

15 The Derivation of Maximum Allowable Gain

15.1. The Justification How Gain is Derived:

This submittal(s) (test report) is intended to comply with Section Part 22, subpart H and Part 24, subpart E of the FCC CFR 47 Rules. As per FCC's ruling part, 1.1310, the power density limit for General Population/Uncontrolled Exposure is f/1500 mW/cm² through 300MHz to 1500MHz, and 1.0 mW/cm² through 1.5 GHz to 100 GHz, respectively. Since this related application is characterized as mobile application as defined by FCC, the MPE is obtained at 20cm in determination for its compliance with the power density limit.

The formula listing as follows is applied in determination of Power Density:

This submittal(s) (test report) is intended to comply with SRSP-503, SRSP-510. As per IC's ruling part, the power density limit for General Population/Uncontrolled Exposure is f/150 W/m² through 300MHz to 1500MHz, and 10W/m² through 1.5GHz to 150GHz, respectively. Since this related application is characterized as mobile application as defined by IC, the MPE is obtained at 20cm in determination for its compliance with the power density limit.

The formula listing as follows is applied in determination of Power Density:

$$S = (P * G) / (4\pi * R^2)$$

Where,

S = Power Density

P = Conducted Output Power Measured at Antenna Port

G = Gain of Maximum Transmitting Antenna (linear gain)

R = Separating Distance from Transmitting Antenna

This related radio application is classified as mobile device in operation of general population / uncontrolled exposure condition.

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Limitation (FCC)

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm ²)	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 ²)	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

(IC)

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m ²)	Averaging Time (minutes)
0.003-1	280	2.19	-	6
1-10	280/f	2.19/f	-	6
10-30	28	2.19/f	-	6
30-300	28	0.073	2*	6
300-1500	1.585 f ^{0.5}	0.0042 f ^{0.5}	f/150	6
1500-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	616000/f ^{1.2}
150000-300000	0.158 f ^{0.5}	4.21 x 10 ⁻⁴ f ^{0.5}	6.67 x 10 ⁻⁵ f	616000/f ^{1.2}

Note: f is frequency in MHz.

* Power density limit is applicable at frequencies greater than 100 MHz.

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15.2. Maximum Linear Gain Determination using MPE

Re-arrange the formula of Power Density in terms of maximum gain,

It yields,

$$G = S \cdot (4 \pi \cdot R^2) / P$$

Where,

(FCC)

$S = F/1500 \text{ mW/cm}^2$ (300-1500MHz) or 1.0 mW/cm^2 (1.5GHz-100GHz)

$P =$ Conducted Output Power Measured at Antenna Port with respect to applied band.

$G =$ Maximum Linear Gain

$R = 20\text{cm}$

(IC)

$S = F/150\text{W/m}^2$ (300MHz -1500MHz) or 10W/m^2 (1.5GHz-150GHz)

$P =$ Conducted Output Power Measured at Antenna Port with respect to applied band.

$G =$ Maximum Linear Gain

$R = 20\text{cm}$

Maximum Linear Gain Determination using ERP/EIRP

As per 22.913a) and 24.232 (b) ERP/EIRP is limited as 7W, 1W, respectively. Maximum allowable gain that complies with them can be obtained by the following relationship.

As per SRSP-503, S SRSP-510 ERP/EIRP is limited as 6.3W, 1W, respectively. Maximum allowable gain that complies with them can be obtained by the following relationship

EIRP/ERP = Maximum Allowable Gain + Maximum Burst Power as measured at antenna terminal.

Re-arrange the above equation in terms of Maximum Allowable Gain, *It yields,*

Maximum Allowable Gain = EIRP/ERP – Maximum Burst Power as measured at antenna terminal

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Conducted Power Measured at Antenna Terminal: (FCC & IC)

Frequency (MHz)	CH	1 Time Slot		2 Time Slot	
		GMSK Mode		GMSK Mode	
		Peak Power (dBm)	AV Power (dBm)	Peak Power (dBm)	AV Power (dBm)
824.2	128	32.80	32.60	32.10	31.90
836.6	190	32.80	32.60	32.10	31.90
848.8	251	32.90	32.60	32.00	31.90
1850.2	512	29.90	29.70	29.10	28.90
1880.0	661	29.70	29.50	28.80	28.70
1909.8	810	29.60	29.40	28.70	28.60

Frequency (MHz)	CH	3 Time Slot		4 Time Slot	
		GMSK Mode		GMSK Mode	
		Peak Power (dBm)	AV Power (dBm)	Peak Power (dBm)	AV Power (dBm)
824.2	128	30.30	30.20	29.20	29.10
836.6	190	30.30	30.20	29.30	29.10
848.8	251	30.40	30.30	29.40	29.20
1850.2	512	27.20	27.10	26.20	26.00
1880.0	661	27.00	26.80	25.90	25.80
1909.8	810	26.90	26.80	25.80	25.70

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Maximum Source-Based Time Average Power calculated by Time-Slot Factor:

Frequency (MHz)	CH	1 Time Slot	2 Time Slot
		GMSK Mode	GMSK Mode
		AV Power (dBm)	AV Power (dBm)
824.2	128	23.57	25.88
836.6	190	23.57	25.88
848.8	251	23.57	25.88
1850.2	512	20.67	22.88
1880.0	661	20.47	22.68
1909.8	810	20.37	22.58

Frequency (MHz)	CH	3 Time Slot	4 Time Slot
		GMSK Mode	GMSK Mode
		AV Power (dBm)	AV Power (dBm)
824.2	128	25.94	26.09
836.6	190	25.94	26.09
848.8	251	26.04	26.19
1850.2	512	22.84	22.99
1880.0	661	22.54	22.79
1909.8	810	22.54	22.69

Where,

Maximum Source-based Time Average is determined by “Burst Power” minus slot factor:

	1TX	2TX	3TX	4TX
power:	0.125	0.25	0.375	0.5
power (dBm):	-9.0309	-6.0206	-4.25969	-3.0103

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15.3. The Computation of Maximum Allowable Linear Gain using MPE limit (FCC)

Operation in cellular band (824 – 849 MHz)

Given the maximum source-based time-averaged power as 23.57dBm, and MPE limit as 0.55 mW/cm².

Therefore, antenna gain is calculated as 10.84dBi

Operation in PCS band (1850 – 1910 MHz)

Given the maximum source-based time-averaged power as 19.9dBm, and MPE limit as 1 mW/cm².

Therefore, antenna gain is calculated as 17.11dBi

15.4. The Computation of Maximum Allowable Linear Gain using MPE limit (IC)

Operation in cellular band (824 – 849 MHz)

Given the maximum source-based time-averaged power as 23.57dBm, and MPE limit as 5.49 W/m².

Therefore, antenna gain is calculated as 20.84dBi

Operation in PCS band (1850 – 1910 MHz)

Given the maximum source-based time-averaged power as 19.9dBm, and MPE limit as 10 W/m².

Therefore, antenna gain is calculated as 27.11dBi

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15.5. The Computation of Maximum Allowable Linear Gain using ERP/EIRP limit (FCC)

Operation in cellular band (824 – 849 MHz)

Given the maximum burst average power as 32.60dBm, and ERP limit as 7W
Therefore, antenna gain is calculated as 5.85dBi

Operation in PCS band (1850 – 1910 MHz)

Given the maximum burst average power r as 29.70dBm, and EIRP limit as 2W
Therefore, antenna gain is calculated as 3.31dBi

15.6. The Computation of Maximum Allowable Linear Gain using ERP/EIRP limit (IC)

Operation in cellular band (824 – 849 MHz)

Given the maximum burst average power as 32.60dBm, and ERP limit as 6.3W
Therefore, antenna gain is calculated as 5.39dBi

Operation in PCS band (1850 – 1910 MHz)

Given the maximum burst average power r as 29.70dBm, and EIRP limit as 2W
Therefore, antenna gain is calculated as 3.31dBi

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