

Nalloy, LLC

REVISED TEST REPORT FOR 107941-30

YRP0R7

Tested to The Following Standards:

FCC Part 15 Subpart C Section(s)

15.207 & 15.247
(HYBRID 902-928MHz)

Report No.: 107941-30A

Date of issue: January 5, 2024



Test Certificate # 803.01

This test report bears the accreditation symbol indicating that the testing performed herein meets the test and reporting requirements of ISO/IEC 17025 under the applicable scope of testing for CKC Laboratories, Inc.

We strive to create long-term, trust based relationships by providing sound, adaptive, customer first testing services. We embrace each of our customers' unique EMC challenges, not as an interruption to set processes, but rather as the reason we are in business.

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ADMINISTRATIVE INFORMATION

Test Report Information

REPORT PREPARED FOR:

Nalloy, LLC
2301 5th Avenue
Seattle, WA 98108

Representative: Naga Suryadevara
Customer Reference Number: 2D-10266822

DATE OF EQUIPMENT RECEIPT:**DATE(S) OF TESTING:****REPORT PREPARED BY:**

Lisa Bevington
CKC Laboratories, Inc.
5046 Sierra Pines Drive
Mariposa, CA 95338

Project Number: 107941

March 14, 2021

March 14 & 21, 2021

January 19, 2023 & March 13, 2023

Revision History

Original: Testing of the YRP0R7 to 15.207 & 15.247(HYBRID 902-928MHz).

Revision A: Updated antenna gain information.

Report Authorization

The test data contained in this report documents the observed testing parameters pertaining to and are relevant for only the equipment provided by the client, tested in the agreed upon operational mode(s) and configuration(s) as identified herein. Compliance assessment remains the client's responsibility. This report may not be used to claim product endorsement by A2LA or any government agencies. This test report has been authorized for release under quality control from CKC Laboratories, Inc.



Steve Behm
Director of Quality Assurance & Engineering Services
CKC Laboratories, Inc.

Test Facility Information



Our laboratories are configured to effectively test a wide variety of product types. CKC utilizes first class test equipment, anechoic chambers, data acquisition and information services to create accurate, repeatable and affordable test results.

TEST LOCATION(S):
CKC Laboratories, Inc.
Canyon Park
22116 23rd Drive S.E., Suite A
Bothell, WA 98021

Software Versions

CKC Laboratories Proprietary Software	Version
EMITest Emissions	5.03.20

Site Registration & Accreditation Information

Location	*NIST CB #	FCC	Canada	Japan
Canyon Park, Bothell, WA	US0103	US1024	3082C	A-0136
Brea, CA	US0103	US1024	3082D	A-0136
Fremont, CA	US0103	US1024	3082B	A-0136
Mariposa, CA	US0103	US1024	3082A	A-0136

*CKC's list of NIST designated countries can be found at: <https://standards.gov/cabs/designations.html>

SUMMARY OF RESULTS

Standard / Specification: FCC Part 15 Subpart C - 15.247 (Hybrid 902-928MHz)

Test Procedure	Description	Modifications	Results
15.247(a)(1)(i)	Occupied Bandwidth	NA	Pass
15.247(a)(1)	Carrier Separation	NA	Pass
15.247(a)(1)(i)	Number of Hopping Channels	NA	Pass
15.247(a)(1)(i)	Average Time of Occupancy	NA	NA1
15.247(b)(2)	Output Power	NA	Pass
15.247(d)	RF Conducted Emissions & Band Edge	NA	NA2
15.247(d)	Radiated Emissions & Band Edge	NA	Pass
15.247 (f)	Hybrid Systems Time of Occupancy	NA	Pass
15.247 (f)	Hybrid Systems Power Spectral Density	NA	Pass
15.207	AC Conducted Emissions	NA	Pass

NA = Not Applicable

NA1 = This test is not applicable under Hybrid System requirements section 15.247 (f)

NA2 = The manufacturer declares the EUT does not have a conducted port.

ISO/IEC 17025 Decision Rule

The equipment sample utilized for testing is selected by the manufacturer. The declaration of pass or fail herein is a binary statement for simple acceptance rule (ILAC G8) based upon assessment to the specification(s) listed above, without consideration of measurement uncertainties. For performance related tests, equipment was monitored for specified criteria identified in that section of testing.

Modifications During Testing

This list is a summary of the modifications made to the equipment during testing.

Summary of Conditions

No modifications were made during testing.

Modifications listed above must be incorporated into all production units.

Conditions During Testing

This list is a summary of the conditions noted to the equipment during testing.

Summary of Conditions

None

EQUIPMENT UNDER TEST (EUT)

During testing, numerous configurations may have been utilized. The configurations listed below support compliance to the standard(s) listed in the Summary of Results section.

Configuration 1

Equipment Tested:

Device	Manufacturer	Model #	S/N
NA	Nalloy, LLC.	YRPOR7	None

Support Equipment:

Device	Manufacturer	Model #	S/N
Laptop	Lenovo	T430	PBPXKGW
Laptop PSU	Lenovo	92P1156	11S92P1156Z1ZDXN0AVB44
Power Supply	ZKTeco Co LTD	ZK-MSS-PS	Power Supply

Configuration 2

Equipment Tested:

Device	Manufacturer	Model #	S/N
NA	Nalloy, LLC.	YRPOR7	None

Support Equipment:

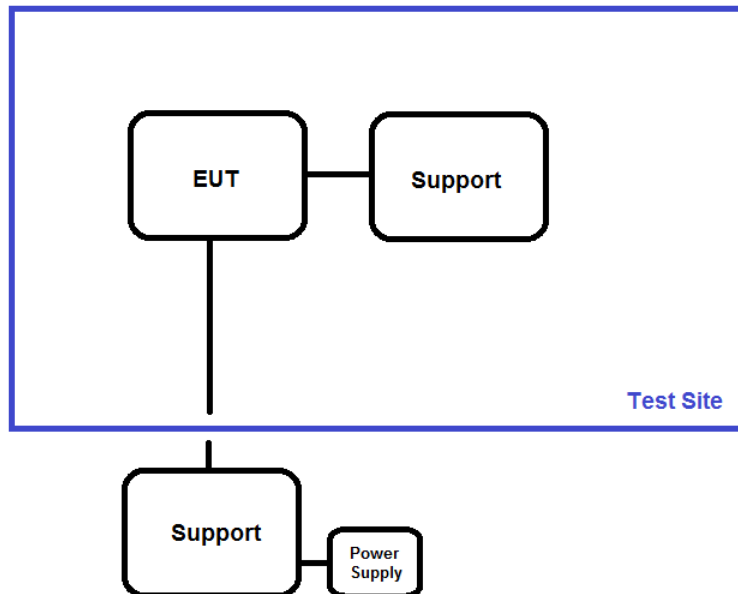
Device	Manufacturer	Model #	S/N
Laptop	Lenovo	T430	PBPXKGW
Laptop PSU	Lenovo	92P1156	11S92P1156Z1ZDXN0AVB44
Battery Pack	Nalloy, LLC.	PN 51-006541	G6A2RE0124360022

General Product Information:

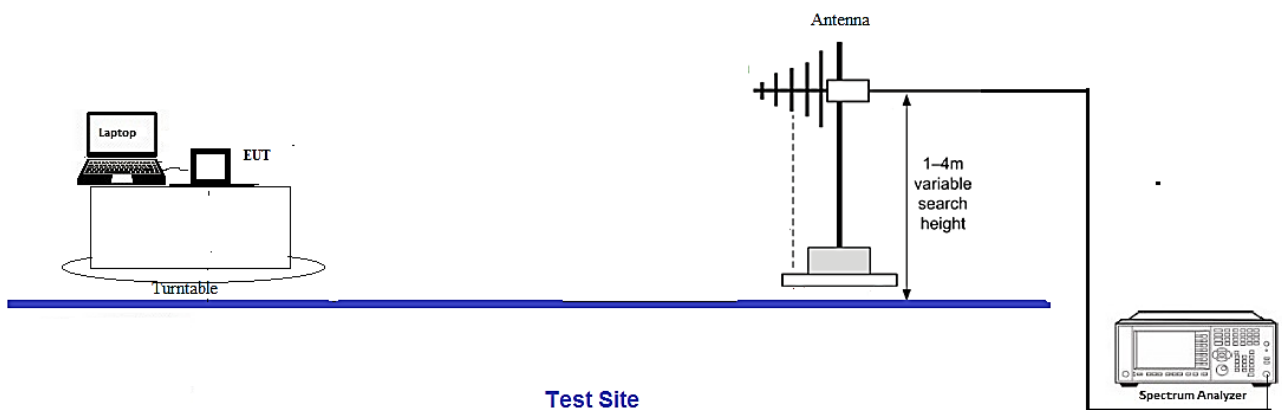
Product Information	Manufacturer-Provided Details
Equipment Type:	Radio Module
Type of Wideband System:	FHSS
Operating Frequency Range:	902.4-927.6 MHz
Number of Hopping Channels:	64
Receiver Bandwidth	The manufacturer declares the receiver input bandwidth matches the transmit channel bandwidth and shifts frequencies in synchronization with the transmitter.
Modulation Type(s):	GFSK-2
Maximum Duty Cycle:	Tested at 100%
Number of TX Chains:	1
Antenna Type(s) and Gain:	PCB Antenna / 2.4 dBi
Beamforming Type:	N/A
Antenna Connection Type:	Integral
Nominal Input Voltage:	5-30 VDC
Firmware / Software used for Test:	Railtest_v2.2.0 Realterm 2.0.0.70
The validity of results is dependent on the stated product details, the accuracy of which the manufacturer assumes full responsibility.	

Block Diagram of Test Setup(s)

Test Setup Block Diagram



Radiated test setup



FCC Part 15 Subpart C

15.247(a) Transmitter Characteristics

Test Setup/Conditions			
Test Location:	Bothell Lab C3	Test Engineer:	M. Harrison
Test Method:	ANSI C63.10 (2013)	Test Date(s):	5/21/2021
Configuration:	1		
Test Setup:	Test Mode: Continuously Modulated The spectrum analyzer is connected to a near field probe located near EUT antenna.		

Environmental Conditions			
Temperature (°C)	23	Relative Humidity (%):	40

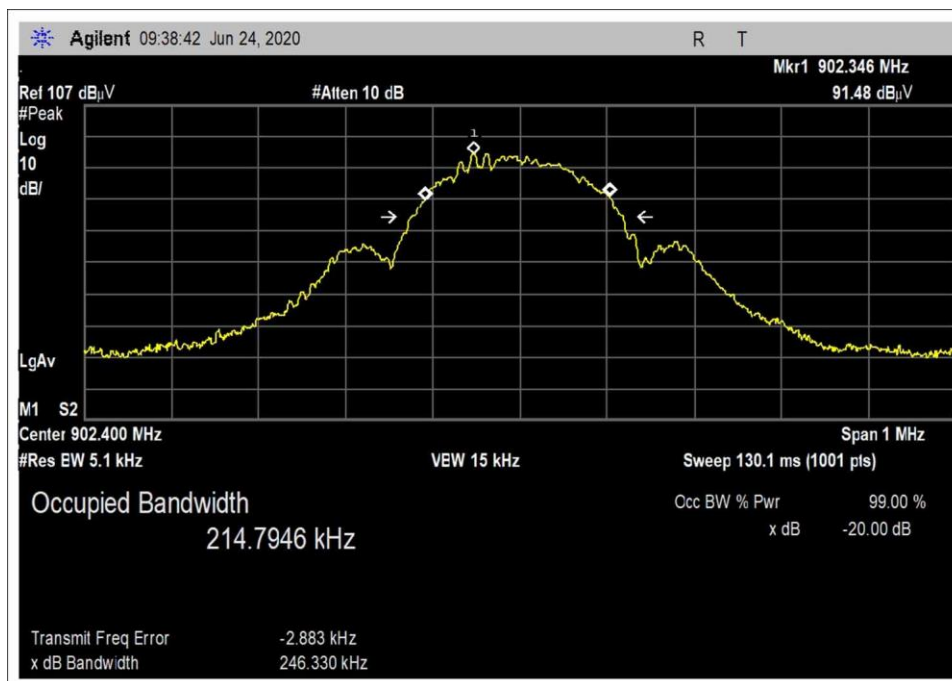
Test Equipment					
Asset#	Description	Manufacturer	Model	Cal Date	Cal Due
2871	Spectrum Analyzer	Agilent	E4440A	3/12/2020	3/12/2022

15.247(a)(1)(i) 20 dB Bandwidth

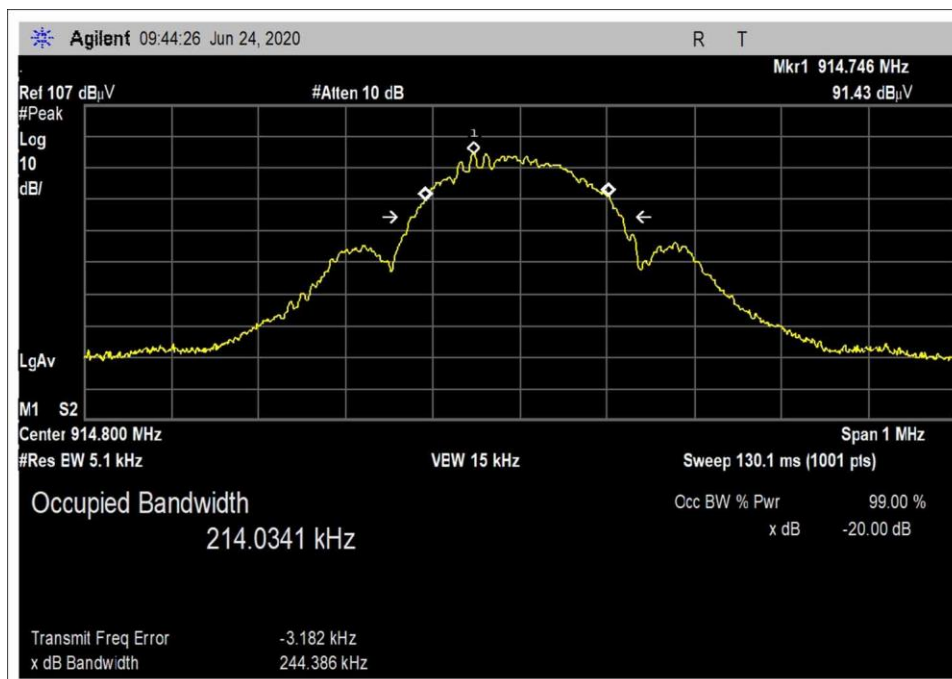
Test Data Summary					
Frequency (MHz)	Antenna Port	Modulation	Measured (kHz)	Limit (kHz)	Results
902.4	1	GFSK-2	246.3	*See Note	N/A
914.8	1	GFSK-2	244.4		
927.6	1	GFSK-2	243.7		

*For this Hybrid mode there is no requirement to meet the FHSS or DTS bandwidth limits. See Supplemental Section of data in 15.247 (f) Hybrid Systems.

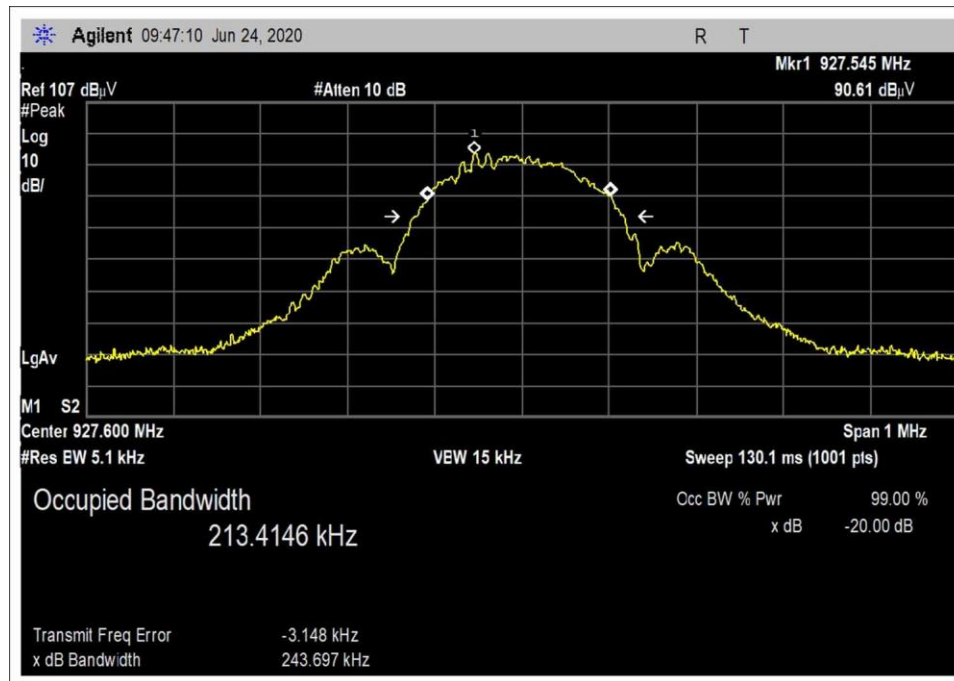
Plot(s)



Low Channel



Middle Channel

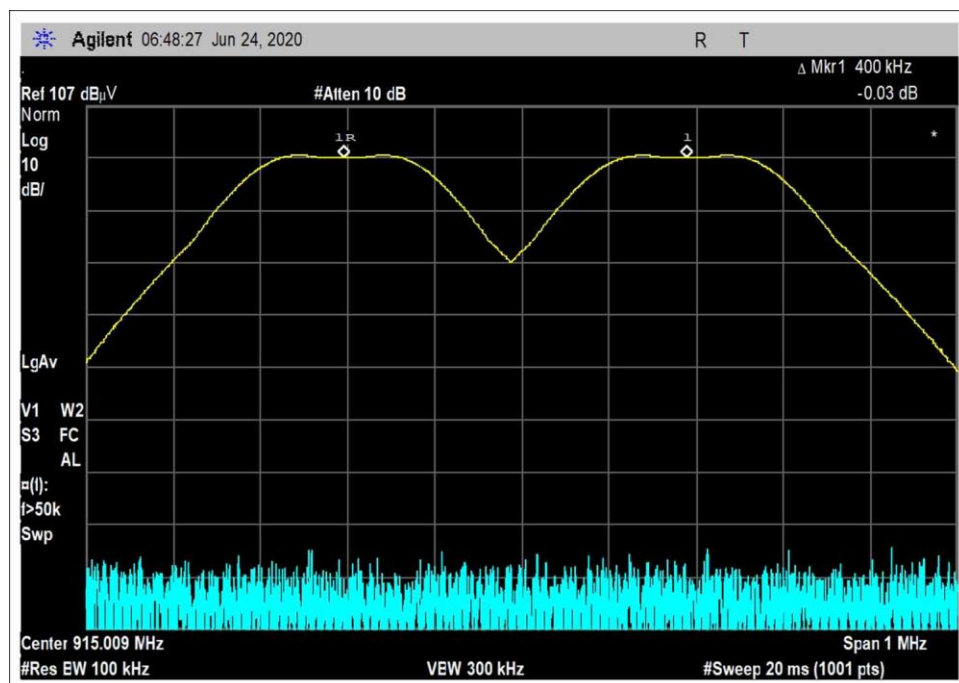


High Channel

15.247(a)(1) Carrier Separation

Test Data Summary				
Limit applied: 20dB bandwidth of the hopping channel.				
Antenna Port	Operational Mode	Measured (kHz)	Limit (kHz)	Results
1	Transmitting	400	≥ 246.3	Pass

Plot(s)

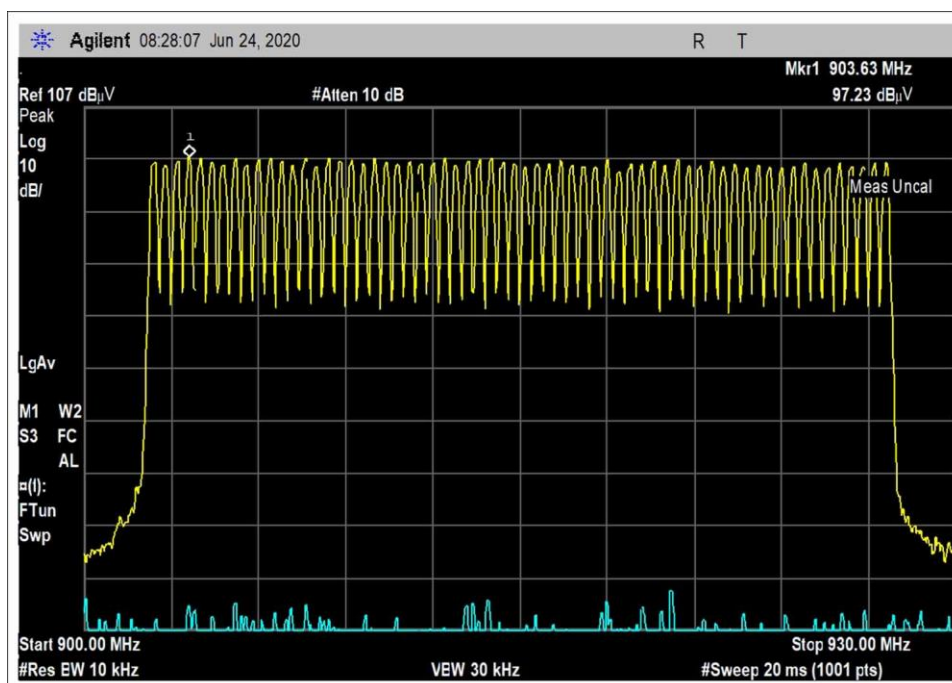


15.247(a)(1)(i) Number of Hopping Channels

Test Data Summary				
$\text{Limit} = \begin{cases} 50 \text{ Channels} & 20 \text{ dB BW} < 250 \text{ kHz} \\ 25 \text{ Channels} & 20 \text{ dB BW} \geq 250 \text{ kHz} \end{cases}$				
Antenna Port	Operational Mode	Measured (Channels)	Limit (Channels)	Results
1	Transmitting	64	≥ 50	Pass

*For this Hybrid Mode there is no minimum number of hopping channels.

Plot(s)



Test Setup Photo(s)



15.247(b)(2) Output Power

Test Equipment					
Asset#	Description	Manufacturer	Model	Cal Date	Cal Due
2871	Spectrum Analyzer	Agilent	E4440A	3/12/2020	3/12/2022
1995	Biconilog Antenna	Chase	CBL6111C	4/14/2020	4/14/2022
02307	Preamp	HP	8447D	1/10/2020	1/10/2022
P05275	Attenuator	Weinschel	1W	3/26/2020	3/26/2022
D06122	Power Supply	Lambda	GEN 125-80	1/18/2021	1/18/2023

Test Data Summary - Voltage Variations					
Frequency (MHz)	Modulation	V _{Minimum} (dBm)	V _{Nominal} (dBm)	V _{Maximum} (dBm)	Max Deviation from V _{Nominal} (dB)
927.6	GFSK-2	17.3	17.4	17.3	0.1

Test performed using operational mode with the highest output power, representing worst case.

Parameter Definitions:

Measurements performed at input voltage according to manufacturer specification.

Parameter	Value
V _{Nominal} :	5-30 VDC
V _{Minimum} :	4.5 VDC (EUT Shut off below 4.5VDC)
V _{Maximum} :	34.5 VDC

Test Data Summary - Radiated Measurement						
Limit = 30dBm Conducted/36dBm EIRP						
Frequency (MHz)	Modulation	Ant. Type / Gain (dBi)	Field Strength (dBuV/m @3m)	Calculated (dBm)	Limit (dBm)	Results
902.4	GFSK-2	PCB Antenna / 2.4 dBi	111.5	13.9	≤ 30	Pass
914.8	GFSK-2	PCB Antenna / 2.4 dBi	110.7	13.1	≤ 30	Pass
927.6	GFSK-2	PCB Antenna / 2.4 dBi	112.6	15.0	≤ 30	Pass

*For this Hybrid Mode there is no minimum number of hopping channels required for the 1 Watt (30dBm) limit.

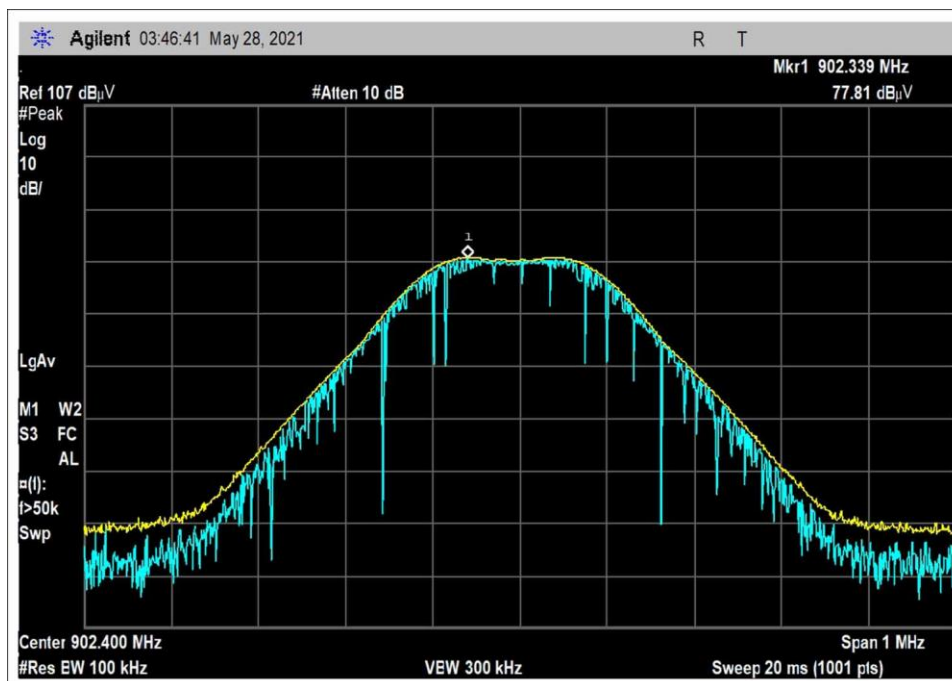
Conducted RF output power calculated in accordance with ANSI C63.10.

$$P(W) = \frac{(E \cdot d)^2}{30 G}$$

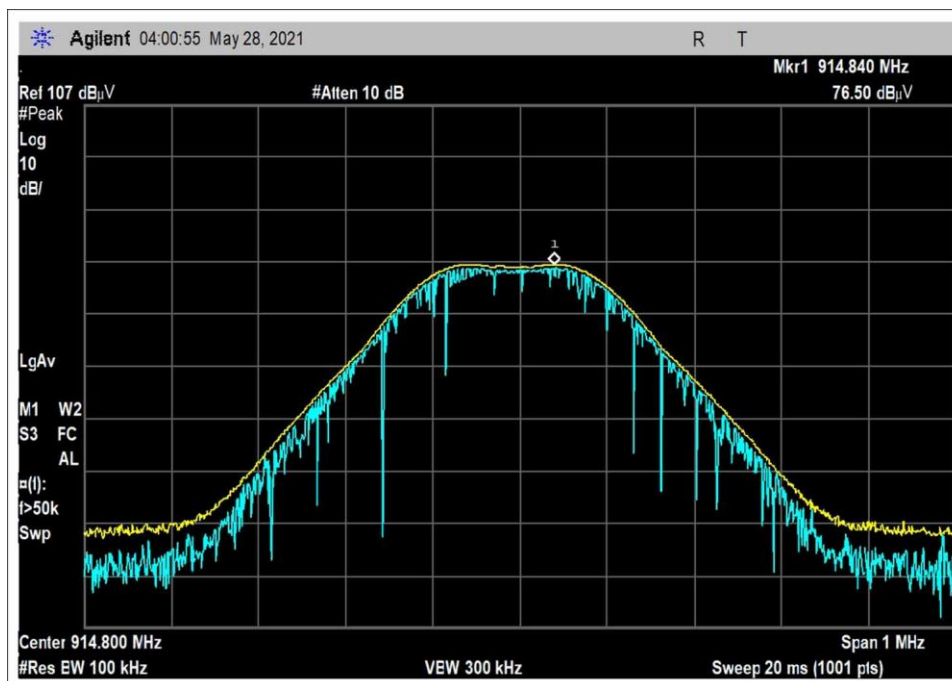
Or equivalently, in logarithmic form:

$$P(dBm) = E(dBuV/m) + 20LOG(d) - G - 104.77$$

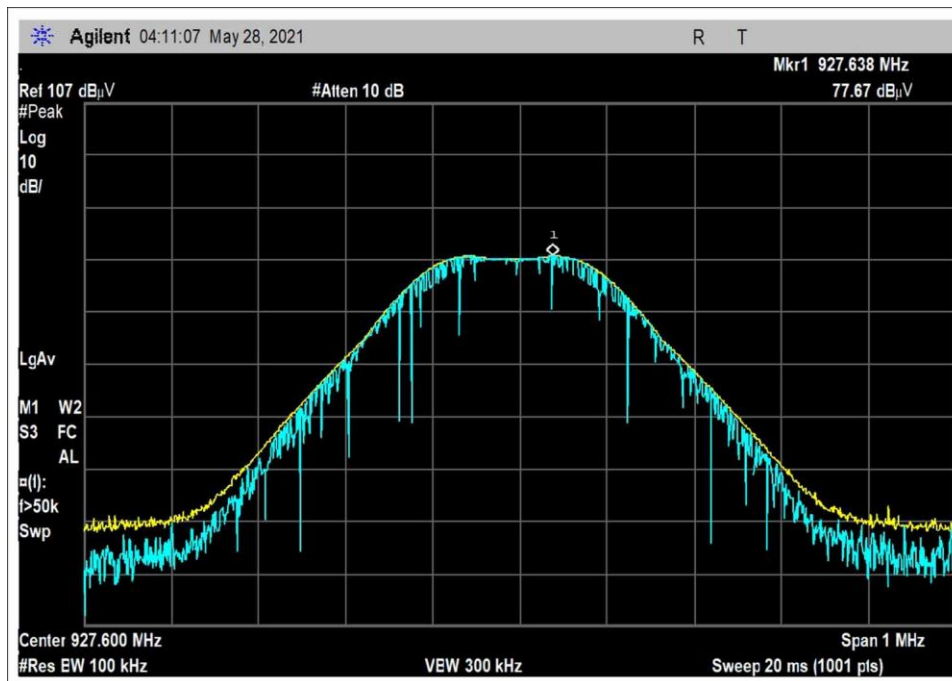
Plots



Low Channel



Middle Channel



High Channel

Test Setup / Conditions / Data

Test Location: CKC Laboratories, Inc. • 22116 23rd Drive SE, Suite A • Bothell, WA 98021 • 1-800-500-4EMC (4362)
 Customer: **Nalloy, LLC**
 Specification: **15.247(b) Power Output (902-928 MHz DTS)**
 Work Order #: **104760** Date: 1/19/2023
 Test Type: **Maximized Emissions** Time: 10:03:07
 Tested By: M. Harrison Sequence#: 8
 Software: EMITest 5.03.20

Equipment Tested:

Device	Manufacturer	Model #	S/N
Configuration 1			

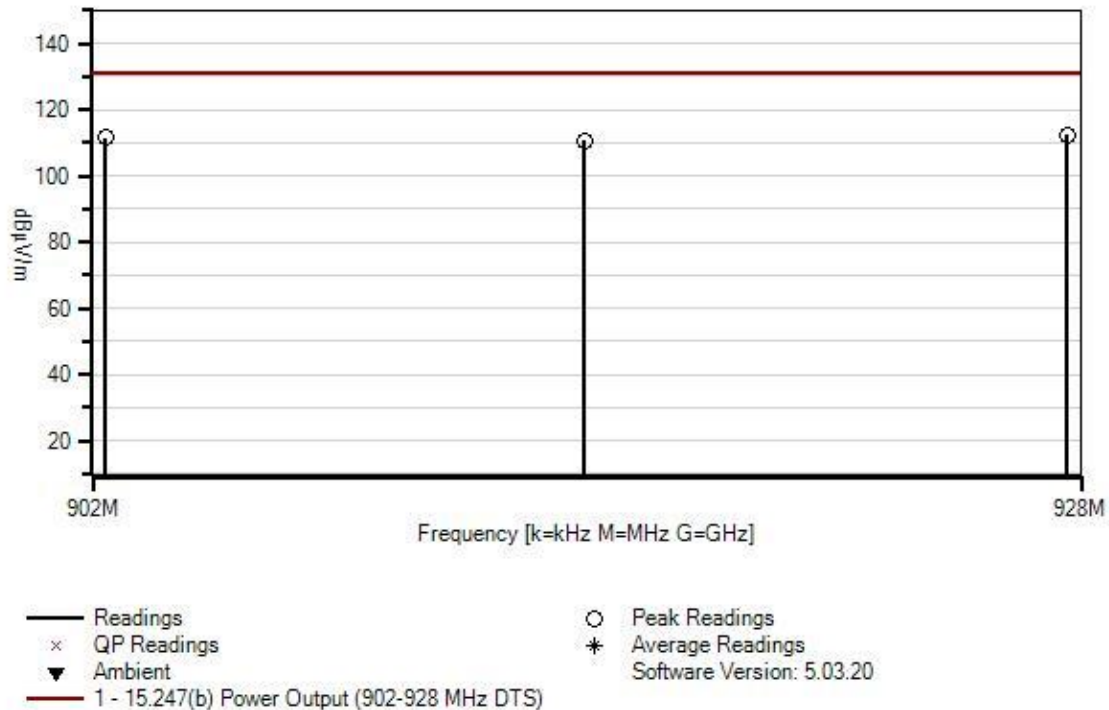
Support Equipment:

Device	Manufacturer	Model #	S/N
Configuration 1			

Test Conditions / Notes:

Test Environment Conditions: Temperature: 20°C Humidity: 33% Pressure: 102.1kPa Method: ANSI C63.10: 2013 Frequency range: 902.4-927.6 MHz Setup: AOS V2 Powered Via Delta PSU (24VDC/100W PSU MSS) Low Channel (0) 902.4 MHz, Mid (31) 914.8MHz, High (63) 927.6MHz GFSK-2 100% Duty Cycle PWR Level Setting: 150 PWR Output: 15dBm
--

Nalloy, LLC W/O#: 104760 Sequence#: 8 Date: 1/19/2023
15.247(b) Power Output (902-928 MHz DTS) Test Distance: 3 Meters Horiz



Test Equipment:

ID	Asset #	Description	Model	Calibration Date	Cal Due Date
T1	AN03628	Biconilog Antenna	3142E	6/3/2021	6/3/2023
T2	ANP05333	Cable	Heliac	3/14/2022	3/14/2024
T3	ANP05360	Cable	RG214	2/4/2022	2/4/2024
T4	ANP06540	Cable	Heliac	1/17/2022	1/17/2024
T5	AN02673	Spectrum Analyzer	E4446A	2/3/2021	2/3/2023

Measurement Data:

Reading listed by margin.

Test Distance: 3 Meters

#	Freq MHz	Rdng dBμV	T1 T5 dB	T2 dB	T3 dB	T4 dB	Dist Table	Corr dBμV/m	Spec dBμV/m	Margin dB	Polar Ant
1	927.642M	77.7	+30.6 +0.0	+1.6	+2.4	+0.3	+0.0	112.6	131.2	-18.6	Horiz
2	902.339M	77.8	+29.6 +0.0	+1.5	+2.3	+0.3	+0.0	111.5	131.2	-19.7	Horiz
3	914.840M	76.5	+29.9 +0.0	+1.6	+2.4	+0.3	+0.0	110.7	131.2	-20.5	Horiz

Test Setup Photo(s)



Below 1GHz; View 1



Below 1GHz; View 2

15.247(d) Radiated Emissions & Band Edge

Test Setup / Conditions / Data

Test Location: CKC Laboratories, Inc. • 22116 23rd Drive SE, Suite A • Bothell, WA 98021 • 1-800-500-4EMC (4362)
 Customer: **Nalloy, LLC**
 Specification: **15.247(d) / 15.209 Radiated Spurious Emissions**
 Work Order #: **104760** Date: 5/14/2021
 Test Type: **Maximized Emissions** Time: 10:02:00
 Tested By: M. Harrison Sequence#: 3
 Software: EMITest 5.03.19

Equipment Tested:

Device	Manufacturer	Model #	S/N
Configuration 1			

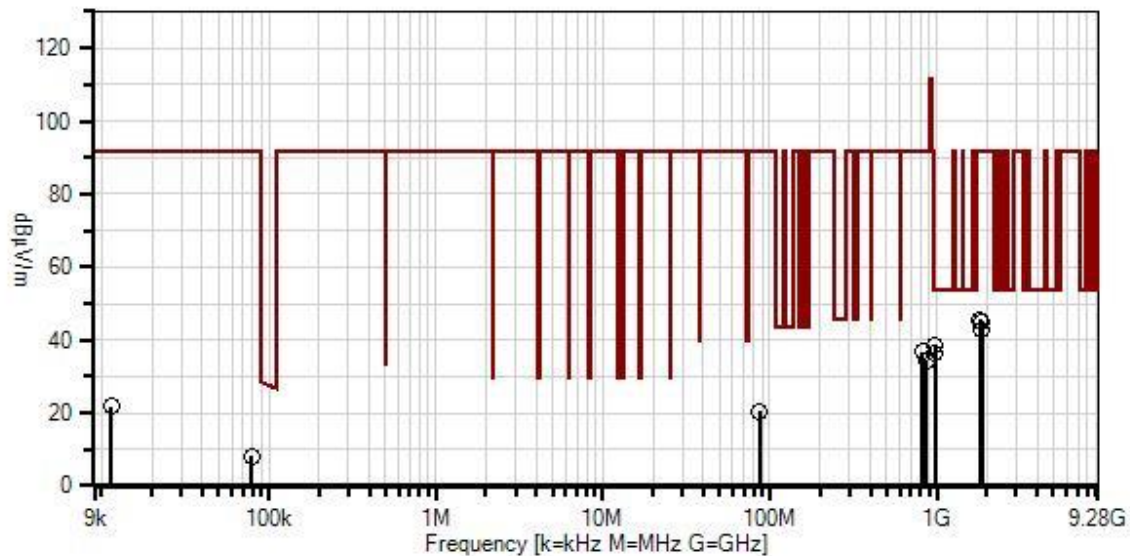
Support Equipment:

Device	Manufacturer	Model #	S/N
Configuration 1			

Test Conditions / Notes:

Test Environment Conditions: Temperature: 20°C Humidity: 33% Pressure: 102.1kPa Method: ANSI C63.4: 2014 Frequency range: 9k-10GHz (Highest Frequency Generated = 927.6MHz) Setup: AOS V2 Powered Via Delta PSU (24VDC/100W PSU MSS) Low Channel (0) 902.4 MHz, Mid (31) 914.8MHz, High (63) 927.6MHz GFSK-2 100% Duty Cycle PWR Level Setting: 150 PWR Output: 15dBm

Nalloy, LLC W/O#: 104760 Sequence#: 3 Date: 5/14/2021
15.247(d) / 15.209 Radiated Spurious Emissions Test Distance: 3 Meters Perp/Para



— Readings
× QP Readings
▼ Ambient
— 1 - 15.247(d) / 15.209 Radiated Spurious Emissions

○ Peak Readings
* Average Readings
Software Version: 5.03.19

Test Equipment:

ID	Asset #	Description	Model	Calibration Date	Cal Due Date
T1	AN02871	Spectrum Analyzer	E4440A	3/12/2020	3/12/2022
T2	AN03540	Preamp	83017A	5/13/2019	5/13/2021
T3	AN01467	Horn Antenna- ANSI C63.5 Calibration	3115	7/5/2019	7/5/2021
T4	ANP06515	Cable	Heliac	7/1/2020	7/1/2022
T5	ANP06540	Cable	Heliac	8/23/2019	8/23/2021
T6	ANP07505	Cable	CLU40-KMKM- 02.00F	1/26/2021	1/26/2023
T7	AN03170	High Pass Filter	HM1155-11SS	10/23/2019	10/23/2021
T8	AN02307	Preamp	8447D	1/10/2020	1/10/2022
T9	ANP05305	Cable	ETSI-50T	9/6/2019	9/6/2021
T10	ANP05360	Cable	RG214	2/3/2020	2/3/2022
T11	AN01995	Biconilog Antenna	CBL6111C	4/14/2020	4/14/2022
T12	ANP05275	Attenuator	1W	3/26/2020	3/26/2022
T13	AN00052	Loop Antenna	6502	5/4/2020	5/4/2022

Measurement Data:

Reading listed by margin.

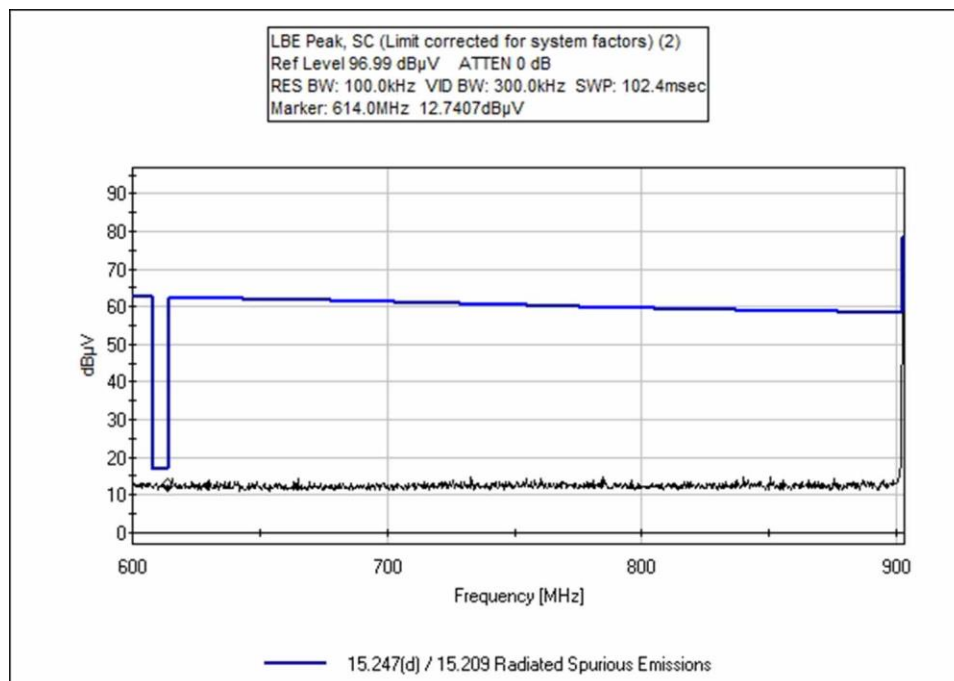
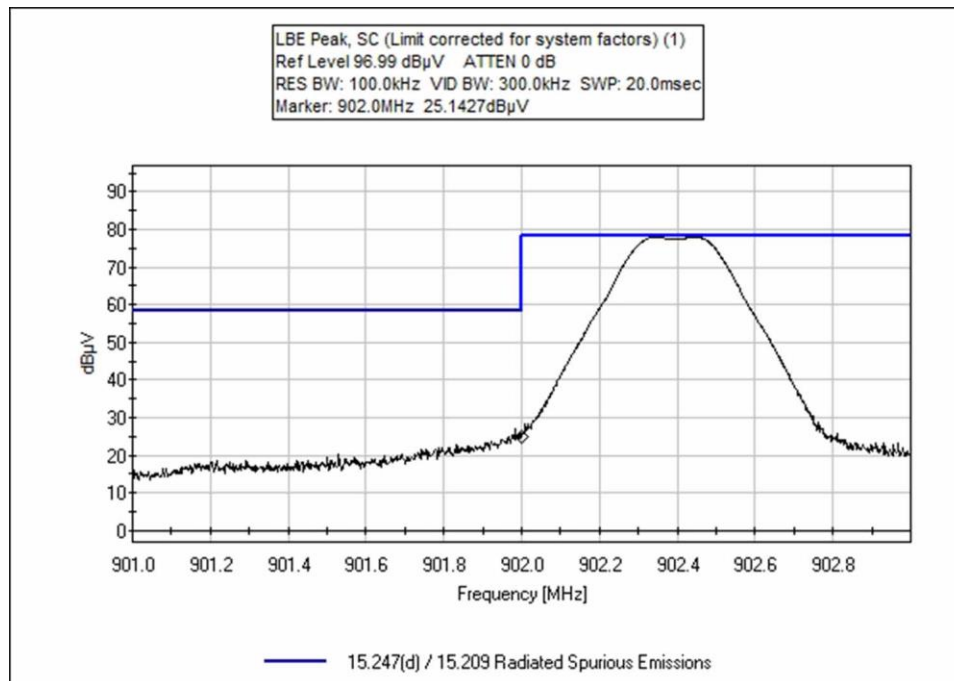
Test Distance: 3 Meters

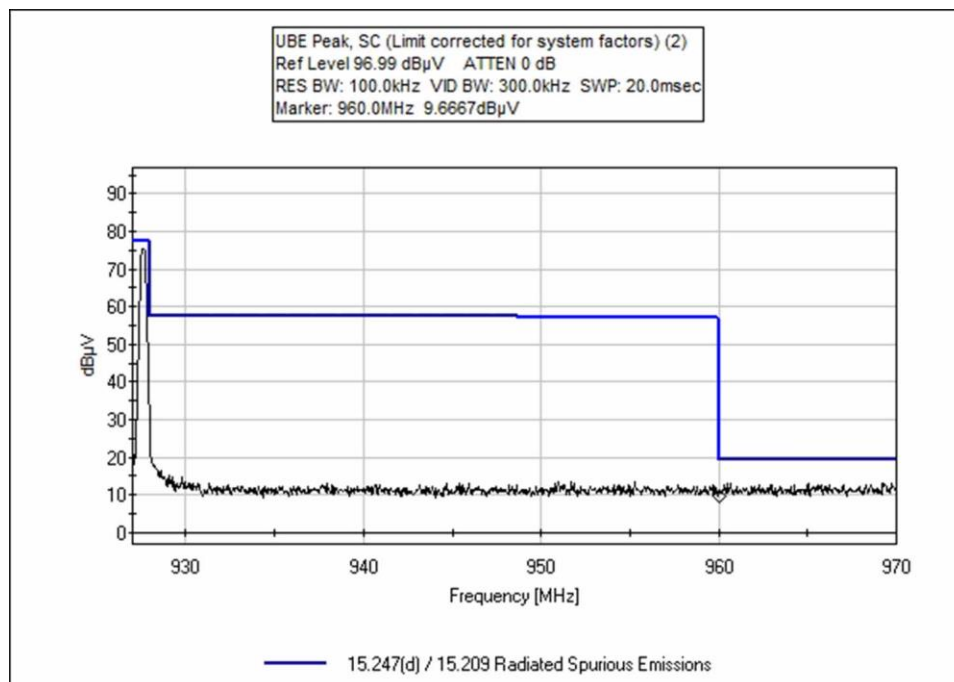
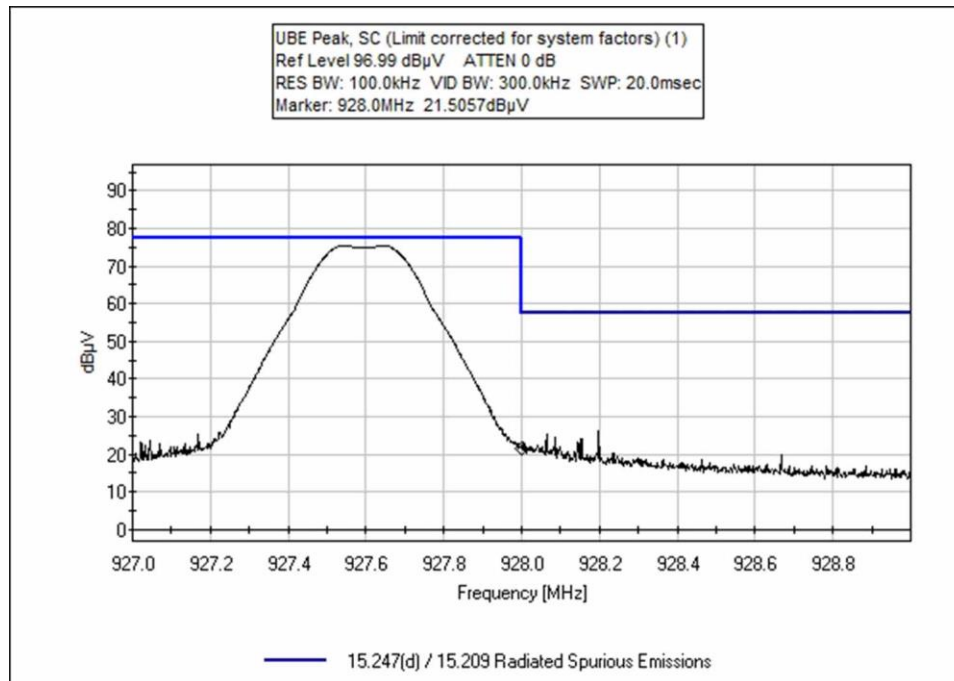
#	Freq	Rdng	T1 T5 T9 T13	T2 T6 T10	T3 T7 T11	T4 T8 T12	Dist	Corr	Spec	Margin	Polar
	MHz	dB μ V	dB	dB	dB	dB	Table	dB μ V/m	dB μ V/m	dB	Ant
1	978.700M	30.8	+0.0 +0.4 +1.5 +0.0	+0.0 +0.0 +2.3	+0.0 +0.0 +24.6	+0.0 -27.1 +6.1	+0.0	38.6	54.0	-15.4	Vert/
2	979.600M	28.8	+0.0 +0.4 +1.5 +0.0	+0.0 +0.0 +2.3	+0.0 +0.0 +24.6	+0.0 -27.1 +6.1	+0.0	36.6	54.0	-17.4	Vert/
3	1805.046M	50.8	+0.0 +0.5 +0.0 +0.0	-34.8 +0.3 +0.0	+26.1 +0.5 +0.0	+2.3 +0.0 +0.0	+0.0	45.7	91.7	-46.0	Vert/
4	1855.170M	49.5	+0.0 +0.5 +0.0 +0.0	-34.7 +0.3 +0.0	+26.5 +0.4 +0.0	+2.4 +0.0 +0.0	+0.0	44.9	91.7	-46.8	Vert/
5	1829.475M	47.5	+0.0 +0.5 +0.0 +0.0	-34.8 +0.3 +0.0	+26.3 +0.4 +0.0	+2.4 +0.0 +0.0	+0.0	42.6	91.7	-49.1	Vert/
6	825.400M	31.9	+0.0 +0.3 +1.4 +0.0	+0.0 +0.0 +1.9	+0.0 +0.0 +22.7	+0.0 -27.6 +6.1	+0.0	36.7	91.7	-55.0	Vert/
7	864.200M	28.9	+0.0 +0.3 +1.4 +0.0	+0.0 +0.0 +2.0	+0.0 +0.0 +23.1	+0.0 -27.5 +6.1	+0.0	34.3	91.7	-57.4	Vert/
8	11.397k	46.8	+0.0 +0.0 +0.0 +15.1	+0.0 +0.0 +0.0	+0.0 +0.0 +0.0	+0.0 +0.0 +0.0	-40.0	21.9	91.7	-69.8	Perp/
9	86.300M	33.0	+0.0 +0.1 +0.4 +0.0	+0.0 +0.0 +0.5	+0.0 +0.0 +8.2	+0.0 -27.8 +6.0	+0.0	20.4	91.7	-71.3	Vert/
10	79.218k	38.5	+0.0 +0.0 +0.0 +9.6	+0.0 +0.0 +0.0	+0.0 +0.0 +0.0	+0.0 +0.0 +0.0	-40.0	8.1	91.7	-83.6	Perp/
11	18.209M	11.5	+0.0 +0.1 +0.0 +8.0	+0.0 +0.0 +0.0	+0.0 +0.0 +0.0	+0.2 +0.0 +0.0	-20.0	-0.2	91.7	-91.9	Perp/

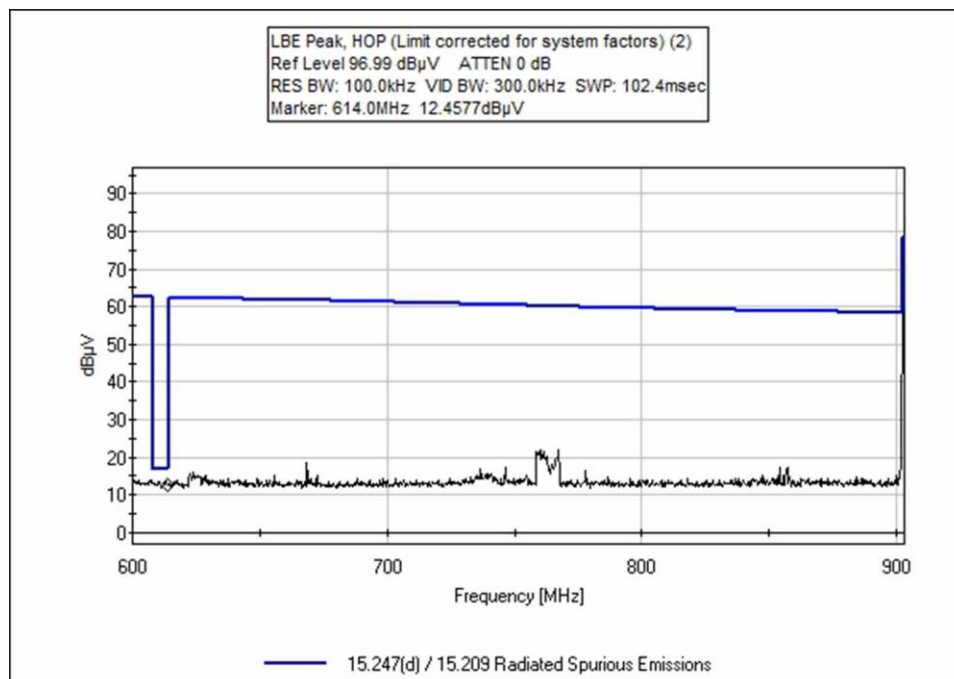
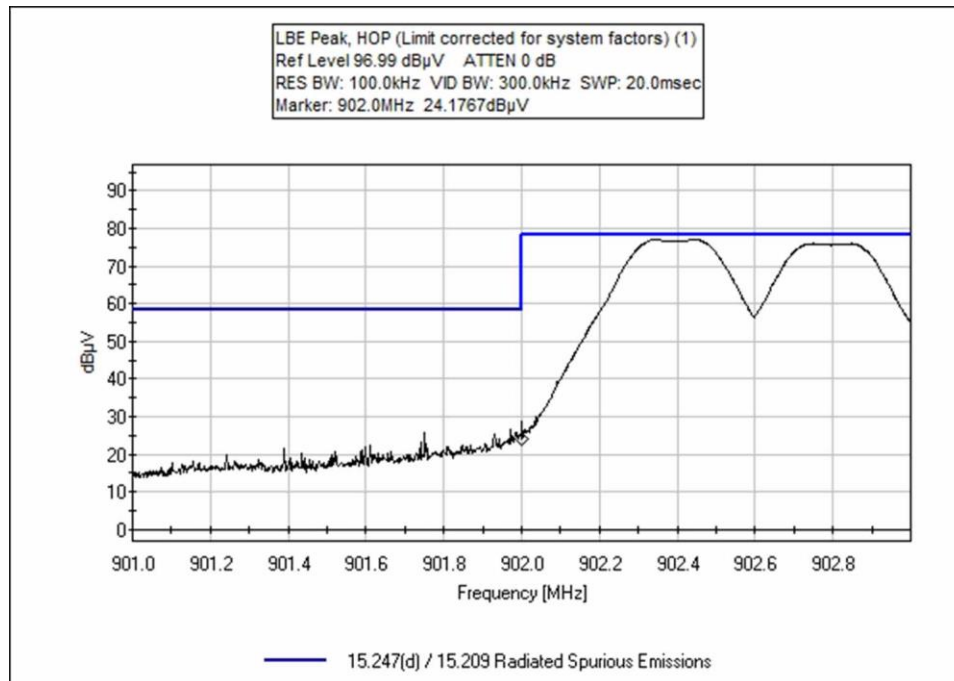
Band Edge

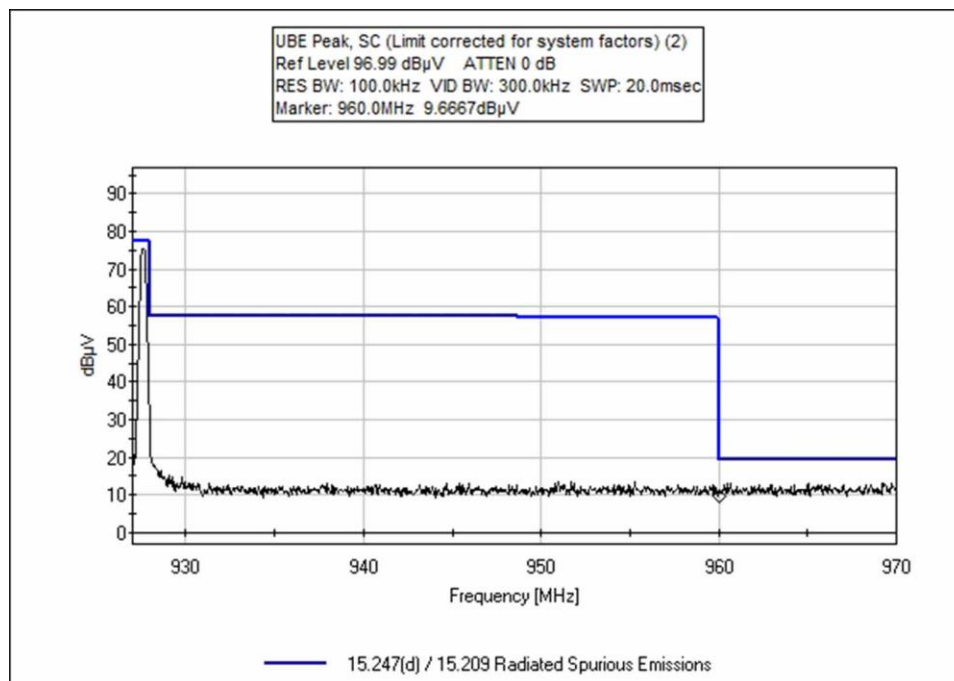
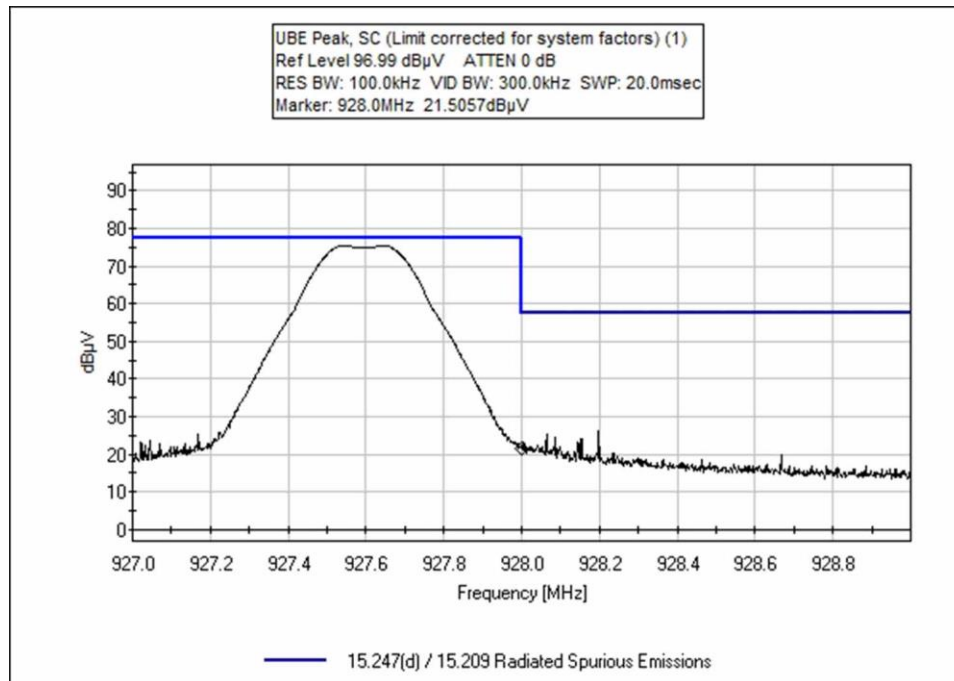
Band Edge Summary					
Frequency (MHz)	Modulation	Ant. Type	Field Strength (dBuV/m @3m)	Limit (dBuV/m @3m)	Results
614	GFSK-2 (Single Channel)	PCB Antenna	42	< 46	Pass
902			58.4	< 91.7	Pass
928			55.5	< 91.7	Pass
960			44.2	< 54	Pass
614	GFSK-2 (Hopping)	PCB Antenna	41.8	< 46	Pass
902			57.5	< 91.7	Pass
928			57.6	< 91.7	Pass
960			47.8	< 54	Pass

Band Edge Plots









Test Setup / Conditions / Data

Test Location: CKC Laboratories, Inc. • 22116 23rd Drive SE, Suite A • Bothell, WA 98021 • 1-800-500-4EMC (4362)
 Customer: **Nalloy, LLC**
 Specification: **15.247(d) / 15.209 Radiated Spurious Emissions**
 Work Order #: **104760** Date: 5/14/2021
 Test Type: **Maximized Emissions** Time: 08:40:47
 Tested By: M. Harrison Sequence#: 6
 Software: EMITest 5.03.19

Equipment Tested:

Device	Manufacturer	Model #	S/N
Configuration 1			

Support Equipment:

Device	Manufacturer	Model #	S/N
Configuration 1			

Test Conditions / Notes:

Test Environment Conditions: Temperature: 20°C Humidity: 33% Pressure: 102.1kPa Method: ANSI C63.10: 2013 Frequency range: 600-970MHz (Highest Frequency Generated = 927.6MHz) Setup: AOS V2 Powered Via Delta PSU (24VDC/100W PSU MSS) Low Channel (0) 902.4 MHz, Mid (31) 914.8MHz, High (63) 927.6MHz GFSK-2 100% Duty Cycle PWR Level Setting: 150 PWR Output: 15dBm
--

Test Equipment:

ID	Asset #	Description	Model	Calibration Date	Cal Due Date
T1	AN02871	Spectrum Analyzer	E4440A	3/12/2020	3/12/2022
T2	ANP05305	Cable	ETSI-50T	9/6/2019	9/6/2021
T3	ANP05360	Cable	RG214	2/3/2020	2/3/2022
T4	ANP06540	Cable	Heliac	8/23/2019	8/23/2021
T5	AN01995	Biconilog Antenna	CBL6111C	4/14/2020	4/14/2022
T6	ANP05275	Attenuator	1W	3/26/2020	3/26/2022

Measurement Data:

Reading listed by margin.

Test Distance: 3 Meters

#	Freq MHz	Rdng dBμV	T1 T5 dB	T2 T6 dB	T3 dB	T4 dB	Dist Table	Corr dBμV/m	Spec dBμV/m	Margin dB	Polar Ant
1	902.345M	78.4	+0.0 +23.4	+1.4 +6.1	+2.1	+0.3	+0.0	111.7	111.7 SC	+0.0	Vert
2	614.000M	12.7	+0.0 +20.0	+1.2 +6.1	+1.7	+0.3	+0.0	42.0	46.0 SC	-4.0	Vert
3	614.000M	12.5	+0.0 +20.0	+1.2 +6.1	+1.7	+0.3	+0.0	41.8	46.0 Hop	-4.2	Vert
4	960.000M	13.3	+0.0 +24.3	+1.5 +6.1	+2.2	+0.4	+0.0	47.8	54.0 Hop	-6.2	Vert
5	960.000M	9.7	+0.0 +24.3	+1.5 +6.1	+2.2	+0.4	+0.0	44.2	54.0 SC	-9.8	Vert
6	902.000M	25.1	+0.0 +23.4	+1.4 +6.1	+2.1	+0.3	+0.0	58.4	91.7 SC	-33.3	Vert
7	928.000M	23.6	+0.0 +23.8	+1.5 +6.1	+2.2	+0.4	+0.0	57.6	91.7 Hop	-34.1	Vert
8	902.000M	24.2	+0.0 +23.4	+1.4 +6.1	+2.1	+0.3	+0.0	57.5	91.7 Hop	-34.2	Vert
9	928.000M	21.5	+0.0 +23.8	+1.5 +6.1	+2.2	+0.4	+0.0	55.5	91.7 SC	-36.2	Vert

Test Setup Photo(s)



Below 1GHz; View 1



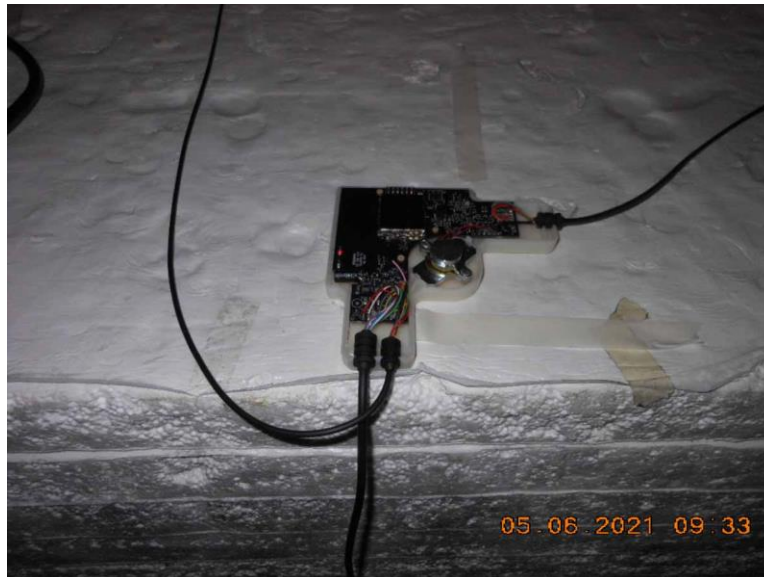
Below 1GHz; View 2



Above 1GHz; View 1



Above 1GHz; View 2



X Axis



Y Axis



Z Axis

15.247 (f) Hybrid Systems Time of Occupancy

Test Setup/Conditions			
Test Location:	Bothell Lab C3	Test Engineer:	M. Harrison
Test Method:	ANSI C63.10 (2013)	Test Date(s):	5/21/2021
Configuration:	1		
Test Setup:	Test Mode: Continuously Modulated The spectrum analyzer is connected to a near field probe located near EUT antenna.		

Environmental Conditions			
Temperature (°C)	23	Relative Humidity (%):	40

Test Equipment					
Asset#	Description	Manufacturer	Model	Cal Date	Cal Due
2871	Spectrum Analyzer	Agilent	E4440A	3/12/2020	3/12/2022

Test Data Summary				
Observation Period, P_{obs} is derived from the following: $P_{obs} = (number\ of\ hopping\ frequencies) * 0.4$				
Antenna Port	Operational Mode	Measured (ms)	Limit (ms/ P_{obs})	Results
1	Hopping	5.74	≤400	Pass

Measured results are calculated as follows:

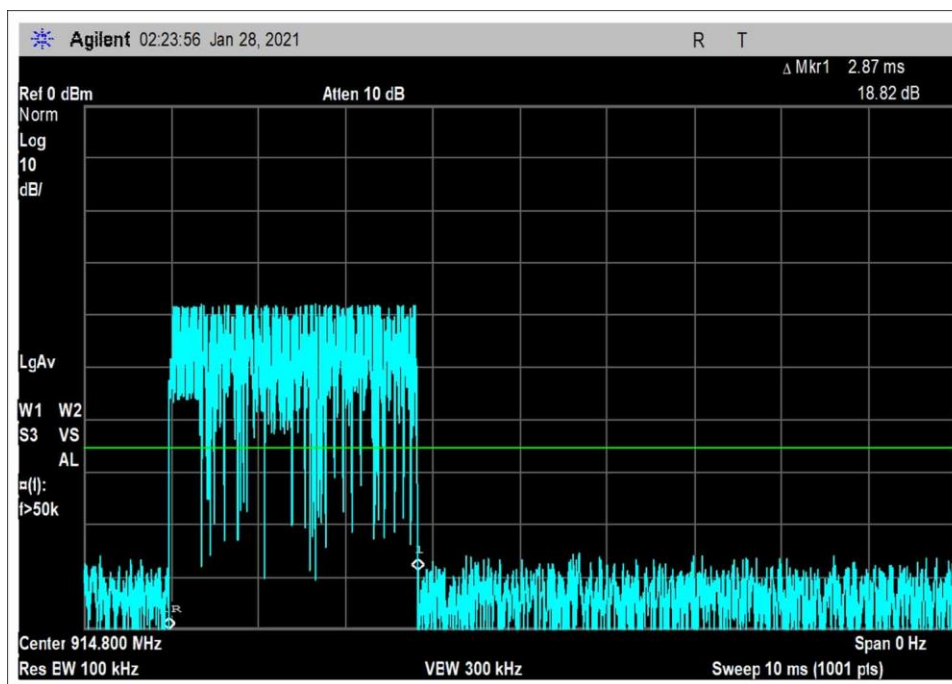
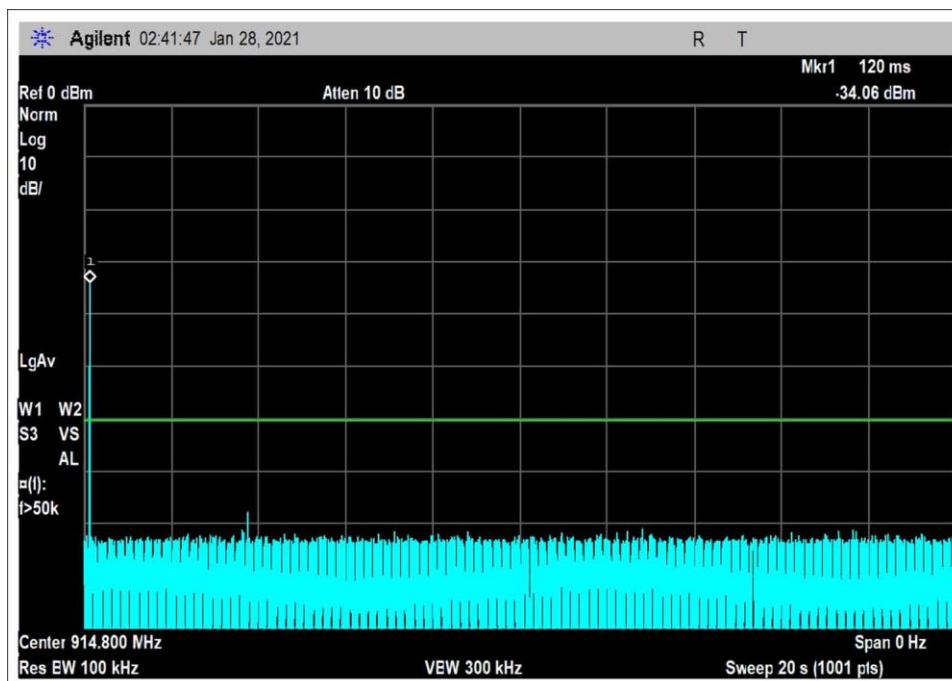
$$Dwell\ time = \left(\sum_{Bursts} RF\ Burst\ On\ Time + \sum_{Control} Control\ Signal\ On\ time \right) \Big|_{P_{obs}}$$

Actual Calculated Values:

Parameter	Value
Observation Period (P_{obs}):	25.6s
Number of RF Bursts / P_{obs} :	2
On time of RF Burst:	2.87ms
Number of Control or other signals / P_{obs} :	0
On time of Control or other Signals:	0
Total Measured On Time:	5.74

Note: The number of bursts in a 25.6 second window was extrapolated from a worst case 20 second measurement window (1 burst in 20 second window = 2 bursts in 25.6 second window).

Plot(s)



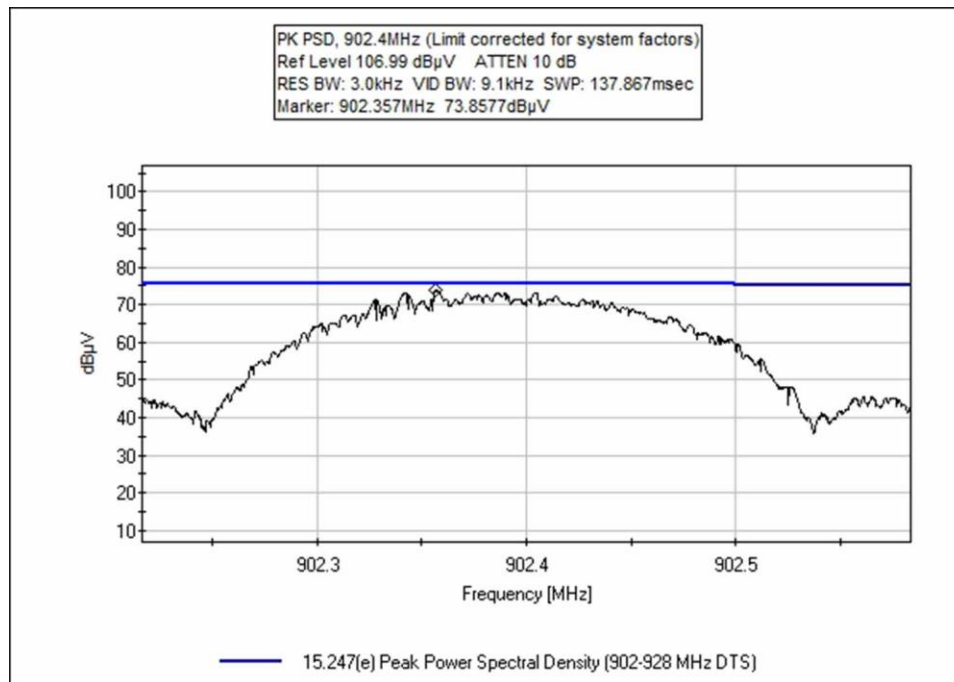
15.247 (f) Hybrid Systems Power Spectral Density

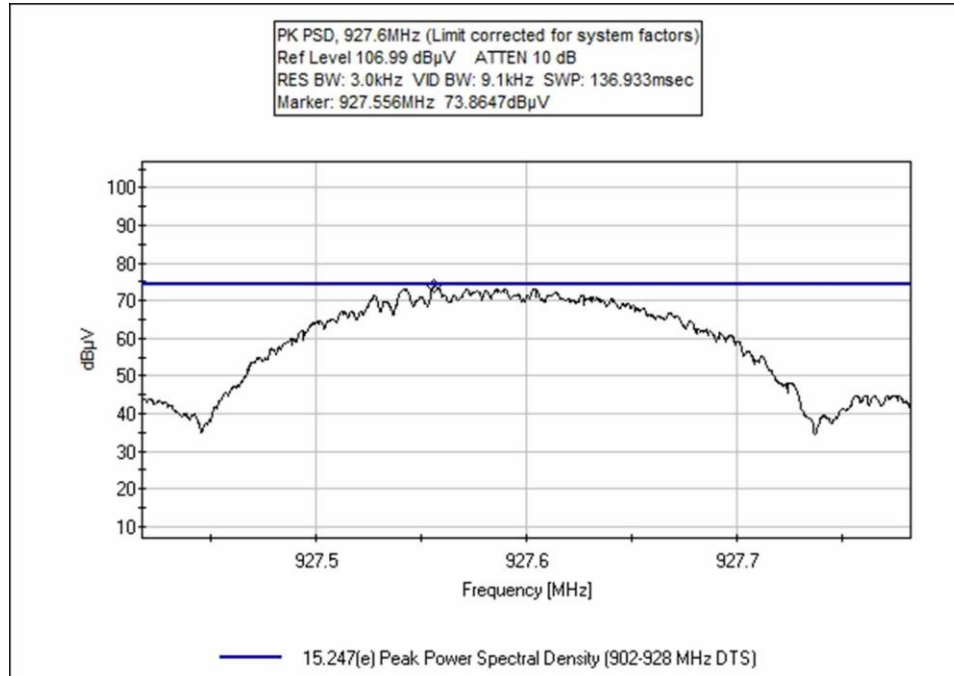
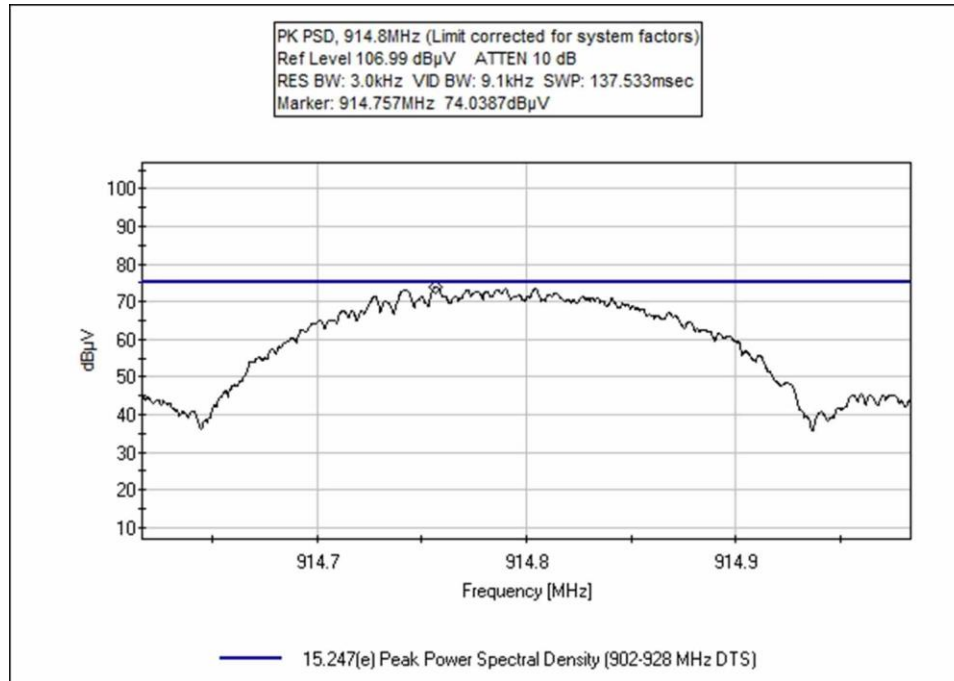
Test Data Summary - RF Conducted Measurement

Measurement Method: PKPSD

Frequency (MHz)	Modulation	Measured (dBμV/3kHz)	Limit (dBμV /3kHz)	Results
902.4	GFSK-2	107.6	≤109.2	Pass
914.8	GFSK-2	108.2	≤109.2	Pass
927.6	GFSK-2	108.8	≤109.2	Pass

Plot(s)





Test Setup / Conditions / Data

Test Location: CKC Laboratories, Inc. • 22116 23rd Drive SE, Suite A • Bothell, WA 98021 • 1-800-500-4EMC (4362)
 Customer: **Nalloy, LLC**
 Specification: **15.247(e) Peak Power Spectral Density (902-928 MHz DTS)**
 Work Order #: **107941** Date: 3/13/2023
 Test Type: **Maximized Emissions** Time: 15:50:37
 Tested By: M. Harrison Sequence#: 9
 Software: EMITest 5.03.20

Equipment Tested:

Device	Manufacturer	Model #	S/N
Configuration 2			

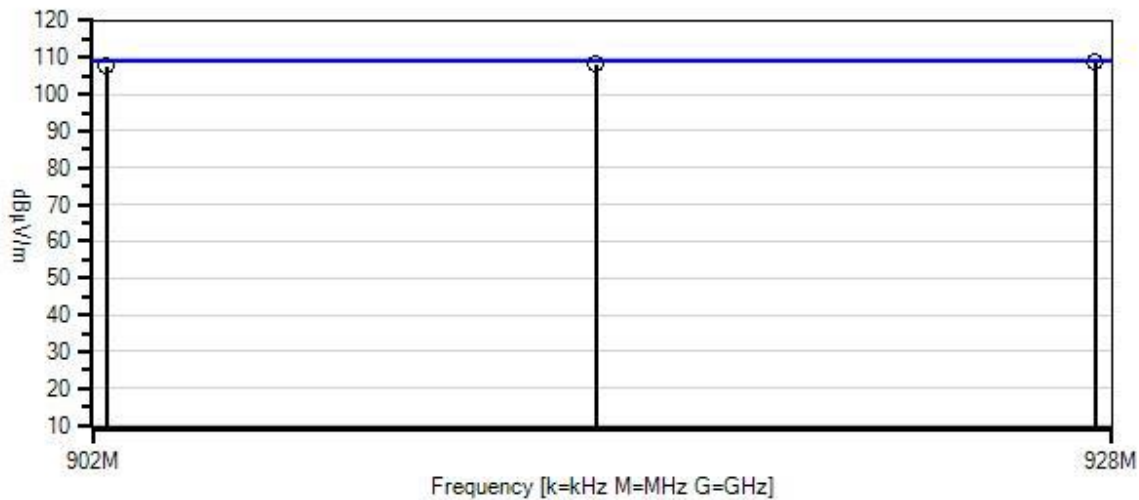
Support Equipment:

Device	Manufacturer	Model #	S/N
Configuration 2			

Test Conditions / Notes:

Temperature: 20°C Humidity: 33% Pressure: 102.1kPa Method: ANSI C63.10: 2013 Frequency range: 902.4-927.6 MHz Setup: AOS V2 Powered Via Delta PSU (24VDC/100W PSU MSS) Low Channel (0) 902.4 MHz, Mid (31) 914.8MHz, High (63) 927.6MHz GFSK-2 100% Duty Cycle PWR Level Setting: 150 PWR Output: 15dBm
--

Nalloy, LLC W/O#: 107941 Sequence#: 9 Date: 3/13/2023
15.247(e) Peak Power Spectral Density (902-928 MHz DTS) Test Distance: 3 Meters Horiz



— Readings
○ Peak Readings
× QP Readings
* Average Readings
▼ Ambient
Software Version: 5.03.20
— 1 - 15.247(e) Peak Power Spectral Density (902-928 MHz DTS)

Test Equipment:

ID	Asset #	Description	Model	Calibration Date	Cal Due Date
T1	AN03628	Biconilog Antenna	3142E	6/3/2021	6/3/2023
T2	ANP05333	Cable	Heliac	3/14/2022	3/14/2024
T3	ANP05360	Cable	RG214	2/4/2022	2/4/2024
T4	ANP06540	Cable	Heliac	1/17/2022	1/17/2024
	AN02672	Spectrum Analyzer	E4446A	5/9/2022	5/9/2024

Measurement Data:

Reading listed by margin.

Test Distance: 3 Meters

#	Freq MHz	Rdng dBμV	T1 dB	T2 dB	T3 dB	T4 dB	Dist Table	Corr dBμV/m	Spec dBμV/m	Margin dB	Polar Ant
1	927.556M	73.9	+30.6	+1.6	+2.4	+0.3	+0.0	108.8	109.2	-0.4	Horiz
2	914.757M	74.0	+29.9	+1.6	+2.4	+0.3	+0.0	108.2	109.2	-1.0	Horiz
3	902.357M	73.9	+29.6	+1.5	+2.3	+0.3	+0.0	107.6	109.2	-1.6	Horiz

Test Setup Photo(s)



Below 1GHz; View 1



Below 1GHz; View 2

15.207 AC Conducted Emissions

Test Setup / Conditions / Data

Test Location: CKC Laboratories, Inc. • 22116 23rd Drive SE, Suite A • Bothell, WA 98021 • 1-800-500-4EMC (4362)
 Customer: **Nalloy, LLC**
 Specification: **15.207 AC Mains - Average**
 Work Order #: **104760** Date: 5/14/2021
 Test Type: **Conducted Emissions** Time: 13:58:29
 Tested By: M. Harrison Sequence#: 8
 Software: EMITest 5.03.19 120V 60Hz

Equipment Tested:

Device	Manufacturer	Model #	S/N
Configuration 1			

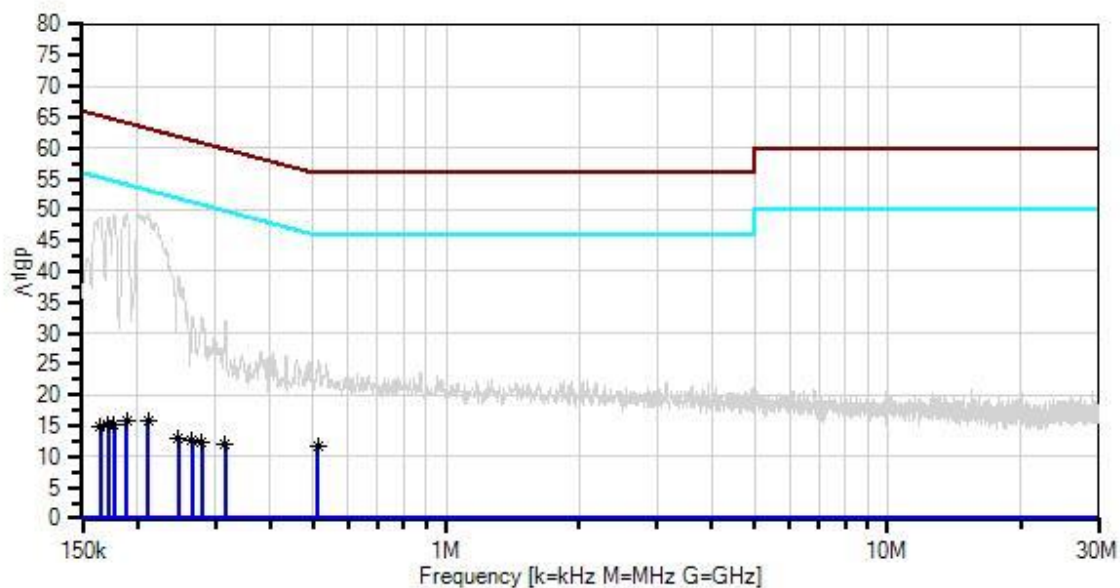
Support Equipment:

Device	Manufacturer	Model #	S/N
Configuration 1			

Test Conditions / Notes:

Test Environment Conditions: Temperature: 20°C Humidity: 33% Pressure: 102.1kPa Method: ANSI C63.10: 2013 Frequency range: 150k-30MHz Setup: AOS V2 Powered Via Delta PSU (24VDC/100W PSU MSS) Low Channel (0) 902.4 MHz, Mid (31) 914.8MHz, High (63) 927.6MHz GFSK-2 100% Duty Cycle PWR Level Setting: 150 PWR Output: 15dBm

Nalloy, LLC WO#: 104760 Sequence#: 8 Date: 5/14/2021
15.207 AC Mains - Average Test Lead: 120V 60Hz Line



— Sweep Data
× QP Readings
Software Version: 5.03.19
— Readings
* Average Readings
○ Peak Readings
▼ Ambient
— 1 - 15.207 AC Mains - Average
— 2 - 15.207 AC Mains - Quasi-peak

Test Equipment:

ID	Asset #	Description	Model	Calibration Date	Cal Due Date
T1	ANP06219	Attenuator	768-10	4/7/2020	4/7/2022
T2	ANP06515	Cable	Heliac	7/1/2020	7/1/2022
T3	ANP06540	Cable	Heliac	8/23/2019	8/23/2021
T4	AN01311	50uH LISN-Line1 (L)	3816/2	2/24/2020	2/24/2022
	AN01311	50uH LISN-Line2 (N)	3816/2	2/24/2020	2/24/2022
T5	AN02871	Spectrum Analyzer	E4440A	3/12/2020	3/12/2022
	AN02611	High Pass Filter	HE9615-150K-50-720B	1/10/2020	1/10/2022

Measurement Data:

Reading listed by margin.

Test Lead: Line

#	Freq MHz	Rdng dBμV	T1 T5 dB	T2 dB	T3 dB	T4 dB	Dist Table	Corr dBμV	Spec dBμV	Margin dB	Polar Ant
1	512.876k Ave	2.8	+9.1 +0.2	+0.0	+0.0	-0.4	+0.0	11.7	46.0	-34.3	Line
^	512.875k	16.8	+9.1 +0.2	+0.0	+0.0	-0.4	+0.0	25.7	46.0	-20.3	Line
3	211.085k Ave	7.4	+9.1 +0.3	+0.0	+0.0	-1.1	+0.0	15.7	53.2	-37.5	Line
^	211.085k	41.1	+9.1 +0.3	+0.0	+0.0	-1.1	+0.0	49.4	53.2	-3.8	Line
5	316.530k Ave	3.4	+9.1 +0.1	+0.0	+0.0	-0.7	+0.0	11.9	49.8	-37.9	Line
^	316.530k	23.5	+9.1 +0.1	+0.0	+0.0	-0.7	+0.0	32.0	49.8	-17.8	Line
7	189.269k Ave	7.6	+9.1 +0.3	+0.0	+0.0	-1.3	+0.0	15.7	54.1	-38.4	Line
^	189.269k	41.1	+9.1 +0.3	+0.0	+0.0	-1.3	+0.0	49.2	54.1	-4.9	Line
9	279.443k Ave	3.9	+9.1 +0.1	+0.0	+0.0	-0.8	+0.0	12.3	50.8	-38.5	Line
^	279.442k	24.3	+9.1 +0.1	+0.0	+0.0	-0.8	+0.0	32.7	50.8	-18.1	Line
11	266.353k Ave	4.2	+9.1 +0.2	+0.0	+0.0	-0.8	+0.0	12.7	51.2	-38.5	Line
^	266.352k	24.3	+9.1 +0.2	+0.0	+0.0	-0.8	+0.0	32.8	51.2	-18.4	Line
13	247.446k Ave	4.5	+9.1 +0.2	+0.0	+0.0	-0.9	+0.0	12.9	51.8	-38.9	Line
^	247.445k	30.9	+9.1 +0.2	+0.0	+0.0	-0.9	+0.0	39.3	51.8	-12.5	Line
15	176.907k Ave	7.0	+9.1 +0.4	+0.0	+0.0	-1.4	+0.0	15.1	54.6	-39.5	Line
^	176.906k	41.0	+9.1 +0.4	+0.0	+0.0	-1.4	+0.0	49.1	54.6	-5.5	Line
17	171.816k Ave	7.2	+9.1 +0.4	+0.0	+0.0	-1.5	+0.0	15.2	54.9	-39.7	Line
^	171.816k	40.8	+9.1 +0.4	+0.0	+0.0	-1.5	+0.0	48.8	54.9	-6.1	Line
19	164.544k Ave	6.9	+9.1 +0.5	+0.0	+0.0	-1.6	+0.0	14.9	55.2	-40.3	Line
^	164.544k	40.8	+9.1 +0.5	+0.0	+0.0	-1.6	+0.0	48.8	55.2	-6.4	Line

Test Location: CKC Laboratories, Inc. • 22116 23rd Drive SE, Suite A • Bothell, WA 98021 • 1-800-500-4EMC (4362)
 Customer: **Nalloy, LLC**
 Specification: **15.207 AC Mains - Average**
 Work Order #: **104760** Date: 5/14/2021
 Test Type: **Conducted Emissions** Time: 14:10:26
 Tested By: M. Harrison Sequence#: 9
 Software: EMITest 5.03.19 120V 60Hz

Equipment Tested:

Device	Manufacturer	Model #	S/N
Configuration 1			

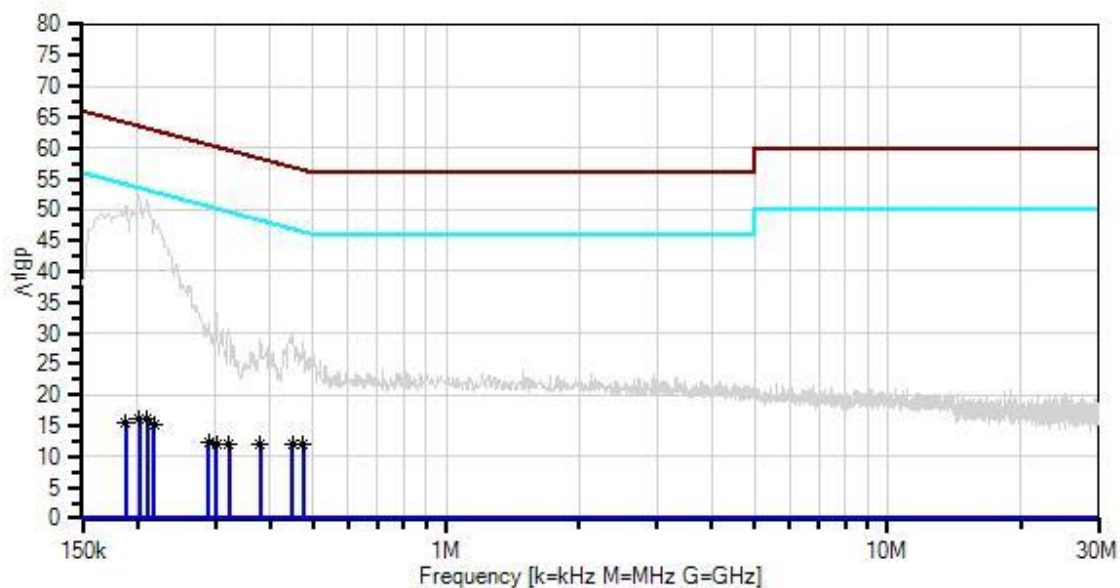
Support Equipment:

Device	Manufacturer	Model #	S/N
Configuration 1			

Test Conditions / Notes:

Test Environment Conditions: Temperature: 20°C Humidity: 33% Pressure: 102.1kPa Method: ANSI C63.10: 2013 Frequency range: 150k-30MHz Setup: AOS V2 Powered Via Delta PSU (24VDC/100W PSU MSS) Low Channel (0) 902.4 MHz, Mid (31) 914.8MHz, High (63) 927.6MHz GFSK-2 100% Duty Cycle PWR Level Setting: 150 PWR Output: 15dBm

Nalloy, LLC WO#: 104760 Sequence#: 9 Date: 5/14/2021
15.207 AC Mains - Average Test Lead: 120V 60Hz Neutral



— Sweep Data
× QP Readings
Software Version: 5.03.19
— Readings
* Average Readings
○ Peak Readings
▼ Ambient
— 1 - 15.207 AC Mains - Average
— 2 - 15.207 AC Mains - Quasi-peak

Test Equipment:

ID	Asset #	Description	Model	Calibration Date	Cal Due Date
T1	ANP06219	Attenuator	768-10	4/7/2020	4/7/2022
T2	ANP06515	Cable	Heliac	7/1/2020	7/1/2022
T3	ANP06540	Cable	Heliac	8/23/2019	8/23/2021
T4	AN01311	50uH LISN-Line1 (L)	3816/2	2/24/2020	2/24/2022
	AN01311	50uH LISN-Line2 (N)	3816/2	2/24/2020	2/24/2022
	AN02871	Spectrum Analyzer	E4440A	3/12/2020	3/12/2022
T5	AN02611	High Pass Filter	HE9615-150K-50-720B	1/10/2020	1/10/2022

Measurement Data:

Reading listed by margin.

Test Lead: Neutral

#	Freq MHz	Rdng dBμV	T1 T5 dB	T2 dB	T3 dB	T4 dB	Dist Table	Corr dBμV	Spec dBμV	Margin dB	Polar Ant
1	473.607k Ave	3.0	+9.1 +0.2	+0.0	+0.0	-0.4	+0.0	11.9	46.5	-34.6	Neutr
^	473.606k	19.5	+9.1 +0.2	+0.0	+0.0	-0.4	+0.0	28.4	46.5	-18.1	Neutr
3	448.882k Ave	3.1	+9.1 +0.2	+0.0	+0.0	-0.5	+0.0	11.9	46.9	-35.0	Neutr
^	448.881k	20.9	+9.1 +0.2	+0.0	+0.0	-0.5	+0.0	29.7	46.9	-17.2	Neutr
5	379.070k Ave	3.2	+9.1 +0.2	+0.0	+0.0	-0.5	+0.0	12.0	48.3	-36.3	Neutr
^	379.069k	20.4	+9.1 +0.2	+0.0	+0.0	-0.5	+0.0	29.2	48.3	-19.1	Neutr
7	210.358k Ave	7.7	+9.1 +0.3	+0.0	+0.0	-1.1	+0.0	16.0	53.2	-37.2	Neutr
^	210.358k	43.2	+9.1 +0.3	+0.0	+0.0	-1.1	+0.0	51.5	53.2	-1.7	Neutr
9	201.632k Ave	7.9	+9.1 +0.2	+0.0	+0.0	-1.2	+0.0	16.0	53.5	-37.5	Neutr
^	201.631k	44.1	+9.1 +0.2	+0.0	+0.0	-1.2	+0.0	52.2	53.5	-1.3	Neutr
11	218.357k Ave	7.0	+9.1 +0.3	+0.0	+0.0	-1.1	+0.0	15.3	52.9	-37.6	Neutr
^	218.357k	40.1	+9.1 +0.3	+0.0	+0.0	-1.1	+0.0	48.4	52.9	-4.5	Neutr
13	321.621k Ave	3.3	+9.1 +0.1	+0.0	+0.0	-0.6	+0.0	11.9	49.7	-37.8	Neutr
^	321.620k	22.1	+9.1 +0.1	+0.0	+0.0	-0.6	+0.0	30.7	49.7	-19.0	Neutr
15	301.259k Ave	3.6	+9.1 +0.1	+0.0	+0.0	-0.7	+0.0	12.1	50.2	-38.1	Neutr
^	301.258k	24.7	+9.1 +0.1	+0.0	+0.0	-0.7	+0.0	33.2	50.2	-17.0	Neutr
17	290.351k Ave	3.7	+9.1 +0.1	+0.0	+0.0	-0.7	+0.0	12.2	50.5	-38.3	Neutr
^	290.350k	23.1	+9.1 +0.1	+0.0	+0.0	-0.7	+0.0	31.6	50.5	-18.9	Neutr
19	188.542k Ave	7.5	+9.1 +0.3	+0.0	+0.0	-1.3	+0.0	15.6	54.1	-38.5	Neutr
^	188.541k	42.8	+9.1 +0.3	+0.0	+0.0	-1.3	+0.0	50.9	54.1	-3.2	Neutr

Test Setup Photo(s)



Front View



Side View

APPENDIX A – ANTENNA GAIN

Based on field strength measurements, antenna gain can be calculated according to the following formula:

Conducted RF output power calculated in accordance with ANSI C63.10.

$$P(W) = \frac{(E \cdot d)^2}{30 G}$$

Or equivalently, in logarithmic form:

$$P(dBm) = E(dBuV/m) + 20LOG(d) - G - 104.77$$

Therefore:

$$G(dBi) = E(dBuV/m) + 20LOG(d) - 104.77 - P(dBm)$$

Where P(dBm) is the RF conducted output power.

The manufacturer declares the RF conducted output to be set at 15dBm at the input to the transmit antenna.

Test Data Summary - Radiated Measurement				
Frequency (MHz)	Antenna Type	RF Power (dBm)	Field Strength (dBuV/m @3m)	Calculated Gain (dBi)
902.4	PCB Antenna	15	111.5	1.3
914.8	PCB Antenna	15	110.7	0.5
927.6	PCB Antenna	15	112.6	2.4

For the purposes of this report, the maximum peak gain is used as the declared antenna gain.

SUPPLEMENTAL INFORMATION

Measurement Uncertainty

Uncertainty Value	Parameter
4.73 dB	Radiated Emissions
3.34 dB	Mains Conducted Emissions
3.30 dB	Disturbance Power

Uncertainties reported are worst case for all CKC Laboratories' sites and represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k=2$. Compliance is deemed to occur provided measurements are below the specified limits.

Emissions Test Details

TESTING PARAMETERS

Unless otherwise indicated, the following configuration parameters are used for equipment setup: The cables were routed consistent with the typical application by varying the configuration of the test sample. Interface cables were connected to the available ports of the test unit. The effect of varying the position of the cables was investigated to find the configuration that produced maximum emissions. Cables were of the type and length specified in the individual requirements. The length of cable that produced maximum emissions was selected.

The equipment under test (EUT) was set up in a manner that represented its normal use, as shown in the setup photographs. Any special conditions required for the EUT to operate normally are identified in the comments that accompany the emissions tables.

The emissions data was taken with a spectrum analyzer or receiver. Incorporating the applicable correction factors for distance, antenna, cable loss and amplifier gain, the data was reduced as shown in the table below. The corrected data was then compared to the applicable emission limits. Preliminary and final measurements were taken in order to ensure that all emissions from the EUT were found and maximized.

CORRECTION FACTORS

The basic spectrum analyzer reading was converted using correction factors as shown in the highest emissions readings in the tables. For radiated emissions in $\text{dB}\mu\text{V}/\text{m}$, the spectrum analyzer reading in $\text{dB}\mu\text{V}$ was corrected by using the following formula. This reading was then compared to the applicable specification limit. Individual measurements were compared with the displayed limit value in the margin column. The margin was calculated based on subtracting the limit value from the corrected measurement value; a positive margin represents a measurement exceeding the limit, while a negative margin represents a measurement less than the limit.

SAMPLE CALCULATIONS		
	Meter reading	($\text{dB}\mu\text{V}$)
+	Antenna Factor	(dB/m)
+	Cable Loss	(dB)
-	Distance Correction	(dB)
-	Preamplifier Gain	(dB)
=	Corrected Reading	($\text{dB}\mu\text{V}/\text{m}$)

TEST INSTRUMENTATION AND ANALYZER SETTINGS

The test instrumentation and equipment listed were used to collect the emissions data. A spectrum analyzer or receiver was used for all measurements. Unless otherwise specified, the following table shows the measuring equipment bandwidth settings that were used in designated frequency bands. For testing emissions, an appropriate reference level and a vertical scale size of 10 dB per division were used.

MEASURING EQUIPMENT BANDWIDTH SETTINGS PER FREQUENCY RANGE			
TEST	BEGINNING FREQUENCY	ENDING FREQUENCY	BANDWIDTH SETTING
CONDUCTED EMISSIONS	150 kHz	30 MHz	9 kHz
RADIATED EMISSIONS	9 kHz	150 kHz	200 Hz
RADIATED EMISSIONS	150 kHz	30 MHz	9 kHz
RADIATED EMISSIONS	30 MHz	1000 MHz	120 kHz
RADIATED EMISSIONS	1000 MHz	>1 GHz	1 MHz

SPECTRUM ANALYZER/RECEIVER DETECTOR FUNCTIONS

The notes that accompany the measurements contained in the emissions tables indicate the type of detector function used to obtain the given readings. Unless otherwise noted, all readings were made in the "positive peak" detector mode. Whenever a "quasi-peak" or "average" reading was recorded, the measurement was annotated with a "QP" or an "Ave" on the appropriate rows of the data sheets. In cases where quasi-peak or average limits were employed and data exists for multiple measurement types for the same frequency then the peak measurement was retained in the report for reference, however the numbering for the affected row was removed and an arrow or caret ("^") was placed in the far left-hand column indicating that the row above takes precedence for comparison to the limit. The following paragraphs describe in more detail the detector functions and when they were used to obtain the emissions data.

Peak

In this mode, the spectrum analyzer or receiver recorded all emissions at their peak value as the frequency band selected was scanned. By combining this function with another feature called "peak hold," the measurement device had the ability to measure intermittent or low duty cycle transient emission peak levels. In this mode the measuring device made a slow scan across the frequency band selected and measured the peak emission value found at each frequency across the band.

Quasi-Peak

Quasi-peak measurements were taken using the quasi-peak detector when the true peak values exceeded or were within 2 dB of a quasi-peak specification limit. Additional QP measurements may have been taken at the discretion of the operator.

Average

Average measurements were taken using the average detector when the true peak values exceeded or were within 2 dB of an average specification limit. Additional average measurements may have been taken at the discretion of the operator. If the specification or test procedure requires trace averaging, then the averaging was performed using 100 samples or as required by the specification. All other average measurements are performed using video bandwidth averaging. To make these measurements, the test engineer reduces the video bandwidth on the measuring device until the modulation of the signal is filtered out. At this point the measuring device is set into the linear mode and the scan time is reduced.