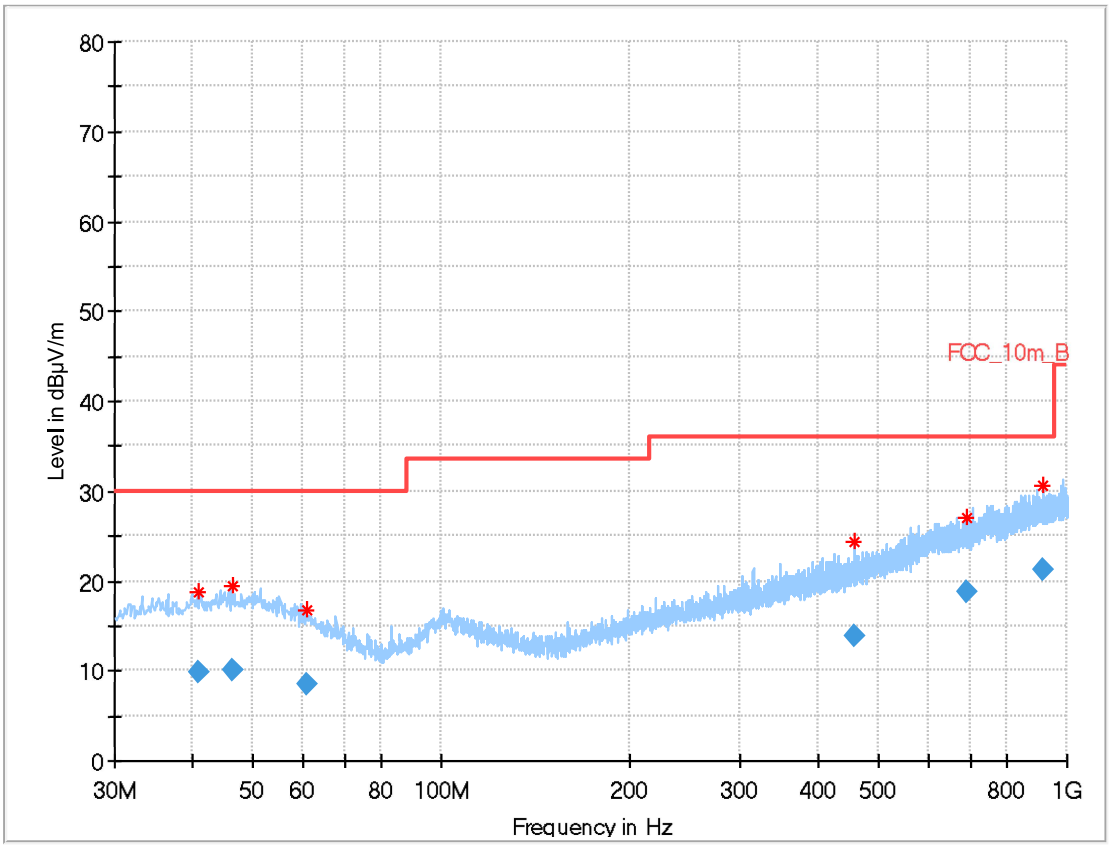
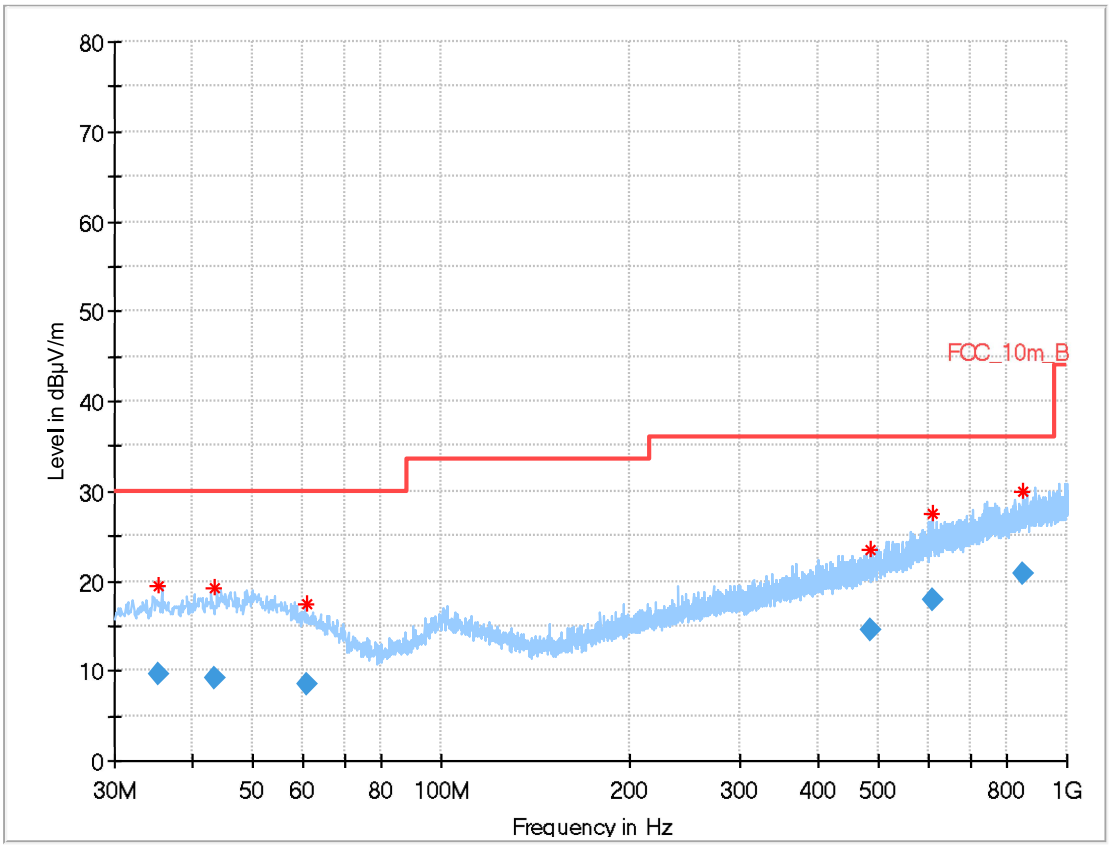
Plot 4: 30 MHz to 1 GHz, TX mode, 2402 MHz, vertical & horizontal polarization, 2 Msps, on-board antenna



Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
40.811	9.92	30.0	20.08	1000	120	101.0	H	336.0	13.3
46.391	10.07	30.0	19.93	1000	120	101.0	V	183.0	13.7
60.968	8.38	30.0	21.62	1000	120	170.0	H	162.0	11.6
457.861	13.91	36.0	22.09	1000	120	170.0	V	340.0	17.8
690.529	18.76	36.0	17.24	1000	120	170.0	H	289.0	21.5
914.734	21.29	36.0	14.71	1000	120	170.0	V	124.0	24.2

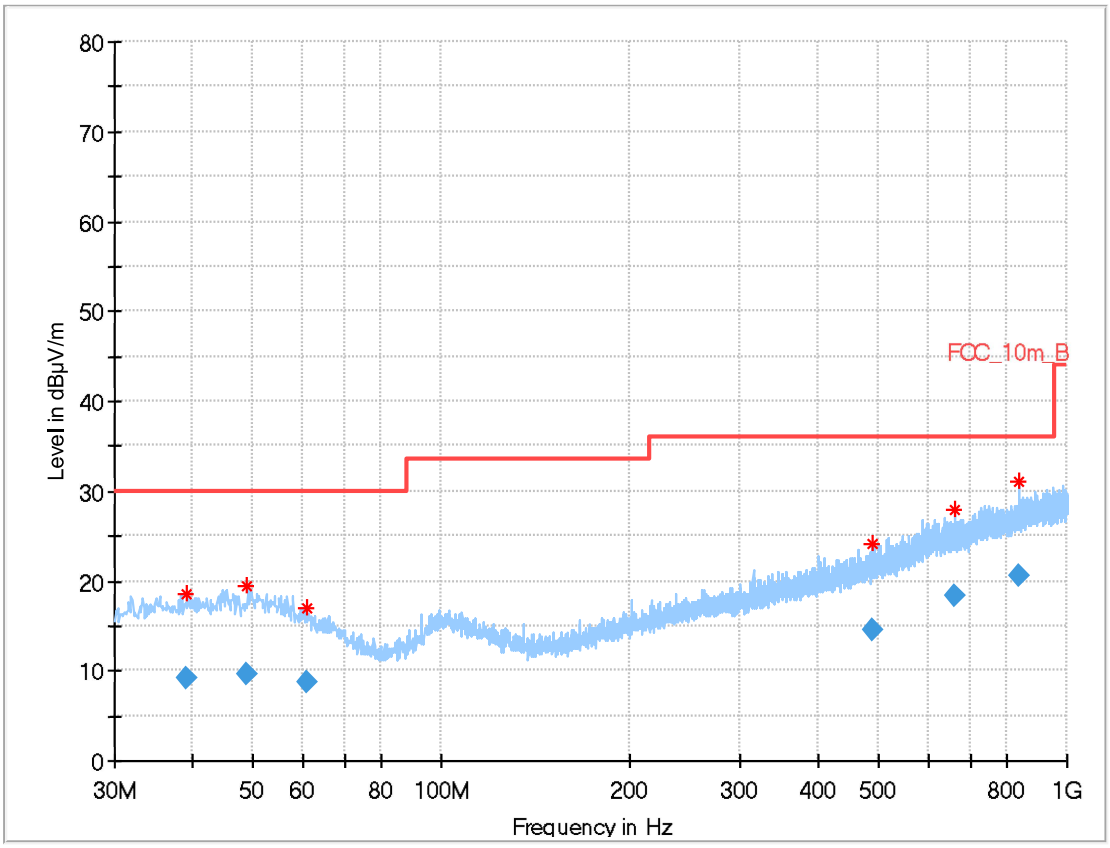
Plot 5: 30 MHz to 1 GHz, TX mode, 2440 MHz, vertical & horizontal polarization, 2 Msps, on-board antenna



Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
35.372	9.69	30.0	20.31	1000	120	101.0	H	332.0	12.7
43.315	9.24	30.0	20.76	1000	120	101.0	H	105.0	13.5
61.020	8.57	30.0	21.43	1000	120	101.0	V	222.0	11.6
484.797	14.43	36.0	21.57	1000	120	170.0	H	333.0	18.4
611.444	17.97	36.0	18.03	1000	120	170.0	H	-3.0	20.8
849.746	20.71	36.0	15.29	1000	120	170.0	H	357.0	23.5

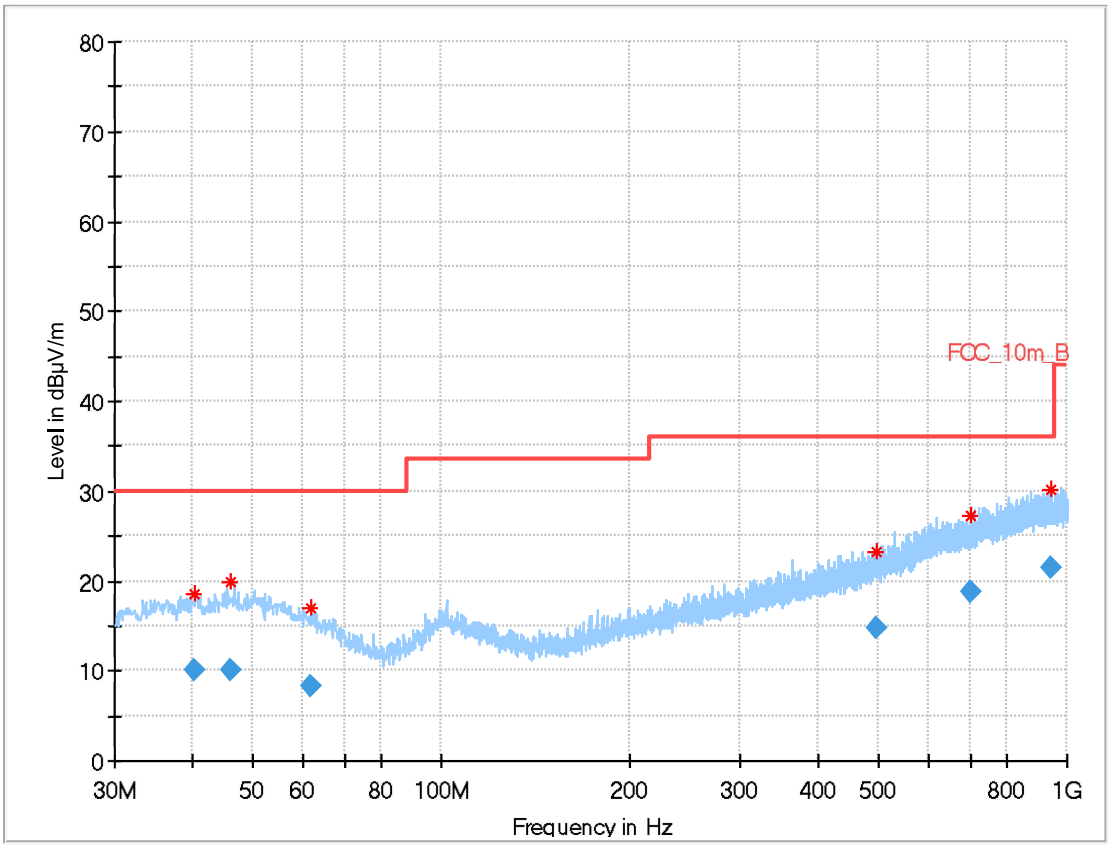
Plot 6: 30 MHz to 1 GHz, TX mode, 2480 MHz, vertical & horizontal polarization, 2 Msps, on-board antenna



Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
39.072	9.24	30.0	20.76	1000	120	100.0	H	165.0	13.1
48.697	9.64	30.0	20.36	1000	120	170.0	H	229.0	13.7
60.976	8.62	30.0	21.38	1000	120	101.0	V	149.0	11.6
488.100	14.47	36.0	21.53	1000	120	98.0	H	75.0	18.5
661.106	18.36	36.0	17.64	1000	120	170.0	H	0.0	21.2
838.633	20.54	36.0	15.46	1000	120	170.0	H	12.0	23.4

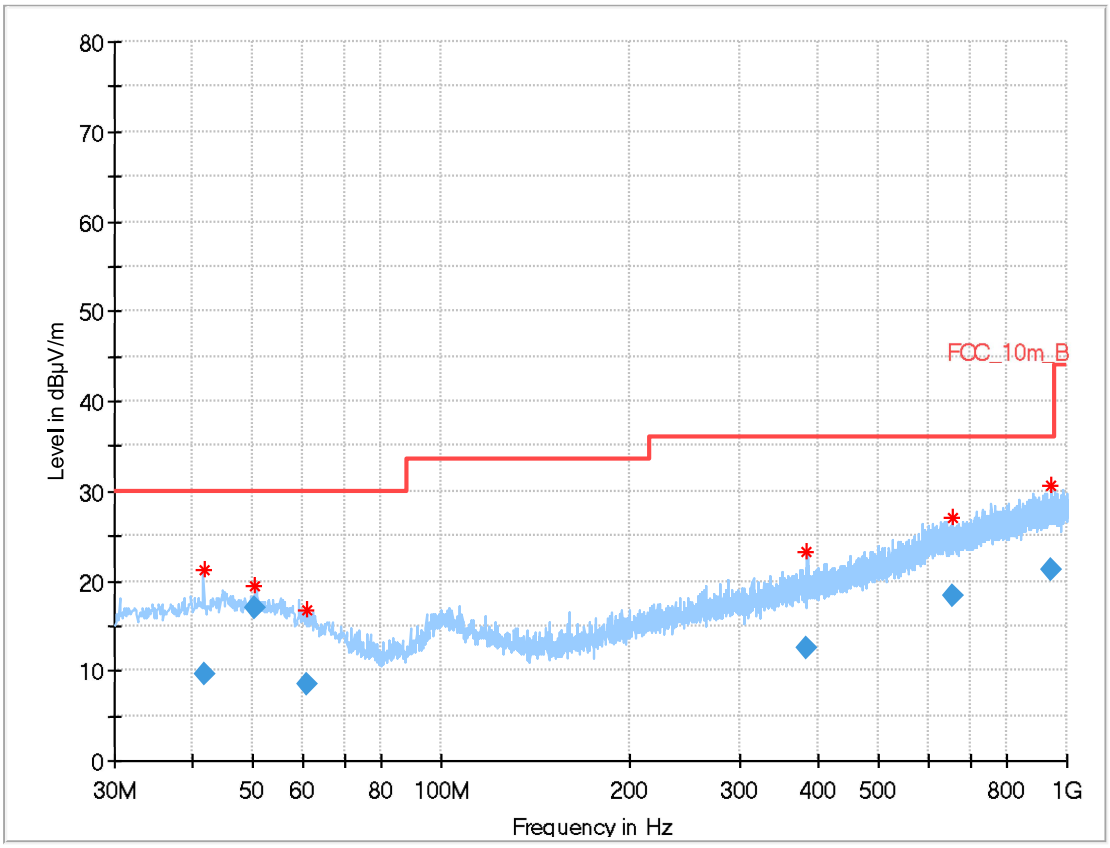
Plot 7: 30 MHz to 1 GHz, TX mode, 2402 MHz, vertical & horizontal polarization, 1 Msps, external antenna



Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
40.223	10.10	30.0	19.90	1000	120	101.0	V	200.0	13.2
46.153	10.13	30.0	19.87	1000	120	101.0	V	357.0	13.7
61.911	8.26	30.0	21.74	1000	120	170.0	V	115.0	11.4
495.182	14.78	36.0	21.22	1000	120	101.0	H	237.0	18.6
700.072	18.83	36.0	17.17	1000	120	170.0	V	306.0	21.6
944.450	21.37	36.0	14.63	1000	120	170.0	V	-10.0	24.3

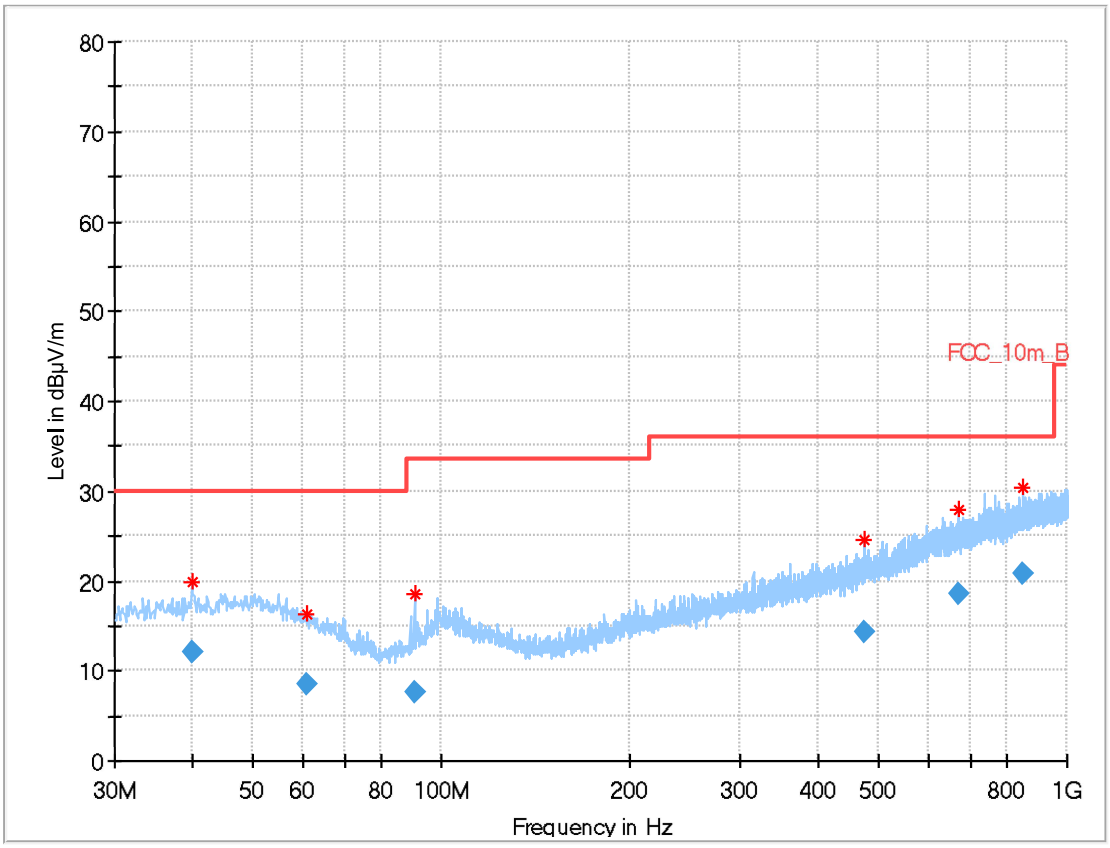
Plot 8: 30 MHz to 1 GHz, TX mode, 2440 MHz, vertical & horizontal polarization, 1 Msps, on-board antenna



Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
41.942	9.62	30.0	20.38	1000	120	101.0	V	284.0	13.4
50.141	16.89	30.0	13.11	1000	120	101.0	V	303.0	13.7
61.044	8.39	30.0	21.61	1000	120	170.0	H	101.0	11.6
384.209	12.44	36.0	23.56	1000	120	170.0	H	304.0	16.6
657.641	18.31	36.0	17.69	1000	120	170.0	V	282.0	21.2
942.000	21.33	36.0	14.67	1000	120	170.0	H	157.0	24.3

Plot 9: 30 MHz to 1 GHz, TX mode, 2480 MHz, vertical & horizontal polarization, external antenna

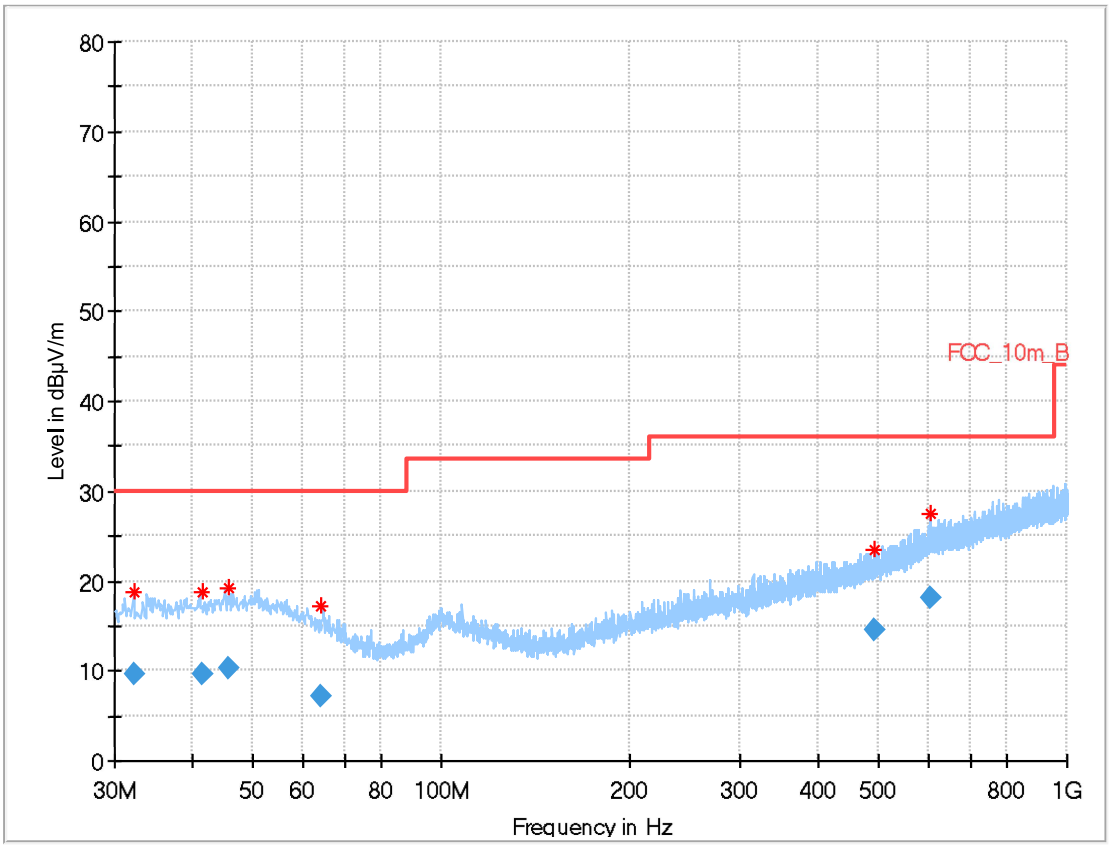


Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
39.940	12.13	30.0	17.87	1000	120	170.0	V	32.0	13.2
61.016	8.44	30.0	21.56	1000	120	170.0	H	347.0	11.6
90.979	7.49	33.5	26.01	1000	120	101.0	V	347.0	9.6
474.818	14.24	36.0	21.76	1000	120	170.0	H	147.0	18.2
670.630	18.61	36.0	17.39	1000	120	98.0	H	267.0	21.3
848.220	20.73	36.0	15.27	1000	120	170.0	H	198.0	23.5

Plots: Receiver mode

Plot 1: 30 MHz to 1 GHz, RX / idle – mode, vertical & horizontal polarization



Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
32.277	9.62	30.0	20.38	1000	120	101.0	V	201.0	12.2
41.486	9.70	30.0	20.30	1000	120	101.0	V	353.0	13.3
45.580	10.35	30.0	19.65	1000	120	101.0	V	103.0	13.6
64.408	7.19	30.0	22.81	1000	120	101.0	V	67.0	10.9
493.557	14.63	36.0	21.37	1000	120	98.0	H	247.0	18.6
606.875	18.01	36.0	17.99	1000	120	170.0	V	0.0	20.8

11.11 Spurious emissions radiated above 1 GHz

Description:

Measurement of the radiated spurious emissions in transmit mode. The EUT is set to single channel mode and the transmit frequencies are 2402 MHz, 2440 MHz and 2480 MHz. The measurement is performed in the mode with the highest output power.

Measurement parameters	
Detector	Peak / RMS
Sweep time	Auto
Resolution bandwidth	1 MHz
Video bandwidth	3 x RBW
Span	1 GHz to 26 GHz
Trace mode	Max hold
Measured modulation	GFSK
Test setup	See sub clause 6.2 A (TX - 1 GHz - 18 GHz) See sub clause 6.2 B (RX - 1 GHz – 18GHz) See sub clause 6.3 A (18 GHz - 26 GHz)
Measurement uncertainty	See sub clause 8

The modulation with the highest output power was used to perform the transmitter spurious emissions. If spurious were detected a re-measurement was performed on the detected frequency with each modulation.

Limits:

FCC		IC
TX spurious emissions radiated		
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).		
§15.209		
Frequency (MHz)	Field strength (dBµV/m)	Measurement distance
Above 960	54.0 (Average)	3
Above 960	74.0 (Peak)	3

Results: Transmitter mode

TX spurious emissions radiated [dBµV/m]								
2402 MHz			2440 MHz			2480 MHz		
F [MHz]	Detector	Level [dBµV/m]	F [MHz]	Detector	Level [dBµV/m]	F [MHz]	Detector	Level [dBµV/m]
All detected emissions are more than 20 dB below the limit.								
	Peak			Peak			Peak	
	AVG			AVG			AVG	
	Peak			Peak			Peak	
	AVG			AVG			AVG	
	Peak			Peak			Peak	
	AVG			AVG			AVG	

*) Average emission adjusting factor:

F = 20 * log (dwell time* / 100 ms)
*with TXon time as dwell time!

Bluetooth LE connected mode: Duty Cycle correction Scenarios

TX payload bytes	TX dwell time [ms]	TXon time [ms]	RX dwell time min [ms]	No of TX within 100 ms 100ms/(TxDwell +RxDwell)	min no of hopping channels (AFH)	max TX time [ms]/channel within 100ms	DC correction F [dB]	Scenario
37	0.625	0.376	0.625	80.0	2	15	-16.46	TX Packet. Rx =ACK
224	1.875	1.875	0.625	40.0	2	38	-8.52	TX Packet. Rx =ACK (worst case)
255	2.500	2.120	0.625	32.0	2	34	-9.39	TX Packet. Rx =ACK
37	0.625	0.376	0.625	80.0	2	15	-16.46	TX Packet = RX Packet
255	2.500	2.120	2.500	20.0	2	21	-13.47	TX Packet = RX Packet

Note: For BT LE the dwell time is a multiple of 0.625ms

Bluetooth LE Advertising mode:

Advertising is always in none Hopping mode.

A Bluetooth LE packet in advertising mode consists of:
Preamble (1 Byte)
Access Address (4 Bytes):always: 0x8E89BED6
PDU Header (2 Bytes)
PDU MAC address (6 Bytes)
PDU Data (0-31 Bytes) (connected undirected advertising (ADV_IND)
CRC (3 Bytes)

The maximum size of a complete advertising packet is 47 Bytes (376us)
Minimum possible advertising interval (per advertising channel): 20 ms
Duty cycle within 100ms: 5*0.376ms /100ms = 0.0188 =1.88%
Correction factor for average calculation:

F = 20 *log (0.0188) = -34.51dB

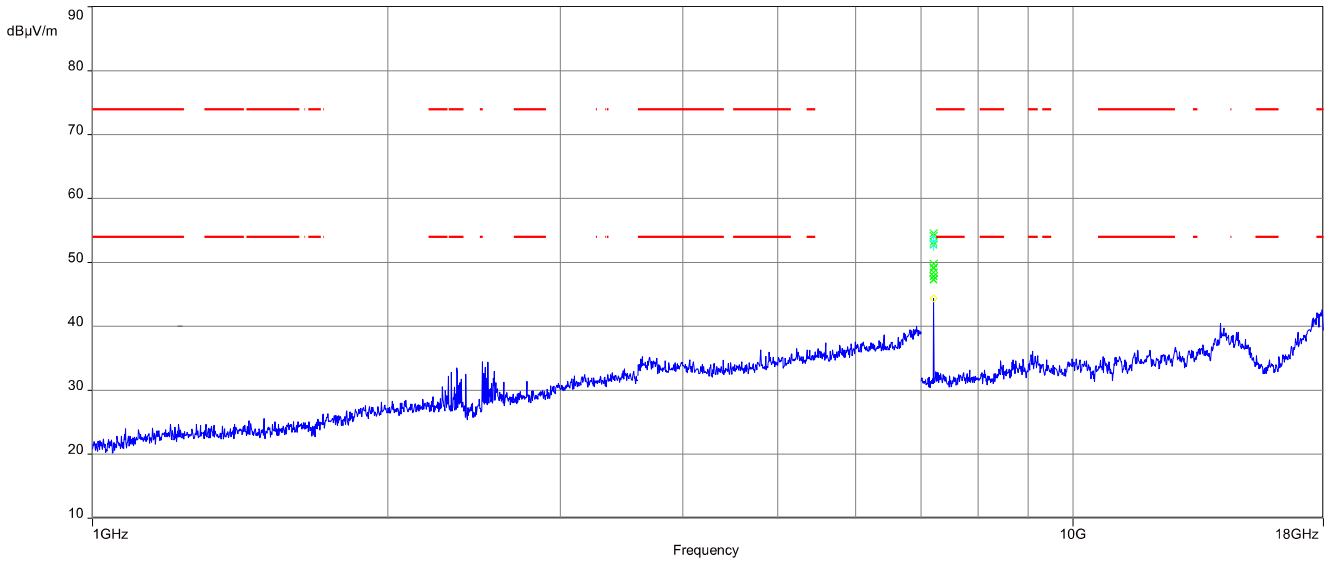
Results: Receiver mode

RX spurious emissions radiated [dBµV/m]		
F [MHz]	Detector	Level [dBµV/m]
All detected emissions are more than 20 dB below the limit.		
	Peak	
	AVG	

Note: The limit was recalculated with 20 dB / decade (Part 15.31) for all radiated spurious emissions 30 MHz to 1 GHz from 3 meter limit to a 10 meter distance. (40dB/decade for emissions < 30MHz)

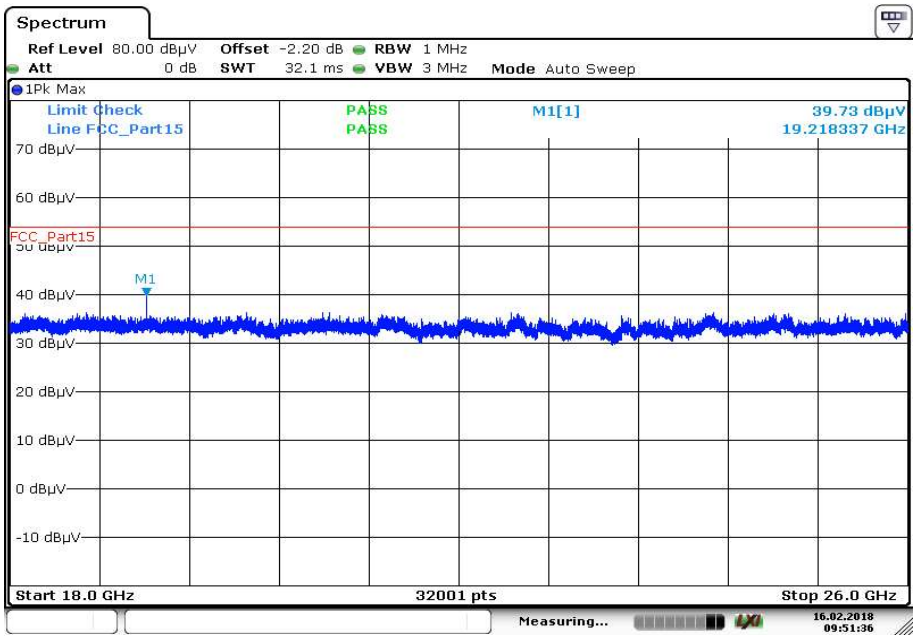
Plots: Transmitter mode

Plot 1: 1 GHz to 18 GHz, TX mode, 2402 MHz, vertical & horizontal polarization, 1 Msps, on-board antenna



The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 2: 18 GHz to 26 GHz, TX mode, 2402 MHz, vertical & horizontal polarization, 1 Msps, on-board antenna



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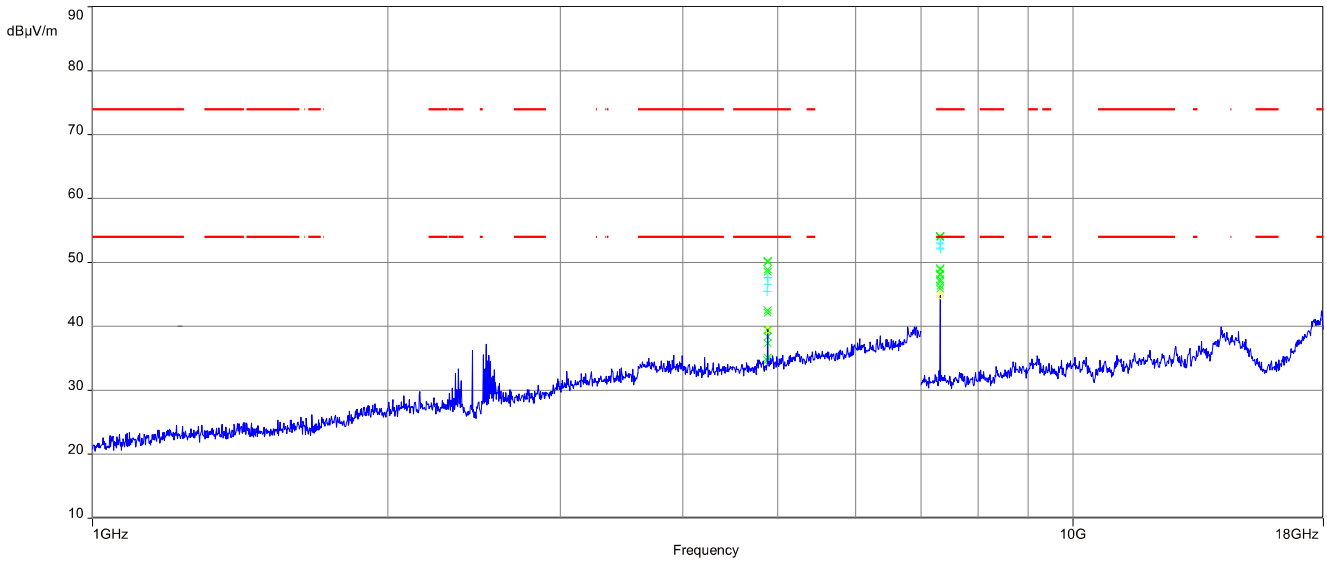
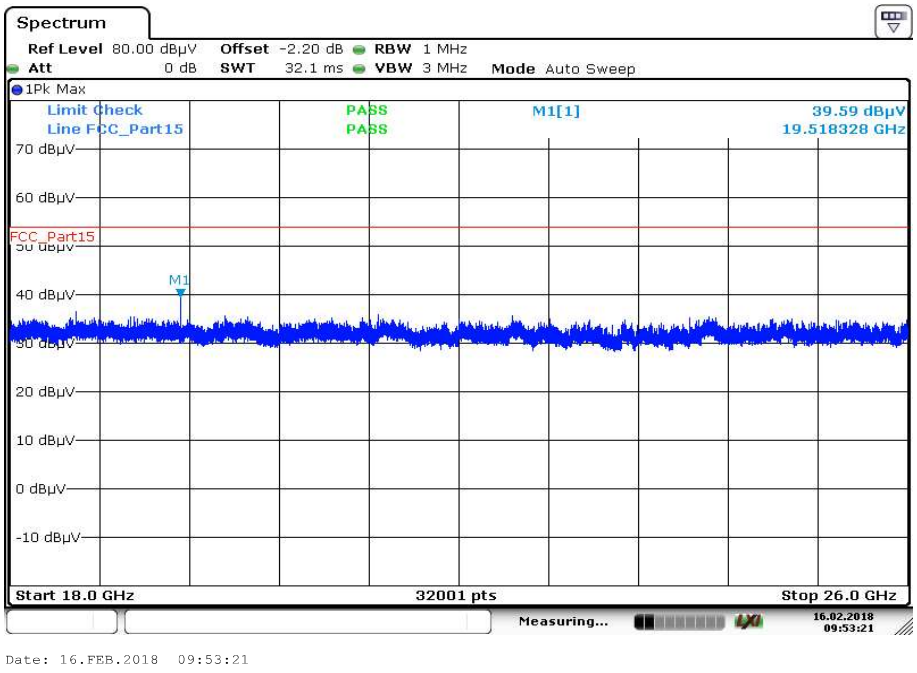
Plot 3: 1 GHz to 18 GHz, TX mode, 2440 MHz, vertical & horizontal polarization, 1 Msps, on-board antenna

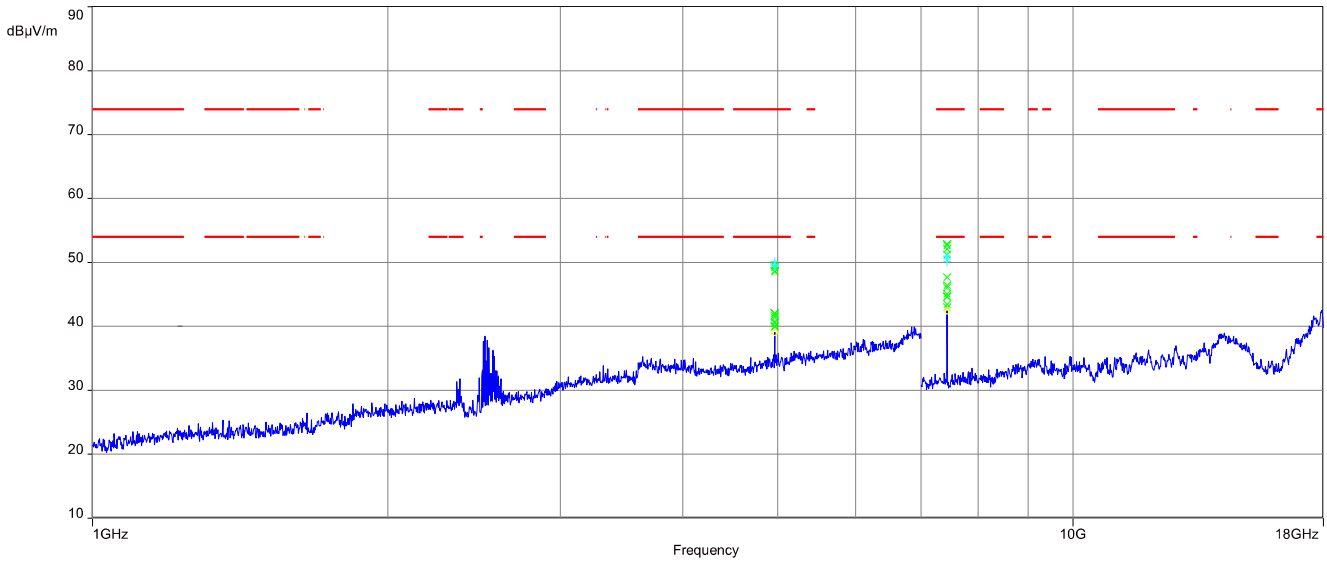


The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 4: 18 GHz to 26 GHz, TX mode, 2440 MHz, vertical & horizontal polarization, 1 Msps, on-board antenna

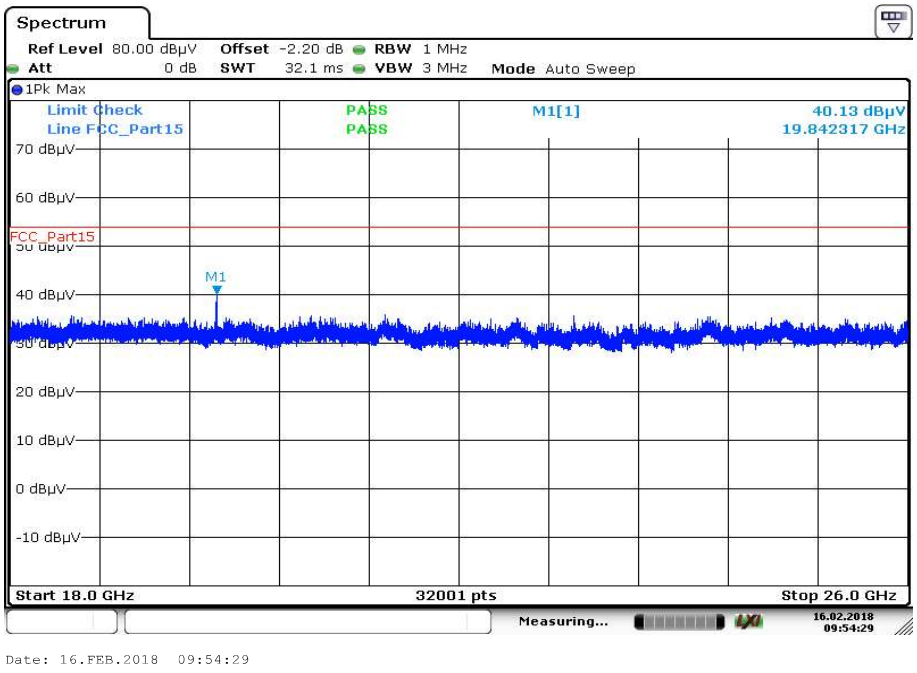


Plot 5: 1 GHz to 18 GHz, TX mode, 2480 MHz, vertical & horizontal polarization, 1 Msps, on-board antenna

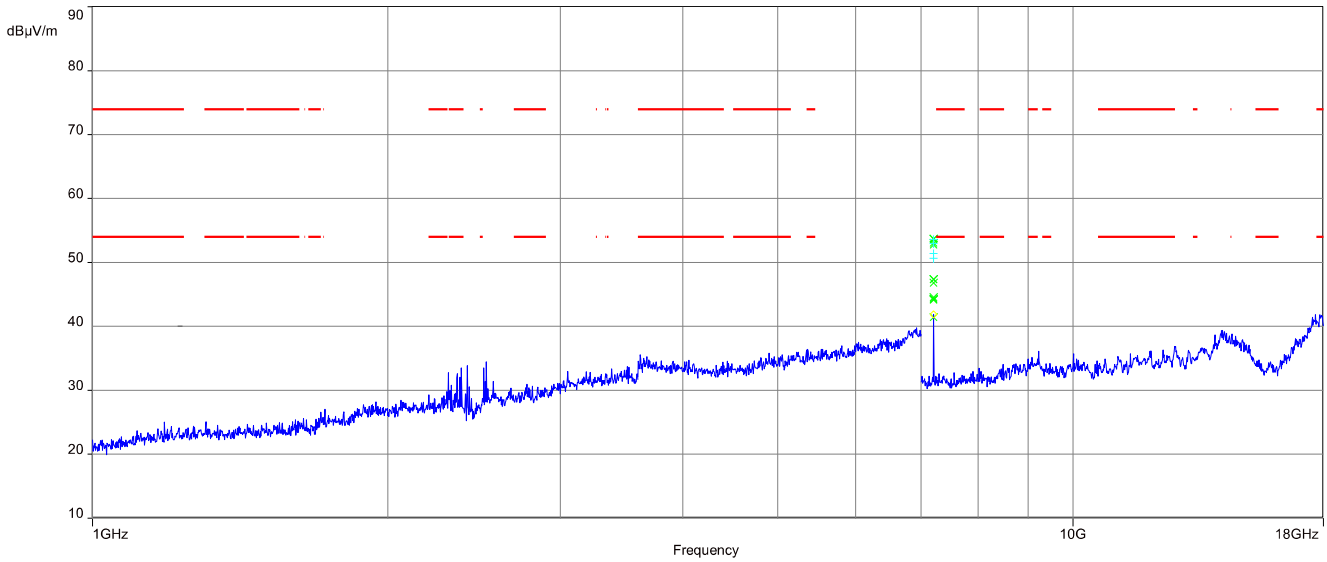


The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 6: 18 GHz to 26 GHz, TX mode, 2480 MHz, vertical & horizontal polarization, 1 Msps, on-board antenna

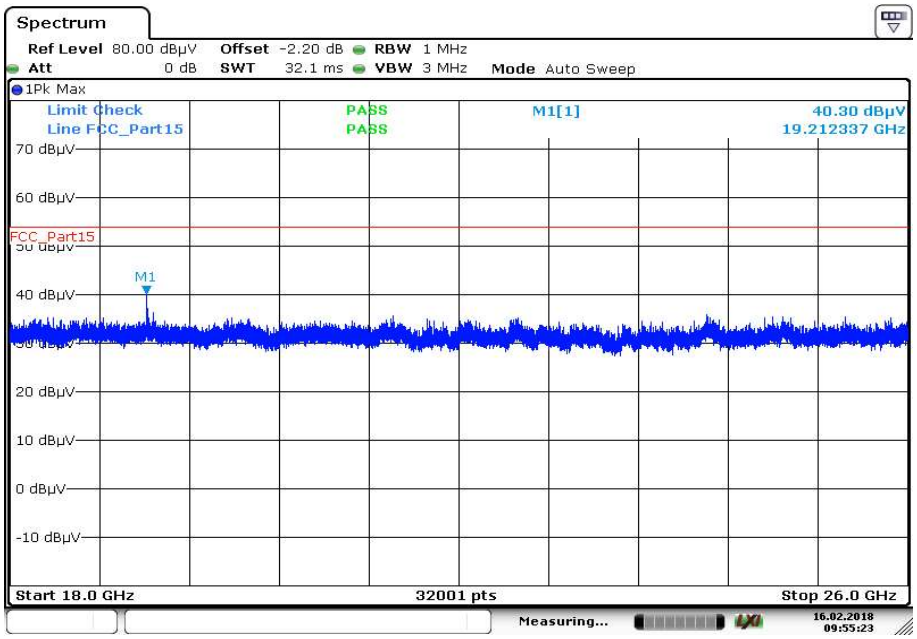


Plot 7: 1 GHz to 18 GHz, TX mode, 2402 MHz, vertical & horizontal polarization, 2 Msps, on-board antenna

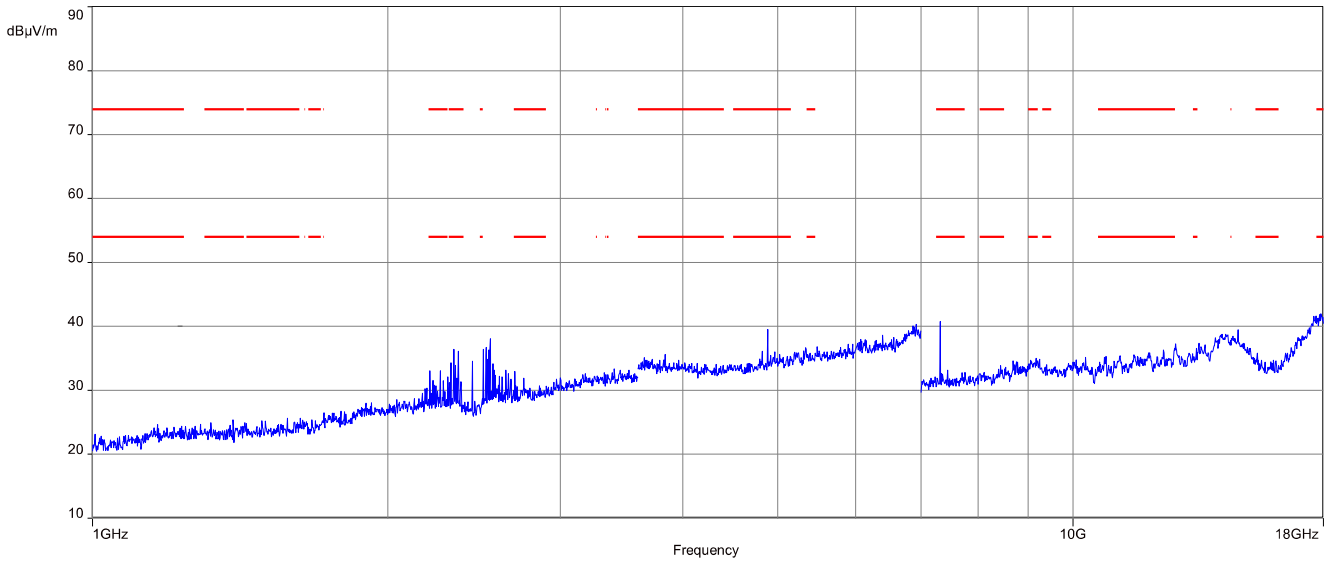


The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 8: 18 GHz to 26 GHz, TX mode, 2402 MHz, vertical & horizontal polarization, 2 Msps, on-board antenna

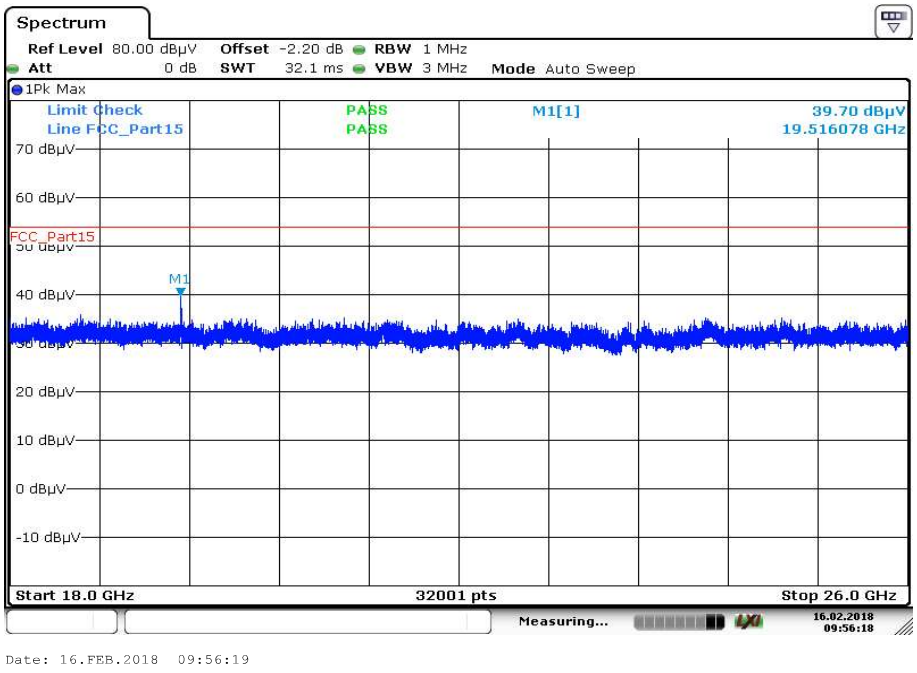


Plot 9: 1 GHz to 18 GHz, TX mode, 2440 MHz, vertical & horizontal polarization, 2 Msps, on-board antenna

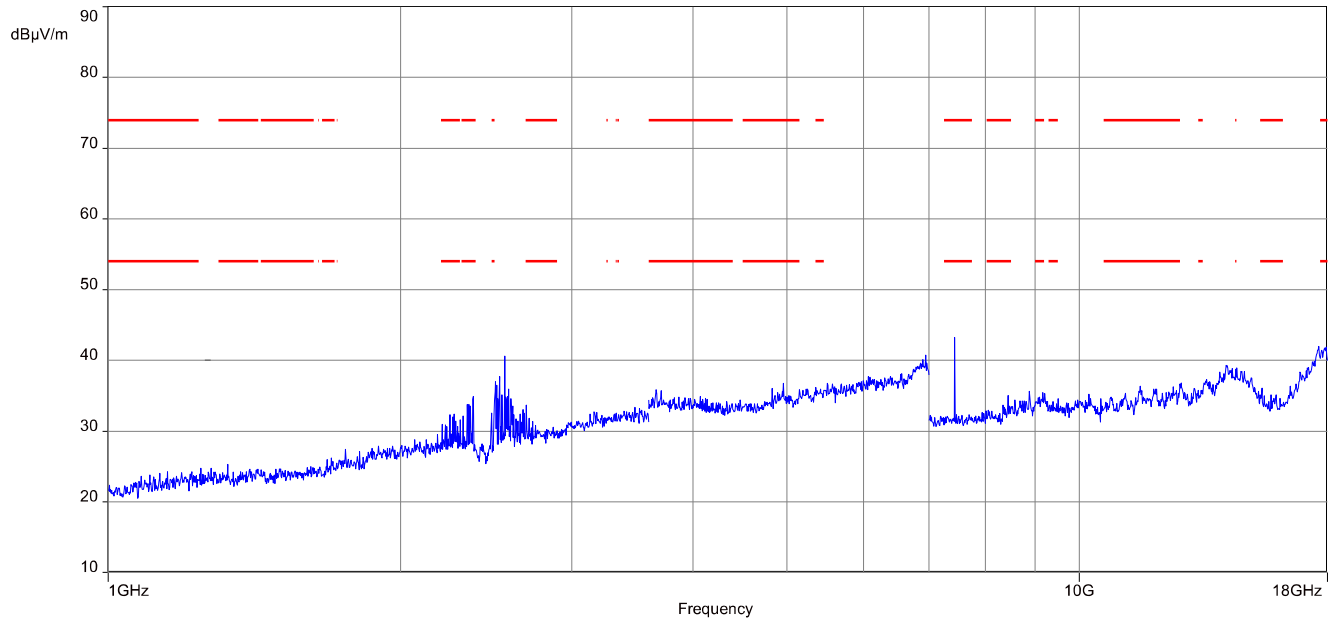


The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 10: 18 GHz to 26 GHz, TX mode, 2440 MHz, vertical & horizontal polarization, 2 Msps, on-board antenna

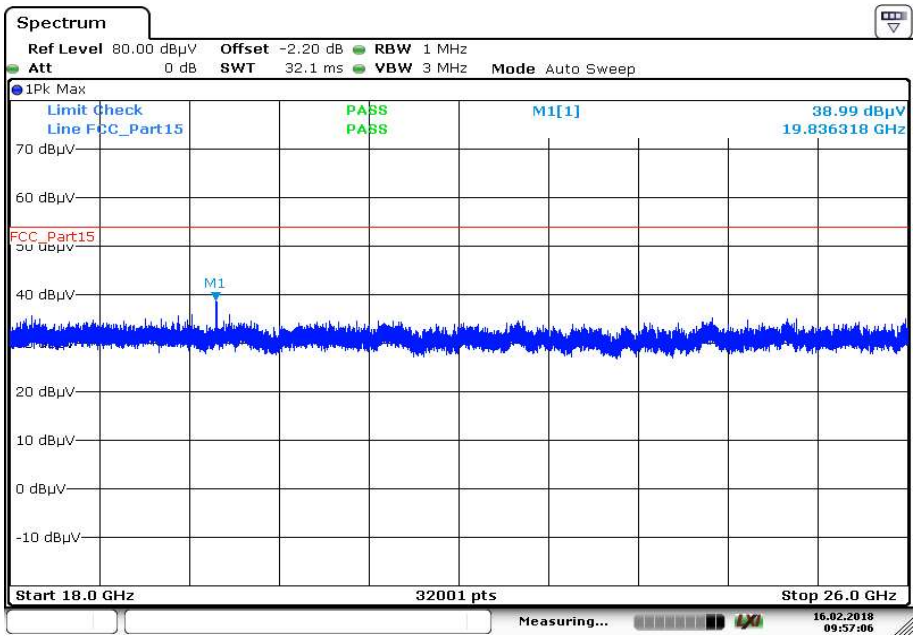


Plot 11: 1 GHz to 18 GHz, TX mode, 2480 MHz, vertical & horizontal polarization, 2 Msps, on-board antenna

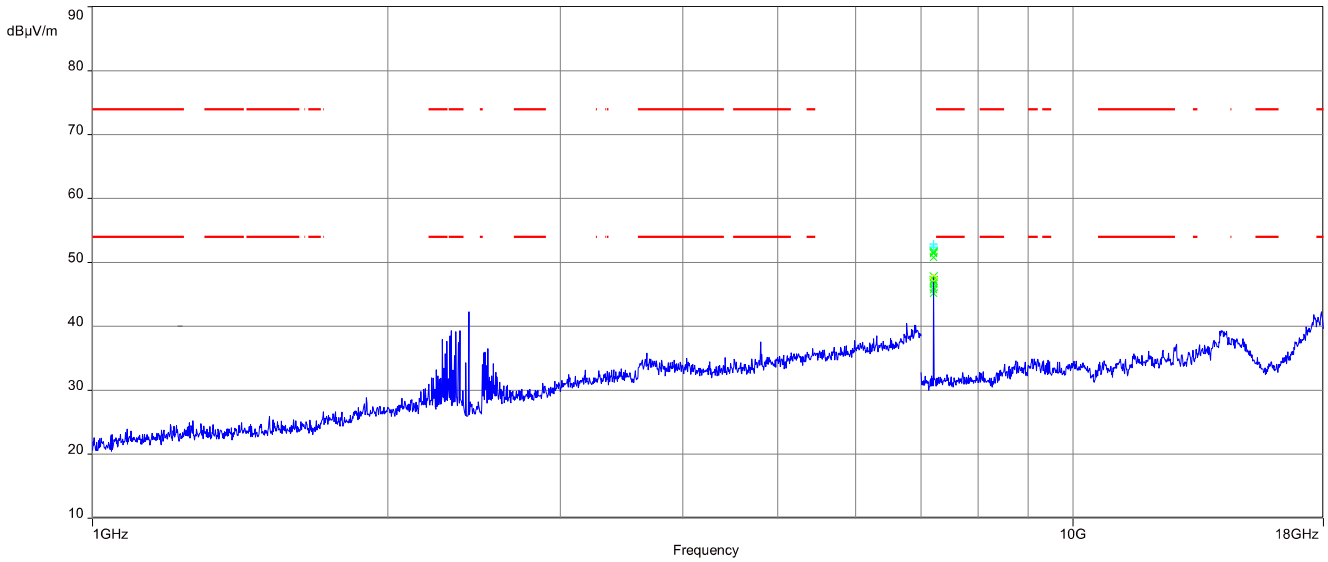


The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 12: 18 GHz to 26 GHz, TX mode, 2480 MHz, vertical & horizontal polarization, 2 Msps, on-board antenna

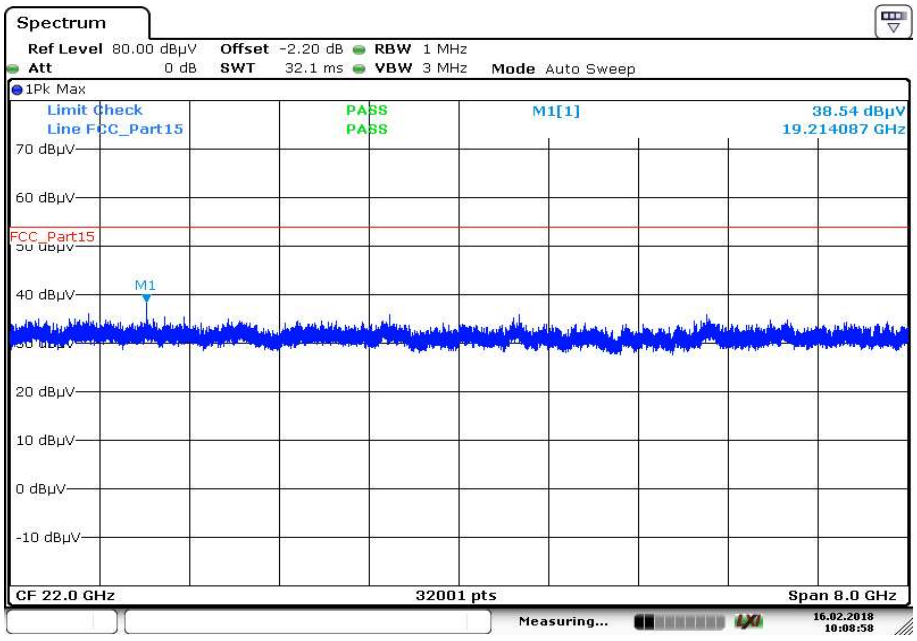


Plot 13: 1 GHz to 18 GHz, TX mode, 2402 MHz, vertical & horizontal polarization, 1 Msps, external antenna

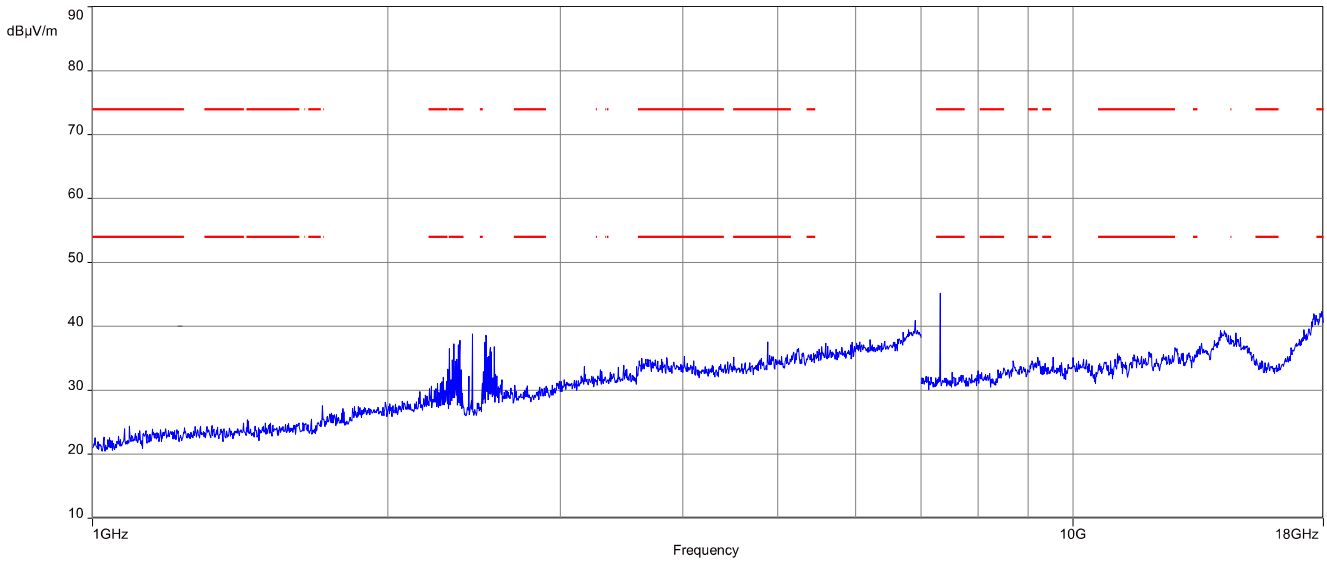


The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 14: 18 GHz to 26 GHz, TX mode, 2402 MHz, vertical & horizontal polarization, 1 Msps, external antenna

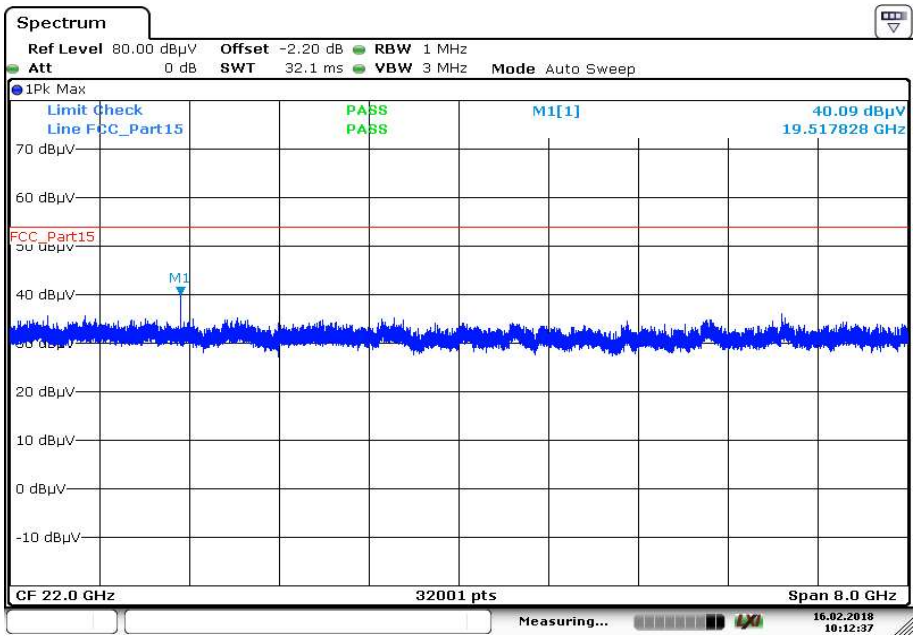


Plot 15: 1 GHz to 18 GHz, TX mode, 2440 MHz, vertical & horizontal polarization, 1 Msps, external antenna

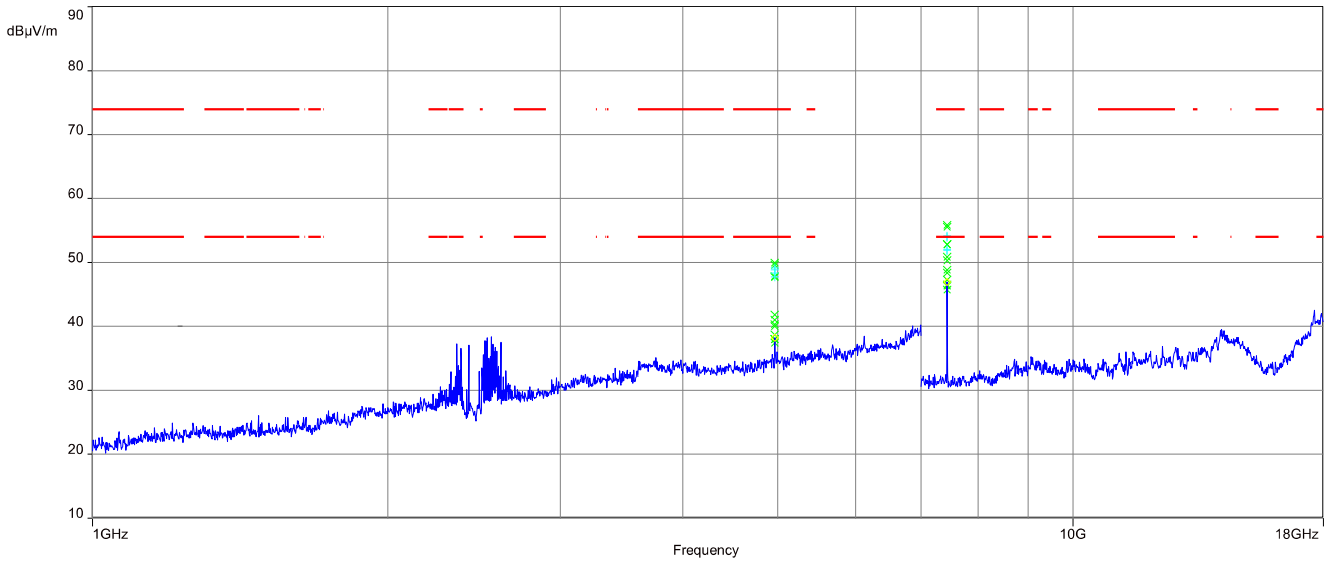


The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 16: 18 GHz to 26 GHz, TX mode, 2440 MHz, vertical & horizontal polarization, 1 Msps, external antenna

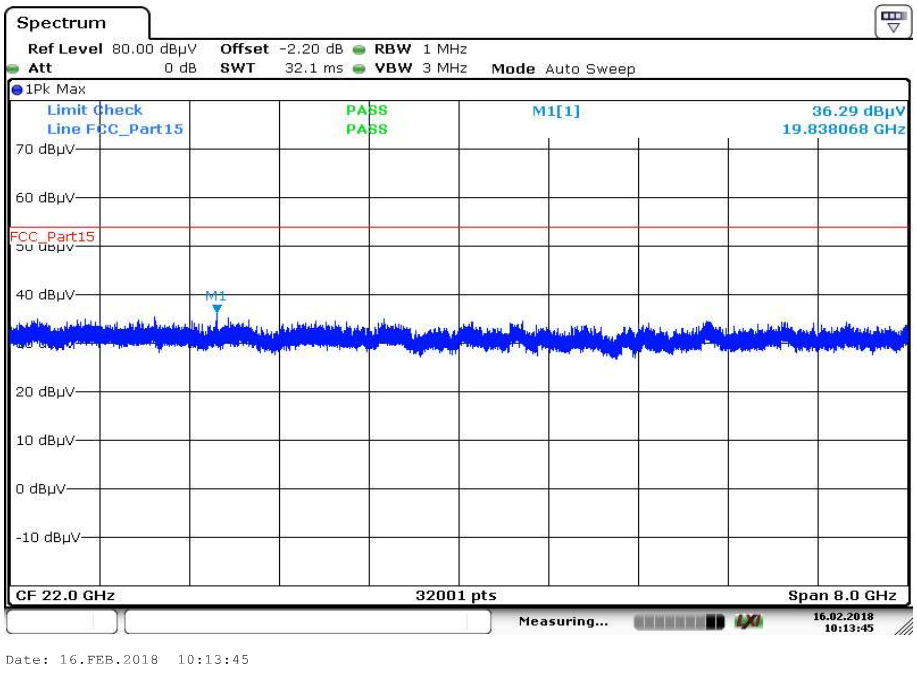


Plot 17: 1 GHz to 18 GHz, TX mode, 2480 MHz, vertical & horizontal polarization, 1 Msps, external antenna

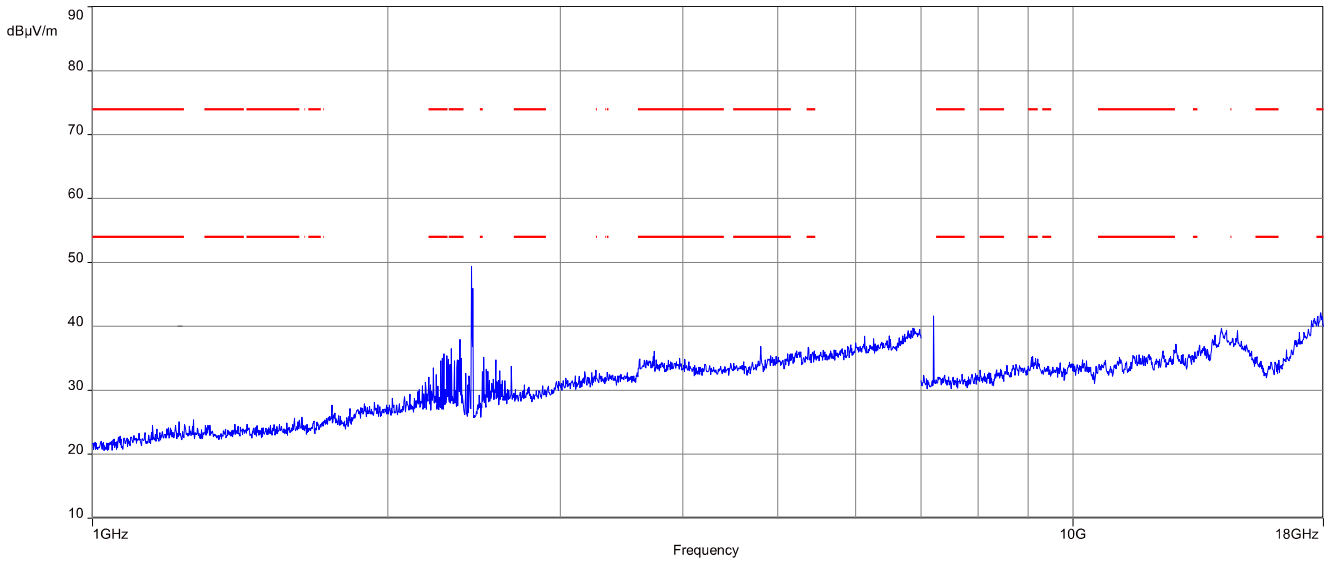


The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 18: 18 GHz to 26 GHz, TX mode, 2480 MHz, vertical & horizontal polarization, 1 Msps, external antenna

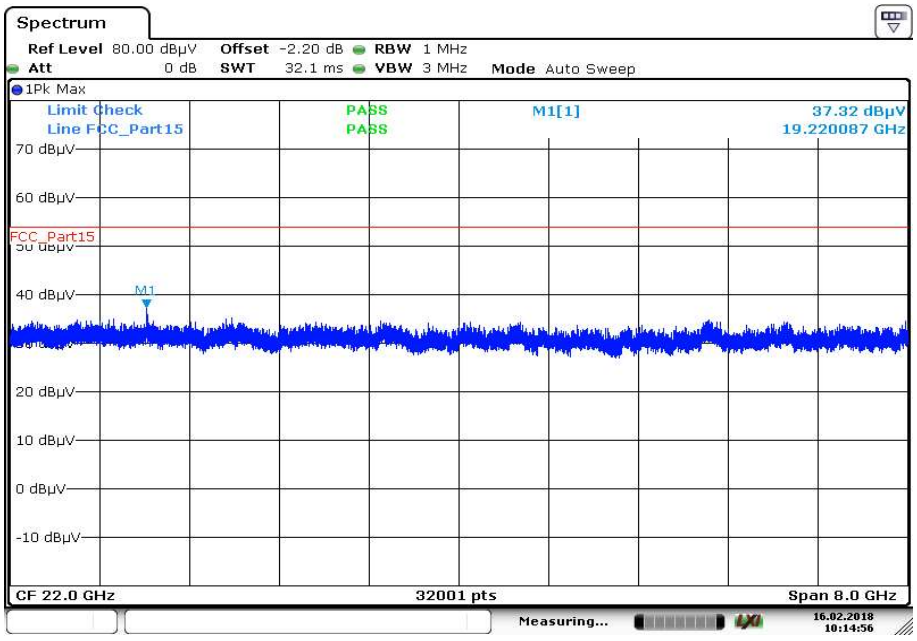


Plot 19: 1 GHz to 18 GHz, TX mode, 2402 MHz, vertical & horizontal polarization, 2 Msps, external antenna

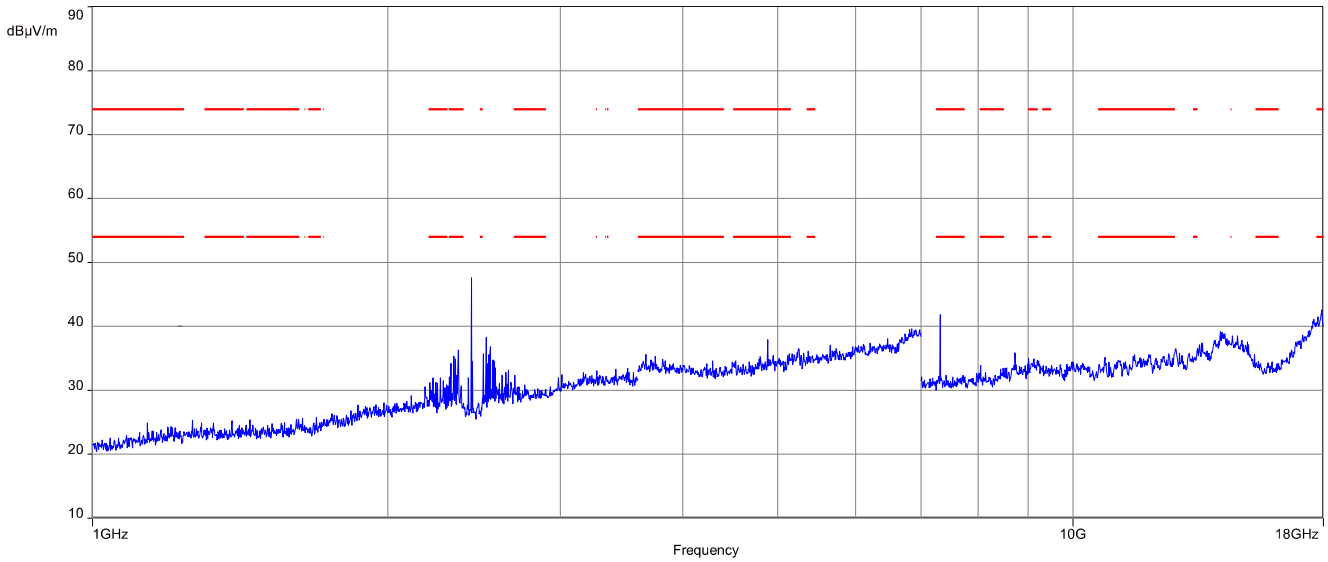


The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 20: 18 GHz to 26 GHz, TX mode, 2402 MHz, vertical & horizontal polarization, 2 Msps, external antenna

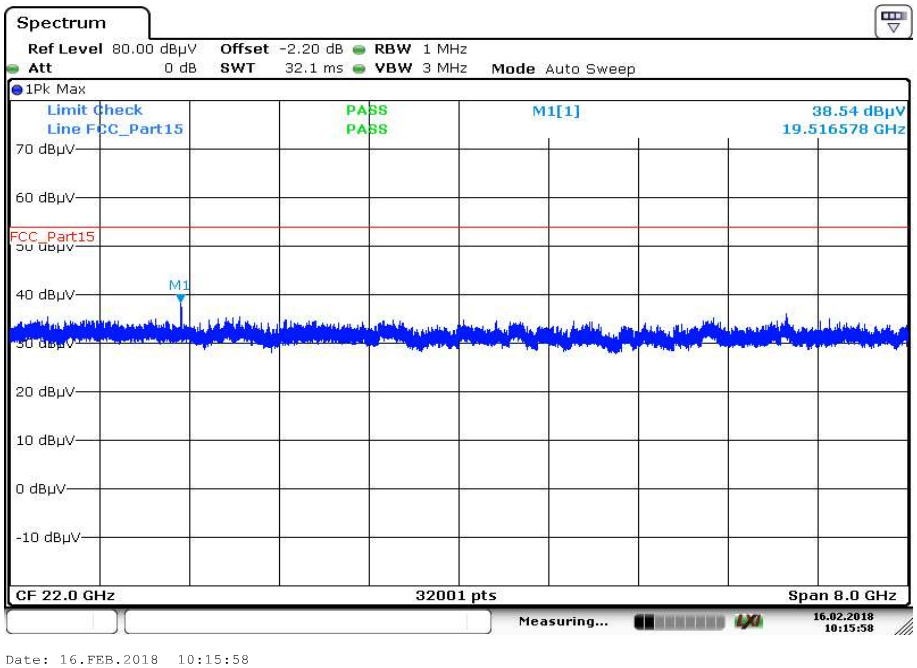


Plot 21: 1 GHz to 18 GHz, TX mode, 2440 MHz, vertical & horizontal polarization, 2 Msps, external antenna

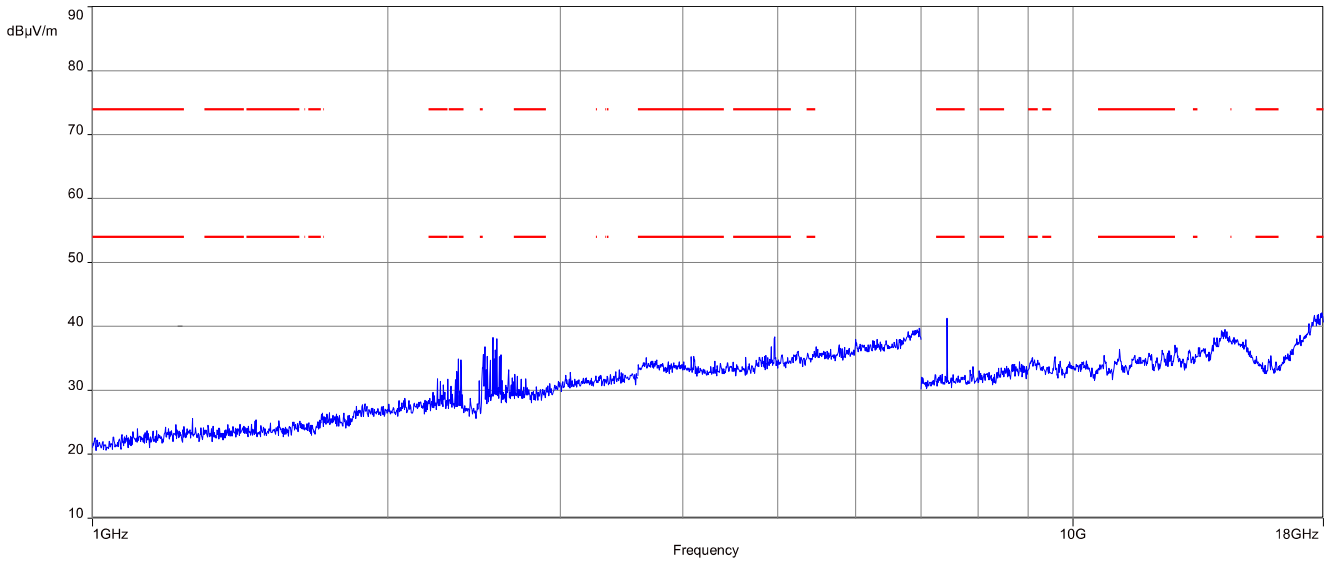


The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 22: 18 GHz to 26 GHz, TX mode, 2440 MHz, vertical & horizontal polarization, 2 Msps, external antenna

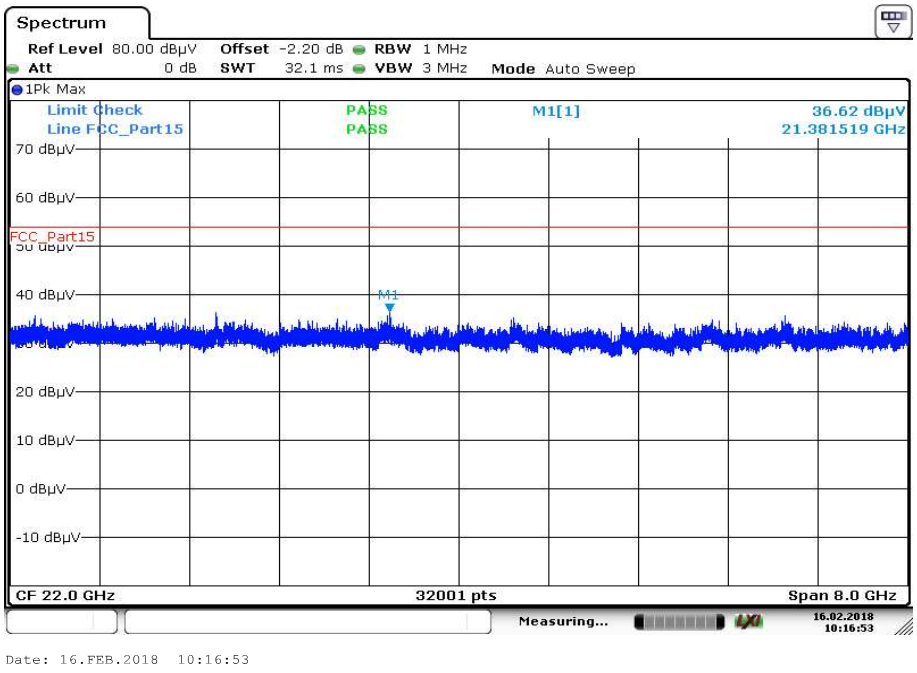


Plot 23: 1 GHz to 18 GHz, TX mode, 2480 MHz, vertical & horizontal polarization, 2 Msps, external antenna



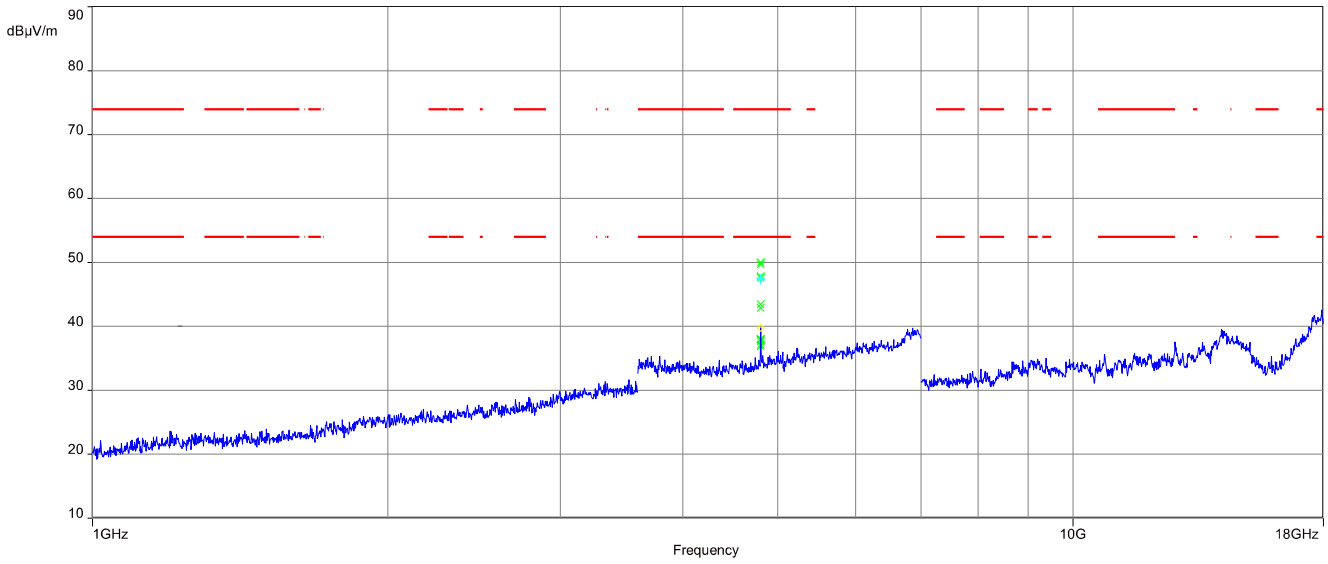
The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 24: 18 GHz to 26 GHz, TX mode, 2480 MHz, vertical & horizontal polarization, 2 Msps, external antenna

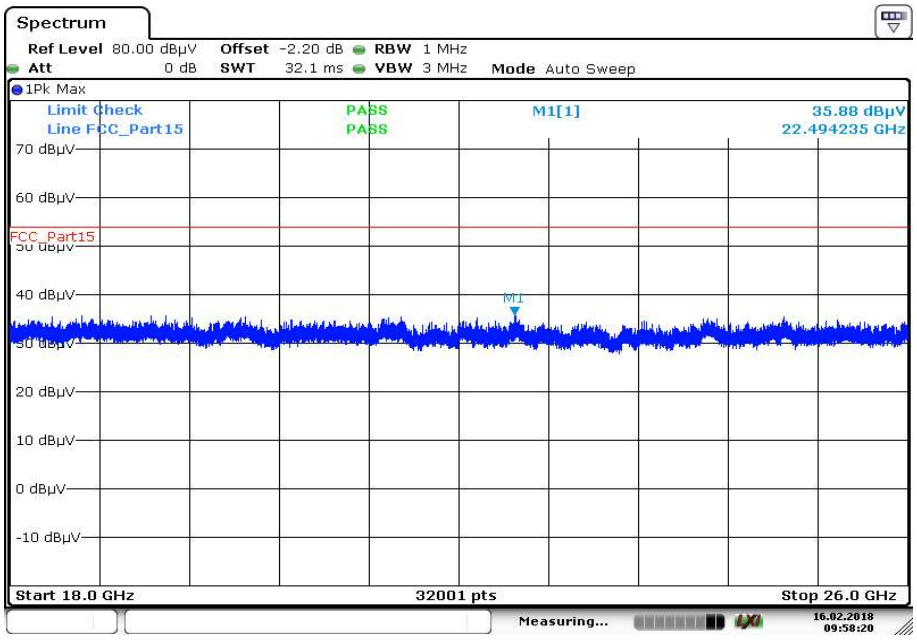


Plots: Receiver mode

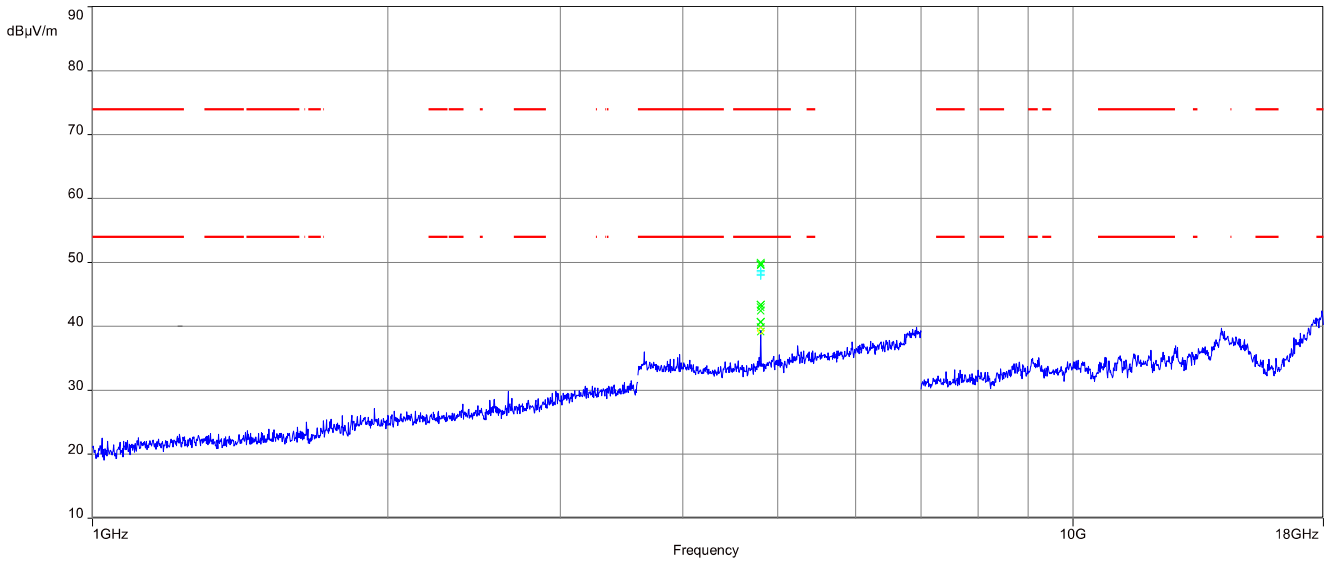
Plot 1: 1 GHz to 18 GHz, RX / idle – mode, vertical & horizontal polarization, on-board antenna



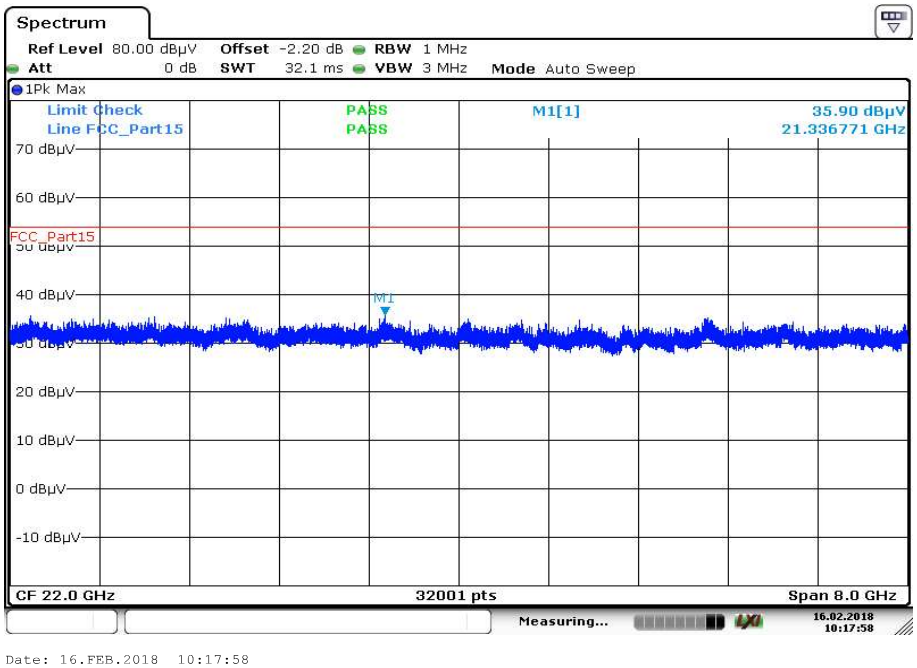
Plot 2: 18 GHz to 26 GHz, RX / idle – mode, vertical & horizontal polarization, on-board antenna



Plot 3: 1 GHz to 18 GHz, RX / idle – mode, vertical & horizontal polarization, external antenna



Plot 4: 18 GHz to 26 GHz, RX / idle – mode, vertical & horizontal polarization, external antenna



11.12 Spurious emissions conducted below 30 MHz (AC conducted)

Description:

Measurement of the conducted spurious emissions in transmit mode below 30 MHz. Both power lines, phase and neutral line, are measured. Found peaks are re-measured with average and quasi peak detection to show compliance to the limits.

Measurement:

Measurement parameter	
Detector	Peak - Quasi Peak / Average
Sweep time	Auto
Resolution bandwidth	F < 150 kHz: 200 Hz F > 150 kHz: 9 kHz
Video bandwidth	F < 150 kHz: 1 kHz F > 150 kHz: 100 kHz
Span	9 kHz to 30 MHz
Trace mode	Max. Hold
Test setup	See chapter 6.1
Measurement uncertainty	See chapter 8

Limits:

FCC		IC
Frequency / MHz)	Quasi-Peak / (dBµV / m)	Average / (dBµV / m)
0.15 – 0.5	66 to 56*	56 to 46*
0.5 – 5	56	46
5 – 30.0	60	50

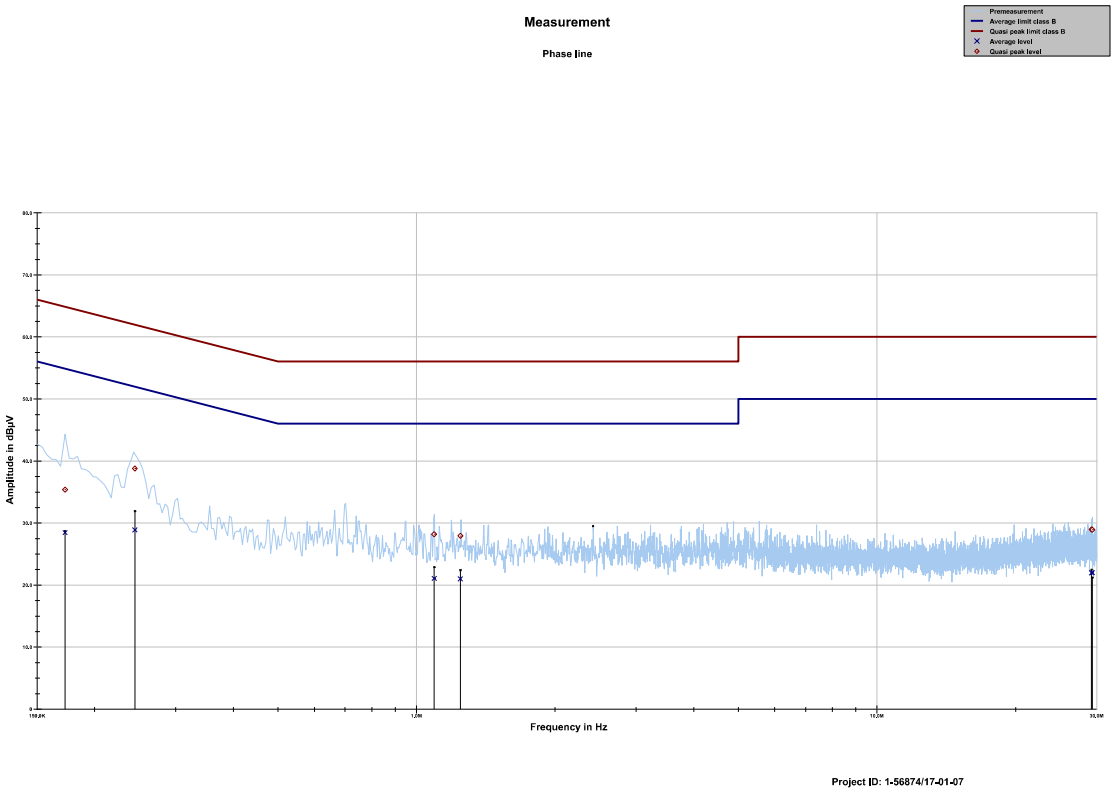
*Decreases with the logarithm of the frequency

Results:

TX spurious emissions conducted < 30 MHz / (dBµV / m) @ 3m		
f / MHz	Detector	Level / dBµV/m
All detected peaks are more than 20 dB below the limit.		

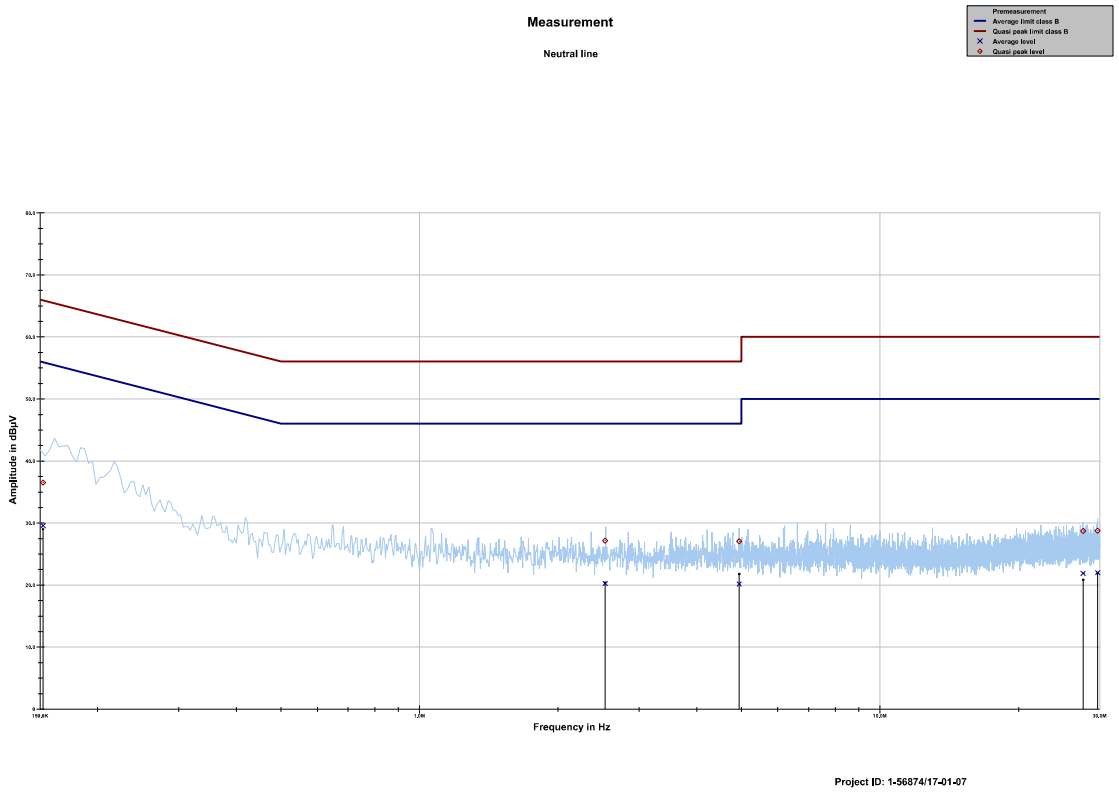
Plots:

Plot 1: 150 kHz to 30 MHz, phase line, external antenna



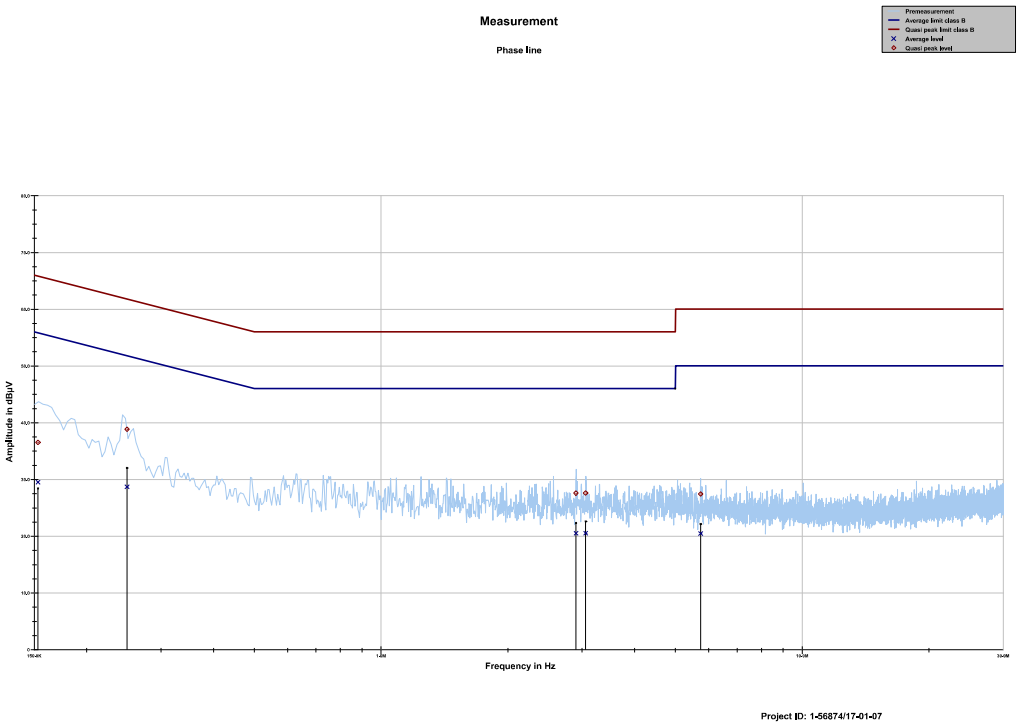
Frequency	Quasi peak level	Margin quasi peak	Limit QP	Average level	Margin average	Limit AV
MHz	dBµV	dB	dBµV	dBµV	dB	dBµV
0.172618	35.37	29.46	64.833	28.45	26.90	55.354
0.244502	38.79	23.16	61.942	28.88	24.42	53.300
1.093214	28.18	27.82	56.000	21.06	24.94	46.000
1.245626	27.91	28.09	56.000	20.98	25.02	46.000
29.254536	28.93	31.07	60.000	21.95	28.05	50.000
29.372774	28.89	31.11	60.000	21.99	28.01	50.000

Plot 2: 150 kHz to 30 MHz, neutral line, external antenna



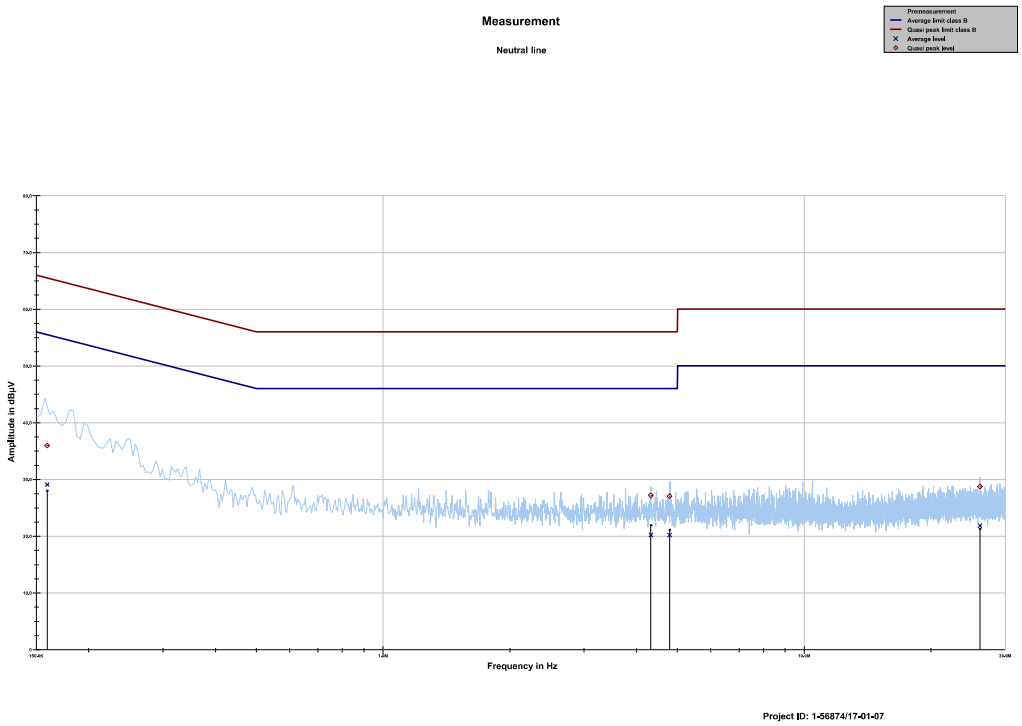
Frequency	Quasi peak level	Margin quasi peak	Limit QP	Average level	Margin average	Limit AV
MHz	dBµV	dB	dBµV	dBµV	dB	dBµV
0.152330	36.50	29.37	65.872	29.57	26.36	55.933
2.531868	27.17	28.83	56.000	20.23	25.77	46.000
4.946187	27.07	28.93	56.000	20.17	25.83	46.000
27.616161	28.69	31.31	60.000	21.87	28.13	50.000
29.714002	28.76	31.24	60.000	21.97	28.03	50.000

Plot 3: 150 kHz to 30 MHz, phase line, internal antenna



Frequency	Quasi peak level	Margin quasi peak	Limit QP	Average level	Margin average	Limit AV
MHz	dBµV	dB	dBµV	dBµV	dB	dBµV
0.153204	36.52	29.30	65.824	29.49	26.42	55.908
0.249198	38.83	22.95	61.784	28.70	24.47	53.166
2.902839	27.58	28.42	56.000	20.51	25.49	46.000
3.060555	27.59	28.41	56.000	20.51	25.49	46.000
5.737430	27.43	32.57	60.000	20.47	29.53	50.000
0.153204	36.52	29.30	65.824	29.49	26.42	55.908

Plot 4: 150 kHz to 30 MHz, neutral line, internal antenna



Frequency	Quasi peak level	Margin quasi peak	Limit QP	Average level	Margin average	Limit AV
MHz	dBµV	dB	dBµV	dBµV	dB	dBµV
0.159310	35.94	29.56	65.500	29.09	26.64	55.734
4.323773	27.19	28.81	56.000	20.21	25.79	46.000
4.791806	27.04	28.96	56.000	20.20	25.80	46.000
26.122718	28.76	31.24	60.000	21.85	28.15	50.000

Annex A Glossary

EUT	Equipment under test
DUT	Device under test
UUT	Unit under test
GUE	GNSS User Equipment
ETSI	European Telecommunications Standards Institute
EN	European Standard
FCC	Federal Communications Commission
FCC ID	Company Identifier at FCC
IC	Industry Canada
PMN	Product marketing name
HMN	Host marketing name
HVIN	Hardware version identification number
FVIN	Firmware version identification number
EMC	Electromagnetic Compatibility
HW	Hardware
SW	Software
Inv. No.	Inventory number
S/N or SN	Serial number
C	Compliant
NC	Not compliant
NA	Not applicable
NP	Not performed
PP	Positive peak
QP	Quasi peak
AVG	Average
OC	Operating channel
OCW	Operating channel bandwidth
OBW	Occupied bandwidth
OOB	Out of band
DFS	Dynamic frequency selection
CAC	Channel availability check
OP	Occupancy period
NOP	Non occupancy period
DC	Duty cycle
PER	Packet error rate
CW	Clean wave
MC	Modulated carrier
WLAN	Wireless local area network
RLAN	Radio local area network
DSSS	Dynamic sequence spread spectrum
OFDM	Orthogonal frequency division multiplexing
FHSS	Frequency hopping spread spectrum
GNSS	Global Navigation Satellite System
C/N_0	Carrier to noise-density ratio, expressed in dB-Hz

Annex B Document history

Version	Applied changes	Date of release
-/-	Initial release	2018-02-20
A	Measurements for conducted emissions below 30 MHz added. Editorial changes	2018-03-26

Annex C Accreditation Certificate

first page	last page
	

Note: The current certificate annex is published on the website (link see below) of the Accreditation Body DAkkS or may be received by CTC advanced GmbH on request

http://www.dakks.de/as/ast/d/D-PL-12076-01-03.pdf