



**FCC & ISED CANADA CERTIFICATION
TEST REPORT**

for the

**FREDERICK ENERGY PRODUCTS LLC
MECHANIZED AREA CONTROLLER (MAC)**

**FCC ID: QUI-HN-MAC
IC ID: 11625-HNMAC**

WLL REPORT# 17067-01 REV 4

Prepared for:

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Prepared By:

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Testing Certificate AT-1448



FCC & ISED Canada Certification

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ISED ID: 11625-HNMAC

June 11, 2021

WLL Report# 17067-01 Rev 4

Prepared by:

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Ryan Mascaro
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Steven D. Koster
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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 Mechanized Area Controller (MAC). 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 Mechanized Area Controller (MAC) 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 11, 2021
Rev 1	ACB Comments, #ATCB027137	June 22, 2021
Rev 2	ACB Comments, #ATCB027137 v2	July 19, 2021
Rev 3	ACB Comments, 15.231(a) Requirements	August 10, 2021
Rev 4	Update DDCF and Worst-Case F/S	August 16, 2021

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1 Introduction

1.1 Compliance Statement

The Frederick Energy Products LLC Mechanized Area Controller (MAC) 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:	9182
Quotation Number:	72674

1.4 Test and Support Personnel

Washington Laboratories, LTD	Ryan Mascaro
Customer Representative	Ishmael Chigumira

1.5 Test Dates

5/19/2021 to 5/21/2021

2 Equipment Under Test

2.1 EUT Identification & Description

Table 1: Device Summary

Manufacturer:	Frederick Energy Products LLC
FCC ID:	QUI-HN-MAC
ISED ID:	11625-HNMAC
EUT Model:	Mechanized Area Controller (MAC)
Serial Number of Unit Tested	MACDCAZ00321
FCC Rule Parts:	§15.231
ISED Rule Parts:	RSS-210
ISED HVIN:	HN-MAC; 1323256
FCC Emission Designator:	161KF1D
IC Emission Designator:	144KF1D
Fixed Frequency:	916.5 MHz
20dB Occupied Bandwidth:	160.50 kHz
99% Occupied Bandwidth:	143.76 kHz
Keying:	Automatic
Modulation or Protocol:	FM, FSK
Firmware/Software:	FEPL Test Mode (TX On)
Type of Information:	Proximity, Telemetry
Number of Channels:	1
Power Output Level	Fixed, < 30 dBm
Antenna Type	Enclosure Integrated, Monopole
Interface Cables:	N/A
Power Source & Voltage:	120 VAC, 60 Hz

The Frederick Energy Products LLC, Mechanized Area Controller (MAC) is an auxiliary device that provides complementary capabilities to other proximity protection devices. The MAC has the ability to transmit and receive 916.5 MHz. It also functions like a generator, transmitting a 73 kHz magnetic field. When a PAD enters the MAC's field, it triggers the MAC's 916.5 MHz transmitter. The PAD and the MAC exchange packets over the 916.5 MHz radio link.

2.2 Test Configuration

For the §15.231 testing, the MAC sample was provided to the test laboratory in one test-mode, which differs slightly than as tested for the §15.209 testing. The EUT was tested in a stand-alone configuration., as depicted in the test setup photographs. A support PAD was brought into proximity of the MAC in order to trigger the 916.5 MHz transmitter, as needed. The "MeanWell" power supply (OWA-90U-12) [depicted in the test setup photographs] is integral to the EUT. This power supply is part of the EUT and was not interchangeable during testing.

Table 2: System Configuration List

EUT Name	FCC ID	Model	Serial Number	Revision
MAC	QUI-HN-MAC	HN-MAC	MACDCAZ00321	N/A

Table 3: Support Equipment

Item	Model/Part Number	Serial Number
PAD	PAD	N/A

Table 4: Cable Configuration

Port Identification	Connector Type	Cable Length	Shielded (Y/N)	Termination Point
AC Mains	IEC – 2 Prong	1m	N	AC Mains – EUT

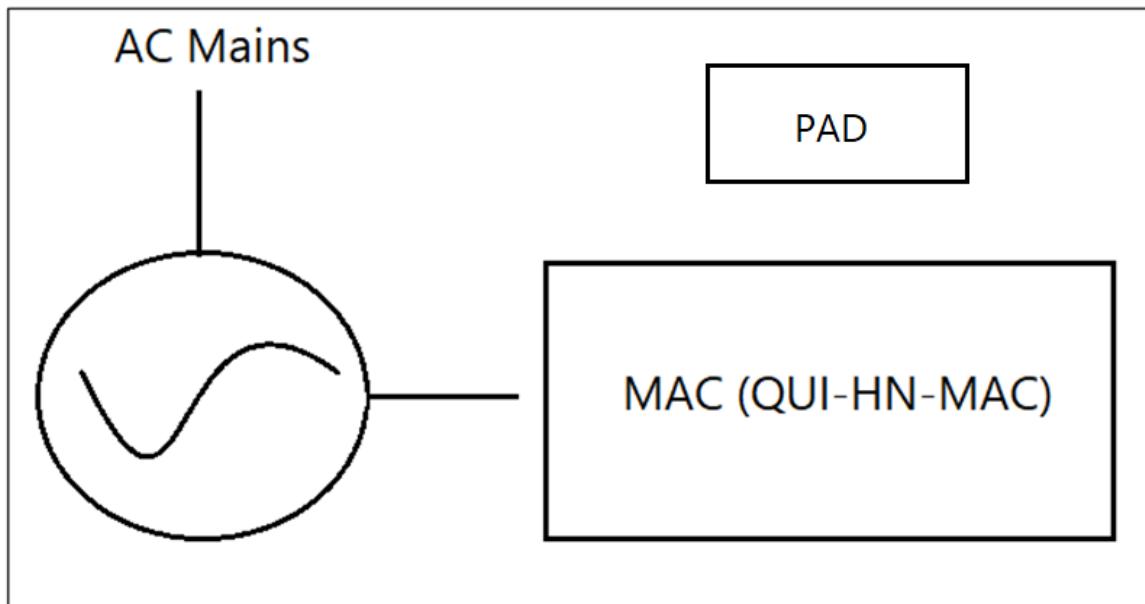
2.3 Testing Algorithm

The Mechanized Area Controller (MAC) was tested in a powered-on, steady state. Worst case emissions are provided throughout this report.

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



2.6 Measurements

2.6.1 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

2.6.2 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 dB μ V to obtain the Radiated Electric Field in dB μ V/m. This logarithm amplitude is converted to a linear amplitude, then compared to the FCC limit.

Example:

Spectrum Analyzer Voltage:	VdB μ V (SA)
Antenna Correction Factor:	AFdB/m
Cable Correction Factor:	CFdB
Pre-Amplifier Gain (if applicable):	GdB
Electric Field:	$EdB\mu V/m = V \text{ dB}\mu V (\text{SA}) + AFdB/m + CFdB - GdB$
To convert to linear units of measure:	Inv Log ($EdB\mu V/m/20$)

2.7 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

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

Where u_c = standard uncertainty
a, b, c,.. = individual uncertainty elements
 div_a, 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

$$U = k u_c$$

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 5 below.

Table 5: 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 6: Transmitter Testing to 15.231 – Summary

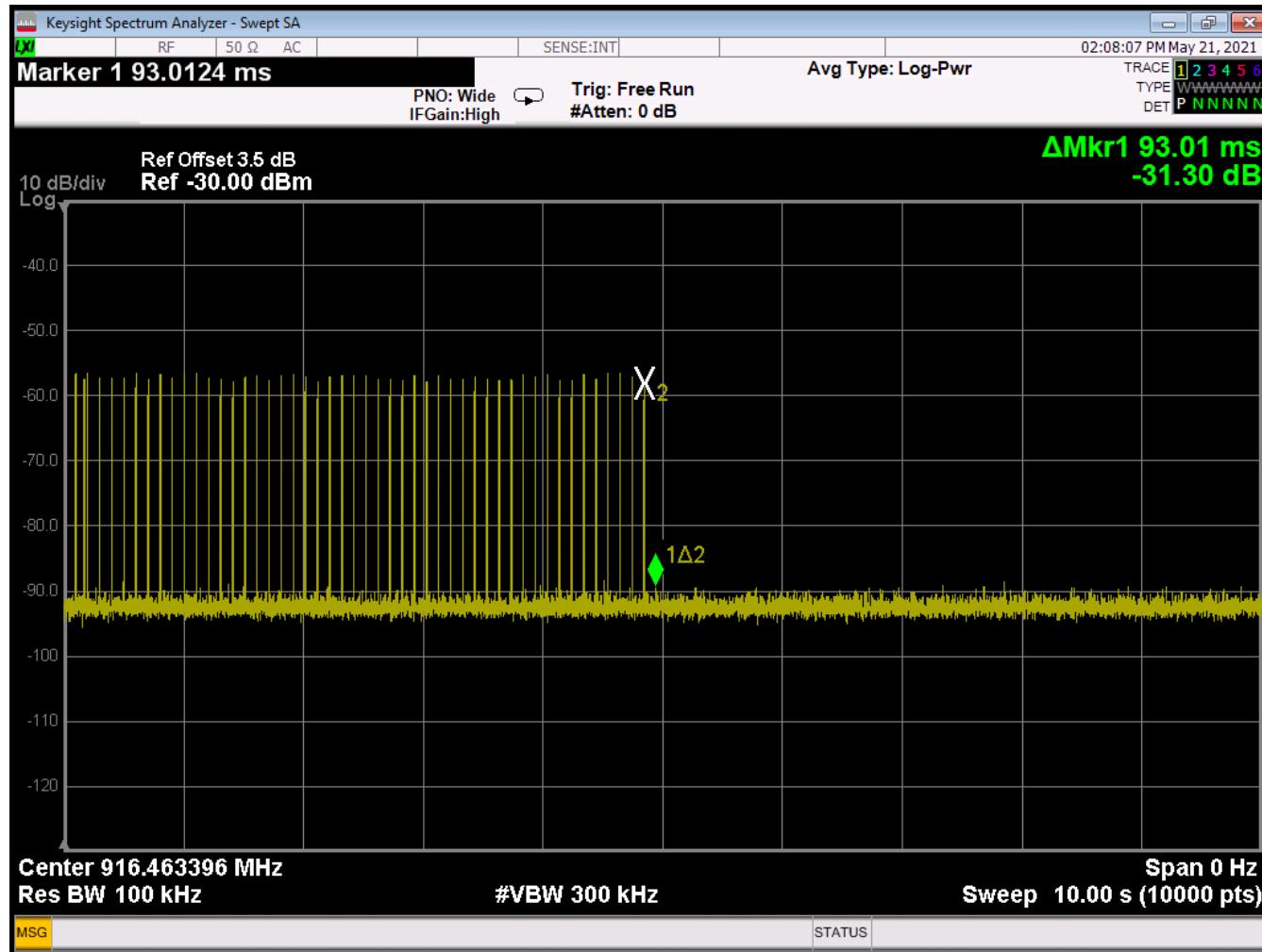
FCC Rule Part	ISED Rule Part	Description	Result
15.231(a)(1)	RSS-210	Transmit Cessation from Release	Pass
15.231(a)(2)	RSS-210	Transmit Cessation from Activation	Pass
15.231(a)(3)	RSS-210	Transmission Polling	N/A
15.231(a)(4)	RSS-210	Pendency of Alarm Conditions	Adopted
15.231(c)	RSS-210	Occupied Bandwidth	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 Mechanized Area Controller (MAC) stopped transmitting within the required time period. A 10-second sweep was made, during which the transmitter was triggered to deactivate and the time to transmission end was measured. 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 93.01 ms.

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 transmitter is disabled. When this occurs, the transmitter is disabled as shown in Figure 2.

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.

The EUT does not have a polling scheme of any kind.

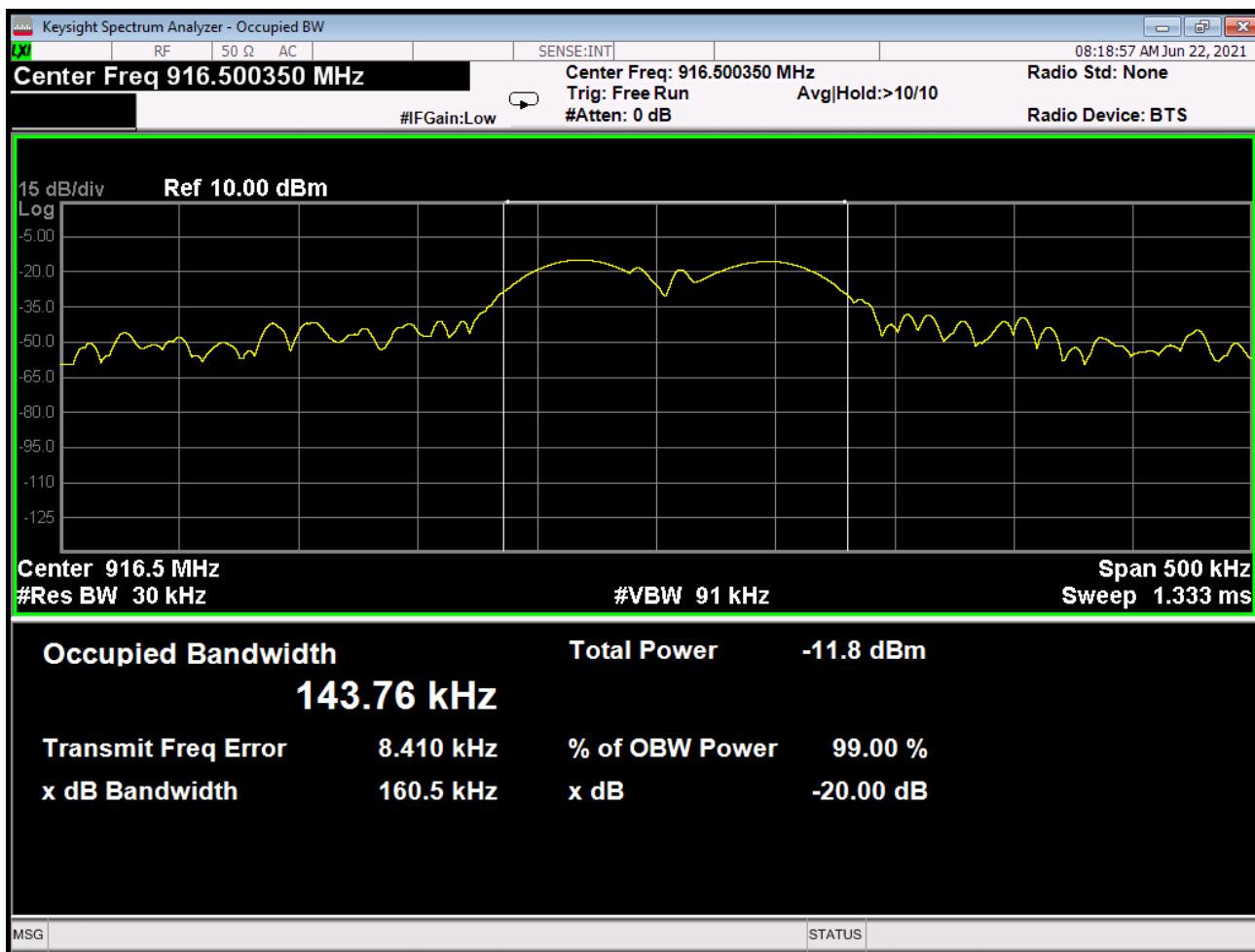
4.4 Occupied Bandwidth – FCC Part §15.231(c)

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 7: Occupied Bandwidth Results

TX Frequency	20 dB Bandwidth	Limit	Results
916.5 MHz	160.50 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 (μ V/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 22.6 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 an 80 cm high 1 X 1.5 meters non-conductive motorized turntable for radiated testing at a 3m open area test site (OATS). 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 peripherals were placed on the table in accordance with ANSI C63.4. Cables were varied in position to produce maximum emissions. Both 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.

Table 8: 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 (μ V/m)	Limit (μ V/m)	Margin (dB)	Detector
916.50	V	90.0	1.2	93.3	0.4	0.0	48426.9	125000.0	-8.2	Peak
916.50	V	90.0	1.2	93.3	0.4	20.7	4467.7	12500.0	-8.9	Peak *
916.50	V	180.0	1.3	92.5	0.4	0.0	44165.8	125000.0	-9.0	Peak
916.50	V	180.0	1.3	92.5	0.4	20.7	4074.6	12500.0	-9.7	Peak *

* note: this data indicates the corrected 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 (μ V/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 of FCC Part 15 and ICES-003 call for the EUT to be placed on an 80 cm high 1 X 1.5 meters non-conductive motorized turntable for radiated testing at a 3m open field test site. 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. The peripherals were placed on the table in accordance with ANSI C63.4. Cables were varied in position to produce maximum emissions. 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). The worst-case emissions are reported below.

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

Spur indicates that an emission was present.

Table 9: Spurious Emissions Test Data – 30 MHz to 1000 MHz

Frequency (MHz)	Polarity H/V	Azimuth (Degree)	Ant. Height (m)	SA Level (dB μ V)	Corr Factors (dB)	Corr. Level (μ V/m)	Limit (μ V/m)	Margin (dB)	Detector	Comments
37.14	V	0.0	2.2	34.8	-8.6	20.4	500.0	-27.8	QP	AMB
130.96	V	0.0	2.0	29.6	-11.0	8.5	500.0	-35.4	QP	AMB
249.83	V	180.0	1.3	37.9	-12.8	18.1	500.0	-28.8	QP	Spur
400.77	V	0.0	1.5	28.7	-8.2	10.6	500.0	-33.5	QP	AMB
833.70	V	0.0	1.6	29.0	-1.0	25.1	500.0	-26.0	QP	AMB
951.16	V	0.0	1.3	31.2	0.4	38.2	500.0	-22.3	QP	AMB
31.81	H	90.0	2.6	27.6	-4.8	13.7	500.0	-31.2	QP	AMB
228.49	H	90.0	2.0	34.6	-13.4	11.5	500.0	-32.8	QP	AMB
259.66	H	270.0	1.3	33.4	-12.5	11.1	500.0	-33.0	QP	Spur
400.77	H	0.0	1.5	28.1	-8.2	9.9	500.0	-34.1	QP	AMB
833.70	H	0.0	1.2	31.0	-1.0	31.7	500.0	-24.0	QP	AMB
951.16	H	0.0	1.5	30.3	0.4	34.4	500.0	-23.2	QP	AMB

Table 10: Spurious Emissions Test Data – 1 GHz to 12 GHz

Frequency (MHz)	Polarity H/V	Azimuth (Degree)	Ant. Height (m)	SA Level (dB μ V)	Corr Factors (dB)	DCCF (dB)	Corr. Level (μ V/m)	Limit (μ V/m)	Margin (dB)	Detector	Comments
1833.00	V	0.0	1.3	61.1	-18.8	0.0	131.0	12500	-39.6	Peak	AMB
1833.00	V	0.0	1.3	61.1	-18.8	20.7	24.2	1250	-32.4	Peak *	AMB
2749.50	V	0.0	1.3	46.0	-13.9	0.0	40.1	12500	-49.9	Peak	AMB
2749.50	V	0.0	1.3	46.0	-13.9	20.7	5.3	1250	-45.5	Peak *	AMB
3666.00	V	90.0	1.2	56.4	-11.7	0.0	171.4	12500	-37.3	Peak	Spur
3666.00	V	90.0	1.2	56.4	-11.7	20.7	19.6	1250	-34.2	Peak *	Spur
4582.50	V	180.0	1.4	55.1	-7.3	0.0	244.7	12500	-34.2	Peak	Spur
4582.50	V	180.0	1.4	55.1	-7.3	20.7	15.2	1250	-36.4	Peak *	Spur
5499.00	V	0.0	1.3	56.0	-5.5	0.0	333.2	12500	-31.5	Peak	AMB
5499.00	V	0.0	1.3	56.0	-5.5	20.7	20.5	1250	-33.8	Peak *	AMB
1833.00	H	90.0	1.2	59.0	-18.8	0.0	102.9	12500	-41.7	Peak	AMB
1833.00	H	90.0	1.2	59.0	-18.8	20.7	19.0	1250	-34.5	Peak *	AMB
2749.50	H	0.0	1.2	61.4	-13.9	0.0	235.8	12500	-34.5	Peak	AMB
2749.50	H	0.0	1.2	61.4	-13.9	20.7	31.5	1250	-30.1	Peak *	AMB
3666.00	H	0.0	1.2	60.0	-11.7	0.0	259.5	12500	-33.7	Peak	Spur
3666.00	H	0.0	1.2	60.0	-11.7	20.7	29.6	1250	-30.6	Peak *	Spur
4582.50	H	180.0	1.2	57.0	-7.3	0.0	304.6	12500	-32.3	Peak	Spur
4582.50	H	180.0	1.2	57.0	-7.3	20.7	18.9	1250	-34.5	Peak *	Spur
5499.00	H	180.0	1.2	55.5	-5.5	0.0	314.6	12500	-32.0	Peak	AMB
5499.00	H	180.0	1.2	55.5	-5.5	20.7	19.4	1250	-34.3	Peak *	AMB

* note: this data indicates the corrected 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 dB μ V	66 dB μ V	66 to 56 dB μ V	56 to 46 dB μ V
0.5 – 5 MHz	79 dB μ V	66 dB μ V	56 dB μ V	46 dB μ V
0.5 – 30 MHz	73 dB μ V	60 dB μ V	60 dB μ V	50 dB μ V

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 μ H 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: $VdB\mu V(\text{raw})$

LISN Correction Factor: LISN dB

Cable Correction Factor: CF dB

Voltage: $VdB\mu V = V dB\mu V (\text{raw}) + \text{LISN dB} + \text{CF dB}$

4.7.2 Test Data

The EUT complies with the Class B Conducted Emissions requirements.

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

Table 11: AC Power Conducted Emissions Test Data

NEUTRAL										
Frequency (MHz)	Level QP (dB μ V)	Level AVG (dB μ V)	Cable Loss (dB)	LISN Corr (dB)	Level QP Corr (dB μ V)	Level Corr Avg (dB μ V)	Limit QP (dB μ V)	Limit AVG (dB μ V)	Margin QP (dB)	Margin AVG (dB)
0.150	36.1	29.2	10.2	1.0	47.2	40.3	66.0	56.0	-18.8	-15.7
0.365	33.6	19.6	10.2	0.9	44.7	30.7	58.6	48.6	-14.0	-18.0
0.439	33.8	17.0	10.2	0.8	44.7	28.0	57.1	47.1	-12.3	-19.1
2.974	22.5	18.0	10.3	0.8	33.5	29.0	56.0	46.0	-22.5	-17.0
3.627	18.9	7.0	10.4	0.8	30.1	18.2	56.0	46.0	-25.9	-27.8
7.590	24.0	9.0	11.0	1.7	36.7	21.7	60.0	50.0	-23.3	-28.3
PHASE / L1										
Frequency (MHz)	Level QP (dB μ V)	Level AVG (dB μ V)	Cable Loss (dB)	LISN Corr (dB)	Level QP Corr (dB μ V)	Level Corr Avg (dB μ V)	Limit QP (dB μ V)	Limit AVG (dB μ V)	Margin QP (dB)	Margin AVG (dB)
0.162	35.6	29.7	10.2	1.4	47.2	41.3	65.4	55.4	-18.1	-14.0
0.420	33.3	25.0	10.2	1.0	44.5	36.2	57.4	47.4	-13.0	-11.3
0.439	33.8	27.0	10.2	1.0	45.0	38.2	57.1	47.1	-12.1	-8.9
0.728	21.6	13.0	10.3	0.9	32.8	24.2	56.0	46.0	-23.2	-21.8
2.985	19.0	7.0	10.3	1.0	30.3	18.3	56.0	46.0	-25.7	-27.7
3.587	20.0	7.0	10.4	1.1	31.5	18.5	56.0	46.0	-24.5	-27.5
7.445	25.6	11.5	11.0	2.0	38.6	24.5	60.0	50.0	-21.4	-25.5

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.

Figure 4: Transmitter Pulse On-Time, per 100ms

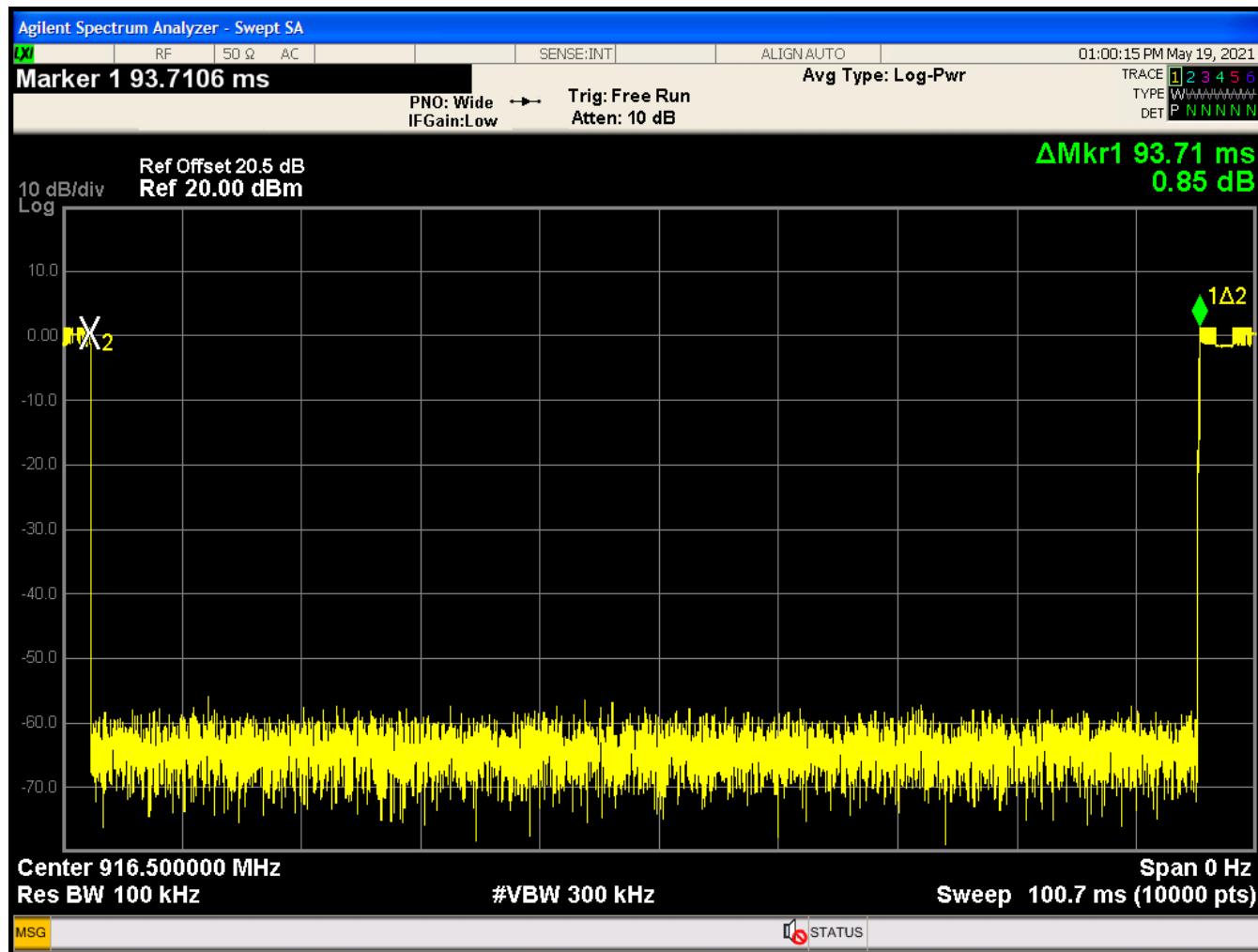
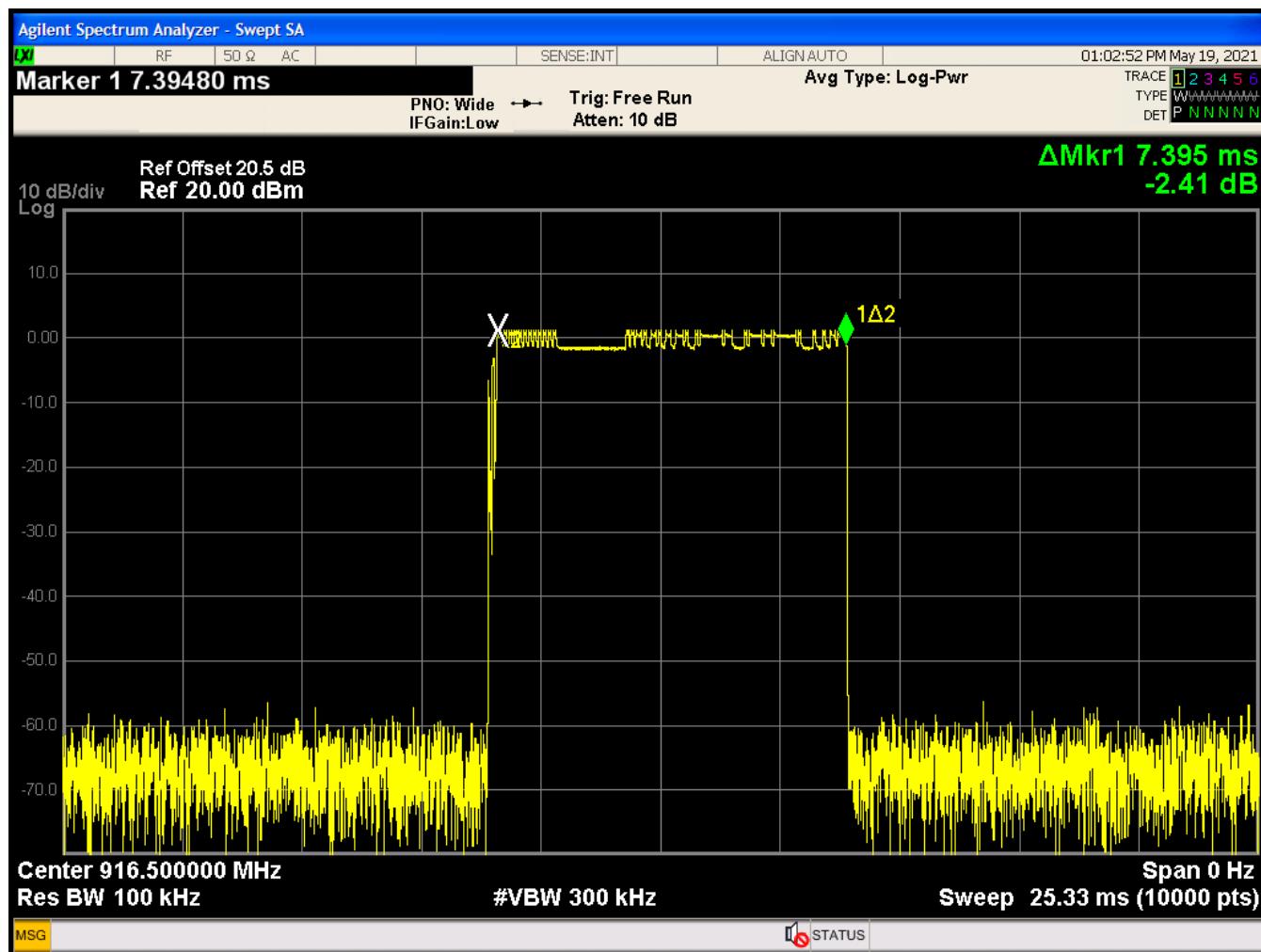


Figure 5: Transmitter Sub-Pulse, On-Time



Note: For emissions testing throughout this report, the EUT transmitter mode (on-time) was configured as shown in Figure 4 and Figure 5. This configuration best represents the 7.68ms transmitter time that is explained in the applicant's theory of operation/operational description. This mode produced the highest recorded amplitude when evaluating the TX field strength. However, please know that the device is also capable of a 9.24ms transmitter on-time. As shown on Page 28, the second mode of 9.24ms yields the worst-case DCCF. As a result, the final DCCF for compliance margin will be 20.7 dB.

Transmitter Mode and DCCF for Testing:

As depicted in Figure 4, the total period of the pulse train is greater than 100 ms.

As such, the cycle time (T_{cycle}) shall be declared as 100ms.

The sweep time in Figure 5 was set to ~ 25 ms, to make an accurate measurement of the pulsed transmitter On-Time.

The duty cycle can be calculated from the following formula:

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

$$7.395 \div 100 = 0.074$$

$$\Delta = 7.4 \%$$

Where Δ is the final duty cycle.

The duty cycle correction factor can be calculated from the following formula:

$$20\text{LOG}(\Delta) = \delta$$

$$20\text{LOG}(0.074) = -22.62$$

$$\delta = 22.6 \text{ dB}$$

Where δ is the final DCCF (as configured for testing).

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

Transmitter Mode and DCCF for Compliance/Table Data:

As explained on Page 26 of this report, and in the applicant's theory of operation, the EUT is capable of a 9.24ms transmitter on-time, in any given 100ms sweep.

As such, these parameters (9.24ms ÷ 100ms) yield the lowest DCCF and shall be used to show compliance in Table 8 and Table 10, of this test report.

The worst-case duty cycle can be calculated from the following formula:

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

$$9.24 \div 100 = 0.0924$$

$$\Delta = 9.2 \%$$

Where Δ is the final duty cycle.

The duty cycle correction factor can be calculated from the following formula:

$$20\text{LOG}(\Delta) = \delta$$

$$20\text{LOG}(0.0924) = -20.69$$

$$\delta = 20.7 \text{ dB}$$

Where δ is the worst-case DCCF (as used for table data/compliance margin).

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

5 Test Equipment

Table 12 shows a list of the test equipment used for measurements along with the calibration information.

Table 12: Test Equipment List

Test Name: Benchtop RF Emissions		Test Date:	05/21/2021
Asset #	Manufacturer/Model	Description	Cal. Due
00823	AGILENT, N9010A	SPECTRUM ANALYZER	6/7/2021
00885	UTIFLEX, UFA2108	HF COAXIAL	5/10/2022

Test Name: Radiated Emissions		Test Date:	05/20/2021
Asset #	Manufacturer/Model	Description	Cal. Due
00823	AGILENT, N9010A	SPECTRUM ANALYZER	6/7/2021
00644	SUNOL SCIENCES CORP.	JB1 LOGPERIOD ANT.	11/9/2022
00425	ARA, DRG-118/A	HORN ANTENNA	8/18/2022
00955	JUNKOSHA USA	HF COAXIAL	5/10/2022
00885	UTIFLEX MICRO COAX	HF COAXIAL	5/10/2022
00280	ITC, 21C-3A1	WAVEGUIDE FILTER	1/18/2022
00885	UTIFLEX, UFA2108	HF COAXIAL	5/10/2022
00721	WEINSCHEL, DS109	ATTENUATOR	CNR

Test Name: Conducted Emissions Voltage		Test Date:	05/19/2021
Asset #	Manufacturer/Model	Description	Cal. Due
00823	AGILENT, N9010A	SPECTRUM ANALYZER	6/11/2021
00125	SOLAR, 8028-50-TS-24-BNC	LISN	9/10/2021
00126	SOLAR, 8028-50-TS-24-BNC	LISN	9/10/2021
00053	HP, 11947A	LIMITER, VOLTAGE	2/18/2022
00330	WLL, RG-223	CE CABLE	5/12/2022
00412	WLL, RG-223	CE CABLE	5/10/2022