TEST REPORT

KOSTEC Co., Ltd. 28(175-20, Annyeong-dong) 406-gil sejaro, Hwaseong-si, Gyeonggi-do, Korea Tel:031-222-4251, Fax:031-222-4252	Report No.: KST-FCR-200011	KOSTEC Co., Ltd. http://www.kostec.org

1. Applicant

   • Name : SamYoungCeletra. Co.,Ltd.

   • Address : 110, Geomdan-ro, Seo-gu, Incheon, South Korea

2. Test Item

   • Product Name: DMR Data/Voice MODEM Module

   • Model Name: CM105

   • Brand: Samyoung Celetra

   • FCC ID: 2AJRJ-CM105

3. Manufacturer

   • Name : SamYoungCeletra. Co.,Ltd.

   • Address : 110, Geomdan-ro, Seo-gu, Incheon, South Korea

4. Date of Test : 2020. 05. 26. ~ 2020. 05. 28.

5. Test Method Used : FCC CFR 47, Part 90
   ANSI/TIA-603-E-2016
   ANSI C63.26-2015
   ANSI C63.4-2014

6. Test Result : Compliance

7. Note: -

Supplementary Information

The device bearing the brand name and FCC ID specified above has been shown to comply with the applicable technical standards as indicated in the measurement report and was tested in accordance with measurement procedures specified in ANSI/TIA-603-E-2016

We attest to the accuracy of data and all measurements reported herein were performed by KOSTEC Co., Ltd. and were made under Chief Engineer's supervision. We assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

The results shown in this test report refer only to the sample(s) tested unless otherwise stated.
This test report is not related to KOLAS accreditation.

Affirmation	Tested by Name : Choo, Kwang-Yeol (Signature)	Technical Manager Name : Park, Gyeong-Hyeon (Signature)

2020. 09. 18.

KOSTEC Co., Ltd.

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1. GENERAL INFORMATION

1.1 Test Facility

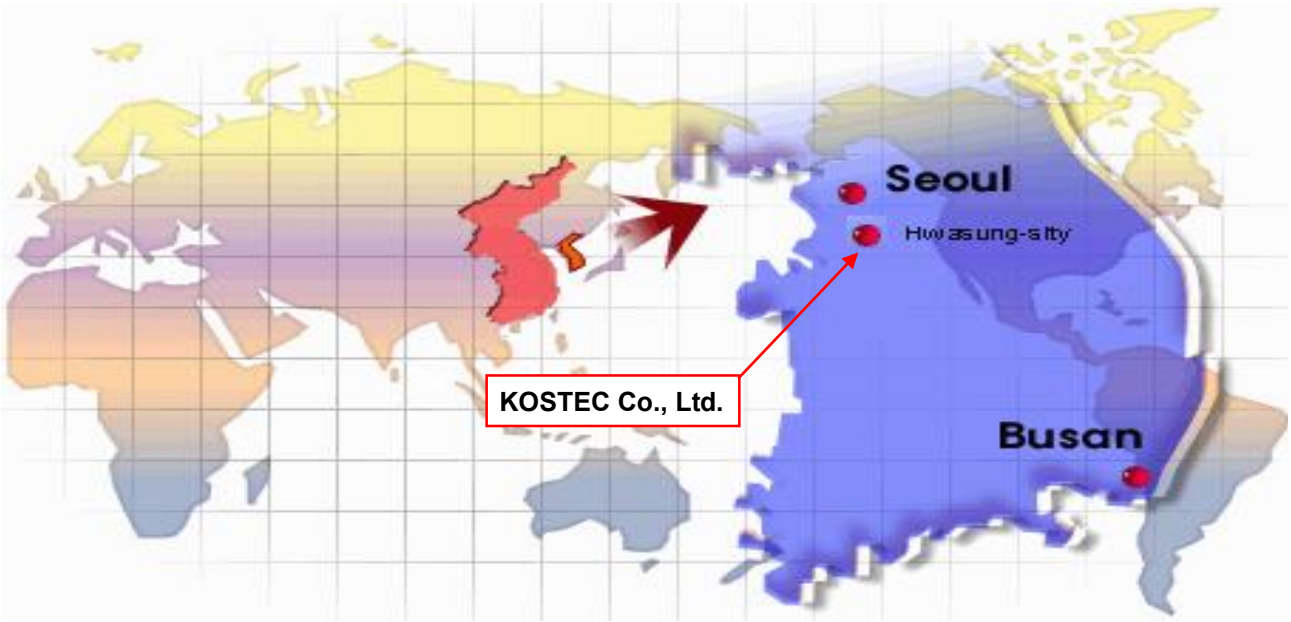
Test laboratory and address

KOSTEC Co., Ltd.
28(175-20,Annyeong-dong)406-gil sejaro, Hwaseong-si Gyeonggi-do, Korea
Telephone Number: 82-31-222-4251
Facsimile Number: 82-31-222-4252

Registration information

KOLAS No.: KT232
RRA (National Radio Research Agency): KR0041
FCC Designation No.: KR0041
IC Designation No.: KR0041
VCCI Membership No.: 2005

1.2 Location



1.3 Revision History of test report

Rev.	Revisions	Effect page	Reviewed	Date
-	Initial issue	All	Park, Gyeong-Hyeon	2020. 09. 18.

2. EQUIPMENT DESCRIPTION

The product specification described herein was declared by manufacturer. And refer to user's manual for the details.

Equipment Name	DMR Data/Voice MODEM Module
Model No	CM105
Type of Equipment	Licensed Non-Broadcast station Transmitter
Intended Operating Environment	General Population/Uncontrolled Exposure
Serial Number	Proto type
Primary User Functions of EUT	2-Way Wireless Voice & Data Communication modem
RF Output Power Rating	5 Watt (High) / 1 Watt (Low)
Assigned Frequency Range	136 ~ 174 MHz
Operating Frequency Range	138.012 5 ~ 173.387 5 MHz
RF Output Impedance	50 Ω
Channel Spacing	12.5 kHz
Modulation	FM for analog voice 4FSK for digital Voice and data
Occupied Bandwidth (99%)	5.72 kHz (for 12.5 kHz Channel Spacing / Analog) 8.00 kHz (for 12.5 kHz Channel Spacing / Digital)
Emission Designation	5K72F3E, 8K00F1D, 8K00F1E
Power Source	7.4 Vdc nominal
Hardware Version	CM105 Rev3.0
Software Version (FW/DSP)	V1.6.0.6P28 / V2.01.06LC
Antenna Description	HW-146H-NPX100 : Helical antenna, Max -3.933 dBi HW-153H-NPX100 : Helical antenna, Max 2.15 dBi HW-170H-NPX100 : Helical antenna, Max 2.15 dBi
FCC ID	2AJRJ-CM105
Remark	The above DUT's information was declared by manufacturer. Please refer to the specifications or user manual for more detailed description.

3. SYSTEM CONFIGURATION FOR TEST

3.1 Characteristics of equipment

The Equipment Under Test (EUT) use for DMR Data/Voice MODEM module.

3.2 Used peripherals list

Description	Model No.	Serial No.	Manufacture	Remark

3.3 Product Modification

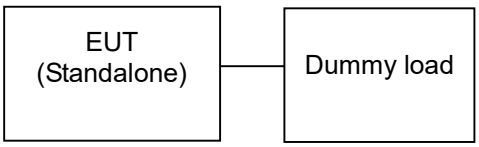
N/A

3.4 Operating Mode

Constantly transmitting with a modulated carrier at maximum power on the low, middle and high channels.
Radiated emissions tests were performed with antenna ports terminated.

3.5 Test Setup of EUT

The measurements were taken in continuous transmit mode.



3.6 Table for Carrier Frequencies

Modulation Type	Tested Channel	Channel separation (kHz)	Test freq. (MHz)
Analog	Low	12.5	138.012 5
	Mid		151.100 0
	Mid		158.550 0
	High		173.387 5
Digital	Low	12.5	138.012 5
	Mid		151.100 0
	Mid		158.550 0
	High		173.387 5

3.7 Antenna requirement

For intentional device, according to §15.203, an intentional radiator shall be designed to ensure that no antenna other than furnished by responsible party shall be used with the device.

The use of a permanently attached antenna or of an antenna that user a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section.

The manufacturer may design the unit so that broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

The EUT has a unique coupling such as RP-SMA.

Antenna model name	Antenna Type	Gain [dBi]	Results
HW-146H-NPX100	RP-SMA helical antenna	-3.933	Compliance
HW-153H-NPX100	RP-SMA helical antenna	2.15	Compliance
HW-170H-NPX100	RP-SMA helical antenna	2.15	Compliance

3.8 Used Test Equipment List

No.	Instrument	Model	S/N	Manufacturer	Next Cal Date	Cal interval	used
1	T & H Chamber	PL-3J	15003623	ESPEC	2020.11.07	1 year	☐
2	T & H Chamber	SH-662	93000067	ESPEC CORP	2020.09.04	1 year	☒
3	Spectrum Analyzer	8563EC	3046A00527	Agilent Technology	2021.01.21	1 year	☐
4	Spectrum Analyzer	FSV30	104029	Rohde & Schwarz	2020.09.24	1 year	☐
5	Spectrum Analyzer	FSV30	20-353063	Rohde& Schwarz	2021.01.21	1 year	☐
6	Signal Analyzer	FSW43	101294	Rohde& Schwarz	2021.02.26	1 year	☒
7	Signal Analyzer	N9010A	MY56070441	Agilent Technologies	2021.05.25	1 year	☐
8	EMI Test Receiver	ESCI7	100823	Rohde& Schwarz	2021.01.21	1 year	☐
9	EMI Test Receiver	ESI	837514/004	Rohde& Schwarz	2020.09.03	1 year	☒
10	Vector Signal Analyzer	89441A	3416A02620	Agilent Technology	2021.01.22	1 year	☐
11	Network Analyzer	8753ES	US39172348	AGILENT	2020.09.04	1 year	☐
12	EPM Series Power meter	E4418B	GB39512547	Agilent Technology	2021.01.22	1 year	☒
13	RF Power Sensor	E9300A	MY41496631	Agilent Technology	2021.01.22	1 year	☒
14	Microwave Frequency Counter	5352B	2908A00480	Agilent Technology	2021.01.22	1 year	☐
15	Audio Analyzer	8903B	3514A16919	Agilent Technology	2021.01.20	1 year	☒
16	Audio Telephone Analyzer	DD-5601CID	520010281	CREDIX	2021.01.20	1 year	☐
17	Modulation Analyzer	8901A	3041A05716	H.P	2021.01.22	1 year	☒
18	Digital storage Oscilloscope	TDS3052	B015962	Tektronix	2020.09.03	1 year	☐
19	ESG-D Series Signal Generator	E4436B	US39260458	Agilent Technology	2021.01.20	1 year	☒
20	Vector Signal Generator	SMBV100A	257557	Rohde & Schwarz	2021.01.20	1 year	☐
21	GNSS Signal Generator	TC-2800A	2800A000494	TESCOM CO., LTD.	2021.01.22	1 year	☐
22	Signal Generator	SMB100A	179628	Rohde & Schwarz	2021.05.13	1 year	☒
23	SLIDAC	None	0207-4	Myoung sung Ele.	2021.01.20	1 year	☐
24	DC Power supply	DRP-5030	9028029	Digital Electronic Co.,Ltd	2021.01.20	1 year	☐
25	DC Power supply	E3610A	KR24104505	Agilent Technology	2021.01.20	1 year	☒
26	DC Power supply	UP-3005T	68	Unicon Co.,Ltd	2021.01.20	1 year	☐
27	DC Power Supply	SM 3004-D	114701000117	DELTA ELEKTRONIKA	2021.01.20	1 year	☐
28	DC Power supply	6632B	MY43004005	Agilent Technology	2021.01.20	1 year	☐
29	DC Power Supply	6632B	MY43004137	Agilent Technology	2021.01.20	1 year	☐
30	Termination	1433-3	LM718	WEINSCHEL	2020.07.11	1 year	☐
31	Termination	1432-3	QR946	AEROFLEX/WEINSCHEL	2020.07.11	1 year	☒
32	Attenuator	24-30-34	BX5630	Aeroflex / Weinschel	2020.12.17	1 year	☐
33	Attenuator	8498A	3318A09485	HP	2021.01.22	1 year	☐
34	Step Attenuator	8494B	3308A32809	HP	2021.01.21	1 year	☐
35	RF Step Attenuator	RSP	100091	Rohde & Schwarz	2021.01.21	1 year	☐
36	Attenuator	18B50W-20F	64671	INMET	2021.01.22	1 year	☐
37	Attenuator	10 dB	1	Rohde & Schwarz	2021.05.13	1 year	☐
38	Attenuator	10 dB	2	Rohde & Schwarz	2021.05.13	1 year	☐
39	Attenuator	10 dB	3	Rohde & Schwarz	2021.05.13	1 year	☐
40	Attenuator	10 dB	4	Rohde & Schwarz	2021.05.13	1 year	☐
41	Attenuator	54A-10	74564	WEINSCHEL	2020.09.05	1 year	☐
42	Attenuator	56-10	66920	WEINSCHEL	2021.05.13	1 year	☐
43	Attenuator	48-20-11	BV2658	Aeroflex/Weinschel	2020.07.11	1 year	☒
44	Attenuator	48-30-33-LIM	BL5350	Weinschel Corp.	2020.07.11	1 year	☒
45	Power divider	11636B	51212	HP	2021.01.23	1 year	☒
46	3Way Power divider	KPDSU3W	00070365	KMW	2020.09.03	1 year	☐
47	4Way Power divider	70052651	173834	KRYTAR	2021.01.23	1 year	☐
48	3Way Power divider	1580	SQ361	WEINSCHEL	2021.05.13	1 year	☐
49	OSP	OSP120	101577	Rohde & Schwarz	2021.05.14	1 year	☐

No.	Instrument	Model	S/N	Manufacturer	Next Cal Date	Cal interval	used
50	White noise audio filter	ST31EQ	101902	SoundTech	2020.09.04	1 year	☐
51	Dual directional coupler	778D	17693	HEWLETT PACKARD	2021.01.21	1 year	☐
52	Dual directional coupler	772D	2839A00924	HEWLETT PACKARD	2021.01.21	1 year	☐
53	Band rejection filter	3TNF-0006	26	DOVER Tech	2021.01.22	1 year	☐
54	Band rejection filter	3TNF-0007	311	DOVER Tech	2021.01.22	1 year	☐
55	Band rejection filter	WTR-BRF2442-84NN	09020001	WAVE TECH Co.,LTD	2021.01.22	1 year	☐
56	Band rejection filter	WRCJV12-5695-5725-5825-5855-50SS	1	Wainwright Instruments GmbH	2021.05.13	1 year	☐
57	Band rejection filter	WRCJV12-5120-5150-5350-5380-40SS	4	Wainwright Instruments GmbH	2021.05.13	1 year	☐
58	Band rejection filter	WRCGV10-2360-2400-2500-2540-50SS	2	Wainwright Instruments GmbH	2021.05.13	1 year	☐
59	Band rejection filter	CTF-155M-S1	001	RF One Electronics	2020.09.02	1 year	☒
60	Band rejection filter	CTF-435M-S1	001	RF One Electronics	2020.09.02	1 year	☐
61	Highpass Filter	WHJS1100-10EF	1	WAINWRIGHT	2021.01.22	1 year	☐
62	Highpass Filter	WHJS3000-10EF	1	WAINWRIGHT	2021.01.22	1 year	☐
63	Highpass Filter	WHNX6-5530-7000-26500-40CC	2	Wainwright Instruments GmbH	2021.05.13	1 year	☐
64	Highpass Filter	WHNX6-2370-3000-26500-40CC	4	Wainwright Instruments GmbH	2021.05.13	1 year	☐
65	WideBand Radio Communication Tester	CMW500	102276	Rohde & Schwarz	2021.01.21	1 year	☐
66	Bluetooth Tester	TC-3000B	3000B6A0166	TESCOM CO., LTD.	2021.01.22	1 year	☐
67	Loop Antenna	6502	9203-0493	EMCO	2021.05.27	2 year	☒
68	BiconiLog Antenna	3142B	1745	EMCO	2022.04.24	2 year	☐
69	Biconical Antenna	VUBA9117	9117-342	Schwarz beck	2022.03.24	2 year	☐
70	Trilog-Broadband Antenna	VULB 9168	9168-606	SCHWARZBECK	2020.09.14	2 year	☒
71	Horn Antenna	3115	2996	EMCO	2022.02.14	2 year	☒
72	Horn Antenna	3115	9605-4834	EMCO	2022.03.06	2 year	☐
73	Horn Antenna	BBHA9170	743	SCHWARZBECK	2021.01.22	2 year	☐
74	PREAMPLIFIER(3)	8449B	3008A00149	Agilent	2020.09.02	1 year	☒
75	AMPLIFIER(10)	TK-PA6S	120009	TESTEK	2021.01.21	1 year	☐
76	AMPLIFIER	TK-PA18	150003	TESTEK	2021.01.21	1 year	☐
77	AMPLIFIER	TK-PA1840H	160010-L	TESTEK	2021.01.28	1 year	☐
78	AMPLIFIER	8447D	2944A07881	H.P	2021.01.21	1 year	☒

4. SUMMARY TEST RESULTS

Description of Test	FCC Rule	Test report Clause	Used	Test Result
RF Output Power	2.1046, 90.205	Clause 5.1	☒	Compliance
Modulation Characteristics	2.1047, 90.210	Clause 5.2	☒	Compliance
Occupied Bandwidth & Emission Mask	2.1047, 2.1049, 90.209, 90.210	Clause 5.3	☒	Compliance
Spurious Emission On Antenna Port	2.1053, 90.210	Clause 5.4	☒	Compliance
Transmitter Radiated Unwanted Emissions	2.1053, 90.210	Clause 5.5	☒	Compliance
Frequency Stability	2.1055, 90.213	Clause 5.6	☒	Compliance
Transmitter Frequency Behavior	90.214	Clause 5.7	☒	Compliance
Compliance/pass : The EUT complies with the essential requirements in the standard. Not Compliance : The EUT does not comply with the essential requirements in the standard. N/A : The test was not applicable in the standard.				

Procedure Reference

FCC CFR 47, Part 90
ANSI/TIA-603-E-2016
ANSI C63.26-2015
ANSI C63.4-2014

5. MEASUREMENT RESULTS

5.1 RF Output Power

5.1.1 Standard Applicable [FCC §90.205 & 2.1046]

Applicants for licenses must request and use no more power than the actual power necessary for satisfactory operation.

The output power shall not exceed by more than 20 percent either the output power shown in the Radio Equipment List for transmitters included in this list or when not so listed, the manufacturer's rated output power for the particular transmitter specifically listed on the authorization.

5.1.2 Test Environment conditions

• Ambient temperature : (20 - 21) °C • Relative Humidity : (48 - 49) % R.H.

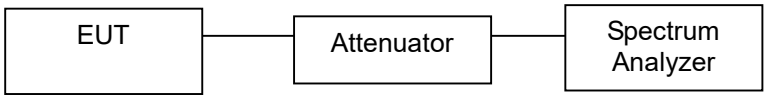
5.1.3 Measurement Procedure

The transmitter output was connected to the spectrum analyzer with an attenuator. The power output shall be monitored and recorded and no adjustment shall be made to the transmitter after the test has begun, except as noted bellow: If the power output is adjustable, measurements shall be made for the highest and lowest power levels.

The spectrum analyzer is set to the as follows :

- RBW : 30 kHz
- VBW : 100 kHz

5.1.4 Test setup



5.1.5 Measurement Result

Modulation	Frequency [MHz]	Power Level	Conducted output Power [dBm]	Conducted output Power [W]	Limit [dBm]	Test Results
Analog	138.0125*	Low	30.25	1.06	0.8 ~ 1.2 W	Compliance
	151.1000	Low	30.43	1.10		Compliance
	158.5500	Low	30.19	1.04		Compliance
	173.3875	Low	30.16	1.04		Compliance
	138.0125*	High	37.45	5.56	4 ~ 6 W	Compliance
	151.1000	High	37.53	5.66		Compliance
	158.5500	High	37.24	5.30		Compliance
	173.3875	High	37.31	5.38		Compliance
Digital	138.0125*	Low	30.26	1.06	0.8 ~ 1.2 W	Compliance
	151.1000	Low	30.43	1.10		Compliance
	158.5500	Low	30.20	1.05		Compliance
	173.3875	Low	30.16	1.04		Compliance
	138.0125*	High	37.43	5.53	4 ~ 6 W	Compliance
	151.1000	High	37.54	5.68		Compliance
	158.5500	High	37.26	5.32		Compliance
	173.3875	High	37.28	5.35		Compliance

* Not for FCC Review

5.2 Modulation Characteristics

5.2.1 Standard Applicable [FCC §Part 2.1047(a) & 90.207]

2.1047(b): Equipment which employs modulation limiting. A curve or family of curves showing the percentage of modulation versus the modulation input voltage shall be supplied. The information submitted shall be sufficient to show modulation limiting capability throughout the range of modulating frequencies and input modulating signal levels employed.

Recommended frequency deviation characteristics are given below:

CH spacing	Frequency deviation
12.5 kHz	2.5 kHz

Part 2.1047(a) A curve or equivalent data showing the frequency response of the audio modulating circuit over a range of 100 to 5000 Hz shall be submitted. For equipment required to have an audio low-pass filter, a curve showing the frequency response of the filter, or of all circuitry installed between the modulation limiter and the modulated stage shall be submitted.

Audio freq.	Minimum Attenuation Rel. to 1 kHz Attenuation
3 - 20 kHz	60 log10(f/3) dB where f is in kHz
20 - 30 kHz	50 dB

5.2.2 Test Environment conditions

• Ambient temperature : (20 - 21) °C • Relative Humidity : (48 - 49) % R.H.

5.2.3 Measurement Procedure

• Modulation Limit

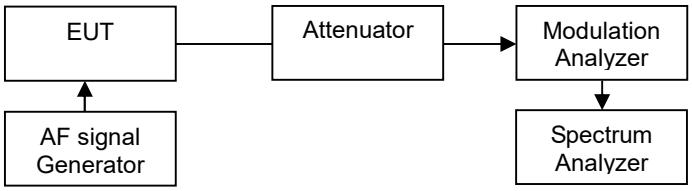
The carrier frequency deviation was measured with the tone adjust the audio input for 60 % of rated system deviation at 1 kHz using this level as a reference (0 dB) and vary the input level from –20 to +20 dB. Record the frequency deviation obtained as a function of the input level at frequencies 0.1, 0.5, 1.0, 3.0 and 5.0 kHz. The maximum deviation was recorded at each test condition.

• Audio frequency response

The audio input level needed for a particular percentage of modulation was measured in accordance with ANSI/TIA-603-E-2016. The audio input curves versus modulation are shown below. Curves are provided for audio input frequencies of 300, 1000, and 3000 Hz.

• Test freq: Mid

5.2.4 Test setup



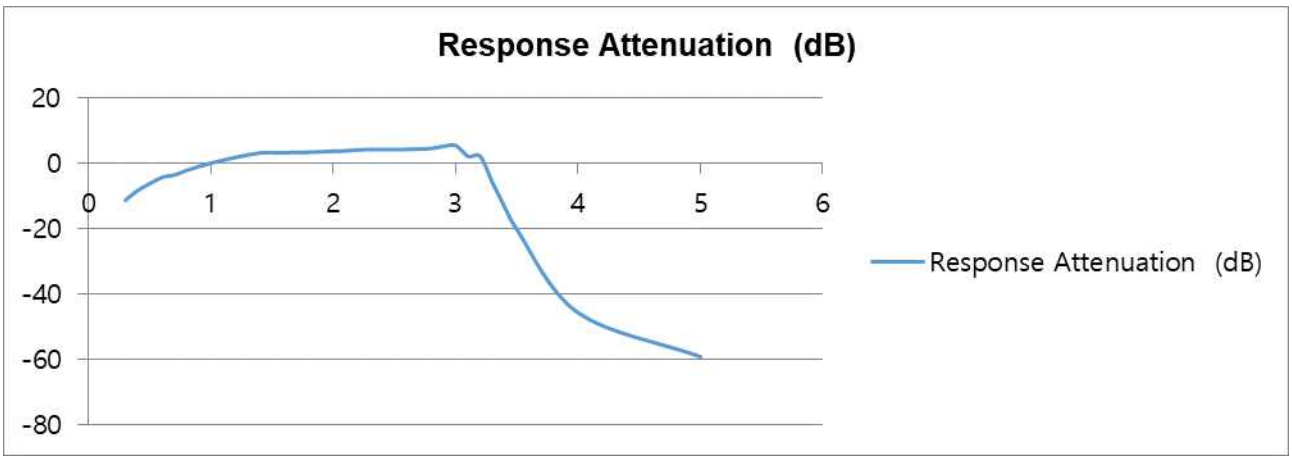
5.2.5 Measurement Result

- Modulation Limit

Audio input Level (dB)	Frequency Deviation (kHz)			Limit (kHz)
	@ 300 Hz	@ 1 kHz	@ 3 kHz	
-20	0.04	0.14	0.31	2.5
-15	0.05	0.23	0.54	2.5
-10	0.09	0.39	0.96	2.5
-5	0.15	0.69	1.51	2.5
0	0.25	1.23	1.66	2.5
5	0.45	1.84	1.72	2.5
10	0.81	2.12	1.72	2.5
15	1.43	2.24	1.72	2.5
20	1.79	2.23	1.73	2.5

• Audio frequency response

Audio Frequency (Hz)	Response Attenuation (dB)	Audio Frequency (Hz)	Response Attenuation (dB)
300	-11.31	2 800	4.49
400	-8.34	2 900	5.12
500	-6.22	3 000	5.34
600	-4.34	3 100	2.09
700	-3.61	3 200	2.01
800	-2.21	3 300	-6.02
900	-1.01	3 400	-13.48
1 000	0.00	3 500	-20.33
1 200	1.76	4 000	-45.69
1 400	3.10	5 000	-59.09
1 600	3.19		
1 800	3.31		
2 000	3.65		
2 100	3.74		
2 200	4.08		
2 300	4.13		
2 400	4.15		
2 500	4.18		
2 600	4.19		
2 700	4.28		



5.3 Occupied Bandwidth & Emission Mask

5.3.1 Standard Applicable [FCC §90.209 & 90.210 & 2.1047 & 2.1049]

The authorized bandwidth shall be 11.25 kHz for 12.5 kHz channel separation and 6 kHz for 6.25 kHz channel separation.

Emission mask D: For transmitters designed to operate with a 12.5 kHz channel bandwidth, any emission must be attenuated below the power (P) of the highest emission contained within the authorized bandwidth as follows:

(1) On any frequency from the center of the authorized bandwidth f0 to 5.625 kHz removed from f0: Zero dB.

(2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 5.625 kHz but no more than 12.5 kHz: At least 7.27(fd−2.88 kHz) dB.

(3) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 12.5 kHz: At least 50 + 10 log (P) dB or 70 dB, whichever is the lesser attenuation.

5.3.2 Test Environment conditions

• Ambient temperature : (20 - 21) °C • Relative Humidity : (48 - 49) % R.H.

5.3.3 Measurement Procedure

• Occupied Bandwidth

The EUT was modulated by 2.5 kHz Sine wave audio signal, The level of the audio signal employed is 16 dB greater than that necessary to produce 50 % of rated system deviation. Rated system deviation is 2.5 kHz (12.5 kHz channel spacing).

The transmitter output (antenna port) was connected to the spectrum analyzer in peak hold mode.

Measure the maximum width of the emission that is 26 dB down from the peak of the emission. The 99 % occupied bandwidth is the frequency bandwidth of the signal power at the 99 % channel power of occupied bandwidth.

The spectrum analyzer is set to the as follows :

- RBW : 300 Hz
- VBW : >3 x RBW
- Detector function : peak
- Trace : max hold

• Emission Mask

• Voice or Digital Modulation Through a Voice Input Port @ 2.1049(c)(i)

The transmitter was modulated by a 2.5 kHz tone signal at an input level 16 dB greater than that required to produce 50 % modulation (e.g.: ±2.5 kHz peak deviation at 1 kHz modulating frequency). The input level was established at the frequency of maximum response of the audio modulating circuit.

• Digital Modulation Through a Data Input Port @ 2.1049(h):

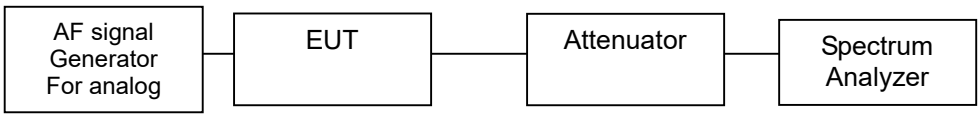
Transmitters employing digital modulation techniques - when modulated by an input signal such that its amplitude and symbol rate represent the maximum rated conditions under which the equipment will be operated. The signal shall be applied through any filter networks, pseudo-random generators or other devices required in normal service. Additionally, the Emission Masks shall be shown for operation with any devices used for modifying the spectrum when such devices are operational at the discretion of the user.

The following EMI Receiver bandwidth shall be used for measurement of Emission Mask/Out-of-Band Emission Measurements:

The spectrum analyzer is set to the as follows

- For 25 kHz Channel Spacing: RBW = 300 Hz
- For 12.5 kHz or 6.25 kHz Channel Spacings: RBW = 100 Hz
- The all cases are set “VBW: >3xRBW”

5.3.4 Test setup



5.3.5 Measurement Result

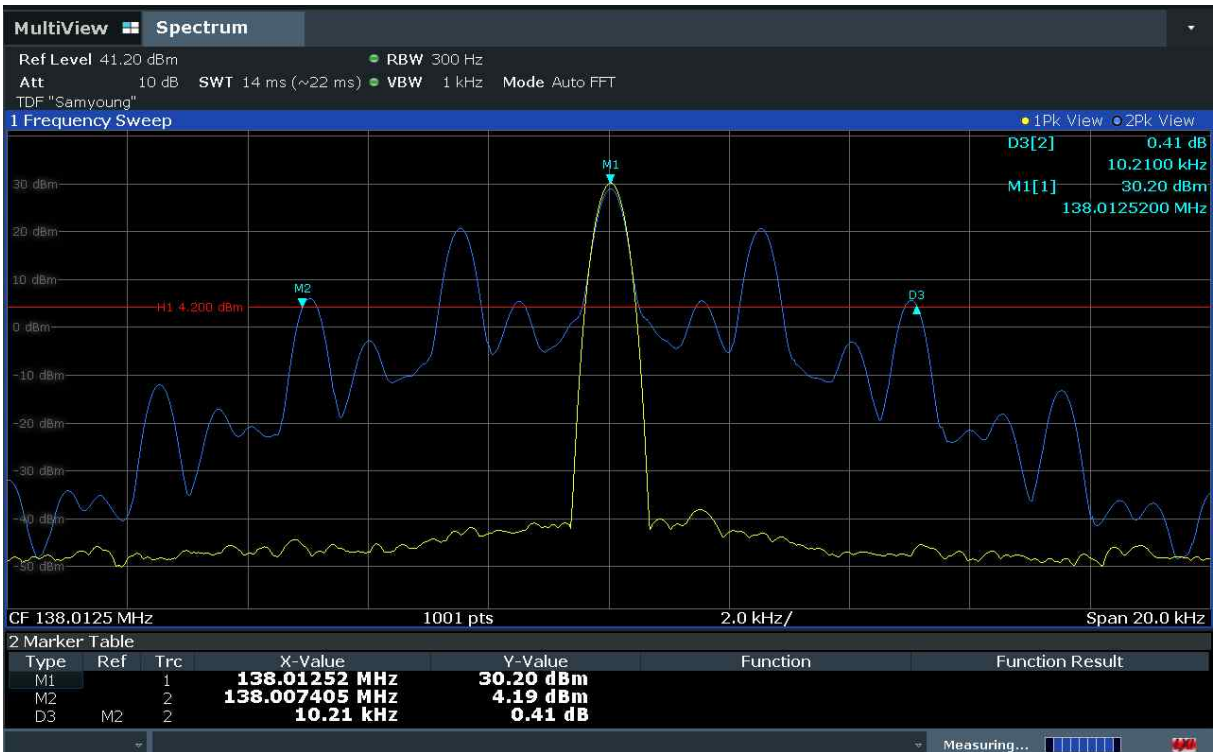
Modulation	Frequency [MHz]	Power Level	99 % Bandwidth [KHz]	26 dB Bandwidth [kHz]	Limit [kHz]	Test Results
Analog	138.0125*	Low	5.71	10.21	≤11.25	Compliance
	151.1000	Low	5.44	5.65		Compliance
	158.5500	Low	5.44	5.65		Compliance
	173.3875	Low	5.70	10.21		Compliance
	138.0125*	High	**5.72**	10.21	≤11.25	Compliance
	151.1000	High	5.44	5.65		Compliance
	158.5500	High	5.44	5.65		Compliance
	173.3875	High	5.71	10.21		Compliance
Digital (Voice and Data)	138.0125*	Low	7.53	9.43	≤11.25	Compliance
	151.1000	Low	6.34	8.75		Compliance
	158.5500	Low	6.55	8.89		Compliance
	173.3875	Low	7.70	9.67		Compliance
	138.0125*	High	**8.00**	9.53	≤11.25	Compliance
	151.1000	High	6.33	8.65		Compliance
	158.5500	High	6.47	8.77		Compliance
	173.3875	High	7.81	9.41		Compliance

* Not for FCC Review

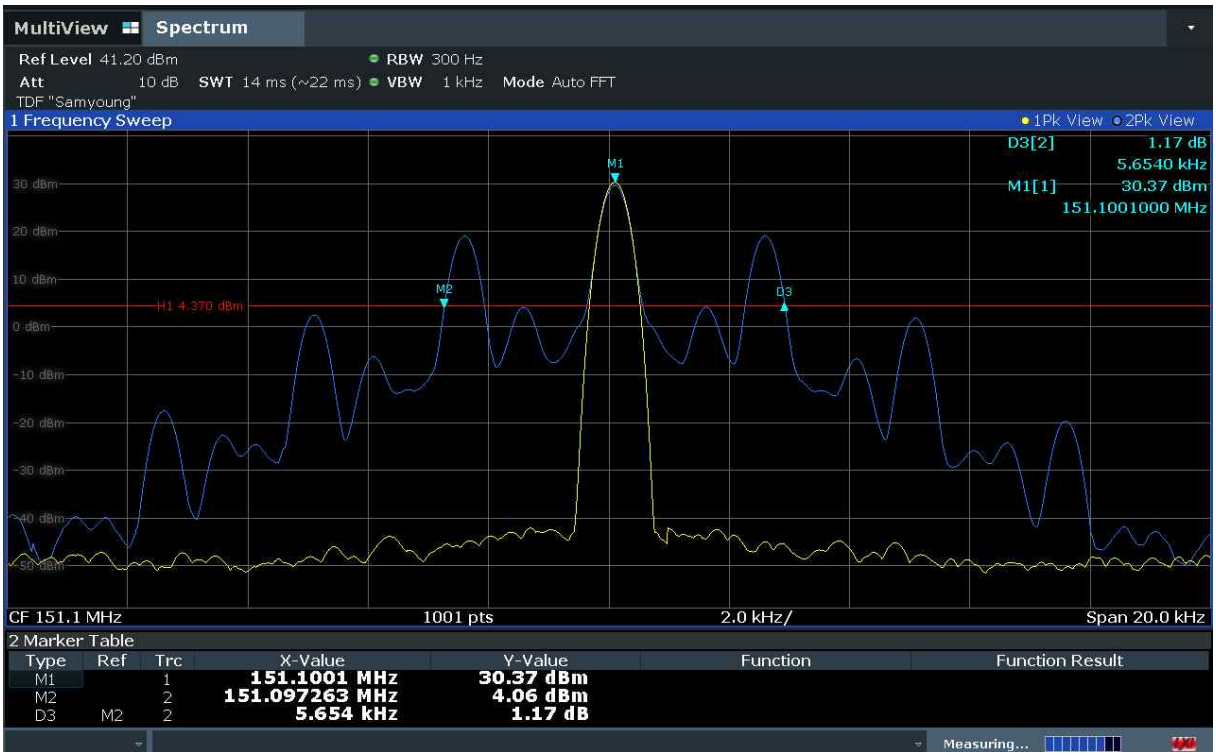
5.3.6 Test Plot

26 dB band width for analog / Power level: Low

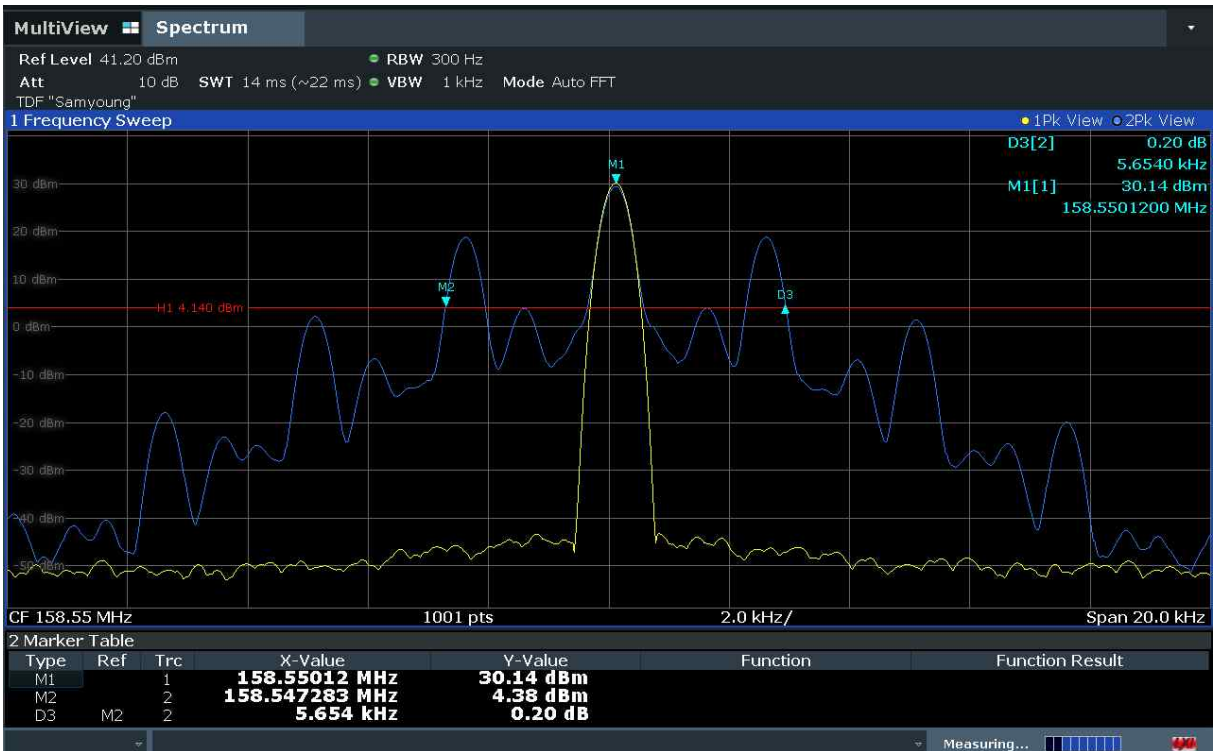
CH Low : 138.0125 MHz



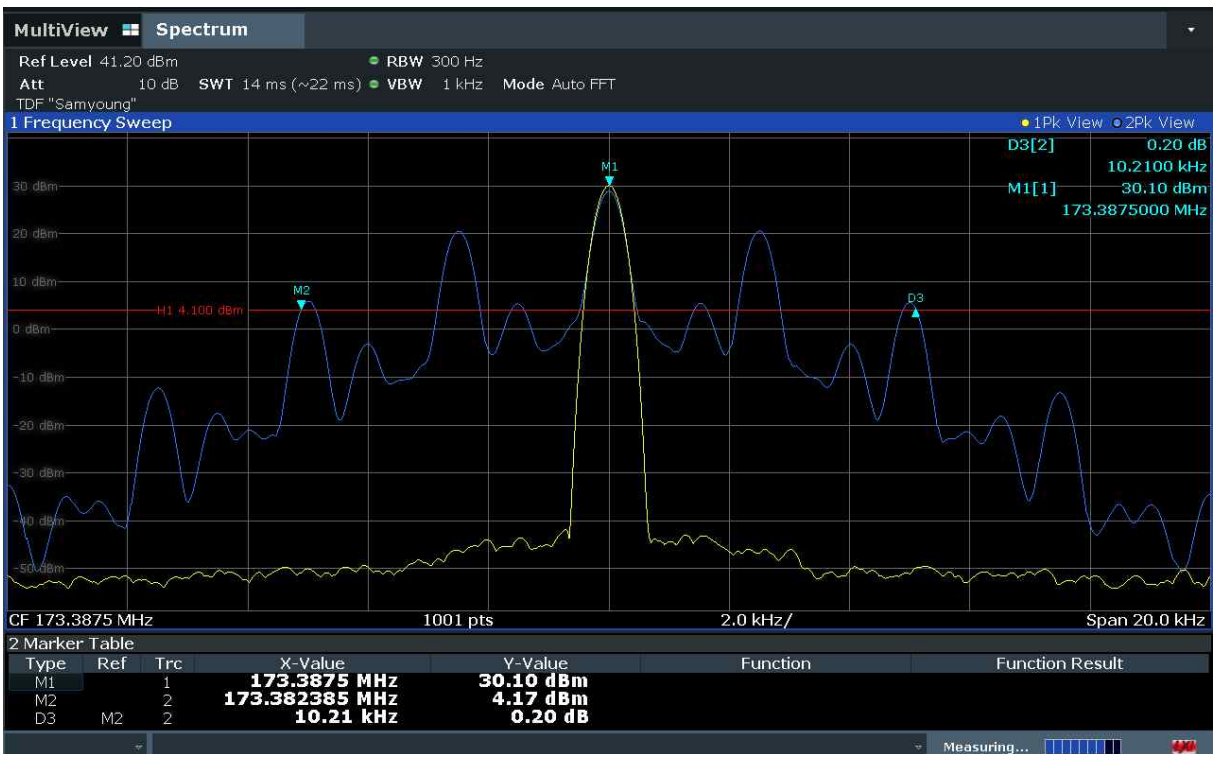
CH Middle : 151.1000 MHz



CH Mid : 158.55 MHz

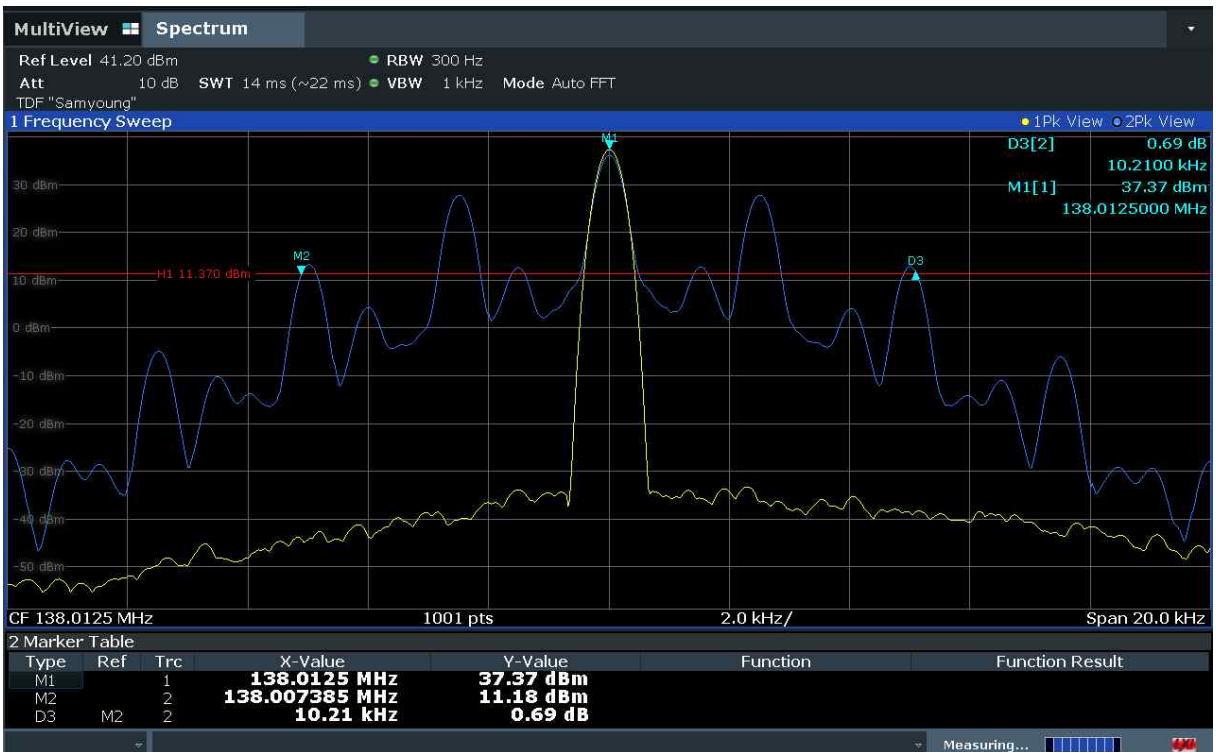


CH High : 173.3875 MHz

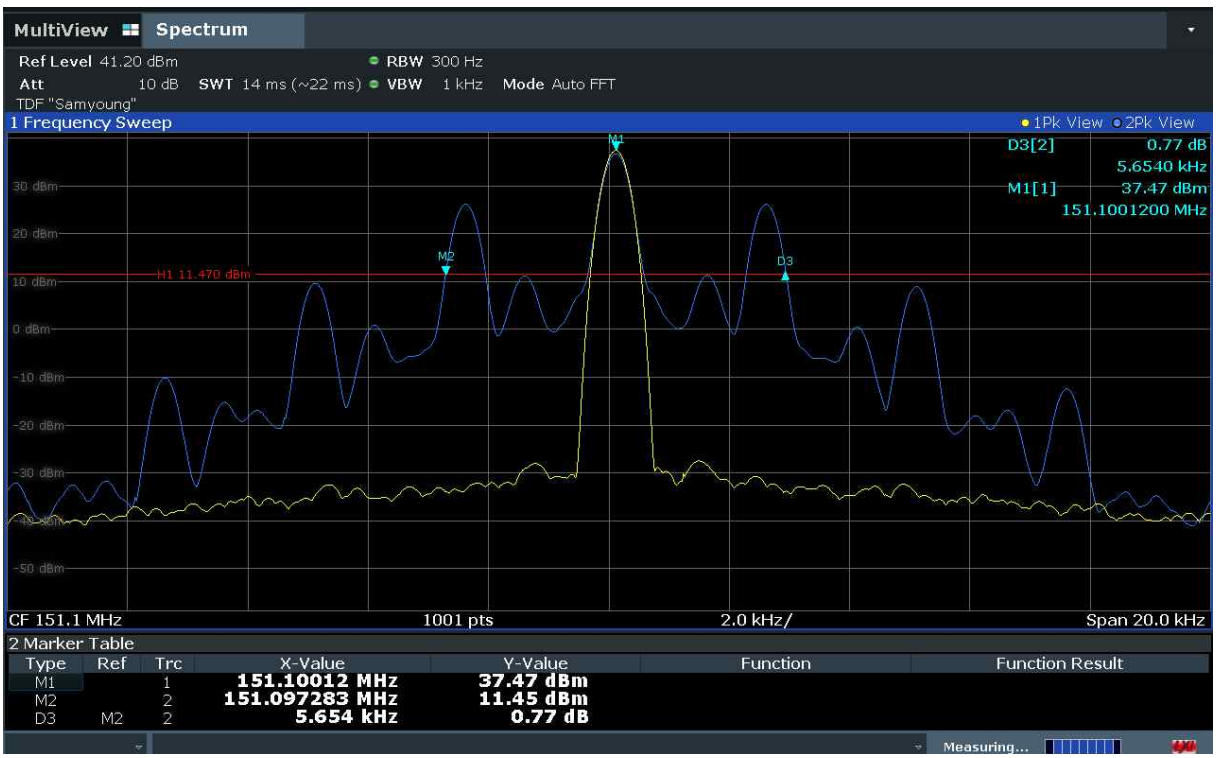


26 dB band width for analog / Power level: High

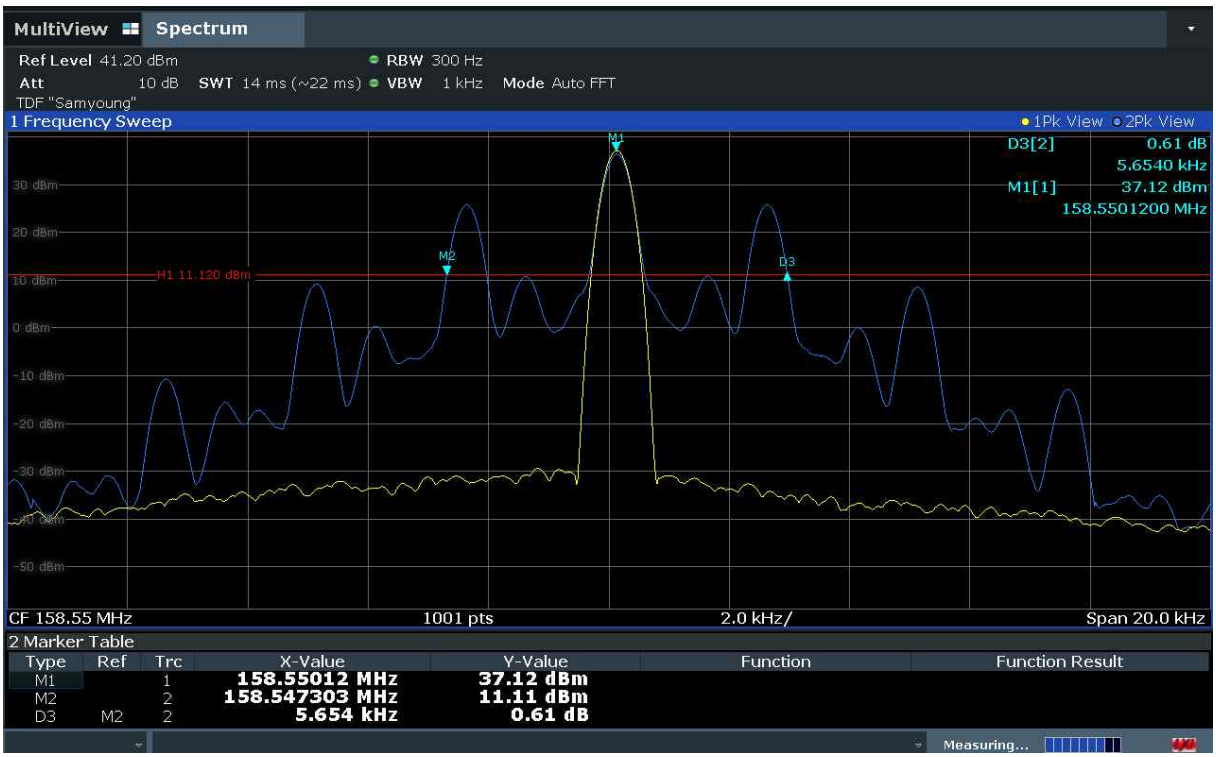
CH Low : 138.0125 MHz



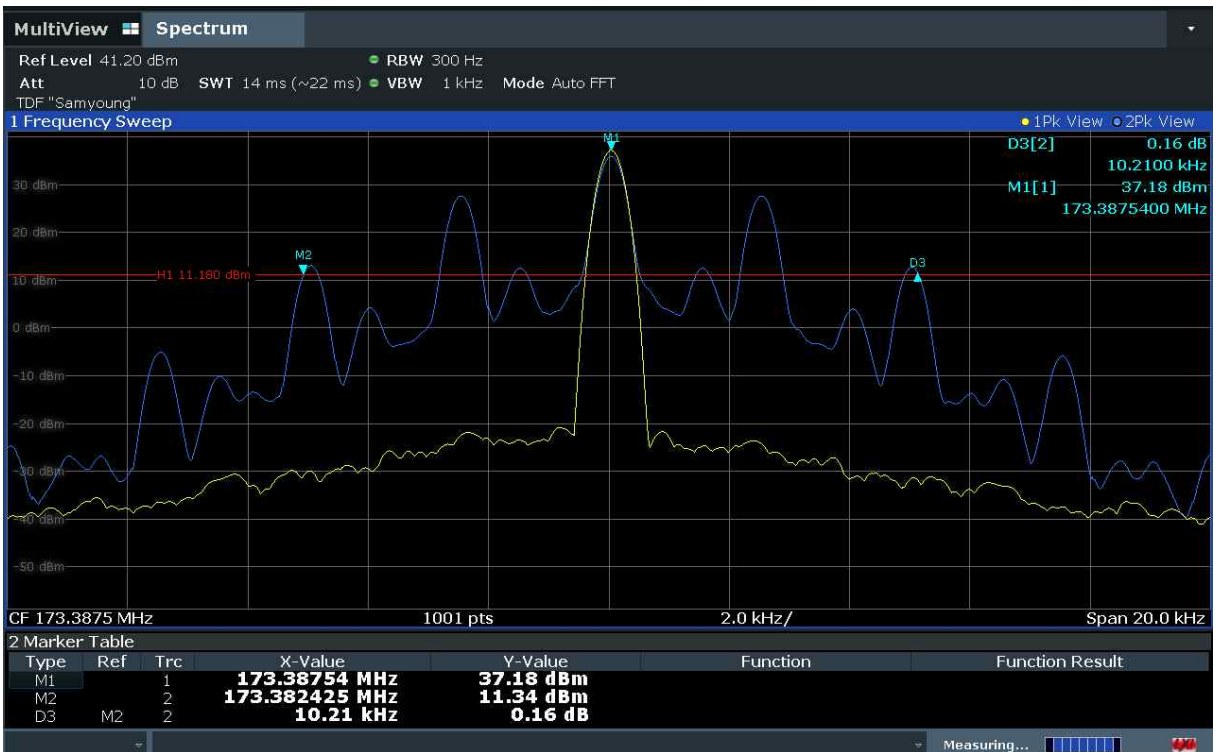
CH Middle : 151.1000 MHz



CH Mid : 158.55 MHz

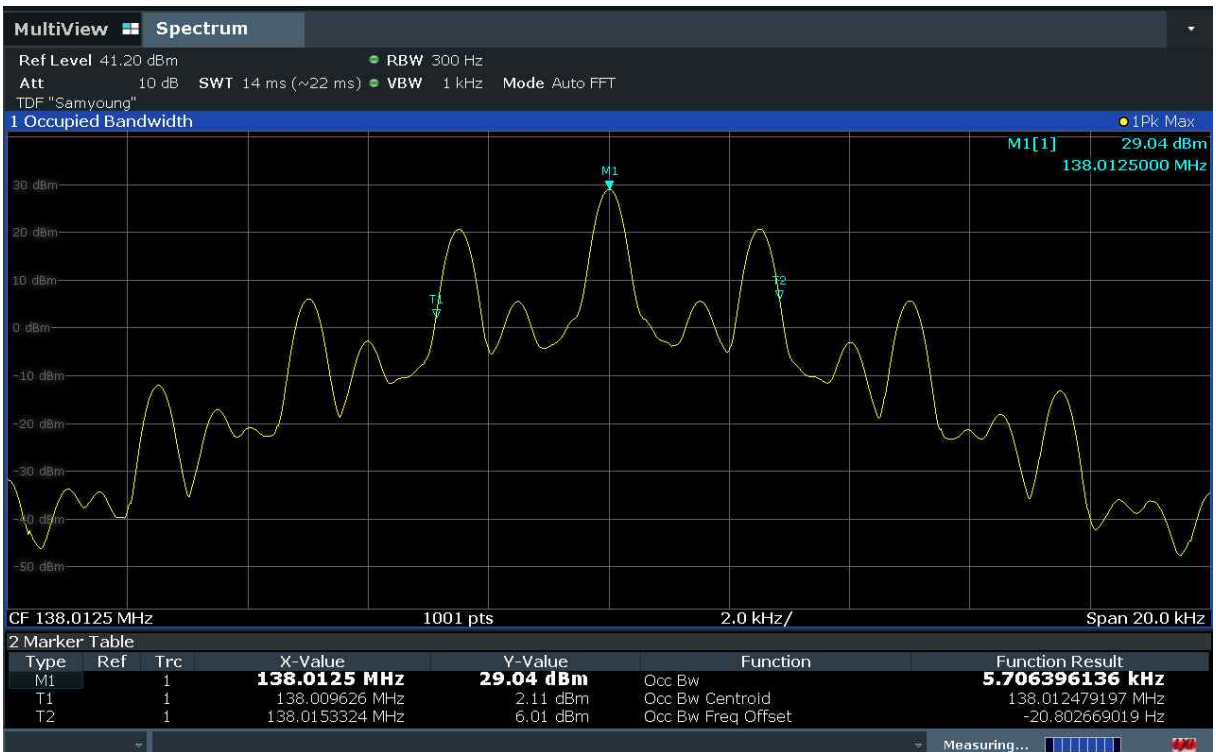


CH High : 173.3875 MHz

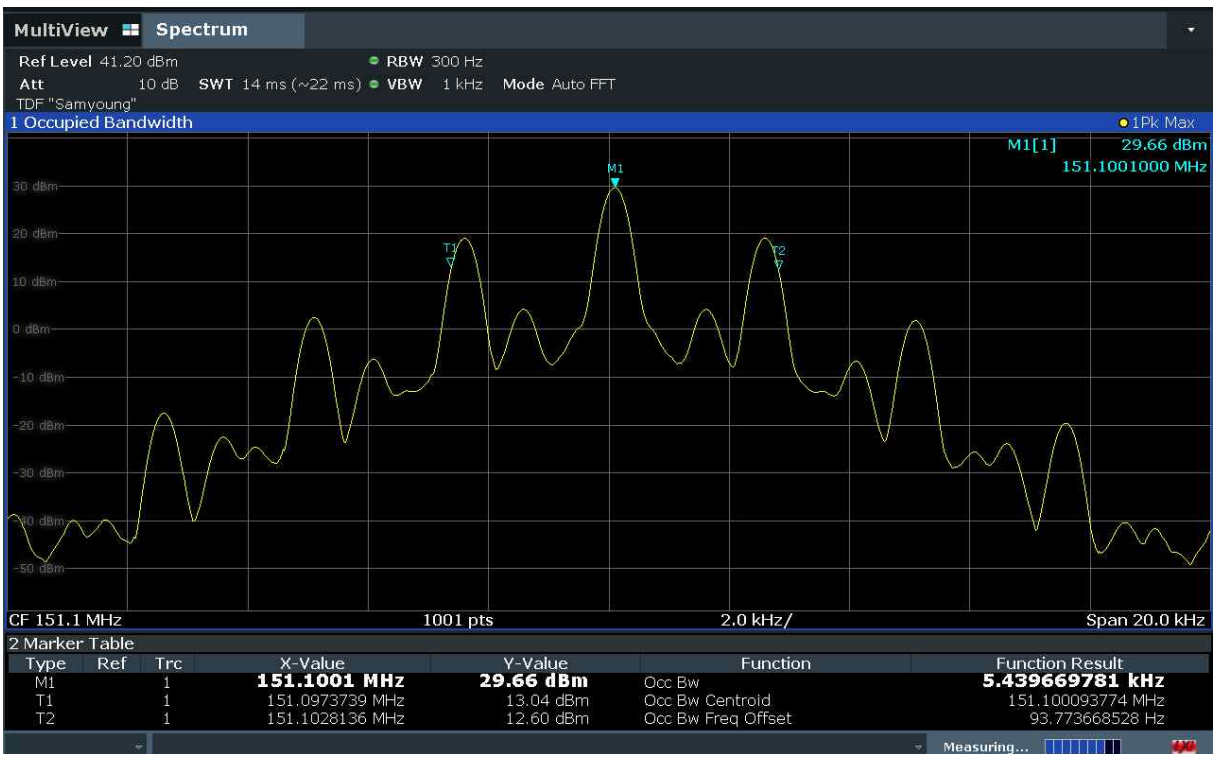


99 % band width for analog / Power level: Low

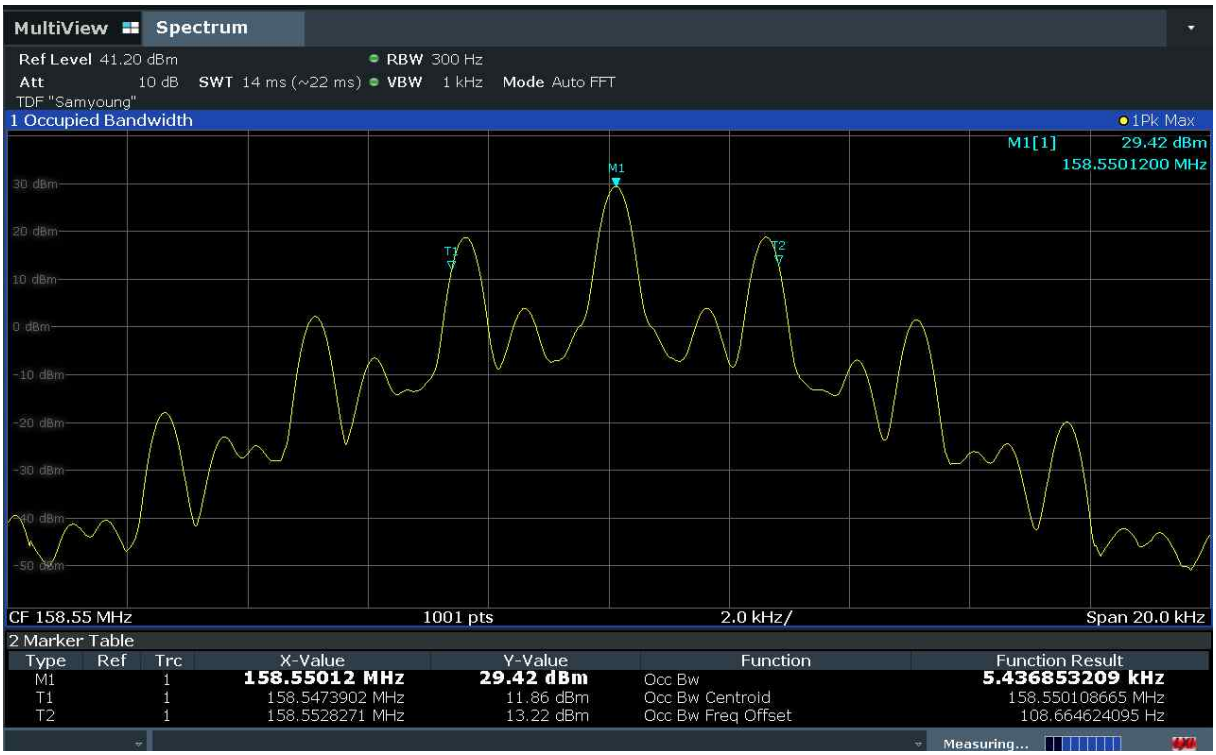
CH Low : 138.0125 MHz



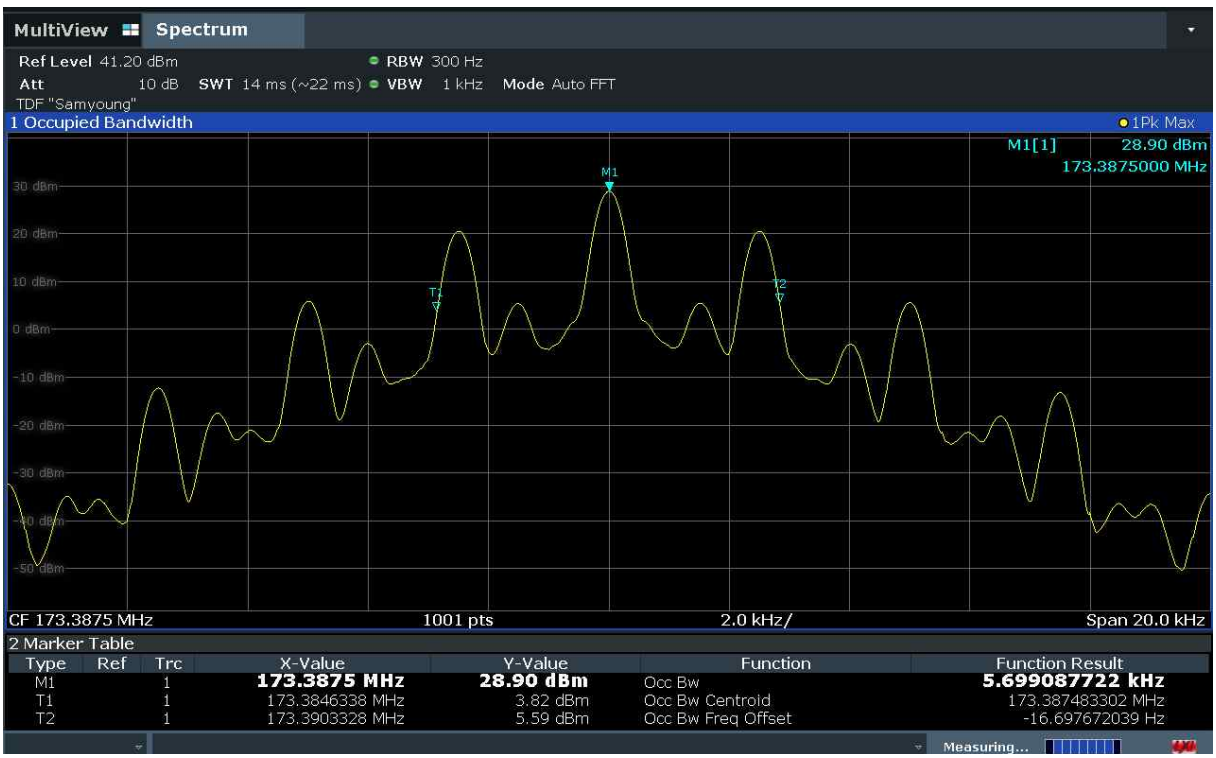
CH Middle : 151.1000 MHz



CH Mid : 158.55 MHz

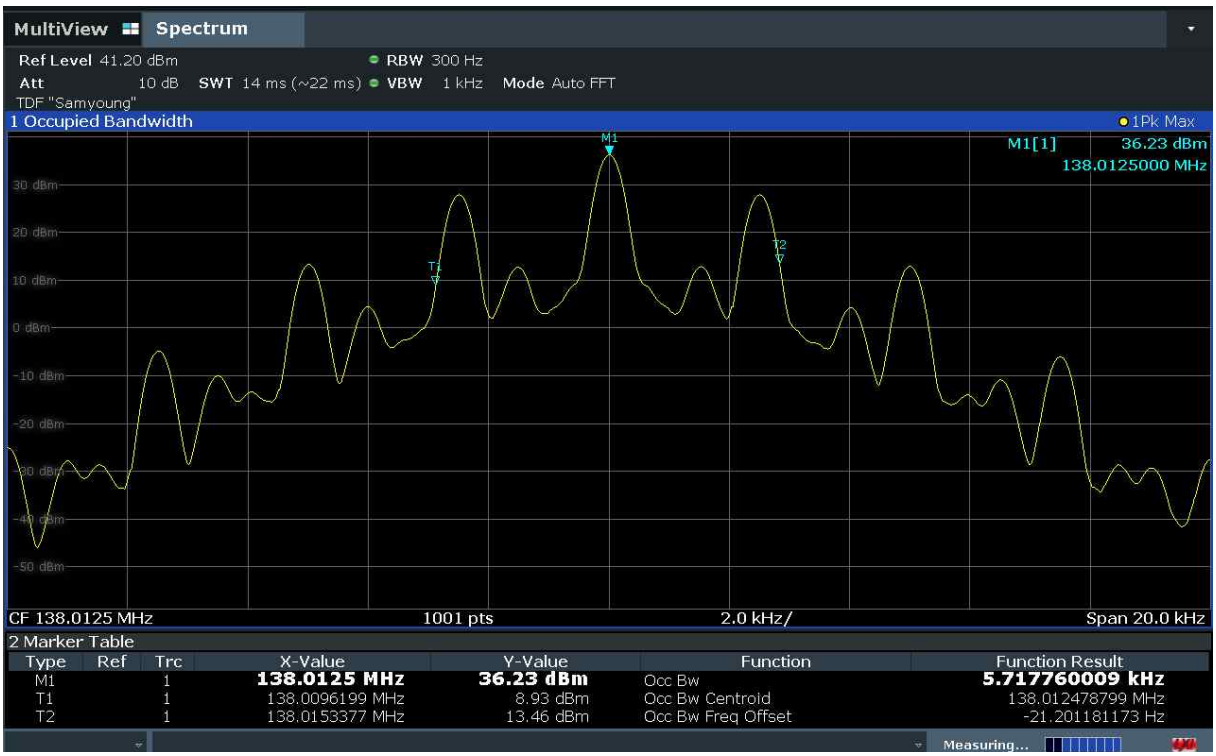


CH High : 173.3875 MHz

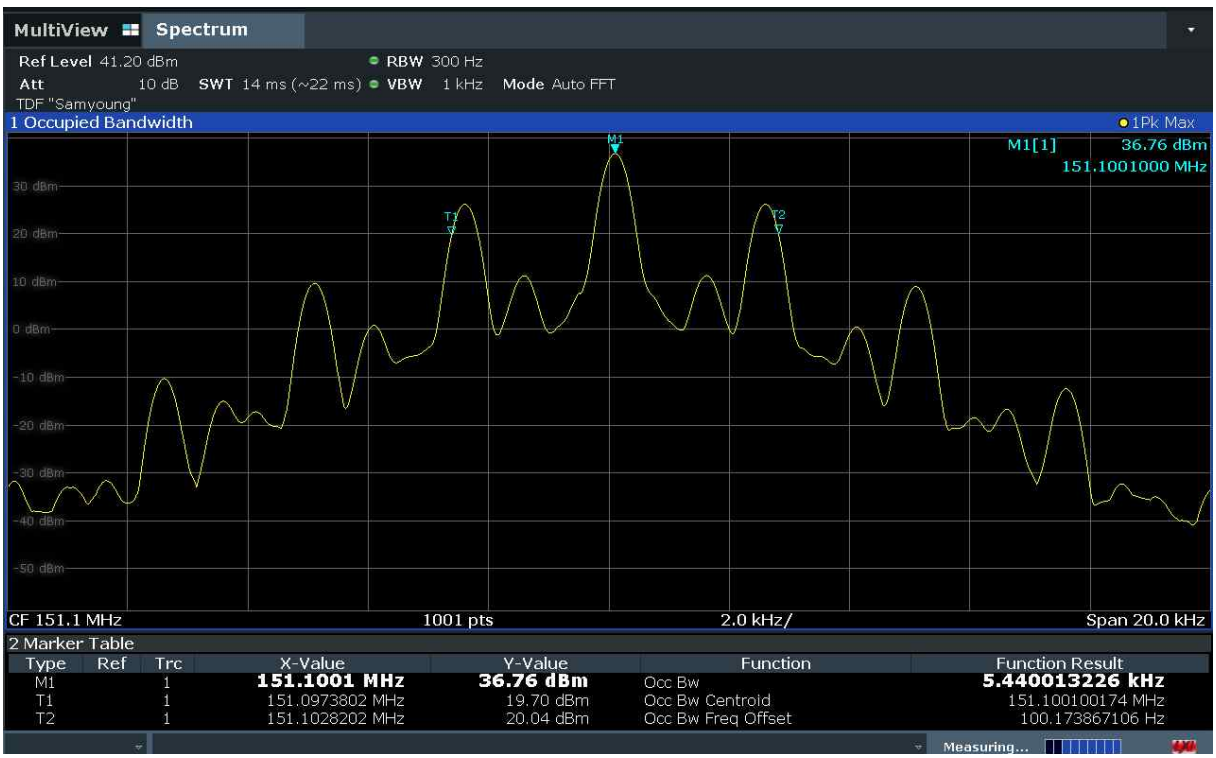


99 % band width for analog / Power level: High

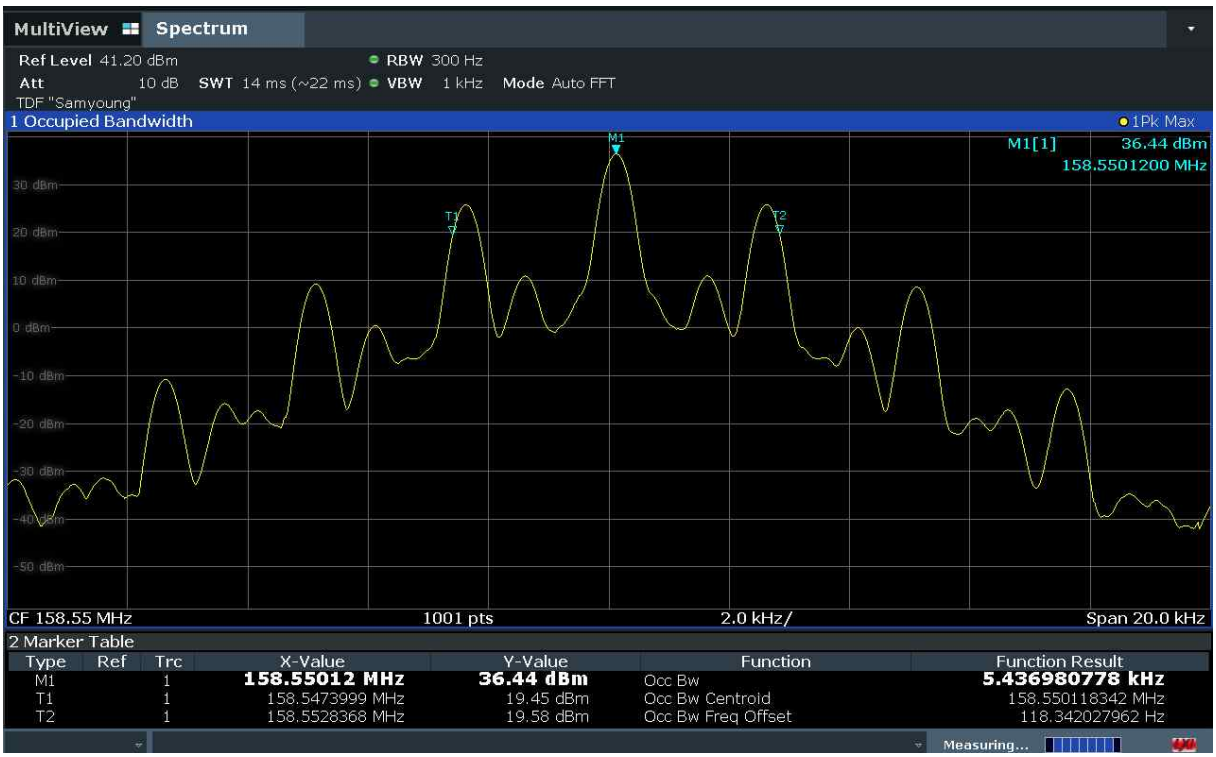
CH Low : 138.0125 MHz



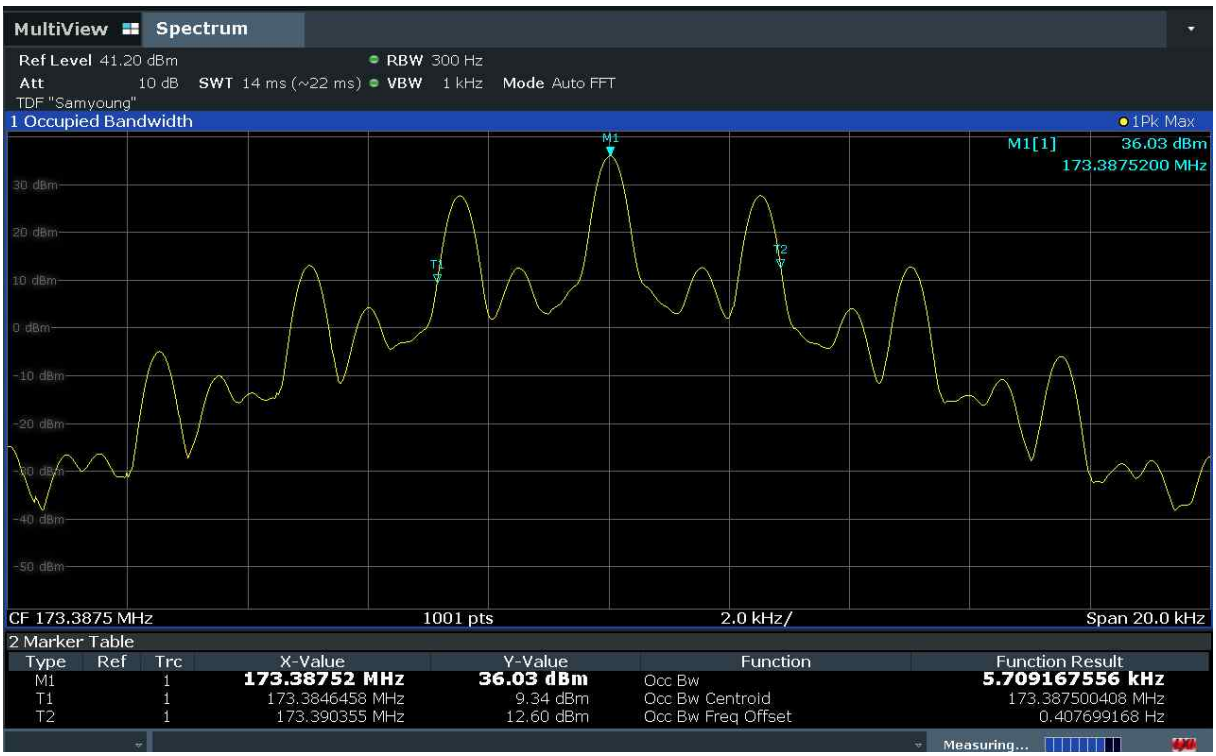
CH Middle : 151.1000 MHz



CH Mid : 158.55 MHz

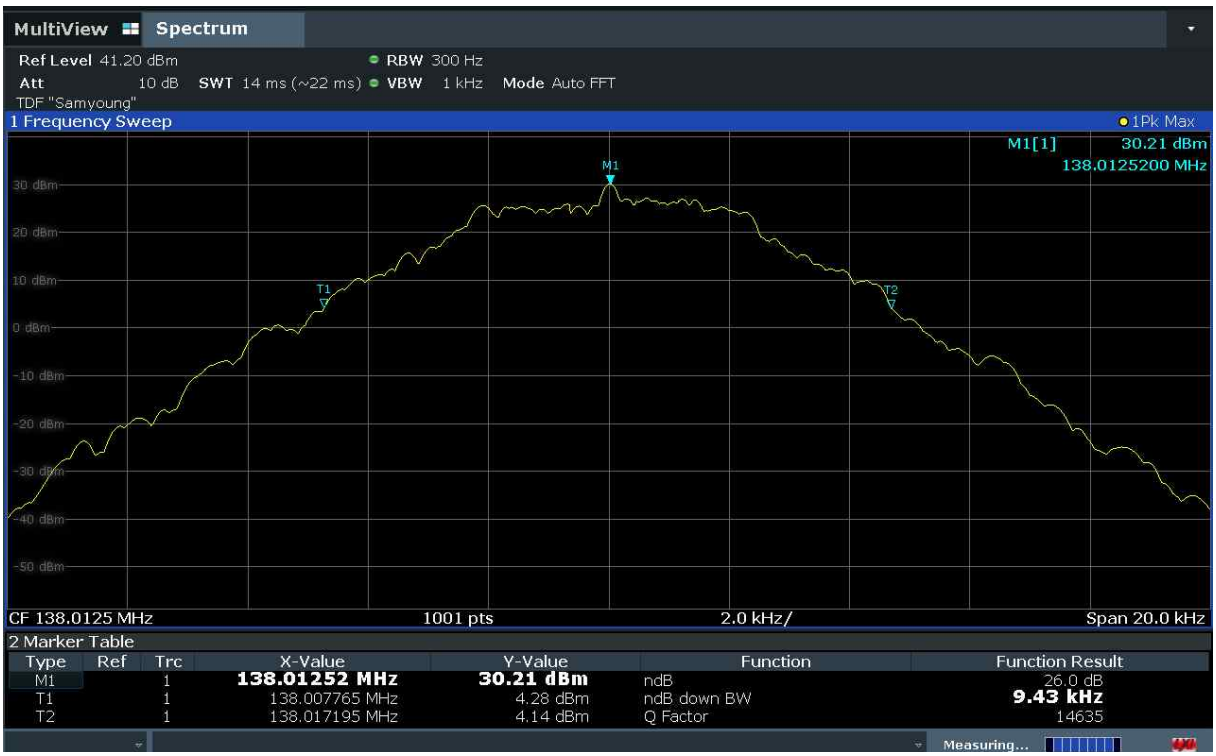


CH High : 173.3875 MHz

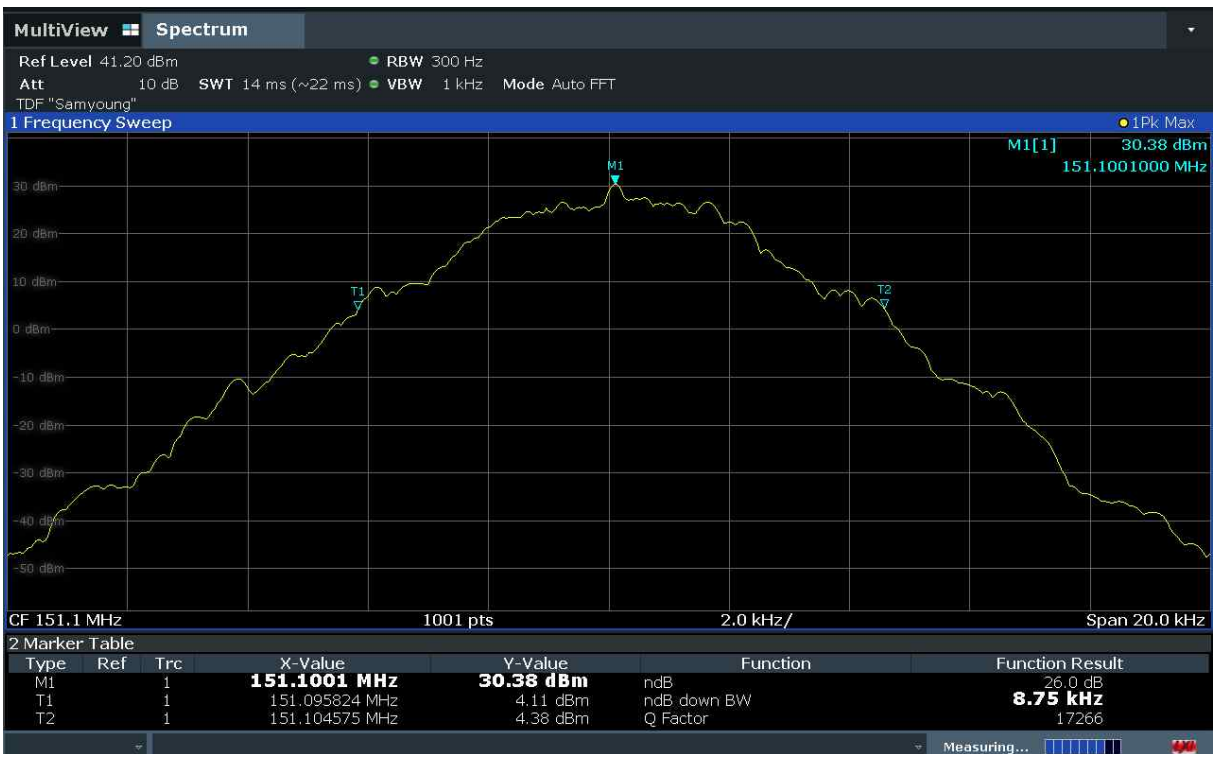


26 dB band width for Digital / Power level: Low

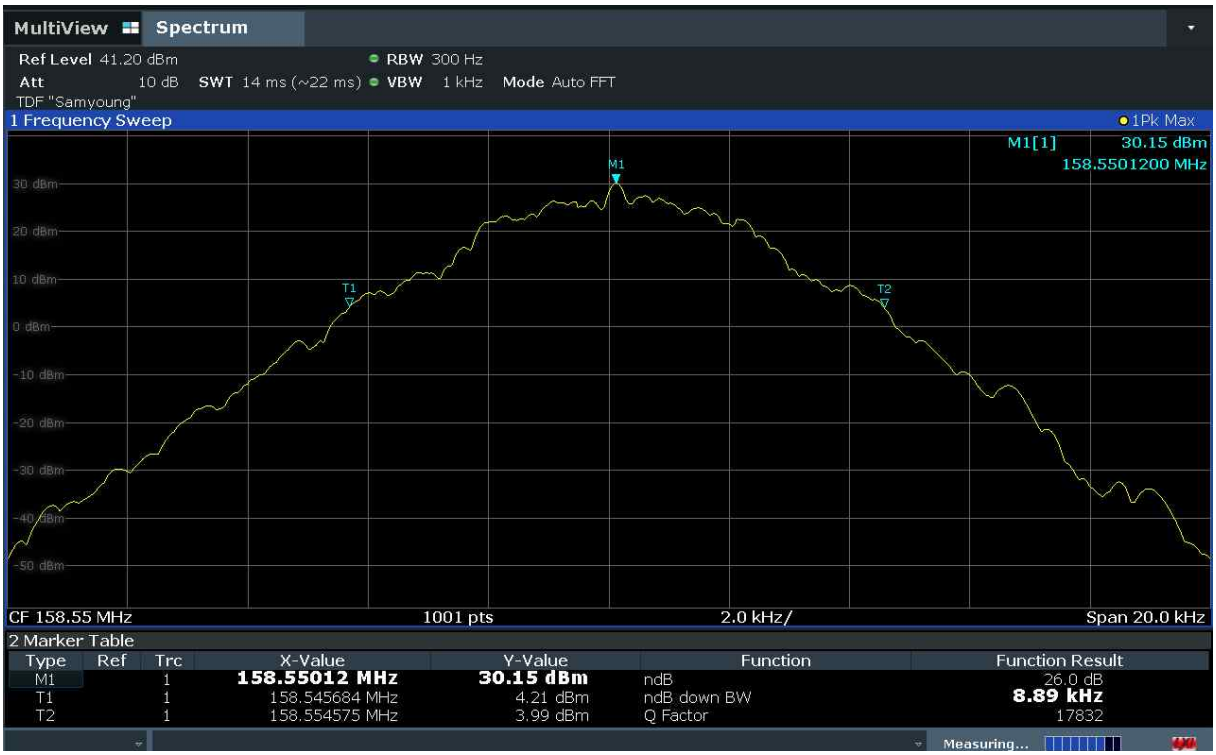
CH Low : 138.0125 MHz



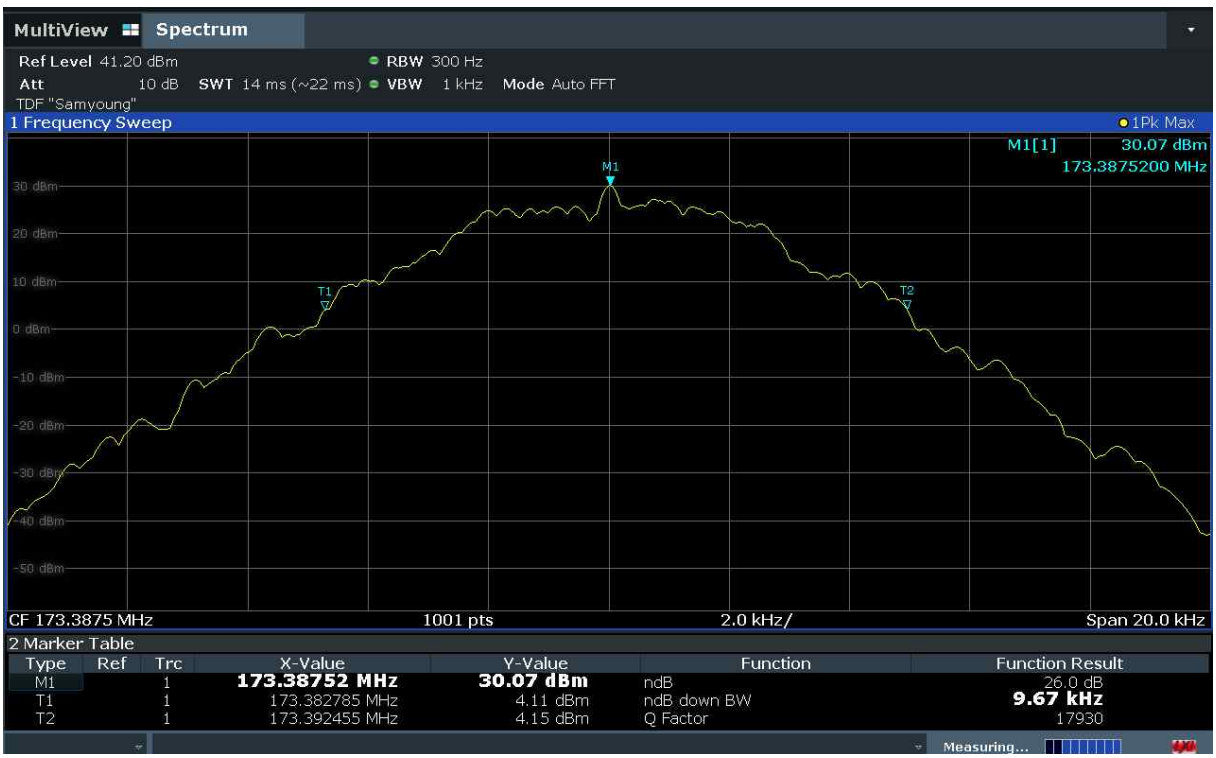
CH Middle : 151.1000 MHz



CH Mid : 158.55 MHz



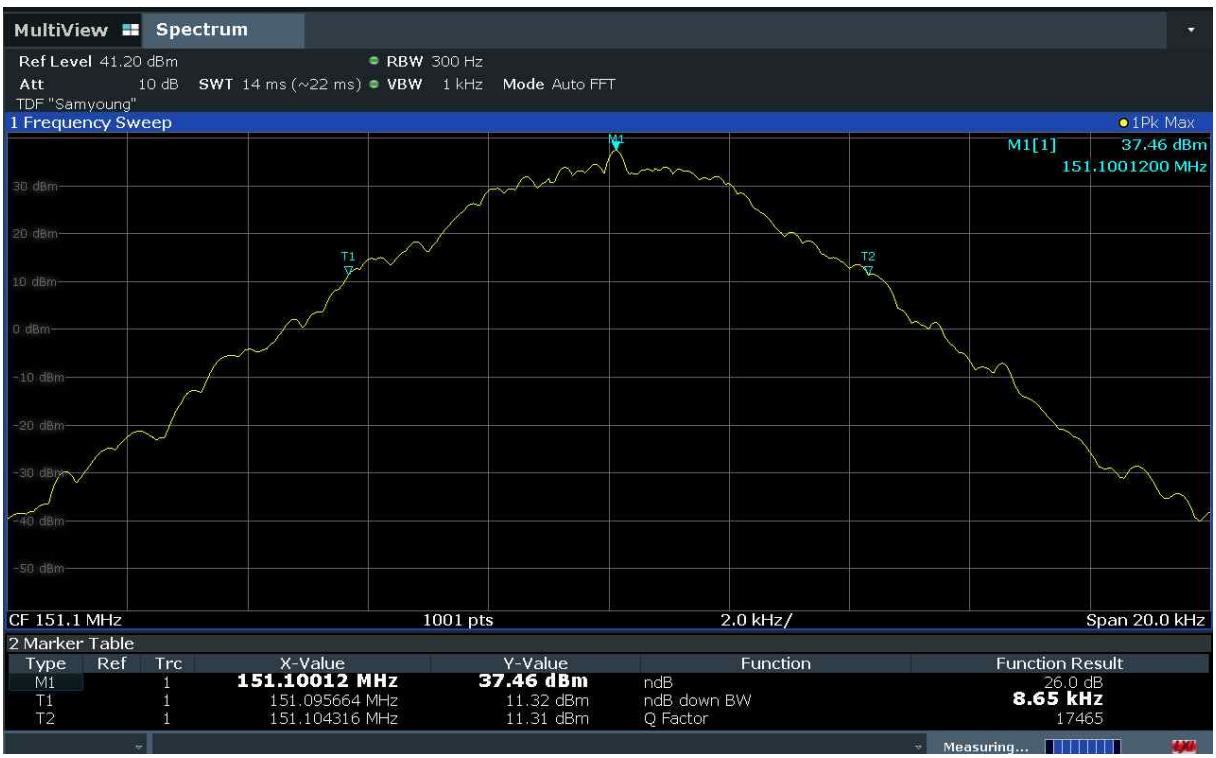
CH High : 173.3875 MHz



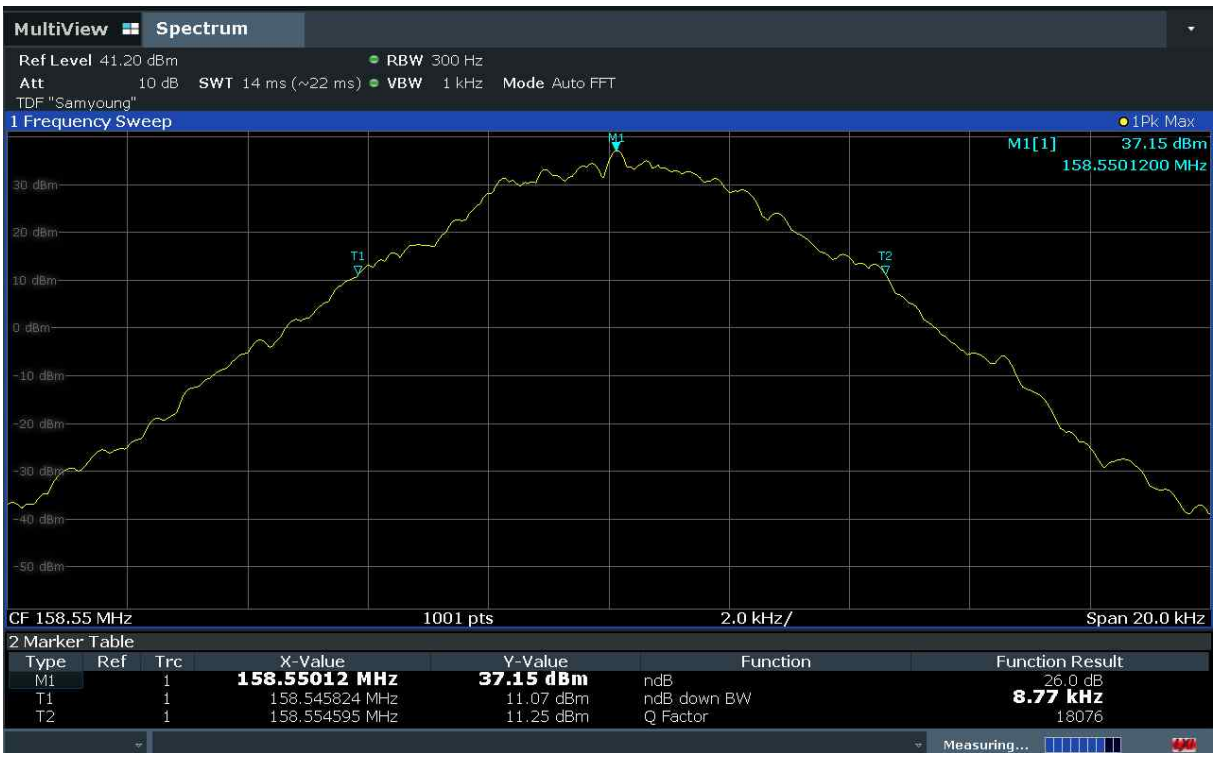
26 dB band width for Digital / Power level: High

CH Low : 138.0125 MHz

CH Middle : 151.1000 MHz



CH Mid : 158.55 MHz

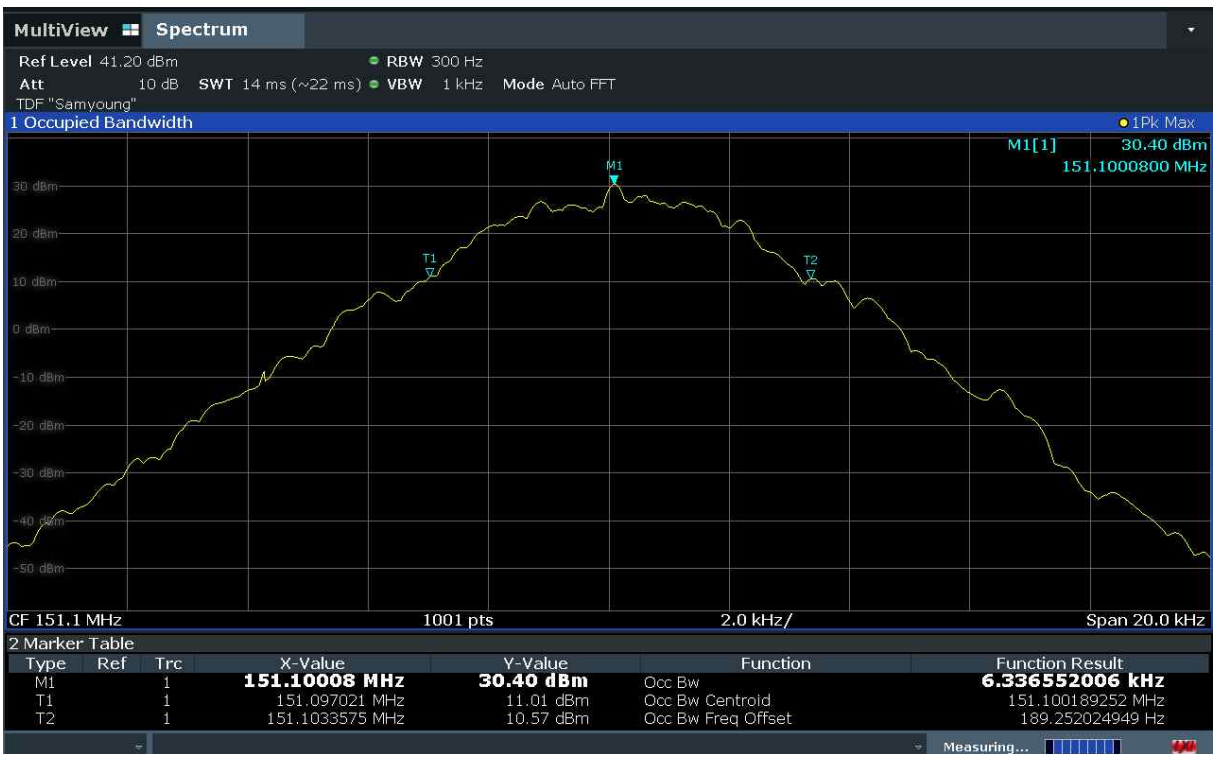


CH High : 173.3875 MHz

99 % band width for Digital / Power level: Low

CH Low : 138.0125 MHz

CH Middle : 151.1000 MHz



CH Mid : 158.55 MHz

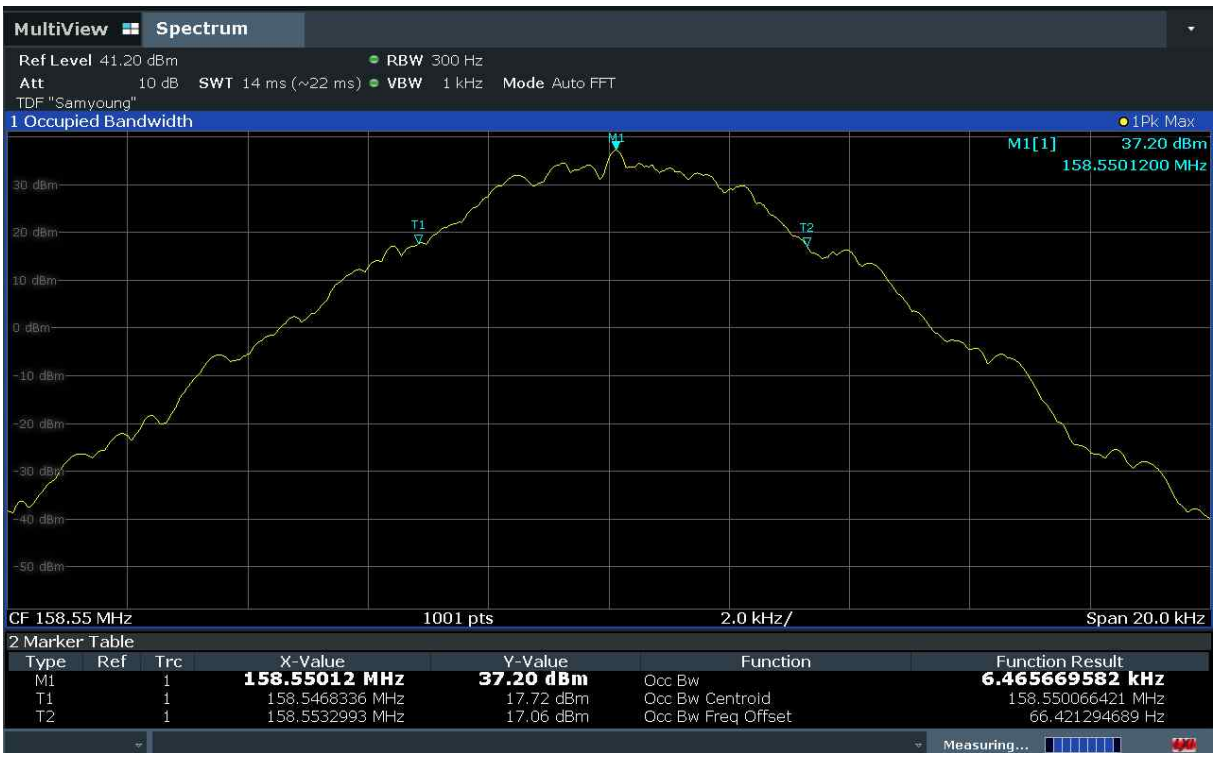
CH High : 173.3875 MHz

99 % band width for Digital / Power level: High

CH Low : 138.0125 MHz

CH Middle : 151.1000 MHz

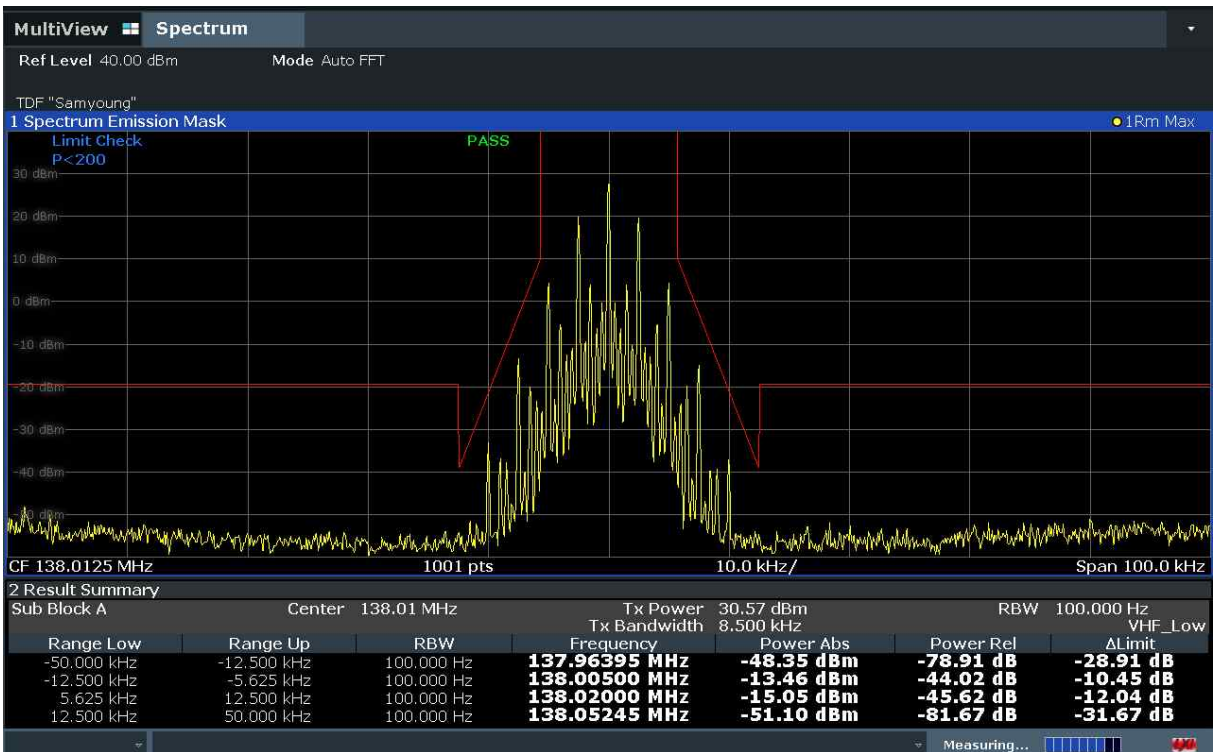
CH Mid : 158.55 MHz



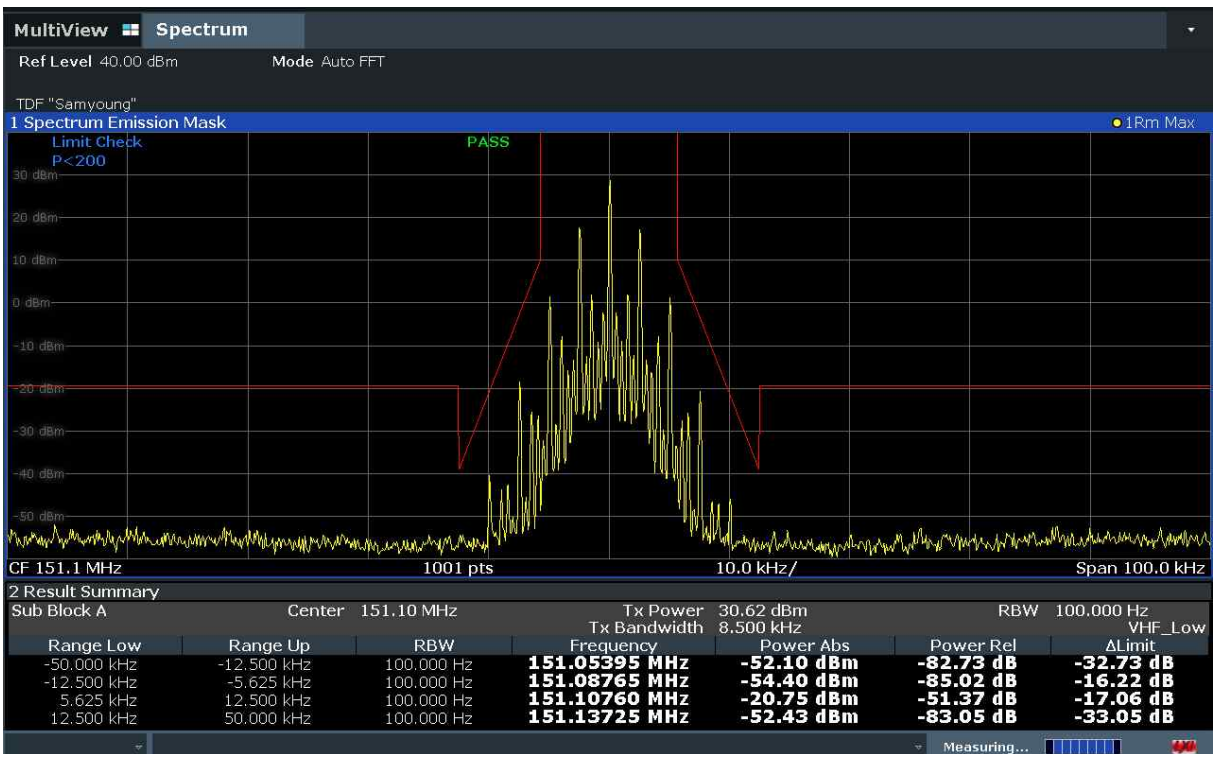
CH High : 173.3875 MHz

Emission Mask for analog / Power level: Low

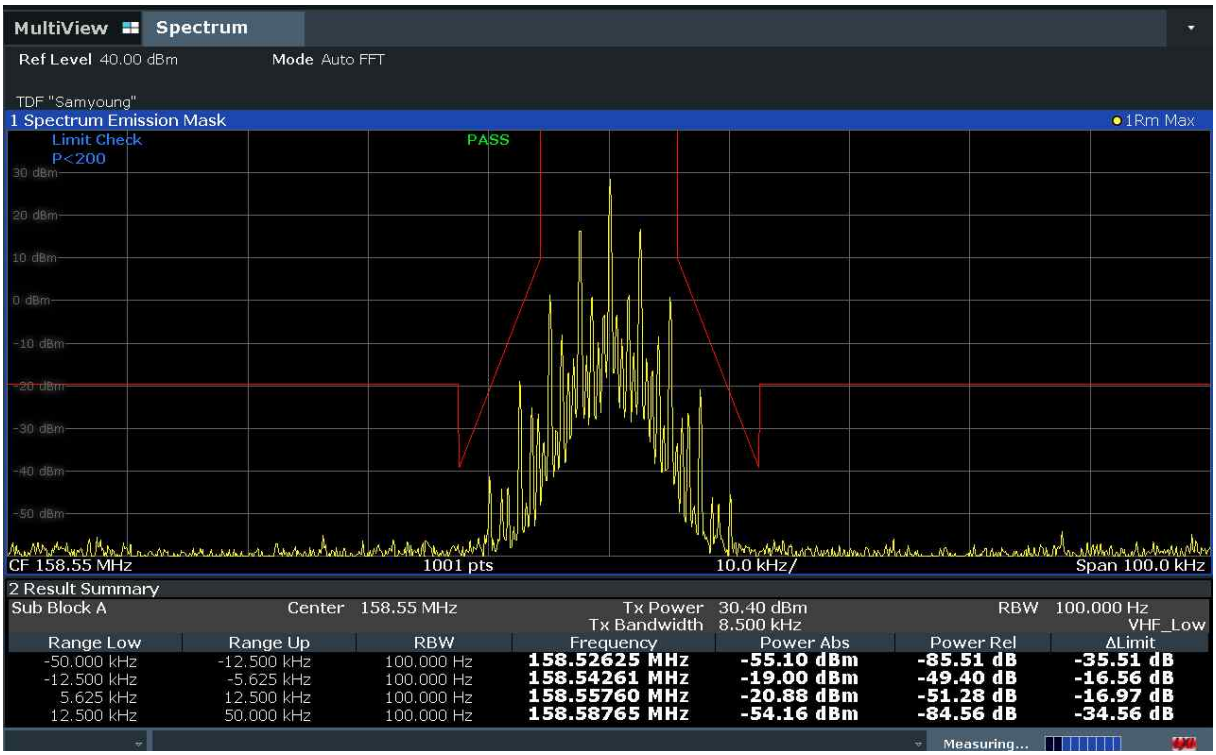
CH Low : 138.0125 MHz



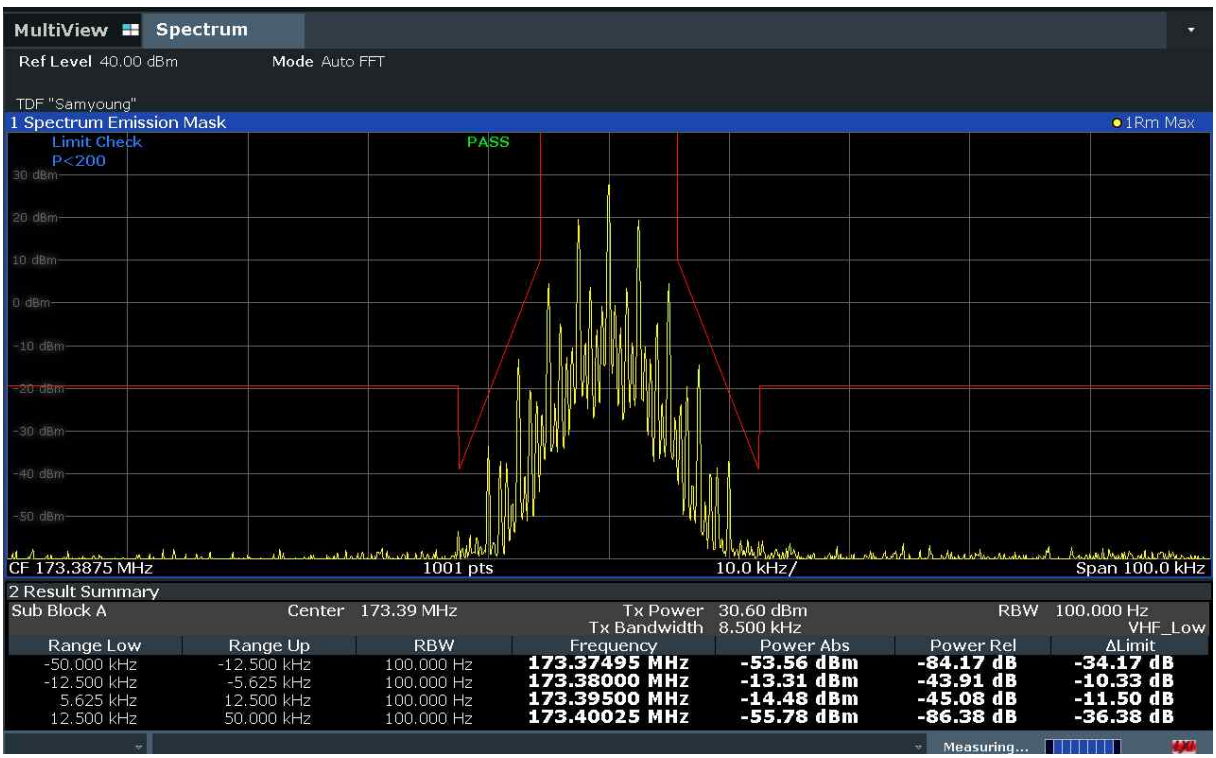
CH Middle : 151.1000 MHz



CH Mid : 158.55 MHz

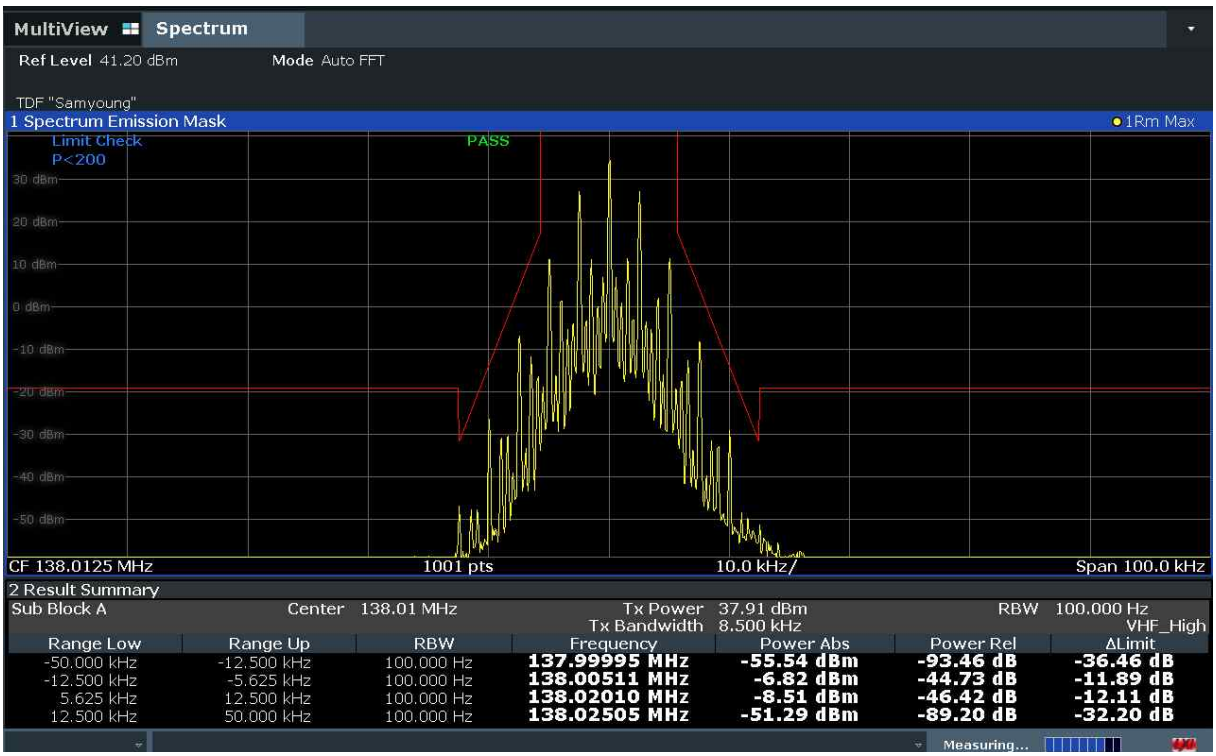


CH High : 173.3875 MHz

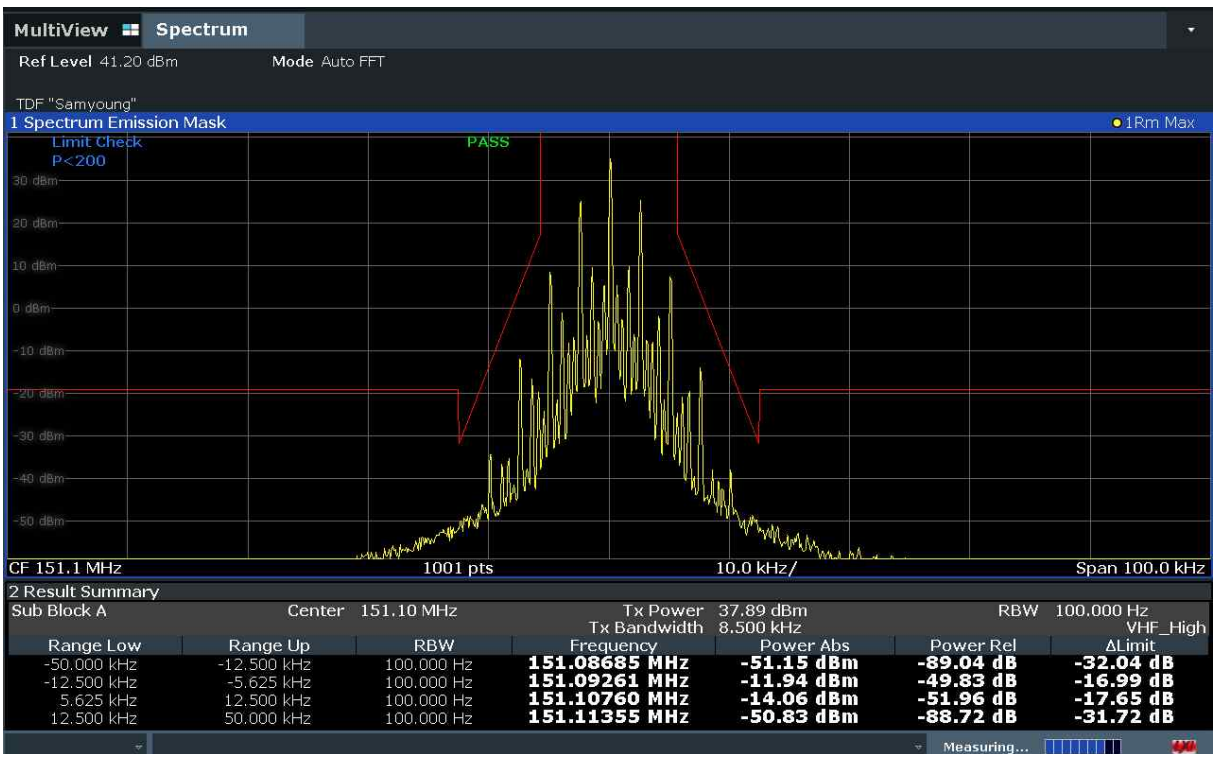


Emission Mask for analog / Power level: High

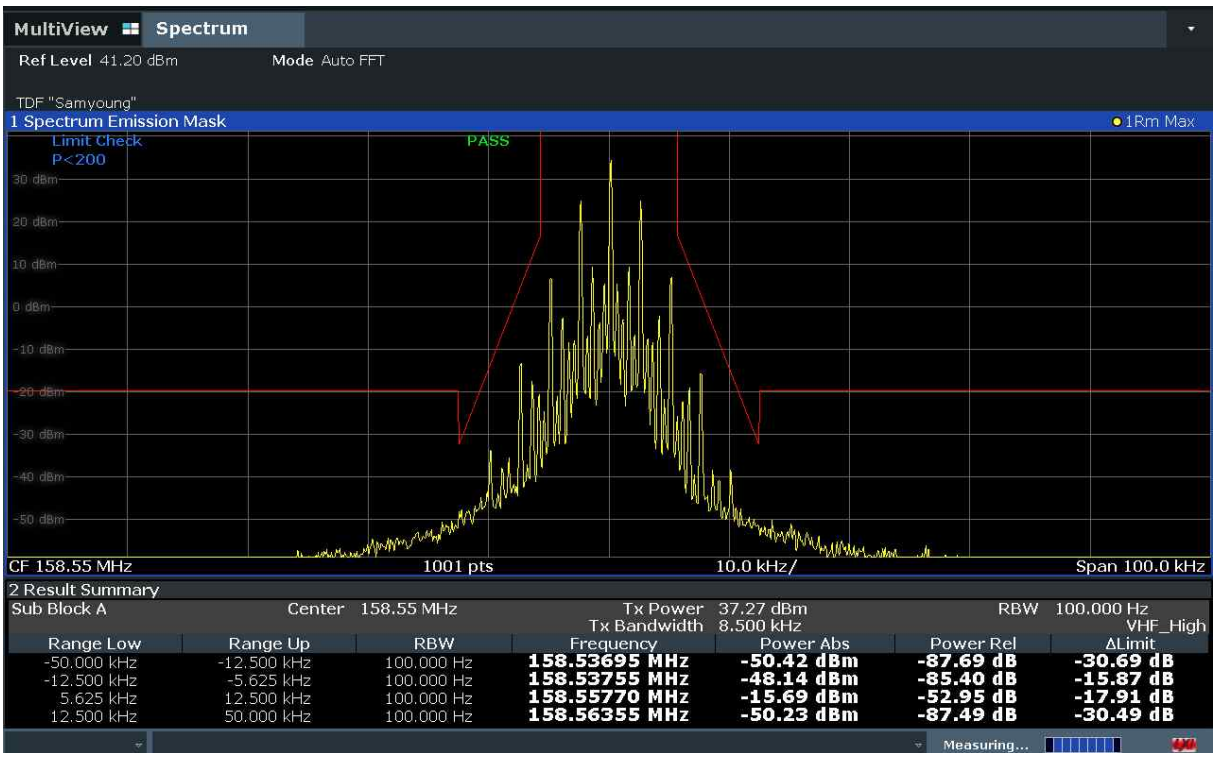
CH Low : 138.0125 MHz



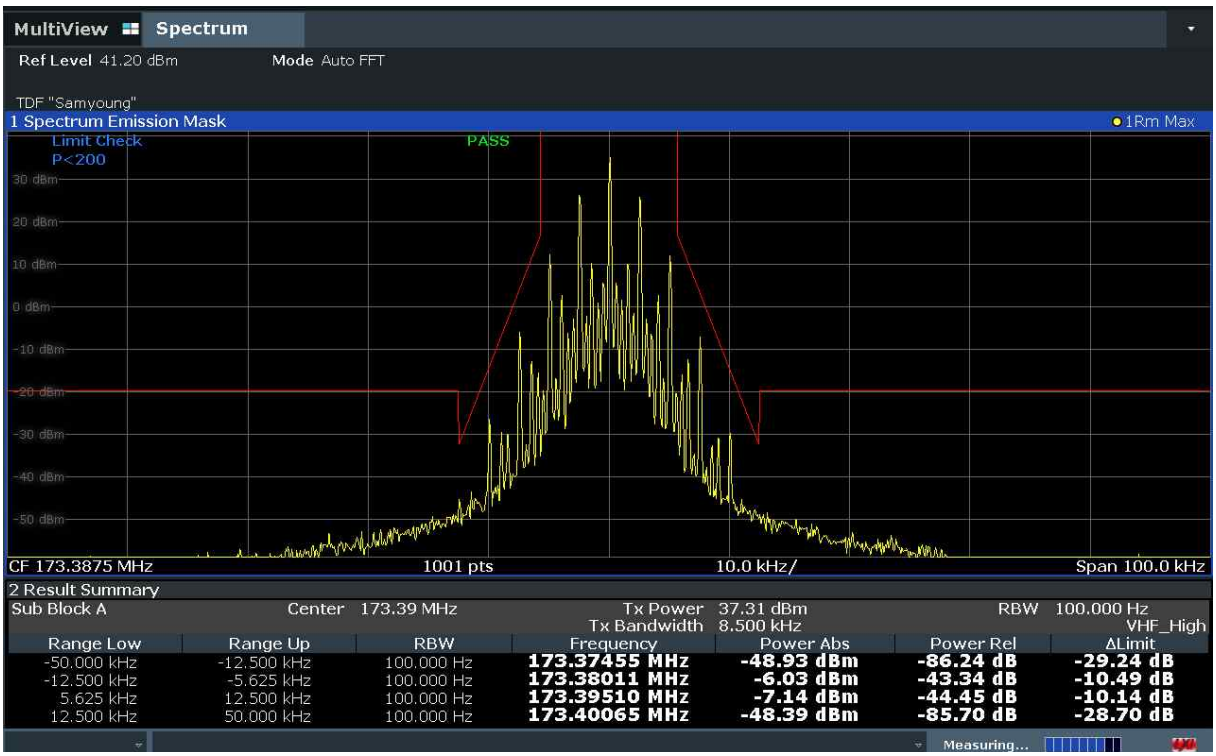
CH Middle : 151.1000 MHz



CH Mid : 158.55 MHz

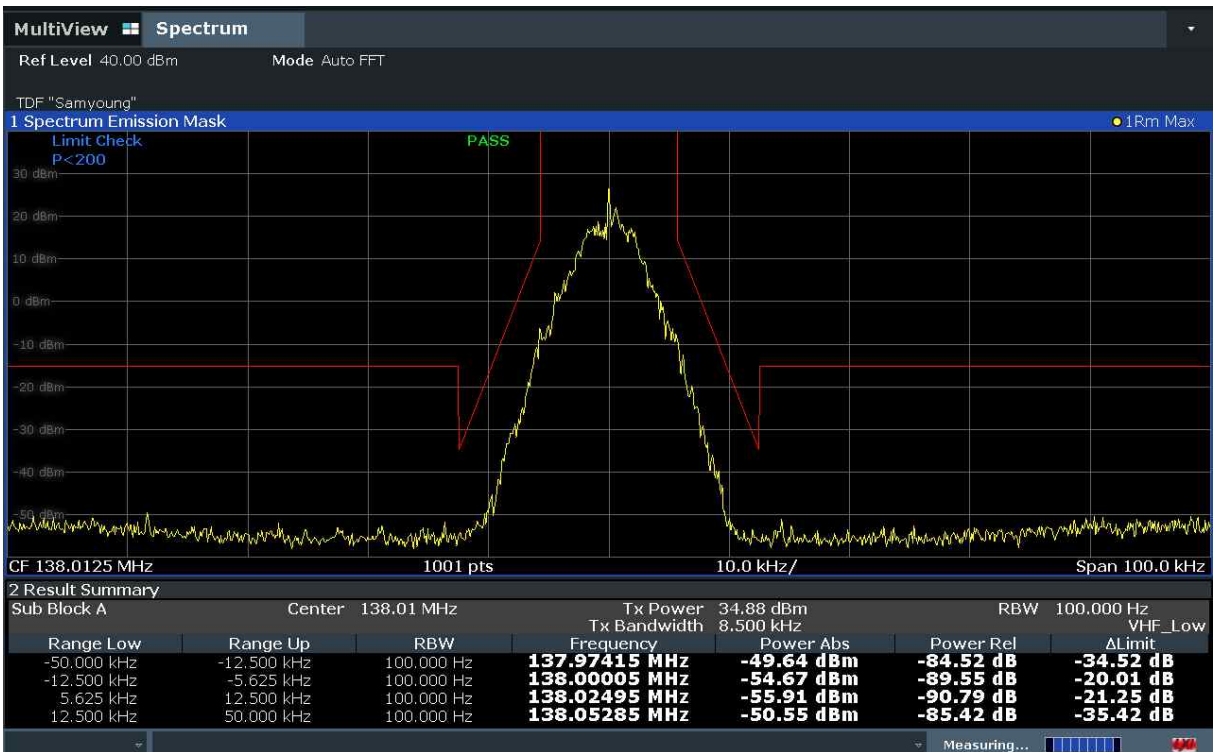


CH High : 173.3875 MHz

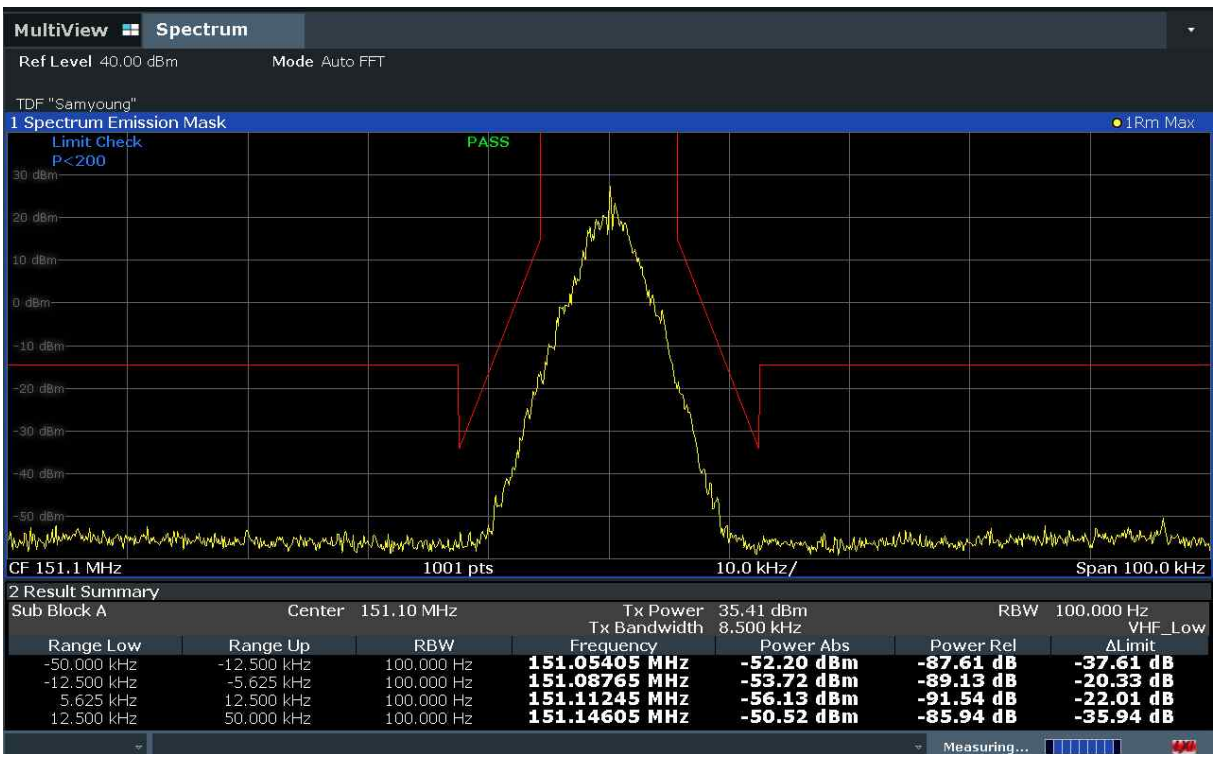


Emission Mask for Digital / Power level: Low

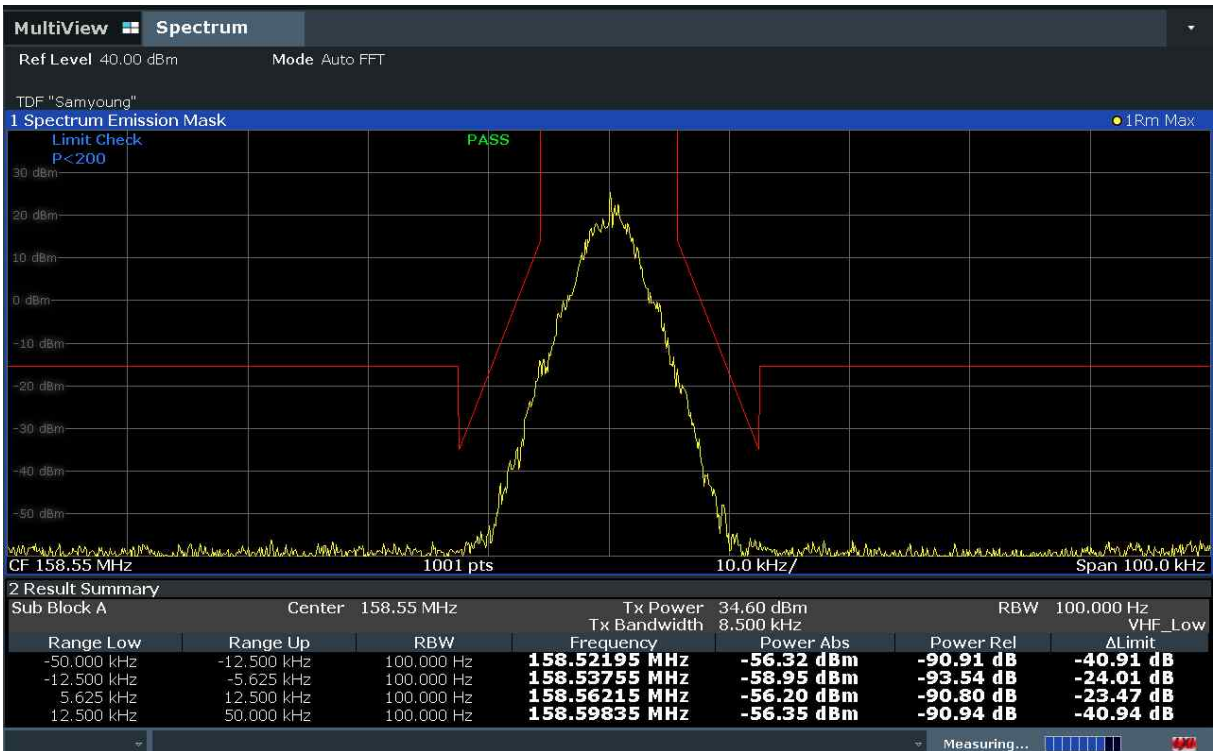
CH Low : 138.0125 MHz



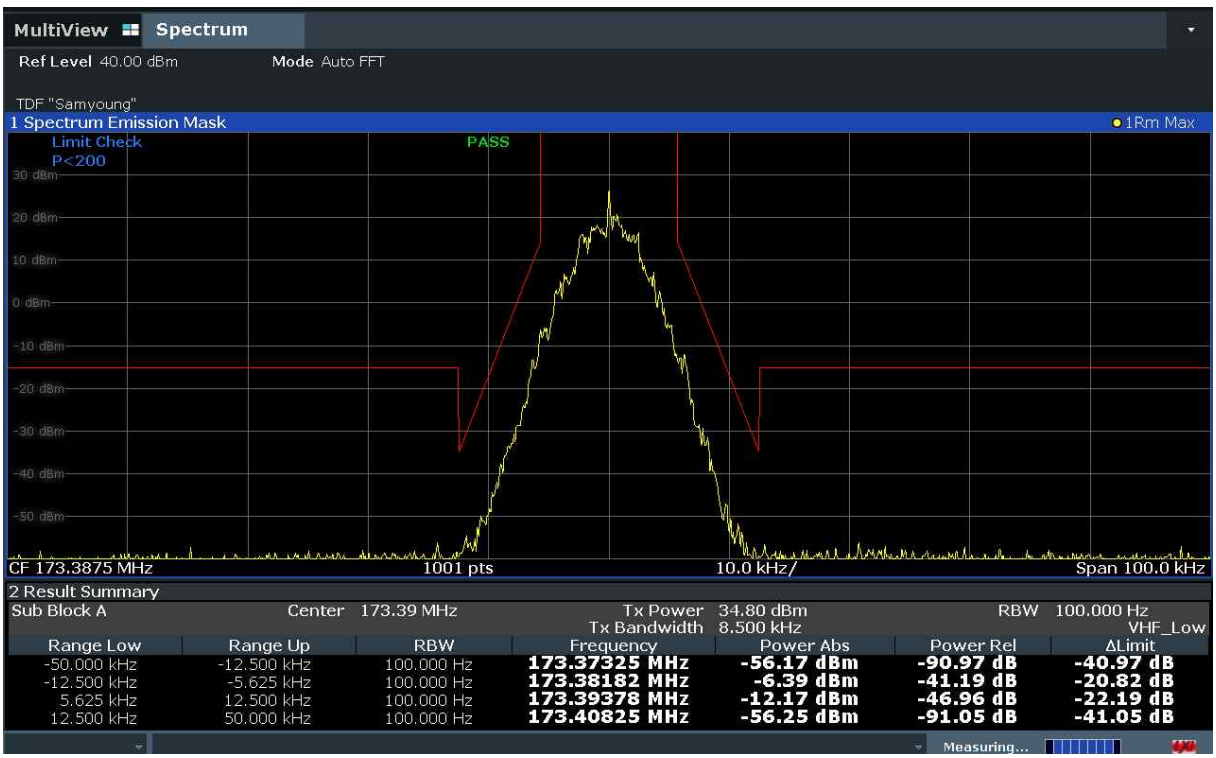
CH Middle : 151.1000 MHz



CH Mid : 158.55 MHz

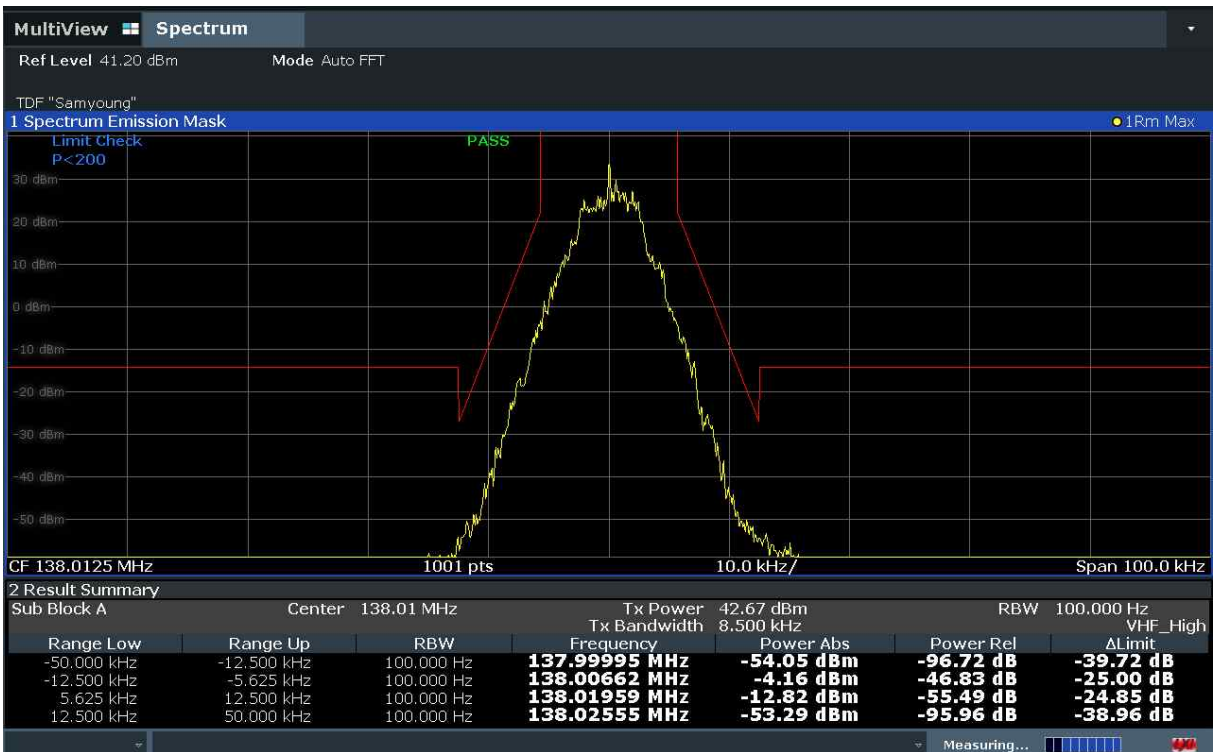


CH High : 173.3875 MHz

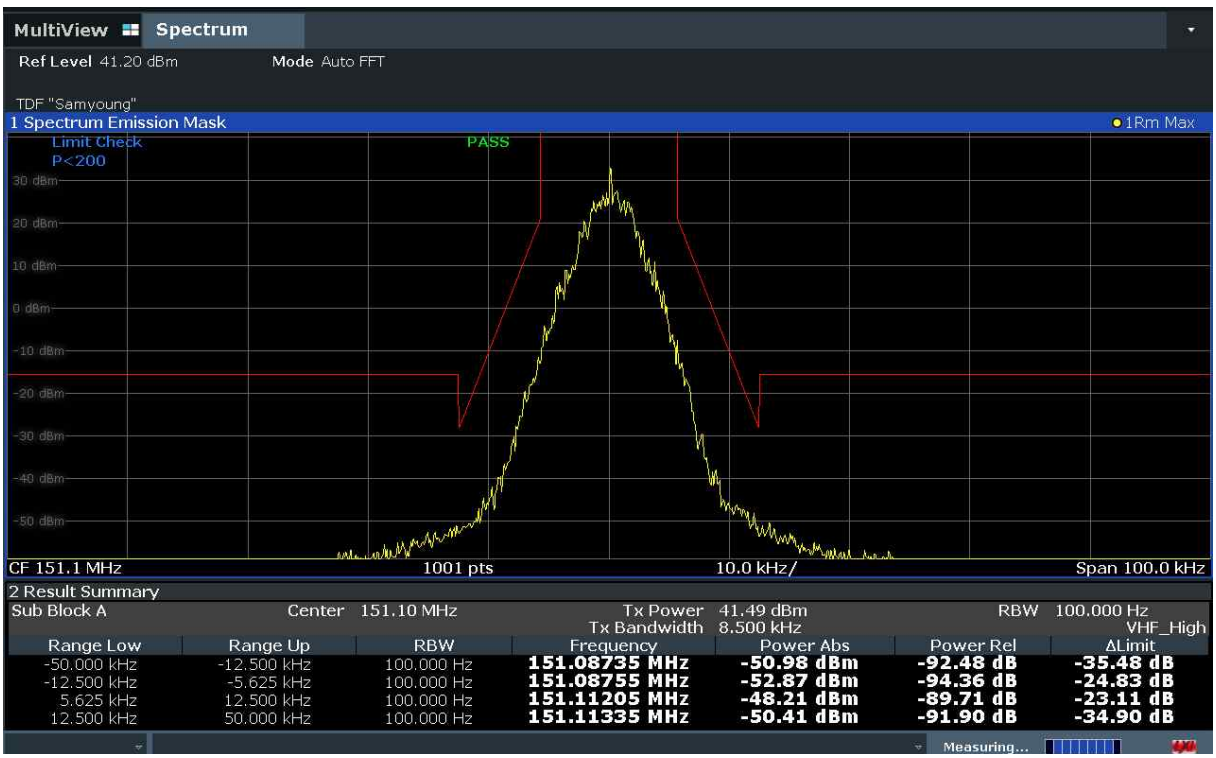


Emission Mask for Digital / Power level: High

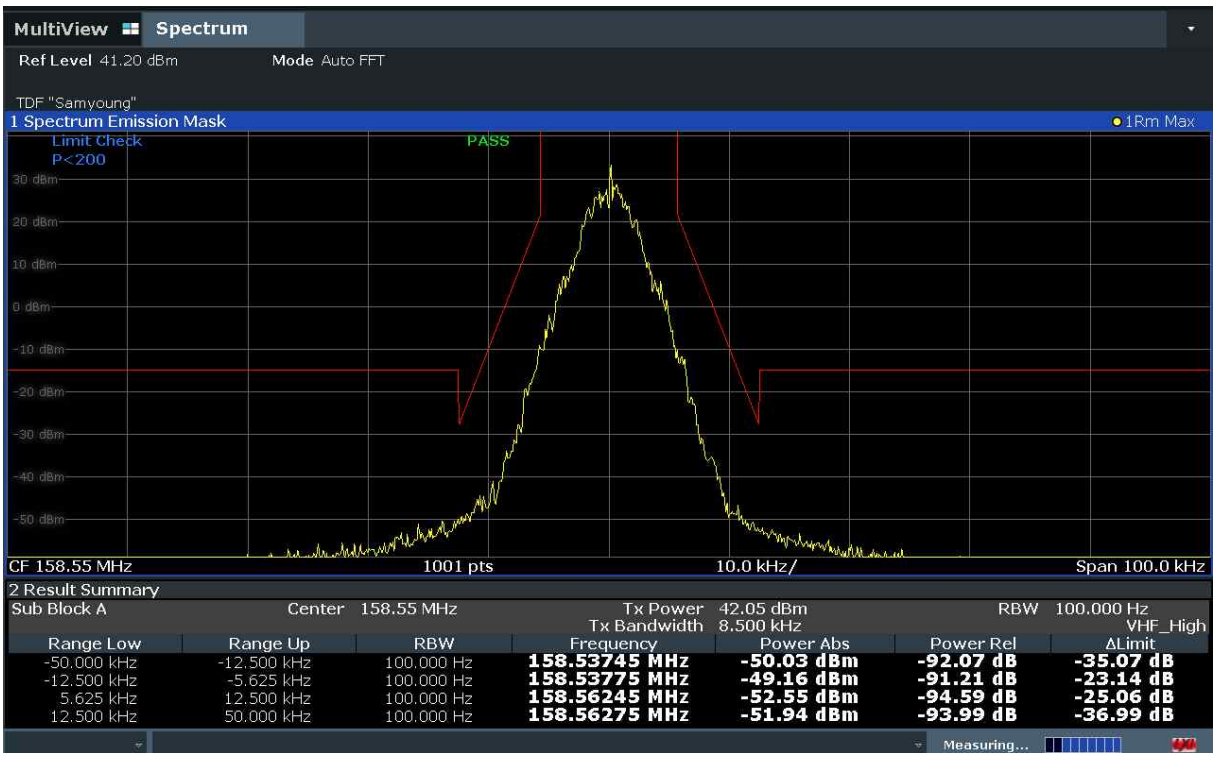
CH Low : 138.0125 MHz



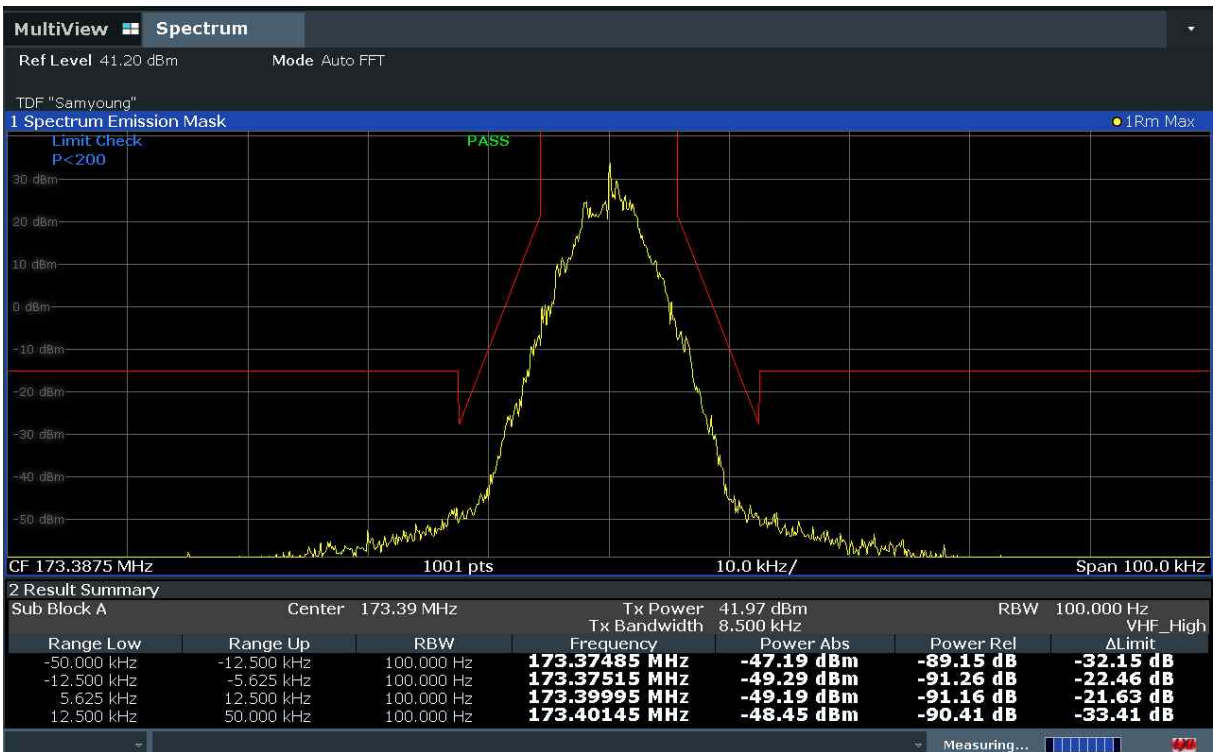
CH Middle : 151.1000 MHz



CH Mid : 158.55 MHz



CH High : 173.3875 MHz



5.4 Spurious Emission On Antenna Port

5.4.1 Standard Applicable [FCC §90.210(d)]

§ 90.210(d)

Emission Mask D: 12.5 kHz channel bandwidth equipment. For transmitters designed to operate with a 12.5 kHz channel bandwidth, any emission must be attenuated below the power (P) of the highest emission contained within the authorized bandwidth as follows:

1) For any frequency removed from the center of the authorized bandwidth f_0 to 5.625 kHz removed from f_0, 0 dB.

2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 5.626 kHz but no more than 12.5 kHz, at least 7.27 (f_d –2.88 kHz) dB.

3) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 12.5 kHz: At least 50 + 10 log (P) dB or 70 dB, whichever is the lesser attenuation.

5.4.2 Test Environment conditions

• Ambient temperature : (20 - 21) °C • Relative Humidity : (48 - 49) % R.H.

5.4.3 Measurement Procedure

The carrier was modulated 100 % using a 2 500 Hz tone. The spectrum was scanned from the lowest frequency generated to at least the 10th harmonic of the fundamental. The measurements were made in accordance with standard ANSI/TIA-603-E-2016. The RBW = 100 kHz, VBW = 300 kHz and the span set to 10.0 MHz and the spectrum was scanned from 30 MHz to the 10th harmonic of the fundamental. Above 1 GHz the resolution bandwidth was 1 MHz and the VBW = 3 MHz and the span to 50 MHz.

5.4.4 Test setup

Refer 5.3.4

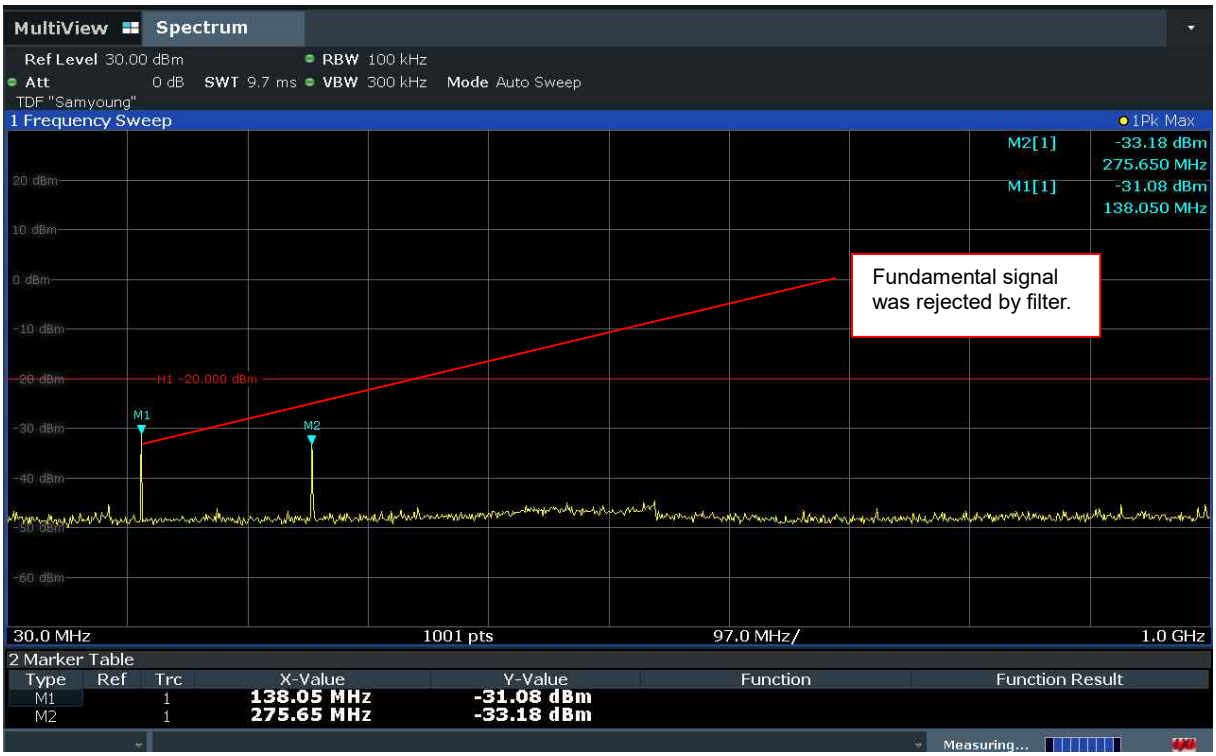
5.4.5 Measurement Result

See the 5.4.6 Test plots

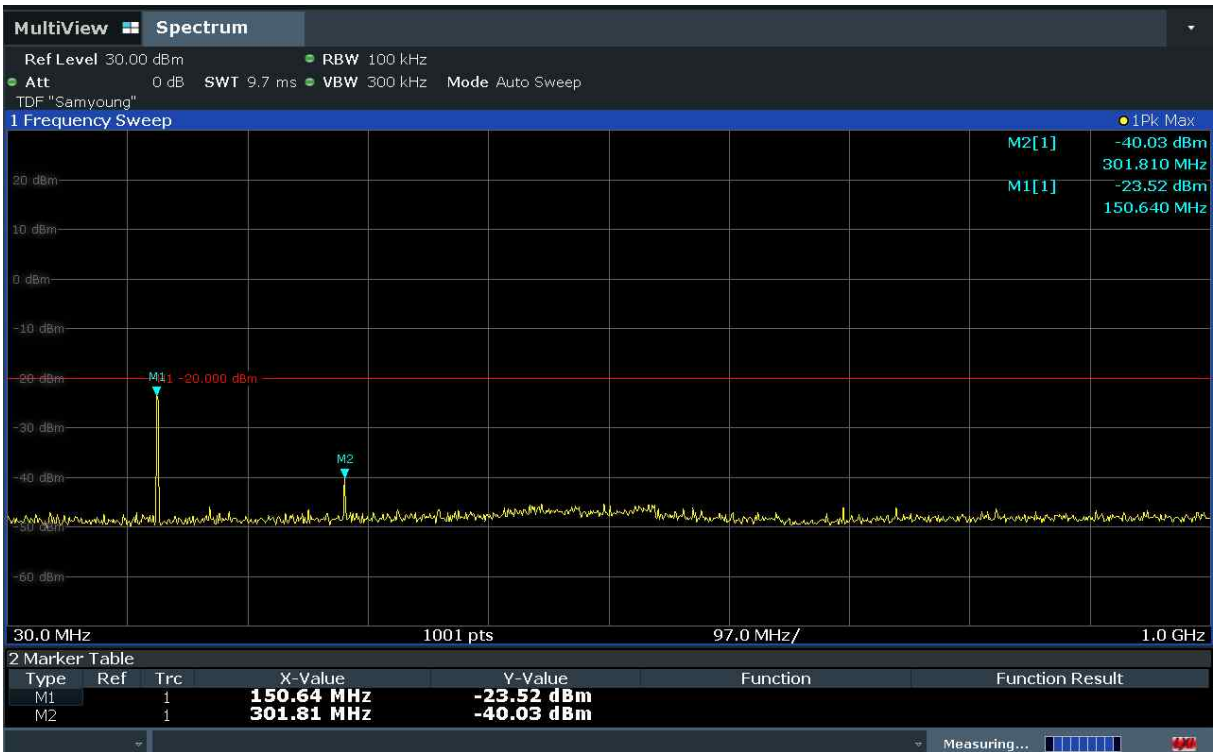
5.4.6 Test Plot

Below 1GHz / Analog / Power level: Low

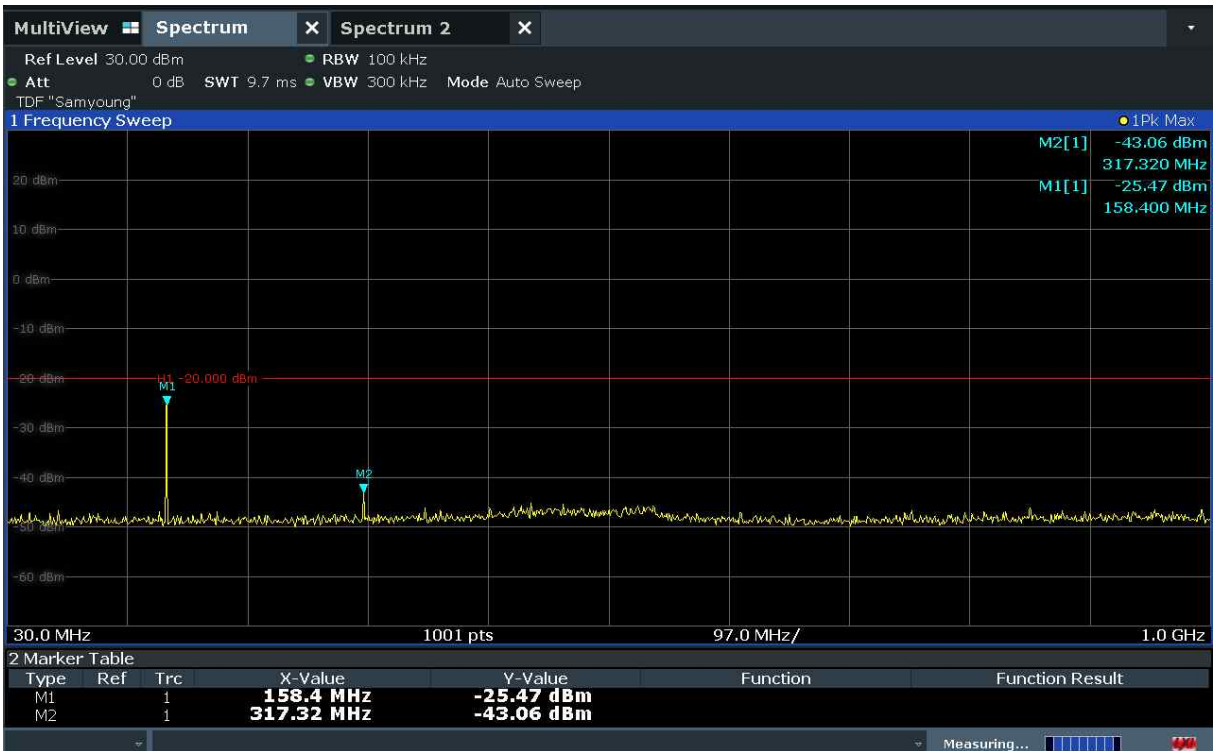
CH Low : 138.0125 MHz



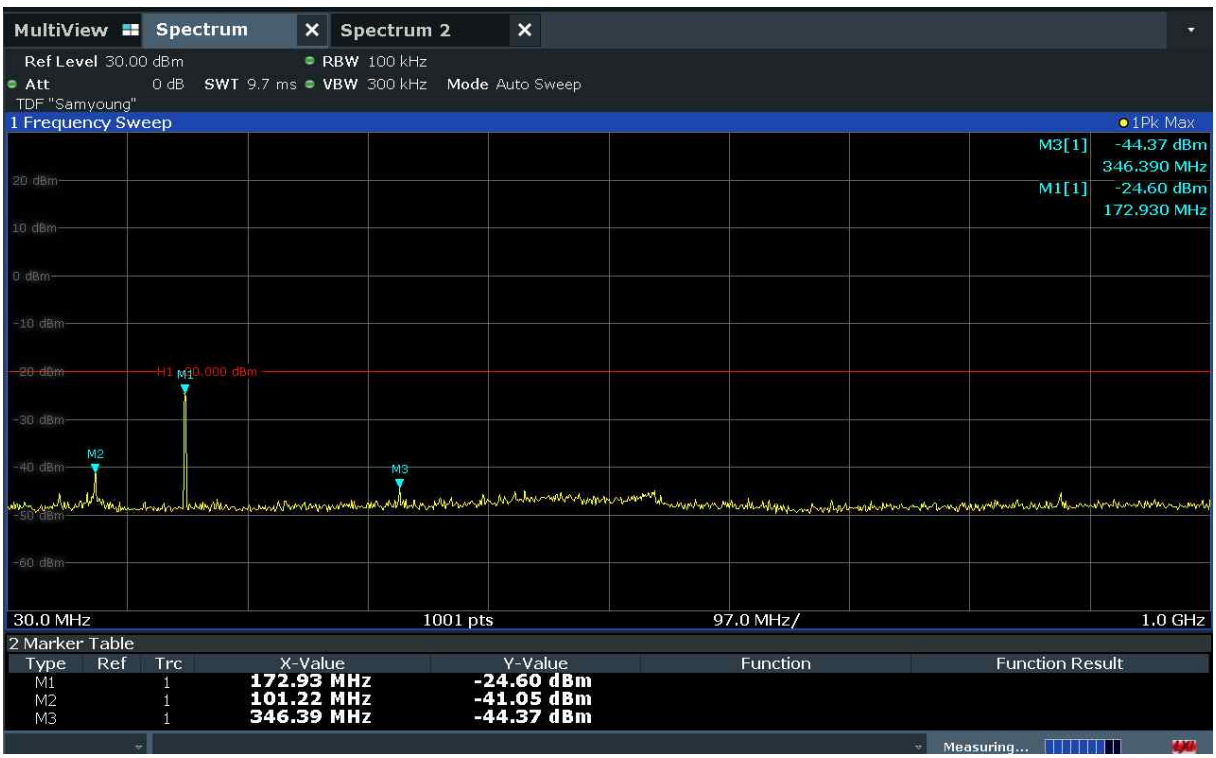
CH Middle : 151.1000 MHz



CH Mid : 158.55 MHz

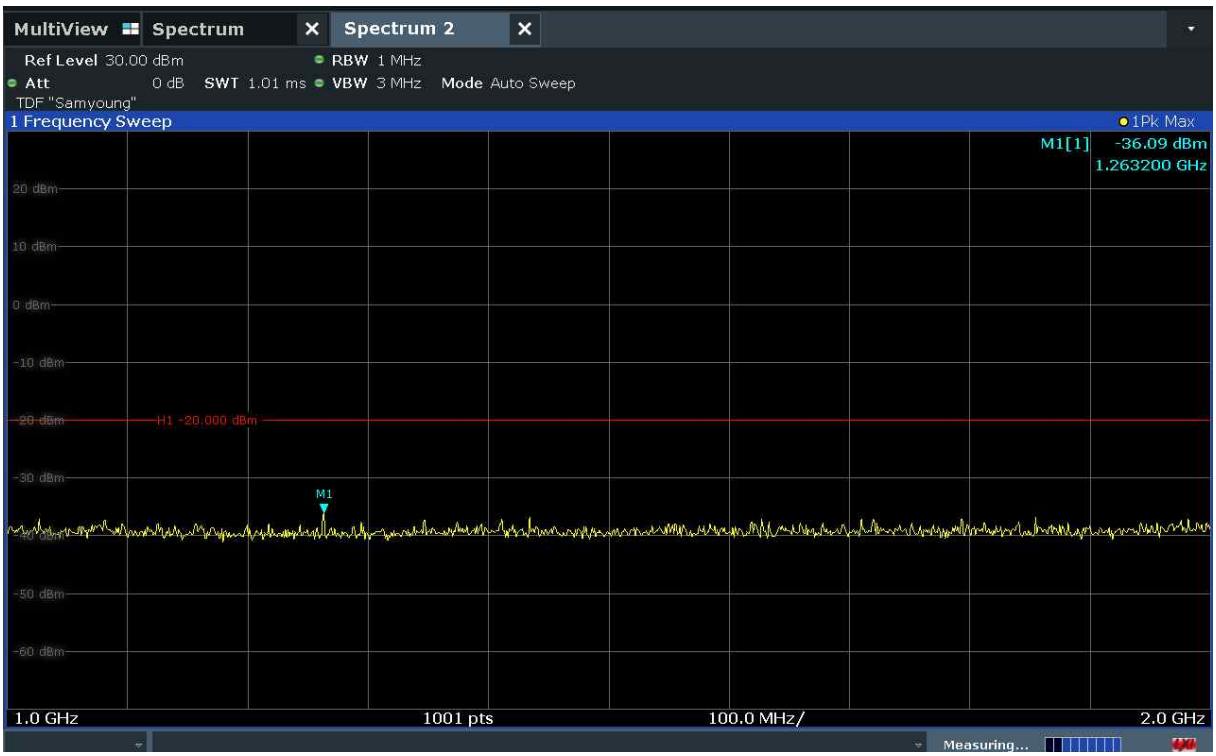


CH High : 173.3875 MHz

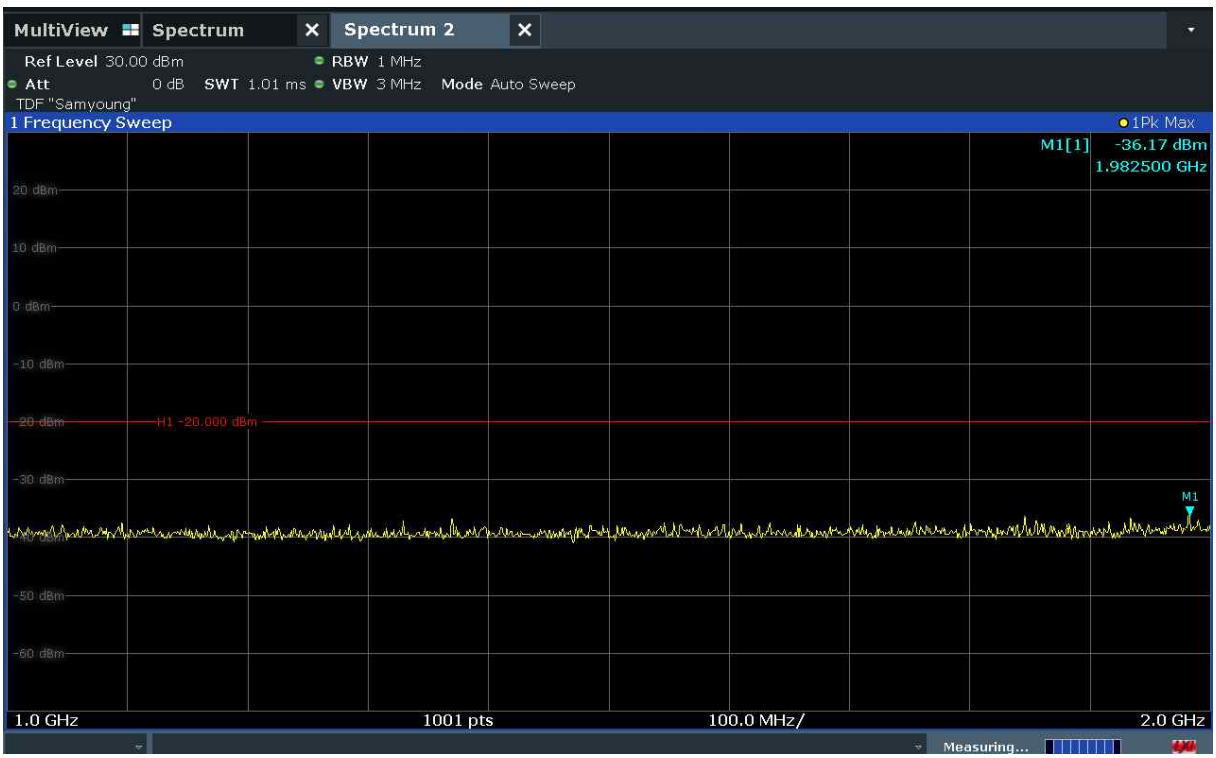


Above 1GHz / Analog / Power level: Low

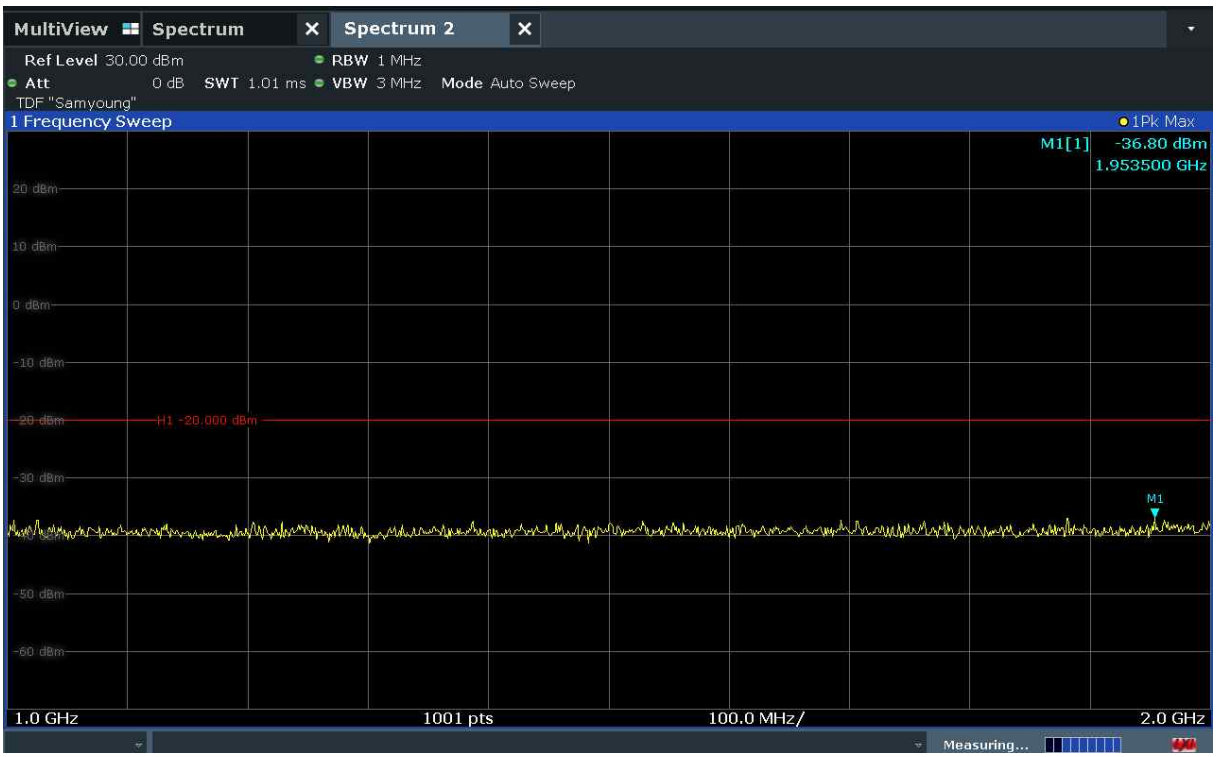
CH Low : 138.0125 MHz



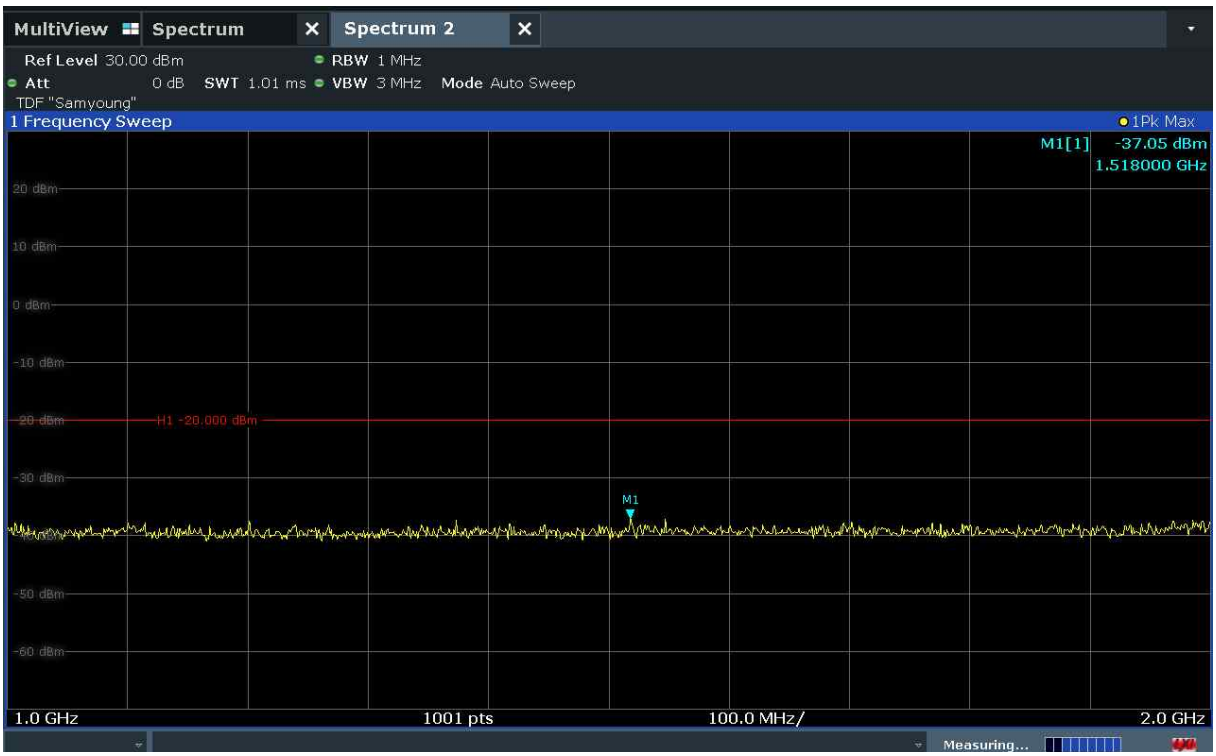
CH Middle : 151.1000 MHz



CH Mid : 158.55 MHz

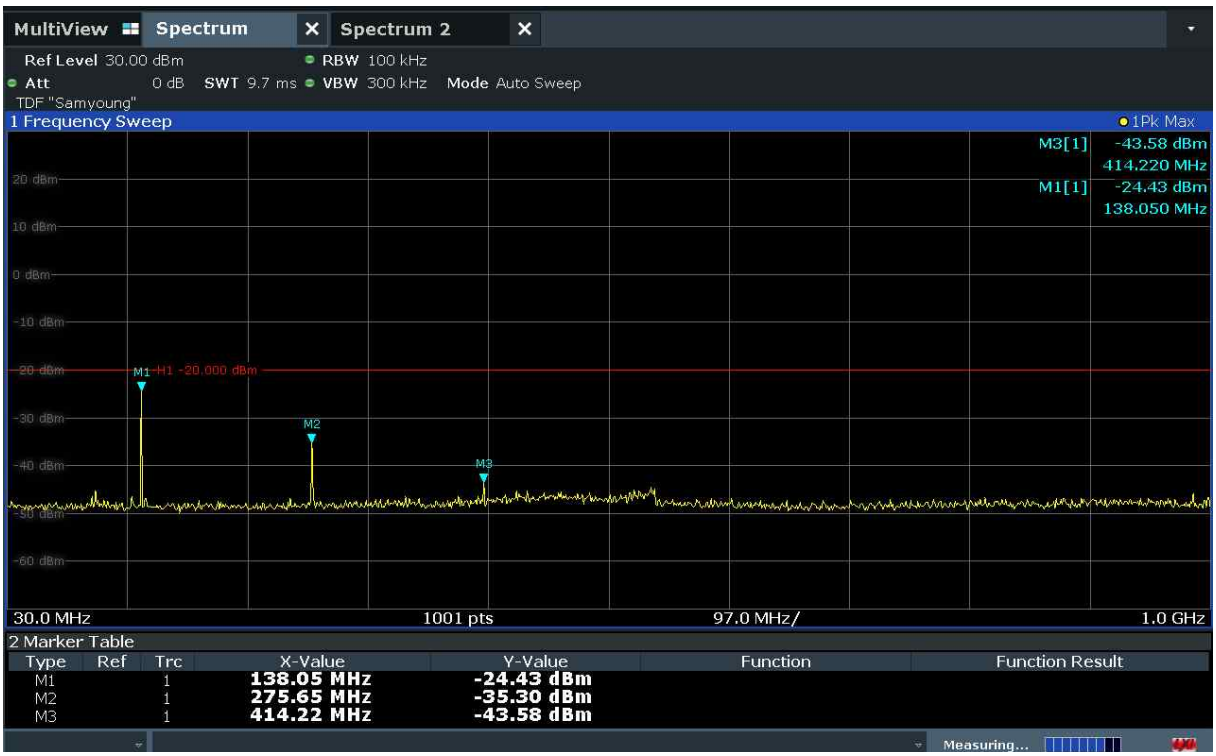


CH High : 173.3875 MHz

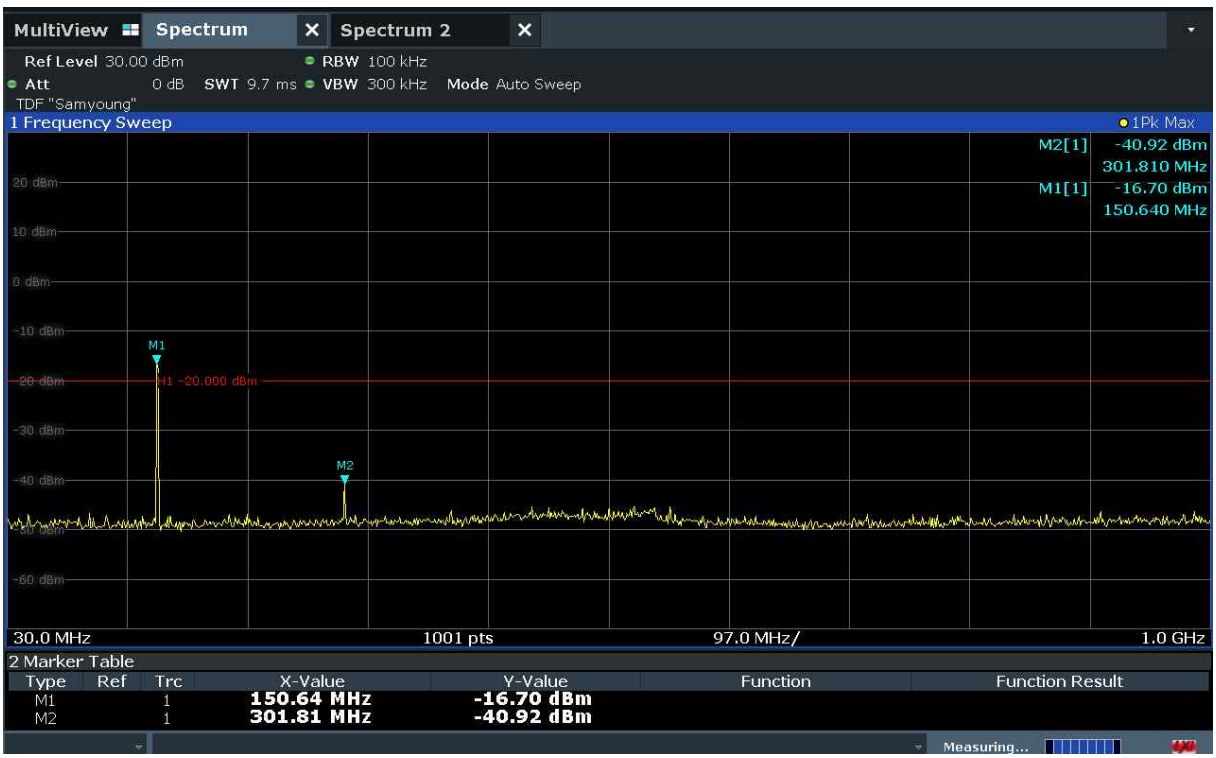


Below 1GHz / Analog / Power level: High

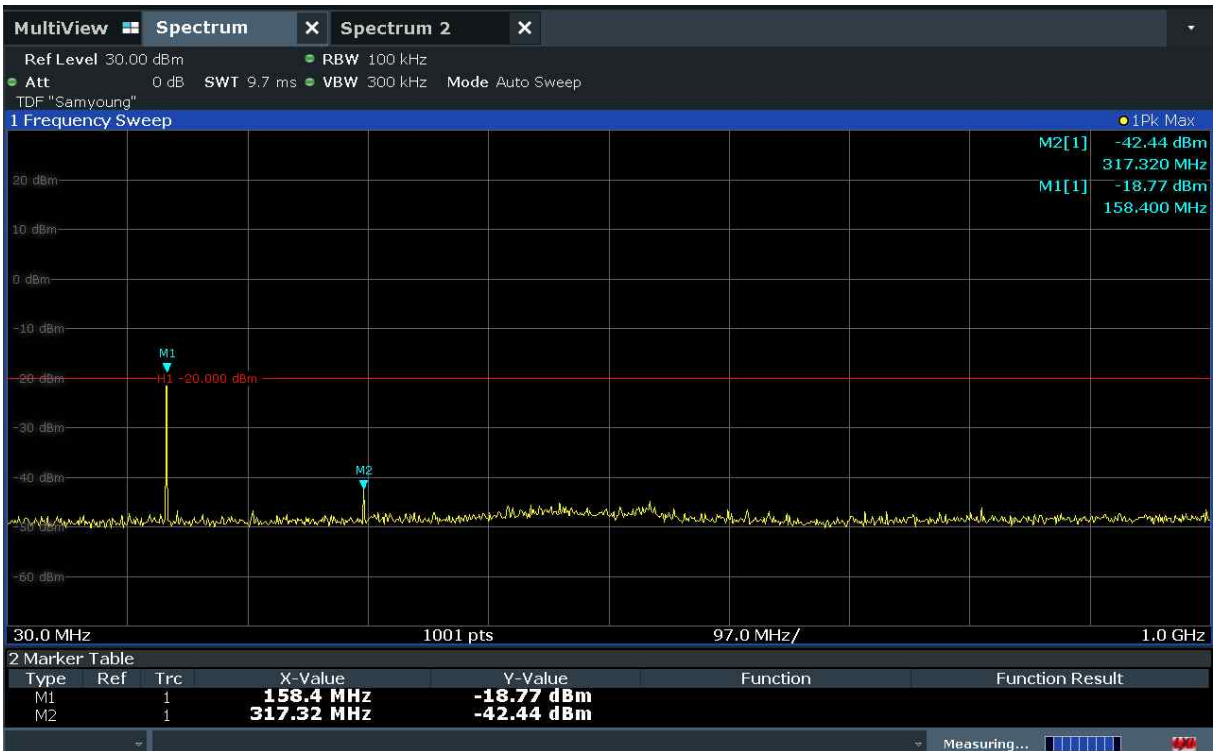
CH Low : 138.0125 MHz



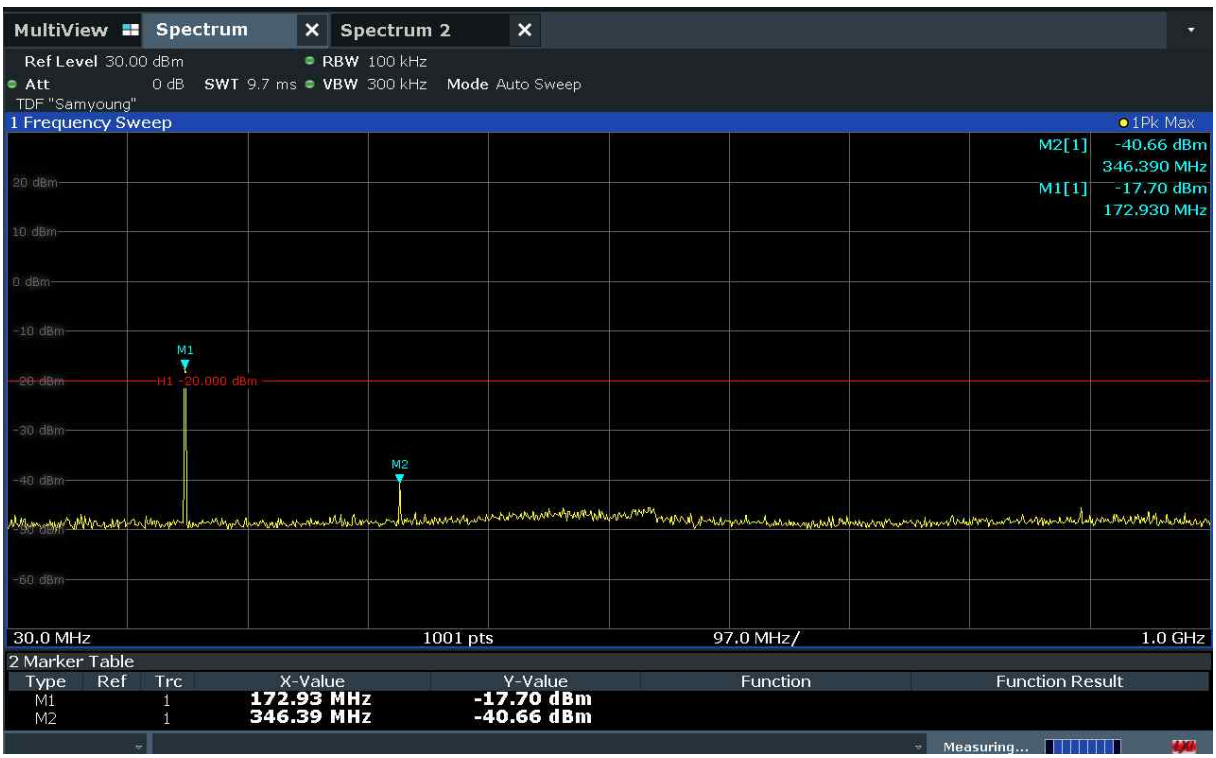
CH Middle : 151.1000 MHz



CH Mid : 158.55 MHz

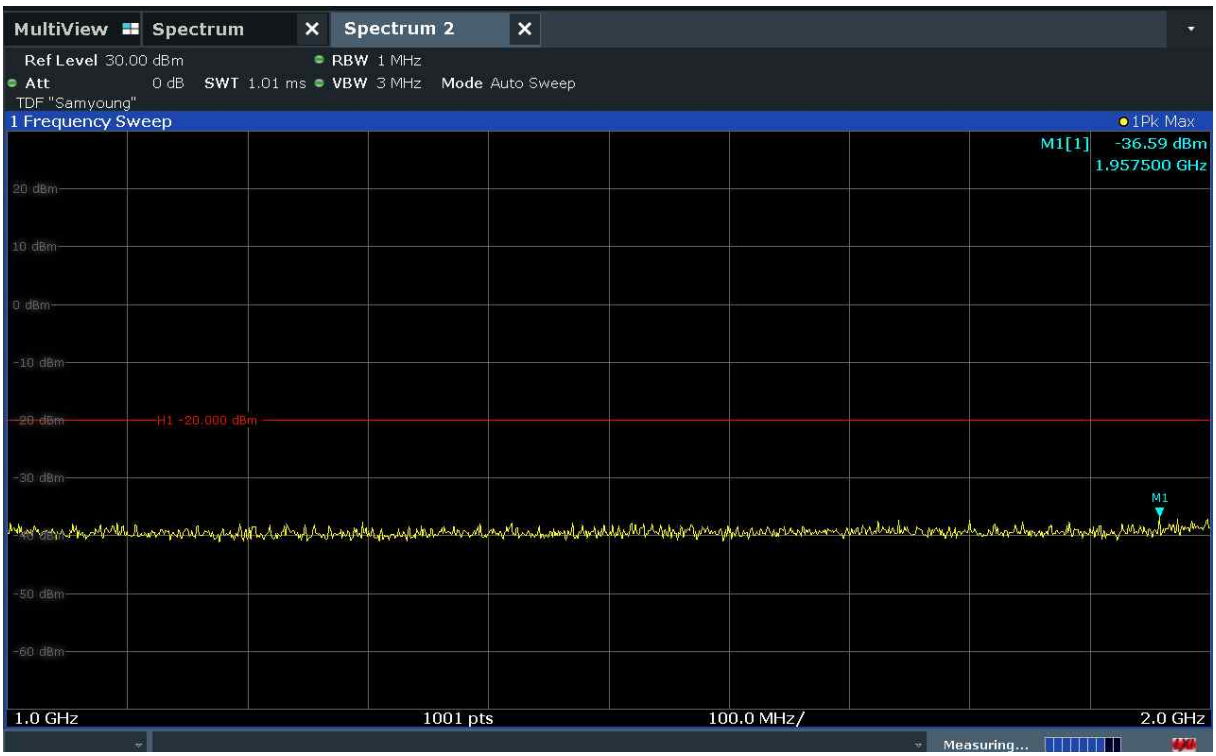


CH High : 173.3875 MHz

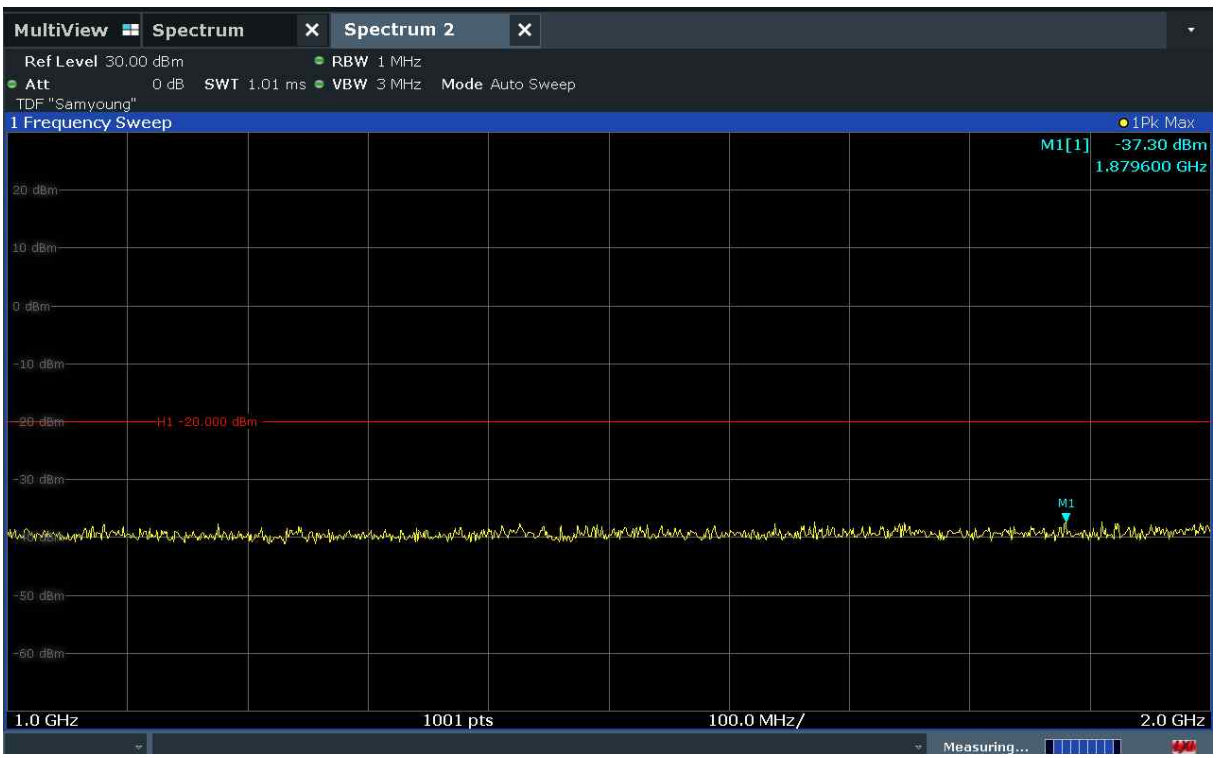


Above 1GHz / Analog / Power level: High

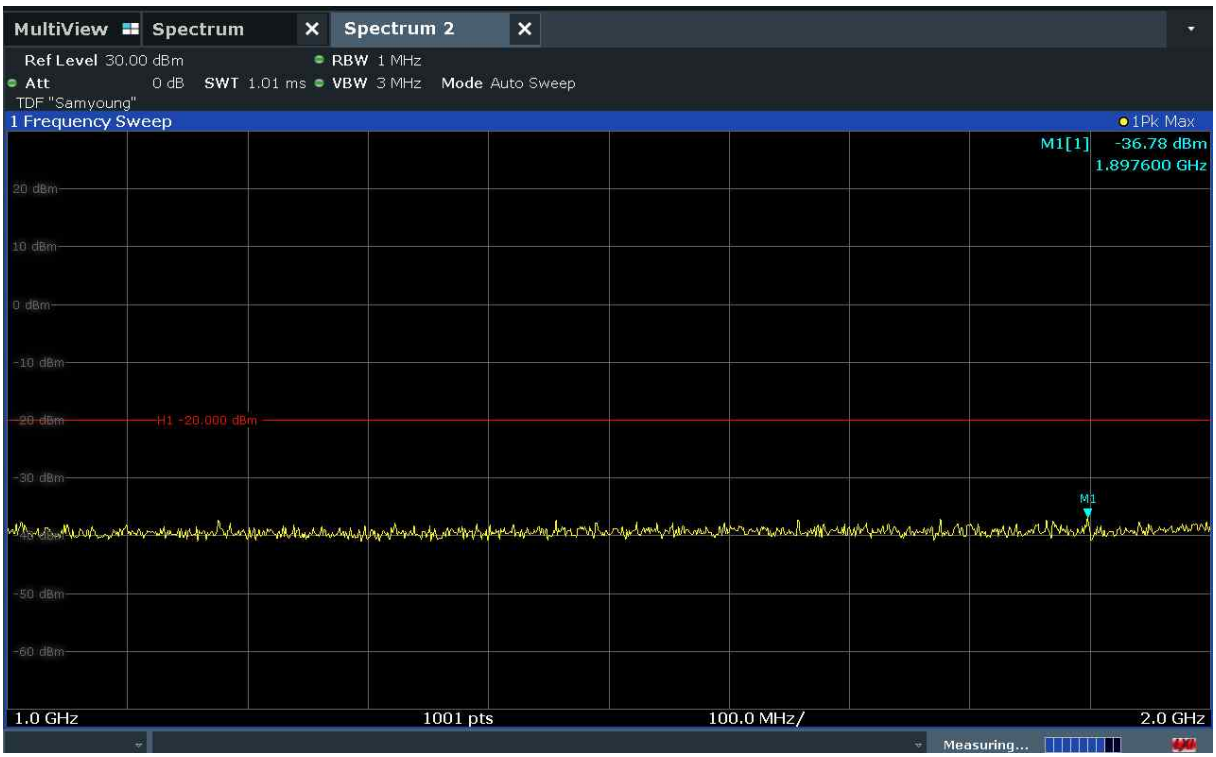
CH Low : 138.0125 MHz



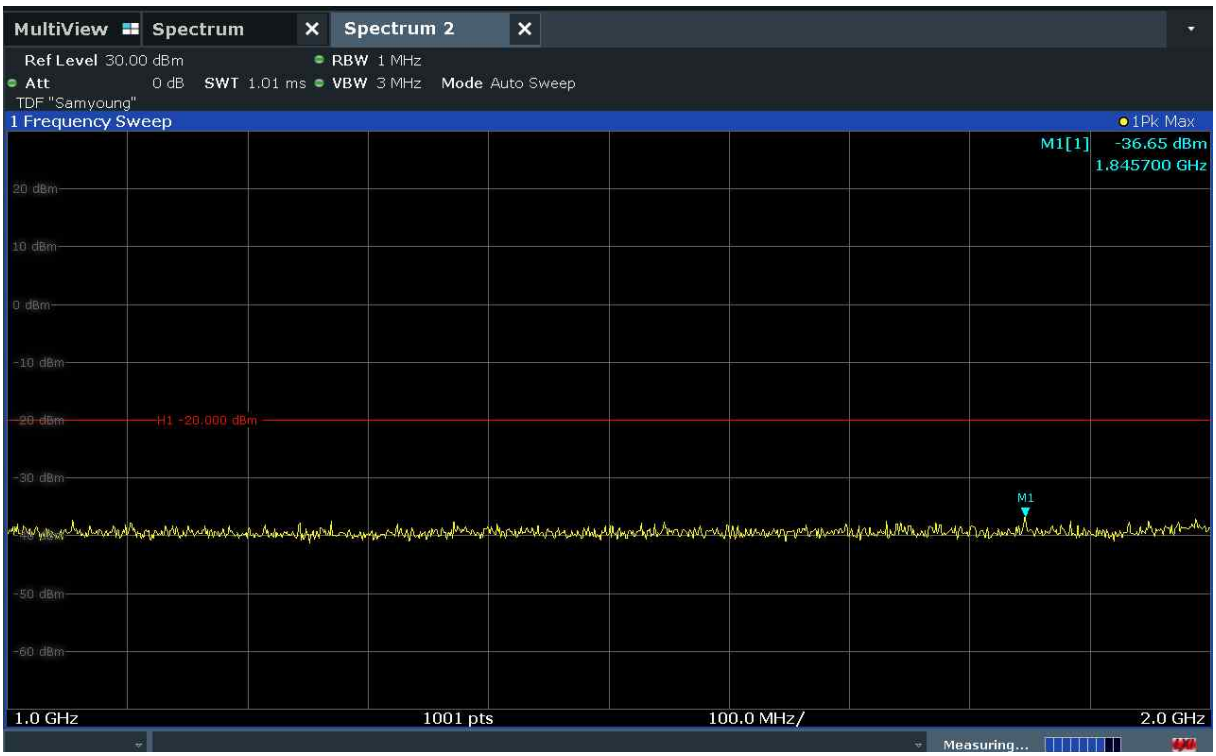
CH Middle : 151.1000 MHz



CH Mid : 158.55 MHz

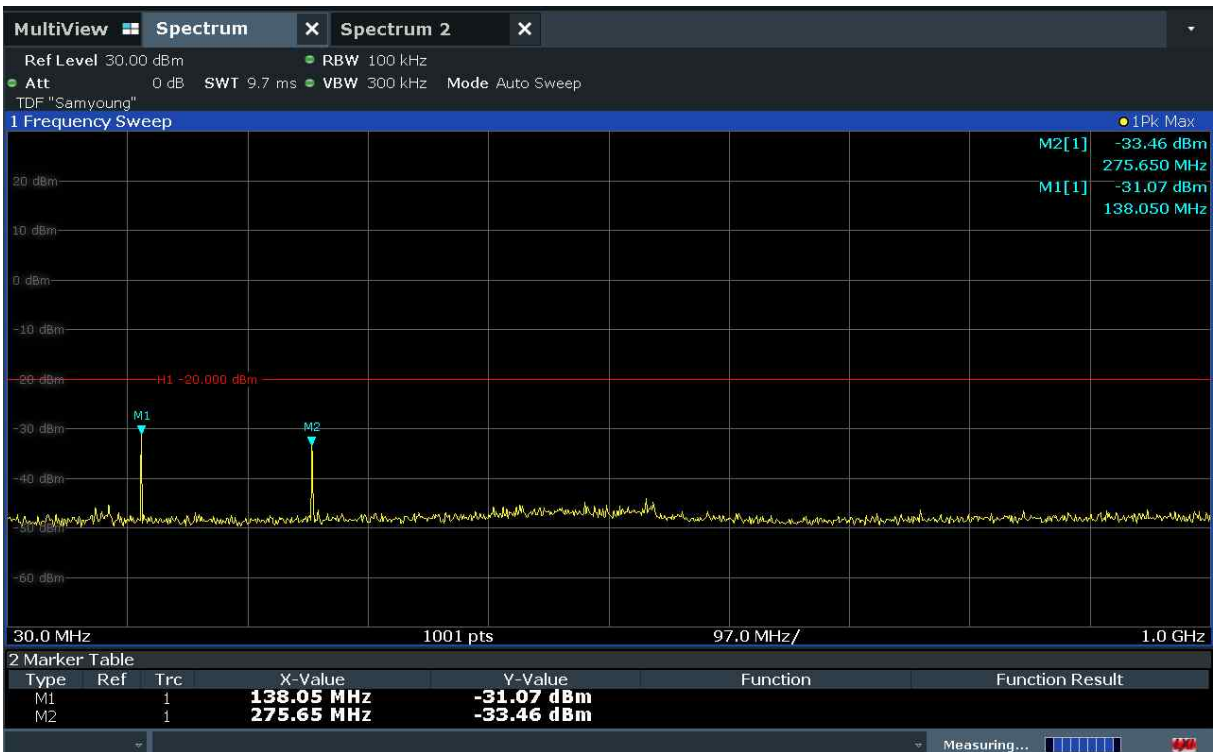


CH High : 173.3875 MHz

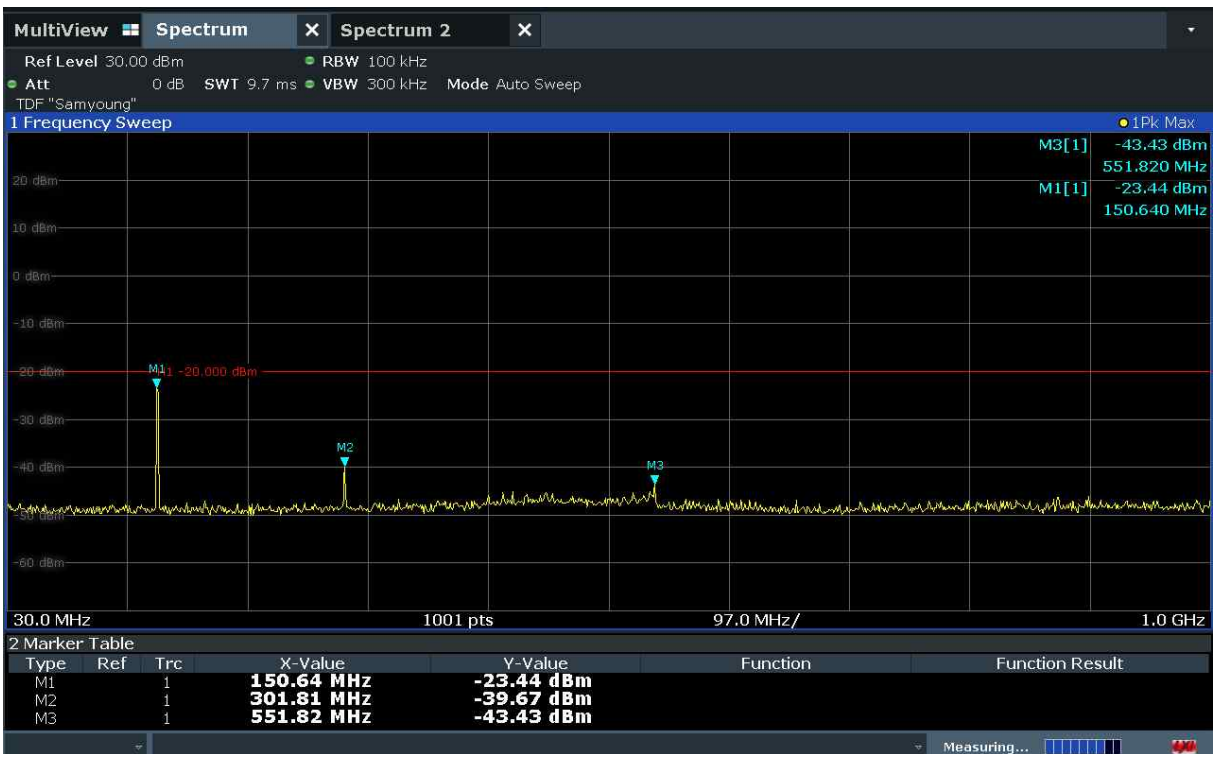


Below 1GHz / Digital / Power level: Low

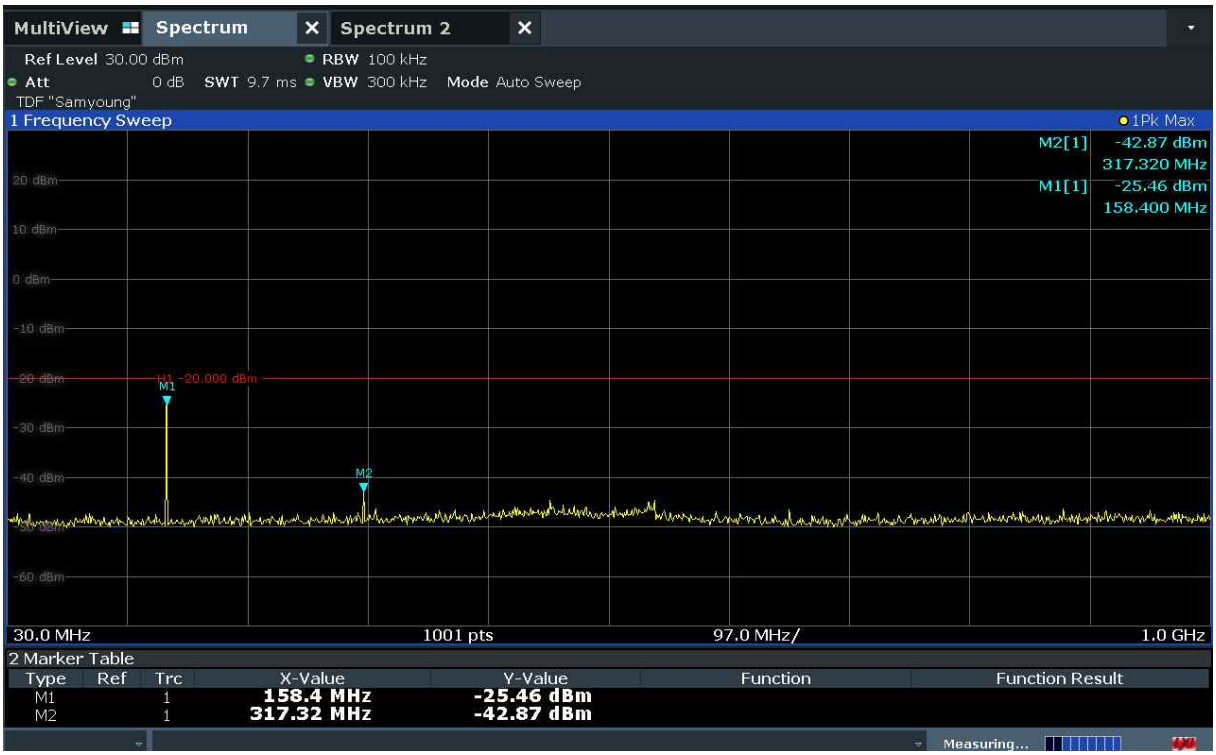
CH Low : 138.0125 MHz



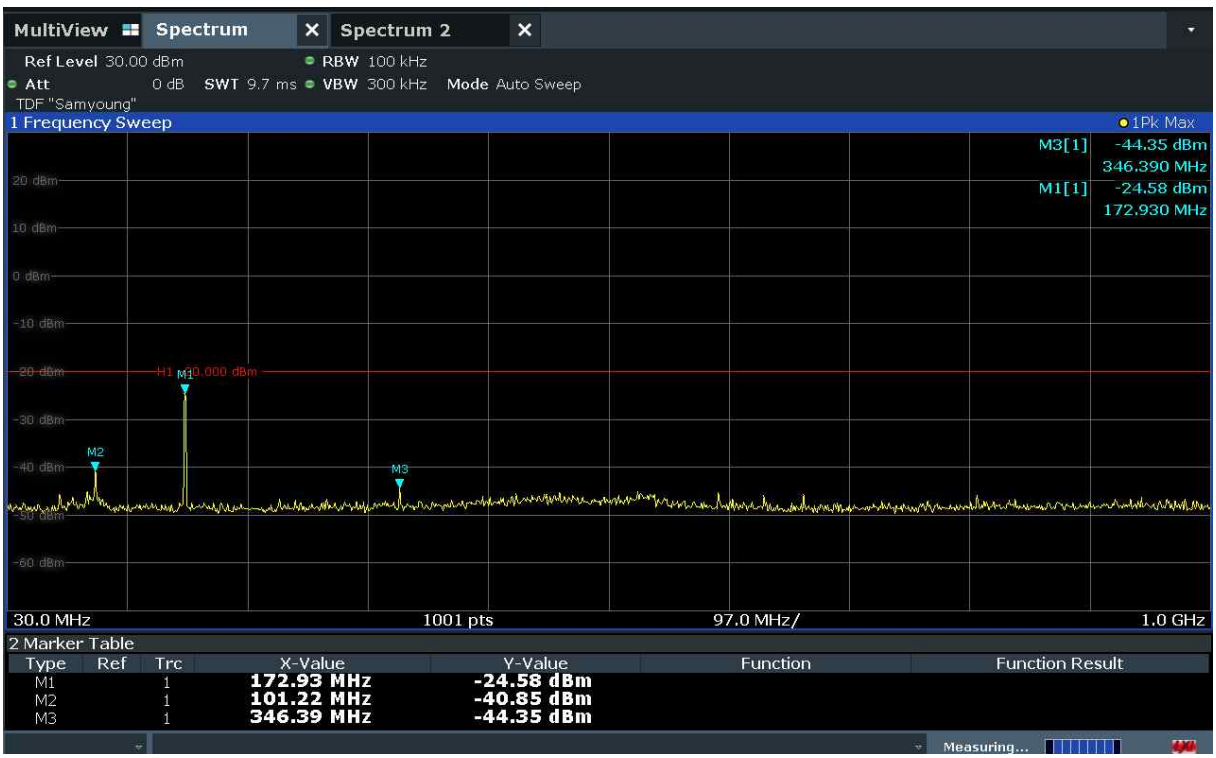
CH Middle : 151.1000 MHz



CH Mid : 158.55 MHz

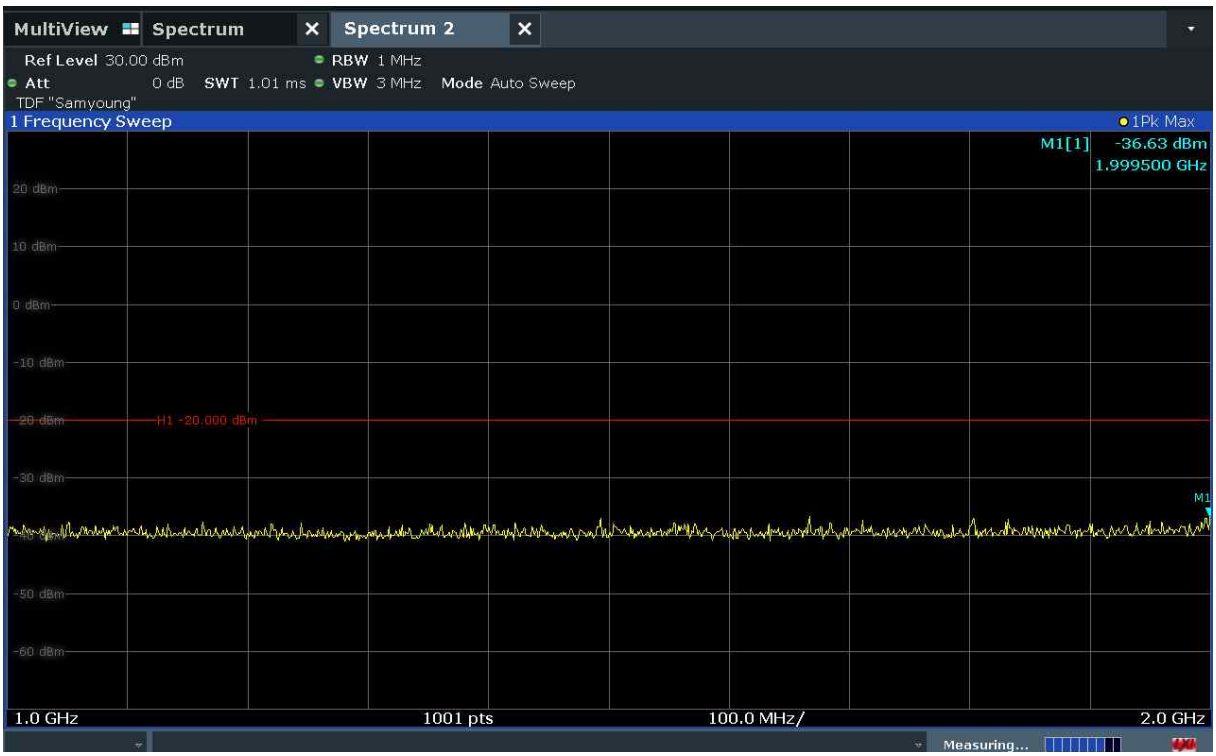


CH High : 173.3875 MHz

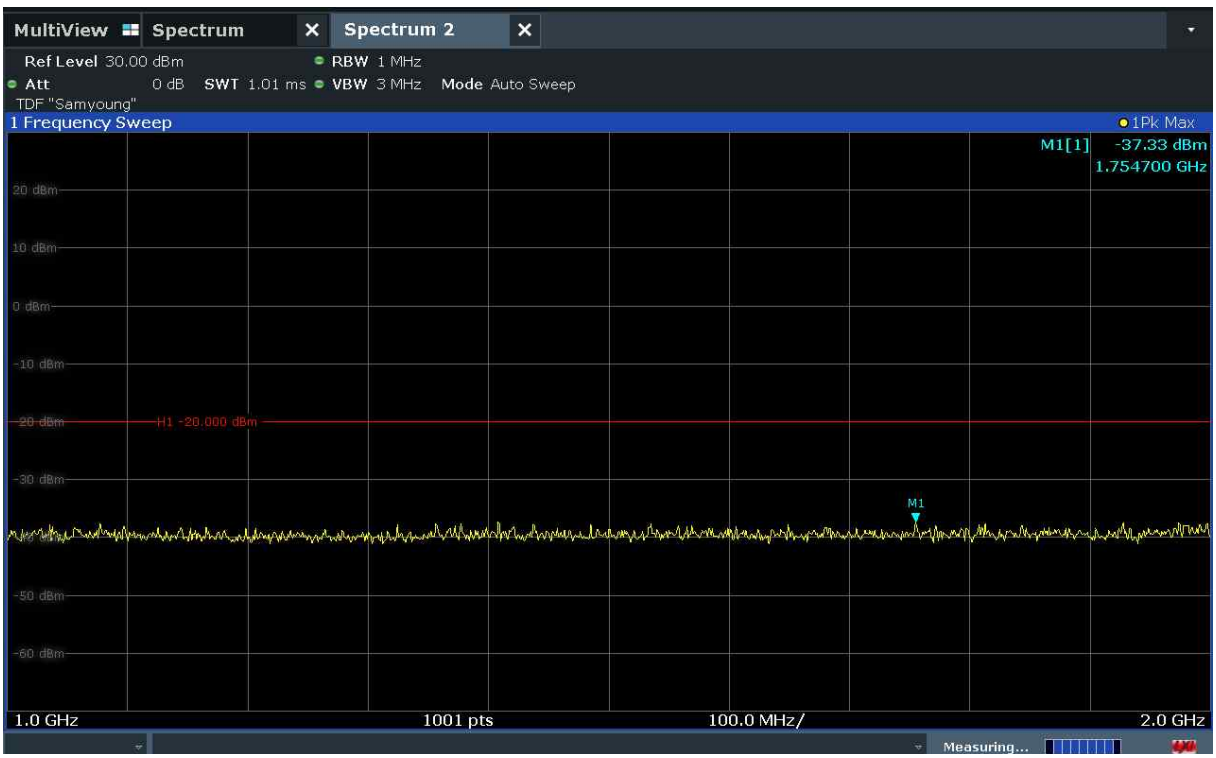


Above 1GHz / Digital / Power level: Low

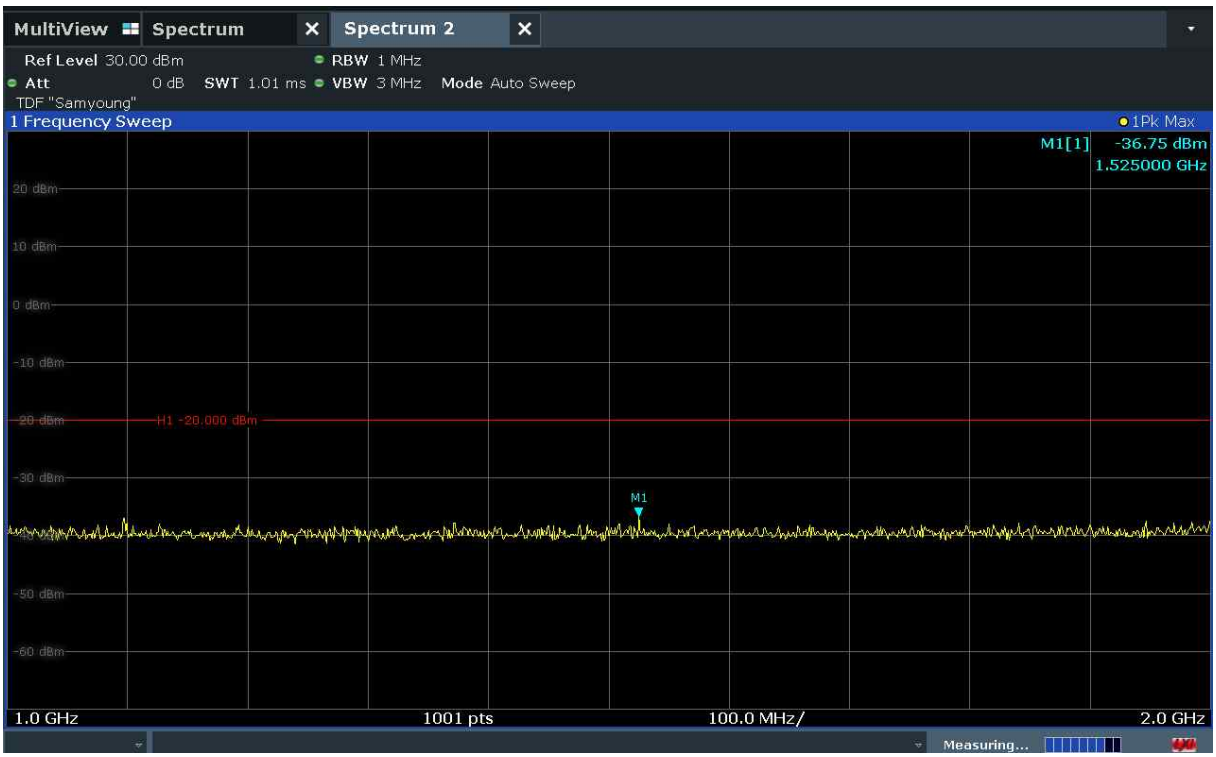
CH Low : 138.0125 MHz



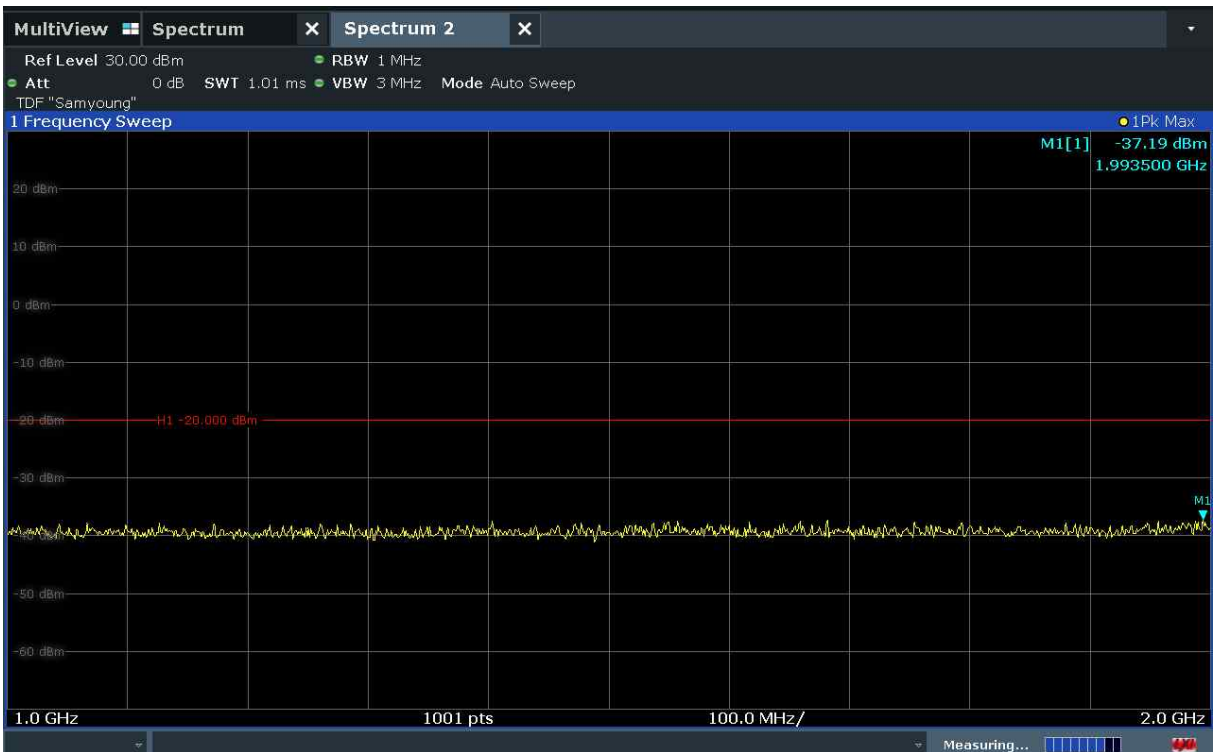
CH Middle : 151.1000 MHz



CH Mid : 158.55 MHz

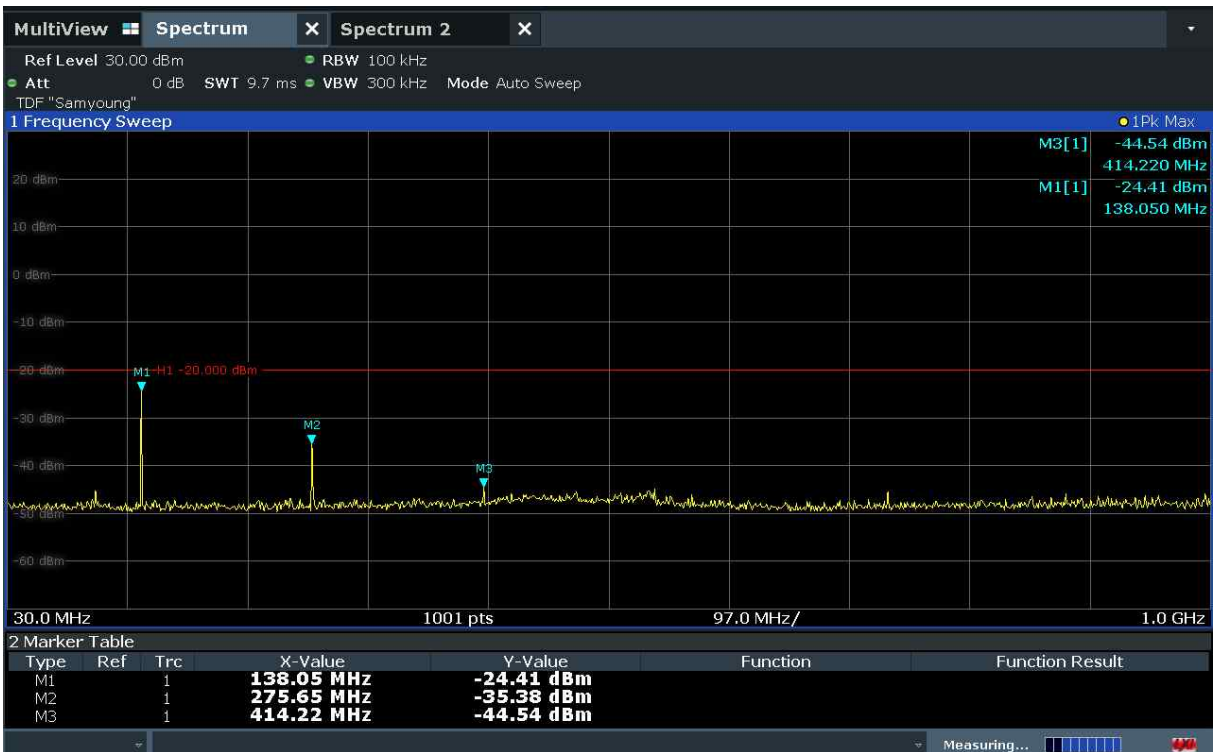


CH High : 173.3875 MHz

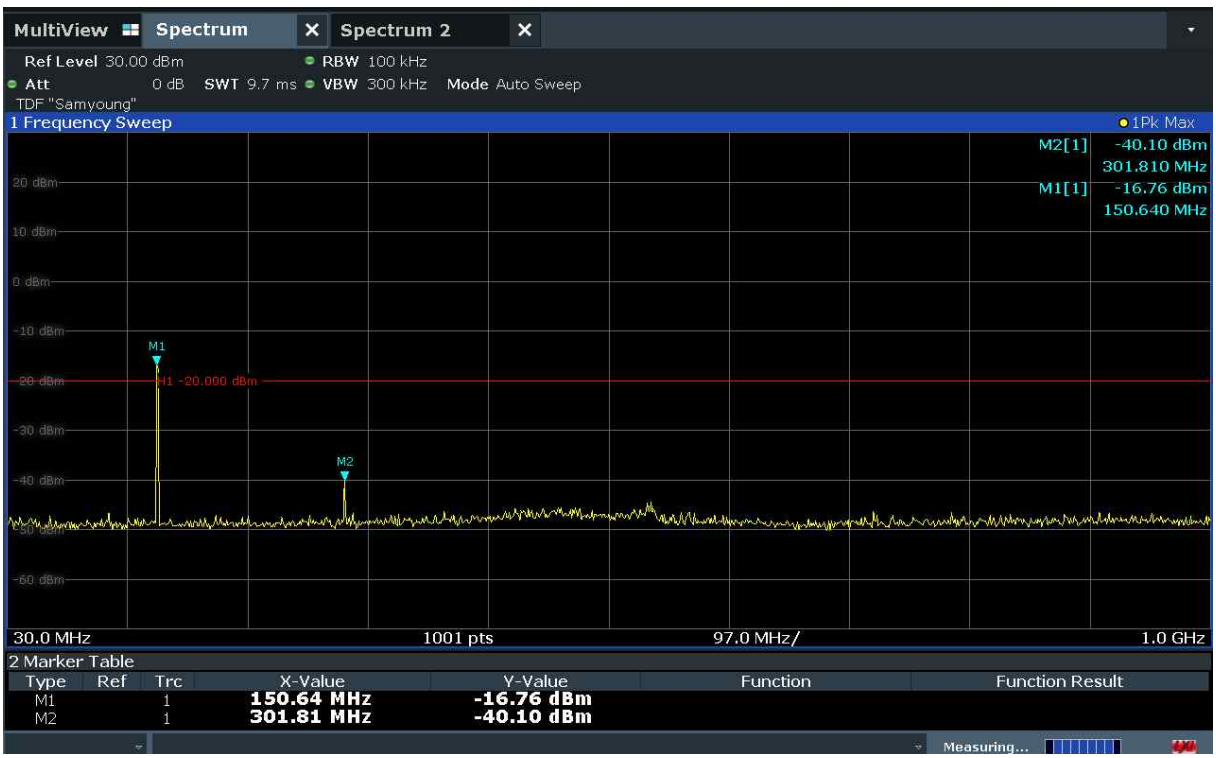


Below 1GHz / Digital / Power level: High

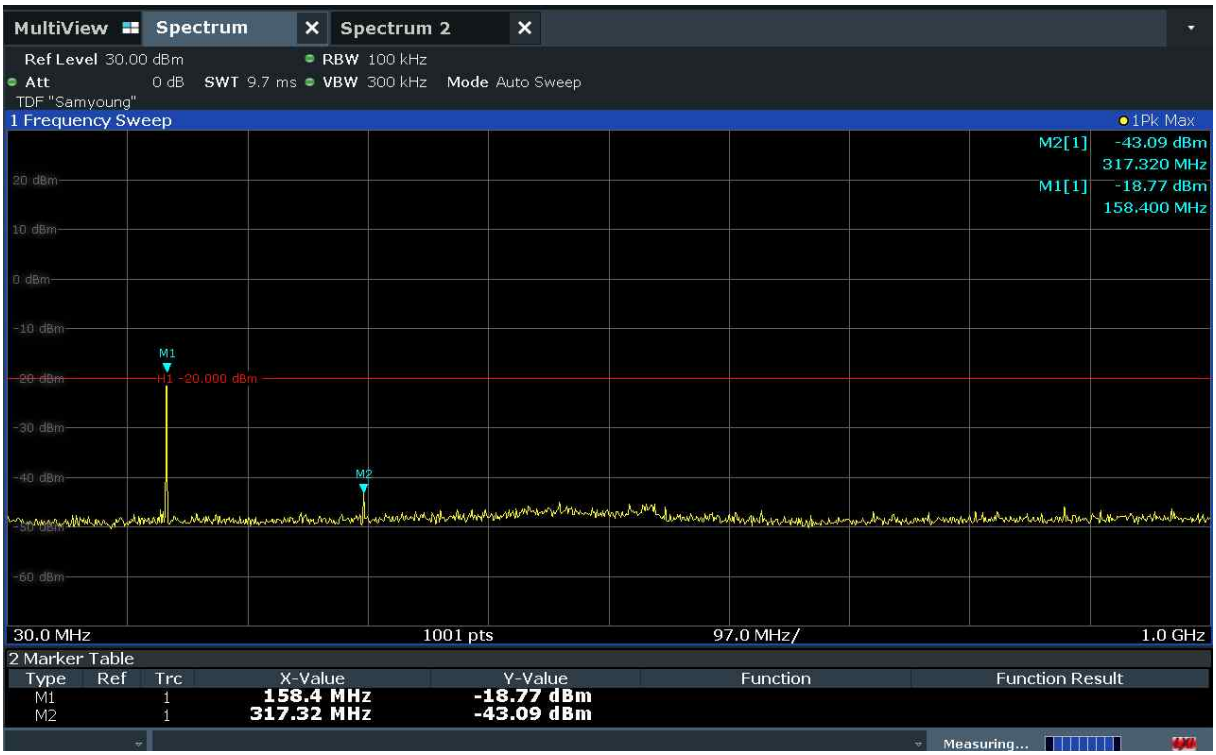
CH Low : 138.0125 MHz



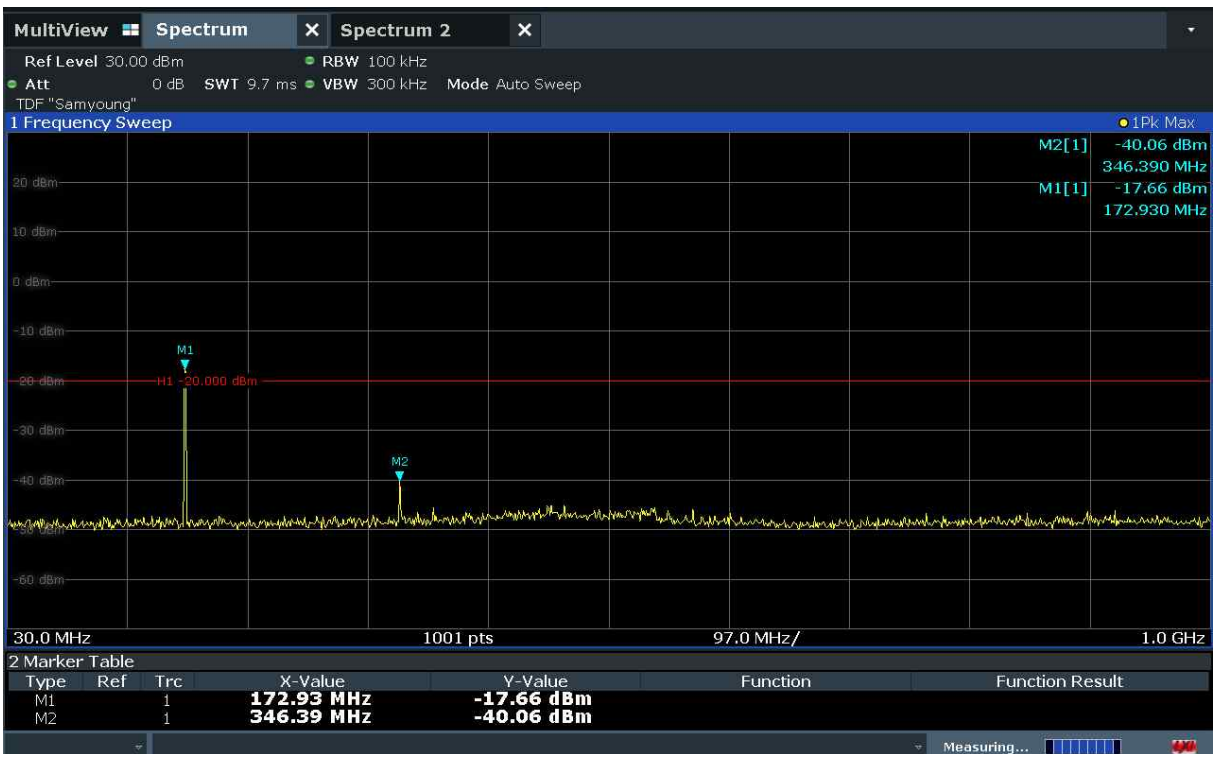
CH Middle : 151.1000 MHz



CH Mid : 158.55 MHz

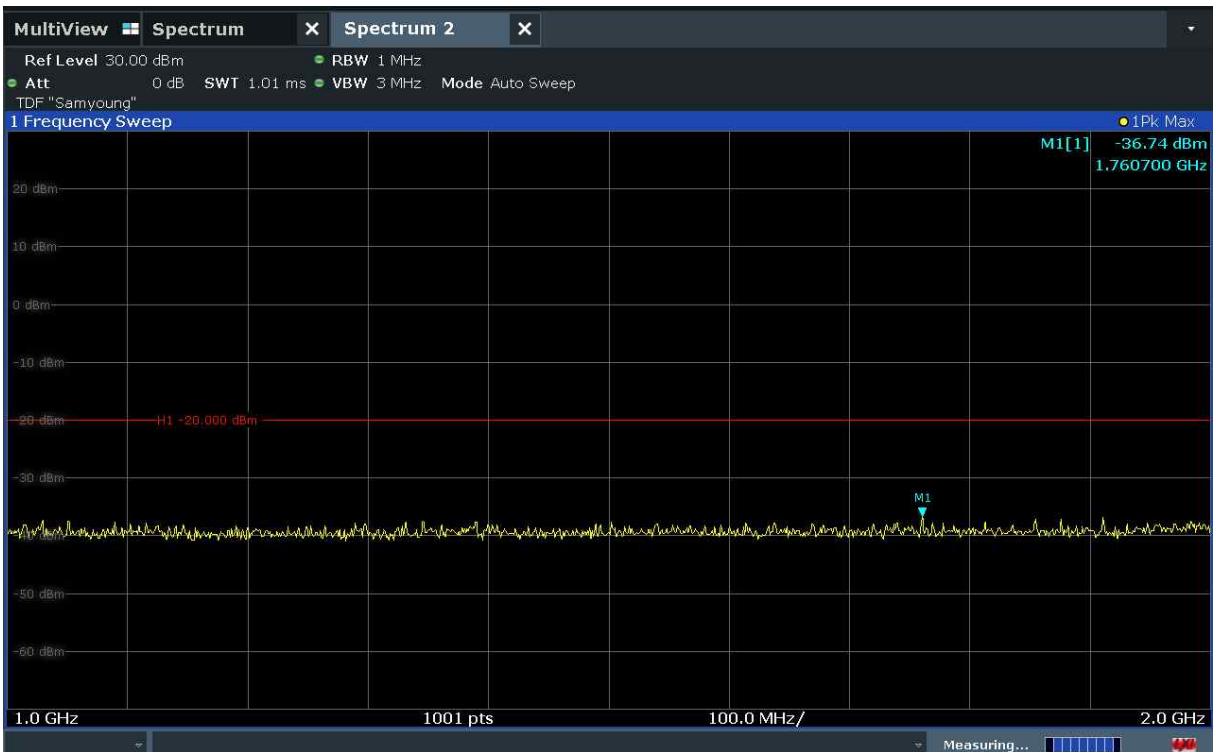


CH High : 173.3875 MHz

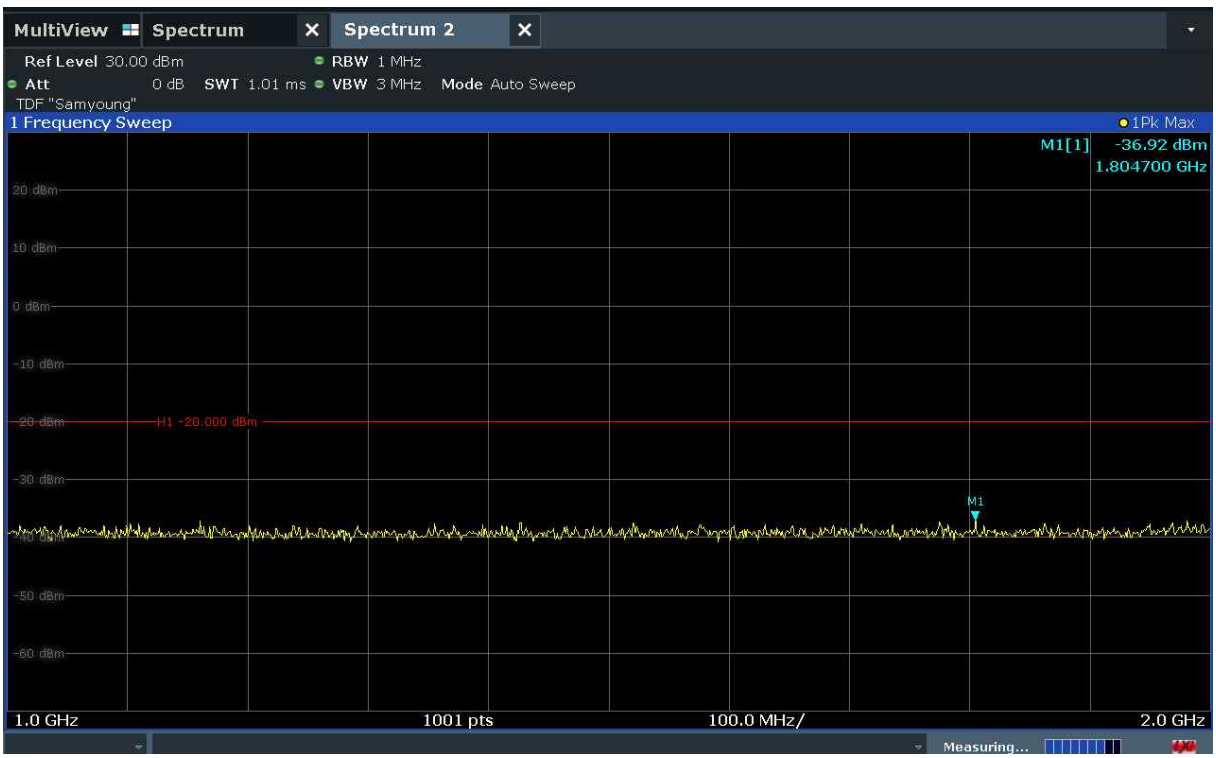


Above 1GHz / Digital / Power level: High

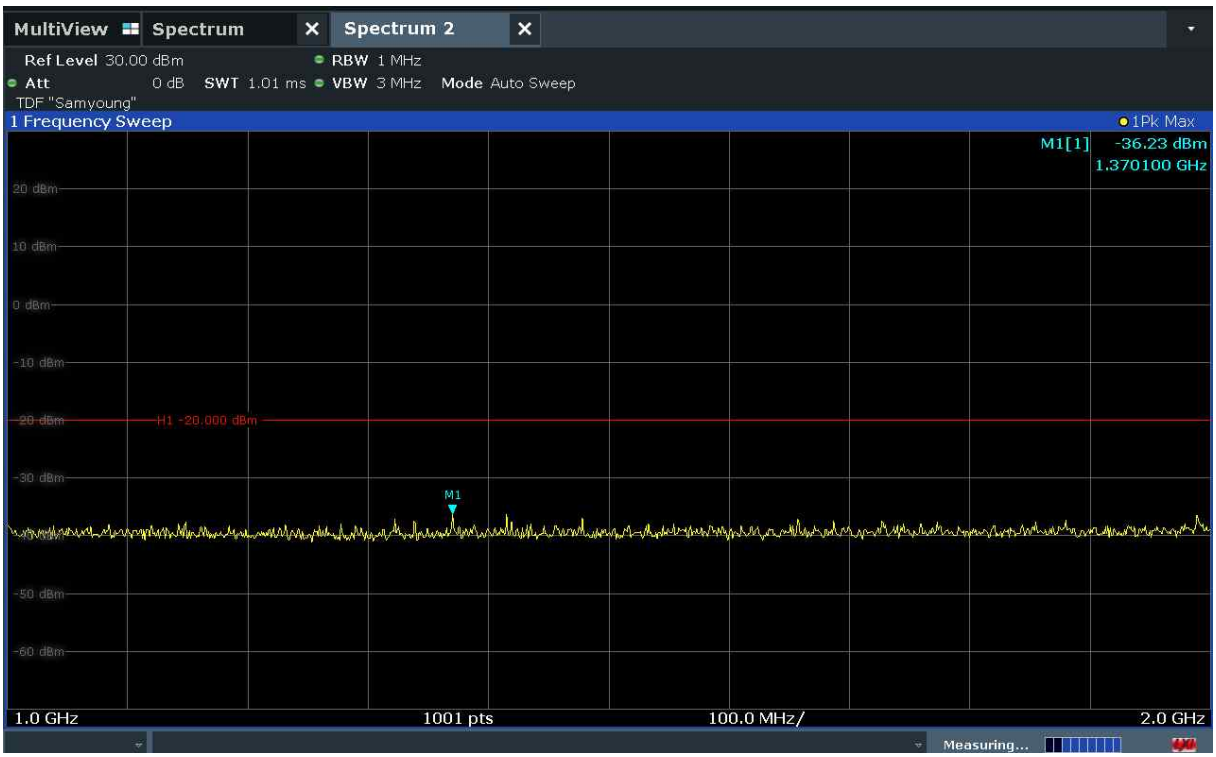
CH Low : 138.0125 MHz



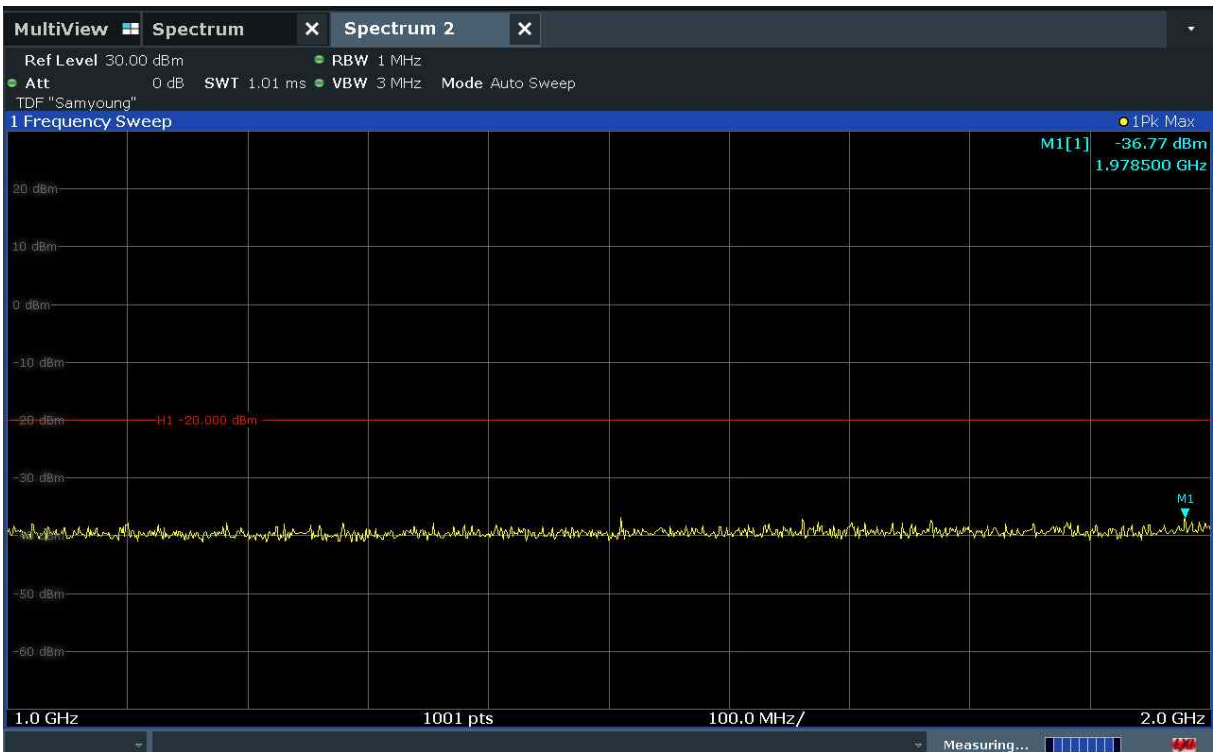
CH Middle : 151.1000 MHz



CH Mid : 158.55 MHz



CH High : 173.3875 MHz



5.5 Transmitter Radiated Unwanted Emissions

5.5.1 Standard Applicable [FCC §90.210(d) & 2.1053]

§90.210

The power of any emission outside a licensee's frequency band(s) of operation shall be attenuated below the transmitter power (P) within the licensed band(s) of operation, measured in watts,

by at least [50+10 log (P)] dB.

5.5.2 Test Environment conditions

• Ambient temperature : (20 - 21) °C • Relative Humidity : (48 - 49) % R.H.

5.5.3 Measurement Procedure

The EUT was setup according to ANSI/TIA 603E-2013 for compliance to FCC 47CFR part 90 requirements.

As a below test procedure (①~⑬), The result value of measurement is performed to condition of the below; The EUT will operate in continuous transmission mode during the time necessary to perform the measured of the frequency. Substitution method was performed to determine the actual P_{erp}(or P_{eirp}) emission levels of the EUT.

The following test procedure as below;

The test is performed in a fully pyramidal chamber to determine the accurate frequencies, after maximum emissions level will be checked on a test chamber and measuring distance is 3 m from EUT to test antenna.

① The EUT was set on with continuous transmission mode and placed on a 0.8 meter high non-conductive table on the chamber.

② The test antenna is used on Bi-Log antenna at above 30 MHz, and used on Horn antenna at 1 GHz and then the measurements are repeated with the test antenna for vertical and horizontal polarization. The output of the test antenna will be connected to a measuring receiver, and it is set to tuned over the required standard measuring frequency range.

③ At each frequency at which a relevant spurious component is detected, the test antenna will be raised and lowered through the specified range of heights until an maximum signal level is detected on the measuring receiver.

④ The EUT is position x, y, z axis on rotating through 360 degrees in the horizontal plane, until the Max. signal level is detected by the measuring receiver.

⑤ The receiver is scanned from requested measuring frequency band and then the maximum meter reading is recorded. The radiated emissions were measured with requested standard specification (detector and resolution bandwidth etc.)

⑥ The EUT was then removed and replaced with substitution antenna .The center of the antenna was approximately at the same location as the center of the EUT, and calibrated for the frequency of the spurious component detected.

⑦ Signal generator output port connected with substitution antenna input port. If necessary, may use shield cable between signal generator and substitution antenna

⑧ The frequency of the calibrated signal generator is set to frequency of the spurious component detected, and the input attenuator setting of the measuring receiver was adjust in order to increase the sensitivity of the measuring receiver, if necessary

⑨ The test antenna was raised and lowered through the specified range of heights to ensure that maximum signal is received.

⑩ The input signal to the substitution antenna was be adjusted until an equal or a known related level to that detected from the transmitter is obtained on the measuring receiver.

⑪ The input signal to the substitution antenna was be recorded as a power level and corrected for any change of input attenuator setting of the measuring receiver

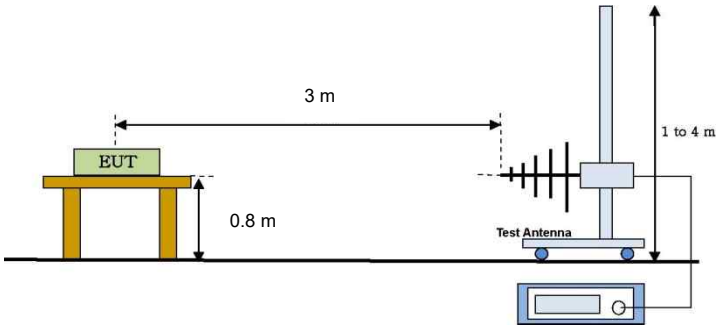
⑫ The measure of P_{erp}(or P_{eirp}) the spurious components is the larger of the two power levels recorded for each spurious component at the input to the substitution antenna, corrected for the gain of the substitution antenna, if necessary.

⑬ It is correction to signal generator's offset value. In this case of P_{erp}(or P_{eirp}) shall calculated as follow as formula ;

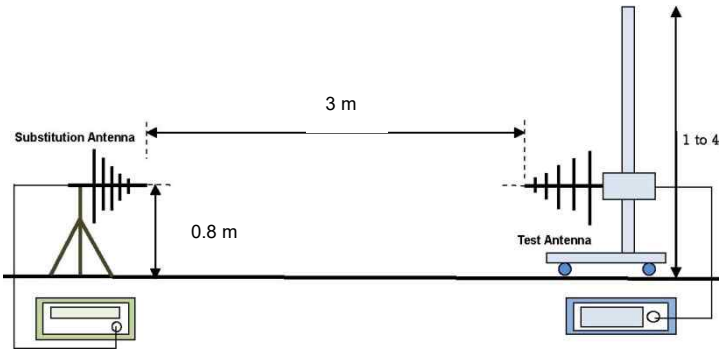
• P_{erp}(or P_{eirp}) = Signal generator level (dBm) – Cable loss(dB)

The measurement frequency range from 30 MHz - 10th Harmonic of fundamental was investigated.

5.5.5 Test Setup



[Radiated measurement setup_Below than 1 GHz]



[Effective Radiated Power measurement setup]

※ Above the test antenna is used on Horn antenna at above 1 GHz.

Measurement Uncertainty

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI C63.10-2013. All measurement uncertainty values are shown with a coverage factor of k = 2 to indicate a 95% level of confidence. The measurement uncertainty shown below meets or exceeds the UCISPR measurement uncertainty values specified in CISPR 16-4-2 and, thus, can be compared directly to specified limits to determine compliance.

Radiated Emission measurement: Below 1 GHz: 3.62 dB (CL: Approx 95 %, k=2)
Above 1 GHz: 4.06 dB (CL: Approx 95 %, k=2)

5.5.6 Measurement Result

The following frequencies were selected based on the antenna conducted results, the worst case for each mode are presented.

Analog / 138.0125 MHz / High power

Emission Frequency [MHz]	Level below Carrier [dBc]	Limit [dBc]	Test Results
276.025	63.24	See Note	Compliance
414.038	75.41		Compliance
552.050	79.43		Compliance
Note: The formula for limit is below; 50+10 log (P) where, P = EUT's output power in W Therefore 50+10log(1.06) = 50.25 dBc			

Digital / 138.0125 MHz / Low power

Emission Frequency [MHz]	Level below Carrier [dBc]	Limit [dBc]	Test Results
276.025	63.53	See Note	Compliance
414.038	76.36		Compliance
552.050	79.84		Compliance
Note: The formula for limit is below; 50+10 log (P) where, P = EUT's output power in W Therefore 50+10log(1.06) = 50.25 dBc			

5.6 Frequency Stability

5.6.1 Standard Applicable [FCC §90.213 & 2.1055]

§90.213

The EUT is placed in a temperature chamber, the EUT is allowed to soak at room temperature for 20 minutes and a reference frequency is read. The temperature is then lowered to -30 C and stepped up to 50 C soaking 20 minutes at each temperature then a frequency is read. According to §90.213, the frequency stability limit is 2.5 ppm for 12.5 kHz channel separation.

5.6.2 Test Environment conditions

• Ambient temperature : (20 - 21) °C • Relative Humidity : (48 - 49) % R.H.

5.6.3 Measurement Procedure

EUT connect to Spectrum analyzer, test is performed in T&H chamber.

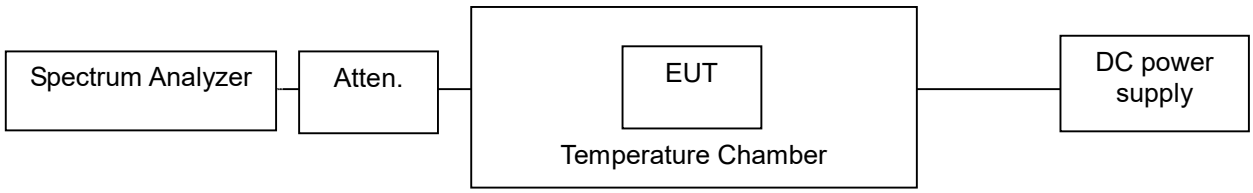
These measurements shall also be performed at normal and extreme test conditions.

▪ Test Method : ANSI/TIA-603-E-2016, clause 3.2.2 for frequency stability tests

-Frequency stability with respect to ambient temperature

-Frequency stability when varying supply voltage

5.6.4 Test setup



5.6.5 Measurement Result

Analog

Temp(℃)	Power Supply	Measured Freq(MHz)	Freq Drift(ppm)
50	DC 7.4 (Vnom)	158.550 120	0.76
40	DC 7.4 (Vnom)	158.550 103	0.65
30	DC 7.4 (Vnom)	158.550 070	0.44
20	DC 7.4 (Vnom)	158.550 043	0.27
10	DC 7.4 (Vnom)	158.550 036	0.23
0	DC 7.4 (Vnom)	158.550 020	0.13
-10	DC 7.4 (Vnom)	158.549 975	-0.16
-20	DC 7.4 (Vnom)	158.549 967	-0.21
-30	DC 7.4 (Vnom)	158.549 963	-0.23
Nom Temperature	DC 6.3 (Vmin)	158.550 040	0.25
Nom Temperature	DC 8.5 (Vmax)	158.550 041	0.26

Digital (Voice and Data)

Temp(℃)	Power Supply	Measured Freq(㎒)	Freq Drift(ppm)
50	DC 7.4 (Vnom)	158.550 147	0.93
40	DC 7.4 (Vnom)	158.550 143	0.90
30	DC 7.4 (Vnom)	158.550 135	0.85
20	DC 7.4 (Vnom)	158.550 092	0.58
10	DC 7.4 (Vnom)	158.550 085	0.54
0	DC 7.4 (Vnom)	158.550 072	0.45
-10	DC 7.4 (Vnom)	158.549 990	-0.06
-20	DC 7.4 (Vnom)	158.549 980	-0.13
-30	DC 7.4 (Vnom)	158.549 971	-0.18
Nom Temperature	DC 6.3 (Vmin)	158.550 094	0.59
Nom Temperature	DC 8.5 (Vmax)	158.550 091	0.57

5.7 Transmitter Frequency Behavior

5.7.1 Standard Applicable [FCC §90.214]

Transient frequencies must be within the maximum frequency difference limits during the time intervals indicated:

Time Intervals	Maximum frequency difference	All equipment (421 to 512 MHz)
Transient Frequency Behavior for Equipment Designed to operate on the 12.5 kHz Channels		
t_1[4]	±12.5 kHz	10 ms
t_2	±6.25 kHz	25 ms
t_3[4]	±12.5 kHz	10 ms

5.7.2 Test Environment conditions

• Ambient temperature : (20 - 21) °C • Relative Humidity : (48 - 49) % R.H.

5.7.3 Measurement Procedure

a) Connect the EUT and test equipment as shown on the following test setup diagram.

b) Set the Spectrum Analyzer to measure FM deviation, and tune the RF frequency to the transmitter assigned frequency.

c) Set the signal generator to the assigned transmitter frequency and modulate it with a 1 kHz tone at ±12.5 kHz deviation and set its output level to -100 dBm.

d) Turn on the transmitter.

e) Supply sufficient attenuation via the RF attenuator to provide an input level to the Spectrum Analyzer that is 40 dB below the maximum allowed input power when the transmitter is operating at its rated power level. Note this power level on the Spectrum Analyzer as P0.

f) Turn off the transmitter.

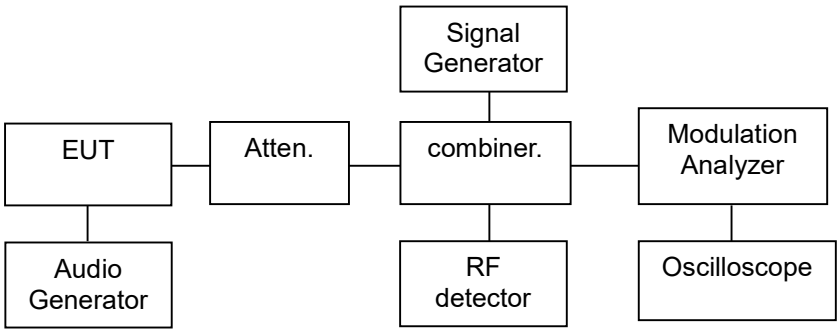
g) Adjust the RF level of the signal generator to provide RF power equal to P0. This signal generator RF level shall be maintained throughout the rest of the measurement.

h) Remove the attenuation 1, so the input power to the Spectrum Analyzer is increased by 30 dB when the transmitter is turned on.

i) Adjust the vertical amplitude control of the spectrum analyzer to display the 1000 Hz at ±4 divisions vertically centered on the display. Set trigger mode of the Spectrum Analyzer to “Video”, and tune the “trigger level” on suitable level. Then set the “tiger offset” to -10ms for turn on and -15 ms for turn off.

j) Turn on the transmitter and the transient wave will be captured on the screen of Spectrum Analyzer. Observe the stored display. The instant when the 1 kHz test signal is completely suppressed is considered to be ton. The trace should be maintained within the allowed divisions during the period t1 and t2.

5.7.4 Test setup



5.7.5 Measurement Result

OFF - ON

ON - OFF