

FCC Spurious Emissions Pre-Scan Report: SX1302/SX1250 CoreCell Reference Design

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1 Introduction

The CoreCell reference design is a new generation of LoRa gateway designed based on the highly integrated SX1302 baseband processor and SX1250 RF transceiver. It is designed to meet the market needs for improved capacity, low cost, low power consumption, and fast time to market.

This document provides the results of an FCC spurious emissions pre-scan measured on the CoreCell reference design (PCB_E539V1oA) with RF shield for both conducted and radiated environment.

Table 1: Summary

PCB Number	Output Power Level	Region	Band
PCB_E539V01A	+27dBm	US	902-928 MHz

2 Board Description

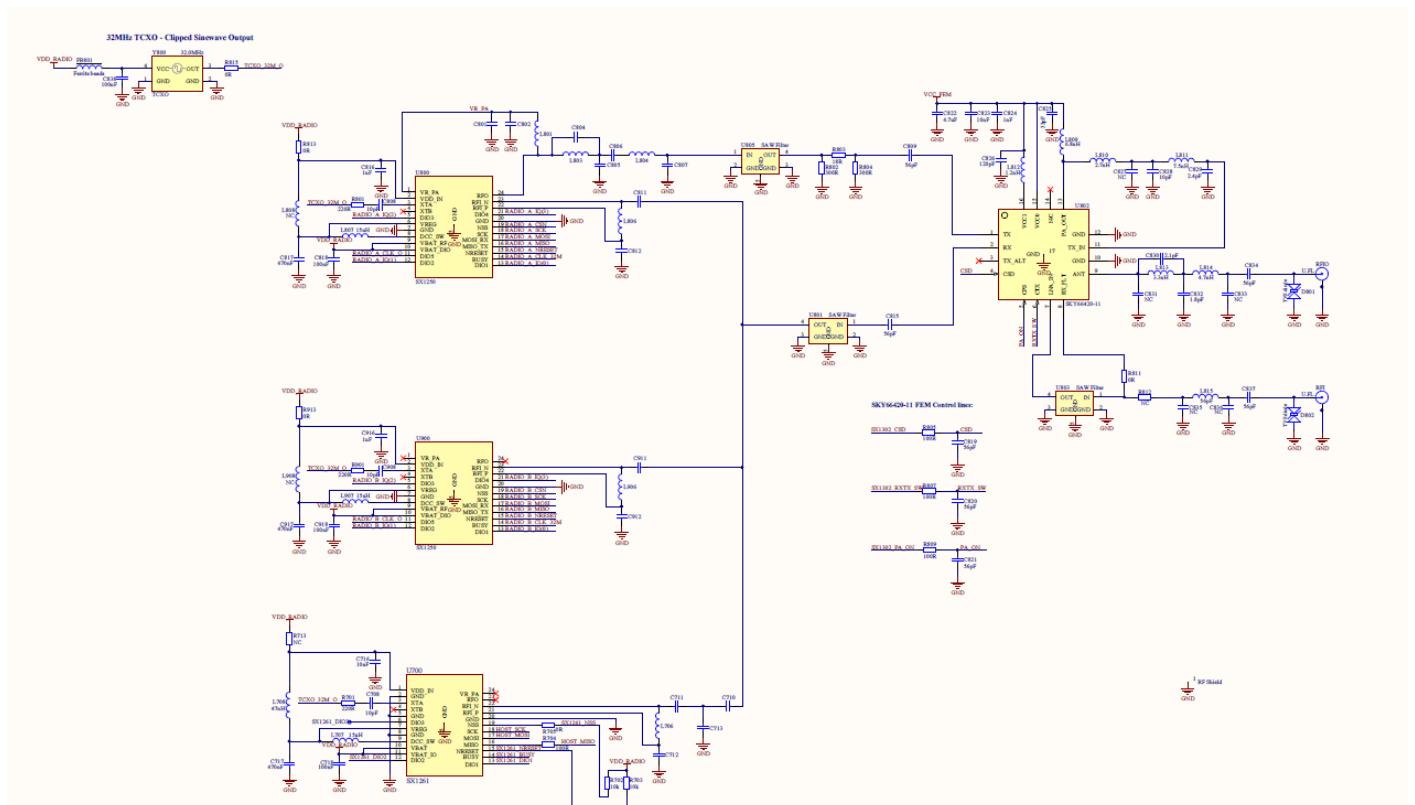


Figure 1. Schematic of RF Section (E539V01a)

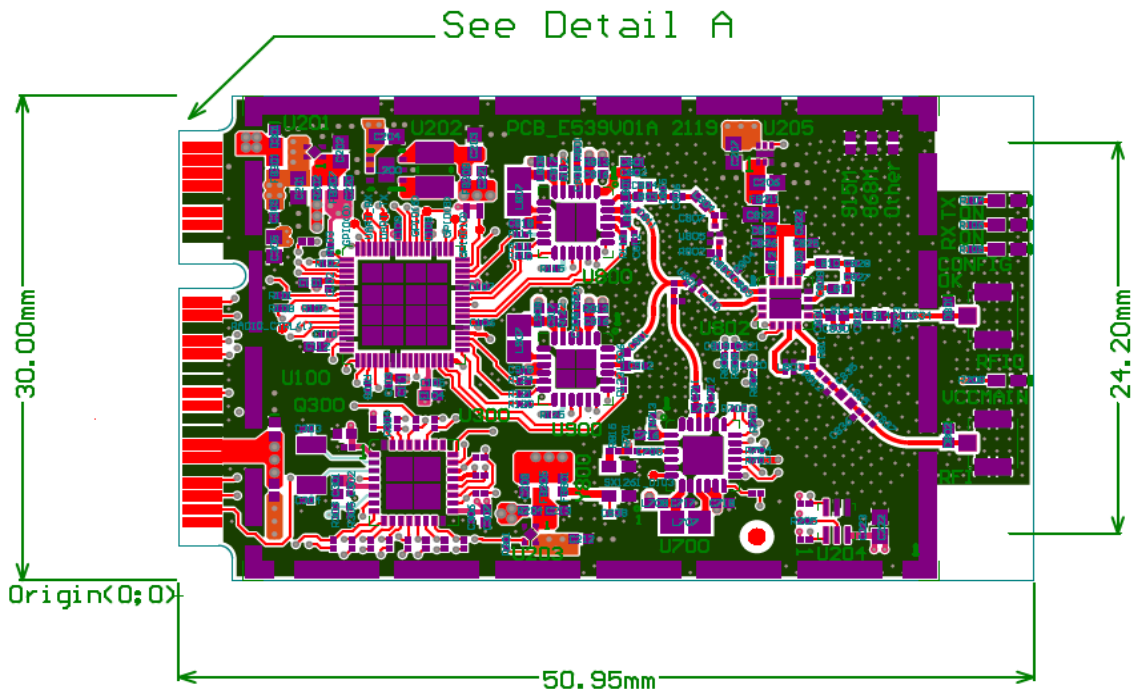


Figure 2. E539V01a CoreCell Layout

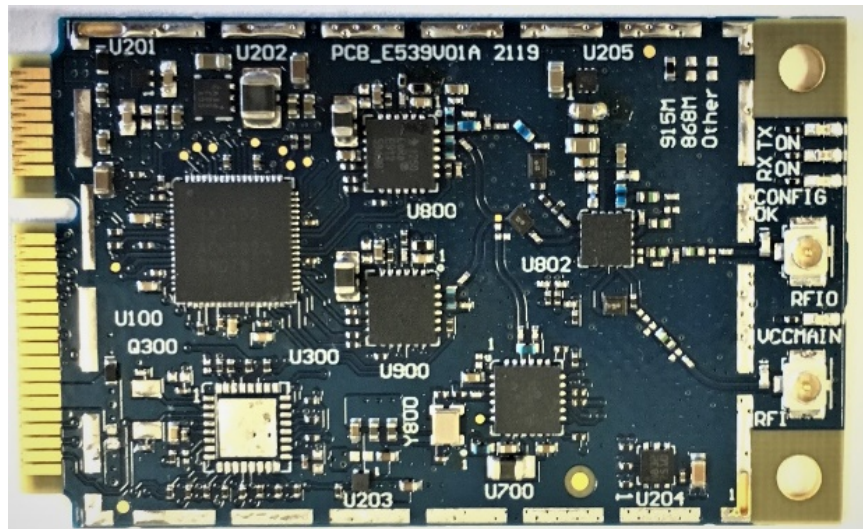


Figure 3. E539V01A Corecell Gateway

3 Setup

To solely characterize the Corecell gateway reference design a Mini –PCIE extension was inserted between the reference design and interface boards. The interface board and Raspberry Pi were then placed inside a shielded box to mitigate any potential interferences and noise. Figures 4 and 5 illustrate the setup used during the radiated tests in test lab 3 meter chamber.

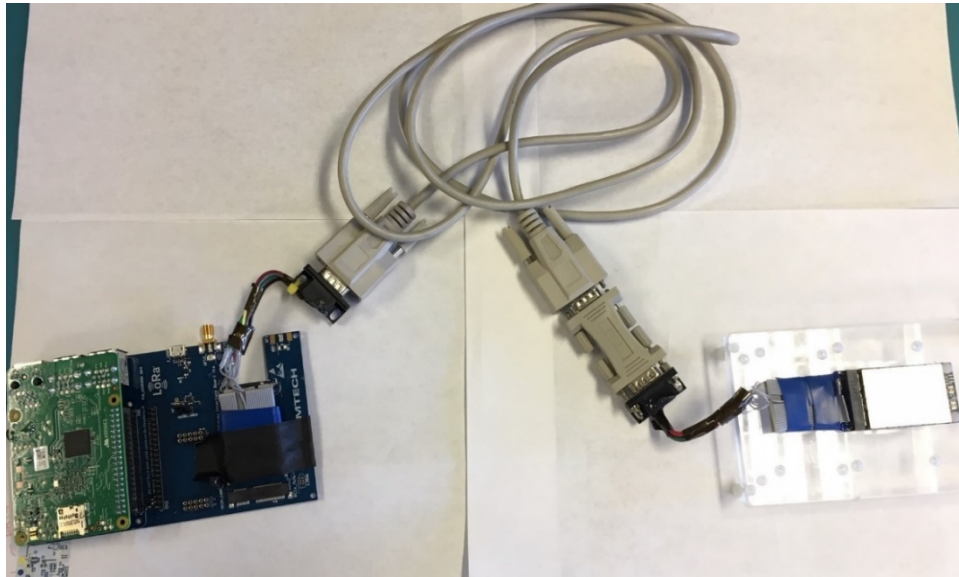


Figure 4. Golden board device, Corecell GW used for testing with extension cable

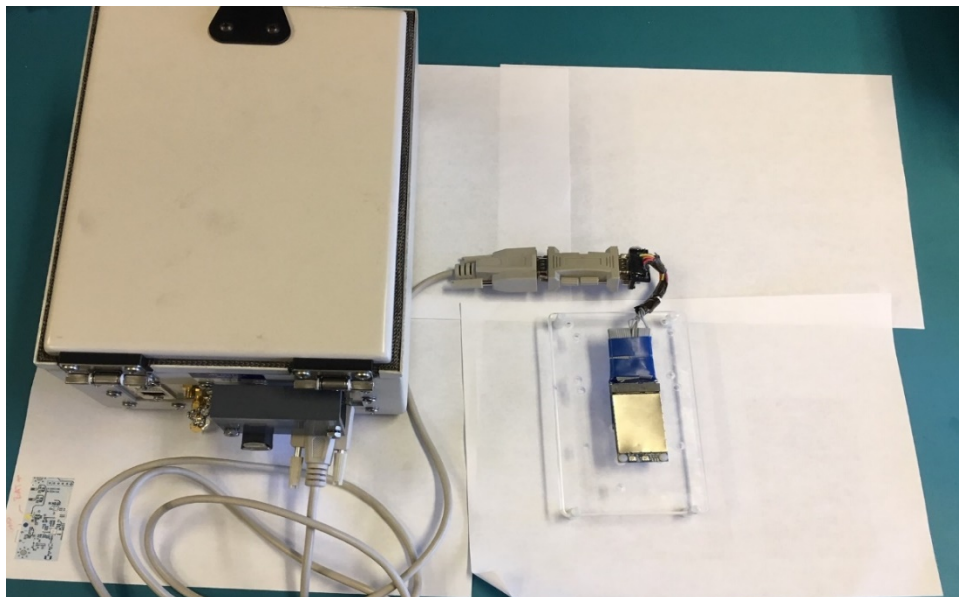


Figure 5. Golden board device with interface board inside the shielded box

4 Regulations

4.1 FCC CFR 47 Part 15.247(d):

There are restrictions placed on radiated field strength emission limits that fall within what are referred to as Restricted Bands in Part 15.205 and tabulated below in Table 2: Part 15.205 Restricted Frequency Bands shall not exceed the radiated emission limits of Part 15.209, as listed in

Table 3: Part 15.209 Radiated Emission Limits for Frequencies above 30MHz .Only spurious emissions are permitted within the restricted frequency bands.

Table 2: Part 15.205 Restricted Frequency Bands

Frequency			
MHz	MHz	MHz	GHz
0.090–0.110	16.42–16.423	399.9–410	* 4.5–5.15 (5)
0.495–0.505	16.69475–16.69525	608–614	* 5.35–5.46 (6)
2.1735–2.1905	16.80425–16.80475	960–1240	* 7.25–7.75 (8)
4.125–4.128	25.5–25.67	1300–1427	* 8.025–8.5 (9)
4.17725–4.17775	37.5–38.25	1435–1626.5	* 9.0–9.2 (10)
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 (3)	22.01–23.12
8.41425–8.41475	162.0125–167.17	3260–3267	23.6–24.0
2.29–12.293	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 (4)	Above 38.6
13.36–13.41			

* Harmonic (n) of emission between 902 – 928MHz may fall within a restricted band of operation

Table 3: Part 15.209 Radiated Emission Limits for Frequencies above 30MHz

Frequency (MHz)	Field Strength (µV/m)	Measurement Distance (meter)	Conducted Power (dBm)
30-88	100	3	-55.2
88-216	150	3	-51.7
216-960	200	3	-49.2
Above 960	500	3	-41.2

5 Conducted Performance

Prior to measuring the radiated emissions at the test lab, conducted measurements were conducted in-house to ensure sufficient margins are available against the specified FCC limits.

Table 4. Conducted measurements for Corecell gateway Golden Board with shield

FREQ (MHz)	IDDTx (mA)	Power (dBm)	Harmonics (dBm)								
			2H	3H	4H	5H	6H	7H	8H	9H	10H
904.3	451	26.98	-25.3	<-65	<-65	<-65	<-65	<-65	<-65	<-65	<-65
914.9	488	27.26	-24.3	<-65	<-65	<-65	<-65	<-65	<-65	<-65	<-65
927.5	481	27.28	-28.9	<-65	<-65	<-65	<-65	<-65	<-65	<-65	<-65

6 Radiated Results – Anechoic Chamber Test

6.1 Pre-scan

Radiated emission tests were performed on Corecell gateway reference design in a 3 meter semi-anechoic chamber to ensure that the device (EUT) is in compliant with FCC radiated limits (4)

All measurements were performed with the EUT configured for nominally +27 dBm output power based on the specified configuration and transmit duty cycle of >98%.

In addition, the test antenna has been oriented in the two polarizations (vertical and horizontal), and EUT was placed in three different positions, X , Y and Z throughout the measurements (6.2).

All the measurements have been performed with the RF shielding on the EUT board.

The results obtained are summarized below and illustrated compliancy with the radiated emission limits for FCC, for the specified BOM.

Date: 7/24/2019

Board: PCB_ E539V10A- Corecell Gateway

LAB: NTS, Fremont

Test Engineer: Roy Zheng

Configuration: Continuous modulated carrier [Lora, SF 7, BW 500 KHz, PL 255, PWID 15]

Driver: SX1302_hal Ver- 1.0.1

Antenna: Linx ANT-916-CW-HW

6.2 EUT Orientations

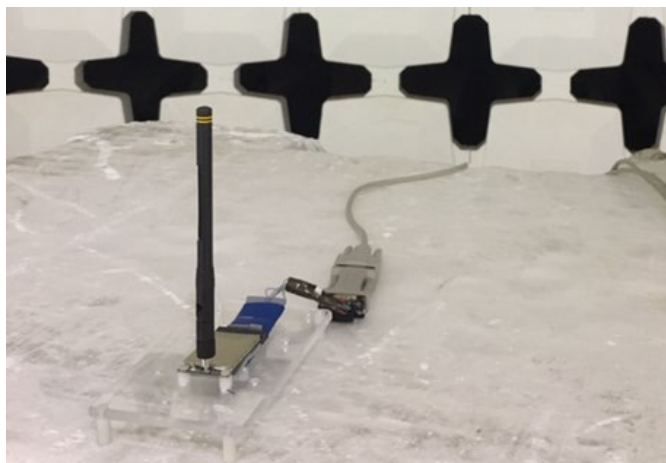


Figure 6: EUT in X Orientation



Figure 7: EUT in Y Orientation



Figure 8: EUT in Z Orientation

6.3 Radiated Spurious Emissions: FCC CFR 47 Part 15

NOTE: The emission limits outside of the restricted bands in the following plots are an estimation. The true limits are used in the results table.

6.3.1 Frequency = 904.3MHz, Output Power = +27dBm

6.3.1.1 EUT Position: X

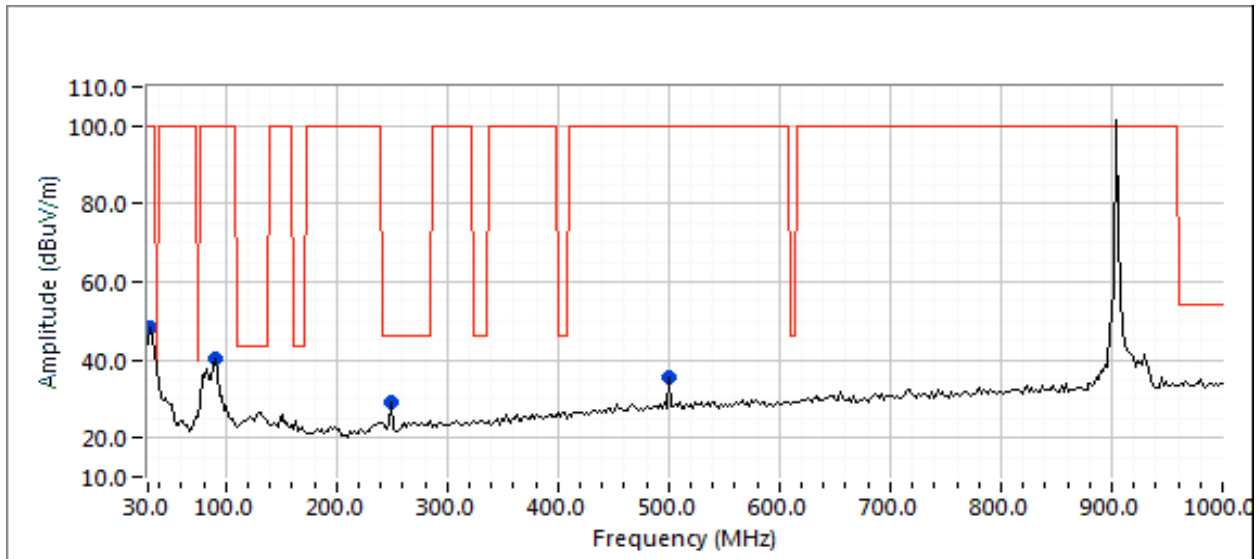


Figure 9: Spectral Plot from 30MHz to 1000MHz, Carrier Frequency = 904.3MHz, X Position

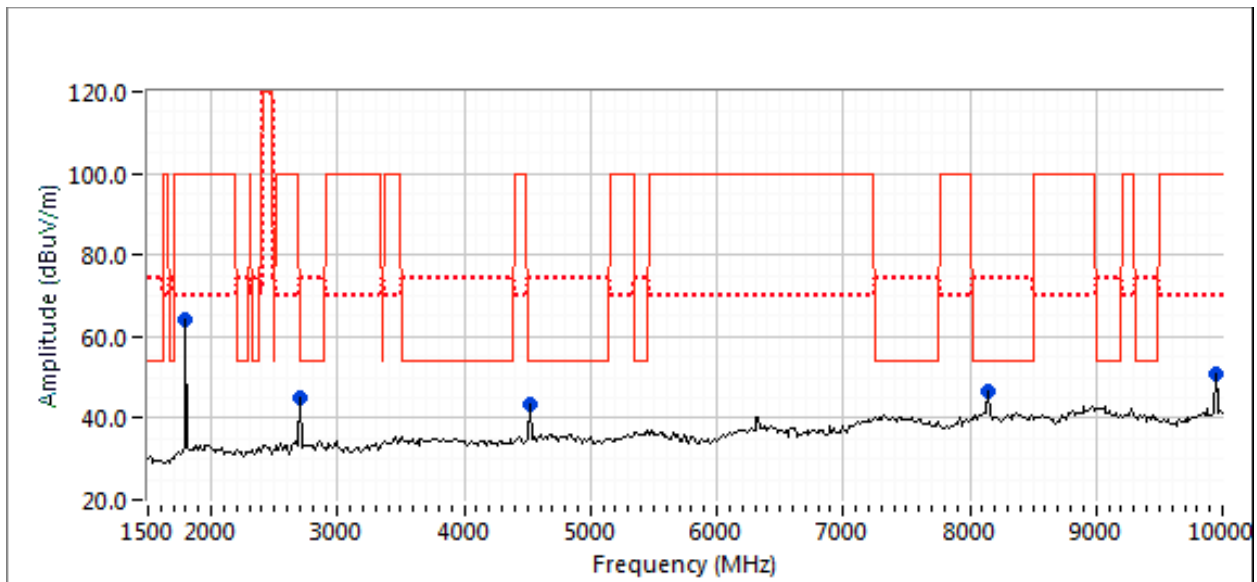


Figure 10: Spectral Plot from 1.5GHz to 10GHz, Carrier Frequency = 904.3MHz, X Position

Fundamental emission level @ 3m in 100 kHz RBW:	124.5	dBuV/m	
Limit for emissions outside of restricted bands:	104.5	dBuV/m	Limit is -20dBc (Peak power measurement)

Frequency MHz	Level dBmV/m	Pol v/h	15.209 / 15.247		Detector Pk/QP/Avg	Azimuth degrees	Height meters
			Limit	Margin			
**31.944	48.1	V	104.5	-56.4	PK	156	1.0
**90.261	40.3	V	104.5	-64.2	PK	359	1.0
249.659	29.2	V	46.0	-16.8	PK	64	1.0
**500.421	35.7	V	104.5	-68.8	PK	52	1.0
**1808.42	64.0	V	104.5	-40.5	PK	337	2.5
2711.17	30.5	H	54.0	-23.5	AVG	252	1.9
2711.27	40.1	H	74.0	-33.9	PK	252	1.9
4521.02	34.3	V	54.0	-19.7	AVG	70	1.3
4520.4	42.9	V	74.0	-31.1	PK	70	1.3
8137.55	40.3	V	54.0	-13.7	AVG	196	2.2
8138.59	50.2	V	74.0	-23.8	PK	196	2.2
**9944.79	50.3	V	104.5	-54.2	PK	208	1.0

** Limit for emissions outside of restricted band

6.3.1.2 EUT Position: Y

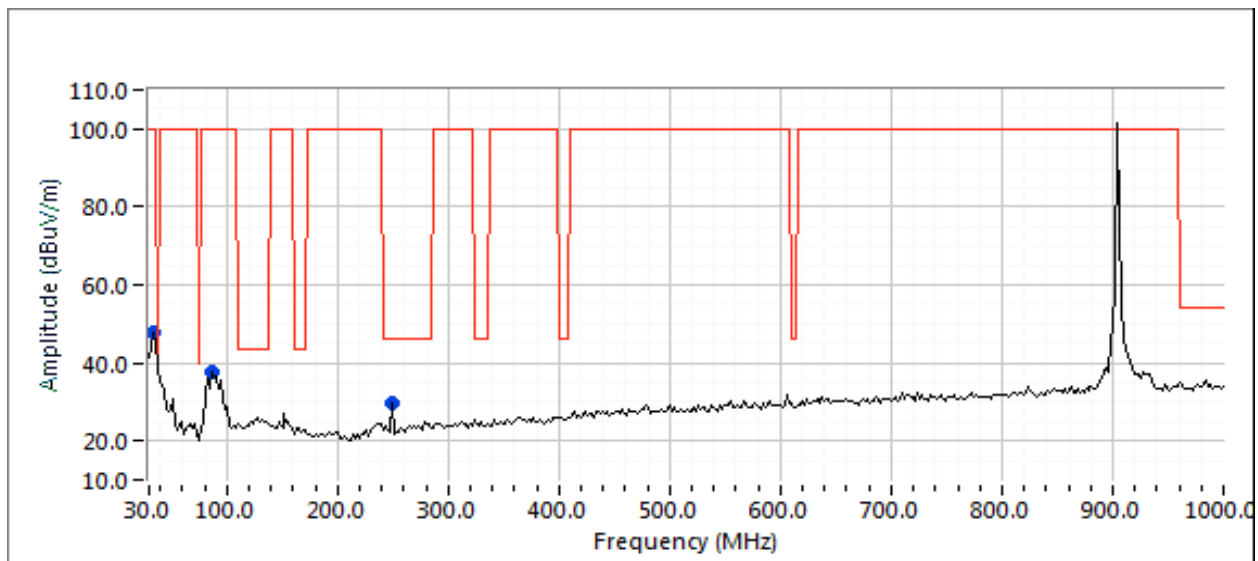


Figure 11: Spectral Plot from 30MHz to 1000MHz, Carrier Frequency = 904.3MHz, Y Position

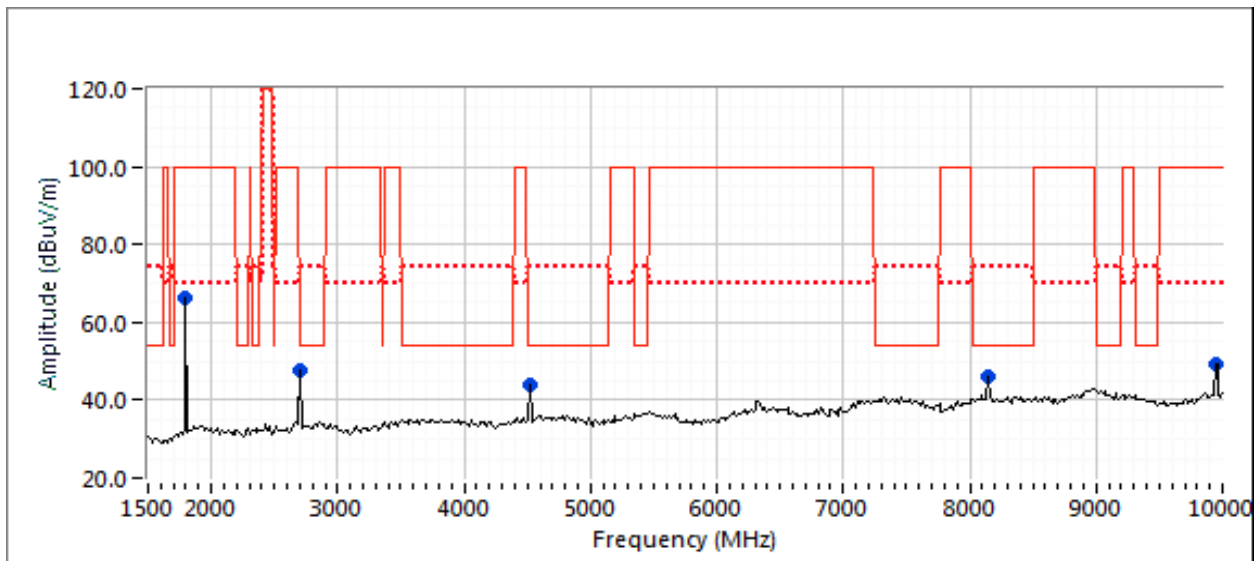


Figure 12: Spectral Plot from 1.5GHz to 10GHz, Carrier Frequency = 904.3MHz, Y Position

Fundamental emission level @ 3m in 100 kHz RBW:	122.4	dBuV/m	
Limit for emissions outside of restricted bands:	102.4	dBuV/m	Limit is -20dBc (Peak power measurement)

Frequency MHz	Level dBmV/m	Pol v/h	15.209 / 15.247		Detector Pk/QP/Avg	Azimuth degrees	Height meters
			Limit	Margin			
**33.888	47.7	V	102.4	-54.7	PK	351	1.0
**86.373	37.8	H	102.4	-64.6	PK	297	3.0
249.659	29.5	H	46.0	-16.5	PK	236	2.0
**1808.16	67.3	H	102.4	-35.1	PK	229	1.0
2712.76	34.8	H	54.0	-19.2	AVG	292	1.6
2712.54	43.4	H	74.0	-30.6	PK	292	1.6
4521.92	38.4	H	54.0	-15.6	AVG	211	1.0
4522.51	47.6	H	74.0	-26.4	PK	211	1.0
8137.21	41.8	V	54.0	-12.2	AVG	179	1.6
8138.77	52.5	V	74.0	-21.5	PK	179	1.6
**9945.17	54.8	V	102.4	-47.6	PK	173	1.9

** Limit for emissions outside of restricted band

6.3.1.3 EUT Position: Z

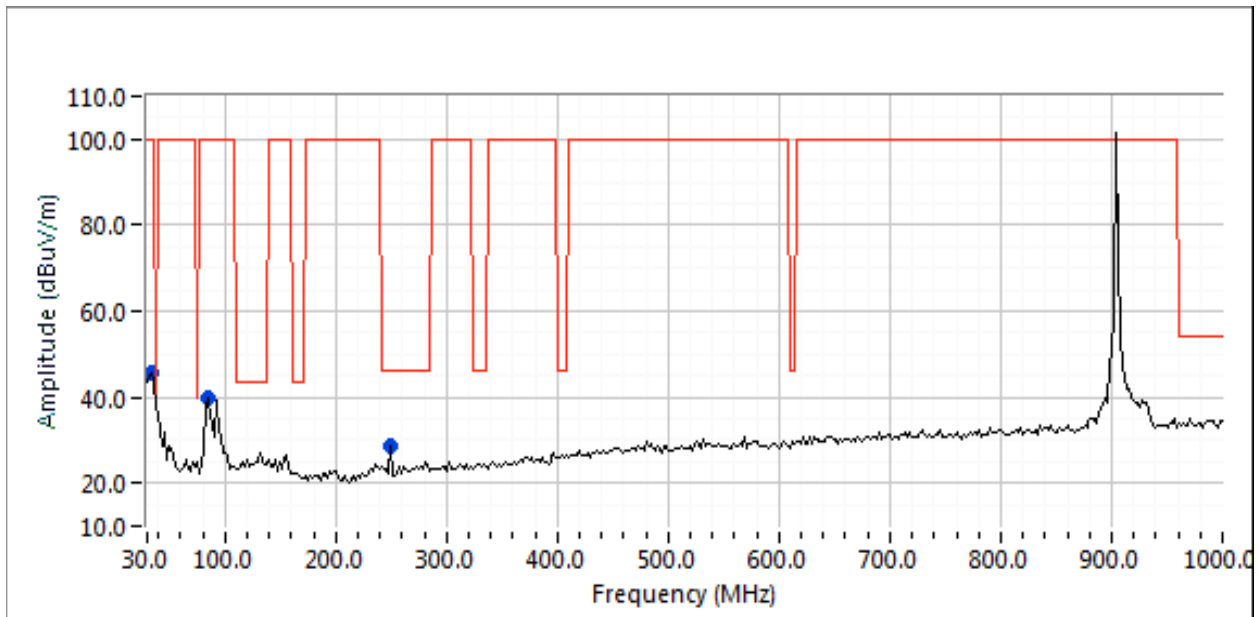


Figure 13: Spectral Plot from 30MHz to 1000MHz, Carrier Frequency = 904.3MHz, Z Position

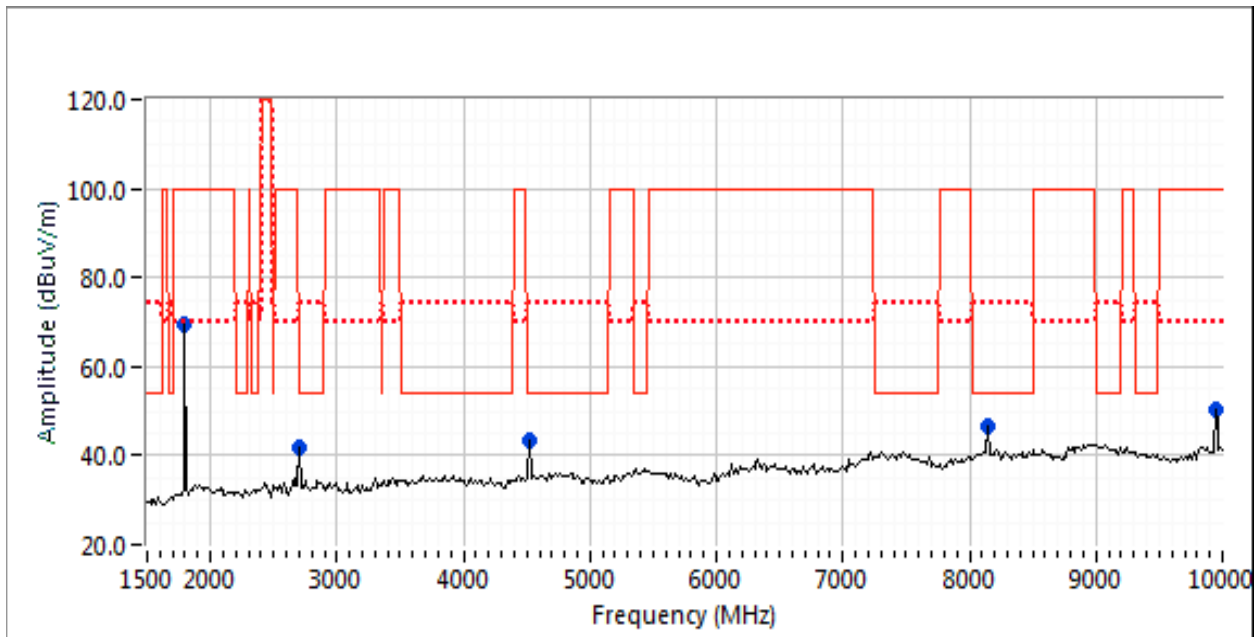


Figure 14: Spectral Plot from 1.5GHz to 10GHz, Carrier Frequency = 904.3MHz, Z Position

Fundamental emission level @ 3m in 100kHz RBW:	124.4	dBuV/m	
Limit for emissions outside of restricted bands:	104.4	dBuV/m	Limit is -20dBc (Peak power measurement)

Frequency MHz	Level dBmV/m	Pol v/h	15.209 / 15.247		Detector Pk/QP/Avg	Azimuth degrees	Height meters
			Limit	Margin			
**33.888	45.7	V	104.4	-58.7	PK	113	2.0
**84.429	39.7	H	104.4	-64.7	PK	67	3.0
249.659	28.7	H	46.0	-17.3	PK	236	2.0
**1808.21	69.3	H	104.4	-35.1	PK	131	1.2
2712.84	37.6	V	54.0	-16.4	AVG	88	1.0
2713.04	44.9	V	74.0	-29.1	PK	88	1.0
4521.56	34.3	V	54.0	-19.7	AVG	149	1.6
4519.88	43.0	V	74.0	-31.0	PK	149	1.6
8138.46	40.3	H	54.0	-13.7	AVG	106	2.2
8138.57	50.1	H	74.0	-23.9	PK	106	2.2
**9945.63	50.4	H	104.4	-54.0	PK	227	2.2

** Limit for emissions outside of restricted band

6.3.2 Frequency = 914.9MHz, Output Power = +27dBm

6.3.2.1 EUT Position: X

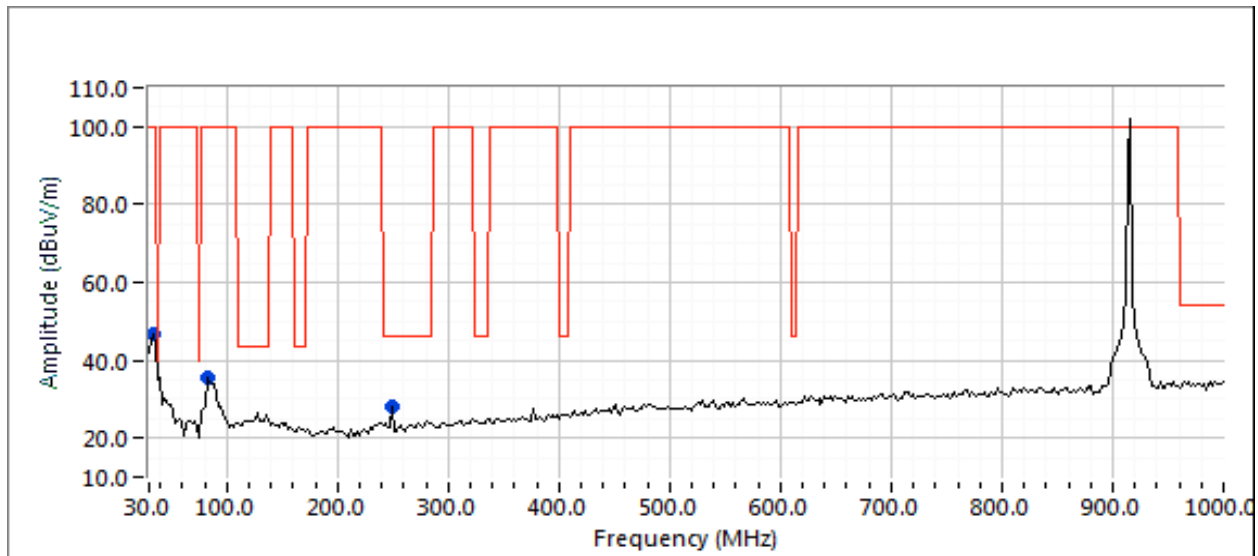


Figure 15: Spectral Plot from 30MHz to 1000MHz, Carrier Frequency = 914.9MHz, X Position

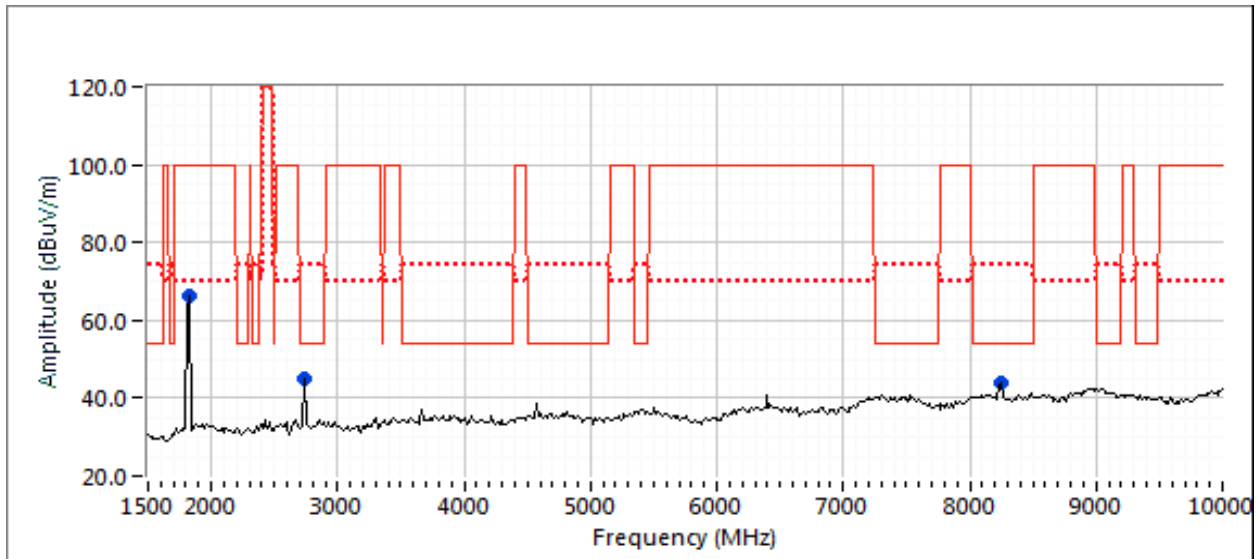


Figure 16: Spectral Plot from 1.5GHz to 10GHz, Carrier Frequency = 914.9MHz, X Position

Fundamental emission level @ 3m in 100kHz RBW:	124.9	dBuV/m	
Limit for emissions outside of restricted bands:	104.9	dBuV/m	Limit is -20dBc (Peak power measurement)

Frequency MHz	Level dBmV/m	Pol v/h	15.209 / 15.247		Detector Pk/QP/Avg	Azimuth degrees	Height meters
			Limit	Margin			
33.888	46.6	V	104.9	-58.3	PK	237	1.0
82.485	35.4	H	104.9	-69.5	PK	271	2.0
249.659	28.1	V	46.0	-17.9	PK	8	1.0
1829.39	67.0	H	104.9	-37.9	PK	61	1.2
2744.95	37.4	H	54.0	-16.6	AVG	264	1.0
2744.13	40.5	H	74.0	-33.5	PK	264	1.0
8232.9	40.1	V	54.0	-13.9	AVG	252	1.9
8233.45	50.4	V	74.0	-23.6	PK	252	1.9

** Limit for emissions outside of restricted band

6.3.2.2 EUT Position: Y

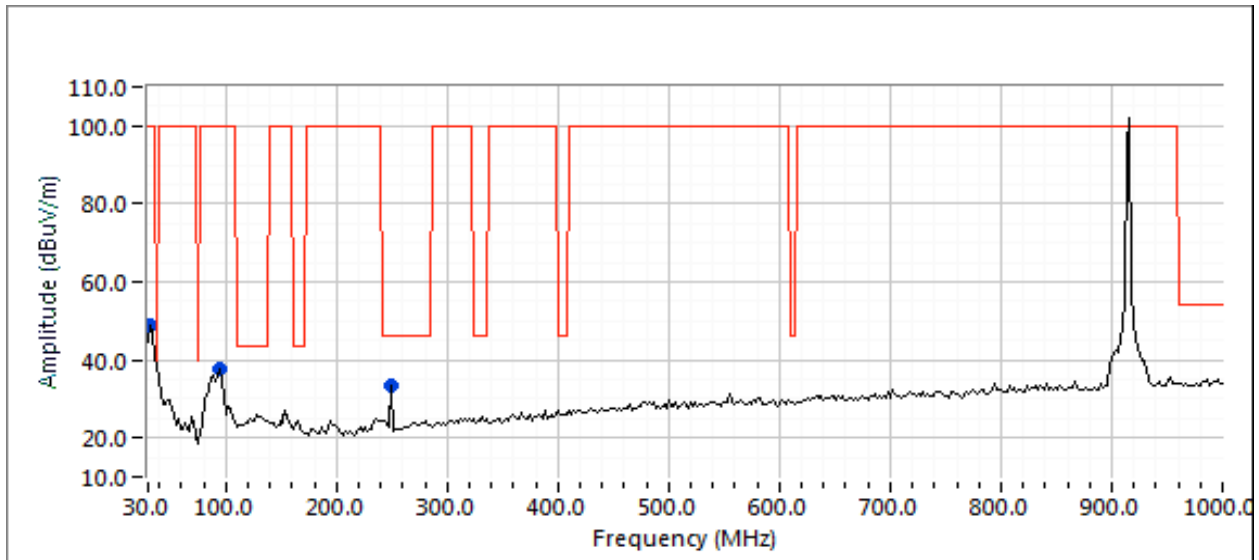


Figure 17: Spectral Plot from 30MHz to 1000MHz, Carrier Frequency = 914.9MHz, Y Position

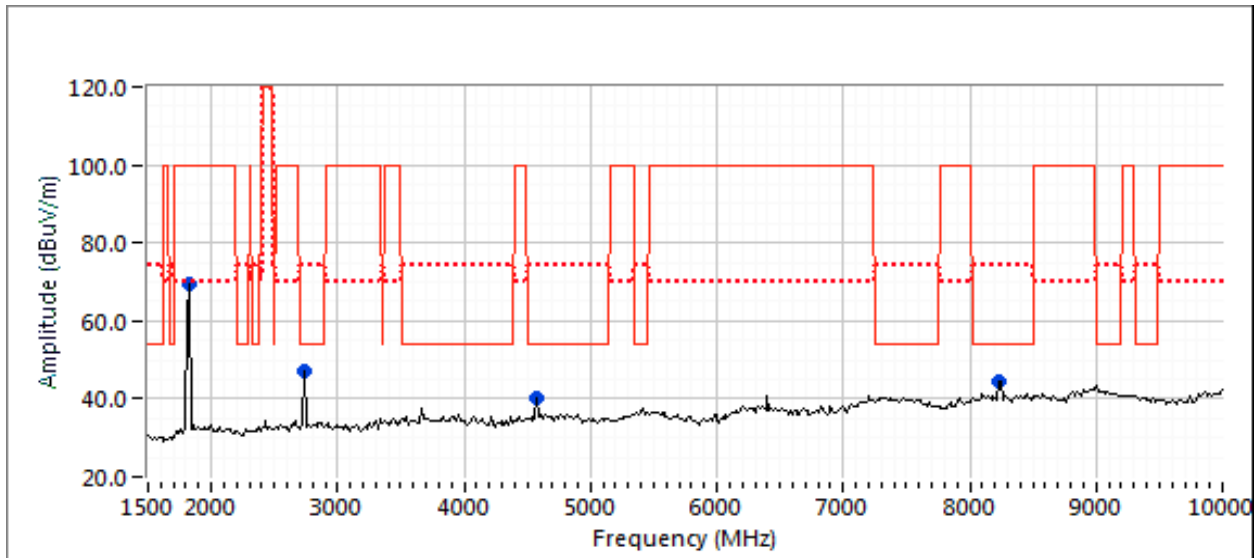


Figure 18: Spectral Plot from 1.5GHz to 10GHz, Carrier Frequency = 914.9MHz, Y Position

Fundamental emission level @ 3m in 100kHz RBW:	122.7	dBuV/m	
Limit for emissions outside of restricted bands:	102.7	dBuV/m	Limit is -20dBc (Peak power measurement)

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height
MHz	dBmV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters
**31.944	49.0	V	102.7	-53.7	PK	92	1.0
**94.148	37.4	V	102.7	-65.3	PK	343	1.0
249.659	33.5	H	46.0	-12.5	PK	234	1.0
**1829.41	69.3	H	102.7	-33.4	PK	308	1.0
2731.35	30.5	H	54.0	-23.5	AVG	1	1.0
2731.77	41.1	H	74.0	-32.9	PK	1	1.0
4554.25	34.4	V	54.0	-19.6	AVG	351	1.6
4553.64	42.9	V	74.0	-31.1	PK	351	1.6
8233.31	41.6	V	54.0	-12.4	AVG	171	1.6
8233.1	52.5	V	74.0	-21.5	PK	171	1.6

** Limit for emissions outside of restricted band

6.3.2.3 EUT Position: Z

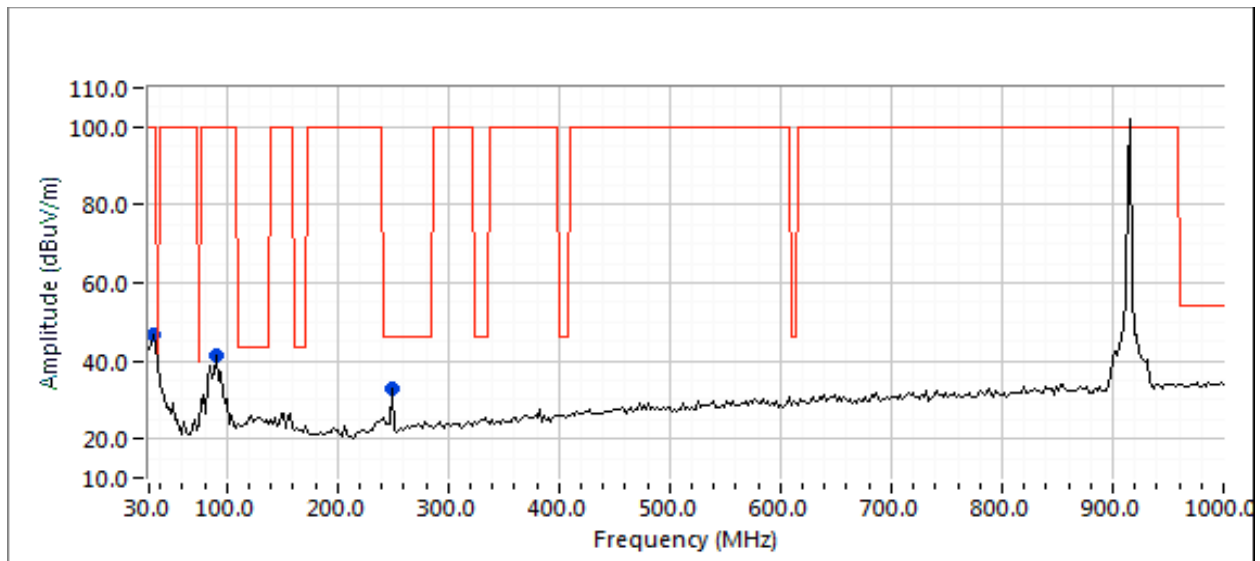


Figure 19: Spectral Plot from 30MHz to 1000MHz, Carrier Frequency = 914.9MHz, Z Position

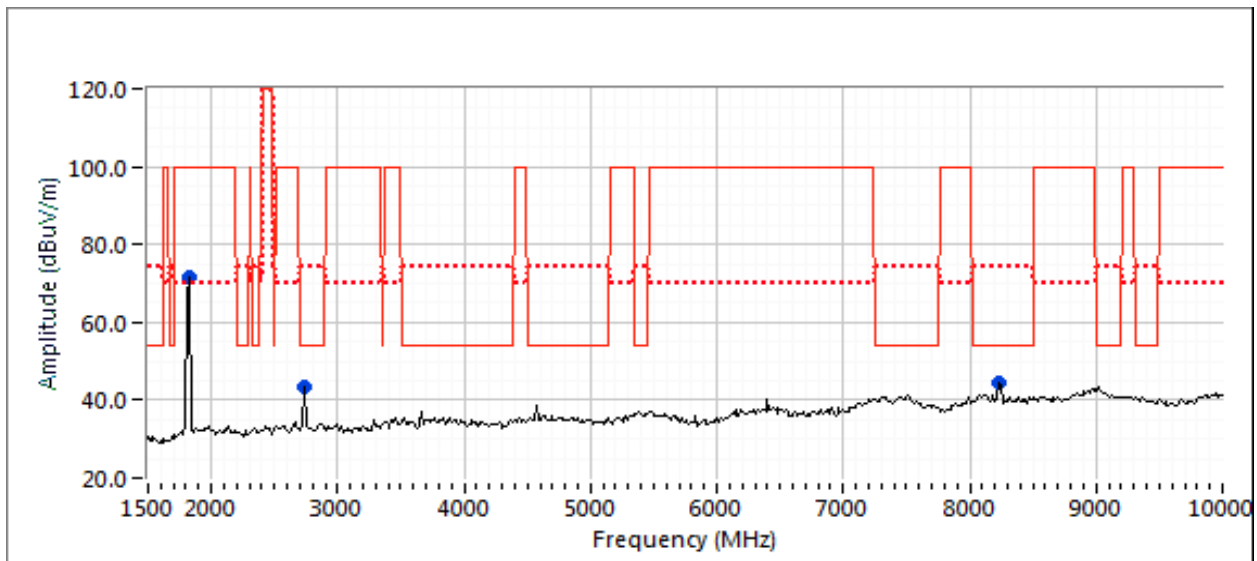


Figure 20: Spectral Plot from 1.5GHz to 10GHz, Carrier Frequency = 914.9MHz, Z Position

Fundamental emission level @ 3m in 100kHz RBW:	124.9	dBuV/m	
Limit for emissions outside of restricted bands:	104.9	dBuV/m	Limit is -20dBc (Peak power measurement)

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height
MHz	dBmV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters
**33.888	46.5	V	104.9	-58.4	PK	2	2.0
**90.261	41.3	V	104.9	-63.6	PK	340	1.0
249.659	32.7	V	46.0	-13.3	PK	160	2.0
**1829.41	72.0	H	104.9	-32.9	PK	124	1.0
2744.66	39.4	H	54.0	-14.6	AVG	359	2.5
2744.96	46.3	H	74.0	-27.7	PK	359	2.5
8232.43	41.3	H	54.0	-12.7	AVG	123	2.2
8232.79	51.9	H	74.0	-22.1	PK	123	2.2

** Limit for emissions outside of restricted band

6.3.3 Frequency = 927.5MHz, Output Power = +27dBm

6.3.3.1 EUT Position: X

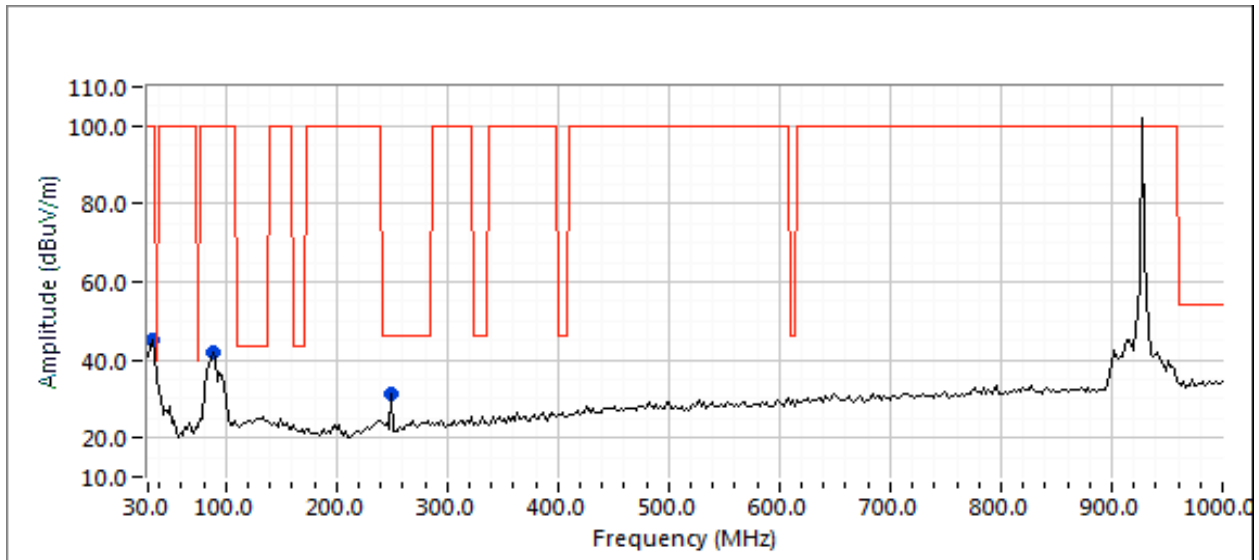


Figure 21: Spectral Plot from 30MHz to 1000MHz, Carrier Frequency = 927.5MHz, X Position

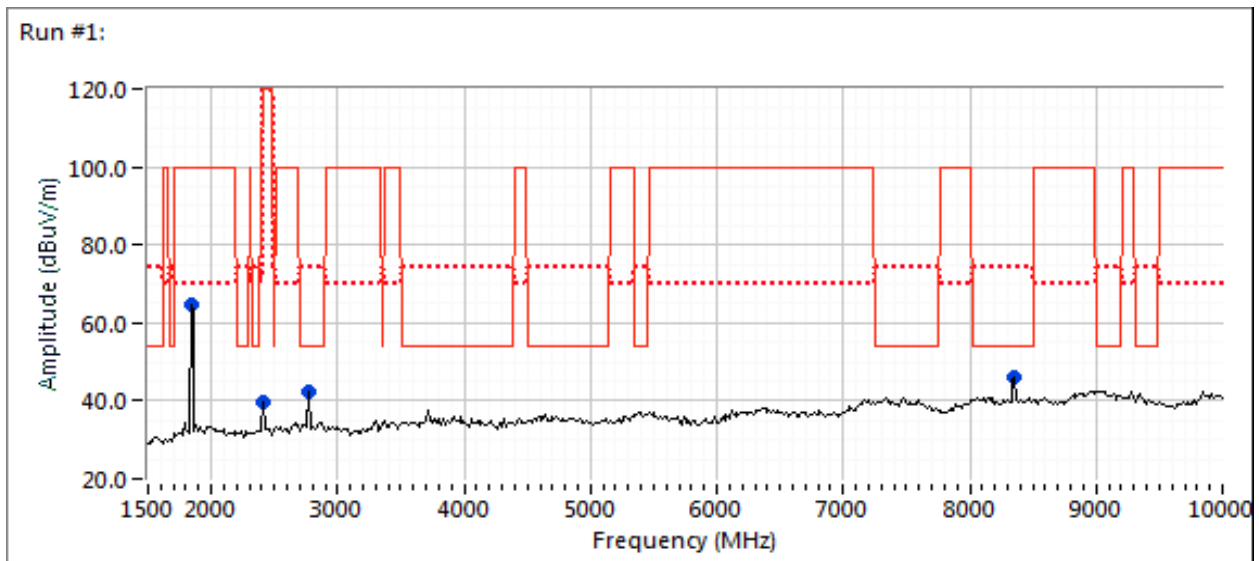


Figure 22: Spectral Plot from 1.5GHz to 10GHz, Carrier Frequency = 927.5MHz, X Position

Fundamental emission level @ 3m in 100kHz RBW:	124.3	dBuV/m	
Limit for emissions outside of restricted bands:	104.3	dBuV/m	Limit is -20dBc (Peak power measurement)

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height
MHz	dBmV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters
**33.888	45.1	V	104.3	-59.2	PK	351	1.0
**88.317	41.9	H	104.3	-62.4	PK	56	3.0
249.659	31.1	H	46.0	-14.9	PK	56	1.0
**1854.07	39.2	H	104.3	-65.1	PK	249	1.0
2782.19	31.5	H	54.0	-22.5	AVG	83	2.2
2781.09	41.5	H	74.0	-32.5	PK	83	2.2
8349.27	40.5	V	54.0	-13.5	AVG	258	1.0
8349.83	50.6	V	74.0	-23.4	PK	258	1.0

** Limit for emissions outside of restricted band

6.3.3.2 EUT Position: Y

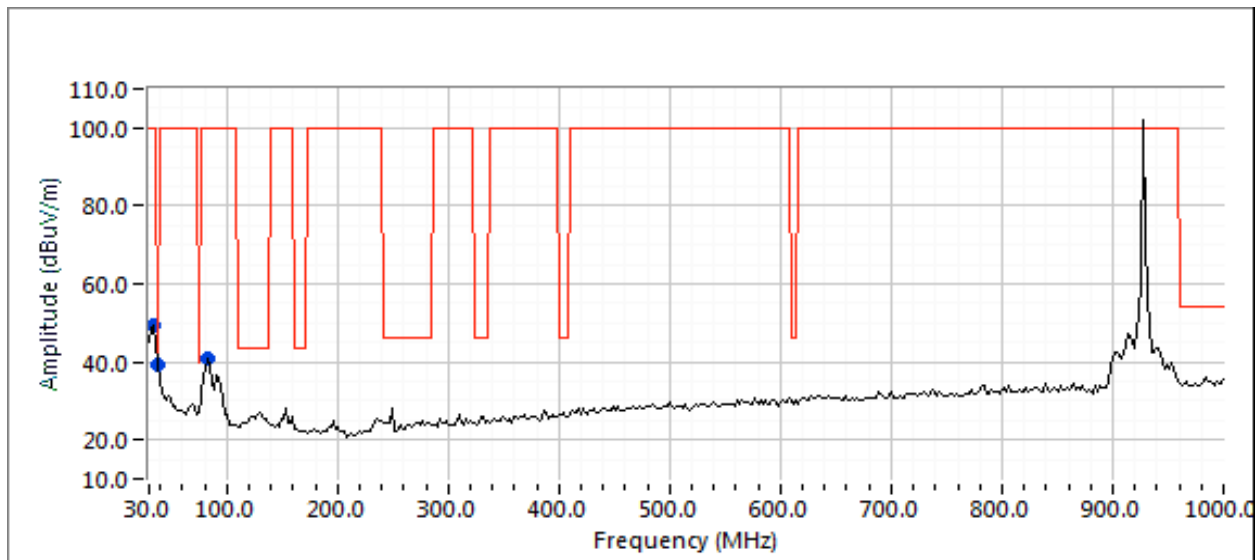


Figure 23: Spectral Plot from 30MHz to 1000MHz, Carrier Frequency = 927.5MHz, Y Position

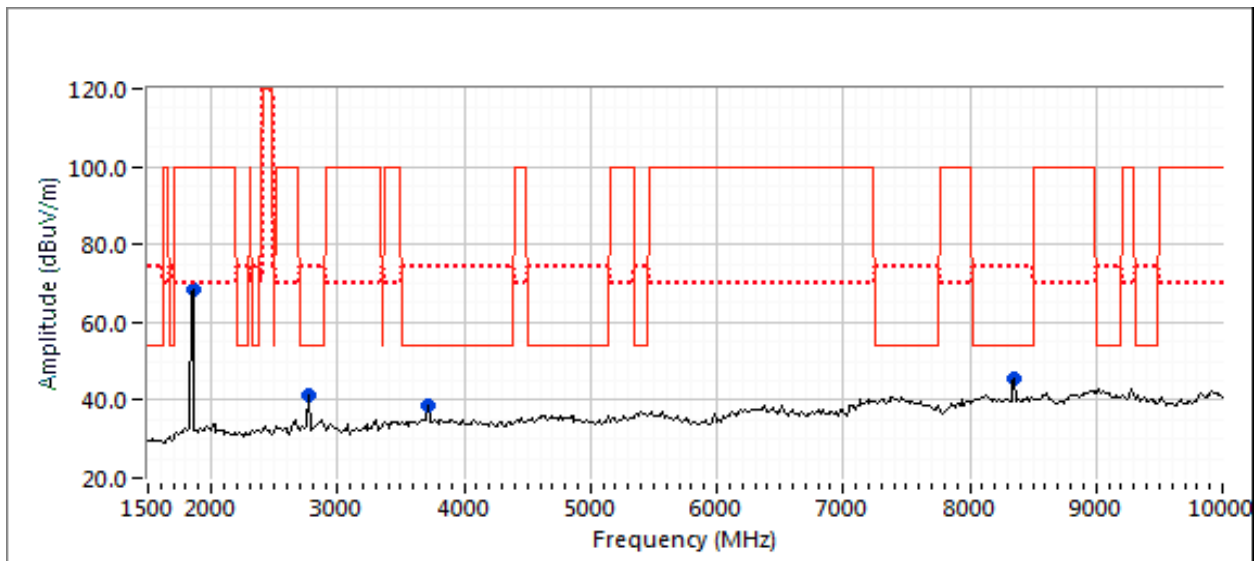


Figure 24: Spectral Plot from 1.5GHz to 10GHz, Carrier Frequency = 927.5MHz, Y Position

Fundamental emission level @ 3m in 100kHz RBW:	123.4	dBuV/m	
Limit for emissions outside of restricted bands:	103.4	dBuV/m	Limit is -20dBc (Peak power measurement)

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height
MHz	dBmV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters
**33.888	49.3	V	103.4	-54.1	PK	156	1.0
**82.485	40.6	H	103.4	-62.8	PK	292	2.5
37.776	39.2	V	40.0	-0.8	PK	199	1.5
**1855.55	68.8	H	103.4	-34.6	PK	318	1.0
2781.81	31.5	H	54.0	-22.5	AVG	32	1.0
2783.39	41.4	H	74.0	-32.6	PK	32	1.0
3709.78	35.9	H	54.0	-18.1	AVG	332	2.2
3709.16	44.6	H	74.0	-29.4	PK	332	2.2
8346.81	42.0	V	54.0	-12.0	AVG	167	1.8
8349.57	52.8	V	74.0	-21.2	PK	167	1.8

** Limit for emissions outside of restricted band

6.3.3.3 EUT Position: Z

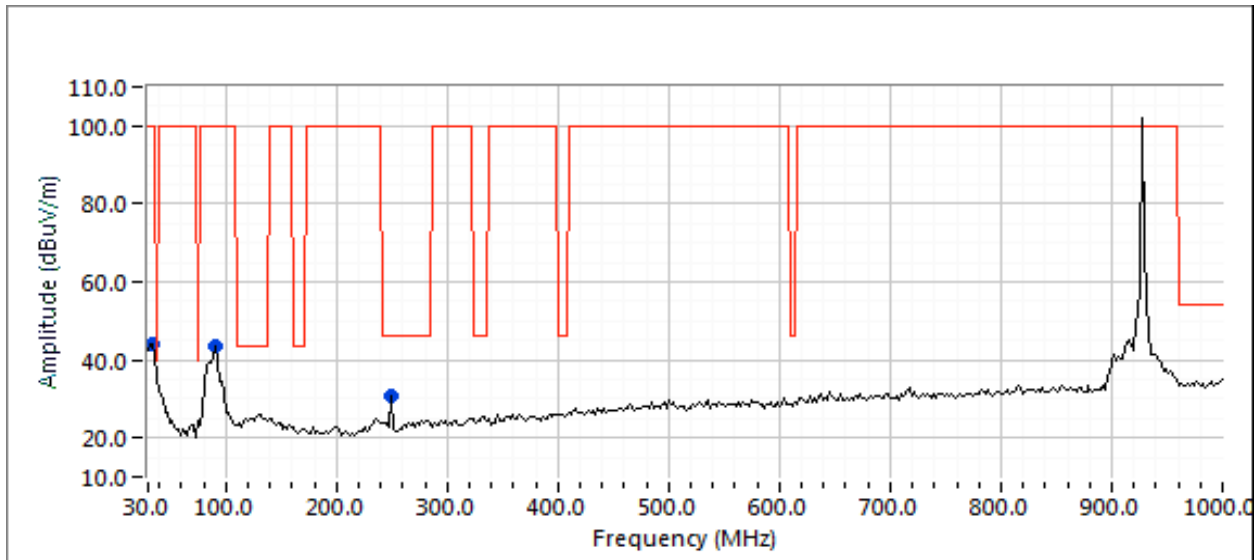


Figure 25: Spectral Plot from 30MHz to 1000MHz, Carrier Frequency = 927.5MHz, Z Position

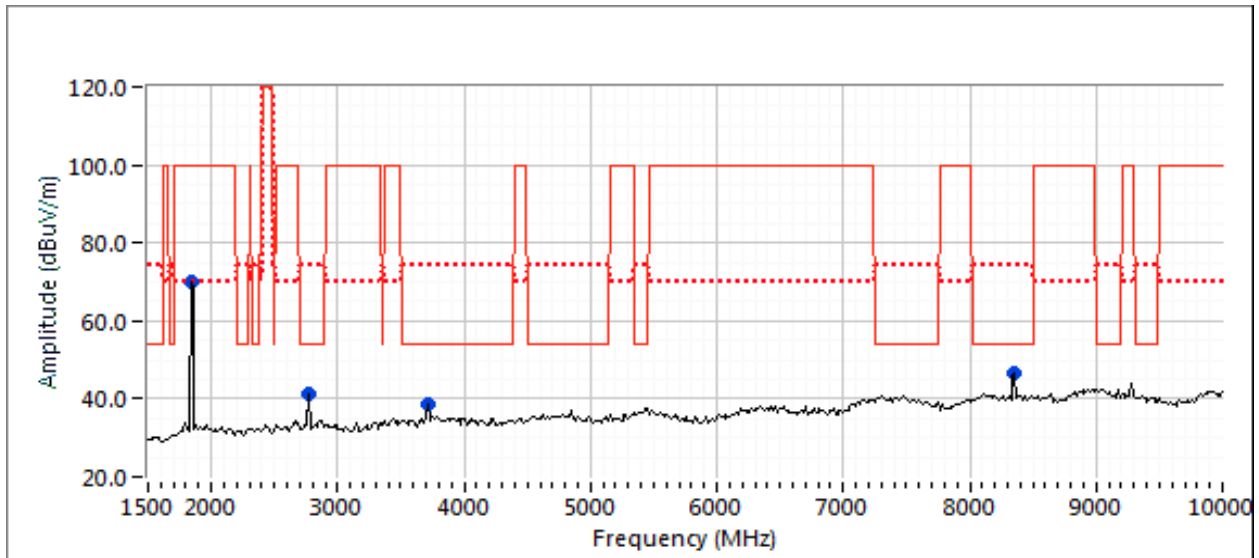


Figure 26: Spectral Plot from 1.5GHz to 10GHz, Carrier Frequency = 927.5MHz, Z Position

Fundamental emission level @ 3m in 100kHz RBW:	125	dBuV/m	
Limit for emissions outside of restricted bands:	105	dBuV/m	Limit is -20dBc (Peak power measurement)

Frequency MHz	Level dBmV/m	Pol v/h	15.209 / 15.247		Detector Pk/QP/Avg	Azimuth degrees	Height meters
			Limit	Margin			
**33.888	44.1	V	105.0	-60.9	PK	8	1.0
**90.261	43.3	H	105.0	-61.7	PK	78	3.0
249.659	30.7	H	46.0	-15.3	PK	149	1.0
**1856.19	69.4	H	105.0	-35.6	PK	130	1.0
2782.18	31.5	V	54.0	-22.5	AVG	37	1.3
2782.7	41.7	V	74.0	-32.3	PK	37	1.3
8344.94	40.9	H	54.0	-13.1	AVG	127	1.9
8346.29	50.3	H	74.0	-23.7	PK	127	1.9
3709.33	33.8	H	54.0	-20.2	AVG	226	1.6
3711.05	43.1	H	74.0	-30.9	PK	226	1.6

** Limit for emissions outside of restricted band

7 Setup Pictures

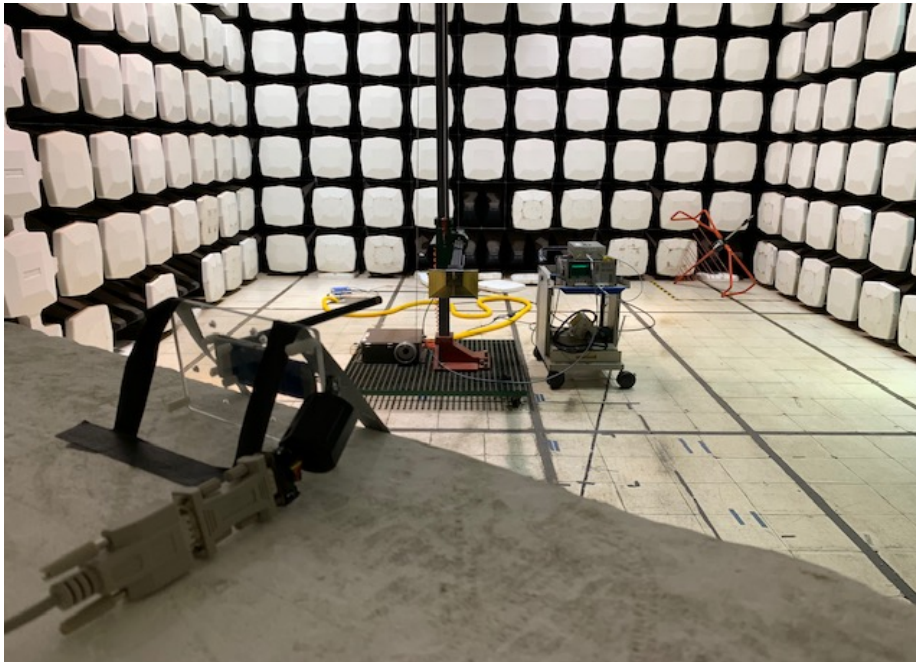


Figure 27 : Horn Antenna Setup for 1GHz to 10GHz Emissions Measurement

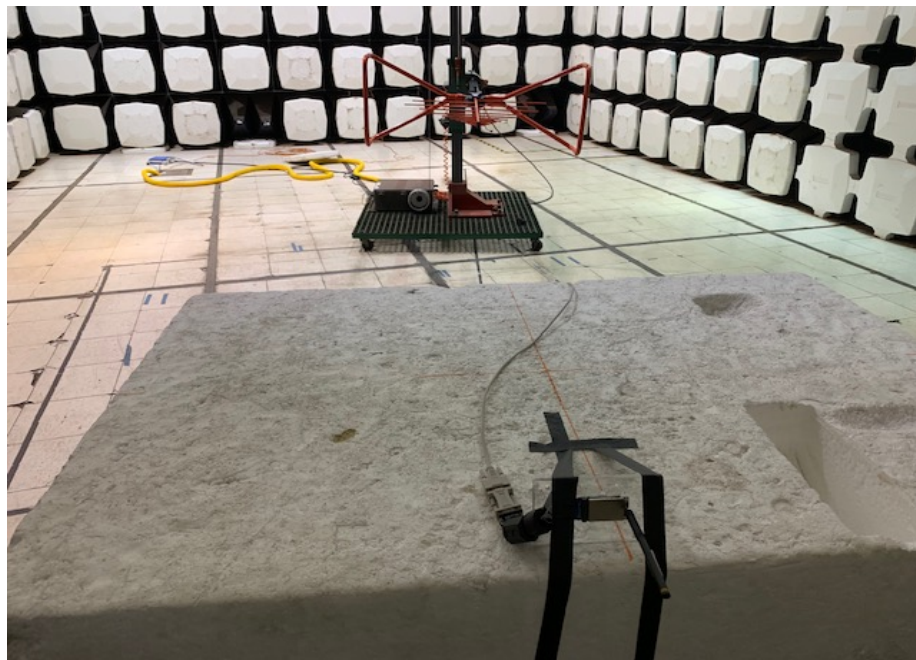


Figure 28 : Log Periodic Antenna Setup for 30MHz to 1000MHz Emissions Measurement

8 Revision History

Version	Date	Edit by	Comment
1.0	Aug 2019	Srinivas N	Initial Release
1.1	8/2019	S. Lee	Editing and reformatting



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