Working Paper

Analysis of the FCC Regulations for Radiation Safe Distance with respect to the Gemini 58XX Range of Products

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Abstract

This document analyses the exclusion zone required to ensure human radiation level limits are not exceeded by the Gemini 58XX range of products with integrated or external antennas. The guidelines in FCC Bulletin 65.

Revision History

Version	Date	Comments	Author
0.001	24 November 2003	Initial Issue	DMS

Operational Parameters of the Gemini 58XX Products

1 Scope

The purpose of this brief working paper is to identify the mean RF power produced by the Gemini 58XX equipments under various operating conditions. This mean RF power plus the antenna gain used in specific installations identifies the effective power density (dBm/cm^2) that is to be compared against allowed limits for human exposure.

2 References

Evaluating Compliance with FCC Guidelines for Human Exposure to Radio frequency Electromagnetic Fields:
OET Bulletin 65, Edition 97-01, August 1997 [1]

3 Background

Reference [1] identifies how the radiated power density should be calculated for different distances from the antenna. The variables used are Radiated Power Density (S), conducted power (P), Antenna Gain (G) and distance (R) . The formula given is

$$S= (P * G)/(4 * Pi * R)^2$$

The limit allowed for S depends on whether the exposure risk is to a member of the public or not. The limits for public exposure are the lower, and so a power density limit of $1mW/cm^2$ is used for S. This is used to compute a ‘safe’ distance from the antenna. It is clear from [1] that the power to be used should be the RMS power averaged over a period of 6 minutes.

4 Gemini 58XX Specific Issues

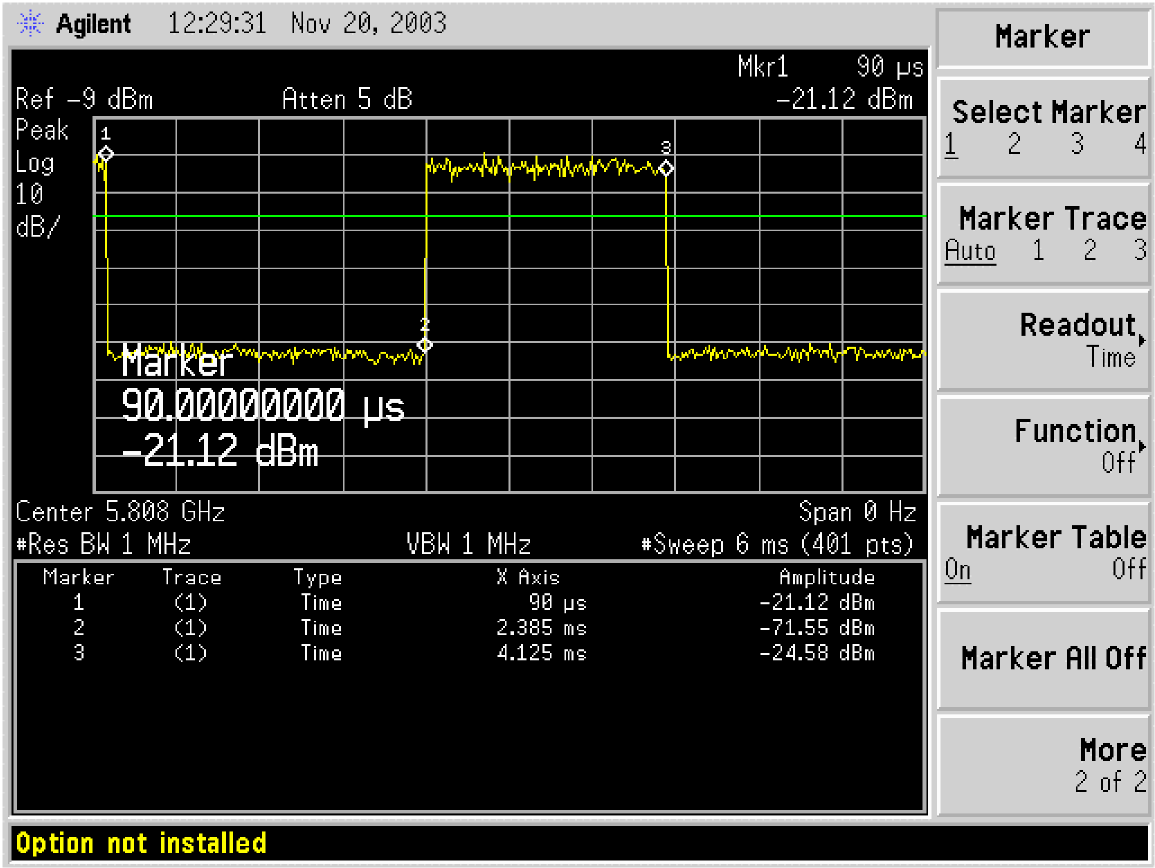
4.1 FCC Testing

The Gemini 58XX is approved under section 15.247 and the only RF power level measured is the Peak Envelope Power during the transmission bursts. The measurement is done using peak detector, maximum resolution bandwidth, maximum video bandwidth and with the equipment set to max hold. If this power level is used for the computation of ‘safe distance’ the result is unduly pessimistic.

4.2 Errors in Using the FCC Recorded Power Levels

The errors arise from :

a) the Gemini 58XX operates as a Time Division Duplex System and only transmits for approximately 43% of the time, over a period of approximately 4msec. The actual transmit/receive burst duration is shown in the plot below.



This shows a transmit duty cycle of 1 – 2385/(4125-90) or 0.409.

Using the more accurate Phy layer timing data, the actual duty cycle for Tx is 42.89%, or a difference of 3.68dB.

b) the formal measurements record peak envelope power, and the OFDM waveform used has a high peak to mean difference. The actual difference depends on modulation mode, but for the case the mode used at maximum power, the peak to mean approaches 6dB.
   Gemini 58XX uses an RF detector and a control loop to hold the power level at the closely to the set level. Gemini has a maximum setting for the mean power output of 24dBm (both channels together). The mean transmitted power level is reduced to this level to ensure meeting the peak envelope power limits contained in 15.247.
c) In the case of the external antennas, the tests were performed with a cable loss of 1.2dB; the handbook mandates that this is the minimum cable loss that can be used.

5 Recommendations

It is recommended that the power level used for computing the 'safe distance' for human exposure is either

a) the nominal maximum power output less the allowance for the duty cycle. This is 24dBm -3.68dB or 20.32dBm. The safe distance calculations for the different antennas are shown below on this basis.
b) The power level in (a) less the minimum cable losses. Safe distance calculations are also included for this case.

Total Mean Transmit Power	20.32		dBm
	107.65		mW
	81.66		mW incl cable loss
Safety Power Density Limit	1		mW/cm2
Antenna Type	Manufacturer's Gain (dBi)	Safe Distance for 0dB Cable Loss (m)	Safe Distance for 1.2dB Cable Loss (m)
Integrated	23.5	0.44	N/A
2 ft Flat Plate	28	0.74	0.64
2ft Parabolic Dish	28.5	0.78	0.68
3ft Parabolic Dish	31.5	1.10	0.96
4ft Parabolic Dish	34.5	1.55	1.35
6ft Parabolic Dish	37.7	2.25	1.96

Annex A

It is somewhat puzzling that 'safe distance' is calculated by the FCC in the way described in [1]. The calculations show increasing distances required with increasing antenna gain. However, as the antenna gain is increased, the beamwidth reduces and the energy is concentrated on a smaller area than the whole body – the $1mW/cm^2$ is a whole body limit.

For example,

a) The biggest antenna we use has a gain of 37.7dBi and X/Y beamwidths of 2^o. The original calculations using 1W of power give a safe distance of 7m. The area exposed to the full power (within 3dB) is approximately a circle of diameter 24cm at a power density of about $1mW/cm^2$. This is obviously smaller than the whole body and so the higher, partial body limits would seem to apply.

b) Indeed, in the limit at the antenna face, the power input to the antenna is spread evenly across the area of the antenna. 1W spread across a 6m diameter dish has an average power density of $3.5\mu W/cm^2$ at the antenna face, well within FCC limits. The smaller integrated antenna is 14 inch square and has a power density at the antenna face of only $800uW/cm^2$ assuming 1W of power.