RF Exposure Calculations for ITC Packet Data Transceivers

Revision History

Revision	Date	Summary of Changes	Contributor
1	10/5/2011	Original	Fred Cleveland Norm Shivley
2	10/6/2011	Clarification edits.	Tim Blom
3	10/21/2011	Revise calculations	Fred Cleveland Tim Blom
4	10/27/2011	Add Locomotive information	Fred Cleveland Tim Blom
5	11/9/11	Updated Locomotive calculations	Fred Cleveland Tim Blom

RF Exposure Calculations

1. Determination of Need for Routine Environmental Evaluation for RF Exposure per §2.1091(c)

It is the view of Meteorcomm LLC that the ITC Radio models 63010, 63020, 63030-24 and 63030-48 also known respectively as Wayside, Locomotive and Base radios, are not subject to routine environmental evaluation for RF exposure. While these models are intended for use in Part 90 applications, they are not designed for use in the Specialized Mobile Radio Service.

2. RF Exposure Environment

Per OET Bulletin 65, there are two environments relevant to RF exposure analysis:

Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/ controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or cannot exercise control over their exposure.

As the Wayside and Locomotive models can be deployed in a mobile/vehicular installation, it is possible for both environments to apply. The radio operator may be considered to be in an occupational/controlled exposure environment if she or he is properly trained to be aware of exposures and to control emissions. Vehicle passengers and bystanders are generally considered to be in a general population/uncontrolled exposure environment. This being the case, vehicular antenna installation must take into account both environments, or, at the least, the

more restrictive requirement, that being the general population/uncontrolled environment.

The occupational/controlled exposure limits generally apply to base station applications.

3. RF Exposure Limit Calculations

Per Table 1 of OET Bulletin 65, Appendix A, the FCC limits for Maximum Permitted Exposure (MPE) in terms of power density, S, are shown below.

For an Occupational/Controlled Exposure environment:

S = 1.0mW/cm^2 for the frequency range of 30-300 MHz,

For a General Population/Uncontrolled Exposure environment:

S = 0.2mW/cm^2 for the frequency range of 30-300 MHz,

The minimum separation required between a human and an antenna connected to an active antenna can be determined by use of the power density expression:

$$S = \frac{PG}{4\pi R}$$

Where

S = power density in mW/cm^2

P = Average RF power into the antenna in mW

G = antenna gain - isotropic (unitless, linear)

R = separation/distance between antenna and point of interest in cm

Solved for R, the formula becomes:

$$R = \sqrt{\frac{PG}{4\pi S}}$$

Note that the π/4DQPSK modulation emitted by all ITC radio transceivers has amplitude components created by the 0.35 excess bandwidth root raised cosine pre-modulation low pass filter. The peak to average power ratio is known to be 3.0 or more dB. The peak envelope power of the transmitters is converted to average power by applying a 3 dB conversion factor in the calculations below.

The charts below show the maximum transmit power levels converted to average, duty cycles, maximum power densities and R, the calculated minimum human separation for each band. Several example antenna types are shown. Antenna gains shown are relative to an isotropic radiator. The gain relative to a dipole (dBd) is 2.15 dB less in each case.

Example calculation for first entry in table of Section 4 below:

Maximum conducted power condition

Rated power = P_{rated} = 30 W PEP.

Measured power = P_{meas} = 30.55 W PEP.

Apply the 3 dB peak to average power ratio conversion

Average power = P_{ave} = 30.55W/(10^(3/10)) = 30.55W/2.0 = 15.28W.

Average power reduced to 10% duty ratio, P = 0.1*15.28 = 1.53 W = 1530 mW.

Gain factor for 2.15 dBi is 10^(2.15/10) = 1.64

S = 0.2 mW/cm2 (uncontrolled)

R = ((1530*1.64)/(4*3.14159*0.2))^0.5 = 31.6 cm.

Radiated power calculation.

Antenna gain in dBd = 2.15 dBi – 2.15 dBi to dBd conversion = 0 dBd = 1 numeric

$P_{radiated}$ = P_{meas}*Antenna Gain (numeric dBd) = 30.55W*1.00 = 30.55 Watts PEP-ERP

Example calculation for second entry in table of Section 4 below:

Set power level = P_{set} = 28.77 W PEP.

Apply the 3 dB peak to average power ratio conversion:

Average power = 28.77W/(10^(3/10)) = 28.77W/2.0 = 14.39W.

Average power reduced to 10% duty ratio, P = 0.1*14.39 = 1.439 W = 1439 mW.

Gain factor for 4.55 dBi is 10^(4.55/10) = 2.851

S = 0.2 mW/cm2 (uncontrolled)

R = ((1439*2.851)/(4*3.14159*0.2))^0.5 = 40.40 cm.

Radiated power calculation.

Antenna gain in dBd = 4.55 dBi – 2.15 dBi to dBd conversion = 2.40 dBd = 1.7378 numeric

$P_{radiated}$ = P_{set} * gain factor (numeric dBd value) = 28.77W * 1.7378 = 50 watts PEP-ERP

Note: When the radiated power is adjusted to the maximum allowed ERP of 50 Watts PEP for the wayside radio, the calculated MPE distance for uncontrolled population exposure is always 40.4 cm.

Example calculation for Locomotive radio:

Maximum conducted power condition

Rated power = P_{rated} = 50 W PEP = 46.99 dBm PEP.

Measured power at antenna port = P_{meas} = 51.05 W PEP = 47.08 dBm PEP.

A typical amount of coaxial loss is included with this calculation.

Typical coaxial loss to antenna = 0.3 dB

Power applied to antenna = P_{app} = Pmeas – Coaxial loss = 47.08 - .3 = 46.78 dBm PEP = 47.64 Watts PEP

Apply the 3 dB peak to average power ratio conversion

Average power = P_{ave} = 47.64W/(10^(3/10)) = 47.64W/2.0 = 23.82W.

Average power reduced to 30% duty ratio, P = 0.3*23.82W= 7.146 W = 7146 mW.

Gain factor for 2.15 dBi is 10^(2.15/10) = 1.64

S = 0.2 mW/cm2 (uncontrolled)

R = ((7146*1.64)/(4*3.14159*0.2))^0.5 = 68.3 cm.

Radiated power calculation.

Antenna gain in dBd = 2.15 dBi – 2.15 dBi to dBd conversion = 0 dBd = 1 numeric

$P_{radiated}$ = P_{app}*Antenna Gain (numeric dBd) = 47.64W*1.00 = 47.64 Watts PEP

Example calculation for Locomotive entry in table of Section 4 below:

To ensure that an installation will meet the minimum requirements for MPE safety for a radiated emission of 50 Watts ERP-PEP, a distance of 70 cm will be listed in the RF Energy Exposure Guide document that is shipped with each radio. A sample calculation is provided below.

$P_{radiated\ as\ allow\ by\ rules}$ = 50 Watts ERP-PEP

Apply the 3 dB peak to average power ratio conversion

Average power = P_{ave} = 50W/(10^(3/10)) = 50W/2.0 = 25W.

Average power reduced to 30% duty ratio, P = 0.3*25 = 7.5 W = 7500 mW.

Gain factor for 2.15 dBi is 10^(2.15/10) = 1.64

S = 0.2 mW/cm2 (uncontrolled)

R = ((7500*1.64)/(4*3.14159*0.2))^0.5 = 70 cm.

The following tables are included in our RF Energy Exposure Guide to be shipped with each radio.

4. Calculated Limits Applied to Mobile Installations

Radio Type	Antenna Type	Antenna gain (dBi)	Nominal power (watts)	Maximum Duty Cycle	Recommended minimum lateral distance from transmitting antenna	
					cm	in.
Wayside Radio	1/4wave dipole mounted to roof or trunk of automobile	2.15	30	10%	31.6	12.4
Wayside Radio	1/2wave dipole mounted to roof or trunk of automobile	4.55	28.77	10%	40.4	15.9
Locomotive Radio	0dBd Locomotive antenna mounted to roof of locomotive	2.15	50	30%	70	27.6

5. Calculated Limits Applied to Fixed Installations

Radio Type	Antenna Type	Antenna gain (dBi)	Nominal power (watts)	Maximum Duty Cycle	Recommended minimum lateral distance from transmitting antenna	
					cm	in.
Wayside Radio	2.0dBd exposed dipole tower leg-mounted fixed antenna	4.1	30	10%	39.6	15.6
Wayside Radio	5.5dBd exposed dipole tower leg-mounted fixed antenna	7.6	14.26	10%	40.4	15.9
Base Radio	2.0dBd exposed dipole tower leg-mounted fixed antenna	4.1	75	50%	140	55.0
Base Radio	5.5dBd exposed dipole tower leg-mounted fixed antenna	7.6	75	50%	209	82.3