Analysis of operating and installation requirements to satisfy FCC Regulations for RF exposure compliance for the PMP 450i / PTP 450i Products

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Abstract

This document analyses the operating and installation requirements to ensure limits for RF Exposure Compliance are not exceeded by the PMP 450i / PTP 450i products with either integral or dedicated external antennas.

Revision History

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000v001	23rd March 2015	Updated to include Part 90Y	DWR
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Operational Parameters of the PMP 450i / PTP 450i Product

1 Scope

The PMP 450i / PTP 450i product is a Point to Multi Point / Point to Point µWave system capable of operating in the 4900 to 5925 MHz frequency band, the product is available with either integral or dedicated external antennas.

The purpose of this brief working paper is to identify the RF power produced by the PMP 450i / PTP 450i equipment's while operating in the frequency bands where regulation is covered by the FCC Parts listed below: -

FCC	Frequency Band (MHz)	
Part 15.247 [4]	5725	5850
Part 15.407 [5]	5150	5250
Part 90Y [6]	4940	4990

The mean RF power plus the antenna gain used in specific installations identifies the effective power density (mW/cm^2) that is to be compared against allowed limits for human exposure.

PMP 450i / PTP 450i products are not available to the general public and are professionally installed while the installations are expected to be remote from the 'general population' exposure limits are calculate to provide guidance to installers on the minimum distances for safe operation of PMP 450i / PTP 450i products.

2 References

Evaluating Compliance with FCC Guidelines for Human Exposure to Radio frequency Electromagnetic Fields:

[1] First R&O further Notice of Proposed Rule Making and notice of inquiry, FCC No. 13-39
[2] KDB 447498 D01 General RF Exposure Guidance v05r02
[3] OET Bulletin 65, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields," and supplements to Bulletin 65
[4] CFR Title 47 Telecommunications Part 15.247 Subpart C
[5] CFR Title 47 Telecommunications Part 15.407 Subpart E
[6] CFR Title 47 Telecommunications Part 90 Subpart Y

3 Background

Reference [3] identifies how the radiated power density should be calculated for different distances from the antenna. The variables used are Radiated Power Density (S), conducted power (P), Antenna Gain (G) and distance (R). The formula given is

$$S = \frac{P.G}{4\pi R^2}$$

Rearranging the terms to solve the distance for compliance with the limit: -

$$R = \sqrt{\frac{P.G}{4\pi.S}}$$

The limit allowed for S depends on whether the exposure risk is to a member of the public or not. The products concerned are approved by the FCC rules under Part 15.247, Part 90 and Part 15.407.

The general regulatory requirements for the USA and Canada is that all products approved as intentional radiators under Part 15 meet the radio frequency radiation requirements for the "general population/uncontrolled environment" case. At the frequency of operation of these products, this requires that the value of S to be used is 1mW/cm^2 or 10W/m^2.

It is clear from [3] that the power to be used should be the maximum transmitted power, subject to any allowance for source-based time-averaging.

4 PTP Product Specific Issues

4.1 FCC Regulations

The PMP 450i / PTP 450i is to be approved under: -

- FCC Part 15.247, in this operating mode the maximum conducted transmit power limit of 1W is given in subpart 15.247(b)(3).

  Note: For Fixed Point to Point operation, unlimited antenna gain is allowed as defined in subpart 247(c)(1)(ii).

- FCC Part 15.407, in this operating mode the maximum conducted transmit power limit of 1W (30dBm) is applied to UNII-1 reference subpart 15.407(a)(1)(iii).
  Note: FCC Part 15.407, Fixed Point to Point operation may employ antenna up to 23dBi directional gain without any reduction in conducted transmit power subpart 15.407(a)(1)(iii)

- FCC Part 90Y, in either PMP or PTP operating mode the High Power maximum conducted transmit power limit of 27dBm in 5MHz BW, 30dBm in 10MHz BW and 33dBm in 20MHz BW is given in 90.1215(a)(1), (2)

  Note: Fixed Point to Point and Point to Multipoint operation, may employ antenna up to 26dBi directional gain without any reduction in conducted transmit power subpart 90.1215(a)(2)

4.2 PMP 450i / PTP 450i Power Capability

This product does not have the capability to generate the full 1W, 30dBm, conducted power during the transmitter burst. The Maximum Transmit Power (conducted) from the products is limited to 28 dBm in the Part 15.247 band, 24 dBm in the Part 90 band and 23 dBm in the Part 15.407 UNII-1 band.

This transmit power is measured as an average value across a transmit burst and is the combined power from both antenna ports. Calibrated power control loops ensure that this power is not exceeded on either product.

4.3 Dual Polarisation

The PMP 450i / PTP 450i products use either: -

a) An integrated dual polarised antenna with each polarisation connected to an identical transceiver circuit inside the unit.
b) A connector plate to allow the connection of external antennas with each polarisation connected to an identical transceiver circuit inside the unit.

In order to comply with the FCC limits, the design of the products reduces by 3dB the conducted power and EIRP of each of the two individual polarisations in each of the above cases.

As the regulations effectively limit the total EIRP produced, then the calculations below apply equally in the case of both the integrated and external antennas.

4.4 Power Control

The power levelling loops in the products measure the transmitted power on each polarisation at all times and limit each to the Maximum Transmit Power shown in Para 4.2, less 3dB.

The products operate on a TDD basis using the same frequency for up/down link. The transmit duty cycle resulting from the TDD operation is typically just less than 50% but for asymmetric data flow, it may be up to 85 %.

The FCC regulations allow source-based time averaging to be used in working out the EIRP value for the exposure calculation. This reduces the effective mean conducted power and EIRP from the levels of conducted power and EIRP that would be applicable if the products were to transmit with a duty cycle of 100%.

It should be noted that this is very much a worst case analysis as the products operate with Receiver driven Transmit power control. The power levels quoted in this document are those applicable to the lowest order modulation modes (QPSK) whereas the normal operating modes are up to 256QAM or above with power levels reduced by up to an additional 4dB compared to the levels shown above.

4.5 Antenna Cable Losses

In the case of external antennas, the need to adjust azimuth and elevation of the antennas imposes minimum limits on the cable losses that can be achieved between the products and the antennas. This limitation is approximately 0.9dB.

5 Analysis

5.1 Transmitted Levels

The Radiated Power Density can be assessed on the basis of the antenna gain for each polarisation and the linear sum of the transmitter powers on the two polarisations.

5.2 Radiation Levels

The PMP 450i / PTP 450i supports operation with the antenna types and manufactures declared gain given below, for these assessments the worst case combination of transmit power and antenna gain has been applied.

Antenna Type	Manufacturers Gain (dBi)		
	4.9 GHz Band	5.1 GHz Band	5.8 GHz Band
6’ Parabolic Dish	37.2	-	38.1
4’ Parabolic Dish	-	34.5	-
Flat Plate	28.0	28.5	28.5
Sectorised	17.0	17.0	17.0
OMNI	13.0	13.0	13.0

5.2.1 Part 15.247 (5.8GHz Band)

This band supports parabolic dish antennas up to the 6' (1.8m) in diameter; Calculations are based upon the worst case highest conducted transmit power and highest gain for each antenna type/configuration supported by the product.

	6' Parabolic Dish	Flat Plate	Sectorized	OMNI
Transmit Power	28	28	20.75	24.5
Antenna Gain	38.1	28.5	17	13

5.2.1.1 Calculations at the Exposure Limit

The table below shows the result of calculating the radiated power density using the formula given in Ref [3] in order to find out the minimum spacing from the antenna at which the radiation has fallen to the 'general population/uncontrolled environment' limit.

Limits in mW/cm^2

	6' Dish	Flat Plat	Sectorized	OMNI	
Transmit Power	28.00	28.0	20.75	24.50	dBm
Duty Cycle Correction (85%)	-0.70	-0.7	-0.70	-0.70	dBm
Total Power in burst	27.30	27.3	20.05	23.80	dBm
Total Mean Power	537.03	537.03	101.16	239.88	mW
Additional Cable Losses	0.90	0.9	0.90	0.90	dB
Antenna Gain	38.10	28.5	17.00	13.00	dBi
Total Mean EIRP	2818382.93	309029.5	4120.98	3890.45	mW
Power Density Limit	1.00	1.0	1.00	1.00	mW/cm2
Separation Distance at Power Density Limit	473.58	156.82	18.11	17.60	cm

Limits in W/m^2

	6' Dish	Flat Plat	Sectorized	OMNI	
Transmit Power	28.00	28.0	20.75	24.50	dBm
Duty Cycle Correction (85%)	-0.70	-0.7	-0.70	-0.70	dBm
Total Power in burst	27.30	27.3	20.05	23.80	dBm
Total Mean Power	537.03	537.0	101.16	239.88	mW
Additional Cable Losses	0.90	0.9	0.90	0.90	dB
Antenna Gain	38.10	28.5	17.00	13.00	dBi
Total Mean EIRP	2818.38	309.0	4.12	3.89	W
Power Density Limit	10.00	10.0	10.00	10.00	W/m2
Separation Distance at Power Density Limit	4.74	1.57	0.18	0.18	m

5.2.2 Part 90Y (4.9GHz Band)

Section 4.1 states that the highest regulatory conducted power limit for this band is 33dBm in the 20 MHz BW, the maximum antenna gain allowed at this full transmit power is 26dBi, as stated in 4.2 the PMP 450i / PTP450i products are limited to a maximum conducted transmit power in this band of 24dBm combined, applying the transmit power back off for antenna with directional gains >26dBi the worst case configuration for each antenna type supported by the PMP 450i / PTP450i is therefore:-

	6' Parabolic Dish	Flat Plate	Sectorized	OMNI
Transmit Power (dBm)	22.2	24	24	24
Antenna Gain (dBi)	37.2	28	17	13

5.2.2.1 Calculations at the Exposure Limit

The table below shows the result of calculating the radiated power density using the formula given in Ref [3] in order to find out the minimum spacing from the antenna at which the radiation has fallen to the 'general population/uncontrolled environment' limit

Limits in mW/cm^2

	6' Dish	Flat Plat	Sectorized	OMNI	
Transmit Power	22.20	24.00	24.00	24.00	dBm
Duty Cycle Correction (80%)	-0.70	-0.70	-0.70	-0.70	dBm
Total Power in burst	21.50	23.30	23.30	23.30	dBm
Total Mean Power	141.25	213.80	213.80	213.80	mW
Additional Cable Losses	0.90	0.90	0.90	0.90	dB
Antenna Gain	37.20	28.00	17.00	13.00	dBi
Total Mean EIRP	602559.59	109647.82	8709.64	3467.37	mW
Power Density Limit	1.00	1.00	1.00	1.00	mW/cm2
Separation Distance at Power Density Limit	218.98	93.41	26.33	16.61	cm

Limits in W/m^2

	6' Dish	Flat Plat	Sectorized	OMNI	
Transmit Power	22.20	24.00	24.00	24.00	dBm
Duty Cycle Correction (80%)	-0.70	-0.70	-0.70	-0.70	dBm
Total Power in burst	21.50	23.30	23.30	23.30	dBm
Total Mean Power	141.25	213.80	213.80	213.80	mW
Additional Cable Losses	0.90	0.90	0.90	0.90	dB
Antenna Gain	37.20	28.00	17.00	13.00	dBi
Total Mean EIRP	602.56	109.65	8.71	3.47	W
Power Density Limit	10.00	10.00	10.00	10.00	W/m2
Separation Distance at Power Density Limit	2.19	0.93	0.26	0.17	m

5.2.3 Part 15.407 (UNII-1, 5150 – 5250 MHz Band)

Calculations are based upon the worst case highest conducted transmit power and highest gain for each antenna type/configuration supported by the product.

	4' Parabolic Dish	Flat Plate	Sectorized	OMNI
Transmit Power (dBm)	11	3	16	23
Antenna Gain (dBi)	34.5	28.5	17	13

5.2.3.1 Calculations at the Exposure Limit

The table below shows the result of calculating the radiated power density using the formula given in Ref [1] in order to find out the minimum spacing from the antenna at which the radiation has fallen to the 'general population/uncontrolled environment' limit.

Limits in mW/cm^2

	4' Dish	Flat Plate	Sectorized	OMNI	
Transmit Power	11.00	3.00	16.00	23.00	dBm
Duty Cycle Correction (80%)	-0.70	-0.70	-0.70	-0.70	dBm
Total Power in burst	10.30	2.30	15.30	22.30	dBm
Total Mean Power	10.72	1.70	33.88	169.82	mW
Additional Cable Losses	0.90	0.90	0.90	0.90	dB
Antenna Gain	34.50	28.50	17.00	13.00	dBi
Total Mean EIRP	24547.09	977.24	1380.38	2754.23	mW
Power Density Limit	1.00	1.00	1.00	1.00	mW/cm^2
Separation Distance at Power Density Limit	44.20	8.82	10.48	14.80	cm

Limits in W/m^2

	4' Dish	Flat Plate	Sectorized	OMNI	
Transmit Power	11.00	3.00	16.00	23.00	dBm
Duty Cycle Correction (80%)	-0.70	-0.70	-0.70	-0.70	dBm
Total Power in burst	10.30	2.30	15.30	22.30	dBm
Total Mean Power	10.72	1.70	33.88	169.82	mW
Additional Cable Losses	0.90	0.90	0.90	0.90	dB
Antenna Gain	34.50	28.50	17.00	13.00	dBi
Total Mean EIRP	24.55	0.98	1.38	2.75	W
Power Density Limit	10.00	10.00	10.00	10.00	W/m^2
Separation Distance at Power Density Limit	0.44	0.09	0.10	0.15	m

6 Conclusion

6.1 Part 15.247

When operated at 5.8GHz the PMP 450i / PTP 450i calculated distance for compliance with the ‘general population/uncontrolled environment’ limit for each antenna type is: -

Antenna Type	Compliant Distance (m)
Parabolic Dish	4.74
Flat Plate	1.57
Sectorized	0.18
OMNI	0.18

6.2 Part 90Y

When operated at 4.9GHz the PMP 450i / PTP 450i calculated distance for compliance with the ‘general population/uncontrolled environment’ limit for each antenna type is: -

Antenna Type	Compliant Distance (m)
Parabolic Dish	2.19
Flat Plate	0.93
Sectorized	0.26
OMNI	0.17

6.3 Part 15E UNII-1

When operated in the 5150 – 5250 MHz UNII-1 Band the PMP 450i / PTP 450i calculated distance for compliance with the ‘general population/uncontrolled environment’ limit for each antenna type is: -

Antenna Type	Compliant Distance (m)
Parabolic Dish	0.44
Flat Plate	0.09
Sectorized	0.10
OMNI	0.15