# DECLARATION OF COMPLIANCE: MPE ASSESSMENT

**Motorola Solutions Inc.**
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**Date of Report:** 10/26/2022
**Report Revision:** A

| | |
|---|---|
| **Responsible Engineer:** | Hoe Kean Loon (EME Engineer) |
| **Report author:** | Muhammad Hizami bin Ismail (EME Senior Technician) |
| **Date(s) Tested:** | 10/14/2022 |
| **Manufacturer:** | Motorola Solutions Inc. |
| **Date submitted for test:** | 09/15/2022 |
| **DUT Description:** | XPR 5550e 403-470M 25W GOB GNSS CD |
| **Test TX mode(s):** | CW |
| **Max. Power output:** | Refer to Table 6 |
| **TX Frequency Bands:** | 403-470MHz |
| **Signaling type:** | FM, TDMA |
| **Model(s) Tested:** | AAM28QNN9RA1AN-1 (PMUE5872A) (IC MODEL: PMUE5872ABUNWA) |
| **Model(s) Certified:** | AAM28QNN9RA1AN-1 (PMUE5872A) (IC MODEL: PMUE5872ABUNWA), AAM28QNC9RA1AN-1 (PMUE5872A) (IC MODEL: PMUE5872ABTNWA) |
| **Serial Number(s):** | 511TYT0376 |
| **Firmware Version:** | D02.22.02.3002 |
| **Applicant Name:** | Motorola Solutions Inc. |
| **Applicant Address:** | 8000 West Sunrise Boulevard, Fort Lauderdale, Florida 33322 |
| **Classification:** | Occupational/Controlled Environment |
| **FCC ID:** | AZ492FT4975<br>This report contains results that are immaterial for FCC equipment approval, which are clearly identified. |
| **IC:** | 109U-92FT4975<br>This report contains results that are immaterial for ISED Canada equipment approval, which are clearly identified. |

The MPE results clearly demonstrate compliance with FCC/ISED Occupational/Controlled RF Exposure limits. FCC/ISED rules require compliance for Passengers and Bystanders to the FCC/ISED 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 4.0 of this report (**no deviation from standard methods)**. 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.**

**Saw Sun Hock (Approved Signatory)**
**Approval Date:** 10/31/2022

## Document Revision History

| Date | Revision | Comments |
|---|---|---|
| 10/26/2022 | A | Initial release |

**Table of Contents**

## 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 AAM28QNN9RA1AN-1 (PMUE5872A) (IC MODEL: PMUE5872ABUNWA).

This model is only able to operate LMR (PTT) mode, without technologies BT and WLAN. It is a depopulated version to the AAM28QNN9RA1AN (PMUE3645C) (IC MODEL: PMUE3645CBMNAA) which has been previously evaluated for MPE in FCC ID: AZ492FT7139, IC ID: 109U-92FT7139. The results of those previous evaluations were taken into consideration when developing the AAM28QNN9RA1AN-1 (PMUE5872A) (IC MODEL: PMUE5872ABUNWA) MPE test plan.

The AAM28QNN9RA1AN-1 (PMUE5872A) (IC MODEL: PMUE5872ABUNWA) uses the same tested accessories as the AAM28QNN9RA1AN (PMUE3645C) (IC MODEL: PMUE3645CBMNAA) with the FCC ID: AZ492FT7139, IC ID: 109U-92FT7139 and these accessories were also taken consideration and/or evaluation as well, This is classified as Occupational/Controlled.

## 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 | 406.1-470 (LMR) | 0.117 | 41.9 | 0.126 | 42.0 | 0.029 | 9.4 | 0.046 | 15.1 |

## 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
GPS: Global Positioning System
LMR: Land Mobile Radio
NA: Not Applicable
BS: Bystander
PB: Passenger Back seat
PF: Passenger Front seat
PTT: Push to Talk
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
- EN 62311:2008 Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz – 300 GHz).

## 5.0 Power Density Limits

**Table 2 – Occupational / Controlled 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 | | | | | 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 | 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**

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

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<br>Probe – E-Field | ETS Model HI-2200<br>ETS Model E100 | 00086887<br>00224511 | 06/16/2022 | 06/16/2023 |

E-field measurements are in mW/cm$^2$.

## 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**<br>(95% CONFIDENCE LEVEL) | | *k*=2 | | 31 | 31 | |

## 9.0 Product and System Description

This product contains transmit and receive circuitry for both analog and digital two way radio communications. The technology details for modes of operation employing transmitters are described below. The modulation scheme used for analog two-way radio communications is narrowband Frequency Modulation (FM). FM is a modulation technique that transmits voice information by altering a radio frequency (RF) signal. The instantaneous frequency of the RF signal is in direct proportion to changes in the amplitude of the voice signal. The rate of change of the RF signal carries the voice frequency information and the deviation of the RF signal carries the voice amplitude information. When the signal is received the change in frequency is converted back into the original voice signal. The FM modulation technique in this product uses sophisticated algorithms and a digital signal processor (DSP) to perform RF modulation/demodulation.

The modulation scheme used for digital two-way radio communications is 4 Level Frequency Shift Keying (4FSK) and Time Division Multiple Access (TDMA). 4FSK is a modulation technique that transmits information by altering the frequency of the radio frequency (RF) signal. Data is converted into complex symbols, which alter the RF signal and transmit the information. When the signal is received, the change in frequency is converted back into symbols and then into the original data. The system can accommodate 2-voice channels in a standard 12.5 kHz channel as used in two-way radio.

Time Division Multiple Access (TDMA) is used to allocate portions of the RF signal by dividing time into two slots. Time allocation enables independent units to transmit voice information without interference from each other. Transmission from a unit or base station is accommodated in time-slot lengths of 30 milliseconds and frame lengths of 60 milliseconds. The 4FSK TDMA modulation technique requires sophisticated algorithms and a digital signal processor (DSP) to perform voice compressions/decompressions and RF modulation/demodulation.

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 | 403-470 | 50 (PTT) | 30 |

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

Refer to Table 7 for complete list of tested antennas.

Below are additional antenna kits that are electrically identical to the tested antennas but have a BNC connector or optional GPS Base:

| No. | Antenna Models | Description | Selected for test | Tested | Comments |
|---|---|---|---|---|---|
| 1 | HAE6019A | Combo GPS/UHF, 403–527 MHz, 1/2 Wave, 4.15dBi | Yes | No | By similarity to HAE6029A |
| 2 | PMAE4030A | Combo GPS/UHF, 403–430 MHz, 1/4 Wave, 2.15dBi | Yes | No | By similarity to PMAE4039A |
| 3 | PMAE4031A | Combo GNSS/UHF, 450–470 MHz, 1/4 Wave, 2.15dBi | Yes | No | By similarity to PMAE4041A |
| 4 | PMAE4032A | Combo GNSS/UHF, 406–420 MHz, 5/8 Wave, 5.65dBi | Yes | No | By similarity to PMAE4040A |
| 5 | PMAE4033A | Combo GNSS/UHF, 450–470 MHz, 5/8 Wave, 5.65dBi | Yes | No | By similarity to PMAE4042A |
| 6 | PMAE4034A | Combo GNSS/UHF, 450–470 MHz, 5/8 Wave, 7.15dBi | Yes | No | By similarity to PMAE4043A |

## 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 UHF R1 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 (12 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)

## 13.1 External/Bystander vehicle MPE measurements

Antenna is located at the center of the roof. 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 60 cm (for UHF R1 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.

## 13.2 Internal/Passenger vehicle MPE measurements

Antenna is located at the center of the roof. 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 FCC 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 FCC 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 D for MPE measurement results and calculations for LMR band.

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**

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

**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.

**Table 7**

| 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 $N_c$ |
|---|---|---|---|---|---|---|---|---|---|
| 1 | HAE4002A | 403-430 | 17.7 | 2.15 | 1/4 WAVE | R | NA | 3 | 4 |
| 2 | HAE4003A | 450-470 | 16.0 | 2.15 | 1/4 WAVE | R | 450-470 | 3 | 3 |
| 3 | HAE4010A | 406-420 | 84.3 | 5.65 | 5/8 WAVE | R/T | 406.1-420 | 3 | 3 |
| 4 | HAE4011A | 450-470 | 73.2 | 5.65 | 1/2 WAVE | R/T | 450-470 | 3 | 3 |
| 5 | HAE6022A | 403-527 | 27.7 | 4.15 | 1/2 WAVE | R/T | 406.1-470 | 5 | 6 |
| 6 | HAE6029A | 403-527 | 28.0 | 4.15 | 1/2 WAVE | R/T | 406.1-470 | 5 | 6 |
| 7 | PMAE4039A | 403-430 | 14.9 | 2.15 | 1/4WAVE | R | NA | 3 | 4 |
| 8 | PMAE4040A | 406-420 | 36.0 | 5.65 | 1/4WAVE | R/T | 406.1-420 | 3 | 3 |
| 9 | PMAE4041A | 450-470 | 12.5 | 2.15 | 1/4 WAVE | R | 450-470 | 3 | 3 |
| 10 | PMAE4042A | 450-470 | 31.0 | 5.65 | 5/8 WAVE | R/T | 450-470 | 3 | 3 |
| 11 | PMAE4043A | 450-470 | 76.8 | 7.15 | 5/8 WAVE | R/T | 450-470 | 3 | 3 |
| 12 | RAE4004ARB* | 445-470 | 95.5 (445.0125MHz)<br>93.9 (450.0125MHz)<br>91.5 (457.5MHz)<br>90.7 (460.0125MHz)<br>89 (469.9875MHz) | 7.15 | 5/8 WAVE | R/T | 445-470 | 5 | 5 |

Note:* Antenna length trimmed to frequency.

# 17.0 Test Results Summary

## 17.1 MPE Test Results Summary for LMR

The highest power density results for LMR transmitters for each locations scaled to maximum allowable power output are indicated in table below for internal/passenger to the vehicle, and external/bystander to the vehicle.
The previous highest configuration from reference model AAM28QNN9RA1AN (PMUE3645C) (IC MODEL: PMUE3645CBMNAA) with the FCC ID: AZ492FT7139, IC ID: 109U-92FT7139 has been performed spot check. Table 8 indicated the reference model and spot check results.

**Table 8**

| Trunk/ Roof | Test Position | E/H Field | Angle (Degree) | Antenna Model | Max Pwr (W) | Initial Pwr (W) | Tx Freq (MHz) | Max Calc. P.D. (mW/cm^ 2) | FCC Limit Spec Limit | %To FCC Limit | ISED Limit | %To ISED Spec Limit | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Spot Check - Highest Configuration at Trunk Mounted Antenna – Bystander** | | | | | | | | | | | | | |
| Trunk | BS | E | 90 | PMAE4043A, 5/8 Wave (450-470 MHz) | 30.0 | 30.0 | 450.0125 | 0.147 | 0.30 | 49.0 | 0.17 | 86.3 | Reference model |
| Trunk | BS | E | 90 | PMAE4043A, 5/8 Wave (450-470 MHz) | 30.0 | 29.9 | 450.0125 | 0.126 | 0.30 | 42.0 | 0.17 | 74.0 | |
| **Spot Check - Highest Configuration at Trunk Mounted Antenna - Passenger Back** | | | | | | | | | | | | | |
| Trunk | PB | E | NA | PMAE4040A, 1/4 Wave (406-420 MHz) | 30.0 | 29.4 | 419.9875 | 0.157 | 0.28 | 56.0 | 0.16 | 96.4 | Reference model |
| Trunk | PB | E | NA | PMAE4040A, 1/4 Wave (406-420 MHz) | 30.0 | 30.0 | 419.9875 | 0.117 | 0.28 | 41.9 | 0.16 | 72.2 | |
| **Spot Check - Highest Configuration at Trunk Mounted Antenna - Passenger Front** | | | | | | | | | | | | | |
| Trunk | PF | E | NA | HAE6029A, 1/2 Wave (403-527 MHz) | 30.0 | 29.5 | 453.0125 | 0.079 | 0.30 | 26.3 | 0.17 | 46.4 | Reference model |
| Trunk | PF | E | NA | HAE6029A, 1/2 Wave (403-527 MHz) | 30.0 | 30.0 | 453.0125 | 0.067 | 0.30 | 22.2 | 0.17 | 39.2 | |
| **Spot Check - Highest Configuration at Roof Mounted Antenna – Bystander** | | | | | | | | | | | | | |
| Roof | BS | E | 90 | HAE4003A, 1/4 Wave (450-470 MHz) | 30.0 | 29.8 | 460.0125 | 0.063 | 0.31 | 20.5 | 0.17 | 36.4 | Reference model |
| Roof | BS | E | 90 | HAE4003A, 1/4 Wave (450-470 MHz) | 30.0 | 29.5 | 460.0125 | 0.046 | 0.31 | 15.1 | 0.17 | 26.7 | |
| **Spot Check - Highest Configuration at Roof Mounted Antenna – Passenger Back** | | | | | | | | | | | | | |
| Roof | PB | E | NA | HAE4003A, 1/4 Wave (450-470 MHz) | 30.0 | 29.8 | 460.0125 | 0.036 | 0.31 | 11.7 | 0.17 | 20.8 | Reference model |
| Roof | PB | E | NA | HAE4003A, 1/4 Wave (450-470 MHz) | 30.0 | 29.5 | 460.0125 | 0.029 | 0.31 | 9.4 | 0.17 | 16.6 | |
| **Spot Check - Highest Configuration at Roof Mounted Antenna – Passenger Front** | | | | | | | | | | | | | |
| Roof | PF | E | NA | HAE6029A, 1/2 Wave (403-527 MHz) | 30.0 | 29.4 | 419.9875 | 0.040 | 0.28 | 14.4 | 0.16 | 24.8 | Reference model |
| Roof | PF | E | NA | HAE6029A, 1/2 Wave (403-527 MHz) | 30.0 | 30.0 | 419.9875 | 0.025 | 0.28 | 8.9 | 0.16 | 15.3 | |

## 18.0 Conclusion

Spot check result indicated the depopulated version model AAM28QNN9RA1AN-1 (PMUE5872A) (IC MODEL: PMUE5872ABUNWA) is within the product variant AAM28QNN9RA1AN (PMUE3645C) (IC MODEL: PMUE3645CBMNAA) with the FCC ID: AZ492FT7139, IC ID: 109U-92FT7139. The highest power density results for LMR transmitter scaled to maximum allowable power output are indicated in Table 9 for internal/passenger to the vehicle, and external/bystander to the vehicle.

**Table 9: Maximum MPE RF Exposure Summary (LMR)**

| Designator | Transmitters | Frequency Band (MHz) | Passenger ($mW/cm^2$) | Bystander ($mW/cm^2$) |
|---|---|---|---|---|
| FCC | LMR UHF R1 | 406.1-470 | 0.117 | 0.126 |
| ISED Canada | LMR UHF R1 | 406.1-430<br>450-470 | 0.117 | 0.126 |

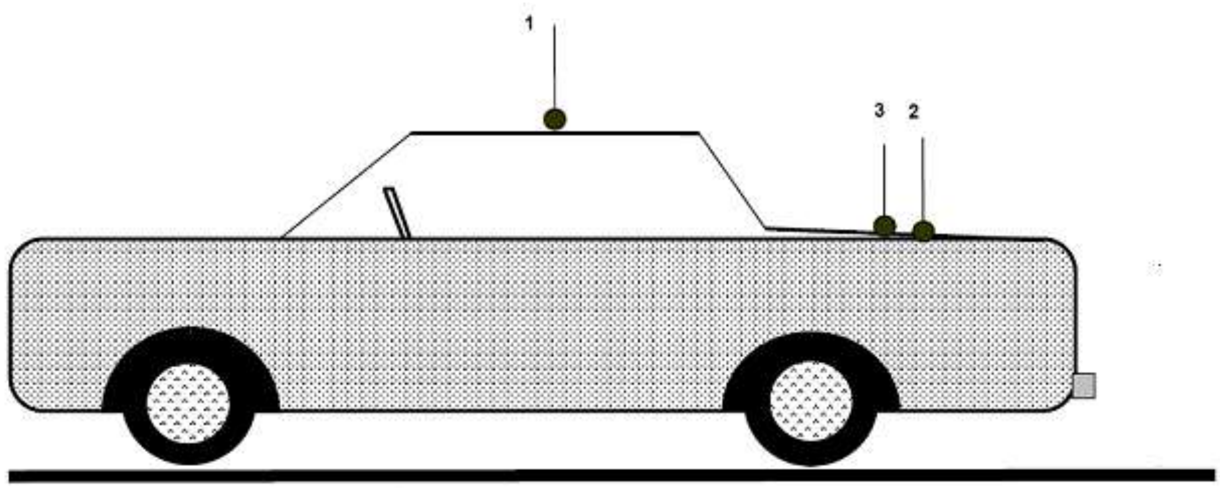
These MPE results herein demonstrate compliance to the FCC and ISED Canada Occupational/Controlled Exposure limit. FCC rules require compliance for Passengers and Bystanders to the FCC General Population/Uncontrolled limits.

## 19.0 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 2 ft (60 cm) from the vehicle Body.

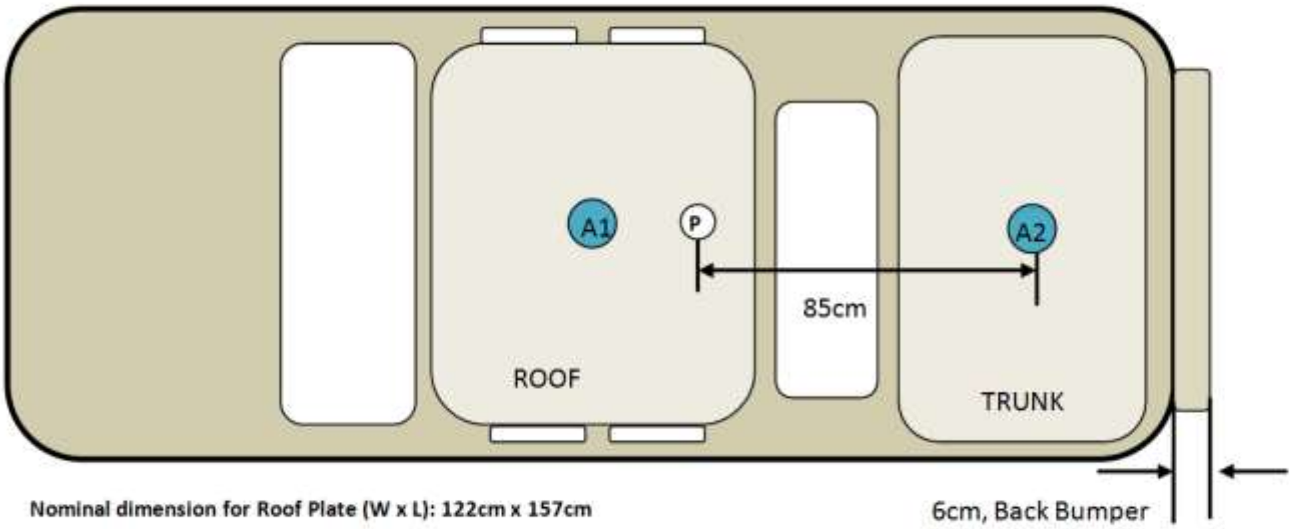
## Appendix A - Antenna Locations, Test Distances, and Cable Losses

Antenna locations




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

# Passenger Antenna mounting (UHF R1)




Nominal dimension for Roof Plate (W x L): 122cm x 157cm

Nominal dimension for Trunk Plate (W x L): 138cm x 72cm

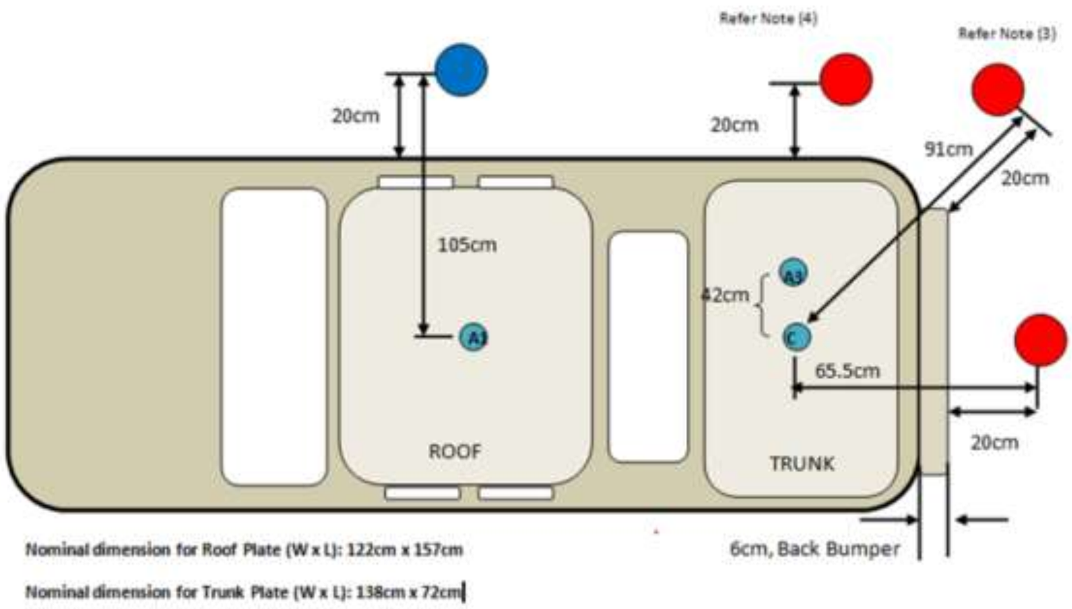
Notes:

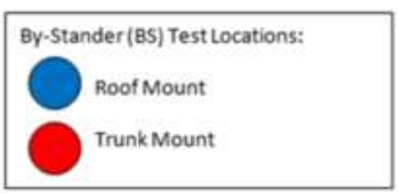
1.) Antenna location A1: Mobile radio roof antenna mounting locations for passenger back and front testing (UHF R1)

2.) Antenna location A2: Mobile trunk antenna mounting locations for passenger back and front testing (UHF R1)

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

# Bystander Antenna mounting
(UHF R1)

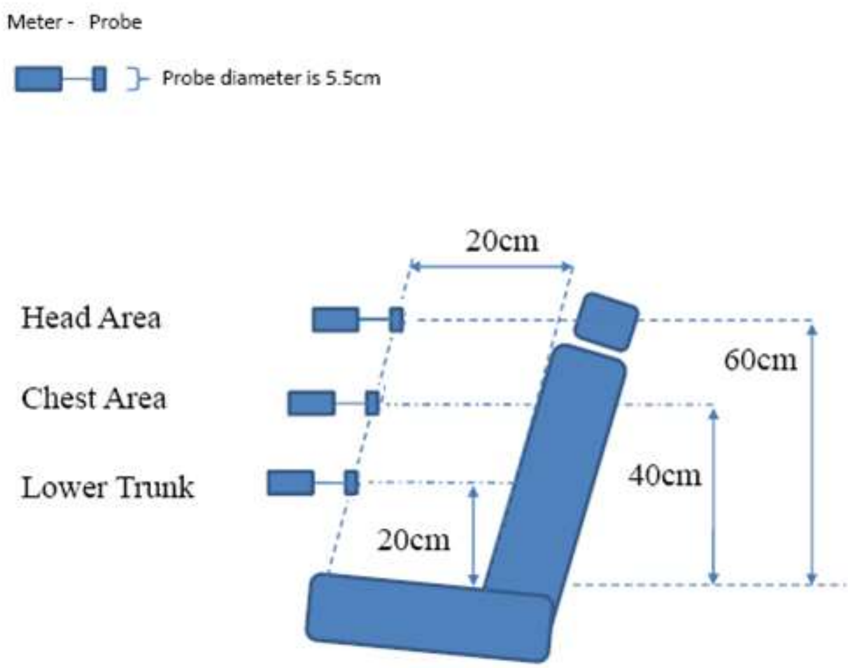



Notes:

1) Antenna location A1: Mobile radio roof antenna mounting location
2) Antenna location A3: Mobile radio trunk antenna mounting location for bystander testing. (42cm away from center)
3) 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.
4) Total distance between Bystander 90 degree angle from the centered-trunk mount antenna is 60cm

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

# Appendix B - Probe Calibration Certificates

## Certificate of Calibration

**ISO/IEC 17025:2017 and ANSI/NCSL Z540.1-1994**

**Certificate Number 220613-142138-6fc978**

ACCREDITED ISO/IEC 17025 CALIBRATION LABORATORY AC-1498.20

| | |
|---|---|
| **Model Number** | E100; HI-2200 |
| **Manufacturer** | ETS - Lindgren |
| **Description** | Field Probe |
| **Serial Number** | 00224511; 00086887 |
| **Customer Asset No.** | MSI0428; MSI0201 |
| **Date of Calibration** | 06/16/2022 |
| **Temperature** | 22°C |
| **Humidity** | 45% RH |

**Customer**
Motorola Solutions Malaysia Sdn Bhd
Plot 2A Medan Bayan Lepas Technoplex
Industrial Park Mukim 12 SWD
Bayan Lepas, Penang 11900
MALAYSIA

**Location of Calibration**
Keysight Technologies Inc.
1346 Yellowwood Road
Kimballton, IA 51543
United States

This certifies that the equipment has been calibrated using applicable Keysight Technologies procedures and in compliance with ISO/IEC 17025:2017 and ANSI/NCSL Z540.1-1994 (R2002). The quality management system is registered to ISO 9001:2015.

**Calibration Standard(s)**
IEEE Std 1309-2013 Section 4.1
IEEE Std 1309-2013 Section 5
IEEE Std 1309-2013 Section 8.2
IEEE Std 1309-2013 Section Annex A
IEEE Std 1309-2013 Section A.3

**Calibration Method(s)**
Calculated, Substitution

**Calibration Procedure(s)**
287330

**Calibration Software**
Probe Calculated Method 3.14
Probe Comparison 1.4.1

**As Received Conditions**
The measured values of the equipment were observed in specification at the points tested.

**Action Taken**
No action was taken.

**As Completed Conditions**
The measured values of the equipment were observed in specification at the points tested.

**Calibration Due**
Based on the customer's request, the next calibration is due on 16 Jun 2023

**Remarks or Special Requirements**
A probe position document is included with this certificate. This calibration is valid only for the alignment/mounting position specified in this report.

This calibration report shall not be reproduced, except in full. The documented results relate to the equipment calibrated only.

The test limits stated in the report correspond to the published specifications of the equipment, at the points tested.

Keysight Technologies, Inc.
1346 Yellowwood Road
Kimballton, IA 51543
United States

Brandt Langer Iowa Service Center Manager

Issue Date 16 Jun 2022

Page 1 of 7

KEYSIGHT TECHNOLOGIES

# Certificate of Calibration

ISO/IEC 17025:2017 and ANSI/NCSL Z540.1-1994

Certificate Number 220613-142138-6fc978

ilac-MRA ANAB ACCREDITED CALIBRATION LABORATORY AC-1498.20

## Traceability Information

**Technician Name** Dennis Bissen

Measurements are traceable to the International System of Units (SI) via national metrology institutes (www.keysight.com/find/NMI) that are signatories to the CIPM Mutual Recognition Arrangement.

## Calibration Equipment Used

| Manufacturer | Model Number | Model Description | Equipment ID | Cal Due Date | Certificate Number |
|---|---|---|---|---|---|
| AR | 00W1000B | Amp | 11546 | NA | |
| AR | 15T4G18 | Amp | 10888 | NA | NA |
| EMCO | 5302 | G/TEM | 10223 | NA | 2003121915 |
| AR | 600A400 | Amplifier, 10KHz-400 MHz, 600W | 624658 | NA | |
| AR | 75A250 | Amp | 10560 | NA | N/A |
| AR | 80S1G4 | Amp | 11728 | NA | |
| Agilent Technologies, Inc. | 83650B | Synthesized Swept Signal Generator | 1354 | 09/30/2022 | 210830-153923-e08fad |
| Hewlett-Packard | 8481A | Power Sensor | 10449 | 06/30/2023 | 220601-144708-684eba |
| Hewlett-Packard | 8487A | Power Sensor | 10577 | 12/31/2022 | 211209-090756-c27f06 |
| Hewlett-Packard | 8648B | Signal Generator | 10272 | 11/30/2022 | 211109-082104-7669a9 |
| Schwarzbeck Mess-Elektronik | BBHA 9120D | Horn | 10194 | 11/17/2022 | 201111-115541-0b3b6c |
| IFI | CC 104 | TEM | 011521 | NA | |
| Agilent Technologies, Inc. | E4419B | EPM Series Power Meter | 10458 | 10/31/2022 | 211001-112510-54fea3 |
| AR | FI7000 | Interface | 11015 | NA | 700516 |
| AR | FL7006 | Isotropic Probe | 10946 | 12/08/2022 | 2021050080-1 |
| Holaday | HI-4422 | Isotropic Probe | 10022 | 10/06/2022 | 2020070063-1 |
| dbwave | PADD200050180 0B | Dual Directional Coupler | 20522 | 03/25/2023 | 220323-090439-3aec96 |

## Compliance with Specification

Unless otherwise noted, the calibration results are reported without factoring in the effect of uncertainty on the assessment of compliance/specification.

### In Specification/Out of Specification Explanation

The standard criteria to determine the "In Specification/Out of Specification" status is based on one or more of the following conditions, as requested by the client:

1. If the manufacturer has a specified specification for the item being calibrated, then the calibration values are compared to this specification, and the values must fall within the manufacturer's specification. The specification may be obtained from the manufacturer's web site, data sheets, equipment manuals, etc.
2. Where specifications are called out in a published standard, the calibration results are compared to this specification, and the measured values must fall within the standard's specification.
3. In cases where the manufacturer, standard, or client does not identify any relevant specifications, applicable calibration results are compared to historical data with a +/- 3 dB specification.

KEYSIGHT TECHNOLOGIES

# Certificate of Calibration

ISO/IEC 17025:2017 and ANSI/NCSL Z540.1-1994

Certificate Number 220613-142138-6fc978

ilac-MRA ANAB ACCREDITED ISO/IEC 17025 CALIBRATION LABORATORY AC-1498.20

**Uncertainty of Measurement**

The uncertainty evaluation has been performed in accordance with ISO/IEC Guide 98-3:2008(GUM). The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k such that the coverage probability corresponds to approximately 95%. This probability corresponds to a coverage factor of k=2 for a normal distribution.

| Parameter | Range | MU (+/-) |
|---|---|---|
| RF Isotropic E-Field Probes - GTEM Cell - Isotropic | 10 kHz to 1000 MHz | 0.97 dB |
| RF Isotropic E-Field Probes - Anechoic Chamber - Frequency Response | (450 to 18,000) MHz | 1.1 dB |
| RF Isotropic E-Field Probes - GTEM Cell - Frequency Response | 10 kHz to 1000 MHz | 0.97 dB |
| RF Isotropic E-Field Probes - TEM Cell - Linearity | 5 kHz to 800 MHz | 0.91 dB |

2022_Frequency Response.txt

Customer Name: Motorola Solutions Malaysia Sdn Bhd
Probe Manufacturer: ETS - Lindgren
Probe Model: E100; HI-2200
Probe Serial No.: 00224511; 00086887
Notes:
CAL CERT #: 220613-142138-6fc978

| | Correction Factors | |
|---|---|---|
| Frequency | 20V/m | |
| in MHz | Multiplier | dB |
| 0.1 | 1.39 | 2.84 |
| 0.5 | 1.18 | 1.42 |
| 1 | 1.08 | 0.71 |
| 3 | 1.00 | -0.03 |
| 15 | 0.98 | -0.18 |
| 27.12 | 1.00 | -0.04 |
| 30 | 0.99 | -0.09 |
| 75 | 1.06 | 0.50 |
| 100 | 1.08 | 0.63 |
| 150 | 1.08 | 0.70 |
| 200 | 1.12 | 0.95 |
| 250 | 1.14 | 1.14 |
| 300 | 1.19 | 1.51 |
| 400 | 0.90 | -0.87 |
| 500 | 1.13 | 1.03 |
| 600 | 1.15 | 1.20 |
| 700 | 1.23 | 1.79 |
| 800 | 0.87 | -1.23 |
| 900 | 1.06 | 0.52 |
| 1000 | 0.93 | -0.67 |
| 2000 | 0.97 | -0.29 |
| 2450 | 0.89 | -0.98 |
| 3000 | 0.86 | -1.33 |
| 3500 | 0.90 | -0.94 |
| 4000 | 0.83 | -1.65 |
| 5000 | 1.03 | 0.22 |
| 5500 | 1.07 | 0.57 |
| 6000 | 1.09 | 0.75 |

Customer Name: Motorola Solutions Malaysia Sdn Bhd
Probe Manufacturer: ETS - Lindgren
Probe Model: E100; HI-2200
Probe Serial No.: 00224511; 00086887
Notes:
CAL CERT # 220613-142138-6fc978

Isotropic Response at 400 MHz at 20V/m

| Deg | Response dB |
|---|---|
| 0 | 0.00 |
| 45 | -0.14 |
| 90 | 0.01 |
| 135 | -0.03 |
| 180 | 0.00 |
| 225 | 0.03 |
| 270 | -0.06 |
| 315 | -0.11 |
| 360 | -0.07 |

Max Dev. 0.18

Customer Name: Motorola Solutions Malaysia Sdn Bhd
Probe Manufacturer: ETS - Lindgren
Probe Model: E100; HI-2200
Probe Serial No.: 00224511; 00086887
Notes:
CAL CERT #: 220613-142138-6fc978

Linearity

| Freq | Applied Field | Indicated Field | Max Dev |
|---|---|---|---|
| MHz | V/m | V/m | dB |
| 27.12 | 0.50 | 0.57 | -1.14 |
| 27.12 | 1.00 | 1.12 | -0.98 |
| 27.12 | 2.04 | 2.22 | -0.73 |
| 27.12 | 4.04 | 4.42 | -0.78 |
| 27.12 | 8.07 | 8.68 | -0.63 |
| 27.12 | 15.02 | 16.04 | -0.57 |
| 27.12 | 20.11 | 21.43 | -0.55 |
| 27.12 | 30.06 | 32.03 | -0.55 |
| 27.12 | 50.15 | 53.30 | -0.53 |
| 27.12 | 65.23 | 69.84 | -0.59 |
| 27.12 | 100.09 | 107.70 | -0.64 |
| 27.12 | 125.90 | 135.80 | -0.66 |
| 27.12 | 201.60 | 220.20 | -0.77 |
| 27.12 | 250.50 | 274.60 | -0.80 |
| 27.12 | 301.40 | 332.20 | -0.85 |
| 27.12 | 350.19 | 374.40 | -0.58 |
| 27.12 | 403.20 | 445.30 | -0.86 |
| 27.12 | 452.20 | 497.50 | -0.83 |
| 27.12 | 503.40 | 557.60 | -0.89 |
| 27.12 | 551.90 | 617.60 | -0.98 |
| 27.12 | 602.70 | 684.40 | -1.10 |

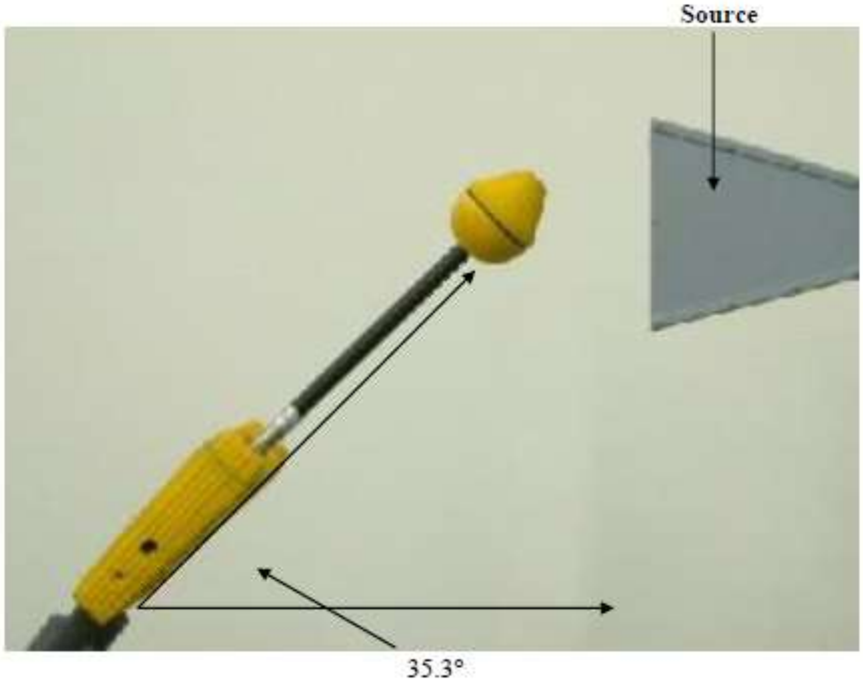
W&G_critical_angle.doc

# Probe Alignment/Mounting Position

The alignment/mounting position of the probe is critical. The correction factors given with calibration are valid only for the indicated alignment/mounting position. Deviation from indicated alignment/mounting position of calibration can produce errors in excess of 6 dB.

The probe was positioned with the probe wand at a 35.3° angle position with the probe head centered in front of the field source. The picture below is for probe positioning reference only. The equipment shown does not necessarily indicate the equipment used for calibration.

**Side View**



## Appendix C - Photos of Assessed Antennas

(Refer to Exhibit 7B)