RF Exposure Info / MPE Sample Calculation

Model: ION-U EB L 23/23 Vac
FCC-ID: XS5-UEBL2323

THE MAIN TASKS OF THE TFBX BOOSTER
Downlink (DL):
• RF output power adjustment: to compensate the gain variation of the auxiliary channel
• RF amplification: RF signal are boosted in order to maintain a good signal-to noise ratio
• RF filtering: a proper filter rejects the spurious emissions
• RF splitting: the boosted RF signal is conveyed to two antenna ports
Uplink (UL):
• Automatic Level Control (ALC): the RF signal level is adjusted according to blocking requirements
• RF amplification: a low noise amplifier boosts the signal received from antennas
in order to maintain a good signal-to-noise ratio
• RF filtering: the boosted signal is cleaned of the spurious emissions

FREQUENCY STABILITY
For not converted paths:
Frequency stability is given by: The system gets an electrical analog signal from the SS which is converted into an analog optical signal, transmitted by the optical link and then reconverted in the Remote Unit into an analog electrical signal. During this process happens no frequency change/modification, so input and output have same frequency.

For converted paths:
Frequency stability is given by: The system gets an electrical analog signal from the BSS which is converted in the Master Unit frequency conversion module (FCM), into 2 analog optical signals on 2 different frequencies. These signals are transmitted by one optical link and then reconverted in the Remote Unit FCM into 2 analog electrical signals with same frequency for each of the 2 transmitting sectors. During this process happens no modification, as the oscillator responsible for both conversions is the same, so input and output have same frequency.

Duplexers and filters limits the frequency bands. A transmitting and receiving of signals outside the permitted limits is not possible. The level will be regulated by power down function at the BTS.

The selection and managing of frequency bands is on responsibility of national US frequency administration which deal with licences.

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.

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

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

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 you 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 – 100,000	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 one frequency band in SISO operation and 5 bands in MIMO operation.
The max measured conducted output power is 31 dBm (1.3 W). The worst case operation is the MIMO configuration.
Calculation for every path with maximum allowed antenna gain and without cable loss:

Frequency [MHz]	Max Power out [dBm]	Antenna gain, **without** cable loss [dBi]	Max. Distance [m]
728	30	9	0.1141
851.5	30	9	0.1055
1930	30	9	0.0795
2110	30	9	0.0795
2355	31	9	0.0892

The worst case would be if all bands were active:

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

$R_{all} > 0.209$ m (see previous page for derivation)

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