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:

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

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.

Limitation

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm2)	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/f2)	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

15.2. Maximum Linear Gain Determination using MPE

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

It yields,

G = S*(4π*R^2) / P

Where,

S = F/1500 mW/cm2 (300-1500Mhz) or 1.0 mW/cm2 (1.5GHz-100GHz)

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

G = Maximum Linear Gain

R = 20cm

Maximum Linear Gain Determination using ERP/EIRP

As per 22.913a) and 24.232 (b), 27.50 (d)(4), 27.50 (c)(9), 27.50 (h)(2) ERP/EIRP is limited as 7W, 2W, 1W, 30W, 2W, 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

Conducted Power Measured at Antenna Terminal:

Frequency (MHz)	CH	1 Time Slot				2 Time Slot			
		GMSK Mode		8-PSK Mode		GMSK Mode		8-PSK Mode	
		Peak Power (dBm)	AV Power (dBm)	Peak Power (dBm)	AV Power (dBm)	Peak Power (dBm)	AV Power (dBm)	Peak Power (dBm)	AV Power (dBm)
824.2	128	32.60	32.50	30.00	27.00	29.50	29.40	26.80	23.50
836.6	190	32.60	32.50	29.70	26.60	29.50	29.40	26.40	23.10
848.8	251	32.60	32.50	29.80	26.80	29.60	29.40	26.40	23.10
1850.2	512	28.70	28.50	28.20	25.20	26.10	25.90	25.00	21.60
1880.0	661	28.60	28.50	28.20	25.10	26.00	25.80	24.90	21.50
1909.8	810	28.60	28.40	27.70	24.50	25.80	25.70	24.30	21.00

Frequency (MHz)	CH	3 Time Slot				4 Time Slot			
		GMSK Mode		8-PSK Mode		GMSK Mode		8-PSK Mode	
		Peak Power (dBm)	AV Power (dBm)	Peak Power (dBm)	AV Power (dBm)	Peak Power (dBm)	AV Power (dBm)	Peak Power (dBm)	AV Power (dBm)
824.2	128	27.60	27.50	24.70	21.30	26.50	26.40	23.40	20.00
836.6	190	27.70	27.60	24.20	21.00	26.50	26.40	22.90	19.60
848.8	251	28.70	27.60	24.40	21.20	26.60	26.40	23.20	19.80
1850.2	512	24.20	24.10	23.60	20.10	23.10	22.90	22.20	18.80
1880.0	661	24.10	24.00	23.50	20.00	22.90	22.80	22.30	18.90
1909.8	810	24.00	23.80	22.90	19.40	22.80	22.60	21.70	18.20

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

Frequency (MHz)	CH	1 Time Slot		2 Time Slot	
		GMSK Mode	8-PSK Mode	GMSK Mode	8-PSK Mode
		AV Power (dBm)	AV Power (dBm)	AV Power (dBm)	AV Power (dBm)
824.2	128	23.5	18.0	23.4	17.5
836.6	190	23.5	17.6	23.4	17.1
848.8	251	23.5	17.8	23.4	17.1
1850.2	512	19.5	16.2	19.9	15.6
1880.0	661	19.5	16.1	19.8	15.5
1909.8	810	19.4	15.5	19.7	15.0

Frequency (MHz)	CH	3 Time Slot		4 Time Slot	
		GMSK Mode	8-PSK Mode	GMSK Mode	8-PSK Mode
		AV Power (dBm)	AV Power (dBm)	AV Power (dBm)	AV Power (dBm)
824.2	128	23.2	17.0	17.0	17.0
836.6	190	23.3	16.7	16.7	16.6
848.8	251	23.3	16.9	16.9	16.8
1850.2	512	19.8	15.8	15.8	15.8
1880.0	661	19.7	15.7	15.7	15.9
1909.8	810	19.5	15.1	15.1	15.2

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

Maximum Source-based Time Average power for WCDMA mode:

Refer to page 32, 22.71dBm for band II, 23.41dBm for band V

Maximum Source-based Time Average power for LTE mode:

Refer to page 37, 24.76dBm (1902.5MHz) for band II, page 40, 24.25dBm (847.5MHz) for band 5, page 47 24.22dBm (1717.5MHz) for band 4, 23.67dBm (2502.5MHz) for band 7, page 53 for 24.30dBm (713.5Mhz) for band 17

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

Operation in cellular band (824 – 849 MHz)
Given the maximum source-based time-averaged power as 23.50dBm, and MPE limit as 0.55 mW/cm^2.
Therefore, antenna gain is calculated as 12.34dBi

Operation in PCS band (1850 – 1910 MHz)
Given the maximum source-based time-averaged power as 19.9dBm, and MPE limit as 1 mW/cm^2.
Therefore, antenna gain is calculated as 51.44dBi

Operation in WCDMA Band II (1850 – 1910MHz)
Given the maximum source-based time-averaged power as 22.71dBm, and MPE limit as 1.0 mW/cm^2.
Therefore, antenna gain is calculated as 14.81dBi

Operation in WCDMA Band V (824 – 850MHz)
Given the maximum source-based time-averaged power as 23.41dBm, and MPE limit as 0.55 mW/cm^2.
Therefore, antenna gain is calculated as 12.60dBi

Operation in LTE band II
Given the maximum source-based time-averaged power as 24.76dBm, and MPE limit as 1 mW/cm^2.
Therefore, antenna gain is calculated as 16.80dBi

Operation in LTE band 5
Given the maximum source-based time-averaged power as 24.75dBm, and MPE limit as 0.57 mW/cm^2.
Therefore, antenna gain is calculated as 9.51dBi

Operation in LTE band 4
Given the maximum source-based time-averaged power as 24.22dBm, and MPE limit as 1.0 mW/cm^2.
Therefore, antenna gain is calculated as 19.02dBi

Operation in LTE band 7
Given the maximum source-based time-averaged power as 23.76dBm, and MPE limit as 1.0 mW/cm^2.
Therefore, antenna gain is calculated as 21.59dBi

Operation in LTE band 17
Given the maximum source-based time-averaged power as 24.30dBm, and MPE limit as 0.48mW/cm^2.
Therefore, antenna gain is calculated as 10.90dBi

15.4. The Computation of Maximum Allowable Linear Gain using ERP/EIRP limit

Operation in cellular band (824 – 849 MHz)
Given the maximum burst power as 32.50dBm, and ERP limit as 7W
Therefore, antenna gain is calculated as 5.95dBi

Operation in PCS band (1850 – 1910 MHz)
Given the maximum burst power r as 28.50dBm, and EIRP limit as 2W
Therefore, antenna gain is calculated as 4.51dBi

Operation in WCDMA Band II (1850 – 1910MHz)
Given the maximum burst averaged power as 22.71dBm, and EIRP limit as 2W
Therefore, antenna gain is calculated as 10.30dBi

Operation in WCDMA Band V (824 – 850MHz)
Given the maximum burst power as 23.41dBm, and ERP limit as 7W
Therefore, antenna gain is calculated as 15.04dBi

Operation in LTE band II
Given the maximum source-based time-averaged power as 24.76dBm, and EIRP limit as 2W
Therefore, antenna gain is calculated as 8.25dBi

Operation in LTE band 5
Given the maximum source-based time-averaged power as 24.75dBm, and ERP limit as 7W
Therefore, antenna gain is calculated as 13.70dBi

Operation in LTE band 4
Given the maximum source-based time-averaged power as 24.22dBm, and EIRP limit as 1W.
Therefore, antenna gain is calculated as 5.78dBi

Operation in LTE band 7
Given the maximum source-based time-averaged power as 23.76dBm, and EIRP limit as 2W
Therefore, antenna gain is calculated as 9.25dBi

Operation in LTE band 17
Given the maximum source-based time-averaged power as 24.30dBm, and ERP limit as 30W
Therefore, antenna gain is calculated as 20.47dBi