AP750WRe Access Point

Everest Networks, Inc.

FCC Compliance Testing of AP750WRe Access Point

of Multiple Transmitters with Multiple Outputs (MIMO) that are connected to Cross-polarized Antennas

Contributors

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Revision History

Version	Change Summary	Author	Date
0.0	Document created, draft version	H. V. Nguyen	Jan. 26, 2024
1.0	Antenna version D. Swap position of U-NII-12a antenna (Radio 2) and U-NII-3 antenna (Radio 1).	H. V. Nguyen	Apr. 9, 2024
2.0	Adding antenna manufacturer information		May 31, 2024
	Modifying photo (Fig. 1) for confidentiality		
4.0	Outdoor operation in Band 1 meeting 15.407 (a)(1)(i)		June 12, 2024

1 Introduction

This document provides,

a) illustrations of the connection between radio transmitters and cross-polarized antennas,
b) explanations of polarization diversity (cross polarized antennas) and space orthogonality, and
c) calculations of directional gain for directional antenna panels of AP750WRe access point.

Conclusions are provided in section 6 and should be used as a guideline for setting antenna gain, TxBF array gain and maximum output conducted power (MOCP).

2 AP750WRe Antenna Panels, Radio Connection and Coverage

Figure 1 illustrates the top-view of directional antenna PCB-000047-000-D of Everest Networks AP750WRe access point. The antenna panels are of microstrip patch antenna. Each patch antenna has two (02) inputs that correspond to a vertical polarization (Vpol) and a horizontal polarization (Hpol).

AP750WRe access point has four (04) RF radios, i.e. Radio 1, Radio 2, Radio 3 and Radio 4. Each radio is a 4x4:4 multiple inputs multiple outputs (MIMO) and thus has four (04) RF chains, i.e. Ch_0, Ch_1, Ch_2, Ch_3. The association of RF radios to directional antenna panels is illustrated in Fig. 1 and summarized in the below table.

Table 1: Radios and its coverage section

	UNII frequency band	North + South Coverage	East + West Coverage	NorthEast + SouthWest Coverage	NorthWest + SouthEast Coverage
Radio 1	UNII-3				Port 1, 2, 3, 4
Radio 2	UNII-1+2a	Port 5, 6, 7, 8			
Radio 3	UNII-2c		Port 10, 12, 14, 16		
	UNII-7		Port 9, 11, 13, 15		
Radio 4	UNII-5			Port 17, 18, 19, 20	

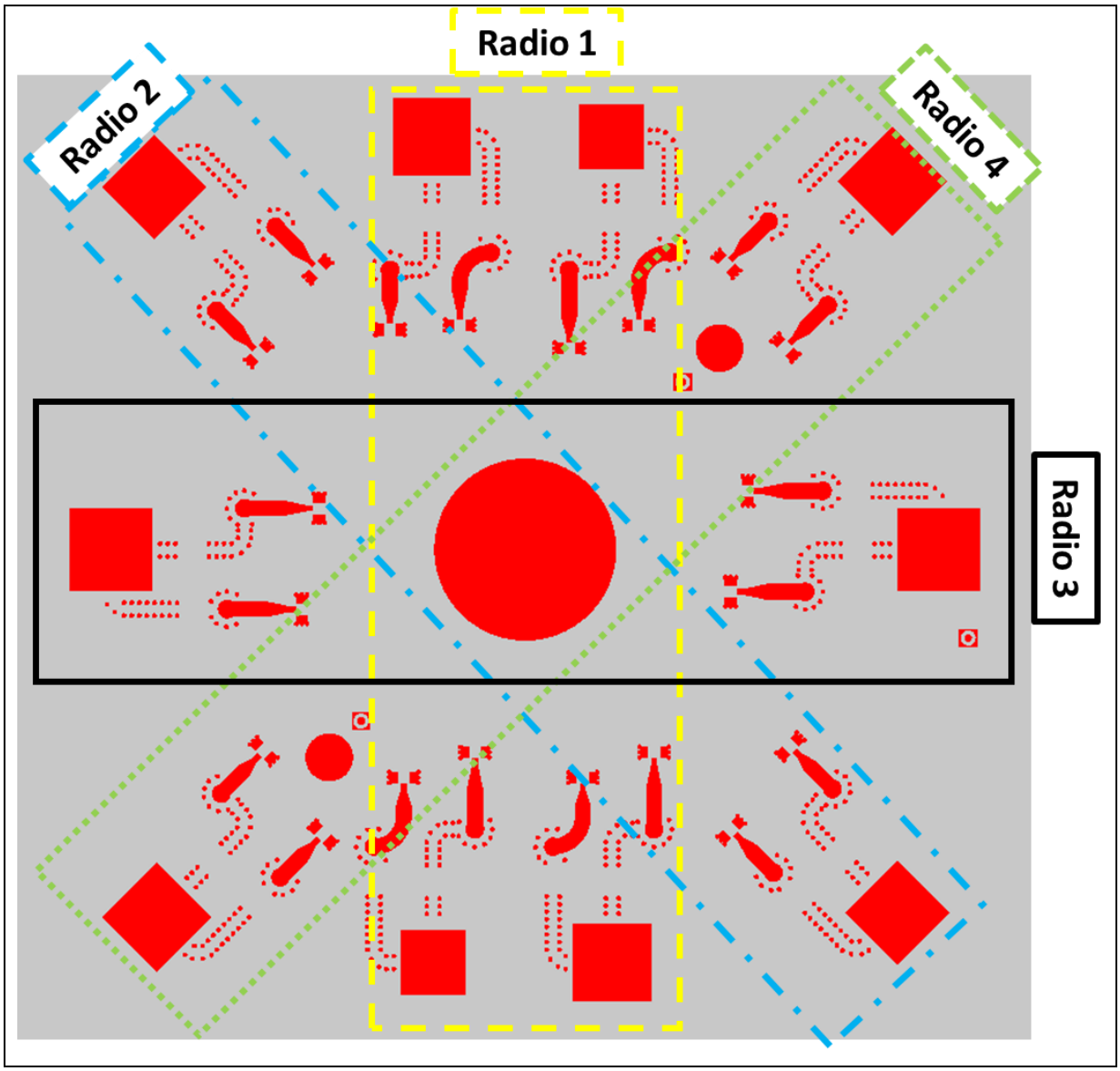

Figure 1: Top view of directional antenna PCB-000047-000-D of Everest Networks AP750WRe

The four (04) radios are directly attached to the corresponding ports of the directional antenna PCB-000047-000-D. Next sections details the radio connections.

3 Radio 1 in U-NII-3 (5725MHz-5850MHz) band

3.1 Radio-Antenna Connection

The four (04) RF chains of Radio 1 are connected to the North-West and South-East directional antenna PCB-000047-000-D at **port 1, 2, 3, and 4**, respectively. The detail mapping of these connections is summarized in below Table 2.

Table 2: RF channel chains of Radio 1 and its connection to North and South directional antenna PCB-000047-000-D

	Directional Antenna panel	Vertical polarization	Horizontal Polarization
Ch_0	North-West panel	Port 1	
Ch_1			Port 2
Ch_2	South-East panel		Port 3
Ch_3		Port 4	

Figure 2 shows radiation patterns in elevation of North-West side microstrip patch antenna at 5.8GHz frequency. Antenna max gain in the U-NII-3 band is summarized in Table 3.

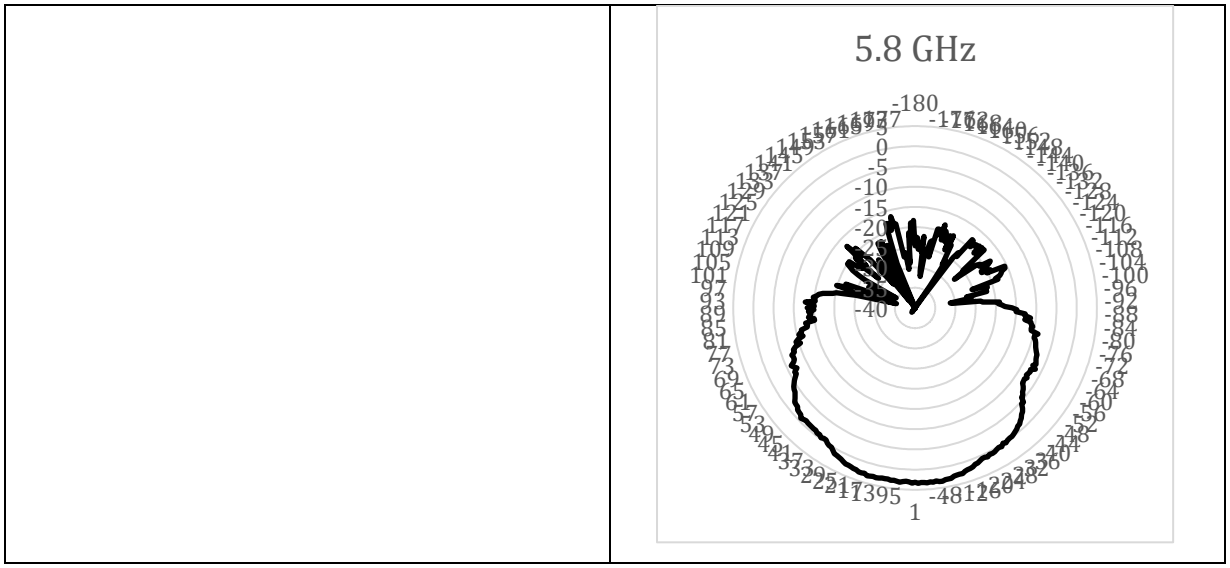

Figure 2: Radiation pattern in elevation cut of North-West side microstrip patch antenna.

Table 3: Maximum gain of North-West and South-East antenna panels in U-NII-3 band

U-NII-3	Vertical polarization	Horizontal polarization
North-West side antenna panel	5 dBi	5 dBi
South-East side antenna panel	5 dBi	5 dBi

4 Radio 2 in U-NII-1 and 2a (5150MHz-5350MHz) bands

4.1 Radio-Antenna Connection

The four (04) RF chains of Radio 2 are connected to the North and South directional antenna PCB-000047-000-D at **port 5, 6, 7, and 8**, respectively. The detail mapping of these connections is summarized in below Table 4.

Table 4: RF channel chains of Radio 2 and its connection to North and South directional antenna PCB-000047-000-D

	Directional Antenna panel	Vertical polarization	Horizontal Polarization
Ch_0	North panel	Port 5	
Ch_1			Port 6
Ch_2	South panel		Port 7
Ch_3		Port 8	

Figure 3 shows radiation patterns in elevation of North side microstrip patch antenna for 5.2 GHz and 5.3GHz frequency. Antenna max gain in the U-NII-1 and U-NII-2a bands is summarized in Table 5.

Table 5: Maximum gain of North and South antenna panels in U-NII-1 and 2a bands

	Vertical polarization	Horizontal polarization
North side antenna panel	5 dBi	5 dBi
South side antenna panel	5 dBi	5 dBi

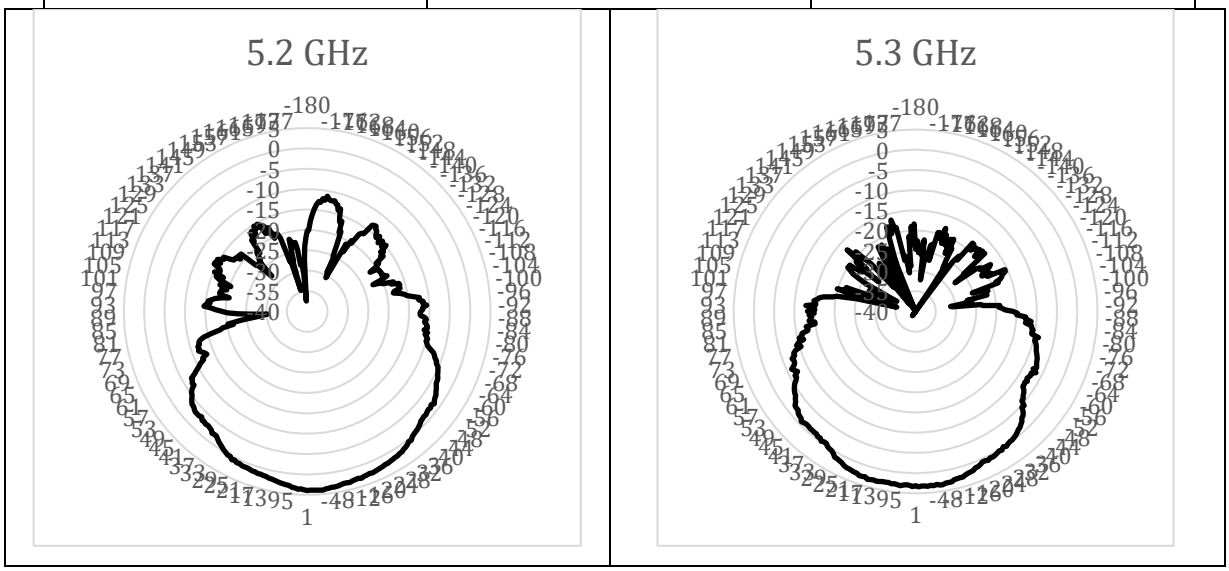

Figure 3: Radiation patterns in elevation cut of North side microstrip patch antenna.

5 Radio 3 in U-NII-2c and 7 (5500MHz-5700MHz) and (6500MHz-6800MHz) bands

5.1 Radio-Antenna Connection

The four (04) RF chains of Radio 3 are connected to the East and West directional antenna PCB-000047-000-D at **ports 9 to 16**. Each of the East and West directional antenna panels consists of two (02) separated and independent microstrip patch antenna panels operating in U-NII-2c and U-NII-7 bands, respectively. Therefore, there are a total of 4 antenna inputs per side, i.e. 4 inputs in the East side and 4 inputs in the West side. Depending on the state of the antenna diversity switch, the 4 RF chains of Radio 3 are connected to either U-NII-2c or U-NII-7 antenna patch. Table 6 summarizes the connections between RF chains and inputs of East and West antenna panels.

Table 6: RF channel chains of Radio 3 and its connection to East and West directional antenna PCB-000047-000-D

		U-NII-2c		U-NII-7	
		Vpol	Hpol	Vpol	Hpol
Ch_0	East panel	10		9	
Ch_1			12		11
Ch_2	West panel		14		13
Ch_3		16		15	

Figure 4 shows radiation patterns in elevation of East side microstrip patch antenna for 5.6 GHz and 6.7GHz frequency. Antenna max gain in the UNII-2c and UNII-7 bands is summarized in Table 7.

Table 7: Maximum gain of East and West antenna PCB-000047-000-D in U-NII-2c and U-NII-7 bands

	UNII-2c		UNII-7	
	Vpol	Hpol	Vpol	Hpol
East side antenna panel	5 dBi	5 dBi	5 dBi	5 dBi
West side antenna panel	5 dBi	5 dBi	5 dBi	5 dBi

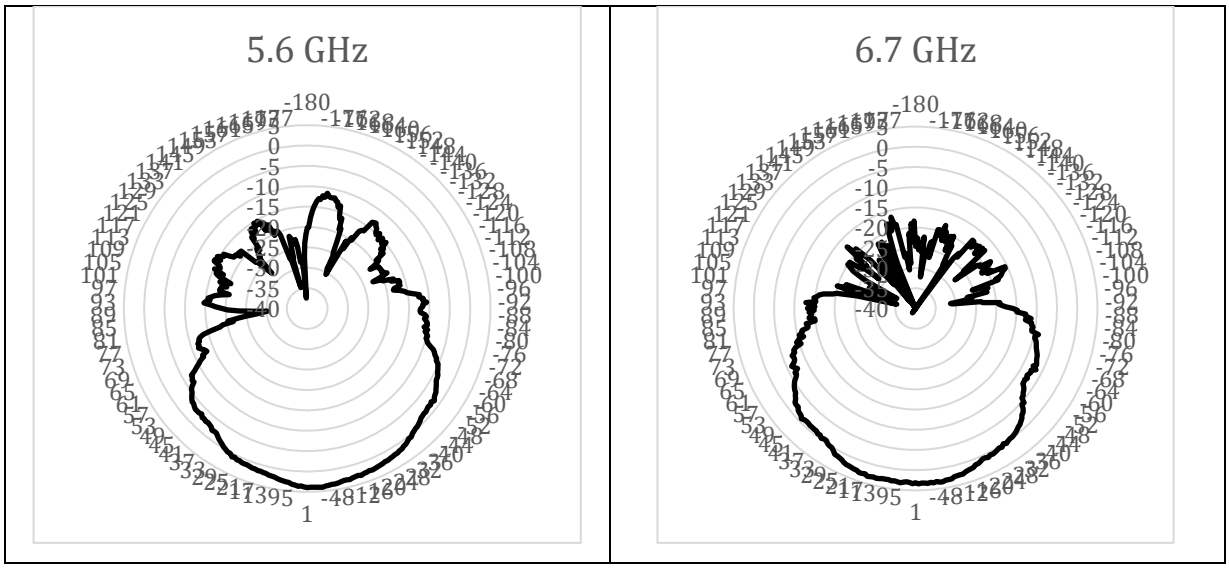

Figure 4: Radiation patterns in elevation cut of East side microstrip patch antenna.

6 Radio 4 in U-NII-5 (5900MHz-6400MHz) band

6.1 Radio-Antenna Connection

The four (04) RF chains of radio 4 are connected to the North-East and South-West directional antenna PCB-000047-000-D at **port 17, 18, 19, and 20**, respectively. The detail mapping of these connections is summarized in below Table 8.

Table 8: RF channel chains of Radio 4 and its connection to North-East and South-West directional antenna PCB-000047-000-D

	Directional Antenna panel	Vertical polarization	Horizontal Polarization
Ch_0	North-East panel	Port 17	
Ch_1			Port 18
Ch_2	South-West panel		Port 19
Ch_3		Port 20	

Figure 5 shows radiation patterns in elevation of North-East side microstrip patch antenna at 6.2GHz frequency. Antenna max gain in the U-NII-5 band is summarized in Table 8.

Table 8: Maximum gain of North-East and South-West antenna panels in U-NII-5 band.

	Vertical polarization	Horizontal polarization
North-East side antenna panel	5 dBi	5 dBi
South-West side antenna panel	5 dBi	5 dBi

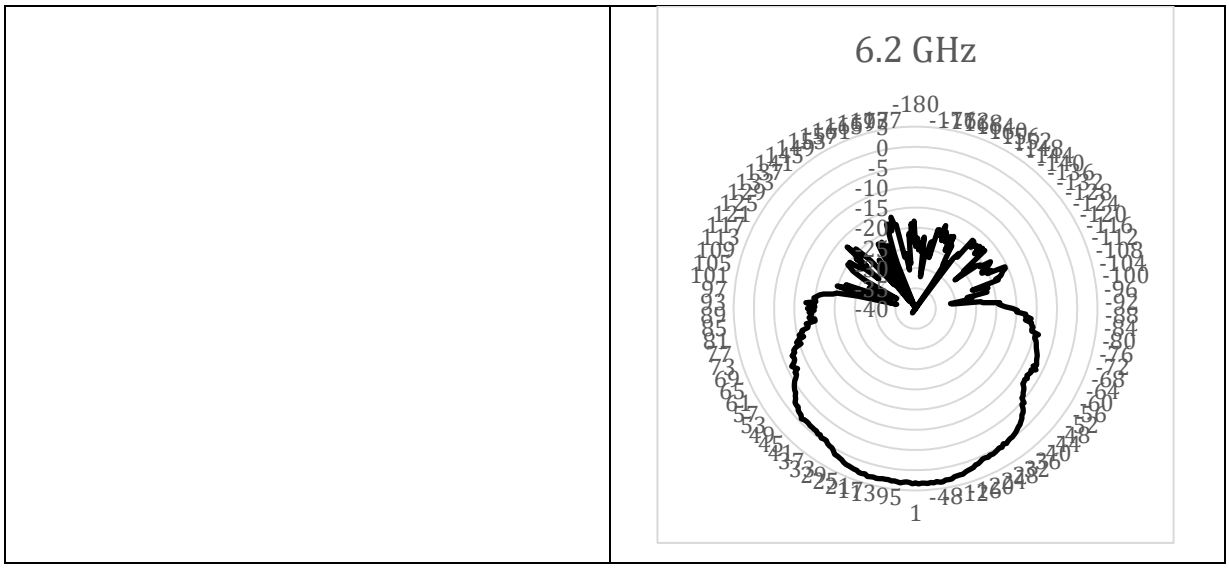

Figure 5: Radiation patterns in elevation cut of North-East side microstrip patch antenna.

7 Pattern (cross-polarized) and Space Diversity Antenna

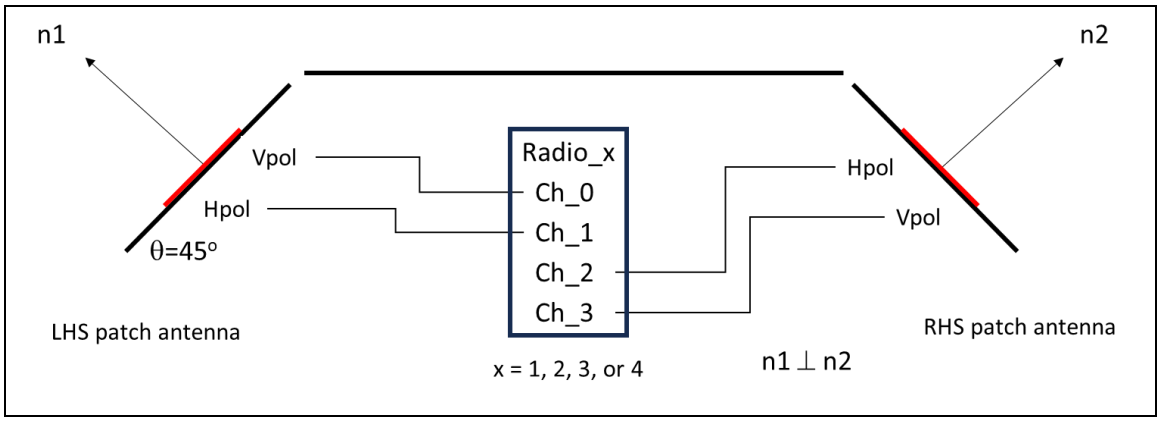

Figure 10: Illustration directional antenna PCB-000047-000-D in its final assembled form. The antenna segments are conformed a 45-degree angle with the horizontal plane. The four (04) RF radio channels are connected to the vertical and horizontal polarizations of the left and right microstrip patch antennas.

The right-hand side (RHS) and left-hand side (LHS) patch antennas have its normal vectors that are perpendicular. Thus, the radiation patterns of the antennas are orthogonal in space. The four RF chains are uncorrelated, therefore, each of the four EIRP or ERP *must be individually below the limit* for the following reasons:

1. Ch_0 and Ch_1 connect to Vpol and Hpol inputs of the LHS patch, which is a cross-polarized antenna.
2. Ch_2 and Ch_3 connect to Hpol and Vpol inputs of the RHS patch, which is a cross-polarized antenna.
3. The LHS and RHS patches are orthogonal in space, and
4. Radiation patterns of LHS and RHS antenna patches are non-overlapping, the directional gain DG = 0 dB.

8 Outdoor operation for U-NII-1 Band

For outdoor operation in the U-NII-1 Band, the maximum EIRP at any angle more than 30 degrees above horizon should be below 21 dBm. The AP750WRe can be mounted in one of two configurations: ceiling mount or wall mount with an down tilt angle of at least 45 degree from vertical. The maximum gain of the microstrip patches operating in UNIII-1 band at any angle more than 30degrees above horizon is -5.0 dBi.

Figure 11: Mounting configurations of AP750WRe: Ceiling mount, wall/pole mount with a minimum 45degree down tilt from vertical as per AP750WRe Installation Manual

Table 9 shows the MOCP at individual antenna's port for the worst case scenario when TxBF is enable and disable for compliance with outdoor operation in U-NII-1 band.

Table 9: MOCP for TxBF disable and enable

Maximum gain of microstrip patch in UNII1 band at angle above 30degree horizon	Net Cable loss	Net Antenna Gain	Number of microstrip patches operating in UNII1 band	TxBF gain in UNII1 band	MOCP at antenna port for outdoor FCC compliance in U-NII-1 band
-5.0 dBi	1.8 dB	-6.8 dBi	2	Disable	27.8 dBm
-5.0 dBi	1.8 dB	-6.8 dBi	2	Enable DG of TxBF = 0	27.8 dBm

9 Conclusions

Table 10 summarizes the antenna gain, array gain for different bands for AP750WRe. The net gain is the combined gain of the antenna and RF switch (for Radio 3) + cable loss. The columns are defined as follows:

- **Tested net antenna gain**: this is the net gain of the antenna used for certification measurements
- **Certified antenna gain**: this is the antenna gain to be used to compute the Maximum Output Conducted Power (MOCP) at radio card.
- **TXBF/STBC/CCD gain:** array gains to be used to compute the MOCP at radio card for the various operating modes.

For US operations, the settings for indoor and outdoor operation are the same except for U-NII-1 band where the EIRP limit for outdoor operation is set at 21dBm. For outdoor operation, TxBF will be disable in Band 1.

Table 10: AP750WRe

FCC Operating band	Number of RF ports	Tested Antenna gain	RF Switch matrix + Cable loss	Tested net antenna gain	Certified net antenna gain	TXBF gain [dB]	STBC gain [dB]	CCD gain [dB]
U-NII-1 Band	4	5.0 dBi	1.8 dB	3.2 dBi	**3 dBi**	**0**	**0**	**0**
U-NII-2-A Band	4	5.0 dBi	1.8 dB	3.2 dBi	**3 dBi**	**0**	**0**	**0**
U-NII-2-C Band	4	5.0 dBi	3.0 dB	2.0 dBi	**2 dBi**	**0**	**0**	**0**
U-NII-3 Band	4	5.0 dBi	1.8 dB	3.2 dBi	**3 dBi**	**0**	**0**	**0**
U-NII-5 Band	4	5.0 dBi	1.8 dB	3.2 dBi	**3 dBi**	**0**	**0**	**0**
U-NII-7 Band	4	5.0 dBi	3.0 dB	2.0 dBi	**2 dBi**	**0**	**0**	**0**

10 References

[1] FCC document KDB 662911 D01 Multiple Transmitter Output v02r01, October 31, 2013

[2] FCC document KDB 662911 D02 MIMO with Cross-Polarized Antenna v01, October 25, 2011

Antenna manufacturer information

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