# RF Exposure Requirements

**General information:**

Device category: Fixed per Part 2.1091
Environment: Uncontrolled Exposure

Fixed devices that operate under Part 90 of this chapter are subject to routine environmental evaluation for RF exposure prior to equipment authorization or use if they operate at frequencies of 1.5 GHz or below and their effective radiated power (ERP) is 1.5 watts or more. However, compliance with the power density limits of 1.1310 is not required.

**Antenna:**

The TR412 transceiver board is designed to be installed and will only fit into DAMM Cellular base stations BS411 and BS414 which are designed for only antenna installation sites with outdoor fixed mounted locations. The manufacturer does not specify an antenna, but in fix mounted antenna installations they typically have gains to 3 dBi.

The base station equipment has a net loss of approximately 3 dB because they contain passive isolators and a physically large final bandpass filter. The base stations can contain more than one TR412 card which can allow more than one carrier to be transmitted simultaneously.

This device has provisions for operation only as a fixed mounted device, meaning a fixed location.

| Configuration | Antenna p/n | Type | Max. Gain (dBi) |
|---|---|---|---|
| Fixed | Any | omni | 3 |
| | | | |

**Operating configuration and exposure conditions:**

The base stations conducted output power is 12 Watts. In base station operation the duty cycle can approach 100 %. The manufacturer also markets this device only for occupation use applications. But, some installations may not control exposure other than separation distance.

- Part 2.1091 states that devices are excluded from routine evaluation if the EIRP is less than 2.46Watt (or 1.5WERP).

- A typical fixed installation consists of an antenna system with a coaxial cable of the type ½ inch hardline which has a loss of 1 dB for a length of 50 feet at UHF frequencies.

**MPE Calculation:**

The minimum separation distance is calculated as follows:

$$E(V/m) = \frac{\sqrt{30 \times P \times G}}{d} \qquad \text{Power density: } P_d(mW/cm^2) = \frac{E^2}{3770}$$

The limit for uncontrolled exposure environment above 300 MHz is f in MHz/1500 = $mW/cm^2$.

Frequency: 450 MHz
The conducted power output is 12 Watts.
The coax loss was taken as 1.0 dB.
Antenna gain was taken as 3 dBi
100% Duty Factor
Power Density = S= 0.3 $mW/cm^2$

$W := 12$ power in Watts

$D := 1$ Duty Factor in decimal % (1=100%)

1 for FM
0.6 for SSB

$E := 30$ exposure time in minutes

$U := 30$ (use 6 for controlled and 30 for uncontrolled)

$$Wexp := W \cdot D \cdot \left( \frac{E}{U} \right)$$

$$PC := \left( \frac{E}{U} \right) \cdot 100$$

$Wexp = 12$ Watts

$PC = 100$ % on time

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$Po := 12000$ mWatts

$f := 450$ Frequency in MHz

$dBd := 0.85$ antenna gain in dBd

$$S := \frac{f}{1500}$$ power density limit for uncontrolled exposure

$G1 := dBd + 2.15$ gain in dBi

$G1 = 3$ dBi

$CL := 1.0$ dB coax loss

$$S = 0.3 \quad \frac{mW}{cm^2}$$

$G := G1 - CL$

General population
S is 1 between 1500 and 100k MHz
S is f/1500 for 300 to 1500 MHz
S is 0.2 between 30 and 300 MHz

$$Gn := 10^{\frac{G}{10}}$$ gain numeric

Occupational
S is 1 between 30 and 300 MHz
S is f/300 between 300 and 1500 MHz
S is 5 between 1500 and 100k MHz
(See 47 CFR 1.1310)

$Gn = 1.585$ dB

$$R := \sqrt{\frac{(Po \cdot Gn)}{|4 \cdot \pi \cdot S|}}$$

$$inches := \frac{R}{2.54}$$

$R = 71.027$ distance in centimeters required for compliance

$inches = 27.963$

$$ft := \frac{inches}{12}$$

$ft = 2.33$

**Conclusion:** Single carrier

The DAMM Cellular TR412 transceiver card only fits BS411 and BS414 base stations and is not designed for nor fit any other installation. The RF output power of the card is 3 dB higher than can be obtained from a single carrier base station as the base station has approximately 3 dB of system loss. The base stations are designed for systems using antennas mounted to outdoor permanent structures.

For a transmitter operating with the above criteria the separation distance should be no less than 71 cm or 2.4 ft between the antenna, including any radiating structure, and any persons when normally operated. This is for only a single transmitting carrier; other operating conditions should follow a procedure like that shown above and following the guidelines such as those in FCC document OET-65.

**Conclusion:** 4 carriers

For a transmitter operating with the criteria below the separation distance should be no less than 142 cm or 4.7 ft between the antenna, including any radiating structure, and any persons when normally operated. Other transmit configurations should follow a procedure like that shown below and following guidelines like those in FCC document OET-65.

**Conclusion:** 8 carriers

For a transmitter operating with the criteria below the separation distance should be no less than 201 cm or 6.6 ft between the antenna, including any radiating structure, and any persons when normally operated. Other transmit configurations should follow a procedure like that shown below and following guidelines like those in FCC document OET-65.

In a multiple carrier setup the carrier powers were summed and the RF exposure calculated based on this.

4 channel system:

Frequency: 450 MHz
The conducted power output is 12 Watts (single) 48 W (4 channels).
The coax loss was taken as 1.0 dB.
Antenna gain was taken as 3 dBi
100% Duty Factor
Power Density = S= 0.3 mW/cm$^2$

$W := 48$ power in Watts

$D := 1$ Duty Factor in decimal % (1=100%)

1 for FM
0.6 for SSB

$E := 30$ exposure time in minutes

$U := 30$ (use 6 for controlled and 30 for uncontrolled)

$$Wexp := W \cdot D \cdot \left(\frac{E}{U}\right)$$

$$PC := \left(\frac{E}{U}\right) \cdot 100$$

$Wexp = 48$ Watts

$PC = 100$ % on time

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$Po := 48000$ mWatts

$f := 450$ Frequency in MHz

$dBd := 0.85$ antenna gain in dBd

$$S := \frac{f}{1500}$$ power density limit for uncontrolled exposure

$G1 := dBd + 2.15$ gain in dBi

$G1 = 3$ dBi

$CL := 1.0$ dB coax loss

$S = 0.3$ $\frac{mW}{cm^2}$

$G := G1 - CL$

General population
S is 1 between 1500 and 100k MHz
S is f/1500 for 300 to 1500 MHz
S is 0.2 between 30 and 300 MHz

$$Gn := 10^{\frac{G}{10}}$$ gain numeric

Occupational
S is 1 between 30 and 300 MHz
S is f/300 between 300 and 1500 MHz
S is 5 between 1500 and 100k MHz
(See 47 CFR 1.1310)

$Gn = 1.585$ dB

$$R := \sqrt{\frac{(Po \cdot Gn)}{|4 \cdot \pi \cdot S|}}$$

$$inches := \frac{R}{2.54}$$

$R = 142.055$ distance in centimeters required for compliance

$inches = 55.927$

$$ft := \frac{inches}{12}$$

$ft = 4.661$

Frequency: 450 MHz
The conducted power output is 12 Watts (single) 96 W (8 channels).
The coax loss was taken as 1.0 dB.
Antenna gain was taken as 3 dBi
100% Duty Factor
Power Density = S= 0.3 $mW/cm^2$

$W := 96$ power in Watts

$D := 1$ Duty Factor in decimal % (1=100%)

1 for FM
0.6 for SSB

$E := 30$ exposure time in minutes

$U := 30$ (use 6 for controlled and 30 for uncontrolled)

$$Wexp := W \cdot D \cdot \left(\frac{E}{U}\right)$$

$$PC := \left(\frac{E}{U}\right) \cdot 100$$

$Wexp = 96$ Watts

$PC = 100$ % on time

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$Po := 96000$ mWatts

$f := 450$ Frequency in MHz

$dBd := 0.85$ antenna gain in dBd

$$S := \frac{f}{1500}$$ power density limit for uncontrolled exposure

$G1 := dBd + 2.15$ gain in dBi

$G1 = 3$ dBi

$CL := 1.0$ dB coax loss

$$S = 0.3 \quad \frac{mW}{cm^2}$$

$G := G1 - CL$

General population
S is 1 between 1500 and 100k MHz
S is f/1500 for 300 to 1500 MHz
S is 0.2 between 30 and 300 MHz

$$Gn := 10^{\frac{G}{10}}$$ gain numeric

Occupational
S is 1 between 30 and 300 MHz
S is f/300 between 300 and 1500 MHz
S is 5 between 1500 and 100k MHz
(See 47 CFR 1.1310)

$Gn = 1.585$ dB

$$R := \sqrt{\frac{(Po \cdot Gn)}{4 \cdot \pi \cdot S}}$$

$$inches := \frac{R}{2.54}$$

$R = 200.895$ distance in centimeters required for compliance

$inches = 79.093$

$$ft := \frac{inches}{12}$$

$ft = 6.591$