Appendix D - Maximum Permissible Exposure Calculations

D.1 REFERENCES

Normative Reference Standard	FCC CFR 47§1.1310 IEEE Std C95.1:2005
Procedure Reference	FCC CFR 47§2.1091

D.2 LIMITS

	Frequency	Power Density
FCC CFR 47§1.1310 Table 1(b)	300 - 1500 MHz	f/1500 mW/cm^2
	1500 - 100,000 MHz	1.0 mW/cm^2

D.3 ENVIRONMENTAL CONDITIONS

Temperature	na
Humidity	na
Barometric Pressure	na

D.4 MEASUREMENT EQUIPMENT SETUP

MEASUREMENT EQUIPMENT CONNECTIONS	The results described herein were determined by calculations, so no measurement equipment was used. The power measurements used in these calculations were made as described in Appendix A of this report.
MEASUREMENT EQUIPMENT SETTINGS	n/a

D.5 DUT OPERATING MODE(S)

The maximum EV-DO RF conducted channel power in each band used for these calculations was measured on Channel 384 for Cellular and Channel 600 for PCS.

D.6 TEST RESULTS

D.6.1 Calculations:

SkyCross Internal Antenna (Max. Measured Average Conducted Power - Cellular)

Prediction of MPE Limit
OET Bulletin 65, Edition 97-01

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

$$R = \sqrt{\frac{PG}{4\pi S}}$$

S= power density
P= power input to the antenna
G= power gain of the antenna in the direction of interest relative to an isotropic radiator
R= distance to the center of radiation of the antenna

Occupational/Controlled ○
General Population/Uncontrolled ◉

Ratio of Time on vs Total TX Time	**1.00**

Tx Frequency:	**836.52**	**(MHz)**
RF Output Power at Antenna Input Terminal:	**24.71**	**(dBm)**
Source-Based Time -Average Factor:	**0.00**	**(dB)**
Source-Based Time-Averaged RF Output Power at Antenna Input Terminal:	**24.71**	**(dBm)**
Antenna gain:	**3.80**	**(dBi)**

S=	**0.56**	**(mW/cm^2)**
P=	**295.8012**	**(mW)**
G=	**2.40**	**(numeric)**

R = 10.06 (cm)

S at 20cm: 0.14101307 (mW/cm^2)

Formulae:

$S = \frac{PG}{4\pi R^2}$ where: S = Power Density Limit
P = Power Output of the Device
G = Numeric Antenna Gain
R = Distance from Antenna

$R = \sqrt{\frac{P}{4\pi S}}$

Source-Based Time-Average Factor = 10 * log (Time On / (Time On + Time Off))
Power Output of the Device (W) = 10 * log (RF Output Power (dBm) + Source-Based Time Average Factor (dB))

D.6.2 Calculations:

SkyCross Internal Antenna (Max. Measured Average Conducted Power - PCS)

Prediction of MPE Limit
OET Bulletin 65, Edition 97-01

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

$$R = \sqrt{\frac{PG}{4\ \pi\ S}}$$

S= power density
P= power input to the antenna
G= power gain of the antenna in the direction of interest relative to an isotropic radiator
R= distance to the center of radiation of the antenna

Occupational/Controlled ○
General Population/Uncontrolled ◉

Ratio of Time on vs Total TX Time	**1.00**

Tx Frequency:	**1880**	**(MHz)**
RF Output Power at Antenna Input Terminal:	**23.98**	**(dBm)**
Source-Based Time -Average Factor:	**0.00**	**(dB)**
Source-Based Time-Averaged RF Output Power at Antenna Input Terminal:	**23.98**	**(dBm)**
Antenna gain:	**-0.30**	**(dBi)**

S=	**1.00**	**(mW/cm^2)**
P=	**250.0345**	**(mW)**
G=	**0.93**	**(numeric)**

R = 4.31 (cm)

S at 20cm: 0.046372378 (mW/cm^2)

Formulae:

$S = \frac{PG}{4\pi R^2}$ where: S = Power Density Limit
P = Power Output of the Device
G = Numeric Antenna Gain
R = Distance from Antenna

$R = \sqrt{\frac{PG}{4\pi S}}$

Source-Based Time-Average Factor = 10 * log (Time On / (Time On + Time Off))
Power Output of the Device (W) = 10 * log (RF Output Power (dBm) + Source-Based Time Average Factor (dB))

D.6.3 Calculations:

MaxRad Vehicle-Mount Antenna (Max. Measured Average Conducted Power - Cellular)

Prediction of MPE Limit
OET Bulletin 65, Edition 97-01

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

$$R = \sqrt{\frac{PG}{4\ \pi\ S}}$$

S= power density
P= power input to the antenna
G= power gain of the antenna in the direction of interest relative to an isotropic radiator
R= distance to the center of radiation of the antenna

Occupational/Controlled ○
General Population/Uncontrolled ◉

Ratio of Time on vs Total TX Time	**1.00**

Tx Frequency:	**836.52**	**(MHz)**
RF Output Power at Antenna Input Terminal:	**24.71**	**(dBm)**
Source-Based Time -Average Factor:	**0.00**	**(dB)**
Source-Based Time-Averaged RF Output Power at Antenna Input Terminal:	**24.71**	**(dBm)**
Antenna gain:	**3.00**	**(dBi)**

S=	**0.56**	**(mW/cm^2)**
P=	**295.8012**	**(mW)**
G=	**2.00**	**(numeric)**

R = 9.18 (cm)

S at 20cm: 0.117289563 (mW/cm^2)

Formulae:

$S = \frac{PG}{4\pi R^2}$ where: S = Power Density Limit
P = Power Output of the Device
G = Numeric Antenna Gain
R = Distance from Antenna

$R = \sqrt{\frac{PG}{4\pi S}}$

Source-Based Time-Average Factor = 10 * log (Time On / (Time On + Time Off))
Power Output of the Device (W) = 10 * log (RF Output Power (dBm) + Source-Based Time Average Factor (dB))

D.6.4 Calculations:

MaxRad Vehicle-Mount Antenna (Max. Measured Average Conducted Power - PCS)

Prediction of MPE Limit
OET Bulletin 65, Edition 97-01

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

$$R = \sqrt{\frac{PG}{4\ \pi\ S}}$$

S= power density
P= power input to the antenna
G= power gain of the antenna in the direction of interest relative to an isotropic radiator
R= distance to the center of radiation of the antenna

Occupational/Controlled ○
General Population/Uncontrolled ◉

Ratio of Time on vs Total TX Time	**1.00**

Tx Frequency:	**1880**	**(MHz)**
RF Output Power at Antenna Input Terminal:	**23.98**	**(dBm)**
Source-Based Time -Average Factor:	**0.00**	**(dB)**
Source-Based Time-Averaged RF Output Power at Antenna Input Terminal:	**23.98**	**(dBm)**
Antenna gain:	**3.00**	**(dBi)**

S=	**1.00**	**(mW/cm^2)**
P=	**250.0345**	**(mW)**
G=	**2.00**	**(numeric)**

R = 6.30 (cm)

S at 20cm: 0.099142386 (mW/cm^2)

Formulae:

$S = \frac{PG}{4\pi R^2}$ where: S = Power Density Limit
P = Power Output of the Device
G = Numeric Antenna Gain
R = Distance from Antenna

$R = \sqrt{\frac{PG}{4\pi S}}$

Source-Based Time-Average Factor = 10 * log (Time On / (Time On + Time Off))
Power Output of the Device (W) = 10 * log (RF Output Power (dBm) + Source-Based Time Average Factor (dB))

Bluetooth Radio

Antenna Type	Antenna Part No.	Transmit Frequency (MHz)	Max Peak Conducted Output Power (mW)	Antenna Gain (dBi)	Minimum Antenna Cable Loss (dB)	Power Density @ 20 cm (mW/cm^2)	General Population Exposure Limit from 1.1310 (mW/cm^2)	Ratio of Power Density to the Exposure Limit
Etenna's AccuWave	EA2400	2402	0.85	3	0	0.0003	1	0.0003
Worst Case Ratio of Power Density to the Exposure Limit = 0.0003								

Results:

Mode of Operation	RF Conducted Output Power	Antenna Gain	MPE Distance	Power Density at 20 cm	Power Density Limit
	dBm	dBi	cm	mW/cm^2	mW/cm^2
Cellular EV-DO	24.71	3.8	10.06	0.1410	0.56
PCS EV-DO	23.98	-0.3	4.31	0.0464	1.0
Bluetooth	-0.7	3.0	0.37	0.0003	1.0

D.6.5 Co-Transmit MPE Calculations

Radio	Power Density at 20 cm	Ratio	Sum	Power Density Limit
	mW/cm^2	(S / Limit)	mW/cm^2	mW/cm^2
Cellular EV-DO	0.1410	0.252	0.2523	1
Bluetooth	0.0003	0.0003		
PCS EV-DO	0.0464	0.0464	0.0467	1
Bluetooth	0.0003	0.0003		

D.7 PASS/FAIL

In reference to the results outlined in D.6 the DUT passes the requirements as stated in the referenced rule part as follows:
1) The DUT must comply with the minimum spacing requirement of 20 cm to ensure an exposure of not more than f/1500 mW/cm^2 for frequencies between 300 and 1500 MHz and 1 mW/cm^2 for frequencies between 1500 and 100,000 MHz.

D.8 SIGN-OFF

I attest to the accuracy of the data. All calculations/measurements reported herein were performed by me and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these calculations/measurements.

Spencer Watson
Senior EMC Technologist
Celltech Labs Inc.

February 14, 2007
Date

Antenna Information

Internal and External WAN Antenna Information

FCC ID: KBCIX-NW620

Antenna Model	Antenna Part No.	Frequency (MHz)	Antenna Type	Antenna Gain (dBi)
Internal Skycross WAN	59-0479-004R	806 - 960	Meander Line Antenna	3.8
Internal Skycross WAN	59-0479-004R	1710-1990	Meander Line Antenna	-0.3
External MaxRad	BMLPVDB800/1900	806 - 960	Low profile vertical	3
External MaxRad	BMLPVDB800/1900	1710-1990	Low profile vertical	3

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EA2400 AccuWave ä 2.4 GHz Bluetooth ä /802.11 Antenna

Product Description

Etenna's EA2400 AccuWave™ is an ultra-small, low-cost, low profile antenna for 802.11b/g wireless local area network (WLAN) and Bluetooth™ personal area network (PAN) applications. Available today for integration within 2.4 GHz wireless devices, the EA2400 AccuWave technology will allow Bluetooth and Wi-Fi module manufacturers to design one antenna that works in multiple devices. The AccuWave antenna product utilizes Etenna's DC-Inductive (DCL) Frequency Selective Surface (FSS) antenna technology (patents pending); its energy storage mechanism and radiation characteristics create a frequency stable antenna. Ultimately, the cost and size of AccuWave antennas will enable the development of Bluetooth or Wi-Fi standard modules that can plug into any wireless device including handsets, PDAs and laptops.

Features & Benefits

- Small form factor (10 x 14 x 2.4 mm)
- Ability to be mounted directly over board components thus saving board space; components can sit beneath the antenna
- High-volume production design using light-weight molded plastics
- Assembled using standard surface mount technology (SMT) processes (no cables or connectors required)
- Very competitive pricing
- Mounts directly to groundplanes
- No external matching components required

Figure 1. Etenna's EA2400 AccuWave antenna.

The EA2400's unique table top form factor is relatively insensitive to anything in its near-field; the frequency of operation varies little with close proximity to other components, plastic housing or users (in-situ). Varying the groundplane size from 30 mm x 20 mm to 250 mm x 250 mm causes a frequency shift of only ±15 MHz. The total shift in resonant frequency due to humidity and temperature extremes is 12 MHz. All environmental tests have been performed on a standard 45 mm x 45 mm test board, with the antenna mounted on the corner of the board (the preferred location).

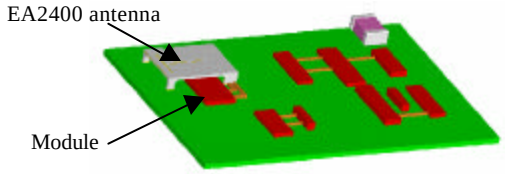


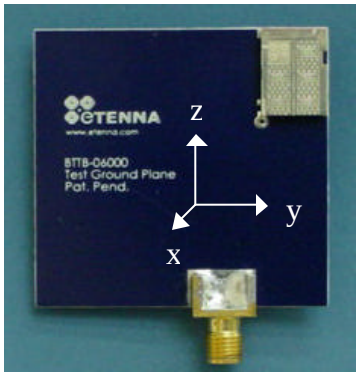
Figure 2. EA2400 antenna covering components on a printed circuit board.

Specifications

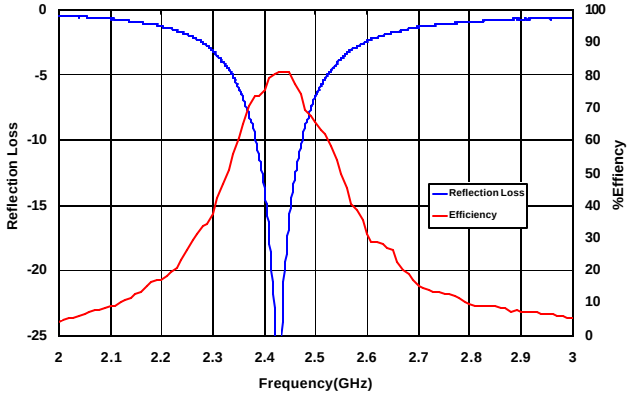
Frequency Range	2400–2485 MHz
Efficiency	50% min., 70% typical
Peak Gain	+3 dBi nominal
3 dB Bandwidth	200 MHz minimum
Voltage Standing Wave Ratio	<2.0:1 nominal
Polarization	Linear
Power Handling	2 watt cw
Feed Point Impedance	50 ohms unbalanced
Temperature	-35° C to 85° C
Size	10 x 14 x 2.4 mm
Weight	0.19 g maximum
Mounting Area Required on Printed Circuit Board (PCB)	140 mm^2 total
Total Contact Area on PCB	2.5 mm^2 total
Maximum Height of Components Under Antenna	1.2 mm

Note: Specs are subject to change without notice.

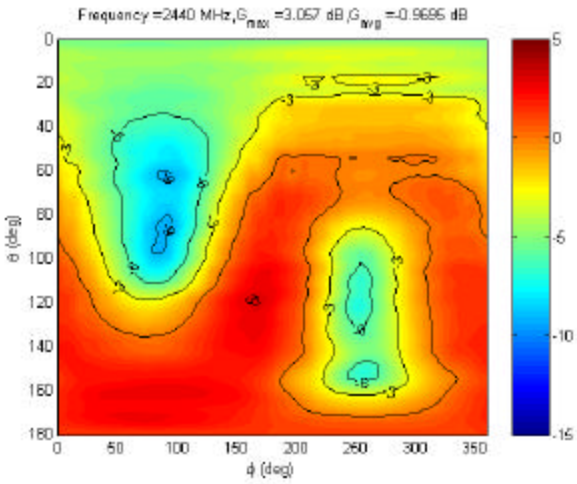
A1.1 - Antenna mounted on a 45 mm sq. test board.



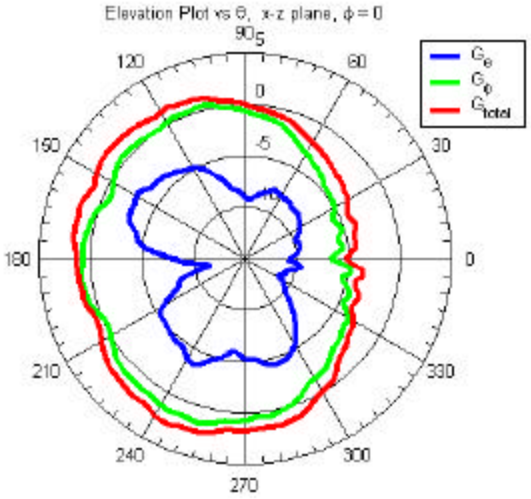
A1.2 – Efficiency and return loss.



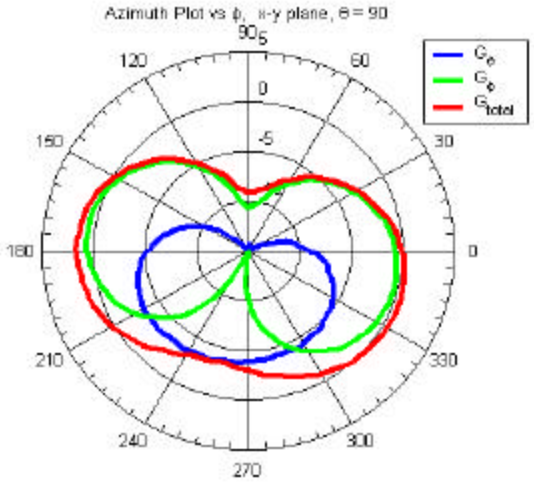
A1.3 – Total gain contour plot (dBi).



A1.4 – Elevation gain plot (dBi).



A1.5 – Azimuth gain plot (dBi).



A1.6 – Elevation gain plot (dBi).