MOTOROLA SOLUTIONS

MS ISO/IEC 17025
TESTING
SAMM No.0826

DECLARATION OF COMPLIANCE: MPE ASSESSMENT Part 1 of 3

Motorola Solutions
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: 7/09/2018
Report Revision: A

Responsible Engineer:	Saw Sun Hock (EME Engineer)
Report author:	Saw Sun Hock (EME Engineer)
Date(s) Tested:	4/25/2018-6/29/2018
Manufacturer:	Motorola Solutions Inc.
Date submitted for test:	12/4/2018
DUT Description:	APX8500 mobile All Bands (VHF, UHF, 7/800)
Test TX mode(s):	CW
Max. Power output:	120W (136-174 MHz), 120 W (380-484 MHz), 48W (485-512 MHz), 30W (512-520 MHz), 36W (764-805 MHz), 42W (806-870 MHz); 63.1 mW (WLAN 2.4 GHz 802.11b), 25 mW (WLAN 2.4 GHz 802.11g/n) ; 31.6 mW (WLAN 5 GHz 802.11 a/n/ac)
TX Frequency Bands:	136-174 MHz; 380-520 MHz; 764-805 MHz; 806-870 MHz; WLAN 2400-2483.5 MHz; WLAN 5180-5825 MHz
Signaling type:	FM, TDMA, FHSS (Bluetooth), 802.11b/g/n (WLAN 2.4 GHz), 802.11 a/n/ac (WLAN 5 GHz)
Model(s) Tested:	M37TXS9PW1AN (HUW1001A)
Model(s) Certified:	M37TXS9PW1AN (HUW1001A)
Serial Number(s):	681P3A0098
Classification:	Occupational/Controlled Environment
FCC ID:	AZ492FT7118; 150.8-173.4 MHz, 406.1-512 MHz, 769-775 MHz, 799-824 MHz, 851-869 MHz, 2412-2462 MHz, 5180-5825 MHz

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.

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.

Tiong

Tiong Nguk Ing
Deputy Technical Manager
Approval Date: 7/9/2018

Tiong Nguk Ing Digitally signed by Tiong Nguk Ing Date: 2018.07.09 07:36:21 +08'00'

Document Revision History

Date	Revision	Comments
7/09/2018	A	Initial release

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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 M37TXS9PW1AN (HUW1001A).

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)	NA	NA	NA	NA	0.42	*212.1	0.41	*202.8
	406.1 – 470 (LMR UHF1)	NA	NA	NA	NA	0.12	45.4	0.27	89.9
	450 – 512 (LMR UHF2)	NA	NA	NA	NA	0.11	37.1	0.27	89.9
	769-775; 799-824; 851-869 (LMR 7/800)	0.13	23.6	0.13	22.9	0.04	8.4	0.06	12.1
DTS	2412 – 2462 (WLAN 2.4 GHz)	0.0301	3.01	0.0301	3.01	0.0301	3.01	0.0301	3.01
NII	5180 - 5825 (WLAN 5 GHz)	0.0120	1.20	0.0120	1.20	0.0120	1.20	0.0120	1.20
Simultaneous (Highest Combined Percentage of Limit)			26.61		25.91		*215.11		*205.81

Note: * Requires SAR Simulation.

3.0 Abbreviations / Definitions

CNR: Calibration Not Required
CW: Continuous Wave
DUT: Device Under Test
EME: Electromagnetic Energy
FM: Frequency Modulation
MPE: Maximum Permissible Exposure
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 D01 SAR Measurement 100 MHz to 6 GHz v01r04
- 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				
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 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					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					

Table 3 Continued – General Population / Uncontrolled 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
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	00086887 00224511 00224521	2/9/2018	2/9/2019
Survey Meter Probe – E-Field	ETS Model HI-2200 ETS Model E100	00206805 00206767	8/15/2017	8/15/2018
Survey Meter Probe – H-Field	ETS Model HI-2200 ETS Model H200	00086316 00206937	8/25/2017	8/25/2018

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	7.1	N	1.00	7.1	50.4	∞
Survey Meter Calibration	0.0	N	1.00	0.0	0.0	¥
Hemispherical Isotropy	8.0	R	1.73	4.6	21.33	∞
Linearity	5.0	R	1.73	2.9	8.33	∞
Pulse Response	1.0	R	1.73	0.6	0.33	∞
RF Ambient Noise	3.0	R	1.73	1.7	3.00	∞
RF Reflections	8.0	R	1.73	4.6	21.33	∞
Probe Positioning	10.0	R	1.73	5.8	33.333	∞
Test sample Related					0.00	
Antenna Positioning	3.0	N	1.00	3.0	9.0	∞
Power drift	5.0	R	1.73	2.9	8.33	∞
Bystander measurement uncertainty	4.8	N	1.00	4.8	23.04	∞
Passenger measurement uncertainty	8.1	N	1.00	8.1	65.61	∞
Combined Standard Uncertainty		RSS		15.6	15.6	∞
Expanded Uncertainty (95% CONFIDENCE LEVEL)		*k*=2		31	31	

9.0 Product and System Description

This mobile device operates in the LMR bands using either frequency modulation (FM) with 100% transmit duty cycle or TDMA signals with maximum of 50% transmit duty cycle. For conservative assessment, FM signal was tested. A duty factor of 50% applies for PTT operation mode.

This device also contains WLAN technology for data capabilities over 802.11b/g/n 2.4 GHz and 802.11 a/n/ac 5 GHz wireless networks.

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

Technologies	Bands (MHz)		Duty Cycle (%)	Max power (W)
LMR	136-174 (VHF band)		50% (PTT)	120
	380- 470 (UHF1) 450- 520 (UHF2)	380–484	50% (PTT)	120
		485-512	50% (PTT)	48
		512-520	50% (PTT)	30
	764-805 ; 806-870 (7/800 band)	764-805	50% (PTT)	36
		806-870	50% (PTT)	42
WLAN	2400 – 2483.5 (802.11b/g/n)		100%	0.0631 (802.11 b) 0.025 (802.11 g) 0.025 (802.11 n)
	5180-5825 (802.11 a/n/ac)		100%	0.0316

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 12.0, 13.0 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 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 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 Variability Requirement for External/Bystander vehicle MPE measurement

If all the MPE bystander measurements for a particular antenna are below 50% of the MPE limit, no variability testing for that antenna is required.

If one or more MPE bystander measurements for a particular is between 50-80% of the MPE limit, with no results > 80%, variability testing shall be done on the single worst case for that antenna.

For any MPE bystander measurement above 80% of the MPE limit, variability testing shall be done for all of such configuration. When SAR simulation is performed for a particular antenna configuration to determine compliance, variability measurements are not required for that antenna configuration.

15.0 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

16.0 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	Roof	150.8-162	3	5
2	HAD4017A	146-174	46.2	2.15	1/4 wave	Roof	150.8-173.4	4	5
3	HAD4021A	136-174	51.7	2.15	1/4 wave	Roof	150.8-173.4	4	6
4	HAD4006A	136-144	52.0	2.15	1/4 wave	Roof	NA	0	3
5	HAD4007A	144-150.8	49.0	2.15	1/4 wave	Roof	150.8	1	2
6	HAD4008A	150.8-162	45.5	2.15	1/4 wave	Roof	150.8-162	3	3
7	HAD4009A	162-174	43.0	2.15	1/4 wave	Roof	162-173.4	3	3
8	*HAD4022A	132-174	130.0 (136 MHz) 118.5 (144 MHz) 114 (150.8 MHz) 102.7 (158.0125 MHz) 96.5 (165.0125 MHz) 89.9 (173.0125 MHz)	5.15	5/8 wave	Roof	150.8-173.4	4	6
9	*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	Roof	150.8-173.4	4	6
UHF1 (380-470 MHz)									
10	HAE6010A	380-433	63.5	5.65	1/2 wave	Roof	406.1-433	3	5
11	HAE6011A	380-433	91.0	7.15	5/8 wave	Roof	406.1-433	3	5
12	HAE6012A	380-433	18.2	2.15	1/4 wave	Roof	406.1-433	3	5
13	HAE6013A(1)	380-470	29	4.15	1/2 wave	Roof	406.1 -470	6	8
14	HAE6031A(1)	380-520	28	4.15	1/2 wave	Roof	406.1-470	5	7
15	HAE4003A(1)	450-470	16	2.15	1/4 wave	Roof	450-470	3	3
16	HAE4011A(1)	450-470	73.2	5.65	1/2 wave	Roof	450-470	3	3
17	HAE6015A(1)	450-520	26.2	4.15	1/2 wave	Roof	450-470	3	3
18	HAE6016A(1)	450-512	8.3	2.15	1/4 wave	Roof	450-470	3	3
19	*RAE4014ARB(1)	445-470	92.7 (450.0125 MHz) 90.5 (460 MHz) 89.0 (469.9875 MHz)	7.15	5/8 wave	Roof	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)									
13	HAE6013A(1)	380-470	29	4.15	1/2 wave	Roof	450-470	3	3
14	HAE6031A(1)	380-520	28	4.15	1/2 wave	Roof	450-512	5	6
15	HAE4003A(1)	450-470	16	2.15	1/4 wave	Roof	450-470	3	3
16	HAE4011A(1)	450-470	73.2	5.65	1/2 wave	Roof	450-470	3	3
17	HAE6015A(1)	450-520	26.2	4.15	1/2 wave	Roof	450-512	6	7
18	HAE6016A(1)	450-512	8.3	2.15	1/4 wave	Roof	450-512	6	6
19	*RAE4014ARB(1)	445-470	92.7 (450.0125 MHz) 90.5 (460 MHz) 89.0 (469.9875 MHz)	7.15	5/8 wave	Roof	450-470	3	3
20	HAE4004A	470-512	15	2.15	1/4 wave	Roof	470-512	4	4
21	HAE4012A	470-495	68.5	5.65	1/2 wave	Roof	470-495	3	3
22	HAE4013A	494-512	64.3	5.65	1/2 wave	Roof	494-512	3	3
23	*RAE4015ARM	470-494	89.0 (470.0125 MHz) 86.4 (482.5 MHz) 85.0 (493.9875 MHz)	7.15	5/8 wave	Roof	470-494	3	3
24	*RAE40416ARB	494-512	85.7 (494.9875 MHz) 83.6 (503 MHz) 83.3 (511.9875 MHz)	7.15	5/8 wave	Roof	494-512	3	3
7/800 (764-870 MHz)									
25	HAF4013A	764-870	6.1	5.15	1/4 wave	Roof/ Trunk	769-775; 799-824; 851-869	8	9
26	HAF4014A	764-870	57.7	5.15	1/4 wave	Roof/ Trunk	769-775; 799-824; 851-869	8	9
27	HAF4016A	764-870	9	2.15	1/4 wave	Roof/ Trunk	769-775; 799-824; 851-869	8	9
28	HAF4017A	764-870	34.5	5.15	1/4 wave	Roof/ Trunk	769-775; 799-824; 851-869	8	9
All bands (136-870 MHz)									
29	AN000131A01	136-870	55.7	2.15	1/4 wave	Roof	150.8-173.4 (VHF)	4	6
						Roof	406.1- 470 (UHF1)	5	7
						Roof	450-512 (UHF2)	5	6
						Roof/ Trunk	769-775; 799-824; 851-869 (7/800)	8	9
WLAN									
30	PMAN5100A	2400-2500	5.7 (L) x 1.9 (W)	6		Glass mount	2412-2462	3	3
31	PMAN5101A	2400-2500 / 4900-5900	5.4 (L) x 1.32 (W)	6 / 3.2		Glass mount	2412-2462 ; 5180-5825	3	3
32	AN000163A01	2400-2500 / 4900-5900	7	5.15	Monopole	Trunk	2412-2462 ; 5180-5825	3	3
33	AN000163A05	2400-2500 / 4900-5900	7	5.15	Monopole	Roof/ Trunk	2412-2462 ; 5180-5825	3	3

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

17.0 Test Results Summary

17.1 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 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

17.2 MPE Test Results for WLAN

Antenna PMAN5100A support WLAN 2.4 GHz only, was intended for mounting on the windshield of the vehicle. This antenna should be installed close to the top, and on the front windshield only. Antennas AN000163A01 and AN000163A05 support WLAN 2.4 GHz / 5 GHz should be installed at roof or trunk of the vehicle. WLAN 2.4 GHz and 5 GHz will not transmit simultaneously.

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

$$S = \frac{P_t G}{4\Pi d^2} F$$

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
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
d = distance from antenna
F = Enhancement factor [1 or 2.56 for predicting ground-level field strength]

Table 8 summarized the MPE calculation for WLAN.

Table 8

Antenna #	Max Power (W)	Duty Cycle (%)	Tx Frequency (MHz)	Antenna Gain (dBi)	Cable Loss, L (dB)	Dist., d (cm)	Enhance Factor, F	Max Calc. MPE (mW/cm^2)	FCC Limit (mW/cm2)	% To FCC Spec Limit
WLAN 2.4 GHz										
PMAN5100A	0.0631	100.00%	2412.0	6.00	2.20	20	1.00	0.0301	1.00	3.01
PMAN5100A	0.0631	100.00%	2437.0	6.00	2.20	20	1.00	0.0301	1.00	3.01
PMAN5100A	0.0631	100.00%	2462.0	6.00	2.20	20	1.00	0.0301	1.00	3.01
PMAN5101A	0.0631	100.00%	2412.0	6.00	3.00	20	1.00	0.0250	1.00	2.50
PMAN5101A	0.0631	100.00%	2437.0	6.00	3.00	20	1.00	0.0250	1.00	2.50
PMAN5101A	0.0631	100.00%	2462.0	6.00	3.00	20	1.00	0.0250	1.00	2.50
AN000163A01 / AN000163A05	0.0631	100.00%	2412.0	5.15	2.20	20	1.00	0.0248	1.00	2.48
AN000163A01 / AN000163A06	0.0631	100.00%	2437.0	5.15	2.20	20	1.00	0.0248	1.00	2.48
AN000163A01 / AN000163A07	0.0631	100.00%	2462.0	5.15	2.20	20	1.00	0.0248	1.00	2.48
WLAN 5 GHz										
AN000163A01 / AN000163A05	0.0316	100.00%	5180.0	5.15	3.47	20	1.00	0.009	1.00	0.93
AN000163A01 / AN000163A06	0.0316	100.00%	5502.5	5.15	3.47	20	1.00	0.009	1.00	0.93
AN000163A01 / AN000163A07	0.0316	100.00%	5825.0	5.15	3.47	20	1.00	0.009	1.00	0.93
PMAN5101A	0.0316	100.00%	5180.0	3.20	4.00	20	1.00	0.0052	1.00	0.52
PMAN5101A	0.0316	100.00%	5502.5	3.20	4.00	20	1.00	0.0052	1.00	0.52
PMAN5101A	0.0316	100.00%	5825.0	3.20	4.00	20	1.00	0.0052	1.00	0.52

Notes:
1) Distance from antenna (d), 20cm for more conservative estimation.
2) Cable loss (L),
   - 2.20 dB with 17' PFP240 cable for 2.4 GHz WLAN (Antenna PMAN5100A, AN000163A0, AN000163A05)
   - 3.00 dB with 1' RG316 and 16' PFP195 cable for 2.4 GHz WLAN (Antenna PMAN5101A)
   - 3.47 dB with 17' PFP240 cable for 5.0 GHz WLAN (Antenna AN000163A0, AN000163A05)
   - 4.00 dB with 1' RG316 and 16' PFP195 cable for 5.0 GHz WLAN (Antenna PMAN5101A)
3) Numeric gain (G), factor in the cable loss with conversion 10^((dBi-L)/10)
4) Enhancement Factor (F), 1 (Ground reflection already factor in during antenna characterization)

17.3 Simultaneous Transmission

LMR bands can transmit simultaneously with WLAN 2.4 GHz or WLAN 5 GHz. WLAN 2.4 GHz and WLAN 5 GHz cannot transmit at the same time.

The highest percentage of limit for each standalone transmitters indicated in Table 10.

Table 9

Transmitters	Frequency Band (MHz)	Highest Percentage of Limit (%)		
		Passenger, Front Seat (PF)	Passenger, Back Seat (PB)	By-Stander (BS)
LMR VHF	150.8 - 173.4	88.0 %	*212.1 %	*202.8 %
LMR UHF1	406.1 - 470	22.7 %	45.4 %	89.9 %
LMR UHF2	450 - 512	22.6 %	37.1 %	89.9 %
LMR 7/800	769-775; 799-824; 851-869	20.9 %	23.6 %	22.9 %
WLAN 2.4 GHz	2412 - 2462	3.01 %	3.01 %	3.01 %
WLAN 5 GHz	5180 - 5825	0.93 %	0.93 %	0.93 %

* 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.

Calculated Maximum Power density for WLAN 2.4 GHz greater than WLAN 5 GHz and both transmitters cannot transmit at the same time. Thus, WLAN 2.4 GHz will be used to evaluate simultaneous transmission test exclusion. The highest combined power density percentage for simultaneous transmission indicated in Table 10.

Table 10

Simultaneous Transmission Scenario	Highest Combined Percentage of Limit (%)		
	Passenger, Front Seat (PF)	Passenger, Back Seat (PB)	Bystander (BS)
LMR VHF and WLAN	91.01 %	*215.11 %	*205.81 %
LMR UHF1 and WLAN	25.71 %	48.41 %	92.91 %
LMR UHF2 and WLAN	25.61 %	40.11 %	92.91 %
LMR 7/800 and WLAN	23.91 %	26.61 %	25.91 %

* Requires SAR Simulations.

18.0 Conclusion

The assessments for this device were performed as indicated in section 17.1 (for LMR) and 17.2 (for WLAN) with an output power range listed in Table 6. 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 WLAN transmitters scaled to maximum allowable power output are indicated in Table 11 for internal/passenger to the vehicle, and external/bystander to the vehicle.

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 with '*' exceed the General Population / Uncontrolled MPE limits.

Table 11: Maximum MPE RF Exposure Summary

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)	NA	NA	NA	NA	0.42	*212.1	0.41	*202.8
	406.1 – 470 (LMR UHF1)	NA	NA	NA	NA	0.12	45.4	0.27	89.9
	450 – 512 (LMR UHF2)	NA	NA	NA	NA	0.11	37.1	0.27	89.9
	769-775; 799-824; 851-869 (LMR 7/800)	0.13	23.6	0.13	22.9	0.04	8.4	0.06	12.1
DTS	2412 – 2462 (WLAN 2.4 GHz)	0.0301	3.01	0.0301	3.01	0.0301	3.01	0.0301	3.01
NII	5180 - 5825 (WLAN 5 GHz)	0.009	0.93	0.009	0.93	0.009	0.93	0.009	0.93
Simultaneous (Highest Combined Percentage of Limit)			26.61		25.91		*215.11		*205.81

Notes:
* Requires SAR Simulations to demonstrate compliance to the basic requirements.
NA – VHF, UHF1 and UHF2 antennas restricted for trunk mount installation.

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 with ‘*’, 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 12

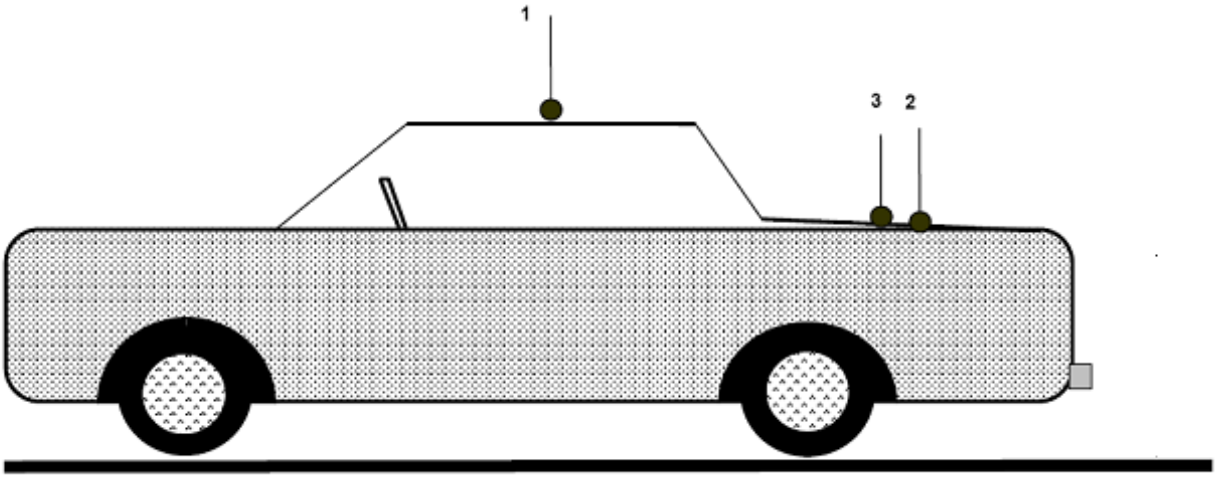
Exposure Conditions	Maximum peak average SAR (1g)
Passenger	0.57 W/kg
Bystander	1.03 W/kg

19.0 User Instructions Considerations

In order to facilitate the requirements for occupational exposure limits, the Safety Manual for this radio requires the radio operator to maintain 90 cm in all directions between the vehicle and external persons while transmitting.

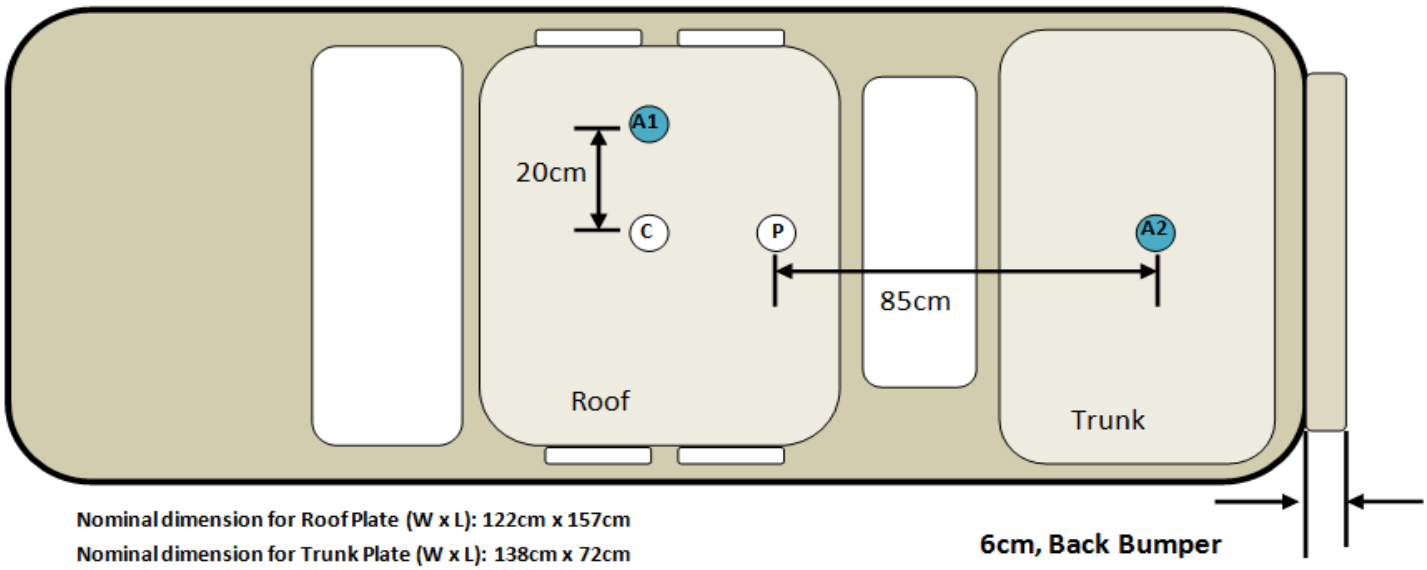
Appendix A - Antenna Locations, Test Distances, and Cable Losses

Antenna locations



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

Passenger Antenna mounting
(LMR VHF, UHF R1, UHF R2 and 7/800 band)



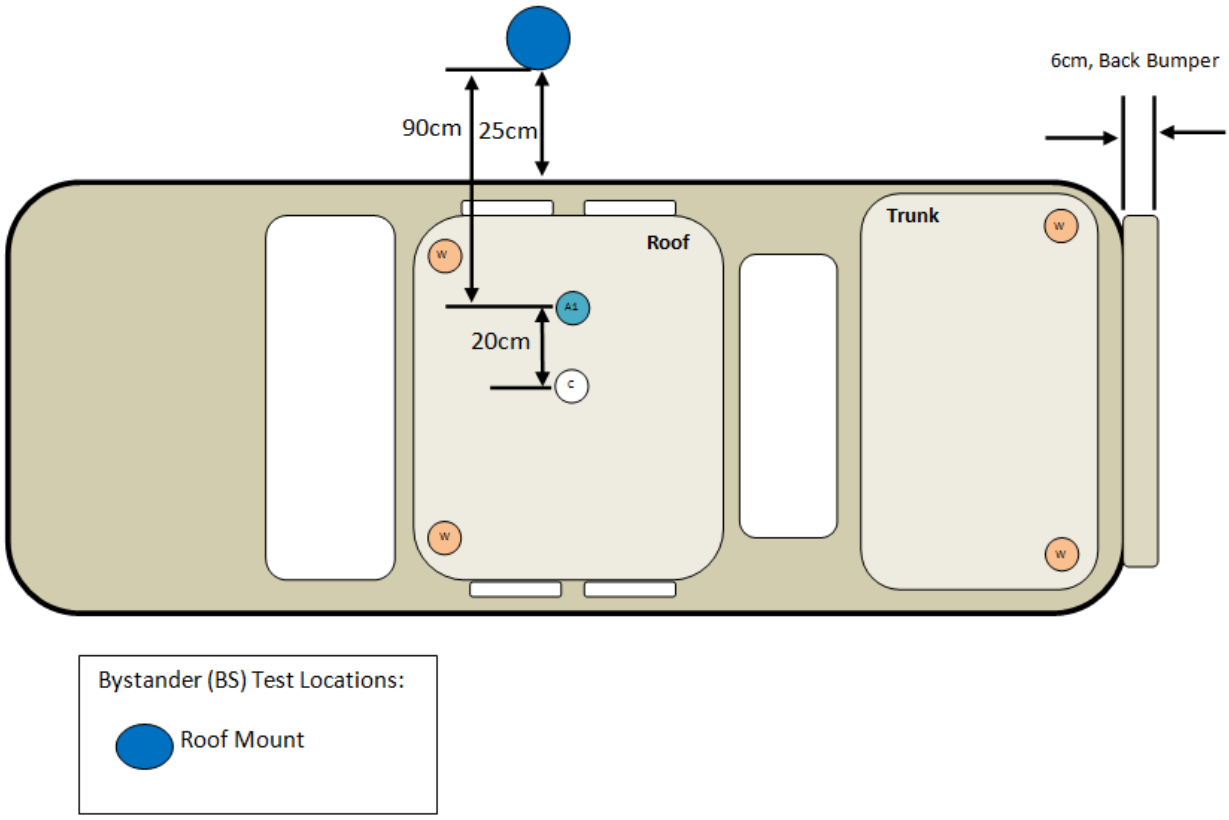
Notes:

1.) Antenna location A1: APX mobile radio roof antenna mounting locations for passenger back and front testing (for LMR VHF, UHF R1, UHF R2 and 7/800 bands)

2.) Antenna location A2: APX mobile trunk antenna mounting locations for passenger back and front testing (for LMR 7/800 band only).

3.) Total distance between trunk mount antenna and rear passenger is 85cm

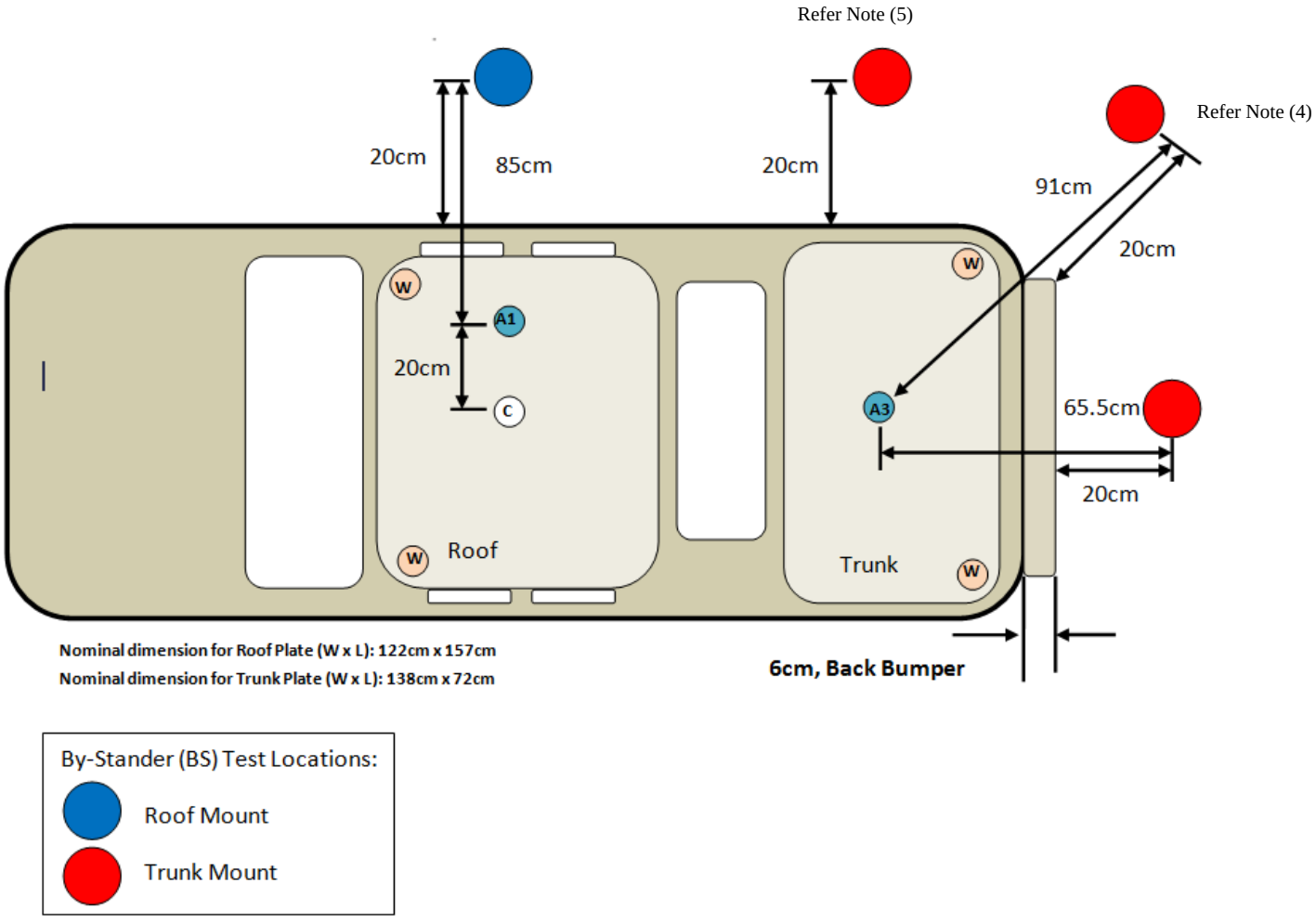
Bystander Antenna mounting and test locations for distance 90cm (LMR VHF, UHF R1and UHF R2 bands)



Notes:

1.) Antenna location A1: LMR antennas roof mount for bystander testing (20cm offset from center)
2.) Antenna location W: Total 4 locations identified for WLAN antenna mounting. (If LMR antennas installed at trunk, WLAN antenna should installed at roof and vice versa)

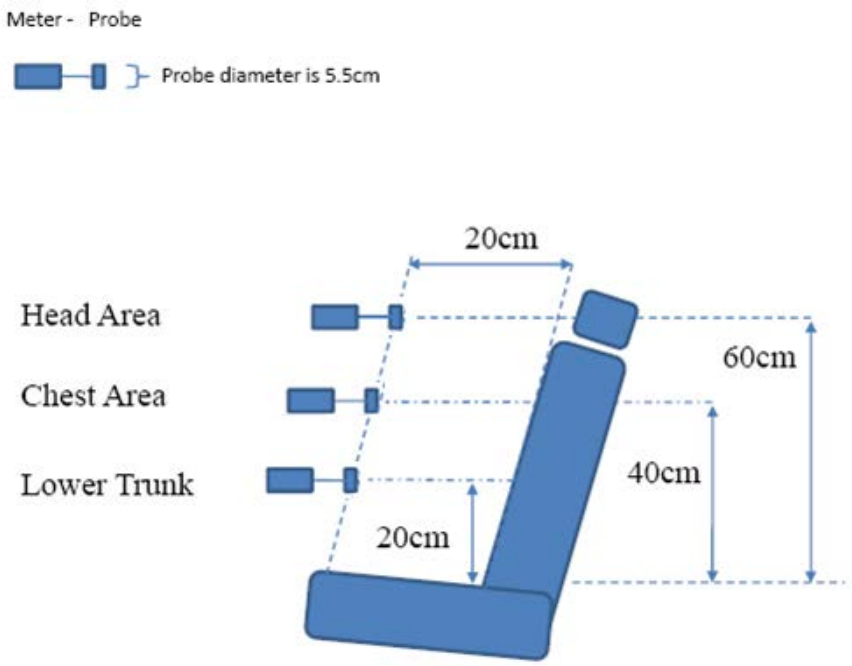
Bystander Antenna mounting and test locations for distance 60cm (LMR 7/800 band)



Notes:

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

136 MHz – 5.5 dB

450 MHz – 9.6 dB

900 MHz – 13.9 dB

PFP 240 Loss Per 100 Feet (For WLAN)

2500 MHz - 12.9 dB

5800 MHz – 20.4 dB

Appendix B - Probe Calibration Certificates

Service Test Report
QAF 1126, 03/11
Report ID: 123337

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

ETS-LINDGREN
An ESCO Technologies Company
Tracking # S000041107
Equipment Check
Attested by GC Date: 09-Feb-18
www.ets-lindgren.com

Certificate of Test Conformance

Page 1 of 1

Reference: S 000041107

Customer: Motorola Solutions Malaysia Sdn. Bhd. - 2A, Medan Bayan Lepas, Baymen Lepas Technoplex, 11900 Bayan Lupas, Pulau Pinang, Malaysia

The instrument listed below has been tested and verified to Internal Quality Standards. Test data is Attached. 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	00086887

Status In
In Tolerance
Date Completed
09-Feb-18
Status Out
Compliant with Internal Quality Standards

Remarks
Functional test performed with customer's new probes E100 s/n 00224511 and H200 s/n 00224521.

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: 09-Feb-18

MSI0438

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 SS Date 09-Feb-18
Next Cal Due
www.ets-lindgren.com

Cert I.D.: 123340

Certificate of Calibration Conformance

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 5305/5402 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:	**00224511**		
Date Completed:	09-Feb-18		
Test Type:	Standard Field, Field Strength		
Calibration Uncertainty:	Std Field Method	100kHz - 6 GHz, +/-0.64 dB, Linearity +/- 0.95 dB, Isotropicity +/- 0.86	

k=2, (95% Confidence Level)

Test Remarks: Calibration performed with HI-2200 s/n 00086887.

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	28-Mar-18
Keysight	E9304A	Power Sensor	MY56100039	10-May-18
Hewlett Packard	E4422B	Signal Generator	US40050591	28-Mar-18
Agilent	E4419B	Power Meter	MY45104171	27-Jan-19
Rohde & Schwarz	SMB 100A	Signal Generator	101558	13-Sep-18
Agilent	E9304A	Power Sensor	MY41499013	15-Mar-18
Agilent	E9304A	Power Sensor	MY41499012	15-Mar-18
Rohde & Schwarz	NRP-Z91	Power Sensor	100733	26-Jan-19
Agilent	E4419B	Power Meter	MY40510693	27-Jan-19
Marconi	2024	Signal Generator	112343/043	05-Apr-18
Rohde & Schwarz	NRVD	Power Meter	100451	06-Sep-18
Hewlett Packard	83650L	Synthesized Sweep Gen	3844A00422	20-Dec-18
Hewlett Packard	E4419B	Power Meter	US39250717	10-Aug-18
Keysight	E9304A	Power Sensor	MY56100005	15-Mar-18
Rohde & Schwarz	NRV-Z55	Thermal Power Sensor	100352	12-Jun-18
Rohde & Schwarz	NRV-Z55	Thermal Power Sensor	100037	06-Sep-18
Rohde & Schwarz	NRV-Z55	Thermal Power Sensor	100362	21-Jun-18
Rohde & Schwarz	NRP-Z91	Power Sensor	100734	06-Sep-18
Rohde & Schwarz	NRP-Z91	Power Sensor	100246	06-Sep-18

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

Calibration Completed By
Shawn Schmitt, Calibration Technician

Attested and Issued on 09-Feb-18
George Cisneros, Calibration Supervisor

CALIBRATION REPORT

Electric Field Sensor

Model	*S/N*
E100	00224511
HI-2200	00086887

Date: 08 Feb 2018

X New Instrument
_ Other
_ Out of Tolerance
_ Within Tolerance

Frequency Response

Frequency Response		*Nominal Field*	*Cal Factor**	*Deviation*
	MHz	*V/m*	(Eapplied/Eindicated)	*dB*
1	0.1	20	1.49	-3.48
2	0.5	20	1.12	-1.00
3	1	20	1.05	-0.41
4	3	20	1.01	-0.11
5	15	20	1.01	-0.10
6	27.12	20	1.01	-0.12
7	100	20	1.03	-0.23
8	200	20	1.02	-0.15
9	1000	20	0.99	0.08
10	1400	20	1.03	-0.24
11	1800	20	1.08	-0.68
12	2000	20	1.10	-0.81
13	2400	20	1.11	-0.92
14	2800	20	1.08	-0.66
15	3000	20	1.06	-0.52
16	3400	20	1.05	-0.46
17	3800	20	1.04	-0.32
18	4000	20	1.07	-0.57
19	5000	20	1.40	-2.94

* 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 0.69 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	00224511
Date	Date of Calibration 08 February 2018
Time	09:26:18 AM
Isotropy *	+ 0.275 dB/ -0.275 dB

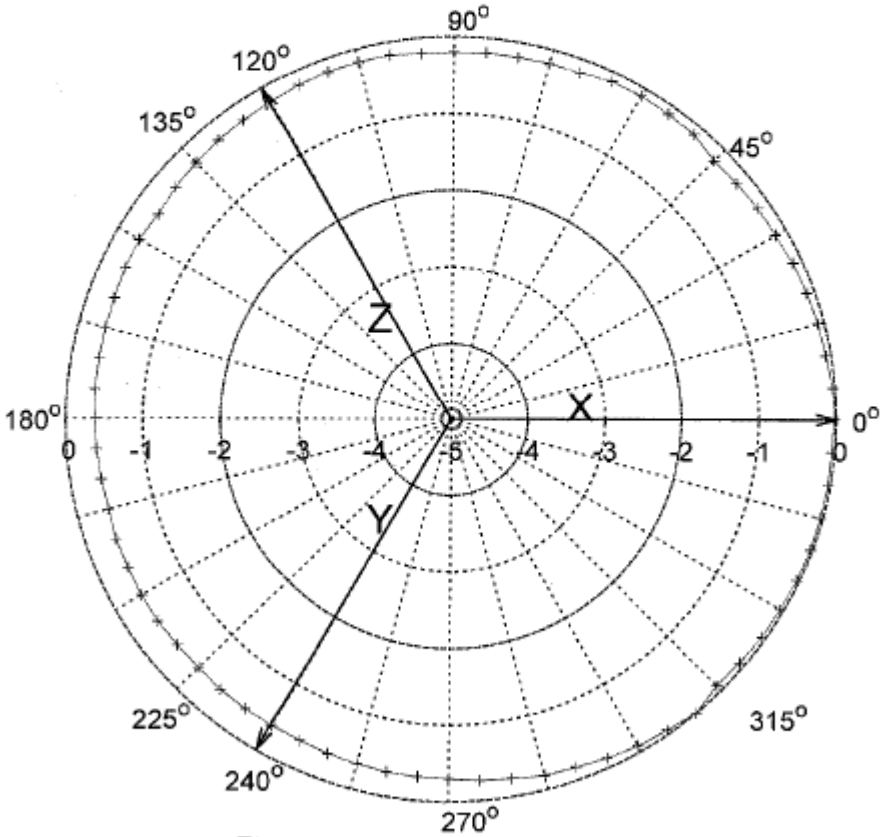


Figure 1: Probe Isotropic Response Chart.

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.

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MSI04439

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

ETS-LINDGREN
An ESCO Technologies Company
Ltd Cal ☐
By SS Date 09-Feb-18
Next Cal Due

Cert I.D.: 123339

Certificate of Calibration Conformance

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 5305/5402 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:	**00224521**		
Date Completed:	09-Feb-18		
Test Type:	Standard Field, Field Strength		
Calibration Uncertainty:	Direct Field Method 1.15dB		
k=2, (95% Confidence Level)			

Test Remarks: Calibration performed with HI-2200 s/n 00086887.

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	28-Mar-18
Keysight	E9304A	Power Sensor	MY56100039	10-May-18
Hewlett Packard	E4422B	Signal Generator	US40050591	28-Mar-18
Agilent	E4419B	Power Meter	MY45104171	27-Jan-19
Rohde & Schwarz	SMB 100A	Signal Generator	101558	13-Sep-18
Agilent	E9304A	Power Sensor	MY41499013	15-Mar-18
Agilent	E9304A	Power Sensor	MY41499012	15-Mar-18
Rohde & Schwarz	NRP-Z91	Power Sensor	100733	26-Jan-19
Agilent	E4419B	Power Meter	MY40510693	27-Jan-19

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

Calibration Completed By
Shawn Schmitt, Calibration Technician

Attested and Issued on 09-Feb-18
George Cisneros, Calibration Supervisor

CALIBRATION REPORT

Magnetic Field Sensor

Model	*S/N*
H200	00224521
HI-2200	00086887

Date: 09 Feb 2018

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	13.56	0.08	1.04	-0.38
2	27.12	0.08	1.02	-0.20
3	100	0.08	0.96	0.32
4	150	0.08	0.87	1.18
5	175	0.08	0.83	1.60

* 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 0.54 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).

Page 2 of 2

Service Test Report
QAF 1126, 03/11
Report ID: 120864
Lab ID:1207.01-Calibration

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

ETS-LINDGREN
Tracking # S000039359
Equipment Check
Attested by GC Date: 15-Aug-17
www.ets-lindgren.com

Certificate of Test Conformance

Page 1 of 1

Reference: S 000039359

Customer: Motorola Solutions Malaysia Sdn. Bhd. - Plot 2A, Medan Bayan Lepas, Mukim 12, S.W.D. - Bayan Lepas - Penang 11900 - Malaysia

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	00206805

Status In
In Tolerance
Date Completed
15-Aug-17
Status Out
Compliant with Internal Quality Standards

Remarks
Functional test performed with customer's probe S/N 00206767.

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: 15-Aug-17

ETS·LINDGREN
An ESCO Technologies Company

Dear ETS-Lindgren Customer,

The Certificate of Calibration accompanying this product states the date this unit was calibrated according to ETS-Lindgren procedures. According to ISO 17025, para 5.10.4.4 we are advised not to indentify an instrument recommended calibration interval, in complying with this requirement we have not included a cal due/recal date on the certificate or the calibration label. Therefore, the recalibration recall date of this unit should be based on when the product is placed in service by the user, plus the user internal calibration interval as defined by the customer's quality system. We have determined that the calibration of this product is not adversely affected by storage prior to its initial receipt by the customer.

ANSI C63series recommends a calibration interval of 12 months. To determine the date for recalibration, the customer should use the appropriate start date and apply either the industry recommended calibration interval on the calibration label, or an interval that satisfies their organizations quality system requirements. This label should then be applied to the instrument.

The recalibration due date should be annotated on the calibration label provided.

For information regarding the establishment of calibration intervals, please contact us via our web page at www.ets-lindgren.com . You may also call your local ETS-Lindgren Sales Representative or our home office in Cedar Park, TX at (512) 531-6400 for more information.

Sincerely,

Ronald W. Bethel
Quality Assurance Mgr

Recal Recommendation Notice (6-10)

1301 Arrow Point Drive • Cedar Park, Texas 78613 • Phone 512.531.6400 • Fax 512.531.6500
info@ets-lindgren.com • www.ets-lindgren.com

ACCREDITED Calibration Laboratory Certificate 1127.01

Cert I.D.: 120863

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

ETS-LINDGREN
An ESCO Technologies Company
Track# S000039359 Ltd Cal ☐
By MR Dat 15-Aug-17
Next Cal Due
www.ets-lindgren.com

Certificate of Calibration Conformance

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 5305/5402 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:	*00206767*	**Date Code:**	
Tracking Number:	**S 000039359**	**Alternate ID:**	
Date Completed:	15-Aug-17	**Customer:**	Motorola Solutions Malaysia Sdn. Bhd. - Plot 2A, Medan Bayan Lepas, Mukim 12, S.W.D. - Bayan Lepas - Penang 11900 - Malaysia
Test Type:	Standard Field, Field Strength		

Calibration Uncertainty: Std Field Method 100kHz - 6 GHz, +/-0.64 dB, Linearity +/- 0.95 dB, Isotropicity +/- 0.86

k=2, (95% Confidence Level)

Test Remarks: Probe received in tolerance thus before and after data are the same. Probe calibrated with HI-2200 S/N 00206605.

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	28-Mar-18
Keysight	E9304A	Power Sensor	MY56100039	10-May-18
Marconi	2024	Signal Generator	112343/043	05-Apr-18
Agilent	N5181B	MXG Signal Generator	MY51350051	05-Dec-17
Agilent	E9304A	Power Sensor	MY41499013	15-Mar-18
Agilent	E9304A	Power Sensor	MY41499012	15-Mar-18
Agilent	N5181A	MXG Analog Signal Gene	MY50140851	08-Mar-18
Agilent	E4419B	Power Meter	MY40510693	27-Jan-18
Agilent	U2004A	USB Power Sensor	MY50000280	06-Dec-17
Hewlett Packard	83650L	Synthesized Sweep Gen	3844A00422	22-Sep-17
Rohde & Schwarz	857.8008.02	Power Meter NRVD	828110/019	29-Nov-17
Rohde & Schwarz	NRV-Z55	Thermal Power Sensor	100363	03-Nov-17
Rohde & Schwarz	NRP-Z91	Power Sensor	100733	03-Nov-17
Rohde & Schwarz	NRP-Z91	Power Sensor	100732	03-Nov-17
Rohde & Schwarz	NRV-Z55	Thermal Power Sensor	100358	23-Nov-17

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

On Release:
In Tolerance to Internal Quality Standards

Calibration Completed By
Maynard Reich, Calibration Technician

Attested and issued on 15-Aug-17
George Cisneros, Calibration Supervisor

CALIBRATION REPORT

Electric Field Sensor

Model	*S/N*
E100	00206767
HI-2200	00206805

Date: 14 Aug 2017

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	1	20	1.07	-0.59
2	15	20	1.00	0.03
3	30	20	1.00	-0.01
4	75	20	1.00	-0.02
5	100	20	1.00	0.00
6	150	20	1.01	-0.07
7	200	20	0.98	0.18
8	250	20	1.00	0.04
9	300	20	1.00	0.02
10	400	20	1.00	0.00
11	500	20	1.04	-0.35
12	600	20	1.05	-0.42
13	700	20	1.07	-0.60
14	800	20	1.09	-0.76
15	900	20	1.04	-0.33
16	1000	20	0.99	0.06
17	2000	20	1.01	-0.05
18	2450	20	1.08	-0.64
19	3000	20	1.10	-0.83
20	3500	20	1.04	-0.37
21	4000	20	1.06	-0.49
22	5000	20	1.28	-2.17
23	5500	20	1.49	-3.46
24	6000	20	1.43	-3.12

* 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

Page 2 of 3

ETS·LINDGREN
An ESCO Technologies Company

PROBE ROTATIONAL RESPONSE

Model	E100
S/N	00206767
Report	S000039359
Date	Date of Calibration 15 August 2017
Time	12:04:21 PM
Isotropy *	+ 0.200 dB/ -0.200 dB

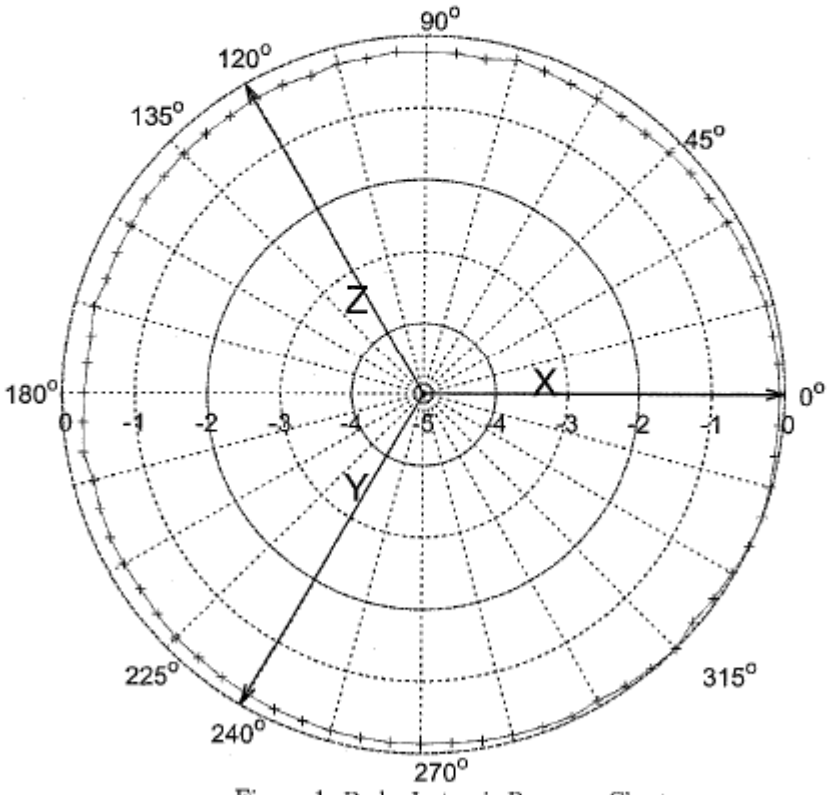

Figure 1: Probe Isotropic Response Chart.

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

Service Test Report
QAF 1126, 03/11
Report ID: 121059

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

ETS-LINDGREN
Tracking # S000039355
Equipment Check
Attested by GC Date: 25-Aug-17
www.ets-lindgren.com

Certificate of Test Conformance

Page 1 of 1

Reference: S 000039355

Customer: Motorola Solutions Malaysia Sdn. Bhd. - Plot 2A, Medan Bayan Lepas, Mukim 12, S.W.D. - Bayan Lepas - Penang 11900 - Malaysia

The instrument listed below has been tested and verified to Internal Quality Standards. Test data is Attached. 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
25-Aug-17
Status Out
Compliant with Internal Quality Standards

Remarks
Functional test performed with customer's probe

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: 25-Aug-17

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

ETS·LINDGREN
Tracks# SC00039355 Ltd Cal ☐
By FM Dat 25-Aug-17
Next Cal Due
www.ets-lindgren.com

Cert I.D.: 121058

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 5305/5402 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 Code:**	
Tracking Number:	**S 000039355**	**Alternate ID:**	MSI0208
Date Completed:	25-Aug-17	**Customer:**	Motorola Solutions Malaysia Sdn. Bhd. - Plot 2A, Medan Bayan Lepas, Mukim 12, S.W.D. - Bayan Lepas - Penang 11900 - Malaysia
Test Type:	Standard Field, Field Strength		

Calibration Uncertainty: Direct Field Method 1.15dB

k=2, (95% Confidence Level)

Test Remarks: Probe calibrated with Hi-2200 S/N 00086316

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	28-Mar-18
Keysight	E9304A	Power Sensor	MY56100039	10-May-18
Marconi	2024	Signal Generator	112343/043	05-Apr-18
Agilent	N5181B	MXG Signal Generator	MY51350051	05-Dec-17
Agilent	E9304A	Power Sensor	MY41499013	15-Mar-18
Agilent	E9304A	Power Sensor	MY41499012	15-Mar-18
Agilent	N5181A	MXG Analog Signal Gene	MY50140851	08-Mar-18
Agilent	E4419B	Power Meter	MY40510693	27-Jan-18
Agilent	U2004A	USB Power Sensor	MY50000280	06-Dec-17

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 25-Aug-17
George Cisneros, Calibration Supervisor

CALIBRATION REPORT

Magnetic Field Sensor

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

Date: 25 Aug 2017

New Instrument
_ Other
_ Out of Tolerance
X Within Tolerance

Frequency Response

Frequency Response		*Nominal Field*	*Cal Factor**	*Deviation*
	MHz	*A/m*	(Eapplied/Eindicated)	*dB*
1	10	30	1.09	-0.78
2	15	30	1.06	-0.54
3	30	30	1.04	-0.30
4	50	30	1.01	-0.12
5	75	30	0.98	0.21
6	100	30	0.90	0.89
7	150	30	0.88	1.08
8	175	30	0.84	1.53
9	200	30	0.79	2.07
10	250	30	0.67	3.43
11	300	30	0.56	4.97

* 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 0.24 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).

Page 2 of 2

Appendix C - Photos of Assessed Antennas

(Refer to Exhibit 7B)