Test Report # 319384 B

Equipment Under Test:	Radio Apparatus
Test Date(s):	8/10/2020 - 8/21/2020
Prepared for:	Vermeer Manufacturing Company Attn: Ty Gross 1716 Vermeer Rd East Pella, IA 50219

Report Issued by: Shane Dock, EMC Engineer

Signature:

Date: 2/5/2021

Report Reviewed by: Adam Alger, Quality Manager

Signature:

Date: 11/5/2020

Report Constructed by: Shane Dock, EMC Engineer

Signature:

Date: 9/24/2020

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Laird Connectivity Test Services in Review

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

TESTING CERT #1255.01

A2LA – American Association for Laboratory Accreditation

Accreditation based on ISO/IEC 17025:2017 with Electrical (EMC) Scope

A2LA Certificate Number: 1255.01

Scope of accreditation includes all test methods listed herein unless otherwise noted

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Federal Communications Commission (FCC) – USA

Accredited Test Firm Registration Number: 953492

Recognition of two 3 meter Semi-Anechoic Chambers

Government of Canada

Innovation, Science and Economic Development Canada

Accredited U.S. Identification Number: US0218

Recognition of two 3 meter Semi-Anechoic Chambers

1 Test Report Summary

During **9/24/2020** the Equipment Under Test (EUT), **Radio Apparatus**, as provided by **Vermeer Manufacturing Company** was tested to the following requirements:

Requirement	Description	Specification	Method	Result
FCC Part 1.1307, 2.1091, 2.1093	RF Exposure and equipment authorization requirements	Reported	FCC KDB 447498	Reported
ISED Canada RSS-102	Radiofrequency Radiation Exposure Evaluation: Portable	Reported	RSS-102 Section 2.5.2	Reported

Notice:

The results relate only to the item tested as configured and described in this report. Any additional configurations, modes of operation, or modifications made to the equipment under test after the specified test date(s) are at the decision of the client and may not apply to the data seen in this test report.

The decision rule for Pass / Fail assessment to the specification or standard listed in this test report has been agreed upon by the client and laboratory to be as follows:

Measurement Type	Rule
Emissions – Amplitude	2 dB below specified limit
Emissions – Frequency	1% less than the specification
Immunity	Tested at specified level

2 CLIENT INFORMATION

Company Name	Vermeer Manufacturing Company
Contact Person	Ty Gross
Address	1716 Vermeer Rd East Pella, IA 50219

2.1 Equipment Under Test (EUT) Information

The following information has been supplied by the client

Product Name	Radio Apparatus
Model Number	VERMEER1
Serial Number	Engineering Samples
FCC/ISED ID:	FCC ID: 2AXF5-VERMEER1 IC: 26431-VERMEER1

2.2 Product Description

The Radio Apparatus is a 2.4 GHz Frequency Hopping Spread Spectrum (FHSS) Wireless Module used in OEM Host applications.

2.3 Modifications Incorporated for Compliance

None noted at time of test

2.4 Deviations and Exclusions from Test Specifications

None noted at time of test

2.5 Additional Information

The EUT is a module facilitated using a devkit (model: DVK-RM024-CE) powered by 120 VAC, 60 Hz. The Radio Apparatus houses a proprietary frequency hopping 2.4 GHz radio that operates from 2404 – 2466.9 MHz. Unit tested in the low mid, and high channels as shown below, and in the hopping mode as required for each test. Unit tested with a set of channels comprising 43 channels with 280kHz and 500 kHz data rates.

Low – 2404 MHz
Mid – 2435.5 MHz
High – 2466.9 MHz

2.6 Antenna Information

This EUT was tested with a cabinet radiation method assuming a worst-case antenna gain of 4.6 dBi in accordance with FCC Guidance.

The following antennas are to be used with this device:
Laird Connectivity TRA6927M3PBN-001 - Phantom 4.6dBi
PCTEL PCTCN24005 - Collinear 4.5dBi
Laird Connectivity TRAB24003P - Phantom 3.0 dBi
PCTEL BMLPV2400NGP - Phantom 3.0 DBi
Nearson S181FL-5(178)-PX-2450 - Half-Wave Dipole 2.0 dBi
Laird Connectivity MAF94045 - PCB Trace 2.0 dBi
Molex 2.4/5GHz Balance Flex Antenna – 3.0 dBi at 2.4 GHz

3 REFERENCES

Publication	Edition	Date
CFR 47 Part 15	-	2020
ANSI C63.10	-	2013
RSS-247	2	2017
RSS GEN	5	2014
RSS-102	5	2015
CFR 47 Part 1 and 2	-	2018
FCC KDB 447498	6	2015

4 Uncertainty Summary

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

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

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

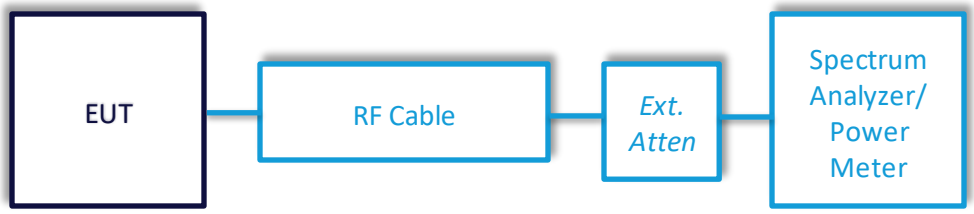
Parameter	ETSI U.C. ±	U.C. ±
Radio Frequency, from F0	$1x10^{-7}$	$0.55x10^{-7}$
Occupied Channel Bandwidth	5 %	2 %
RF conducted Power (Power Meter)	1.5 dB	1.2 dB
RF conducted emissions (Spectrum Analyzer)	3.0 dB	1.7 dB
All emissions, radiated	6.0 dB	5.3 dB
Temperature	1° C	0.65° C
Humidity	5 %	2.9 %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

5 TEST DATA

5.1 Antenna Port Conducted Emissions

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

Block Diagram



5.1.1 Antenna Port Conducted Emissions

Operator	Jon Dilley, Anthony Smith	**QA**	Shane Dock
Temperature	22.6°C	**R.H. %**	51.70%
Test Date	8/21/2020 – 9/12/2020	**Location**	Conducted RF Bench
Requirement	FCC Part 15.247	**Method**	ANSI C63.10 Sections 6.8, 6.9, 7.8.2, 7.8.3, 7.8.4, 7.8.5, 7.8.6, 7.8.8

Limits:

Maximum Conducted Output Power (watts)	Maximum Conducted Output Power (dBm)
1	30

Test Parameters

Frequency	2400-2483.5 MHz	**Setup**	RM024 connected to Spectrum Analyzer via SMA cable.

Instrumentation

Date : 6-Aug-2020 Test : Cunducted RF Job : C-3379

PE : Shane Dock Customer : Vermeer Quote : 319384

No.	Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due Date	Equipment Status
1	EE 960087	Analyzer - Spectrum	Agilent	N9010A	MY53400296	7/14/2020	7/14/2021	Active Calibration
2	AA 960143	Cable	Gore	EKD01D01048.0	5546519	12/9/2019	12/9/2020	Active Verification
3	EE 960203	Analyzer - EMI Receiver	Keysight	N9038A	MY56400072	7/14/2020	7/14/2021	Active Calibration
4	AA 960144	Cable	Gore	EKD01D010720	5800373	12/9/2019	12/9/2020	Active Verification

EUT Parameters

Input Power	7.5 VDC	**Mode**	Modulated Tx Mode Hopping Mode
Frequency	2404 MHz 2435.5 MHz 2466.9 MHz	**Channel**	Low, Mid, High Channel tested. All channels active in Hopping mode.
Notes	EUT tested at both 280 kHz and 500 kHz.		

Data

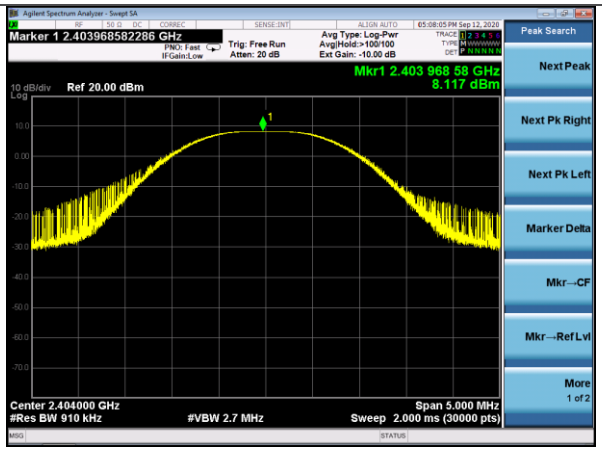
Table – 280 kHz

Channel	Measured Output Power (dBm)	Output Power Limit (dBm)	Margin (dB)
Low	8.1	30.0	21.9
Mid	8.6	30.0	21.4
High	8.8	30.0	21.2

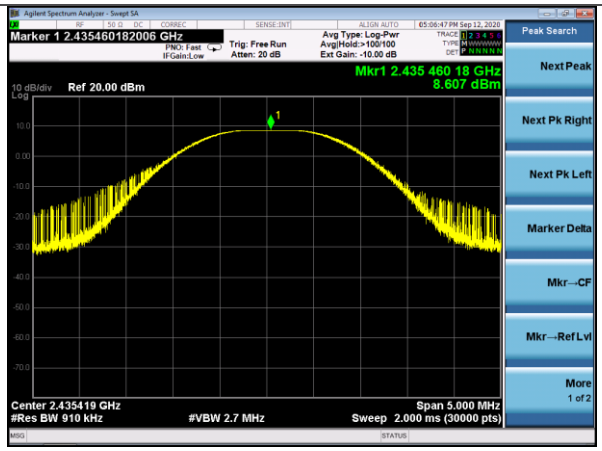
Table – 500 kHz

Channel	Measured Output Power (dBm)	Output Power Limit (dBm)	Margin (dB)
Low	8.1	30.0	21.9
Mid	8.6	30.0	21.4
High	8.8	30.0	21.2

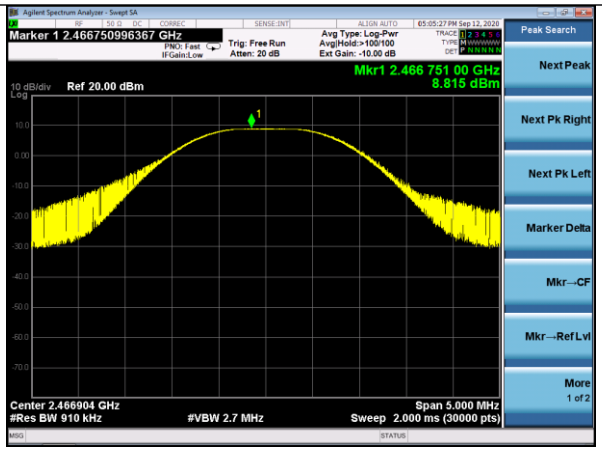
Plots – 280 kHz (Worst Case Shown)



Low Channel

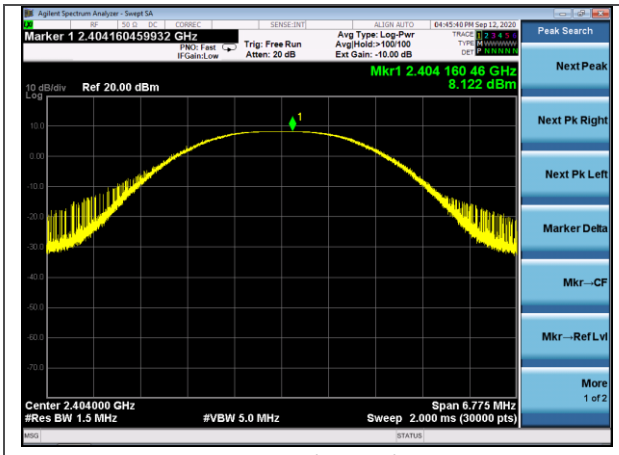


Mid Channel

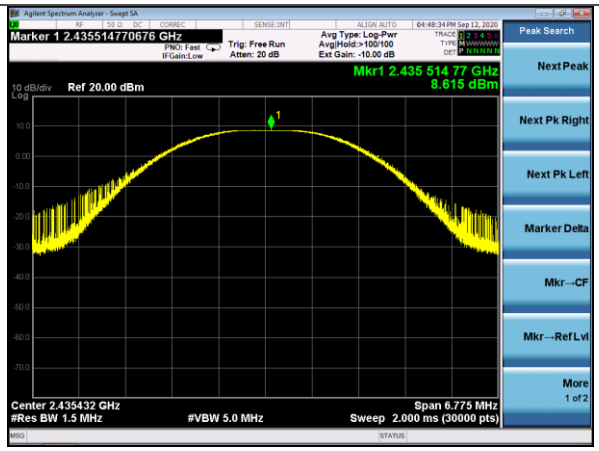


High Channel

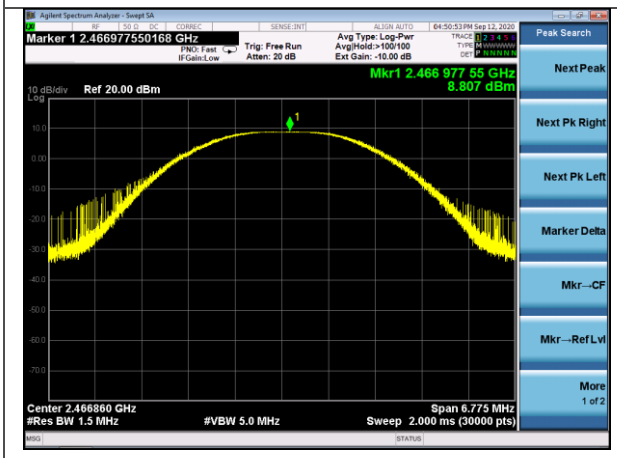
Plots – 500 kHz (Worst Case Shown)



Low Channel



Mid Channel



High Channel

5.2 Exposure Calculations

FCC

Worst Case Output Power: 8.8 dBm at 2466.9 MHz = 12.0 mW

Tune Up Tolerance: 2 dB

Per KDB 447498 D01 General RF Exposure Guidance v06:
[Max power (mW)/ Separation distance (mm)] * sqrt[f(GHz)] <= 3.0 (1-g SAR)

Minimum Separation Distance = 12.0 mW * sqrt(2.4669)/3 = 6.3mm, which must be rounded to 7 mm.

At 7 mm:

12.0 mW / 7 mm * sqrt(2.4669) = 2.7, which is less than 3.0. This EUT is exempt from routine evaluation at all separation distances 7mm or greater for 1-g SAR.

[Max power (mW)/ Separation distance (mm)] * sqrt[f(GHz)] <= 7.5 (10-g SAR)

Minimum Separation Distance = 12.0 mW * sqrt(2.4669)/7.5 = 2.5 mm, which must be rounded to 5 mm.

At 5 mm:

12.0 mW / 5.0 mm, * sqrt(2.4669) = 3.8 which is less than 7.5. This EUT is exempt from routing evaluation at all separation distances 5 mm or greater for 10-g SAR.

ISED

Per RSS-102 Ed 5:

Table 1: SAR evaluation – Exemption limits for routine evaluation based on frequency and separation distance[4,5]

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of ≤5 mm	At separation distance of 10 mm	At separation distance of 15 mm	At separation distance of 20 mm	At separation distance of 25 mm
≤300	71 mW	101 mW	132 mW	162 mW	193 mW
450	52 mW	70 mW	88 mW	106 mW	123 mW
835	17 mW	30 mW	42 mW	55 mW	67 mW
1900	7 mW	10 mW	18 mW	34 mW	60 mW
2450	4 mW	7 mW	15 mW	30 mW	52 mW
3500	2 mW	6 mW	16 mW	32 mW	55 mW
5800	1 mW	6 mW	15 mW	27 mW	41 mW

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of 30 mm	At separation distance of 35 mm	At separation distance of 40 mm	At separation distance of 45 mm	At separation distance of ≥50 mm
≤300	223 mW	254 mW	284 mW	315 mW	345 mW
450	141 mW	159 mW	177 mW	195 mW	213 mW
835	80 mW	92 mW	105 mW	117 mW	130 mW
1900	99 mW	153 mW	225 mW	316 mW	431 mW
2450	83 mW	123 mW	173 mW	235 mW	309 mW
3500	86 mW	124 mW	170 mW	225 mW	290 mW
5800	56 mW	71 mW	85 mW	97 mW	106 mW

Output Power + Tune up Tolerance = 10.8 dBm = 12.0 mW.

Using the 2450 MHz limit (worst-case), this EUT is exempt from routine evaluation at all separation distances 15 mm or greater, since 7 mW < 12.0 mW < 15 mW for 1-g SAR.

Using the 2450 MHz limit (worst-case), this EUT is exempt from routine evaluation at all separation distances 10 mm or greater, since 10 mW < 12.0 mW < 17.5 mW for 10-g SAR.

6 Revision History

Version	Date	Notes	Person
0	9/24/20	First Draft	Shane Dock
1	11/2/20	Updated Draft	Shane Dock
2	11/5/20	Further Revision	Shane Dock
3	11/5/20	Final Draft	Shane Dock
4	12/7/20	TCB Responses	Shane Dock
5	2/5/21	Address Change	Shane Dock

END OF REPORT