FCC & ISED Canada Certification

Test Report

for the

Frederick Energy Products LLC

Bump Cap Personal Alarm Device

FCC ID: QUI-DDAC-PAD-CAP

IC ID: 11625A-DDACPADCAP

WLL REPORT# 17004-01 REV 4

Prepared for:

Frederick Energy Products LLC

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Huntsville, Alabama 35806

Prepared By:

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4840 Winchester Boulevard

Frederick, Maryland 21703

Testing Certificate AT-1448

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June 2, 2021

WLL Report# 17004-01 Rev 4

Prepared by:

Ryan Mascaro
RF Test Engineer

Reviewed by:

Steven D. Koster
President

Abstract

This report has been prepared on behalf of Frederick Energy Products LLC to support the attached Application for Equipment Authorization. The test report and application are submitted for an Intentional Radiator under Part 15.231 of the FCC Rules and Regulations current at the time of testing and Innovation, Science and Economic Development (ISED) Canada Spectrum Management and Telecommunications Policy. This Certification Test Report documents the test configuration and test results for the Frederick Energy Products LLC Bump Cap Personal Alarm Device. The information provided on this report is only applicable to device herein documented.

Radiated testing was performed on an Open Area Test Site (OATS) of Washington Laboratories, Ltd, 4840 Winchester Boulevard, Frederick MD 21703. Site description and site attenuation data have been placed on file with the FCC's Sampling and Measurements Branch at the FCC laboratory in Columbia, MD.

Washington Laboratories, Ltd. has been accepted by the FCC and approved by ANAB under Certificate AT-1448 as an independent FCC test laboratory (ISED Canada number 3035A).

The Frederick Energy Products LLC, Bump Cap Personal Alarm Device complies with the limits for an Intentional Radiator under FCC Part 15.231 and RSS-210 Issue 10 (6/2019).

Revision History	Description of Change	Date
Rev 0	Initial Release	June 2, 2021
Rev 1	ACB Comments # ATCB027208	July 7, 2021
Rev 2	ISED Rule Parts added to Table 6	July 8, 2021
Rev 3	CB Comments; 15.231 Requirements	July 29, 2021
Rev 4	CB Comments, ATCB0227208	August 12, 2021

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1 Introduction

1.1 Compliance Statement

The Frederick Energy Products LLC, Bump Cap Personal Alarm Device complies with the limits for an Intentional Radiator device under FCC Part 15.231 and ISED Canada RSS-210 Issue 10 (6.2019).

1.2 Test Scope

Tests for radiated emissions were performed. All measurements were performed in accordance with ANSI C63.10. The measurement equipment conforms to ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation.

1.3 Contract Information

Customer:	Frederick Energy Products, LLC
Purchase Order Number:	9157
Quotation Number:	72644

1.4 Test and Support Personnel

Washington Laboratories, LTD	Ryan Mascaro
Customer Representative	Andrew Nichols

1.5 Test Dates

5/24/2021 to 7/27/2021

2 Equipment Under Test

2.1 EUT Identification & Description

Table 1: Device Summary

Manufacturer:	Frederick Energy Products LLC
FCC ID:	QUI-DDAC-PAD-CAP
ISED ID:	11625A-DDACPADCAP
EUT Name (Model):	Bump Cap Personal Alarm Device
HVIN:	DDAC-PAD-CAP
FCC Rule Parts:	§15.231
ISED Rule Parts:	RSS-210
FCC Emission Designator:	172K6F1DXN
IC Emission Designator:	179K0F1DXN
Fixed Frequency:	916.5 MHz
20dB Occupied Bandwidth:	172.6 kHz
Keying:	Automatic
Modulation or Protocol:	FM, FSK
Type of Information:	Proximity, Telemetry
Number of Channels:	1
Power Output Level	Fixed, < 30 dBm
Antenna Type:	Enclosure Integrated
Test Software/Firmware:	FEPL Proprietary Software/Firmware, Test Mode; REV 1
Power Source & Voltage:	Battery Powered (Cannot Charge and Transmit Simultaneously)

The Frederick Energy Products LLC, Bump Cap Personal Alarm Device (PAD) is a proximity alarm device, used for collision avoidance. This EUT may be referred to as a Hard Hat PAD. The PAD has the ability to detect a 73 kHz H-Field, from a Generator device, in three distinct proximity zones. These zones, as defined in the product user's manual, cause the EUT to go into different transmit modes. The three modes are (1) Health Mode, (2) Warning Mode, and (3) Danger Mode. The PAD is triggered into these modes based on its proximity to a Generator.

Please note that output power from the 916.5 MHz transmitter, nor its radiated field strength, is not affected by the changing of modes. Moreover, during a transmission in any of the modes, the type of data (number/size of packets) that is sent from the PAD, does not change. The only transmitter variation that occurs is the duration of the pulsed emission. The changing modes cause the transmitter to be enabled for a longer, or shorter, period of time based on the mode. This inherently effects the Duty Cycle of the device, per mode. The EUT is always [~8.7ms/40s] periodically transmitting; increasing in duty cycle as it is triggered into the other modes.

The PAD is battery powered, and was provided with a 120 VAC wall charging unit. The PAD cannot transmit while it is charging.

2.2 Testing Algorithm

The Bump Cap Personal Alarm Device was tested in a powered-on, steady state, with the transmitter enabled as appropriate. The absolute worst-case mode is the Danger mode. When the transmitter is in this mode, the pulsed emissions are set to transmit at their highest duty cycle. In this regard, this mode also yields the lowest duty cycle correction factor (DCCF). The 18.4 dB DCCF, as denoted in the table below, shall be employed when averaging the Peak field strength of the device radiated emissions. Overall, worst-case emissions are provided throughout this report. Table 2 provides a summary of the transmit modes, their duty cycle information.

Table 2: TX Mode Summary, with DCCF

Proximity to Generator	Transmit Mode	Duty Cycle	DCCF
≥ 12m *	Health Status	8.7 %	21.2 dB
~ 6m to 12m *	Warning	9.9 %	20.1 dB
≤ 6m *	Danger	12 %	18.4 dB

** note: these distances were solely used for testing purposes. Actual zone/mode distance may vary, as defined by the manufacturer's theory of operation, or user's manual.*

2.3 Test Configuration

The Bump Cap Personal Alarm Device was tested in a stand-alone configuration. The EUT was positioned in proximity to a 73 kHz generator as a means to trigger the 916.5 MHz radio.

Table 3: System Configuration List

Name / Description	Model Number	Part Number	Serial Number	Revision
Bump Cap PAD	DDACPADCAP	N/A	N/A	N/A

Table 4: Support Equipment

Item	Model/Part Number	Serial Number
AC Power Supply	YNQX09G050055UU	Charger
73 kHz Generator	DDAC SXL	N/A

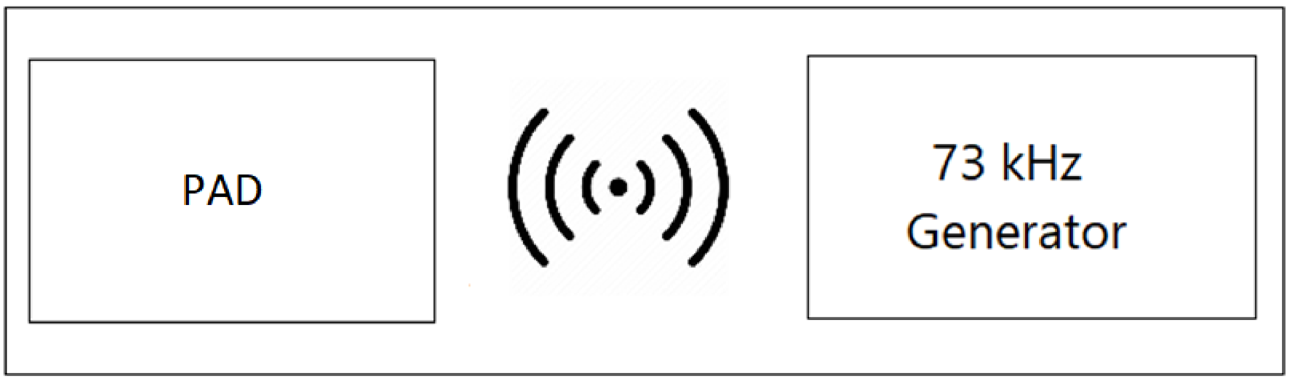
Table 5: Cable Configuration

Port Identification	Connector Type	Cable Length	Shielded (Y/N)	Termination Point
N/A	N/A	N/A	N/A	N/A

2.4 Test Location

All measurements herein were performed at Washington Laboratories, Ltd. test center in Frederick, MD. Site description and site attenuation data have been placed on file with the FCC's Sampling and Measurements Branch at the FCC laboratory in Columbia, MD. The ISED Canada OATS number for Washington Laboratories, Ltd. is 3035A. Washington Laboratories, Ltd. has been accepted by the FCC and approved by ANAB under Testing Certificate AT-1448 as an independent FCC test laboratory.

Figure 1: Test Configuration



2.5 Measurements

2.5.1 References

ANSI C63.2 (Jan-2016) Specifications for Electromagnetic Noise and Field Strength Instrumentation

ANSI C63.4 (Jan 2014) American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

ANSI C63.10 (Jun 2013) American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

2.5.2 Radiated Data Reduction and Reporting

To convert the raw spectrum analyzer radiated data into a form that can be compared with the FCC limits, it is necessary to account for various calibration factors that are supplied with the antennas and other measurement accessories. These factors are included into the antenna factor (AF) column of the table and in the cable factor (CF) column of the table. The AF (in dB/m) and the CF (in dB) is algebraically added to the raw Spectrum Analyzer Voltage in dBµV to obtain the Radiated Electric Field in dBµV/m. This logarithm amplitude is converted to a linear amplitude, then compared to the FCC limit.

Example:

Spectrum Analyzer Voltage:	VdBµV (SA)
Antenna Correction Factor:	AFdB/m
Cable Correction Factor:	CFdB
Pre-Amplifier Gain (if applicable):	GdB
Electric Field:	EdBµV/m = V dBµV (SA) + AFdB/m + CFdB - GdB
To convert to linear units of measure:	Inv Log (EdBµV/m/20)

2.6 Measurement Uncertainty

All results reported herein relate only to the equipment tested. The basis for uncertainty calculation uses ANSI/NCSL Z540-2-1997 (R2002) with a type B evaluation of the standard uncertainty. Elements contributing to the standard uncertainty are combined using the method described in Equation 1 to arrive at the total standard uncertainty. The standard uncertainty is multiplied by the coverage factor to determine the expanded uncertainty which is generally accepted for use in commercial, industrial, and regulatory applications and when health and safety are concerned (see Equation 2). A coverage factor was selected to yield a 95% confidence in the uncertainty estimation

Equation 1: Standard Uncertainty

$$u_c = \pm\sqrt{\frac{a^2}{{div_a}^2} + \frac{b^2}{{div_b}^2} + \frac{c^2}{{div_c}^2} + \ldots\ldots}$$

Where uc = standard uncertainty
a, b, c,.. = individual uncertainty elements
Diva, b, c = the individual uncertainty element divisor based on the probability distribution
Divisor = 1.732 for rectangular distribution
Divisor = 2 for normal distribution
Divisor = 1.414 for trapezoid distribution

Equation 2: Expanded Uncertainty

$$U = ku_c$$

Where:
U = expanded uncertainty
k = coverage factor
k ≤ 2 for 95% coverage (ANSI/NCSL Z540-2 Annex G)
uc = standard uncertainty

The measurement uncertainty complies with the maximum allowed uncertainty from CISPR 16-4-2. Measurement uncertainty is not used to adjust the measurements to determine compliance. The expanded uncertainty values for the various scopes in the WLL accreditation are provided in Table 6 below.

Table 6: Expanded Uncertainty List

Scope	**Standard(s)**	**Expanded Uncertainty**
Conducted Emissions	CISPR11, CISPR22, CISPR32, CISPR14, FCC Part 15	± 2.63 dB
Radiated Emissions	CISPR11, CISPR22, CISPR32, CISPR14, FCC Part 15	± 4.55 dB

3 Test Sequence and Results Summary

Table 7: Transmitter Testing to 15.231 – Summary

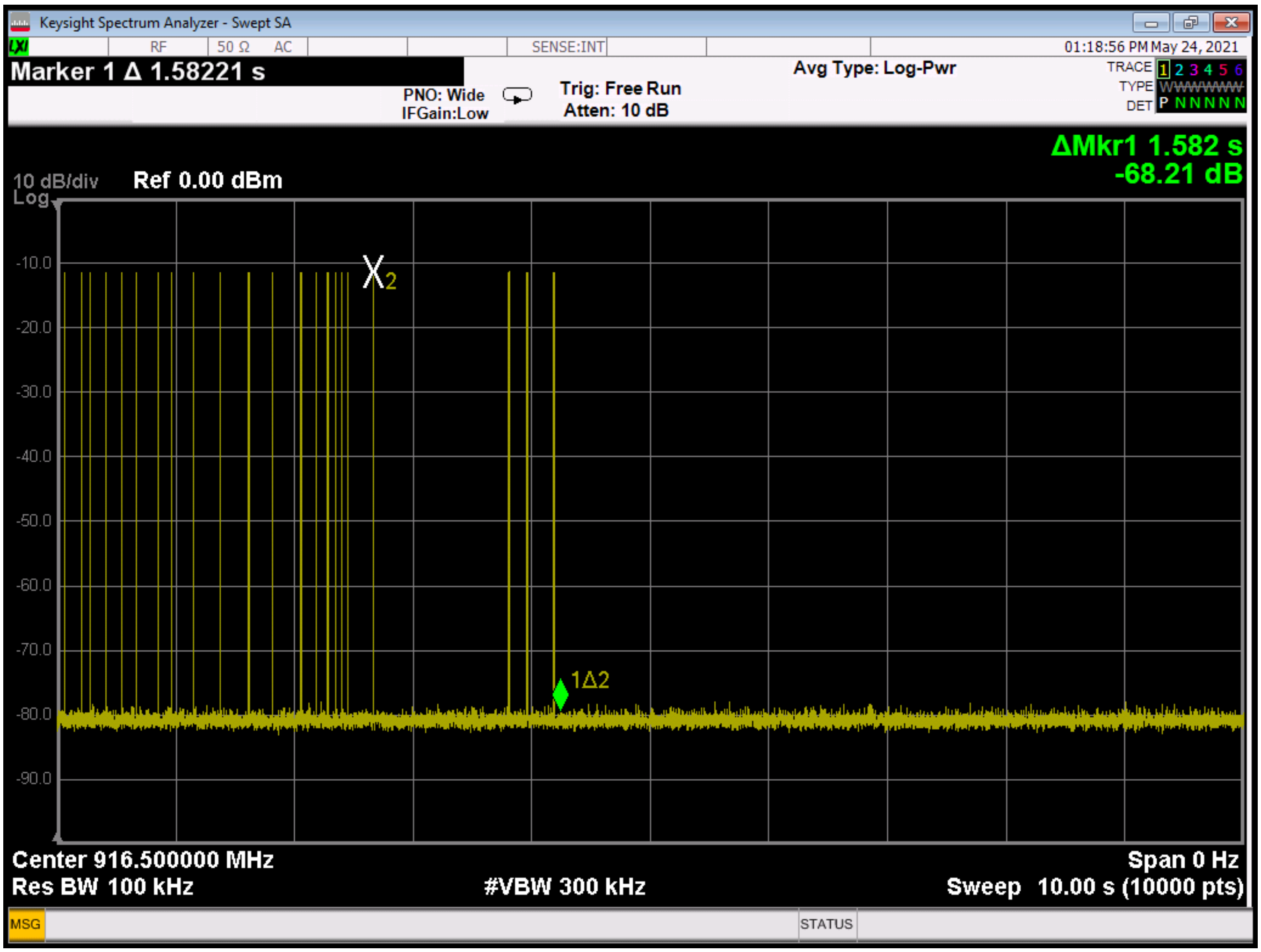
FCC Rule Part	ISED Rule Part	Description	Result
15.231(a)(1)	RSS-210	Transmit Cessation from Release	Pass
15.231(a)(2)	RSS-210	Transmit Cessation from Activation	Pass
15.231(a)(3)	RSS-210	Transmission Polling	Pass
15.231(a)(4)	RSS-210	Pendency of Alarm Conditions	Adopted
15.231(c)	RSS-210	Occupied Bandwidth	Pass
15.231(b)	RSS-210	Field Strength, Fundamental	Pass
15.207(a)	RSS-GEN	AC Power Line Emissions	Pass
15.35(c)	RSS-GEN	100ms Duty Cycle	Completed

4 Test Results

4.1 Transmission Cessation From Time of Release – FCC Part §15.231(a)(1)

A periodic intentional radiator shall cease transmission within a five second period from release of automatic or manual keying of operation. Testing was done to verify that the Bump Cap Personal Alarm Device stopped transmitting within the required time period. A 10-second sweep was made, during which time, the transmitter was triggered from Warning Mode into Health Mode. By moving the EUT away from the Generator, the transmitter was triggered into a mode that periodically deactivates transmission. Figure 2 shows the indicated time period from un-keying the device until cessation of transmission. The EUT complies with the requirements of this section, as the cessation time is 1.582 seconds.

Figure 2: Deactivation of Transmitter (TX Cessation)



4.2 Transmission Cessation From Time of Activation – FCC Part §15.231(a)(2)

Under this provision, a periodic transmitter, that is activated automatically, shall cease transmission within 5 seconds after activation.

Given the safety of life of this device, and how the proximity detection is incorporated into the transmitter operation, it is important to note that the transmitter remains enabled for the duration of the alarm condition, specifically for safety of life application. However, when the alarm condition is cleared, the EUT reverts back to a polling Health Mode. When this occurs, the transmitter is disabled as shown in Figure 3.

Under the exception of §15.231(a)(4), the EUT complies with the requirements of this rule part.

4.3 Transmission Polling – FCC Part §15.231(a)(3)

Under this provision, polling transmissions, or supervision transmissions, including data, to determine system integrity of transmitters used in security or safety applications are allowed. However, the total duration of transmissions shall not exceed more than two seconds per hour for each transmitter. There is no limit on the number of individual transmissions, provided the total transmission time does not exceed two seconds per hour.

When the PAD is not in a Warning or Danger zone/mode it only transmits in the Health Status mode, once every 40 seconds. During this mode, each transmission is ~ 8.7 ms, resulting in a total of 0.8 seconds per hour of polling transmissions.

The EUT complies with the requirements of this rule part.

See Section 4.8.3 of this report for details regarding the Health mode transmit time.

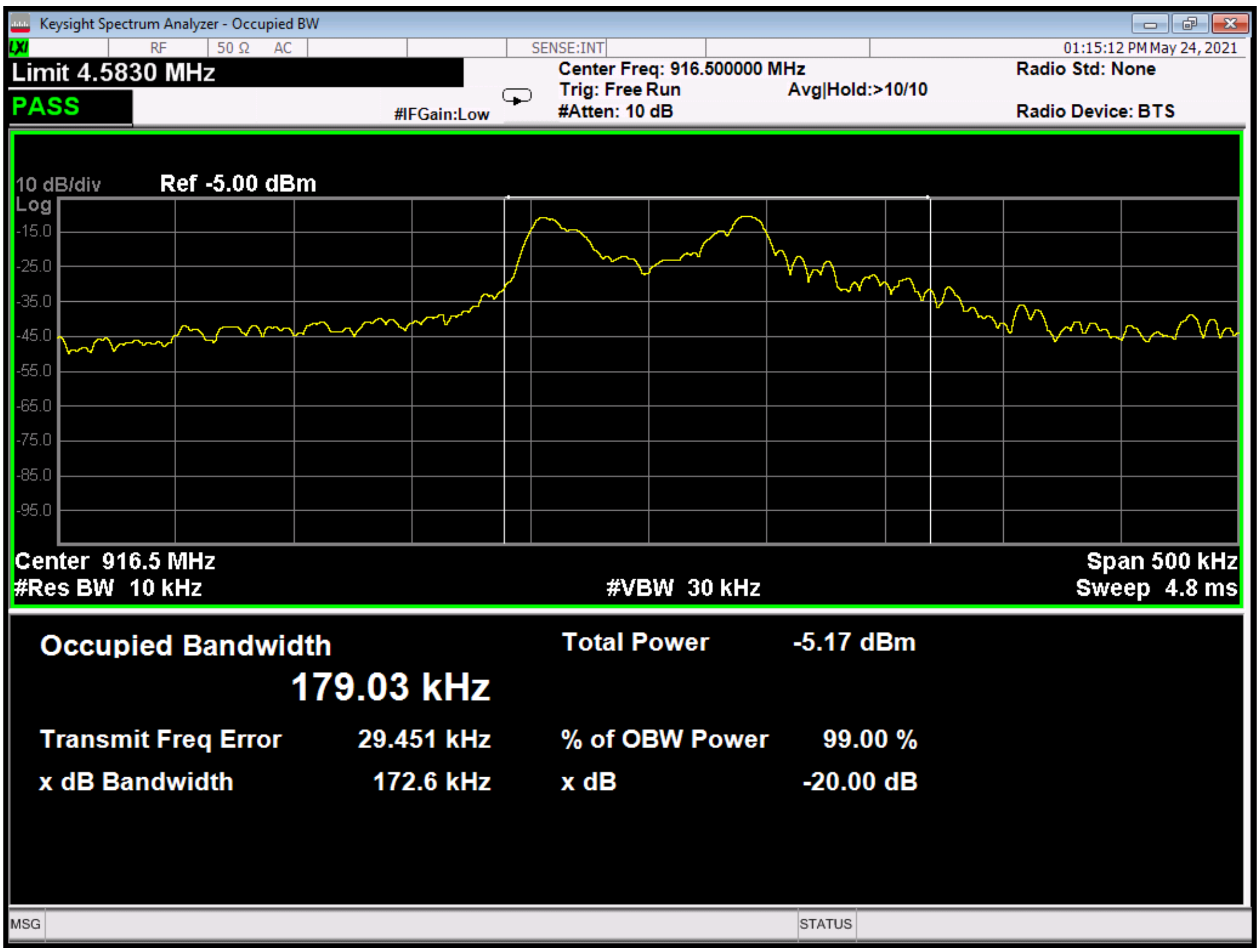
4.4 Occupied Bandwidth – FCC Part §15.231(c)

The bandwidth of the emission shall be no wider than 0.25% of the center frequency for devices operating above 70 MHz and below 900 MHz. For devices operating above 900 MHz, the emission shall be no wider than 0.5% of the center frequency. The OBW is determined at the points 20 dB down from the peak of the transmitter carrier. The EUT complies with the requirements of this section.

Table 8: Occupied Bandwidth Results

TX Frequency	Bandwidth	Limit	Results
916.5 MHz	172.6 kHz	4.583 MHz	Pass

Figure 3: Occupied Bandwidth



4.5 Radiated Emissions, Fundamental Transmitter – FCC Part §15.231(b)

The field strength of emissions from intentional radiators operated under this section shall not exceed the following limits, as measured at a distance of 3m:

Fundamental Frequency (MHz)	Field Strength of Fundamental (µV/m)
40.66 – 40.70	2250
70 – 130	1250
130 – 174	1250 to 3750
174 – 260	3750
260 – 470	3750 to 12500
Above 470	12500

The above limits are based on the average value of the measured emissions. The provisions in §15.35(c) for averaging pulsed emissions, and for limiting peak emissions, shall apply. The calculated DCCF of 18.4 dB shall be applied to the Peak Field Strength in order to obtain the Average Field Strength and compared to limits in the table above.

The requirements for this test call for the EUT to be placed on a 1m X 1.5m non-conductive motorized turntable for radiated testing at a 3m open area test site (OATS). The height of the table shall be 80cm for testing below 1000 MHz, and 1.5m for testing above 1000 MHz, both in accordance with ANSI C63.10. The emissions from the EUT were measured continuously at every azimuth by rotating the turntable. A log periodic broadband antenna was mounted on an antenna mast to determine the height of maximum emissions. The height of the antenna was varied between 1 and 4 meters. The output of the antenna was connected to the input of the spectrum analyzer and the 916.5 MHz radio emissions were measured. the horizontal and vertical field components were measured, to determine the worst-case levels. The detector function was set to peak mode, for measurements of the fundamental. The measurement bandwidth of the spectrum analyzer system was set to at least 120 kHz, with all post-detector filtering no less than 10 times the measurement bandwidth.

The EUT complies with the requirements of this section.

The EUT was evaluated at three orthogonal axes (X, Y, Z) to determine the orientation that yielded the highest radiated field strength. The worst-case emissions are reported below.

The final test data appears on the next page.

Table 9: Fundamental Field Strength, Test Results

Frequency (MHz)	Polarity H/V	Azimuth (Degree)	Ant. Height (m)	SA Level (dBuV)	Corr. Factors (dB)	DCCF (dB	Corr. Level (uV/m)	Limit (uV/m)	Margin (dB)	Detector Mode
916.50	V	90.0	1.0	81.4	0.4	0.0	12318.2	125000	-20.1	Peak
916.50	V	90.0	1.0	81.4	0.4	18.4	1479.1	12500	-18.5	AVG *
916.50	H	180.0	1.1	78.5	0.4	0.0	8821.6	125000	-23.0	Peak
916.50	H	180.0	1.1	78.5	0.4	18.4	1059.3	12500	-21.4	AVG *

** note: this data indicates the corrected peak field strength, applied to the average limit.*

4.6 Radiated Spurious Emissions – FCC Part §15.231(b)

The field strength of spurious emissions, related to the transmitter, shall not exceed the following limits, as measured at a distance of 3m:

Fundamental Frequency (MHz)	Field Strength of Spurious Emissions (µV/M)
40.66 – 40.70	225
70 – 130	125
130 – 174	125 to 375
174 – 260	375
260 – 470	375 to 1250
Above 470	1250

The limits for the field strength of the spurious emissions, in the above table, are based on the fundamental frequency of the intentional radiator. Spurious emissions shall be attenuated to the average (or, alternatively, CISPR quasi-peak) limits shown in this table, or to the general limits shown in §15.209, whichever limit permits a higher field strength. In accordance with the provisions outlined in §15.205(b), compliance with the limits in the above table may be based on the use of measurement instrumentation with a CISPR quasi-peak detector, for spurious measurements made below 1000 MHz.

Because the device transmitter is pulsed, the harmonic spurious emissions shall be measured using only a Peak Detector, and then corrected using a DCCF, in order to calculate the Average Field Strength and compare to the limits in the table above. The uncorrected Peak Field Strength shall not be more than 20 dB over the Average limit.

The requirements for this test call for the EUT to be placed on a 1m X 1.5m non-conductive motorized turntable for radiated testing at a 3m open area test site (OATS). The height of the table shall be 80cm for testing below 1000 MHz, and 1.5m for testing above 1000 MHz, both in accordance with ANSI C63.10. The emissions from the EUT were measured continuously at every azimuth by rotating the turntable. Bi-conical and log periodic broadband antennas were mounted on an antenna mast to determine the height of maximum emissions. The height of the antenna was varied between 1 and 4 meters. The output of the antenna was connected to the input of the spectrum analyzer and the emissions in the frequency range of 30 MHz to 12 GHz were measured. Both the horizontal and vertical field components were measured. The detector function was set to quasi-peak for measurements below 1 GHz. The measurement bandwidth of the spectrum analyzer system was set to at least 120 kHz, with all post-detector filtering no less than 10 times the measurement bandwidth.

The EUT complies with the requirements of this section.

The EUT was evaluated at three orthogonal axes (X, Y, Z) to determine the orientation that yielded the highest radiated field strength. The worst-case emissions are reported below.

Frequencies denoted in Table 10 were identified via a near field pre-scan while the transmitter was enabled.

No other emissions below 1000 MHz were detected from the EUT.

AMB indicates that the measurement was taken at the Noise Floor.

Spur indicates that a digital unintentional emission was present.

The Harmonic emissions were evaluated to the 10th harmonic of the fundamental.

Table 10: Spurious Emissions Test Data – 30 MHz to 1000 MHz

Frequency (MHz)	**Polarity H/V**	**Azimuth (Degree)**	**Ant. Height (m)**	**SA Level (dBµV)**	**Corr Factors (dB)**	**Corr. Level (µV/m)**	**Limit (µV/m)**	**Margin (dB)**	**Detector**	**Comments**
40.50	V	90.0	1.1	36.9	-11.0	19.7	100.0	-14.1	QP	Spur
45.70	V	180.0	1.5	45.3	-13.7	38.2	100.0	-8.4	QP	Spur
58.79	V	270.0	1.3	35.6	-16.6	8.9	100.0	-21.0	QP	Spur
59.56	V	180.0	1.3	39.6	-16.5	14.3	100.0	-16.9	QP	Spur
122.60	V	0.0	1.6	28.9	-9.4	9.4	150.0	-24.1	QP	AMB
906.30	V	0.0	1.0	32.0	1.5	47.6	200.0	-12.5	QP	AMB
40.50	H	270.0	1.5	33.0	-11.0	65.3	100.0	-3.7	QP	Spur
45.70	H	0.0	1.3	41.9	-13.7	9.3	100.0	-20.7	QP	Spur
58.79	H	0.0	1.3	34.0	-16.6	18.5	100.0	-14.7	QP	Spur
59.56	H	0.0	1.2	38.1	-16.5	7.5	100.0	-22.5	QP	Spur
122.60	H	181.0	1.2	29.0	-9.4	27.1	150.0	-14.9	QP	AMB
906.30	H	90.0	1.2	29.6	1.5	33.7	200.0	-15.5	QP	AMB

Table 11: Spurious Emissions Test Data – Above 1 GHz

Frequency (MHz)	Polarity H/V	Azimuth (Degree)	Ant. Height (m)	SA Level (dBμV)	Corr Factors (dB)	DCCF (dB	Corr. Level (μV/m)	Limit (μV/m)	Margin (dB)	Detector
1833.00	V	90.0	1.5	63.9	-10.8	0.0	451.0	12500	-28.9	Peak
1833.00	V	90.0	1.5	63.9	-10.8	18.4	54.3	1250	-27.2	AVG *
2749.50	V	180.0	1.5	62.0	-8.8	0.0	455.2	5000	-20.8	Peak
2749.50	V	180.0	1.5	62.0	-8.8	18.4	54.7	500	-19.2	AVG *
3666.00	V	270.0	1.5	65.2	-8.0	0.0	726.8	5000	-16.8	Peak
3666.00	V	270.0	1.5	65.2	-8.0	18.4	87.4	500	-15.1	AVG *
4582.50	V	0.0	1.5	56.0	-8.9	0.0	226.8	5000	-26.9	Peak
4582.50	V	0.0	1.5	56.0	-8.9	18.4	27.3	500	-25.3	AVG *
5499.00	V	0.0	1.5	58.1	-7.2	0.0	352.3	12500	-31.0	Peak
5499.00	V	0.0	1.5	58.1	-7.2	18.4	42.4	1250	-29.4	AVG *
6415.50	V	180.0	1.5	55.0	-6.9	0.0	254.7	12500	-33.8	Peak
6415.50	V	180.0	1.5	55.0	-6.9	18.4	30.6	1250	-32.2	AVG *
7332.00	V	0.0	1.5	57.6	-4.9	0.0	429.6	5000	-21.3	Peak
7332.00	V	0.0	1.5	57.6	-4.9	18.4	51.7	500	-19.7	AVG *
1833.00	H	90.0	1.5	65.3	-10.8	0.0	529.9	12500	-27.5	Peak
1833.00	H	90.0	1.5	65.3	-29.2	18.4	63.8	1250	-25.8	AVG *
2749.50	H	180.0	1.5	61.0	-8.8	0.0	405.7	5000	-21.8	Peak
2749.50	H	180.0	1.5	61.0	-27.2	18.4	48.8	500	-20.2	AVG *
3666.00	H	0.0	1.5	66.4	-8.0	0.0	834.5	5000	-15.6	Peak
3666.00	H	0.0	1.5	66.4	-26.4	18.4	100.3	500	-14.0	AVG *
4582.50	H	90.0	1.5	56.9	-8.9	0.0	251.5	5000	-26.0	Peak
4582.50	H	90.0	1.5	56.9	-27.3	18.4	30.2	500	-24.4	AVG *
5499.00	H	0.0	1.5	57.8	-7.2	0.0	340.4	12500	-31.3	Peak
5499.00	H	0.0	1.5	57.8	-25.6	18.4	40.9	1250	-29.7	AVG *
6415.50	H	270.0	1.5	54.1	-6.9	0.0	229.6	12500	-34.7	Peak
6415.50	H	270.0	1.5	54.1	-25.3	18.4	27.6	1250	-33.1	AVG *
7332.00	H	90.0	1.5	56.9	-4.9	0.0	396.4	5000	-22.0	Peak
7332.00	H	90.0	1.5	56.9	-23.3	18.4	47.7	500	-20.4	AVG *

** note: this data indicates the corrected peak field strength, applied to the average limit.*

4.7 AC Power Conducted Emissions, Voltage

Compliance Standard: FCC Part 15, Class B

FCC Compliance Limits				
Frequency Range	Class A Device		Class B Device	
	Quasi-peak	Average	Quasi-peak	Average
0.15 – 0.5 MHz	79 dBµV	66 dBµV	66 to 56 dBµV	56 to 46 dBµV
0.5 – 5 MHz	79 dBµV	66 dBµV	56 dBµV	46 dBµV
0.5 – 30 MHz	73 dBµV	60 dBµV	60 dBµV	50 dBµV

The requirements of FCC Part 15 and ICES-003 call for the EUT to be placed on an 80cm-high 1 X 1.5-meter non-conductive table above a ground plane. Power to the EUT was provided through a Solar Corporation 50 Ω/50 µH Line Impedance Stabilization Network bonded to a 3 X 2-meter ground plane. The LISN has its AC input supplied from a filtered AC power source. Power was supplied to the peripherals through a second LISN. The peripherals were placed on the table in accordance with ANSI C63.4. Power and data cables were moved about to obtain maximum emissions.

The 50 Ω output of the LISN was connected to the input of the spectrum analyzer and the emissions in the frequency range of 150 kHz to 30 MHz were measured. The detector function was set to quasi-peak, peak, or average as appropriate, and the resolution bandwidth during testing was at least 9 kHz, with all post-detector filtering no less than 10 times the resolution bandwidth. For average measurements, the post-detector filter was set to 10 Hz.

These emissions must meet the limits specified in §15.107 for quasi-peak and average measurements.

Environmental Conditions During Conducted Emissions Testing

Ambient Temperature:	22.1 °C
Relative Humidity:	56 %

4.7.1 Conducted Data Reduction and Reporting

The comparison between the Conducted emissions level and the FCC limit is calculated as shown in the following example:

Spectrum Analyzer Voltage: VdBµV(raw)

LISN Correction Factor: LISN dB

Cable Correction Factor: CF dB

Voltage: VdBµV = V dBµV (raw) + LISN dB + CF dB

4.7.2 Test Data

The EUT complies with the Class B Conducted Emissions requirements.

These emissions are not related to the transmitter, as the EUT cannot charge and transmit at the same time.

The Conducted Emissions test data is provided in the tables below.

Table 12: AC Power Conducted Emissions Test Data

NEUTRAL										
Frequency (MHz)	**Level QP (dBμV)**	**Level AVG (dBμV)**	**Cable Loss (dB)**	**LISN Corr (dB)**	**Level QP Corr (dBμV)**	**Level Corr Avg (dBμV)**	**Limit QP (dBμV)**	**Limit AVG (dBμV)**	**Margin QP (dB)**	**Margin AVG (dB)**
0.170	41.0	35.3	10.2	1.1	52.2	46.5	65.0	55.0	-12.7	-8.4
0.280	32.1	28.5	10.2	0.9	43.1	39.5	60.8	50.8	-17.7	-11.3
0.453	31.9	26.0	10.2	0.8	42.9	37.0	56.8	46.8	-13.9	-9.8
0.618	23.7	18.0	10.3	0.8	34.7	29.0	56.0	46.0	-21.3	-17.0
2.859	15.0	9.0	10.2	0.8	26.0	20.0	56.0	46.0	-30.0	-26.0
15.132	11.0	5.0	11.3	2.2	24.5	18.5	60.0	50.0	-35.5	-31.5
20.416	10.3	4.1	11.5	3.3	25.2	19.0	60.0	50.0	-34.8	-31.0

PHASE / L1										
Frequency (MHz)	**Level QP (dBμV)**	**Level AVG (dBμV)**	**Cable Loss (dB)**	**LISN Corr (dB)**	**Level QP Corr (dBμV)**	**Level Corr Avg (dBμV)**	**Limit QP (dBμV)**	**Limit AVG (dBμV)**	**Margin QP (dB)**	**Margin AVG (dB)**
0.169	42.6	39.8	10.2	1.4	54.1	51.3	65.0	55.0	-10.9	-3.7
0.188	35.0	21.0	10.2	1.3	46.5	32.5	64.1	54.1	-17.6	-21.6
0.283	37.6	36.2	10.2	1.0	48.8	47.4	60.7	50.7	-11.9	-3.3
0.439	25.0	20.3	10.2	1.0	36.2	31.5	57.1	47.1	-20.9	-15.6
0.735	21.0	21.2	10.3	0.9	32.2	32.4	56.0	46.0	-23.8	-13.6
1.449	16.9	9.9	10.2	0.9	28.1	21.1	56.0	46.0	-27.9	-24.9
14.870	9.6	6.0	11.3	3.0	23.9	20.3	60.0	50.0	-36.1	-29.7

4.8 Transmitter, Duty Cycle Correction Factor (DCCF)

When the average-mode field strength of a pulsed transmitter is measured, a DCCF shall be applied to the Peak value, and compared to the applicable Average limits. Under the provisions of §15.35(c), the duty cycle measurement shall be made in reference to a 100 ms period.

4.8.1 Danger Mode (worst-case)

Figure 4: Transmitter Pulse On-Time (1) – Danger Mode

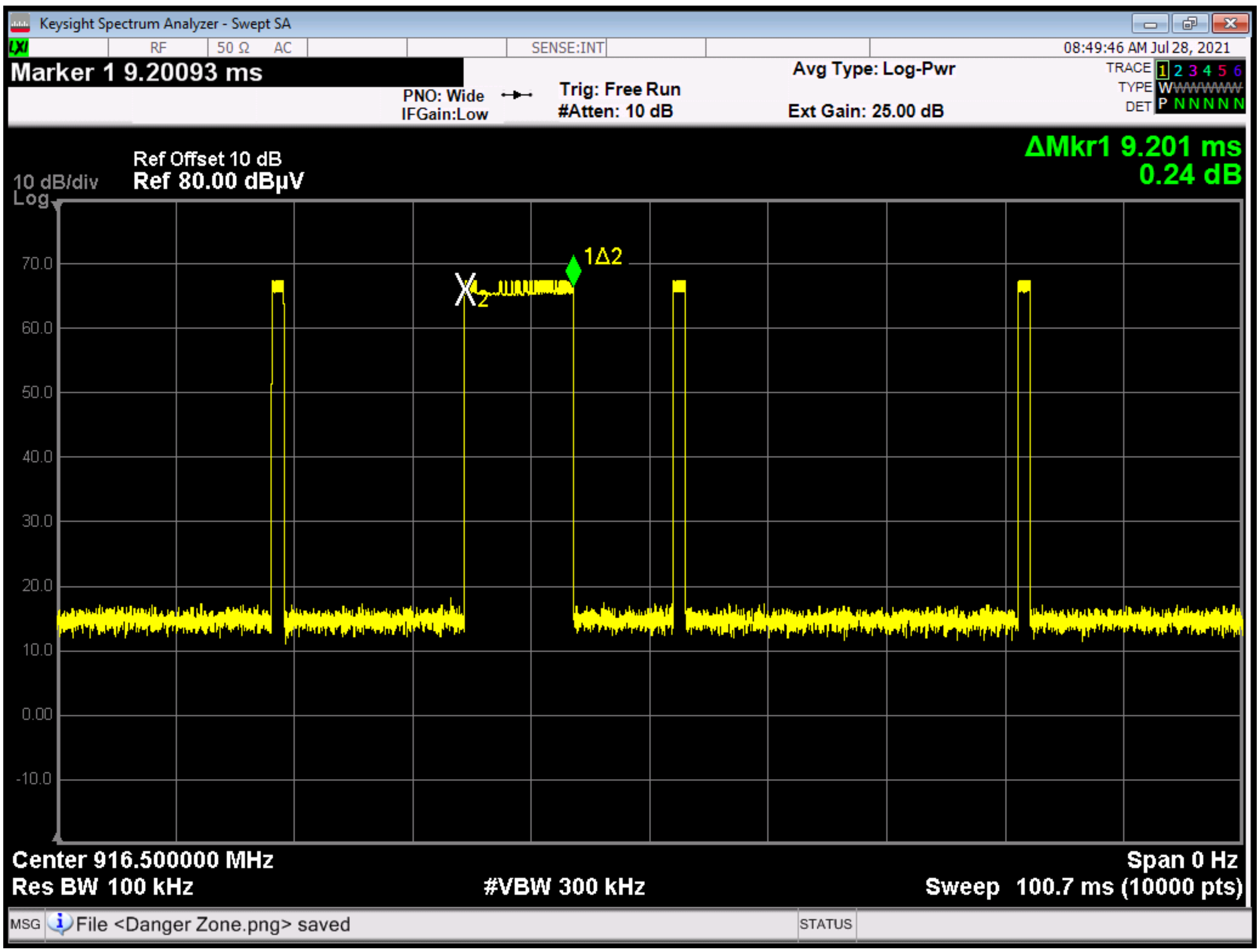
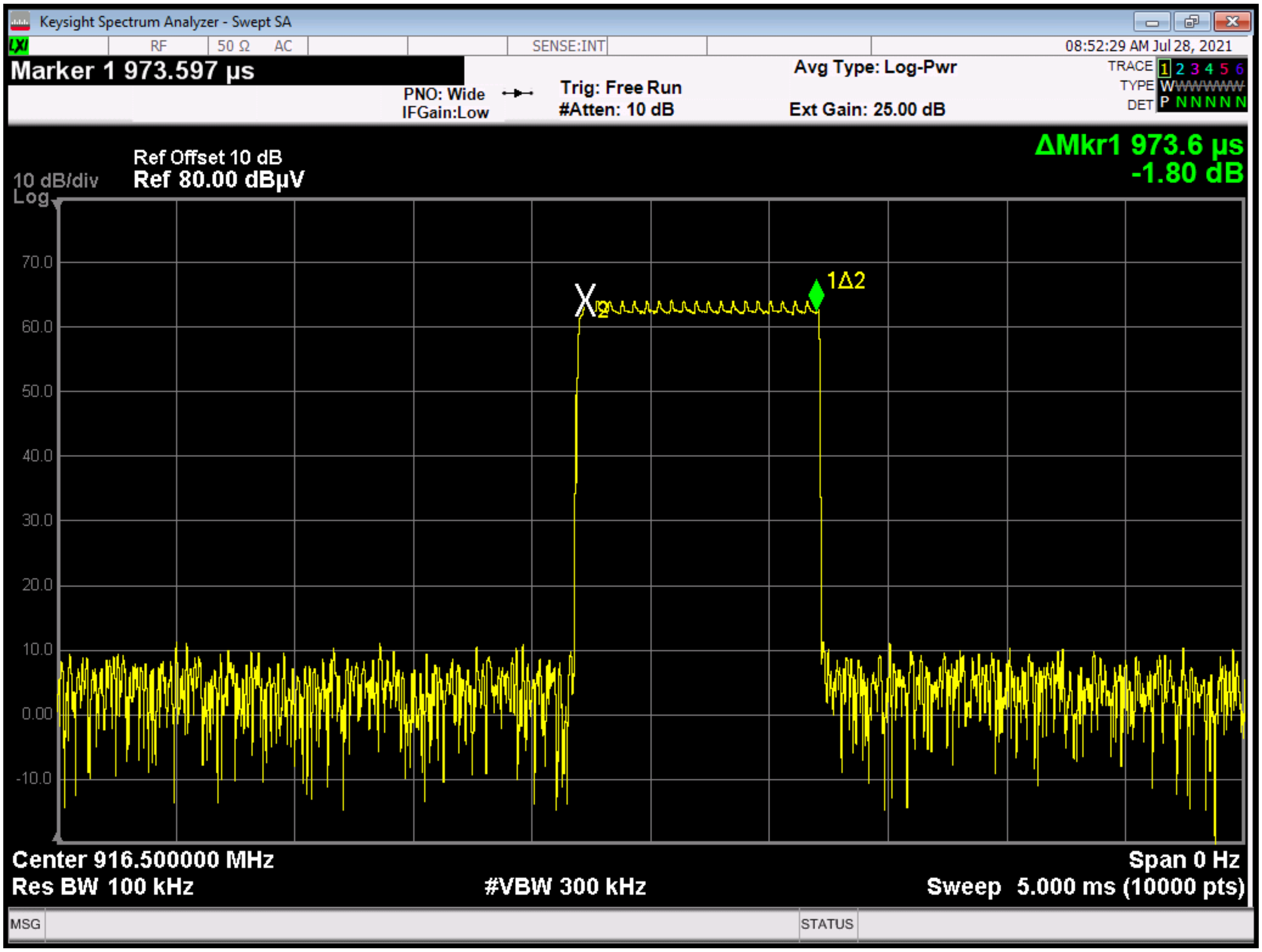


Figure 5: Transmitter Pulse On-Time (2) – Danger Mode



The Danger Mode pulse train was observed over a 100 ms sweep. In this case, the total pulse train is greater than the measurement period. As such, the cycle time (Tcycle) shall be declared as 100 ms.

As depicted in Figure 33, the total transmitter on-time is made of four sub-pulses. The longer sub-pulse measures 9.201 ms, with three additional shorter pulses.

The sweep time in Figure 34 was set to 5 ms, to make an accurate measurement of the individual, shorter sub-pulse. Either of these pulses measure 973.6 µs.

As such, the worst case on-time ($t$on) is: 9.201 + 3(.9736) = 12.121 ms (worst-case).

<u>The duty cycle can be calculated from the following formula:</u>

$t$on ÷ Tcycle = Δ

12.121 ÷ 100 = 0.1212

Δ = 12%

Where Δ is the final duty cycle.

<u>The duty cycle correction factor can be calculated from the following formula:</u>

20LOG(Δ) = δ

20LOG(0.12) = –18.416

δ = 18.4 dB (worst-case)

Where δ is the final DCCF (Danger Mode)

(Reference ANSI C63.10-2013, Section 7.5)

4.8.2 Warning Mode (for reference only)

Figure 6: Transmitter Pulse On-Time (1) – Warning Mode

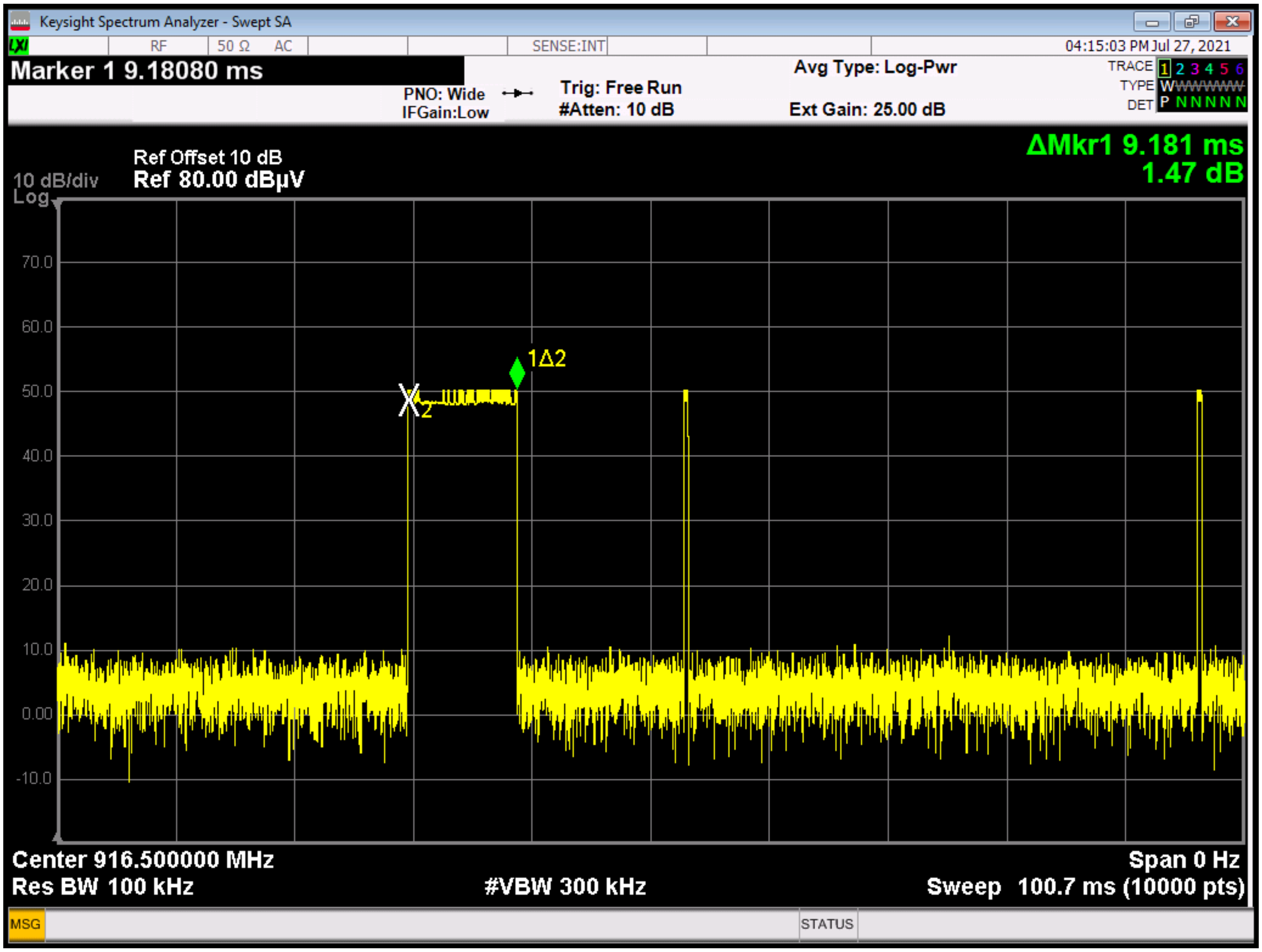
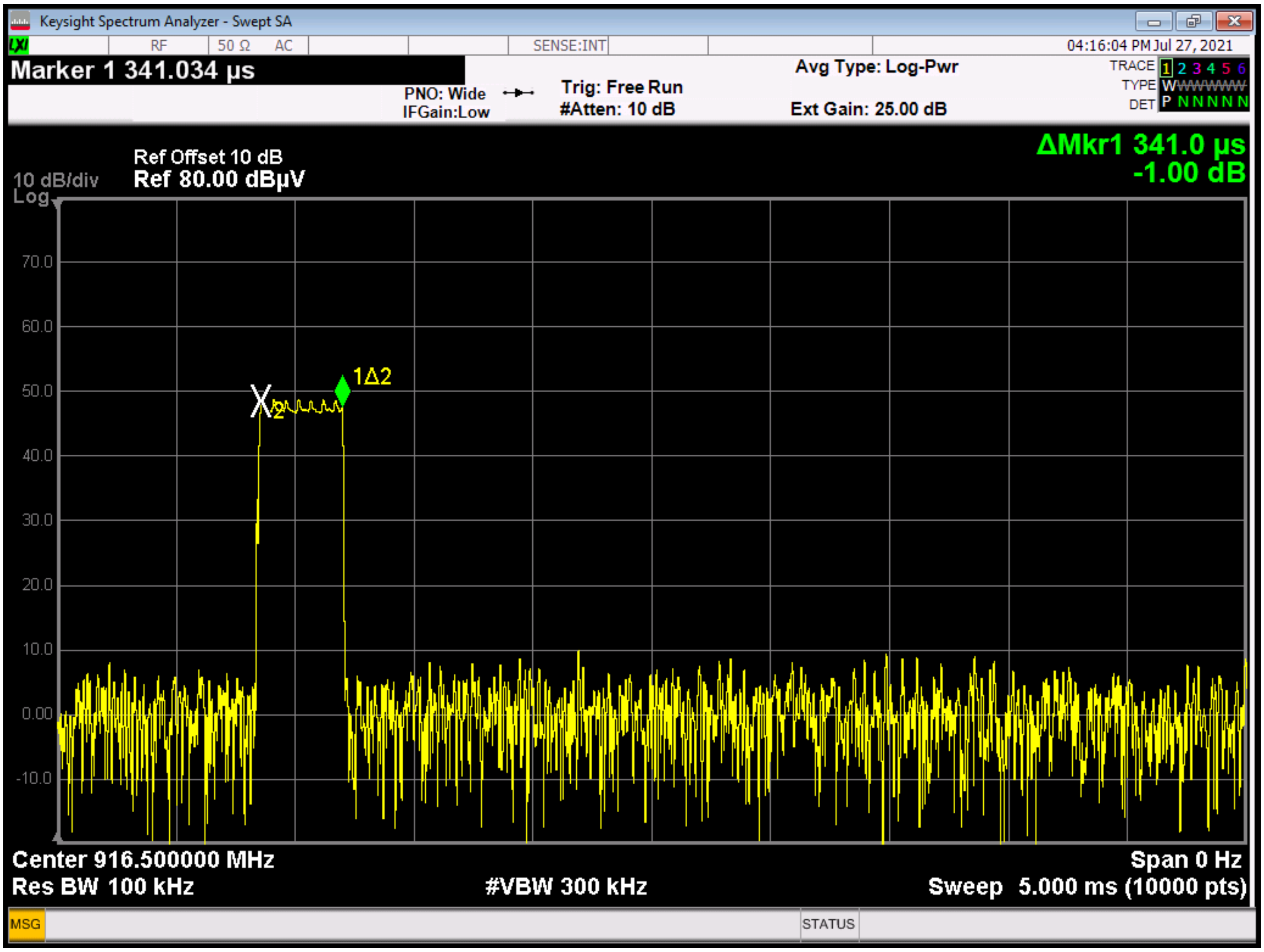


Figure 7: Transmitter Pulse On-Time (2) – Warning Mode



The Warning Mode pulse train was observed over a 100 ms sweep. In this case, the total pulse train is greater than the measurement period. As such, the cycle time (Tcycle) shall be declared as 100 ms.

As depicted in Figure 33, the total transmitter on-time is made of three sub-pulses. The longer sub-pulse measures 9.18 ms, with two shorter pulses that follow.

The sweep time in Figure 34 was set to 5 ms, to make an accurate measurement of the individual, shorter sub-pulse. Either of these pulses measure 341 µs.

As such, the worst case on-time ($t$on) is: 9.18 + 2(.340) = 9.86 ms

<u>The duty cycle can be calculated from the following formula:</u>

$t_{on} \div T_{cycle} = \Delta$

$9.86 \div 100 = 0.0986$

$\Delta = 9.9\%$

Where Δ is the final duty cycle.

<u>The duty cycle correction factor can be calculated from the following formula:</u>

$20LOG(\Delta) = \delta$

$20LOG(0.099) = -20.08$

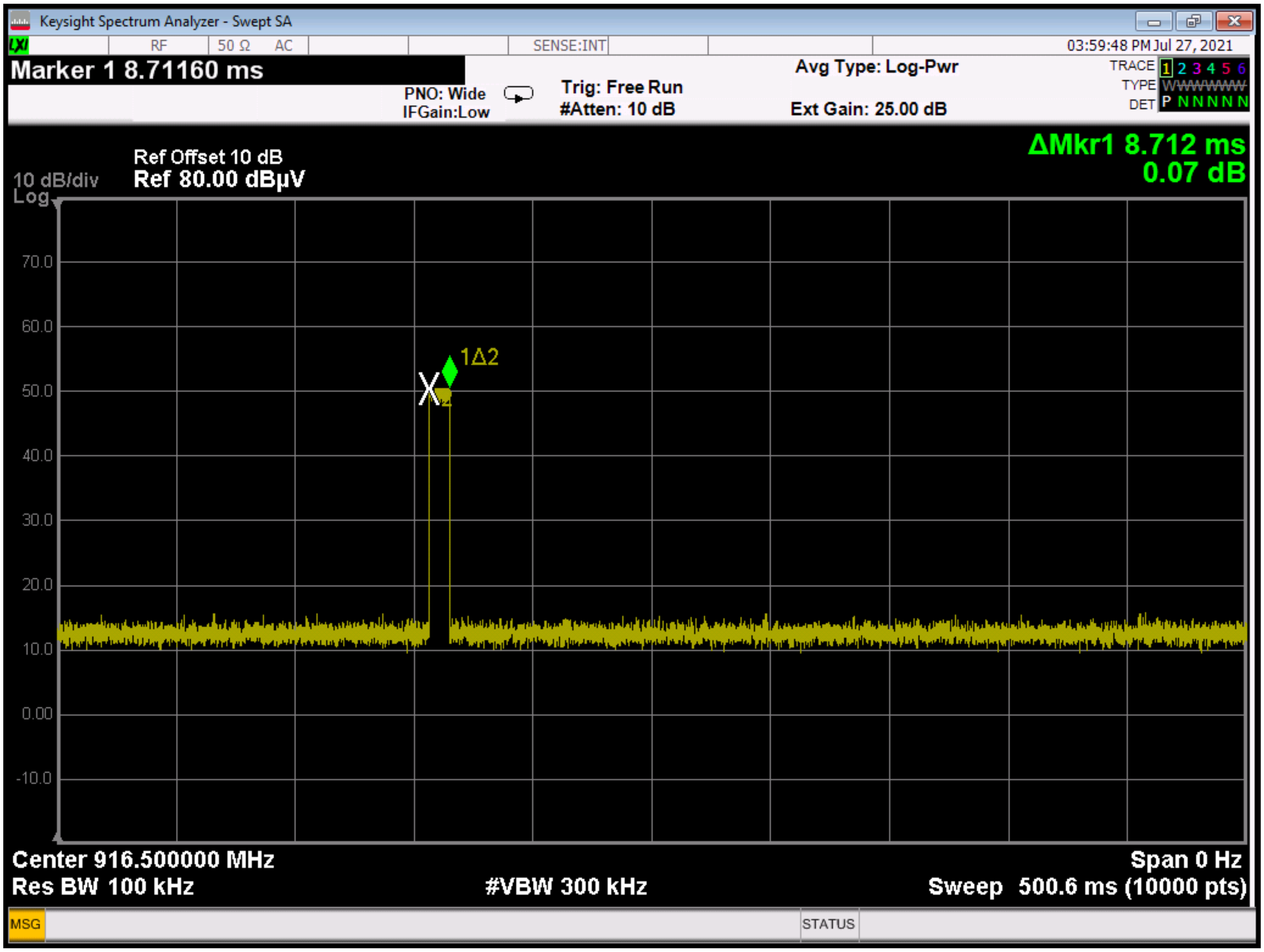
$\delta = 20.1$ dB

Where δ is the final DCCF (Warning Mode)

(Reference ANSI C63.10-2013, Section 7.5)

4.8.3 Health Status Mode (for Section 4.3 of this report)

Figure 8: Transmitter Pulse On-Time – Health Mode



The sweep time in Figure 1 was set to 350 ms, in order to observe the Health Mode pulsed transmitter on-time. In this case, the full pulse train is greater than the measurement period. As such, the cycle time (Tcycle) shall be declared as 100 ms.

Any given individual transmitter pulse, measures 8.712 ms. As such, the worst case on-time ($t$on) is 8.712 ms.

<u>The duty cycle can be calculated from the following formula:</u>

$t$on ÷ Tcycle = Δ

8.712 ÷ 100 = 0.08712

Δ = 8.7%

Where Δ is the final duty cycle.

<u>The duty cycle correction factor can be calculated from the following formula:</u>

20LOG(Δ) = δ

20LOG(0.087) = –21.209

δ = 21.2 dB

Where δ is the final DCCF (Health Mode)

(Reference ANSI C63.10-2013, Section 7.5)

5 Test Equipment

Table 13 shows a list of the test equipment used for measurements along with the calibration information.

Table 13: Test Equipment List

Test Name:	**Benchtop RF Emissions**	Test Date:	**5/24/2021 & 7/27/2021**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
00823	AGILENT, N9010A	SPECTRUM ANALYZER	6/7/2021
00065	HP 8447D	PRE-AMPLIER	6/3/2022
00885	UTIFLEX, UFA2108	HF COAXIAL	5/10/2022

Test Name:	**Radiated Emissions**	Test Date: **5/25/2021 & 6/1/2021**	
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
00528	AGILENT, E4446	SPECTRUM ANALYZER	3/18/2022
00644	SUNOL SCIENCES CORP.	JB1, LOGPERIOD ANTENNA	11/9/2022
00425	ARA DRG-118/A	HORN ANTENNA	8/18/2022
00955	JUNKOSHA USA	HF COAXIAL CABLE	5/10/2022
00885	UTIFLEX MICRO SMA	HF COAXIAL CABLE	5/10/2022
00280	ITC 21C-3A1	WAVEGUIDE FILTER	1/18/2022
00885	UTIFLEX, UFA2108	HF COAXIAL CABLE	5/10/2022
00721	WEINSCHEL DS109	ATTENUATOR, NOTCH	CNR

Test Name:	**Conducted Emissions Voltage**	Test Date:	**6/1/2021**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
00528	AGILENT E4446	SPECTRUM ANALYZER	3/18/2022
00125	SOLAR 8028-50	LISN, BNC	9/10/2021
00126	SOLAR 8028-50	LISN, BNC	9/10/2021
00053	HP 11947A	TRANSIENT LIMITER	2/18/2022
00330	WLL RG-223	CE CABLE 1	5/12/2022
00412	WLL RG-223	CE CABLE 2	5/10/2022