# RF Exposure Info / MPE Sample Calculation

**Model:** **CAP M 80-85/17E/19/26**
**FCC-ID:** **XS5-CAPM8171926**

INTRODUCTION

## CAP M Base Unit Overview

The CAP M serves as a remote unit in an ION-E DAS. The CAP M interfaces with the CAN/TEN via an optical link. The CAP M can also be cascaded to a second unit using the same transport mechanism, and/or an auxiliary PoE (Class 3) Ethernet device such as a wireless access point. On the DL, the CAP M converts some or all the data arriving at the CAP M to analog signals and sends them to the antenna ports. On the UL, received signals are digitized and serialized into data streams which are sent back to the CAN. Each unit contains up to four transceiver paths for RF coverage. Each path is dedicated to a fixed band (set in the factory).

Physically, the CAP M base unit consists of 3 major PCBAs, the Main board and 2 separate RF boards for optimization of the thermal dissipation. A cavity Duplexer and Power supply module.

### MAIN BOARD

The Main Board contains the FPGA, reference clocks, and power supplies for the unit. Main Board provides the interface to the ERA head end (CAN or TEN) by optical connection. The Main Board also provides the interfaces for a cascaded CAP M and/or auxiliary Ethernet port.

Additional connections to the “outside world” from the Main Board include status & alarm indicator bi-color LED, and the fan kit connector (optional). Internally, the board contains the A/D and D/A converters as well as the IF and frequency-translating components for the RF transceivers. The main board transceiver paths are frequency-agnostic, so that only the RF board must be changed to cover a different set of frequency bands.

### RF BOARDS

The RF boards contain the PAs, LNAs, filters, and combiners for each coverage band. These bands are combined in the cavity multiplexer, 1 ANT port for SISO version and 2 ANT ports for MIMO version. The RF Boards are the parts, where all of the frequency-specific devices reside, thus the bands supported by a CAP M unit are generally determined by the RF Board variant and a specific cavity multiplexer.

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.

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

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

We are looking for a distance of ensures that the formula is satisfied.

$R_1 = R_2 = R_3 = \ldots = R_n$

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

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

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

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

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

**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/cm²) |
|---|---|
| 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 in **4** frequency bands:

***DL*** Frequency Bands are:

| Band | Freq. DL |
|---|---|
| 80 | 862-869 MHz |
| 85 | 869-894 MHz |
| 17E | 2110-2180 MHz |
| 19 | 1930-1995 MHz |
| 26 | 2620-2690 MHz |

**The max conducted output power is 31 dBm (1.3W) 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] | Recommended Distance [m] |
|---|---|---|---|---|
| 862 | 26 | 9 | **0,209** | **0.25** |
| 2110 | 30 | 9 | **0,251** | **0.29** |
| 1930 | 30 | 9 | **0,251** | **0.29** |
| 2620 | 31 | 9 | **0,282** | **0.32** |

**The worst case would be if all bands were active:**

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

$R_{all} > 0,577m$ (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.**

Thomas Hufnagel
Test Engineer

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