5.9. TRANSMITTER ANTENNA POWER SPURIOUS/HARMONIC CONDUCTED EMISSIONS [§ 2.1051, 2.1057, 22.359 & 90.210]

5.9.1. Limits

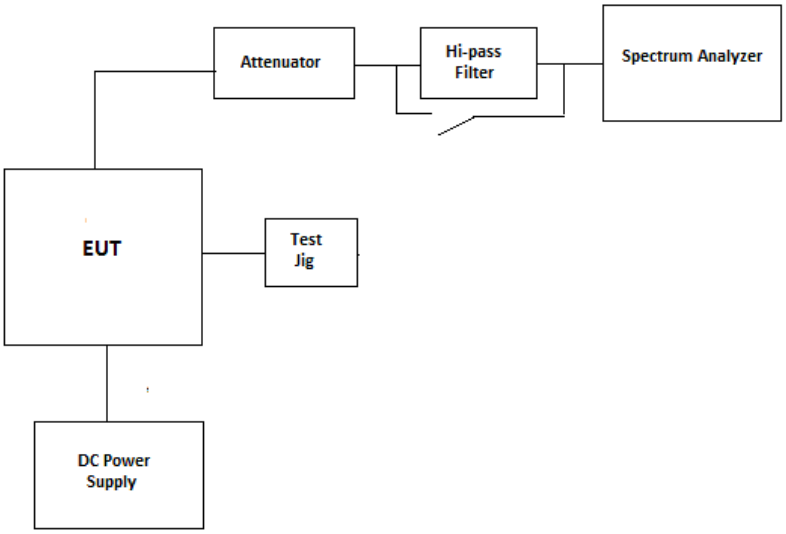
Emissions shall be attenuated below the mean output power of the transmitter as follows:

FCC Rules	Attenuation Limit (dBc)
§ 90.210(b)	At least 43 + 10 log (P) dB.
§ 90.210(d)	At least 50 + 10 log (P) dB or 70 dB, whichever is the lesser attenuation.
§ 90.543(b)	At least 43 + 10 log (P) dB

5.9.2. Method of Measurements

Refer to Section 8.5 of this report for measurement details

5.9.3. Test Arrangement

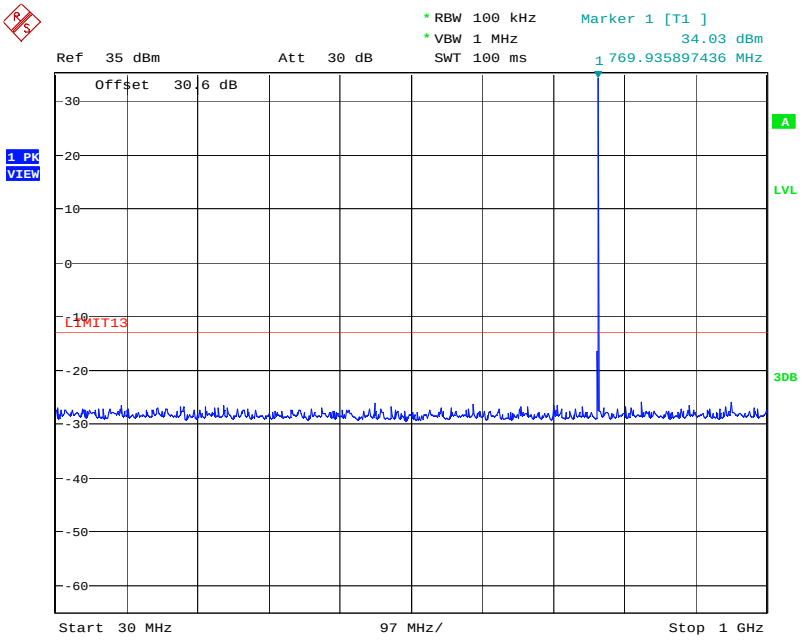


5.9.4. Test Data

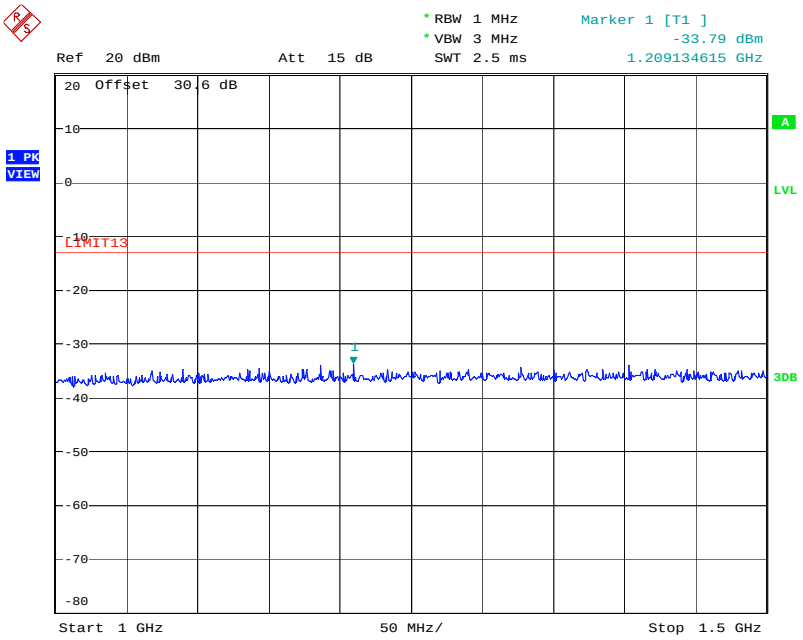
Note: There was no difference in spurious/harmonic emissions on the pre-scans for different channel spacing and modulation types. Therefore, the rf spurious/harmonic emissions in this section would be performed for Digital modulation with 12.5 kHz channel spacing F1W Digital. The frequencies were investigated from 30 MHz- 9 GHz.

High Power

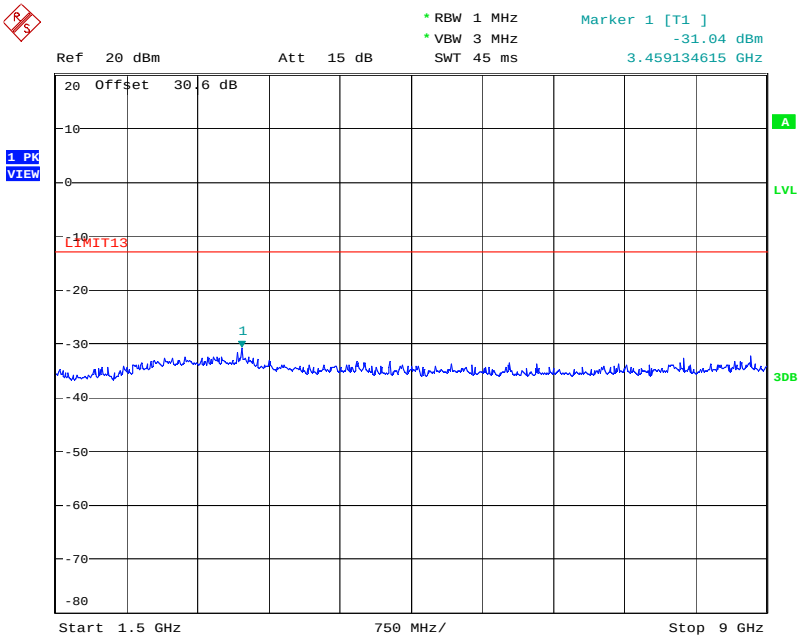
5.9.4.1. Configuration: Tx Conducted Emission, Band 1: 769-775MHz, 769.1MHz, F1W, Digital, High power



Date: 5.JUN.2018 10:47:20

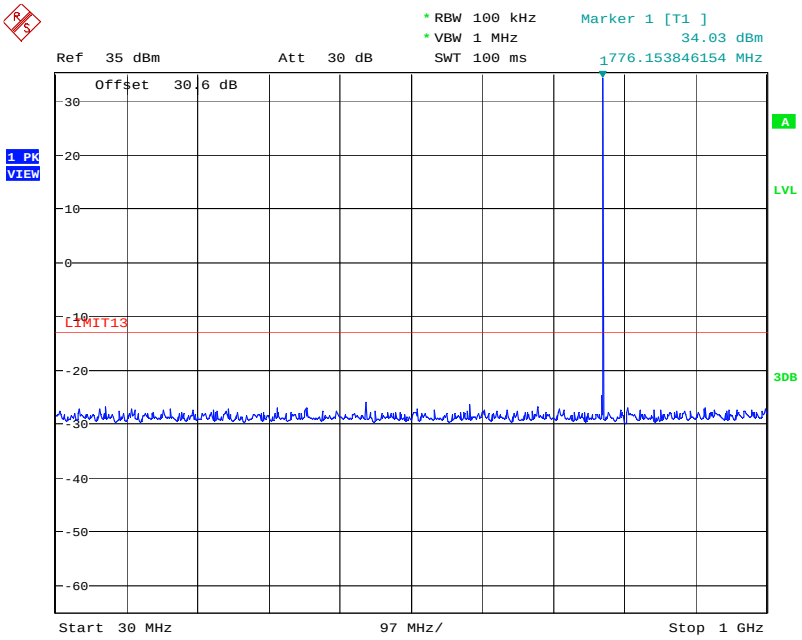


Date: 5.JUN.2018 11:18:40

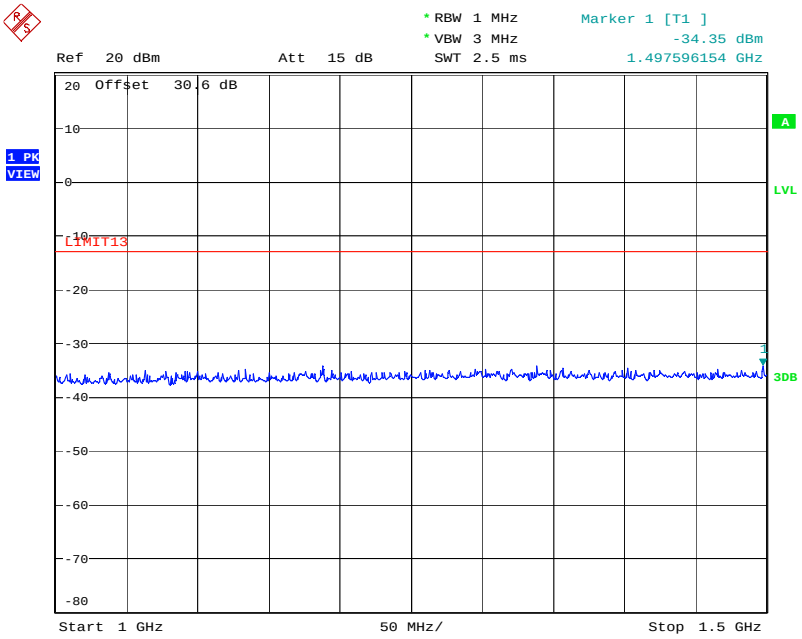


Date: 5.JUN.2018 12:04:07

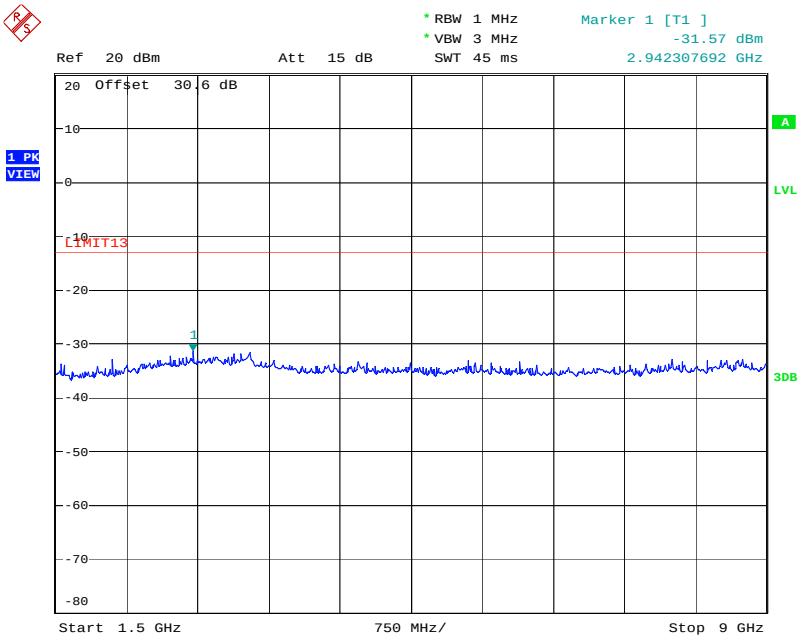
5.9.4.2. Configuration: Tx Conducted Emission, Band 1: 769-775MHz, 774.9MHz, F1W, Digital, High power



Date: 5.JUN.2018 10:48:59



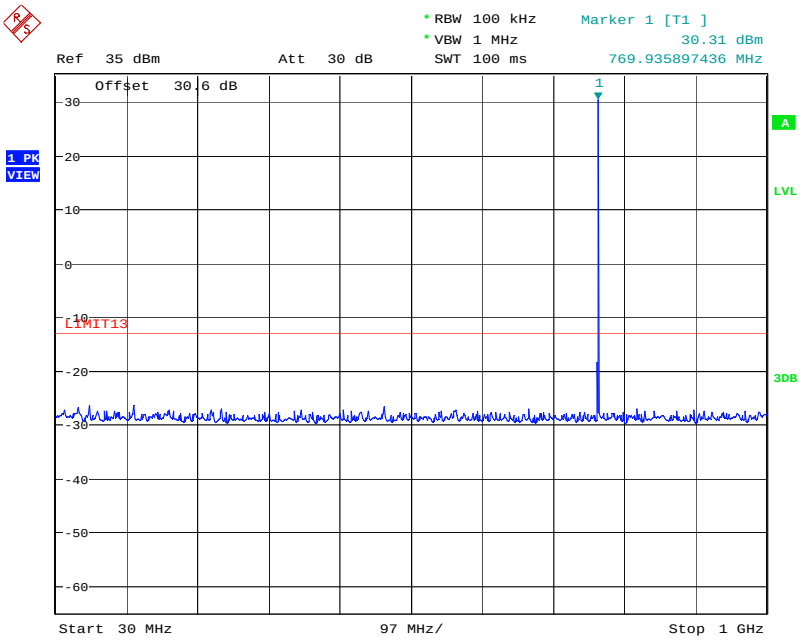
Date: 5.JUN.2018 11:19:51



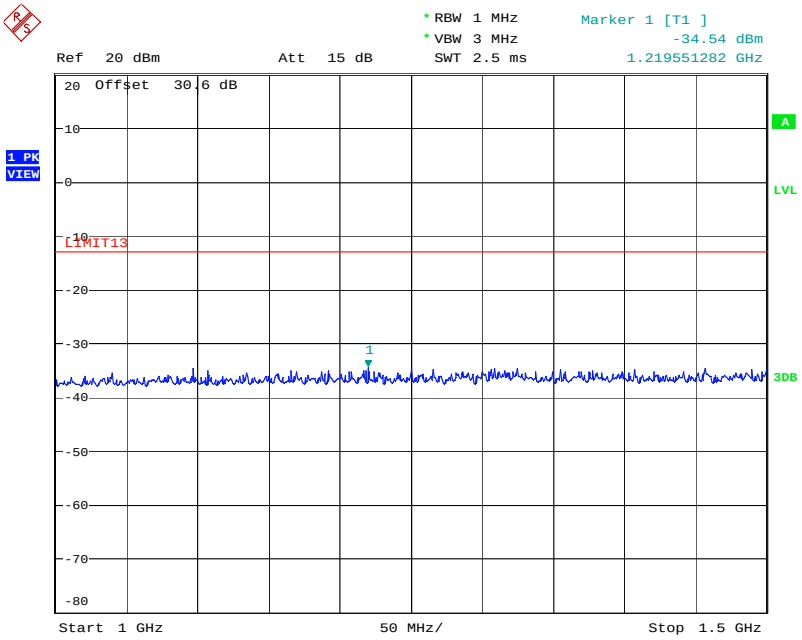
Date: 5.JUN.2018 12:03:18

Low Power

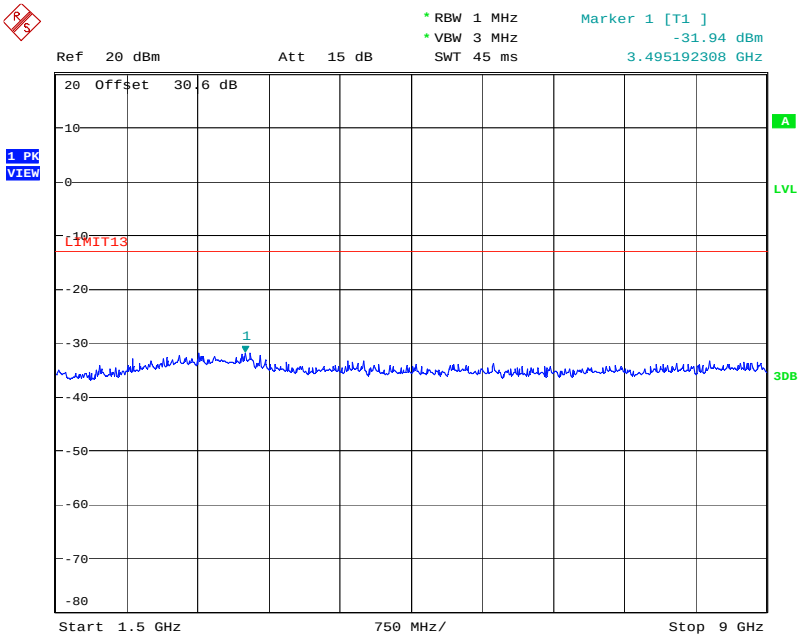
5.9.4.3. Configuration: Tx Conducted Emission, Band 1: 769-775MHz, 769.1MHz, F1W, Digital, Low power



Date: 5.JUN.2018 11:00:57

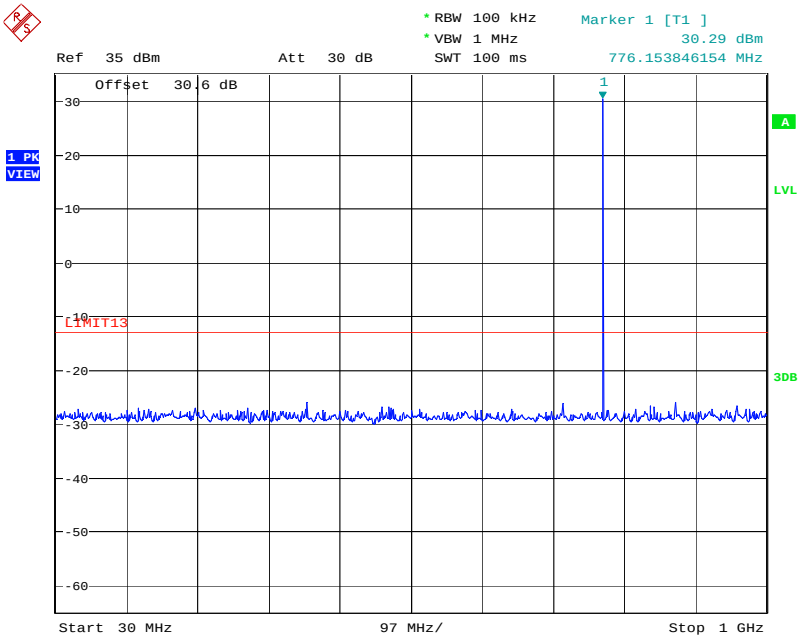


Date: 5.JUN.2018 11:27:56

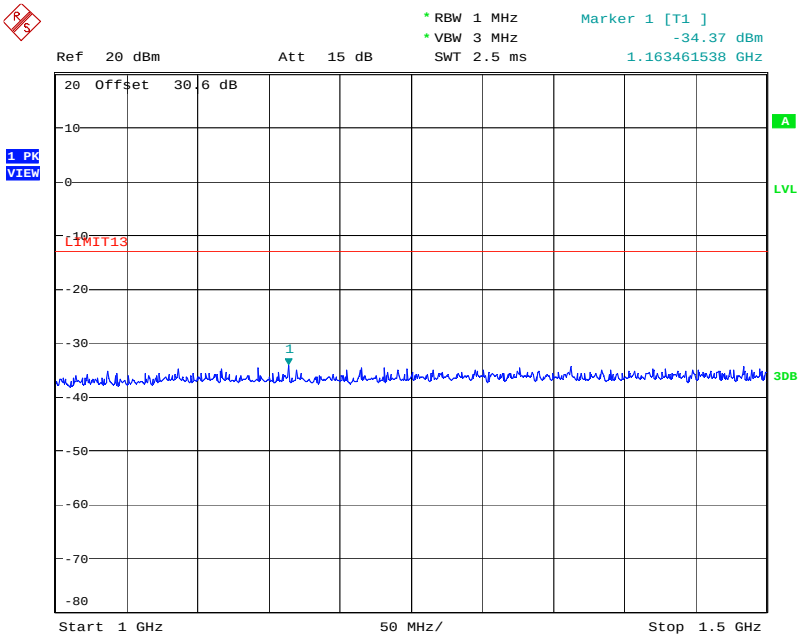


Date: 5.JUN.2018 11:40:23

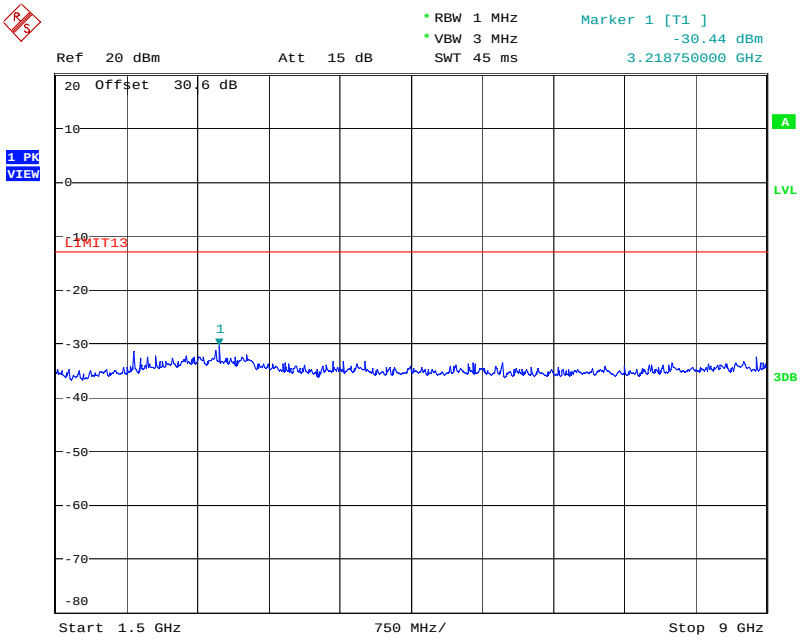
5.9.4.4. Configuration: Tx Conducted Emission, Band 1: 769-775MHz, 774.9MHz, F1W, Digital, Low power



Date: 5.JUN.2018 11:01:49



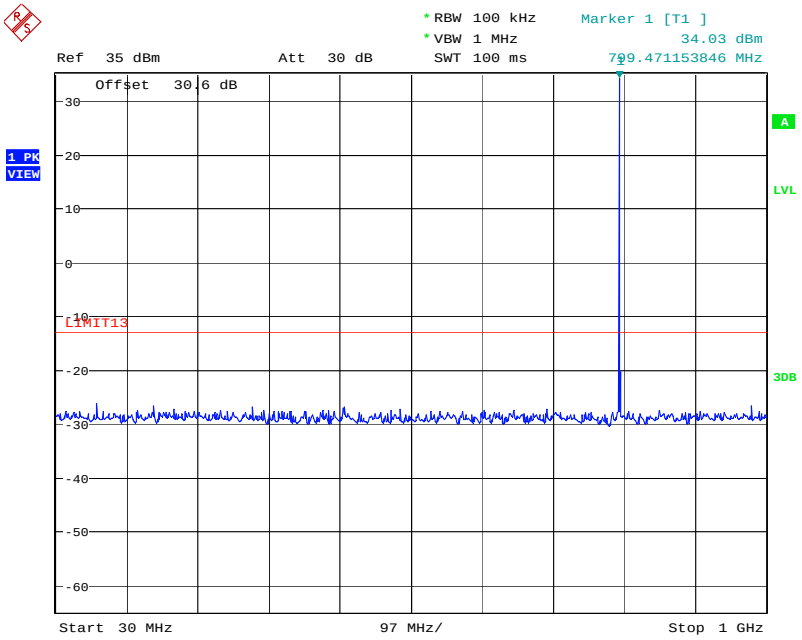
Date: 5.JUN.2018 11:28:42



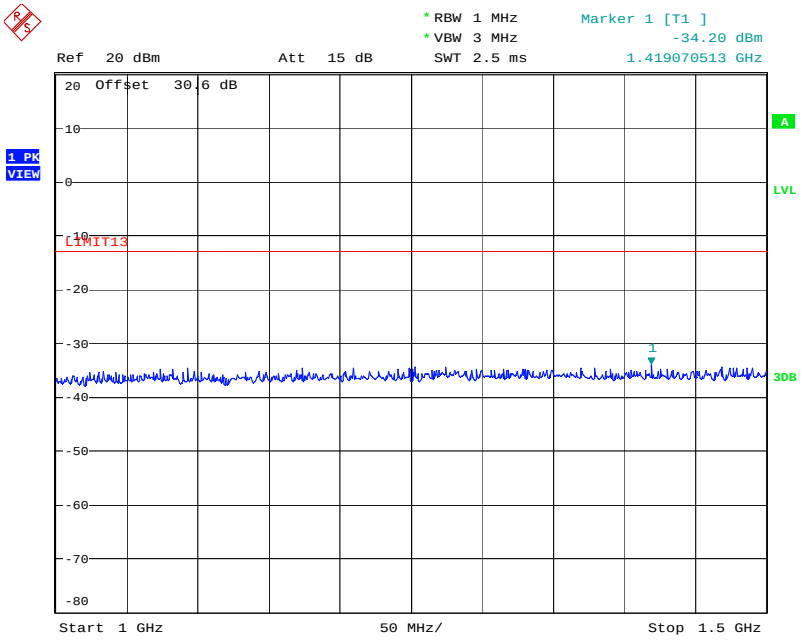
Date: 5.JUN.2018 11:41:51

High Power

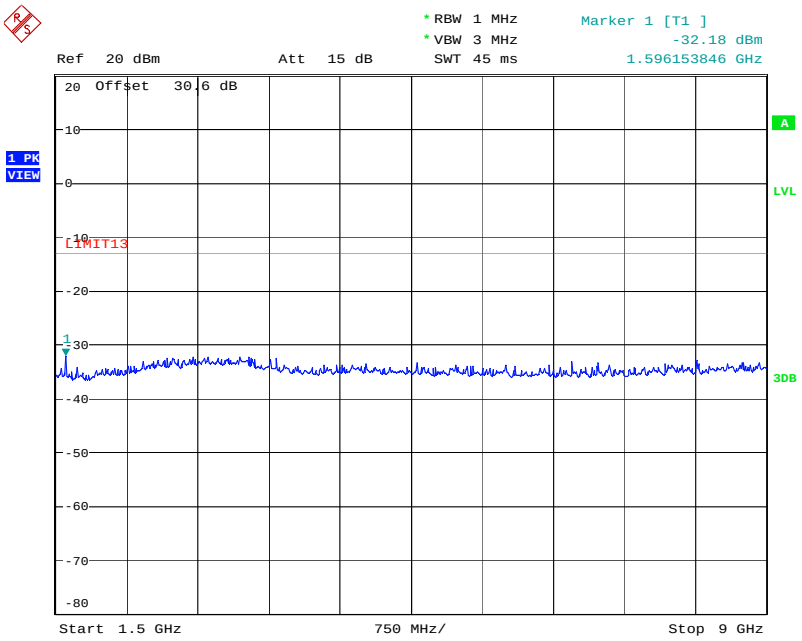
5.9.4.5. Configuration: Tx Conducted Emission, Band 2: 799-805MHz, 799.1MHz, F1W, Digital, High power



Date: 5.JUN.2018 10:50:23

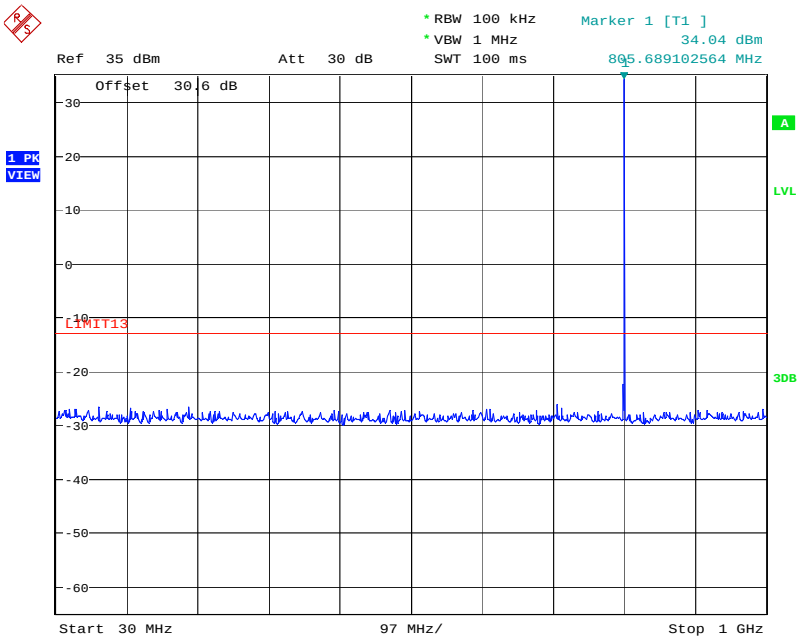


Date: 5.JUN.2018 11:20:57

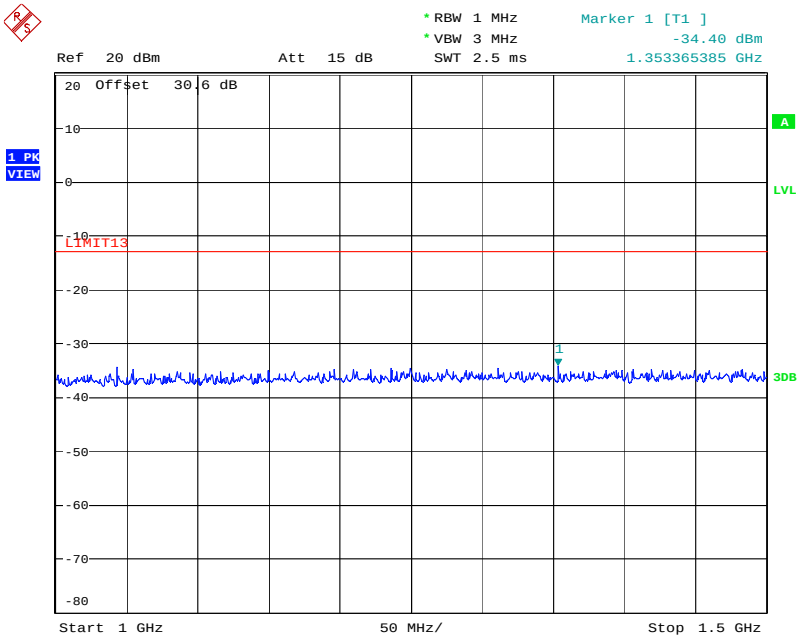


Date: 5.JUN.2018 12:02:03

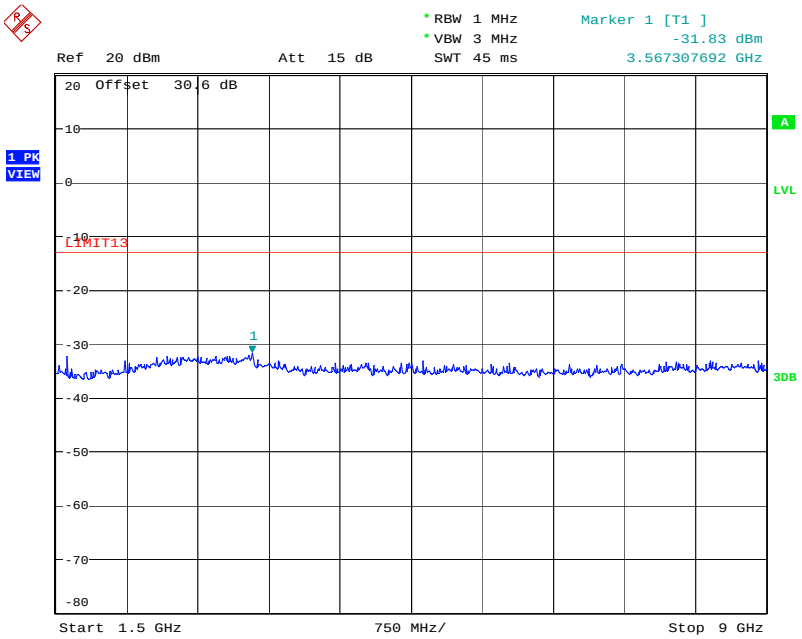
5.9.4.6. Configuration: Tx Conducted Emission, Band 2: 799-805MHz, 804.9MHz, F1W, Digital, High power



Date: 5.JUN.2018 10:51:18



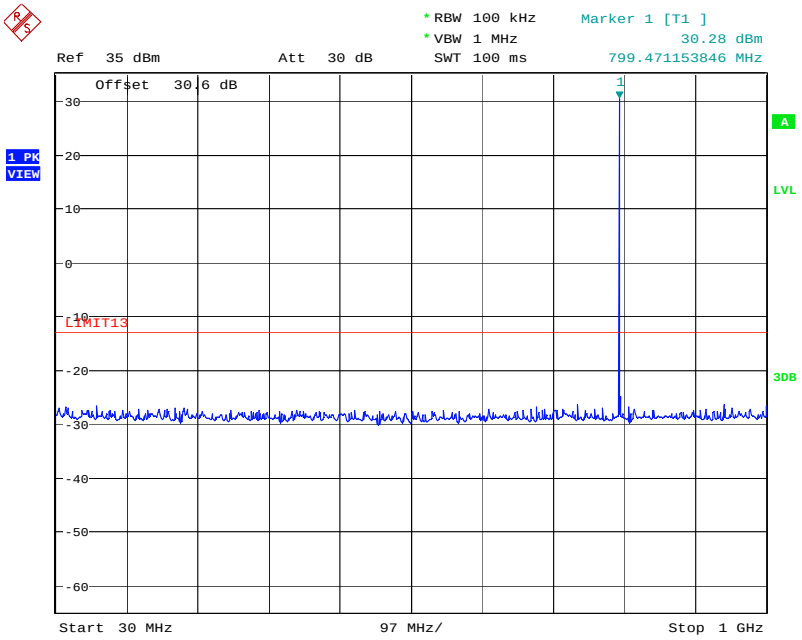
Date: 5.JUN.2018 11:21:47



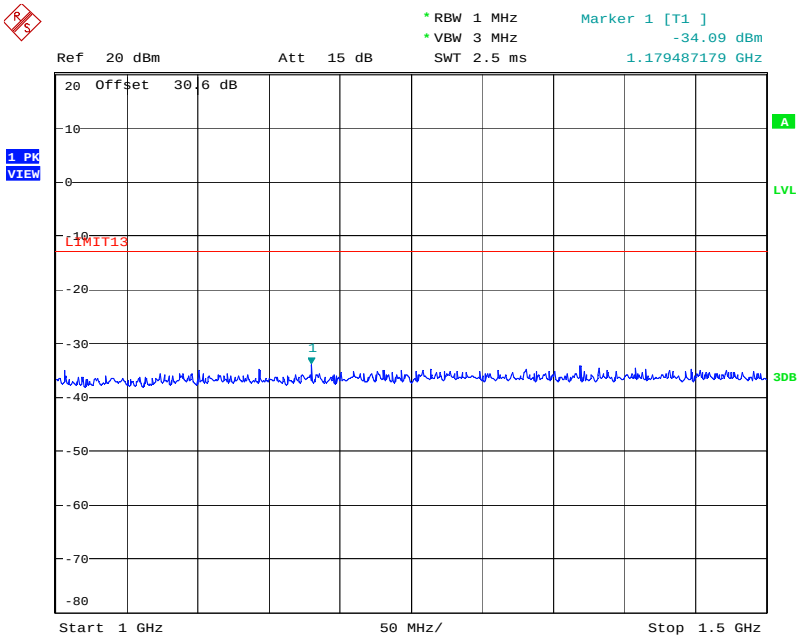
Date: 5.JUN.2018 12:01:05

Low Power

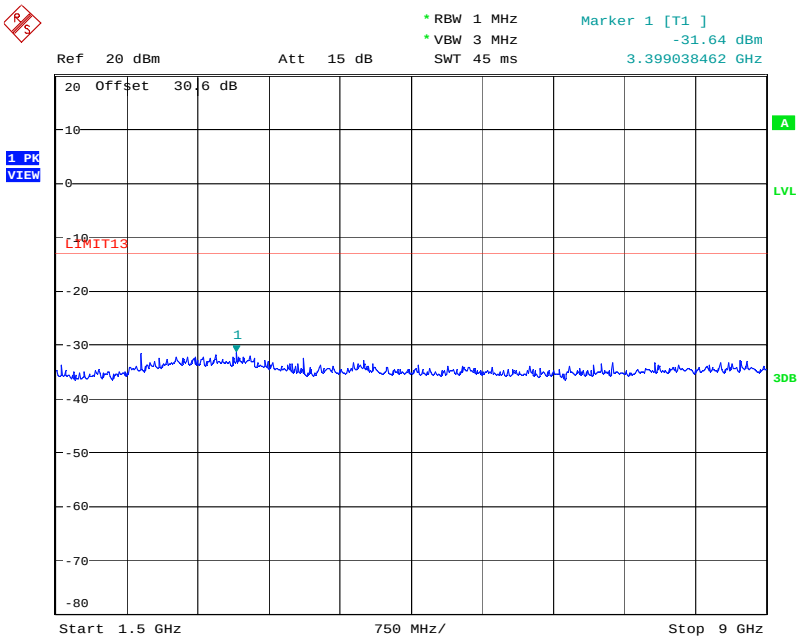
5.9.4.7. Configuration: Tx Conducted Emission, Band 2: 799-805MHz, 799.1MHz, F1W, Digital, Low power



Date: 5.JUN.2018 11:03:24

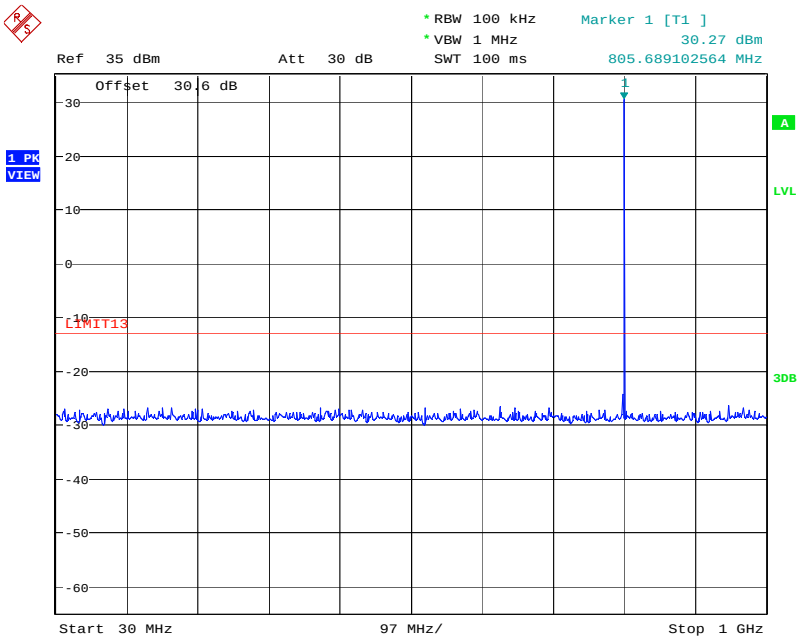


Date: 5.JUN.2018 11:29:35

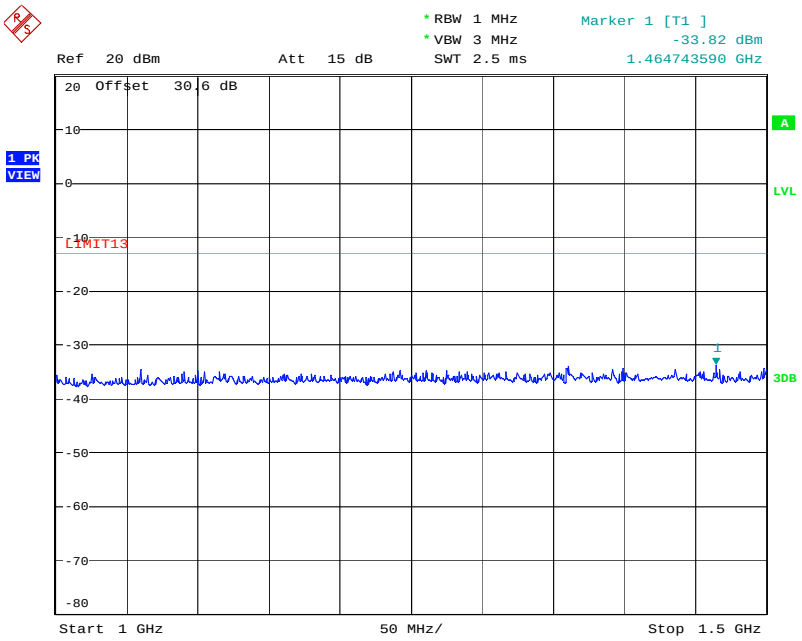


Date: 5.JUN.2018 11:43:13

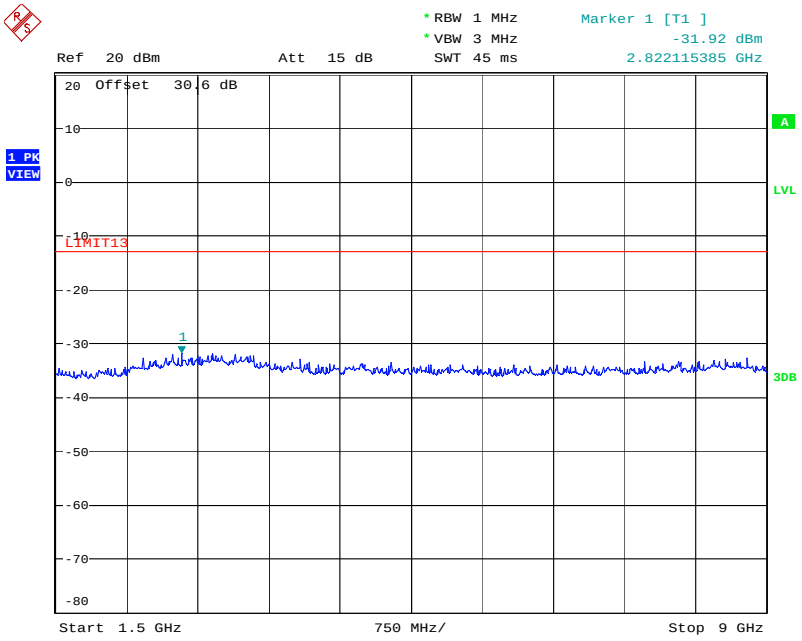
5.9.4.8. Configuration: Tx Conducted Emission, Band 2: 799-805MHz, 804.9MHz, F1W, Digital, Low power



Date: 5.JUN.2018 11:04:13



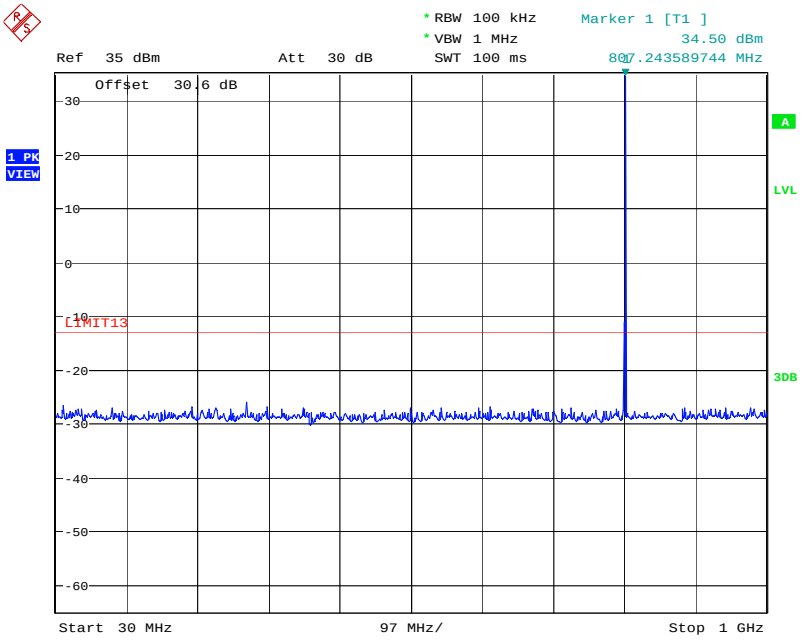
Date: 5.JUN.2018 11:30:24



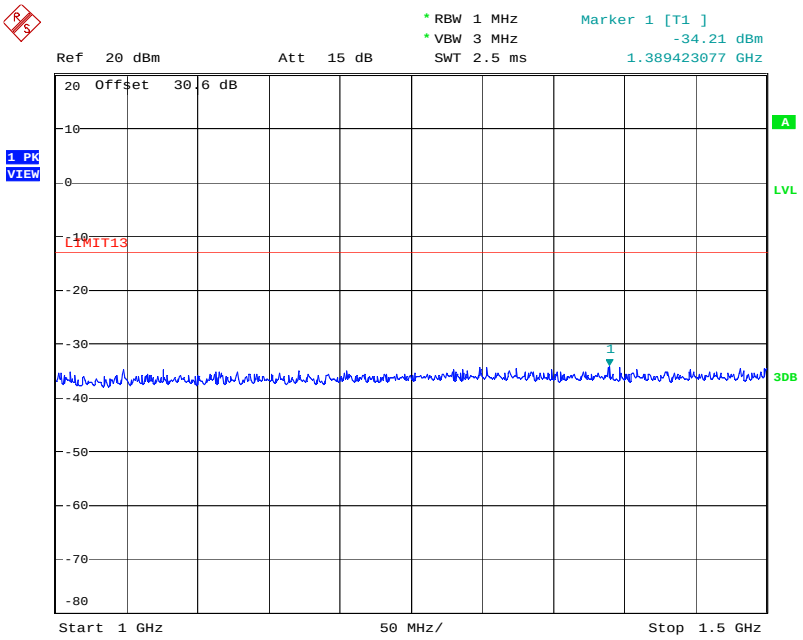
Date: 5.JUN.2018 11:44:10

High Power

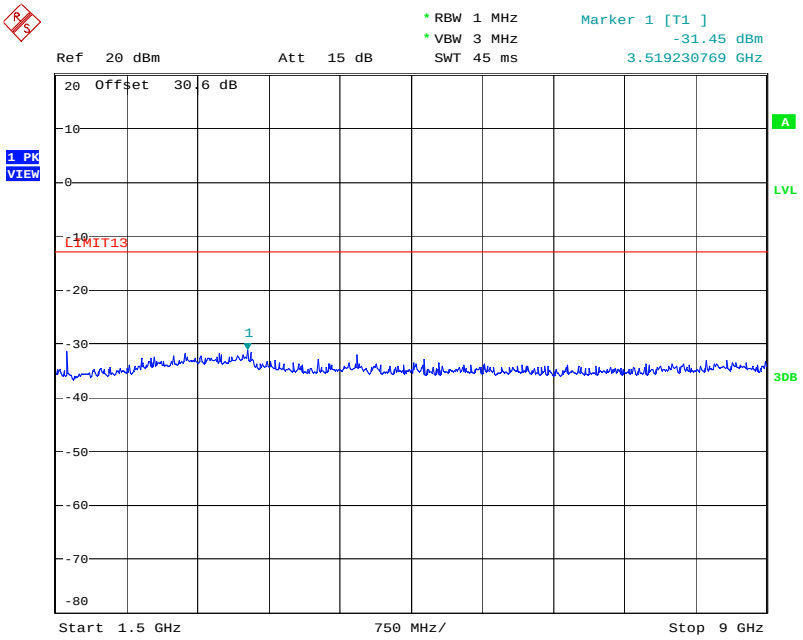
5.9.4.9. Configuration: Tx Conducted Emission, Band 3: 806-824MHz, 806.1MHz, F1W, Digital, High power



Date: 5.JUN.2018 10:53:02

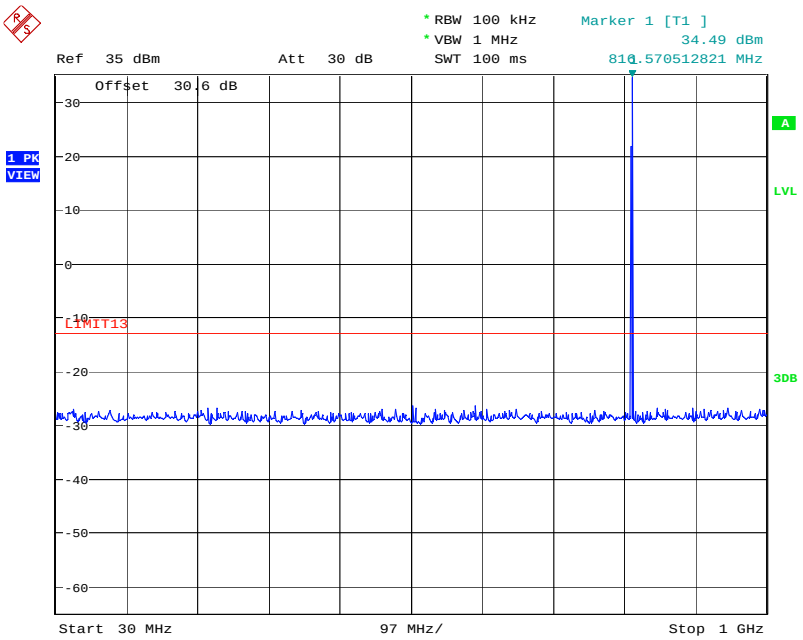


Date: 5.JUN.2018 11:22:48

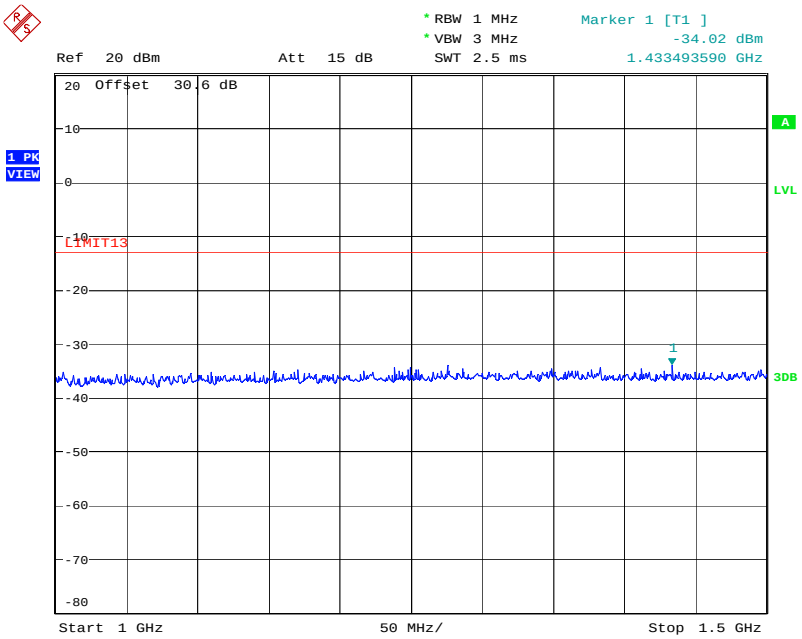


Date: 5.JUN.2018 11:59:46

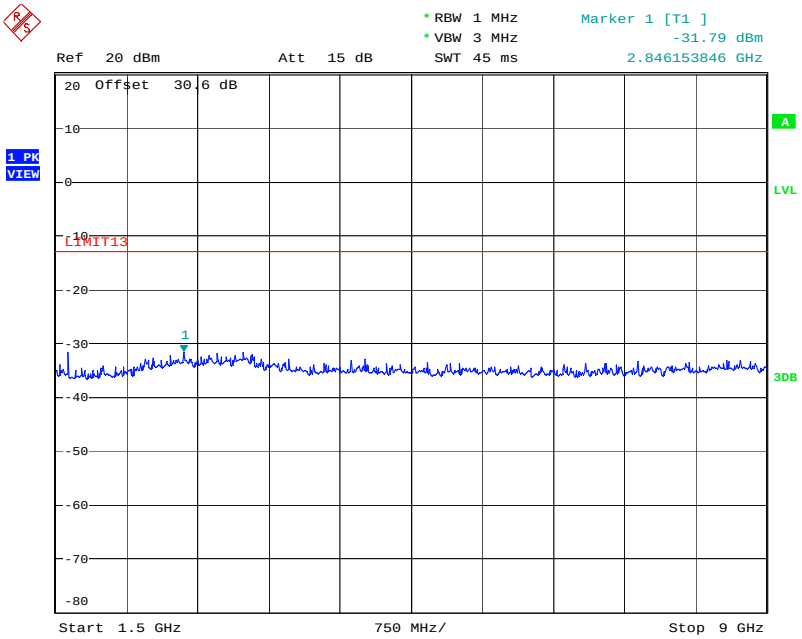
5.9.4.10. Configuration: Tx Conducted Emission, Band 3: 806-824MHz, 815.1MHz, F1W, Digital, High power



Date: 5.JUN.2018 10:54:10

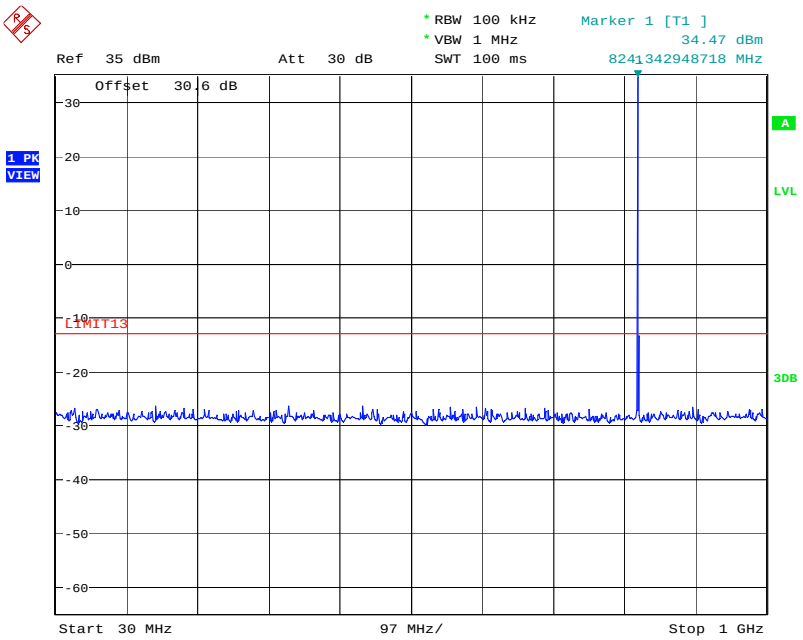


Date: 5.JUN.2018 11:23:40

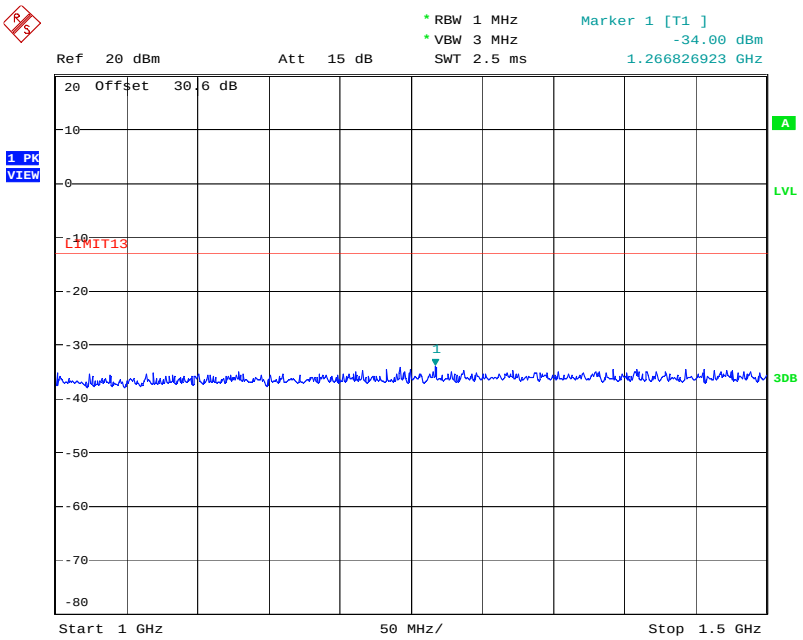


Date: 5.JUN.2018 11:58:36

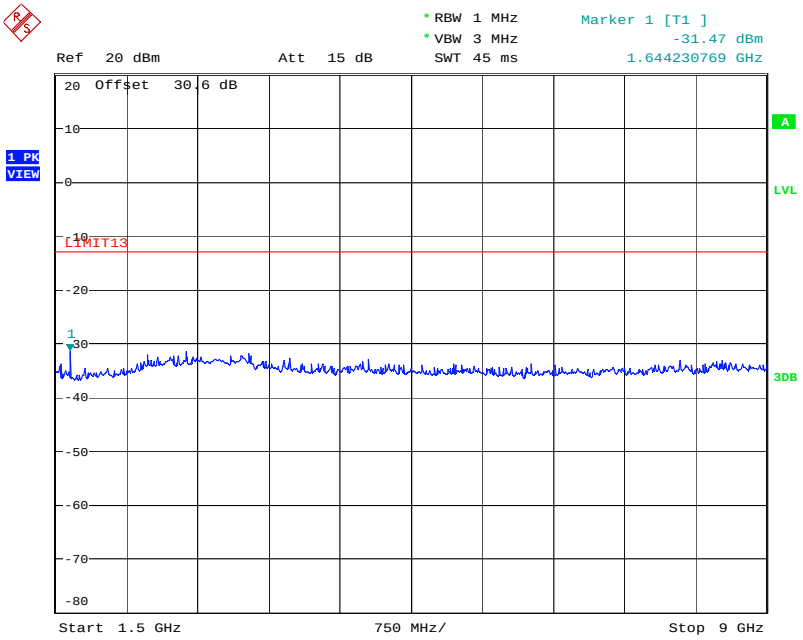
5.9.4.11. Configuration: Tx Conducted Emission, Band 3: 806-824MHz, 823.9MHz, F1W, Digital, High power



Date: 5.JUN.2018 10:55:20



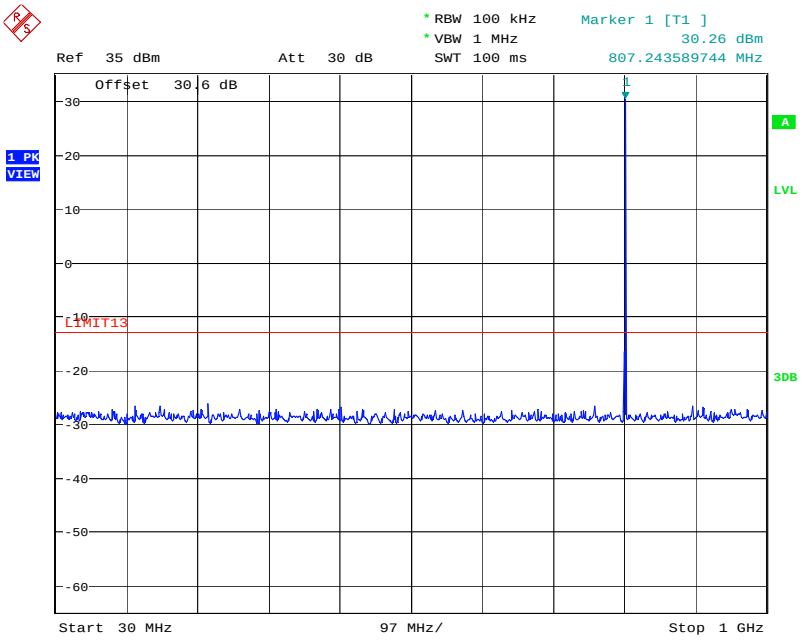
Date: 5.JUN.2018 11:24:31



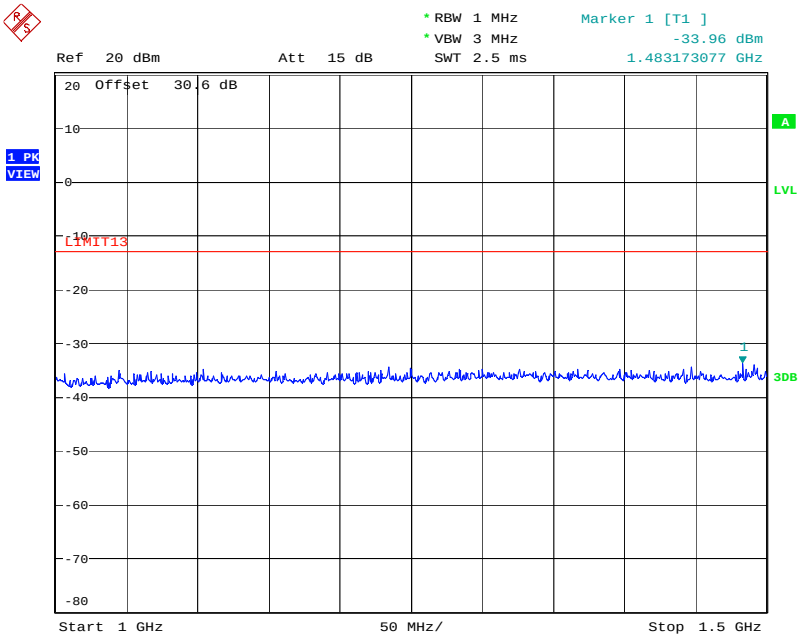
Date: 5.JUN.2018 11:57:39

Low Power

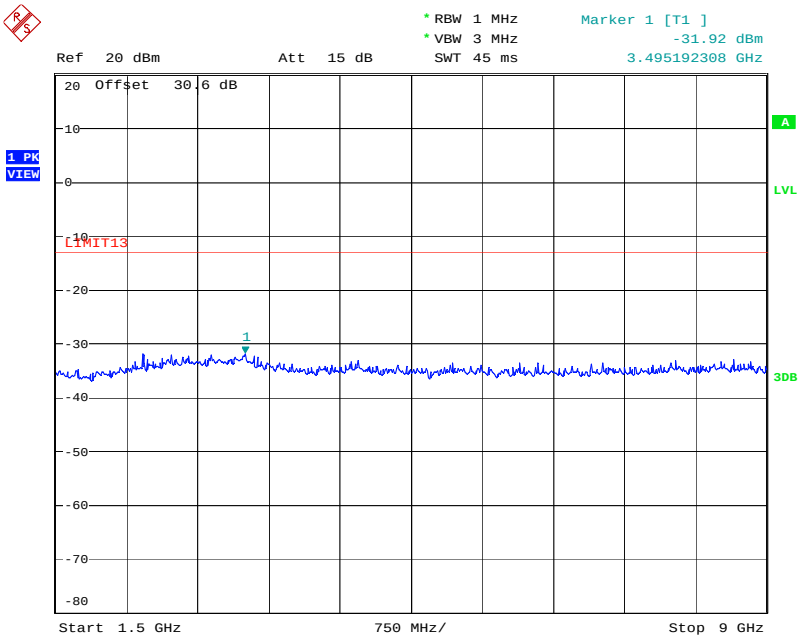
5.9.4.12. Configuration: Tx Conducted Emission, Band 3: 806-824MHz, 806.1MHz, F1W, Digital, Low power



Date: 5.JUN.2018 11:05:10

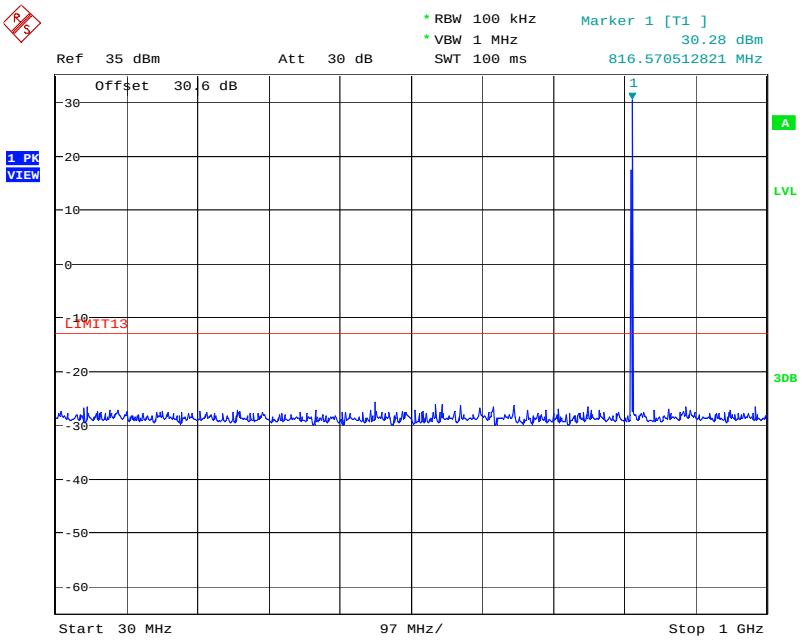


Date: 5.JUN.2018 11:31:27

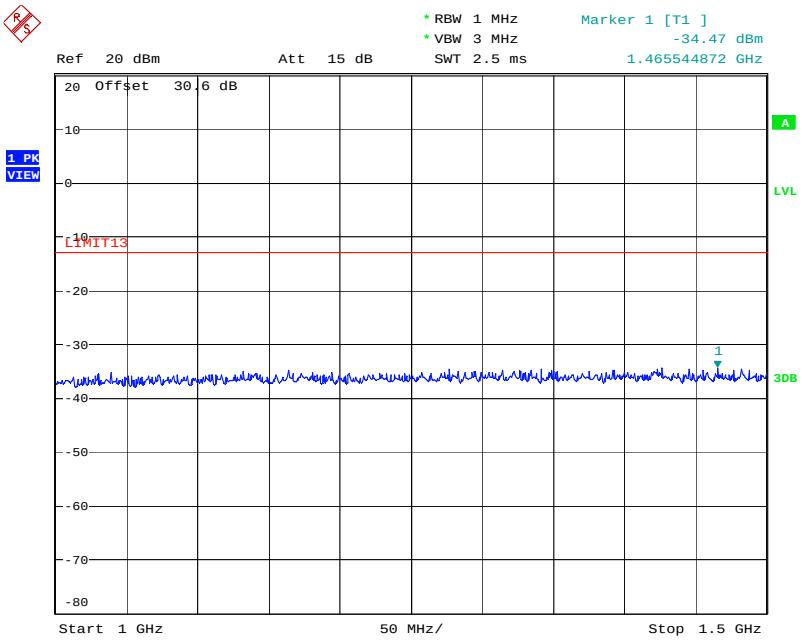


Date: 5.JUN.2018 11:45:25

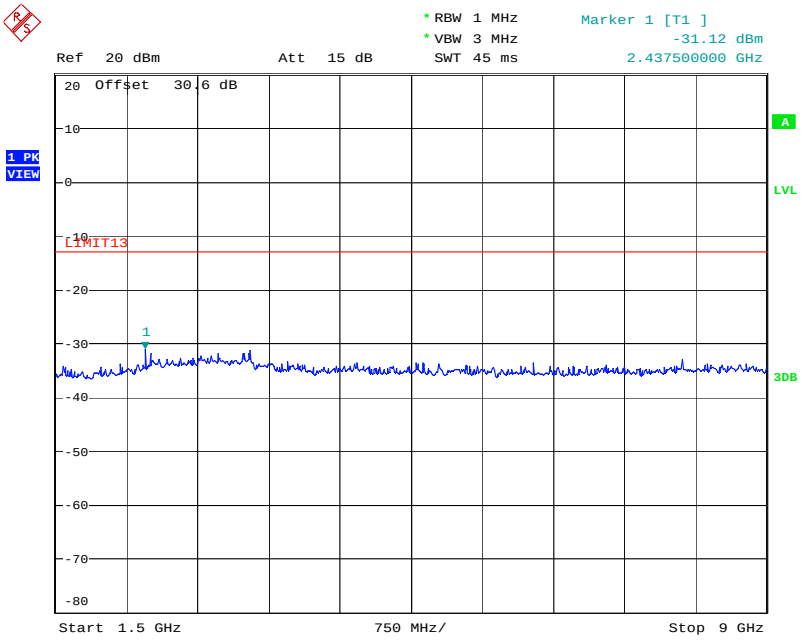
5.9.4.13. Configuration: Tx Conducted Emission, Band 3: 806-824MHz, 815.1MHz, F1W, Digital, Low power



Date: 5.JUN.2018 11:05:54

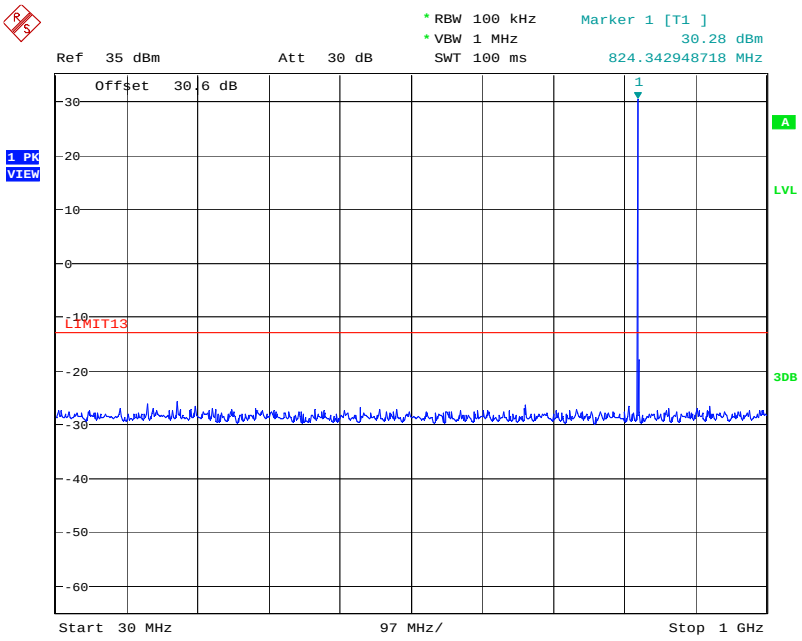


Date: 5.JUN.2018 11:32:10

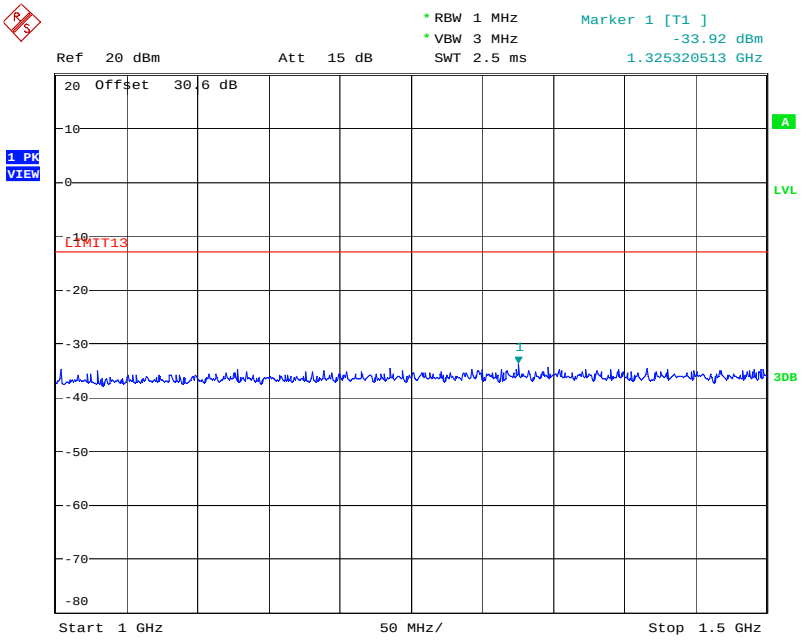


Date: 5.JUN.2018 11:46:33

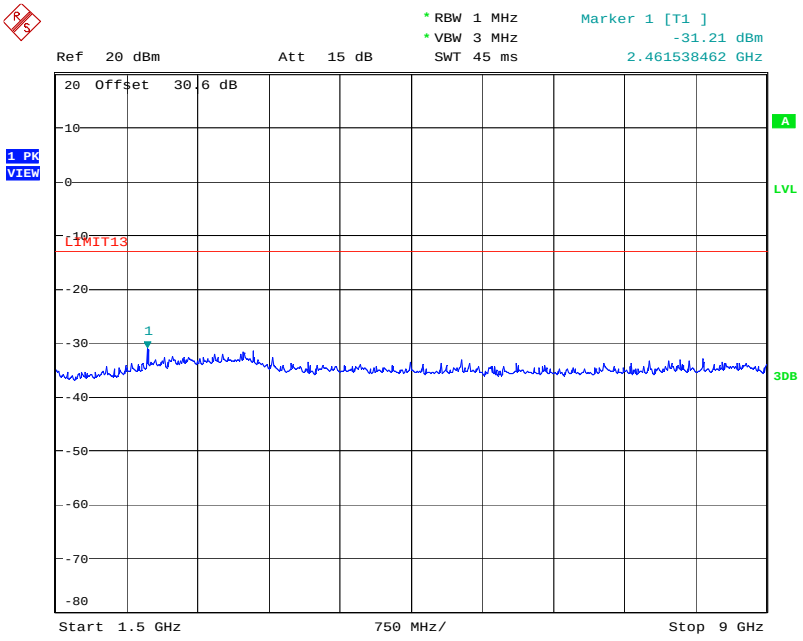
5.9.4.14. Configuration: Tx Conducted Emission, Band 3: 806-824MHz, 823.9MHz, F1W, Digital, Low power



Date: 5.JUN.2018 11:06:41



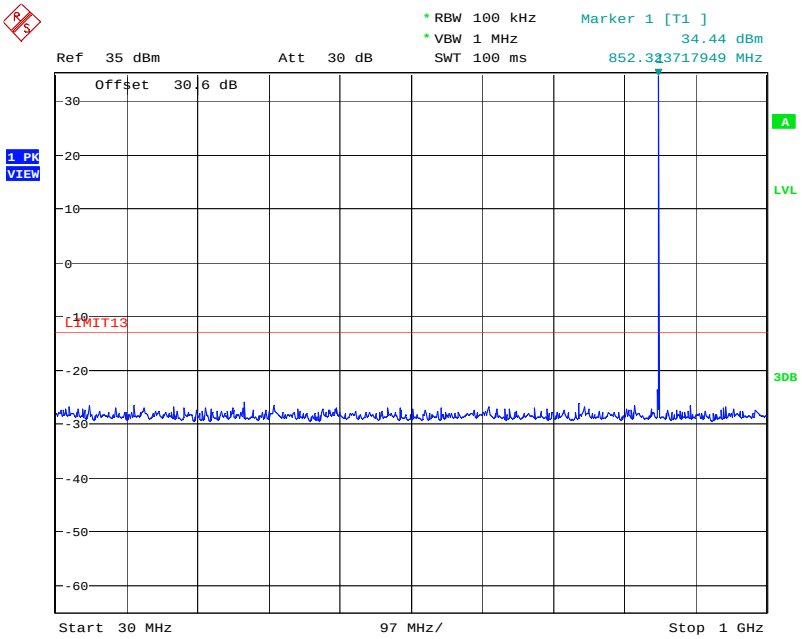
Date: 5.JUN.2018 11:33:00



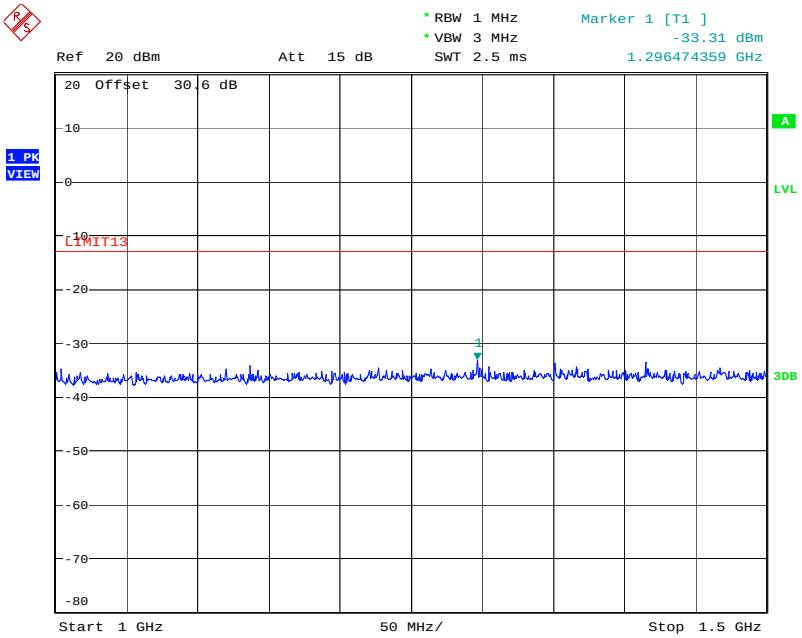
Date: 5.JUN.2018 11:47:32

High Power

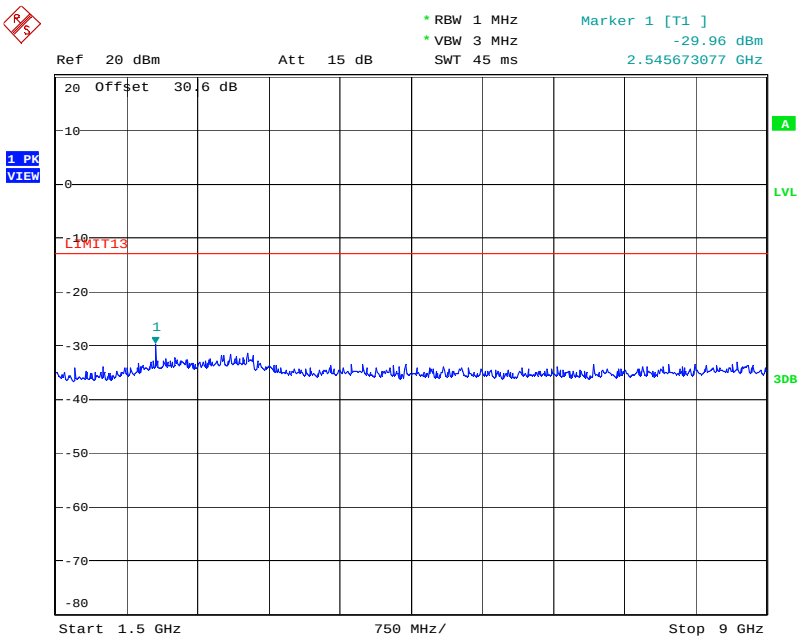
5.9.4.15. Configuration: Tx Conducted Emission, Band 4: 851-869MHz, 851.1MHz, F1W, Digital, High power



Date: 5.JUN.2018 10:56:19

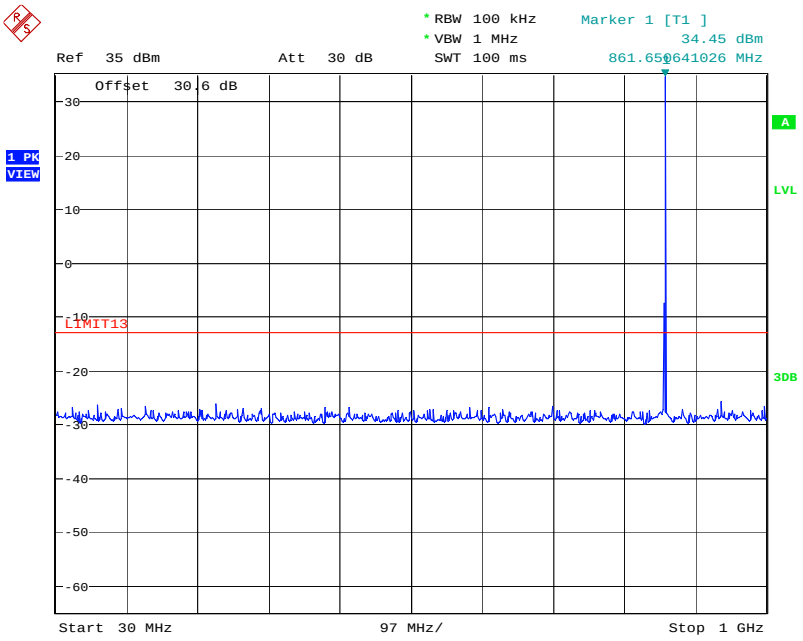


Date: 5.JUN.2018 11:25:32

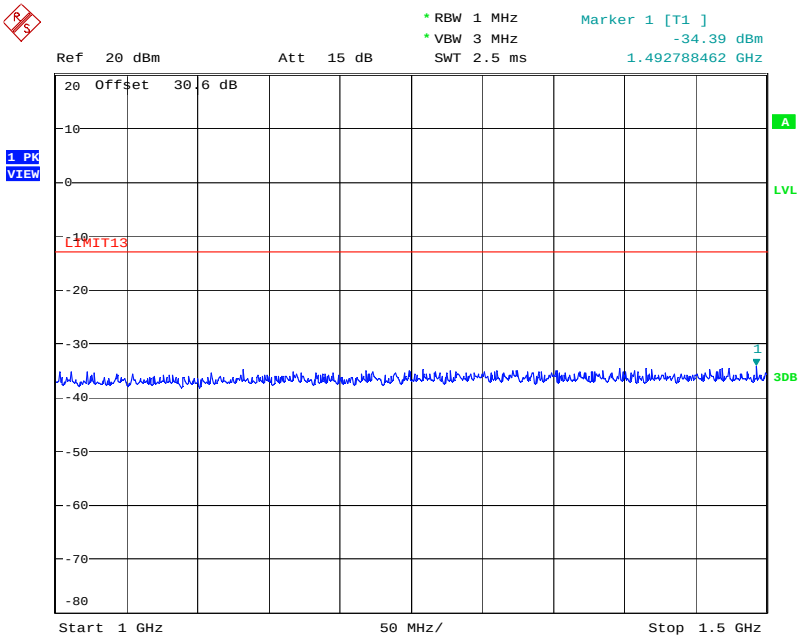


Date: 5.JUN.2018 11:56:02

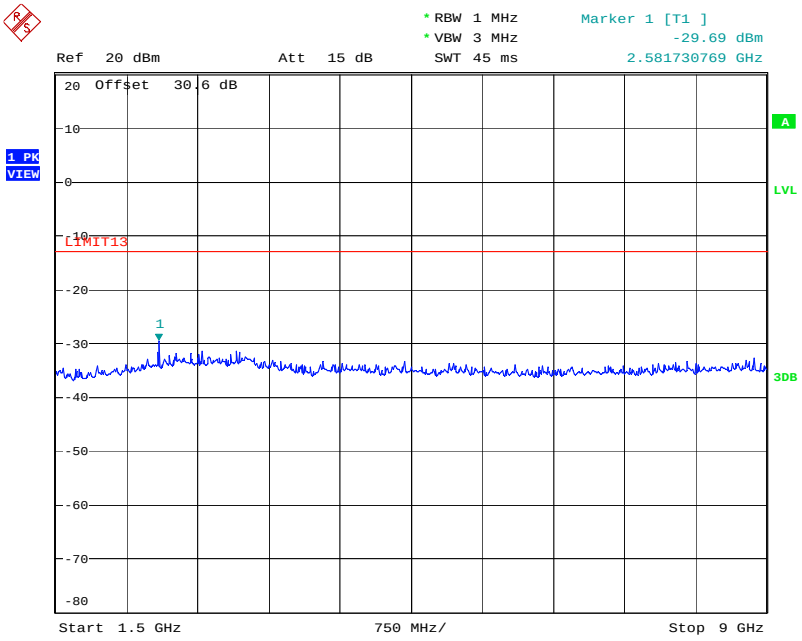
5.9.4.16. Configuration: Tx Conducted Emission, Band 4: 851-869MHz, 860.1MHz, F1W, Digital, High power



Date: 5.JUN.2018 10:57:09

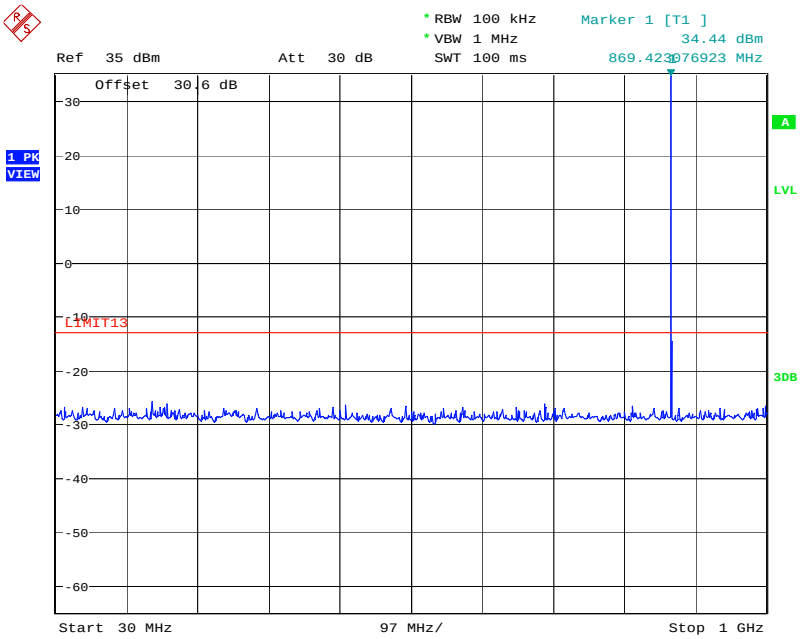


Date: 5.JUN.2018 11:26:18

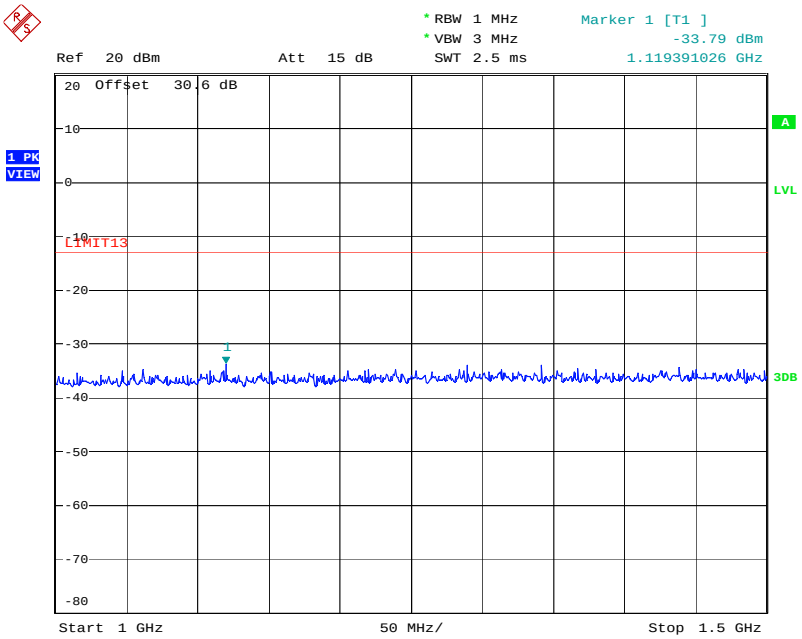


Date: 5.JUN.2018 11:55:08

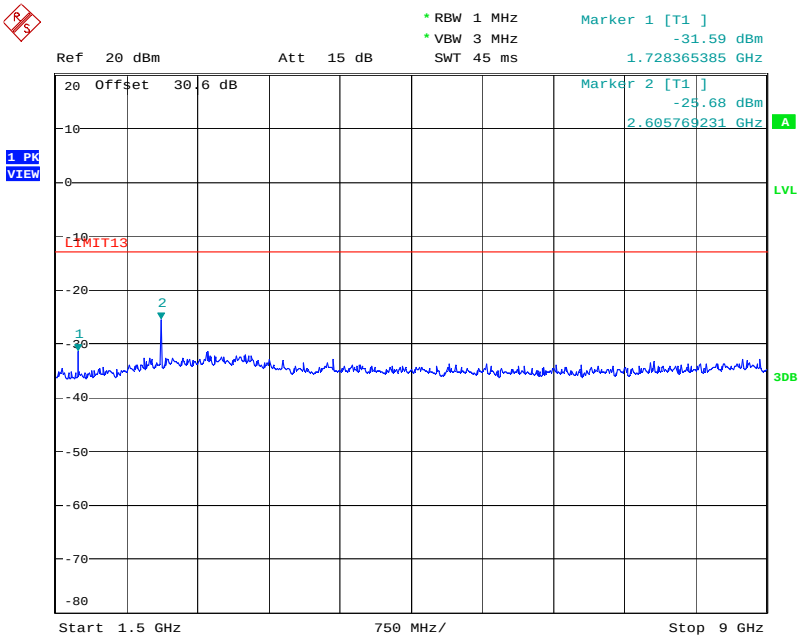
5.9.4.17. Configuration: Tx Conducted Emission, Band 4: 851-869MHz, 868.9MHz, F1W, Digital, High power



Date: 5.JUN.2018 10:58:06



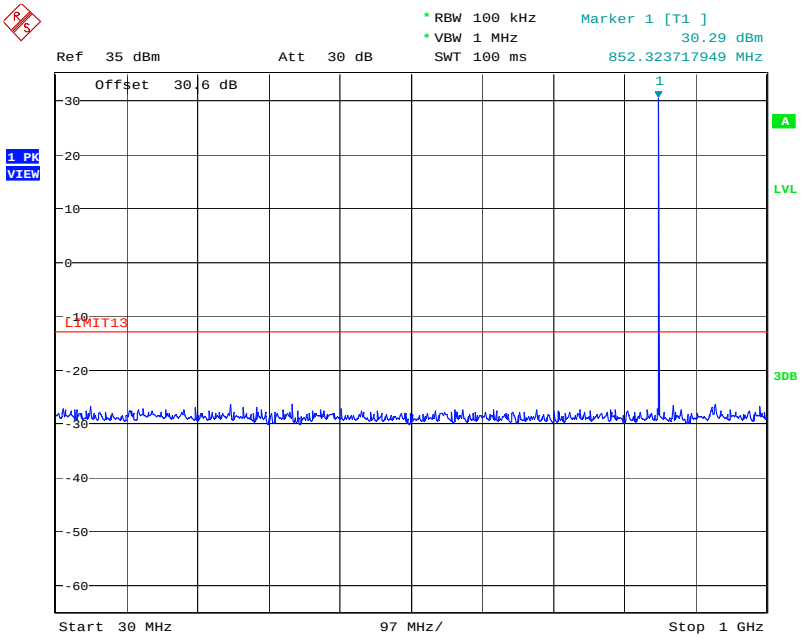
Date: 5.JUN.2018 11:27:04



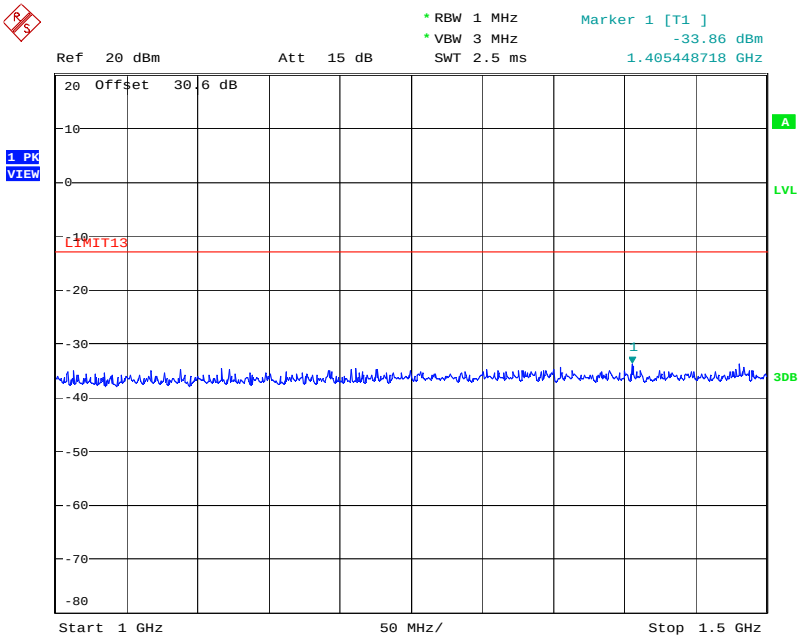
Date: 5.JUN.2018 11:53:20

Low Power

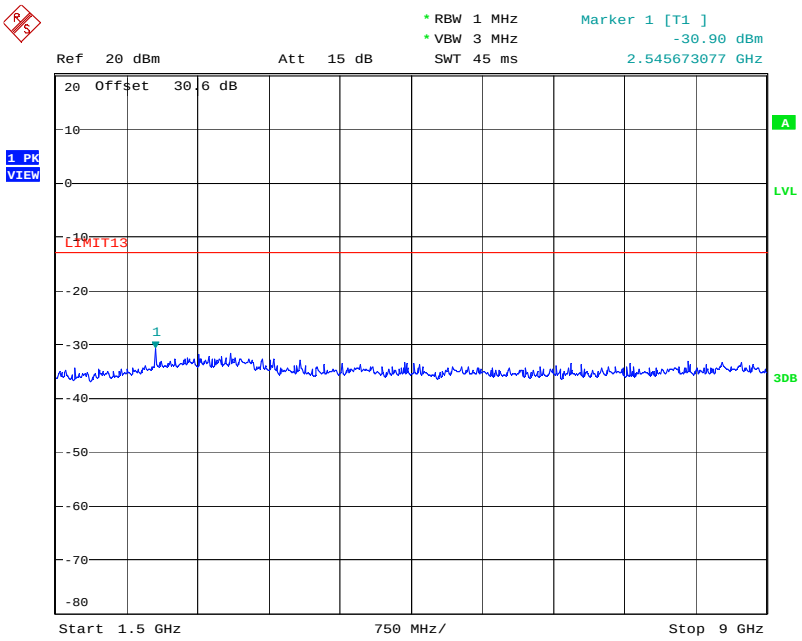
5.9.4.18. Configuration: Tx Conducted Emission, Band 4: 851-869MHz, 851.1MHz, F1W, Digital, Low power



Date: 5.JUN.2018 11:07:31

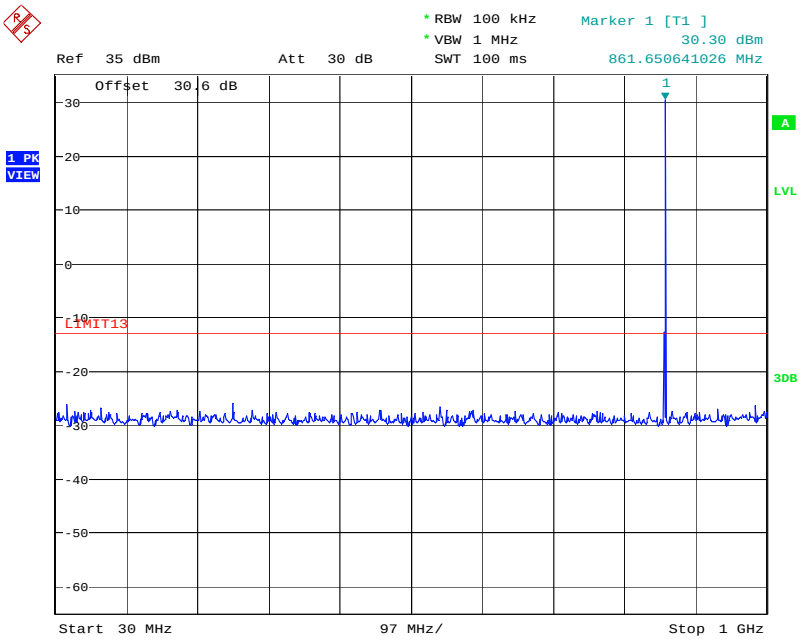


Date: 5.JUN.2018 11:34:28

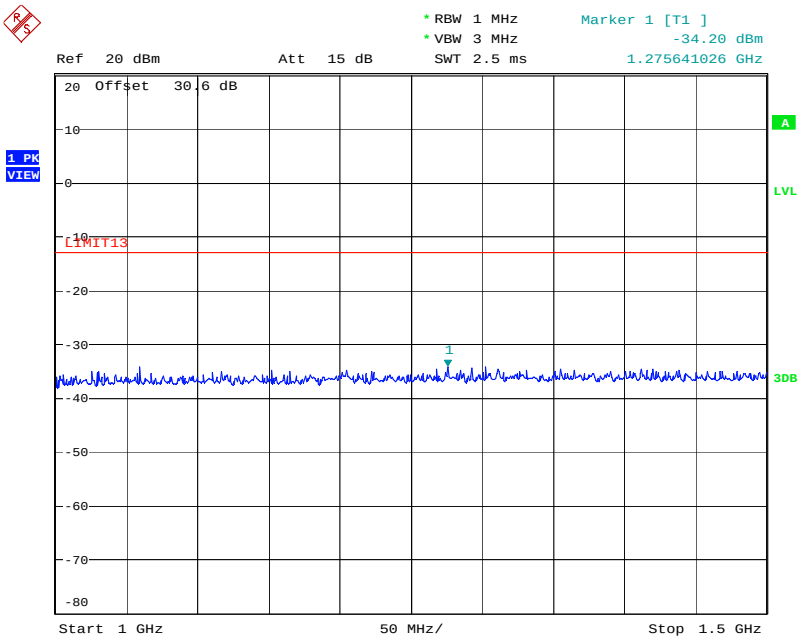


Date: 5.JUN.2018 11:48:34

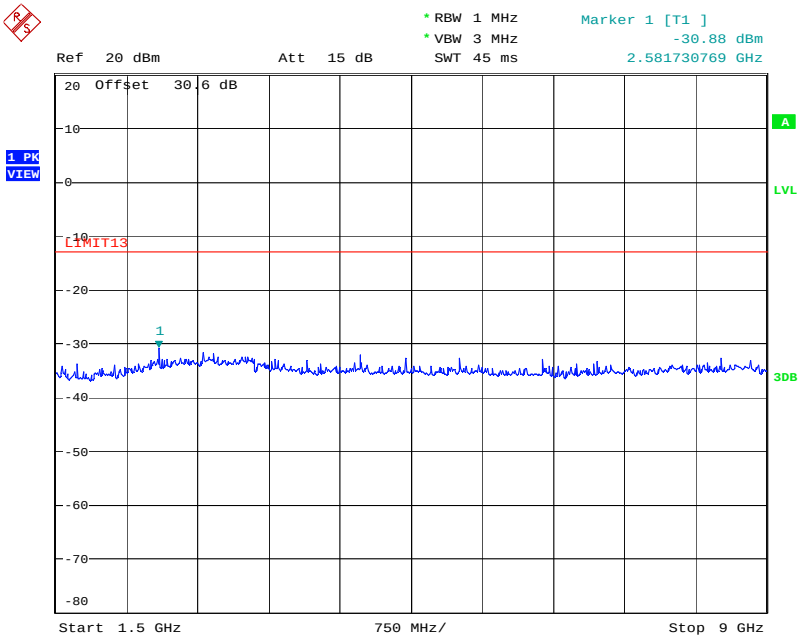
5.9.4.19. Configuration: Tx Conducted Emission, Band 4: 851-869MHz, 860.1MHz, F1W, Digital, Low power



Date: 5.JUN.2018 11:08:13

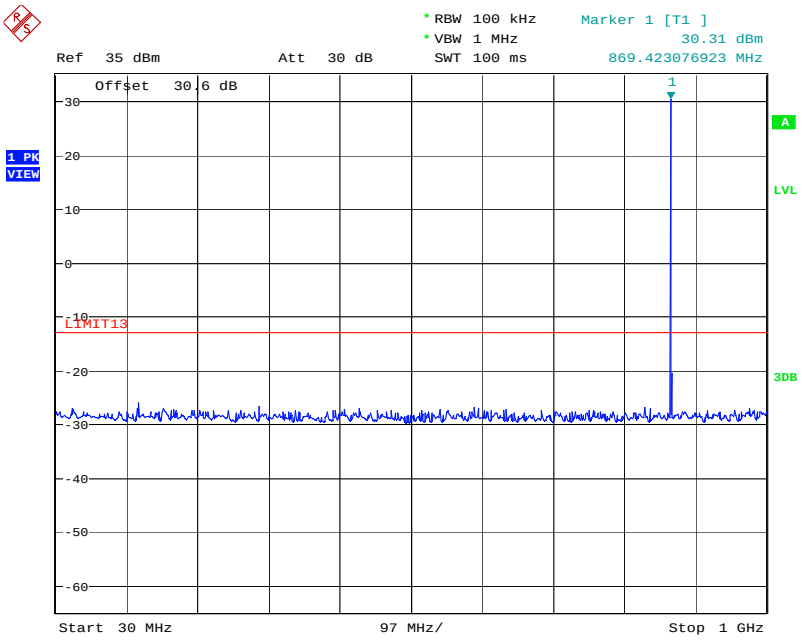


Date: 5.JUN.2018 11:35:14

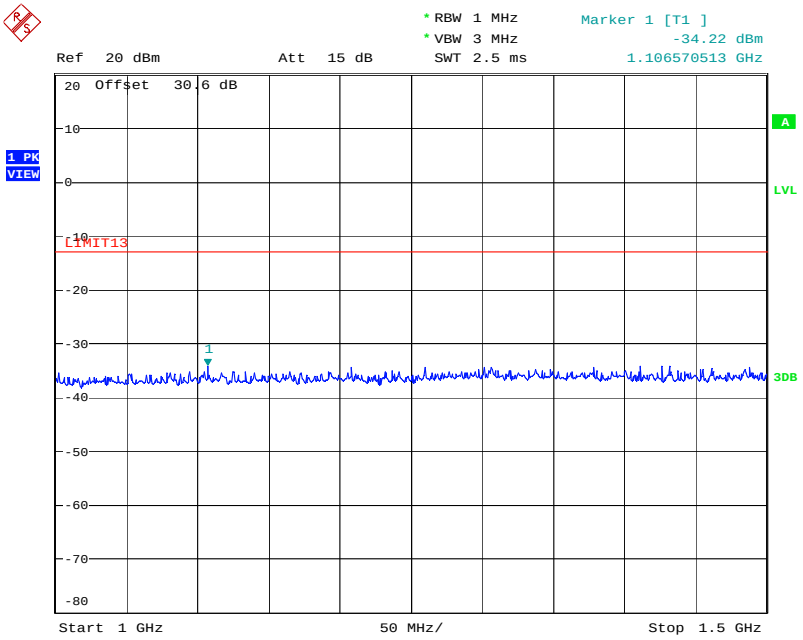


Date: 5.JUN.2018 11:49:58

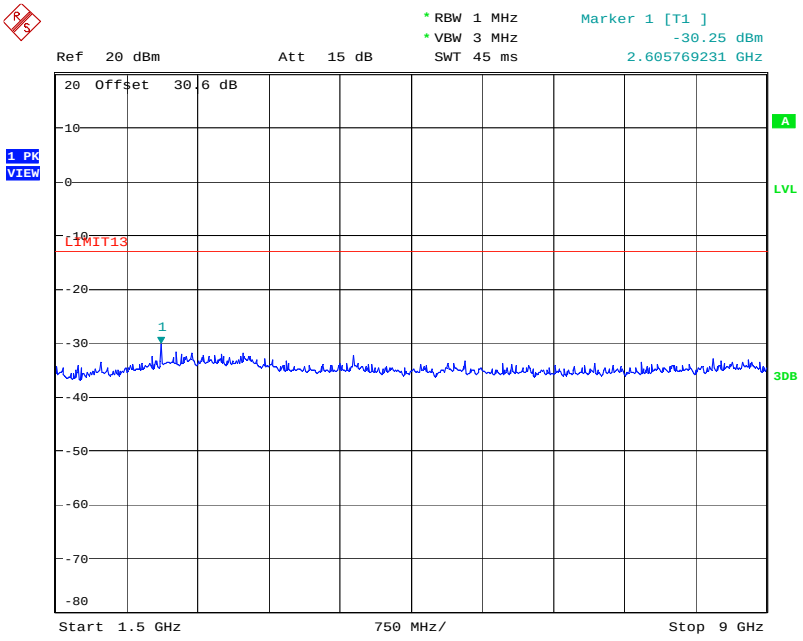
5.9.4.20. Configuration: Tx Conducted Emission, Band 4: 851-869MHz, 868.9MHz, F1W, Digital, Low power



Date: 5.JUN.2018 11:09:03



Date: 5.JUN.2018 11:36:01



Date: 5.JUN.2018 11:50:48

5.10. EIRP measurement in the GNSS band 1559-1610MHz [90.543(f)]

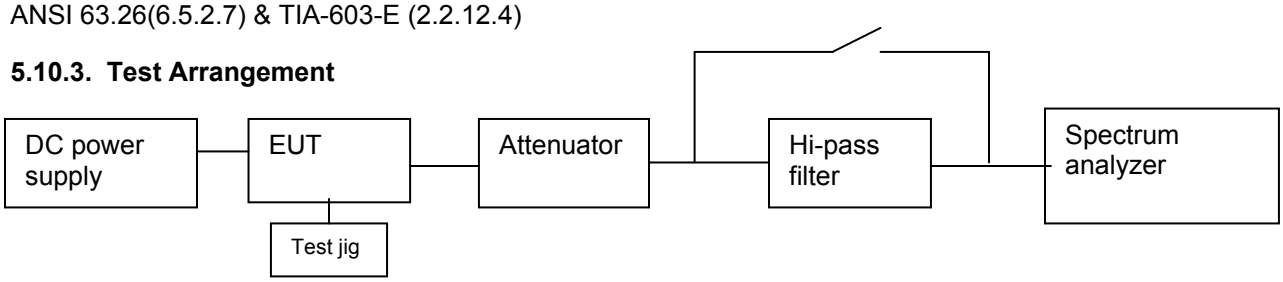
5.10.1. Limits

For operations in the 758-775 MHz and 788-805 MHz bands, all emissions including harmonics in the band 1559-1610 MHz shall be limited to −70 dBW/MHz equivalent isotropically radiated power (EIRP) for wideband signals, and −80 dBW EIRP for discrete emissions of less than 700 Hz bandwidth. For the purpose of equipment authorization, a transmitter shall be tested with an antenna that is representative of the type that will be used with the equipment in normal operation.

5.10.2. Method of Measurements

ANSI 63.26(6.5.2.7) & TIA-603-E (2.2.12.4)

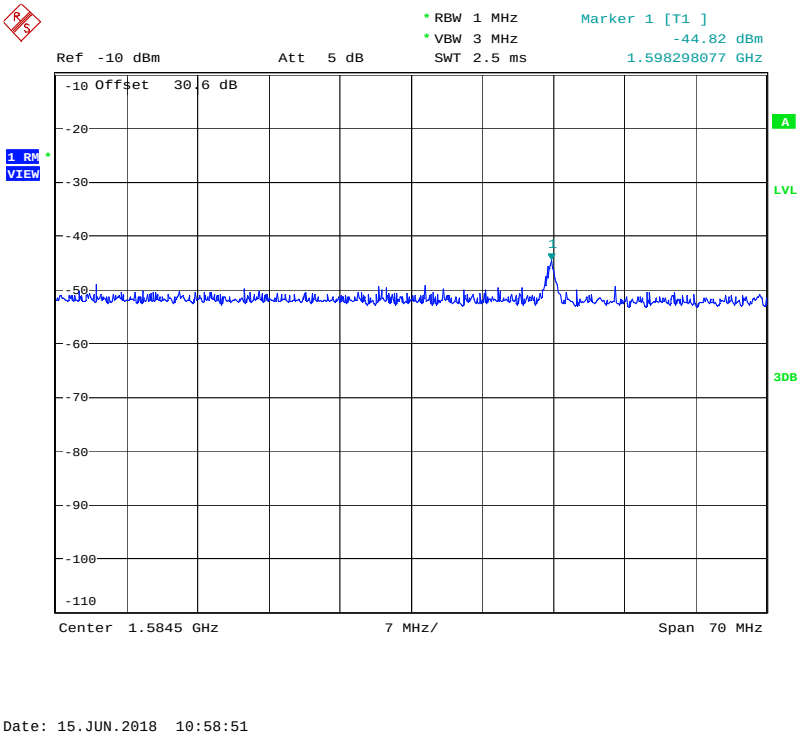
5.10.3. Test Arrangement



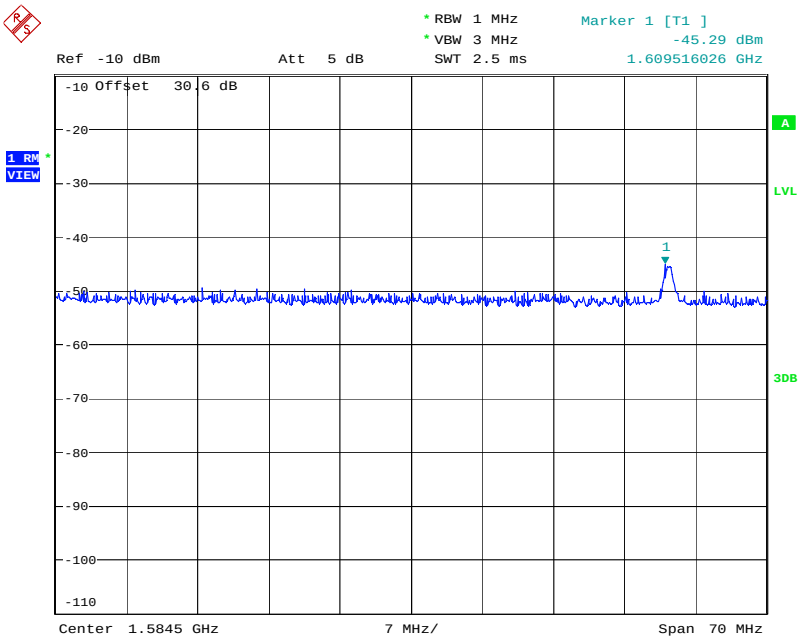
5.10.4. Test Data

Signal is Broadband so 1MHz Resolution BW used

5.10.4.1. Configuration: Tx Conducted Emission, Band 2: 799-805MHz, 799.1MHz, Digital, F1W, High power



5.10.4.2. Configuration: Tx Conducted Emission, Band 2: 799-805MHz, 804.9MHz, Digital, F1W, High power



Date: 15.JUN.2018 11:01:02

PSD(dBm/z)= Power(dBm)-10log(RBW)

Tx Frequency (MHz)	Measured Frequency (MHz)	Measured Level (dBm)	PSD (dBm/Hz)	PSD (dBW/MHz)	EIRP (dBW/MHz)	EIRP Limit (dBW/MHz)
799.1	1598.2	-44.82	-104.82	-74.82	-72.22	-70
804.9	1609.8	-45.29	-105.29	-75.29	-72.69	-70

5.11. ADJACENT CHANNEL POWER [§ 90.543]

5.11.1. Limits

§ 90.543 (a) The adjacent channel power (ACP) requirements for transmitters designed for various channel sizes are shown in the following tables. Mobile station requirements apply to handheld, car mounted and control station units. The tables specify a value for the ACP as a function of the displacement from the channel center frequency and measurement bandwidth. In the following tables, "(s)" indicates a swept measurement may be used.

12.5 kHz Mobile Transmitter ACP Requirements

Offset from center frequency (kHz)	Measurement bandwidth (kHz)	Maximum ACP relative (dBc)
9.375	6.25	−40
15.625	6.25	−60
21.875	6.25	−60
37.50	25.00	−60
62.50	25.00	−65
87.50	25.00	−65
150.00	100	−65
250.00	100	−65
350.00	100	−65
>400 to 12 MHz	30 (s)	−75
12 MHz to paired receive band	30 (s)	−75
In the paired receive band	30 (s)	−100

25 kHz Mobile Transmitter ACP Requirements

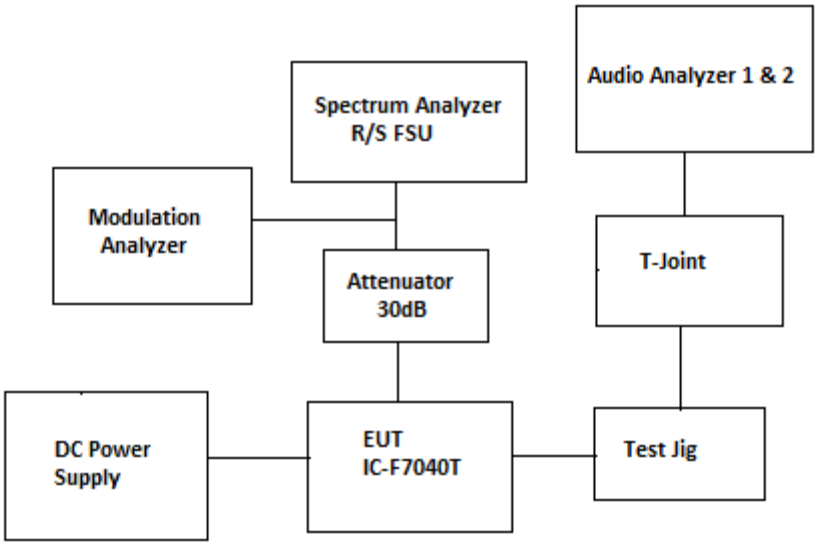
Offset from center frequency (kHz)	Measurement bandwidth (kHz)	Maximum ACP relative (dBc)
15.625	6.25	−40
21.875	6.25	−60
37.50	25	−60
62.50	25	−65
87.50	25	−65
150.00	100	−65
250.00	100	−65
350.00	100	−65
>400 kHz to 12 MHz	30 (s)	−75
12 MHz to paired receive band	30 (s)	−75
In the paired receive band	30 (s)	−100

5.11.2. Method of Measurements

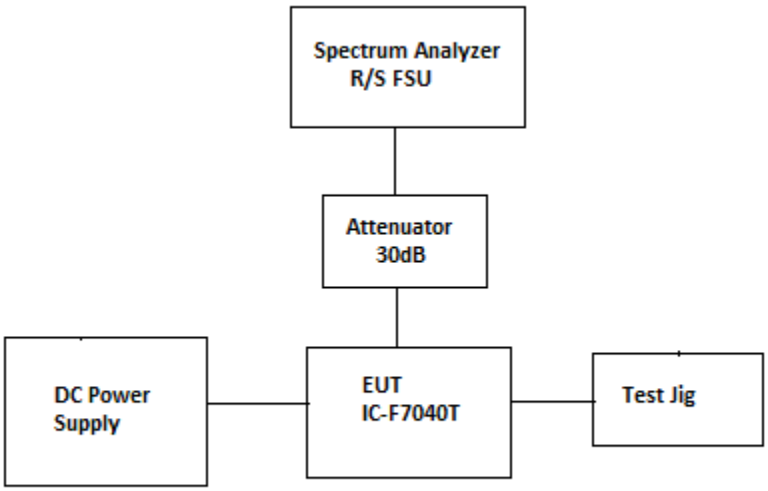
TIA-603-E and § 90.543

5.11.3. Test Arrangement

Test Setup (Analog)



Test Setup (Digital)



5.11.4. Test Data

Mode Frequency(MHz) Channel Spacing(KHz)		Analog 769.1 12.5			
Offset (KHz)	Resolution BW (Hz)	Measurement BW (KHz)	Lower ACP (dBc)	Upper ACP (dBc)	Maximum ACP Relative (dBc)
9.375	100	6.25	-51.00	-51.44	-40
15.625	100	6.25	-76.79	-76.04	-60
21.875	100	6.25	-76.71	-76.05	-60
37.5	300	25	-69.16	-69.45	-60
62.5	300	25	-69.24	-69.49	-65
87.5	300	25	-69.00	-68.89	-65
150	1000	100	-66.06	-66.5	-65
250	1000	100	-72.57	-72.54	-65
350	1000	100	-75.17	-75.79	-65
400	30000	30(Swept)	<-75	<-75	-75
12M	30000	30(Swept)	<-75	<-75	-75
In receive band	30000	30(Swept)	<-100	<-100	-100

Mode Frequency(MHz) Channel Spacing(KHz)		Analog 774.9 12.5			
Offset (KHz)	Resolution BW (Hz)	Measurement BW (KHz)	Lower ACP (dBc)	Upper ACP (dBc)	Maximum ACP Relative (dBc)
9.375	100	6.25	-51.82	-52.25	-40
15.625	100	6.25	-76.79	-76.81	-60
21.875	100	6.25	-76.02	-76.68	-60
37.5	300	25	-68.91	-69.24	-60
62.5	300	25	-69.02	-68.59	-65
87.5	300	25	-68.66	-68.74	-65
150	1000	100	-66.72	-66.25	-65
250	1000	100	-72.66	-73.30	-65
350	1000	100	-76.28	-75.93	-65
400	30000	30(Swept)	<-75	<-75	-75
12M	30000	30(Swept)	<-75	<-75	-75
In receive band	30000	30(Swept)	<-100	<-100	-100

Mode		Analog			
Frequency(MHz)		799.1			
Channel Spacing(KHz)		12.5			
Offset (KHz)	Resolution BW (Hz)	Measurement BW (KHz)	Lower ACP (dBc)	Upper ACP (dBc)	Maximum ACP Relative (dBc)
9.375	100	6.25	-51.16	-50.55	-40
15.625	100	6.25	-76.37	-76.76	-60
21.875	100	6.25	-75.95	-76.29	-60
37.5	300	25	-69.03	-68.49	-60
62.5	300	25	-68.43	-68.84	-65
87.5	300	25	-68.71	-69.34	-65
150	1000	100	-66.10	-66.71	-65
250	1000	100	-73.13	-72.88	-65
350	1000	100	-77.01	-76.97	-65
400	30000	30(Swept)	<-75	<-75	-75
12M	30000	30(Swept)	<-75	<-75	-75
In receive band	30000	30(Swept)	<-100	<-100	-100

Mode		Analog			
Frequency(MHz)		804.9			
Channel Spacing(KHz)		12.5			
Offset (KHz)	Resolution BW (Hz)	Measurement BW (KHz)	Lower ACP (dBc)	Upper ACP (dBc)	Maximum ACP Relative (dBc)
9.375	100	6.25	-49.85	-50.47	-40
15.625	100	6.25	-75.17	-75.03	-60
21.875	100	6.25	-75.13	-74.82	-60
37.5	300	25	-68.95	-68.53	-60
62.5	300	25	-68.19	-68.53	-65
87.5	300	25	-68.09	-67.99	-65
150	1000	100	-66.09	-66.45	-65
250	1000	100	-71.80	-72.96	-65
350	1000	100	-75.18	-75.83	-65
400	30000	30(Swept)	<-75	<-75	-75
12M	30000	30(Swept)	<-75	<-75	-75
In receive band	30000	30(Swept)	<-100	<-100	-100

Mode Frequency(MHz) Channel Spacing(KHz)		Digital F1E&F1D 769.1 12.5			
Offset (KHz)	Resolution BW (Hz)	Measurement BW (KHz)	Lower ACP (dBc)	Upper ACP (dBc)	Maximum ACP Relative (dBc)
9.375	100	6.25	-41.54	-42.52	-40
15.625	100	6.25	-78.01	-77.87	-60
21.875	100	6.25	-77.09	-77.54	-60
37.5	300	25	-68.14	-68.25	-65
62.5	300	25	-67.96	-68.09	-65
87.5	300	25	-68.44	-67.77	-65
150	1000	100	-66.10	-66.35	-65
250	1000	100	-72.15	-72.37	-65
350	1000	100	-74.78	-75.60	-65
400	30000	30(Swept)	<-75	<-75	-75
12M	30000	30(Swept)	<-75	<-75	-75
In receive band	30000	30(Swept)	<-100	<-100	-100

Mode Frequency(MHz) Channel Spacing(KHz)		Digital F1E&F1D 774.9 12.5			
Offset (KHz)	Resolution BW (Hz)	Measurement BW (KHz)	Lower ACP (dBc)	Upper ACP (dBc)	Maximum ACP Relative (dBc)
9.375	100	6.25	-41.54	-44.48	-40
15.625	100	6.25	-78.53	-77.25	-60
21.875	100	6.25	-77.15	-77.32	-60
37.5	300	25	-68.43	-68.65	-65
62.5	300	25	-68.08	-68.52	-65
87.5	300	25	-68.49	-68.45	-65
150	1000	100	-66.37	-66.72	-65
250	1000	100	-72.87	-72.43	-65
350	1000	100	-75.39	-75.46	-65
400	30000	30(Swept)	<-75	<-75	-75
12M	30000	30(Swept)	<-75	<-75	-75
In receive band	30000	30(Swept)	<-100	<-100	-100

Mode Frequency(MHz) Channel Spacing(KHz)		Digital F1E&F1D 799.1 12.5			
Offset (KHz)	Resolution BW (Hz)	Measurement BW (KHz)	Lower ACP (dBc)	Upper ACP (dBc)	Maximum ACP Relative (dBc)
9.375	100	6.25	-41.82	-41.68	-40
15.625	100	6.25	-76.03	-76.97	-60
21.875	100	6.25	-76.56	-76.48	-60
37.5	300	25	-68.9	-68.81	-65
62.5	300	25	-68.43	-68.65	-65
87.5	300	25	-68.59	-69.16	-65
150	1000	100	-66.2	-66.63	-65
250	1000	100	-72.74	-72.33	-65
350	1000	100	-75.15	-76.13	-65
400	30000	30(Swept)	<-75	<-75	-75
12M	30000	30(Swept)	<-75	<-75	-75
In receive band	30000	30(Swept)	<-100	<-100	-100

Mode Frequency(MHz) Channel Spacing(KHz)		Digital F1E&F1D 804.9 12.5			
Offset (KHz)	Resolution BW (Hz)	Measurement BW (KHz)	Lower ACP (dBc)	Upper ACP (dBc)	Maximum ACP Relative (dBc)
9.375	100	6.25	-42.68	-41.73	-40
15.625	100	6.25	-76.94	-77.19	-60
21.875	100	6.25	-75.95	-76.56	-60
37.5	300	25	-68.33	-68.03	-65
62.5	300	25	-68.29	-68.03	-65
87.5	300	25	-67.76	-67.96	-65
150	1000	100	-66.24	-66.05	-65
250	1000	100	-72.29	-72.33	-65
350	1000	100	-74.56	-75.18	-65
400	30000	30(Swept)	<-75	<-75	-75
12M	30000	30(Swept)	<-75	<-75	-75
In receive band	30000	30(Swept)	<-100	<-100	-100

Mode Frequency(MHz) Channel Spacing(KHz)		Digital F1W 769.1 12.5			
Offset (KHz)	Resolution BW (Hz)	Measurement BW (KHz)	Lower ACP (dBc)	Upper ACP (dBc)	Maximum ACP Relative (dBc)
9.375	100	6.25	-43.76	-44.17	-40
15.625	100	6.25	-75.34	-74.20	-60
21.875	100	6.25	-77.99	-78.63	-60
37.5	300	25	-69.86	-69.71	-65
62.5	300	25	-69.91	-69.42	-65
87.5	300	25	-69.75	-69.48	-65
150	1000	100	-66.36	-66.39	-65
250	1000	100	-73.22	-73.00	-65
350	1000	100	-75.49	-75.64	-65
400	30000	30(Swept)	<-75	<-75	-75
12M	30000	30(Swept)	<-75	<-75	-75
In receive band	30000	30(Swept)	<-100	<-100	-100

Mode Frequency(MHz) Channel Spacing(KHz)		Digital F1W 774.9 12.5			
Offset (KHz)	Resolution BW (Hz)	Measurement BW (KHz)	Lower ACP (dBc)	Upper ACP (dBc)	Maximum ACP Relative (dBc)
9.375	100	6.25	-42.00	-42.90	-40
15.625	100	6.25	-74.26	-72.39	-60
21.875	100	6.25	-77.29	-77.80	-60
37.5	300	25	-69.33	-69.17	-65
62.5	300	25	-68.43	-69.32	-65
87.5	300	25	-68.82	-68.85	-65
150	1000	100	-65.83	-66.53	-65
250	1000	100	-71.91	-72.07	-65
350	1000	100	-75.16	-75.35	-65
400	30000	30(Swept)	<-75	<-75	-75
12M	30000	30(Swept)	<-75	<-75	-75
In receive band	30000	30(Swept)	<-100	<-100	-100

Mode Frequency(MHz) Channel Spacing(KHz)		Digital F1W 799.1 12.5			
Offset (KHz)	Resolution BW (Hz)	Measurement BW (KHz)	Lower ACP (dBc)	Upper ACP (dBc)	Maximum ACP Relative (dBc)
9.375	100	6.25	-42.23	-43.45	-40
15.625	100	6.25	-73.40	-71.09	-60
21.875	100	6.25	-76.48	-76.85	-60
37.5	300	25	-69.29	-68.94	-65
62.5	300	25	-69.33	-68.92	-65
87.5	300	25	-69.42	-68.69	-65
150	1000	100	-66.37	-66.97	-65
250	1000	100	-72.39	-73.10	-65
350	1000	100	-76.80	-76.08	-65
400	30000	30(Swept)	<-75	<-75	-75
12M	30000	30(Swept)	<-75	<-75	-75
In receive band	30000	30(Swept)	<-100	<-100	-100

Mode Frequency(MHz) Channel Spacing(KHz)		Digital F1W 804.9 12.5			
Offset (KHz)	Resolution BW (Hz)	Measurement BW (KHz)	Lower ACP (dBc)	Upper ACP (dBc)	Maximum ACP Relative (dBc)
9.375	100	6.25	-44.03	-43.37	-40
15.625	100	6.25	-74.97	-72.73	-60
21.875	100	6.25	-76.74	-76.99	-60
37.5	300	25	-68.85	-68.40	-65
62.5	300	25	-68.26	-68.40	-65
87.5	300	25	-68.01	-68.48	-65
150	1000	100	-65.83	-66.35	-65
250	1000	100	-72.00	-72.26	-65
350	1000	100	-74.37	-74.83	-65
400	30000	30(Swept)	<-75	<-75	-75
12M	30000	30(Swept)	<-75	<-75	-75
In receive band	30000	30(Swept)	<-100	<-100	-100

5.12. TRANSMITTER SPURIOUS/HARMONIC RADIATED EMISSIONS [§§ 2.1053, 2.1057, 22.359, & 90.210]

5.12.1. Limits

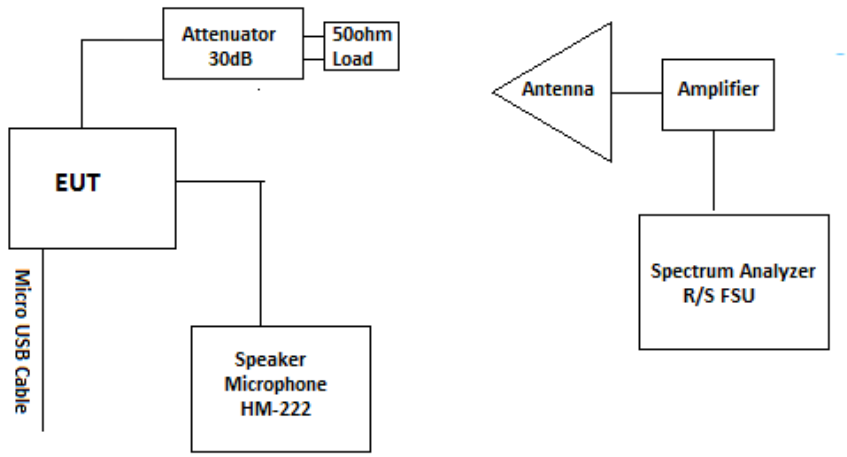
Emissions shall be attenuated below the mean output power of the transmitter as follows:

FCC Rules	Attenuation Limit (dBc)
§ 90.210(b)	At least 43 + 10 log (P) dB.
§ 90.210(d)	At least 50 + 10 log (P) dB or 70 dB, whichever is the lesser attenuation.
§ 90.543(b)	At least 43 + 10 log (P) dB

5.12.2. Method of Measurements

The spurious/harmonic ERP measurements are using substitution method specified in Section 8.2 of this report.

5.12.3. Test Arrangement



5.12.4. Test Data

Remarks:

- The RF spurious/harmonic emission characteristics for different channel spacing are indistinguishable. Therefore, the following radiated emissions were performed at 12.5 kHz channel spacing Digital F1W operation,
- The radiated emissions were performed with high power setting at 3 m distance to represents the worst-case test configuration.
- The emissions were scanned from 30 MHz to 10th harmonics; all spurious emissions that are in excess of 20dB below the specified limit shall be recorded.

5.12.4.1. Near Lowest Frequency (769.1MHz) –Band 1

Test Frequency (MHz):	769.1					
Power $_{conducted}$ (dBm):	34.51					
Limit (dBm):	-13.0					
Frequency (MHz)	**E-Field (dBµV/m)**	**EMI Detector (Peak/QP)**	**Antenna Polarization (H/V)**	**ERP Measured (dBm)**	**Limit (dBm)**	**Margin (dB)**
1538.2	64.85	PEAK	V	-32.39	-13.0	-19.39
1538.2	67.60	PEAK	H	-29.59	-13.0	-16.59
All other emissions are more than 20 dB below the limit line.						

5.12.4.2. Near Highest Frequency (774.9MHz) –Band 1

Test Frequency (MHz):	774.9					
Power $_{conducted}$ (dBm):	34.51					
Limit (dBm):	-13.0					
Frequency (MHz)	**E-Field (dBµV/m)**	**EMI Detector (Peak/QP)**	**Antenna Polarization (H/V)**	**ERP Measured (dBm)**	**Limit (dBm)**	**Margin (dB)**
1549.8	67.31	PEAK	V	-29.69	-13.0	-16.69
All other emissions are more than 20 dB below the limit line.						

5.12.4.3. Near Lowest Frequency (799.1 MHz) –Band 2

Test Frequency (MHz):	799.1					
Power $_{conducted}$ (dBm):	34.52					
Limit (dBm):	-13.0					
Frequency (MHz)	**E-Field (dBµV/m)**	**EMI Detector (Peak/QP)**	**Antenna Polarization (H/V)**	**ERP Measured (dBm)**	**Limit (dBm)**	**Margin (dB)**
All emissions are more than 20 dB below the limit line.						

5.12.4.4. Near Highest Frequency (804.9MHz) –Band 2

Test Frequency (MHz):	804.9					
Power $_{conducted}$ (dBm):	34.52					
Limit (dBm):	-13.0					
Frequency (MHz)	**E-Field (dBµV/m)**	**EMI Detector (Peak/QP)**	**Antenna Polarization (H/V)**	**ERP Measured (dBm)**	**Limit (dBm)**	**Margin (dB)**
All emissions are more than 20 dB below the limit line.						

5.12.4.5. Near Lowest Frequency (806.1MHz) –Band 3

Test Frequency (MHz):	806.1					
Power $_{conducted}$ (dBm):	34.91					
Limit (dBm):	-13.0					
Frequency (MHz)	E-Field (dBµV/m)	EMI Detector (Peak/QP)	Antenna Polarization (H/V)	ERP Measured (dBm)	Limit (dBm)	Margin (dB)
1612.2	65.6	PEAK	H	-31.73	-13.0	-18.73
All other emissions are more than 20 dB below the limit line.						

5.12.4.6. Near Middle Frequency (815.1 MHz) –Band 3

Test Frequency (MHz):	815.1					
Power $_{conducted}$ (dBm):	34.91					
Limit (dBm):	-13.0					
Frequency (MHz)	E-Field (dBµV/m)	EMI Detector (Peak/QP)	Antenna Polarization (H/V)	ERP Measured (dBm)	Limit (dBm)	Margin (dB)
1630.2	68.37	PEAK	H	-29.33	-13.0	-16.33
All other emissions are more than 20 dB below the limit line.						

5.12.4.7. Near Highest Frequency (823.9MHz) –Band 3

Test Frequency (MHz):	823.9					
Power $_{conducted}$ (dBm):	34.90					
Limit (dBm):	-13.0					
Frequency (MHz)	E-Field (dBµV/m)	EMI Detector (Peak/QP)	Antenna Polarization (H/V)	ERP Measured (dBm)	Limit (dBm)	Margin (dB)
1647.8	66.19	PEAK	V	-30.43	-13.0	-17.43
1647.8	66.30	PEAK	H	-30.33	-13.0	-17.33
All other emissions are more than 20 dB below the limit line.						

5.12.4.8. Near Lowest Frequency (851.1MHz) –Band 4

Test Frequency (MHz):		**851.1**				
Power $_{conducted}$ (dBm):		34.87				
Limit (dBm):		-13.0				
Frequency (MHz)	**E-Field (dBµV/m)**	**EMI Detector (Peak/QP)**	**Antenna Polarization (H/V)**	**ERP Measured (dBm)**	**Limit (dBm)**	**Margin (dB)**
All emissions are more than 20 dB below the limit line.						

5.12.4.9. Near Middle Frequency (860.1 MHz) –Band 4

Test Frequency (MHz):		**860.1**				
Power $_{conducted}$ (dBm):		34.88				
Limit (dBm):		-13.0				
Frequency (MHz)	**E-Field (dBµV/m)**	**EMI Detector (Peak/QP)**	**Antenna Polarization (H/V)**	**ERP Measured (dBm)**	**Limit (dBm)**	**Margin (dB)**
All emissions are more than 20 dB below the limit line.						

5.12.4.10. Near Highest Frequency (868.9 MHz) –Band 4

Test Frequency (MHz):		**868.9**				
Power $_{conducted}$ (dBm):		34.87				
Limit (dBm):		-13.0				
Frequency (MHz)	**E-Field (dBµV/m)**	**EMI Detector (Peak/QP)**	**Antenna Polarization (H/V)**	**ERP Measured (dBm)**	**Limit (dBm)**	**Margin (dB)**
All emissions are more than 20 dB below the limit line.						

5.13. FREQUENCY STABILITY [§§ 2.1055, 22.355 & 90.213]

5.13.1. Limits

§ 90.213 Transmitters used must have minimum frequency stability as specified in the following table.

Frequency Range (MHz)	Channel Bandwidth (KHz)	Frequency Tolerance (ppm)		
		Fixed and Base Stations	Mobile Stations	
			> 2 W	≤ 2 W
150-174 MHz	6.25 12.5 25	1.0 2.5 5.0	2.0 5.0 5.0	2.0 5.0 50.0*
421-512 MHz	6.25 12.5 25	0.5 1.5 2.5	1.0 2.5 5.0	1.0 2.5 5.0

- Stations operating in the 154.45 to 154.49 MHz or the 173.2 to 173.4 MHz bands must have a frequency stability of 5 ppm.
- Paging transmitters operating on paging-only frequencies must operate with frequency stability of 5 ppm in the 150-174 MHz band and 2.5 ppm in the 421-512 MHz band.

§ 22.355 Transmitters used must have minimum frequency stability as specified in the following table.

TABLE C–1—FREQUENCY TOLERANCE FOR TRANSMITTERS IN THE PUBLIC MOBILE SERVICES

Frequency range (MHz)	Base, fixed (ppm)	Mobile ≤3 watts (ppm)	Mobile ≤3 watts (ppm)
25 to 50	20.0	20.0	50.0
50 to 450	5.0	5.0	50.0
450 to 512	2.5	5.0	5.0
821 to 896	1.5	2.5	2.5
928 to 929	5.0	n/a	n/a
929 to 960	1.5	n/a	n/a
2110 to 2220	10.0	n/a	n/a

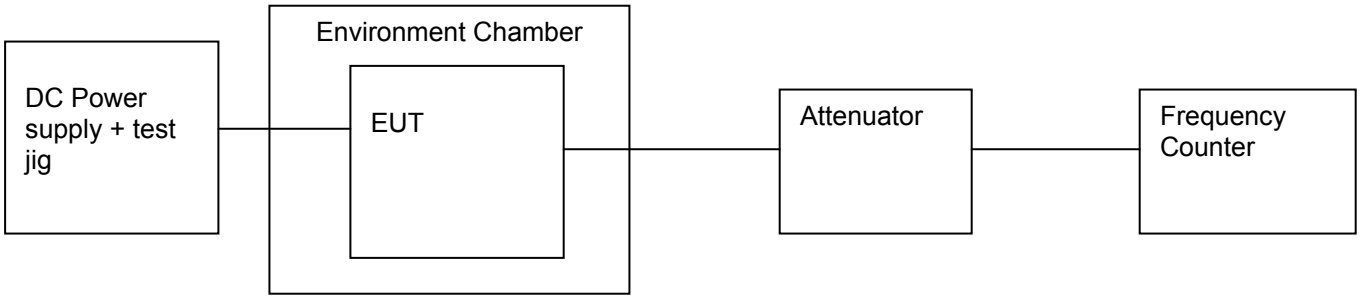
§ 74.464 - For operations on frequencies above 25 MHz using authorized bandwidths up to 30 kHz, the licensee of a remote pickup broadcast station or system shall maintain the operating frequency of each station in compliance with the frequency tolerance requirements of §90.213 of this chapter. For all other operations, the licensee of a remote pickup broadcast station or system shall maintain the operating frequency of each station in accordance with the following:

Frequency range	Tolerance (percent)	
	Base station	Mobile station
25 to 30 MHz:		
3 W or less	.002	.005
Over 3 W	.002	.002
30 to 300 MHz:		
3 W or less	.0005	.005
Over 3 W	.0005	.0005
300 to 500 MHz, all powers	.00025	.0005

5.13.2. Method of Measurements

Refer to Section 8.3 of this report for measurement details

5.13.3. Test Arrangement



5.13.4. Test Data

BAND 1

Test Frequency:	**769.1 MHz**
Full Power Level:	2.82 W
Frequency Tolerance Limit:	± 1.0 ppm or ± 769.1 Hz
Max. Frequency Tolerance Measured:	461 Hz or 0.60 ppm
Input Voltage Rating:	7.5 VDC (nominal)

Ambient Temperature (°C)	**Frequency Drift (Hz)**		
	Supply Voltage (Nominal) 7.5 VDC	**Supply Voltage (Battery end point) 5.9 Vdc**	**Supply Voltage(+15%) 8.62 Vdc**
-30	461	--	--
-20	415	--	--
-10	405	--	--
0	379	--	--
10	357	--	--
20	-186	145	-204
30	-206	--	--
40	-205	--	--
50	-205	--	--
60	-225	--	--

BAND 2

Test Frequency:	**799.1 MHz**
Full Power Level:	2.83 W
Frequency Tolerance Limit:	± 1.0 ppm or ± 799.1 Hz
Max. Frequency Tolerance Measured:	466 Hz or 0.58 ppm
Input Voltage Rating:	7.5 VDC (nominal)

Ambient Temperature (°C)	Frequency Drift (Hz)		
	Supply Voltage (Nominal) 7.5 VDC	Supply Voltage (Battery end point) 5.9 Vdc	Supply Voltage(+15%) 8.62 Vdc
-30	466	--	--
-20	445	--	--
-10	421	--	--
0	384	--	--
10	337	--	--
20	-149	212	-212
30	-213	--	--
40	-223	--	--
50	-229	--	--
60	-150	--	--

BAND 3

Test Frequency:	**806.1 MHz**
Full Power Level:	3.1 W
Frequency Tolerance Limit:	± 1.0 ppm or ± 806.1 Hz
Max. Frequency Tolerance Measured:	249 Hz or 0.31 ppm
Input Voltage Rating:	7.5 VDC (nominal)

Ambient Temperature (°C)	Frequency Drift (Hz)		
	Supply Voltage (Nominal) 7.5 VDC	Supply Voltage (Battery end point) 5.9 Vdc	Supply Voltage(+15%) 8.62 Vdc
-30	249	--	--
-20	213	--	--
-10	176	--	--
0	114	--	--
10	-68	--	--
20	-80	-78	-81
30	-90	--	--
40	-116	--	--
50	-112	--	--
60	-176	--	--

BAND 4

Test Frequency:	**851.1 MHz**
Full Power Level:	3.07 W
Frequency Tolerance Limit:	± 1.0 ppm or ± 851.1 Hz
Max. Frequency Tolerance Measured:	448 Hz or 0.53 ppm
Input Voltage Rating:	7.5 VDC (nominal)

Ambient Temperature (°C)	**Frequency Drift (Hz)**		
	Supply Voltage (Nominal) 7.5 VDC	**Supply Voltage (Battery end point) 5.9 Vdc**	**Supply Voltage(+15%) 8.62 Vdc**
-30	423	--	--
-20	448	--	--
-10	394	--	--
0	385	--	--
10	312	--	--
20	-143	153	-230
30	-245	--	--
40	-266	--	--
50	-266	--	--
60	-244	--	--

EXHIBIT 6. TEST EQUIPMENT LIST

Test Instrument	Manufacturer	Model No	Serial No	Frequency Range	Cal Due date
Power Meter	HP	436A	2709A27515	100KHz-sensor dependant	04 May 2019
Power Sensor	HP	8482A	MY41172054	10MHz-4GHz	26 Oct 2019
Attenuator(30dB)	Aeroflex\Weinschel	46-30-34	BR9127	DC-18GHz	Cal on use
Power Supply	Tenma	72-7295	490300297	1-40V, DC 5A	----
Modulation Analyzer	HP	HP-8901B	3226A04606	150KHz-1300MHz	23 Mar 2020
AF Signal Generator	HP	HP-8920B	US39064699	30MHz-1GHz	20 Mar 2020
Digital Voltmeter	HP	3456A	2015A04523		19 Dec 2019
FFT Digital Spectrum Analyzer	Advantest	R9211E	8202336	10MHz-100KHz	13 Sep 2018
Signal Generator	Marconi	2024	112255/164	9KHz-2.4GHz	16 Aug 2018
Spectrum Analyzer	Rohde & Schwarz	FSU	100398	20Hz-26.5GHz	06 Oct 2019
Hi-pass filter	K&L	11SH10-1500/T8000-0/0	2	Cut off 1500MHz	Cal on use
Combiner	Weinschel 93458	1515	PS119	DC-18GHz	Cal on use
Dual Channel Arbitrary Waveform Generator	Kuman	FY6600-60M	170966000106	DC-60MHz	02 Apr 2020
Bicon Antenna	ETS-Lindgren	3110B	3379	30-200MHz	06 Feb 2020
Dipole	ETS-Lindgren	3121C-DB1	434	400-1000	20 Jul 2018
Log Periodic Antenna	ETS-Lindgren	3148	00023845	200-2000MHz	20 Jul 2018
Horn Antenna	ETS-Lindgren	3115	6570	1-18GHz	13 Oct 2018
Horn Antenna	ETS-Lindgren	3117	00119425	1-18GHz	29 Jun 2019
Preamplifier	Com-Power	PAM-118A	551016	500MHz-18GHz	09 Mar 2019
Preamplifier	Com-Power	PA-103	161040	1-1000MHz	16 May 2019
Frequency Counter	EIP	545A	2683	10MHz-1GHz	20 Jul 2018
Attenuator(20dB)	Aeroflex\Weinschel	34-20-34	BP6023	DC-18GHz	Cal on use
Attenuator(20dB)	Weinschel	WA 35-20-33	A164	DC-8.5GHz	Cal on use
Multimeter	Tenma	72-6202	02080027	---	14 Dec 2019
Multimeter	Fluke	8842A	5021295	---	23 Oct 2019
Environmental Chamber	Envirotronics	SSH32C	11994847-S-11059	-60 to 177° C	15 Jun 2019

EXHIBIT 7. MEASUREMENT UNCERTAINTY

The measurement uncertainties stated were calculated in accordance with the requirements of CISPR 16-4-2 @ IEC:2003 and JCGM 100:2008 (GUM 1995) – Guide to the Expression of Uncertainty in Measurement.

7.1. RADIATED EMISSION MEASUREMENT UNCERTAINTY

	Radiated Emission Measurement Uncertainty @ 3m, Horizontal (30-1000 MHz):	**Measured**	**Limit**
u_c	**Combined standard uncertainty:** $u_c(y) = \sqrt{\sum_{I=1}^{m} u_i^2(y)}$	**± 2.15**	**± 2.6**
U	**Expanded uncertainty U:** $U = 2u_c(y)$	**± 4.30**	**± 5.2**

	Radiated Emission Measurement Uncertainty @ 3m, Vertical (30-1000 MHz):	**Measured**	**Limit**
u_c	**Combined standard uncertainty:** $u_c(y) = \sqrt{\sum_{I=1}^{m} u_i^2(y)}$	**± 2.39**	**± 2.6**
U	**Expanded uncertainty U:** $U = 2u_c(y)$	**± 4.78**	**± 5.2**

	Radiated Emission Measurement Uncertainty @ 3 m, Horizontal & Vertical (1 – 18 GHz):	**Measured**	**Limit**
u_c	**Combined standard uncertainty:** $u_c(y) = \sqrt{\sum_{I=1}^{m} u_i^2(y)}$	**± 1.87**	**Under consideration**
U	**Expanded uncertainty U:** $U = 2u_c(y)$	**± 3.75**	**Under consideration**

EXHIBIT 8. MEASUREMENT METHODS

8.1. CONDUCTED POWER MEASUREMENTS

- The following shall be applied to the combination(s) of the radio device and its intended antenna(e).
- I f the RF level is user adjustable, all measurements shall be made with the highest power level available to the user for that combination.
- The following method of measurement shall apply to both conducted and radiated measurements.
- The radiated measurements are performed at the Ultratech Calibrated Open Field Test Site.
- The measurement shall be performed using normal operation of the equipment with modulation.

Test procedure shall be as follows:

Step 1: Duty Cycle measurements if the transmitter's transmission is transient

- Using a EMI Receiver with the frequency span set to 0 Hz and the sweep time set at a suitable value to capture the envelope peaks and the duty cycle of the transmitter output signal;
- The duty cycle of the transmitter, x = Tx on / (Tx on + Tx off) with 0<x<1, is measure and recorded in the test report. For the purpose of testing, the equipment shall be operated with a duty cycle that is equal or more than 0.1.

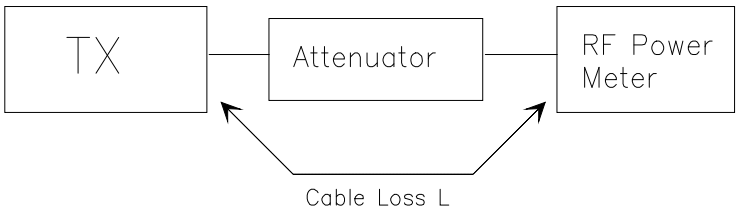
Step 2: Calculation of Average EIRP. See Figure 1

- The average output power of the transmitter shall be determined using a wideband, calibrated RF average power meter with the power sensor with an integration period that exceeds the repetition period of the transmitter by a factor 5 or more. The observed value shall be recorded as "A" (in dBm);
- The e.i.r.p. shall be calculated from the above measured power output "A", the observed duty cycle x, and the applicable antenna assembly gain "G" in dBi, according to the formula:

  EIRP = A + G + 10log(1/x)

  {X = 1 for continuous transmission => 10log(1/x) = 0 dB}

  Figure 1.



8.2. RADIATED POWER MEASUREMENTS (ERP & EIRP) USING SUBSTITUTION METHOD

8.2.1. MAXIMIZING RF EMISSION LEVEL (E-FIELD)

(a) The measurements were performed with full rf output power and modulation.
(b) Test was performed at listed 3m open area test site (listed with FCC, IC, ITI, NVLAP, ACA & VCCI).
(c) The transmitter under test was placed at the specified height on a non-conducting turntable (80 cm height)
(d) The BICONILOG antenna (20 MHz to 1 GHz) or HORN antenna (1 GHz to 18 GHz) was used for measuring.
(e) Load an appropriate correction factors file in EMI Receiver for correcting the field strength reading level

Total Correction Factor recorded in the EMI Receiver = Cable Loss + Antenna Factor
E (dBμV/m) = Reading (dBμV) + Total Correction Factor (dB/m)

(f) Set the EMI Receiver and #2 as follows:

Center Frequency:	test frequency
Resolution BW:	100 KHz
Video BW:	same
Detector Mode:	positive
Average:	off
Span:	3 x the signal bandwidth

(g) The test antenna was lowered or raised from 1 to 4 meters until the maximum signal level was detected.
(h) The transmitter was rotated through 360° about a vertical axis until a higher maximum signal was received.
(i) The test antenna was lowered or raised again from 1 to 4 meters until a maximum was obtained. This level was recorded.
(j) The recorded reading was corrected to the true field strength level by adding the antenna factor, cable loss and subtracting the pre-amplifier gain.
(k) The above steps were repeated with both transmitters' antenna and test receiving antenna placed in vertical and horizontal polarization. Both readings with the antennas placed in vertical and horizontal polarization shall be recorded.
(l) Repeat for all different test signal frequencies.

8.2.2. Measuring the EIRP of Spurious/Harmonic Emissions using Substitution Method

(a) Set the EMI Receiver (for measuring E-Field) and Receiver #2 (for measuring EIRP) as follows:

Center Frequency:	equal to the signal source
Resolution BW:	100 KHz
Video BW:	VBW > RBW
Detector Mode:	positive
Average:	off
Span:	3 x the signal bandwidth

(b) Load an appropriate correction factors file in EMI Receiver for correcting the field strength reading level

Total Correction Factor recorded in the EMI Receiver = Cable Loss + Antenna Factor
E (dBuV/m) = Reading (dBuV) + Total Correction Factor (dB/m)

(c) Select the frequency and E-field levels obtained in the Section 8.2.1 for ERP/EIRP measurements.
(d) Substitute the EUT by a signal generator and one of the following transmitting antenna (substitution antenna):
- DIPOLE antenna for frequency from 30-1000 MHz or
- HORN antenna for frequency above 1 GHz }.

(e) Mount the transmitting antenna at 1.5 meter high from the ground plane.
(f) Use one of the following antenna as a receiving antenna:
- DIPOLE antenna for frequency from 30-1000 MHz or
- HORN antenna for frequency above 1 GHz }.

(g) If the DIPOLE antenna is used, tune it's elements to the frequency as specified in the calibration manual.
(h) Adjust both transmitting and receiving antenna in a VERTICAL polarization.
(i) Tune the EMI Receivers to the test frequency.
(j) Lower or raise the test antenna from 1 to 4 meters until the maximum signal level was detected.
(k) The transmitter was rotated through 360° about a vertical axis until a higher maximum signal was received.
(l) Lower or raise the test antenna from 1 to 4 meters until the maximum signal level was detected.
(m) Adjust input signal to the substitution antenna until an equal or a known related level to that detected from the transmitter was obtained in the test receiver.
(n) Record the power level read from the Average Power Meter and calculate the ERP/EIRP as follows:

P = P1 - L1 = (P2 + L2) – L1 = P3 + A + L2 - L1
EIRP = P + G1 = P3 + L2 - L1 + A + G1
ERP = EIRP – 2.15 dB
Total Correction factor in EMI Receiver # 2 = L2 – L1 + G1

Where:	P:	Actual RF Power fed into the substitution antenna port after corrected.
	P1:	Power output from the signal generator
	P2:	Power measured at attenuator A input
	P3:	Power reading on the Average Power Meter
	EIRP:	EIRP after correction
	ERP:	ERP after correction

(o) Adjust both transmitting and receiving antenna in a HORIZONTAL polarization, then repeat step (k) to (o)
(p) Repeat step (d) to (o) for different test frequency
(q) Repeat steps (c) to (j) with the substitution antenna oriented in horizontal polarization.
(r) Actual gain of the EUT's antenna is the difference of the measured EIRP and measured RF power at the RF port. Correct the antenna gain if necessary.

Figure 2

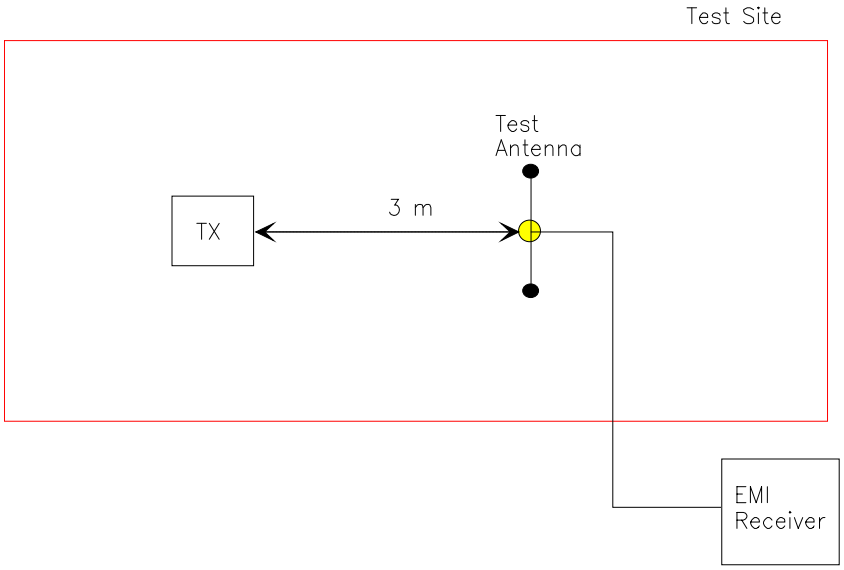
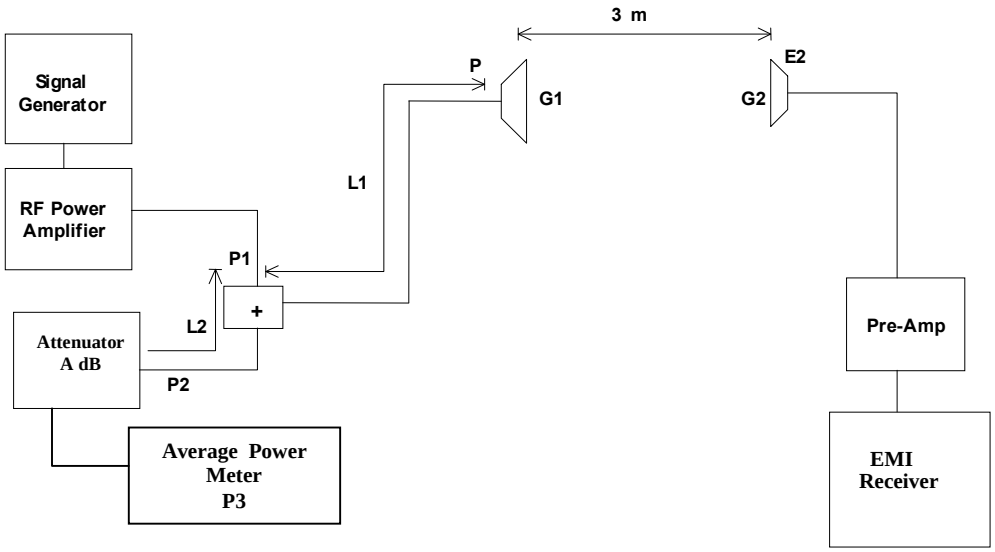


Figure 3



8.3. FREQUENCY STABILITY

Refer to FCC @ 2.1055.

(a) The frequency stability shall be measured with variation of ambient temperature as follows: From -30 to +50 centigrade except that specified in subparagraph (2) & (3) of this paragraph.

(b) Frequency measurements shall be made at extremes of the specified temperature range and at intervals of not more than 10 centigrade through the range. A period of time sufficient to stabilize all of the components of the oscillator circuit at each temperature level shall be allowed prior to frequency measurement. The short-term transient effects on the frequency of the transmitter due to keying (except for broadcast transmitters) and any heating element cycling normally occurring at each ambient temperature level also shall be shown. Only the portion or portions of the transmitter containing the frequency determining and stability circuitry need be subjected to the temperature variation test.

(d) The frequency stability supply shall be measured with variation of primary supply voltage as follows:

(1) Vary primary supply voltage from 85 to 115 percent of the nominal value for other than hand carried battery equipment.

(2) For hand carried, battery powered equipment, reduce primary supply voltage to the battery operating end point which shall be specified by the manufacturer.

(3) The supply voltage shall be measured at the input to the cable normally provide with the equipment, or at the power supply terminals if cables are not normally provided. Effects on frequency of transmitter keying (except for broadcast transmitters) and any heating element cycling at the nominal supply voltage and at each extreme also shall be shown.

(e) When deemed necessary, the Commission may require tests of frequency stability under conditions in addition to those specifically set out in paragraphs (a), (b), (c) and (d) of this section. (For example, measurements showing the effect of proximity to large metal objects, or of various types of antennas, may be required for portable equipment).

8.4. EMISSION MASK

Voice or Digital Modulation Through a Voice Input Port @ 2.1049(c)(i):- The transmitter was modulated by a 2.5 KHz tone signal at an input level 16 dB greater than that required to produce 50% modulation (e.g.: ±2.5 KHz peak deviation at 1 KHz modulating frequency). The input level was established at the frequency of maximum response of the audio modulating circuit.

Digital Modulation Through a Data Input Port @ 2.1049(h):- Transmitters employing digital modulation techniques - when modulated by an input signal such that its amplitude and symbol rate represent the maximum rated conditions under which the equipment will be operated. The signal shall be applied through any filter networks, pseudo-random generators or other devices required in normal service. Additionally, the Emission Masks shall be shown for operation with any devices used for modifying the spectrum when such devices are operational at the discretion of the user.

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

(1) For 25 KHz Channel Spacing: RBW = 300 Hz
(2) For 12.5 KHz or 6.25 KHz Channel Spacings: RBW = 100 Hz

The all cases the Video Bandwidth shall be equal or greater than the measuring bandwidth.

8.5. SPURIOUS EMISSIONS (CONDUCTED)

With transmitter modulation characteristics described in Out-of-Band Emissions measurements @ 2.1049, the transmitter spurious and harmonic emissions were scanned. The spurious and harmonic emissions were measured with the EMI Receiver controls set as RBW = 30 KHz minimum , VBW ≥ RBW and SWEEP TIME = AUTO). The transmitter was operated at a full rated power output, and modulated as follows:

FCC 47 CFR 2.1057 - Frequency spectrum to be investigated: The spectrum was investigated from the lowest radio generated in the equipment up to at least the 10th harmonic of the carrier frequency or to the highest frequency practicable in the present state of the art of measuring techniques, whichever is lower. Particular attention should be paid to harmonics and subharmonics of the carrier frequency. Radiation at the frequencies of multiplier stages should be checked. The
amplitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be reported.

FCC 47 CFR 2.1051 - Spurious Emissions at Antenna Terminal: The radio frequency voltage or powers generated within the equipment and appearing on a spurious frequency shall be checked at the equipment output terminals when properly loaded with a suitable artificial antenna. Curves or equivalent data shall show the magnitude of the harmonic and other spurious emission that can be detected when the equipment is operated under the conditions specified in 2.1049 as appropriate. The magnitude of spurious emissions, which are attenuated more than 20 dB below the permissible value, need not be specified.

8.6. TRANSIENT FREQUENCY BEHAVIOR

1. Connect the transmitter under tests as shown in the above block diagram
2. Set the signal generator to the assigned frequency and modulate with a 1 KHz tone at ±12.5 KHz deviation and its output level to be 50 dB below the transmitter rf output at the test receiver end.
3. Set the horizontal sweep rate on the storage scope to 10 milliseconds per division and adjust the display to continuously view the 1000 Hz tone from the Demodulator Output Port (DOP) of the Test Receiver. Adjust the vertical scale amplitude control of the scope to display the 1000 Hz at ±4 divisions vertical Center at the display.
4. Adjust the scope so it will trigger on an increasing magnitude from the RF trigger signal of the transmitter under test when the transmitter was turned on. Set the controls to store the display.
5. The output at the DOP, due to the change in the ratio of the power between the signal generator input power and transmitter output power will, because of the capture effect of the test receiver, produce a change in display: For the first part of the sweep it will show the 1 KHz test signal. Then once the receiver's demodulator has been captured by the transmitter power, the display will show the frequency difference from the assigned frequency to the actual transmitter frequency versus time. The instant when the 1 KHz test signal is completely suppressed (including any capture time due to phasing) is considered to be t_{on}. The trace should be maintained within the allowed divisions during the period t_1 and t_2.
6. During the time from the end of t_2 to the beginning of t_3 the frequency difference should not exceed the limits set by the FCC in Part 90.214 and the outlined in the Carrier Frequency Stability sections. The allowed limit is equal to FCC frequency tolerance limits specified in FCC 90.213.
7. Repeat the above steps when the transmitter was turned off for measuring t_3.