



The University of Michigan Radiation Laboratory
3228 EECS Building
Ann Arbor, Michigan 48109-2122 USA
Tel: (734) 483-4211
Fax: (734) 647-2106
e-mail: liepa@umich.edu

Testing of
Electromagnetic Emissions
per

USA: CFR Title 47, Part 15.109

are herein reported for

Robert Bosch Corporation
PFJG2TN23

Test Report No.: 417124-677
Copyright © 2014

Applicant/Provider:
Robert Bosch Corporation
15000 Haggerty Rd., Plymouth Michigan 48170 USA
Phone: +1 (734) 979-3035, Fax: +1 (734) 979-3781
Contact Person: Marco Toppi; marco.toppi@us.bosch.com

Report by: Valdis V. Liepa Report Date of Issue: August 6, 2014
Valdis V. Liepa, Ph.D.

Results of testing completed on (or before) July 22, 2014 are as follows.

Emissions: Radiated spurious emissions associated with the receive chain of this device **COMPLY** the regulatory limit(s) by no less than 4.9 dB.

Contents

1	Test Specifications, General Procedures, and Location	3
1.1	Test Specification and General Procedures	3
1.2	Test Location and Equipment Used	4
2	Configuration and Identification of the Equipment Under Test	5
2.1	Description and Declarations	5
2.1.1	EUT Configuration	5
2.1.2	Modes of Operation	6
2.1.3	Variants	6
2.1.4	Test Samples	6
2.1.5	Functional Exerciser	6
2.1.6	Modifications Made	6
2.1.7	Production Intent	6
2.1.8	Declared Exemptions and Additional Product Notes	6
3	Emissions	7
3.1	General Test Procedures	7
3.1.1	Radiated Test Setup and Procedures	7
3.1.2	Conducted Emissions Test Setup and Procedures	9
3.1.3	Power Supply Variation	9
3.2	Unintentional Emissions	10
3.2.1	Radiated Receiver Spurious	10

List of Tables

1	The University of Michigan Radiation Laboratory Equipment List.	4
2	EUT Declarations.	5
3	Receiver Chain Spurious Emissions $\geq$ 30 MHz.	10

List of Figures

1	Photos of EUT.	5
2	EUT Test Configuration Diagram.	5
3	Radiated Emissions Diagram of the EUT.	7
4	Radiated Emissions Test Setup Photograph(s).	8
5	Receiver LO (or VCO) relative emission.	10

1 Test Specifications, General Procedures, and Location

1.1 Test Specification and General Procedures

The ultimate goal of Robert Bosch Corporation 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 Corporation PFJG2TN23 for compliance to:

Country/Region	Rules or Directive	Referenced Section(s)
United States	Code of Federal Regulations	CFR Title 47, Part 15.109

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"
-----------------	--

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.

Test Instrument	Manufacturer/Model	Q Number
Spectrum Analyzer (9kHz-26GHz)	Hewlett-Packard 8593E, SN: 3412A01131	HP8593E1
Power Meter	Hewlett-Packard, 432A	HP432A1
Harmonic Mixer (26-40 GHz)	Hewlett-Packard 11970A, SN: 3003A08327	HP11970A1
Harmonic Mixer (40-60 GHz)	Hewlett-Packard 11970U, SN: 2332A00500	HP11970U1
Harmonic Mixer (75-110 GHz)	Hewlett-Packard 11970W, SN: 2521A00179	HP11970W1
Harmonic Mixer (140-220 GHz)	Pacific Millimeter Prod., GMA, SN: 26	PMPGMA1
S-Band Std. Gain Horn	S/A, Model SGH-2.6	SBAND1
C-Band Std. Gain Horn	University of Michigan, NRL design	CBAND1
XN-Band Std. Gain Horn	University of Michigan, NRL design	XNBAND1
X-Band Std. Gain Horn	S/A, Model 12-8.2	XBAND1
X-band horn (8.2- 12.4 GHz)	Narda 640	XBAND2
X-band horn (8.2- 12.4 GHz)	Scientific Atlanta , 12-8.2, SN: 730	XBAND3
K-band horn (18-26.5 GHz)	FXR, Inc., K638KF	KBAND1
Ka-band horn (26.5-40 GHz)	FXR, Inc., U638A	KABAND1
U-band horn (40-60 GHz)	Custom Microwave, HO19	UBAND1
W-band horn(75-110 GHz)	Custom Microwave, HO10	WBAND1
G-band horn (140-220 GHz)	Custom Microwave, HO5R	GBAND1
Bicone Antenna (30-250 MHz)	University of Michigan, RLBC-1	LBBIC1
Bicone Antenna (200-1000 MHz)	University of Michigan, RLBC-2	HBBIC1
Dipole Antenna Set (30-1000 MHz)	University of Michigan, RLDP-1,-2,-3	UMDIP1
Dipole Antenna Set (30-1000 MHz)	EMCO 3121C, SN: 992 (Ref. Antennas)	EMDIP1
Active Rod Antenna (30 Hz-50 MHz)	EMCO 3301B, SN: 3223	EMROD1
Active Loop Antenna (30 Hz-50 MHz)	EMCO 6502, SN:2855	EMLOOP1
Ridge-horn Antenna (300-5000 MHz)	University of Michigan	UMRH1
Magnetic Field Strength Probe	HP 11941A	HPMFSP1
Electric Field Strength Probe	EG&G ACD-4A(R)	EGGACD41
Amplifier (5-1000 MHz)	Avantek, A11-1, A25-1S	AVAMP1
Amplifier (5-4500 MHz)	Avantek	AVAMP2
Amplifier (4.5-13 GHz)	Avantek, AFT-12665	AVAMP3
Amplifier (6-16 GHz)	Trek	TRAMP1
Amplifier (16-26 GHz)	Avantek	AVAMP4
LISN Box	University of Michigan	UMLISN1
Signal Generator	Hewlett-Packard 8657B	HPSG1

2 Configuration and Identification of the Equipment Under Test

2.1 Description and Declarations

The EUT is a superheterodyne receiver. The EUT is approximately 4 x 2 x 0.5 in 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 a motor vehicle. Table 2 outlines provider declared EUT specifications.



Figure 1: Photos of EUT.

Table 2: EUT Declarations.

General Declarations			
Equipment Type:	Receiver	Country of Origin:	Not Declared
Nominal Supply:	13.2 VDC	Oper. Temp Range:	Not Declared
Frequency Range:	314.9 MHz	Antenna Dimension:	Not Declared
Antenna Type:	metal spiral whip	Antenna Gain:	Not Declared
United States			
FCC ID Number:	PFJG2TN23	Classification:	CYY

2.1.1 EUT Configuration

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

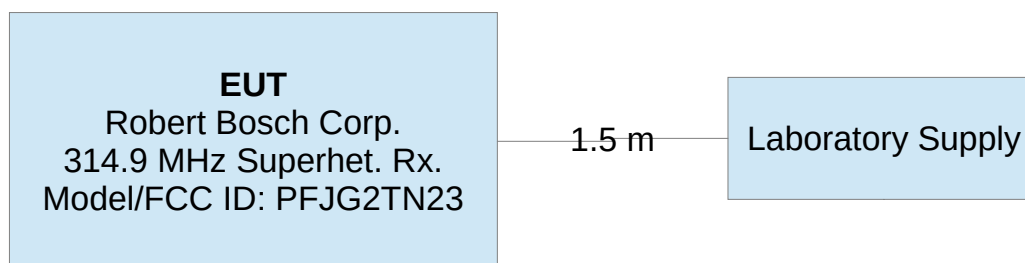


Figure 2: EUT Test Configuration Diagram.

2.1.2 Modes of Operation

The EUT operates as a superheterodyne receiver.

2.1.3 Variants

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

2.1.4 Test Samples

Two samples in total were provided. One Rx awake sample and one normal sample to take apart for photos.

2.1.5 Functional Exerciser

Normal operating EUT functionality was verified by observation LO(VCO) of the receiver.

2.1.6 Modifications Made

No modifications were made to the EUT.

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 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 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. All

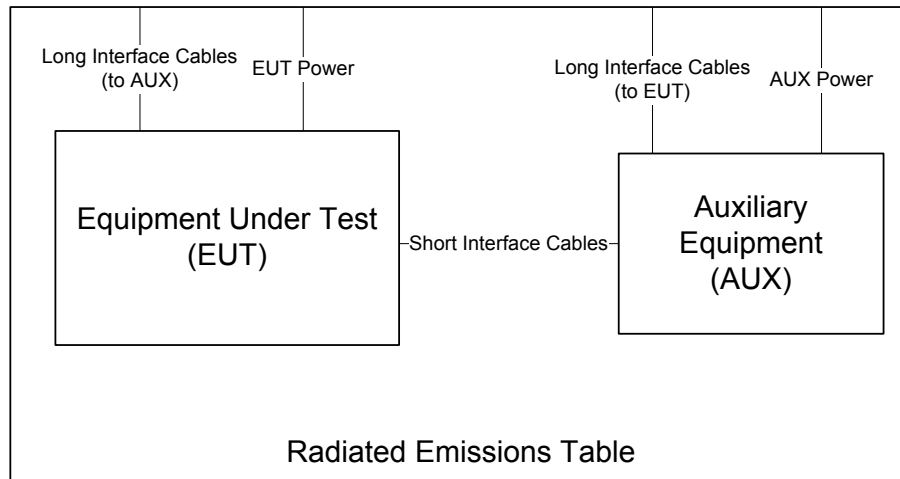


Figure 3: Radiated Emissions Diagram of the EUT.

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. 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. 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 horn antennas or calibrated broadband ridge-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. 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 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.

3.2 Unintentional Emissions

3.2.1 Radiated Receiver Spurious

The results for the measurement of radiated receiver spurious emissions (emissions arising from the receiver chain, e.g. LO or VCO) at the nominal voltage and temperature are reported in Table 3. Receive chain emissions are measured to 5 times the highest receive chain frequency employed or 4 GHz, whichever is higher. If no emissions are detected, only those noise floor emissions at the LO/VCO frequency are reported. Relative relative emissions are depicted in Figure 5.

Table 3: Receiver Chain Spurious Emissions ≥ 30 MHz.

Frequency Range	Det	IF Bandwidth	Video Bandwidth
25 MHz $\leq f \leq 1\,000$ MHz	Pk/QPk	120 kHz	300 kHz
$f > 1\,000$ MHz	Pk	1 MHz	3 MHz
$f > 1\,000$ MHz	Avg	1 MHz	10kHz

Radiated Emission - RF											Bosch Rx; FCC/IC
#	Freq. MHz	Ant. Used	Ant. Pol.	Pr dBm	Det. Used	Ka dB/m	Kg dB	E3 dBμV/m	E3lim dBμV/m	Pass dB	Comments
1	314.7	Sbic	H	-81.9	Pk	18.9	20.8	23.2	46.0	22.8	max. of all, noise
2	314.7	Sbic	V	-81.1	Pk	18.9	20.8	24.0	46.0	22.0	max. of all, noise
3	629.4	Sbic	H	-78.3	Pk	25.2	17.7	36.2	46.0	9.8	max. of all, noise
4	629.4	Sbic	V	-78.4	Pk	25.2	17.7	36.1	46.0	9.9	max. of all, noise
5	944.1	Sbic	H	-82.5	Pk	28.9	15.7	37.7	46.0	8.3	max. of all, background
6	944.1	Sbic	V	-79.1	Pk	28.9	15.7	41.1	46.0	4.9	max. of all, background
7											
8	1 to 2 GHz	R-Horn	H	-67.5	Pk	19.6	28.0	31.1	54.0	22.9	max. of all, noise
9	2 to 2.9 GHz	R-Horn	H	-70.6	Pk	22.5	28.2	30.7	54.0	23.3	max. of all, noise
10	2.9 to 4.5 GHz	R-Horn	H	-71.1	Pk	25.0	24.5	36.5	54.0	17.5	max. of all, noise
11											
12											
13											

TEST EQUIPMENT USED: HP8593E1, HBBIC1, UMRH

Meas. 07/22/2014; U of Mich.

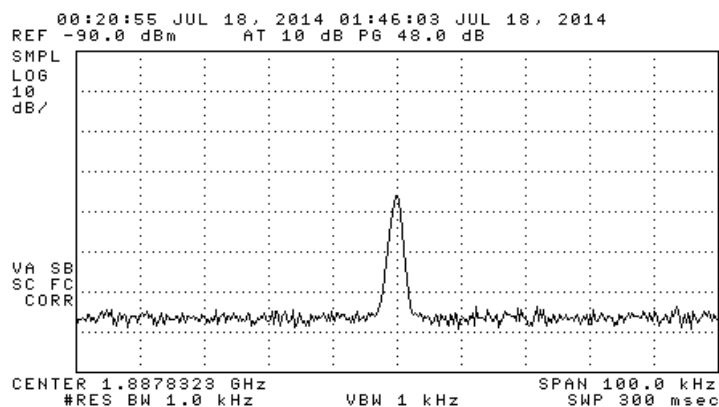


Figure 5: Receiver LO (or VCO) relative emission.