

Code of Federal Regulations 47 Part 15 – Radio Frequency Devices

Subpart C – Intentional Radiators

Section 15.231

Periodic operation in the band 40.66 - 40.70 MHz
and above 70 MHz

THE FOLLOWING **MEETS** THE ABOVE TEST SPECIFICATION

FCC ID: P36-3701

Formal Name: MX Fuel Vibrator Remote Control

Kind of Equipment: RF Remote Control Transmitter

Frequency Range: 433 MHz

Test Configuration: Table top, battery operated device tested in three orthogonal positions.

Model Number(s): 3701

Model(s) Tested: 3701

Serial Number(s): N/A

Date of Tests: March 11-12 , 2021

Test Conducted For: Milwaukee Electric Tool Corp.
13135 W. Lisbon Road
Brookfield, WI 53005, USA

NOTICE: The test report contains test data, equipment lists, photographs and/or other information regarding only the sample provided by the client for testing. This test report shall not be used to claim product approval or endorsement by any governmental, regulatory, or accrediting agency. Please see the "Description of Test Sample" page listed inside of this report.

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166 South Carter, Genoa City, WI 53128

Company:
Model Tested:
Report Number:
Project Number:

Milwaukee Electric Tool Corp.
3701
25988 rev2.0
11382

SIGNATURE PAGE

Report By:

John Schneider
Test Engineer

Reviewed By:

William Stumpf
OATS Manager

Approved By:

Brian Mattson
General Manager

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CERTIFICATE OF ACCREDITATION

The ANSI National Accreditation Board

Hereby attests that

DLS Electronic Systems, Inc.
200 E. Marquardt Drive
Wheeling, IL 60090
(and satellite sites as shown on the scope)

Fulfills the requirements of

ISO/IEC 17025:2017

In the field of

TESTING

This certificate is valid only when accompanied by a current scope of accreditation document.
The current scope of accreditation can be verified at www.anab.org.

R. Douglas Leonard Jr., VP, PILR SBU
Expiry Date: 23 April 2022
Certificate Number: AT-1859



This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017.
This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated April 2017).

SATELLITE SITE

DLS Electronic Systems, Inc. (Oats site)
166 South Carter
Genoa City, Wisconsin 53128
www.dlsemc.com

1.0 Summary of Test Report

It was determined that the MX Fuel Vibrator Remote Control, model 3701, complies with the requirements of CFR 47 Part 15 Subpart C Section 15.231.

Subpart C Applicable Technical Requirements Tested:

Section	Description	Procedure	Note	Compliant?
15.231(c)	20 dB Emission Bandwidth	ANSI C63.10-2013 Section 6.9.2	1,2	Yes
15.231(a)(1)	Transmission Deactivation	ANSI C63.10-2013 Section 7.4	1	Yes
15.231(b)	Field Strength of Emissions - Fundamental and Spurious -	ANSI C63.10-2013 Section 7.6	1,2	Yes
15.35(c)	Duty Cycle Correction for Pulsed Operation	ANSI C63.10-2013 Section 7.5	1	Informative
15.31(e)	Supply Voltage Statement	N/A		Yes
15.230	Antenna Requirement Statement	N/A		Yes

Note 1: Radiated emission measurement.

Note 2: Tested in 3 orthogonal axes.

2.0 Introduction

On March 11-12, 2021 the MX Fuel Vibrator Remote Control, model 3701, as provided by Milwaukee Electric Tool Corp. was tested to the requirements of CFR 47 Part 15 Subpart C Section 15.231. To meet these requirements, the procedures contained within this report were performed by personnel of D.L.S. Electronic Systems, Inc.



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3.0 Test Facilities

D.L.S. Electronic Systems, Inc. is a full-service EMC/Safety Testing Laboratory accredited to ISO 17025. ANAB Certificate and Scope can be viewed at <http://www.dlsemc.com/certificate>. Our facilities are registered with the FCC, ISED Canada, and VCCI.

Wisconsin Test Facility:

D.L.S. Electronic Systems, Inc.
166 S. Carter Street
Genoa City, Wisconsin 53128

Wheeling Test Facility:

D.L.S. Electronic Systems, Inc.
1250 Peterson Drive
Wheeling, IL 60090

FCC Registration #90531

4.0 Description of Test Sample

Description:

Remote Control for Concrete Vibrator - Controls On / Off function

Type of Equipment / Frequency Range:

DSC – periodic transmitter operating at 433.92 MHz

Hand-held / Benchtop

Physical Dimensions of Equipment Under Test:

Length: 5 inches x Width: 2 inches x Height: 1 inches

Power Source:

3.0 VDC; Two AAA Batteries



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4.0 Description of Test Sample (continued)

Internal Frequencies:

433.92 MHz

Transmit Frequencies Used For Test Purpose:

433.94 MHz

Type of Modulation(s) / Antenna Type:

FSK / Spring antenna (-1 dBi gain)

5.0 Test Equipment

A list of the equipment used can be found in the table below. All primary equipment was calibrated against known reference standards with a verified traceable path to NIST.

D.L.S. Wisconsin – Radiated Emissions 30-1000 MHz – Site 2 – Test Equipment:

Description	Manufacturer	Model Number	Serial Number	Frequency Range	Cal Dates	Cal Due Dates
Receiver	Rohde & Schwarz	ESI 40	837808/006	20 Hz-40 GHz	4-14-20	4-14-21
Antenna	EMCO	3146	9702-4895	200 MHz-1GHz	4-15-20	4-15-22
Preamplifier	Rohde & Schwarz	TS-PR10	032001/004	9kHz-1 GHz	10-28-20	10-28-22
Cable	Beldin	9914	CBL-005	9 kHz-1 GHz	2-5-21	2-5-22
Cable	Beldin	9273	CBL-028	9 kHz-1 GHz	2-5-21	2-5-22
Cable	Coleman Cable	RG-223/U	CBL-051	9 kHz-1 GHz	2-5-21	2-5-22
Test Software	Rohde & Schwarz	ESK1	V1.7.1	N/A	N/A	N/A

D.L.S. Wisconsin – Radiated Emissions 1-5 GHz – Site G1 – Test Equipment:

Description	Manufacturer	Model Number	Serial Number	Frequency Range	Cal Dates	Cal Due Dates
Receiver	Rohde & Schwarz	ESI 40	837808/005	20 Hz-40 GHz	1-29-2021	1-29-2022
Horn Antenna	EMCO	3115	9903-5731	1 GHz-18 GHz	1-16-20	1-16-22
Cable	Micro-Coax	UFB311A	CBL-100	30 MHz-18 GHz	5-5-20	5-5-21
High Pass Filter	Mini-Circuits	NHP-600	1 0521	600 MHz-7 GHz	6-3-20	6-3-21
Preamplifier	Miteq	AMF-7D-01001800-22-10P	1777990	1 GHz-18 GHz	1-16-20	1-16-22
Test Software	Rohde & Schwarz	ESK1	V1.7.1	N/A	N/A	N/A

6.0 Test Arrangements

Radiated Emissions Measurement Arrangement:

All radiated emission measurements were performed at D.L.S. Electronic Systems, Inc. and set up according to ANSI C63.10-2013, unless otherwise noted. Description of procedures and measurements can be found in Section A – Measurement Data. See separate exhibit “Setup Photos” for additional photos of the test set up. See Section B for measurement uncertainty.

Unless otherwise noted, the bandwidth of the measuring receiver / analyzer used during testing is shown below.

Frequency Range	Bandwidth (-6 dB)
10 to 150 kHz	200 Hz
150 kHz to 30 MHz	9 kHz
30 MHz to 1 GHz	120 kHz
Above 1 GHz	1 MHz

7.0 Test Conditions

Temperature and Humidity:

65 °F at 33% RH

Battery Voltage:

3.13 Volts (2 new AAA batteries)

8.0 Modifications Made to EUT For Compliance

None noted at time of test.



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9.0 Additional Descriptions

The EUT was rotated through three orthogonal axes to find the worst-case emissions. The EUT was tested with new batteries. Each function (mode) of the transmitter was tested for worst-case duty cycle and emission levels. Emissions levels were found to be identical for each mode.

10.0 FCC 15.31(e) Supply Voltage Requirement statement

FCC 15.31(e) - For intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage.

Compliance Statement: This device complies with the requirements of Part 15.31(e):

- ☒ This device is battery operated. All tests were performed using a new (or fully charged) battery.
- ☐ This device provides a constant regulated voltage to the RF circuitry regardless of supply voltage (see schematic diagrams).
- ☐ This device does not provide a constant regulated voltage to the RF circuitry regardless of supply voltage. Data has been supplied in this test report that supports compliance. Details:



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11.0 FCC 15.203 Antenna Requirement statement

SECTION 15.203 ANTENNA REQUIREMENT

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device.... This requirement does not apply to carrier current devices or to devices operated under the provisions of Sections 15.211, 15.213, 15.217, 15.219, or 15.221.

Statement: This wireless device (Intentional Radiator) meets the requirements of FCC Part 15.203:

- ☒ The antenna is permanently attached.
- ☐ The antenna has a unique coupling to the intentional radiator.
Description of coupling:
- ☐ This intentional radiator is professionally installed.
- ☐ This intentional radiator, in accordance with Section 15.31(d), must be measured at the installation site.

12.0 Results

Measurements were performed in accordance with ANSI C63.10-2013. Graphical and tabular data can be found in Section A at the end of this report.

13.0 Conclusion

The MX Fuel Vibrator Remote Control, model 3701, as provided from Milwaukee Electric Tool Corp., tested on March 11-12, 2021 **meets** the requirements of CFR 47 Part 15 Subpart C Section 15.231.



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Company:	Milwaukee Electric Tool Corp.
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Section A – Measurement Data

1.0 Emission Bandwidth – 20 dB

Rule Part:

Section 15.231(c)

Test Procedure:

ANSI C63.10-2013, Section 6.9.2
Occupied bandwidth – relative measurement procedure

Limit:

Section 15.231(c):
 0.25% of center frequency (433.94 MHz) = 1.084 MHz

Results:

Compliant
20 dB bandwidth: **122.65 kHz**

Sample Equation(s):

None

Notes:

This was a radiated emissions measurement. The maximum field strength of the emission was determined, and the bandwidth was measured from the points 20 dB down from the modulated carrier.



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Company:
Model Tested:
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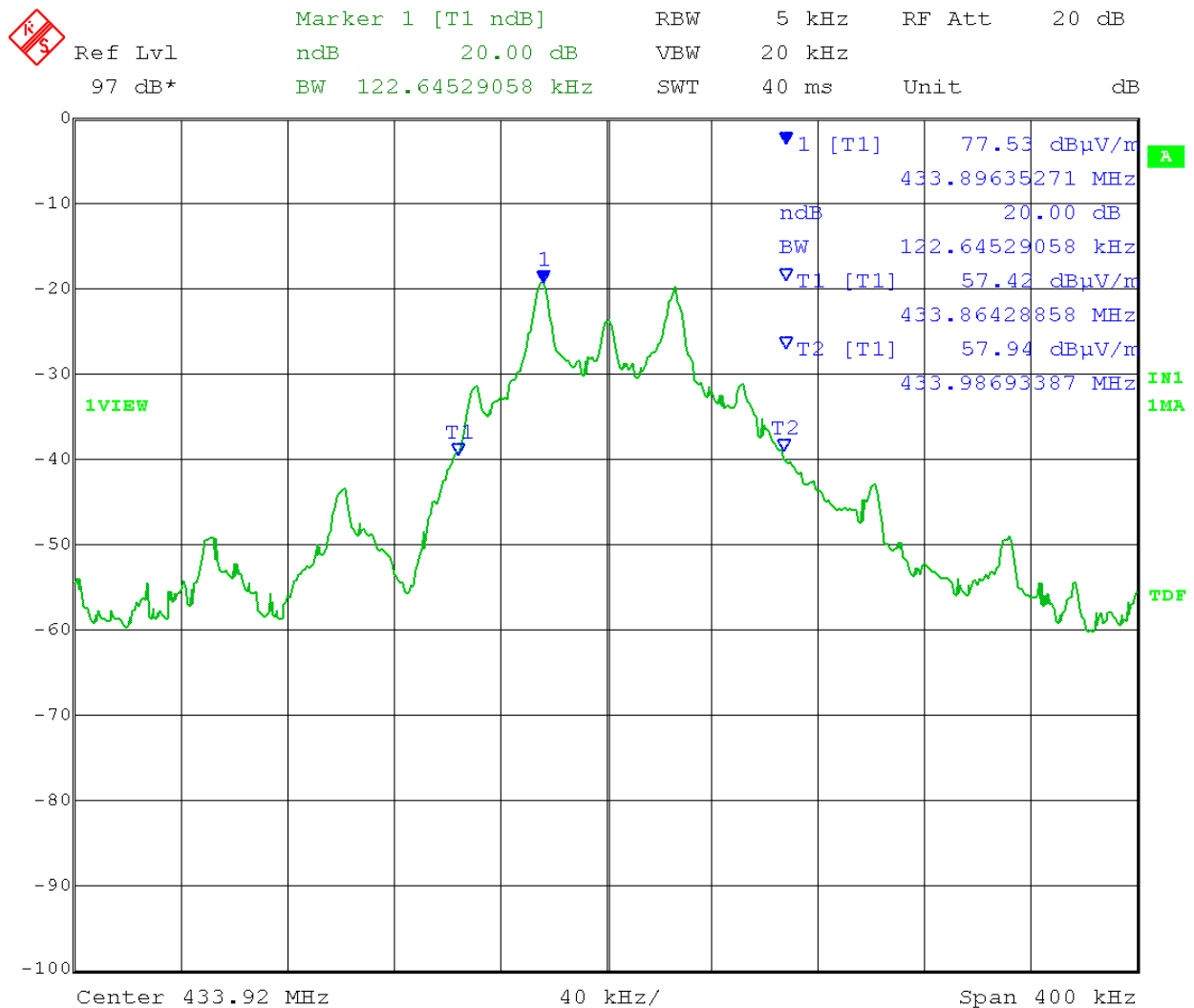
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Section A

Test Date: 03-11-2021
Company: Milwaukee Tool
EUT: MX Fuel Concrete Vibrator Remote
Test: 20 dB Bandwidth
Operator: J. Schneider

Comment: SPAN 2 to 5 times occupied bandwidth
RBW between 1% and 5% of occupied bandwidth
Limit: 0.25% of center frequency (433.94 MHz) = 1.08 MHz

20 dB Bandwidth = 122.65 kHz



Date: 11.MAR.2021 11:14:24



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Company:	Milwaukee Electric Tool Corp.
Model Tested:	3701
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Section A

2.0 Transmission Deactivation

Rule Part:

Section 15.231(a)(1)

Test Procedure:

ANSI C63.10-2013, Section 7.4

Procedure for determining compliance of unlicensed wireless devices having periodic operation

Limit:

A manually operated transmitter shall employ a switch that will automatically deactivate the transmitter within not more than 5 seconds of being released.

Results:

Compliant

Deactivation time: **90.18 ms**

Sample Equation(s):

None

Notes:

Transmission deactivates within five seconds of switch being released.
Each switch (mode) was tested. Worst-case is reported.



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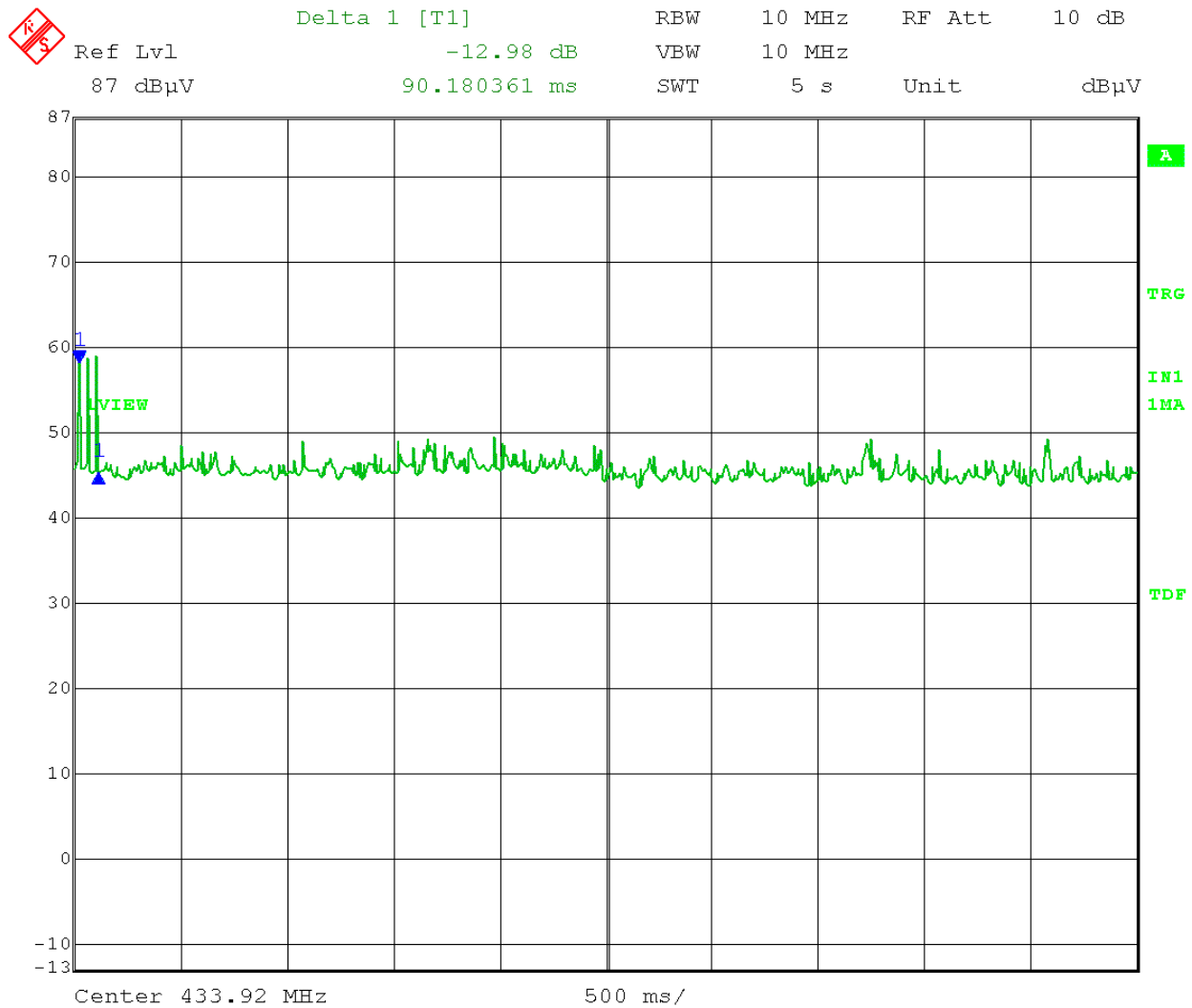
Company: Milwaukee Electric Tool Corp.
Model Tested: 3701
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Section A

Test Date: 03-11-2021
Company: Milwaukee Tool
EUT: MX Fuel Concrete Vibrator Remote
Test: Dwell Time
Operator: J. Schneider

Comment: A manually operated transmitter shall cease transmission within 5 seconds after being released.

Dwell Time = 90.18 ms



Date: 11.MAR.2021 10:04:17



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Company:	Milwaukee Electric Tool Corp.
Model Tested:	3701
Report Number:	25988 rev2.0
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Section A

3.0 Field Strength of Emissions – Fundamental and Spurious

Rule Part:

Section 15.231(b) including section 15.205 (restricted bands)

Test Procedure:

ANSI C63.10-2013, Section 7.6

Determination of spurious and fundamental emissions

Limit:

Limit table if section 15.231(b) {linear interpolation}

Limit is based on the average value of the measured emission.

Fundamental limit (F) $\mu\text{V/m}$ at 3 meters: $41.6667(F) - 7083.3333$

The maximum permitted unwanted emission level is 20 dB below the maximum permitted fundamental level.

There is also a limit on peak radio frequency emissions that is 20 dB above the maximum permitted average emission limit.

Results:

Compliant

Sample Equation(s): $Y = MX + C$; $(C = Y - MX)$; $M = Y2 - Y1 / X2 - X1$

Amplitude ($\mu\text{V/m}$): $Y1 = 3750$
 $Y2 = 12500$

Frequency (MHz): $X1 = 260$
 $X2 = 470$

Solve for 433.94 MHz: $M = (12500 - 3750) / (470 - 260) = 41.66667$

$C = 3750 - (41.66667 \times 260) = -7083.33$

$Y = (41.66667 \times 433.94) + (-7083.33) = 10996.51 \mu\text{V/m}$

$20 \times \log(10996.67) = 80.82 \text{ dB}\mu\text{V/m}$ at 3 meters (Average emission limit)

Limit on Peak emission = $80.82 \text{ dB}\mu\text{V/m} + 20 \text{ dB} = 100.82 \text{ dB}\mu\text{V/m}$

Notes:

The emissions were measured of the fundamental and spurious at a distance of 3 meters between the EUT and the measuring antenna. The EUT was rotated in 3 orthogonal axes and the highest emissions were recorded. Compliance is determined by comparing peak data, minus duty cycle correction factor, to the average limit.



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Company: Milwaukee Electric Tool Corp.
Model Tested: 3701
Report Number: 25988 rev2.0
Project Number: 11382

Section A

Radiated Fundamental and Spurious Emissions – 30 MHz to 1000 MHz Tested at a 3 Meter Distance

EUT: MX Fuel Concrete Vibrator Remote
Manufacturer: Milwaukee Tool
Operating Condition: 65 deg F; 33% R.H.
Test Site: Site 2
Operator: J. Schneider
Test Specification: FCC Part 15.231(b)
Comment: Battery Operated
Date: 03-11-2021

Notes: All other emissions at least 20 dB under the limit.
All measurements were made with a peak detector.

Frequency (MHz)	Measurement Type	Antenna Polarization	Level (dBuV)	Antenna Factor (dB/m)	System Loss (dB)	Total Level (dBuV/m)	Duty Cycle Correction	Final Corrected (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	EUT Angle (deg)	Comment
433.940	Max Peak	Vertical	57.65	15.95	5.5	79.10	0	79.10	100.82	21.7	1.0	300	F
	Average						17.49	61.61	80.82	19.2			
	Max Peak	Horizontal	57.75	15.95	5.5	79.20	0	79.20	100.82	21.6	1.7	250	F
	Average						17.49	61.71	80.82	19.1			
867.880	Max Peak	Vertical	43.47	22.58	-20.7	45.40	0	45.40	80.82	35.4	1.2	204	H
	Average						17.49	27.91	60.82	32.9			
	Max Peak	Horizontal	42.44	22.58	-20.7	44.40	0	44.40	80.82	36.4	1.2	186	H
	Average						17.49	26.91	60.82	33.9			

Legend: H=Harmonic ; RB=Restricted Band ; F=Fundamental

Total Level = Level + Antenna Factor + System Loss

Final Corrected = Total Level - Duty Cycle Correction

Margin = Limit - Final Corrected



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Company: Milwaukee Electric Tool Corp.
 Model Tested: 3701
 Report Number: 25988 rev2.0
 Project Number: 11382

Section A

Radiated Fundamental and Spurious Emissions – 1 GHz to 5 GHz Tested at a 3 Meter Distance

EUT: MX Fuel Concrete Vibrator Remote
 Manufacturer: Milwaukee Tool
 Operating Condition: 60 deg F; 33% R.H.
 Test Site: Site G1
 Operator: J. Schneider
 Test Specification: FCC Part 15.231(b)
 Comment: Battery Operated
 Date: 03-12-2021

Notes: All other emissions at least 20 dB under the limit.
 All measurements were made with a peak detector.

Frequency (MHz)	Measurement Type	Antenna Polarization	Level (dBuV)	Antenna Factor (dB/m)	System Loss (dB)	Total Level (dBuV/m)	Duty Cycle Correction	Final Corrected (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	EUT Angle (deg)	Comment
1301.820	Max Peak	Vertical	100.23	25.57	-55.4	70.40	0	70.40	74.00	3.6	1.3	161	H / RB
	Average						17.49	52.91	54.00	1.1			
	Max Peak	Horizontal	99.53	25.57	-55.4	69.70	0	69.70	74.00	4.3	1.8	166	H / RB
	Average						17.49	52.21	54.00	1.8			
1735.760	Max Peak	Vertical	97.66	26.44	-54.4	69.70	0	69.70	80.82	11.1	1.7	165	H
	Average						17.49	52.21	60.82	8.6			
	Max Peak	Horizontal	96.96	26.44	-54.4	69.00	0	69.00	80.82	11.8	1.4	199	H
	Average						17.49	51.51	60.82	9.3			
2169.700	Max Peak	Vertical	77.06	27.64	-54.3	50.40	0	50.40	80.82	30.4	2.0	232	H
	Average						17.49	32.91	60.82	27.9			
	Max Peak	Horizontal	81.26	27.64	-54.3	54.60	0	54.60	80.82	26.2	1.3	32	H
	Average						17.49	37.11	60.82	23.7			
2603.640	Max Peak	Vertical	77.86	28.84	-54.5	52.20	0	52.20	80.82	28.6	1.0	270	H
	Average						17.49	34.71	60.82	26.1			
	Max Peak	Horizontal	81.66	28.84	-54.5	56.00	0	56.00	80.82	24.8	1.0	335	H
	Average						17.49	38.51	60.82	22.3			
3037.580	Max Peak	Vertical	67.14	30.36	-54.9	42.60	0	42.60	80.82	38.2	1.3	35	H
	Average						17.49	25.11	60.82	35.7			
	Max Peak	Horizontal	67.84	30.36	-54.9	43.30	0	43.30	80.82	37.5	1.0	365	H
	Average						17.49	25.81	60.82	35.0			
3471.600	Max Peak	Vertical	86.88	31.12	-55.2	62.80	0	62.80	80.82	18.0	1.2	80	H
	Average						17.49	45.31	60.82	15.5			
	Max Peak	Horizontal	86.78	31.12	-55.2	62.70	0	62.70	80.82	18.1	1.4	171	H
	Average						17.49	45.21	60.82	15.6			
3905.460	Max Peak	Vertical	76.34	32.56	-55.5	53.40	0	53.40	74.00	20.6	1.2	306	H / RB
	Average						17.49	35.91	54.00	18.1			
	Max Peak	Horizontal	72.79	32.56	-55.6	49.80	0	49.80	74.00	24.2	1.5	0	H / RB
	Average						17.49	32.31	54.00	21.7			
4339.400	Max Peak	Vertical	81.08	32.02	-55.6	57.50	0	57.50	74.00	16.5	1.0	319	H / RB
	Average						17.49	40.01	54.00	14.0			
	Max Peak	Horizontal	80.18	32.02	-55.6	56.60	0	56.60	74.00	17.4	1.6	328	H / RB
	Average						17.49	39.11	54.00	14.9			

Legend: H=Harmonic ; RB=Restricted Band ; F=Fundamental
 Total Level = Level + Antenna Factor + System Loss
 Final Corrected = Total Level - Duty Cycle Correction
 Margin = Limit - Final Corrected



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Section A

4.0 Duty Cycle Correction

Rule Part:

Section 15.35(c)

Test Procedure:

ANSI C63.10-2013, Section 7.5

Procedure for determining the average value of pulsed emissions

Limit:

Informative

Results:

Duty Cycle Correction Factor = **-17.49 dB**

Sample Equation(s):

One complete pulse train (T): $T = 76.55$ ms

ON time of one pulse: 3.406814 ms

Total ON time in 76.55 ms = 3.406814 ms x 3 pulses = 10.220442 ms

Duty Cycle Correction Factor = $20 \log (10.220442/76.55) = -17.49$ dB

Notes:

Compliance is determined by comparing peak detector data, minus duty cycle correction, to the average limit. Transmission Duty Cycle is source-based and not changeable.



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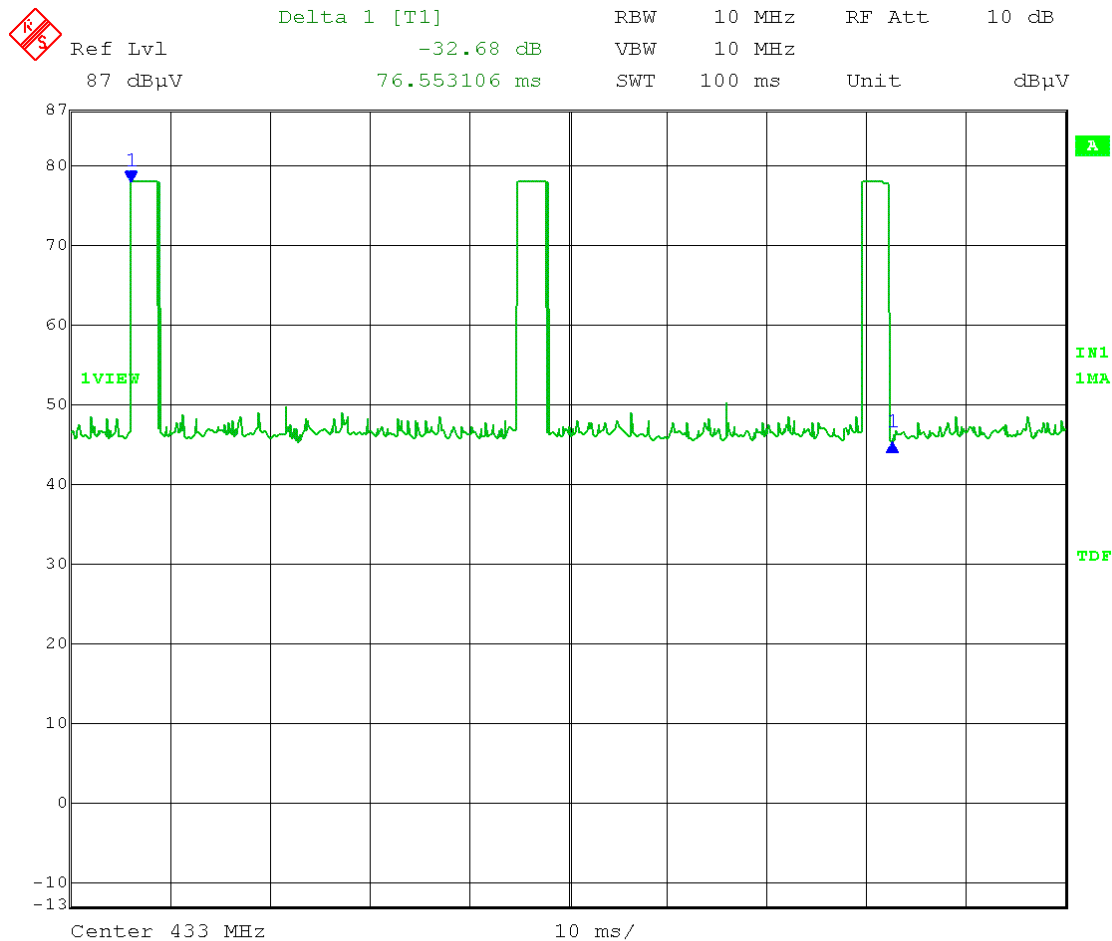
Section A

Company: Milwaukee Electric Tool Corp.
Model Tested: 3701
Report Number: 25988 rev2.0
Project Number: 11382

Test Date: 03-11-2021
Company: Milwaukee Tool
EUT: MX Fuel Concrete Vibrator Remote
Test: Duty Cycle – worst-case normal operation
Operator: J. Schneider

Comment: One complete pulse train (T): $T = 76.55$ ms
ON time of one pulse: 3.406814 ms
Total ON time in 76.55 ms = 3.406814 ms x 3 pulses = 10.220442 ms
Duty Cycle Correction Factor = $20 \log (10.220442/76.55) = -17.49$ dB

100 ms sweep: (pulse train resulting from one press of the button; not multiple presses)



Date: 11.MAR.2021 09:19:36



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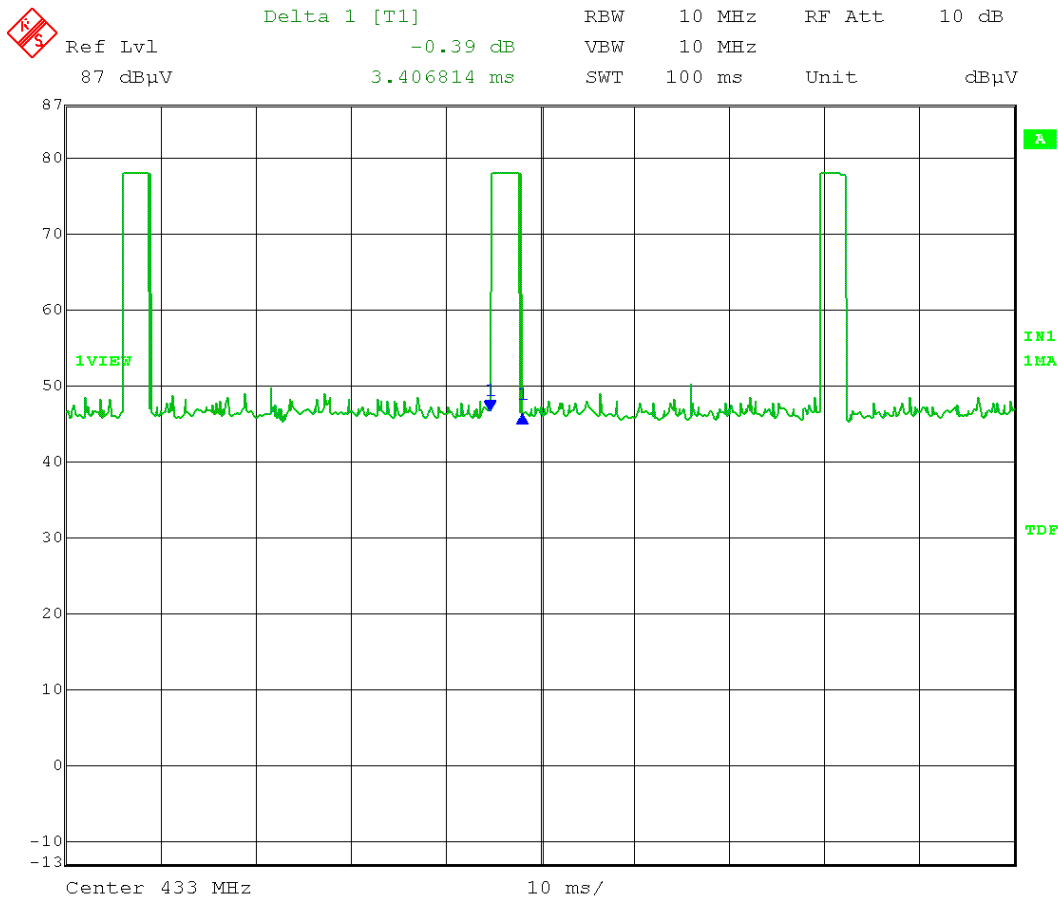
Section A

Company: Milwaukee Electric Tool Corp.
Model Tested: 3701
Report Number: 25988 rev2.0
Project Number: 11382

Test Date: 03-11-2021
Company: Milwaukee Tool
EUT: MX Fuel Concrete Vibrator Remote
Test: Duty Cycle – worst-case normal operation
Operator: J. Schneider

Comment: One complete pulse train (T): $T = 76.55$ ms
ON time of one pulse: 3.406814 ms
Total ON time in 76.55 ms = 3.406814 ms x 3 pulses = 10.220442 ms
Duty Cycle Correction Factor = $20 \text{ Log } (10.220442/76.55) = -17.49 \text{ dB}$

ON time of one pulse:



Date: 11.MAR.2021 09:21:33



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Section B – Measurement Uncertainty

Compliance with the limits in this standard are based on the results of the compliance measurement. Our calculated measurement uncertainty including the measurement instrumentation, associated connections between the various instruments in the measurement chain, and other contributions, are provided in this section of the test report.

Radiated Emission 30 MHz to 18 GHz Uncertainty

		Uncertainty (+/- dB)	Uncertainty (+/- dB)	Uncertainty (+/- dB)	Uncertainty (+/- dB)	Uncertainty (+/- dB)	Uncertainty (+/- dB)	Uncertainty (+/- dB)	Uncertainty (+/- dB)	Uncertainty (+/- dB)
Contribution	Probability Distribution	3M	3M	3M	3M	3M	3M	10M	10M	10M
		30- 100MHz.	100- 700MHz	700- 1000MHz.	1- 4.5Ghz	4.5 - 7Ghz	7 - 18Ghz	30- 100MHz.	100- 700MHz.	700- 1000MHz.
Combined Standard Un certainty	Normal	1.70	1.62	1.66	2.13	2.48	2.85	1.64	1.58	1.66
Expanded Uncertainty	Normal (k=2)	3.40	3.23	3.33	4.26	4.95	5.69	3.29	3.16	3.31



166 South Carter, Genoa City, WI 53128

Company: Milwaukee Electric Tool Corp.
Model Tested: 3701
Report Number: 25988 rev2.0
Project Number: 11382

END OF REPORT

Revision #	Date	Comments	By
1.0	03-16-2021	Initial Release	JS
2.0	05-11-2021	Corrected "Report By" info; Removed Setup Photos (Setup Photos can be found in separate exhibit)	CB