MOTOROLA SOLUTIONS

ACCREDITED
TESTING CERT # 2518.01

DECLARATION OF COMPLIANCE: MPE ASSESSMENT

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Date of Report: February 13, 2015
Report Revision: A

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Assessment Date(s):	09/23/2014
Manufacturer/Location:	Motorola Solutions, Reynosa / Schaumberg
Sector/Group/Div.:	AESS - Astro Engineering Subscriber Solutions
Date submitted:	07/30/2014
DUT Description:	APX5000 / 6000 136-174 1-6W 6.25K/12.5K/25K. Capable of digital and analog FM transmission. Also capable of TDMA transmission. This radio is also equipped with Bluetooth.
TX mode(s):	FM and TDMA
Max. Power output:	6.6 Watts; BT 10mW
Nominal Power:	6.0 Watts; BT 10mW
TX Frequency Bands:	136 - 174 MHz; 2402 – 2480 MHz
Signaling type:	FM and TDMA (VHF); FHSS (Bluetooth)
Model(s) Certified:	H98KGD9PW5AN (MNUD1002B), H98KGH9PW7AN (MNUD1006B), H98KGD9PW5AN (NUD1020), H98KGH9PW7AN (NUD1024), H99KGD9PW5AN, H99KGH9PW7AN
Classification:	Occupational/Controlled Environment
FCC ID:	AZ489FT3829 Part 90 (150.8 – 173.4 MHz) Part 15 (2402 – 2480 MHz) Results outside FCC bands are not applicable for FCC compliance demonstration.
IC:	109U-89FT3829 IC bands (138 – 174 MHz); BT (2402 – 2480 MHz) Results outside IC bands are not applicable for IC compliance demonstration.

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. 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.

Deanna Zakharia
Digitally signed by Deanna Zakharia
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Approval Date: 2/13/2015

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Certification No.: 141007AD

Document Revision History

Date	Revision	Comments
09/23/2014	O	Initial release
02/13/2015	A	Correct reference to KDB 447498 to most recent version

Table of Contents

1.0 Introduction

This report contains calculated Maximum Permissible Exposure (MPE) results for radio product models presently Certified as portable radio equipment under FCC ID: AZ489FT3829 and IC: 109U-89FT3829 when used in conjunction with vehicle adapter NNTN8527A and antennas listed in Section 8 of this report for vehicular mobile applications.

2.0 FCC MPE Summary

Table 1

Equipment Class	Frequency band (MHz)	Power Density (mW/cm^2)	% of FCC MPE Limit
TNB	150.8 – 173.4	0.106	53.1
*DSS	2402-2480	NA	NA
*Simultaneous Results		NA	NA

Results are based on highest percentage of limit.
*Note Results not required per KDB 447498

3.0 Abbreviations / Definitions

C4FM: Continuous Four Level FM
CQPSK: Compatible Differential Offset Quadrature Phase Shift Keying
DUT: Device Under Test
EME: Electromagnetic Energy
FHSS: Frequency Hopping Spread Spectrum
FM: Frequency Modulation
MPE: Maximum Permissible Exposure
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.

- Federal Communications Commission, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radio frequency Electromagnetic Fields", OET Bulletin 65, FCC, Washington, D.C.: 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 (2014), Limits of Human Exposure to Radio frequency Electromagnetic Fields in the Frequency Range from 3 kHz to 300 GHz
- Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands), Industry Canada RSS-102 Issue 4, 2010
- FCC KDB – 447498 D01 General RF Exposure Guidance v05r02 (02/07/2014)
- FCC KDB – 865664 D02 RF Exposure Reporting v01r01 (05/28/2013)

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 4 – 2010 W/m^2	Health Canada Safety Code 6 (2014) W/m^2
10 - 20						10.0
20 – 48						$44.72 / f^{0.5}$
30 – 300	1.0				*10.0	
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				f/30	
300 - 3,000			f/300	f/30		
400 – 2,000		f/40				
1,500 – 15,000					50.0	
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						$3.33\times10^{-4} f$

*Power density limit is applicable at frequencies greater than 100MHz

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 4 – 2010	Health Canada Safety Code 6 (2014)
	mW/cm^2	W/m^2	mW/cm^2	W/m^2	W/m^2	W/m^2
10 - 20						2.0
20 – 48						$8.944 / f^{0.5}$
30 – 300	0.2				*2.0	
48 – 300						1.291
10 – 400		2.0				
100 – 300			0.2			
100 – 400				2.0		
300 – 1,500	f/1,500				f/150	
300 – 6000						$0.02619 f^{0.6834}$
400 – 2,000		f/200		f/200		
300 – 15,000			f/1,500			
1,500 – 15,000					10.0	
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						$6.67\times10^{-5} f$

*Power density limit is applicable at frequencies greater than 100MHz

6.0 Product and System Description

This device operates using digital and analog frequency modulation (FM) as well as TDMA signaling incorporating traditional simplex two-way radio transmission protocol.

Time Division Multiple Access (TDMA) is used to allocate portions of the RF signal by dividing time into two slots. Time allocation enables each unit to transmit its voice information without interference from other transmitting units. Transmission from a unit or base station is accommodated during two time-slot lengths of 30 milliseconds with frame length of 60 milliseconds. C4FM CQPSK modulation is used and includes 12.5kHz channel spacing. The TDMA technique requires sophisticated algorithms and a digital signal processor (DSP) to perform voice compressions/decompressions and RF modulation/demodulation. The maximum duty cycle for TDMA 1:2 is 50%.

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

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

In the evaluated configuration of the radio models represented in this report, a vehicle adapter is utilized to connect the RF connector of the certified portable radio to external vehicular antennas to form a mobile radio solution.

Table 4 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 4

Radio Type	Band (MHz)	Transmission	Duty Cycle (%)	Max Power (W)
LMR	136-174	FM or TDMA	*50 / *25	6.6
BT	2400	FHSS	76	0.010

Note - * includes 50% PTT operation

This device is capable of operating in the TX frequency range(s), duty cycle(s), maximum output power(s) and antenna gain(s) presented in Table 4 above and Table 5 in section 8.0 MPE Assessment.

7.0 Assessment Method

MPE calculations were used to determine the RF exposure for this device. 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. For example, in the case of a single radiating antenna, a prediction for power density in the far-field of the antenna can be made by use of the general Equations (1) or (2) below. These equations are generally accurate in the far-field of an antenna but will over-predict power density in the near field, where they could be used for making a "worst case" or conservative prediction. Equation 2 was used to show compliance for this device.

Equation 1

$$S = \frac{PG}{4\pi R^2} = \frac{EIRP}{4\pi R^2}$$

Where:
S = power density (mW/cm^2)
P = power input to the antenna (mW)
G = power gain of the antenna in the direction of interest relative to an isotropic radiator (dBi)
R = distance to center of radiation of the antenna (cm)
EIRP = equivalent (or effective) isotropically radiated power

Or Equation 2

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

Equation (2) accounts for the maximum duty cycle of the signal, and the factor, F, to provide a worst-case prediction of power density per FCC OET Bulletin 65, Edition 97-01 1997.

Where:
S = power density (mW/cm^2)
P_t = maximum output power scaled by the maximum duty cycle of the signal
G = power gain of the antenna in the direction of interest relative to an isotropic radiator (dBi)
d = distance from antenna (cm)
L = cable loss (dB)
F = 1.0

The separation distance chosen to demonstrate compliance with the uncontrolled limits for general population (bystanders) was 90cm for all antennas being offered with the product.

8.0 MPE Assessment

Table 5

MPE Calculation Results

Antenna #	Tx Frequency (MHz)	User Category	MPE Spec Limit (mW/cm^2) FCC	ICNIRP	Proposed IC Limits	Duty Cycle (%)	Max Power (W)	Antenna Gain (dBi)	Cable Loss, L (dB)	Dist., d (cm)	Max Calc. MPE (mW/cm^2)	Highest Percentage of Lowest Limit
HAD4006A	136.0125	Uncontrolled	0.20	0.20	0.13	50%	6.600	2.15	0.00	90	0.053	41.2
HAD4006A	140.0125	Uncontrolled	0.20	0.20	0.13	50%	6.600	2.15	0.00	90	0.053	41.2
HAD4006A	143.9875	Uncontrolled	0.20	0.20	0.13	50%	6.600	2.15	0.00	90	0.053	41.2
HAD4007A	146.0125	Uncontrolled	0.20	0.20	0.13	50%	6.600	2.15	0.00	90	0.053	41.2
HAD4007A	148.4000	Uncontrolled	0.20	0.20	0.13	50%	6.600	2.15	0.00	90	0.053	41.2
HAD4007A	150.8000	Uncontrolled	0.20	0.20	0.13	50%	6.600	2.15	0.00	90	0.053	41.2
HAD4008A	150.8000	Uncontrolled	0.20	0.20	0.13	50%	6.600	2.15	0.00	90	0.053	41.2
HAD4008A	156.4000	Uncontrolled	0.20	0.20	0.13	50%	6.600	2.15	0.00	90	0.053	41.2
HAD4008A	161.9875	Uncontrolled	0.20	0.20	0.13	50%	6.600	2.15	0.00	90	0.053	41.2
HAD4009A	162.0125	Uncontrolled	0.20	0.20	0.13	50%	6.600	2.15	0.00	90	0.053	41.2
HAD4009A	167.7000	Uncontrolled	0.20	0.20	0.13	50%	6.600	2.15	0.00	90	0.053	41.2
HAD4009A	173.4000	Uncontrolled	0.20	0.20	0.13	50%	6.600	2.15	0.00	90	0.053	41.2
HAD4021A	136.0125	Uncontrolled	0.20	0.20	0.13	50%	6.600	2.15	0.00	90	0.053	41.2
HAD4021A	143.9875	Uncontrolled	0.20	0.20	0.13	50%	6.600	2.15	0.00	90	0.053	41.2
HAD4021A	150.8000	Uncontrolled	0.20	0.20	0.13	50%	6.600	2.15	0.00	90	0.053	41.2
HAD4021A	158.3000	Uncontrolled	0.20	0.20	0.13	50%	6.600	2.15	0.00	90	0.053	41.2
HAD4021A	165.9875	Uncontrolled	0.20	0.20	0.13	50%	6.600	2.15	0.00	90	0.053	41.2
HAD4021A	173.4000	Uncontrolled	0.20	0.20	0.13	50%	6.600	2.15	0.00	90	0.053	41.2
HAD4022A	136.0125	Uncontrolled	0.20	0.20	0.13	50%	6.600	5.15	0.00	90	0.106	82.2
HAD4022A	143.9875	Uncontrolled	0.20	0.20	0.13	50%	6.600	5.15	0.00	90	0.106	82.2
HAD4022A	150.8000	Uncontrolled	0.20	0.20	0.13	50%	6.600	5.15	0.00	90	0.106	82.2
HAD4022A	158.3000	Uncontrolled	0.20	0.20	0.13	50%	6.600	5.15	0.00	90	0.106	82.2
HAD4022A	165.9875	Uncontrolled	0.20	0.20	0.13	50%	6.600	5.15	0.00	90	0.106	82.2
HAD4022A	173.4000	Uncontrolled	0.20	0.20	0.13	50%	6.600	5.15	0.00	90	0.106	82.2

Assessment of Bluetooth Radio and Simultaneous Transmission

Pursuant to the guidance in KDB 447498 Section 7.1 and the provision in CFR 47 Part 2.1091(c)(3), the standalone MPE categorical exclusion applies to the Bluetooth transmitter in this mobile device and no further evaluation is required.

Since the transmitter was evaluated for MPE compliance and the Bluetooth radio qualifies for the standalone test exclusion, according to KDB 447498 Section 7.2 the mobile platform qualifies to be evaluated to determine if the simultaneous transmission MPE exclusion applies.

The simultaneous transmission MPE exclusion applies when the sum of the MPE ratios for all simultaneous transmitting antennas incorporated in a host device is ≤ 1.0. The MPE ratio of each antenna is determined at the minimum test separation distance according to the ratio of field strengths or power density to the MPE limit at the test frequency.

The Max Calc power density in this condition is 0.106 mW/cm^2 . The applicable FCC limit at that frequency is 0.20.

The MPE ratio for the transmitter is therefore 0.106/0.20 = 0.53

The following formula was used to calculate the power density of the Bluetooth radio.

$$S = \frac{P_t G_t}{4\pi d^2 L} F = \frac{c P_m G_t}{4\pi d^2 L} F$$

Where

Maximum output power, P_m
Duty cycle, c
frequency, f
Antenna gain, G_t
Cable loss, L
Distance, d
Enhancement factor, F

A worst case separation distance of 20 cm was chosen even though in practice the separation distances between the user and the Bluetooth antenna will be greater than that. The enhancement factor described in OET Bulletin 65 (2.56) was used to account for reflections.

The maximum power for the Bluetooth radio is 10mW and the internal PIFA antenna gain is 2.5dBi. The calculated MPE for the Bluetooth radio is therefore 0.0027 mW/cm^2. The applicable FCC limit at Bluetooth frequencies is 1.0.

The MPE ratio for the Bluetooth transmitter is therefore 0.0027/1.0 = 0.0027

The sum of the MPE ratios for the simultaneous transmitting antennas is:

$$0.53 + 0.0027 = 0.5327$$

The sum of the MPE ratios is < 1, therefore the simultaneous transmission MPE exclusion does apply.

9.0 Conclusion

The MPE results per the assessment in Table 5 are compliant to the FCC General Population/Uncontrolled RF exposure limits in OET Bulletin 65 for every antenna offered with this product.

The MPE results per the assessment in Table 5 are also compliant to the ICNIRP general public exposure limits, per ICNIRP (1998) Guidelines for limiting exposure in time-varying electric, magnetic, and electromagnetic fields (up to 300GHz) and IEEE C95.1-2005..

Finally, the MPE results per the assessment in Table 5 are compliant with the proposed uncontrolled RF exposure limits found in Health Canada Safety Code 6 (2014).

Table 6: Maximum MPE RF Exposure Summary

Designator	Frequency (MHz)	Bystander (mW/cm^2)
Overall	136-174	0.106
FCC	150.8 – 173.4	0.106
IC	138 - 174	0.106

*Results are based on highest percentage of limit.