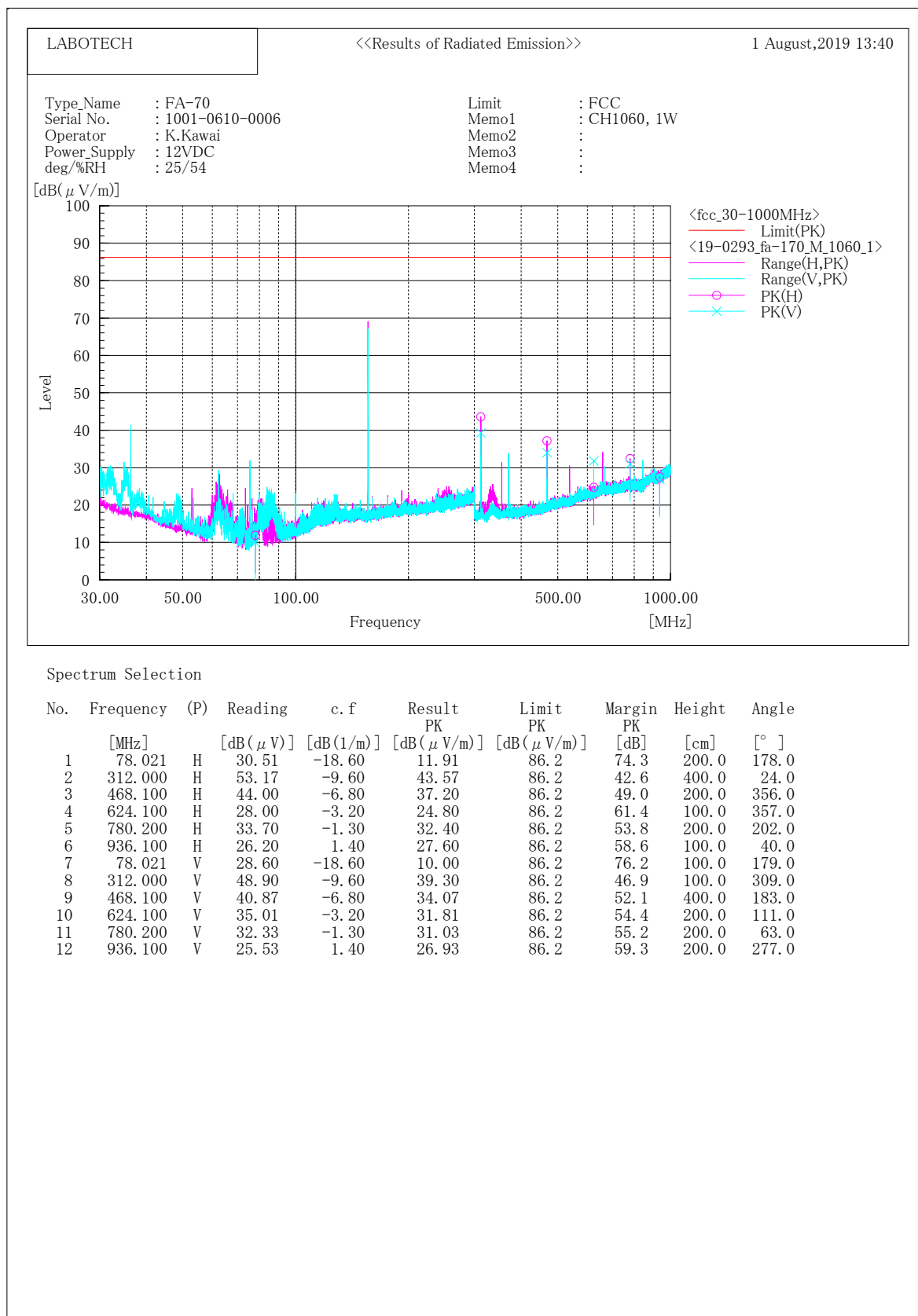


Fig. 8.5 156.025 MHz, 1 W Field Strength of Spurious Radiation (30 MHz to 1 GHz)

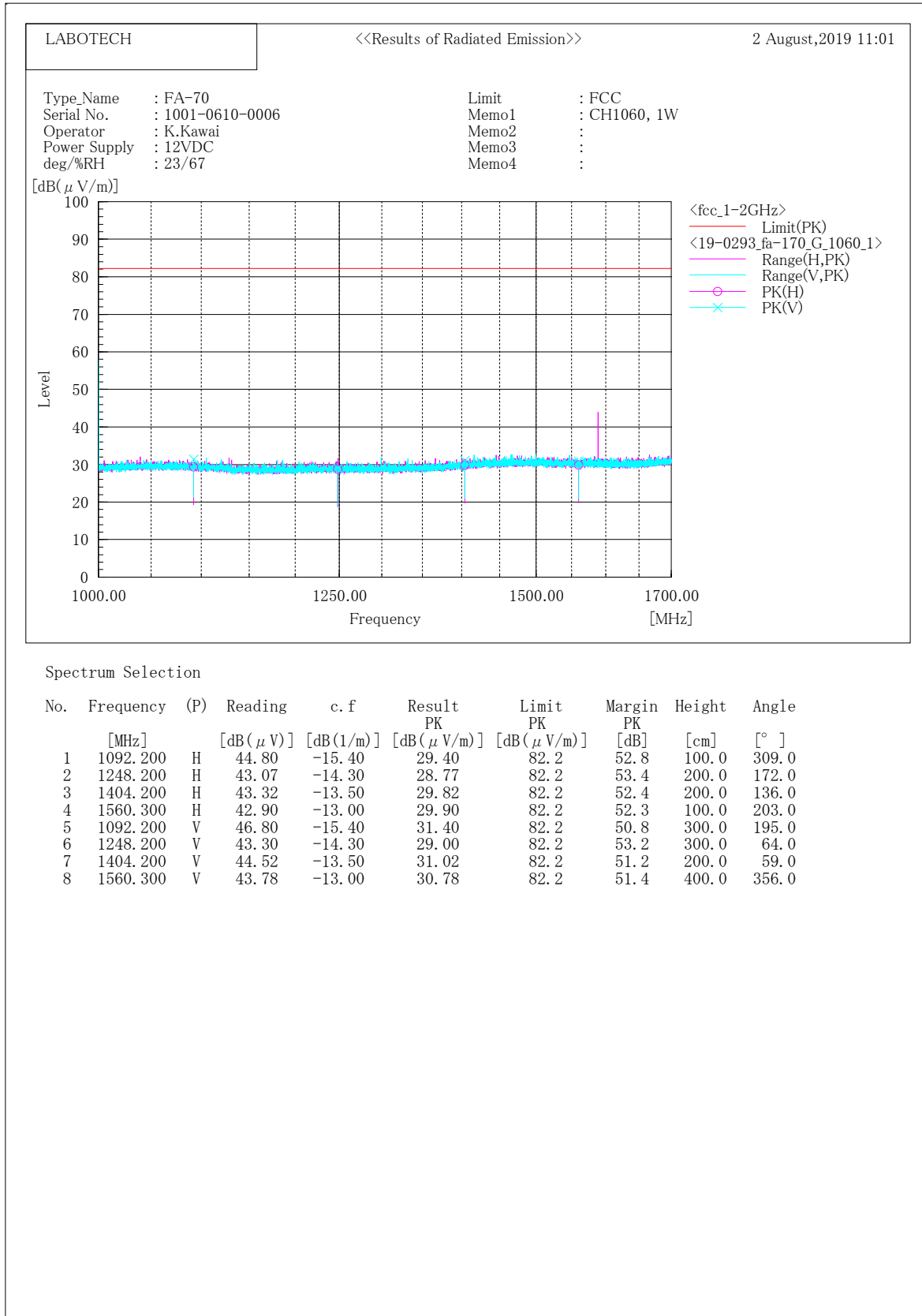
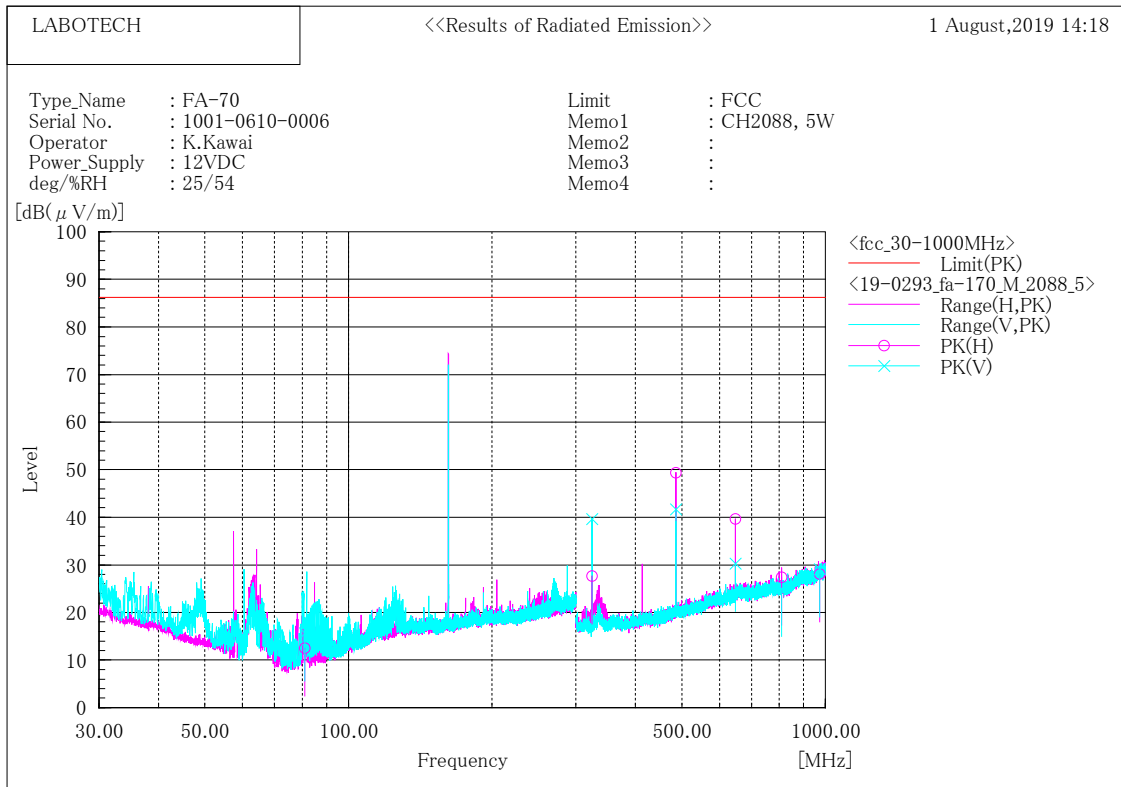


Fig. 8.6 156.025 MHz, 1 W Field Strength of Spurious Radiation (1 GHz to 1.7 GHz)



Spectrum Selection

No.	Frequency [MHz]	(P)	Reading [dB(μ V)]	c. f [dB(1/m)]	Result PK [dB(μ V/m)]	Limit PK [dB(μ V/m)]	Margin PK [dB]	Height [cm]	Angle [°]
1	81.030	H	30.80	-18.30	12.50	86.2	73.7	200.0	3.0
2	324.000	H	37.60	-9.90	27.70	86.2	58.5	400.0	119.0
3	486.100	H	55.50	-6.10	49.40	86.2	36.8	200.0	273.0
4	648.100	H	42.18	-2.50	39.68	86.2	46.5	100.0	311.0
5	810.100	H	28.30	-0.90	27.40	86.2	58.8	400.0	226.0
6	972.100	H	25.60	2.50	28.10	86.2	58.1	400.0	95.0
7	81.030	V	33.95	-18.30	15.65	86.2	70.6	100.0	155.0
8	324.300	V	49.55	-9.90	39.65	86.2	46.6	200.0	278.0
9	486.100	V	47.80	-6.10	41.70	86.2	44.5	300.0	107.0
10	648.100	V	32.80	-2.50	30.30	86.2	55.9	300.0	3.0
11	810.100	V	25.90	-0.90	25.00	86.2	61.2	400.0	182.0
12	972.100	V	26.60	2.50	29.10	86.2	57.1	300.0	95.0

Fig. 8.7 162.025 MHz, 5 W Field Strength of Spurious Radiation (30 MHz to 1 GHz)

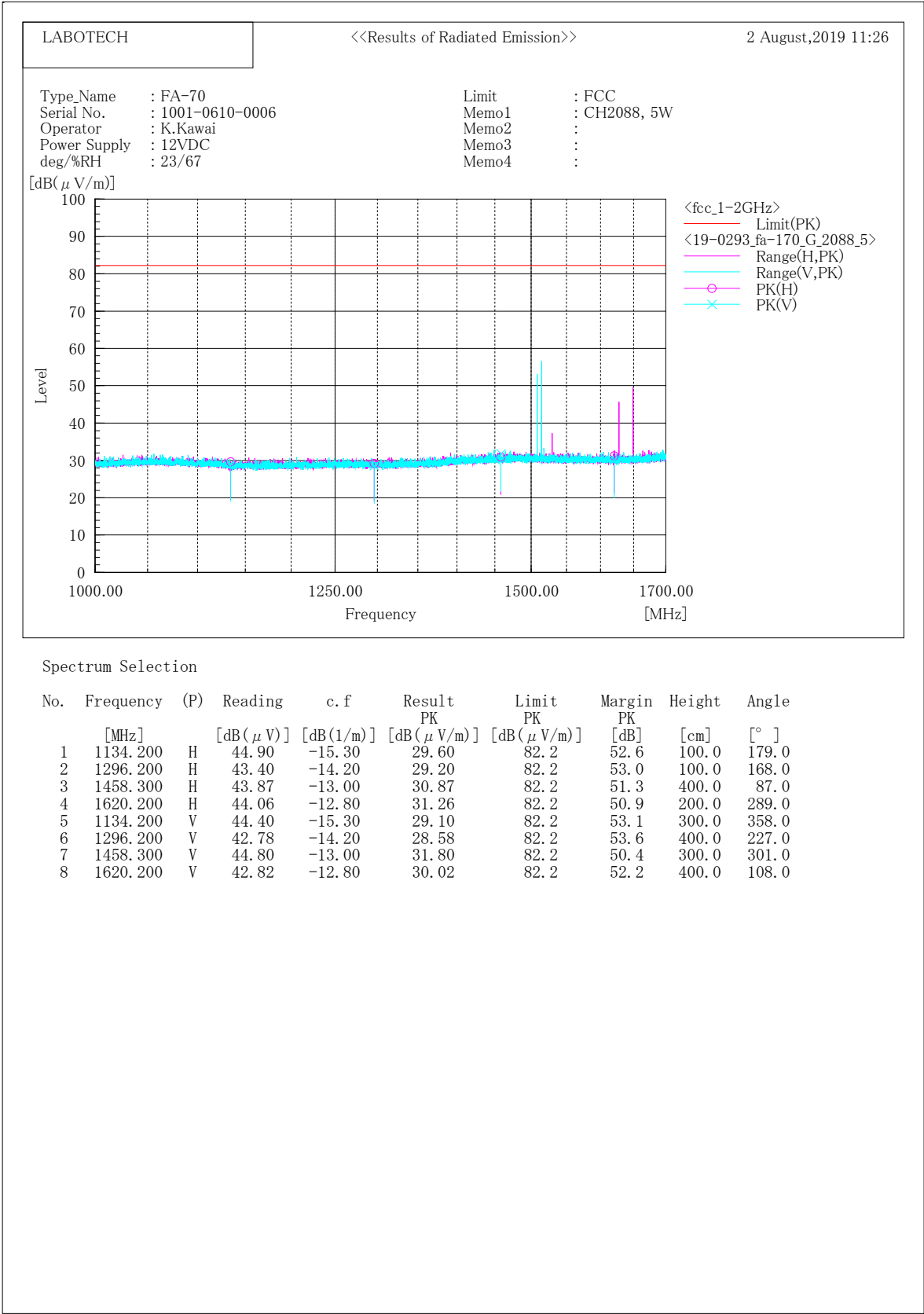


Fig. 8.8 162.025 MHz, 5 W Field Strength of Spurious Radiation (1 GHz to 1.7 GHz)

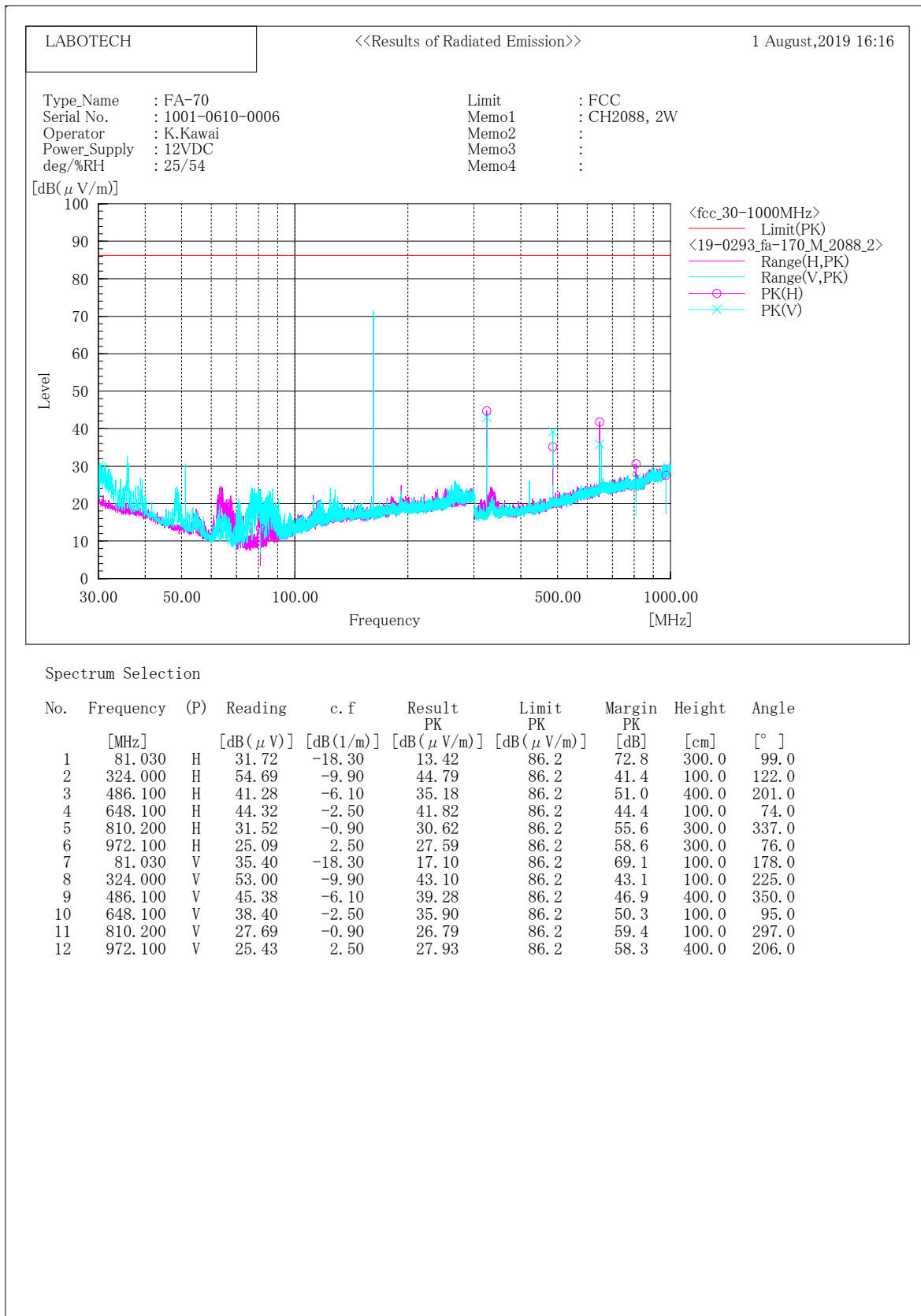


Fig. 8.9 162.025 MHz, 2 W Field Strength of Spurious Radiation (30 MHz to 1 GHz)

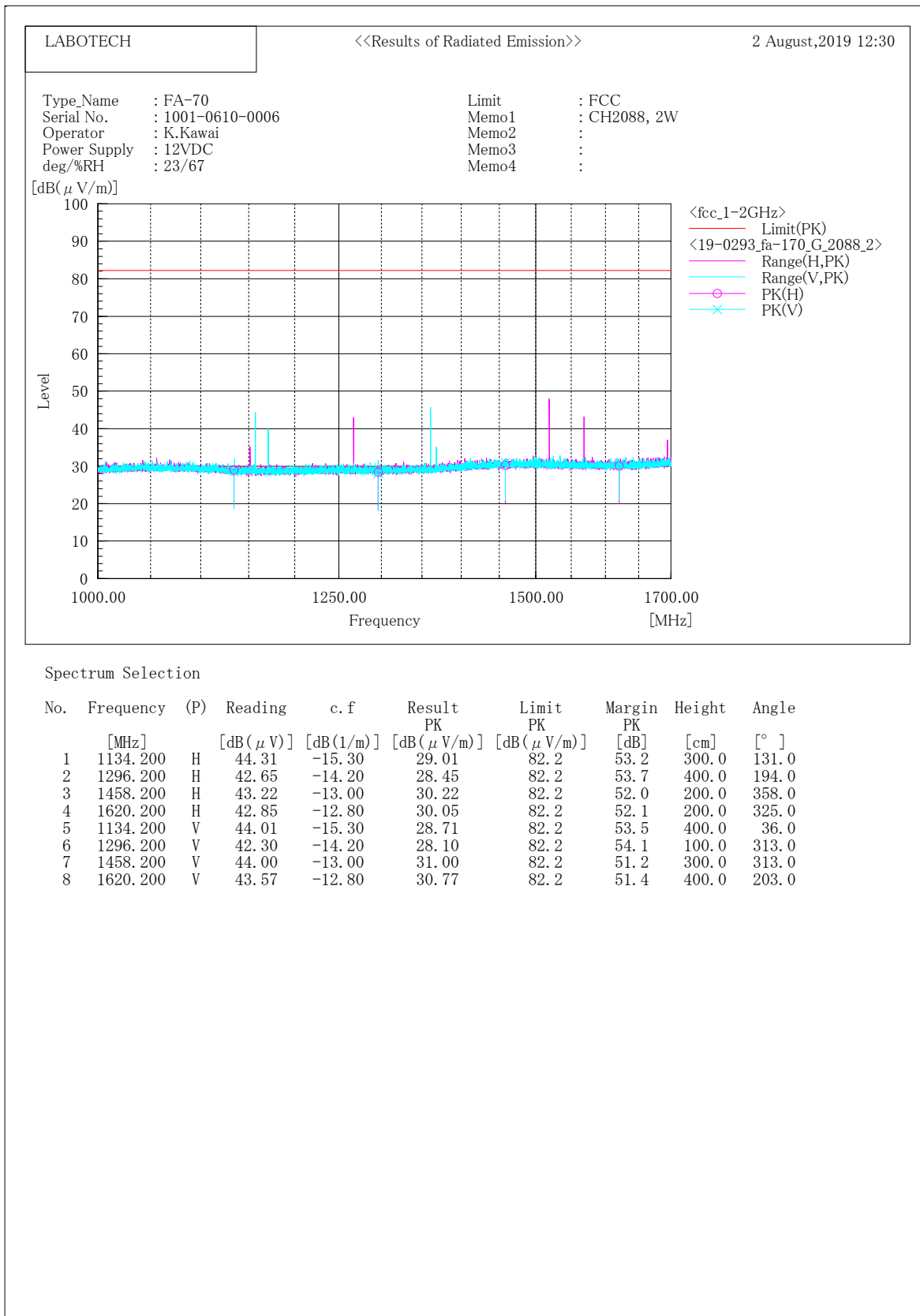


Fig. 8.10 162.025 MHz, 2 W Field Strength of Spurious Radiation (1 GHz to 1.7 GHz)

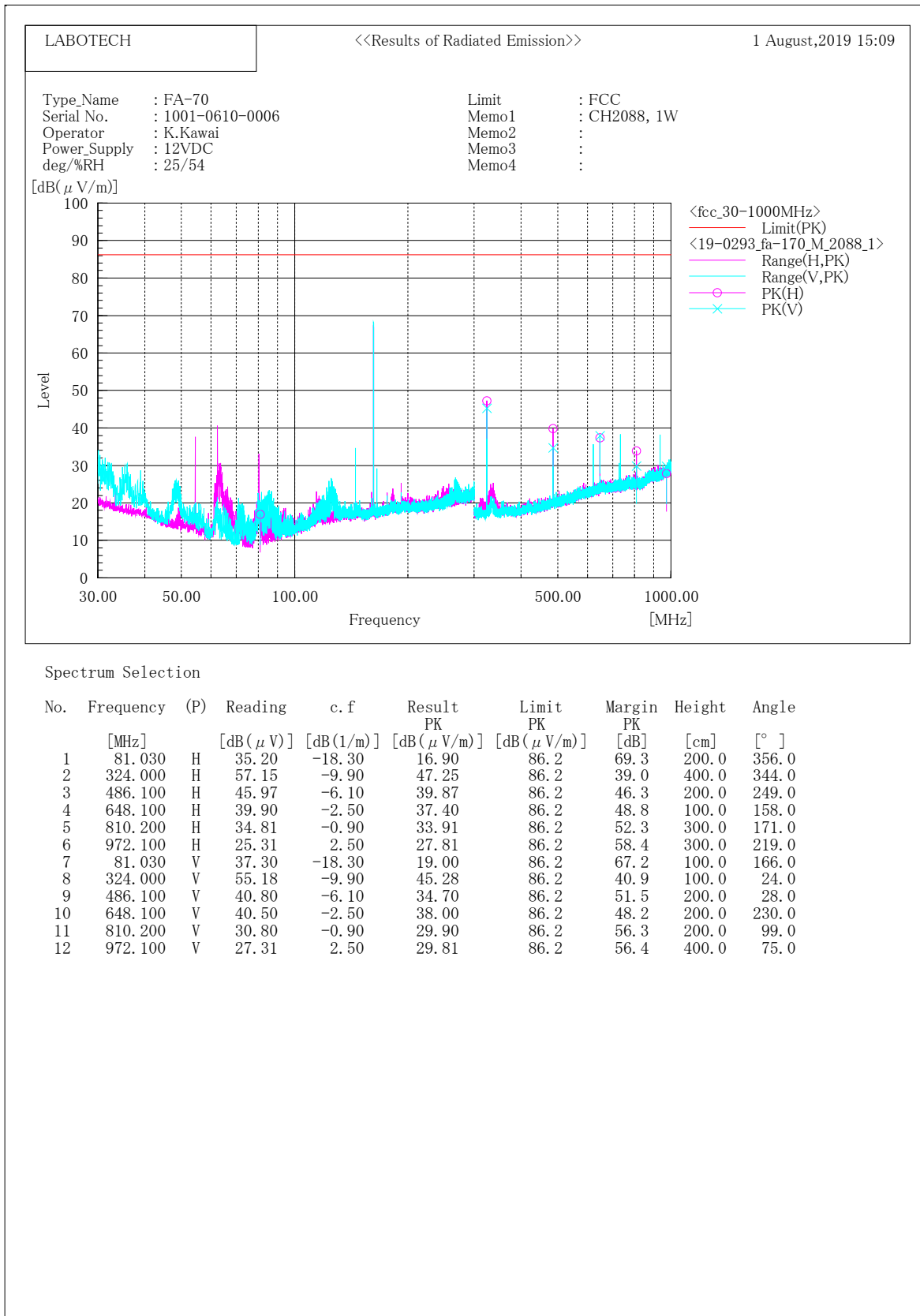


Fig. 8.11 162.025 MHz, 1 W Field Strength of Spurious Radiation (30 MHz to 1 GHz)

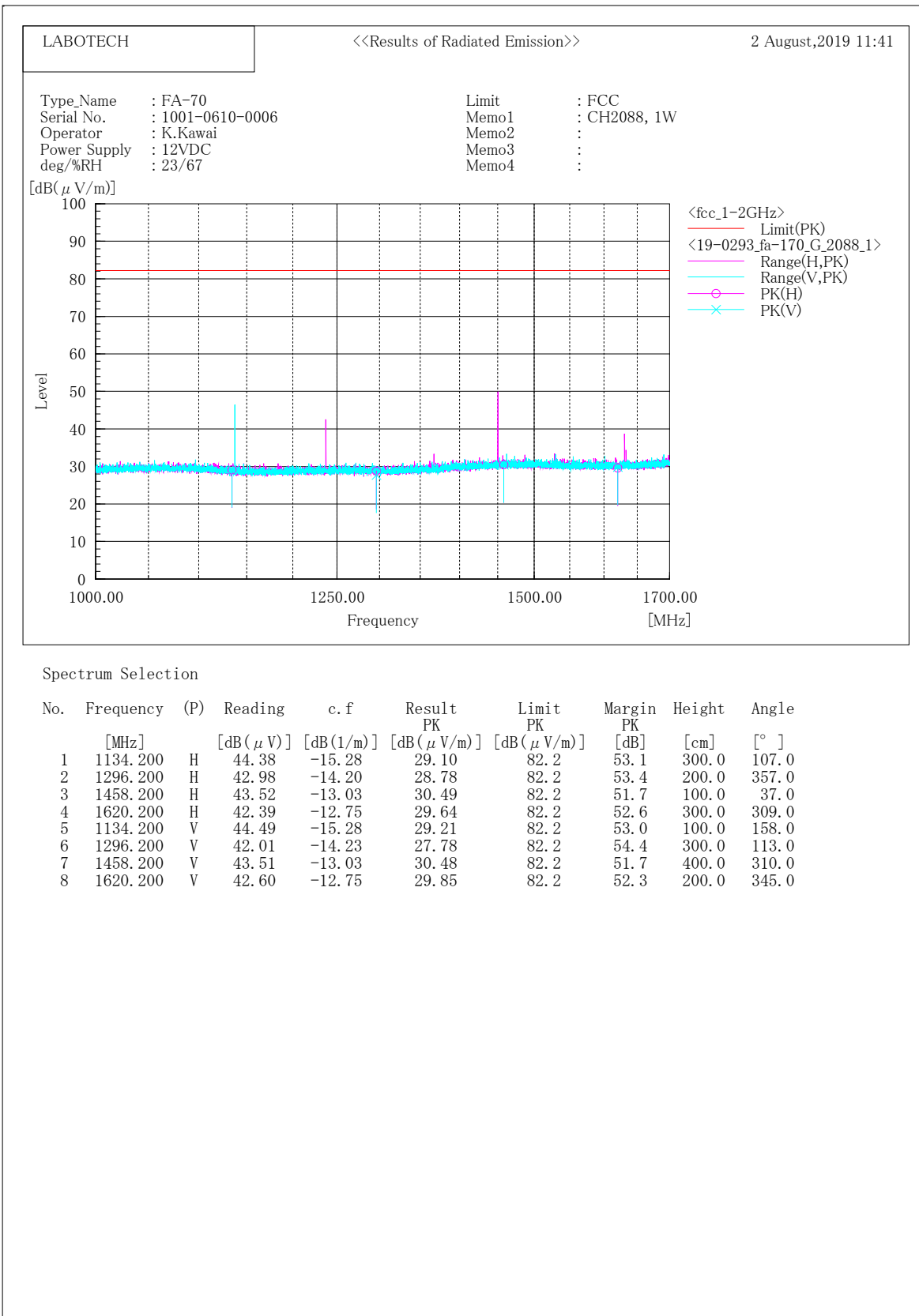


Fig. 8.12 162.025 MHz, 1 W Field Strength of Spurious Radiation (1 GHz to 1.7 GHz)

9 Field Strength Plots for Suppression of Interference Aboard Ships

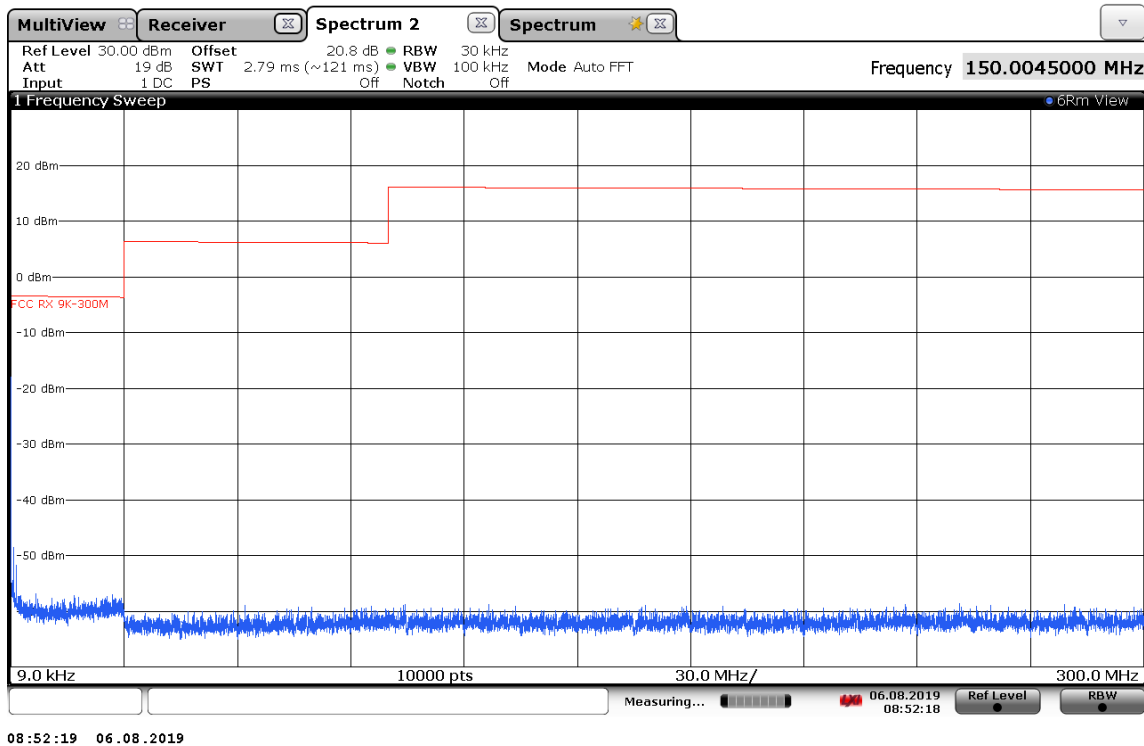


Fig. 9.1 RX1=156.025 MHz, RX2=162.025 MHz, Suppression of Interference Aboard Ships (9 kHz to 300 MHz)

9 kHz – 30 MHz: Limit = 400 μ W (-4 dBm)

30 MHz – 100 MHz: Limit = 4,000 μ W (+6 dBm)

100 MHz – 300 MHz: Limit = 40,000 μ W (+16 dBm)

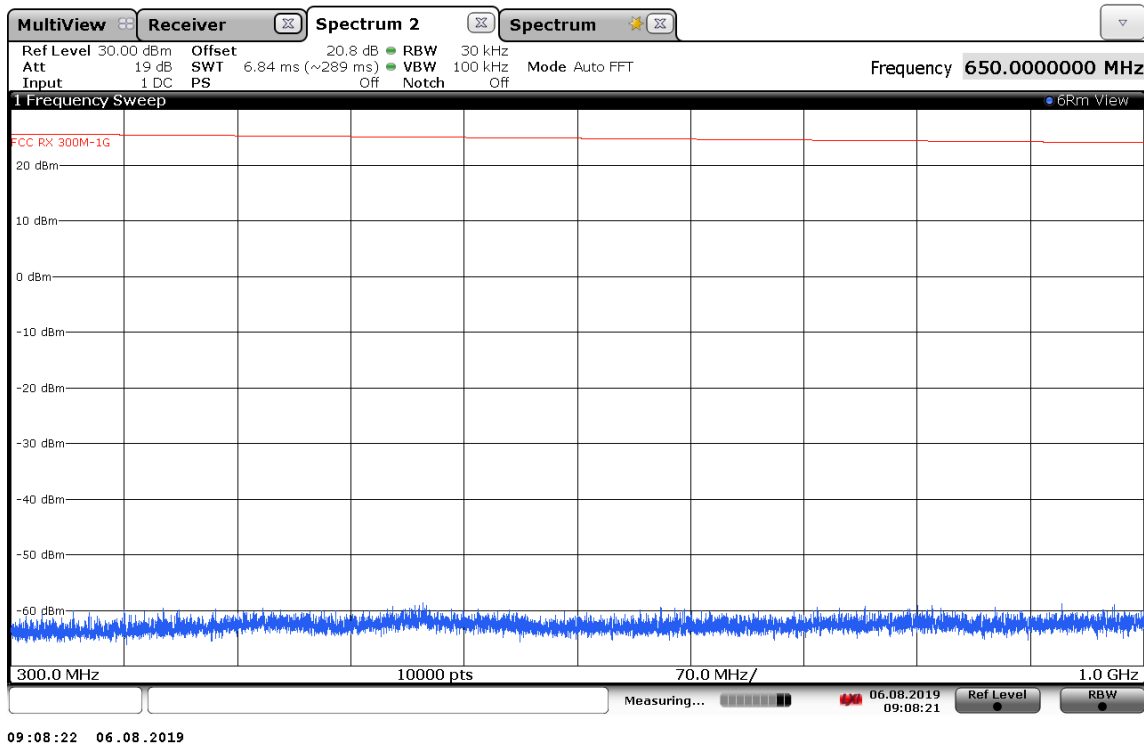


Fig. 9.2 RX1=156.025 MHz, RX2=162.025 MHz, Suppression of Interference Aboard Ships (300 MHz to 1 GHz)

300 MHz – 1 GHz: Limit = 400,000 μ W (+26 dBm)

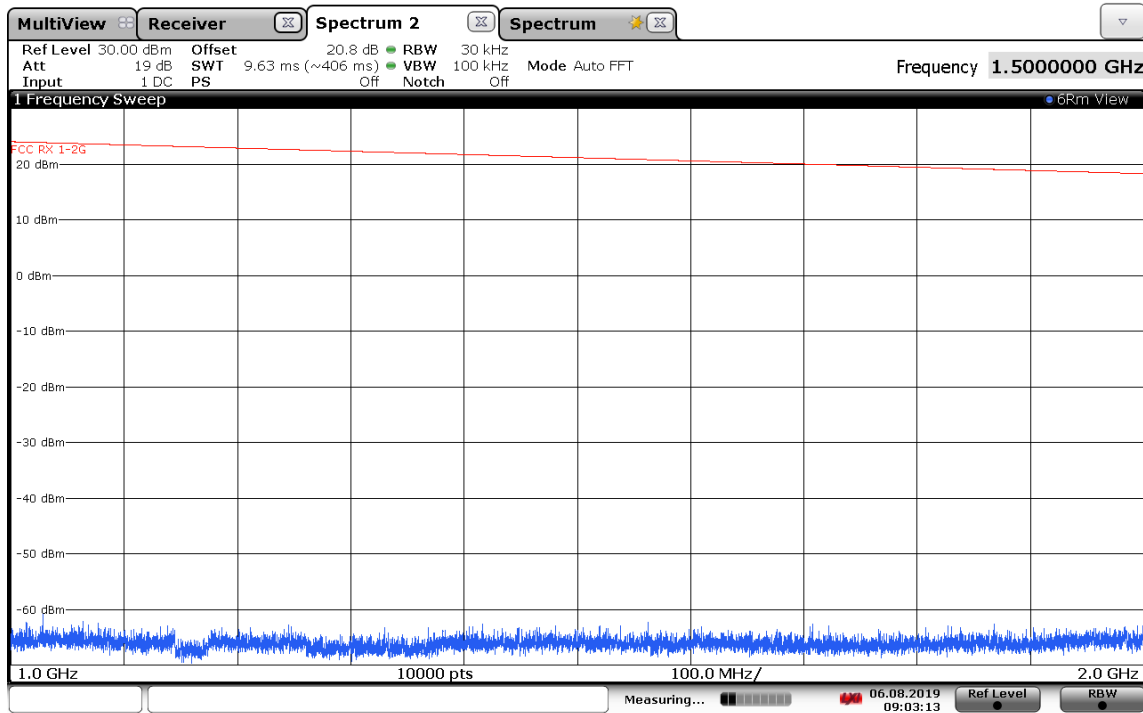


Fig. 9.3 RX1=156.025 MHz, RX2=162.025 MHz, Suppression of Interference Aboard Ships (1 GHz to 2 GHz)

1 GHz – 2 GHz: Limit = 400,000 μ W (+26 dBm)

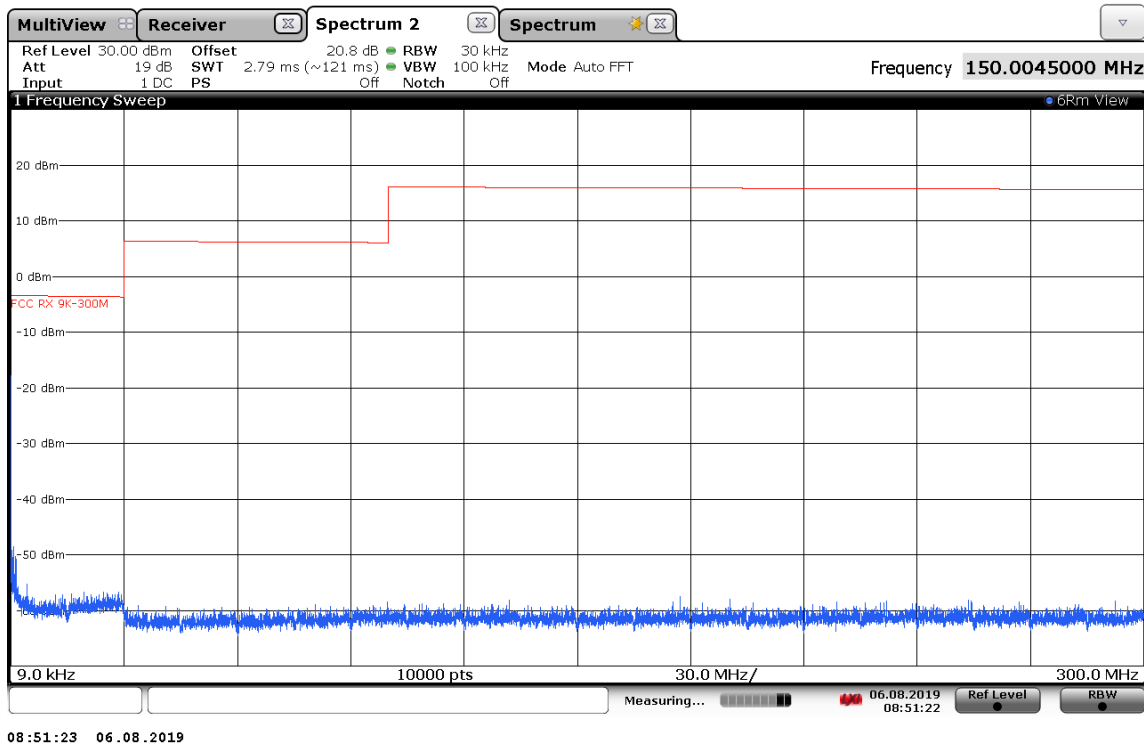
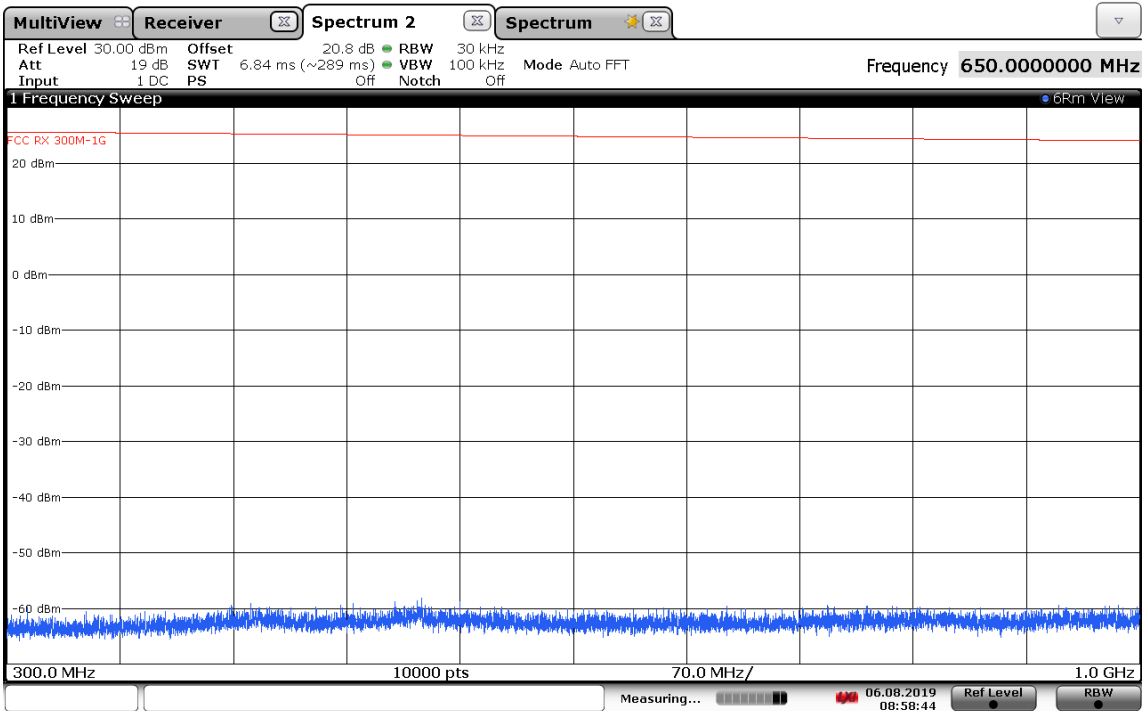


Fig. 9.4 RX1=162.025 MHz, RX2=156.025 MHz, Suppression of Interference Aboard Ships (9 kHz to 300 MHz)

9 kHz – 30 MHz: Limit = 400 μ W (-4 dBm)

30 MHz – 100 MHz: Limit = 4,000 μ W (+6 dBm)

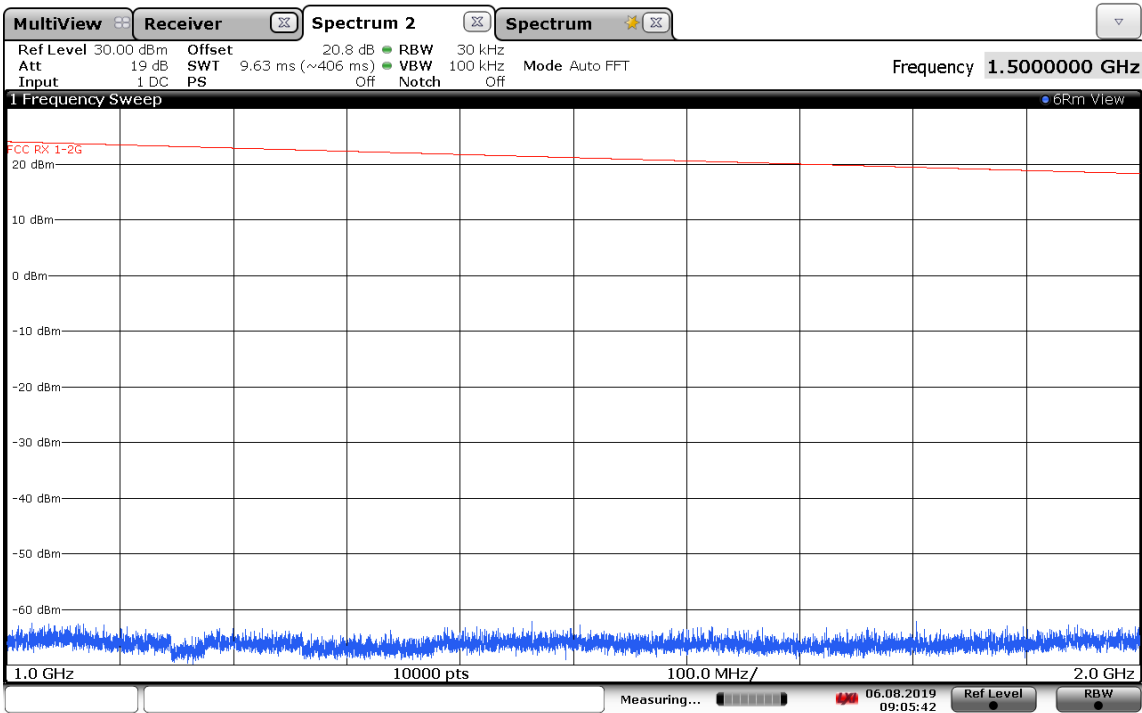
100 MHz – 300 MHz: Limit = 40,000 μ W (+16 dBm)



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Fig. 9.5 RX1=162.025 MHz, RX2=156.025 MHz, Suppression of Interference Aboard Ships (300 MHz to 1 GHz)

300 MHz – 1 GHz: Limit = 400,000 μ W (+26 dBm)



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Fig. 9.6 RX1=162.025 MHz, RX2=156.025 MHz, Suppression of Interference Aboard Ships (1 GHz to 2 GHz)
1 GHz – 2 GHz: Limit = 400,000 μ W (+26 dBm)

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