DECLARATION OF COMPLIANCE: MPE ASSESSMENT Part 1 of 3

Motorola Solutions Inc.
EME Test Laboratory
Motorola Solutions Malaysia Sdn Bhd (Innoplex)
Plot 2A, Medan Bayan Lepas,
Mukim 12 SWD 11900 Bayan Lepas Penang, Malaysia.

Date of Report: 12/15/2016
Report Revision: B

Responsible Engineer:	Saw Sun Hock (EME Engineer)
Report author:	Saw Sun Hock (EME Engineer)
Date(s) Tested:	8/11/2016~8/18/2016; 8/20/2016~8/21/2016; 8/24~8/30/2016; 9/20/2016~9/22/2016
Manufacturer:	Motorola Solutions Inc.
Date submitted for test:	08/08/2016
DUT Description:	APX8500 mobile All Bands (VHF, UHF, 7/800)
Test TX mode(s):	CW
Max. Power output:	60W (136-174 MHz), 54W (380-484 MHz), 48W (485-512 MHz), 30W (512-520 MHz), 36W (764-805 MHz), 42W (806-870 MHz); 10mW (Bluetooth); 2.5mW (Bluetooth LE); 63.1 mW (WLAN 802.11b), 20 mW (WLAN 802.11g/n)
TX Frequency Bands:	136-174 MHz; 380-520 MHz; 764-805 MHz; 806-870 MHz; WLAN 2400-2483.5 MHz; Bluetooth 2402-2480 MHz
Signaling type:	FM, TDMA, FHSS (Bluetooth), 802.11b/g/n (WLAN)
Model(s) Tested:	M37TSS9PW1AN
Model(s) Certified:	M37TSS9PW1AN
Serial Number(s):	KLDORDDUC
Classification:	Occupational/Controlled Environment
FCC ID:	AZ492FT7089 150.8-173.4 MHz, 406.1-512 MHz, 769-775 MHz, 799-824 MHz, 851-869 MHz, 2402-2480 MHz, 2412-2462 MHz This report contains results that are immaterial for FCC equipment approval, which are clearly identified.
ISED Canada:	109U-92FT7089 This report contains results that are immaterial for ISED Canada equipment approval, which are clearly identified.

The MPE results clearly demonstrate compliance with FCC Occupational/Controlled RF Exposure limits. FCC rules require compliance for Passengers and Bystanders to the FCC General Population/Uncontrolled limits. The test results clearly demonstrate compliance with ICNIRP Guidelines for limiting exposure in time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz).

Based on the information and the testing results provided herein, the undersigned certifies that when used as stated in the operating instructions supplied, said product complies with the national and international reference standards and guidelines listed in section 3.0 of this report. This report shall not be reproduced without written approval from an officially designated representative of the Motorola Solutions Inc. EME Laboratory.
I attest to the accuracy of the data and assume full responsibility for the completeness of these measurements.
This reporting format is consistent with the suggested guidelines of the TIA TSB-159 April 2006
The results and statements contained in this report pertain only to the device(s) evaluated herein.

Signature on file
Tiong Nguk Ing
Deputy Technical Manager
Approval Date: 12/15/2016

Certification Date: 10/25/2016

Certification No.: L1161004

Document Revision History

Date	Revision	Comments
10/27/2016	A	Initial release
12/15/2016	B	Several areas updated per FCC response

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Appendices

1.0 Introduction

This report details the test setup, test equipment and test results of Maximum Permissible Exposure (MPE) performed at Motorola Solutions' outside test site for product model M37TSS9PW1AN.

2.0 FCC MPE Summary

Table 1

Equipment Class	Frequency band (MHz)	Trunk Mounted Antennas				Roof Mounted Antennas			
		Passenger		Bystander		Passenger		Bystander	
		Power Density (mW/cm^2)	Percentage of Limit (%)	Power Density (mW/cm^2)	Percentage of Limit (%)	Power Density (mW/cm^2)	Percentage of Limit (%)	Power Density (mW/cm^2)	Percentage of Limit (%)
TNB	150.8 – 173.4 (LMR VHF)	0.50	**250.1	0.16	79.2	0.17	84.8	0.17	85.5
	406.1 – 470 (LMR UHF1)	0.42	**140.1	0.20	74.7	0.16	23.3	0.13	46
	450 – 512 (LMR UHF2)	0.42	**140.1	0.15	51.1	0.15	18.1	0.13	43.6
	769-775; 799-824; 851-869 (LMR 7/800)	0.17	31.7	0.22	38.7	0.06	10.2	0.1	22.1
DTS	2412 – 2462 (WLAN 802.11 b/g/n)	0.0247	2.47	0.0247	2.47	0.0247	2.47	0.0247	2.47
DSS	2402-2480 (Bluetooth)	0.0030	0.30	0.0030	0.30	0.0030	0.30	0.0030	0.30
Simultaneous (Highest Combined Percentage of Limit)			**252.6		81.7		87.3		88.0

** Requires SAR Simulation.

3.0 Abbreviations / Definitions

CNR: Calibration Not Required
CW: Continuous Wave
DUT: Device Under Test
EME: Electromagnetic Energy
FHSS: Frequency Hopping Spread Spectrum
FM: Frequency Modulation
MPE: Maximum Permissible Exposure
GPS: Global Positioning System
LMR: Land Mobile Radio
SAR: Specific Absorption Rate
NA: Not Applicable
BS: Bystander
PB: Passenger Back seat
PF: Passenger Front seat
PTT: Push to Talk
WLAN: Wireless Local Area Network
TDMA: Time Division Multiple Access

4.0 Referenced Standards and Guidelines

This product is designed to comply with the following applicable national and international standards and guidelines.

- United States Federal Communications Commission, Code of Federal Regulations; Rule Part 47CFR § 1.1310, § 2.1091 (d) and § 2.1093 for RF Exposure, where applicable.
- Federal Communications Commission, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radio frequency Electromagnetic Fields", OET Bulletin 65 (Edition 97-01), FCC, Washington, D.C.: August 1997.
- American National Standards Institute (ANSI) / Institute of Electrical and Electronics Engineers (IEEE) C95. 1-1999
- American National Standards Institute (ANSI) / Institute of Electrical and Electronics Engineers (IEEE) C95. 1-1992. Specific to FCC rules and regulations.
- Institute of Electrical and Electronics Engineers (IEEE) C95.3-2002
- International Commission on Non-Ionizing Radiation Protection (ICNIRP) 1998
- Ministry of Health (Canada) Safety Code 6 (2015), Limits of Human Exposure to Radio frequency Electromagnetic Fields in the Frequency Range from 3 kHz to 300 GHz
- RSS-102 (Issue 5) – Radio Frequency (RF) Exposure Compliance of Radio communication Apparatus (All Frequency Bands)
- FCC KDB – 447498 D01 General RF Exposure Guidance v06
- FCC KDB – 865664 D02 RF Exposure Reporting v01r02

5.0 Power Density Limits

Table 2 – Occupational / Controlled Exposure Limits

Frequency Range (MHz)	FCC OET Bulletin 65 mW/cm^2	ICNIRP W/m^2	IEEE C95.1 1992/1999 mW/cm^2	IEEE C95.1 2005 W/m^2	RSS-102 Issue 5 2015 W/m^2
10 – 20					10.0
20 – 48					$44.72 / f^{0.5}$
30 – 300	1.0				
48 – 100					6.455
10 – 400		10.0			
100 – 300			1.0	10.0	
100 – 6,000					$0.6455 f^{0.5}$
300 – 1,500	f/300				

Table 2 – Occupational / Controlled Exposure Limits (Con't.)

Frequency Range (MHz)	FCC OET Bulletin 65	ICNIRP	IEEE C95.1 1992/1999	IEEE C95.1 2005	RSS-102 Issue 5 2015
	mW/cm^2	W/m^2	mW/cm^2	W/m^2	W/m^2
300 – 3,000			f/300	f/30	
400 – 2,000		f/40			
1,500 – 15,000					
1,500 – 100,000	5.0				
2,000 – 300,000		50.0			
3,000 – 300,000			10.0	100.0	
6,000 – 15,000					50.0
15000 – 150,000					50.0
150000 –300,000					$3.33\times10^{-4} f$

Table 3 – General Population / Uncontrolled Exposure Limits

Frequency Range (MHz)	FCC OET Bulletin 65	ICNIRP	IEEE C95.1 1992/1999	IEEE C95.1 2005	RSS-102 Issue 5 2015
	mW/cm^2	W/m^2	mW/cm^2	W/m^2	W/m^2
10 – 20					2.0
20 – 48					$8.944 / f^{0.5}$
30 – 300	0.2				
48 – 300					1.291
10 – 400		2.0			
100 – 300			0.2		
100 – 400				2.0	
300 – 1,500	f/1,500				
300 – 6000					$0.02619 f^{0.6834}$
400 – 2,000		f/200		f/200	
300 – 15,000			f/1,500		
1,500 – 15,000					
1,500 – 100,000	1.0				
2,000 – 100,000				10.0	
2,000 – 300,000		10.0			
6,000 – 15,000					10.0
15,000 – 150,000					10.0
150,000 – 300,000					$6.67\times10^{-5} f$

6.0 N_c Test Channels

The number of test channels is determined by using Equation 1 below. This equation is available in FCC's KDB 447498. The test channels are appropriately spaced across the antenna's frequency range.

Equation 1 – Number of test channels

$N_c = \text{Round}\{[100(f_{high} - f_{low})/f_c]^{0.5} \times (f_c / 100)^{0.2}\}$

where N_c is the number of test channels, f_{high} and f_{low} are the highest and lowest frequencies within the transmission band, f_c is the mid-band frequency, and frequencies are in MHz.

7.0 Measurement Equipment

Table 4 – Equipment

Equipment Type	Model #	SN	Calibration Date	Calibration Due Date
Automobile	Volvo 240-1988	NA	NA	NA
Survey Meter Probe – E-Field Probe – H-Field	ETS Model HI-2200 ETS Model E100 ETS Model H200	00086316 000153632 00206937	5/16/2016	5/16/2017

E-field measurements are in mW/cm^2.
H field measurements are in A/m.

8.0 Measurement System Uncertainty Levels

Table 5 – Uncertainty Budget for Near Field Probe Measurements

	Tol. (± %)	Prob. Dist.	Divisor	u_i (±%)	v_i
Measurement System					
Probe Calibration	6.0	N	1.00	6.0	∞
Survey Meter Calibration	3.0	N	1.00	3.0	∞
Hemispherical Isotropy	8.0	R	1.73	4.6	∞
Linearity	5.0	R	1.73	2.9	∞
Pulse Response	1.0	R	1.73	0.6	∞
RF Ambient Noise	3.0	R	1.73	1.7	∞
RF Reflections	8.0	R	1.73	4.6	∞
Probe Positioning	10.0	R	1.73	5.8	∞
Test sample Related					
Antenna Positioning	3.0	N	1.00	3.0	∞
Power drift	5.0	R	1.73	2.9	∞
Combined Standard Uncertainty		RSS		12.2	∞
Expanded Uncertainty (95% CONFIDENCE LEVEL)		*k*=2		24	

9.0 Product and System Description

This mobile device operate in the LMR bands using frequency modulation (FM) and TDMA signals incorporating traditional simplex two-way radio transmission protocol.
This device also contains WLAN technology for data capabilities over 802.11b/g/n wireless networks and Bluetooth technology for short range wireless devices.

Time Division Multiple Access (TDMA) is used to allocate portions of the RF signal by dividing time into two slots. Time allocation enables each unit to transmit its voice information without interference from other transmitting units. Transmission from a unit or base station is accommodated during two time-slot lengths of 30 milliseconds with frame length of 60 milliseconds. The TDMA technique requires sophisticated algorithms and a digital signal processor (DSP) to perform voice compressions/decompressions and RF modulation/demodulation. The maximum duty cycle for TDMA 1:2 is 50%.

The LMR bands in this device operate in a half duplex system. A half duplex system only allows the user to transmit or receive. This device cannot transmit and receive simultaneously. The user must stop transmitting in order to receive a signal or listen for a response, regardless of PTT button or use of voice activated audio accessories. This type of operation which instructs the user to transmit no more than 50% of the time, justifies the use of 50% duty factor for this device.

The maximum duty cycle for TDMA is 1:2 (50%) and is controlled by software. The FM signal is continuous. However, because of hand shaking or Push-To-Talk (PTT) between users and/or base stations a conservative 50% duty cycle is applied. The TDMA mode was not tested because its duty cycle is inherently 50% and would include an additional 50% duty cycle for PTT.

This device also incorporates a Class 1 Bluetooth device which is a Frequency Hopping Spread Spectrum (FHSS) technology. The Bluetooth radio modem is used to wireless link audio accessories. The maximum actual transmission duty cycle is imposed by the Bluetooth standard. The maximum duty cycle for BT is 76.1%. Bluetooth Low Energy (BT LE) intended to reduce power consumption.

WLAN 802.11b/g/n operates using Direct Sequence Spread Spectrum (DSSS). This devices work in accordance with the IEEE 802.11b/g/n standard. The Bluetooth and WLAN transmitters cannot transmit at the same time.

Table 6 below summarizes the technologies, bands, maximum duty cycles and maximum output powers. Maximum output powers are defined as upper limit of the production line final test station.

Table 6

Radio Type	Band (MHz)	Transmission	Duty Cycle (%)	Max Power (W)
LMR	136-174	FM / TDMA	*50 / *25	60
LMR	380 – 484; 485-512; 512-520	FM / TDMA	*50 / *25	54 ; 48 ; 30
LMR	764-805	FM / TDMA	*50 / *25	36
LMR	806-870	FM / TDMA	*50 / *25	42
BT	2402-2480	FHSS	76.1	0.010

BT LE	2402-2480	FHSS	100	0.0025
WLAN	2400-2483.5	802.11 b	99.87	0.0631
WLAN	2400-2483.5	802.11 g	99.20	0.020
WLAN	2400-2483.5	802.11 n	99.17	0.020

Note - * includes 50% PTT operation

This device will be marketed to and used by employees solely for work-related operations, such as public safety agencies, e.g. police, fire and emergency medical. User training is the responsibility of these agencies which can be expected to employ the usage instructions, safety information and operational cautions set forth in the user's manual, instructional sessions or other means.

Accordingly this product is classified as Occupational/Controlled Exposure. However, in accordance with FCC requirements, the passengers inside the vehicle and the bystanders external to the vehicle are evaluated to the General Population/Uncontrolled Exposure Limits.

(Note that “Bystanders” as used herein are people other than operator)

10.0 Additional Options and Accessories

Not available.

11.0 Test Set-Up Description

Assessments were performed with mobile radio installed in the test vehicle, at the specified distances and test locations indicated in sections 11.0, 12.0 and Appendix A.

All antennas described in Table 7 were considered in order to develop the test plan for this product. Antennas were installed and tested per their appropriate mount locations (Roof / Trunk) and defined test channels.

The system was tested using a low-loss 16’ Teflon RG58A/U cable attaching the radio to the transmit antenna. This cable is shorter and lower attenuation than the 17’ RG58A/U cables supplied in the customer kits for connecting the radio to the transmit antenna. The cable used in the test setup also has lower attenuation over the test frequency range than the cable provided in the customer kits. The use of a shorter cable with lower attenuation in the test setup ensures that the test data is more conservative with regards to the actual installation. Cable losses are reported in Appendix A.

12.0 Method of Measurement with trunk mounted antenna(s)

12.1 External/Bystander vehicle MPE measurements

Initially the antenna is located at the center of the trunk. Refer to Appendix A for antenna location and distance.

MPE measurements for bystander (BS) conditions are determined by taking the average of (10) measurements in a 2 m vertical line for each of the (3) bystander test locations indicated in Appendix A with 20 cm height increments, with the distance between the antenna and the geometric center of the probe sensor equal to 90 cm (for VHF , UHF bands) and 60 cm (for 7/800 band). The measurement probe is positioned orthogonal to antenna (typically parallel to ground with a vertically mounted antenna) and aimed directly at the antenna's axis. These measurements are representative of persons other than the operator standing next to the vehicle.

Each of the offered antennas mounted at the center of the trunk were assessed at the rear of the vehicle while maintaining a minimum of twenty (20) centimeter separation distance between the probe sensor and vehicle body. The worst case antenna was then tested at a 45º radial at the corner of the trunk, and 90º radial at the side of the trunk.

Tests for the 90º radial direction where conducted with the antenna displaced towards the "bystander on the side of the trunk" test location in order to attain either 90 cm (requiring a 12 cm antenna displacement) or 60 cm (42 cm antenna displacement) distances from that test location. In this way, the antenna is closer to the test location, and the MPE is higher, than it would be if the antenna was left at the center of the trunk.

12.2 Internal/Passenger vehicle MPE measurements

Antenna is located toward the center of the trunk at a minimum 85 cm from backseat passenger. Users are instructed, per installation manual, to mount antennas on the roof only if a minimum 85cm cannot be achieved. Refer to Appendix A for antenna location and distance.

MPE measurements for passenger front seat (PF) and backseat (PB) conditions are determined by taking the average of the (3) measurements (Head, Chest, and Lower Trunk) inside the vehicle for both the front and back seats.

The backseat is a bench seat and therefore each position (Head, Chest & Lower Trunk) were scanned across (horizontally) the seat starting from the middle of the seat to the edge of the seat stopping 20 cm from the vehicle door. Similar process was used in the front bucket seat.

The probe handle is oriented parallel (horizontal) to the ground and pointed towards the back of the vehicle. The probe handle is not oriented normal to the seat surface. The probe head (incorporating the field sensors) is scanned continuously (using the max-hold function available in the meter) along three test axes which are parallel to the seat angle (intended as the line determined by the intersection of the plane of the seat and the plane of the backrest) and are 20 cm from the seat surface. One test axis is at the Head height, another is at the Chest height, and another is at the Lower Trunk height. The maximum field level value recorded for each test axis is logged. The MPE is determined by averaging these three maximum values regardless of the geometrical location where they were observed. For instance, the locations of the three maxima may lie on different vertical (relative to ground) lines.

This approach leads to results that are representative of the exposure of vehicle occupants since it is based on an average across the body portions closest to the antenna for both trunk and roof mount positions, and is conservatively biased because the highest results for each test axis are combined, e.g. the highest head exposure could be in the middle of the seat while the highest lower trunk exposure could be closer to the door.

13.0 Method of Measurement with roof mounted antenna(s)

Introduction:

The installation requirements for this radio indicate that in multiple single-band antenna configurations the antennas should be installed along a transverse line bisecting the roof, with one of the antennas in the center and the remaining two at 8" (20 cm) on each side. We tested all the antennas at one of the lateral positions (8" from the center along the mentioned bisecting line) in order to be closer to the edge of the roof. Additional measurements with antennas placed in the center of the roof are not needed because that placement would increase the distance to bystanders. Notice that in the Safety Manual (and the associated leaflet) we define minimum bystander distances from the vehicle although we test at corresponding distances, as attainable, from the antennas. Therefore, the exposures occurring at the recommended distance from the vehicle per the Safety manual will be lower than those occurring in the MPE test set-ups described in the following.

13.1 External/Bystander vehicle MPE measurements

Antenna is located at the side of the roof (20 cm from the center of the roof, along the width of the vehicle, driver side). Refer to Appendix A for antenna location and distance.

MPE measurements for bystander (BS) conditions are determined by taking the average of (10) measurements in a 2m vertical line for the test location indicated in Appendix A with 20 cm height increments, with the distance between the antenna and the geometric center of the probe sensor equal to 90 cm (for VHF , UHF bands) and 60 cm (for 7/800 band). The measurement probe is positioned orthogonal to antenna (typically parallel to ground with a vertically mounted antenna) and aimed directly at the antenna's axis. These measurements are representative of persons other than the operator standing next to the vehicle.

Note: Actual test distance for 7/800 band was approximately 85cm from roof mounted antenna to the measurement probe. This is the closet distance that can be achieved to maintain minimum 20cm separation between probe sensor and vehicle body used for MPE compliance assessment herein.

13.2 Internal/Passenger vehicle MPE measurements

Antenna is located at the side of the roof (20 cm from the center of the roof, along the width of the vehicle, driver side). Refer to Appendix A for antenna location and distance.

MPE measurements for passenger front seat (PF) and backseat (PB) conditions are determined by taking the average of the (3) measurements (Head, Chest, and Lower Trunk) inside the vehicle for both the front and back seats.

The backseat is a bench seat and therefore each position (Head, Chest & Lower Trunk) were scanned across (horizontally) the seat starting from the middle of the seat to the edge of the seat stopping 20 cm from the vehicle door. Similar process was used in the front bucket seat.
The probe handle is oriented parallel (horizontal) to the ground and pointed towards the back of the vehicle. The probe handle is not oriented normal to the seat surface. The probe head (incorporating the field sensors) is scanned continuously (using the max-hold function available in the meter) along three test axes which are parallel to the seat angle (intended as the line determined by the intersection of the plane of the seat and the plane of the backrest) and are 20 cm from the seat surface. One test axis is at the Head height, another is at the Chest height, and another is at the Lower Trunk height. The maximum field level value recorded for each test axis is logged. The MPE is determined by averaging these three maximum values regardless of the geometrical location where they were observed. For instance, the locations of the three maxima may lie on different vertical (relative to ground) lines.

This approach leads to results that are representative of the exposure of vehicle occupants since it is based on an average across the body portions closest to the antenna for both trunk and roof mount positions, and is conservatively biased because the highest results for each test axis are combined, e.g. the highest head exposure could be in the middle of the seat while the highest lower trunk exposure could be closer to the door.

14.0 MPE Calculations

The final MPE results for this mobile radio are presented in section 16.0. These results are based on 50% duty cycle for PTT for LMR bands.

Below is an explanation of how the MPE results are calculated. Refer to Appendix H, I, J and K for MPE measurement results and calculations for LMR bands VHF, UHF1, UHF2 and 7/800.

External to vehicle (Bystander) - 10 measurements are averaged over the body (*Avg_over_body*).
Internal to vehicle (Passengers) - 3 measurements are averaged over the body (*Avg_over_body*).

The Average over Body test methodology is consistent with IEEE/ANSI C95.3-2002 guidelines.

Therefore;

Equation 2 – Power Density Calculation *(Calc._P.D.)*

$$Calc.\_P.D. = (Avg\_over\_body) * (probe\_frequency\_cal\_factor) * (duty\_cycle)$$

Note 1: The highest "average" cal factors from the calibration certificates were selected for the applicable frequency range. Linear interpretation was used to determine "probe_frequency_cal_factor" for the specific test frequencies.

Note 2: The E-field probe calibration certificate's frequency cal factors were determined by measuring V/m. The survey meter's results were measured in power density (mW/cm^2) and therefore the "probe_frequency_cal_factor" was squared in equation 2 to account for these results.

Note 3: The H-field probe calibration certificate's frequency cal factors were determined by measuring A/m. The survey meter's results were measured in A/m and therefore the "Avg_over_body" A/m results were converted to power density (mW/cm^2) using the equation 3. H-field measurements are only applicable to frequencies below 300MHz.

Equation 3 – Converting A/m to mW/cm^2

$$mW / cm\text{^}2 = (A / m)\text{^}2 * 37.699$$

Equation 4 – Power Density Maximum Calculation

$$Max\_Calc.\_P.D. = P.D.\_calc * \frac{\max\_output\_power}{initial\_output\_power}$$

Note 4: For initial output power> max_output_power; max_output_power / initial output power = 1

15.0 Antenna Summary

Table below summarizes the tested or evaluated antennas and their descriptions, mount location (roof/trunk), overlap of FCC bands, number of test channels per FCC KDB 447498 (FCC N_c) and actual number of tested channels (Actual N_c). This information was used to determine the test configurations presented in this report.

The gain antennas marked with an asterisk are trimmed (meaning their wire is physically cut) to the optimal length for each operating test frequency so that the measured MPE is representative of the optimal performing antenna at that frequency.

Table 7

Antenna No.	Antenna Model	Frequency Range (MHz)	Physical Length (cm)	Gain (dBi)	Remarks	Mount Location (Roof/ Trunk)	Overlap FCC Bands (MHz)	FCC Nc	Actual Nc
VHF (136- 174 MHz)									
1	HAD4016A	136-162	51.3	2.15	1/4 wave	R	150.8-162	3	5
2	HAD4017A	146-174	46.2	2.15	1/4 wave	R	150.8-173.4	4	5
3	HAD4021A	136-174	51.7	2.15	1/4 wave	R	150.8-173.4	4	6
4	*HAD4022A	132-174	130.0 (136 MHz) 118.5 (144 MHz) 114 (150.8 MHz)	5.15	5/8 wave	R/T	150.8-173.4	4	6

			102.7 (158.0125 MHz) 96.5 (165.0125 MHz) 89.9 (173.0125 MHz)						
5	*RAD4010ARB	136-174	143.5 (136 MHz) 130.5 (146 MHz) 126.8 (150.8 MHz) 116.5 (158.0125 MHz) 112.5 (165.0125 MHz) 103.7 (173.0125 MHz)	5.15	1/2 wave	R/T	150.8-173.4	4	6
UHF1 (380-470 MHz)									
6	HAE6010A	380-433	63.5	5.65	1/2 wave	R/T	406.1-433	3	5
7	HAE6011A	380-433	91.0	7.15	5/8 wave	R/T	406.1-433	3	5
8	HAE6012A	380-433	18.2	2.15	1/4 wave	R	406.1-433	3	5
9	HAE6013A(1)	380-470	29	4.15	1/2 wave	R/T	406.1 -470	6	8
10	HAE6031A(1)	380-520	28	4.15	1/2 wave	R/T	406.1-470	5	7
11	HAE4003A(1)	450-470	16	2.15	1/4 wave	R	450-470	3	3
12	HAE4011A(1)	450-470	73.2	5.65	1/2 wave	R/T	450-470	3	3
13	HAE6015A(1)	450-520	26.2	4.15	1/2 wave	R/T	450-470	3	3
14	HAE6016A(1)	450-512	8.3	2.15	1/4 wave	R	450-470	3	3
15	*RAE4014ARB(1)	445-470	92.7 (450.0125 MHz) 90.5 (460 MHz) 89.0 (469.9875 MHz)	7.15	5/8 wave	R/T	450-470	3	3

Notes:
(1): Antennas support UHF1 & UHF2 frequency range.
* Antenna length trimmed to frequency.

Table 7 Continued

Antenna No.	Antenna Model	Frequency Range (MHz)	Physical Length (cm)	Gain (dBi)	Remarks	Mount Location (Roof/ Trunk)	Overlap FCC Bands (MHz)	FCC N_c	Actual N_c
UHF2 (450-520 MHz)									
9	HAE6013A(1)	380-470	29	4.15	1/2 wave	R/T	450-470	3	3
10	HAE6031A(1)	380-520	28	4.15	1/2 wave	R/T	450-512	5	6
11	HAE4003A(1)	450-470	16	2.15	1/4 wave	R	450-470	3	3
12	HAE4011A(1)	450-470	73.2	5.65	1/2 wave	R/T	450-470	3	3
13	HAE6015A(1)	450-520	26.2	4.15	1/2 wave	R/T	450-512	5	7
14	HAE6016A(1)	450-512	8.3	2.15	1/4 wave	R	450-512	5	6
15	*RAE4014ARB(1)	445-470	92.7 (450.0125 MHz) 90.5 (460 MHz) 89.0 (469.9875 MHz)	7.15	5/8 wave	R/T	450-470	3	3
16	HAE4004A	470-512	15	2.15	1/4 wave	R	470-512	4	4
17	HAE4012A	470-495	68.5	5.65	1/2 wave	R/T	470-495	3	3
18	HAE4013A	494-512	64.3	5.65	1/2 wave	R/T	494-512	3	3
19	*RAE4015ARM	470-494	89.0 (470.0125 MHz) 86.4 (482.5 MHz)	7.15	5/8 wave	R/T	470-494	3	3

			85.0 (493.9875 MHz)						
20	*RAE40416ARB	494-512	85.7 (494.9875 MHz) 83.6 (503 MHz) 83.3 (511.9875 MHz)	7.15	5/8 wave	R/T	494-512	3	3
7/800 (764-870 MHz)									
21	HAF4013A	764-870	6.1	5.15	1/4 wave	R/T	769-775; 799-824; 851-869	8	9
22	HAF4014A	764-870	57.7	5.15	1/4 wave	R/T	769-775; 799-824; 851-869	8	9
23	HAF4016A	764-870	9	2.15	1/4 wave	R/T	769-775; 799-824; 851-869	8	9
24	HAF4017A	764-870	34.5	5.15	1/4 wave	R/T	769-775; 799-824; 851-869	8	9
All bands (136-870 MHz)									
25	AN000131A01	136-870	55.7	2.15	1/4 wave	R	150.8-173.4 (VHF)	4	6
						R/T	406.1- 470 (UHF1)	5	7
						R/T	450-512 (UHF2)	5	6
						R/T	764-775; 799-824; 851-869 (7/800)	8	9
BT/WiFi / GPS									
26	AN000163A01	2400-2500	7	5.15	Monopole	R/T	2402-2480 (BT) ; 2412-2462 (WLAN)		

Notes:
(1): Antennas support UHF1 & UHF2 frequency range.
* Antenna length trimmed to frequency.

16.0 Test Results Summary

16.1 MPE Test Results Summary for LMR

Refer to the following appendices for MPE test results summary for each test configuration: antenna location, test positions (BS-Bystander, PB-Passenger Backseat, PF-Passenger Front seat), E/H field measurements, angle, antenna model & freq. range, maximum output power, initial power, TX frequency, max calculated power density results, applicable FCC/ICNIRP/ISED Canada specification limits and
% of the applicable specification limits.

- Appendix D for VHF
- Appendix E for UHF1
- Appendix F for UHF2
- Appendix G for 7/800

16.2 MPE Test Results for Bluetooth and WLAN

Maximum power for Bluetooth = 7.6 mW (10 mW * 76.1% duty cycle)
Maximum power for Bluetooth LE = 2.5 mW (2.5 mW * 100% duty cycle)
Maximum power for WLAN = 63.02 mW (63.1 mW *99.87 % duty cycle)

Bluetooth has higher source-based-time-averaging output power compare to Bluetooth LE and will be used for the MPE assessment.

MPE calculation was use to determine power density for these transmitters due to lower power. According to FCC's OET Bulletin 65 Edition 97-01 Section 2, calculations can be made to predict RF field strength and power density levels around typical RF sources. Equation (5) is generally accurate in far-field of an antenna.

Equation 5 – Power Density Calculation

$$S = \frac{P_t\,G}{4\pi d^2 L} F$$

Equation (5) accounts for the maximum duty cycle of the signal, and the factor, F, to provide a worst-case prediction of power density per FCC OET Bulletin 65, Edition 97-01 1997.

Where:
- S = power density (mW/cm^2)
- P_t = maximum output power scaled by the maximum duty cycle of the signal
- G = power gain of the antenna in the direction of interest relative to an isotropic radiator (dBi)
- d = distance from antenna (cm), *20 cm for more conservative estimation.*
- L = cable loss (dB), *2.2 dB with 17' PFP240 cable (attenuation 12.9 dB/100ft)*
- F = Enhancement factor

Table 8 summarized the MPE calculation for each standalone transmitter bands, Bluetooth and WLAN.

Table 8

Antenna #	Max Power (W)	Duty Cycle (%)	Tx Frequency (MHz)	Antenna Gain (dBi)	Cable Loss, L (dB)	Dist., d (cm)	(4)Enhance Factor, F	Max Calc. MPE (mW/cm^2)	MPE Spec Limit (mW/cm^2) FCC	% To FCC Spec Limit	ICNIRP	% To ICNIRP Spec Limit	ISED limit	% To ISED Spec Limit
Bluetooth														
AN000163A01	0.010	76.10%	2400.0	5.15	2.20	20	1.00	0.0030	1.00	0.30	1.00	0.30	0.53	0.56
WLAN														
AN000163A01	0.063	99.87%	2400.0	5.15	2.20	20	1.00	0.0247	1.00	2.47	1.00	2.47	0.53	4.62

16.3 Simultaneous Transmission

LMR bands can transmit simultaneously with Bluetooth or WLAN. Bluetooth and WLAN transmitters cannot transmit at the same time.

The highest percentage of limit for each standalone transmitters indicated in Table 9.

Table 9

Transmitters	Frequency Band (MHz)	Highest Percentage of Limit (%)		
		Passenger, Front Seat (PF)	Passenger, Back Seat (PB)	By-Stander (BS)
FCC				
LMR VHF	150.8 - 173.4	42.9 %	**250.1 %	85.5 %
LMR UHF1	406.1 - 470	27.4 %	**140.1 %	74.7 %
LMR UHF2	450 - 512	29.2 %	**140.1 %	51.1 %
LMR 7/800	769-775; 799-824; 851-869	22.3 %	31.7 %	38.7 %
Bluetooth	2402 - 2480	0.30 %	0.30 %	0.30 %
WLAN	2412 - 2462	2.47 %	2.47 %	2.47 %
ISED Canada				
LMR VHF	138 - 174	66.4 %	**387.5 %	**138.6 %
LMR UHF1	406.1 – 430; 450 -470	48.8 %	**246.6 %	**127.4 %
LMR UHF2	450 - 470	48.8%	**246.6 %	90.0 %
LMR 7/800	769-775; 799-824; 851-869	47.5%	67.2 %	83.4 %
Bluetooth	2402 - 2480	0.56 %	0.56 %	0.56 %
WLAN	2412 - 2462	4.62 %	4.62 %	4.62 %
Overall				
LMR VHF	136 - 174	66.4 %	**387.5 %	**138.6 %
LMR UHF1	380 - 470	50.1 %	**246.6 %	**127.4 %
LMR UHF2	450 -520	48.8 %	**246.6 %	90.0 %
LMR 7/800	764 – 805; 806 -870	47.5%	67.2 %	83.4 %
Bluetooth	2402 - 2480	0.56 %	0.56 %	0.56 %
WLAN	2400 – 2483.5	4.62 %	4.62 %	4.62 %

** Requires SAR Simulation.

Per KDB 447498 D01, simultaneous transmission MPE test exclusion applies when the sum of MPE ratios for all simultaneous transmitting antennas incorporated in a host device is ≤ 1.0, according to calculated/estimated, numerically modeled, or measured field strengths or power density.

Since WLAN source based average power is greater than Bluetooth and they both cannot transmit at the same time, the WLAN transmitter will be used to evaluate simultaneous transmission test exclusion. The highest combined power density percentage for simultaneous transmission indicated in Table 10.

Table 10

Designator	Simultaneous Transmission Scenario	Highest Combined Percentage of Limit (%)		
		Passenger, Front Seat (PF)	Passenger, Back Seat (PB)	Bystander (BS)
FCC	LMR VHF and WLAN	45.4 %	**252.6 %	88.0 %
	LMR UHF1 and WLAN	29.9 %	**142.6 %	77.2 %
	LMR UHF2 and WLAN	31.7 %	**142.6 %	53.6 %
	LMR 7/800 and WLAN	24.8 %	34.2 %	41.2 %
ISED Canada	LMR VHF and WLAN	71.0 %	**392.1 %	**143.2 %
	LMR UHF1 and WLAN	53.4 %	**251.2 %	**132.0 %
	LMR UHF2 and WLAN	53.4 %	**251.2 %	94.6 %
	LMR 7/800 and WLAN	52.1 %	71.8 %	88.0 %
Overall	LMR VHF and WLAN	71.0 %	**392.1 %	**143.2 %
	LMR UHF1 and WLAN	54.7 %	**251.2 %	**132.0 %
	LMR UHF2 and WLAN	53.4 %	**251.2 %	94.6 %
	LMR 7/800 and WLAN	52.1 %	71.8 %	88.0 %

** Requires SAR Simulations.

17.0 Conclusion

The assessments for this device were performed with an output power range as indicated in section 16.1 (for LMR) and 16.2 (for BT/WLAN). The maximum allowable output power is equal to the upper limit of the final test factory transmit power specification listed in Table 6. The highest power density results for LMR and BT/WLAN transmitters scaled to maximum allowable power output are indicated in Table 12 and 13 for internal/passenger to the vehicle, and external/bystander to the vehicle.

Table 12: Maximum MPE RF Exposure Summary (LMR)

Designator	Transmitters	Frequency Band (MHz)	Passenger (mW/cm²)	Bystander (mW/cm²)
FCC	LMR VHF	150.8 - 173.4	0.50	0.17
	LMR UHF1	406.1 - 470	0.42	0.20
	LMR UHF2	450 - 512	0.42	0.15
	LMR 7/800	769-775; 799-824; 851-869	0.17	0.22
ISED Canada	LMR VHF	138 - 174	0.50	0.18
	LMR UHF1	406.1 – 430; 450 -470	0.42	0.20
	LMR UHF2	450 -470	0.42	0.15
	LMR 7/800	769-775; 799-824; 851-869	0.17	0.22
Overall	LMR VHF	136 - 174	0.50	0.18
	LMR UHF1	380 - 470	0.42	0.20
	LMR UHF2	450 -520	0.42	0.15
	LMR 7/800	764 – 805; 806 -870	0.17	0.22

Table 13: Maximum MPE RF Exposure Summary (BT/WLAN)

Designator	Transmitters	Frequency Band (MHz)	Passenger (mW/cm²)	Bystander (mW/cm²)
FCC / ISED Canada / Overall	Bluetooth	2402 – 2480	0.0030	0.0030
	WLAN	2412-2462	0.0247	0.0247

These MPE results herein demonstrate compliance to the FCC, ISED Canada and ICNIRP Occupational/Controlled Exposure limit.

However, FCC rules require compliance for Passengers and Bystanders to the FCC General Population/Uncontrolled limits. The configurations in Appendix D, E, F and G results in bold font exceed the General Population / Uncontrolled MPE limits.

Table below summarized Maximum Combined MPE percentage for configuration exceed General Population / Uncontrolled MPE limits.

Table 14

Designator	Simultaneous Transmission Scenario	Highest Combined Percentage of General Population/Uncontrolled Limit (%)	
		Passenger	Bystander
FCC	LMR VHF and WLAN	**252.6 %	88.0 %
	LMR UHF1 and WLAN	**142.6 %	77.2 %
	LMR UHF2 and WLAN	**142.6 %	53.6 %
	LMR 7/800 and WLAN	34.2 %	41.2 %
ISED Canada	LMR VHF and WLAN	**392.1 %	**143.2 %
	LMR UHF1 and WLAN	**251.2 %	**132.0 %
	LMR UHF2 and WLAN	**251.2 %	94.6 %
	LMR 7/800 and WLAN	71.8 %	88.0 %
Overall	LMR VHF and WLAN	**392.1 %	**143.2 %
	LMR UHF1 and WLAN	**251.2 %	**132.0 %
	LMR UHF2 and WLAN	**251.2 %	94.6 %
	LMR 7/800 and WLAN	71.8 %	88.0 %

** Requires SAR Simulations to demonstrate compliance to the basic requirements.

Although MPE is a convenient method of demonstrating RF Exposure requirements, SAR is recognized as the “basic restriction”. For those configurations in Appendix D, E, F and G results in bold font, compliance to the General Population / Uncontrolled SAR 1g limit of 1.6 W/kg is demonstrated through SAR computational analysis.

The computational results show that this device, when used with the offered antennas in accordance with the user manual instructions, exhibits the maximum peak average SAR values indicated in the Table below for the configurations requiring SAR analysis.

Table 15

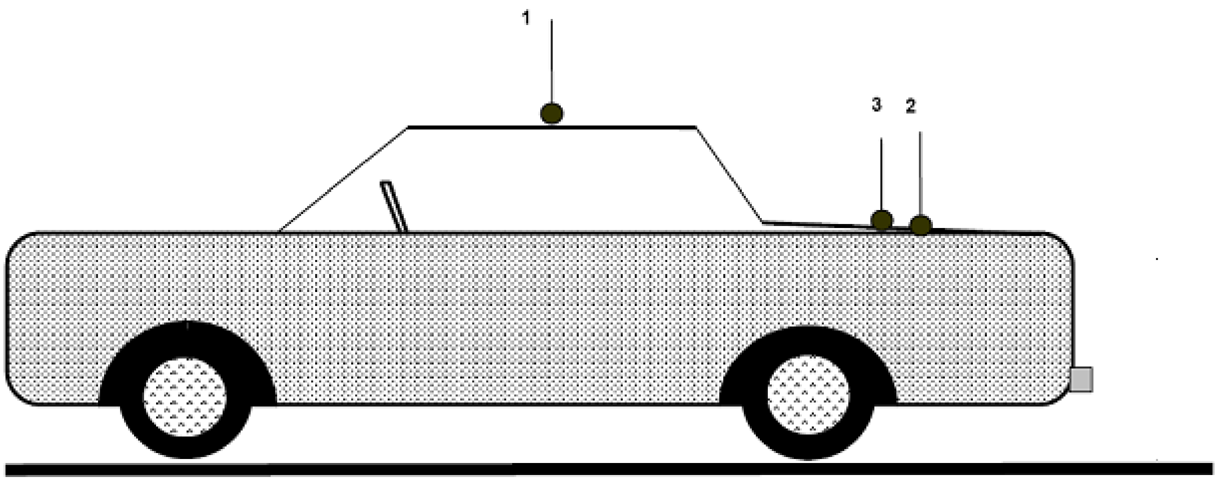
Designator	Frequency Band (MHz)	Maximum peak average SAR (1g)
FCC	150.8 - 173.4	1.25 W/kg
	406.1 - 470	1.39 W/kg
	450 - 512	0.96 W/kg
ISED Canada	138 - 174	1.25 W/kg
	406.1 – 430; 450 -470	1.39 W/kg
	450 -470	0.96 W/kg
Overall	136 - 174	1.25 W/kg
	380 - 470	1.39 W/kg
	450 -520	0.96 W/kg

18.0 User Instructions Considerations

In order to facilitate the task of professional users, the Safety Manual for this radio requires that bystanders be kept at least 3 ft (90 cm) from the vehicle during radio use, even though the reported MPE tests data demonstrates compliance at 2 ft (60 cm) from the vehicle in the 700/800 MHz band.

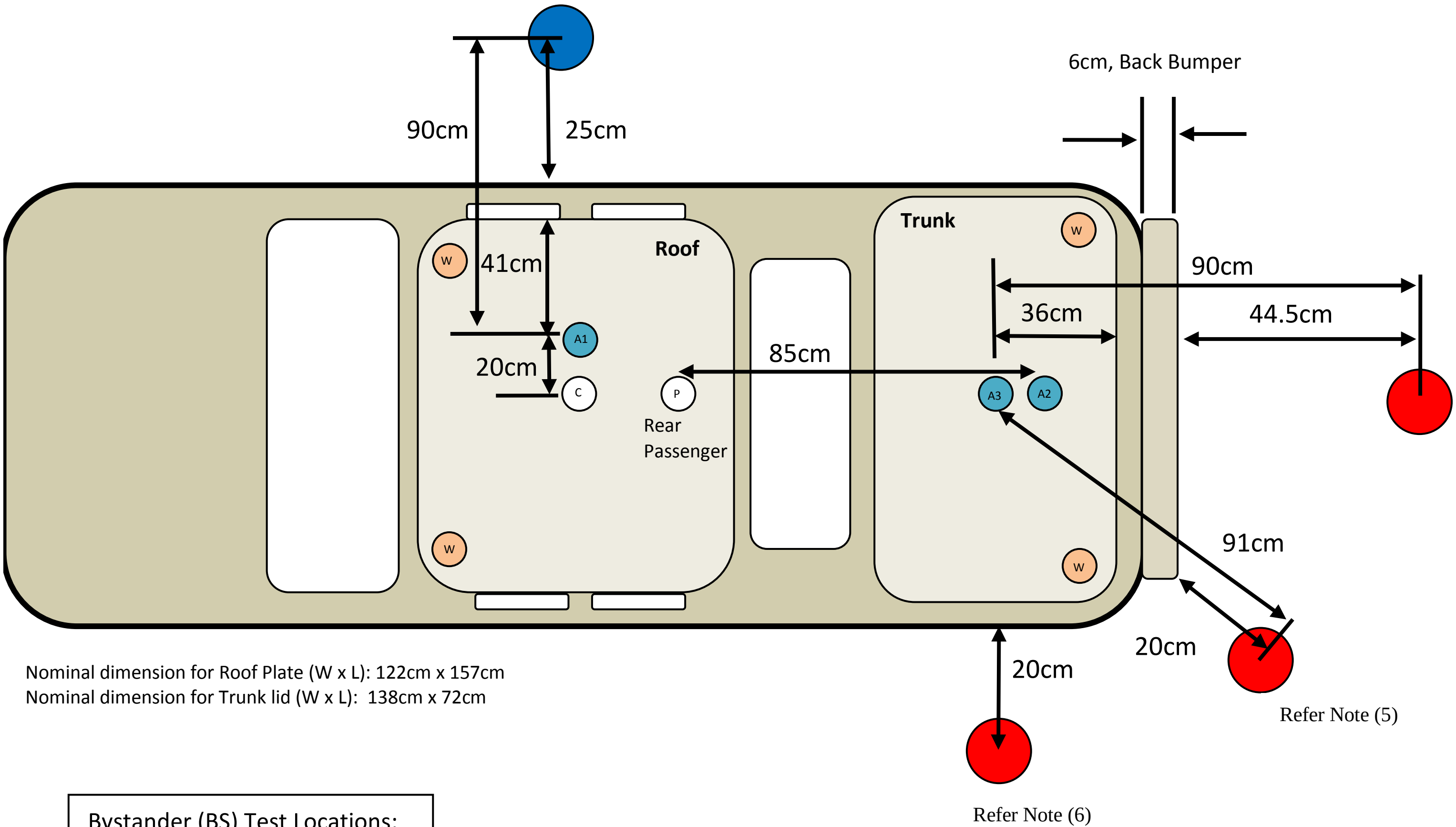
Appendix A - Antenna Locations, Test Distances, and Cable Losses

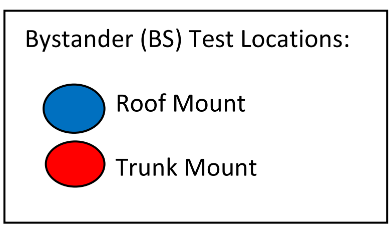
Antenna locations



1. Roof (20cm from center)
2. Trunk (85cm from back of the back seat)
3. Trunk (center)

Bystander Test Distance (90 cm)

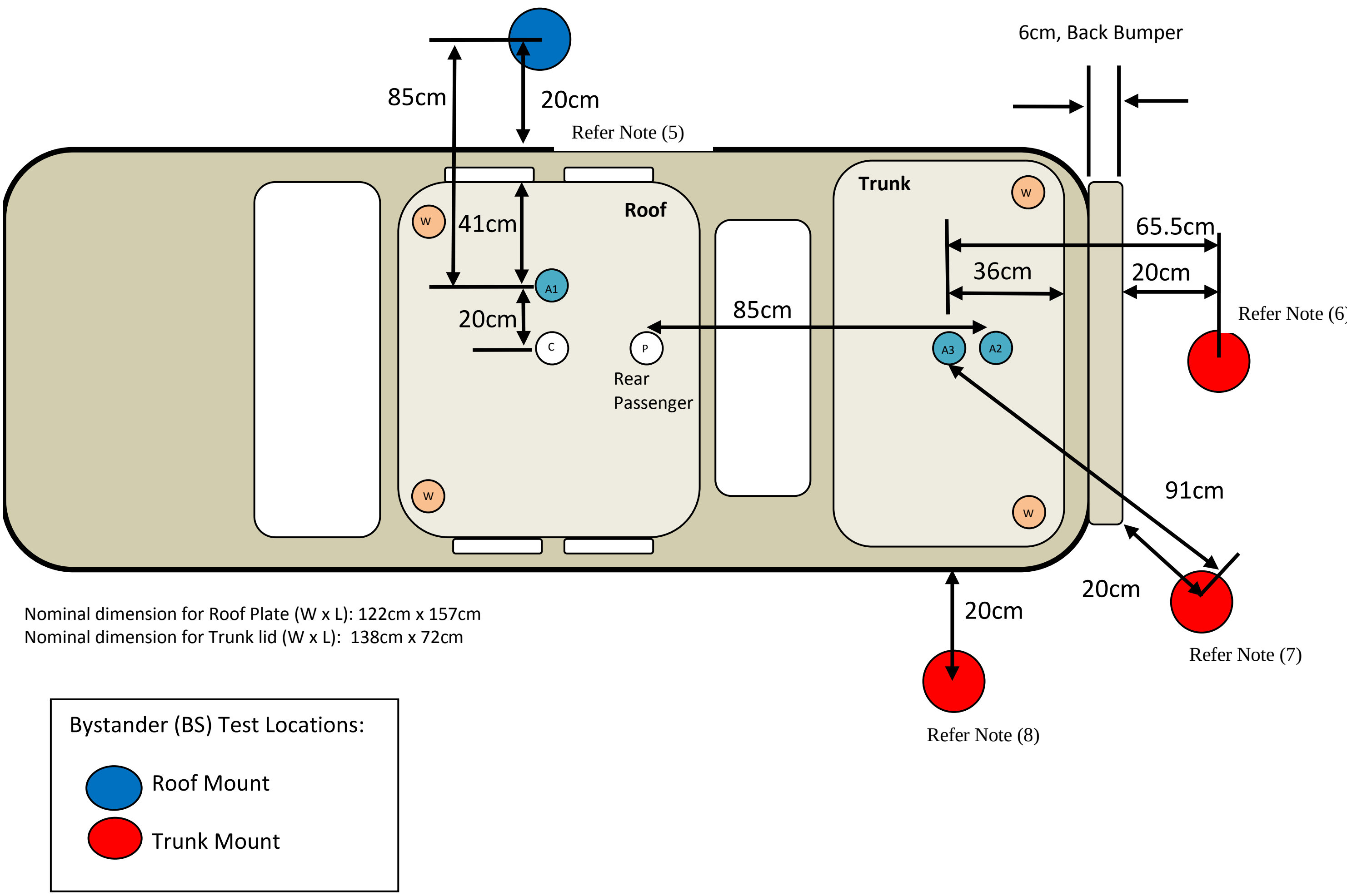




Notes:

1) Antenna location A1: LMR antennas roof mount (20cm offset from center).
2) Antenna location A2: LMR antennas trunk mount for passenger, back seat testing.
3) Antenna location A3: LMR antennas trunk mount for bystander testing.
4) Antenna location W: Total 4 locations identified for BT/WLAN antenna mounting. (If LMR antennas installed at trunk, BT/WLAN should installed at roof and vice versa).
5) Total distance between Bystander 45 degree angles from the centered-trunk mount antenna is 91cm to maintain a minimum 20cm separation between probe sensor and vehicle body.
6) Total distance between Bystander 90 degree angle from the centered-trunk mount antenna is 90cm (by moving antenna location A3 12cm from center of the trunk).

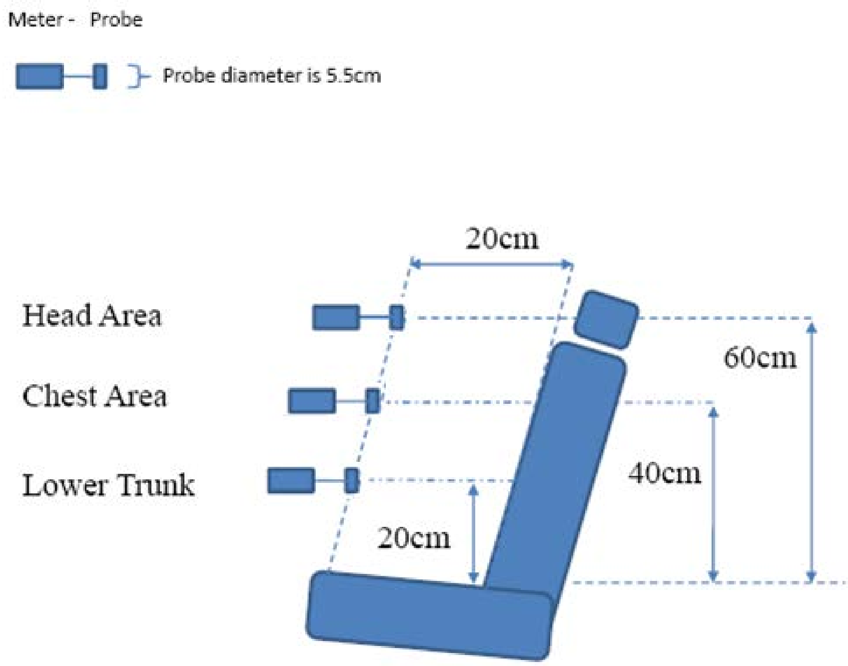
Bystander Test Distance (60 cm)



Notes:

1) Antenna location A1: LMR antennas roof mount (20cm offset from center).
2) Antenna location A2: LMR antennas trunk mount for passenger, back seat testing.
3) Antenna location A3: LMR antennas trunk mount for bystander testing.
4) Antenna location W: Total 4 locations identified for BT/WLAN antenna mounting. (If LMR antennas installed at trunk, BT/WLAN should installed at roof and vice versa)
5) Total distance between Bystanders from roof mount antenna is 85cm. This is the closet distance to maintain minimum 20cm separation between probe sensor and vehicle body.
6) Total distance between Bystanders from the centered-trunk mount antenna is 60cm and 65.5cm at bumper to maintain a minimum 20cm separation between probe sensor and vehicle body.
7) Total distance between Bystander 45 degree angles from the centered-trunk mount antenna is 91cm to maintain a minimum 20cm separation between probe sensor and vehicle body.
8) Total distance between Bystander 90 degree angles from the centered-trunk mount antenna is 60cm (by moving antenna location A3 42cm from center of the trunk).

Seat scan areas
(Applicable to both front and back seats)



Cable Losses

Test Cable

Teflon RG58A/U Loss Per 100 Feet

160 MHz - 5 dB

450 MHz - 9 dB

1 GHz - 13.8 dB

Customer Cable

RG-58A/U Loss Per 100 Feet (For LMR)

136 MHz – 5.5 dB

450 MHz – 9.6 dB

900 MHz – 13.9 dB

PFP 240 Loss Per 100 Feet (For BT/WLAN)

2500 MHz - 12.9 dB

Appendix B - Probe Calibration Certificates

Service Test Report
QAF 1126, 03/11
Report ID: 114201

ETS-LINDGREN
An ESCO Technologies Company
1301 Arrow Point Drive
Cedar Park, Texas 78613
(512) 531-6400

ETS-LINDGREN
An ESCO Technologies Company
Tracking # SC000035042
Equipment Check
Attested by GC Date: 16-May-16
www.ets-lindgren.com

Certificate of Test Conformance

Page 1 of 1

Reference: S 000035042

Customer: Keysight Cal Lab C/O Motrola Solutions - 8000 West Sunrise Blvd. Plantation, FL. 33322

The instrument listed below has been tested and verified to Internal Quality Standards. Test data is Not Applicable. Equipment used during instrument testing is controlled by laboratory compliance with ISO/IEC 17025-2005 and ANSI/NCSL Z540-1-1994 using ETS-Lindgren Quality Management System internal procedures.

Manufacturer	ETS-Lindgren
Instrument Type	RF Survey Meter
Model	HI-2200
Serial Number/ID	00086316

Status In
In Tolerance
Date Completed
16-May-16
Status Out
Compliant with Internal Quality Standards

Remarks
Functional test performed with customer's probe S/N 00153632.

I would like to take this opportunity to express our appreciation for using ETS-Lindgren for your EMI test equipment services and I am looking forward to continued business with your organization. Please feel free to contact our offices at (512) 531-6400, if you have any questions regarding this report.

Sincerely,

George Cisneros
Calibration Supervisor

Date Attested: 16-May-16

ilac-MRA ACCREDITED Calibration Laboratory Certificate 1207.01

Cert I.D.: 114197

ETS·LINDGREN
An ESCO Technologies Company
1301 Arrow Point Drive
Cedar Park, Texas 78613
(512) 531-6400

ETS·LINDGREN An ESCO Technologies Company
Track# S000035042 Ltd Cal ☐
By FM Dat 16-May-16
Next Cal Due
www.ets-lindgren.com

Certificate of Calibration Conformance

Page 1 of 3

The instrument identified below has been individually calibrated in compliance with the following standard(s):
IEEE 1309 - 2013, Institute of Electrical and Electronics Engineers, Standard for Calibration of Electromagnetic Field Sensors and Probes, Excluding Antennas from 9 kHz to 40 GHz

Environment: Laboratory MTE is maintained in a temperature controlled environment with ambient conditions from 18 to 28 C, relative humidity less than 90%. The instrument under test has been calibrated in a suitable environment using an EMCO TEM Cell 5101C, GTEM! 5305 and an RF Shielded EMC Chamber which is conducive to maintaining accurate and reliable measurement quality.

Manufacturer:	ETS-Lindgren	**Operating Range:**	100kHz - 5GHz
Model Number:	E100	**Instrument Type:**	Isotropic Probe > 1 GHz
Serial Number/ ID:	*00153632*	**Date Code:**	
Tracking Number:	**S 000035042**	**Alternate ID:**	
Date Completed:	16-May-16	**Customer:**	Keysight Cal Lab C/O Motrola Solutions - 8000 West Sunrise Blvd. Plantation, FL. 33322
Test Type:	Standard Field, Field Strength		

Calibration Uncertainty: k=2, (95% Confidence Level) Std Field Method 100kHz - 6 GHz, +/-0.7 dB, Isotropicity +/- 0.86

Test Remarks: Probe received in tolerance thus before and after data are the same.

Calibration Traceability: All Measuring and Test Equipment (M/TE) identified below are traceable to the SI units through the National Institute for Standards and Technology (NIST) or other recognized National Metrology Institute. Calibration Laboratory and Quality System controls are compliant with ISO/IEC 17025-2005 and ANSI/NCSL Z540-1-1994.

Standards and Equipment Used:
Make / Model / Name / S/N / Recall Date

HP	8648C	Signal Generator	3836U02236	25-Feb-17
Marconi	2024	Signal Generator	112343/043	02-Feb-17
Hewlett Packard	E4422B	Signal Generator	US40050591	22-Jul-16
Rohde & Schwarz	SMB 100A	Signal Generator	101558	17-Aug-16
Keysight	E9304A	Power Sensor	MY56100005	18-Mar-17
Agilent	E9304A	Power Sensor	MY41499013	01-Mar-17
Agilent	E9304A	Power Sensor	MY41499012	17-Jun-16
Agilent	E4419B	Power Meter	MY40510693	22-Jan-17
Agilent	E4419B	Power Meter	GB40202754	22-Oct-16
Agilent	U2004A	USB Power Sensor	MY50000280	08-Oct-16
Rohde & Schwarz	857.8008.02	Power Meter NRVD	100451	17-Jul-16
Hewlett Packard	83650L	Synthesized Sweep Gen	3844A00422	21-Jan-17
Rohde & Schwarz	NRV-Z55	Thermal Power Sensor	100037	16-Jul-16
Rohde & Schwarz	NRV-Z55	Thermal Power Sensor	100362	14-Nov-16
Rohde & Schwarz	NRV-Z55	Thermal Power Sensor	100363	18-Aug-16
Rohde & Schwarz	NRP-Z91	Power Sensor	100733	16-Jul-16
Rohde & Schwarz	NRP-Z91	Power Sensor	100732	16-Jul-16

Condition of Instrument Upon Receipt:
In Tolerance to Internal Quality Standards

On Release:
In Tolerance to Internal Quality Standards

Calibration Completed By
Francisco D Maldonado, Calibration Technician

Attested and Issued on 16-May-16
George Cisneros, Calibration Supervisor

CALIBRATION REPORT

Electric Field Sensor

Model	S/N
E100	00153632
HI-2200	00086316

Date: 16 May 2016

New Instrument
_ Other
_ Out of Tolerance
X Within Tolerance

Frequency Response

Frequency Response		Nominal Field	Cal Factor*	Deviation
	MHz	V/m	(Eapplied/Eindicated)	dB
1	0.1	20	1.30	-2.26
2	0.5	20	1.08	-0.64
3	1	20	1.08	-0.64
4	3	20	1.01	-0.12
5	15	20	1.00	-0.02
6	27.12	20	1.00	-0.04
7	100	20	1.02	-0.15
8	200	20	1.00	0.03
9	1	20	1.08	-0.64
10	15	20	1.00	-0.02
11	30	20	1.00	-0.04
12	75	20	1.01	-0.11
13	100	20	1.02	-0.15
14	150	20	1.01	-0.06
15	200	20	1.00	0.03
16	250	20	0.99	0.12
17	300	20	0.99	0.10
18	400	20	0.99	0.08
19	500	20	1.03	-0.25
20	600	20	1.04	-0.36
21	700	20	1.07	-0.55
22	800	20	1.08	-0.69
23	900	20	1.03	-0.24
24	1000	20	0.99	0.13
25	2000	20	1.05	-0.40
26	2450	20	1.08	-0.69
27	3000	20	1.06	-0.54
28	3500	20	1.01	-0.12
29	4000	20	1.03	-0.24
30	5000	20	1.32	-2.41
31	5500	20	1.45	-3.25
32	6000	20	1.41	-3.00

* Corrected electric field values (V/m) can be obtained by multiplying the Cal Factor with the indicated E field readings.

Linearity

maximum linearity deviation is 0.34 dB

(measurements taken from 0.3 V/m to 800 V/m at 27.12 MHz)

Test Conditions

Calibration performed at ambient room temperature: 23 ±3°C

ETS-LINDGREN
An ESCO Technologies Company

PROBE ROTATIONAL RESPONSE

Model	E100
S/N	00153632
Report	S000035042
Date	Date of Calibration 16 May 2016
Time	01:40:27 PM
Isotropy *	+ 0.270 dB/ -0.270 dB

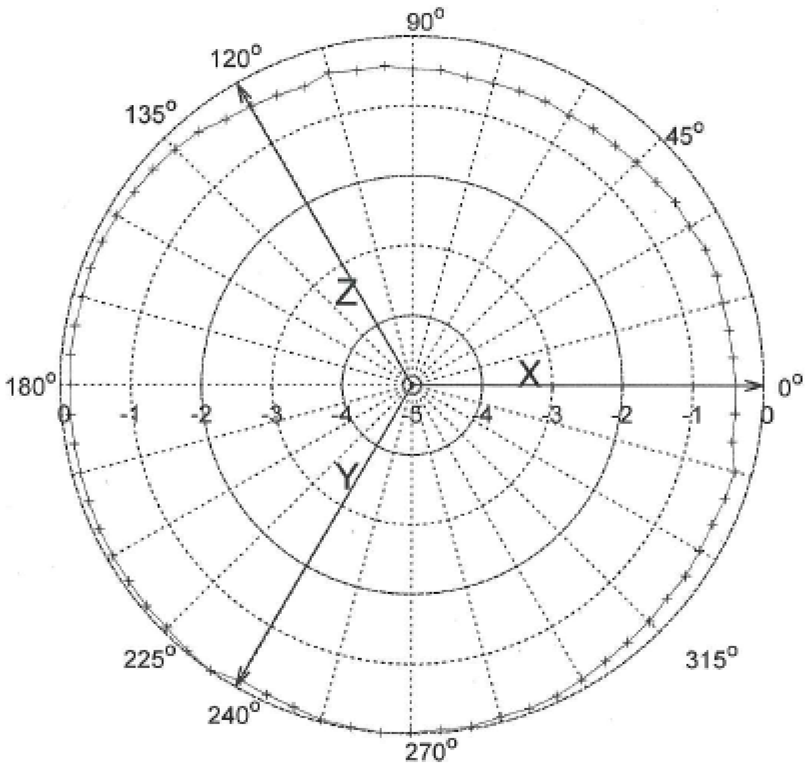


Figure 1: Probe Isotropic Response Chart.

Isotropic response is measured in a 20 V/m field at 400 MHz
*Isotropy is the maximum deviation from the geometric mean as defined by IEEE 1309-2013.

Page 3 of 3

ilac-MRA A2LA ACCREDITED Calibration Laboratory Certificate 1297.01

Cert I.D.: 114199

ETS·LINDGREN
An ESCO Technologies Company
1301 Arrow Point Drive
Cedar Park, Texas 78613
(512) 531-6400

ETS·LINDGREN An ESCO Technologies Company
Ltd Cal ☐
By FM Date 16-May-16
Next Cal Due
www.ets-lindgren.com

Certificate of Calibration Conformance

Page 1 of 2

The instrument identified below has been individually calibrated in compliance with the following standard(s):
IEEE 1309 - 2013, Institute of Electrical and Electronics Engineers, Standard for Calibration of Electromagnetic Field Sensors and Probes, Excluding Antennas from 9 kHz to 40 GHz

Environment: Laboratory MTE is maintained in a temperature controlled environment with ambient conditions from 18 to 28 C, relative humidity less than 90%. The instrument under test has been calibrated in a suitable environment using an EMCO TEM Cell 5101C, GTEM! 5305 and an RF Shielded EMC Chamber which is conducive to maintaining accurate and reliable measurement quality.

Manufacturer:	ETS-Lindgren	**Operating Range:**	5-300MHz / 30mA/m-10A/m
Model Number:	H200	**Instrument Type:**	Isotropic Magnetic Field Probe (2)
Serial Number / ID:	00206937		
Date Completed:	16-May-16		
Test Type:	Standard Field, Field Strength		
Calibration Uncertainty: k=2, (95% Confidence Level)	Direct Field Method 1.15dB		

Test Remarks:

Calibration Traceability: All Measuring and Test Equipment (M/TE) identified below are traceable to the SI units through the National Institute for Standards and Technology (NIST) or other recognized National Metrology Institute. Calibration Laboratory and Quality System controls are compliant with ISO/IEC 17025-2005 and ANSI/NCSL Z540-1-1994.

Standards and Equipment Used: Make / Model / Name / S/N / Recall Date

HP	8648C	Signal Generator	3836U02236	25-Feb-17
Marconi	2024	Signal Generator	112343/043	02-Feb-17
Hewlett Packard	E4422B	Signal Generator	US40050591	22-Jul-16
Rohde & Schwarz	SMB 100A	Signal Generator	101558	17-Aug-16
Keysight	E9304A	Power Sensor	MY56100005	18-Mar-17
Agilent	E9304A	Power Sensor	MY41499013	01-Mar-17
Agilent	E9304A	Power Sensor	MY41499012	17-Jun-16
Agilent	E4419B	Power Meter	MY40510693	22-Jan-17
Agilent	E4419B	Power Meter	GB40202754	22-Oct-16
Agilent	U2004A	USB Power Sensor	MY50000280	08-Oct-16

Condition of Instrument On Release:
In Tolerance to Internal Quality Standards

Calibration Completed By
Francisco D Maldonado, Calibration Technician

Attested and Issued on 16-May-16
George Cisneros, Calibration Supervisor

CALIBRATION REPORT

Magnetic Field Sensor

Model	*S/N*
H200	00206937
HI-2200	00086316

Date: 16 May 2016

X New Instrument
_ Other
_ Out of Tolerance
Within Tolerance

Frequency Response

Frequency Response		*Nominal Field*	*Cal Factor**	*Deviation*
	MHz	*A/m*	(Eapplied/Eindicated)	*dB*
1	10	30	1.07	-0.58
2	15	30	1.05	-0.42
3	30	30	1.01	-0.09
4	50	30	0.99	0.05
5	75	30	0.96	0.33
6	100	30	0.90	0.94
7	150	30	0.87	1.18
8	175	30	0.84	1.53
9	200	30	0.80	1.94
10	250	30	0.70	3.12
11	300	30	0.56	5.09

* Corrected magnetic field values (A/m) can be obtained by multiplying the Cal Factor with the indicated H field readings.

Linearity

maximum linearity deviation is 0.06 dB

(measurements taken from 30 mA/m to 9 A/m at 27.12 MHz)

Test Conditions

Calibration performed at ambient room temperature: 23 ±3°C

The above sensor was calibrated to factory specifications. This calibration is performed per IEEE 1309 standard. All equipment used are traceable to US National Institute of Standards and Technology (NIST).

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Appendix C - Photos of Assessed Antennas

(Refer to Exhibit 7B)