

Amber Helm Development L.C.

92723 Michigan Hwy-152

Sister Lakes, Michigan 49047 USA

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EMC Test Report

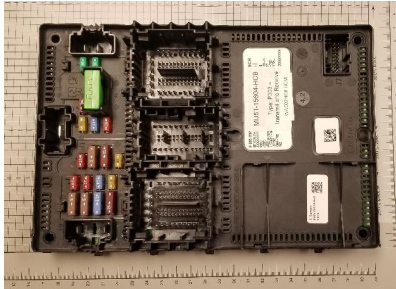
BOSCH1-WR2003TX

Issued: February 8, 2020

regarding

USA: CFR Title 47, Part 15.209 (Emissions)
Canada: ISED RSS-210v10/GENv5 (Emissions)

for



P004 Series

Category: LF Initiator

Judgments:

15.209/RSS-210v10 Compliant Transmitter

Testing Completed: December 22, 2019



Prepared for:

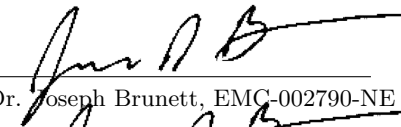
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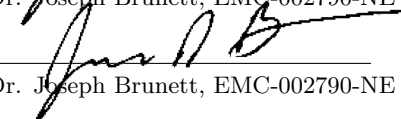
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Date of Issue: February 8, 2020

Revision History

| Rev. No. | Date | Details | Revised By |
|----------|-------------------|------------------------------------|------------|
| r0 | February 8, 2020 | Initial Release. | J. Brunett |
| r1 | February 22, 2020 | Clarify ISED units in data tables. | J. Brunett |

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1 Test Report Scope and Limitations

1.1 Laboratory Authorization

Test Facility description and attenuation characteristics are on file with the FCC Laboratory, Columbia, Maryland (FCC Reg. No: US5348 and US5356) and with ISED Canada, Ottawa, ON (File Ref. No: 3161A and 24249). Amber Helm Development L.C. holds accreditation under NVLAP Lab Code 200129-0.

1.2 Report Retention

For equipment verified to comply with the regulations herein, the manufacturer is obliged to retain this report with the product records for the life of the product, and no less than ten years. A copy of this Report will remain on file with this laboratory until March 2030.

1.3 Subcontracted Testing

This report does not contain data produced under subcontract.

1.4 Test Data

This test report contains data included within the laboratories scope of accreditation.

1.5 Limitation of Results

The test results contained in this report relate only to the item(s) tested. Any electrical or mechanical modification made to the test item subsequent to the test date shall invalidate the data presented in this report. Any electrical or mechanical modification made to the test item subsequent to this test date shall require reevaluation.

1.6 Copyright

This report shall not be reproduced, except in full, without the written approval of Amber Helm Development L.C.

1.7 Endorsements

This report shall not be used to claim product endorsement by any accrediting, regulatory, or governmental agency.

1.8 Test Location

The EUT was fully tested by **Amber Helm Development L.C.**, headquartered at 92723 Michigan Hwy-152, Sister Lakes, Michigan 49047 USA. Table 1 lists all sites employed herein. Specific test sites utilized are also listed in the test results sections of this report where needed.

Table 1: Test Site List.

| Description | Location | Quality Num. |
|----------------|---|--------------|
| OATS (3 meter) | 3615 E Grand River Rd., Williamston, Michigan 48895 | OATSC |

1.9 Traceability and Equipment Used

Pertinent test equipment used for measurements at this facility is listed in Table 2. The quality system employed at Amber Helm Development L.C. has been established to ensure all equipment has a clearly identifiable classification, calibration expiry date, and that all calibrations are traceable to the SI through NIST, other recognized national laboratories, accepted fundamental or natural physical constants, ratio type of calibration, or by comparison to consensus standards.

Table 2: Equipment List.

| Description | Manufacturer/Model | SN | Quality Num. | Cal/Ver By / Date Due |
|-----------------------|-----------------------|-----------|--------------|-----------------------|
| Spectrum Analyzer | R & S / FPC1500 | 101692 | RSFPC15001 | RS / May-2020 |
| Spectrum Analyzer | R & S / FSV30 | 101660 | RSFSV30001 | RS / Apr-2021 |
| Biconical | EMCO / 93110B | 9802-3039 | BICEMCO01 | Keysight / Aug-2020 |
| Log Periodic Antenna | EMCO / 3146 | 9305-3614 | LOGEMCO01 | Keysight / Aug-2020 |
| BNC-BNC Coax | WRTL / RG58/U | 001 | CAB001-BLACK | AHD / Jul-2020 |
| 3.5-3.5MM Coax | PhaseFlex / PhaseFlex | 001 | CAB015-PURP | AHD / Jul-2020 |
| Shielded Loop Antenna | EMCO / 6502 | 9502-2926 | EMCOLOOP1 | Lib. Labs. / Aug-2020 |

2 Test Specifications and Procedures

2.1 Test Specification and General Procedures

The goal of Robert Bosch (Australia) Pty Ltd is to demonstrate that the Equipment Under Test (EUT) complies with the Rules and/or Directives below. Detailed in this report are the results of testing the Robert Bosch (Australia) Pty Ltd P004 Series for compliance to:

| Country/Region | Rules or Directive | Referenced Section(s) |
|----------------|-----------------------------|---------------------------|
| United States | Code of Federal Regulations | CFR Title 47, Part 15.209 |
| Canada | ISED Canada | ISED RSS-210v10/GENv5 |

It has been determined that the equipment under test is subject to the rules and directives above at the date of this testing. In conjunction with these rules and directives, the following specifications and procedures are followed herein to demonstrate compliance (in whole or in part) with these regulations.

| | |
|---|--|
| ANSI C63.4:2014 | "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz" |
| ANSI C63.10:2013 | "American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices" |
| IEEE Trans. EMC, Vol. 47, No. 3 August 2005 | "Extrapolating Near-Field Emissions of Low-Frequency Loop Transmitters," J.D.Brunett, V.V.Liepa, D.L.Sengupta |
| TP0102RA | "AHD Internal Document TP0102 - Radiated Emissions Test Procedure" |
| TP0106RC | "AHD Internal Document TP0106 - Emissions Measurement Procedures (above 40 GHz)" |
| ISED Canada | "The Measurement of Occupied Bandwidth" |

3 Configuration and Identification of the Equipment Under Test

3.1 Description and Declarations

The equipment under test is a Body Control Module containing an LF transmitter for automotive use. The EUT is approximately 17 x 25 x 3 cm in dimension, and is depicted in Figure 1. It is powered by 12 VDC automotive power system. In use, this device is permanently installed in a motor vehicle. Table 3 outlines provider declared EUT specifications.

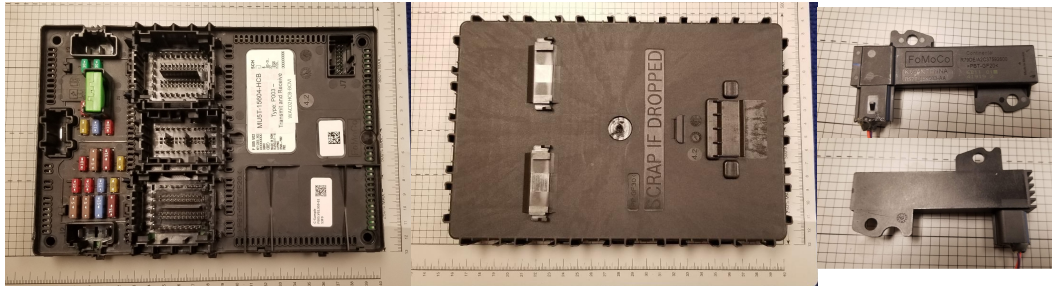


Figure 1: Photos of EUT.

Table 3: EUT Declarations.

| | |
|-----------------------------|---|
| General Declarations | |
| Equipment Type: | LF Initiator |
| Country of Origin: | Not Declared |
| Nominal Supply: | 12 VDC |
| Oper. Temp Range: | Not Declared |
| Frequency Range: | 125 kHz |
| Antenna Dimension: | Not Declared |
| Antenna Type: | loop |
| Antenna Gain: | Not Declared |
| Number of Channels: | 1 |
| Channel Spacing: | Not Applicable |
| Alignment Range: | Not Declared |
| Type of Modulation: | ASK |
| United States | |
| FCC ID Number: | LXPP004 |
| Classification: | DSC |
| Canada | |
| IC Number: | 2298A-P004 |
| Classification: | Remote Control Device, Vehicular Device |

3.1.1 EUT Configuration

The EUT is configured for testing as depicted in Figure 2.

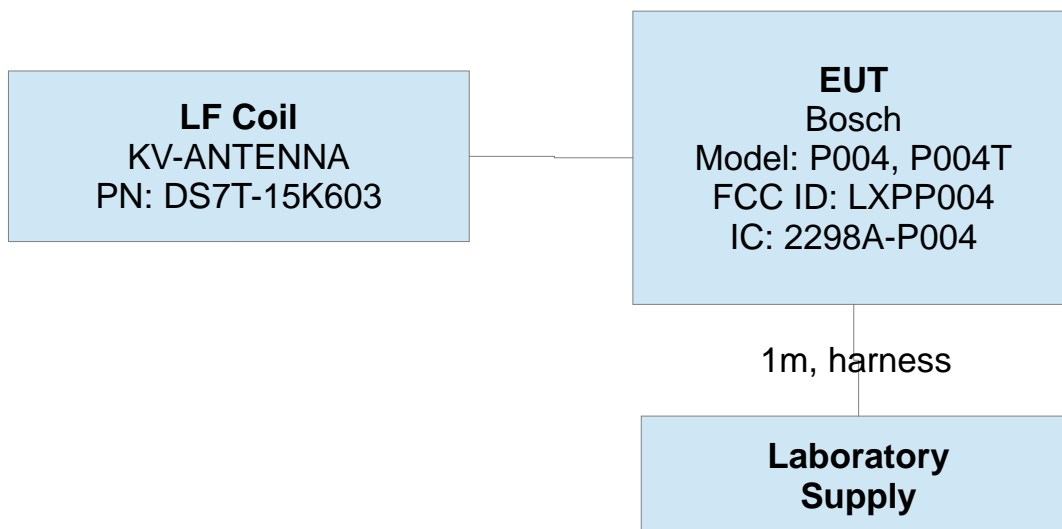


Figure 2: EUT Test Configuration Diagram.

3.1.2 Modes of Operation

This device is capable of only a single mode of operation, as an LF transmitter.

3.1.3 Variants

There is only a single variant of the EUT. HVIN P004 is fully populated and was tested herein. HVIN P004T will have its UHF receiver circuitry depopulated. Pre-scans of the depopulated version indicated that the populated version was representative of the worst-case emissions.

3.1.4 Test Samples

Three samples in total were provided, all setup for repeated LF transmission and with active UHF receiver.

3.1.5 Functional Exerciser

Normal operating EUT functionality was verified by observation of transmitted signal.

3.1.6 Modifications Made

There were no modifications made to the EUT by this laboratory.

3.1.7 Production Intent

The EUT appears to be a production ready sample.

3.1.8 Declared Exemptions and Additional Product Notes

The EUT is permanently installed in a transportation vehicle. As such, digital emissions are exempt from US and Canadian digital emissions regulations (per FCC 15.103(a) and IC correspondence on ICES-003).

4 Emissions

4.1 General Test Procedures

4.1.1 Radiated Test Setup and Procedures

Radiated electromagnetic emissions from the EUT are first pre-scanned in our screen room. Spectrum and modulation characteristics of all emissions are recorded. Instrumentation, including spectrum analyzers and other test equipment as detailed in Section 1.8 are employed. After pre-scan, emission measurements are made on the test site of record. If the EUT connects to auxiliary equipment and is table or floor standing, the configurations prescribed in relevant test standards are followed. Alternatively, a layout closest to normal use (as declared by the provider) is employed if the resulting emissions appear to be worst-case in such a configuration. See Figure 3. All intentionally radiating elements that are not fixed-mounted in use are placed on the test table lying flat, on their side, and on their end (3-axes) and the resulting worst case emissions are recorded. If the EUT is fixed-mounted in use, measurements are made with the device oriented in the manner consistent with installation and then emissions are recorded. If the EUT exhibits spurious emissions due to internal receiver circuitry, such emissions are measured with an appropriate carrier signal applied.

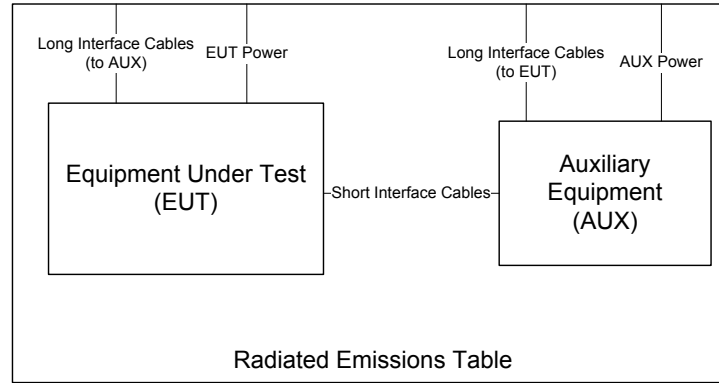


Figure 3: Radiated Emissions Diagram of the EUT.

For devices with intentional emissions below 30 MHz, a shielded loop antenna and/or E-field and H-Field broadband probes are used depending on the regulations. Shielded loops are placed at a 1 meter receive height at the desired measurement distance. For exposure in this band, the broadband probes employed are 10cm diameter single-axis shielded transducers and measurements are repeated and summed over three axes.

Emissions between 30 MHz and 1 GHz are measured using calibrated broadband antennas. For both horizontal and vertical polarizations, the test antenna is raised and lowered from 1 to 4 m in height until a maximum emission level is detected. The EUT is then rotated through 360° in azimuth until the highest emission is detected. The test antenna is then raised and lowered one last time from 1 to 4 m and the worst case value is recorded. Emissions above 1 GHz are characterized using standard gain or broadband ridge-horn antennas on our OATS with a 4×5 m rectangle of ECCOSORB absorber covering the OATS ground screen and a 1.5m table height. Care is taken to ensure that test receiver resolution and video bandwidths meet the regulatory requirements, and that the emission bandwidth of the EUT is not reduced. Photographs of the test setup employed are depicted in Figure 4.

Where regulations allow for direct measurement of field strength, power values (dBm) measured on the test receiver / analyzer are converted to $\text{dB}\mu\text{V}/\text{m}$ at the regulatory distance, using

$$E_{dist} = 107 + P_R + K_A - K_G + K_E - C_F$$

where P_R is the power recorded on spectrum analyzer, in dBm, K_A is the test antenna factor in dB/m, K_G is the combined pre-amplifier gain and cable loss in dB, K_E is duty correction factor (when applicable) in dB, and C_F is a distance conversion (employed only if limits are specified at alternate distance) in dB. This field strength value is then compared with the regulatory limit. If effective isotropic radiated power (EIRP) is computed, it is computed as

$$\text{EIRP}(\text{dBm}) = E_{3m}(\text{dB}\mu\text{V}/\text{m}) - 95.2.$$

When presenting data at each frequency, the highest measured emission under all possible EUT orientations (3-axes) is reported.



Figure 4: Radiated Emissions Test Setup Photograph(s).

4.1.2 Conducted Emissions Test Setup and Procedures

4.1.3 Power Supply Variation

Tests at extreme supply voltages are made if required by the procedures specified in the test standard, and results of this testing are detailed in this report.

4.2 Intentional Emissions

4.2.1 Fundamental Emission Pulsed Operation

The details and results of testing the EUT for pulsed operation are summarized in Table 4.

Table 4: Pulsed Emission Characteristics (Duty Cycle).

Frequency Range
9 kHz f 150 kHz

Det
Pk/QPk

IF Bandwidth
120 kHz

Video Bandwidth
1 MHz

Test Date: 24-Jan-20
Test Engineer: Joseph Brunett
EUT Mode: See Below
Meas. Distance: 30 CM
EUT Tested: Bosch P004

| # | EUT Mode | Overall Transmission | | | Max. Frame Length (ms) | Min. Frame Period (s) | Frame Encoding | Computed Duty Cycle* | |
|---|----------|----------------------------|--------------------|---------------------------------|------------------------|-----------------------|--|----------------------|-----------|
| | | Min. Repetition Rate (sec) | Max. No. of Frames | Total Transmission Length (sec) | | | | (%) | Duty (dB) |
| 1 | POLLING | 1.00 | 1 | 0.032 | 32.0 | 1 | When polling, the EUT transmits one 32 ms frames every 1 seconds | 32.000 | * |

* No Duty Cycle is employed when demonstrating compliance.

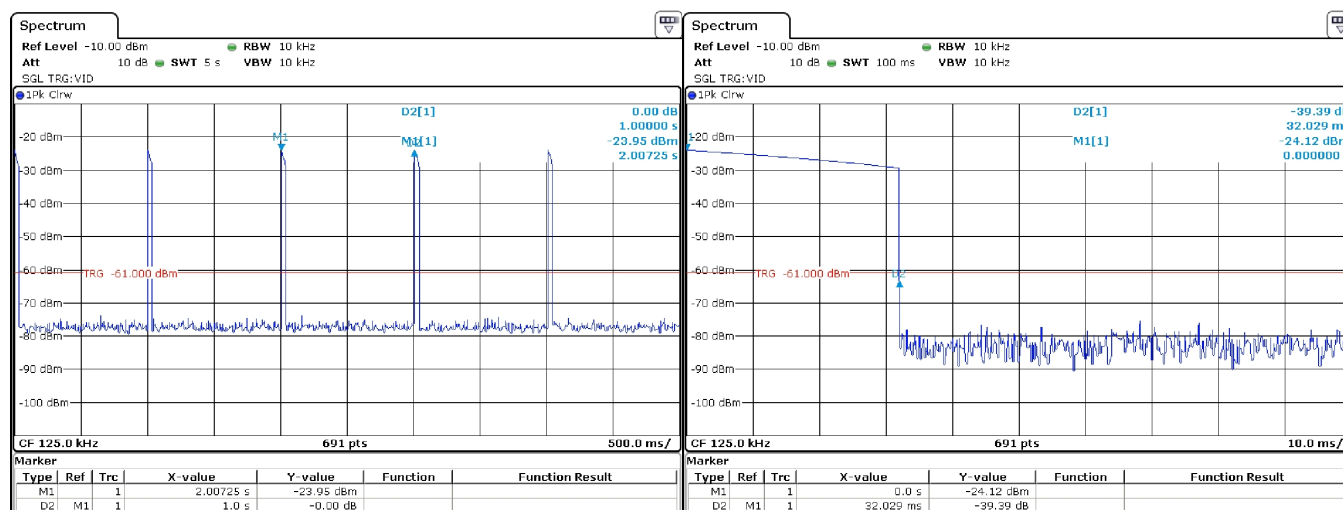


Figure 5: Pulsed Emission Characteristics (Duty Cycle).

4.2.2 Fundamental Emission Bandwidth

Emission bandwidth (EBW) of the EUT is measured with the device placed in the test mode(s) with the shortest available frame length and minimum frame spacing. Radiated emissions are recorded following the test procedures listed in Section 2.1. The 20 dB EBW is measured as the max-held peak-detected signal when the IF bandwidth is greater than or equal to 1% of the receiver span. For complex modulations other than ASK and FSK, the 99% emission bandwidth per IC test procedures has a different result, and is also separately reported. The results of EBW testing are summarized in Table 5. Plots showing measurements employed to obtain the emission bandwidth reported are provided in Figure 6.

Table 5: Intentional Emission Bandwidth.

| | | | | | |
|------------------------|------------|---------------------|------------------------|------------------------|----------------|
| Frequency Range | Det | IF Bandwidth | Video Bandwidth | Test Date: | 24-Jan-20 |
| 9 kHz f 150 kHz | Pk | > 1% Span | >= 3 * IFBW | Test Engineer: | Joseph Brunett |
| 150 kHz f 30 MHz | Pk | > 1% Span | >= 3 * IFBW | EUT Mode: | See Below |
| | | | | Meas. Distance: | 0.6 m |
| | | | | EUT Tested: | Bosch P004 |

| # | Mode | Frequency (MHz) | Temp (C) | Supply (VDC) | 20 dB EBW (kHz) | 99% EBW (kHz) | 110 kHz Restricted Band* (dBc) |
|---|---------|-----------------|----------|--------------|-----------------|---------------|--------------------------------|
| 1 | POLLING | 0.125 | 21 | 13.4 | 0.779 | 2.237 | >-48 |

* Note: The EUT emissions in the 90-110 kHz restricted band is down > 26 dB from the fundamental. The FCC requests that the sideband of the modulated spectrum be at least 26 dB down in the restricted band, and the emissions from the EUT that fall into that band is outside of the first null of the modulated spectrum, and thus are not considered part of the fundamental emission, per FCC guidelines.

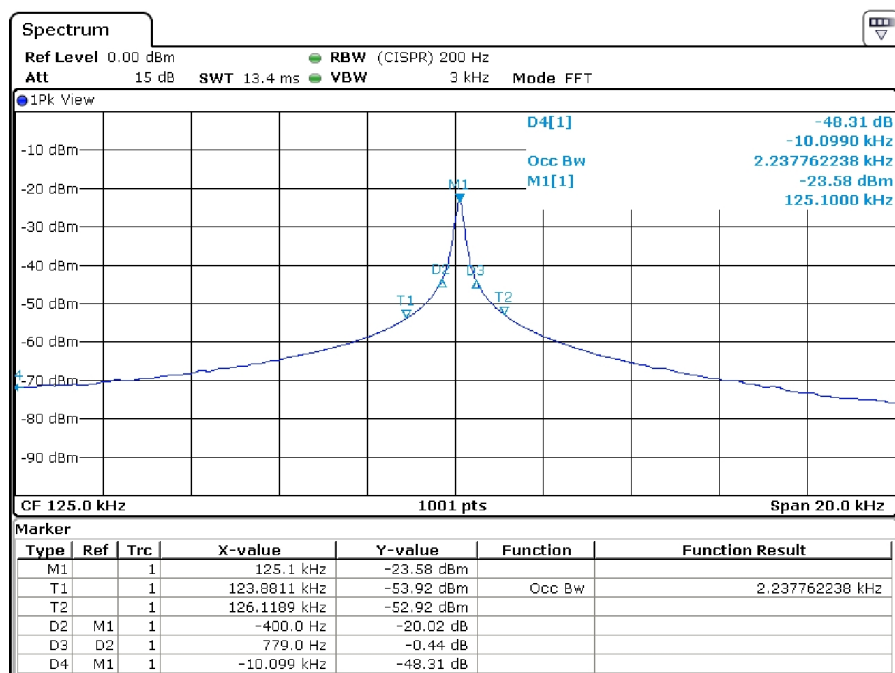


Figure 6: Intentional Emission Bandwidth.

4.2.3 Fundamental Emission

Following the test procedures listed in Section 2.1, field emissions measurements are made on the EUT for both Horizontal and Vertically polarized coupling fields. The EUT's loop antenna(s) are measured along all three axes, including when the EUT loop axes are aligned in the same axis as the test loop and aligned coplanar (in the same plane) with the test loop antenna. Table 6 details the results of these measurements.

Table 6: Fundamental Radiated Emissions.

| | | | | | | | | | |
|-----------------|-------------|--------|--------------|--|-----------------|--|-----------------|--|------------|
| Frequency Range | | Det | IF Bandwidth | | Video Bandwidth | | Test Date: | | 24-Jan-20 |
| 9 kHz | f 150 kHz | Pk/QPk | 200 Hz | | 300 Hz | | Test Engineer: | | J. Brunett |
| 150 kHz | f 30 MHz | Pk/QPk | 9 kHz | | 30 kHz | | EUT Mode: | | POLLING |
| 25 MHz | f 1 000 MHz | Pk/QPk | 120 kHz | | 300 kHz | | Meas. Distance: | | 3 meters |
| f > 1 000 MHz | | Pk | 1 MHz | | 3MHz | | EUT Tested: | | Bosch P004 |
| f > 1 000 MHz | | Avg | 1 MHz | | 3MHz | | | | |

| Fundamental Emissions Measurements | | | | | | | | | | | | | | | | | | | |
|------------------------------------|---------|-----------------|-----------|--------------|-----------------|----------------|---------|-------|--------------------|------------------------------|------------------------------|------------------------------------|-------|------------------|-------------------------------------|-------|------------------|-------------|------|
| # | Mode | EUT Orientation | Freq. kHz | Ant. Used QN | Ant.** Height m | Table Azim deg | Ka dB/m | Kg dB | C**** 3m / 300m dB | E-field @ 3m Pk Qpk dBuV/m | H-field @ 3m Pk Qpk dBuA/m | FCC E-field @ 300m Pk Qpk dBuV/m | | Limit Qpk dBuV/m | ISED H-field @ 300m Pk Qpk dBuA/m | | Limit Qpk dBuA/m | Pass By**** | |
| 1 | POLLING | Flat | 125.0 | EMCOLOOP1 | 1.0 | 0 | 10.1 | 0.0 | 80.0 | 72.0 | 20.7 | | -8.0 | | 25.7 | -59.5 | | -25.8 | 33.7 |
| 2 | | Side | 125.0 | EMCOLOOP1 | 1.0 | 0 | 10.1 | 0.0 | 80.0 | 68.2 | 16.9 | | -11.8 | | 25.7 | -63.3 | | -25.8 | 37.5 |
| 3 | | End | 125.0 | EMCOLOOP1 | 1.0 | 0 | 10.1 | 0.0 | 80.0 | 67.1 | 15.8 | | -12.9 | | 25.7 | -64.4 | | -25.8 | 38.6 |

| # | Mode | Test Antenna Polarization | Freq. kHz | DC Supply Voltage | E-field dBuV/m |
|---|---------|---------------------------|-----------|-------------------|----------------|
| 4 | POLLING | Flat | 125.0 | 15.2 | 72.0 |
| 5 | | | 125.0 | 13.4 | 72.0 |
| 6 | | | 125.0 | 11.5 | 72.0 |

* EUT was tested in CW mode. No averaging applies and Quasi-Peak data was not needed to demonstrate compliance.

** Emissions were evaluated at 1m test antenna height.

*** FCC E-field 40 dB/dec decay assumed. EUT field decay rate was not measured over a range of distances to determine CF between measurement and limit distance.

4.3 Unintentional Emissions

4.3.1 Transmit Chain Spurious Emissions

The results for the measurement of transmit chain spurious emissions at the nominal voltage and temperature are provided in Table 7. Following the test procedures listed in Section 2.1, field emissions measurements are made on the EUT for both Horizontal and Vertically polarized coupling fields. The EUT's loop antenna(s) are measured when the EUT loop axes placed in all three axes, including when they are aligned along the same axis as the test loop antenna and are aligned coplanar with the test loop antenna. For all arrangements, test loop is rotated for maximum field. The results for the measurement of transmit chain spurious emissions at the nominal voltage and temperature are provided in Table 7. Measurements are performed to 10 times the highest fundamental operating frequency.

Table 7: Transmit Chain Spurious Emissions.

| Frequency Range | Det | IF Bandwidth | Video Bandwidth | Test Date: | 24-Jan-20 |
|--------------------|--------|--------------|-----------------|-----------------|------------|
| 9 kHz f 150 kHz | Pk/QPk | 200 Hz | 300 Hz | Test Engineer: | J. Brunett |
| 150 kHz f 30 MHz | Pk/QPk | 9 kHz | 30 kHz | EUT Mode: | POLLING |
| 25 MHz f 1 000 MHz | Pk/QPk | 120 kHz | 300 kHz | Meas. Distance: | 3 meters |
| f > 1 000 MHz | Pk/Avg | 1 MHz | 3MHz | EUT Tested: | Bosch P004 |

| Transmit Chain Spurious Emissions | | | | | | | | | | | | | | | | | | | |
|-----------------------------------|---------|--------------------|--------------|--------------|-----------------------|----------------------|------------|----------|-------------------------------|------------------------------------|---|--|------|--|--|-------|---------|------------|--|
| # | Mode | EUT Orientation | Freq. kHz | Ant. Used | Ant.** Height m | Table Azim deg | Ka dB/m | Kg dB | CF*** (3 to 30/300m) dB | E-field @ 3m Pk Qpk dBuV/m | FCC E-field @ 30/300m Pk Qpk Limit (Qpk) dBuV/m | | | ISED H-field @ 30/300m Pk Qpk Limit (Qpk) dBuV/m | | | Pass By | Comments | |
| 1 | POLLING | Max All, Worst | 250.0 | EMCOLOOP1 | 1.0 | 0 | 10.0 | 0.0 | 80.0 | 19.5 | -60.5 | | 19.6 | -112.0 | | -31.9 | 80.1 | noise | |
| 2 | | Max All, Worst | 375.0 | EMCOLOOP1 | 1.0 | 90 | 10.0 | 0.0 | 80.0 | 22.9 | -57.1 | | 16.1 | -108.6 | | -35.4 | 73.2 | noise | |
| 3 | | Max All, Worst | 500.0 | EMCOLOOP1 | 1.0 | 0 | 10.2 | 0.0 | 40.0 | 21.5 | -18.5 | | 33.6 | -70.0 | | -17.9 | 52.1 | noise | |
| 4 | | Max All, Worst | 625.0 | EMCOLOOP1 | 1.0 | 0 | 10.2 | 0.0 | 40.0 | 30.2 | -9.8 | | 31.7 | -61.3 | | -19.8 | 41.5 | background | |
| 5 | | Max All, Worst | 750.0 | EMCOLOOP1 | 1.0 | 0 | 10.1 | 0.0 | 40.0 | 19.8 | -20.2 | | 30.1 | -71.7 | | -21.4 | 50.3 | noise | |
| 6 | | Max All, Worst | 875.0 | EMCOLOOP1 | 1.0 | 0 | 10.3 | 0.0 | 40.0 | 52.9 | 12.9 | | 28.8 | -38.6 | | -22.7 | 15.9 | background | |
| 7 | | Max All, Worst | 1000.0 | EMCOLOOP1 | 1.0 | 90 | 11.5 | 0.0 | 40.0 | 36.7 | -3.3 | | 27.6 | -54.8 | | -23.9 | 30.9 | background | |
| 8 | | Max All, Worst | 1125.0 | EMCOLOOP1 | 1.0 | 0 | 11.3 | 0.0 | 40.0 | 25.1 | -14.9 | | 26.6 | -66.4 | | -24.9 | 41.5 | noise | |
| 9 | | Max All, Worst | 1250.0 | EMCOLOOP1 | 1.0 | 0 | 12.3 | 0.0 | 40.0 | 34.0 | -6.0 | | 25.7 | -57.5 | | -25.8 | 31.7 | background | |
| 10 | | | | | | | | | | | | | | | | | | | |

* EUT was tested in CW mode. No averaging applies and Quasi-Peak data was not needed to demonstrate compliance.

** Emissions were evaluated at 1m test antenna height from 9 kHz to 30 MHz. No significant spurious were observed past the 10th harmonic.

*** FCC E-field 40 dB/dec decay assumed. EUT field decay rate was not measured over a range of distances to determine CF between measurement and limit distance.

5 Measurement Uncertainty and Accreditation Documents

The maximum values of measurement uncertainty for the laboratory test equipment and facilities associated with each test are given in the table below. This uncertainty is computed for a 95.45% confidence level based on a coverage factor of $k = 2$.

Table 8: Measurement Uncertainty.

| Measured Parameter | Measurement Uncertainty [†] |
|--|---|
| Radio Frequency | $\pm(f_{Mkr}/10^7 + RBW/10 + (SPN/(PTS - 1))/2 + 1 \text{ Hz})$ |
| Conducted Emm. Amplitude | $\pm 1.9 \text{ dB}$ |
| Radiated Emm. Amplitude (30 – 200 MHz) | $\pm 4.0 \text{ dB}$ |
| Radiated Emm. Amplitude (200 – 1000 MHz) | $\pm 5.2 \text{ dB}$ |
| Radiated Emm. Amplitude ($f > 1000 \text{ MHz}$) | $\pm 3.7 \text{ dB}$ |

[†]Ref: CISPR 16-4-2:2011+A1:2014



Figure 7: Accreditation Documents