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Testing of

Electromagnetic Emissions

per

USA: CFR Title 47, Part 15.209
Canada: RSS-210 and RSS-Gen

are herein reported for

Lear Automotive (EEDS) Spain, SL TTRBDCLR01

Test Report No.: 20130204-01

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Report by:	Dr. Joseph Brunett, EMC-002790-NE	Report Date of Issue:	February 4, 2013

Results of testing the equipment under test (EUT) as completed on February 4, 2013 are as follows.

Emissions: The transmitter fundamental emission meets the regulatory limit(s) by no less than 54.9 dB. Transmit chain spurious harmonic emissions comply by no less than 24.5 dB.

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1 Test Specifications, General Procedures, and Location

1.1 Test Specification and General Procedures

The ultimate goal of Lear Automotive (EEDS) Spain, SL is to demonstrate that the EUT complies with the Rules and/or Directives below. Detailed in this report are the results of testing the Lear Automotive (EEDS) Spain, SL TTRBDCLR01 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	RSS-210 and RSS-Gen

In association with the rules and directives outlined above, the following specifications and procedures are followed herein.

ANSI C63.4-2003	"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
Industry Canada	"The Measurement of Occupied Bandwidth"

1.2 Test Location and Equipment Used

Test Location The EUT was fully tested at **Willow Run Test Labs, LLC**, 8501 Beck Road, Building 2227, Belleville, Michigan 48111 USA. The **Open Area Test Site (OATS)** description and attenuation characteristics are on file with the FCC Laboratory, Columbia, Maryland (FCC Reg. No: 688478) and with Industry Canada, Ottawa, ON (File Ref. No: IC 8719A-1).

Test Equipment Pertinent test equipment used for measurements at this facility is listed in Table 1. The quality system employed at Willow Run Test Labs, LLC 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: Willow Run Test Labs, LLC Equipment List.

Description	Manufacturer/Model	SN	Quality Number	Last Cal By / Date Due
Antennas				
Shielded Loop (9 kHz - 50 MHz)	EMCO/6502	2855	UMLOOP1	UMRL / July-2013
Dipole Set (20 MHz - 1000 MHz)	EMCO/3121C	9504-1121	DIPEMC001	Liberty Labs / Sept-2013
Bicone (20 MHz - 250 MHz)	JEF	1	BICJEF001	UMRL / July-2013
Bicone (200 MHz - 1000 MHz)	JEF	1	SBICJEF001	UMRL / July-2013
Log-Periodic Array (200 MHz - 1000 MHz)	JEF/Isbell	1	LOGJEF001	UMRL / July-2013
Ridge-Horn Antenna	Univ. of Michigan	5	UMHORN005	UMRL / July-2013
L-Band	JEF		HRNL001	JEF / July-2013*
LS-Band Horns	JEF/NRL	001, 002	HRN15001, HRN15002	JEF / July-2013*
S-Band Horns	Scientific-Atlanta	1854	HRNSB001	JEF / July-2013*
C-Band	JEF/NRL	1	HRNC001	JEF / July-2013*
XN-Band Horns	JEF/NRL	001, 002	HRNXN001, HRNXN002	JEF / July-2013*
X-Band Horns	JEF/NRL	001, 002	HRNXB001, HRNXB002	JEF / July-2013*
Ku-Band Horns	JEF/NRL	001, 002	HRNKU001, HRNKU002	JEF / July-2013*
Ka-Band Horns	JEF/NRL	001, 002	HRNKA001, HRNKA002	JEF / July-2013*
Receiver's / Spectrum Analyzers				
Spectrum Analyzer	HP/8593E	3649A02722	HP8593E001	DTI / Nov-2013
Signal Generators				
Tracking Generator	HP/8593E	3649A02722	HP8593E001	DTI / Nov-2013
Line Impedance Stabilization Networks				
LISN	EMCO	9304-2081	LISNEM001	JEF / Jan-2014

* Verification Only - Standard Gain Horn Antennas

2 Configuration and Identification of the Equipment Under Test

2.1 Description and Declarations

TThe equipment under test is an automotive comfort access and immobilizer device. The equipment under test (EUT) is approximately 30 x 16 x 5 cm in dimension, and is depicted in Figure 1. It is powered by a 12 VDC vehicular power system. This device is employed in a motor vehicle, transmitting encoded LF when a door handle is lifted (Comfort Access / Comfort Entry) or the vehicle start button is pressed (Comfort Go immobilizer). For Comfort Access / Comfort Entry, encoded LF is transmitted sequentially to each of 8 LF coils and a response from the user's hand-held UHF transmitter is listened for by a receiver elsewhere in the vehicle. For Comfort Go immobilizer functionality, the EUT's single immobilizer coil is actuated by manual button press and the coil loading in response to the user's passive key coil is used for authentication. Table 2 outlines provider declared EUT specifications.

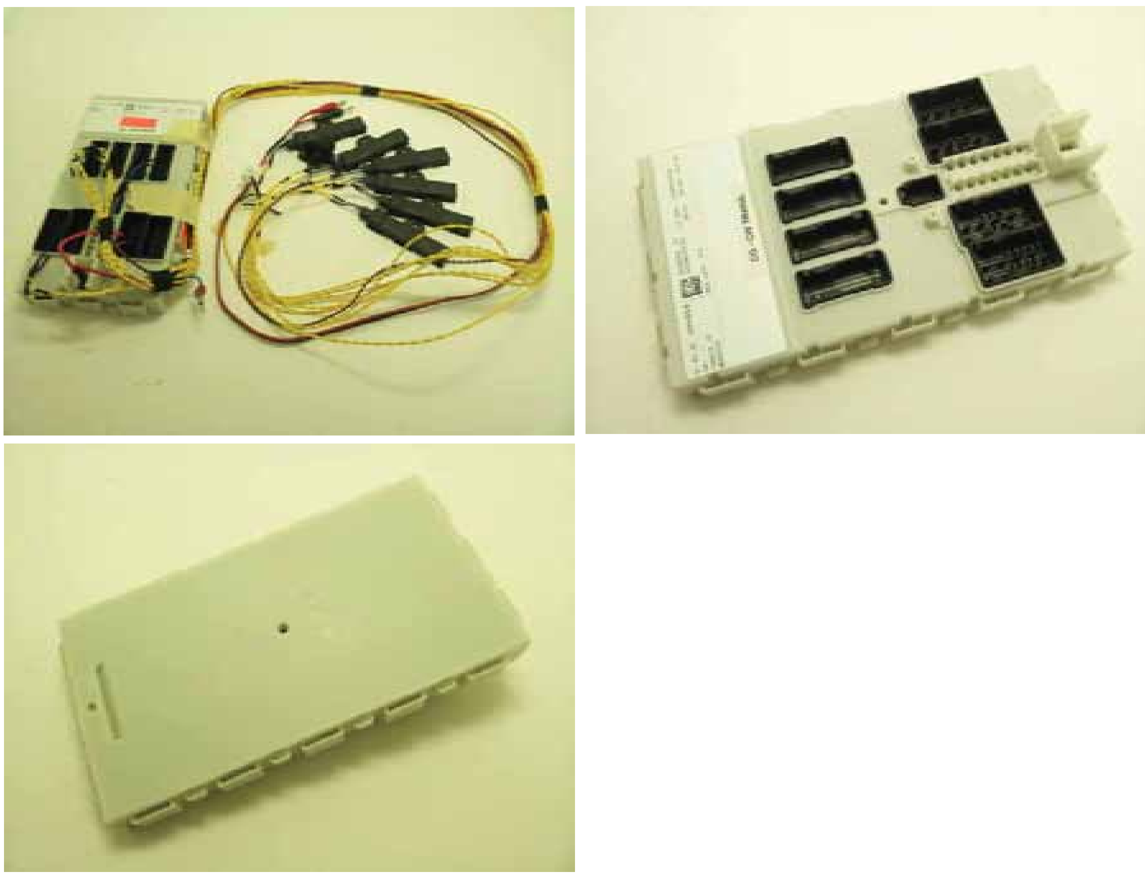

Figure 1: Photos of EUT.

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 operating an an ignition immobilizer authenticator and as a vehicle entry/access interrogator.

2.1.3 Variants

There is only a single variant of the EUT, as tested. The fully functional EUT employs 8 (eight) 5WK49377 initiator coils and both Comfort Access and Comfort Go functionality. CW modified variants were supplied to test the two mode of operation using the same harness.

Table 2: EUT Declarations.

General Declarations			
Equipment Type:	LF Transmitter	**Country of Origin:**	Spain
Nominal Supply:	12 VDC	**Oper. Temp Range:**	-40^{o}C to $+85^{o}$C
Frequency Range:	125 kHz	**Antenna Dimension:**	10x2x1 cm (VDO), 4x4x4 cm (BMW)
Antenna Type:	Siemens VDO 5WK49377, BMW 9178927	**Antenna Gain:**	LF Coil
Number of Channels:	1	**Channel Spacing:**	-
Alignment Range:	-	**Type of Modulation:**	ASK
United States			
FCC ID Number:	TTRBDCLR01	**Classification:**	DCD: LPT ¡ 1705 kHz
Canada			
IC Number:	6276A-BDCRL01	**Classification:**	Vehicular Device

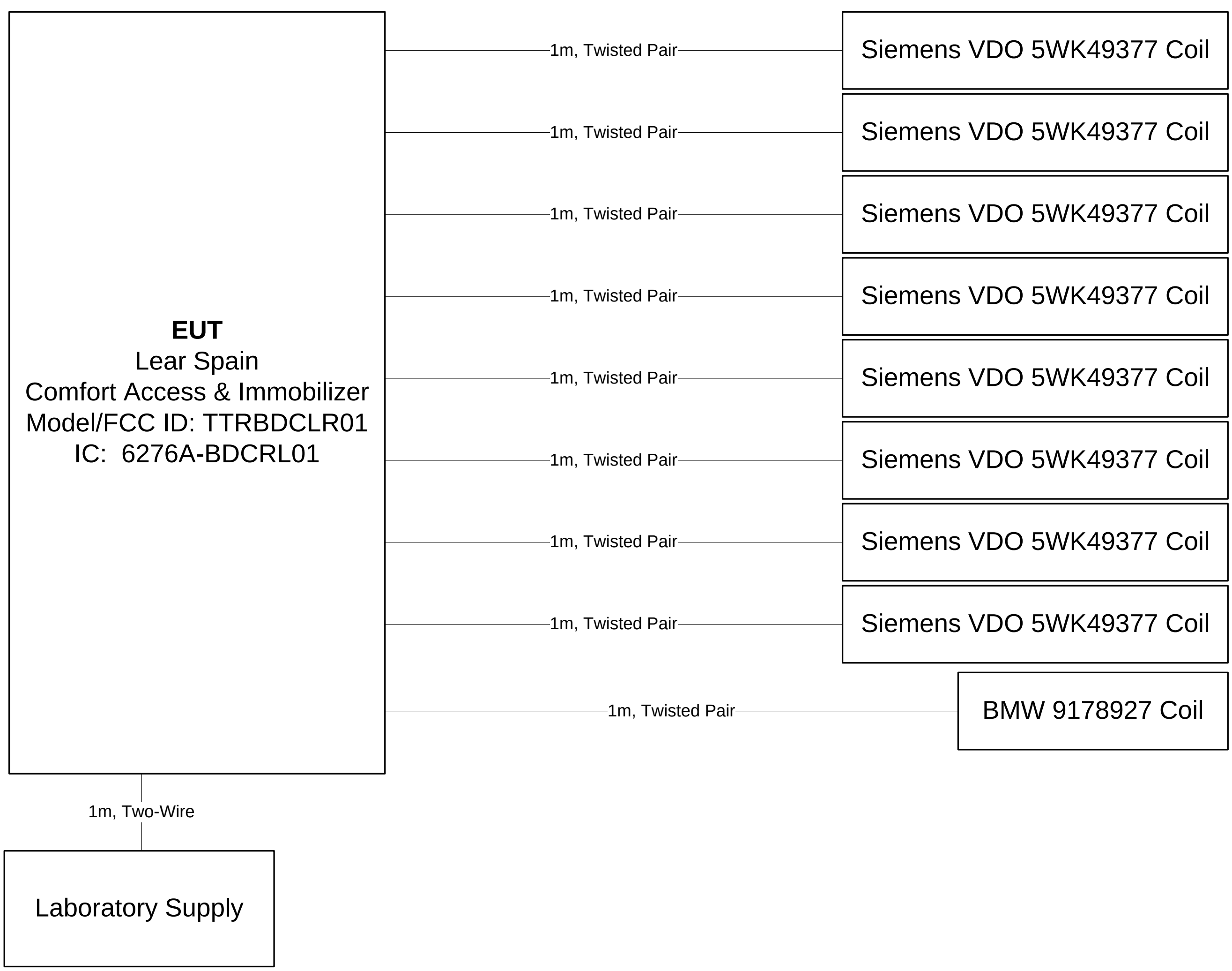

Figure 2: EUT Test Configuration Diagram.

2.1.4 Test Samples

Three samples were provided for testing, one normal operating sample and two modified samples capable of CW transmission as well as continuously modulated transmission.

2.1.5 Functional Exerciser

Functionality was verified by observing the LF signal transmitted when power was applied to the EUT.

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 product ready sample.

2.1.8 Declared Exemptions and Additional Product Notes

Worst case (highest field strength) fundamental emissions were observed form the CW modified unit, and were fully tested on the OATS as photographed. As only 6 initiator coils were available at the time of emissions testing, all 8 transmit chains were evaluated and the worst case 6 were populated with antennas during the CW test on the OATS. Transmit chain harmonic emissions were measured with the modified device placed in continually modulated transmit mode.

3 Emissions

3.1 General Test Procedures

3.1.1 Radiated Test Setup and Procedures

Radiated electromagnetic emissions from the EUT are first evaluated in our shielded fully anechoic chamber. Spectrum and modulation characteristics of all emissions are recorded, and emissions above 1 GHz are fully characterized. The anechoic chamber contains a set-up similar to that of our outdoor 3-meter site, with a turntable and antenna mast. Instrumentation, including spectrum analyzers and other test equipment as detailed in Section 1.2 are employed. After indoor pre-scans, emission measurements up to 1 GHz 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 ANSI C63.4 / CISPR 22 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.

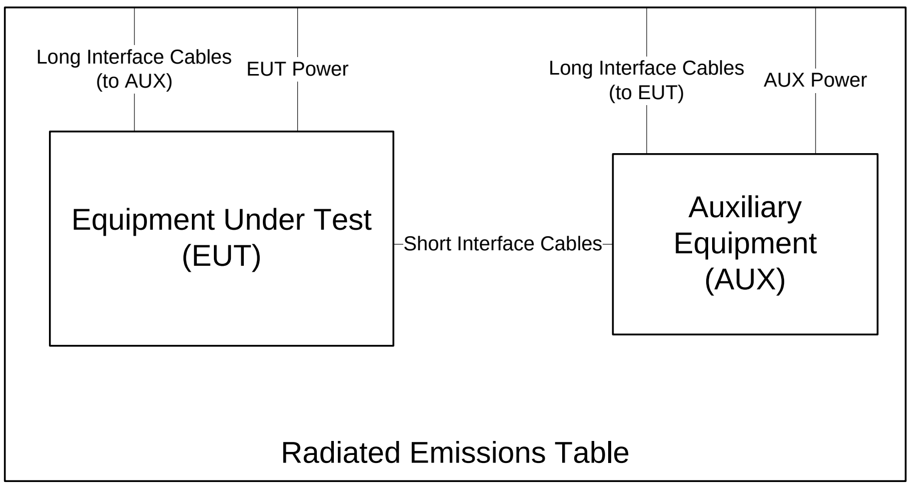

Figure 3: Radiated Emissions Diagram of the EUT.

All intentionally radiating elements 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. 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. Photographs of the test setup employed are depicted in Figure 4.

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 as the test antenna. It is placed at a 1 meter receive height and appropriate low frequency magnetic field extrapolation to the regulatory limit distance is employed. Emissions between 30 MHz and 1 GHz are measured using tuned dipoles and/or calibrated broadband antennas. Emissions above 1 GHz are characterized using standard gain horn antennas. 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.

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 compute, 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.

3.1.4 Thermal Variation

Tests at extreme temperatures are made if required by the procedures specified in the test standard, and results of this testing are detailed in this report. The provider has declared that the EUT is designed for operation over the temperature range -40^{o}C to $+85^{o}$C. Before any temperature measurements are made, the equipment is allowed to reach a thermal balance in the test chamber, temperature and humidity are recorded, and thermal balance is verified via a thermocouple based probe.

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).

Frequency Range	Det	IF Bandwidth	Video Bandwidth
9 kHz ≤ f ≤ 150 kHz	Pk/QPk	200 Hz	300 Hz
150 kHz ≤ f ≤ 30 MHz	Pk/QPk	9 kHz	30 kHz
25 MHz ≤ f ≤ 1 000 MHz	Pk/QPk	120 kHz	300 kHz
f > 1 000 MHz	Pk	3 MHz	3MHz
f > 1 000 MHz	Avg	3 MHz	10kHz

Test Date:	28-Dec-12
Test Engineer:	Joseph Brunett
EUT Mode:	CA+CG Modulated
Meas. Distance:	3 meters
EUT Tested:	Lear BCM

		Overall Transmission			Internal Frame Characteristics			Computed Duty Cycle (per 100ms window)	
#	**EUT Mode**	**Min. Repetition Rate (sec)**	**Max. No. of Frames**	**Total Transmission Length (sec)**	**Min. Frame Length (ms)**	**Min. Frame Period (ms)**	**Frame Encoding**	**(%)**	**Duty (dB)**
1	Comfort-Access + Comfort Go Worst Case	Manual	One	< 0.035	<35	N/A	In the worst case, the EUT transmits one Comfort Go LF frame on the immobilizer (BMW) coil followed by a set of Comfort Access LF frames for each initiator (Siemens) coil. The one (1) Comfort-Go frame is measured to be 12.25ms in duration followed by up to eight (8) Comfort-Access frames that are each 1.91 ms in duration within a given 100 ms window. (Only 6 are observed in the plots provided as 2 antennas were not attached at the time of testing.)	27.530	-11.2
2									

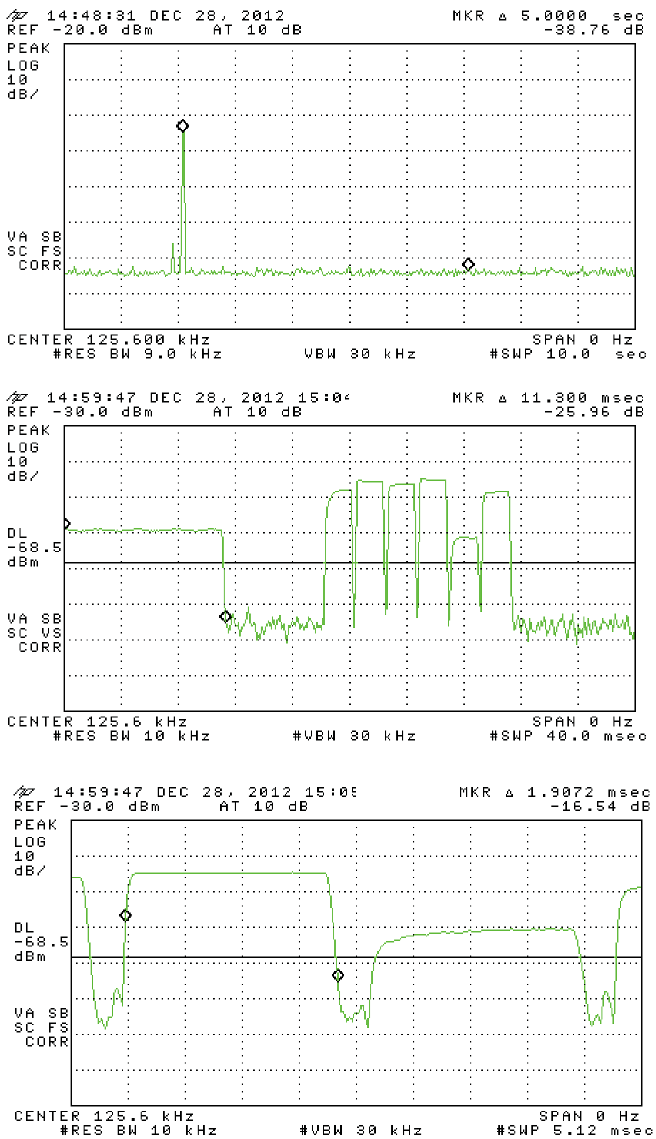

Figure 5: Pulsed Emission Characteristics (Duty Cycle).

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.

Frequency Range	**Det**	**IF Bandwidth**	**Video Bandwidth**
9 kHz ≤ f ≤ 150 kHz	Pk/QPk	> 1% Span	>= 3 * IFBW

Test Date: 28-Dec-12
Test Engineer: Joseph Brunett
EUT Mode: Worst Case Modulated
Meas. Distance: 0.1 meters

#	Mode	Temp (C)	Supply (VDC)	99% PWR BW (kHz)	20 dB EBW (kHz)				
1	CA+CG	Nom.	13.4	7.75	7.75				
2									

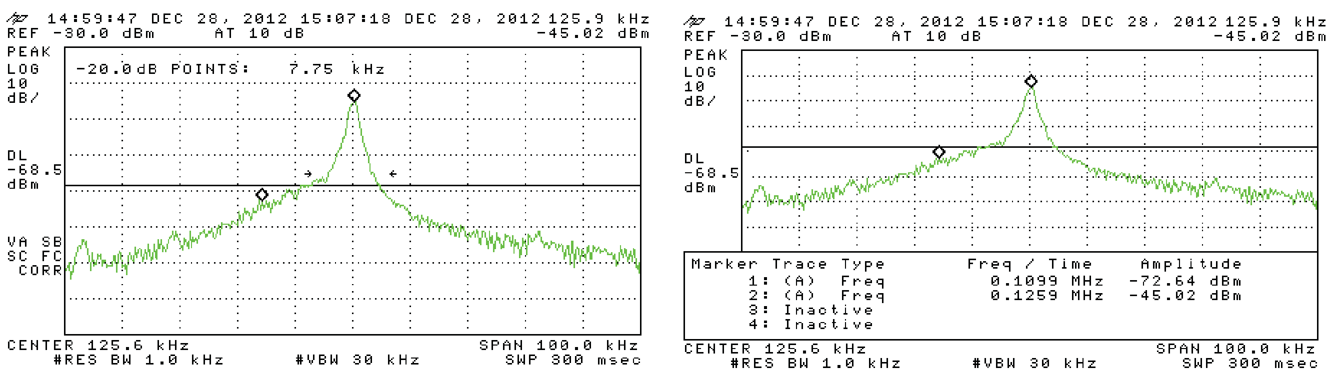

Figure 6: Intentional Emission Bandwidth.

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.

Frequency Range	**Det**	**IF Bandwidth**	**Video Bandwidth**
9 kHz ≤ f ≤ 150 kHz	Pk/QPk	200 Hz	300 Hz
150 kHz ≤ f ≤ 30 MHz	Pk/QPk	9 kHz	30 kHz
25 MHz ≤ f ≤ 1 000 MHz	Pk/QPk	120 kHz	300 kHz
f > 1 000 MHz	Pk	3 MHz	3MHz
f > 1 000 MHz	Avg	3 MHz	10kHz

Test Date:	28-Dec-12
Test Engineer:	Joseph Brunett
EUT Mode:	CW
Meas. Distance:	3 meters
EUT Tested:	Lear BCM

#	Mode	Test Antenna Polarization	Freq. kHz	Ant. Used	Pr (Pk) dBm	Pr (QPk/Avg)* dBm	Ka dB/m	Kg dB	Cf** 3m / 300m (dB)	E300m (Pk) dBuV/m	E300m (QPk/Avg) dBuV/m	E300m Limit dBuV/m	Pass By
1	Comfort-Access	Coaxial - Horz	125.0	S. Loop	-20.1	-31.3	9.9	0.0	114.8	-18.0	-29.2	25.7	**54.9**
2		Coplanar - Vert	125.0	S. Loop	-27.0	-38.2	9.9	0.0	114.8	-24.9	-36.1	25.7	61.8
3		Coplanar - Horz	125.0	S. Loop	-24.2	-35.4	9.9	0.0	114.8	-22.1	-33.3	25.7	59.0
4	Comfort-Go	Coaxial - Horz	125.0	S. Loop	-37.1	-48.3	9.9	0.0	114.8	-35.0	-46.2	25.7	71.9
5		Coplanar - Vert	125.0	S. Loop	-41.2	-52.4	9.9	0.0	114.8	-39.1	-50.3	25.7	76.0
6		Coplanar - Horz	125.0	S. Loop	-40.0	-51.2	9.9	0.0	114.8	-37.9	-49.1	25.7	74.8

#	Mode	Polarization	Freq. kHz'	DC Supply Voltage	Pr (Pk) dBm
7	Comfort-Access	Coaxial - Horz	125.0	9.00	-20.1
8			125.0	13.40	-20.1
9			125.0	18.00	-20.0
10	Comfort-Access	Coaxial - Horz	125.0	9.00	-37.1
11			125.0	13.40	-37.1
12			125.0	18.00	-37.1

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
125.0	2.0	-10.1	-25.51 ln(x) + 7.45
125.0	3.0	-20.8	Base 10 Rate of Decay*** (dB/dec)
125.0	4.0	-27.9	
125.0	5.0	-33.5	**-58.7**

* Averaging applies up to 490 kHz as computed in Duty Cycle section of test report. *** A Ln (x) = 2.303*A Log(x).

** 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.

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.

Frequency Range	Det	IF Bandwidth	Video Bandwidth		
9 kHz ≤ f ≤ 150 kHz	Pk/QPk	200 Hz	300 Hz	**Test Date:**	5-Jan-13
150 kHz ≤ f ≤ 30 MHz	Pk/QPk	9 kHz	30 kHz	**Test Engineer:**	Joseph Brunett
25 MHz ≤ f ≤ 1 000 MHz	Pk/QPk	120 kHz	300 kHz	**EUT Mode:**	CW
f > 1 000 MHz	Pk	3 MHz	3MHz	**Meas. Distance:**	3 meters
f > 1 000 MHz	Avg	3 MHz	10kHz	**EUT Tested:**	Lear BCM

Transmit Chain Spurious Emissions

#	Mode	Test Antenna Polarization	Freq. MHz	Ant. Used	Pr (Pk) dBm	Pr (QPk/Avg)* dBm	Ka dB/m	Kg dB	Cf** 3/30/300m (dB)	E30/300m (Pk) dBuV/m	E30/300m (QPk/Avg) dBuV/m	E-field Limit (30/300m) dBuV/m	Pass By	Comments
1	Comfort-Access	Max. All	250.0	S. Loop	-67.3	-78.5	9.9	0.0	110.4	-60.8	-72.0	19.6	91.6	
2		Max. All	375.0	S. Loop	-69.2	-80.4	9.9	0.0	104.5	-56.8	-68.0	16.1	84.1	
3		Max. All	500.0	S. Loop	-71.0		9.9	0.0	56.3	-10.4		33.6	44.0	
4		Max. All	625.0	S. Loop	-63.5		9.9	0.0	56.1	- 2.7		31.7	34.4	
5		Max. All	750.0	S. Loop	-55.4		9.9	0.0	55.9	5.6		30.1	**24.5**	background
6		Max. All	875.0	S. Loop	-84.3		9.9	0.0	55.6	-23.0		28.8	51.8	
7		Max. All	1000.0	S. Loop	-77.9		9.9	0.0	55.4	-16.4		27.6	44.0	background
8		Max. All	1125.0	S. Loop	-65.1		9.9	0.0	55.1	- 3.3		26.6	29.9	background
9		Max. All	1250.0	S. Loop	-73.4		9.9	0.0	54.8	-11.3		25.7	36.9	
10														
11	Comfort-Go	Max. All	250.0	S. Loop	-73.5	-84.7	9.9	0.0	110.4	-67.0	-78.2	19.6	97.8	
12		Max. All	375.0	S. Loop	-75.7	-86.9	9.9	0.0	104.5	-63.3	-74.5	16.1	90.6	
13		Max. All	500.0	S. Loop	-85.0		9.9	0.0	56.3	-24.4		33.6	58.0	
14		Max. All	625.0	S. Loop	-81.4		9.9	0.0	56.1	-20.6		31.7	52.3	
15		Max. All	750.0	S. Loop	-55.9		9.9	0.0	55.9	5.1		30.1	**25.0**	background
16		Max. All	875.0	S. Loop	-87.0		9.9	0.0	55.6	-25.7		28.8	54.5	
17		Max. All	1000.0	S. Loop	-75.2		9.9	0.0	55.4	-13.7		27.6	41.3	background
18		Max. All	1125.0	S. Loop	-65.9		9.9	0.0	55.1	- 4.1		26.6	30.7	background
19		Max. All	1250.0	S. Loop	-77.5		9.9	0.0	54.8	-15.4		25.7	41.0	
20														

* Averaging applies up to 490 kHz as computed in Duty Cycle section of test report.

** 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 2