



FCC Test Report

For:
Itron, Inc.

Brand:
Itron

Marketing Name:
Solar Battery AP

Model Name:
Solar Battery AP

Product Description:
Solar battery access point

FCC ID: EWQ-SBAP
IC: 864D-SBAP

Applied Rules and Standards:
47 CFR Part 15.247 (FHSS) / (HYBIRD)
RSS-247 Issue 3 (FHSS) / (HYBIRD) & RSS-Gen Issue 5

REPORT #: EMC_ITRO1_071_23001_15_247_FHSS_HYBRID_Rev1

DATE: 2024-07-03



A2LA Accredited

IC recognized #
3462B

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1 Assessment

The following device was evaluated against the applicable criteria specified in FCC rules Parts 15.247 of Title 47 of the Code of Federal Regulations and the relevant ISED Canada standard RSS-247.

No deviations were ascertained.

Company	Description	Model #
Itron, Inc	Solar Battery Access Point	Solar Battery AP

Responsible for the Report:

2024-07-03	Compliance	Art Thammanavarat (Senior EMC Engineer)	
Date	Section	Name	Signature

The test results of this test report relate exclusively to the test item specified in Section 3.
CETECOM Inc. USA does not assume responsibility for any conclusions and generalizations drawn from the test results with regard to other specimens or samples of the type of the equipment represented by the test item. The test report may only be reproduced or published in full. Reproduction or publication of extracts from the report requires the prior written approval of CETECOM Inc. USA.

2 Administrative Data

2.1 Identification of the Testing Laboratory Issuing the EMC Test Report

Company Name:	CETECOM Inc.
Department:	Compliance
Street Address:	411 Dixon Landing Road
City/Zip Code	Milpitas, CA 95035
Country	USA
Telephone:	+1 (408) 586 6200
Fax:	+1 (408) 586 6299
EMC Lab Manager:	Issa Ghama
Project Manager:	Rami Saman

2.2 Identification of the Client

Client's Name:	Itron, Inc.
Street Address:	2401 North State St
City/Zip Code	Waseca, MN 56093
Country	USA

2.3 Identification of the Manufacturer

Manufacturer's Name:	Itron, Inc.
Manufacturers Address:	313 North Hwy 11
City/Zip Code	West Union, SC 29696-2706
Country	USA

3 Equipment Under Test (EUT)

3.1 EUT Specifications

Model No:	Solar Battery AP
Marketing Name:	Solar Battery AP
HW Version :	3
SW Version :	CSL 10.0.7.0
FCC ID :	EWQ-SBAP
IC :	864D-SBAP
FVIN:	CSL 10.0.7.0
HVIN:	SBAP
PMN:	Solar Battery AP
Product Description:	Solar battery access point
Frequency Range / number of channels:	GFSK 150kbps, 54kHz deviation, Pwr Lvl 2 (Hybrid) – 902-928MHz - 64 channels max GFSK 150kbps, 75kHz deviation, Pwr Lvl 3 (FHSS) - 902-928MHz – 64 channels max OOK Pwr Lvl 3 (FHSS) - 902-928MHz - 120 channels max
Maximum Peak Conducted Output Power (dBm)	GFSK (Hybrid) = 13.47 dBm GFSK (FHSS) = 26.79 dBm OOK (FHSS) = 26.82 dBm
Radio Information:	915MHz Radio Model Name : SBAP Part Number : CC1354P10
Modes of Operation:	GFSK 150kbps, 54kHz deviation, Pwr Lvl 2 (Hybrid) GFSK 150kbps, 75kHz deviation, Pwr Lvl 3 (FHSS) OOK Pwr Lvl 3 (FHSS)
Antenna Information as declared:	Name : Itron Model Number : EWQ-SBAP Type : Integral PCB Antennas Peak Gain ISM900MHz: 3.3 dBi
Power Supply / Rated operating Voltage Range:	3.3V / 3.6V / 3.9V
Operating Temperature Range	-40C - 70C
Other Radios included in the device:	Cellular modem
Sample Revision	Pre-production
EUT Dimensions	160 x 236 x 77 mm
Note: The information of the EUT specifications in the table above is provided by the client.	

3.2 EUT Sample details

EUT #	Part Number	Series Number	HW Version	SW Version	Comments
1	200-9000000/1	2956120-01	3	CSL 10.0.7.0	Radiated Emission
2	200-9000000/1	2956120-04	3	CSL 10.0.7.0	Conducted

Note: information provided by the customer.

3.3 Accessory Equipment (AE) details

AE #	Type	Model	Manufacturer	Serial Number	Comments
1	Laptop	Latitude 5420	Dell	36638266611	Support laptop provided by client

3.4 Test Setup Configurations

Set-up #	EUT / AE used for set-up	Comments
1	EUT1 + AE1	- EUT power by 3.6Vdc battery - Radiated RF measurements were performed with EUT configured via customer provided CLI Tool and instructions to select modulation that lists below : 1. GFSK 150kbps, 54kHz deviation, Pwr Lvl 2 (Hybrid) 2. GFSK 150kbps, 75kHz deviation, Pwr Lvl 3 (FHSS) 3. OOK Pwr Lvl 3 (FHSS)

3.5 Mode of Operation

Mode #	Mode of Operation	Comments
1	915MHz Radio (GFSK)	915MHz Radio (GFSK) was tested on Low, Mid, High Channels at maximum power. Continuously transmitting continuous wave (for compliance test purpose only)
2	915MHz Radio (OOK)	915MHz Radio (OOK) was tested on Low, Mid, High Channels at maximum power. Continuously transmitting continuous wave (for compliance test purpose only)
3	915MHz Radio GFSK(Hybrid)	915MHz Radio (HYBRID) was tested on Low, Mid, High Channels at maximum power. Continuously transmitting continuous wave (for compliance test purpose only)

3.6 Justification for Worst Case Mode of Operation

During the testing process, the EUT was tested with transmitter sets on low, mid and high channels, and continuous wave transmission.

For radiated measurements, all data in this report shows the worst case between horizontal and vertical antenna polarizations and for all orientations of the EUT.

4 Subject of Investigation

The objective of the measurements done by CETECOM Inc. was to assess the performance of the EUT according to the relevant requirements specified in FCC rules Part 15.247 of Title 47 of the Code of Federal Regulations and Radio Standard Specification RSS-247 of ISED Canada.

This test report is to support a request for new equipment authorization under the
FCC ID: EWQ-SBAP
IC: 864D-SBAP

Testing procedures are based on 558074 D01 15.247 Meas Guidance v05r02 – “GUIDANCE FOR COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEM, FREQUENCY HOPPING SPREAD SPECTRUM SYSTEM, AND HYBRID SYSTEM DEVICES OPERATING UNDER SECTION 15.247 OF THE FCC RULES” - April 2, 2019, by the Federal Communications Commission, Office of Engineering and Technology, Laboratory Division.

5 Measurement Results Summary

Test Specification	Test Case	Temperature and Voltage Conditions	Mode	Pass	NA	NP	Result
§15.247(b)(2) RSS-247 5.4(a)	Maximum Peak Conducted Output Power	Nominal	GFSK(HYBRID)/ GFSK/OOK	■	□	□	Complies
§15.247(d) RSS-247 5.5 RSS-Gen 8.10	Band Edge Compliance	Nominal	GFSK(HYBRID)/ GFSK/OOK	■	□	□	Complies
§15.247(a)(1) RSS-247 5.1(c)	Spectrum Bandwidth	Nominal	GFSK(HYBRID)/ GFSK/OOK	■	□	□	Complies
§15.247(e) RSS-247 5.3(a)	Power Spectral Density	Nominal	GFSK(HYBRID)	■	□	□	Complies
§15.247(a)(1) RSS-247 5.1(c)	Carrier Frequency Separation	Nominal	GFSK(HYBRID)/ GFSK/OOK	■	□	□	Complies
§15.247(a)(1) RSS-247 5.1(c)	Number of Hopping Channels	Nominal	GFSK(HYBRID)/ GFSK/OOK	■	□	□	Complies
§15.247(a)(1) RSS-247 5.1(c)	Time of occupancy	Nominal	N/A	□	□	■	See Note 1, 3
§15.247(d) §15.209 (a) RSS-Gen 6.13	TX Spurious emissions-Radiated	Nominal	GFSK(HYBRID)/ GFSK/OOK	■	□	□	Complies
§15.207(a) RSS-Gen 8.8	AC Conducted Emissions	Nominal	N/A	□	□	■	See Note 1, 2

Note 1: NA= Not Applicable; NP= Not Performed.

Note 2: The DUT operate by 3.6Vdc battery.

Note 3: Please refer to BPD Time of use and Equal Usage document # 800-0016-06

6 Measurement Uncertainty

6.1 Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus, with 95% confidence interval (in dB delta to result), based on a coverage factor $k=2$.

Radiated measurement

Measurement System	EMC 1	EMC 2
Conducted emissions (mains port)	1.12	N/A
Radiated emissions (< 30 MHz)	3.28	2.98
(30 MHz – 1 GHz)	3.16	2.81
(1 – 3 GHz)	4.71	4.51
(3 – 18 GHz)	4.23	4.16
(18 – 40 GHz)	2.42	2.42

RF conducted measurement ± 0.5 dB

According to TR 102 273 a multiplicative propagation of error is assumed for RF measurement systems. For this reason the RMS method is applied to dB values and not to linear values as appropriate for additive propagation of error. Also used: <http://physics.nist.gov/cuu/Uncertainty/typeb.html>. The above calculated uncertainties apply to direct application of the Substitution method. The Substitution method is always used when the EUT comes closer than 3dB to the limit.

6.2 Environmental Conditions during Testing:

The following environmental conditions were maintained during the course of testing:

- Ambient Temperature: 20-25°C
- Relative humidity: 40-60%

Deviating test conditions are indicated at individual test description where applicable.+

6.3 Date of Testing:

2024-02-29 – 2024-04-10

6.4 Decision Rule:

Cetecom advanced follows ILAC G8:2019 chapter 4.2.1 (Simple Acceptance Rule).

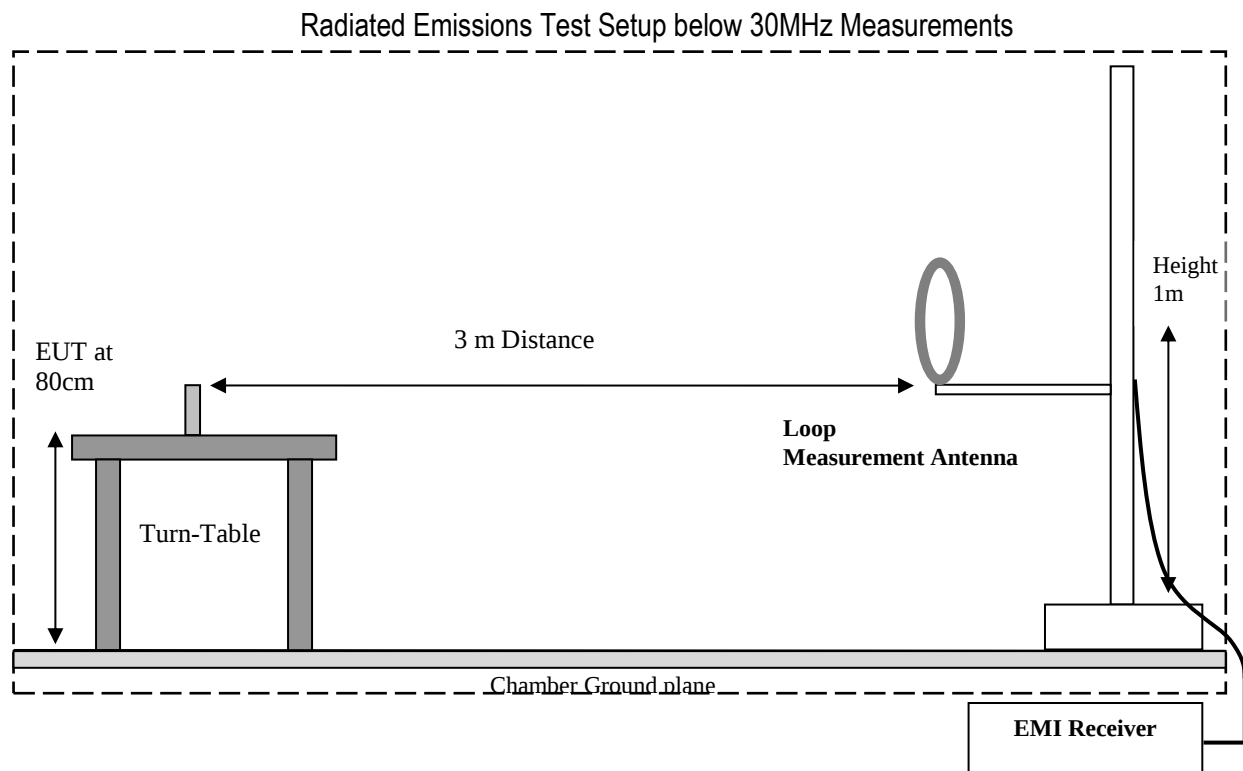
Only the measured values related to their corresponding limits will be used to decide whether the equipment under test meets the requirements of the test standards listed in chapter 3. The measurement uncertainty is mentioned in this test report, See chapter 9, but is not taken into account – neither to the limits nor to the measurement results. Measurement results with a smaller margin to the corresponding limits than the measurement uncertainty have a potential risk of more than 5% that the decision might be wrong.

7 Measurement Procedures

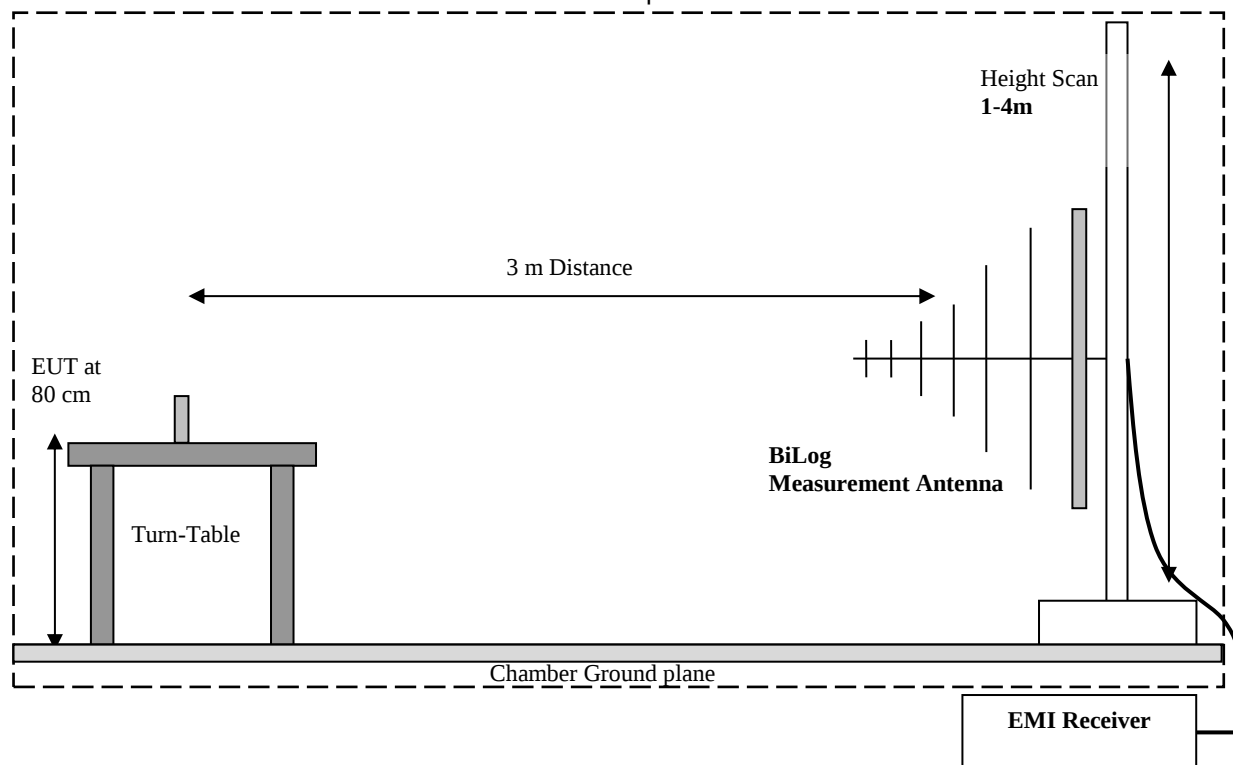
7.1 Radiated Measurement

The radiated measurement is performed according to ANSI C63.10 (2020)

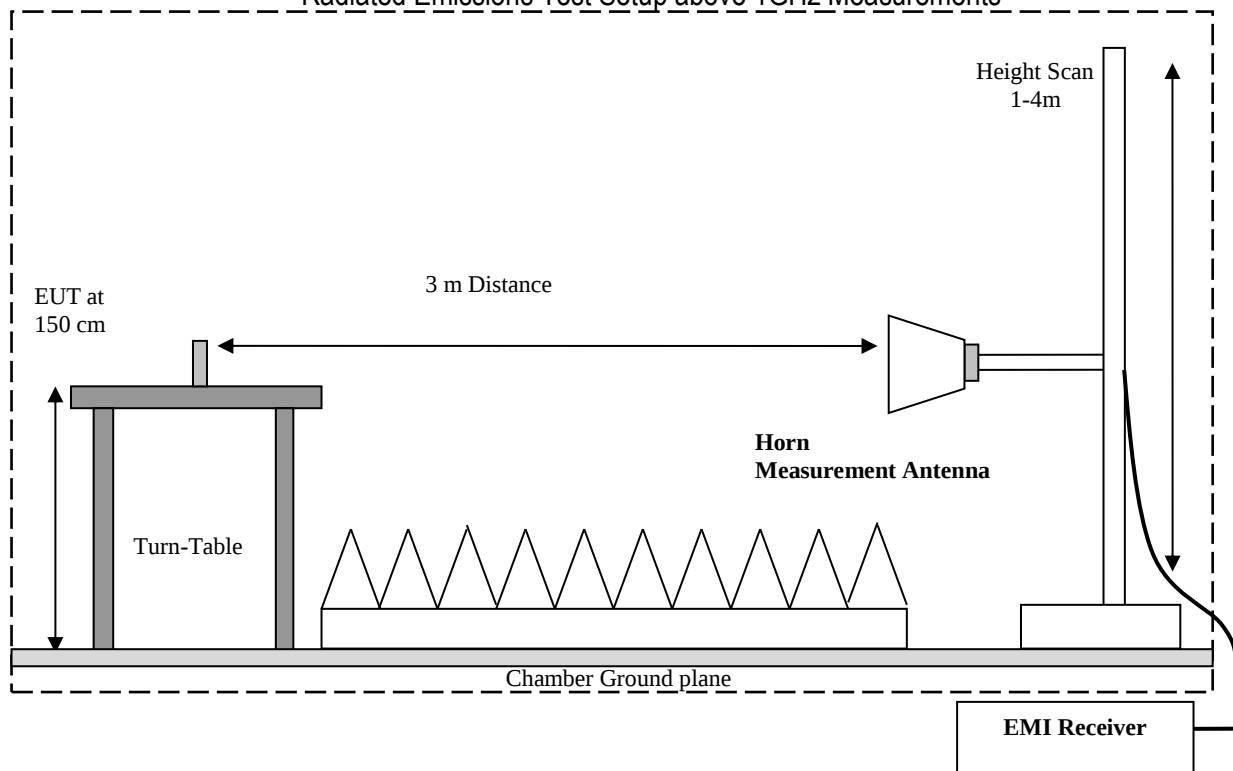
- The exploratory measurement is accomplished by running a matrix of 16 sweeps over the required frequency range with R&S Test-SW EMC32 for 4 positions of the turntable, two orthogonal positions of the EUT and both antenna polarizations. This procedure exceeds the requirement of the above standards to cover the 3 orthogonal axis of the EUT. A max peak detector is utilized during the exploratory measurement. The Test-SW creates an overall maximum trace for all 12 sweeps and saves the settings for each point of this trace. The maximum trace is part of the test report.
- The 10 highest emissions are selected with an automatic algorithm of EMC32 searching for peaks in the noise floor and ensuring that broadband signals are not selected multiple times.
- The maxima are then put through the final measurement and again maximized in a 90deg range of the turntable, fine search in frequency domain and height scan between 1m and 4m.
- The above procedure is repeated for all possible ways of power supply to EUT and for all supported modulations.
- In case there are no emissions above noise floor level only the maximum trace is reported as described above.
- The results are split up into up to 4 frequency ranges due to antenna bandwidth restrictions. A magnetic loop is used from 9 kHz to 30 MHz, a Biconilog antenna is used from 30 MHz to 1 GHz, and two different horn antennas are used to cover frequencies up to 40 GHz.



Radiated Emissions Test Setup 30MHz-1GHz Measurements



Radiated Emissions Test Setup above 1GHz Measurements



7.1.1 Sample Calculations for Field Strength Measurements

Field Strength is calculated from the Spectrum Analyzer/ Receiver readings, taking into account the following parameters:

1. Measured reading in dB μ V
2. Cable Loss between the receiving antenna and SA in dB and
3. Antenna Factor in dB/m

All radiated measurement plots in this report are taken from a test SW that calculates the Field Strength based on the following equation:

$$FS \text{ (dB}\mu\text{V/m)} = \text{Measured Value on SA (dB}\mu\text{V)} + \text{Cable Loss (dB)} + \text{Antenna Factor (dB/m)}$$

Example:

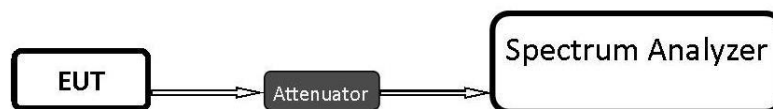
Frequency (MHz)	Measured SA (dB μ V)	Cable Loss (dB)	Antenna Factor Correction (dB)	Field Strength Result (dB μ V/m)
1000	80.5	3.5	14	98.0

7.2 Power Line Conducted Measurement Procedure

AC Power Line conducted emissions measurements performed according to: ANSI C63.4 (2014)

7.3 RF Conducted Measurement Procedure

Testing procedures are based on 558074 D01 15.247 Meas Guidance v05r02 – “GUIDANCE FOR COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEM, FREQUENCY HOPPING SPREAD SPECTRUM SYSTEM, AND HYBRID SYSTEM DEVICES OPERATING UNDER SECTION 15.247 OF THE FCC RULES” - April 2, 2019, by the Federal Communications Commission, Office of Engineering and Technology, Laboratory Division.



- Connect the equipment as shown in the above diagram.
- Adjust the settings of the SA (Rohde-Schwarz Spectrum Analyzer) to connect the EUT at the required mode of test.
- Measurements are to be performed with the EUT set to the low, middle and high channels and for worst case modulation schemes.

8 Test Result Data

8.1 Maximum Peak Conducted Output Power

8.1.1 Measurement according to FCC 558074 D01 15.247 Meas Guidance v05r02 and ANSI C63.10 Section 7.8.5

Spectrum Analyzer settings:

- Span = approximately 5 times the 20 dB bandwidth
- RBW > the 20 dB bandwidth of the emission being measured
- VBW $\geq$ RBW
- Sweep = Auto Couple
- Detector function = Peak
- Trace = Max hold
- Use the marker-peak function to set the marker to the peak of the emission.

Measurement according to FCC 558074 D01 15.247 Meas Guidance v05r02 and ANSI C63.11.9

Spectrum Analyzer settings:

- RBW $\geq$ DTS bandwidth
- VBW $\geq 3 \times$ RBW
- Span $\geq 3 \times$ RBW
- Sweep = Auto couple
- Detector function = Peak
- Trace = Max hold
- Use peak marker function to determine the peak amplitude level

8.1.2 Limits:

Maximum Peak Output Power:

FCC §15.247: (b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:

- (2) For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels.

IC RSS-247 5.4:

- (a) For FHSs operating in the band 902-928 MHz, the maximum peak conducted output power shall not exceed 1.0 W, and the e.i.r.p. shall not exceed 4 W if the hopset uses 50 or more hopping channels; the maximum peak conducted output power shall not exceed 0.25 W and the e.i.r.p. shall not exceed 1 W if the hopset uses less than 50 hopping channels.

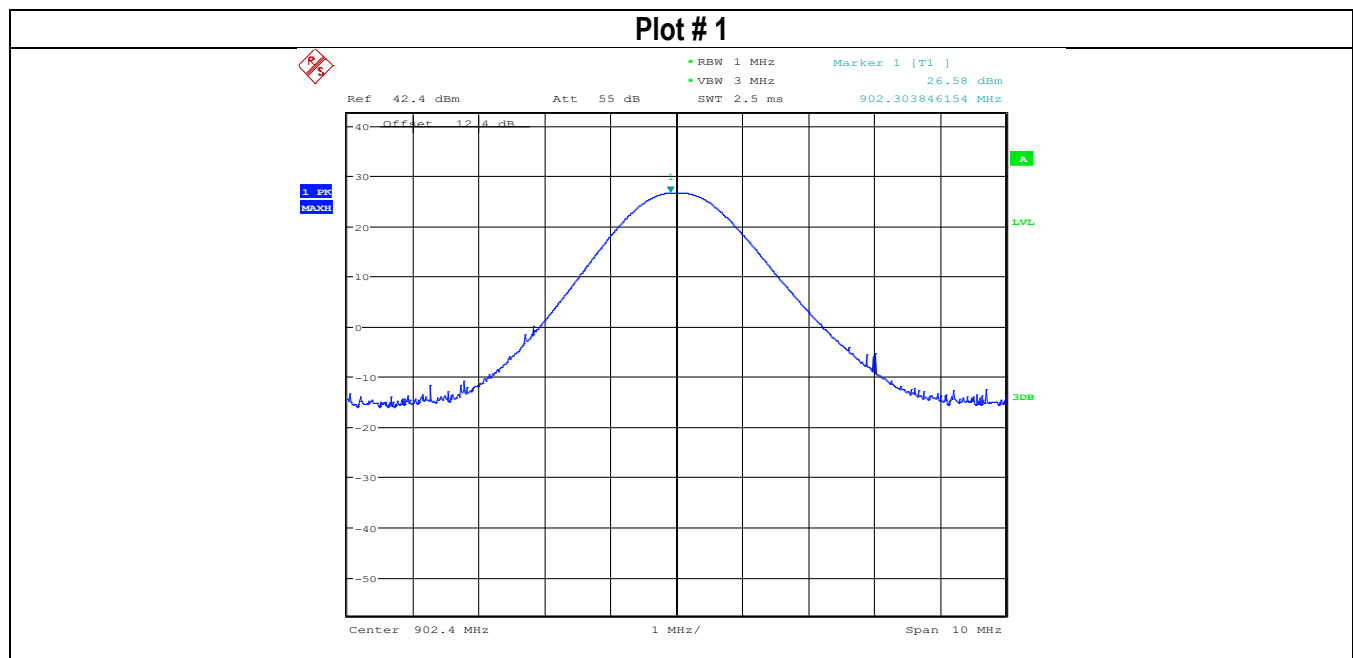
8.1.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
22.8.°C	1	1,2,3	Power by 3.6Vdc battery	3.3 dBi

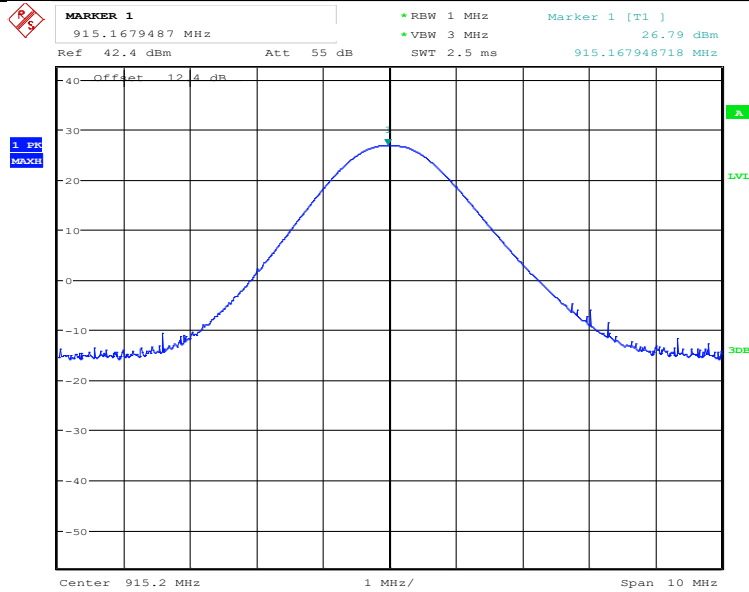
8.1.4 Measurement result:

Plot #	Frequency (MHz)	EUT operating mode	Maximum Peak Conducted Output Power (dBm)	EIRP (dBm)	Limit (dBm)	Result
1	902.4	GFSK (FHSS)	26.58	29.88	30(Pk) / 36(EIRP)	Pass
2	915.2	GFSK (FHSS)	26.79	30.09	30(Pk) / 36(EIRP)	Pass
3	927.6	GFSK (FHSS)	26.75	29.97	30(Pk) / 36(EIRP)	Pass
4	903.0	OOK (FHSS)	26.63	29.93	30(Pk) / 36(EIRP)	Pass
5	915.0	OOK (FHSS)	26.82	30.12	30(Pk) / 36(EIRP)	Pass
6	926.8	OOK (FHSS)	26.72	30.02	30(Pk) / 36(EIRP)	Pass
7	902.4	GFSK (HYBRID)	13.05	16.35	30(Pk) / 36(EIRP)	Pass
8	915.2	GFSK (HYBRID)	13.35	16.65	30(Pk) / 36(EIRP)	Pass
9	927.6	GFSK (HYBRID)	13.47	16.77	30(Pk) / 36(EIRP)	Pass

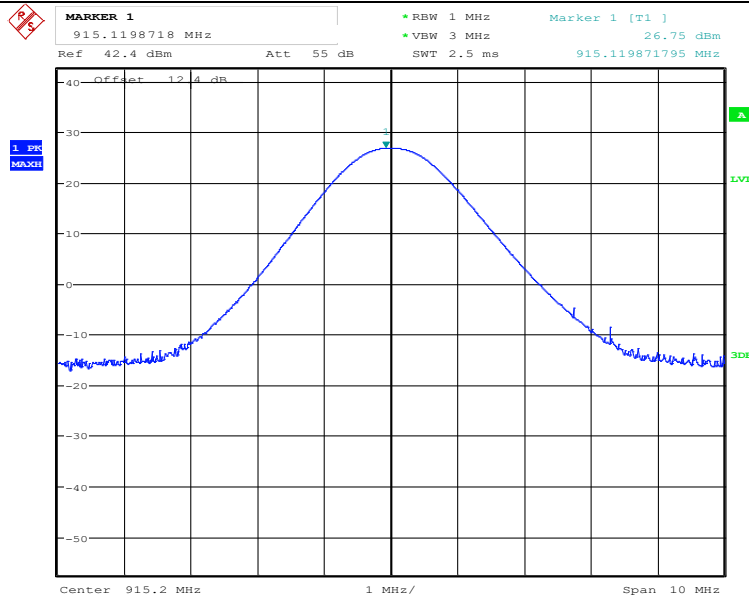
8.1.5 Measurement Plots:



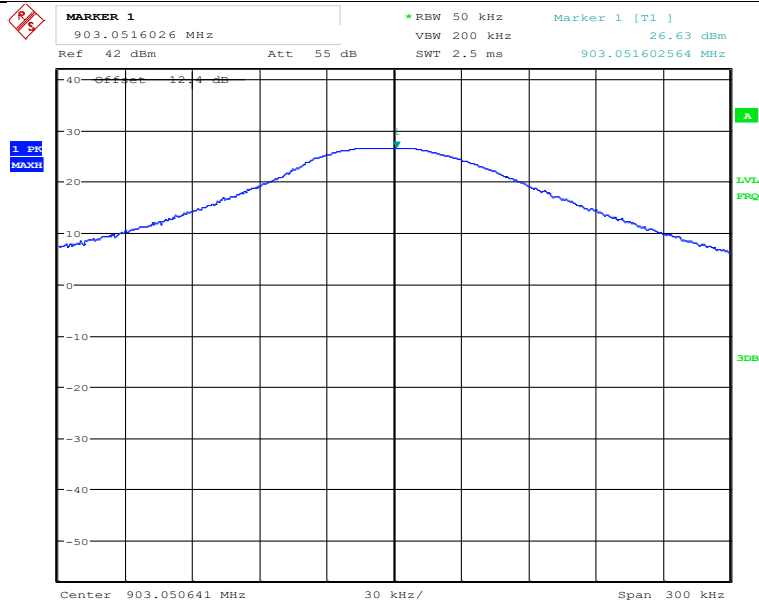
Plot # 2



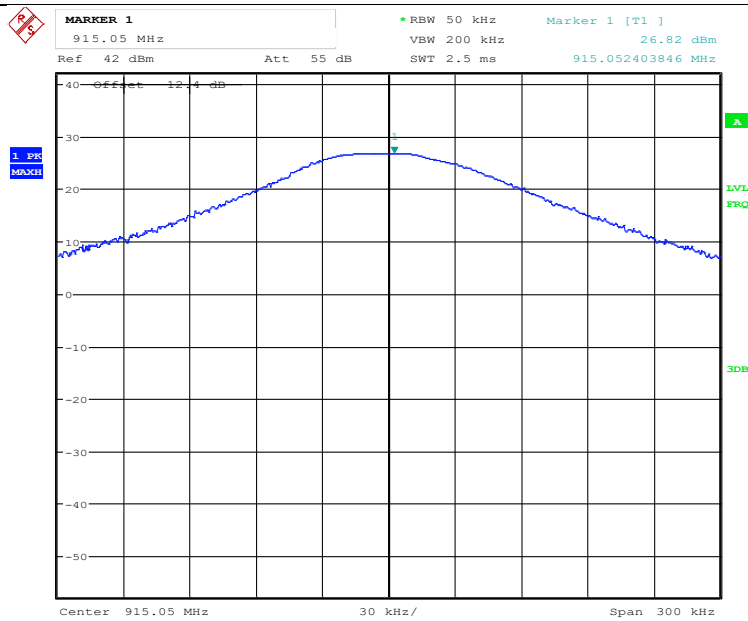
Plot # 3



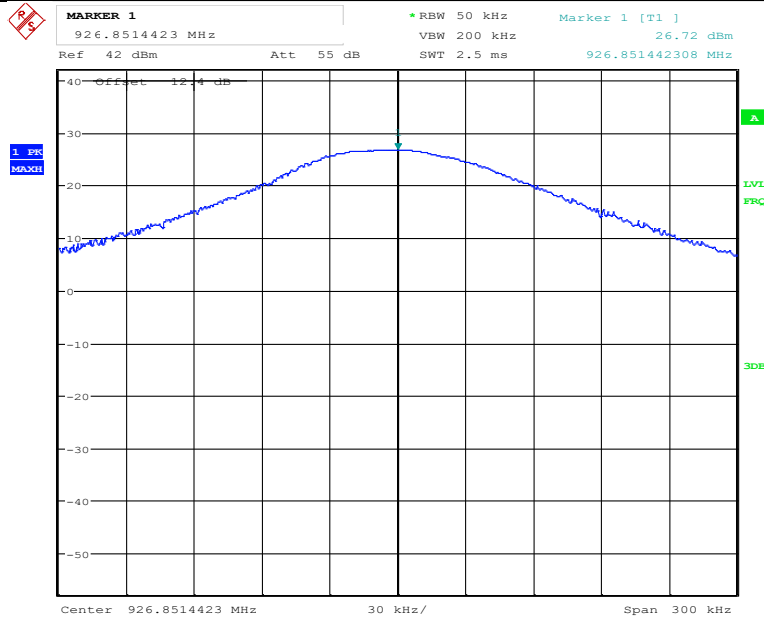
Plot # 4



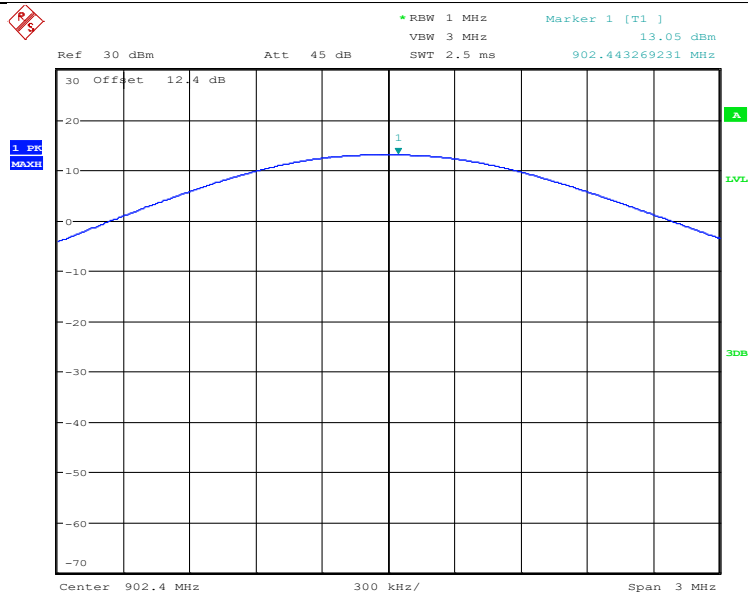
Plot # 5



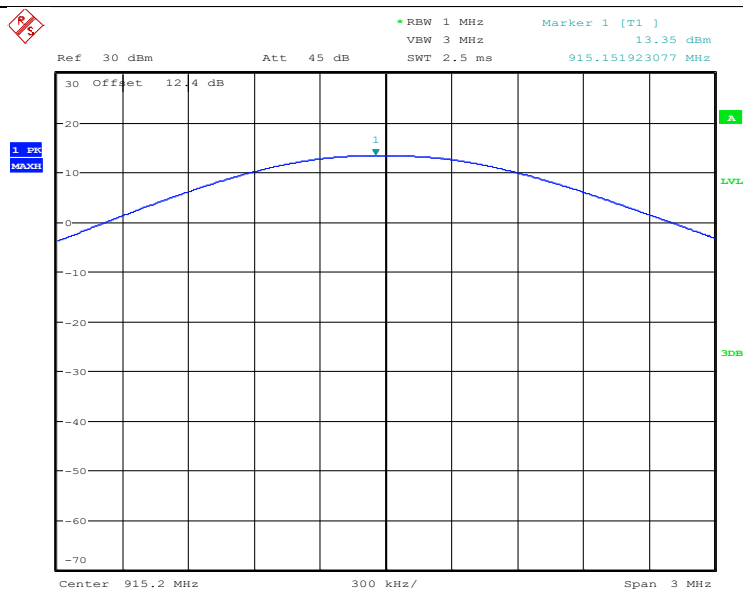
Plot # 6



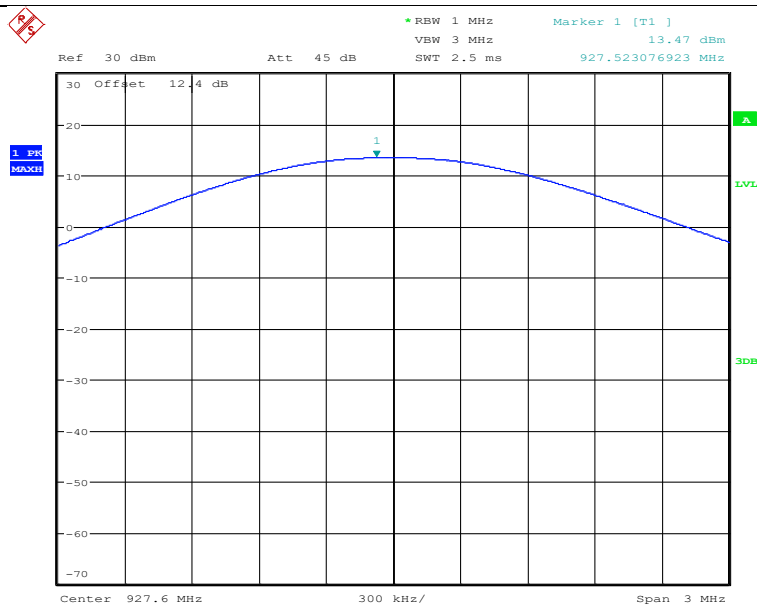
Plot # 7



Plot # 8



Plot # 9



8.2 Power Spectral Density

8.2.1 Measurement according to FCC 558074 D01 15.247 Meas Guidance v05r02 and ANSI C63.10 Section 11.10.2

Spectrum Analyzer settings for Peak PSD method:

- Set analyzer center frequency to DTS channel center frequency
- Set the span to 1.5 x DTS bandwidth
- Set RBW to: $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$
- Set the VBW $\geq 3 \times \text{RBW}$
- Detector = Peak
- Sweep time = Auto couple
- Trace mode = Max hold
- Allow trace to fully stabilize
- Use the peak marker function to determine the maximum amplitude level within the RBW
- If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat

8.2.2 Limits:

FCC§15.247(f) & RSS-247 5.3(a)

- For the purposes of this section, hybrid systems are those that employ a combination of both frequency hopping and digital modulation techniques. The frequency hopping operation of the hybrid system, with the direct sequence or digital modulation operation turned-off, shall have an average time of occupancy on any frequency not to exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4. The power spectral density conducted from the intentional radiator to the antenna due to the digital modulation operation of the hybrid system, with the frequency hopping operation turned off, shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

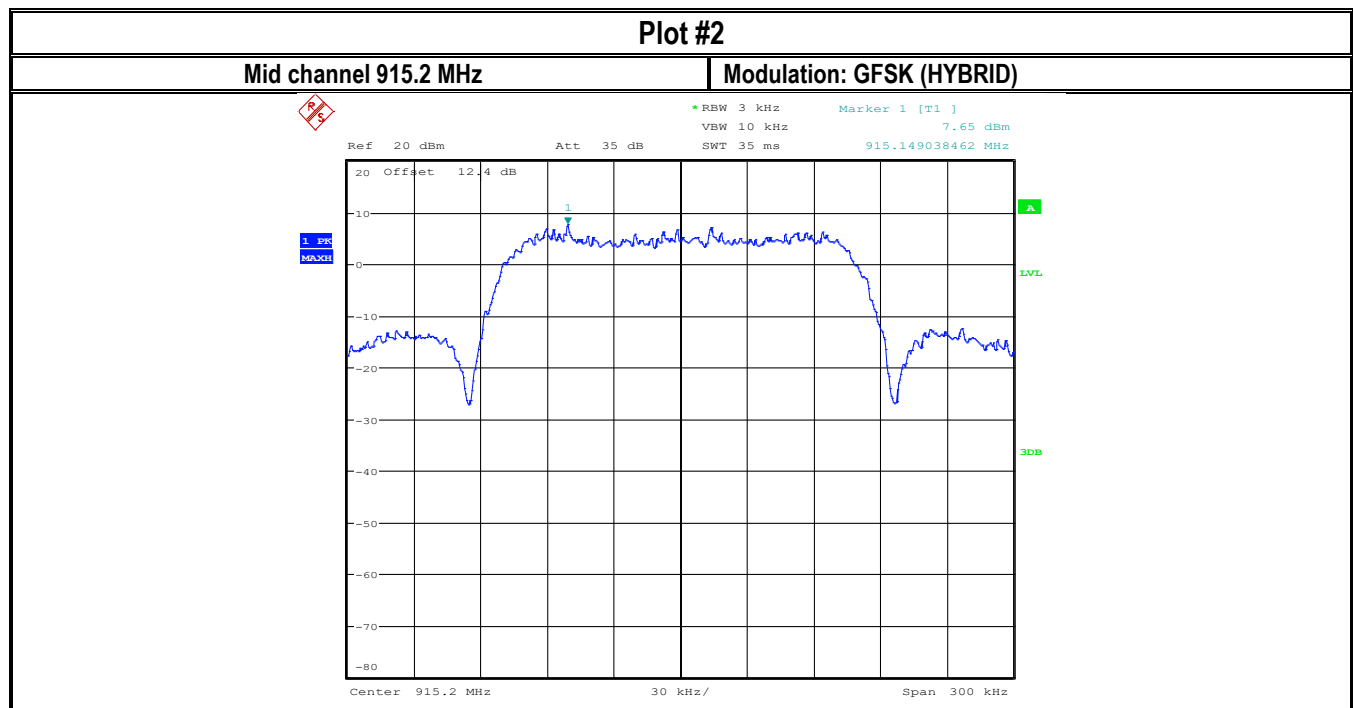
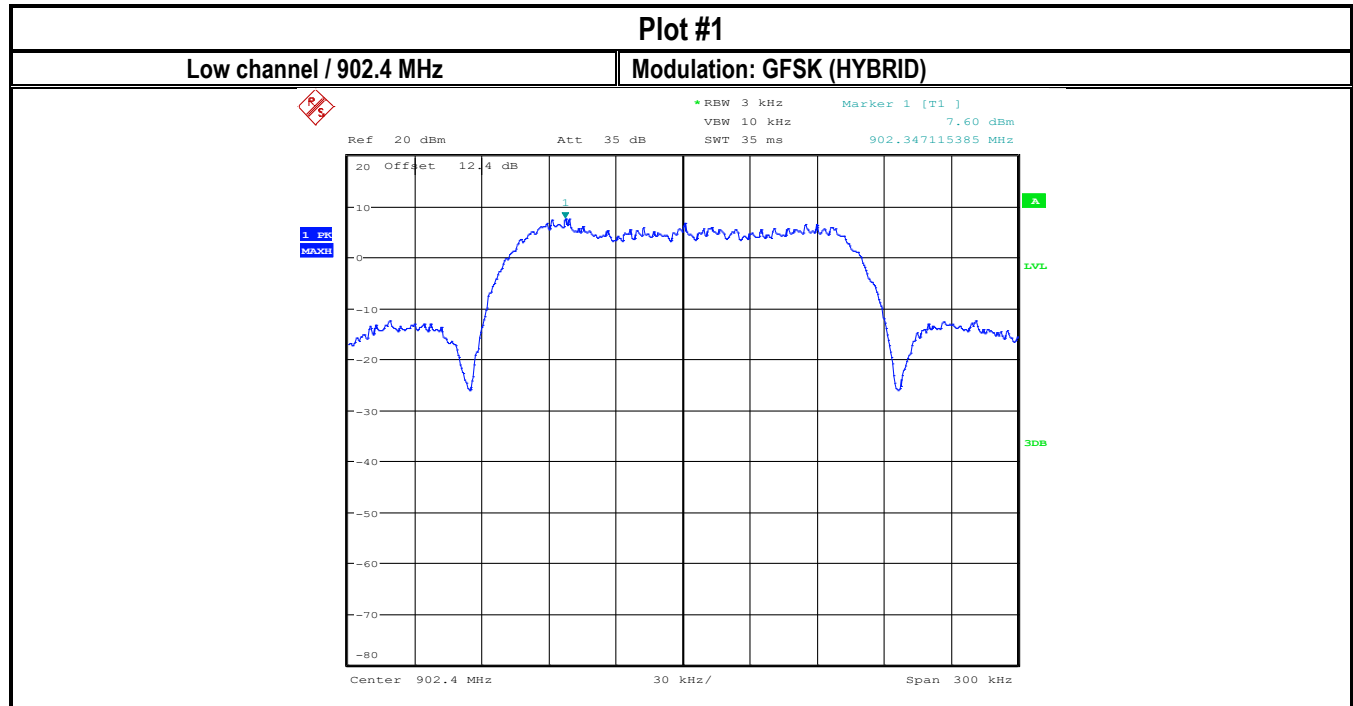
8.2.3 Test conditions and setup:

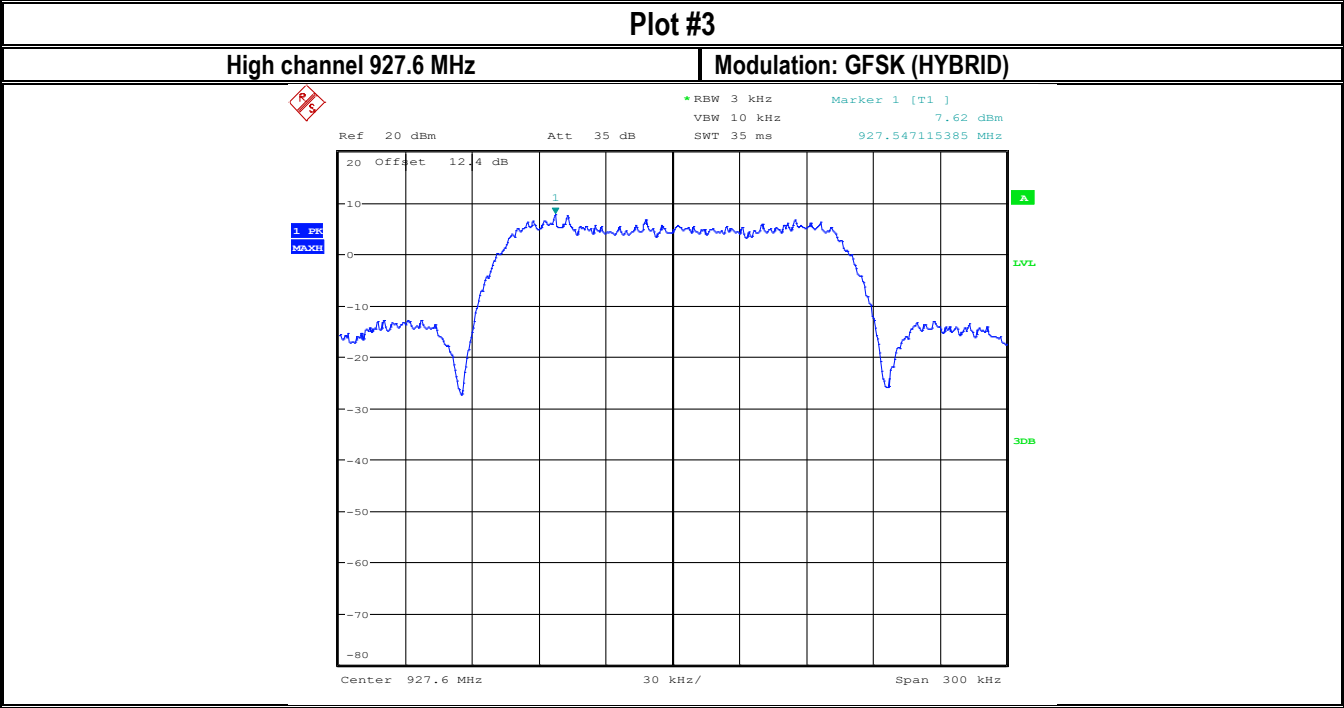
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
22.8.°C	1	GFSK (HYBRID)	Power by 3.6Vdc battery	3.3 dBi

8.2.4 Measurement result:

Plot #	Frequency (MHz)	Maximum Power Spectral Density (dBm/3 kHz)	Limit (dBm / 3 kHz)	Result
1	902.4	7.60	8	Pass
2	915.2	7.65	8	Pass
3	927.6	7.62	8	Pass

8.2.5 Measurement Plots:





8.3 Band Edge Compliance (Conducted and Radiated)

8.3.1 Measurement according to FCC 558074 D01 15.247 Meas Guidance v05r02 & ANSI C63.10 Section 6.10

Spectrum Analyzer settings for non-restricted band edge:

- Span: wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products which fall outside of the authorized band of operation.
- RBW $\geq$ 1% of the span
- VBW $\geq$ RBW
- Sweep Time: Auto couple
- Detector = Peak
- Trace = Max hold
- Allow the trace to stabilize. Set the marker on the emission at the band edge, or on the highest modulation product outside of the band, if this level is greater than that at the band edge.
- Enable the marker-delta function, and then use the marker-to-peak function to move the marker to the peak of the in-band emission.
- Now, using the same instrument settings, enable the hopping function of the EUT.
- Allow the trace to stabilize. Follow the same procedure listed above to determine if any spurious emissions caused by the hopping function also comply with the specified limit.

Spectrum Analyzer settings for restricted band:

- Peak measurements are made using a peak detector and RBW=1 MHz

8.3.2 Limits: Restricted Band FCC 15.209 and RSS-Gen 8.10

- PEAK LIMIT= 74 dB μ V/m @3 m =-21.23 dBm
- AVG. LIMIT= 54 dB μ V/m @3 m =-41.23 dBm
- Start frequency & stop frequency according to frequency range specified in the restricted band table in FCC section 15.205

Restricted bands of operation:

- Except as shown in CFR 47 Part 15.205 paragraph (d), only spurious emissions are permitted in any of the frequency bands listed below

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
10.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	Above 38.6
13.36-13.41			

8.3.3 Limits: Non-restricted Band §15.247 and RSS-247 5.5

FCC15.247 (d)

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, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §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)).

RSS-247 5.5

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

8.3.4 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
22.8.°C	1	1,2,3	Power by 3.6Vdc battery	3.3 dBi

8.3.5 Measurement result for Band edges hopping disabled.

Plot #	Frequency	EUT operating mode	Band Edge	Band Edge Delta (dBc)	Limit (dBc)	Result
1	902.4	GFSK (FHSS)	Lower, non-restricted	42.54	> 20	Pass
2	903.0	OOK (FHSS)	Lower, non-restricted	35.35	> 20	Pass
3	902.4	GFSK (HYBRID)	Lower, non-restricted	34.04	> 20	Pass

Plot #	Frequency	EUT operating mode	Band Edge	Measured value (dBμV/m)	Limit (dBμV/m)	Result
4	927.6	GFSK (FHSS)	Upper restricted Peak	38.813	74.00	Pass
5	926.8	OOK (FHSS)	Upper restricted Peak	38.425	74.00	Pass
6	927.6	GFSK (HYBRID)	Upper restricted Peak	38.772	74.00	Pass

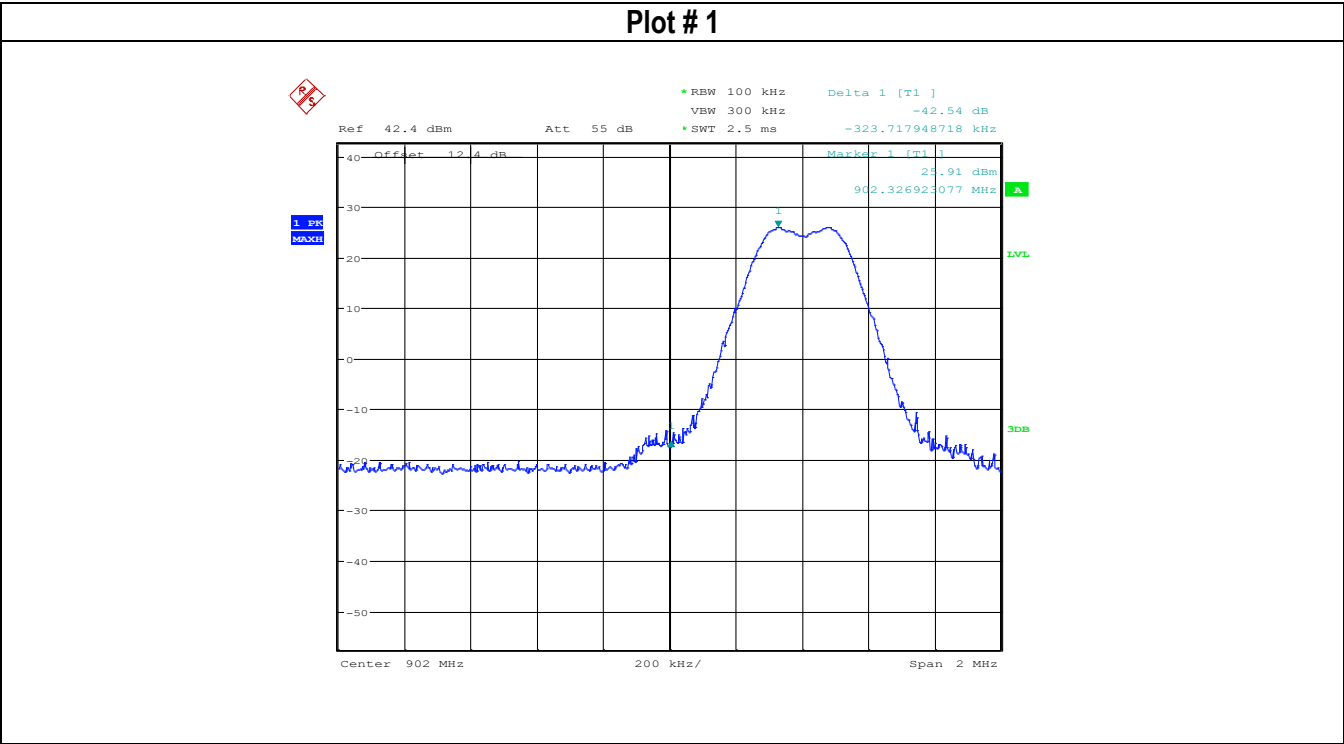
8.3.6 Measurement result for Band edges hopping enabled.

Plot #	EUT operating mode	Band Edge Delta (dBc)	Limit (dBc)	Result
7	GFSK (FHSS)	37.62	> 20	Pass
8	OOK (FHSS)	34.36	> 20	Pass
9	GFSK (HYBRID)	40.95	> 20	Pass

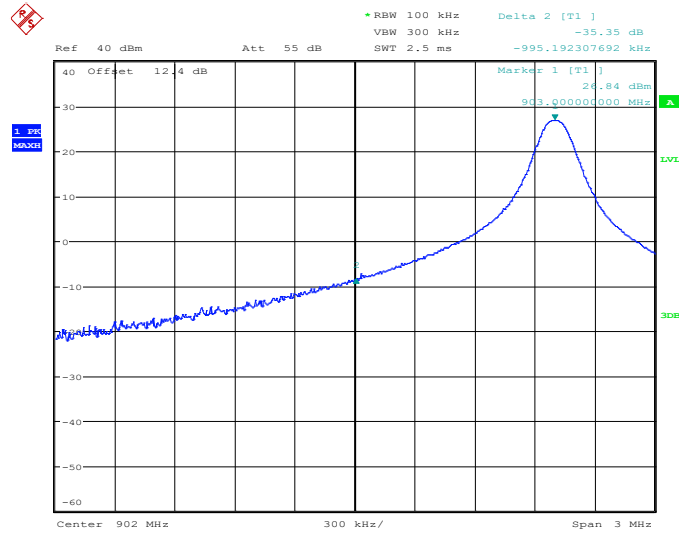
8.3.7 Measurement result: conducted spurious emission

Plot #	Frequency	EUT operating mode	Measured lowest margin (dBc)	Limit (dBc)	Result
10	902.4	GFSK (FHSS)	43.76	> 20	Pass
11	915.2	GFSK (FHSS)	43.69	> 20	Pass
12	927.6	GFSK (FHSS)	42.92	> 20	Pass
13	903.0	OOK (FHSS)	44.17	> 20	Pass
14	915.0	OOK (FHSS)	43.28	> 20	Pass
15	926.8	OOK (FHSS)	42.52	> 20	Pass
16	902.4	GFSK (HYBRID)	38.38	> 20	Pass
17	915.2	GFSK (HYBRID)	39.02	> 20	Pass
18	927.6	GFSK (HYBRID)	39.91	> 20	Pass

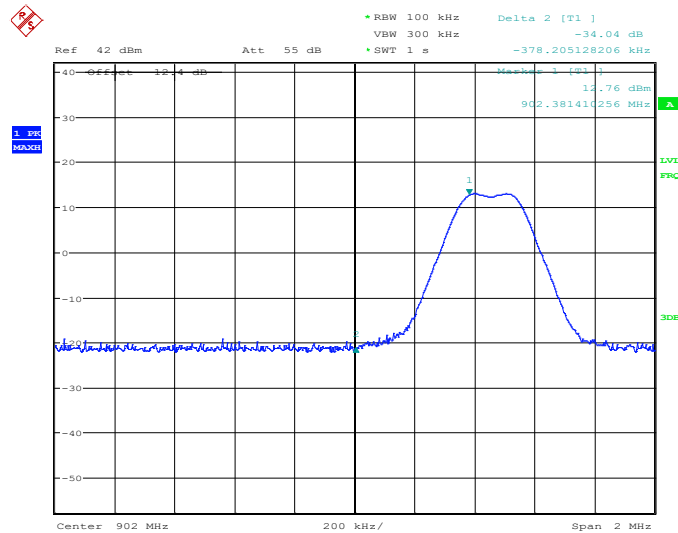
8.3.8 Measurement Plots:

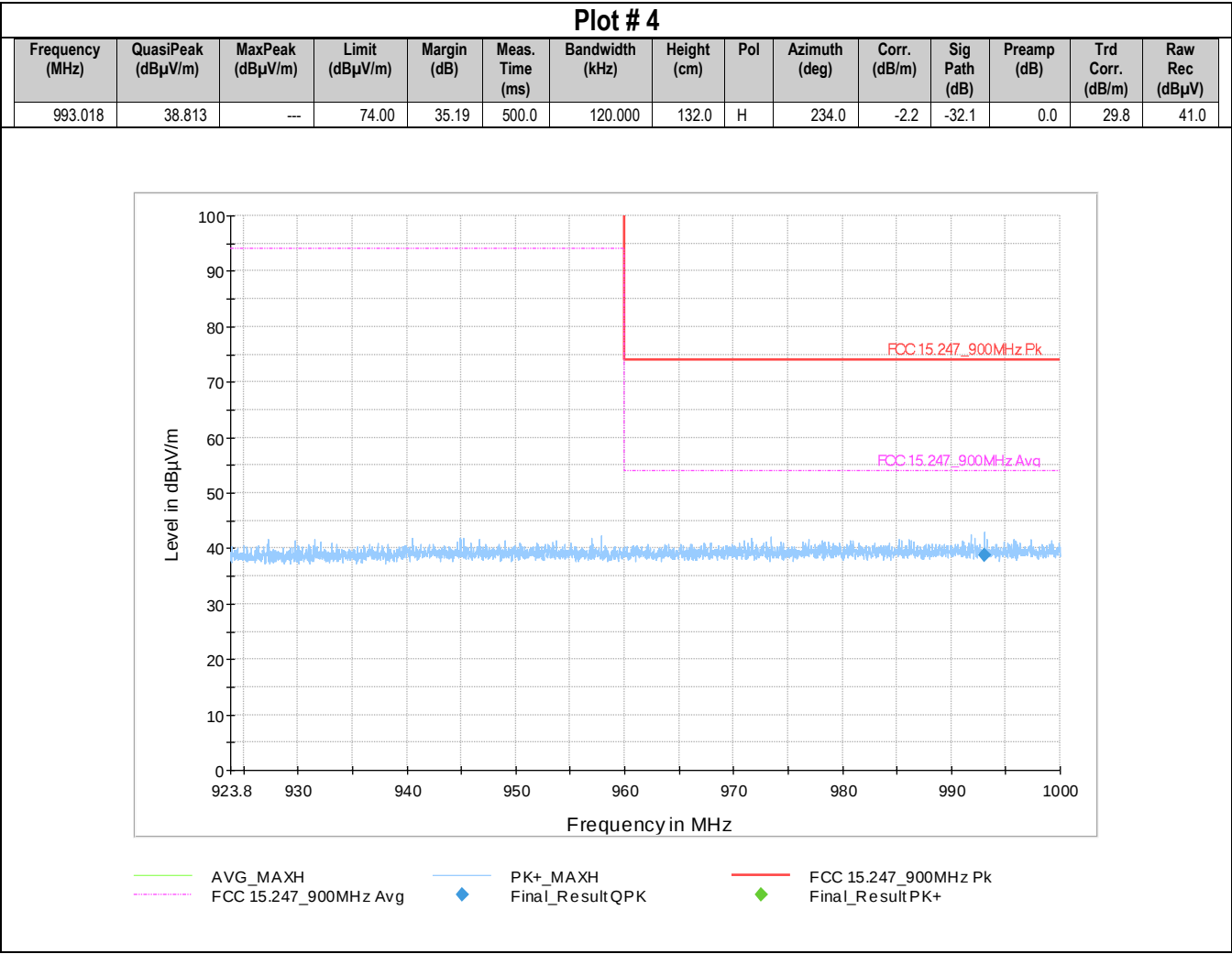


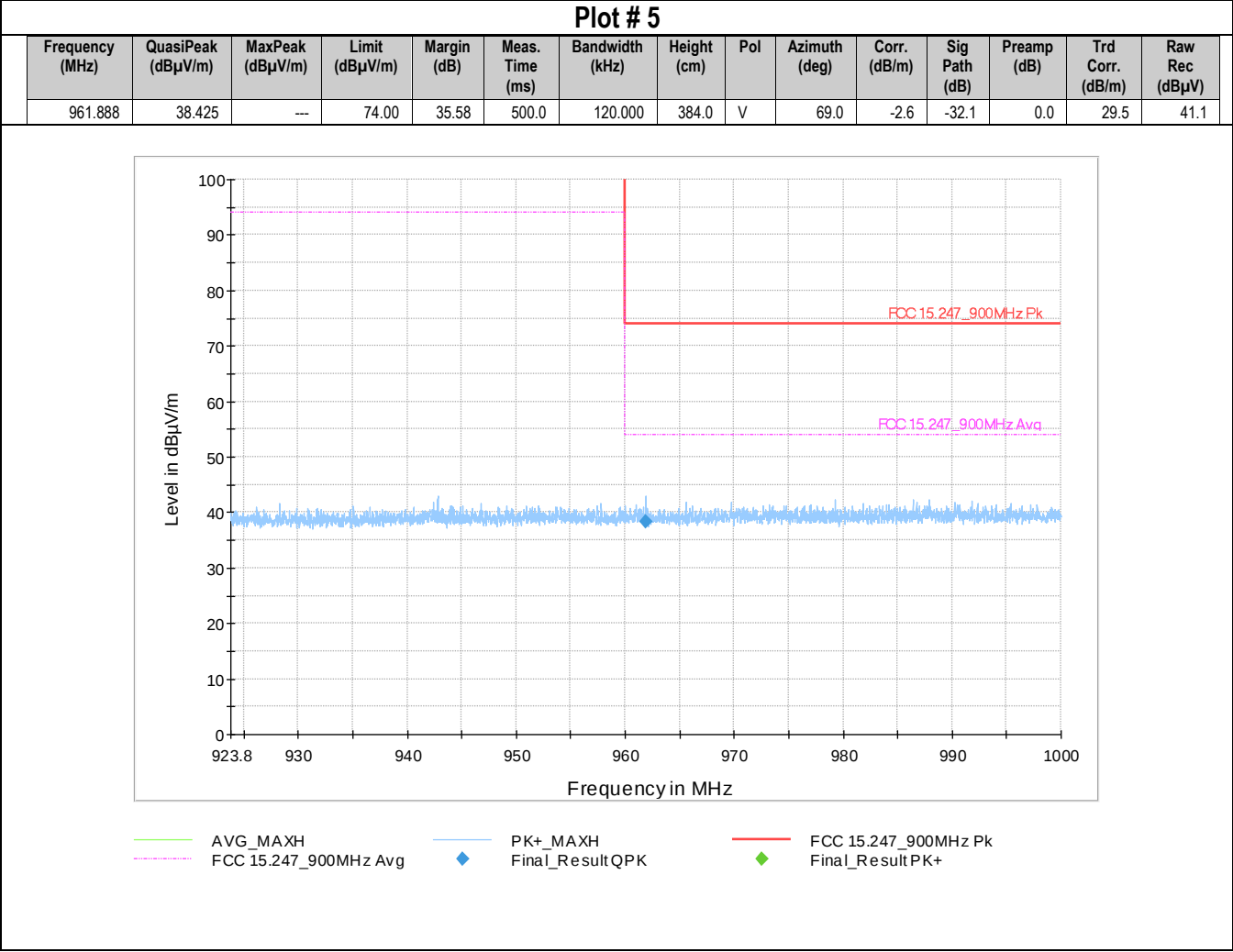
Plot # 2

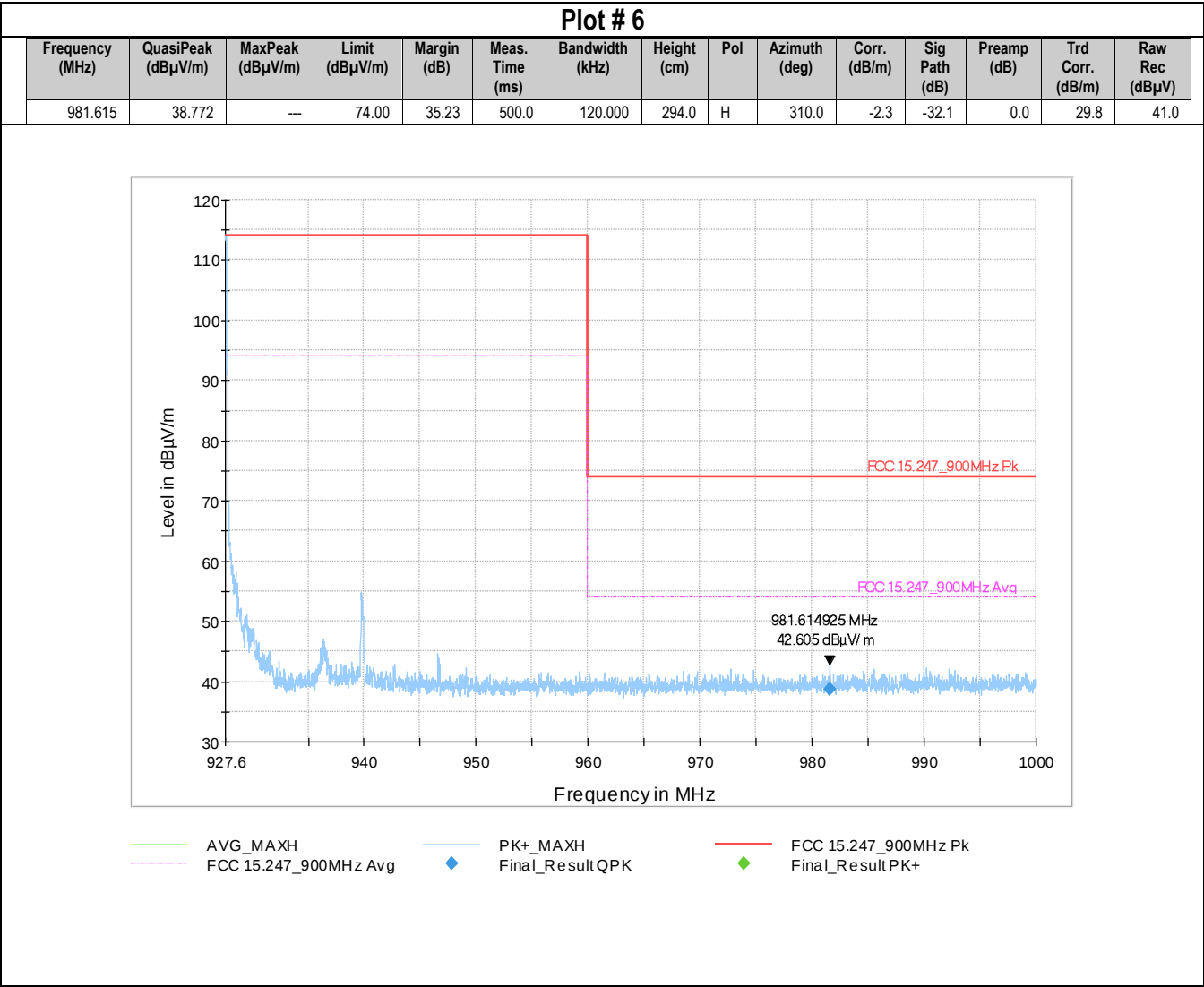


Plot # 3

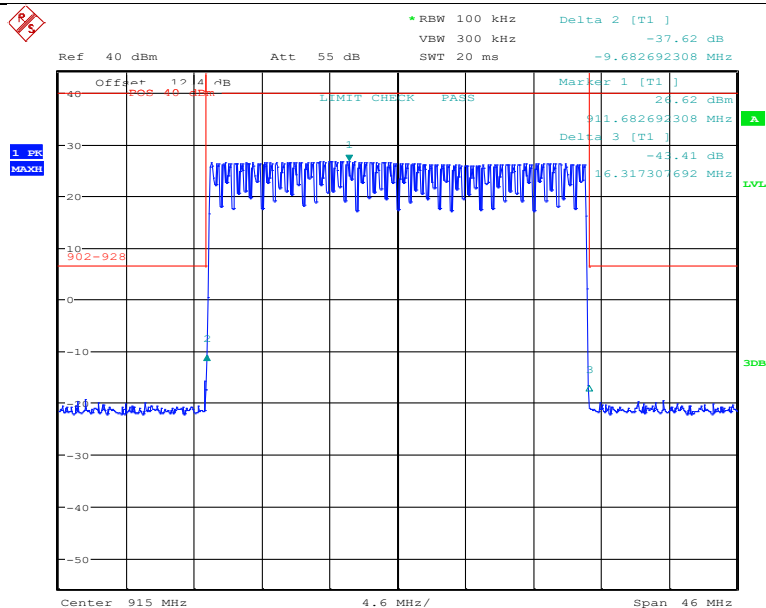




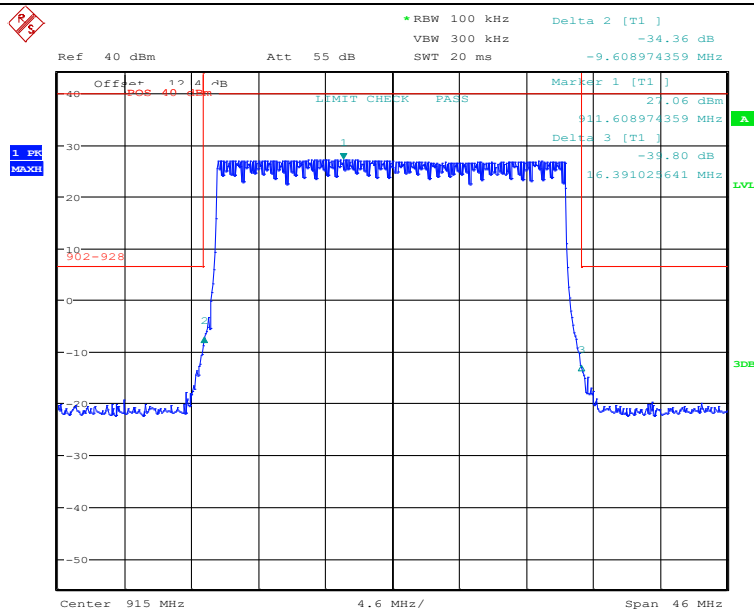




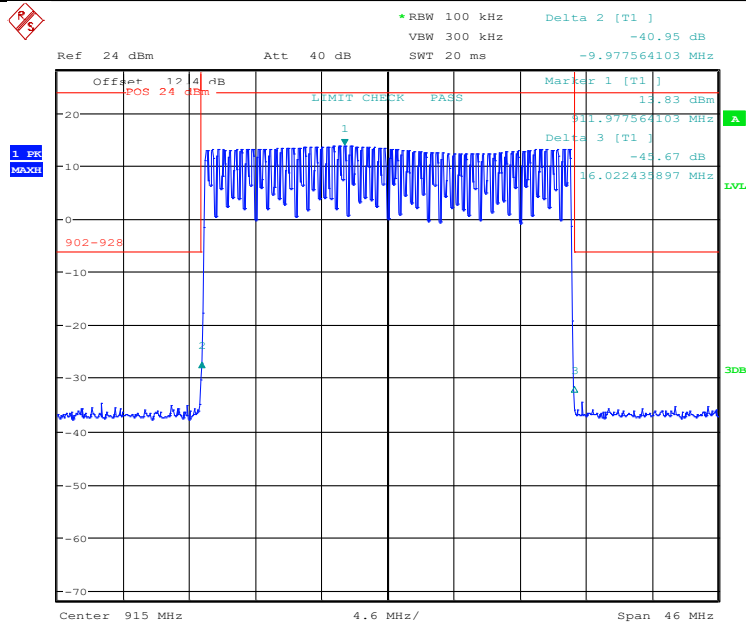
Plot # 7



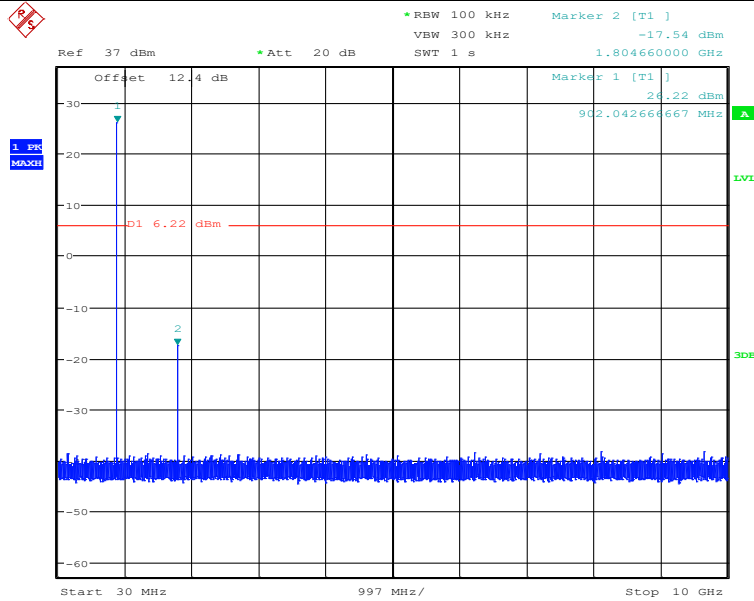
Plot # 8



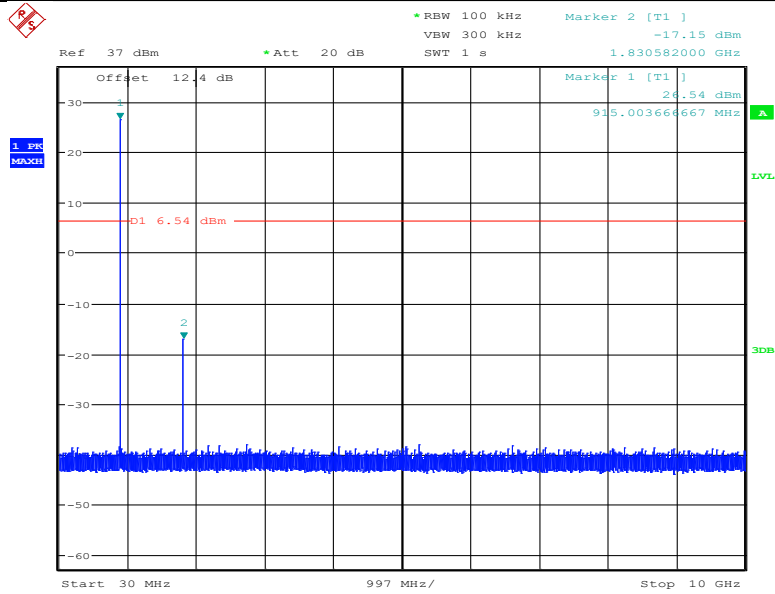
Plot # 9



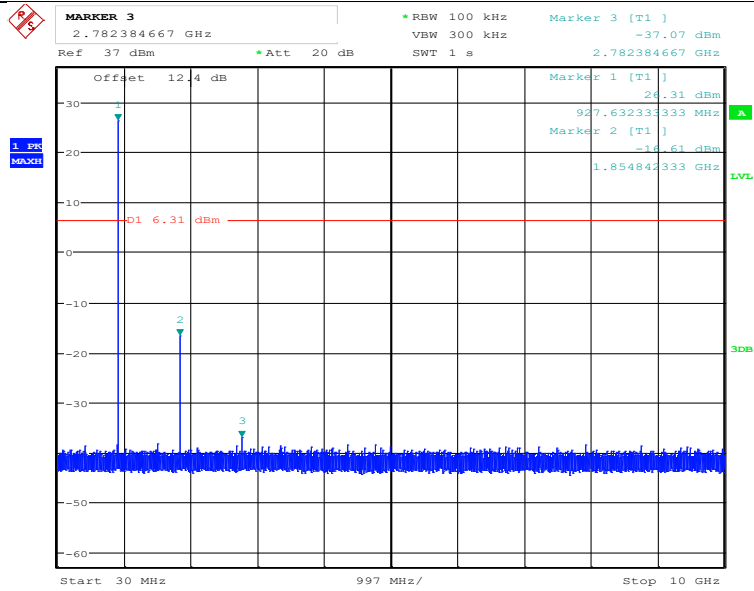
Plot # 10



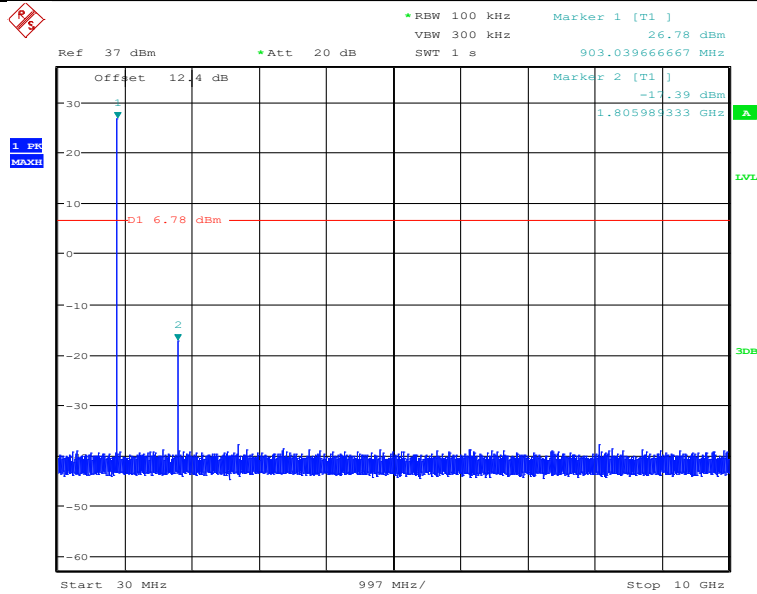
Plot # 11



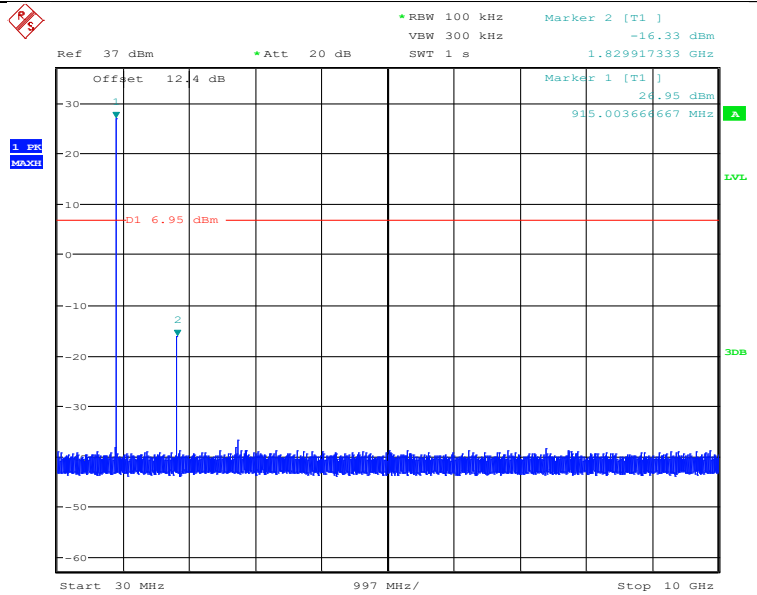
Plot # 12



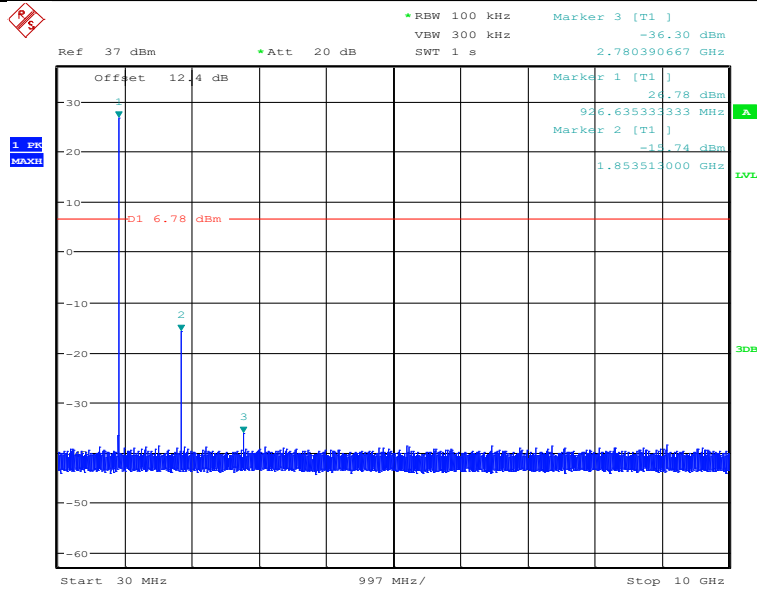
Plot # 13



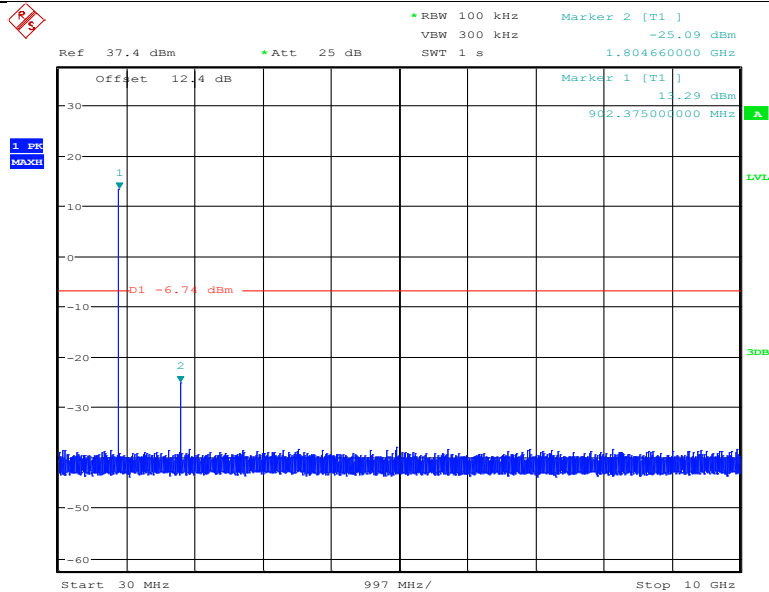
Plot # 14



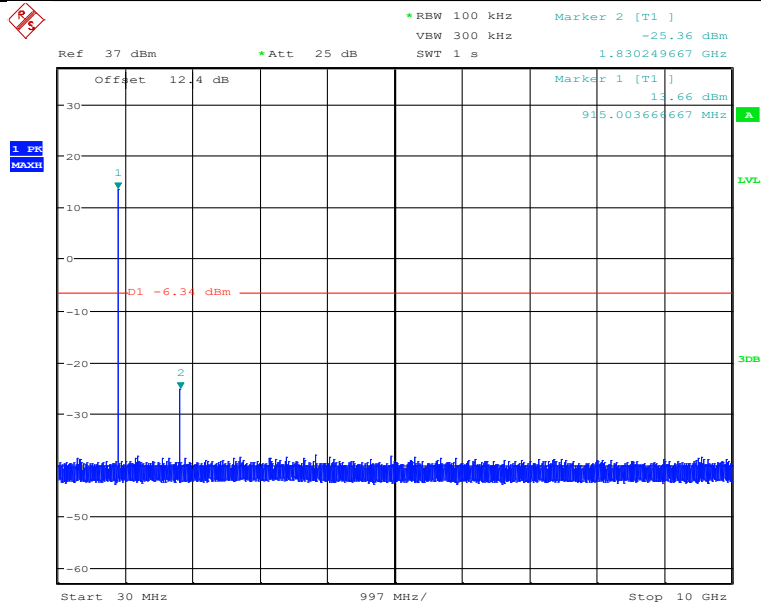
Plot # 15



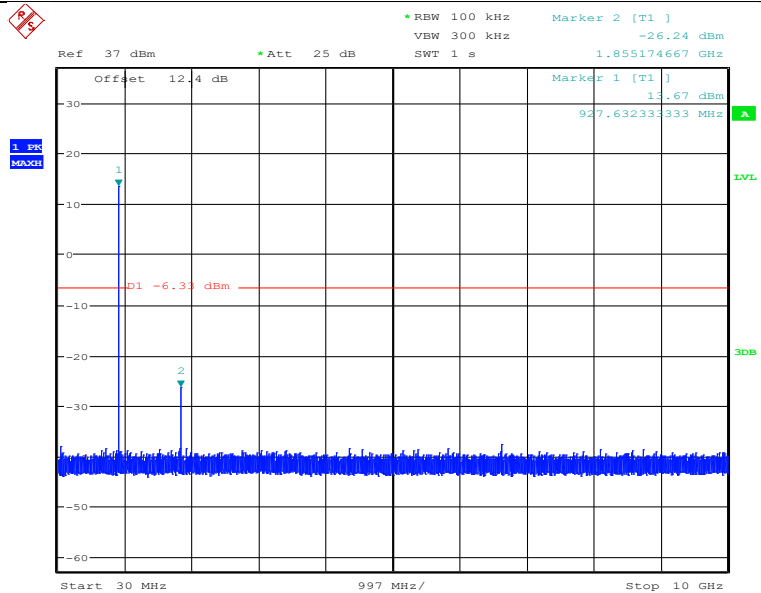
Plot # 16



Plot # 17



Plot # 18



8.4 Emission Bandwidth 20dB Bandwidth and 99% Occupied Bandwidth

8.4.1 Measurement according to FCC 558074 D01 15.247 ANSI C63.10 Section 6.9.2

Spectrum Analyzer settings:

20dB (FHSS) Bandwidth:

- Span: approximately 2 to 5 times the 20 dB bandwidth, centered on the hopping channel
- RBW = 1% to 5% of the 20 dB bandwidth
- VBW = 3 x RBW
- Sweep Time = Auto couple
- Detector = Peak
- Trace = Max hold

99% Occupied Bandwidth:

- Set frequency = nominal EUT channel center frequency
- Set Span = 1.5 x to 5.0 x OBW
- Set RBW = 1% to 5% of OBW
- Set the video bandwidth (VBW) $\approx 3 \times$ RBW
- Detector = Peak
- Trace mode = Max hold
- Sweep = Auto couple
- Allow the trace to stabilize
- Use the 99% power bandwidth function of the instrument (if available) and report the measured bandwidth
- If the instrument does not have a 99% power bandwidth function, then the trace data points are recovered and directly summed in linear power terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached; that frequency is recorded as the lower frequency. The process is repeated until 99.5% of the total is reached; that frequency is recorded as the upper frequency. The 99% power bandwidth is the difference between these two frequencies.

8.4.2 Limits:

FCC §15.247(a)(2) and RSS-247 5.2(a)

- Systems using digital modulation techniques may operate in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

8.4.3 Limits: FCC §15.247(a)(1), RSS-247 5.1(c)

FCC §15.247(a)(1):

For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

RSS-247 5.1(c):

For FHSs in the band 902-928 MHz: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping channels and the average time of occupancy on any channel shall not be greater than 0.4 seconds within a 20-second period. If the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping channels and the average time of occupancy on any channel shall not be greater than 0.4 seconds within a 10-second period. The maximum 20 dB bandwidth of the hopping channel shall be 500 kHz.

8.4.4 Test conditions and setup:

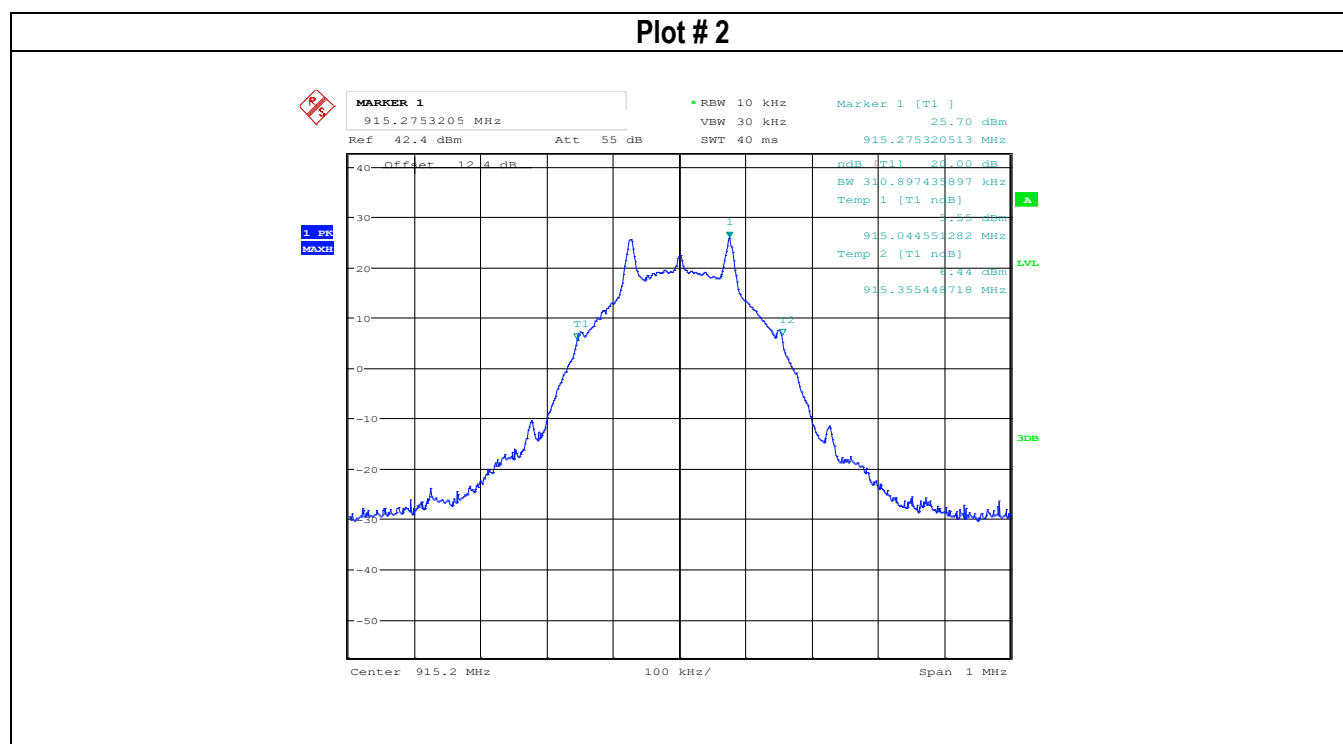
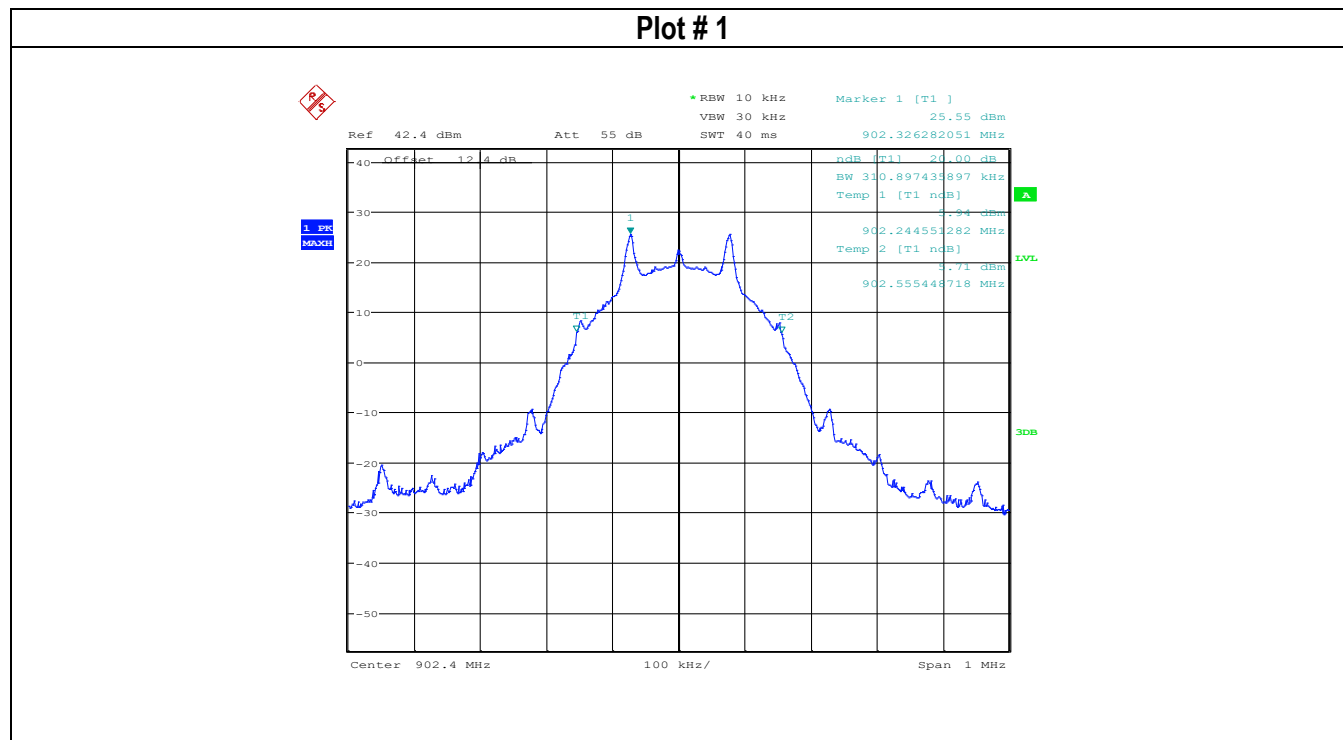
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
22.8.°C	1	1,2,3	Power by 3.6Vdc battery	3.3 dBi

8.4.5 Measurement result:

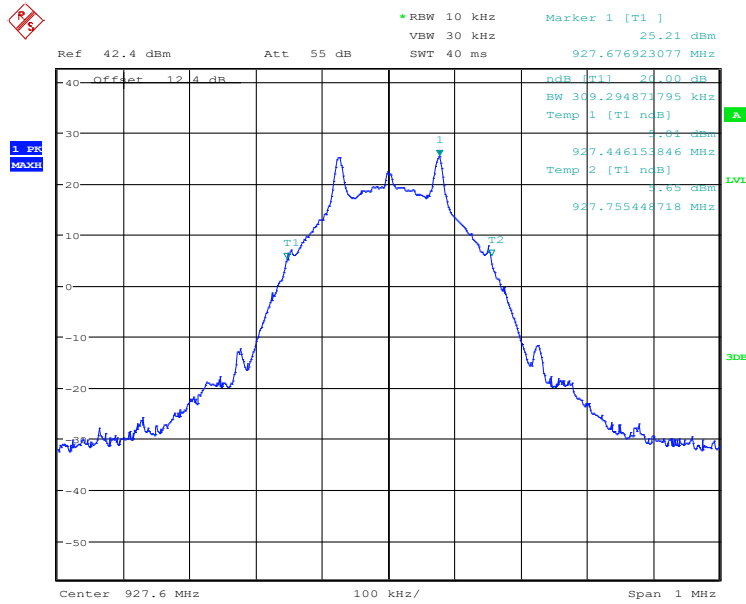
Plot #	Frequency (MHz)	EUT operating mode	20 dB Bandwidth (MHz)
1	902.4	GFSK (FHSS)	0.311
2	915.2	GFSK (FHSS)	0.311
3	927.6	GFSK (FHSS)	0.309
4	903.0	OOK (FHSS)	0.129
5	915.0	OOK (FHSS)	0.133
6	926.8	OOK (FHSS)	0.136
7	902.4	GFSK (HYBRID)	0.185
8	915.2	GFSK (HYBRID)	0.184
9	927.6	GFSK (HYBRID)	0.184

Plot #	Frequency (MHz)	EUT operating mode	99% Occupied Bandwidth (MHz)
10	902.4	GFSK (HYBRID)	0.185
11	915.2	GFSK (HYBRID)	0.180
12	927.6	GFSK (HYBRID)	0.178

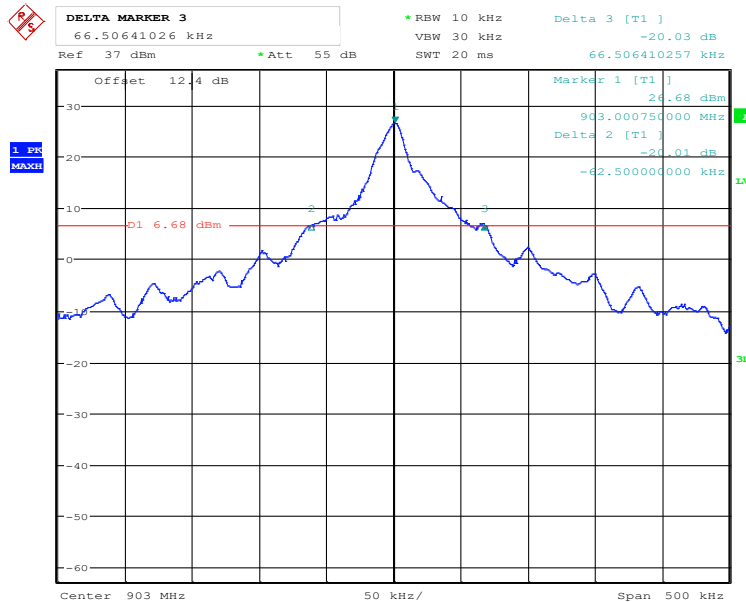
8.4.6 Measurement Plots:



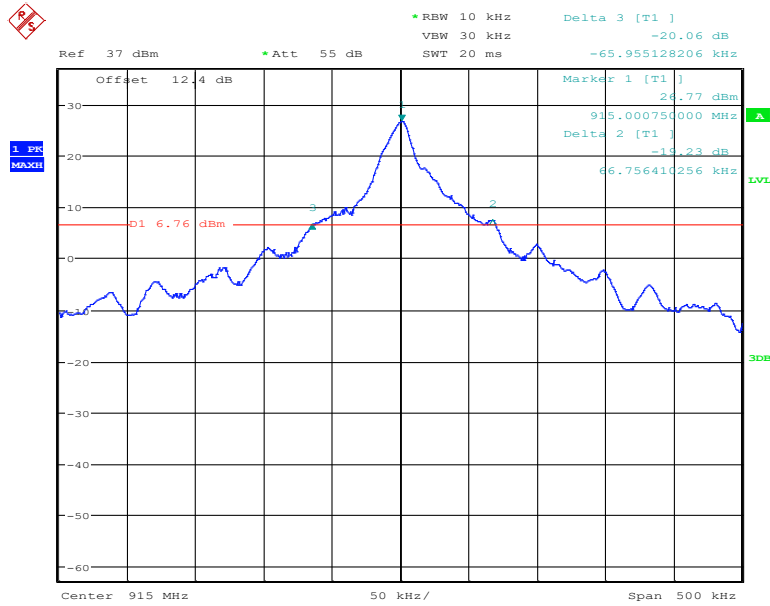
Plot # 3



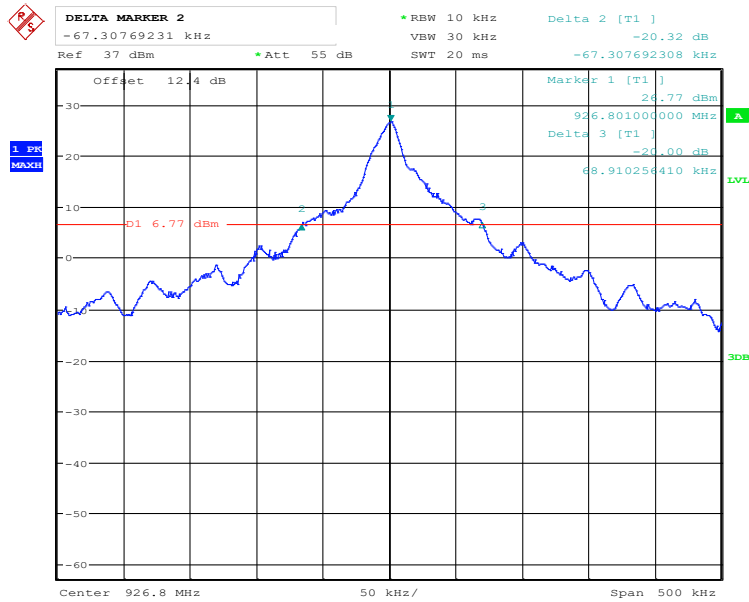
Plot # 4



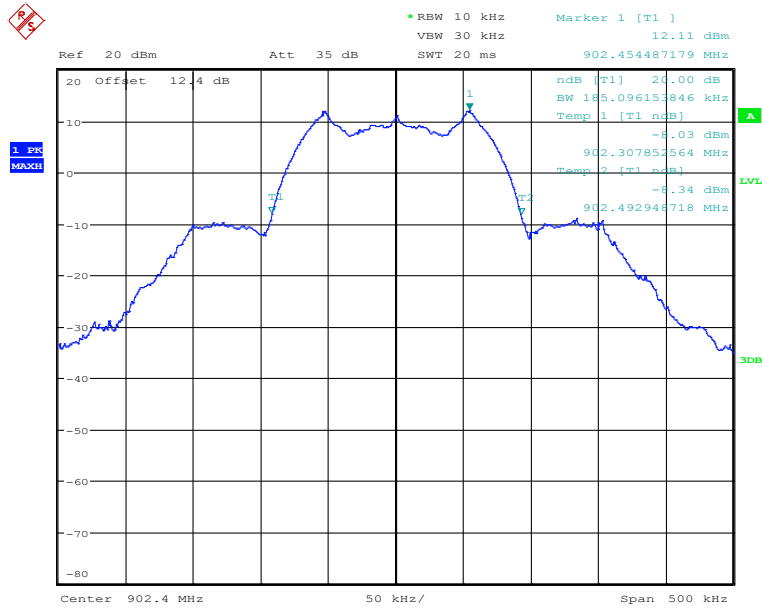
Plot # 5



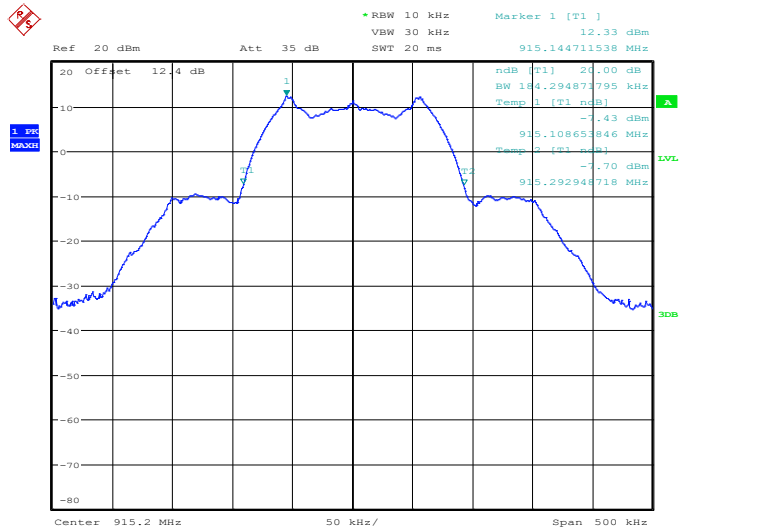
Plot # 6



Plot # 7

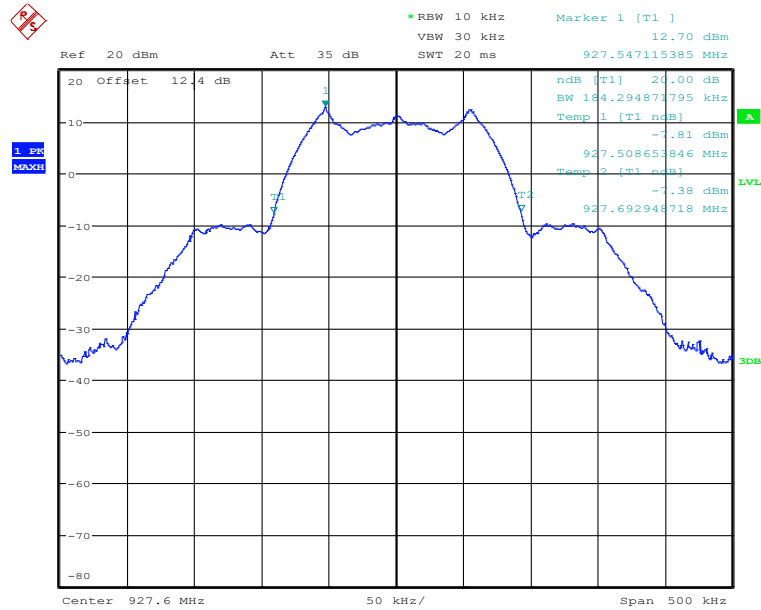


Plot # 8

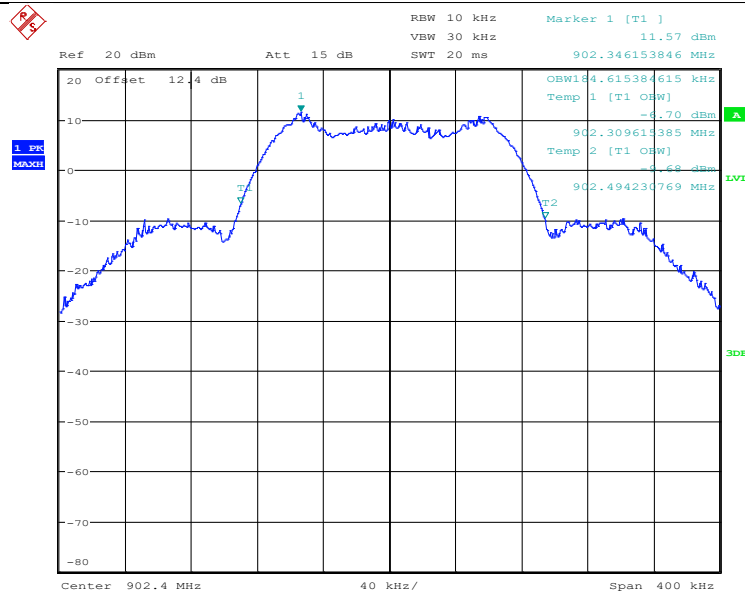


Date: 11.MAR.2024 15:14:13

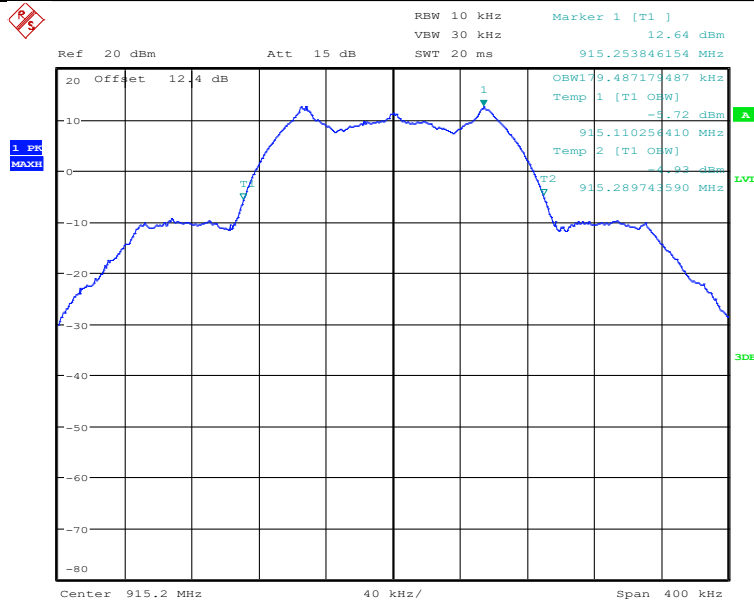
Plot # 9



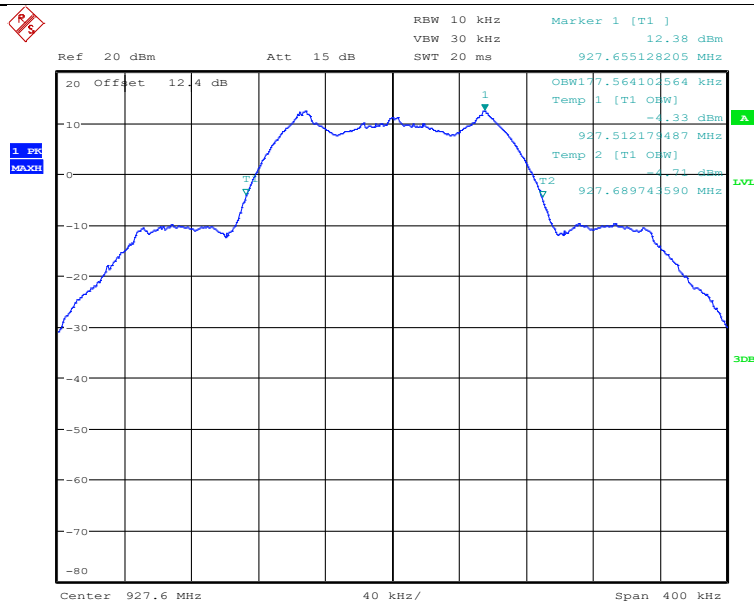
Plot # 10



Plot # 11



Plot # 12



8.5 Carrier Frequency Separation

8.5.1 Measurement according to ANSI C63.10 Section 7.8.2

Spectrum Analyzer settings:

- Span = Wide enough to capture the peaks of the two adjacent channels
- RBW: Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.
- VBW $\geq$ RBW
- Sweep = Auto couple
- Detector function = Peak
- Trace = Max hold
- Use marker-delta function to determine the separation between the peaks of the two adjacent channels.

8.5.2 Limits: FCC §15.247(a)(1) & RSS-247 5.1(b)

FCC §15.247(a)(1):

For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

RSS-247 5.1(c):

For FHSs in the band 902-928 MHz: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping channels and the average time of occupancy on any channel shall not be greater than 0.4 seconds within a 20-second period. If the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping channels and the average time of occupancy on any channel shall not be greater than 0.4 seconds within a 10-second period. The maximum 20 dB bandwidth of the hopping channel shall be 500 kHz.

8.5.3 Test conditions and setup:

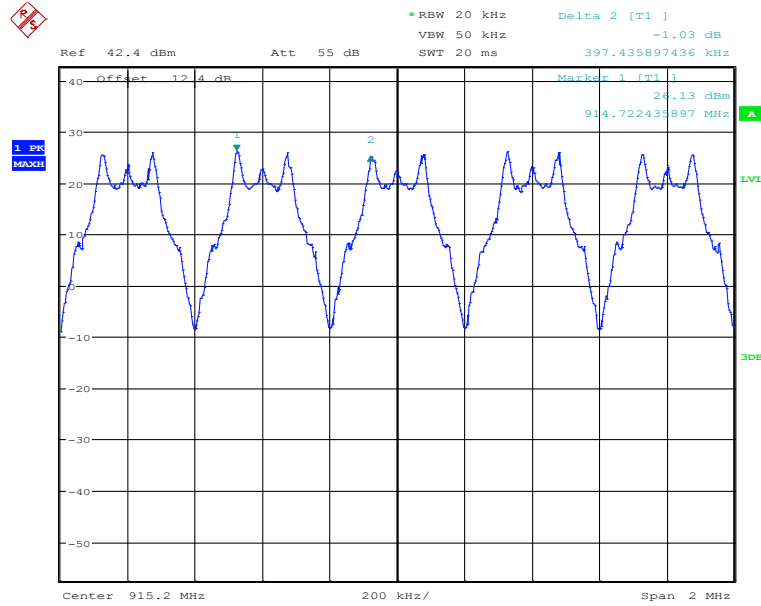
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
22.8.°C	1	1,2,3	Power by 3.6Vdc battery	3.3 dBi

8.5.3.1 Measurement result:

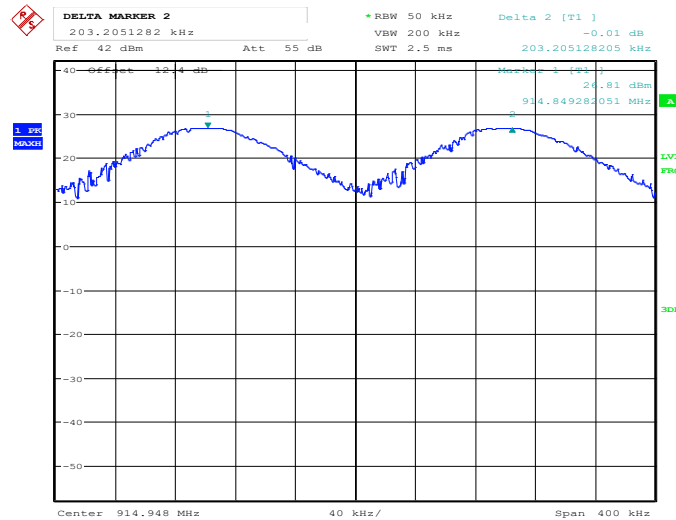
Plot #	EUT operating mode	Carrier Frequency Separation (MHz)	Limit (MHz)	Result
1	GFSK (FHSS)	0.397	$\Delta f \geq \text{MAX} \{ 25 \text{ kHz or BW20dB} \} = 0.311 \text{ kHz}$	Pass
2	OOK (FHSS)	0.203	$\Delta f \geq \text{MAX} \{ 25 \text{ kHz or BW20dB} \} = 0.136 \text{ kHz}$	Pass
3	GFSK (HYBRID)	0.400	$\Delta f \geq \text{MAX} \{ 25 \text{ kHz or BW20dB} \} = 0.185 \text{ kHz}$	Pass

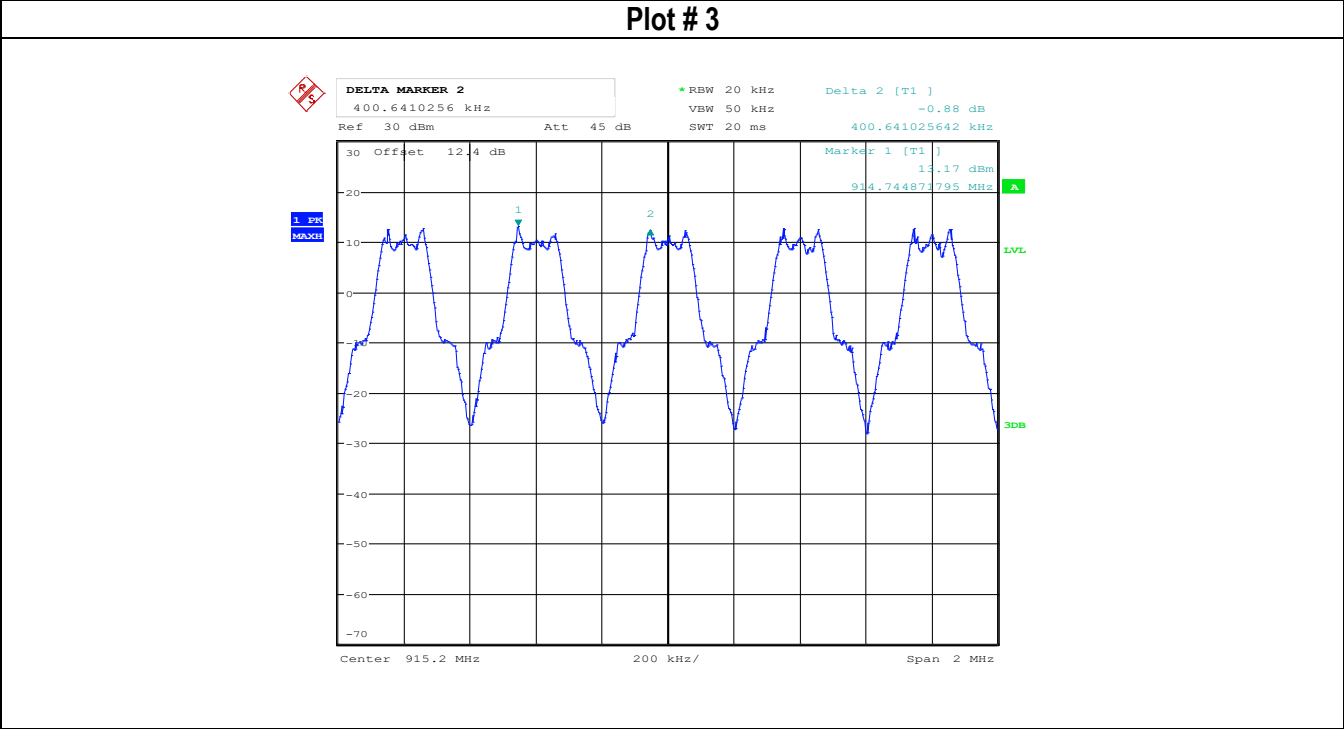
8.5.4 Measurement Plots:

Plot # 1



Plot # 2





8.6 Number of hopping channels

8.6.1 Measurement according to ANSI C63.10 Section 7.8.3

Spectrum Analyzer settings:

- Span: The frequency band of operation. Depending on the number of channels the device supports, it may be necessary to divide the frequency range of operation across multiple spans, to allow the individual channels to be clearly seen.
- RBW: To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.
- VBW $\geq$ RBW
- Sweep = Auto couple
- Detector function = Peak
- Trace = Max hold
- Allow the trace to stabilize

It might prove necessary to break the span up into subranges to show clearly all of the hopping frequencies. Compliance of an EUT with the appropriate regulatory limit shall be determined for the number of hopping channels.. A plot of the data shall be included in the test report.

8.6.2 Limits: FCC §15.247(a)(1)(i) & RSS-247 5.1(c)

For frequency hopping systems operating in the 902–928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz

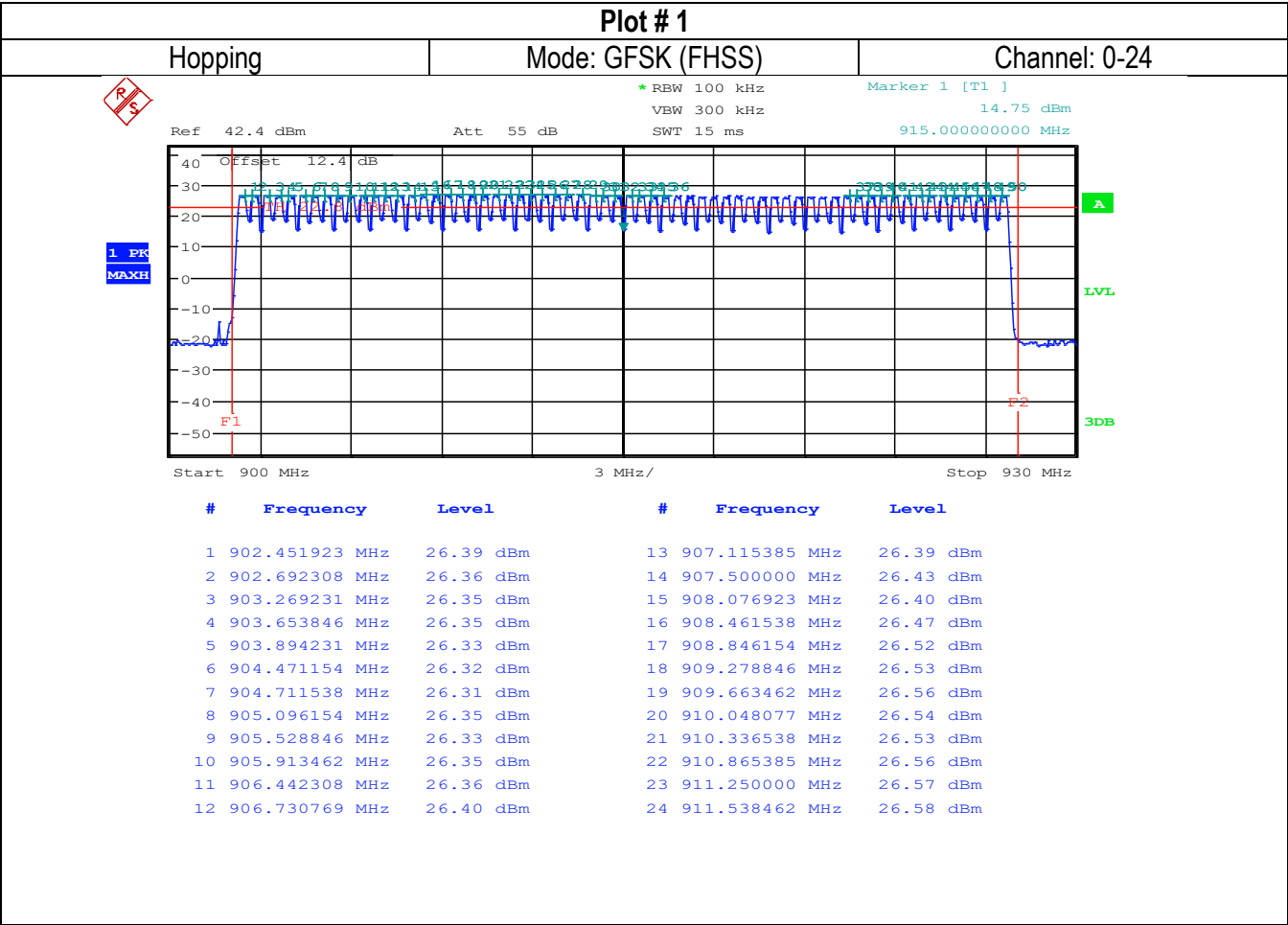
8.6.3 Test conditions and setup:

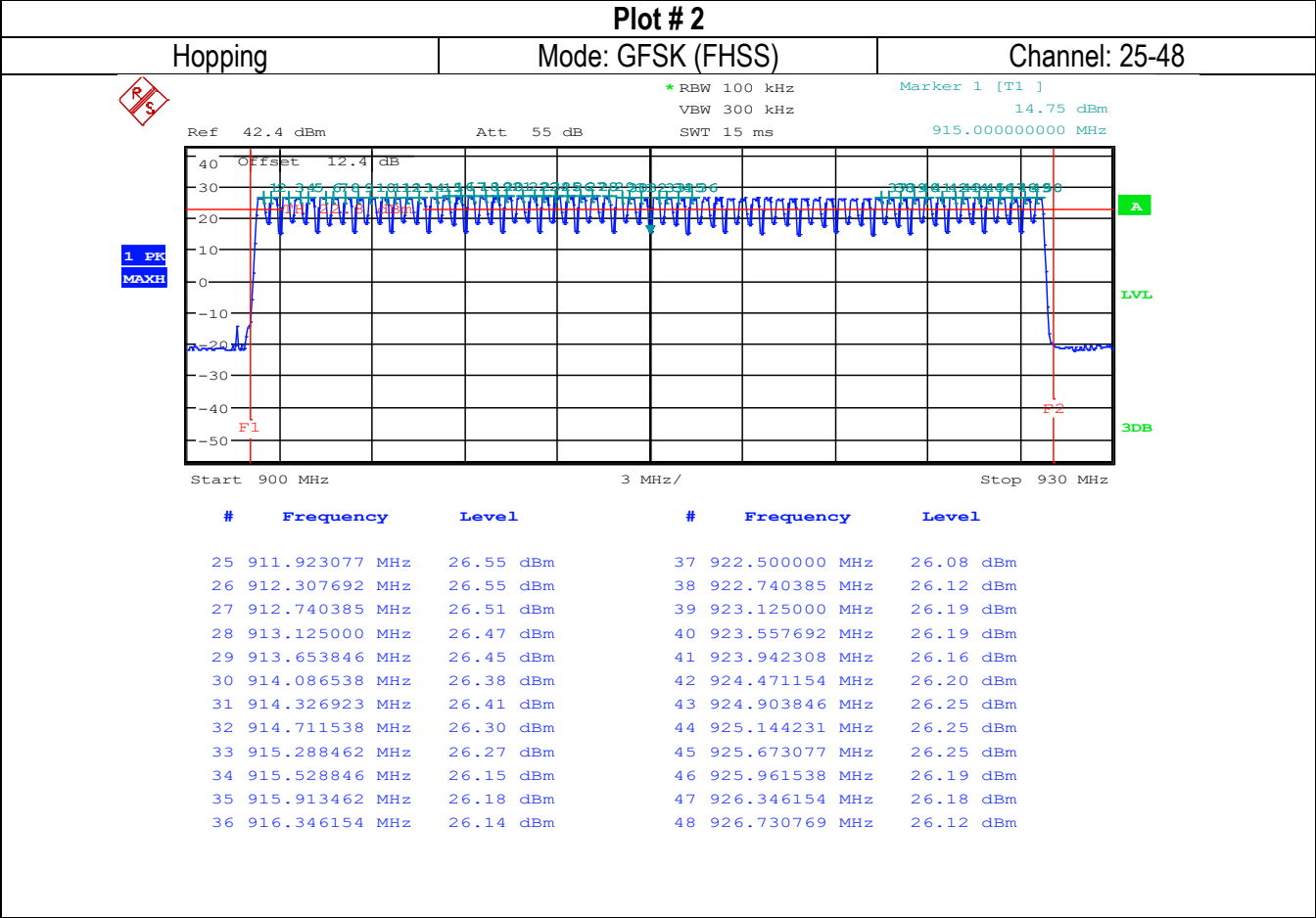
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
22.8. °C	1	1.2.3	Power by 3.6Vdc battery	3.3 dBi

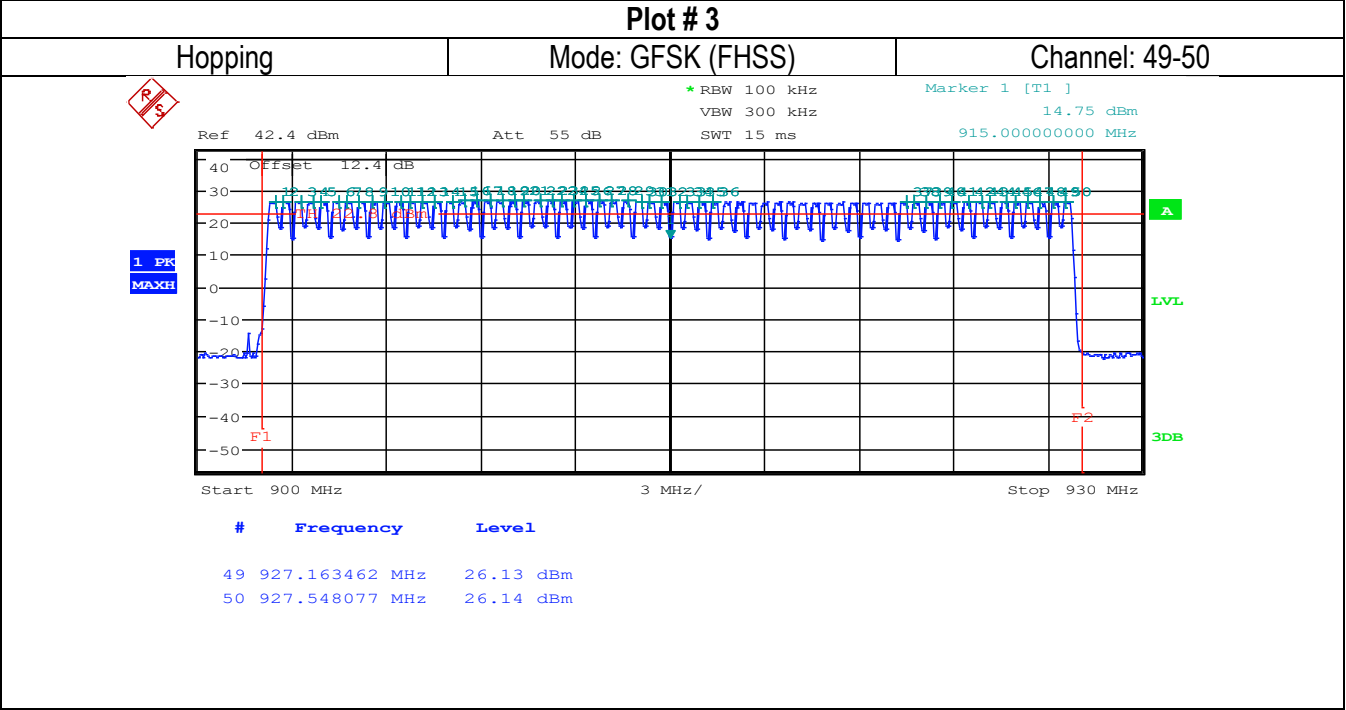
8.6.4 Measurement result:

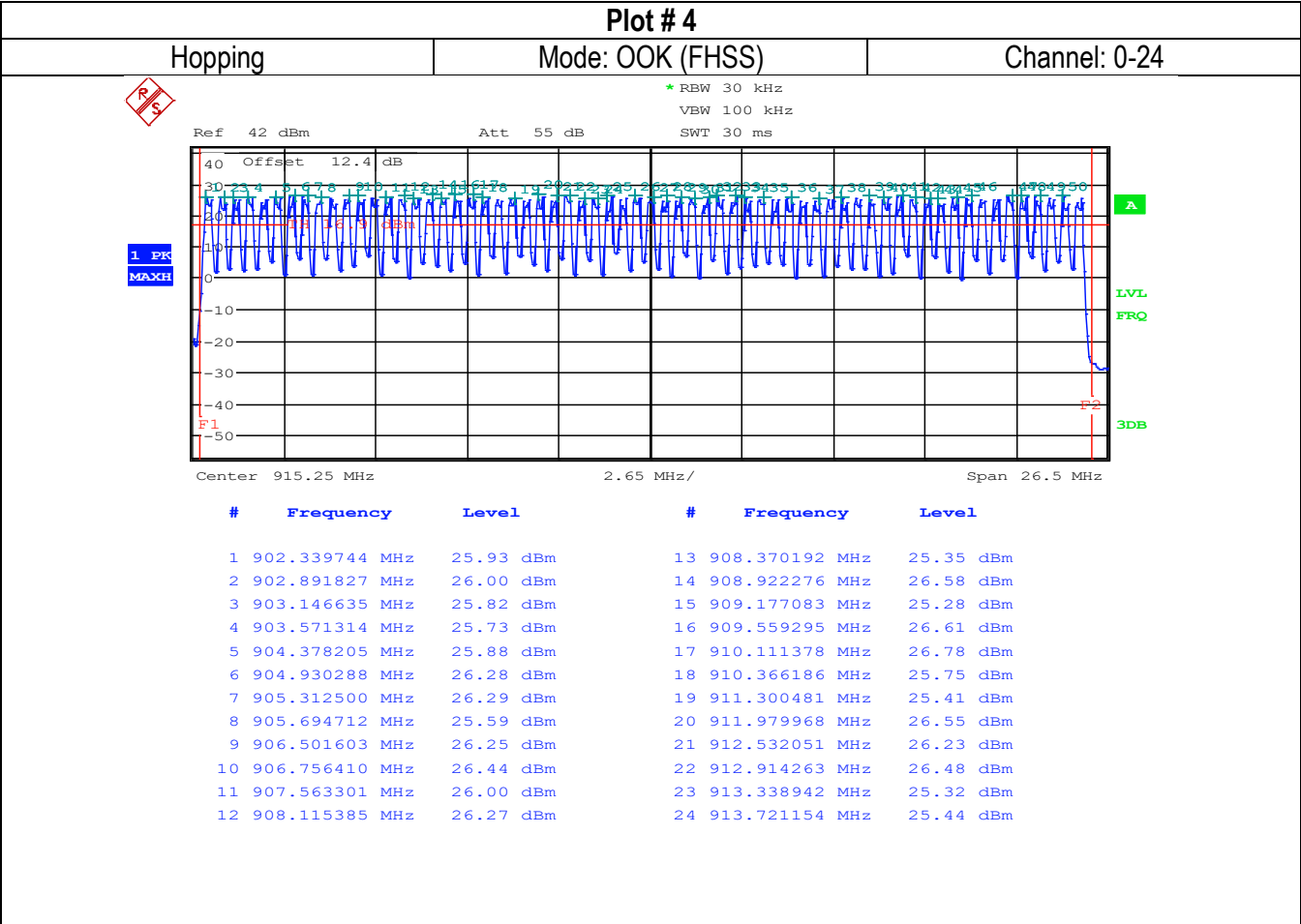
Plot #	EUT operating mode	Number of Hopping Frequencies	Limit	Result
1-3	GFSK (FHSS)	50	$25 \leq N_{ch} < 50$	Pass
4-6	OOK (FHSS)	50	$25 \leq N_{ch} < 50$	Pass
7-9	GFSK (HYBRID)	50	$25 \leq N_{ch} < 50$	Pass

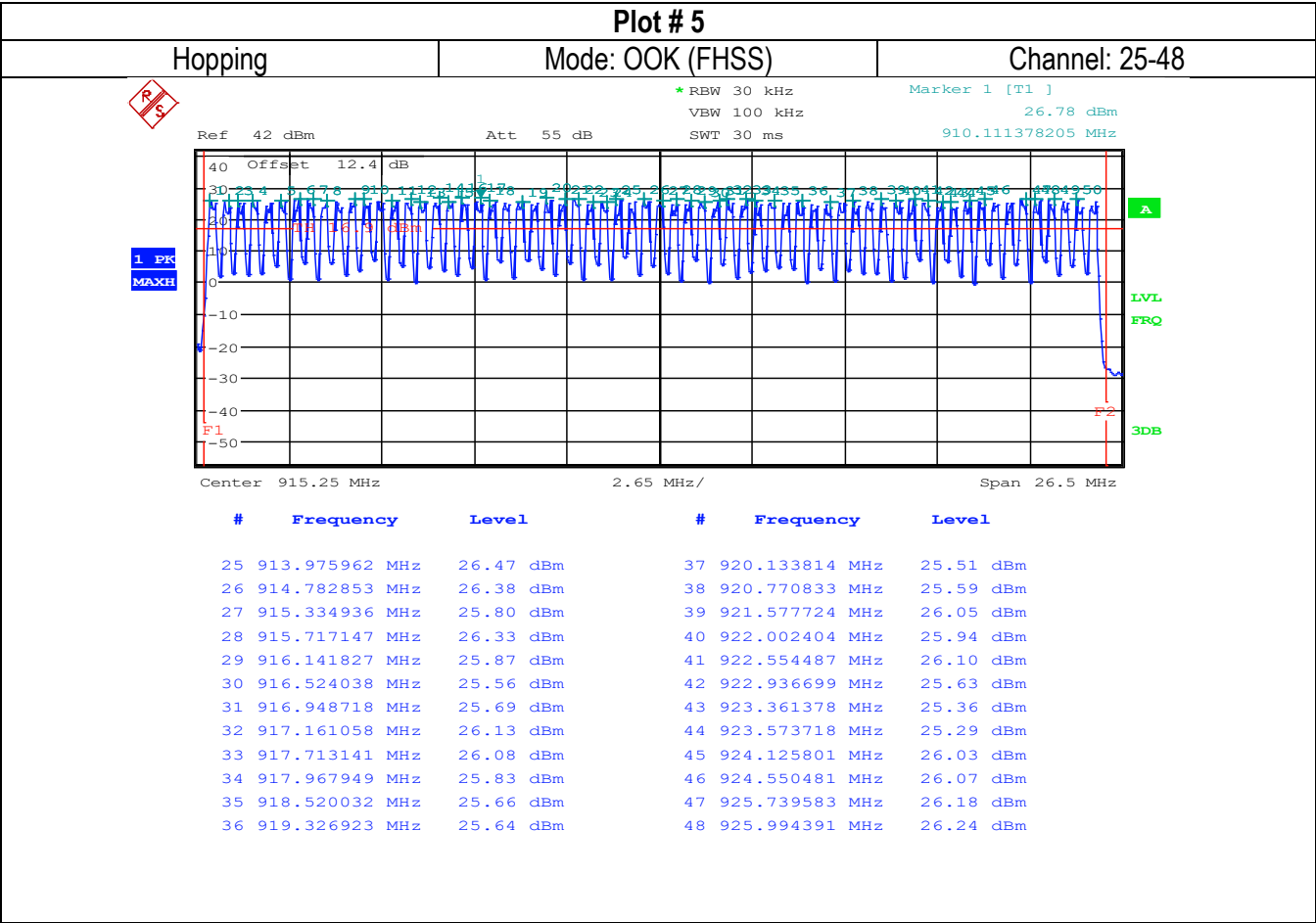
8.6.5 Measurement Plots:

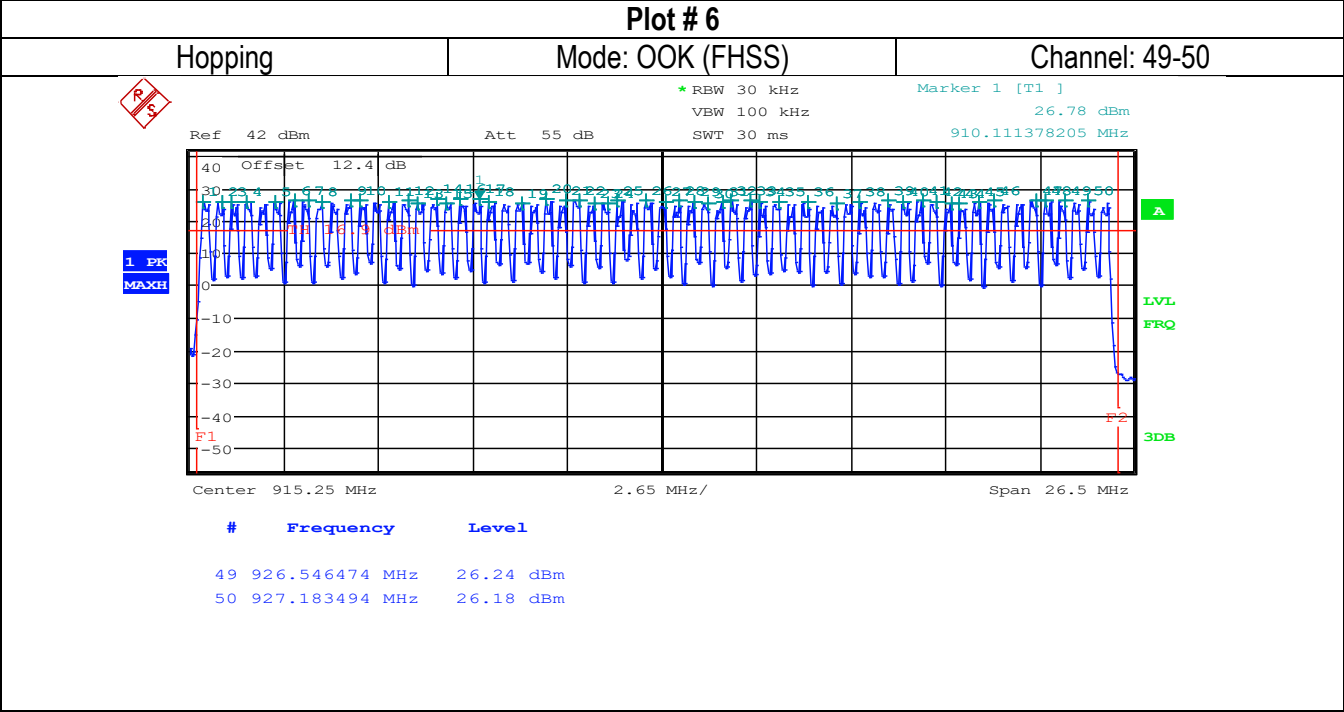


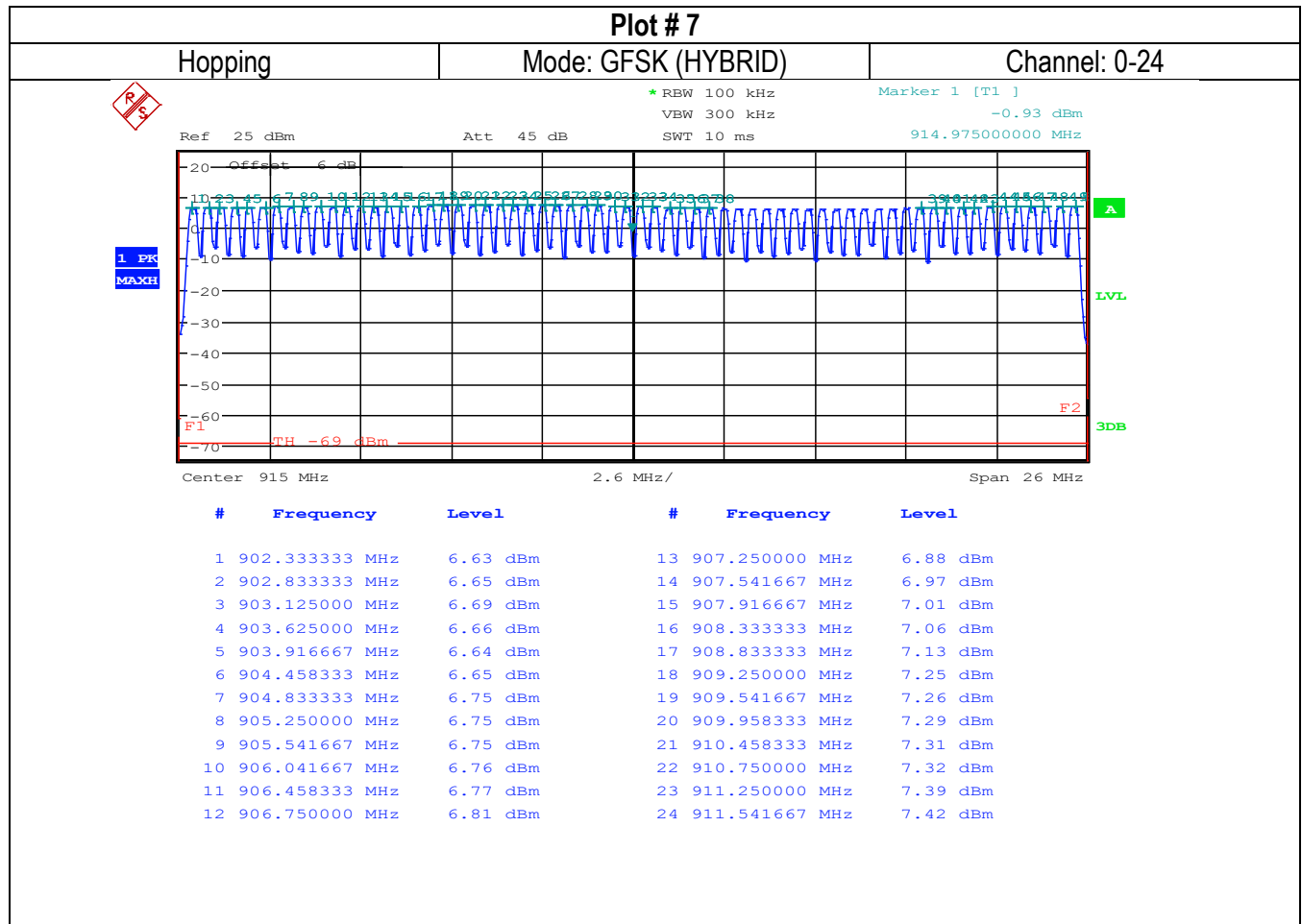


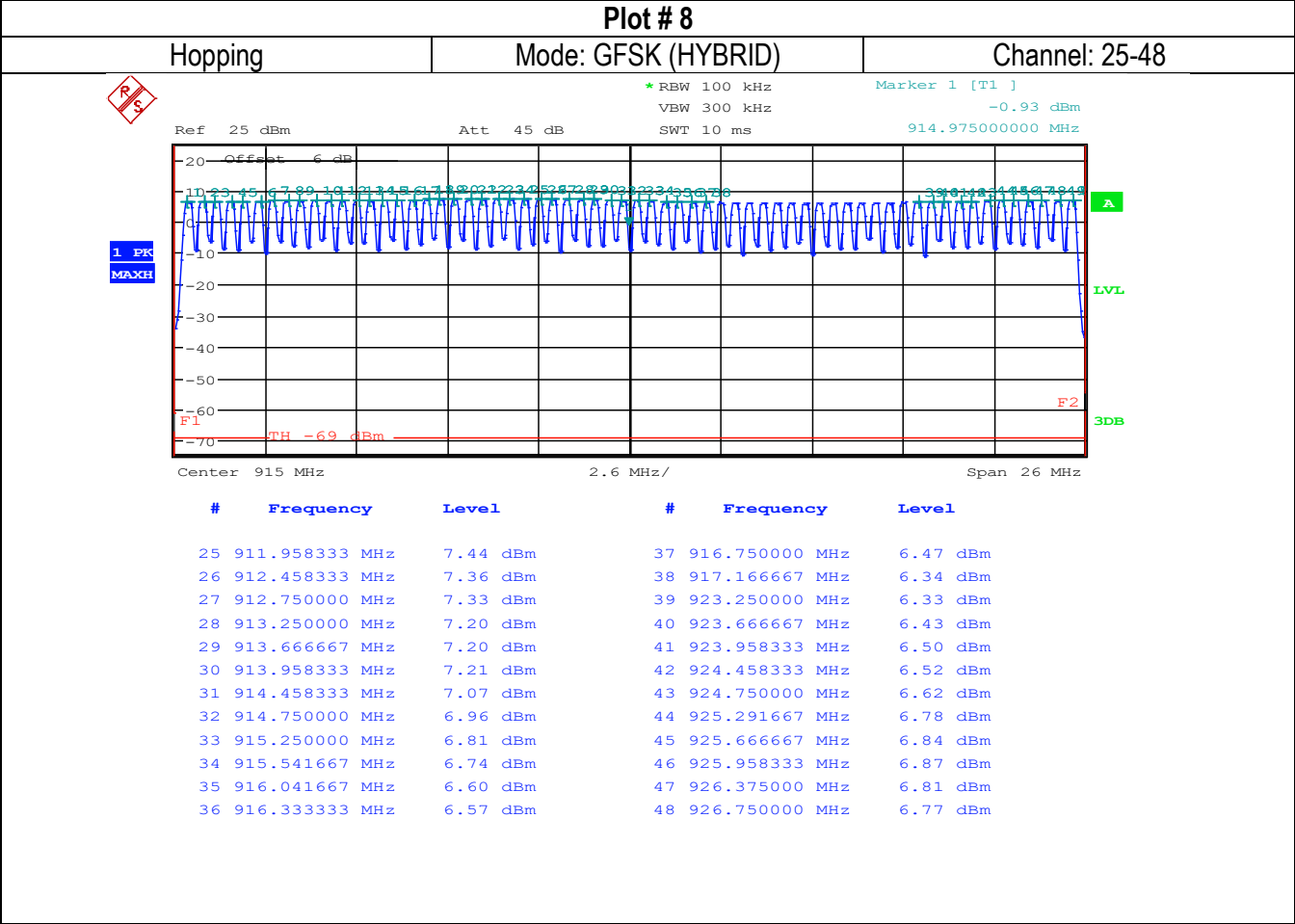


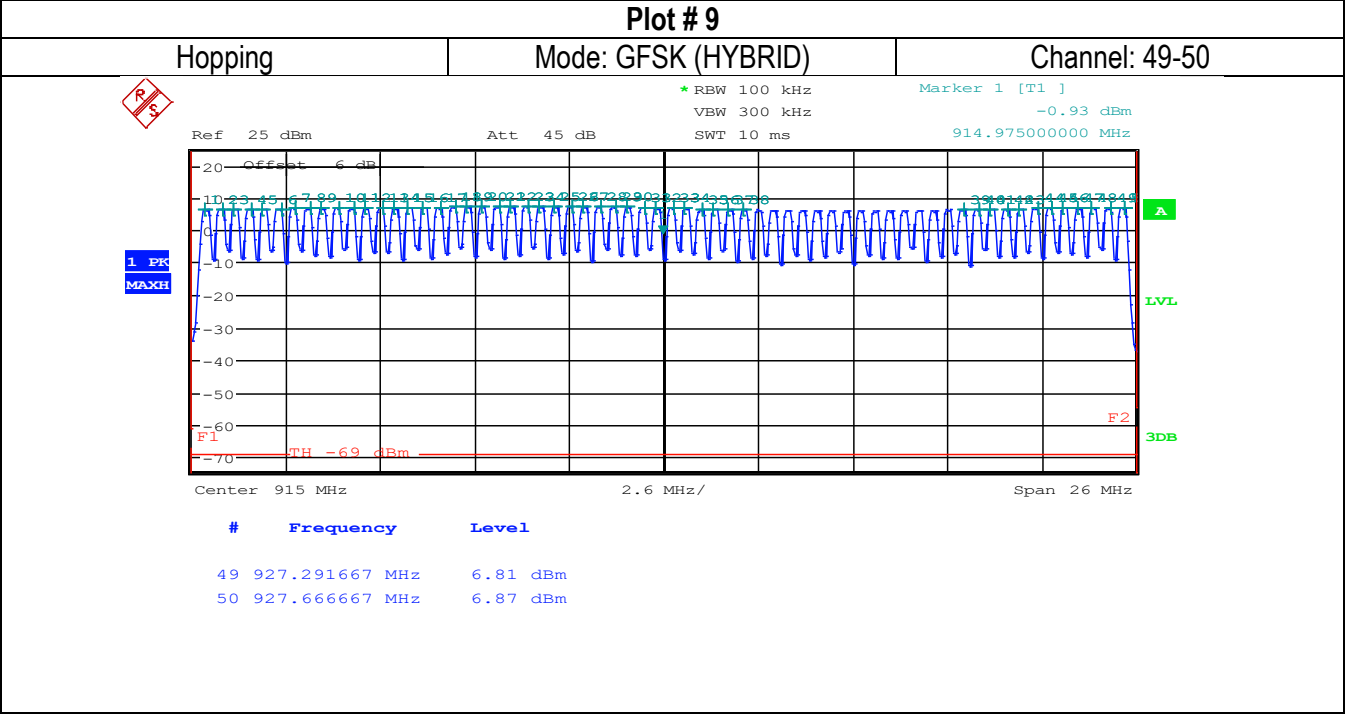












8.7 Transmitter Spurious Emissions and Restricted Bands

8.7.1 Measurement according to ANSI C63.10

Analyzer Settings:

- Frequency = 9 KHz – 30 MHz
- RBW = 9 KHz
- Detector = Peak

- Frequency = 30 MHz – 1 GHz
- Detector = Peak / Quasi-Peak
- RBW = 120 KHz (<1 GHz)

- Frequency > 1 GHz
- Detector = Peak / Average
- RBW = 1MHz

- Radiated spurious emissions shall be measured for the transmit frequencies, transmit power, and data rate for the lowest, middle and highest channel in each frequency band of operation and for the highest gain antenna for each antenna type, and using the appropriate parameters and test requirements.
- The highest (or worst-case) data rate shall be recorded for each measurement.
- For testing frequencies below 30 MHz at distance other than the specified in the standard, the limit conversion is calculated by using the FCC materials for the ANSI 63 committee issued on January, 27 1991.

8.7.2 Limits: FCC 15.247(d)/15.209(a) /RSS-Gen 6.13

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
10.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	Above 38.6
13.36-13.41			

- 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)).
- PEAK LIMIT= 74dB μ V/m
- AVG. LIMIT= 54dB μ V/m
- Except as shown in CFR 47 Part 15.205 paragraph (d), only spurious emissions are permitted in any of the frequency bands listed below

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	30
30-88	100**	3
88-216	150**	3
216-960	200**	3
Above 960	500	3

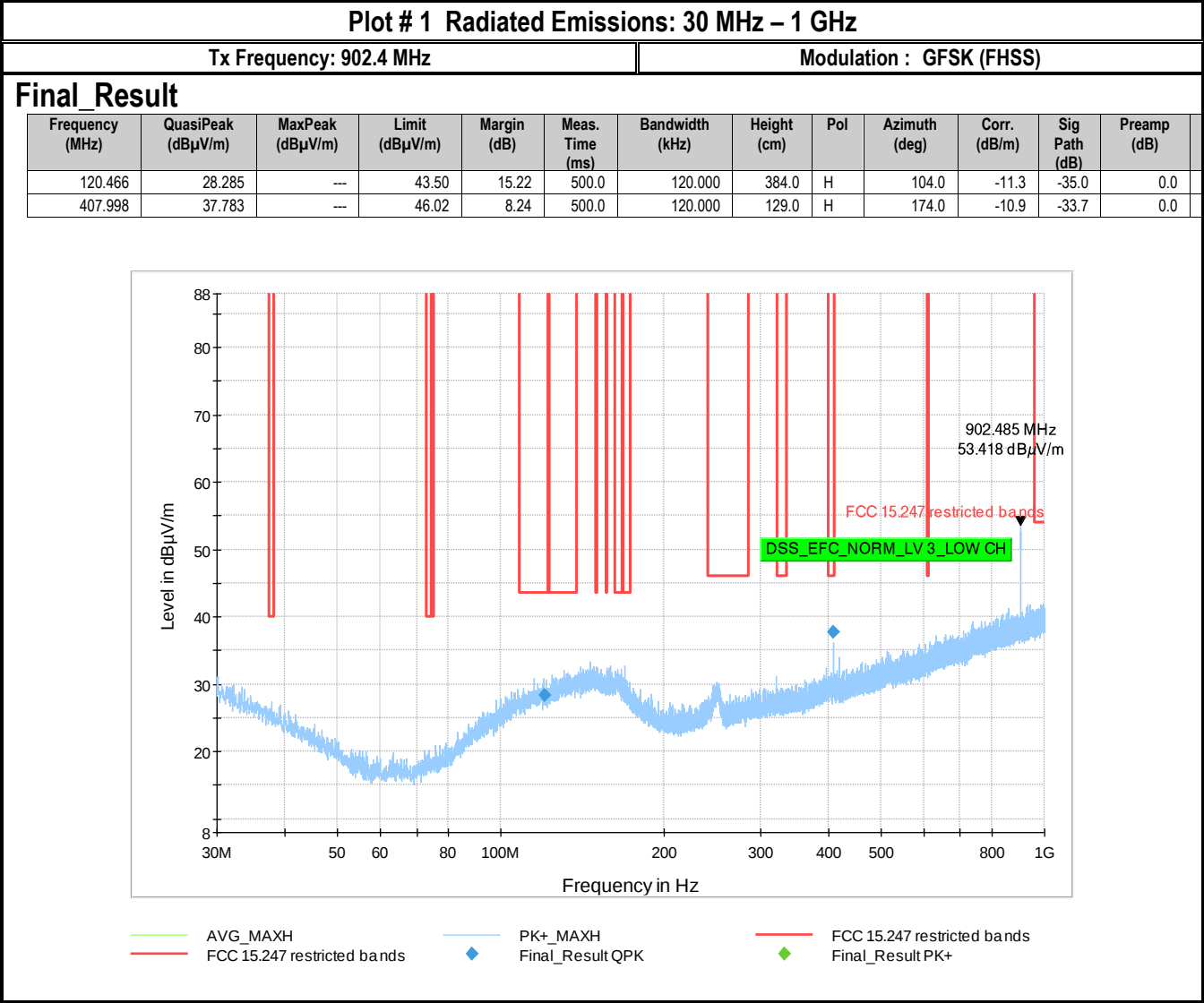
8.7.3 Test conditions and setup:

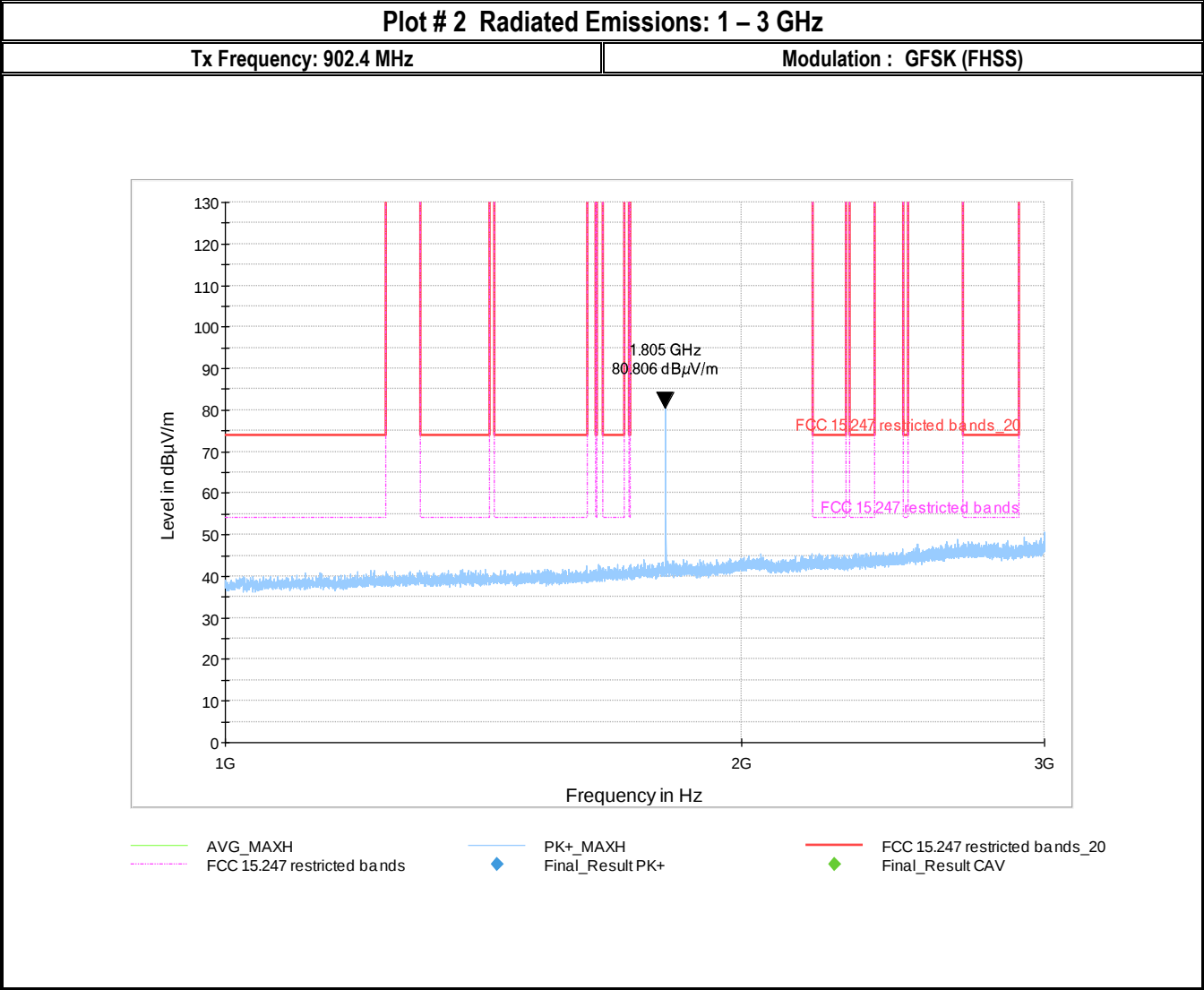
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
22.8.°C	1	1,2,3	Power by 3.6Vdc battery	3.3 dBi

8.7.4 Measurement result:

Plot #	Mode	Channel #	Scan Frequency	Lowest Margin Emission (dB μ V/m)	Limit	Result
1-3	GFSK (FHSS)	Low	30 MHz – 10 GHz	37.78	See section 8.7.2	Pass
4-7	GFSK (FHSS)	Mid	9 kHz – 10 GHz	38.04	See section 8.7.2	Pass
8-10	GFSK (FHSS)	High	30 MHz – 10 GHz	37.82	See section 8.7.2	Pass
11-13	OOK (FHSS)	Low	30 MHz – 10 GHz	37.66	See section 8.7.2	Pass
14-17	OOK (FHSS)	Mid	9 kHz – 10 GHz	37.52	See section 8.7.2	Pass
18-20	OOK (FHSS)	High	30 MHz – 10 GHz	37.71	See section 8.7.2	Pass
21-23	GFSK (HYBRID)	Low	30 MHz – 10 GHz	44.41	See section 8.7.2	Pass
24-27	GFSK (HYBRID)	Mid	9 kHz – 10 GHz	43.96	See section 8.7.2	Pass
28-30	GFSK (HYBRID)	High	30 MHz – 10 GHz	45.01	See section 8.7.2	Pass

8.7.5 Measurement Plots:

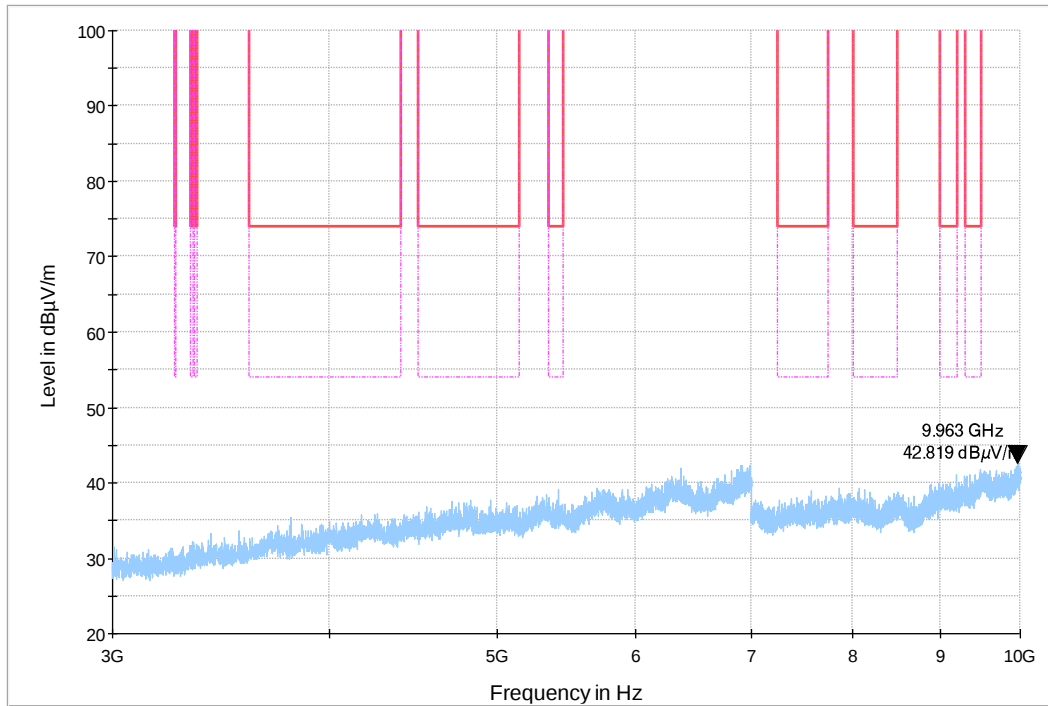




Plot # 3 Radiated Emissions: 3 – 18 GHz

Tx Frequency: 902.4 MHz

Modulation : GFSK (FHSS)



— AVG_MAXH
— FCC 15.247 restricted bands

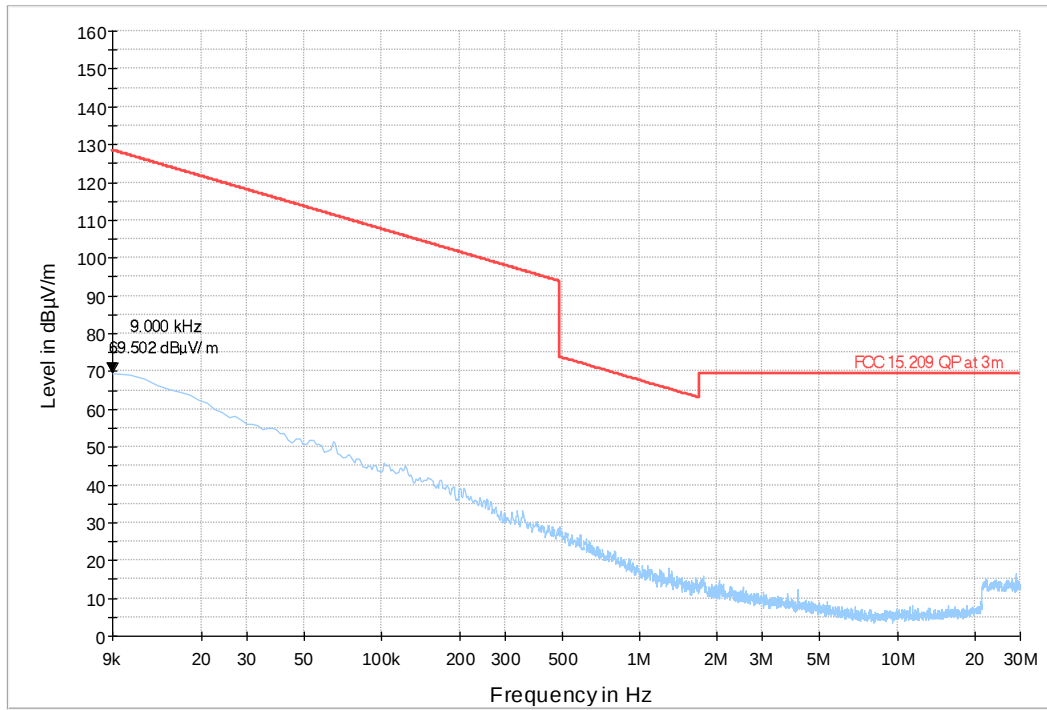
— PK+_MAXH
◆ Final_Result PK+

— FCC 15.247 restricted bands_20
◆ Final_Result CAV

Plot # 4 Radiated Emissions: 9 KHz – 30 MHz

Tx Frequency: 915.2 MHz

Modulation : GFSK (FHSS)



AVG_MAXH Final_Result QPK
PK+_MAXH Final_Result PK+
FCC 15.209 QP at 3m

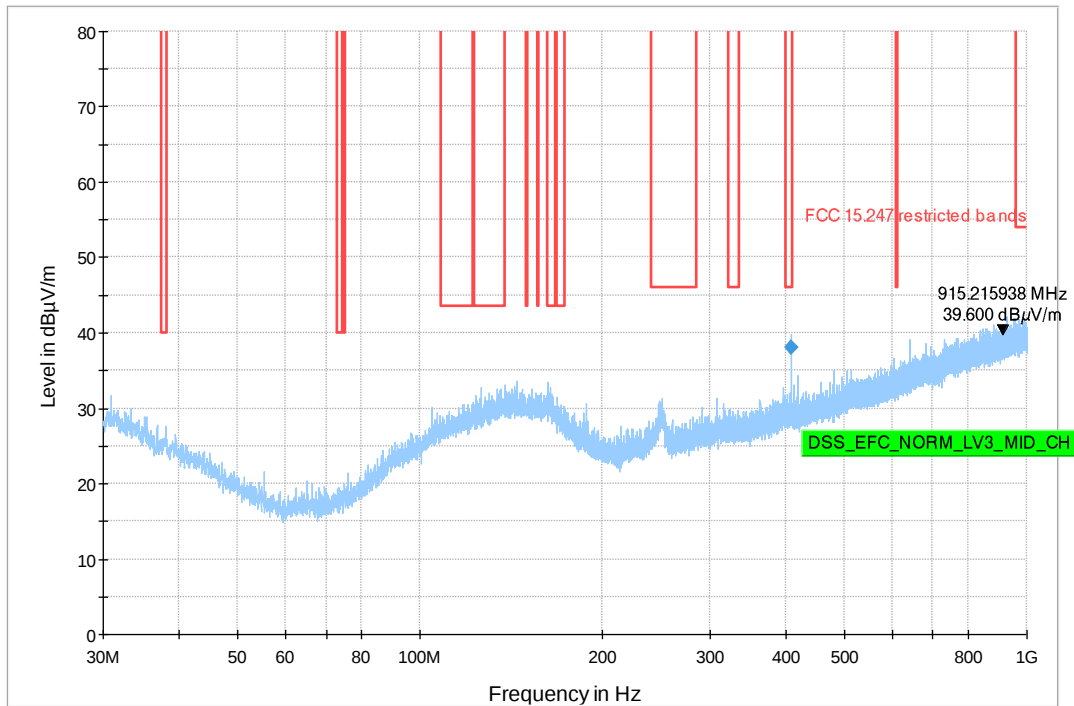
Plot # 5 Radiated Emissions: 30 MHz – 1 GHz

Tx Frequency: 915.2 MHz

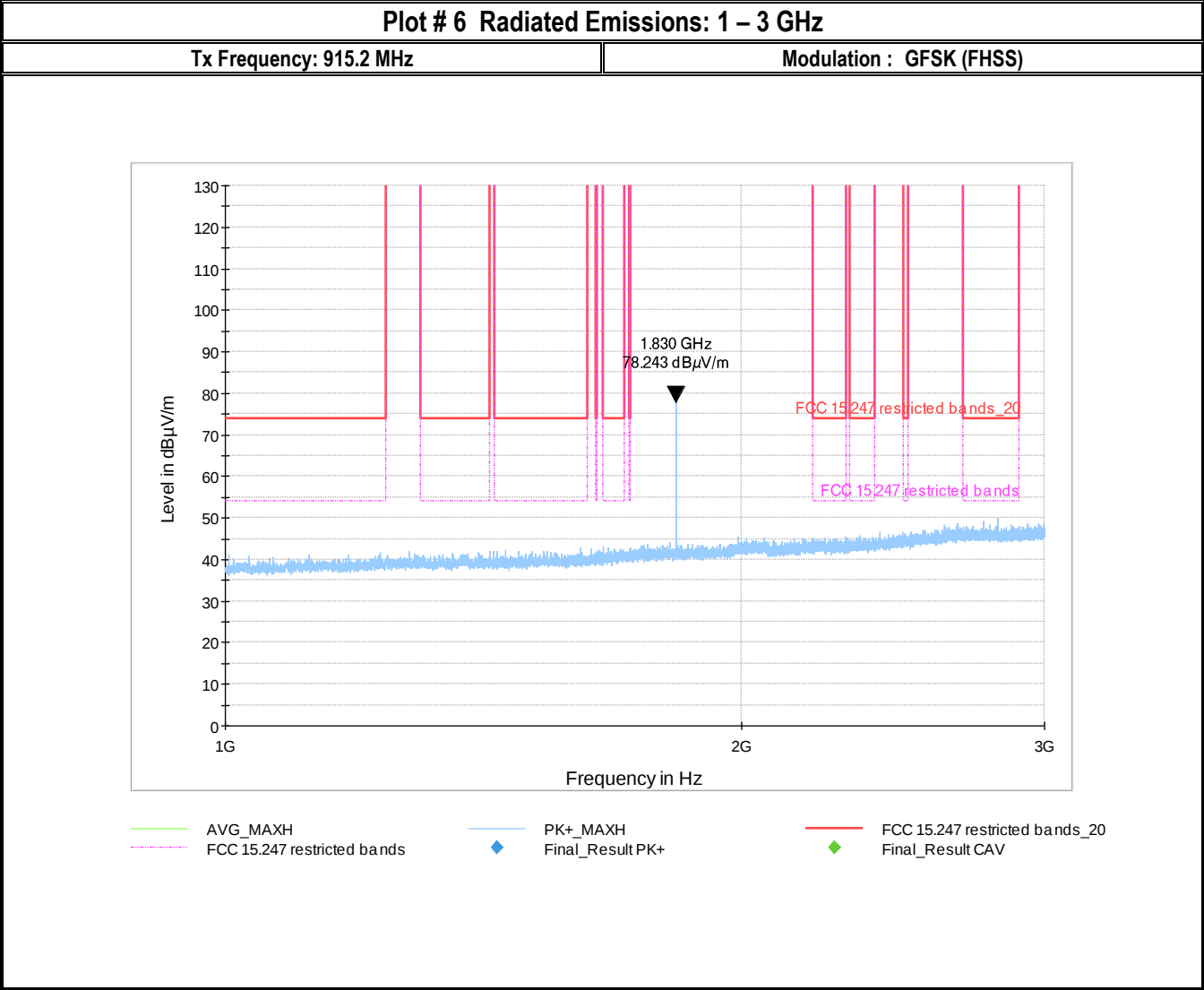
Modulation : GFSK (FHSS)

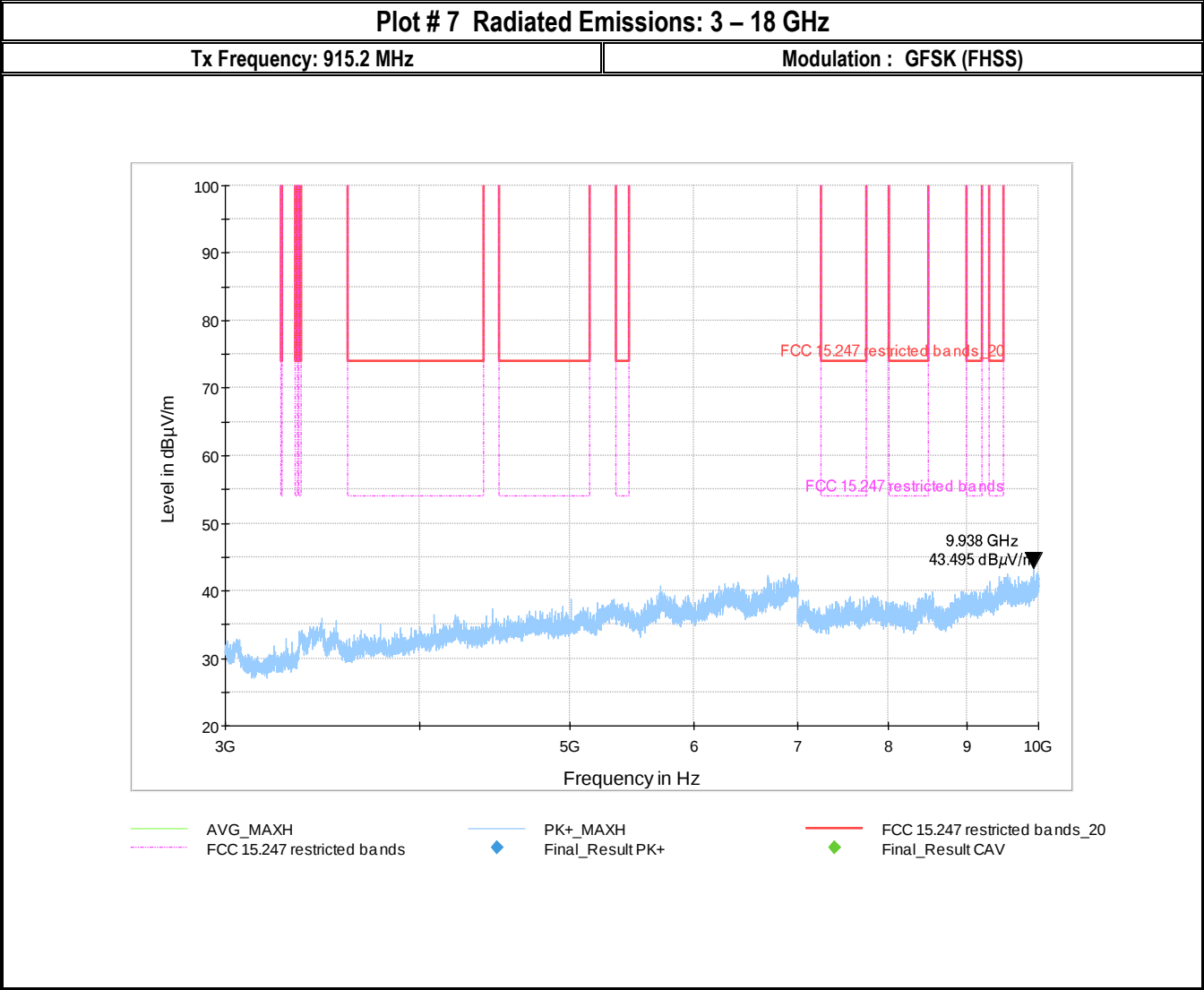
Final_Result

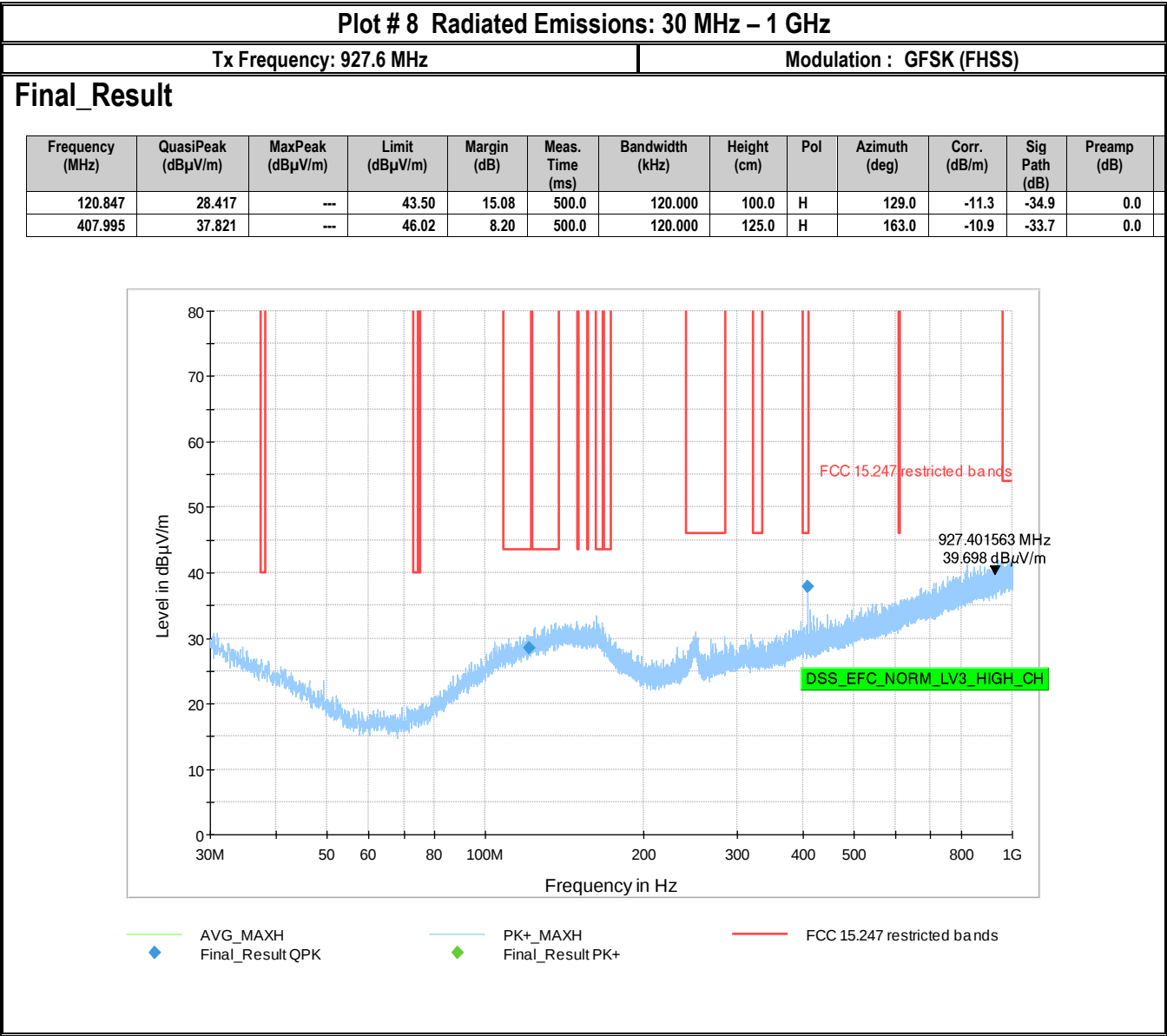
Frequency (MHz)	QuasiPeak (dBμV/m)	MaxPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Sig Path (dB)	Preamp (dB)	Trd Corr. (dB/m)	Raw Rec (dBμV)
408.001	38.036	---	46.02	7.98	500.0	120.000	100.0	H	169.0	-10.9	-33.7	0.0	22.8	49.0

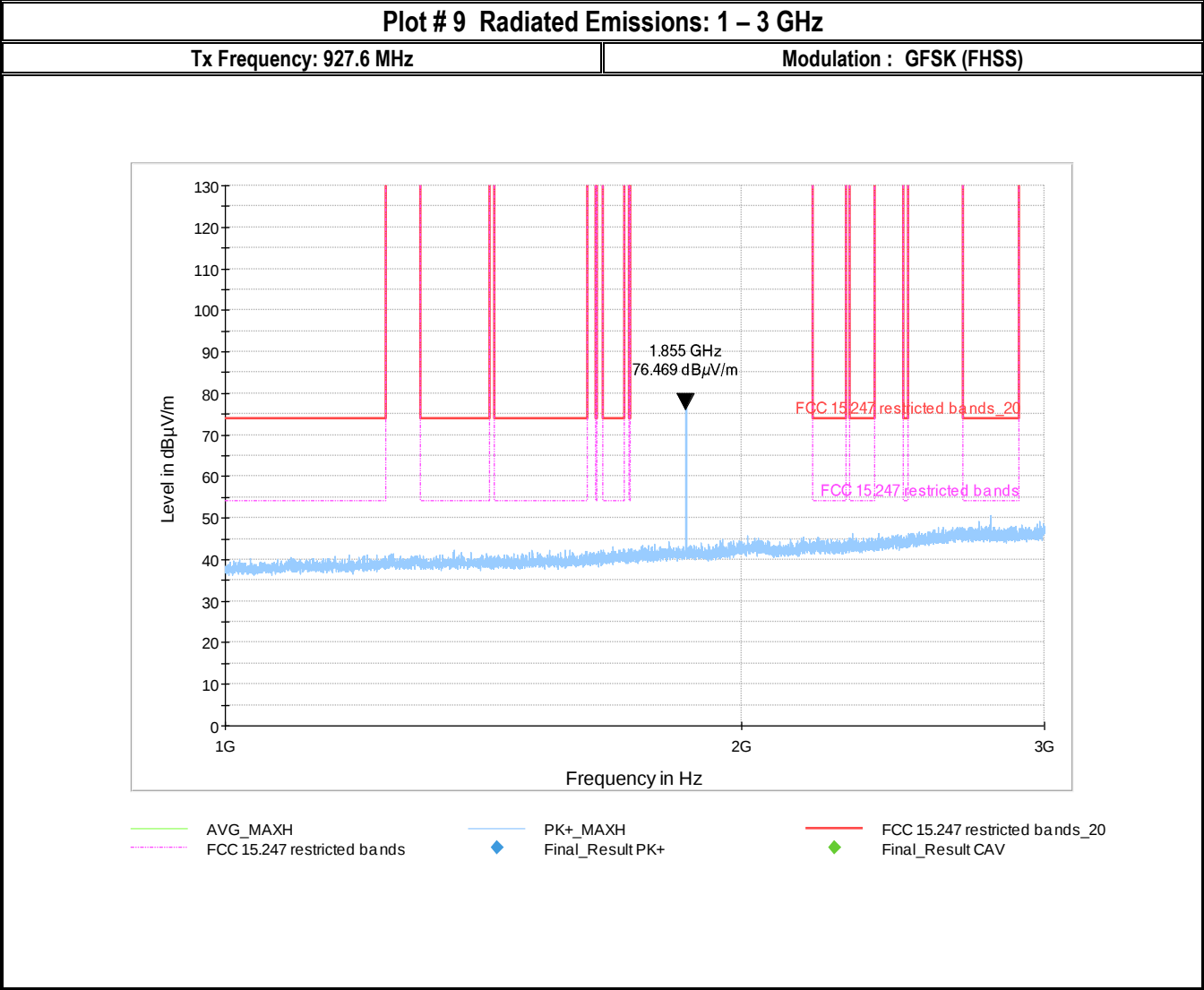


◆ AVG_MAXH Final_Result QPK
 ◆ PK+_MAXH Final_Result PK+
 — FCC 15.247 restricted bands





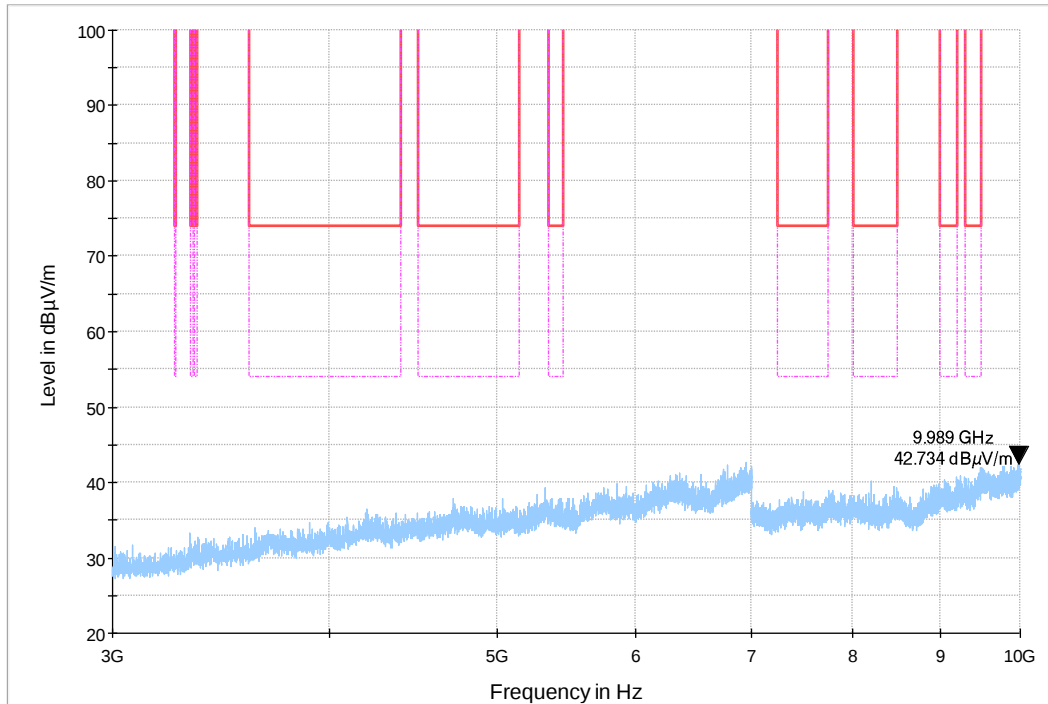




Plot # 10 Radiated Emissions: 3 – 18 GHz

Tx Frequency: 927.6 MHz

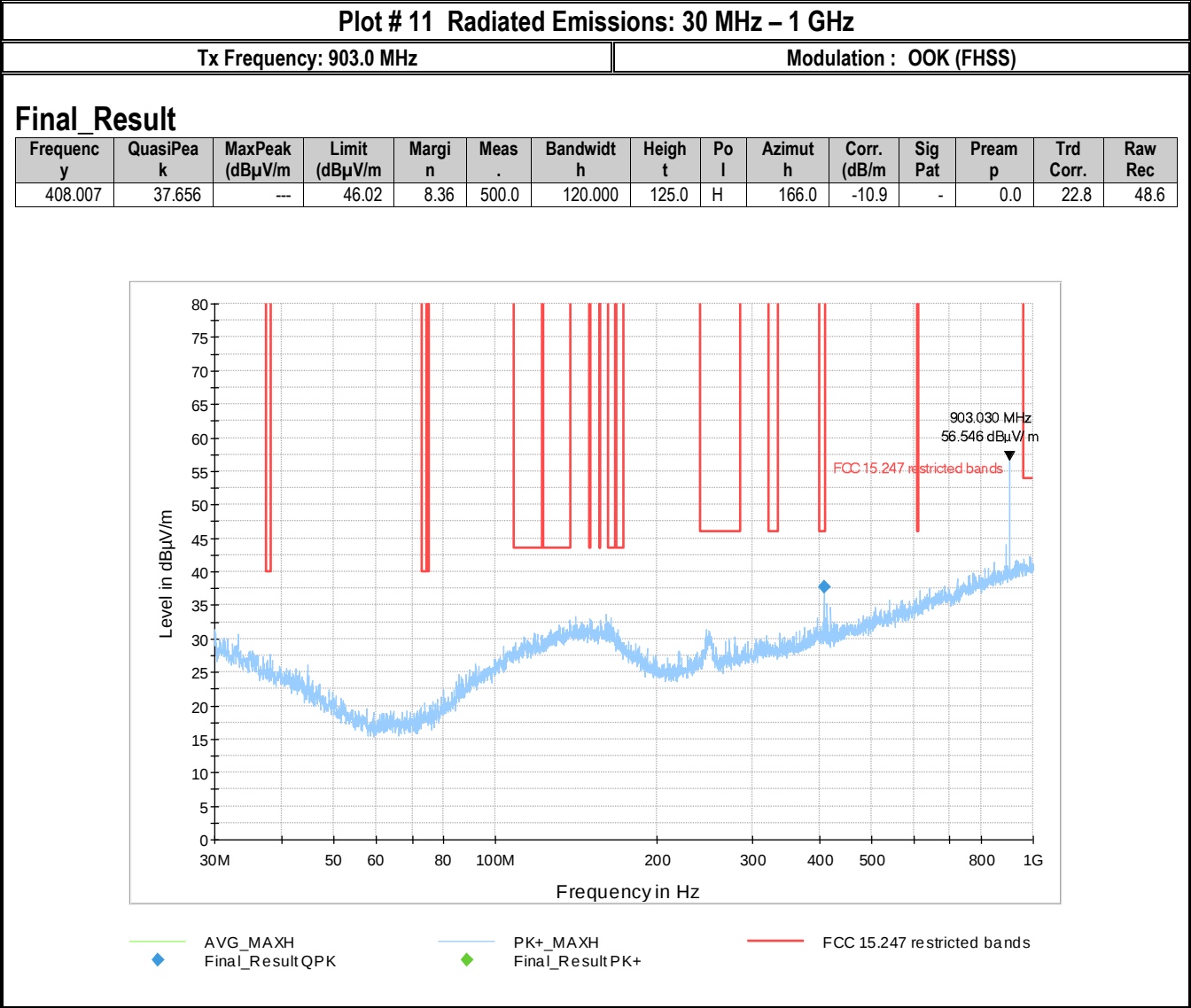
Modulation : GFSK (FHSS)

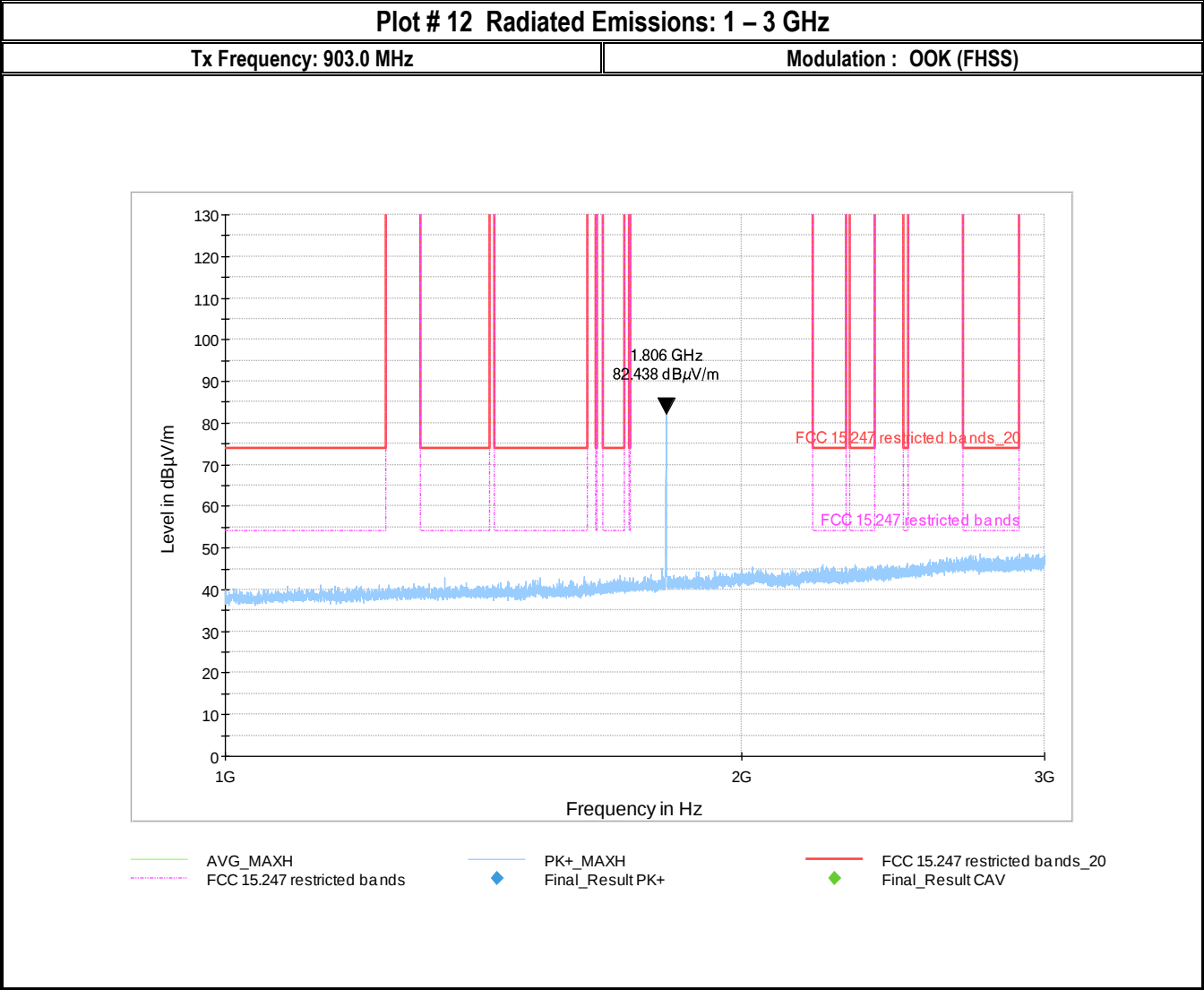


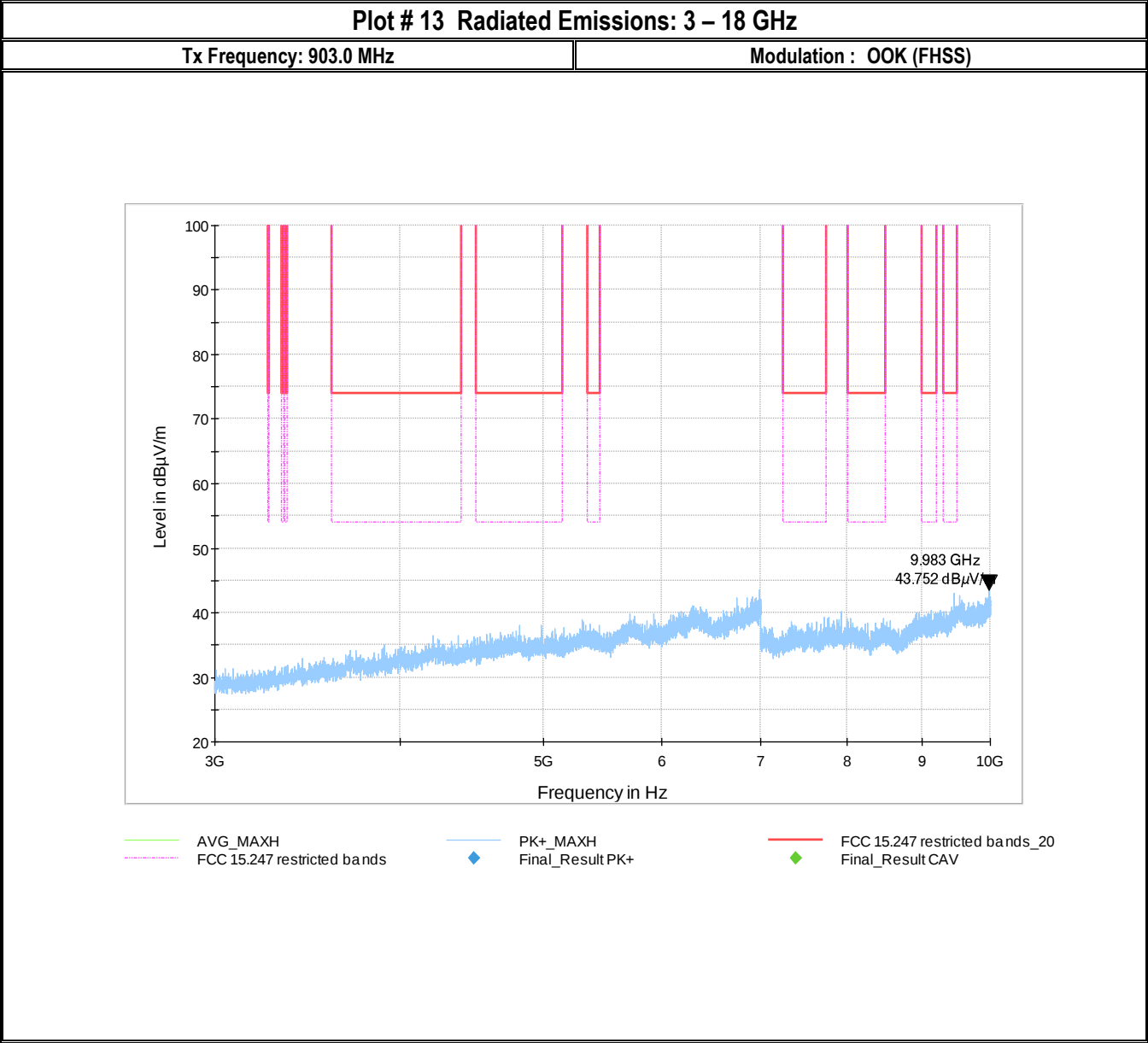
AVG_MAXH
FCC 15.247 restricted bands

PK+ MAXH
Final_Result PK+

FCC 15.247 restricted bands_20
Final_Result CAV



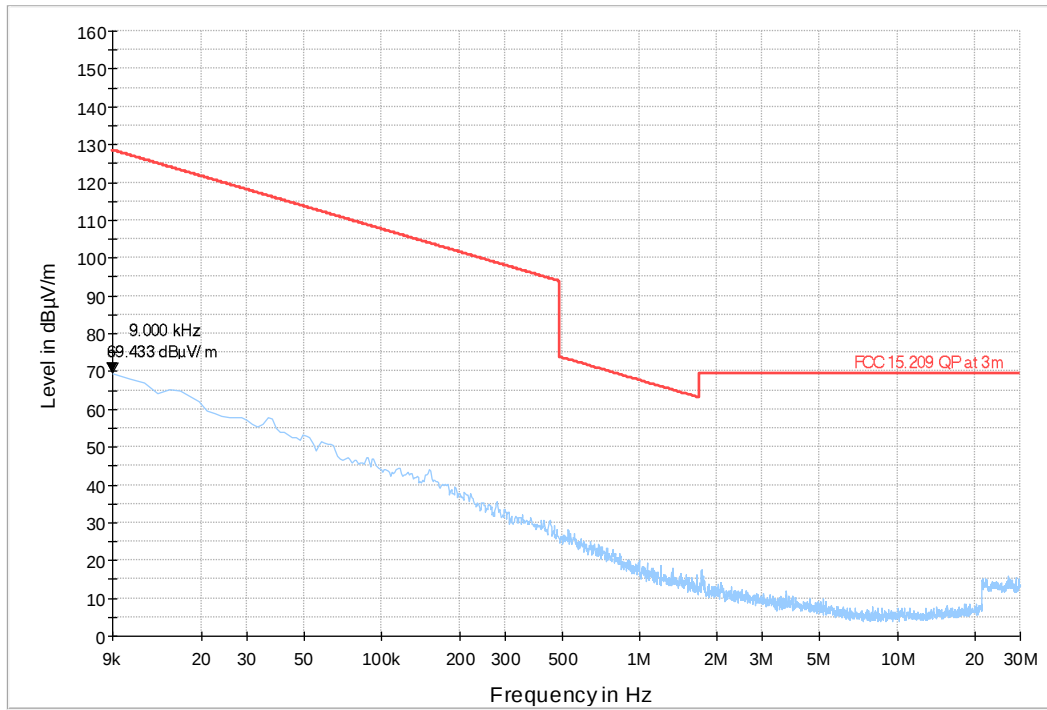




Plot # 14 Radiated Emissions: 9 KHz – 30 MHz

Tx Frequency: 915.0 MHz

Modulation : OOK (FHSS)



AVG_MAXH Final_Result QPK
PK+_MAXH Final_Result PK+
FCC 15.209 QP at 3m

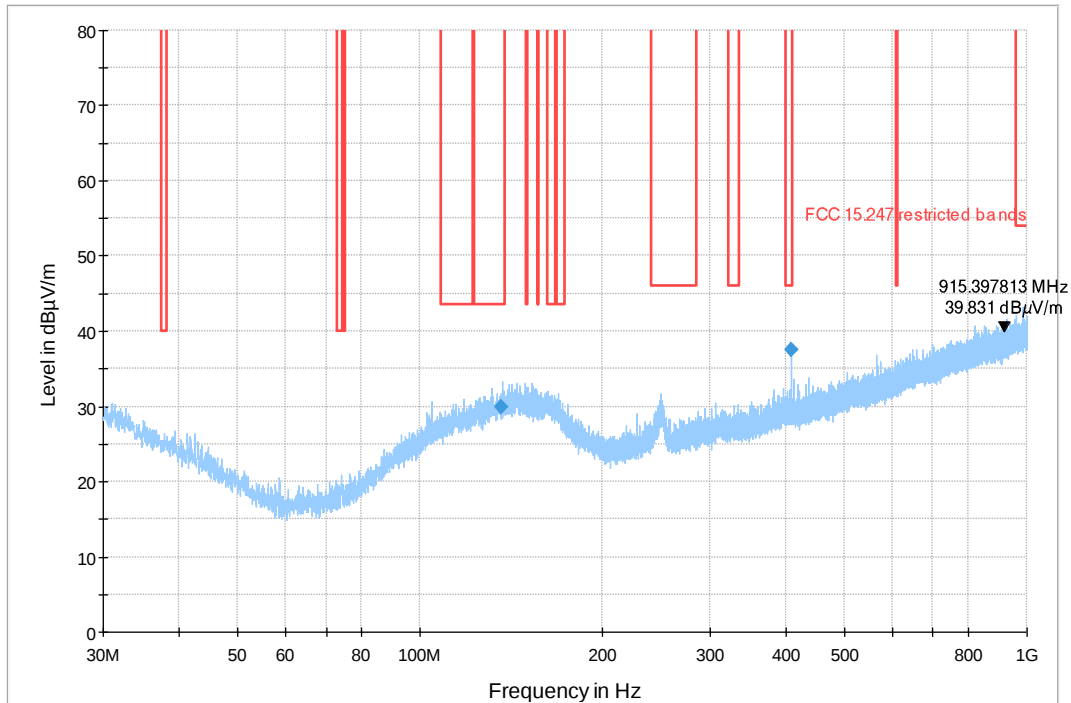
Plot # 15 Radiated Emissions: 30 MHz – 1 GHz

Tx Frequency: 915.0 MHz

Modulation : OOK (FHSS)

Final Result

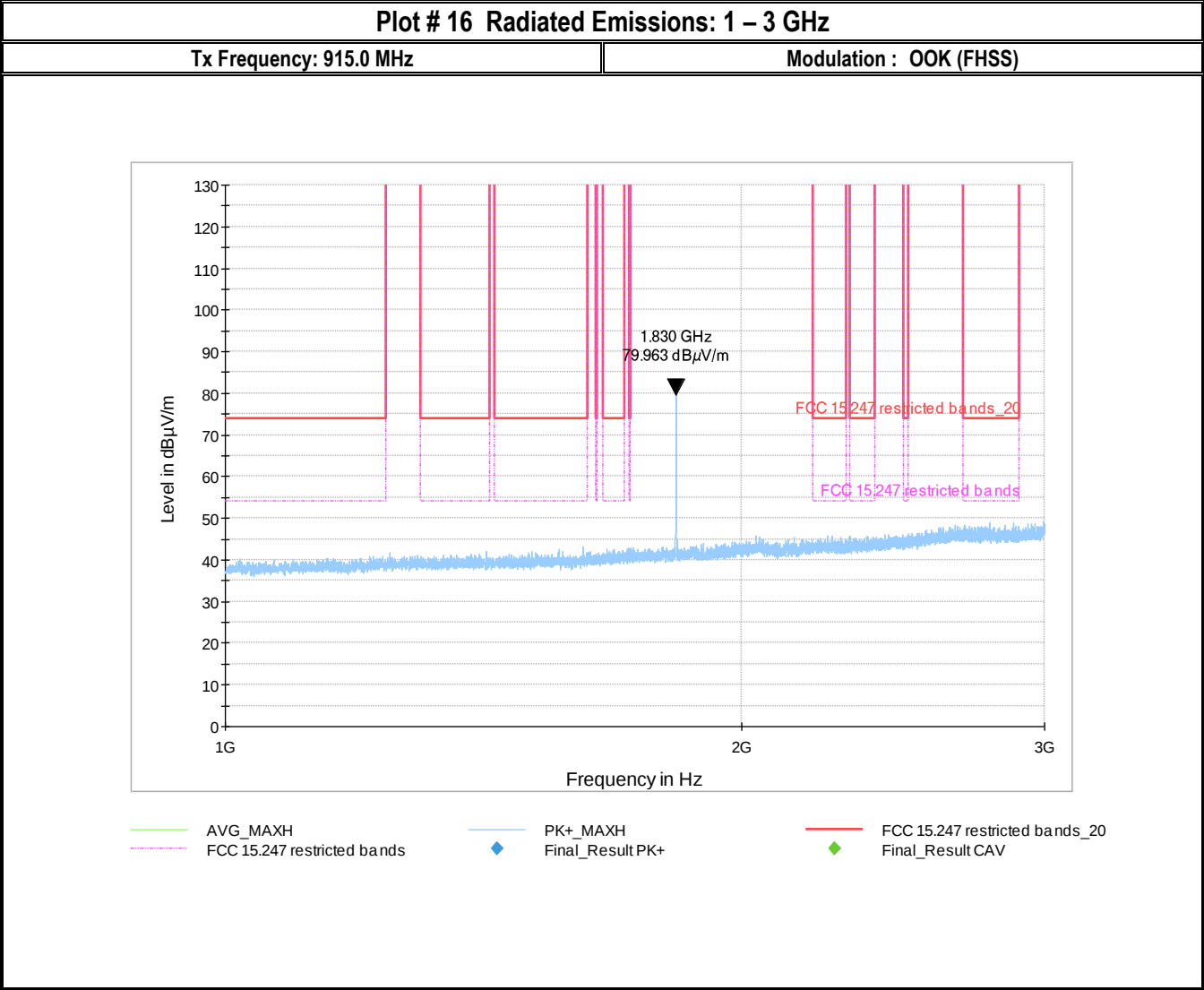
Frequency (MHz)	QuasiPeak (dBμV/m)	MaxPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Sig Path (dB)	Preamp (dB)
135.692	29.860	---	43.50	13.64	500.0	120.000	351.0	H	176.0	-9.9	-34.8	0.0
407.995	37.515	---	46.02	8.51	500.0	120.000	117.0	H	164.0	-10.9	-33.7	0.0

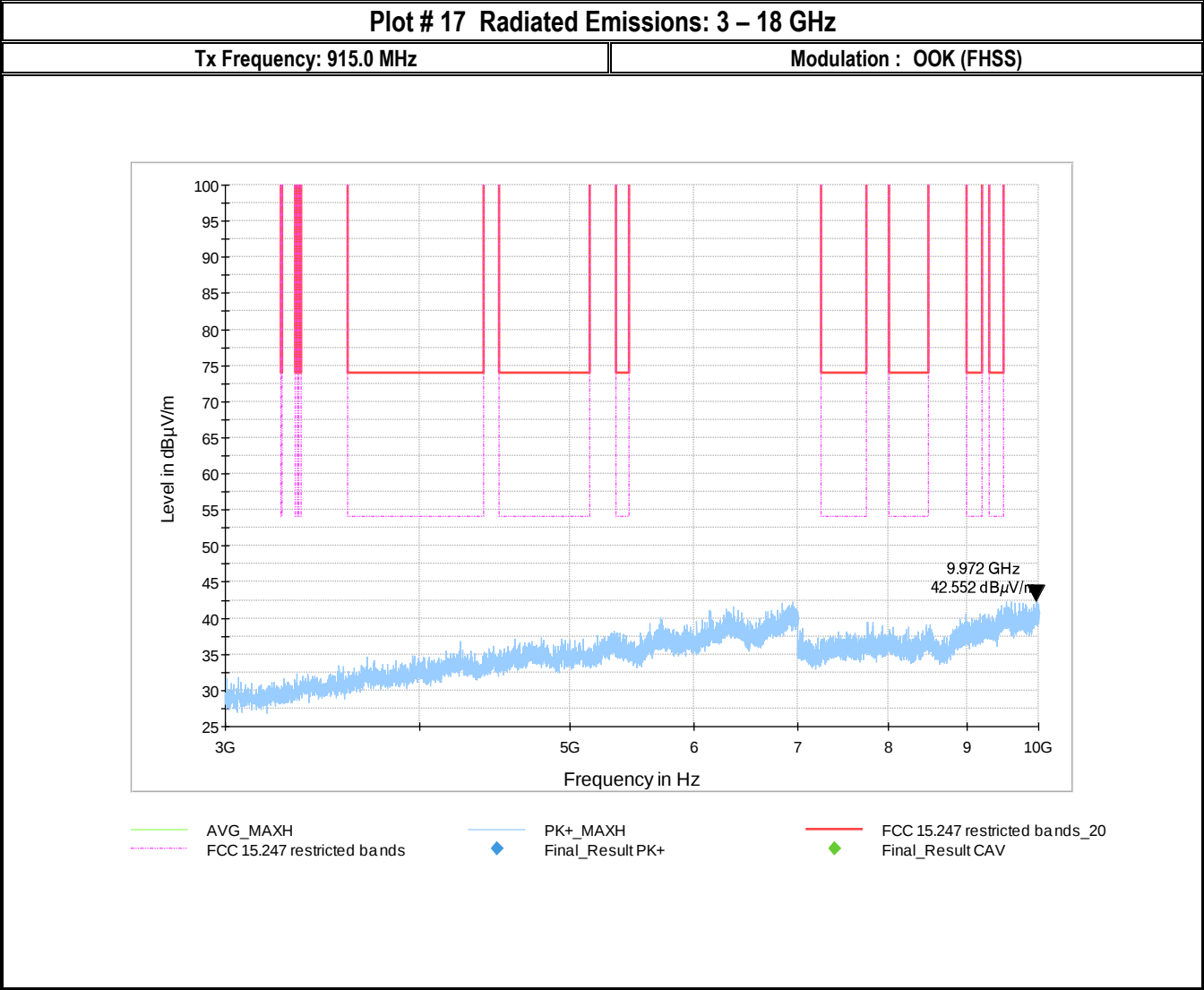


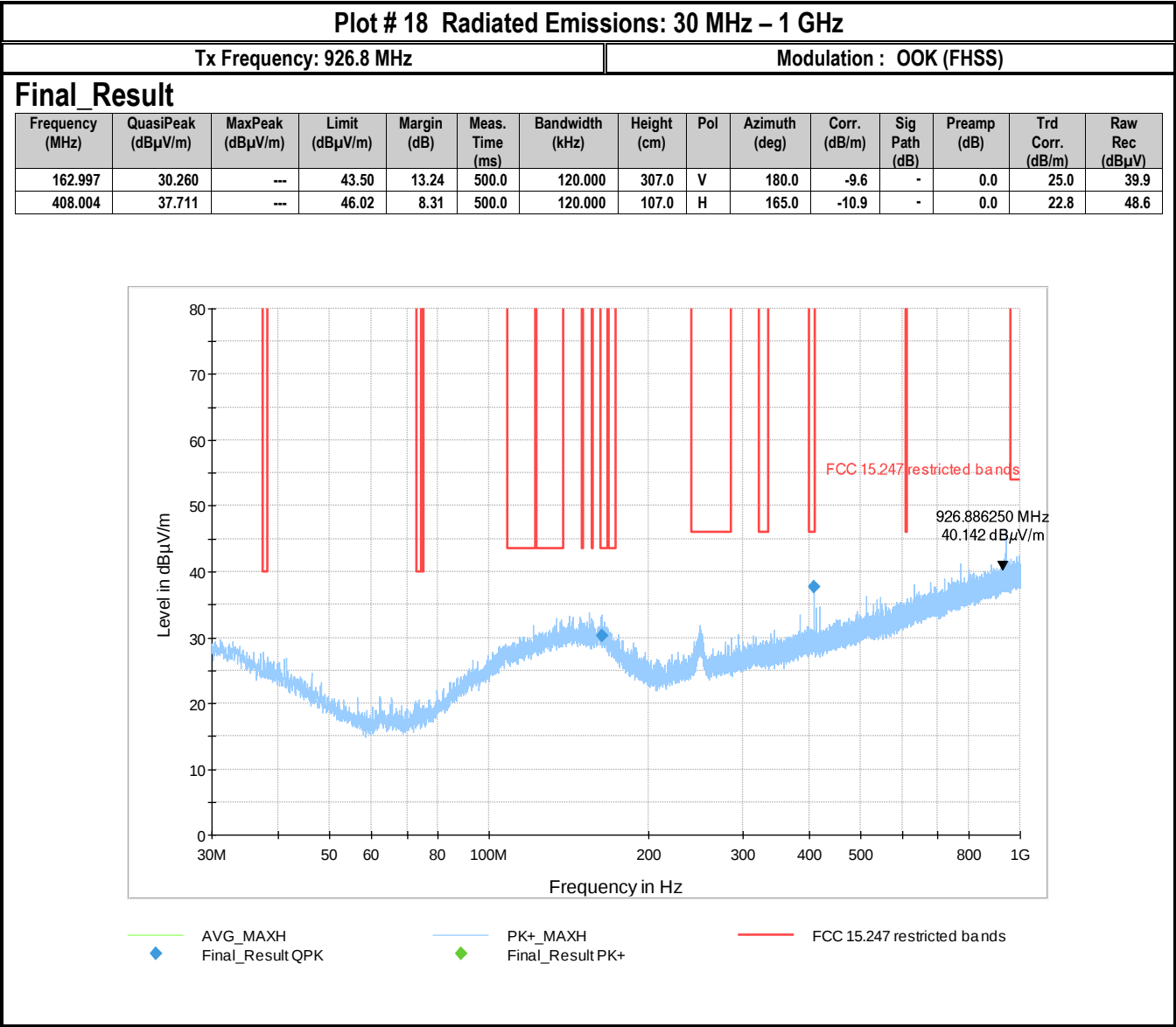
◆ AVG_MAXH
Final_Result QPK

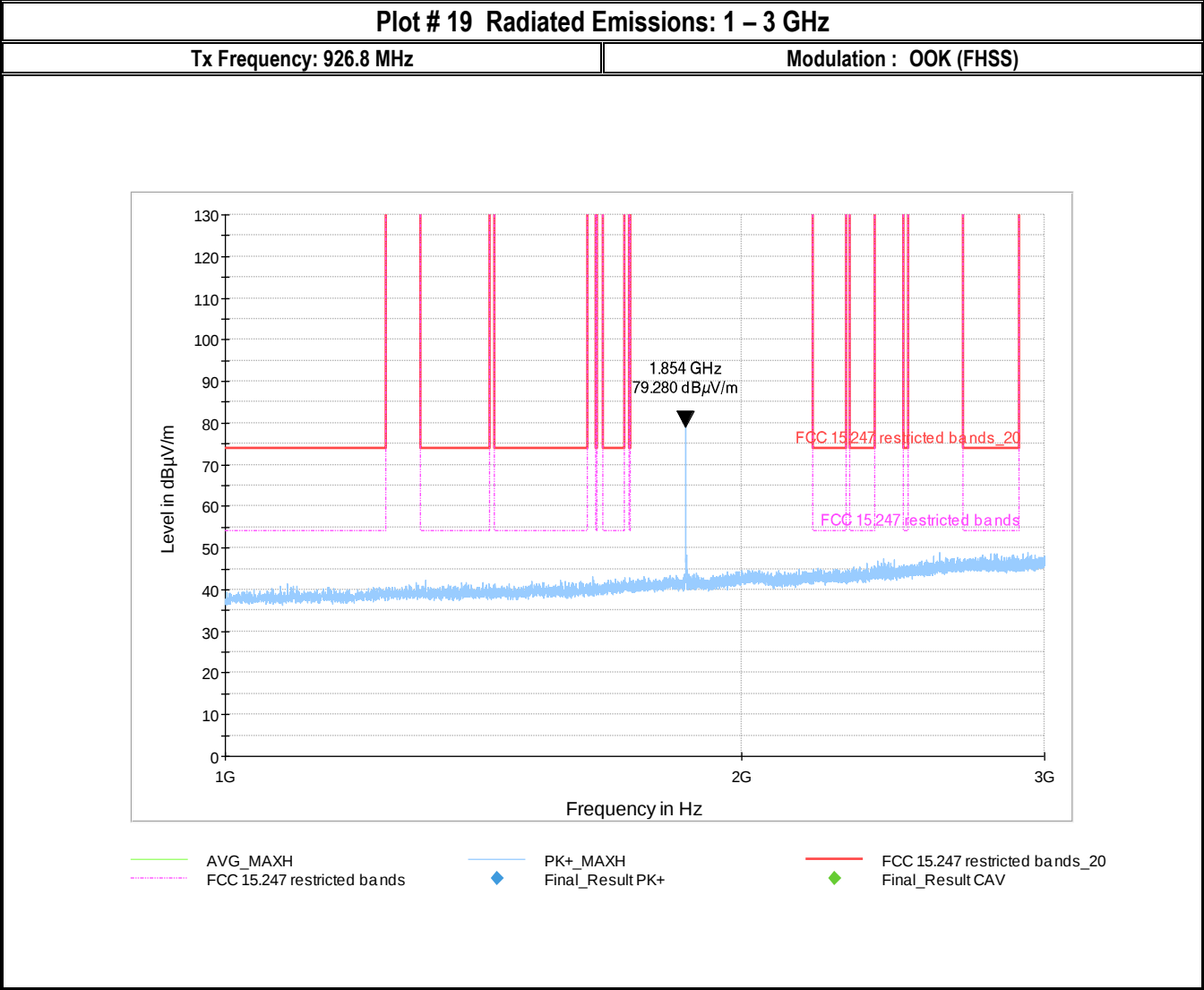
◆ PK+_MAXH
Final_Result PK+

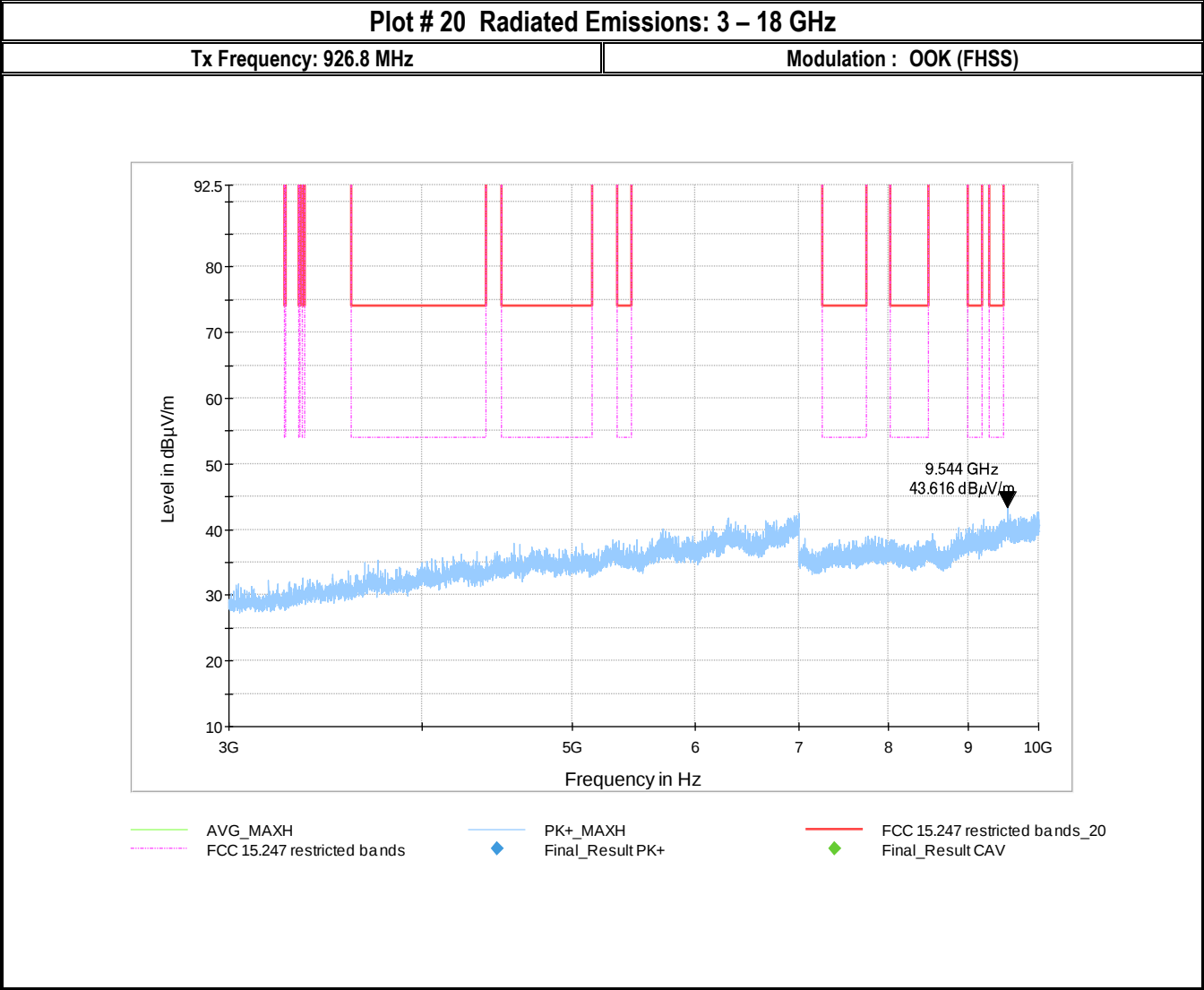
— FCC 15.247 restricted bands

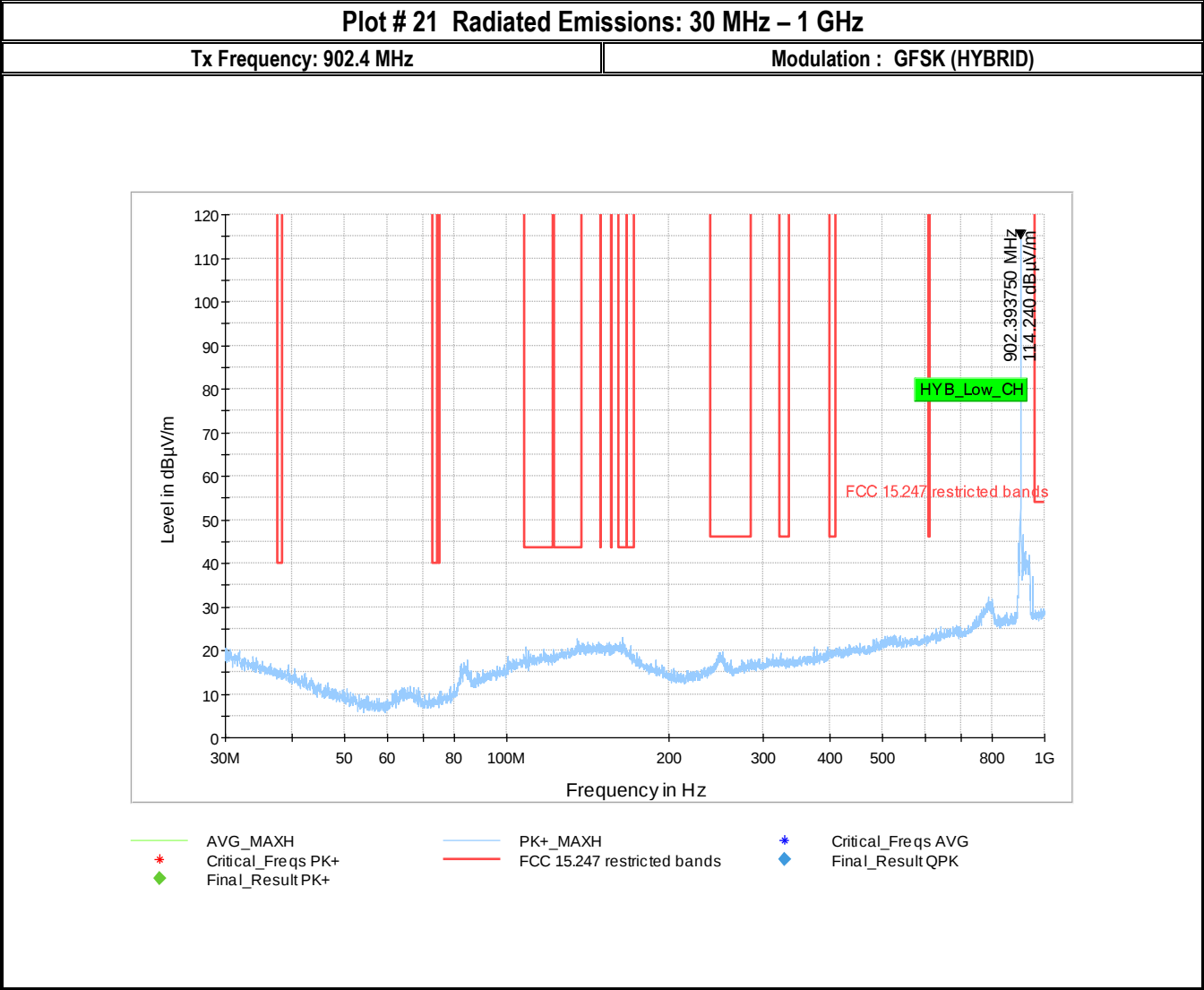


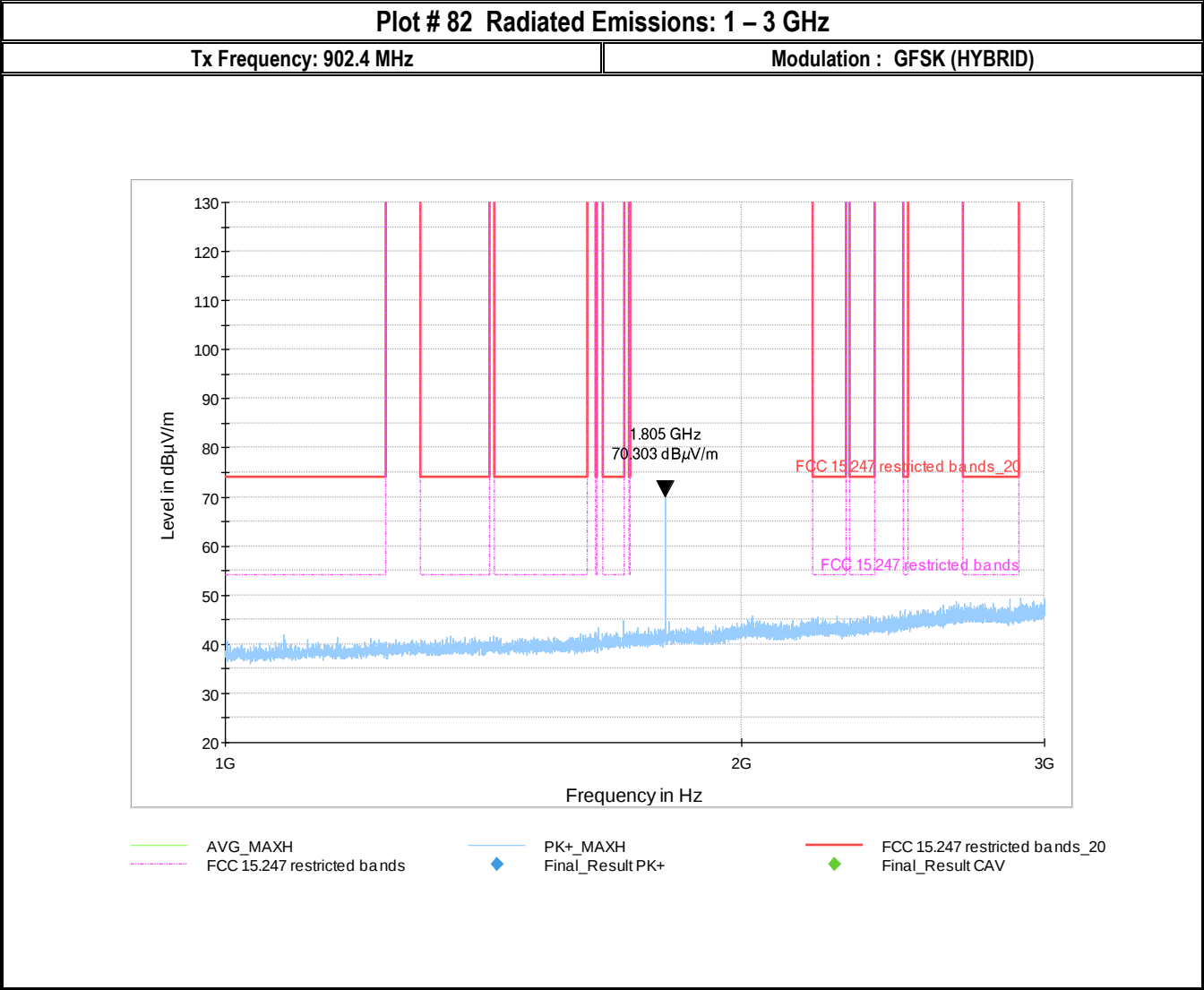


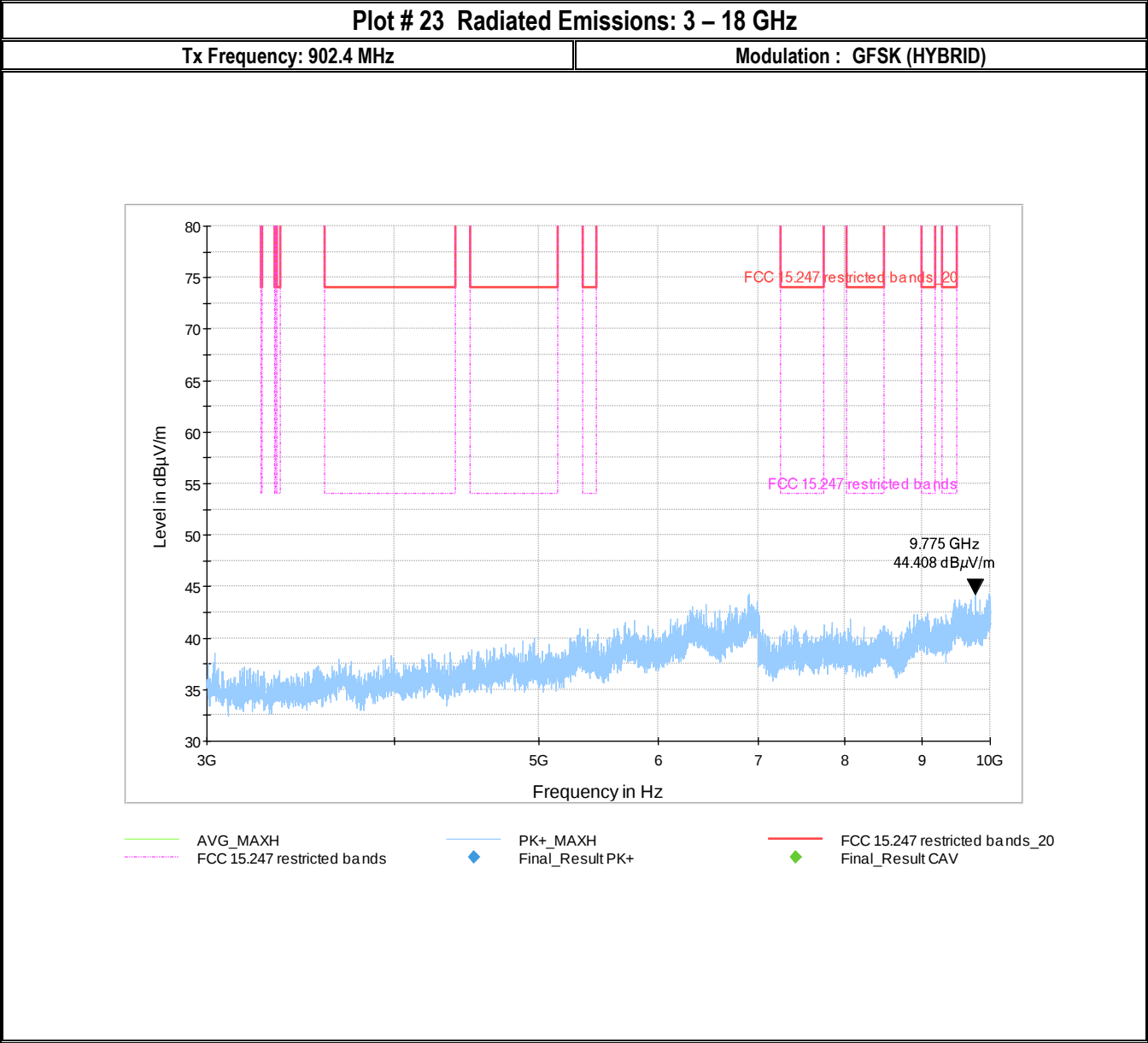


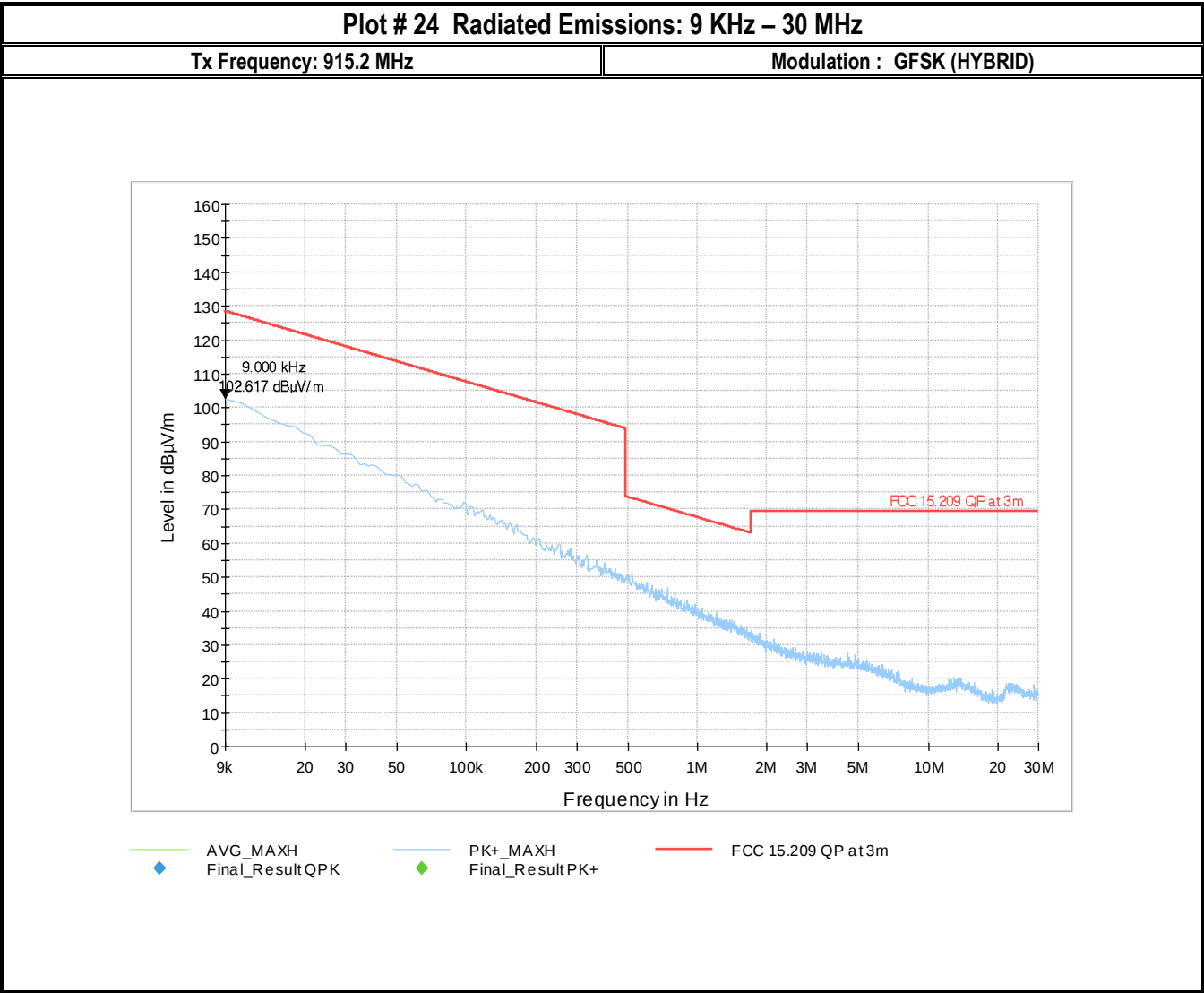


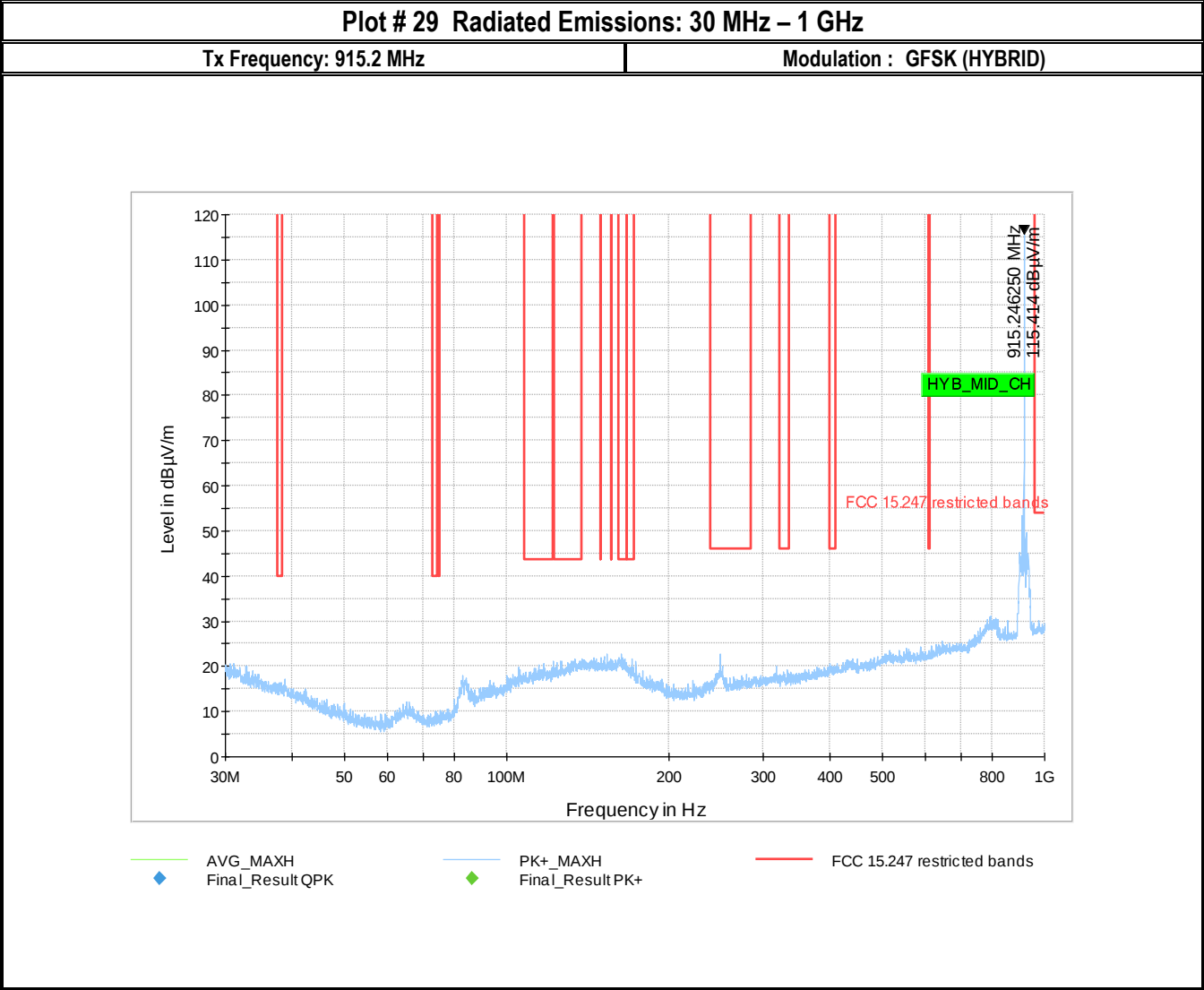


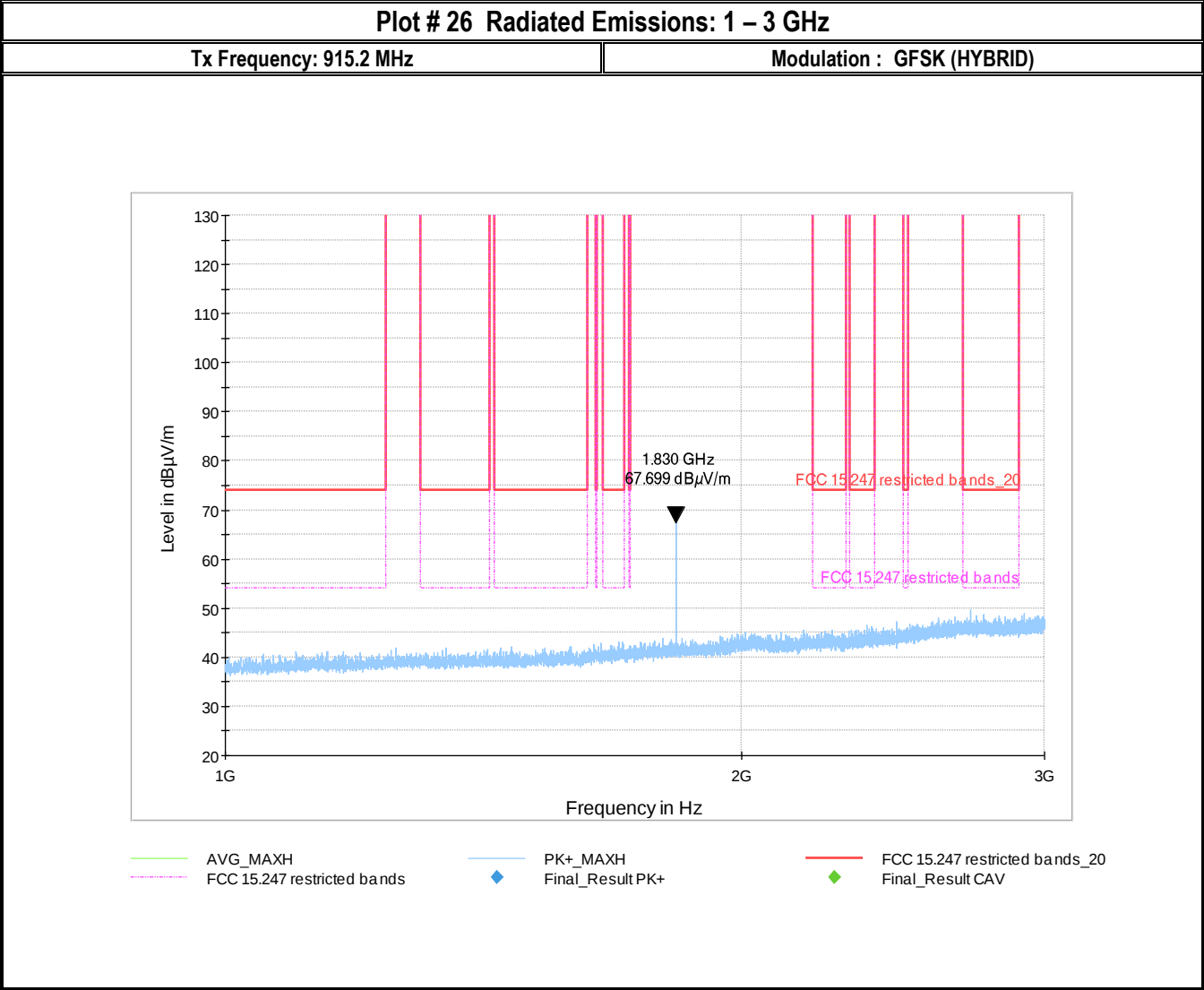


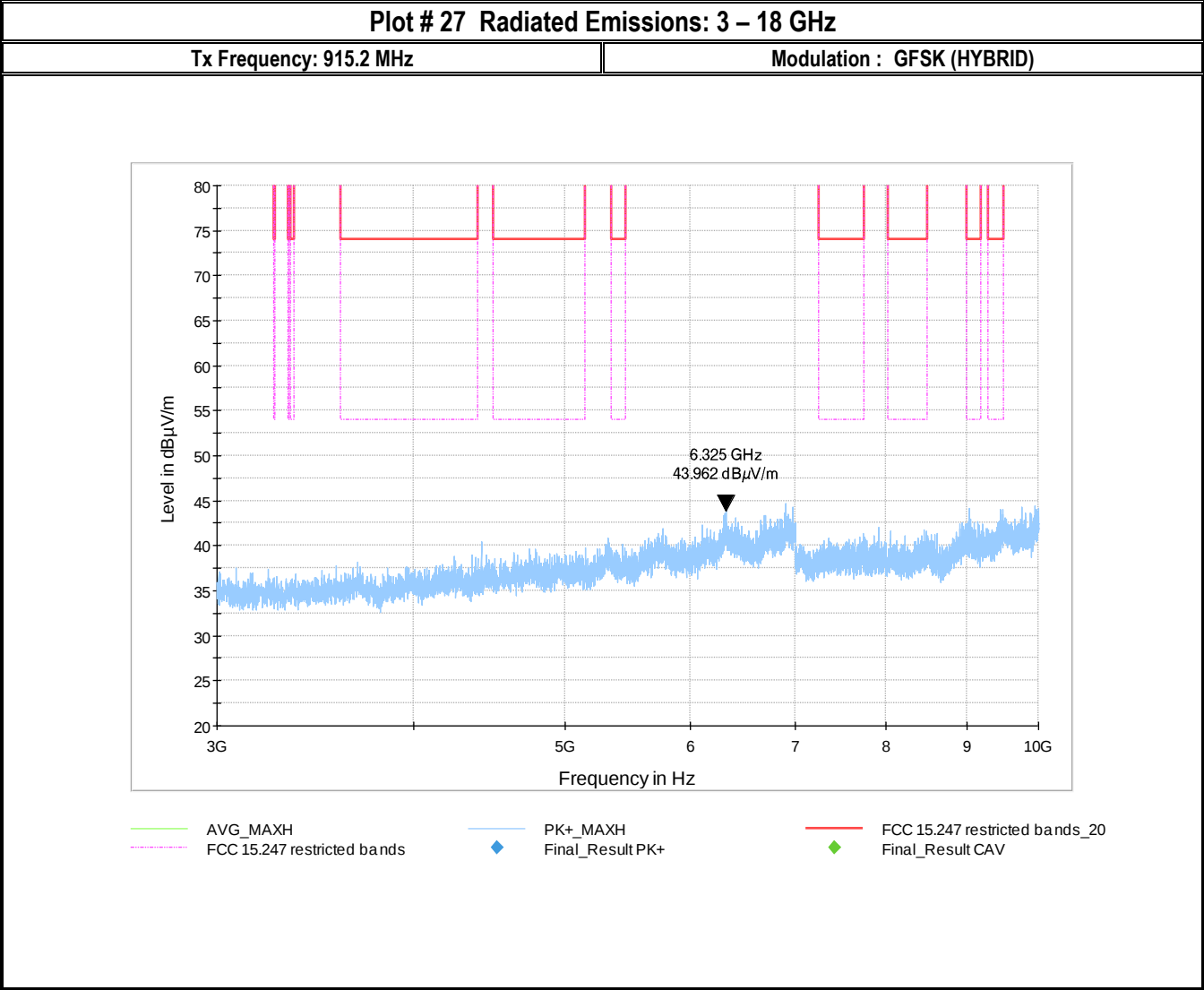


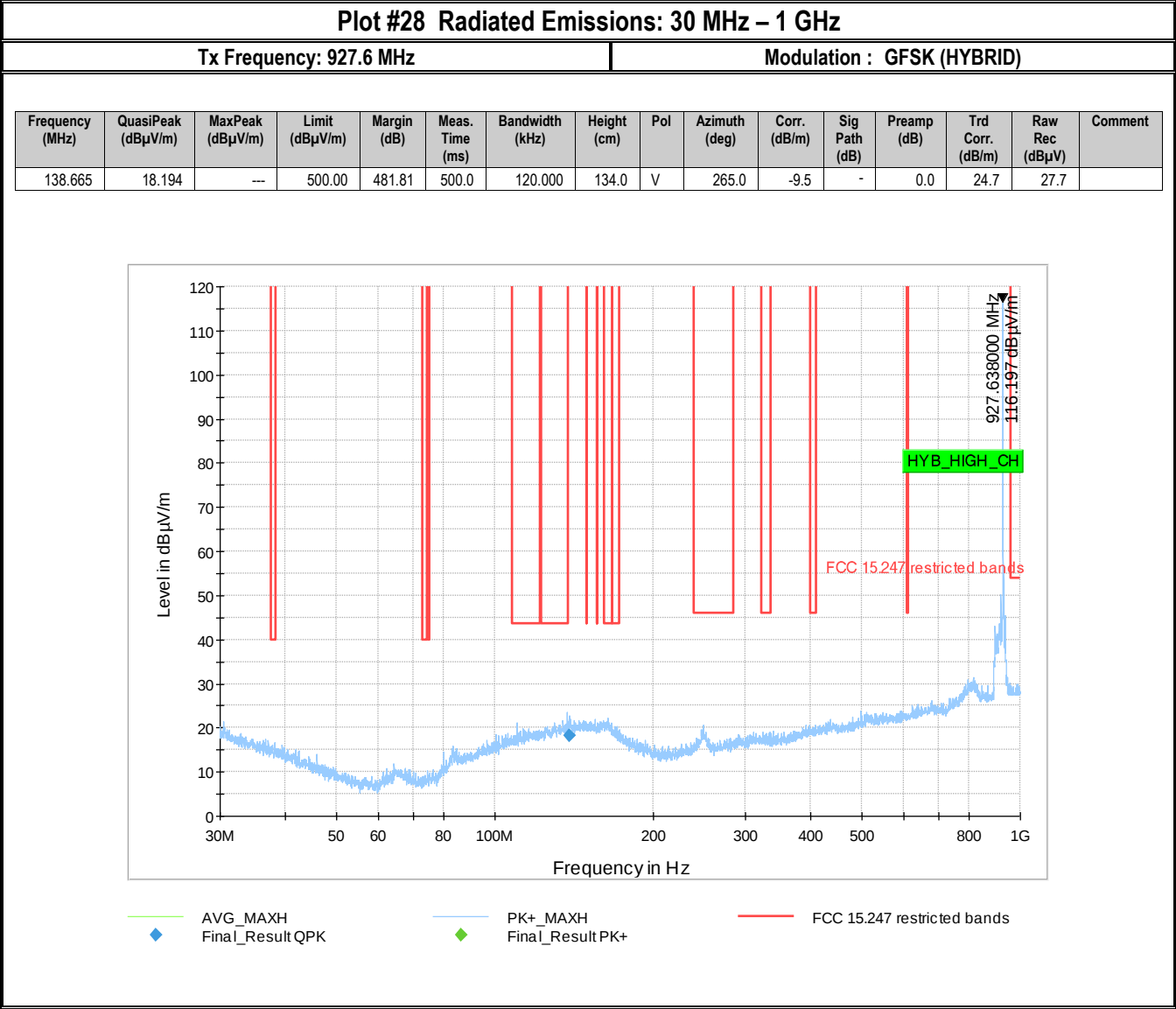


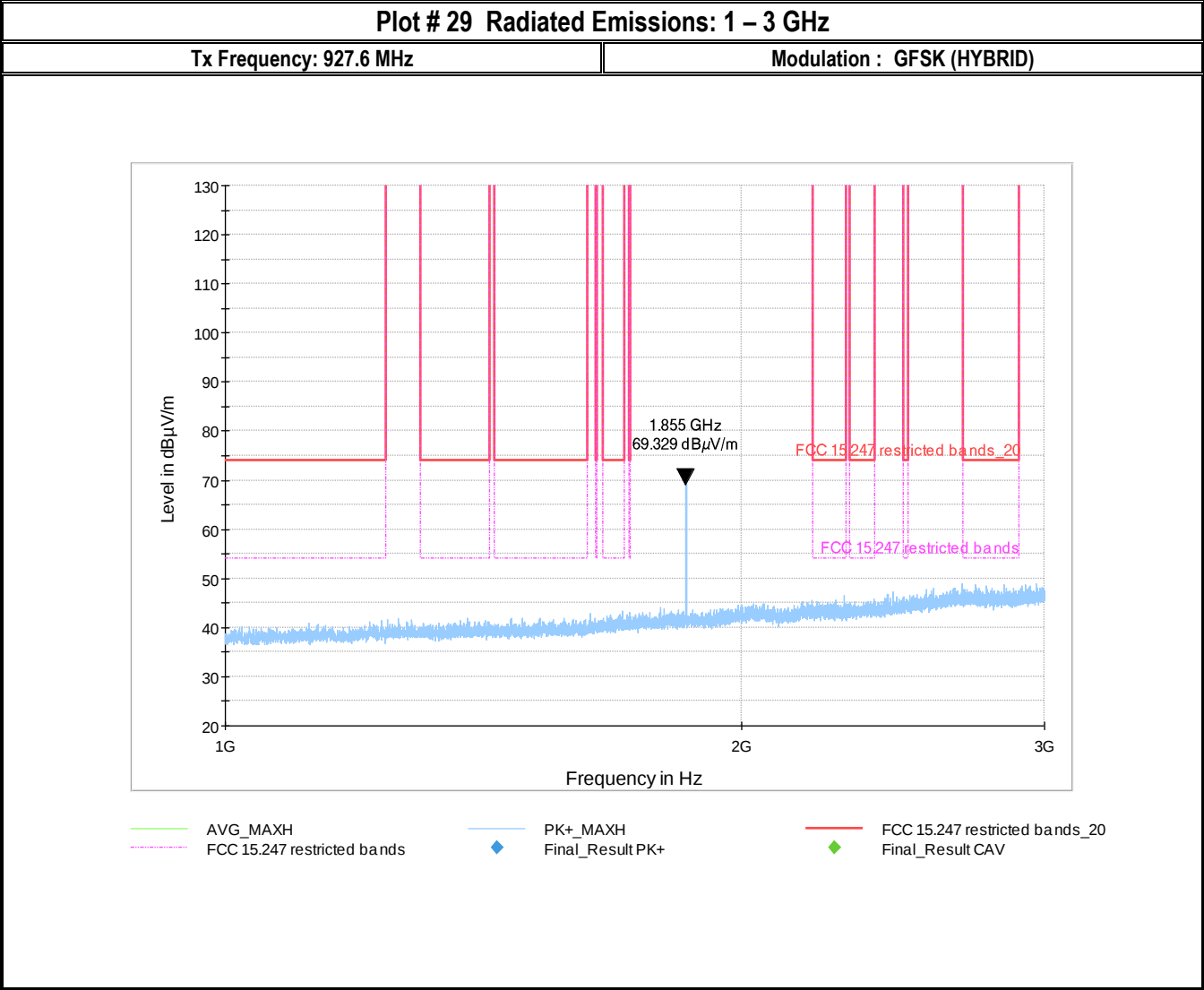


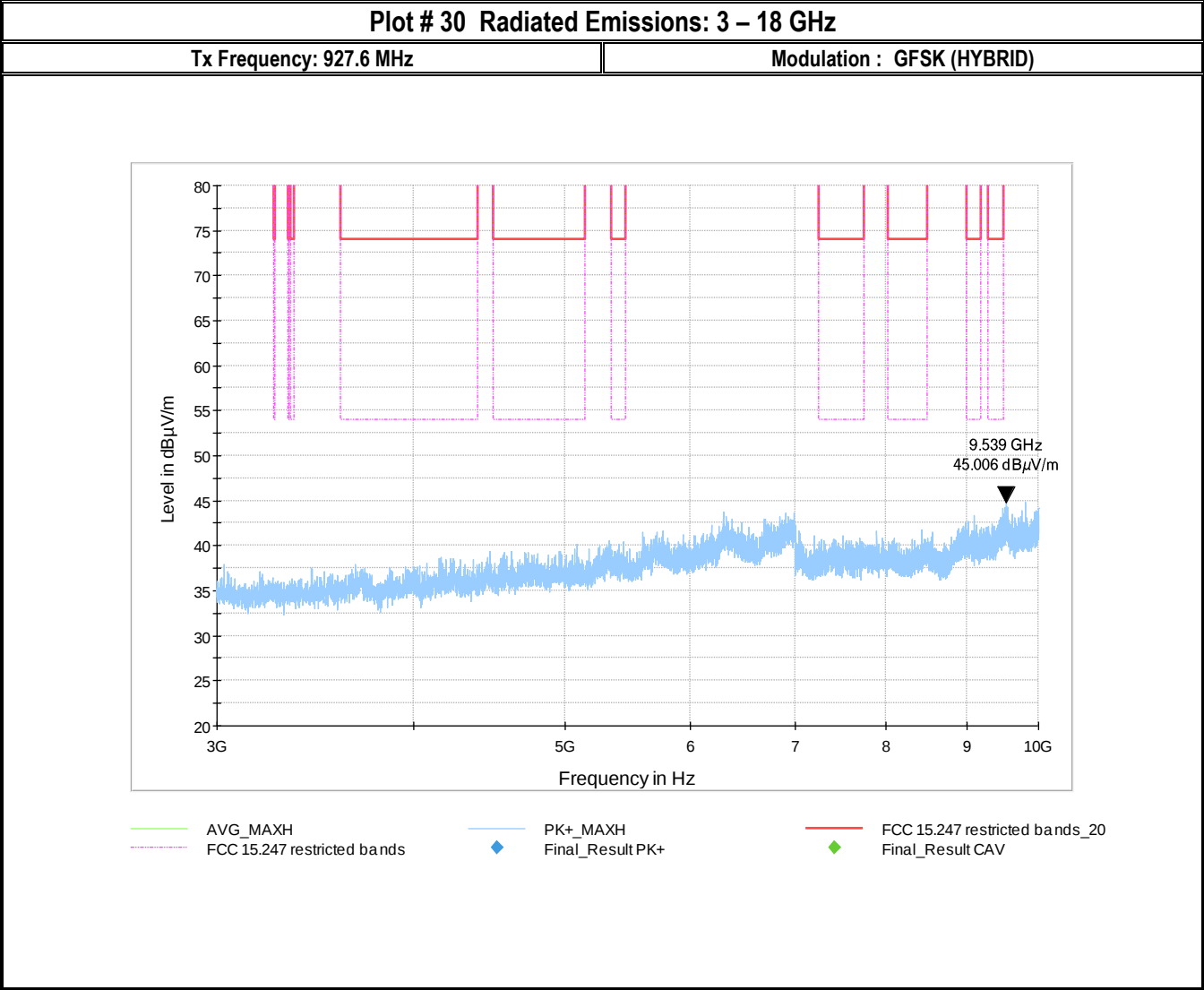












9 Test setup photos

Setup photos are included in supporting file name: "EMC_ITRO1_071_23001_FCC_Setup_Photos"

10 Test Equipment And Ancillaries Used For Testing

Equipment Type	Manufacturer	Model	Serial #	Calibration Cycle	Last Calibration Date
BILOG ANTENNA	A.H. SYSTEMS	BiLA2G	569	3 YEARS	10/30/2023
HORN ANTENNA	EMCO	3115	00035111	3 YEARS	10/26/2023
HORN ANTENNA	ETS LINDGREN	3117-PA	00167061	3 YEARS	9/25/2023
HORN ANTENNA	ETS LINDGREN	3116C-PA	00166821	3 YEARS	10/26/2023
ESW.EMI TEST RECEIVER	ROHDE & SCHWARZ	ESW44	101715	3 YEARS	10/24/2023
DIGITAL THERMOMETER	Control Company	4410,90080-03	230712972	3 YEARS	10/18/2023
Notch Filter	MICRO-TRONICS	BRC50722	G051	-	-
Software	EMC32	Version 10.50.40	-	-	-

Note: Equipment used meets the measurement uncertainty requirements as required per applicable standards for 95% confidence levels.

Calibration due dates, unless defined specifically, falls on the last day of the month. Items indicated "N/A" for cal status either do not specifically require calibration or is internally characterized before use.

11 Revision History

Date	Report Name	Changes to report	Prepared by
2024-06-03	EMC_ITRO1_071_23001_FCC_15_247_FHSS	Initial Version	Art Thammanavarat
2024-07-03	EMC_ITRO1_071_23001_FCC_15_247_FHSS_HYBRID_Rev1	Section 3.5: Updated table. Section 8.3: Updated Table & Added table and plots. Section 8.7.5: Updated plots. Section 10: Added Notch filter	Art Thammanavarat

<<< The End >>>