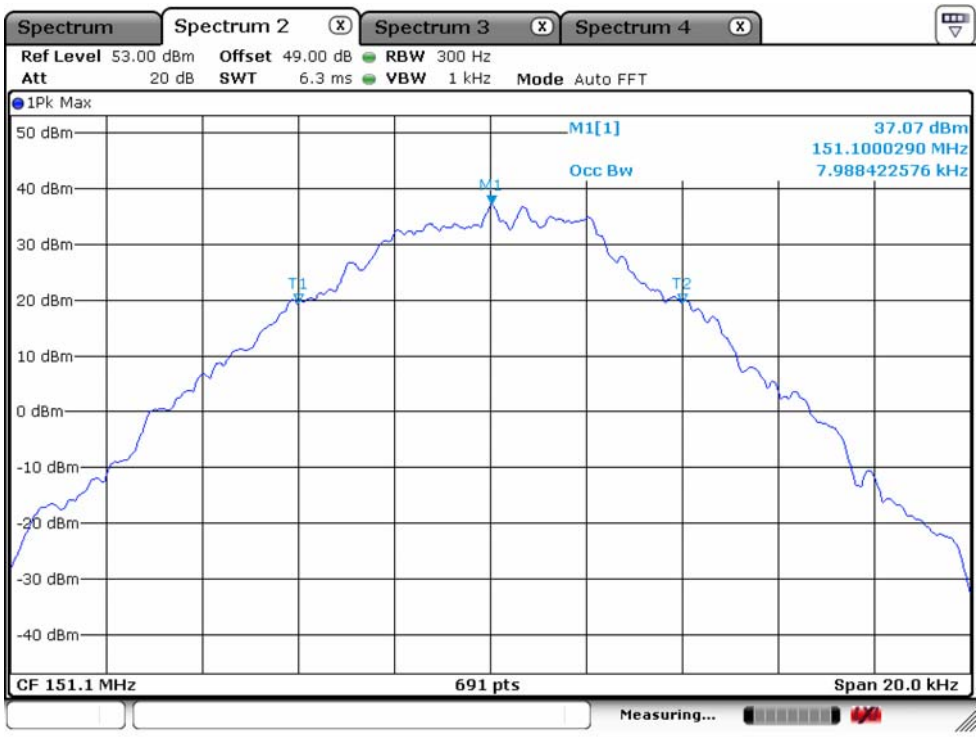
99 % band width for Digital / Power level: High

CH Low : 138.0125 MHz

CH Middle : 151.1000 MHz

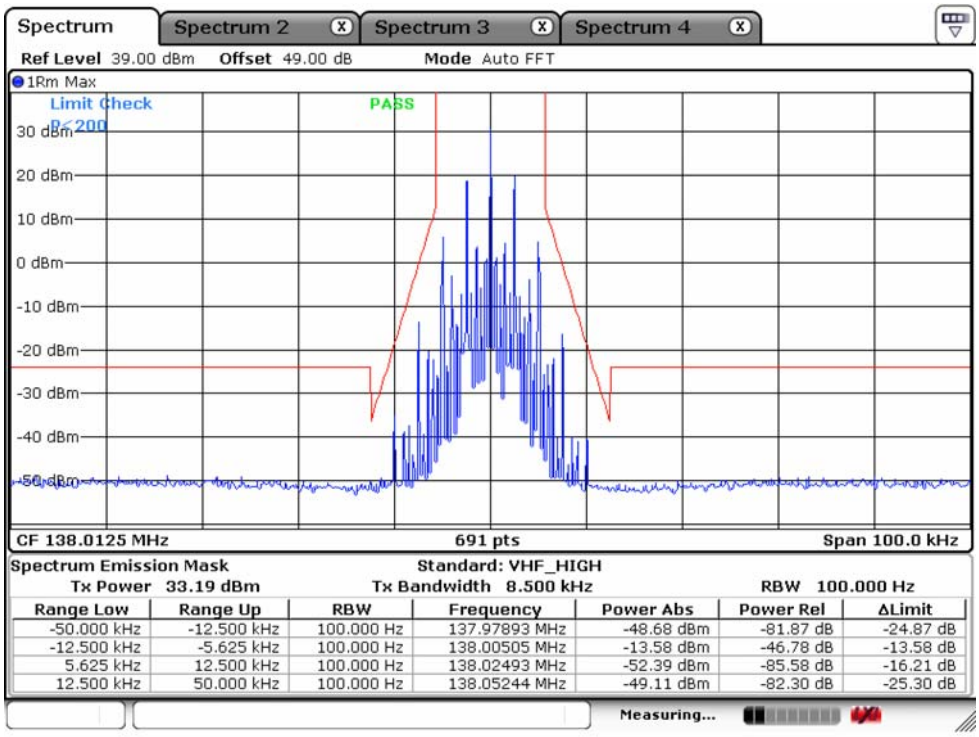


CH Mid : 158.55 MHz

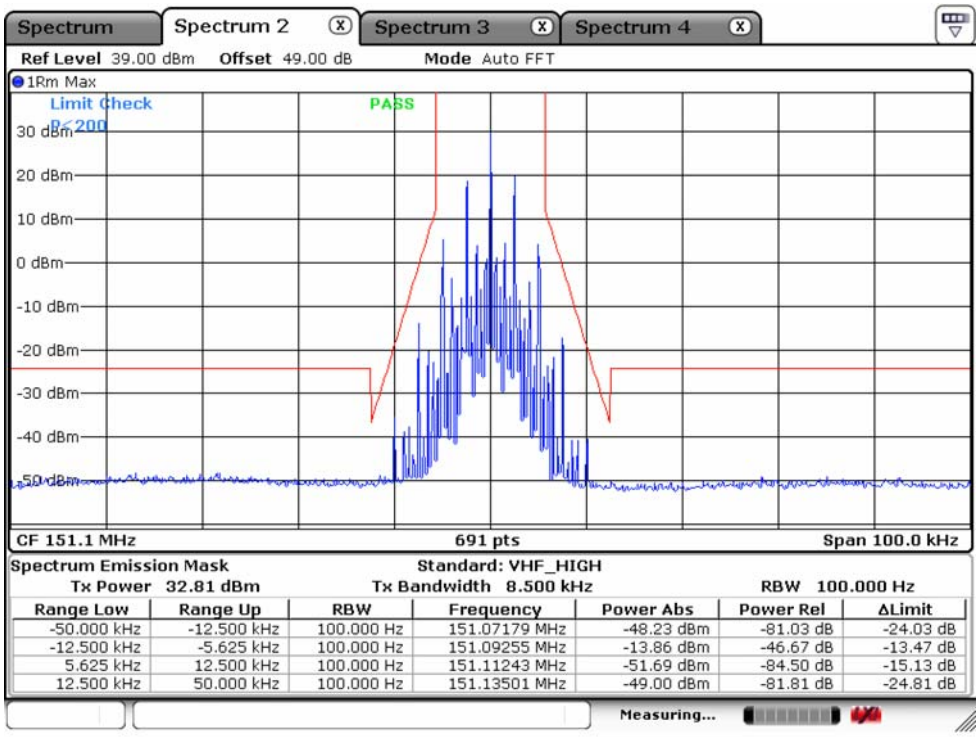
CH High : 173.3875 MHz

Emission Mask for analog / Power level: Low

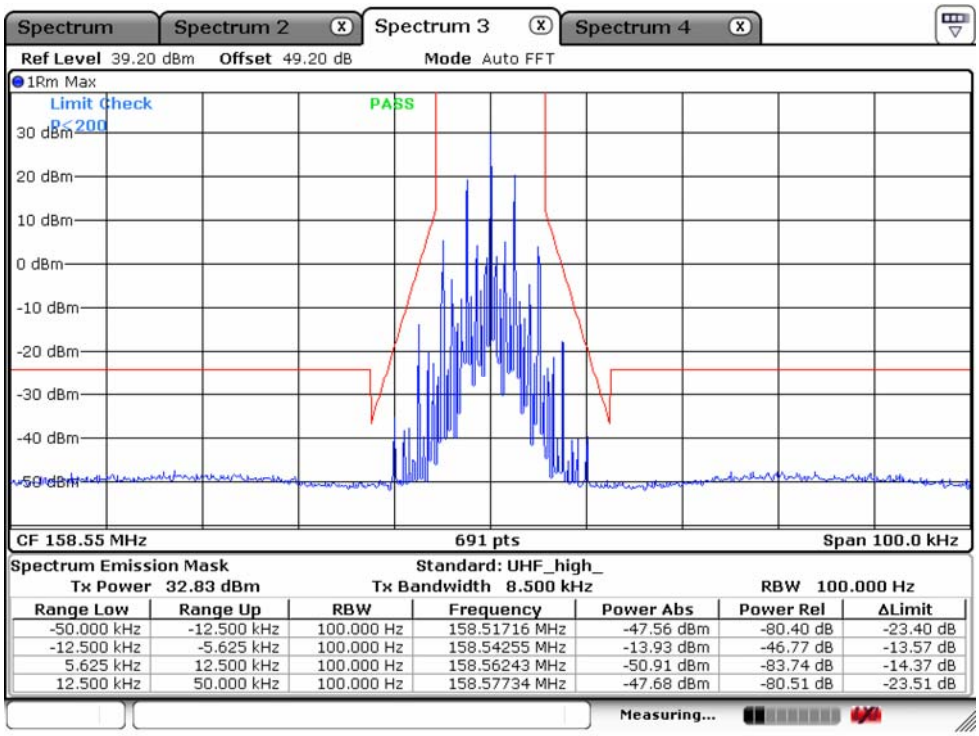
CH Low : 138.0125 MHz



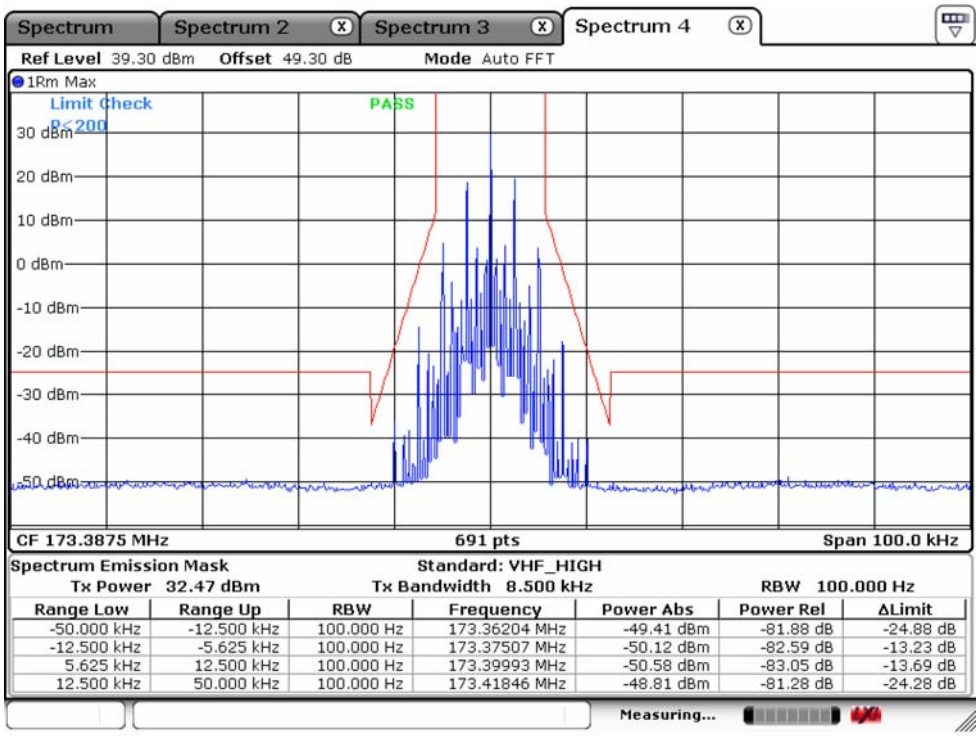
CH Middle : 151.1000 MHz



CH Mid : 158.55 MHz

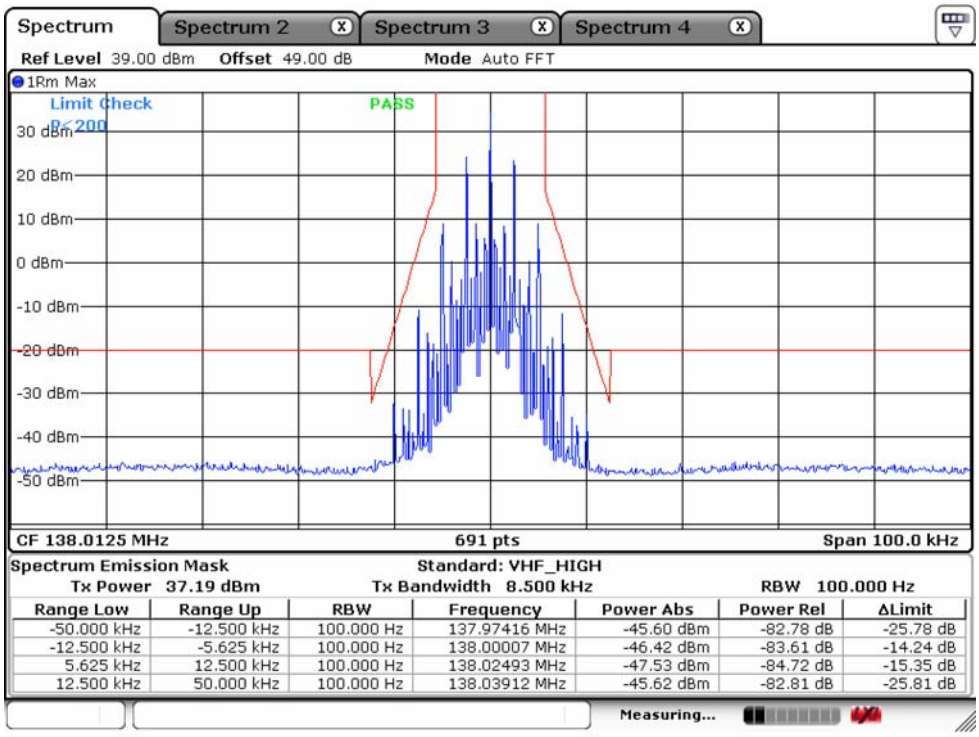


CH High : 173.3875 MHz

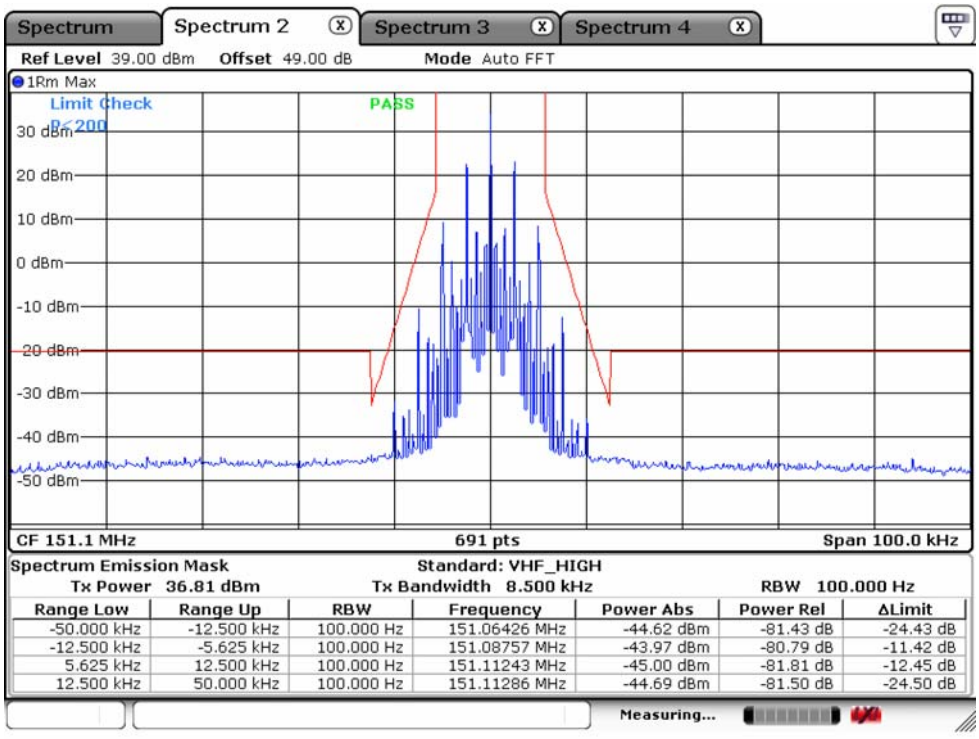


Emission Mask for analog / Power level: High

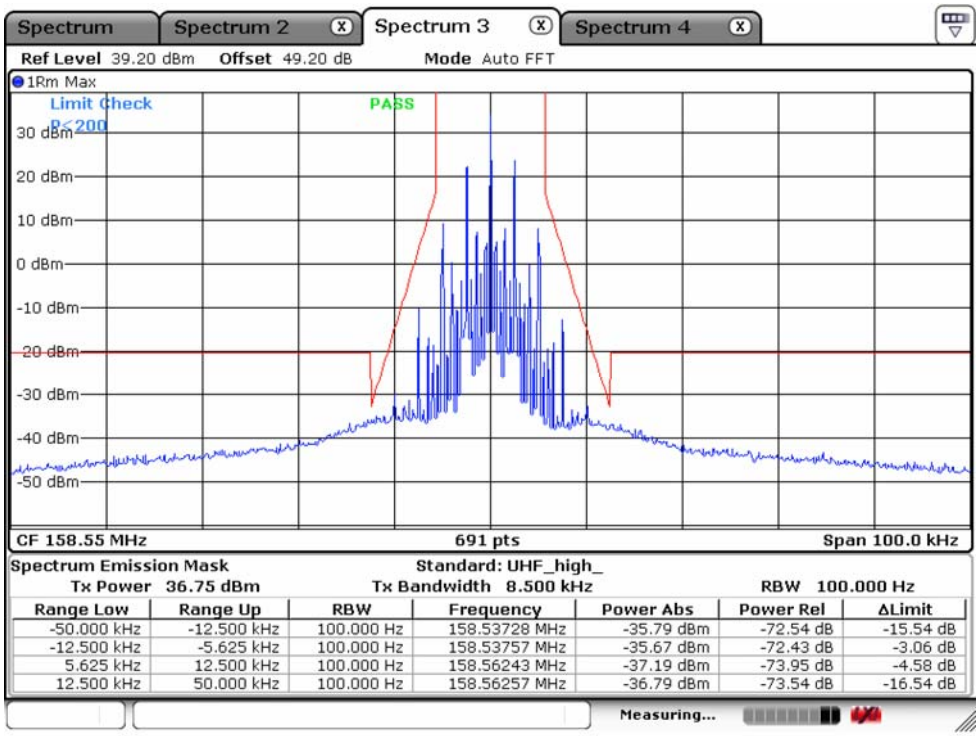
CH Low : 138.0125 MHz



CH Middle : 151.1000 MHz

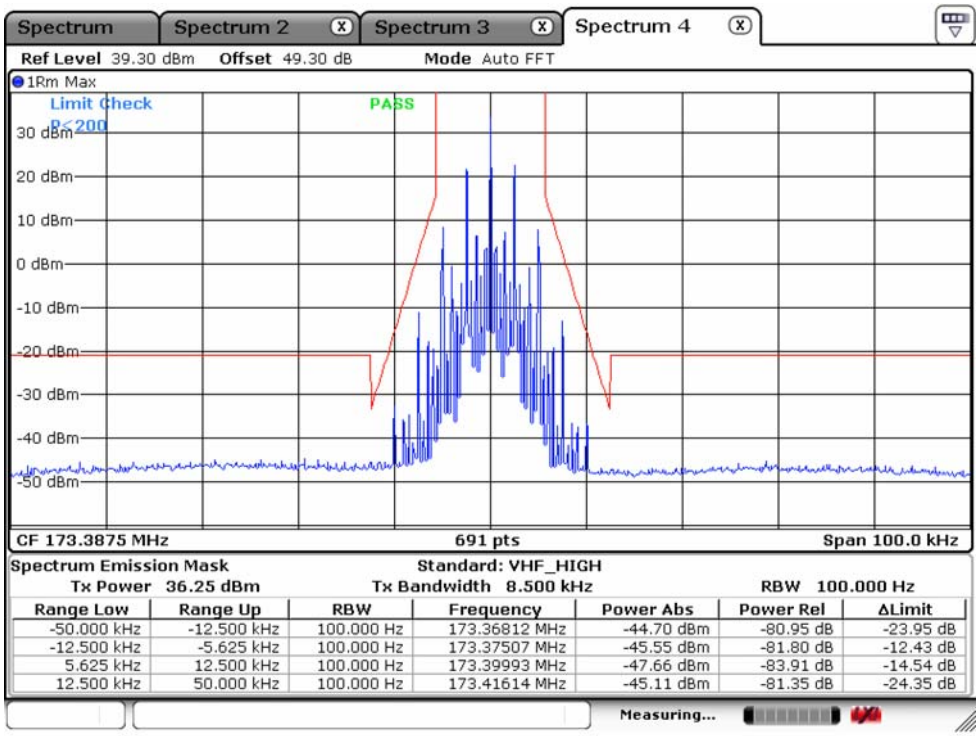


CH Mid : 158.55 MHz



Range Low	Range Up	RBW	Frequency	Power Abs	Power Rel	ΔLimit
-50.000 kHz	-12.500 kHz	100.000 Hz	158.53728 MHz	-35.79 dBm	-72.54 dB	-15.54 dB
-12.500 kHz	-5.625 kHz	100.000 Hz	158.53757 MHz	-35.67 dBm	-72.43 dB	-3.06 dB
5.625 kHz	12.500 kHz	100.000 Hz	158.56243 MHz	-37.19 dBm	-73.95 dB	-4.58 dB
12.500 kHz	50.000 kHz	100.000 Hz	158.56257 MHz	-36.79 dBm	-73.54 dB	-16.54 dB

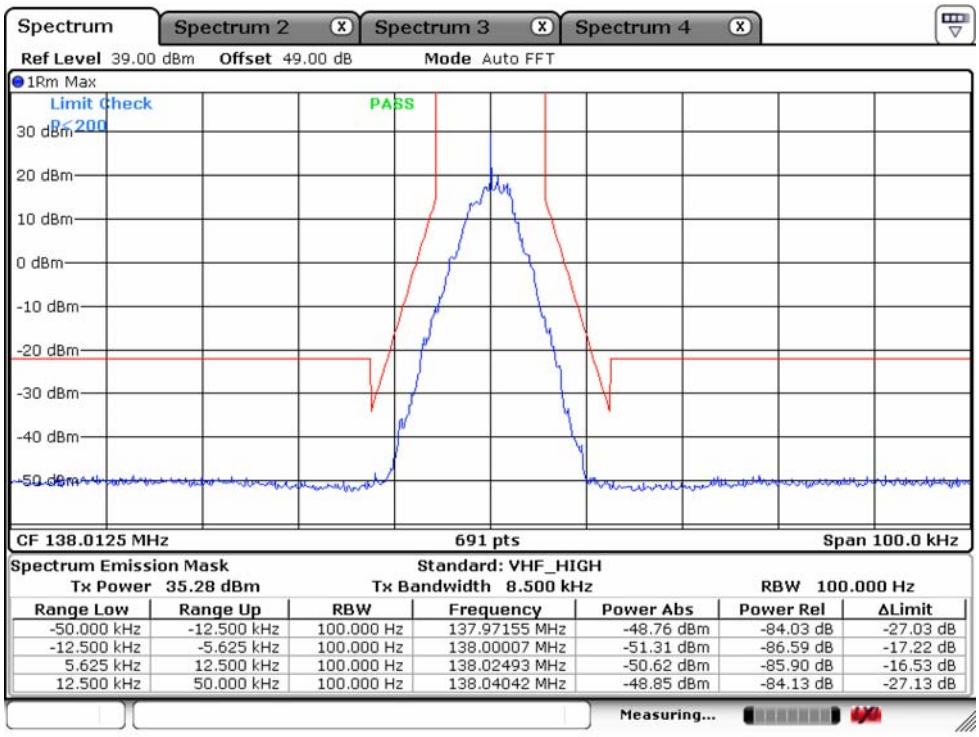
CH High : 173.3875 MHz



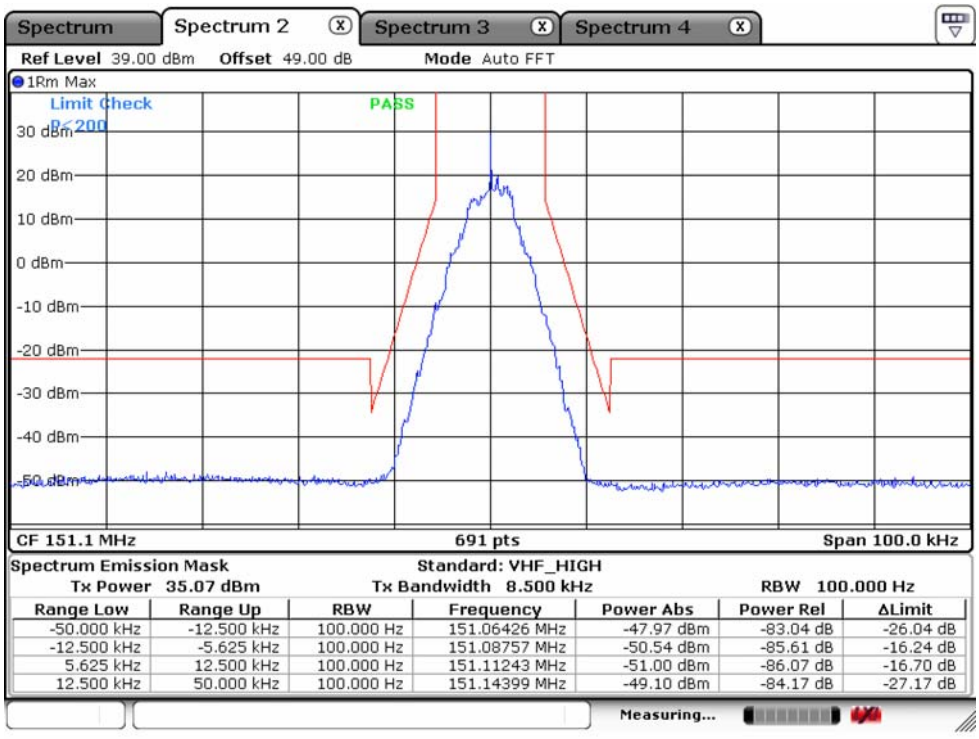
Range Low	Range Up	RBW	Frequency	Power Abs	Power Rel	ΔLimit
-50.000 kHz	-12.500 kHz	100.000 Hz	173.36812 MHz	-44.70 dBm	-80.95 dB	-23.95 dB
-12.500 kHz	-5.625 kHz	100.000 Hz	173.37507 MHz	-45.55 dBm	-81.80 dB	-12.43 dB
5.625 kHz	12.500 kHz	100.000 Hz	173.39993 MHz	-47.66 dBm	-83.91 dB	-14.54 dB
12.500 kHz	50.000 kHz	100.000 Hz	173.41614 MHz	-45.11 dBm	-81.35 dB	-24.35 dB

Emission Mask for Digital / Power level: Low

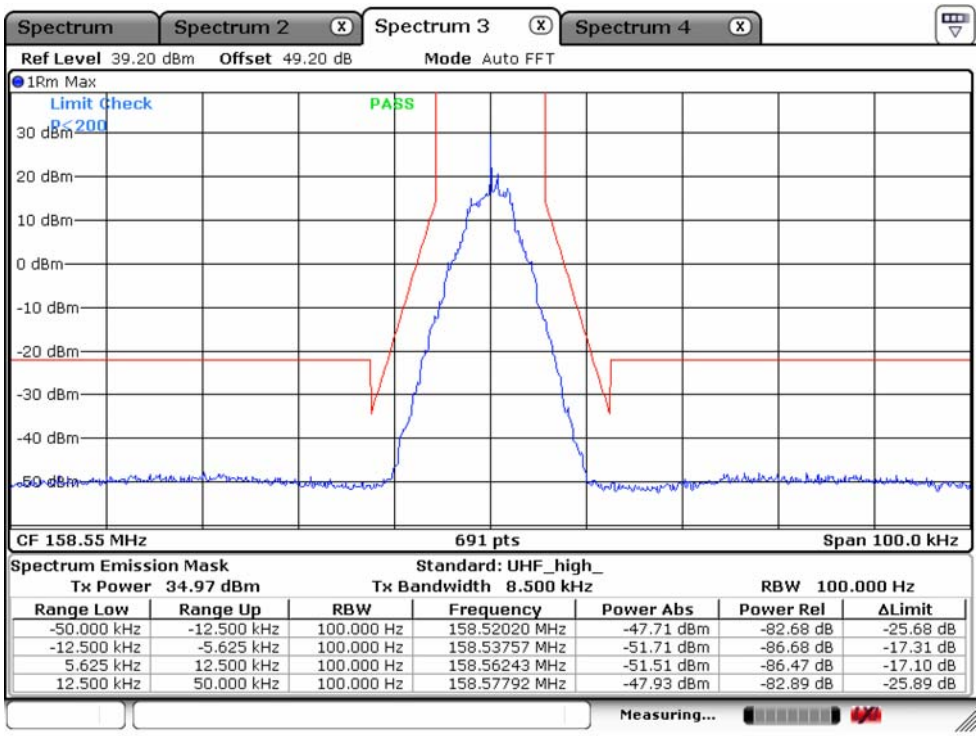
CH Low : 138.0125 MHz



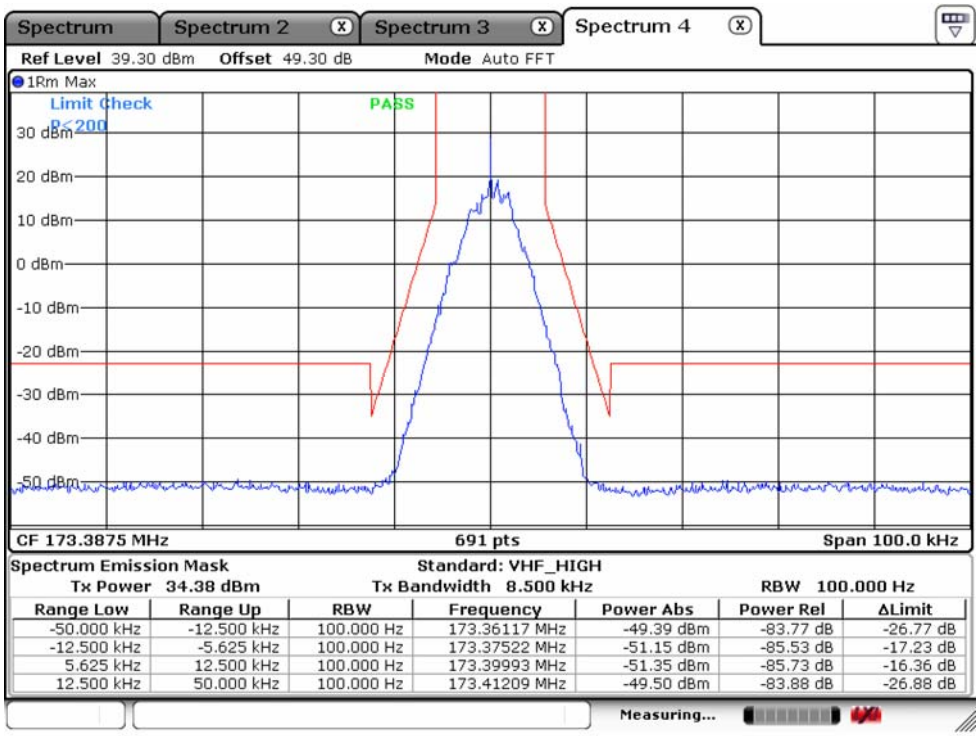
CH Middle : 151.1000 MHz



CH Mid : 158.55 MHz

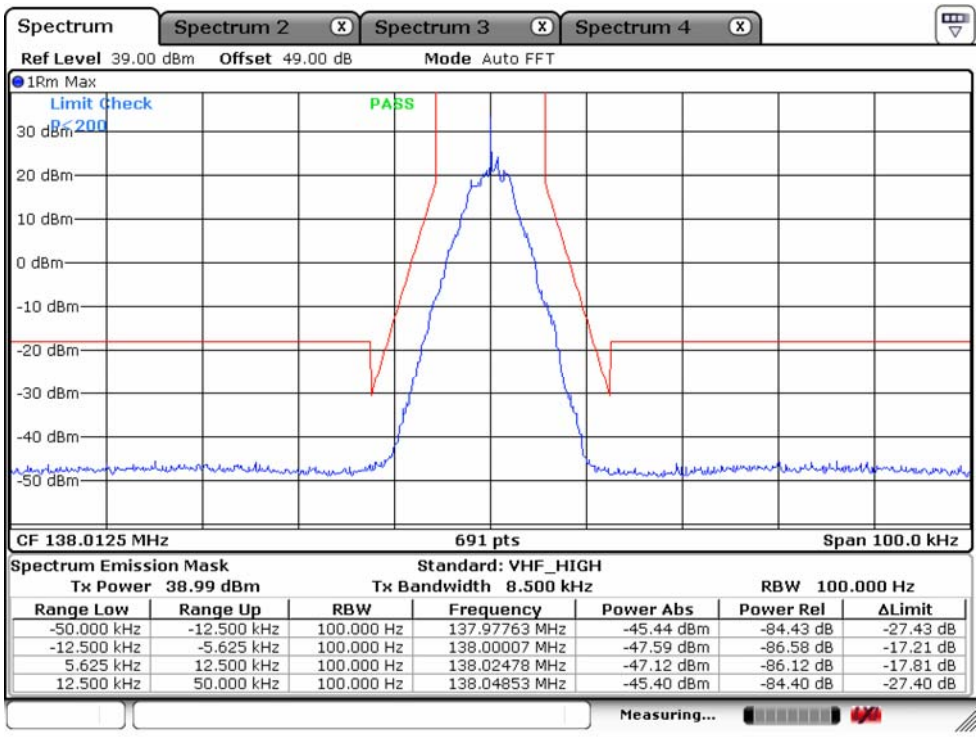


CH High : 173.3875 MHz



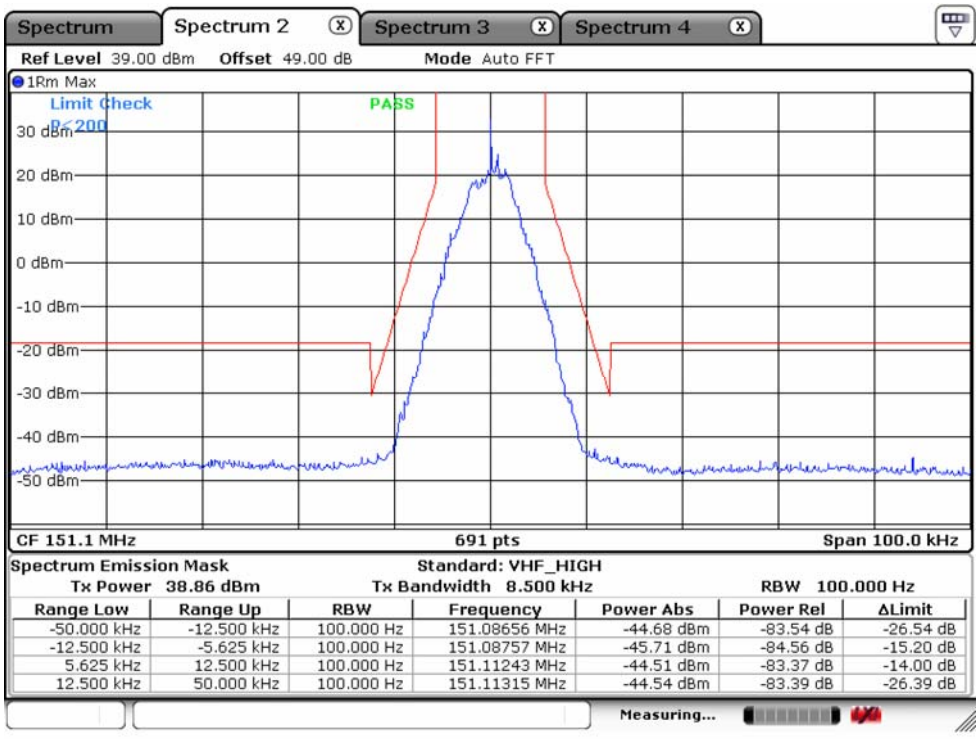
Emission Mask for Digital / Power level: High

CH Low : 138.0125 MHz



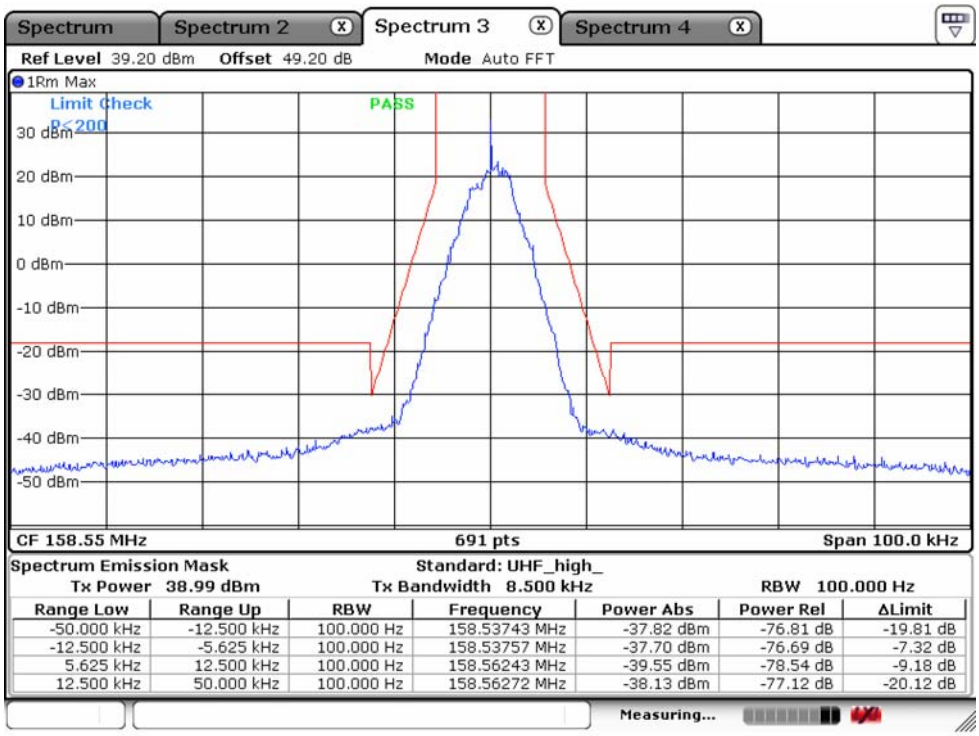
Range Low	Range Up	RBW	Frequency	Power Abs	Power Rel	ΔLimit
-50.000 kHz	-12.500 kHz	100.000 Hz	137.97763 MHz	-45.44 dBm	-84.43 dB	-27.43 dB
-12.500 kHz	-5.625 kHz	100.000 Hz	138.00007 MHz	-47.59 dBm	-86.58 dB	-17.21 dB
5.625 kHz	12.500 kHz	100.000 Hz	138.02478 MHz	-47.12 dBm	-86.12 dB	-17.81 dB
12.500 kHz	50.000 kHz	100.000 Hz	138.04853 MHz	-45.40 dBm	-84.40 dB	-27.40 dB

CH Middle : 151.1000 MHz



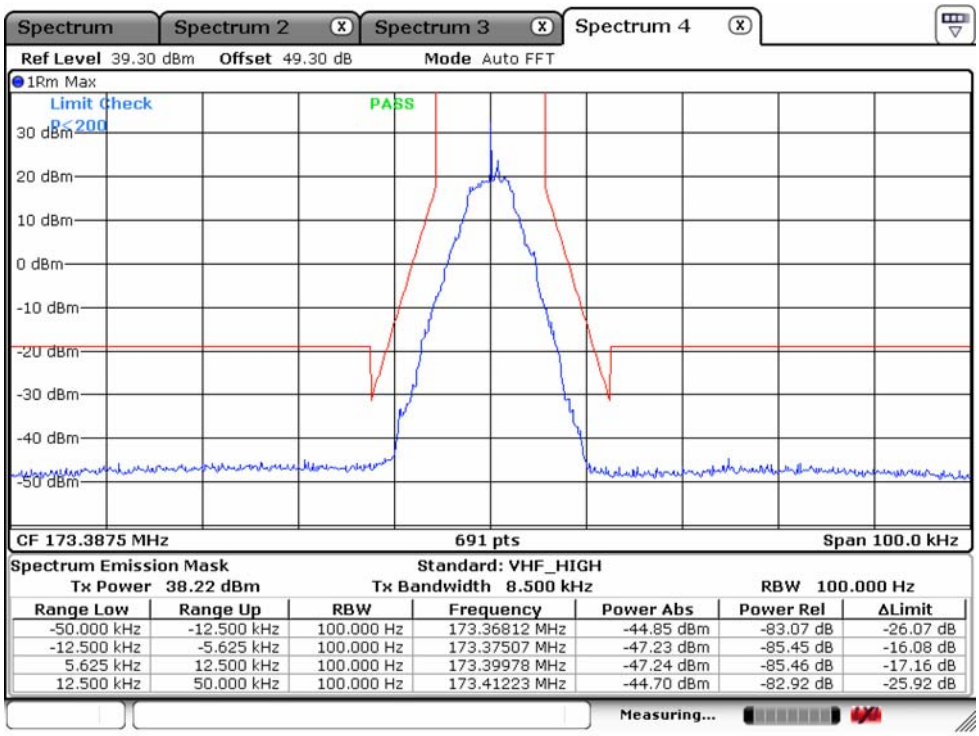
Range Low	Range Up	RBW	Frequency	Power Abs	Power Rel	ΔLimit
-50.000 kHz	-12.500 kHz	100.000 Hz	151.08656 MHz	-44.68 dBm	-83.54 dB	-26.54 dB
-12.500 kHz	-5.625 kHz	100.000 Hz	151.08757 MHz	-45.71 dBm	-84.56 dB	-15.20 dB
5.625 kHz	12.500 kHz	100.000 Hz	151.11243 MHz	-44.51 dBm	-83.37 dB	-14.00 dB
12.500 kHz	50.000 kHz	100.000 Hz	151.11315 MHz	-44.54 dBm	-83.39 dB	-26.39 dB

CH Mid : 158.55 MHz



Range Low	Range Up	RBW	Frequency	Power Abs	Power Rel	ΔLimit
-50.000 kHz	-12.500 kHz	100.000 Hz	158.53743 MHz	-37.82 dBm	-76.81 dB	-19.81 dB
-12.500 kHz	-5.625 kHz	100.000 Hz	158.53757 MHz	-37.70 dBm	-76.69 dB	-7.32 dB
5.625 kHz	12.500 kHz	100.000 Hz	158.56243 MHz	-39.55 dBm	-78.54 dB	-9.18 dB
12.500 kHz	50.000 kHz	100.000 Hz	158.56272 MHz	-38.13 dBm	-77.12 dB	-20.12 dB

CH High : 173.3875 MHz



Range Low	Range Up	RBW	Frequency	Power Abs	Power Rel	ΔLimit
-50.000 kHz	-12.500 kHz	100.000 Hz	173.36812 MHz	-44.85 dBm	-83.07 dB	-26.07 dB
-12.500 kHz	-5.625 kHz	100.000 Hz	173.37507 MHz	-47.23 dBm	-85.45 dB	-16.08 dB
5.625 kHz	12.500 kHz	100.000 Hz	173.39978 MHz	-47.24 dBm	-85.46 dB	-17.16 dB
12.500 kHz	50.000 kHz	100.000 Hz	173.41223 MHz	-44.70 dBm	-82.92 dB	-25.92 dB

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

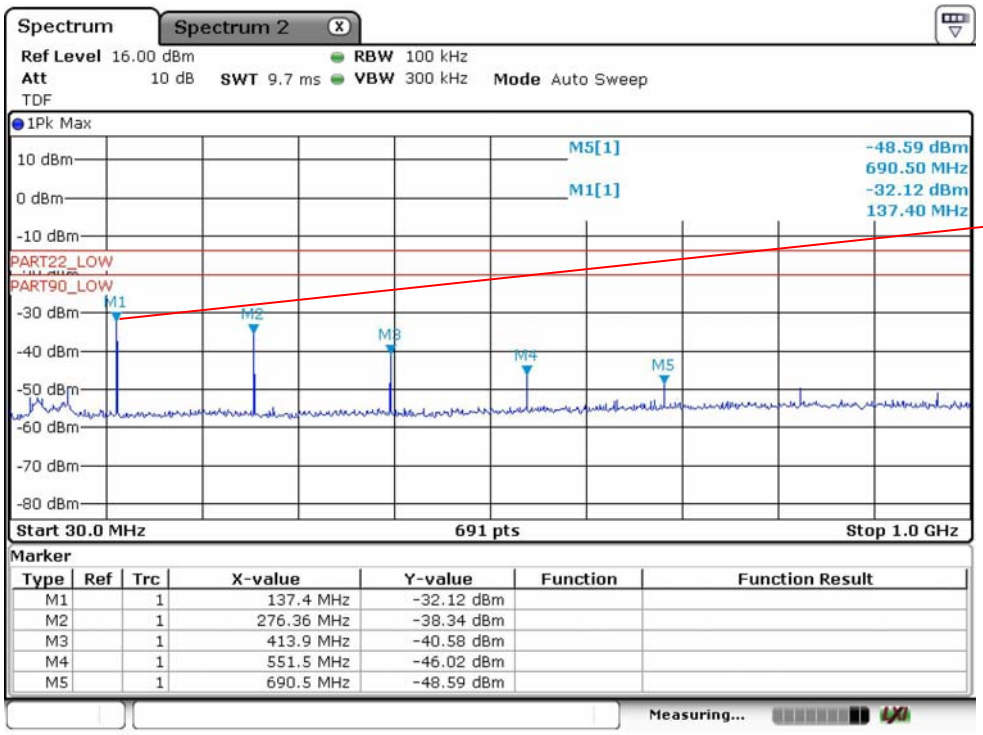
5.4.5 Measurement Result

See the 5.4.6 Test plots

5.4.6 Test Plot

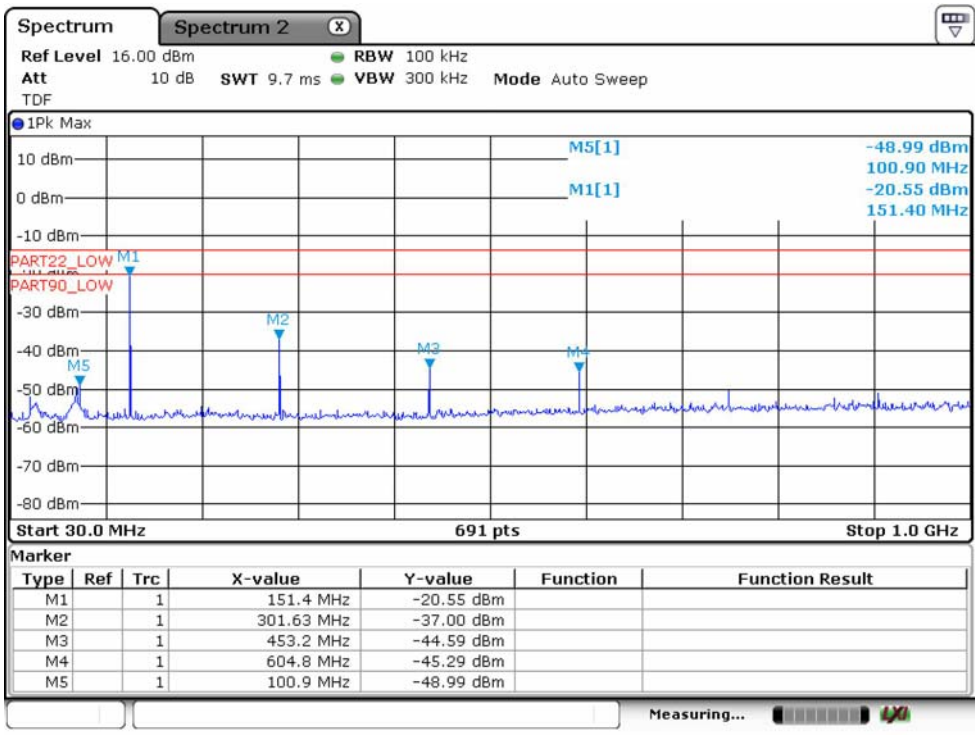
Below 1GHz / Analog / Power level: Low

CH Low : 138.0125 MHz

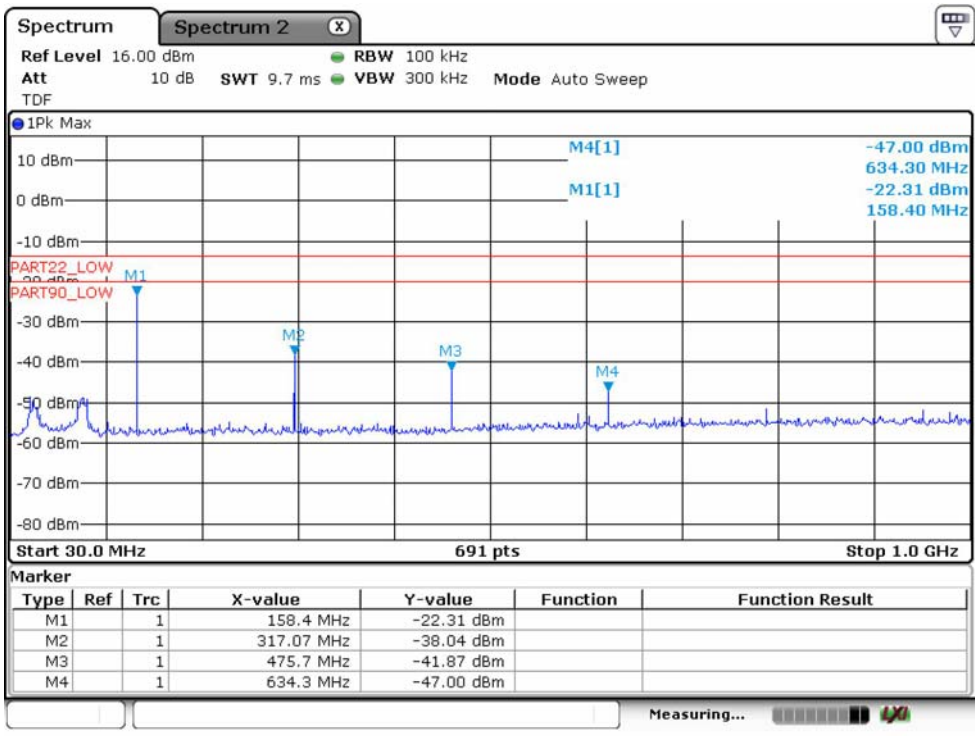


Fundamental signal was rejected by filter.

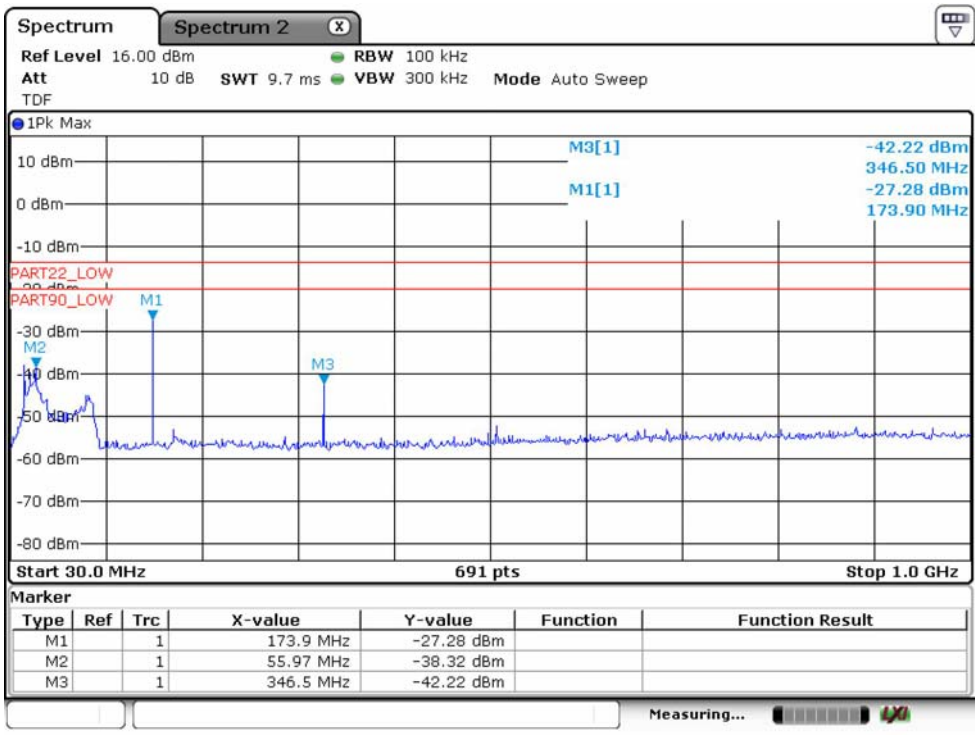
CH Middle : 151.1000 MHz



CH Mid : 158.55 MHz

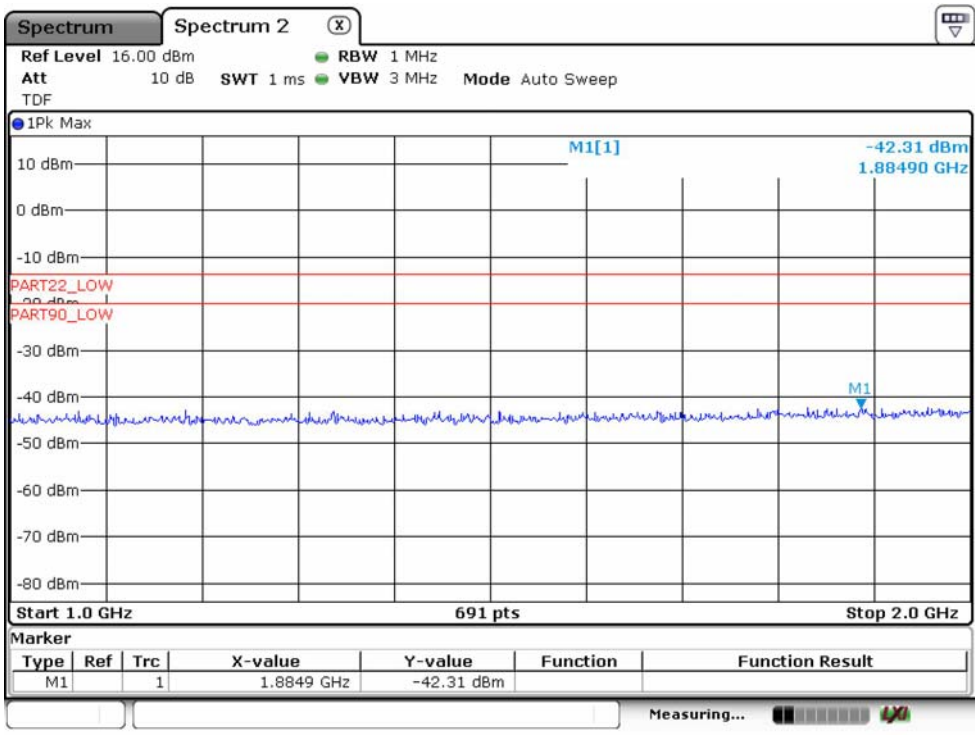


CH High : 173.3875 MHz

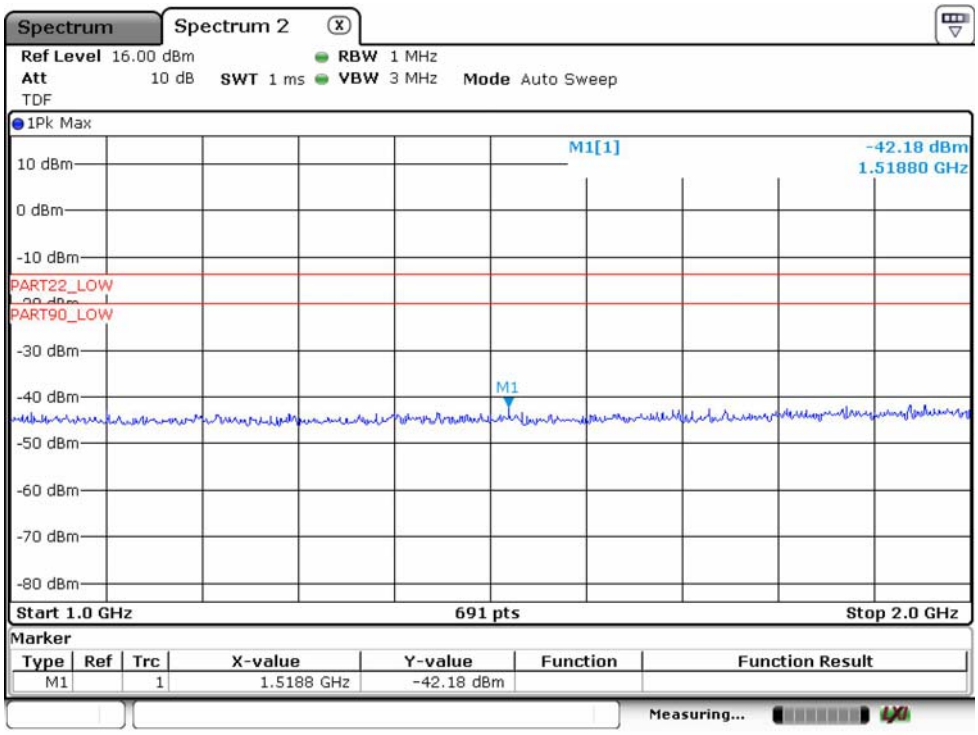


Above 1GHz / Analog / Power level: Low

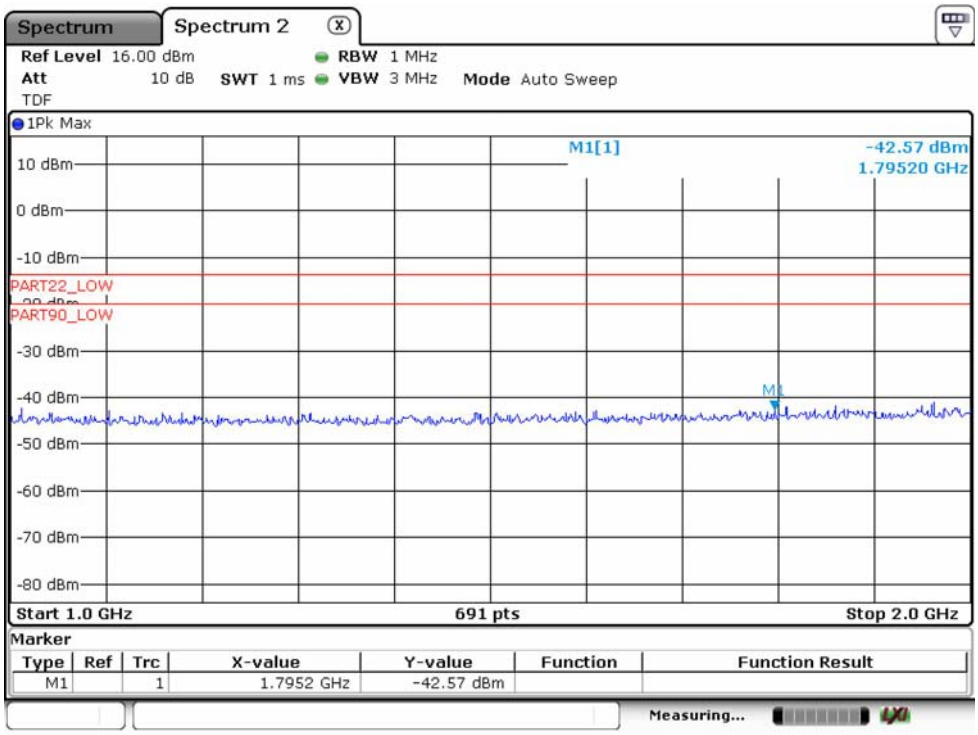
CH Low : 138.0125 MHz



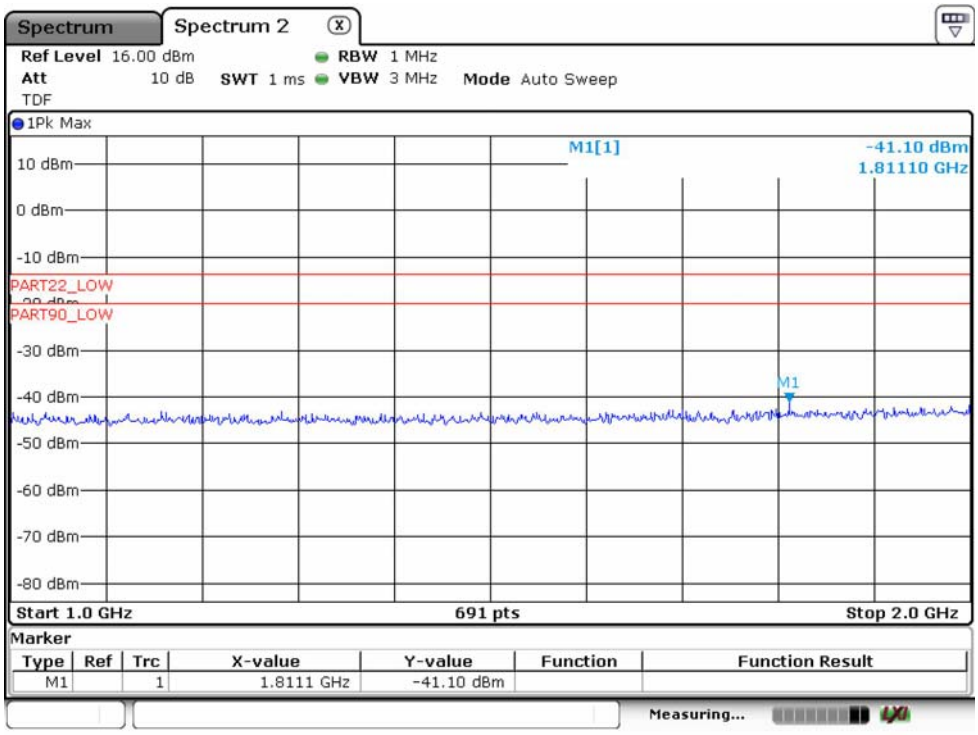
CH Middle : 151.1000 MHz



CH Mid : 158.55 MHz

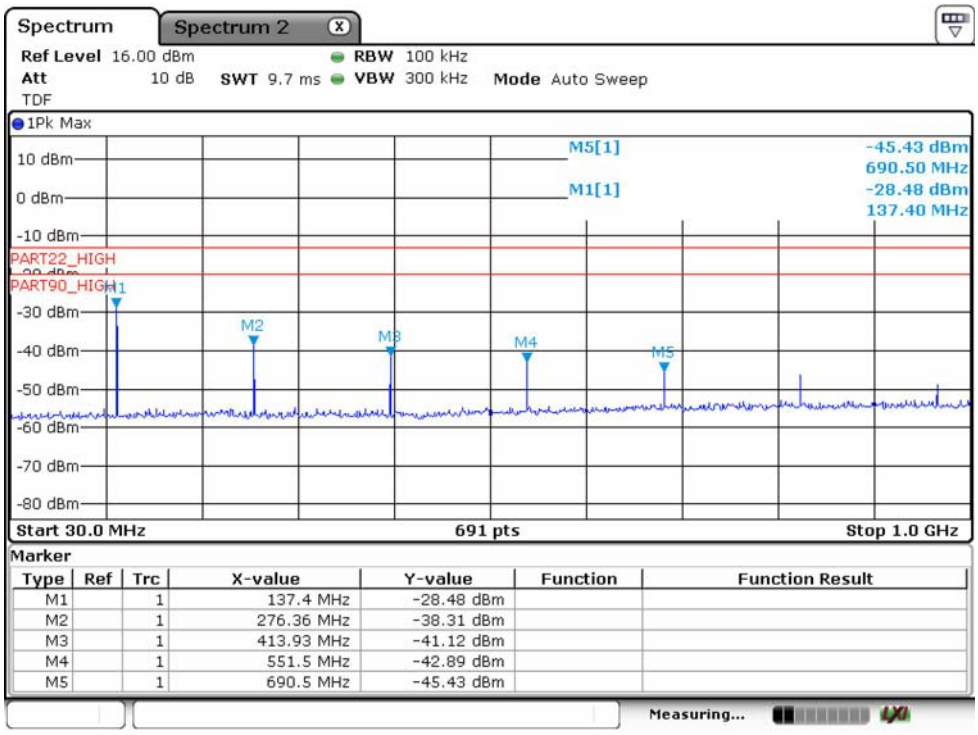


CH High : 173.3875 MHz

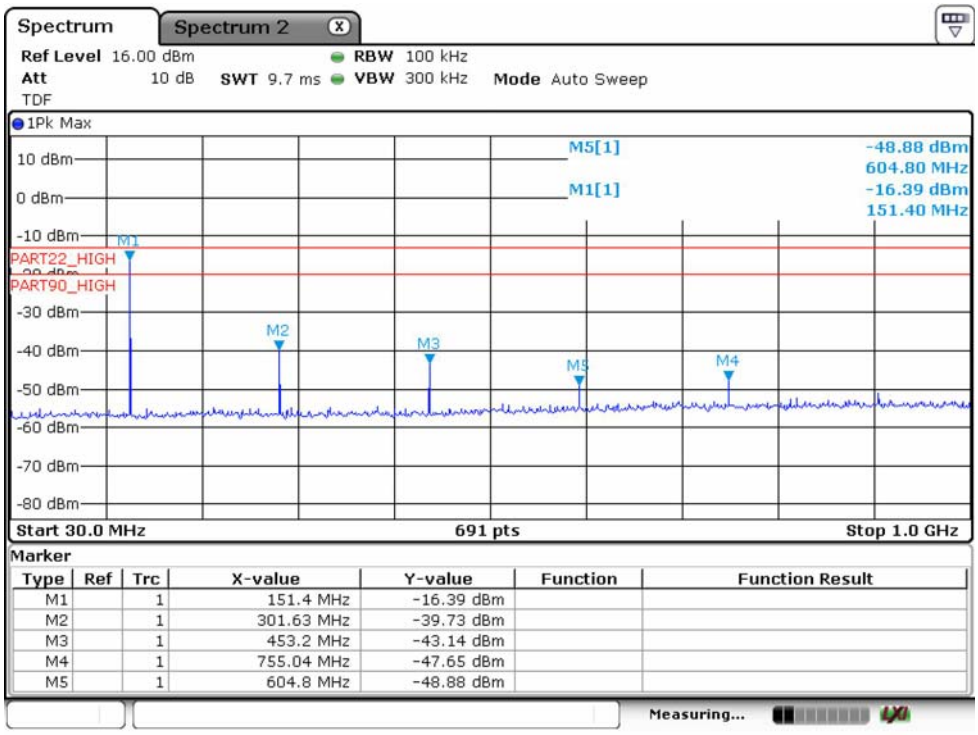


Below 1GHz / Analog / Power level: High

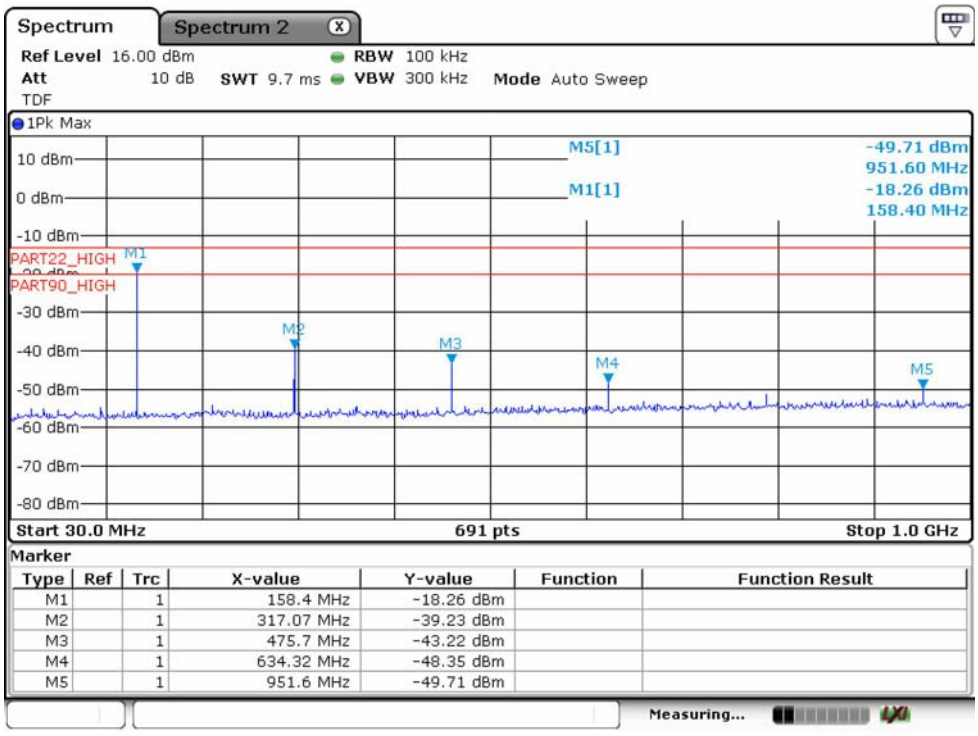
CH Low : 138.0125 MHz



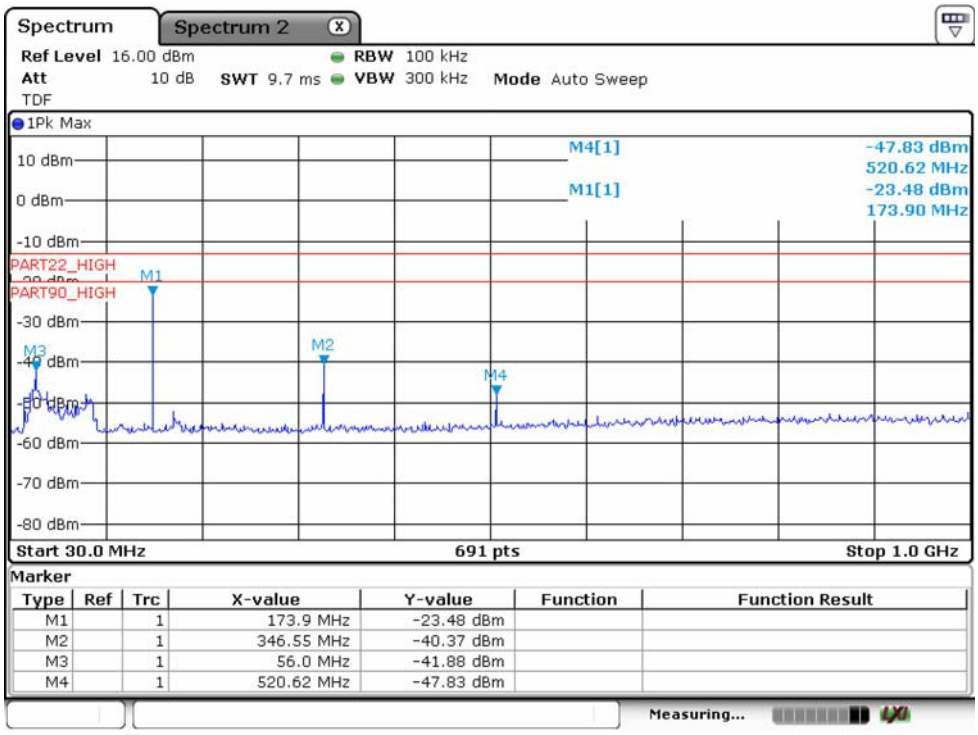
CH Middle : 151.1000 MHz



CH Mid : 158.55 MHz

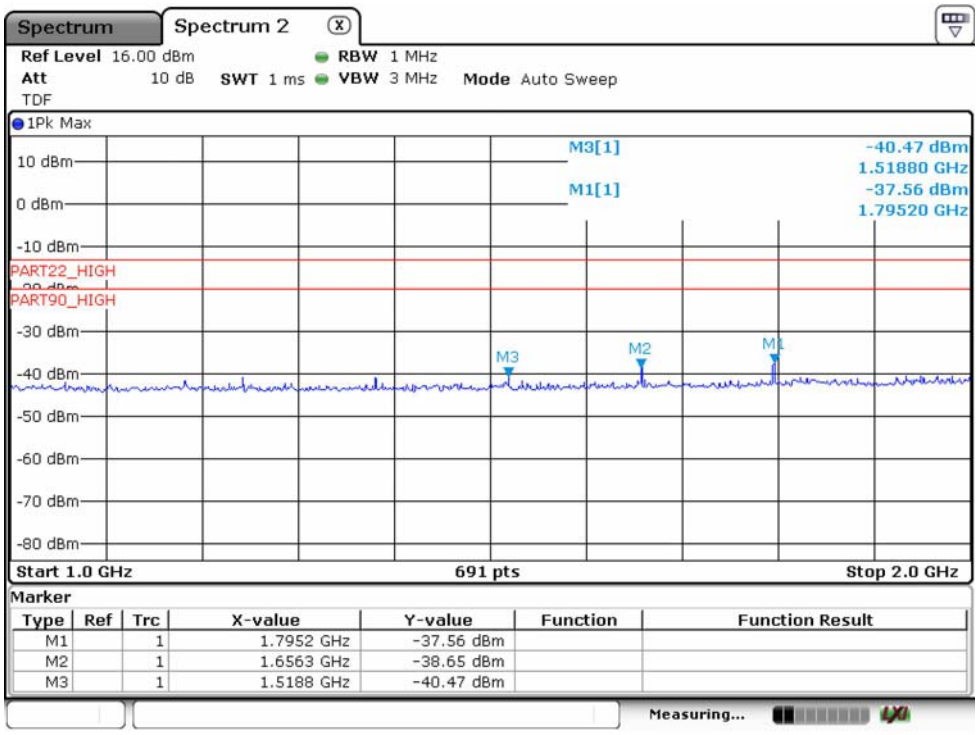


CH High : 173.3875 MHz

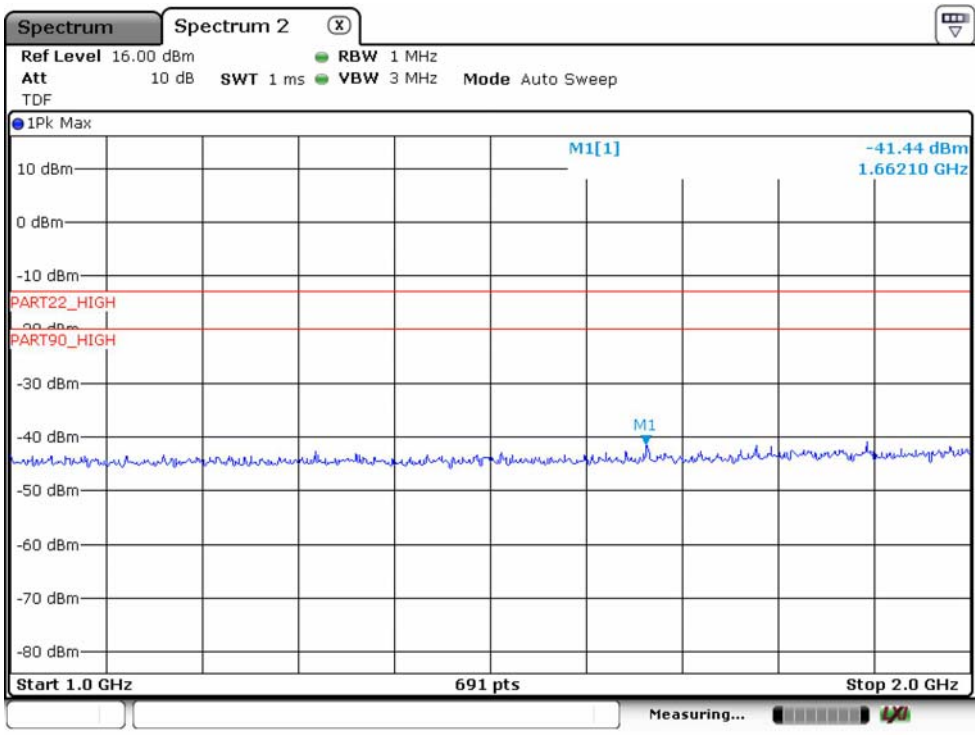


Above 1GHz / Analog / Power level: High

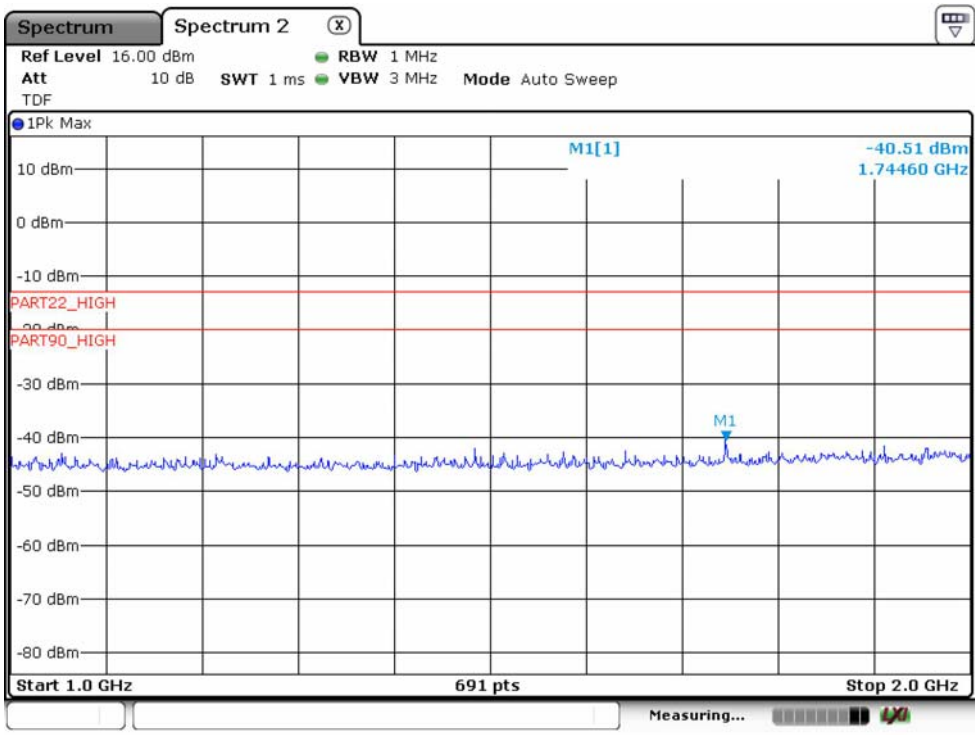
CH Low : 138.0125 MHz



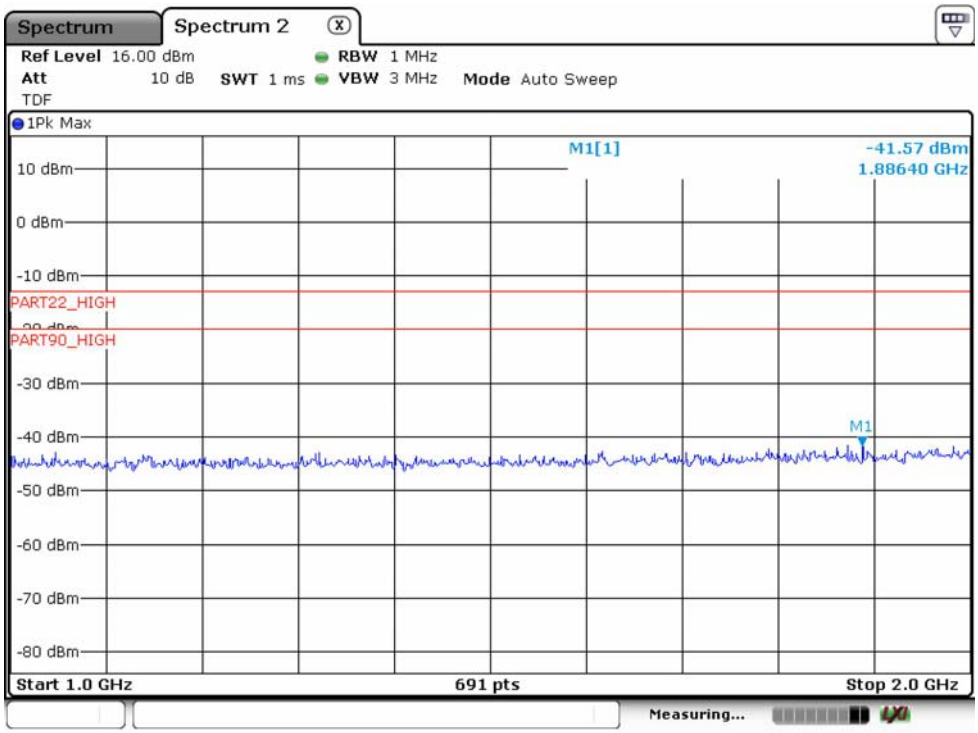
CH Middle : 151.1000 MHz



CH Mid : 158.55 MHz

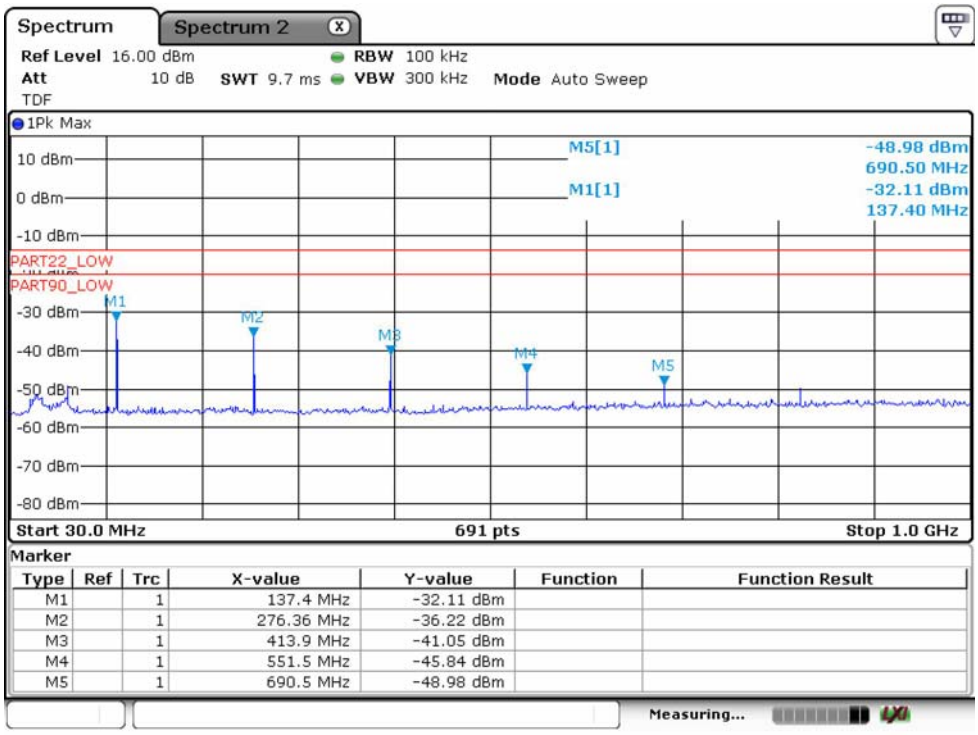


CH High : 173.3875 MHz

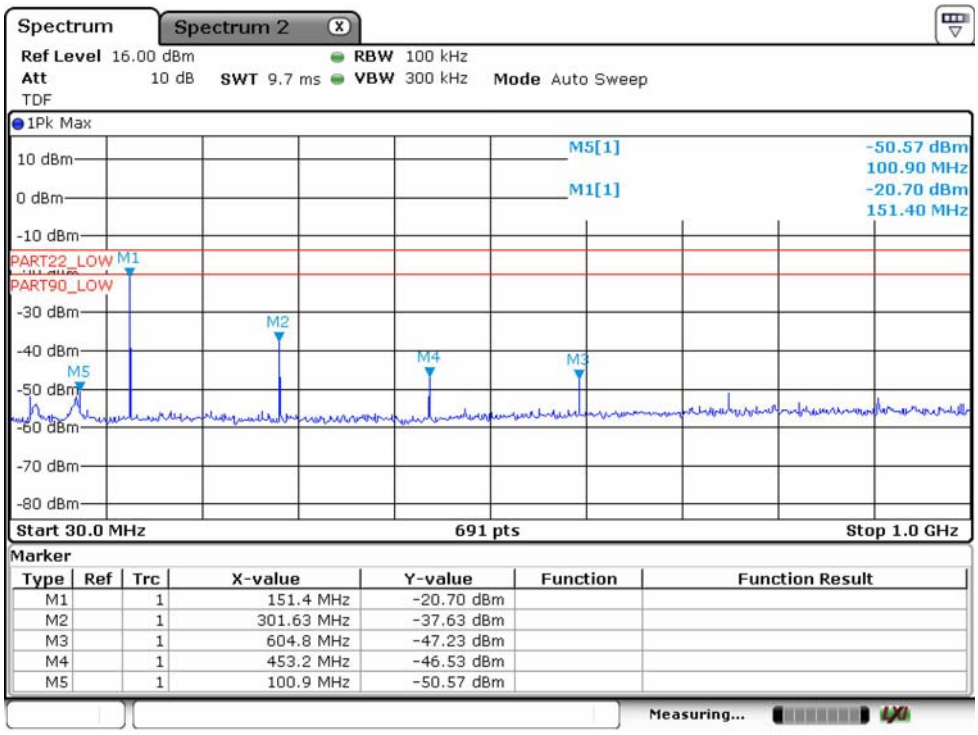


Below 1GHz / Digital / Power level: Low

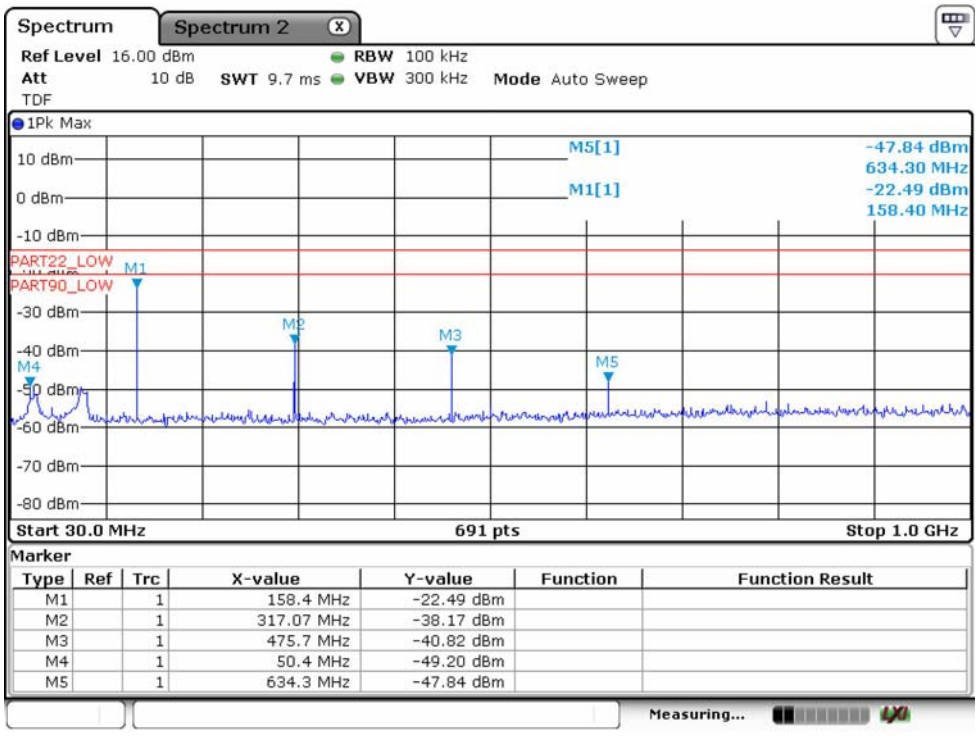
CH Low : 138.0125 MHz



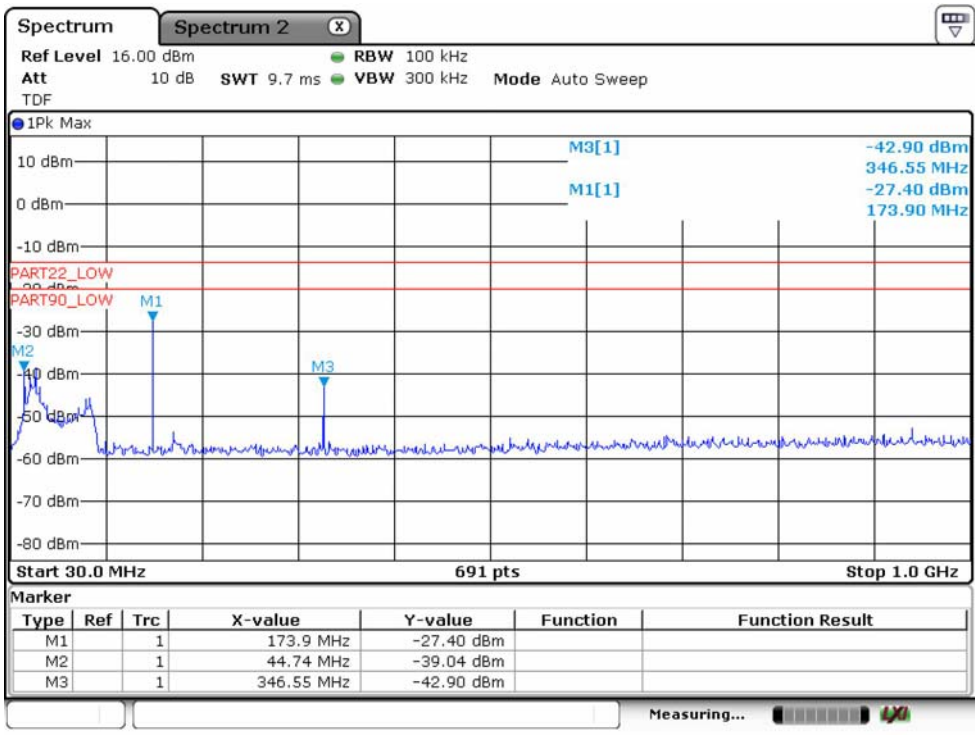
CH Middle : 151.1000 MHz



CH Mid : 158.55 MHz

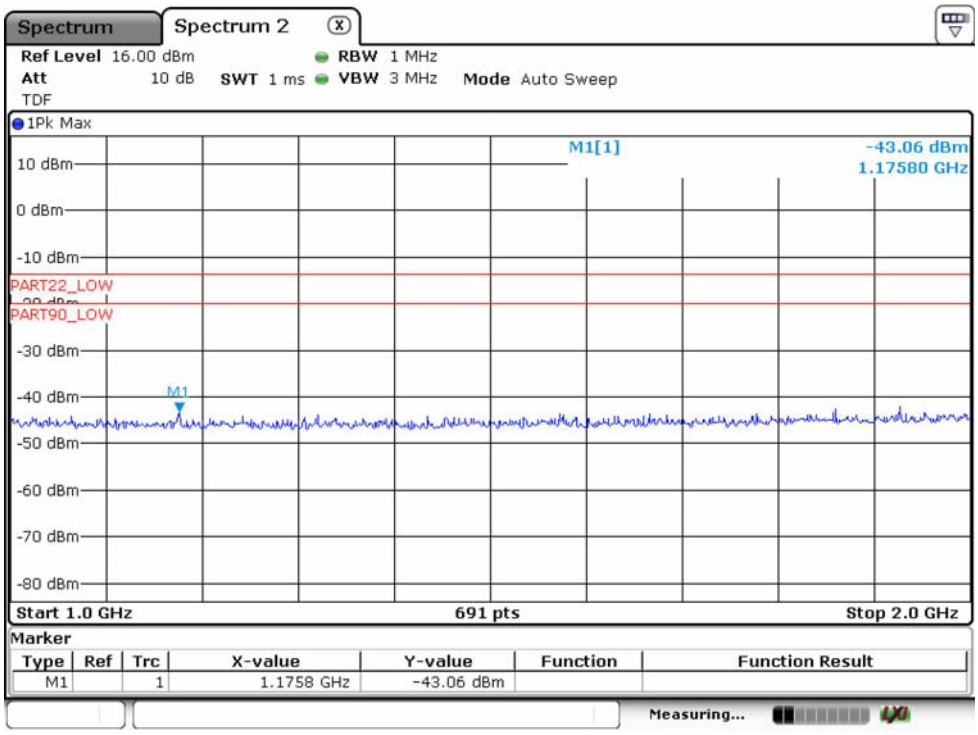


CH High : 173.3875 MHz

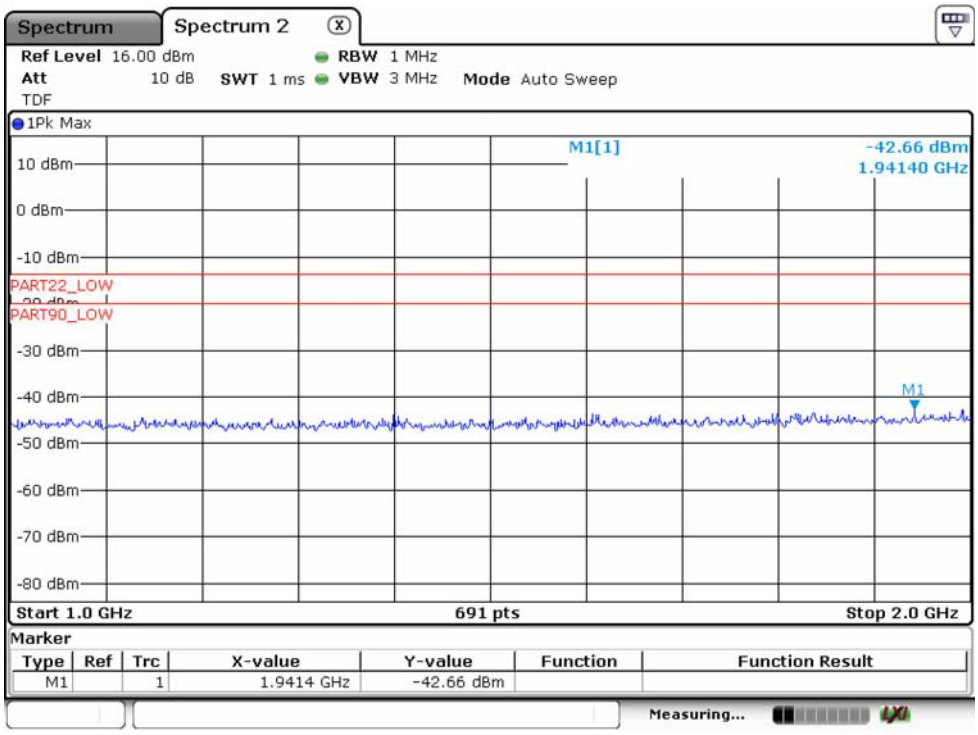


Above 1GHz / Digital / Power level: Low

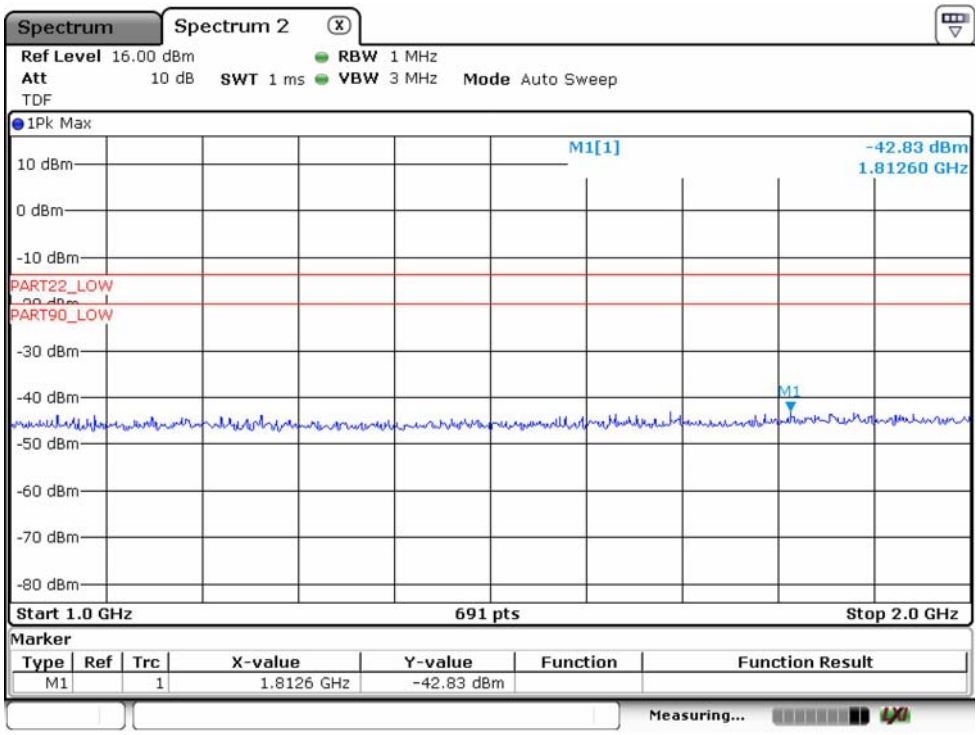
CH Low : 138.0125 MHz



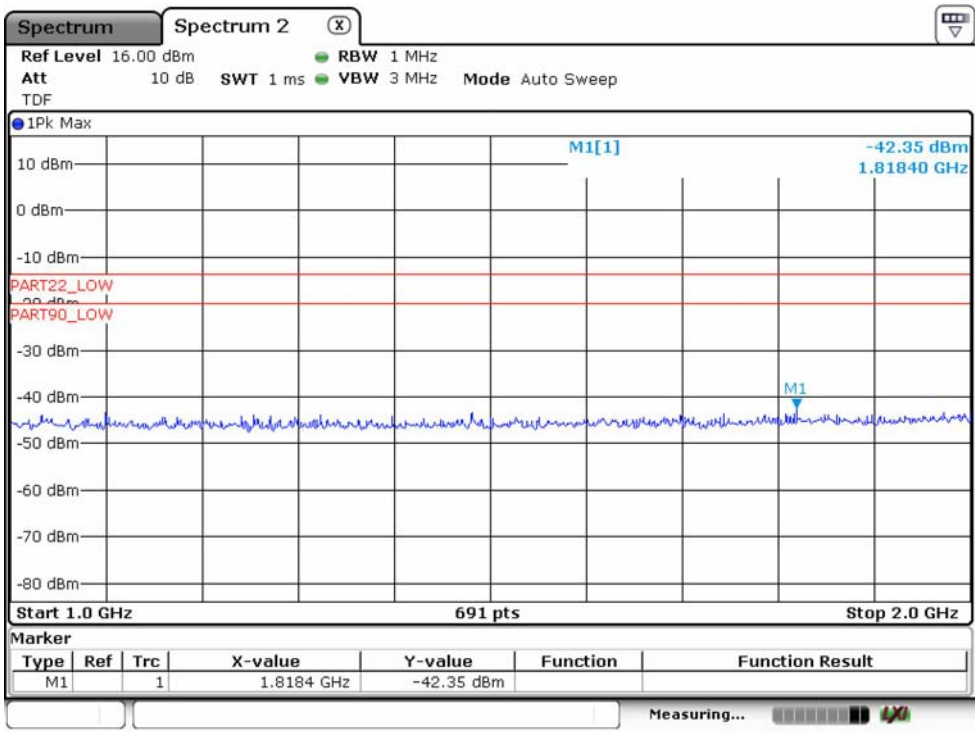
CH Middle : 151.1000 MHz



CH Mid : 158.55 MHz

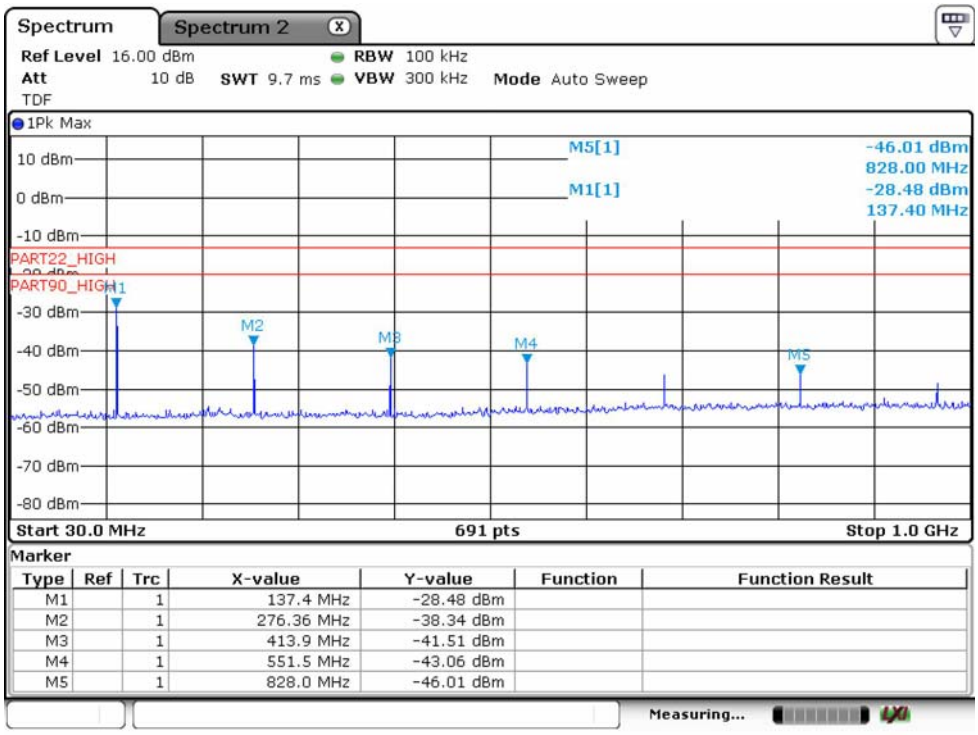


CH High : 173.3875 MHz

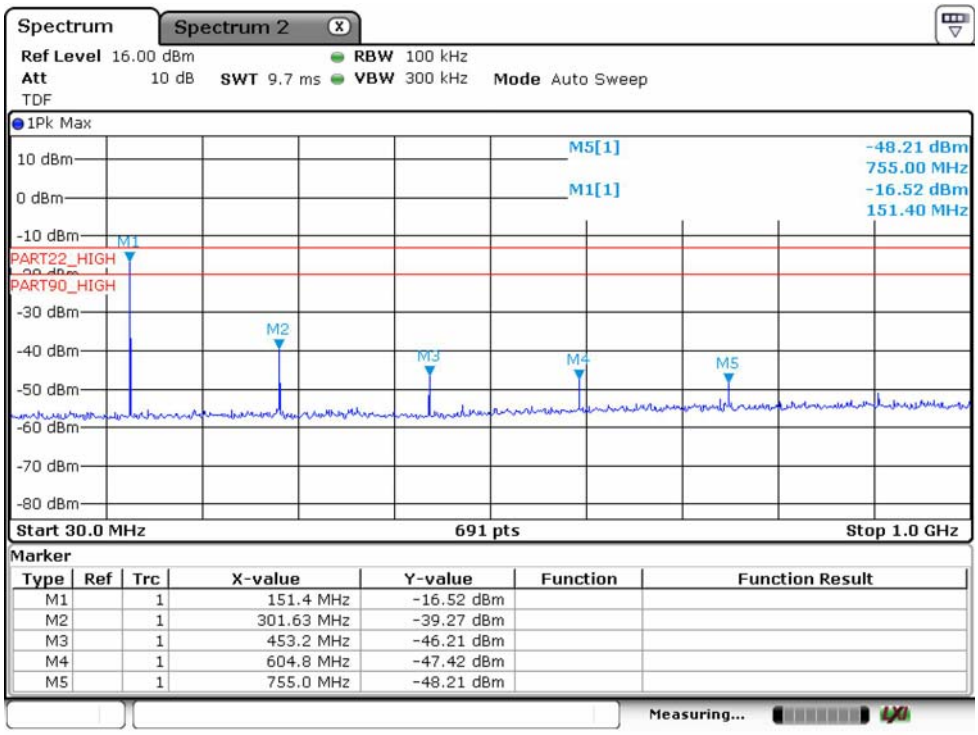


Below 1GHz / Digital / Power level: High

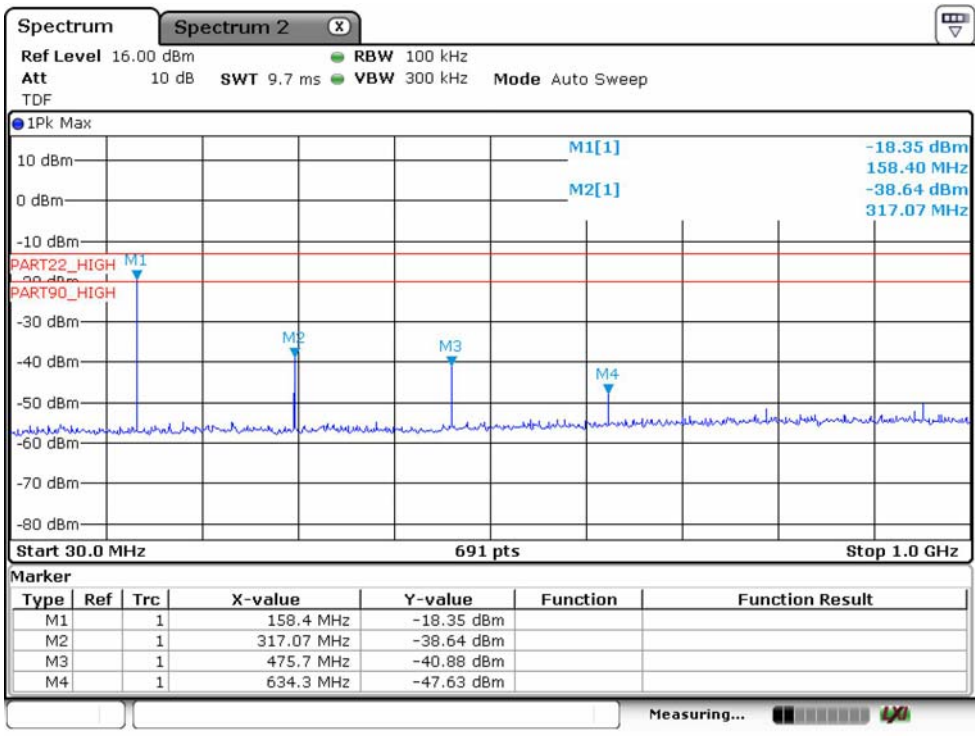
CH Low : 138.0125 MHz



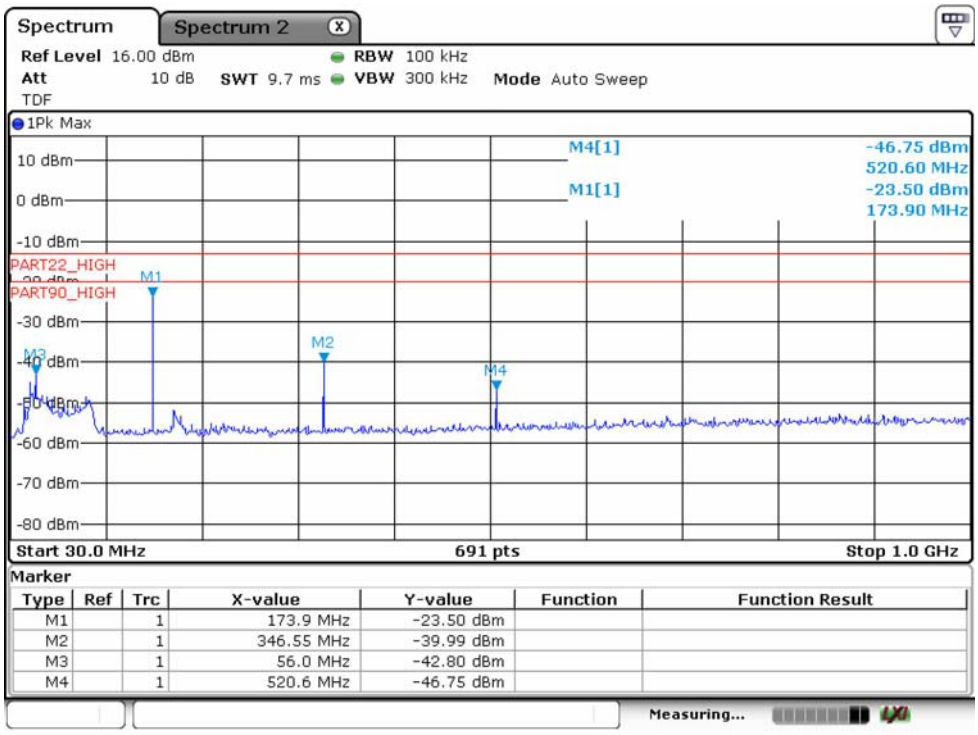
CH Middle : 151.1000 MHz



CH Mid : 158.55 MHz

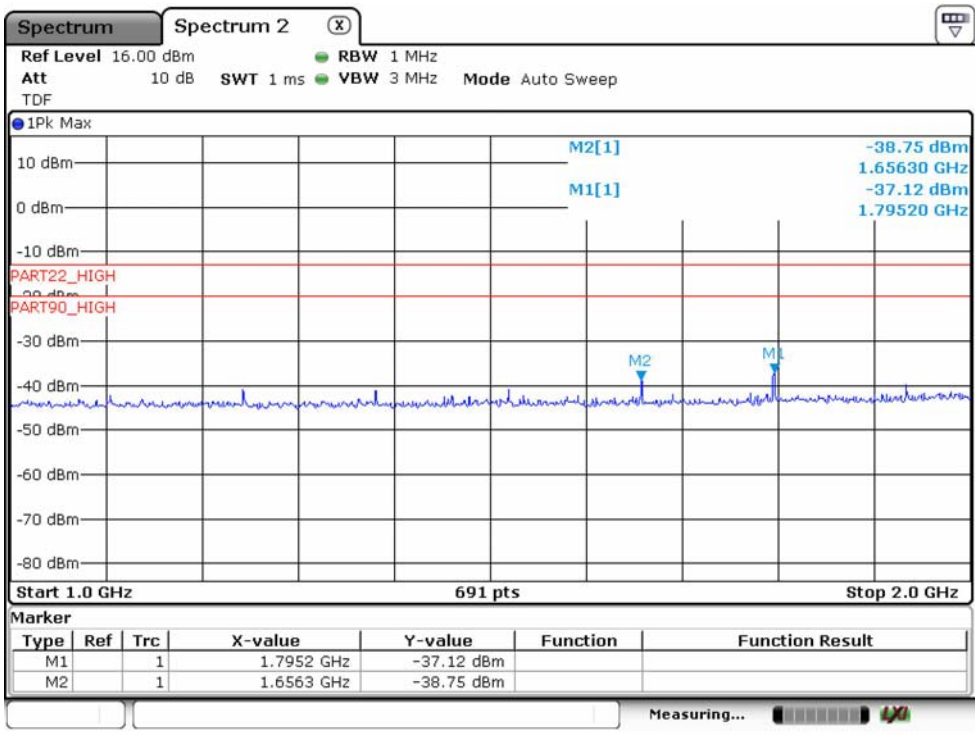


CH High : 173.3875 MHz

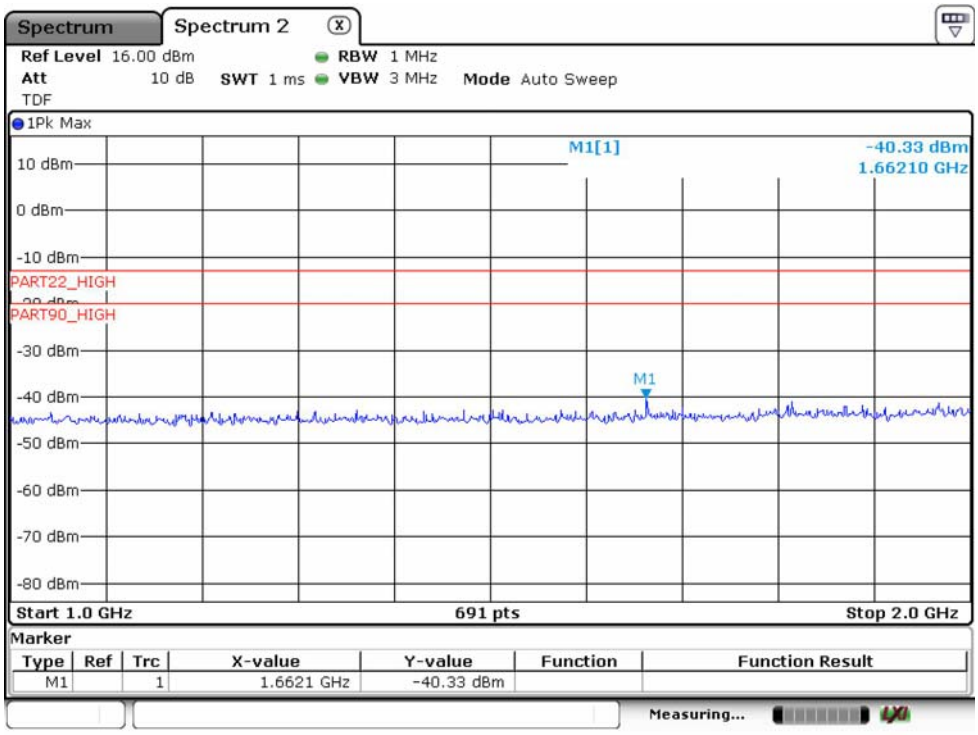


Above 1GHz / Digital / Power level: High

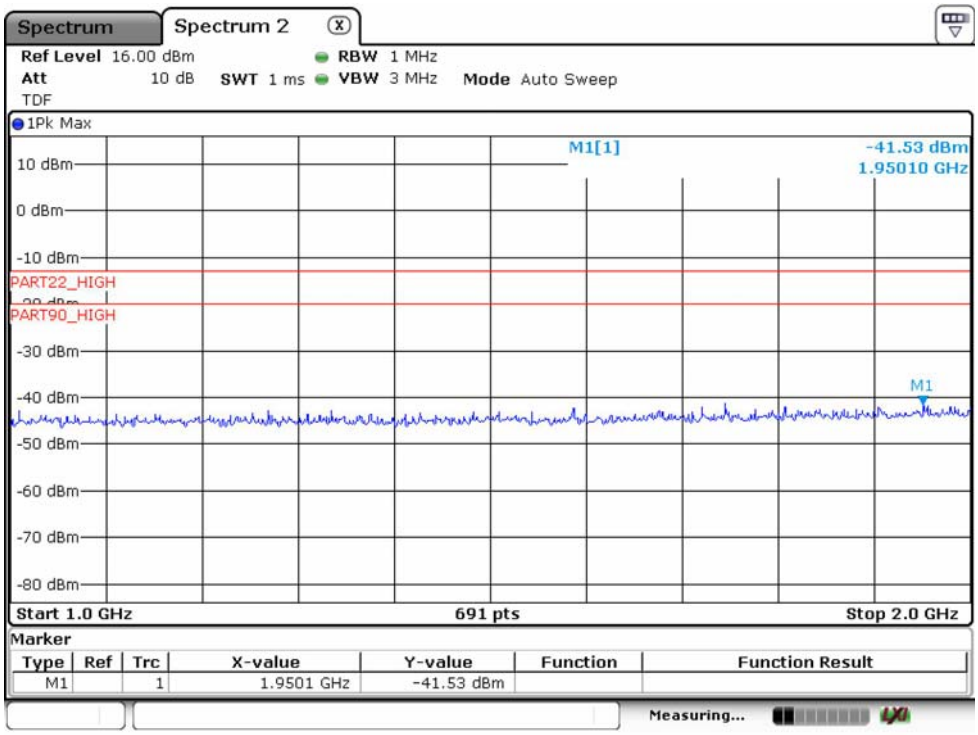
CH Low : 138.0125 MHz



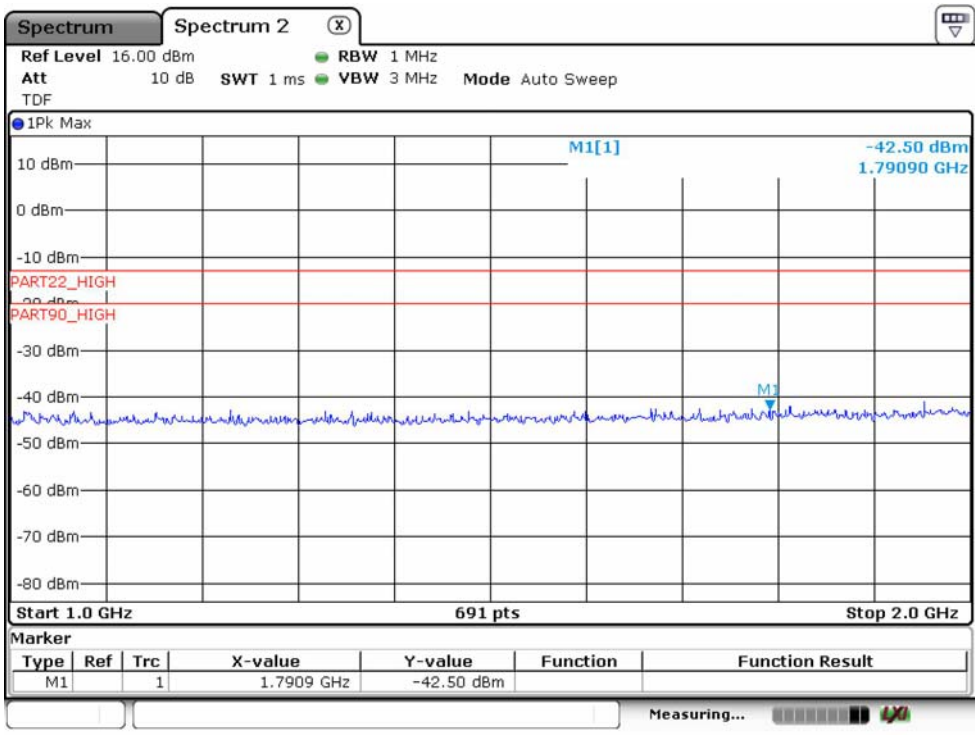
CH Middle : 151.1000 MHz



CH Mid : 158.55 MHz



CH High : 173.3875 MHz



5.6 Transmitter Radiated Unwanted Emissions

5.6.1 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.

5.6.2 Test Environment conditions

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

5.6.3 Measurement Procedure

The EUT was setup according to ANSI/TIA 603E-2013 for compliance to FCC 47CFR part 22 & 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

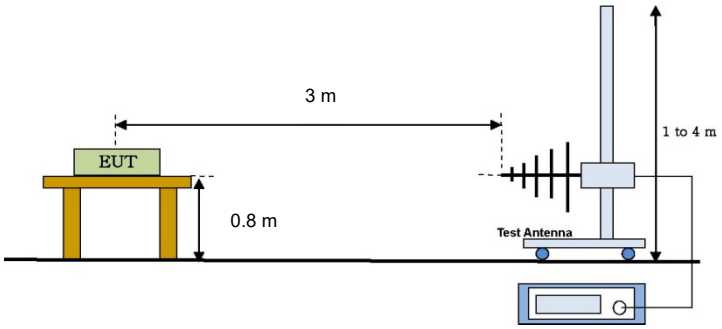
⑫ The measure of P_{erp}(or P_{eirp}) the spurious components is the larger of the two power levels recorded for each spurious component at the input to the substitution antenna, corrected for the gain of the substitution antenna, if necessary.

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 ;

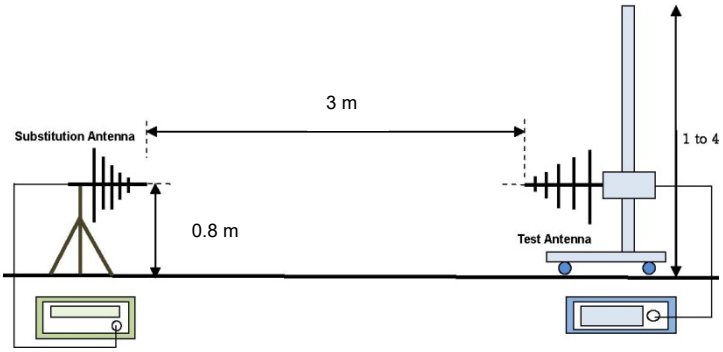
• P_{erp}(or P_{eirp}) = Signal generator level (dBm) – Cable loss(dB)

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

5.6.5 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

All measurements involve certain levels of uncertainties. The factors contributing to uncertainties are test receiver, Cable loss, Antenna factor calibration, antenna directivity, antenna factor variation with height, antenna phase center variation, Antenna frequency interpolation, measurement distance variation, Site imperfection, mismatch, and system repeatability based on NIS 80,81.

Radiated Emission measurement: Below 1 GHz: 3.66 dB (CL: Approx 95 %, k=2)
Above 1 GHz: 4.04 dB (CL: Approx 95 %, k=2)

5.6.6 Measurement Result

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

Analog / 151.100 MHz / Low power

Emission Frequency [MHz]	Level below Carrier [dBc]	Limit [dBc]	Test Results
301.65	72.21	See Note	Compliance
453.1	79.51		Compliance
604.9	80.13		Compliance

Note: The formula for limit is below;
Part22 : 50+10 log (P) where, P = EUT's output power in W
Therefore 50+10log(2.00) = 46 dBc
Part90 : 50+10 log (P) where, P = EUT's output power in W
Therefore 50+10log(2.00) = 53 dBc

Digital / 138.0125 MHz / Low power

Emission Frequency [MHz]	Level below Carrier [dBc]	Limit [dBc]	Test Results
276.35	71.65	See Note	Compliance
414	76.53		Compliance
551.4	79.51		Compliance

Note: The formula for limit is below;
Part22 : 50+10 log (P) where, P = EUT's output power in W
Therefore 50+10log(2.19) = 46.4 dBc
Part90 : 50+10 log (P) where, P = EUT's output power in W
Therefore 50+10log(2.19) = 53.4 dBc

5.7 Frequency Stability

5.7.1 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.

5.7.2 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.

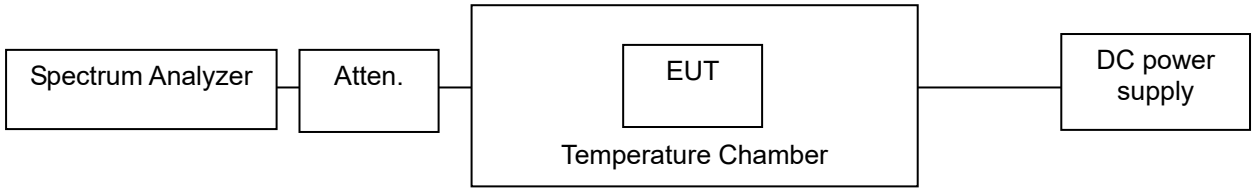
These measurements shall also be performed at normal and extreme test conditions.

▪ 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

5.7.4 Test setup



5.7.5 Measurement Result

Analog

Temp(℃)	Power Supply	Measured Freq(MHz)	Freq Drift(ppm)
50	DC 7.2 (Vnom)	158.549 879	-0.76
40	DC 7.2 (Vnom)	158.549 882	-0.74
30	DC 7.2 (Vnom)	158.549 970	-0.19
20	DC 7.2 (Vnom)	158.549 964	-0.23
10	DC 7.2 (Vnom)	158.549 982	-0.11
0	DC 7.2 (Vnom)	158.550 050	0.32
-10	DC 7.2 (Vnom)	158.550 043	0.27
-20	DC 7.2 (Vnom)	158.550 049	0.31
-30	DC 7.2 (Vnom)	158.550 046	0.29
Nom Temperature	DC 6.5 (Vmin)	158.549 967	-0.21
Nom Temperature	DC 8.0 (Vmax)	158.549 970	-0.19

Digital (Voice and Data)

Temp(℃)	Power Supply	Measured Freq(㎒)	Freq Drift(ppm)
50	DC 7.2 (Vnom)	158.549 880	-0.76
40	DC 7.2 (Vnom)	158.549 883	-0.74
30	DC 7.2 (Vnom)	158.549 972	-0.18
20	DC 7.2 (Vnom)	158.549 961	-0.25
10	DC 7.2 (Vnom)	158.549 980	-0.13
0	DC 7.2 (Vnom)	158.550 041	0.26
-10	DC 7.2 (Vnom)	158.550 040	0.25
-20	DC 7.2 (Vnom)	158.550 039	0.25
-30	DC 7.2 (Vnom)	158.550 037	0.23
Nom Temperature	DC 6.5 (Vmin)	158.549 970	-0.19
Nom Temperature	DC 8.0 (Vmax)	158.549 973	-0.17

5.8 Transmitter Frequency Behavior

5.8.1 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

5.8.2 Test Environment conditions

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

5.8.3 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.

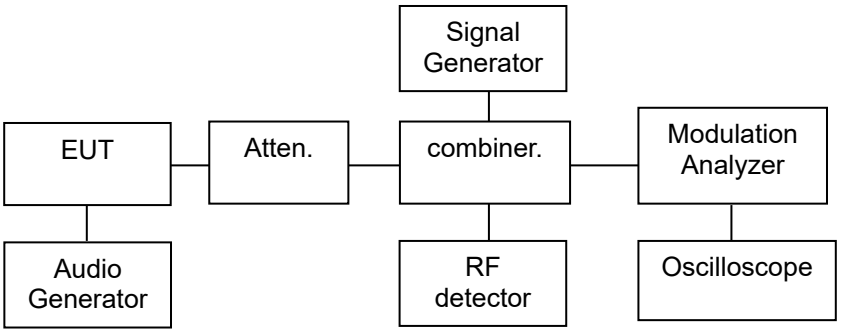
g) Adjust the RF level of the signal generator to provide RF power equal to P0. This signal generator RF level shall be maintained throughout the rest of the measurement.

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.

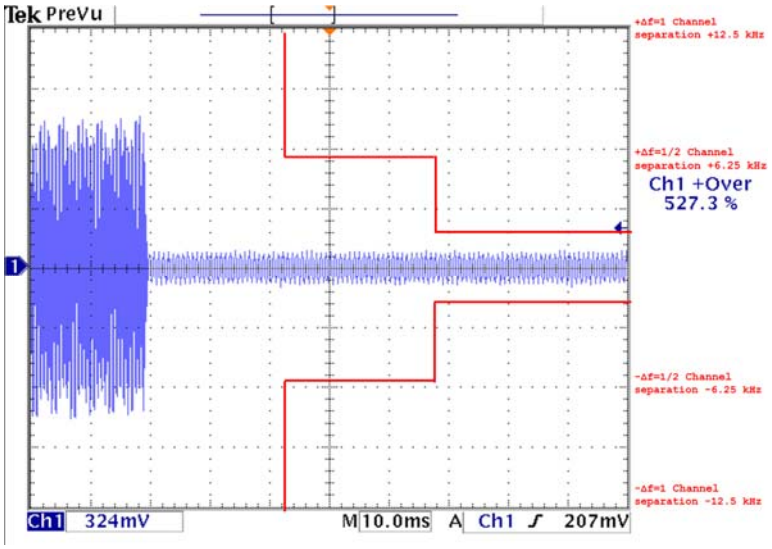
j) Turn on the transmitter and the transient wave will be captured on the screen of Spectrum Analyzer. Observe the stored display. The instant when the 1 kHz test signal is completely suppressed is considered to be ton. The trace should be maintained within the allowed divisions during the period t1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

5.8.4 Test setup



5.8.5 Measurement Result

OFF - ON



ON - OFF