

The effective eirp for each additional radio operating in a band is determined by looking at the increase in total eirp within that band as the additional radio comes on-line. In the 5150-5250 MHz band the effective eirp of the additional radios is 0 since the output power is backed off on the existing radios to maintain the total power below 17dBm and eirp below 23dBm.

NII 3 = 5470-5725 MHz  
 NII 2 = 5250-5350 MHz  
 NII 1 = 5150-5250 MHz

EIRP per additional radio (mW) = Delta between the total EIRP for X number of radios and X-1 number of radios

Radios operating in band	Band	Total EIRP (dBm)	Total EIRP (mW)	EIRP per additional radio	
1	NII 3	29.4	871	871	NII 3 (#1)
2	NII 3	30.0	1000	129	NII 3 (#2)
3	NII 3	30.0	1000	0	NII 3 (#3)
4	NII 3	30.0	1000	0	NII 3 (#4)
5	NII 3	30.0	1000	0	NII 3 (#5)
6	NII 3	30.0	1000	0	NII 3 (#6)
7	NII 3	30.0	1000	0	NII 3 (#7)
8	NII 3	30.0	1000	0	NII 3 (#8)
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1	NII 2	29.8	955	955	NII 2 (#1)
2	NII 2	30.0	1000	45	NII 2 (#2)
3	NII 2	30.0	1000	0	NII 2 (#3)
4	NII 2	30.0	1000	0	NII 2 (#4)
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1	NII 1	22.5	178	178	NII 1 (#1)
2	NII 1	23.0	200	22	NII 1 (#2)
3	NII 1	23.0	200	0	NII 1 (#3)
4	NII 1	23.0	200	0	NII 1 (#4)
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1	5.7 DTS	35.9	3890	3890	5.7 DTS (#1)
2	5.7 DTS	36.0	3981	91	5.7 DTS (#2)
3	5.7 DTS	36.0	3981	0	5.7 DTS (#3)
4	5.7 DTS	36.0	3981	0	5.7 DTS (#4)
5	5.7 DTS	36.0	3981	0	5.7 DTS (#5)
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1	2.4 DTS	31.0	1259	1259	2.4 DTS (#1)
2	2.4 DTS	34.0	2518	1259	2.4 DTS (#2)
3	2.4 DTS	35.8	3777	1259	2.4 DTS (#3)

As this application is requesting grant notes to allow multiple radio modules to be collocated the rf exposure calculation needs to account for multiple radios being operational simultaneously. The following page provides calculations for the power density 20cm from the host system with 4, 8, 12 and 16 co-located modules.

The calculations are conservative as they assume all radios would be transmitting at 100% duty cycle and does not consider the separation distance between the individual modules' antennas.

Listing the eirps in order of power, highest first, we can then determine the maximum eirp from the complete device with multiple radios operating. This allows the rf exposure hazard to be evaluated based on a maximum power density of  $1\text{mW/cm}^2$  allowed for devices operating in either 2.4GHz or 5GHz bands:

Band	EIRP	Ranking
5.7 DTS (#1)	3890	1
2.4 DTS (#3)	1259	2
2.4 DTS (#1)	1259	3
2.4 DTS (#2)	1259	3
NII 2 (#1)	955	5
NII 3 (#1)	871	6
NII 1 (#1)	178	7
NII 3 (#2)	129	8
5.7 DTS (#2)	91	9
NII 2 (#2)	45	10
NII 1 (#2)	22	11
NII 3 (#3)	0	12
NII 3 (#4)	0	12
NII 3 (#5)	0	12
NII 3 (#6)	0	12
NII 3 (#7)	0	12
NII 3 (#8)	0	12
NII 2 (#3)	0	12
NII 2 (#4)	0	12
NII 1 (#3)	0	12
NII 1 (#4)	0	12
5.7 DTS (#3)	0	12
5.7 DTS (#4)	0	12
5.7 DTS (#5)	0	12

Once there are a total of 11 radios operational the total eirp remains constant (i.e the maximum eirp per band has been reached)

For 4 radios operating simultaneously:

Total EIRP: 7667 mW  
 S @ 20cm: **1.53 mW/cm<sup>2</sup>** 15.3 W/m<sup>2</sup>

Minimum separation distance for  $1\text{mW/cm}^2$ : **24.7 cm**

For 8 radios operating simultaneously:

Total EIRP: 9800 mW  
 S @ 20cm: **1.95 mW/cm<sup>2</sup>** 19.5 W/m<sup>2</sup>

Minimum separation distance for  $1\text{mW/cm}^2$ : **27.9 cm**

For 12 radios operating simultaneously:

Total EIRP: 9957 mW  
 S @ 20cm: **1.98 mW/cm<sup>2</sup>** 19.8 W/m<sup>2</sup>

Minimum separation distance for  $1\text{mW/cm}^2$ : **28.1 cm**

For 16 radios operating simultaneously:

Total EIRP: 9957 mW  
 S @ 20cm: **1.98 mW/cm<sup>2</sup>** 19.8 W/m<sup>2</sup>

Minimum separation distance for  $1\text{mW/cm}^2$ : **28.1 cm**

Note: Power Density (S) is calculated from:

$$S = \frac{\text{EIRP}}{4\pi d^2}$$

where d is the distance from the device.

The following tables list the maximum output power per channel for each operating mode.

Yellow highlighted cells indicate a channel with power reduced from the nominal power to meet band edge requirements

Additional information is provided to show how the total output power with multiple radios operating in a band is still compliant with the limits.

### 2400-2483.5MHz

Total power allowed is 1 Watt, with EIRP limited to 4 Watts (effective MIMO gain is 4dBi)

No power reduction when module is co-located with other modules and the other modules are operating in the same band.

Host system firmware will not permit multiple radios to operate on the same channel or overlapping channels

Total of three available 20MHz non-overlapping channels or one 40MHz and one 20MHz channel

	1	2	3	4	5	6	7	8	9	10	11
802.11b	24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2
802.11g	18.5	21.7	23.6	23.6	23.6	23.6	23.6	23.6	23.6	21.8	19.6
802.11n20	17.5	20.0	21.7	21.7	21.7	21.7	21.7	21.7	21.7	19.5	16.5
802.11n40			13.0	13.5	14.5	18.5	17.0	16.5	14.0		

Number of radios operating in the band	Max Power per transceiver (MIMO)	Max Power per transceiver (SISO)	Total Power in Band		Total EIRP	Allocation of channels
			Pout	EIRP	mW	
1	24.2		24.2	31.0	1259	802.11b #6
2	24.2		27.2	34.0	2518	802.11b #6, #1 or #2
3	24.2		29.0	35.8	3777	802.11b #6, #1 or #2, #10 or #11

### 5725-5850MHz

Total power allowed is 1 Watt, with EIRP limited to 4 Watts (effective MIMO gain is 7dBi)

No power reduction when module is co-located with other modules and the other modules are operating in the same band.

Host system firmware will not permit multiple radios to operate on the same channel or overlapping channels

Total of five available 20MHz non-overlapping channels, two 40MHz channels or one 40MHz and three 20MHz channels

	5745	5755	5765	5785	5795	5805	5825
802.11a	21.4		21.4	21.4		21.4	21.4
802.11n20	20.9		20.9	20.9		20.9	20.9
802.11n40		27.1			27.1		

Average powers

Average powers

These are peak powers, average power is < 20dBm.

Number of radios operating in the band	Max Power per transceiver (MIMO)		Max Power per transceiver (SISO)	Total Power in Band		Total EIRP	Allocation of channels
	40MHz	30MHz		Pout (dBm)	EIRP (dBm)	mW	
1	27.1	21.4		27.1	35.9	3890	1 x 40 MHz
2	24.2	21.4		27.2	36.0	3981	2 x 40 MHz
3	22.4	21.4		26.9	35.7	3701	1 x 40MHz and 2 x 20MHz
4		21.2		27.2	36.0	3981	4 x 20MHz
5		20.2		27.2	36.0	3981	5 x 20 MHz

Host system firmware will reduce output power per radio to ensure that the total eirp and/or total output power do not exceed the limits of 30dBm and 36dBm respectively.

### 5150-5250 MHz

Maximum permitted total power for legacy (SISO) modes is 17dBm (antenna gain = 4dBi)

Maximum permitted total output power for MIMO modes is 14.2dBm (effective antenna gain = 8.8dBi)

Host system firmware will not permit multiple radios to operate on the same channel or overlapping channels

Total of four 20MHz channels or one 40MHz and two 20MHz channels or two 40MHz channels

	5180	5190	5200	5220	5230	5240	
802.11a S	15.3		16.0	16.0		16.3	SISO Legacy Mode
802.11a M	12.9		13.5	13.5		13.0	MIMO Legacy Mode
802.11n20	13.7		13.6	13.7		13.7	
802.11n40		9.2			13.6		

Number of radios operating in the band	Max Power (MIMO)	Max Power (SISO)	Total Power in Band		Total EIRP mW	
			Pout	EIRP		
1	13.7	16.3	16.3	22.5	178	
2	11.2	14.0	17.0	23.0	200	
3	9.4	12.2	17.0	23.0	200	MIMO give highest eirp
4	8.2	11.0	17.0	23.0	200	MIMO give highest eirp

Host system firmware will reduce output power per radio to ensure that the total eirp and/or total output power do not exceed the limits of 17dBm and 23dBm respectively

### 5250-5350 MHz

Maximum permitted total power for legacy (SISO) modes is 24dBm (antenna gain = 4dBi)

Maximum permitted total output power for MIMO modes is 21.2dBm (effective antenna gain = 8.8dBi)

Host system firmware will not permit multiple radios to operate on the same channel or overlapping channels

Total of four 20MHz channels or one 40MHz and two 20MHz channels or two 40MHz channels

	5260	5270	5280	5300	5310	5320
802.11a S	20.3		20.1	20.1		13.6
802.11a M	20.0		20.0	19.9		17.4
802.11n20	20.5		20.8	20.8		14.3
802.11n40		21			10.8	

Number of radios operating in the band	Max Power per transceiver (MIMO)	Max Power per transceiver (SISO)	Total Power in Band		Total EIRP mW	
			Pout	EIRP		
1	21.0	20.1	21.0	29.8	955	SISO Legacy Mode
2	18.2	20.1	23.1	30.0	1000	MIMO Legacy Mode
3	16.4	19.2	24.0	30.0	1000	
4	15.2	18.0	22.5	30.0	1000	

Host system firmware will reduce output power per radio to ensure that the total eirp and/or total output power do not exceed the limits of 23dBm and 30dBm respectively

**5470-725 MHz**

Maximum permitted total power for legacy (SISO) modes is 24dBm (antenna gain = 4dBi)

Maximum permitted total output power for MIMO modes is 21.2dBm (effective antenna gain = 8.8dBi)

Host system firmware will not permit multiple radios to operate on the same channel or overlapping channels

Total of eight 20MHz channels or one 40MHz and six 20MHz channels or two 40MHz and four 20MHz channels or three 40MHz channels

Maximum power per channel is limited to the lowest powers listed in the tables below.

	5500	5510	5520	5540	5550	5560	5580	5660	5670	5680	5700	
802.11a S	17.4		16.4	16.4		16.4	16.4	16.4		16.4	16	SISO MIMO
802.11a M	20.1		20.1	20.1		20.1	19.9	20.3		20.3	20.3	
802.11n20	18.7		18.9	18.9		18.9	18.9	18.9		20.1	20.1	
802.11n40		11.1			20.1				20.6			

Number of radios operating in the band	Max Power per transceiver (MIMO)	Max Power per transceiver (SISO)	Total Power in Band		Total EIRP
			Pout	EIRP	mW
1	20.6	17.4	20.6	29.4	871
2	18.2	17.4	21.2	30.0	1000
3	16.4	17.4	22.2	30.0	1000
4	15.2	17.4	23.4	30.0	1000
5	14.2	17.0	24.0	30.0	1000
6	13.4	16.2	24.0	30.0	1000
7	12.7	15.5	24.0	30.0	1000
8	12.2	15.0	24.0	30.0	1000

Host system firmware will reduce output power per radio to ensure that the total eirp and/or total output power do not exceed the limits of 17dBm and 23dBm respectively