Washington Laboratories, Ltd.
www.wll.com
7560 Lindbergh Drive . Gaithersburg, MD 20879
301.216.1500 . info@wll.com

Maximum Permissible Exposure Evaluation

For the

Evolv Technology

Evolv Edge Screener

20 February 2018

WLL Report: 15277-MPE Rev 3

Prepared for:

EVOLV TECHNOLOGY

200 WEST STREET

WALTHAM, MA 02451 USA

Prepared by:

WASHINGTON LABORATORIES, LTD.
7560 LINDBERGH DRIVE
GAITHERSBURG, MARYLAND 20879

ANAB ACCREDITED ISO/IEC 17025 TESTING LABORATORY

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Prepared by:

Michael F. Violette, PE
Test Engineer

Reviewed by:

Steven D. Koster
President

Abstract

This report has been prepared on behalf of Evolv Technology Evolv Edge Screener to document the findings of the maximum permissible exposure evaluation on the Evolv Technology Evolv Edge Screener. 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 and "ANSI/IEEE C95.1-2005 - IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz."

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	29 January 2018
Rev 1	Editorial changes	7 February 2018
Rev 2	Editorial changes	16 February 2018
Rev 3	Editorial changes	20 February 2018

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1 Introduction & Summary

This report has been prepared on behalf of Evolv Technology Evolv Edge Screener Transmitter to show compliance with the RF exposure requirements as defined in FCC §1.1307 and ANSI C95.1: 2005.

The Evolv Edge Screener device complies with the FCC and ANSI C95.1 MPE limits.

2 Description of Equipment

Evolv Edge Screener is a walk-thru, fully automated, threat detection system designed to detect mass casualty threats concealed upon a person (or visitor). Evolv Edge Screener is intended for use at any facility or event desiring to screen visitors in an efficient and seamless manner for the presence of concealed threats.

The device's primary mode of detection is enabled via a Stepped Frequency Modulated Continuous Wave ("SFMCW") Synthetic Aperture Radar ("SAR") system operating over the 24.0 to 28.8 GHz band. The system incorporates two synthetic apertures, one looking forward scanning visitor's front as they enter the system and one looking backwards scanning the visitor's back as they exit the system.

R.F. Power Output:

Peak EIRP = +1.0 dBm.

The system sweeps through the transmit antennas one-at-a-time over the four arrays that produce the field. The array is composed of patch antennas each with a nominal gain of +5dBi.

To perform an analysis of the exposure from a radiator it is allowed to account for averaging time due to non-continuous operation.

From the technical description of the device:

"While a visitor is being scanned, one and only one transmitter is on at any instant in time, all transmitters are cycled through serially at any given channel. Channels then cycle through serially as well. Between each channel selection (step) all transmitters are off. At any one channel (frequency step) the ON time required to serially cycle through all transmitters is ~ 62us. The time required to get back to that same channel is 33msec. Therefore the average power at anyone channel is -29.7 dB less than the instantaneous peak power at that same channel."

However, this averaging cannot be considered for this device because the device is, in effect, continuously "on," somewhere in the band, except for the off times between switching channels.

For worst-case analysis, we consider that no averaging will be applied.

3 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.

3.1 Transmitter Categories

3.1.1 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.

3.1.2 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 20 centimeter separation requirement. The FCC rules for evaluating mobile devices for RF compliance are found in 47 CFR §2.1091.

The Evolv Edge Screener is a Mobile device.

3.1.3 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).

3.2 Exposure Categories

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

3.2.1 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.

3.2.2 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.

The Evolv Edge Screener is intended to be used in uncontrolled environments.

There are two different levels of MPE that are applicable. Limits from FCC §1.1307 & §1.1310 are found in Table 1 and limits from ANSI C95.1 for uncontrolled environments are found in Table 2.

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: ANSI C95.1 MPE Limits for Uncontrolled Environments

Frequency range (MHz)	RMS electric field strength (E)[a] (V/m)	RMS magnetic field strength (H)[a] (A/m)	RMS power density (S) E-field, H-field (W/m^2)	Averaging time[b] $\|E\|^2$, $\|H\|^2$ or S (min)	
0.1–1.34	614	$16.3/f_M$	$(1000, 100\,000/f_M^2)$[c]	6	6
1.34–3	$823.8/f_M$	$16.3/f_M$	$(1800/f_M^2, 100\,000/f_M^2)$	$f_M^2/0.3$	6
3–30	$823.8/f_M$	$16.3/f_M$	$(1800/f_M^2, 100\,000/f_M^2)$	30	6
30–100	27.5	$158.3/f_M^{1.668}$	$(2, 9\,400\,000/f_M^{3.336})$	30	$0.0636 f_M^{1.337}$
100–400	27.5	0.0729	2	30	30
400–2000	–	–	$f_M/200$	30	
2000–5000	–	–	10	30	
5000–30 000	–	–	10	$150/f_G$	
30 000–100 000	–	–	10	$25.24/f_G^{0.476}$	
100 000–300 000	–	–	$(90f_G–7000)/200$	$5048/[(9f_G–700)f_G^{0.476}]$	

NOTE—f_M is the frequency in MHz, f_G is the frequency in GHz.

[a]For exposures that are uniform over the dimensions of the body, such as certain far-field plane-wave exposures, the exposure field strengths and power densities are compared with the MPEs in the Table. For non-uniform exposures, the mean values of the exposure fields, as obtained by spatially averaging the squares of the field strengths or averaging the power densities over an area equivalent to the vertical cross section of the human body (projected area) or a smaller area depending on the frequency (see NOTES to Table 8 and Table 9 below), are compared with the MPEs in the Table.

[b]The left column is the averaging time for $|E|^2$, the right column is the averaging time for $|H|^2$. For frequencies greater than 400 MHz, the averaging time is for power density S

[c]These plane-wave equivalent power density values are commonly used as a convenient comparison with MPEs at higher frequencies and are displayed on some instruments in use.

The FCC and ANSI C95.1 limits are the same at the frequency of interest as 1 mW/cm^2 = 10 W/m^2.

4 Device Summary

Table 1 below summarizes the criteria used to evaluate the Evolv Edge Screener.

Table 3: Device Summary of the Evolv Edge Screener

Model Evaluated:	Evolv Edge Screener
Transmitter Category:	Sensing
Exposure Category:	Uncontrolled
Antenna Gain:	5 dBi
Power Output EIRP (dBm):	+1dBm
Evaluation Distance:	3 cm
Frequency Range:	24.0-28.8 GHz
Limit:	1mW/cm^2 (FCC Limit)

5 Radio Frequency Radiation Exposure Evaluation

5.1 MPE Calculation

For the FCC, the MPE is normally calculated at 20cm to determine 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 MPE Calculation Summary

One Transmitter					
Frequency	24000	MHz			
Limit	1.000	mW/cm^2			
Distance (cm), R =	20	cm			
Power (dBm), P =	-4	dBm			
TX Ant Gain (dBi), G =	5	dB			
Power Density:	0.000250	mW/cm^2	**Separation<20 cm**		
Minimum Distance:	**0.3**	cm			

The above ratio at a very conservative separation distance of 20 cm shows a margin of 10*log(1/.000250) = 36.0 dB at 20 cm.

5.2 Field Strength Measurements

Radiated emissions measurements of the fundamental of the device were performed. The peak E-field value was found at 28.6 GHz and resolved to a level of 95.2 dBuV/m at a 3 meter test distance.

According the ANSI C95.1, from 3 GHz to 30 GHz, the power density is spatially averaged over any contiguous area corresponding to $100\lambda^2$, where λ is the free space wavelength of the RF field in centimeters.

At 24 GHz this quantity is 100*(c/f) = 100*(300/fMHz) = $1.05m^{2.}$

For our measurements, summarized below, no spatial averaging was employed. A peak measurement of the field was taken.

5.3 MPE Calculations

The power density can be calculated using the familiar formula:

$$S = E^2/377 \text{ W/m}^2$$

Converting the measured field strength to V/m,

$$V/m = 10\text{^}(dBuV/m*(1E\text{-}6))/20$$

Thus, the field strength is 0.057 V/m

Computing the equivalent power density:

$$S = (0.057\text{^}2)/377 \text{ W/m}^2$$

$$S = 8.8E\text{-}6 \text{ W/m}^2$$

$$S = 8.8 \text{ uW/m}^2$$

Or,

$$S = 0.0088 \text{ mW/m}^2$$

This represents a margin of 60.5 dB.

The power density at closer distances were computed, by extrapolating from 3 m to 20 cm and 1 cm and the results are shown in the following table.

Table 5. Calculation of MPE Derived from 3 m Measurements

D	Frequency GHz	Limit W/m2	E-field dBuV/m	E-field uV/m	S W/m2	Margin dB
@3m	28.6	10	95.2	57544.0	8.78332E-06	60.563
@20cm	28.6	10	118.7	860993.8	0.00196634	37.063
@1cm	28.6	10	145.2	18197008.6	0.878331887	10.563

Note that the measurements and calculated MPE disagree by approximately 1 dB, with the measured levels being higher than the calculation.

6 Summary

The field strength that is emitted by the Evolv Edge Screener device is extremely low, when compared with the FCC and ANSI C95.1 limits. And, even at very close distances, a large margin exists.

In addition, the inherent usage of the Evolv Edge Screener implies a very low spatial duty factor. That is, the visitors who pass by the panels are in the field for a few seconds, much less than the averaging time for uncontrolled populations (30 minutes). This would imply an additional safety factor for the purposes of evaluating RF exposure from the device.

The Evolv Edge Screener device complies with the FCC and ANSI MPE C95.1 limits.