

# 1 MAXIMUM PERMISSIBLE EXPOSURE (MPE)

## 1.1 Standard Applicable

According to §1.1307(b)(1), systems operating under the provisions of this section shall be operated in a manner that ensure that the public is not exposed to radio frequency energy level in excess of the Commission’s guideline.

This is a Mobile device, the MPE is required.

According to §1.1310 and §2.1093 RF exposure is calculated.

Limits for Maximum Permissive Exposure (MPE)

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm <sup>2</sup> )	Averaging Time (minute)
Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	*(100)	30
1.34-30	824/f	2.19/f	*(180/f <sup>2</sup> )	30
30-300	27.5	0.073	0.2	30
300-1500	/	/	F/1500	30
1500-15000	/	/	1.0	30

F = frequency in MHz

\* = Plane-wave equipment power density

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## 1.2 Maximum Permissible Exposure (MPE) Evaluation

### Internal Antenna

#### 802.11b Power Table

Frequency (MHz)	Reading Power (dBm)
2412.00	19.10
2437.00	19.63
2462.00	<b>19.92</b>

### MPE Prediction (802.11b)

Prediction of MPE limit at a given distance

Equation from page 18 of OET Bulletin 65, Edition 97-01

$$S = PG / 4 \pi R^2$$

Where: S = Power density

P = Power input to antenna

G = Power gain of the antenna in the direction of interest relative to an isotropic radiator

R = Distance to the center of radiation of the antenna

Maximum average output power at antenna input	19.92	(dBm)
Maximum average output power at antenna input	98.1747943	(mW)
Duty cycle:	99	(%)
Maximum Pav :	97.1930464	(mW)
Antenna gain (typical):	4.25	(dBi)
Maximum antenna gain:	2.66072506	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	2462	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm <sup>2</sup> )
Power density at predication frequency at 20 (cm)	0.051474	(mW/cm <sup>2</sup> )

### Measurement Result

The predicted power density level at 20 cm is 0.051474 mW/cm<sup>2</sup>. This is below the uncontrolled exposure limit of 1 mW/cm<sup>2</sup> at 2462MHz.

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**802.11g Power Table**

Frequency (MHz)	Reading Power (dBm)
2412.00	14.35
2437.00	<b>14.38</b>
2462.00	14.22

**MPE Prediction (802.11g)**

Prediction of MPE limit at a given distance

Equation from page 18 of OET Bulletin 65, Edition 97-01

$$S = PG / 4 \pi R^2$$

Where: S = Power density

P = Power input to antenna

G = Power gain of the antenna in the direction of interest relative to an isotropic radiator

R = Distance to the center of radiation of the antenna

Maximum average output power at antenna input	14.38	(dBm)
Maximum average output power at antenna input	27.4157417	(mW)
Duty cycle:	98	(%)
Maximum Pav :	26.8674269	(mW)
Antenna gain (typical):	4.25	(dBi)
Maximum antenna gain:	2.66072506	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	2437	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm <sup>2</sup> )
Power density at predication frequency at 20 (cm)	0.014229	(mW/cm <sup>2</sup> )

**Measurement Result**

The predicted power density level at 20 cm is 0.014229 mW/cm<sup>2</sup>. This is below the uncontrolled exposure limit of 1 mW/cm<sup>2</sup> at 2437.

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**802.11n\_20M (2.4G) MIMO Chain 0+Chain 1 Power Table**

Frequency (MHz)	Reading Power (dBm)
2412.00	15.01
2437.00	16.22
2462.00	<b>16.42</b>

**MPE Prediction (802.11n\_20M (2.4G))**

Prediction of MPE limit at a given distance

Equation from page 18 of OET Bulletin 65, Edition 97-01

$$S = PG / 4 \pi R^2$$

Where: S = Power density

P = Power input to antenna

G = Power gain of the antenna in the direction of interest relative to an isotropic radiator

R = Distance to the center of radiation of the antenna

Maximum average output power at antenna input	<b>16.42</b>	(dBm)
Maximum average output power at antenna input	43.8530698	(mW)
Duty cycle:	<b>97</b>	(%)
Maximum Pav :	42.5374777	(mW)
Antenna gain (typical):	<b>7.26</b>	(dBi)
Maximum antenna gain:	5.32108259	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	<b>2462</b>	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm <sup>2</sup> )
Power density at predication frequency at 20 (cm)	0.045053	(mW/cm <sup>2</sup> )

**Measurement Result**

The predicted power density level at 20 cm is 0.045053 mW/cm<sup>2</sup>. This is below the uncontrolled exposure limit of 1 mW/cm<sup>2</sup> at 2462.

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**802.11n\_40M (2.4G) MIMO Chain 0+Chain 1 Power Table**

Frequency (MHz)	Reading Power (dBm)
2422.00	14.15
2437.00	<b>15.21</b>
2452.00	14.54

**MPE Prediction (802.11n\_40M (2.4G))**

Prediction of MPE limit at a given distance

Equation from page 18 of OET Bulletin 65, Edition 97-01

$$S = PG / 4 \pi R^2$$

Where: S = Power density

P = Power input to antenna

G = Power gain of the antenna in the direction of interest relative to an isotropic radiator

R = Distance to the center of radiation of the antenna

Maximum average output power at antenna input	15.21	(dBm)
Maximum average output power at antenna input	33.1894458	(mW)
Duty cycle:	93	(%)
Maximum Pav :	30.8661846	(mW)
Antenna gain (typical):	7.26	(dBi)
Maximum antenna gain:	5.32108259	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	2437	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm <sup>2</sup> )
Power density at predication frequency at 20 (cm)	0.032691	(mW/cm <sup>2</sup> )

**Measurement Result**

The predicted power density level at 20 cm is 0.032691 mW/cm<sup>2</sup>. This is below the uncontrolled exposure limit of 1 mW/cm<sup>2</sup> at 2437.

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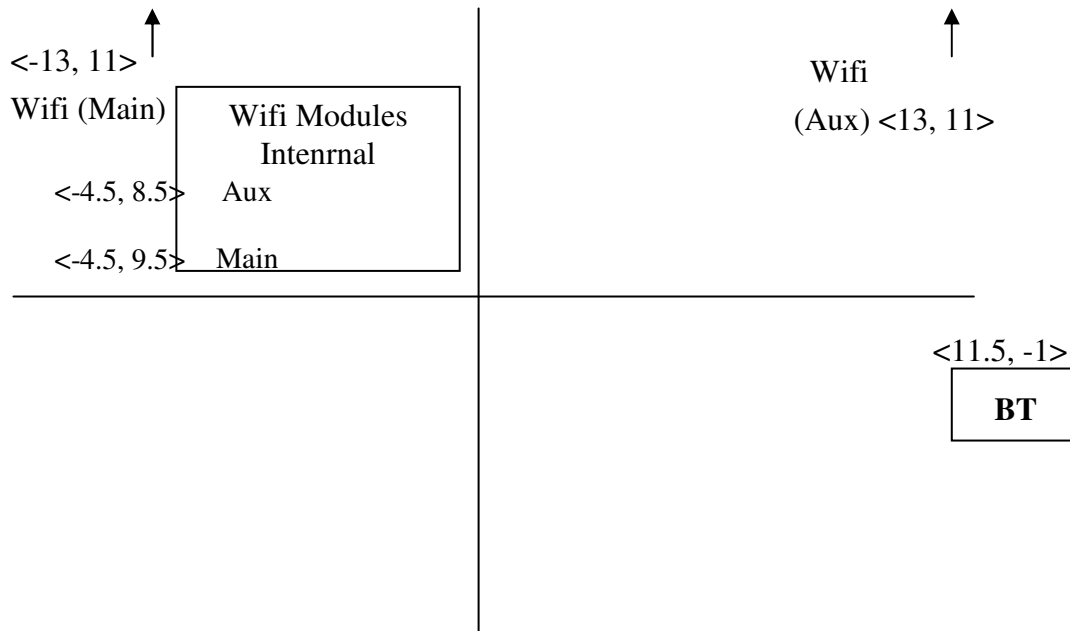
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Collocated MPE analysis:

As per KDB447498 D01, if the radio application is composed of the multiple transmitters confining in the host platform, and placing nearby, the simultaneous transmission due to impact of accumulation of individual MPE shall be evaluated if or not given application could conditionally qualify for MPE test exclusion.

**Location of the transmitting antennas where they distribute:**



Scenario of operation when simultaneous transmission occurs:

Scenario 1:

External Antenna:  
Wifi b or g + Bluetooth

Scenario 2:

External Antenna:  
Wifi n\_MIMO + Bluetooth

Scenario 3:

External Antenna:  
Wifi a + Bluetooth

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Scenario 4:

External Antenna:

Wifi n\_5G (MIMO) + Bluetooth

Scenario 5:

Internal Antenna:

Wifi b or g + Bluetooth

Scenario 6:

Internal Antenna:

Wifi n\_MIMO + Bluetooth

Scenario 7:

Internal Antenna:

Wifi a + Bluetooth

Scenario 8:

Internal Antenna:

Wifi n 5G\_MIMO + Bluetooth

Scenario 9:

External Antenna:

Wifi b or g + Bluetooth LE

Scenario 10:

External Antenna:

Wifi n\_MIMO + Bluetooth LE

Scenario 11:

External Antenna:

Wifi a + Bluetooth LE

Scenario 12:

External Antenna:

Wifi n\_5G (MIMO) + Bluetooth LE

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Scenario 13:

Internal Antenna:

Wifi b or g + Bluetooth LE

Scenario 14:

Internal Antenna:

Wifi n\_MIMO + Bluetooth LE

Scenario 15:

Internal Antenna:

Wifi a + Bluetooth LE

Scenario 16:

Internal Antenna:

Wifi n 5G\_MIMO + Bluetooth LE

Exclusion of test condition:

*Simultaneous transmission MPE test exclusion applies when the sum of the MPE ratios for all simultaneous transmitting antennas incorporated in a host device, based on calculated or measured field strengths or power density, is  $\leq 1.0$ .*

$$\sum MPE\ ratio1 + MPE\ ratio2 + MPE\ ratio3 \leq 1.0$$

*The spreadsheet as FCC deduces, and releases is employed to conduct the measurement:*

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Scenario 1:

External Antenna:  
Wifi b or g + Bluetooth

Antenna No.		Total	1	2
Tx Status			On	On
Frequency	MHz		2462	2441
MPE Limit	mW/cm <sup>2</sup>		1.00	1.00
Max % MPE	%	3.2	3.2	0.0
Power	(W)	0.099	0.098	0.001
Antenna Gain	dBi		2.10	0.5
EIRP	(W)	0.16	0.159	0.001
X	(cm)		-13.0	11.5
Y	(cm)		11.0	-1.0
Sector			FALSE	FALSE
Arc			FALSE	FALSE
θ <sub>1</sub>	degs	input	-120	-120
θ <sub>2</sub>			60	60
θ <sub>1</sub>		actual	-120	-120
θ <sub>2</sub>			60	60

MPE = 3.2/100 = 0.032 < 1.0, and therefore maximum MPE generated from individual transmitter can be excluded.

Scenario 2:

External Antenna:  
Wifi n\_MIMO + Bluetooth

Antenna No.		Total	1	2	3
Tx Status			On	On	On
Frequency	MHz		2462	2441	2462
MPE Limit	mW/cm <sup>2</sup>		1.00	1.00	1.00
Max % MPE	%	1.3	0.6	0.0	0.7
Power	(W)	0.044	0.020	0.001	0.023
Antenna Gain	dBi		2.10	0.5	2.10
EIRP	(W)	0.07	0.032	0.001	0.037
X	(cm)		-13.0	11.5	13.0
Y	(cm)		11.0	-1.0	11
Sector			FALSE	FALSE	FALSE
Arc			FALSE	FALSE	FALSE
θ <sub>1</sub>	degs	input	-120	-120	-120
θ <sub>2</sub>			60	60	60
θ <sub>1</sub>		actual	-120	-120	-120
θ <sub>2</sub>			60	60	60

MPE = 1.3/100 = 0.013 < 1.0, and therefore maximum MPE generated from individual transmitter can be excluded.

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Scenario 3:

External Antenna:  
Wifi a + Bluetooth

Antenna No.		Total	1	2
Tx Status			On	On
Frequency	MHz		5500	2441
MPE Limit	mW/cm <sup>2</sup>		1.00	1.00
Max % MPE	%	2.2	2.1	0.0
Power	(W)	0.058	0.034	0.001
Antenna Gain	dBi		5.00	0.5
EIRP	(W)	0.11	0.108	0.001
X	(cm)		-13.0	11.5
Y	(cm)		11.0	-1.0
Sector			FALSE	FALSE
Arc			FALSE	FALSE
θ <sub>1</sub>	degs	input	-120	-120
θ <sub>2</sub>			60	60
θ <sub>1</sub>		actual	-120	-120
θ <sub>2</sub>			60	60

MPE = 2.2/100 = 0.022 < 1.0, and therefore maximum MPE generated from individual transmitter can be excluded.

Scenario 4:

External Antenna:  
Wifi n\_MIMO 5G + Bluetooth

Antenna No.		Total	1	2	3
Tx Status			On	On	On
Frequency	MHz		5500	2441	5500
MPE Limit	mW/cm <sup>2</sup>		1.00	1.00	1.00
Max % MPE	%	4.4	2.1	0.0	2.5
Power	(W)	0.074	0.033	0.001	0.040
Antenna Gain	dBi		5.00	0.5	5.00
EIRP	(W)	0.23	0.104	0.001	0.126
X	(cm)		-13.0	11.5	13.0
Y	(cm)		11.0	-1.0	11.0
Sector			FALSE	FALSE	FALSE
Arc			FALSE	FALSE	FALSE
θ <sub>1</sub>	degs	input	-120	-120	-120
θ <sub>2</sub>			60	60	60
θ <sub>1</sub>		actual	-120	-120	-120
θ <sub>2</sub>			60	60	60

MPE = 4.4/100 = 0.044 < 1.0, and therefore maximum MPE generated from individual transmitter can be excluded.

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Scenario 5:

Internal Antenna:

Wifi b or g + Bluetooth

Antenna No.		Total	1	2
Tx Status			On	On
Frequency	MHz		2462	2441
MPE Limit	mW/cm <sup>2</sup>		1.00	1.00
Max % MPE	%	5.2	5.2	0.0
Power	(W)	0.099	0.098	0.001
Antenna Gain	dBi		4.25	0.5
EIRP	(W)	0.26	0.036	0.001
X	(cm)		-4.5	11.5
Y	(cm)		9.5	-1.0
Sector			FALSE	FALSE
Arc			FALSE	FALSE
θ <sub>1</sub>	degs	input	-120	-120
θ <sub>2</sub>			60	60
θ <sub>1</sub>		actual	-120	-120
θ <sub>2</sub>			60	60

MPE = 5.2/100 = 0.052 < 1.0, and therefore maximum MPE generated from individual transmitter can be excluded.

Scenario 6:

Internal Antenna:

Wifi n\_MIMO + Bluetooth

Antenna No.		Total	1	2	3
Tx Status			On	On	On
Frequency	MHz		2462	2441	2462
MPE Limit	mW/cm <sup>2</sup>		1.00	1.00	1.00
Max % MPE	%	2.3	1.1	0.0	1.2
Power	(W)	0.044	0.020	0.001	0.023
Antenna Gain	dBi		4.25	0.5	4.25
EIRP	(W)	0.12	0.053	0.001	0.061
X	(cm)		-4.5	11.5	-4.5
Y	(cm)		9.5	-1.0	8.5
Sector			FALSE	FALSE	FALSE
Arc			FALSE	FALSE	FALSE
θ <sub>1</sub>	degs	input	-120	-120	-120
θ <sub>2</sub>			60	60	60
θ <sub>1</sub>		actual	-120	-120	-120
θ <sub>2</sub>			60	60	60

MPE = 2.3/100 = 0.023 < 1.0, and therefore maximum MPE generated from individual transmitter can be excluded.

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Scenario 7:

Internal Antenna:  
Wifi a + Bluetooth

Antenna No.		Total	1	2
Tx Status			On	On
Frequency	MHz		5500	2441
MPE Limit	mW/cm <sup>2</sup>		1.00	1.00
Max % MPE	%	2.2	2.4	0.0
Power	(W)	0.035	0.034	0.001
Antenna Gain	dBi		5.00	0.5
EIRP	(W)	0.11	0.121	0.001
X	(cm)		-4.5	11.5
Y	(cm)		9.5	-1.0
Sector			FALSE	FALSE
Arc			FALSE	FALSE
θ <sub>1</sub>	degs	input	-120	-120
θ <sub>2</sub>			60	60
θ <sub>1</sub>		actual	-120	-120
θ <sub>2</sub>			60	60

MPE = 2.2 / 100 = 0.022 < 1.0, and therefore maximum MPE generated from individual transmitter can be excluded.

Scenario 8:

Internal Antenna:  
Wifi n\_5G\_MIMO + Bluetooth

Antenna No.		Total	1	2	3
Tx Status			On	On	On
Frequency	MHz		5500	2441	5500
MPE Limit	mW/cm <sup>2</sup>		1.00	1.00	1.00
Max % MPE	%	5.2	2.4	0.0	2.8
Power	(W)	0.075	0.034	0.001	0.040
Antenna Gain	dBi		5.50	0.5	5.50
EIRP	(W)	0.26	0.121	0.001	0.142
X	(cm)		-4.5	11.5	-4.5
Y	(cm)		9.5	-1.0	8.5
Sector			FALSE	FALSE	FALSE
Arc			FALSE	FALSE	FALSE
θ <sub>1</sub>	degs	input	-120	-120	-120
θ <sub>2</sub>			60	60	60
θ <sub>1</sub>		actual	-120	-120	-120
θ <sub>2</sub>			60	60	60

MPE = 5.2/100 = 0.052 < 1.0, and therefore maximum MPE generated from individual transmitter can be excluded.

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Scenario 9:

External Antenna:  
Wifi b or g + Bluetooth LE

Antenna No.		Total	1	2
Tx Status			On	On
Frequency	MHz		2462	2402
MPE Limit	mW/cm <sup>2</sup>		1.00	1.00
Max % MPE	%	3.2	3.2	0.0
Power	(W)	0.099	0.098	0.001
Antenna Gain	dBi		2.10	0.50
EIRP	(W)	0.30	0.048	0.001
X	(cm)		-13.0	11.5
Y	(cm)		11.0	-1.0
Sector			FALSE	FALSE
Arc			FALSE	FALSE
θ <sub>1</sub>	degs	input	-120	-120
θ <sub>2</sub>			60	60
θ <sub>1</sub>		actual	-120	-120
θ <sub>2</sub>			60	60

MPE = 3.2/100 = 0.032 < 1.0, and therefore maximum MPE generated from individual transmitter can be excluded.

Scenario 10:

External Antenna:  
Wifi n\_MIMO + Bluetooth LE

Antenna No.		Total	1	2	3
Tx Status			On	On	On
Frequency	MHz		2462	2402	2462
MPE Limit	mW/cm <sup>2</sup>		1.00	1.00	1.00
Max % MPE	%	1.3	0.6	0.0	0.7
Power	(W)	0.044	0.020	0.001	0.023
Antenna Gain	dBi		2.10	0.50	2.10
EIRP	(W)	0.07	0.032	0.001	0.037
X	(cm)		-13.0	11.5	13.0
Y	(cm)		11.0	-1.0	11.0
Sector			FALSE	FALSE	FALSE
Arc			FALSE	FALSE	FALSE
θ <sub>1</sub>	degs	input	-120	-120	-120
θ <sub>2</sub>			60	60	60
θ <sub>1</sub>		actual	-120	-120	-120
θ <sub>2</sub>			60	60	60

MPE = 1.3/100 = 0.013 < 1.0, and therefore maximum MPE generated from individual transmitter can be excluded.

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Scenario 11:

External Antenna:  
Wifi a + Bluetooth LE

Antenna No.		Total	1	2
Tx Status			On	On
Frequency	MHz		5500	2402
MPE Limit	mW/cm <sup>2</sup>		1.00	1.00
Max % MPE	%	2.2	2.1	0.0
Power	(W)	0.035	0.034	0.001
Antenna Gain	dBi		5.00	0.50
EIRP	(W)	0.11	0.108	0.001
X	(cm)		-13.0	11.5
Y	(cm)		11.0	-1.0
Sector			FALSE	FALSE
Arc			FALSE	FALSE
θ <sub>1</sub>	degs	input	-120	-120
θ <sub>2</sub>			60	60
θ <sub>1</sub>		actual	-120	-120
θ <sub>2</sub>			60	60

MPE = 2.2/100 = 0.022 < 1.0, and therefore maximum MPE generated from individual transmitter can be excluded.

Scenario 12:

External Antenna:  
Wifi n\_MIMO 5G + Bluetooth LE

Antenna No.		Total	1	2	3
Tx Status			On	On	On
Frequency	MHz		5500	2402	5500
MPE Limit	mW/cm <sup>2</sup>		1.00	1.00	1.00
Max % MPE	%	4.4	2.1	0.0	2.5
Power	(W)	0.075	0.034	0.001	0.040
Antenna Gain	dBi		5.00	0.50	5.00
EIRP	(W)	0.24	0.108	0.001	0.142
X	(cm)		-13.0	11.5	13.0
Y	(cm)		11.0	-1.0	11.0
Sector			FALSE	FALSE	FALSE
Arc			FALSE	FALSE	FALSE
θ <sub>1</sub>	degs	input	-120	-120	-120
θ <sub>2</sub>			60	60	60
θ <sub>1</sub>		actual	-120	-120	-120
θ <sub>2</sub>			60	60	60

MPE = 4.4/100 = 0.044 < 1.0, and therefore maximum MPE generated from individual transmitter can be excluded.

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Scenario 13:

Internal Antenna:

Wifi b or g + Bluetooth LE

Antenna No.		Total	1	2
Tx Status			On	On
Frequency	MHz		2462	2402
MPE Limit	mW/cm <sup>2</sup>		1.00	1.00
Max % MPE	%	1.1	1.1	0.0
Power	(W)	0.021	0.020	0.001
Antenna Gain	dBi		4.25	0.50
EIRP	(W)	0.05	0.053	0.001
X	(cm)		-4.5	11.5
Y	(cm)		9.5	-1.0
Sector			FALSE	FALSE
Arc			FALSE	FALSE
θ <sub>1</sub>	degs	input	-120	-120
θ <sub>2</sub>			60	60
θ <sub>1</sub>		actual	-120	-120
θ <sub>2</sub>			60	60

MPE = 1.1/100 = 0.011 < 1.0, and therefore maximum MPE generated from individual transmitter can be excluded.

Scenario 14:

Internal Antenna:

Wifi n\_MIMO + Bluetooth LE

Antenna No.		Total	1	2	3
Tx Status			On	On	On
Frequency	MHz		2462	2402	2462
MPE Limit	mW/cm <sup>2</sup>		1.00	1.00	1.00
Max % MPE	%	1.8	1.1	0.0	1.2
Power	(W)	0.044	0.020	0.001	0.023
Antenna Gain	dBi		4.25	0.50	2.10
EIRP	(W)	0.09	0.053	0.001	0.061
X	(cm)		-4.5	11.5	-4.5
Y	(cm)		9.5	-1.0	8.5
Sector			FALSE	FALSE	FALSE
Arc			FALSE	FALSE	FALSE
θ <sub>1</sub>	degs	input	-120	-120	-120
θ <sub>2</sub>			60	60	60
θ <sub>1</sub>		actual	-120	-120	-120
θ <sub>2</sub>			60	60	60

MPE = 1.8/100 = 0.018 < 1.0, and therefore maximum MPE generated from individual transmitter can be excluded.

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Scenario 15:

Internal Antenna:  
Wifi a + Bluetooth LE

Antenna No.		Total	1	2
Tx Status			On	On
Frequency	MHz		5500	2402
MPE Limit	mW/cm <sup>2</sup>		1.00	1.00
Max % MPE	%	2.4	2.4	0.0
Power	(W)	0.035	0.034	0.001
Antenna Gain	dBi		5.50	0.50
EIRP	(W)	0.12	0.121	0.001
X	(cm)		-4.5	11.5
Y	(cm)		9.5	-1.0
Sector			FALSE	FALSE
Arc			FALSE	FALSE
θ <sub>1</sub>	degs	input	-120	-120
θ <sub>2</sub>			60	60
θ <sub>1</sub>		actual	-120	-120
θ <sub>2</sub>			60	60

MPE = 2.4 / 100 = 0.024 < 1.0, and therefore maximum MPE generated from individual transmitter can be excluded.

Scenario 16:

Internal Antenna:  
Wifi n\_5G\_MIMO + Bluetooth LE

Antenna No.		Total	1	2	3
Tx Status			On	On	On
Frequency	MHz		5500	2402	5500
MPE Limit	mW/cm <sup>2</sup>		1.00	1.00	1.00
Max % MPE	%	5.2	2.4	0.0	2.8
Power	(W)	0.075	0.034	0.001	0.040
Antenna Gain	dBi		5.50	0.50	5.50
EIRP	(W)	0.26	0.121	0.001	0.142
X	(cm)		-4.5	11.5	-4.5
Y	(cm)		9.5	-1.0	8.5
Sector			FALSE	FALSE	FALSE
Arc			FALSE	FALSE	FALSE
θ <sub>1</sub>	degs	input	-120	-120	-120
θ <sub>2</sub>			60	60	60
θ <sub>1</sub>		actual	-120	-120	-120
θ <sub>2</sub>			60	60	60

MPE = 5.2/100 = 0.052 < 1.0, and therefore maximum MPE generated from individual transmitter can be excluded.

~ End of Report ~

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