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Maximum Permissible Exposure Evaluation

For the

ZEBRA TECHNOLOGIES CORPORATION

RFID Reader ATR7000

FCC ID: UZ7ATR7000

September 24, 2018

WLL Report: 15707-02 Rev 2

Prepared for:

ZEBRA TECHNOLOGIES CORPORATION

1 ZEBRA PLAZA

HOLTSVILLE, NY 11742

Prepared by:

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WLL Report: 15707-02 Rev 2

Re-Issued

September 14, 2018

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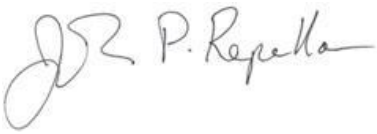

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Abstract

This report has been prepared on behalf of **Error! Reference source not found.** ATR7000 to document the findings of the maximum permissible exposure evaluation on the **Error! Reference source not found.** ATR7000. The purpose of this evaluation is to establish a minimum safe distance as per the RF exposure requirements as defined in FCC §1.1307 & §1.1310.

This report documents the results of testing to the requirements of:

- CFR Title 47 Volume 1 Practice and Procedure; (1.1307) Environmental Assessments

The Evaluation was performed by Washington Laboratories, Ltd, 7560 Lindbergh Drive, Gaithersburg, MD 20879. Washington Laboratories, Ltd. has been accepted as an EMC Conformity Assessment Body (CAB) under the United States/European Union Memorandum of Agreement. Washington Laboratories, Ltd. is accredited by ANAB under Testing Certificate AT-1448.

Revision History	Reason	Date
Rev 0	Initial Release	August 30, 2018
Rev 1	Report updated to address comments	September 5, 2018
Rev 2	Added Power Density at Minimum distance	September 24, 2018

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1 Introduction

This report has been prepared on behalf of **Error! Reference source not found.**?? ATR7000 Transmitter to show compliance with the RF exposure requirements as defined in FCC §1.1307.

Testing supporting this evaluation was performed at Washington Laboratories, Ltd, 7560 Lindbergh Drive, Gaithersburg, MD 20879. Washington Laboratories, Ltd. has been accepted as an EMC Conformity Assessment Body (CAB) under the United States/European Union Memorandum of Agreement. Washington Laboratories, Ltd. is accredited with ANAB under Testing Certificate AT-1448.

2 Requirements

Three different categories of transmitters are defined by the FCC in OET Bulletin 65. These categories are fixed installation, mobile, and portable. Additionally, the FCC categorizes the use of the devices based on the user's awareness and the ability to exercise control over his or her exposure. The two categories are defined as Occupational/Controlled Exposure and General Population/Uncontrolled Exposure.

2.1 Transmitter Categories

2.1.1 Fixed Installations

A fixed location means that the device, including its antenna, is physically secured at a permanent location and is not able to be easily moved to another location. Additionally, distance to humans from the antenna is maintained to at least 2 meters.

2.1.2 Mobile Devices

A mobile device is defined as a transmitting device designed to be used in other than fixed locations and to be generally used in such a way that a separation distance of at least 20 centimeters is normally maintained between the transmitter's radiating structures and the body of the user or nearby persons. Transmitters designed to be used by consumers or workers that can be easily re-located, such as a wireless modem operating in a laptop computer, are considered mobile devices if they meet the 20centimeter separation requirement. The FCC rules for evaluating mobile devices for RF compliance are found in 47 CFR §2.1091.

2.1.3 Portable Devices

A portable device is defined as a transmitting device designed to be used so that the radiating structure(s) of the device is/are within 20 centimeters of the body of the user. Portable device requirements are found in Section 2.1093 of the FCC's Rules (47 CFR§2.1093).

2.2 Exposure Categories

The limits for exposure are determined by the type of situation in which the individual is exposed. Table 1 lists the limits for the particular environment.

2.2.1 Occupational/Controlled Exposure

In general, occupational/controlled exposure limits are applicable to situations in which persons are exposed as a consequence of their employment, who have been made fully aware of the potential for

exposure and can exercise control over their exposure. This exposure category is also applicable when the exposure is of a transient nature due to incidental passage through a location where the exposure levels may be higher than the general population/uncontrolled limits, but the exposed person is fully aware of the potential for exposure and can exercise control over his or her exposure by leaving the area or by some other appropriate means. Awareness of the potential for RF exposure in a workplace or similar environment can be provided through specific training as part of a RF safety program. If appropriate, warning signs and labels can also be used to establish such awareness by providing prominent information on the risk of potential exposure and instructions on methods to minimize such exposure risks.

2.2.2 General Population/Uncontrolled Exposure

The general population / uncontrolled exposure limits are applicable to situations in which the general public may be exposed or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure or cannot exercise control over their exposure. Members of the general public would come under this category when exposure is not employment-related; for example, in the case of a wireless transmitter that exposes persons in its vicinity. Warning labels placed on low-power consumer devices such as cellular telephones are not considered sufficient to allow the device to be considered under the occupational/controlled category and the general population/uncontrolled exposure limits apply to these devices.

Table 1: FCC MPE Limits

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm2)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposures				
0.3–3.0	614	1.63	*(100)	6
3.0–30	1842/f	4.89/f	*(900/f2)	6
30–300	61.4	0.163	1	6
300–1500	N/A	N/A	f/300	6
1500–100,000	N/A	N/A	5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3–1.34	614	1.63	*(100)	30
1.34–30	824/f	2.19/f	*(180/f2)	30
30–300	27.5	0.073	0.2	30
300–1500	N/A	N/A	f/1500	30
1500–100,000	N/A	N/A	1	30

Table 2: ISED MPE Limits (General Population, Uncontrolled Exposure)

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m2)	Reference Period (minutes)
0.003-10^{21}	83	90	-	Instantaneous*
0.1-10	-	$0.73/f$	-	6**
1.1-10	$87/f^{0.5}$	-	-	6**
10-20	27.46	0.0728	2	6
20-48	$58.07/f^{0.25}$	$0.1540/f^{0.25}$	$8.944/f^{0.5}$	6
48-300	22.06	0.05852	1.291	6
300-6000	$3.142\ f^{0.3417}$	$0.008335\ f^{0.3417}$	$0.02619f^{0.6834}$	6
6000-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	$616000/f^{1.2}$
150000-300000	$0.158\ f^{0.5}$	$4.21 \times 10\text{-}4\ f^{0.5}$	$6.67 \times 10^{-5}\ f$	$616000/f^{1.2}$
Note: f is frequency in MHz.				
*Based on nerve stimulation (NS). ** Based on specific absorption rate (SAR).				

3 Device Summary

Table 1 below summarizes the criteria used to evaluate the ATR7000.

Table 3: Device Summary of the ATR7000

Model Evaluated:	RFID Reader ATR7000
Transmitter Category:	Fixed Installation
Exposure Category:	General Population
Antenna Gain:	12.5dBi
Power Output (dBm):	211.33mW (23.25dBm)
Evaluation Distance:	20cm
Frequency Range:	902 – 928 MHz
FCC Limit:	0.618mW/cm^2
ISED Limit:	0.28024mW/cm^2
FCC Safe Distance	22cm
ISED Safe Distance	32.7cm

3.1 Antenna Array Discussion

Accounting for the cross-polarization of the structure the directional gain of the antenna array is computed as follows:

GArray (dBi) = (4.0 - 3.0) + 10 log (14) = 12.5 dBi

Therefore, to achieve a desired level of radiated power PTX,EIRP (dBm), the conducted power delivered to the antennas is controlled such that

Therefore, to achieve a desired level of radiated power PTX,EIRP (dBm), the conducted power delivered to the antennas is controlled such that:

PConducted (dBm) = PTX, EIRP (dBm) - 12.5

To ensure that the radiated power never exceeds the Part 15 limit of +36 dBm EIRP when taking manufacturing tolerances into account, the internal software of the ATR7000 limits PTX, EIRP used in the above formula to 35.3 dBm when calculating the amount of conducted power to deliver to the antenna array. Note that a tolerance was also included in the gain of each element. When directional gain of the antenna array GArray (dBi) was computed to be 12.5 dB, the 4 dBic used in the formula was the maximum total gain. The typical element gain is 3.3 dBic and not 4 dBic.

4 Radio Frequency Radiation Exposure Evaluation

The highest RF output power of the unit was measured and recorded. According to §1.1310 of the FCC rules, the power density limit for General Population/Uncontrolled Exposure is = f/1500(0.618mW/cm^2) where f is the frequency of concern in MHz. The power density limit for General Population/Uncontrolled Exposure for ISED is = $0.02619f^{0.6834}$ (0.280mW/cm^2) where f is the frequency of concern in MHz.

The MPE shall be calculated at 20cm to show compliance with the power density limit. The following formula was used to calculate the Power Density:

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

Where:
S = Power Density
P = Output Power at the Antenna Terminals
G = Gain of Transmit Antenna (linear gain-isotropic)
R = Distance from Transmitting Antenna

Table 4: Transmitter FCC MPE Calculation Summary

One Transmitter			
Frequency	927.5	MHz	
Limit	0.618	mW/cm^2	
Distance (cm), R =	20	cm	
Power (dBm), P =	23.25	dBm	
TX Ant Gain (dBi), G	12.5	dBi	
Power Density:	0.75	mW/cm^2	**Separation>20 cm**
Minimum Distance:	**22.0**	cm	

Power Density at minimum Distance:

S=(10^(23.25/10))*(10^(12.5/10))/(4*3.14*0.22^2)

S=(211*17.8)/0.608

S= 6177 mW/m^2

S= 0.6177 mW/cm^2

Table 5: Transmitter ISED MPE Calculation Summary

One Transmitter			
Frequency	927.5	MHz	
Limit	0.280	mW/cm^2	
Distance (cm), R =	20	cm	
Power (dBm), P =	23.25	dBm	
TX Ant Gain (dBi), G	12.5	dBi	
Power Density:	0.75	mW/cm^2	**Separation>20 cm**
Minimum Distance:	**32.7**	cm	

Power Density at minimum Distance:

S=(10^(23.25/10))*(10^(12.5/10))/(4*3.14*0.327^2)

S=(211*17.8)/1.343

S= 2796.58 mW/m^2

S= 0.2797 mW/cm^2

