RF Exposure Info / MPE Sample Calculation

Model: CAP M2 C-Band
FCC-ID: XS5-CAPM2CBand

INTRODUCTION

The Era product is a digital distribution system with focus on flexibility, easy installing, commissioning and reliable operation. The system is designed in a way to satisfy all of today's needs as well as unknown future standards and requirements.
The Era system comprises of two main parts. A base station interface (Master or Head End Unit) that takes RF signals as well as digital signals from the base stations, conditions the signals for the given application and assigns them to the coverage zones.
The coverage side is built of one or more Remote Units. The "Remote Unit" (hereinafter referred to as "**RU**") is connected via a 10GBASE SFP+ fiber optical link to the Era Master Unit. This link gives a total RF bandwidth of up to 320 MHz. For higher bandwidth requirements up to 640 MHz, a secondary 10G link can be used in parallel. RF signals between Master Unit and Remote Units are sent digitally over the fiber opticallink. At the receiver side these signals are converted back to analog and amplified up to appropriate transmit levels.

The RU allows cascading of up to in total 4 RUs. This shall be done either in the optical domain by CWDM or digitally in the FPGA.
The unit is designed to support up to 2 Radio Modules with 2 medium power amplifiers each within one RU cabinet. Depending on the market needs the outputs of the PAs can be all combined to one common or multiple antenna ports.
The RU is equipped with a signal processing module with an ARM Cortex A-53 controller core embedded in a Xilinx Zynq® UltraScale+™ MPSoC device.
The RU shall have capability to measure the unit's input and output power at the antenna port, passive intermodulation (PIM) and determine VSWR.
The RU can be equipped optionally with an AC or DC power supply.
The Era medium power RU is primarily intended for indoor and outdoor use, while the master unit mainly operates in indoor environments. Although this is not a rule especially in cases where master unit components are used together with air-conditioned outdoor racks.

The specific device generally will be professionally installed.
Hereby the gain of the finally installed antenna(s), cable attenuation and antenna height will be defined site specific at the time of licensing with the appropriate FCC Bureau(s).

The maximum permissible exposure limit is defined in **47 CFR 1.1310 (B).**

S = power density limit [W/m]
P = power [W]
R = distance [m]

$S_n = \frac{P_n G_n}{4\pi R_n^2}$ => $R_n = \sqrt{\frac{P_n G_n}{4\pi S_n}}$ (to calculate the distance at one frequency)

If we have more bands, than we have to calculated as a percentage:
The additional of the terms have to be lower than 1.

$$\frac{S_{cal1}}{S_1} + \frac{S_{cal2}}{S_2} + \frac{S_{cal3}}{S_3} + ... + \frac{S_{caln}}{S_n} < 1$$

$$\frac{\frac{P_1 G_1}{4\pi R_1^2}}{S_1} + \frac{\frac{P_2 G_2}{4\pi R_2^2}}{S_2} + \frac{\frac{P_3 G_3}{4\pi R_3^2}}{S_3} + ... + \frac{\frac{P_n G_n}{4\pi R_n^2}}{S_n} < 1$$

We are looking for a distance of ensures that the formula is satisfied.
$R_1 = R_2 = R_3 = ... = R_n$

$$\frac{P_1 G_1}{4\pi R^2 S_1} + \frac{P_2 G_2}{4\pi R^2 S_2} + \frac{P_3 G_3}{4\pi R^2 S_3} + ... + \frac{P_n G_n}{4\pi R^2 S_n} < 1$$

$$\frac{P_1 G_1}{4\pi S_1} + \frac{P_2 G_2}{4\pi S_2} + \frac{P_3 G_3}{4\pi S_3} + ... + \frac{P_n G_n}{4\pi S_n} < R^2$$

$$\sqrt{\frac{P_1 G_1}{4\pi S_1} + \frac{P_2 G_2}{4\pi S_2} + \frac{P_3 G_3}{4\pi S_3} + ... + \frac{P_n G_n}{4\pi S_n}} < R$$

With $R_n = \sqrt{\frac{P_n G_n}{4\pi S_n}}$ => $R_n^2 = \frac{P_n G_n}{4\pi S_n}$

$$\sqrt{R_1^2 + R_2^2 + R_3^2 + ... + R_n^2} < R$$

What you have to do for calculate the minimum distance were the power density limit is met:

1) If you have **one path**, you have to put your special values in the following formula.

$$R_n = \sqrt{\frac{P_n G_n}{4\pi S_n}}$$ (Distance for one carrier)

Limits for General Population / Uncontrolled Exposures

Frequency Range (MHz)	Power Density (mW/cm^2)
300 – 1500	S = f/1500
1550 – 100000	S = 1

2) If you have **more than one path**, you must add the individual terms quadratic.

$$R_n = \sqrt{\frac{P_n G_n}{4\pi S_n}}$$ (Distance for individual carrier)

$$\sqrt{R_1^{\;2} + R_2^{\;2} + R_3^{\;2} + \ldots + R_n^{\;2}} < R$$ (See previous page)

For example:

The EUT operates with 4 Outputs:

DL Frequency Band are:

Band	Freq. DL
C	3700 - 3980 MHz

The nominal conducted output power is 35 dBm (3.2W) per antenna port.

Calculation for every path with maximum allowed antenna gain and without cable loss:

Frequency [MHz]	Output Power [dBm]	Antenna Gain [dBi]	Calculated Distance [m]
3700	35	15	**0.8921**
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3700	35	15	**0.8921**
3700	35	15	**0.8921**

The worst case would be if all bands were active:

$$\sqrt{R_1^2 + R_2^2 + R_3^2 + \ldots + R_n^2} < R$$

$R_{all} > 1.784$ m (see previous page for derivation)

For more accurate calculation, the cable loss and actual antenna gain have to be included in the final system.

The antenna(s) used with device must be fixed-mounted on permanent structures with a distance to any human body to comply with the RF Exposure limit.