Test Report # 317244 A

Equipment Under Test:	NRU1C
Test Date(s):	September 8, 9, 11, 14, 15, 18, 19, 21 2017
Prepared for:	**Geophysical Technology, Inc.** Attn: Andrew Sedlmayr 800 Mulberry Lane Bellaire, Texas 77401 USA

Report Issued by: Adam Alger, Quality Systems Engineer

Signature: Date: 10/18/2017

Report Reviewed by: Ryan Urness, Director of Test Services

Signature: Date: 10/9/17

Report Constructed by: Adam Alger, Quality Systems Engineer

Signature: Date: 10/04/2017

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Laird Technologies Test Services in Review

The Laird Technologies, Inc. laboratory located at W66 N220 Commerce Court Cedarburg, Wisconsin, 53012 USA is recognized through the following organizations:

A2LA – American Association for Laboratory Accreditation

Accreditation based on ISO/IEC 17025: 2005 with Electrical (EMC) Scope
A2LA Certificate Number: 1255.01
Scope of accreditation includes all test methods listed herein, unless otherwise noted.

Federal Communications Commission (FCC) – USA

Accredited recognition of two 3 meter Semi-Anechoic Chambers

Accredited Test Firm Registration Number: 953492

Government of Canada

Innovation, Science and Economic Development Canada

ISED Site listing of two 3 meter Semi-Anechoic Chambers based on RSS-GEN – Issue 4
File Number: IC 3088A-2
File Number: IC 3088A-3

1 TEST REPORT SUMMARY

During **September 2017** the Equipment Under Test (EUT), **NRU1C**, as provided by **Geophysical Technology, Inc.** was tested to the following requirements:

Requirement	Description	Specification	Method	Compliant
15.247 (a)(2)	Digital Modulation System 6 dB bandwidth	500 kHz	ANSI C63.10	Yes
2.1049	Occupied Bandwidth	Reported	ANSI C63.10	Yes
15.247 (b)(3)	Maximum Conducted Output Power	30 dBm	ANSI C63.10	Yes
15.247 (e)	Digital Modulation System Power Spectral Density	8 dBm / 3 kHz	ANSI C63.10	Yes
15.247 (d)	RF Spurious Emissions at the Transmitter Antenna Terminal	20 dBc	ANSI C63.10	Yes
15.247 (d)	Spurious Radiated Emissions in Restricted Bands	FCC 15.209	ANSI C63.10	Yes
2.1055 (d)	Frequency Stability	Reported	ANSI C63.10	Yes
15.207	AC Power Line Conducted Emissions	0.150-30 MHz	ANSI C63.10	Yes

Notice:

The results relate only to the item tested and described in this report. Any modifications made to the equipment under test after the specified test date(s) may invalidate the data herein.

If the resulting measurement margin is seen to be within the uncertainty value, as listed in this report, the possibility exists that this unit may not meet the required limit specification if subsequently tested.

2 CLIENT INFORMATION

Company Name	Geophysical Technology, Inc.
Contact Person	Andrew Sedlmayr
Address	800 Mulberry Lane Bellaire Texas 77401 USA

2.1 Equipment Under Test (EUT) Information

The following information has been supplied by the client

Product Name	NRU1C
Model Number	NRU-1C
Serial Number	210000019
FCC ID	2AM2Z-NRU1C9G2Y1

2.2 Product Description

The NRU-1C is deployed in the field to record seismic data. It contains Bluetooth Low Energy and Ultra-Wide Band communication.

2.3 Modifications Incorporated for Compliance

Ferrite added to charger on AC and DC sides.

DC Ferrite two passes: Laird 28A5776-0A2
AC Ferrite one pass: Laird 28A0807-0A2

2.4 Deviations and Exclusions from Test Specifications

None noted at time of test

2.5 Additional Information

EUT powered by internal battery 4.2 VDC maximum

Channels low (2402 MHz), mid (2440 MHz), and high (2480 MHz) programmed via BLE link to Android tablet running special test codes developed by manufacturer version NuSite Version 1.0.22.6 Android Version 7.0 (API 24).

EUT can transmit BLE stand-alone and when in charging base.

3 REFERENCES

Publication	Date
CFR Title 47 Chapter I Subchapter A Part 15	2017
CFR Title 47 Chapter I Subchapter A Part 2	2017
ANSI C63.10	2013

4 UNCERTAINTY SUMMARY

Using the guidance of the following publications the calculated measurement uncertainty represents an expanded uncertainty expressed at approximately the 95 % confidence level, using a coverage factor of k = 2.

References	Version / Date
CISPR 16-4-1	Ed. 2 (2009-02)
CISPR 16-4-2	Ed. 2 (2011-06)
CISPR 32	Ed. 1 (2012-01)
ANSI C63.23	2012
A2LA P103	February 4, 2016
A2LA P103c	August 10, 2015
ETSI TR 100-028	V1.3.1 (2001-03)

Measurement Type	Configuration	Uncertainty ±
Radiated Emissions	Biconical Antenna	5.0 dB
Radiated Emissions	Log Periodic Antenna	5.3 dB
Radiated Emissions	Horn Antenna	4.7 dB
AC Line Conducted Emissions	Artificial Mains Network	3.4 dB
Telecom Conducted Emissions	Asymmetric Artificial Network	4.9 dB
Disturbance Power Emissions	Absorbing Clamp	4.1 dB
Radiated Immunity	3 Volts/meter	2.2 dB
Conducted Immunity	CDN/EM/BCI	2.4/3.5/3.4 dB
EFT Burst/Surge	Peak pulse voltage	164 volts
ESD Immunity	15 kV level	1377 Volts

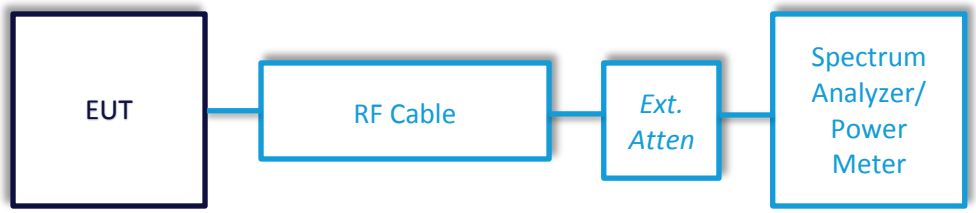
Parameter	ETSI U.C. ±	U.C. ±
Radio Frequency, from F0	$1x10^{-7}$	$0.55x10^{-7}$
Occupied Channel Bandwidth	5 %	2 %
RF conducted Power (Power Meter)	1.5 dB	1.2 dB
RF conducted emissions (Spectrum Analyzer)	3.0 dB	1.7 dB
All emissions, radiated	6.0 dB	5.3 dB
Temperature	1° C	0.65° C
Humidity	5 %	2.9 %
Supply voltages	3 %	1 %

5 TEST DATA

5.1 Antenna Port Conducted Emissions

Description of Measurement	The direct measurement of emissions at the antenna port of the EUT is achieved by use of a RF connection to a spectrum analyzer or power meter. The cable and attenuator factors are loaded into the analyzer or power meter allowing for direct measurement readings without the need for further corrections.
Example Calculations	Measurement (dBm) + Cable factor (dB) + External Attenuator (dB) = Corrected Reading (dBm) Margin (dB) = Limit (dBm) – Corrected Reading (dBm)

Block Diagram



5.1.1 Antenna Port Conducted Emissions

Operator	Adam Alger
QA	Khairul Aidi Zainal
Test Date	09/21/2017
Location	Radio bench
Temp. / R.H.	68/65
Requirement	FCC 15.247
Method	ANSI C63.10 Section 11

Limits:

Type	Limit
Output Power	30 dBm
PSD	8 dBm / 3 kHz
Spurious	20 dBc
DTS BW	500 kHz

Test Parameters

Frequency	30-25000 MHz
RBW	100 kHz (spurious, PSD, DTS BW); RBW > DTS BW = 3 MHz (output power)
Detector	Peak Max Hold
EUT	Battery 4.2 VDC
EUT Channels	Low (2402 MHz), Mid (2440 MHz), High (2480 MHz)
Example Calculation	Spurious Limit = 100 kHz reference (PSD Plot) – 20 dB

Instrumentation

Smart Technology. Delivered.

Date : 21-Sep-2017 Test : Antenna Port Conducted Emissions Job : C-2809

PE : Adam Alger Customer : GTI Quote : 317244

No.	Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due Date	Equipment Status
1	EE 960087	Spectrum Analyzer	Agilent	N9010A	MY53400296	12/22/2016	12/22/2017	Active Calibration

Table – BW, Power, PSD

Frequency (MHz)	99 % BW (MHz)	DTS BW (MHz)	PSD 100 kHz (dBm)	PSD 3 kHz limit (dBm)	PSD Margin (dB)	Output Power (dBm)	Output Power Limit (dBm)	Output Power Margin (dBm)
2402	1.00	0.667	1.03	8.00	7.0	1.03	30.00	29.0
2440	1.03	0.681	1.21	8.00	6.8	1.31	30.00	28.7
2480	1.01	0.67	1.20	8.00	6.8	1.24	30.00	28.8

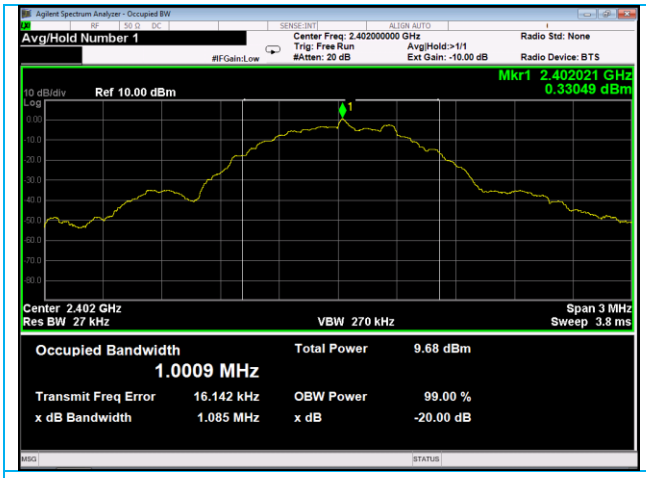
Table - Spurious Emissions

Channel	Frequency (MHz)	Spurious Emission (dBm)	Spurious Limit (dBm)	Margin (dB)
Low	2382	-38.42	-18.97	19.45
Low	2325	-39.91	-18.97	20.94
Low	4807	-51.93	-18.97	32.96
Mid	4879	-54.16	-18.79	35.37
High	2503	-36.96	-18.80	18.16
High	2573	-37.52	-18.80	18.73
High	4960	-51.41	-18.80	32.61

Table – Frequency Stability

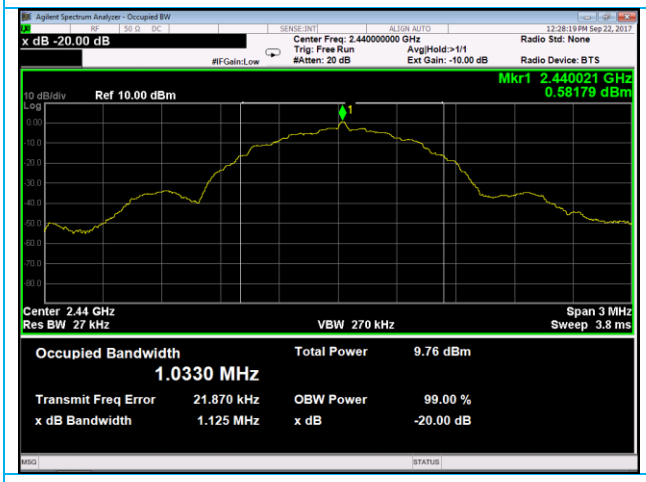
Channel	3.15 VDC (Hz)	3.57 VDC (Hz)	4.2 VDC (Hz)	Max Deviation (Hz)
Low	2402018267	2402018717	2402018729	462
Mid	2440017677	2440017951	2440018190	513
High	2480017934	2480018118	2480018193	259

Plots



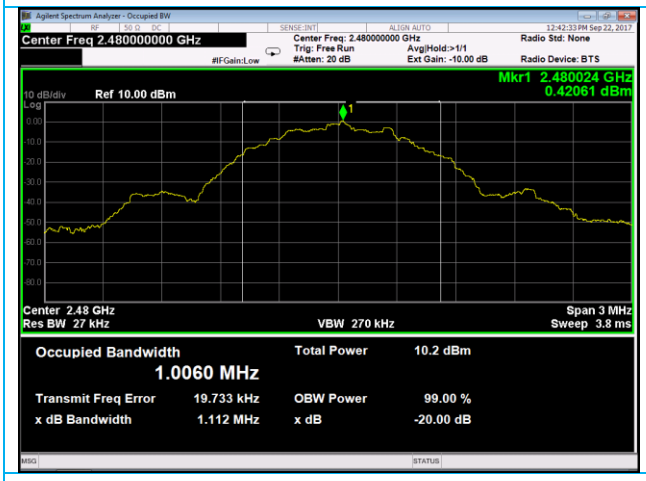
Low Channel 99 % BW

Low Channel DTS BW, PSD, Spurious reference



Mid Channel 99 % BW

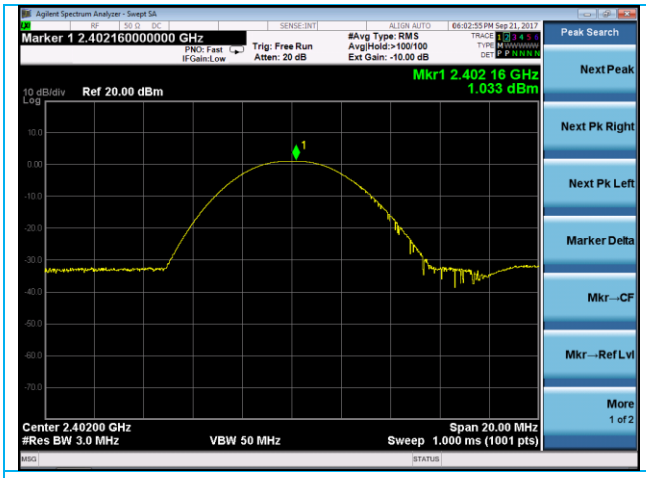
Mid Channel DTS BW, PSD, Spurious reference



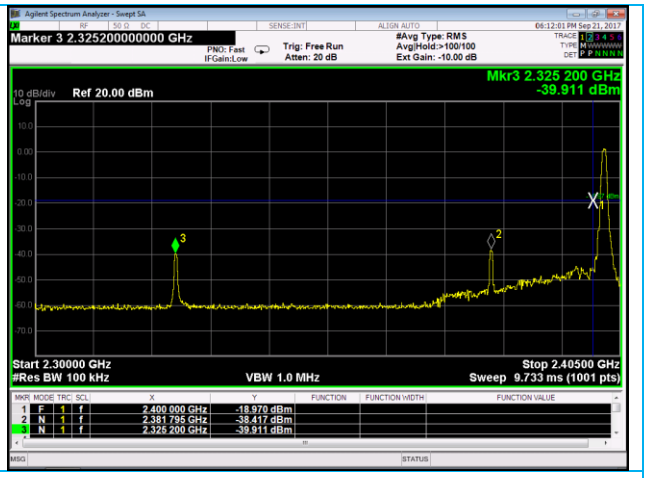
High Channel 99 % BW

High Channel DTS BW, PSD, Spurious reference

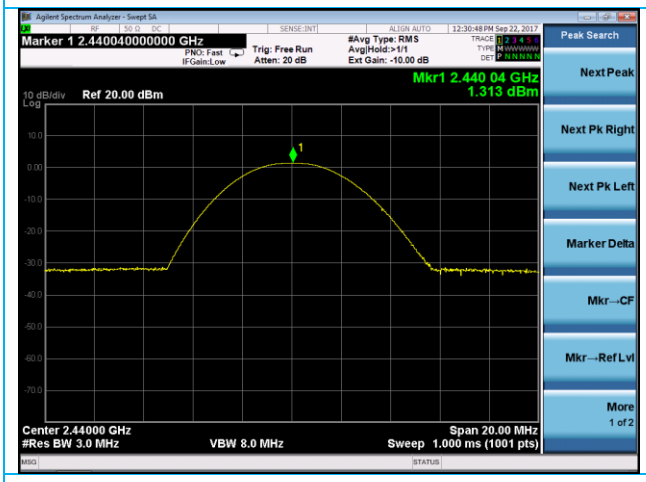
Plots



Low Channel Power



Low Channel Band-edge



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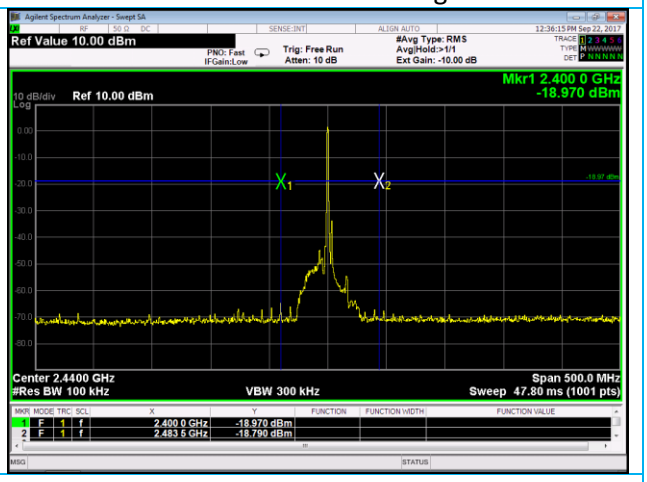

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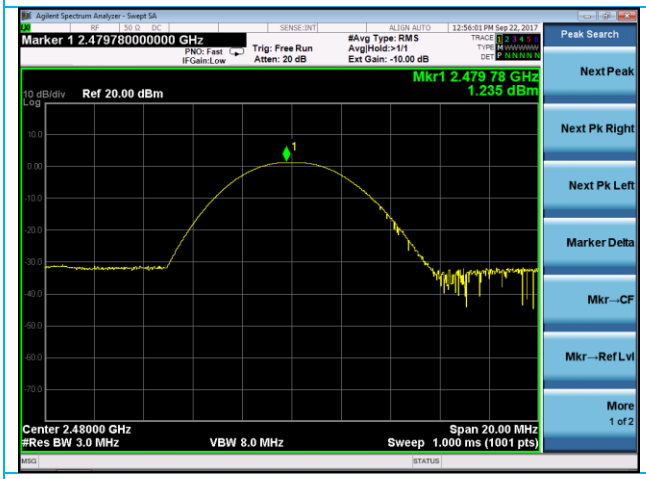
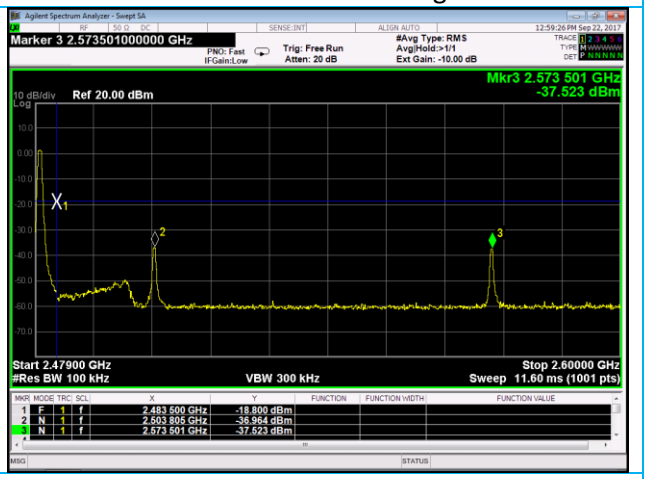
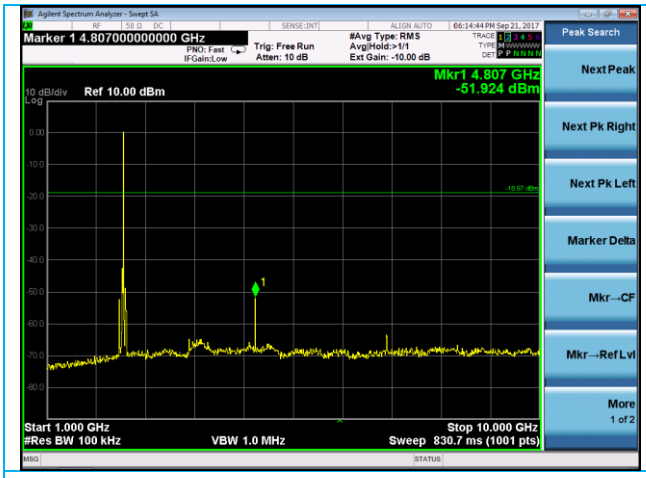


High Channel Power



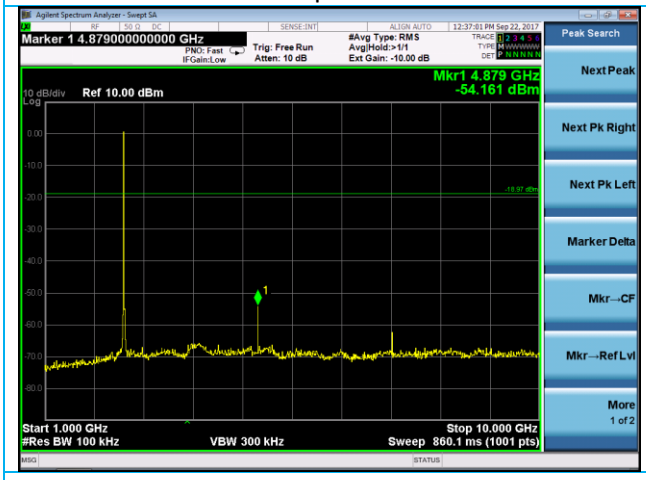
High Channel Band-edge

Plots



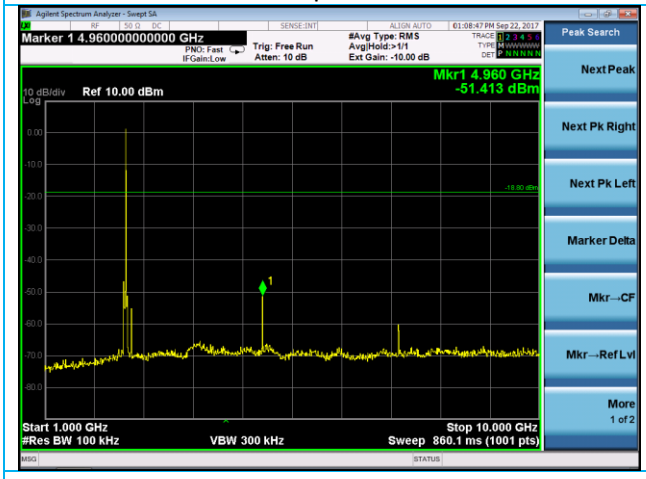
Low Channel Spurious 1-10 GHz

Low Channel Spurious 10-25 GHz



Mid Channel Spurious 1-10 GHz

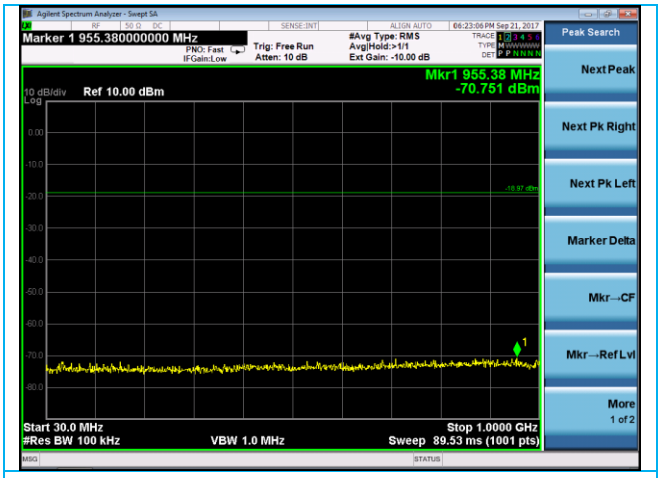
Mid Channel Spurious 10-25 GHz



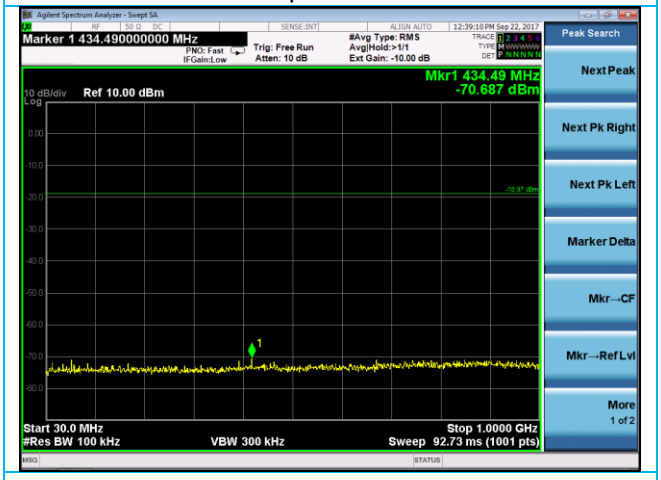
High Channel Spurious 1-10 GHz

High Channel Spurious 10-25 GHz

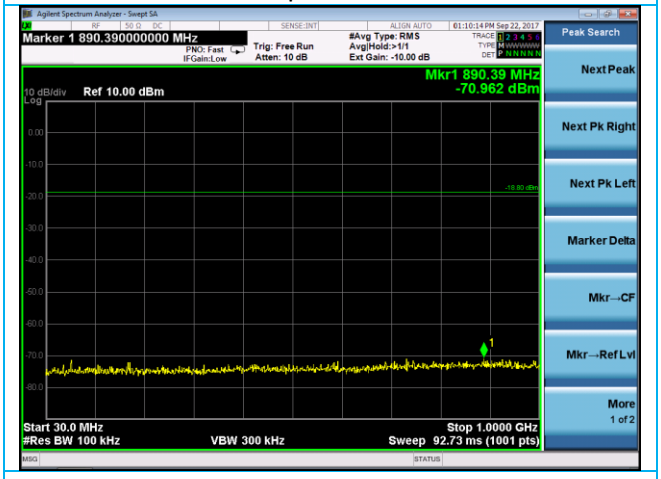
Plots



Low Channel Spurious 30-1000 MHz



Mid Channel Spurious 30-1000 MHz

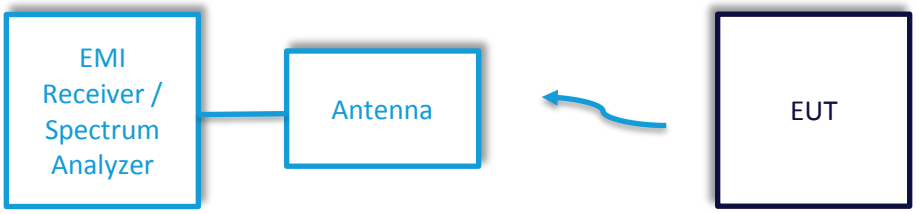


High Channel Spurious 30-1000 MHz

5.2 Radiated Emissions

Description of Measurement	The frequency spectrum is investigated for intentional and / or unintentional signals emanating from the EUT by use of a standardized test site and measurement antenna. The antenna, cable, pre-amp, and other necessary measurement system correction factors are loaded onto the EMI receiver / spectrum analyzer when the measurements are performed allowing the data to be gathered and reported as corrected values. The maximum emissions from the EUT are determined by turn-table azimuth rotation (360°) and scanning of the measurement antenna. Maximized levels are noted at degree values of azimuth, measurement antenna height, and measurement antenna polarity.
Example Calculations	Measurement (dBµV) + Cable factor (dB) + Other (dB) + Antenna Factor (dB/m) = Corrected Reading (dBµV/m) Margin (dB) = Limit (dBµV/m) - Corrected Reading (dBµV/m) Example at 4000 MHz: Reading = 40 dBµV + 3.4 dB + 0.9 dB + 6.5 dB/m = 50.8 dBµV/m Average Limit = 20 log (500) = 54 dBµV/m Margin = 54 dBµV/m - 50.8 dBµV/m = 3.2 dB

Block Diagram



5.2.1 Radiated Emissions

Operator	Adam Alger
QA	Coty Hammerer
Test Date	September 8,11,15,18,19 2017
Location	Chamber 3 < 1 GHz > Chamber 5
Temp. / R.H.	70/52
Requirement	FCC 15.209
Method	ANSI C63.10 Section 11.12, 6.3, 6.5, 6.6

Limits:

Frequency of emission (MHz)	Field strength (microvolts/meter)	Limit (dBµV/m) 3 meter	Limit Type
30-88	100	40.0	Quasi-Peak
88-216	150	43.5	
216-960	200	46.0	
Above 960	500	54.0	Average

Test Parameters

Frequency	30-25000 MHz
Distance	3m
Measurement Settings: RBW	120 kHz < 1 GHz > 1 MHz
Measurement Settings: VBW	1.2 MHz < 1 GHz > 3 MHz (peak) 510 Hz (average)
Measurement Settings	Peak detector Max hold trace
Measurement Settings: Final	Final Quasi-Peak < 1 GHz > Peak and Average
EUT	Continuous transmit low, mid, high channel
Notes	Tested in three orthogonal orientations stand alone and in charging base

Instrumentation

Laird
Smart Technology. Delivered.

Date : 19-Sep-2017 Test : Radiated Emissions Job : C-2809

PE : Adam Alger Customer : GTI Quote : 317244

No.	Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due Date	Equipment Status
1	EE 960088	EMI Receiver	Agilent	N9038A	MY51210138	3/2/2017	3/2/2018	Active Calibration
2	AA 960128	Biconical Antenna	ETS Lindgren	3110B	00062899	4/13/2017	4/13/2018	Active Calibration
3	AA 960078	Log Periodic Antenna	EMCO	93146	9701-4855	4/17/2017	4/17/2018	Active Calibration
4	EE 960085	EMI Receiver	Agilent	N9038A	MY51210148	5/12/2017	5/12/2018	Active Calibration
5	AA 960158	Double Ridge Horn Antenna	ETS Lindgren	3117	109300	10/13/2016	10/13/2017	Active Calibration
6	EE 960159	Low Noise Amplifier	Mini-Circuits	ZVA-213X-S+	462101702	4/12/2017	4/12/2018	Active Calibration
7	AA 960153	High Pass Filter 2.4 GHz	KWM	HPF-L-14186	7272-04	5/2/2017	5/2/2018	Active Calibration
8	AA 960171	Cable - low loss 6m	A.H. Systems, Inc	SAC-26G-6	386	3/31/2016	11/21/2017	Active Verification
9	AA 960174	Small Horn Antenna	ETS Lindgren	3116C-PA	00206880	5/1/2017	5/1/2018	Active Calibration
10	AA 960162	EM Series Cable	MegaPhase	EM26-S1S1-120	12024301 001	6/29/2016	11/11/2017	Active Verification
11	EE 960087	Spectrum Analyzer	Agilent	N9010A	MY53400296	12/22/2016	12/22/2017	Active Calibration

Table 30-1000 MHz – Continuous transmit stand-alone

Frequency (MHz)	Antenna Polarity	Height (cm)	Azimuth (degree)	Peak Reading (dBµV/m)	Quasi Peak Reading (dBµV/m)	Quasi Peak Limit (dBµV/m)	Margin (dB)
192.0	Vertical	100	360	33.55	29.66	43.5	13.8
106.0	Horizontal	159	0	30.39	25.50	43.5	18.0
319.0	Horizontal	200	73	29.33	27.56	46.0	18.4
352.2	Vertical	136	228	44.13	42.86	46.0	3.1
368.6	Vertical	135	216	45.03	43.91	46.0	2.1
385.0	Vertical	135	230	44.66	43.67	46.0	2.3
319.5	Vertical	135	165	44.47	43.14	46.0	2.9
499.7	Vertical	100	261	43.83	42.78	46.0	3.2
499.7	Horizontal	172	208	39.57	37.92	46.0	8.1
100.0	Vertical	100	216	44.36	39.52	43.5	4.0
176.8	Horizontal	100	208	44.91	38.67	43.5	4.8
368.0	Horizontal	100	190	45.93	44.80	46.0	1.2
385.0	Horizontal	100	0	46.67	45.62	46.0	0.4
319.5	Horizontal	100	190	46.44	45.42	46.0	0.6
352.2	Horizontal	100	0	45.36	44.29	46.0	1.7
532.5	Horizontal	159	183	45.38	44.36	46.0	1.6

Table 30-1000 MHz – Continuous transmit on charger

Frequency (MHz)	Antenna Polarity	Height (cm)	Azimuth (degree)	Peak Reading (dBµV/m)	Quasi Peak Reading (dBµV/m)	Quasi Peak Limit (dBµV/m)	Margin (dB)
173.6	Horizontal	200	0	44.13	43.36	43.5	0.1
169.2	Horizontal	198	189	41.65	40.97	43.5	2.5
170.6	Horizontal	201	190	41.27	40.55	43.5	3.0
173.6	Vertical	100	154	41.45	40.87	43.5	2.6
312.0	Horizontal	156	177	38.08	37.13	46.0	8.9
498.2	Vertical	137	56	43.72	42.19	46.0	3.8
515.7	Vertical	130	60	43.03	41.88	46.0	4.1
335.8	Vertical	151	297	43.20	42.12	46.0	3.9

Table 1000-25000 MHz – Stand-alone and charger

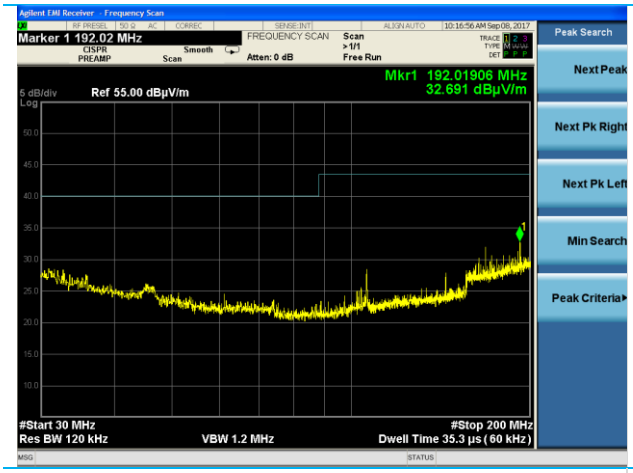
Frequency (MHz)	EUT orientation	Antenna Polarity	Azimuth (degree)	Height (cm)	Average Reading (dBµV/m)	Peak Reading (dBµV/m)	Avg Limit (dBµV/m)	Avg Margin (dB)	Peak Limit (dBµV/m)	Peak Margin (dB)
4880	Flat	Vertical	267	130	39.05	44.08	54.0	15.0	74.0	29.9
4804	Flat	Vertical	266	137	39.05	44.95	54.0	15.0	74.0	29.1
4960	Flat	Vertical	266	145	37.48	44.62	54.0	16.5	74.0	29.4
4880	Charger	Horizontal	273	233	37.47	43.97	54.0	16.5	74.0	30.0
4804	Charger	Horizontal	83	255	39.05	49.19	54.0	15.0	74.0	24.8
4960	Charger	Horizontal	272	241	35.05	43.13	54.0	19.0	74.0	30.9

Table – Restricted Band at authorized band-edge

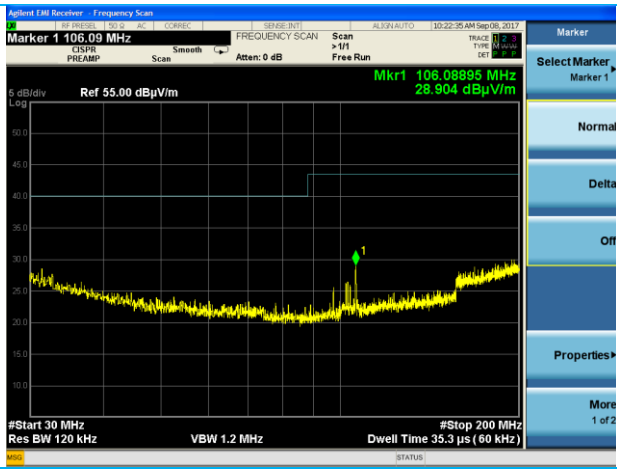
Frequency (MHz)	EUT orientation	Antenna Polarity	Azimuth (degree)	Height (cm)	Average Reading (dBµV/m)	Peak Reading (dBµV/m)	Avg Limit (dBµV/m)	Avg Margin (dB)	Peak Limit (dBµV/m)	Peak Margin (dB)
2380	Flat	Horizontal	22	147	43.46	61.29	54.0	10.5	74.0	12.7
2483	Flat	Horizontal	14	134	40.02	-	54.0	14.0	-	-
2495	Flat	Horizontal	14	134	-	56.49	-	-	74.0	17.5

Plots

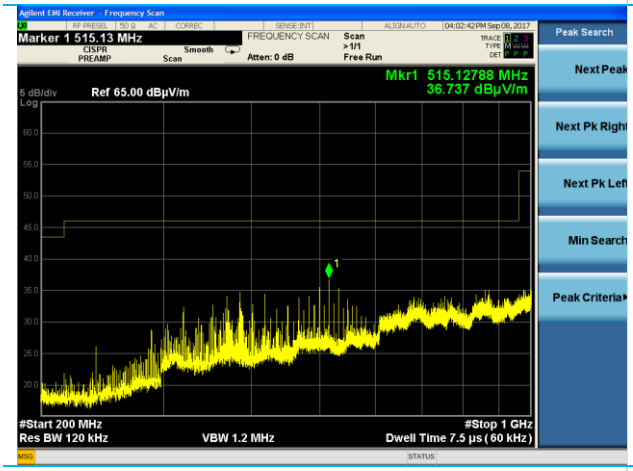
Continuous transmit stand-alone



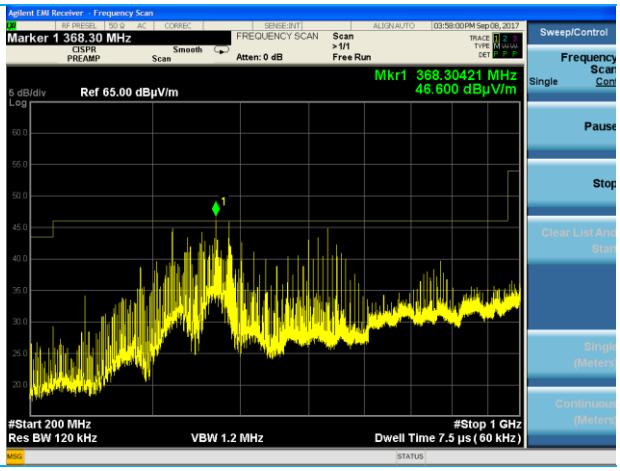
30-200 MHz Vertical



30-200 MHz Horizontal

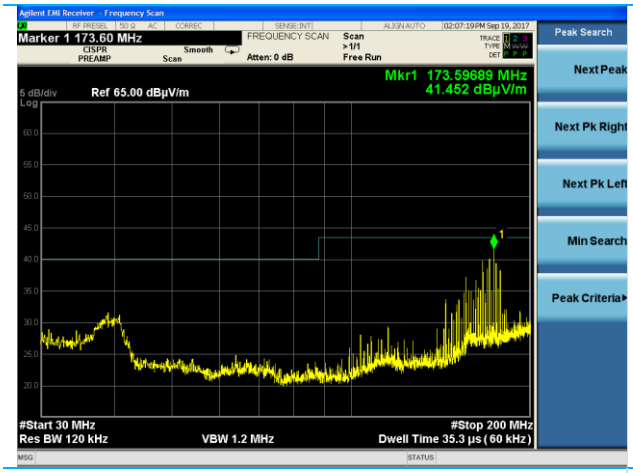


200-1000 MHz Vertical

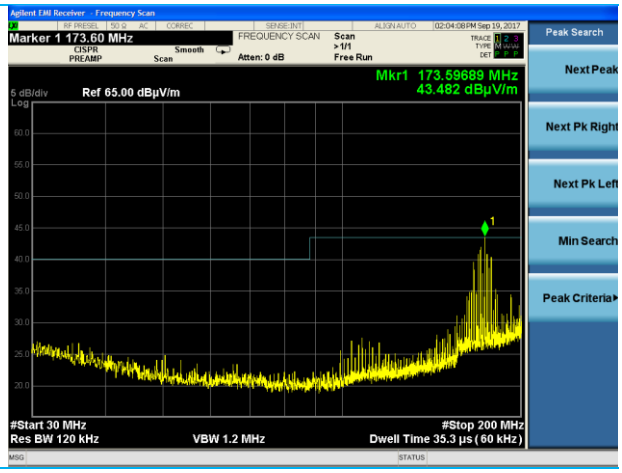


200-1000 MHz Horizontal

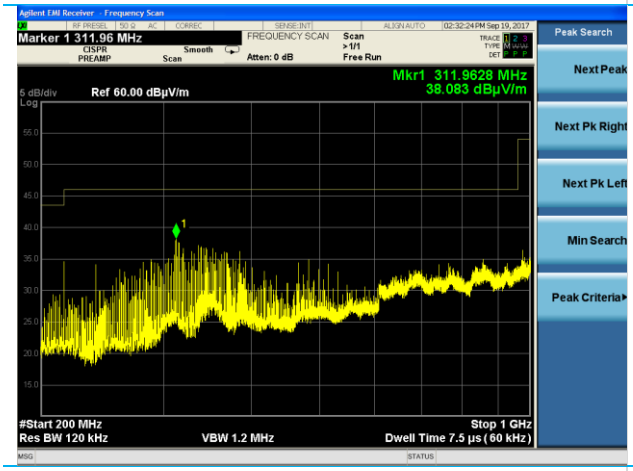
Continuous transmit while in charging base



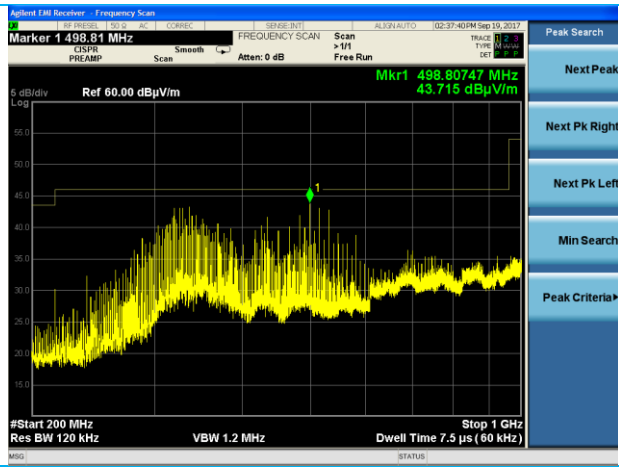
30-200 MHz Vertical



30-200 MHz Horizontal

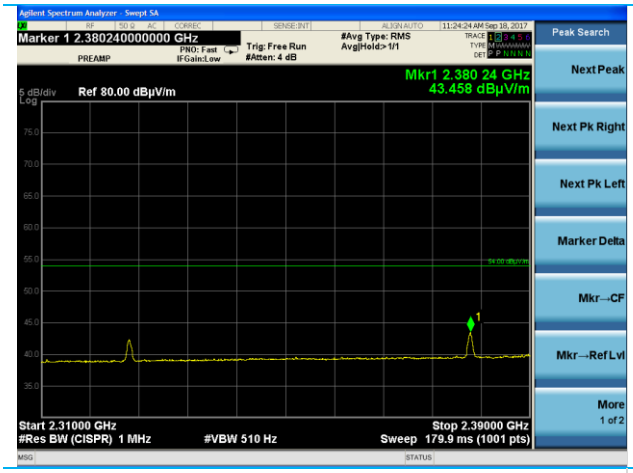


200-1000 MHz Vertical

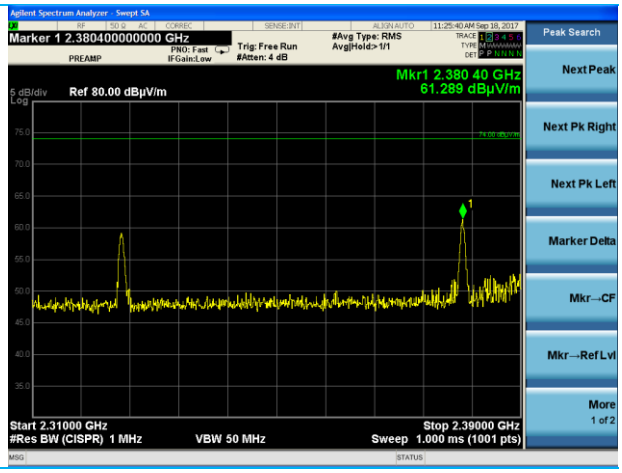


200-1000 MHz Horizontal

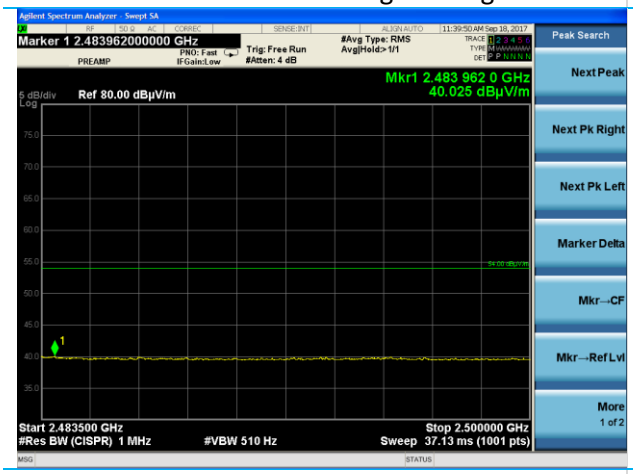
Plots – Representative of stand-alone and on charger – Worst case EUT Flat, Antenna Horizontal



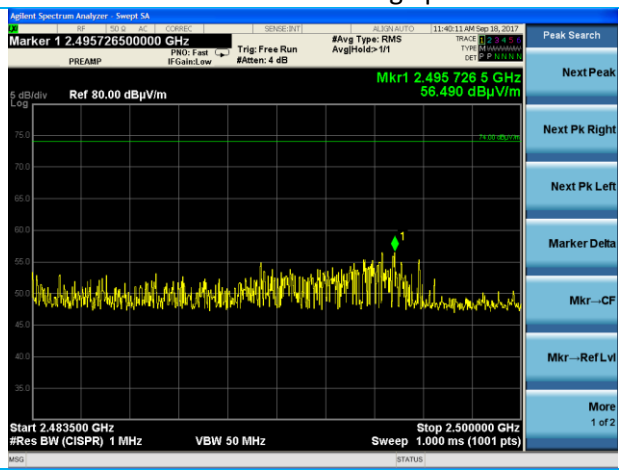
Low Channel band-edge average



Low Channel band-edge peak



High Channel band-edge average



High Channel band-edge peak

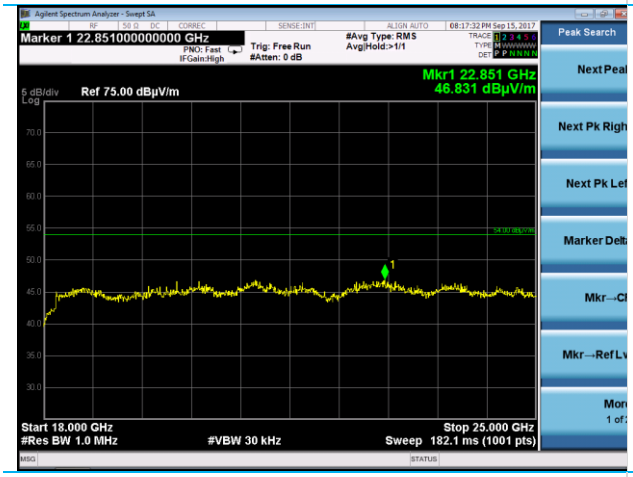
Plots – Representative worst case of stand-alone and on charger

1-2.31 GHz

2.5-4 GHz

4-18 GHz Vertical

4-18 GHz Horizontal



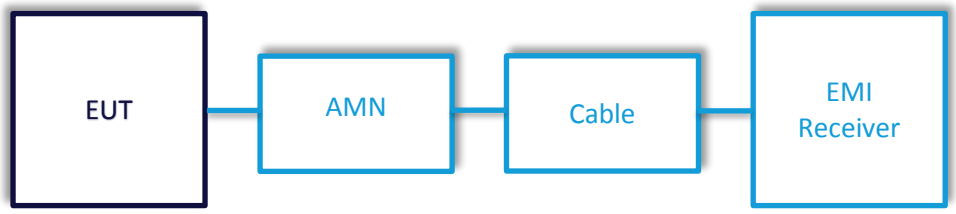
18-25 GHz

25-40 GHz

5.3 AC Mains Conducted Emissions

Description of Measurement	A line impedance stabilization network (LISN) or artificial mains network (AMN) allows the emissions of the power supply conductors to be measured while isolating the EUT from the supply mains. The AMN, cable, and other necessary measurement system correction factors are loaded onto the EMI receiver when the measurements are performed. The data is gathered and reported as the corrected values. Maximum emissions are determined with a peak max hold trace then measurements at a selection of the highest points are made with quasi-peak and average detectors. Results are recorded and compared to limit for each line. (e.g. line and neutral)
Example Calculations	Measurement (dBµV) + Cable factor (dB) + Other (dB) = Corrected Reading (dBµV) Margin (dB) = Limit (dBµV) - Corrected Reading (dBµV)

Block Diagram



5.3.1 AC Mains Conducted Emissions

Operator	Adam Alger
QA	Coty Hammerer
Test Date	9/14/2017
Location	Bench
Temp. / R.H.	68/60
Requirement	FCC 15.207
Method	ANSI C63.10 Section 6.2

Limits:

Frequency of emission (MHz)	Conducted limit (dBµV)	
	Quasi-peak	Average
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50

*Decreases with the logarithm of the frequency.

Test Parameters

Frequency	0.150-30 MHz
Distance	80 cm table; 40cm vertical ground plane
Settings	9 kHz RBW
Settings	Peak max hold trace, Quasi-Peak, Average final
EUT Spec	120 VAC 60 Hz
EUT Spec	BLE Transmit continuously modulated
Notes	No significant change in emissions on low, mid, high channel

Instrumentation

Laird
Smart Technology. Delivered.

Date : 14-Sep-2017 Test : AC Emissions Job : C-2809

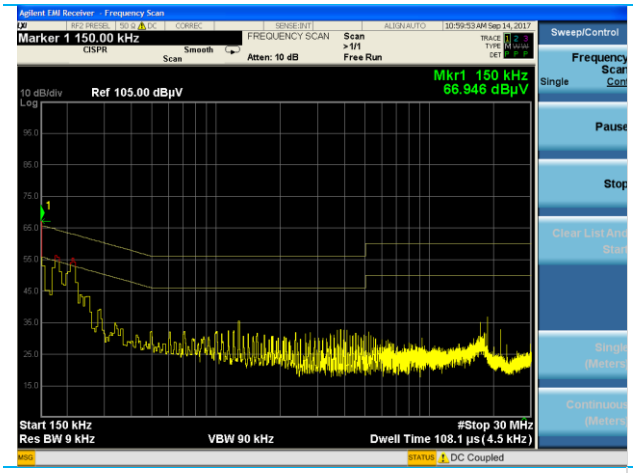
PE : Adam Alger Customer : GTI Quote : 317244

No.	Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due Date	Equipment Status
1	EE 960162	LISN	COM-POWER	LI-215A	191969	8/28/2017	8/28/2018	Active Calibration
2	EE 960085	EMI Receiver	Agilent	N9038A	MY51210148	5/12/2017	5/12/2018	Active Calibration

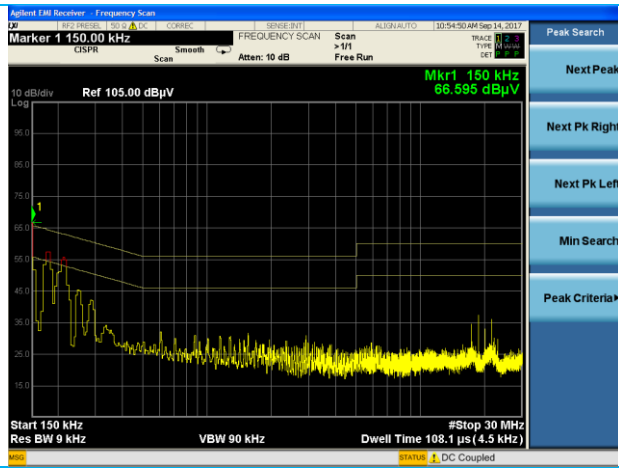
Table

Frequency (MHz)	Line	Peak Reading (dBµV)	Q-Peak Reading (dBµV)	Q-Peak Limit (dBµV)	Quasi-Peak Margin (dB)	Average Reading (dBµV)	Average Limit (dBµV)	Average Margin (dB)
0.150	1	59.8	56.8	66.0	9.2	47.7	56.0	8.3
0.213	1	58.2	57.1	63.1	6.0	49.1	53.1	4.0
0.303	1	44.7	41.2	60.2	19.0	35.1	50.2	15.1
0.150	2	59.7	57.3	66.0	8.7	49.0	56.0	7.0
0.150	2	60.7	57.3	66.0	8.7	48.4	56.0	7.6
0.303	2	43.9	41.0	60.2	19.2	34.9	50.2	15.3

Plots



Line 1



Line 2

6 REVISION HISTORY

Version	Date	Notes	Person
V0	10/04/2017	Initial Draft	Adam Alger
V1	10/10/2017	Final Release	Adam Alger
V2	10/18/2017	Updated for TCB Comments (page 9 example calculation)	Adam Alger

END OF REPORT