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Testing of

Electromagnetic Emissions

per

USA: CFR Title 47, Part 15.209
Canada: IC RSS-210/GENe

are herein reported for

OMRON Automotive Elect. Co. Ltd.
OUC22273285

Test Report No.: 417124-150715-01r1

Applicant/Provider:
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Report Approved by: Valdis V. Liepa — Dr. Valdis V. Liepa
Report by: Valdis V. Liepa — Dr. Valdis V. Liepa
Report Date of Issue: July 15, 2015

Results of testing completed on (or before) May 5, 2015 are as follows.

Emissions: The transmitter intentional emissions **COMPLY** with the regulatory limit(s) by no less than 52.5 dB. Transmit chain spurious harmonic emissions **COMPLY** by no less than 26.7 dB.

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1 Test Specifications, General Procedures, and Location

1.1 Test Specification and General Procedures

The ultimate goal of OMRON Automotive Elect. Co. 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 OMRON Automotive Elect. Co. Ltd. OUC22273285 for compliance to:

Country/Region	**Rules or Directive**	**Referenced Section(s)**
United States	Code of Federal Regulations	CFR Title 47, Part 15.209
Canada	Industry Canada	IC RSS-210/GENe

OMRON Automotive Elect. Co. Ltd. has 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 C63.4:2009 (USA)	"Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz"
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
ANSI C63.4:2014 (CAN)	"Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz"
Industry Canada	"The Measurement of Occupied Bandwidth"

1.2 Test Location and Equipment Used

Test Location The EUT was fully tested by **The University of Michigan Radiation Laboratory**, 3228 EECS Building, Ann Arbor, Michigan 48109-2122 USA. The Test Facility description and attenuation characteristics are on file with the FCC Laboratory, Columbia, Maryland (FCC Reg. No: 91050) and with Industry Canada, Ottawa, ON (File Ref. No: IC 2057A-1).

Test Equipment Pertinent test equipment used for measurements at this facility is listed in Table 1. The quality system employed at The University of Michigan Radiation Laboratory 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 1: The University of Michigan Radiation Laboratory Equipment List

Description	Manufacturer/Model	SN	Quality Num.	Last Cal By / Date Due
Spectrum Analyzer	Hewlett Packard / 8593E	3412A01131	HP8593E1	Agilent / Jul-2016
Dipole Set (20-1000 MHz)	UM / RLDP	RLDP-1,-2,-3	UMDIP1	UM / Jul-2016
Ridge-Horn Antenna	Univ. of Michigan / VVL	5	UMRH1	UM / Jul-2016
Shielded Loop Antenna	EMCO / 6502	2855	EMLOOP1	UM / Jul-2016

2 Configuration and Identification of the Equipment Under Test

2.1 Description and Declarations

The EUT is an automobile ignition immobilizer. The EUT is approximately 3 x 3 x 5 cm (approx) in dimension, and is depicted in Figure 1. It is powered by a 13.2 VDC vehicle power system. In use, this device is permanently affixed in the dash of a motor vehicle. Table 2 outlines provider declared EUT specifications.

Figure 1: Photos of EUT.

Table 2: EUT Declarations.

General Declarations			
Equipment Type:	Ignition Immobilizer	**Country of Origin:**	USA
Nominal Supply:	13.2 VDC	**Oper. Temp Range:**	Not Declared
Frequency Range:	0.1349 MHz	**Antenna Dimension:**	Not Declared
Antenna Type:	air coil, non-removable	**Antenna Gain:**	Not Declared (integral)
Number of Channels:	1	**Channel Spacing:**	Not Applicable
Alignment Range:	134.9 kHz	**Type of Modulation:**	AM
United States			
FCC ID Number:	OUC22273285	**Classification:**	DCD
Canada			
IC Number:	850K-22273285	**Classification:**	RFID Device, Vehicular Device

2.1.1 EUT Configuration

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

2.1.2 Modes of Operation

The EUT is capable of only a single mode of operation. After manual activation (key insertion in vehicle) the EUT will transmit a CW signal for approximately 103ms to energize and interrogate the passive transponder in the key.

2.1.3 Variants

There is only a single variant of the EUT, as tested.

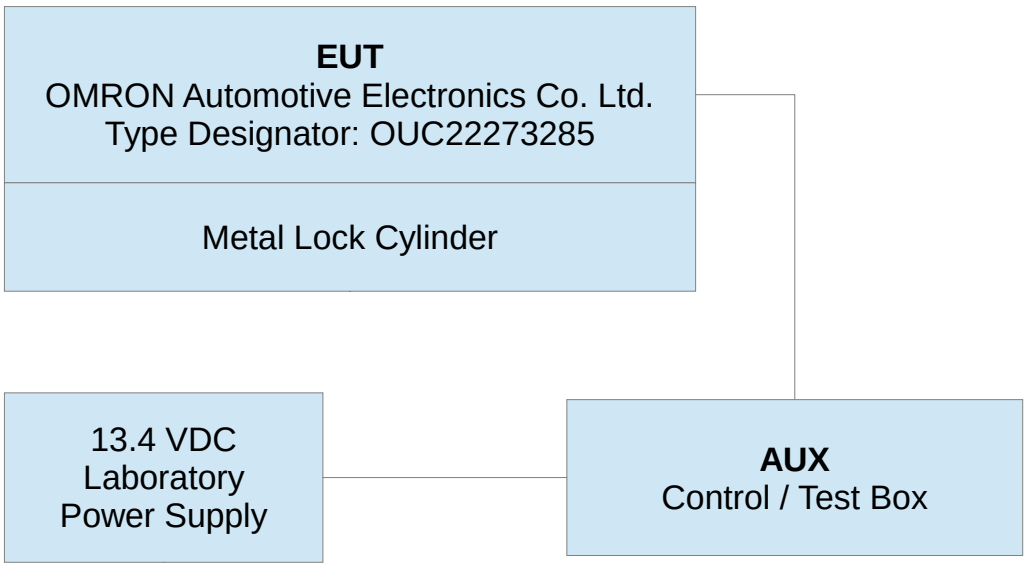


Figure 2: EUT Test Configuration Diagram.

2.1.4 Test Samples

Two samples in total were provided. One normal sample capable of normal activation and one sample to take apart for photos.

2.1.5 Functional Exerciser

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

2.1.6 Modifications Made

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

2.1.7 Production Intent

The EUT appears to be a production ready sample.

2.1.8 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).

3 Emissions

3.1 General Test Procedures

3.1.1 Radiated Test Setup and Procedures

Radiated electromagnetic emissions from the EUT are first pre-scanned in our shielded anechoic chamber. Spectrum and modulation characteristics of all emissions are recorded. Instrumentation, including spectrum analyzers and other test equipment as detailed in Section 1.2 are employed. After indoor pre-scans, emission measurements are made on our outdoor 3-meter Open Area Test Site (OATS). 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.

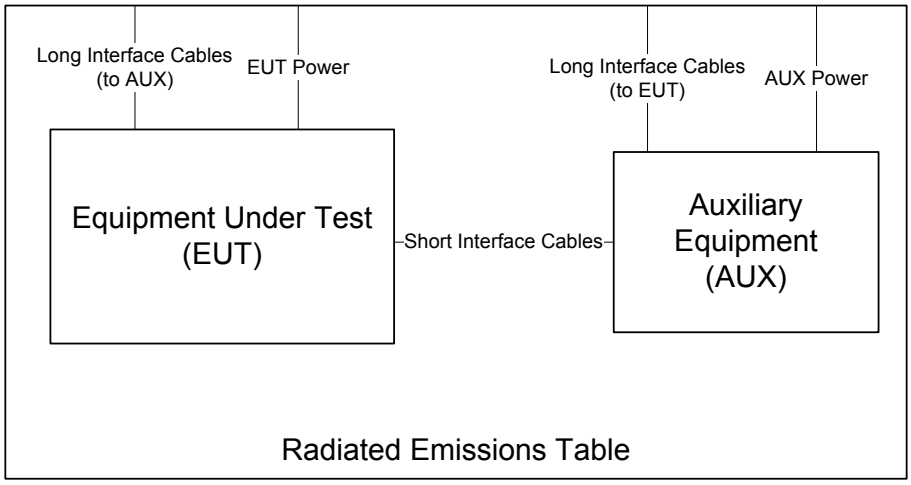


Figure 3: Radiated Emissions Diagram of the EUT.

If the EUT exhibits spurious emissions due to internal receiver circuitry, such emissions are measured with an appropriate carrier signal applied. For devices with intentional emissions below 30 MHz, a shielded loop antenna is used. It is placed at a 1 meter receive height. Emissions between 30 MHz and 1 GHz are measured using tuned dipoles and/or 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^o 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 horn antennas or calibrated broadband ridge-horn antennas on our OATS with a 2.4m x 2.4m square of AN-79 or H-4 absorber placed over the ground screen between the EUT and the test antenna. 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 dBμV/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

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

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).

3.1.2 Conducted Emissions Test Setup and Procedures

Vehicle Power Conducted Spurious The EUT is not subject to power line conducted emissions regulations as it is powered solely by the vehicle power system for use in said motor vehicle.

3.1.3 Power Supply Variation

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

3.2 Intentional Emissions

3.2.1 Fundamental Emission Pulsed Operation

The details and results of testing the EUT for pulsed operation are summarized in Table 3. Plots showing the measurements made to obtain these values are provided in Figure 5.

Table 3: Pulsed Emission Characteristics (Duty Cycle).

The EUT employs a cw transmission in excess of 100 ms. Thus, no duty cycle applies. Load(key) identification is performed in a passive transponder fashion, where the battery/load modulates its coil resulting only in a observed loading variation of the source.

	Duty Cycle Computation						Omron Imm.; FCC/IC
1	KE = 0.0 dB						
2							

TEST EQUIPMENT USED: HP8593E1, EMLOOP1 Univ. of Mich. 05/01/2015

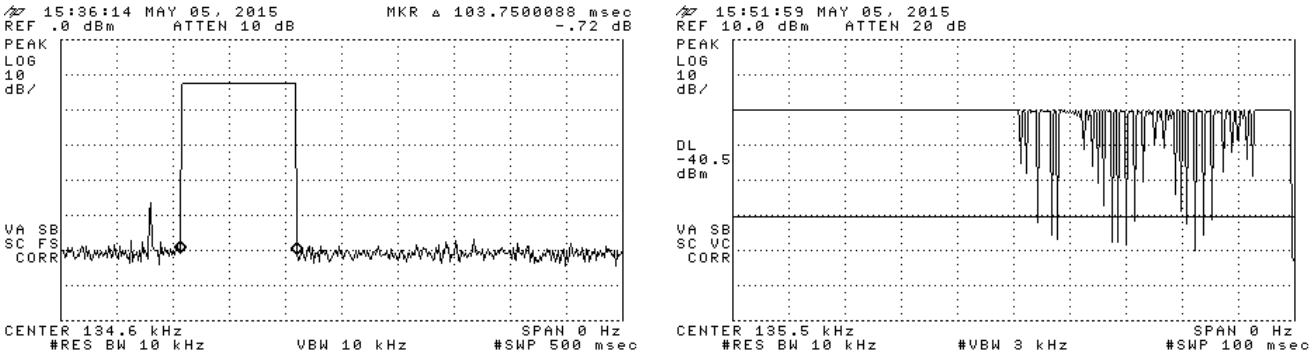


Figure 5: Pulsed Emission Characteristics (Duty Cycle).

3.2.2 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 1.1. 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 4. Plots showing measurements employed to obtain the emission bandwidth reported are provided in Figure 6.

Table 4: Intentional Emission Bandwidth.

The CW emission of the signal is shown in the following Figure. During operation, the emission in the 110 kHz restricted band remains more than 30 dB down from the fundamental emission.

Measured Emission Bandwidth							Omron Imm.; FCC/IC
#	EBW meas. (kHz)						
1	6.4						

TEST EQUIPMENT USED: HP8593E1, EMLOOP1 Univ. of Mich. 05/01/2015

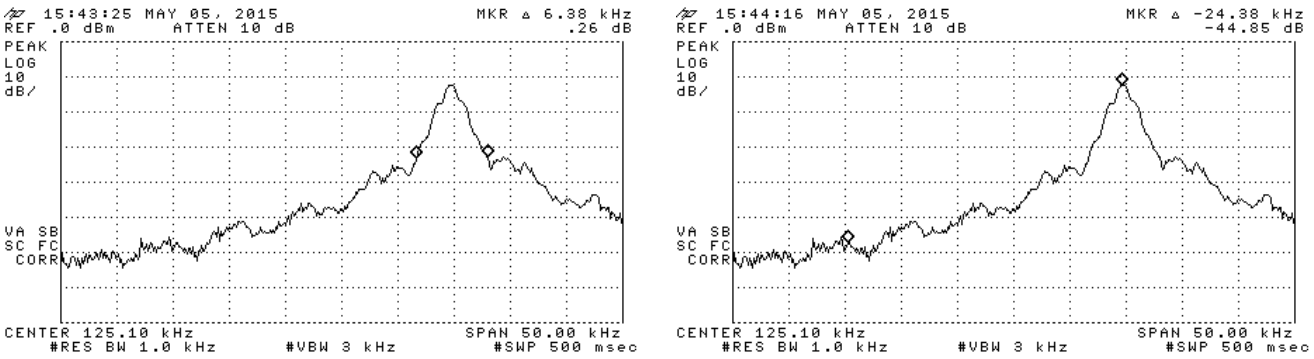


Figure 6: Intentional Emission Bandwidth.

3.2.3 Fundamental Emission

Following the test procedures listed in Section 1.1, 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 are (1) aligned along the same axis as the test loop antenna and horizontal with respect to the test site ground plane, (2) aligned coplanar (in the same plane) with the test antenna and aligned horizontal with respect to the test site ground plane, and (3) aligned coplanar (in the same plane) with the test antenna and vertical with respect to the test site ground plane. Table 5 details the results of these measurements.

Table 5: Fundamental Radiated Emissions.

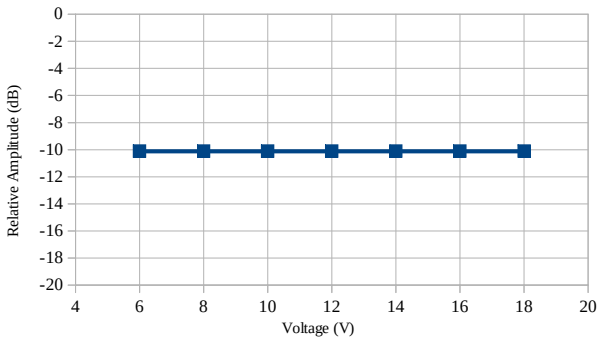
Averaging applies up to 490 kHz, 0.0 dB in this case (CW transmission for power transfer)
Limit at 300m for f<0.490MHz; 30m for f>0.490MHz
9 kHz RBW for f > 150 kHz; 300 Hz RBW for f<150 kHz

Radiated Fundamental Emission — Omron Imm.; FCC/IC

#	Freq. kHz	Ant. Used	Ant. Orien.	Pr, 3m dBm	Det. Used	Ka dB/m	Kg dB	NF/FF m	CF* 3/30/300 m	FCC Part 15 E dBµV/m	FCC Part 15 Elim dBµV/m	IC RSS-210 E dBµV/m	IC RSS-210 Elim dBµV/m	Pass dB	Comments
1	135	Loop	V/perp	-29.8	Pk	9.9	.0	353.9	114.6	-27.5	25.0	-27.5	25.0	**52.5**	loop perp. (axis in dir. of prop.)
2	135	Loop	V/par	-30.2	Pk	9.9	.0	353.9	114.6	-27.9	25.0	-27.9	25.0	52.9	loop paral. (loop in dir. of prop.)
3	135	Loop	H	-35.8	Pk	9.9	.0	353.9	114.6	-33.5	25.0	-33.5	25.0	58.5	loop horiz. (loop in horiz. plane)
4															
5															
6															
7															
8															

TEST EQUIPMENT USED: HP8593E1, EMLOOP1 — Univ. of Mich. 05/01/2015

*NOTE: CF represents the worst case field conversion factor for loop transmitters over all possible orientations and ground materials, as demonstrated in IEEE Trans. EMC, Vol. 47, No. 3 August 2005.



Measured OATS Field Decay Rate to Confirm Field Conversion			
Freq. kHz'	Distance From EUT (m)	Relative Pr (Pk) dBm	Formula Fit Pr (Pk) vs Distance
134.9	2.0	-11.1	-25.51 ln(x) + 7.45
134.9	3.0	-21.8	Base 10 Rate of Decay*** (dB/dec)
134.9	4.0	-28.9	
134.9	5.0	-34.9	**-58.7**

*** A Ln (x) = 2.303*A Log(x).

3.3 Unintentional Emissions

3.3.1 Transmit Chain Spurious Emissions

The results for the measurement of transmit chain spurious emissions at the nominal voltage and temperature are provided in Table 6. Following the test procedures listed in Section 1.1, 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 are (1) aligned along the same axis as the test loop antenna and horizontal with respect to the test site ground plane, (2) aligned coplanar (in the same plane) with the test antenna and aligned horizontal with respect to the test site ground plane, and (3) aligned coplanar (in the same plane) with the test antenna and vertical with respect to the test site ground plane. The results for the measurement of transmit chain spurious emissions at the nominal voltage and temperature are provided in Table 6. Measurements are performed to 10 times the highest fundamental operating frequency.

Table 6: Transmit Chain Spurious Emissions.

Averaging applies up to 490 kHz, 0.0 dB in this case (CW transmission for power transfer)
Limit at 300m for f<0.490MHz; 30m for f>0.490MHz
9 kHz RBW for f > 150 kHz; 300 Hz RBW for f<150 kHz

Radiated TX Harmonic Emissions															Omron Imm.; FCC/IC
										FCC Part 15		IC RSS-210			
#	Freq. kHz	Ant. Used	Ant. Orien.	Pr, 3m dBm	Det. Used	Ka dB/m	Kg dB	NF/FF m	CF* 3/30/300 m	E dBµV/m	Elim dBµV/m	E dBµV/m	Elim dBµV/m	Pass dB	Comments
1	135	Loop	V/perp												
2	135	Loop	V/par												
3	135	Loop	H												
4	270	Loop	V/perp	-54.9	Pk	10.2	.0	177.0	109.5	-47.2	19.0	-47.2	19.0	66.2	noise
5	270	Loop	V/par	-55.2	Pk	10.2	.0	177.0	109.5	-47.5	19.0	-47.5	19.0	66.5	noise
6	270	Loop	H	-55.6	Pk	10.2	.0	177.0	109.5	-47.9	19.0	-47.9	19.0	66.9	noise
7	405	Loop	V/perp	-59.4	Pk	10.2	.0	118.0	103.0	-45.2	15.5	-45.2	15.5	60.7	noise
8	405	Loop	V/par	-58.3	Pk	10.2	.0	118.0	103.0	-44.1	15.5	-44.1	15.5	59.6	noise
9	405	Loop	H	-60.0	Pk	10.2	.0	118.0	103.0	-45.8	15.5	-45.8	15.5	61.3	noise
10	540	Loop	V/perp	-61.4	Pk	10.2	.0	88.5	56.2	-.4	33.0	-.4	33.0	33.4	background
11	675	Loop	V/perp	-67.9	Pk	10.2	.0	70.8	56.0	-6.7	31.0	-6.7	31.0	37.7	background
12	809	Loop	V/perp	-65.6	Pk	10.1	.0	59.0	55.8	-4.3	29.4	-4.3	29.4	33.7	background
13	944	Loop	V/perp	-60.1	Pk	10.0	.0	50.6	55.5	1.4	28.1	1.4	28.1	**26.7**	background
14	1079	Loop	V/perp	-72.7	Pk	10.0	.0	44.2	55.2	-10.9	26.9	-10.9	26.9	37.8	background
15	1214	Loop	V/perp	-74.0	Pk	10.0	.0	39.3	54.9	-11.9	25.9	-11.9	25.9	37.8	background
16	1349	Loop	V/perp	-75.2	Pk	9.9	.0	35.4	54.5	-12.8	25.0	-12.8	25.0	37.8	background
17															
18															
19															

TEST EQUIPMENT USED: HP8593E1, EMLOOP1 Univ. of Mich. 05/01/2015