RF Exposure Exhibit

EUT Name: Gemini

Model Nos.: Ti400, Ti300 and Ti200

CFR Part 1.1310 and RSS 102

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Report/Issue Date: September 13, 2013
Report Number: 31362328.001 Appendix A

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1 Test Methodology

In this document, we evaluate the RF Exposure to human body due the intentional transmission from the transmitter (EUT). The limit for Maximum Permissible Exposure (MPE) specified in FCC 1.1310 is followed. Through the Friis transmission formula and the maximum gain of the antenna, we can calculate the distance, away from the product, where the limit of MPE is reached.

Although the Friis transmission formula is a far field assumption, the calculated result of that is an over-prediction for near field power density. We will take that as the worst case to specify the safety range.

1.1 RF Exposure Limit

According to FCC 1.1310 table 1: The criteria listed in the following table shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in 1.1307(b)

LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm^2)	Average Time (minutes)
(A)Limits For Occupational / Control Exposures				
0.3-1.34	614	1.63	*(100)	6
1.34-30	1842/f	4.89/f	*($900/f^2$)	6
30-300	61.4	0.163	1.0	6
30-1500	…	…	F/300	6
1500-100000	…	…	1.0	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	*($180/f^2$)	30
30-300	27.5	0.073	0.2	30
30-1500	…	…	F(MHz)/1500MHz	30
1500-100000	…	…	1.0	30

F = Frequency in MHz

*=Plane wave equivalent density

1.2 EUT Operating Condition

The Ti400 Series of Thermal Imagers are handheld imaging products that can detect infrared radiation (IR). The primary use is for preventive maintenance and diagnosing problems in industrial environments. These products are not intended for sale to consumers. The series has three versions labeled Ti400, Ti300, and Ti200.

The versions use the same common IR camera body assembly (Fluke part number 4340874). This IR camera body IR Camera body of the thermal imager contains the following radios:

- 802.11b/g (WLAN)
- Bluetooth
- 802.15.4 (Communicates with other Fluke-made devices having a Fluke proprietary 802.15.4 type radio)

The three transceivers share an antenna and matching network. The system processor controlled RF switch selects which radios are connected to the antenna. The radios operate in one of two modes:

1. 802.15.4 enabled, WiFi and Bluetooth both disabled.

2. WiFi and Bluetooth both enabled, 802.15.4 disabled

The antenna used is a 2.45GHz Ceramic Chip Antenna with a peak gain of 1.5dBi. The thermal imager, including the radios, will automatically cease operation and thus communication once battery capacity reaches a specified minimum threshold.

RF exposure for co-location and simultaneous transmission is evaluated in this report.

1.3 SAR requirements and justification

1.3.1 Antenna Gain

The antenna used is a 2.45GHz Ceramic Chip Antenna with a peak gain of 1.5dBi.

1.3.2 Portable configuration and hand position

Transmitter in Wi-Fi band transmitter with EIRP of 57mwatts operating at 30mm distance is excluded from SAR testing as per guide lines given appendix A of KDB 447498 D01 General 1 RF Exposure Guidance v05r01 dated 05/18/2013.

As per IEEE publication 1528-2013 (adopted by Industry Canada by NOTICE 2013-DRS0911) SAR exemption at device operation at 50mm and above 2.4GHz radio is 309mWatts. Please see table of above notice.

The highest EIRP of Gemini 46mwatts and closest distance operation is 80mm.

The closest position Gemini operated is 3.11 inches (80 mm), see Pictures below


4.95 inches
antenna


antenna
3.11
inches

1.4 MPE calculation

1.4.1 Portable Configuration

Calculations for this report are based on highest permitted power for each band.

Band MHz	Mode	Output Power dBm	Antenna gain (Max)	EIRP/ERP		Channels Available	Channels Used	Total EIRP	
				dBm	W			W	dBm
2400-2483.5	Wi-fi b	15.51	1.5	16.61	0.0458	11	1	0.0458	16.61
2400-2483.5	Wi-fi g	15.03	1.5	16.03	0.040	11			
2400-2483.5	Bluetooth	7.99	1.5	8.45	0.0069		1	0.007	
2400-2483.5	Zigbee	-9.91	1.5	-8.41	0.00014		1	-	
						Totals:		0.046	16.62

EUT can operate simultaneously in Wi-Fi and Bluetooth modes. Considering worst case scenario, highest EIRP possible is 16.62dBm

The highest measured power is +16.62dBm or 0.046W; average power.

Using the Friss transmission formula, the EIRP is Pout*G, and R is 20cm.

Pd= EIRP/(1600π)

Pd = (46) / (1600π) = 0.009 mW/cm2, which is well below the limit.

Calculating the distance at which Power density equals the limit

Calculation uses the free space transmission formula:

$$S = (PG)/(4 \pi d^2)$$

Where: S is power density (W/m^2), P is output power (W), G is antenna gain relative to isotropic, d is separation distance from the transmitting antenna (m).

d = Sqroot (PG/4π) d in Cm when PG in mW/cm^2 Limit at 2440MHz permissible power density 1.0 mW/cm^2

d = Sqroot 46/4π1.0

d= 3.14 cms

1.4.2 Sample Calculation

The Friss transmission formula: $Pd = (Pout*G) / (4*\pi*R^2)$

Where;

Pd = power density in mW/cm^2
Pout = output power to antenna in mW
G = gain of antenna in linear scale
$\pi \approx 3.1416$
R = distance between observation point and center of the radiator in cm

Ref. : David K. Cheng, *Field and Wave Electromagnetics*, Second Edition, Page 640, Eq. (11-133).