

Maximum Permissible Exposure (MPE)

Related Submittal(s) / Grant (s)

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 Radio frequency Radiation Exposure requirement.

Special Accessories

Not available for this EUT intended for grant.

Equipment Modifications

Not available for this EUT intended for grant.

Limitation

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

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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Maximum Permissible Exposure (MPE) Evaluation

In this application we seek approval to the MO6092. Based on the FCC OET Bulletin 65 Supplement C and 47 CFR §2.1091, we have concluded that the MO6092 module will comply with the FCC rules on RF exposure for mobile devices in cellular band and PCS band. The following analysis will demonstrate such compliance. The analysis will be done in two US bands.

Operation in cellular band (824 – 849 MHz)

The ERP of MO6092 in cellular band is 31.81dBm max at GSM/GPRS mode. The resulted power density at a distance of 20 cm can be deducted as follows:

EUT Mode	Frequency (MHz)	CH	EUT Pol.	Antenna Pol.	SPA Reading (dBuV)	S.G. Output (dBm)	Antenna Gain (dBi)	Cable Loss (dB)	ERP (dBm)	Limit (dBm)
GPRS 850 (Class 12)	824.20	128	E2	V	115.61	29.22	-7.87	3.62	17.72	38.45
				H	125.29	39.02	-7.87	3.62	27.52	38.45
	836.60	190	E2	V	107.33	21.08	-7.88	3.65	9.55	38.45
				H	125.83	39.60	-7.88	3.65	28.07	38.45
	848.80	251	E2	V	108.09	21.97	-7.88	3.68	10.41	38.45
				H	129.56	43.37	-7.88	3.68	31.81	38.45

$$\text{ERP} = 31.81 \text{ dBm} = 1517.05 \text{ mW}$$

$$\begin{aligned} \text{Power Density} &= \text{ERP} \cdot \text{Duty Cycle} / (4 \pi R^2) \\ &= 1517.05 \cdot 0.5 / (4 \cdot \pi \cdot 20^2) = 0.1509 \text{ mW/cm}^2 \end{aligned}$$

where Duty Cycle is 0.5 for GPRS operation (class 12) and R is 20 cm.

The MPE limit for General Population/Uncontrolled Exposure is shown in the FCC OET Bulletin 65 Supplement C and can be calculated as follows:

$$\text{MPE limit} = 824/1500 = 0.55 \text{ mW/cm}^2$$

As we can see the resulted power density is below the MPE limit, therefore MO6092 in cellular band is compliant with the FCC rules on RF exposure.

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Operation in PCS band (1850 – 1910 MHz)

The EIRP of MO6092 in PCS band is 28.79 dBm. max. The resulted EIRP can be expressed as follows:

EUT Mode	Frequency (MHz)	CH	EUT Pol.	Antenna Pol.	SPA Reading (dBuV)	S.G. Output (dBm)	Antenna Gain (dBi)	Cable Loss (dB)	EIRP (dBm)	Limit (dBm)
GPRS 1900	1850.20	512	E2	V	112.12	7.73	9.90	5.56	12.07	33.00
				H	127.91	23.73	9.90	5.84	27.79	33.00
	1880.00	661	E2	V	115.06	10.70	9.99	5.61	15.08	33.00
				H	128.05	23.91	9.99	5.61	28.28	33.00
	1909.80	810	E2	V	114.81	10.48	10.08	5.66	14.90	33.00
				H	128.48	24.37	10.08	5.66	28.79	33.00

$EIRP = 28.79 \text{ dBm} = 756.83 \text{ mW}$

$Power \text{ Density} = EIRP * Duty \text{ Cycle} / (4 \pi R^2)$
 $= 756.83 * 0.5 / (4 * \pi * 20^2) = 0.0753 \text{ mW/cm}^2$

where Duty Cycle is 0. 5 for GPRS operation (class 12) and R is 20 cm.

The MPE limit for General Population/Uncontrolled Exposure is shown in the FCC OET Bulletin 65 Supplement C and can be calculated as follows:

$MPE \text{ limit} = 1.0 \text{ mW/cm}^2$

As we can see the resulted power density is below the MPE limit, therefore MO6092 in PCS band is compliant with the FCC rules on RF exposure.

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Operation in WCDMA band II (1850 – 1910 MHz)

The ERP of MO6092 in cellular band is 24.42dBm max at WCDMA II mode. The resulted power density at a distance of 20 cm can be deducted as follows:

EUT Mode	Frequency (MHz)	CH	EUT Pol.	Antenna Pol.	SPA Reading (dBuV)	S.G. Output (dBm)	Antenna Gain (dBi)	Cable Loss (dB)	EIRP (dBm)	Limit (dBm)
WCDMA II	1852.40	9262	E2	V	111.43	6.91	9.48	5.33	11.05	33.00
				H	124.51	20.18	9.90	5.84	24.24	33.00
	1880.00	600	E2	V	112.48	7.98	9.54	5.36	12.15	33.00
				H	124.56	20.25	9.54	5.36	24.42	33.00
	1908.75	1175	E2	V	112.92	8.44	9.61	5.40	12.64	33.00
				H	124.06	19.77	9.61	5.40	23.98	33.00

$$ERP = 24.42 \text{ dBm} = 276.69 \text{ mW}$$

$$\text{Power Density} = ERP * \text{Duty Cycle} / (4 \pi R^2)$$

$$= 345.14 * 1 / (4 * \pi * 20^2) = 0.0550 \text{ mW/cm}^2$$

where Duty Cycle is 1 for HSUPA band II mode and R is 20 cm.

The MPE limit for General Population/Uncontrolled Exposure is shown in the FCC OET Bulletin 65 Supplement C and can be calculated as follows:

$$\text{MPE limit} = 1.0 \text{ mW/cm}^2$$

As we can see the resulted power density is below the MPE limit, therefore MO6092 in cellular band is compliant with the FCC rules on RF exposure.

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Operation in HSUPA band V (826 – 849 MHz)

The EIRP of MO6092 in PCS band is 24.14dBm. max. The resulted EIRP can be expressed as follows:

EUT Mode	Frequency (MHz)	CH	EUT Pol.	Antenna Pol.	SPA Reading (dBuV)	S.G. Output (dBm)	Antenna Gain (dBi)	Cable Loss (dB)	ERP (dBm)	Limit (dBm)
WCDMA Band V	826.40	4132	E2	V	106.90	20.54	-7.88	3.63	9.03	38.45
				H	121.16	34.90	-7.88	3.63	23.40	38.45
	1880.00	600	E2	V	105.73	19.47	-7.88	3.65	7.94	38.45
				H	121.90	35.67	-7.88	3.65	24.14	38.45
	1908.75	1175	E2	V	106.48	20.33	-7.88	3.67	8.78	38.45
				H	121.80	35.60	-7.88	3.67	24.05	38.45

$$EIRP = 24.14 \text{ dBm} = 259.418 \text{ mW}$$

$$\begin{aligned} \text{Power Density} &= EIRP * \text{Duty Cycle} / (4 \pi R^2) \\ &= 259.418 * 1 / (4 * \pi * 20^2) = 0.0516 \text{ mW/cm}^2 \end{aligned}$$

where Duty Cycle is 1 for HSUPA band V mode and R is 20 cm.

The MPE limit for General Population/Uncontrolled Exposure is shown in the FCC OET Bulletin 65 Supplement C and can be calculated as follows:

$$MPE \text{ limit} = 826.4 / 1500 = 0.55 \text{ mW/cm}^2$$

As we can see the resulted power density is below the MPE limit, therefore MO6092 in PCS band is compliant with the FCC rules on RF exposure.

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Operation in cellular band (824 – 849 MHz)

The ERP of MO6092 in cellular band is 26.04dBm max at CDMA2000 mode. The resulted power density at a distance of 20 cm can be deducted as follows:

EUT Mode	Frequency (MHz)	CH	EUT Pol.	Antenna Pol.	SPA Reading (dBuV)	S.G. Output (dBm)	Antenna Gain (dBi)	Cable Loss (dB)	ERP (dBm)	Limit (dBm)
CDMA 2000 Cellular	824.70	1013	E2	V	113.39	27.03	-7.88	3.63	15.52	38.45
				H	123.44	37.18	-7.88	3.63	25.68	38.45
	836.52	384	E2	V	113.79	27.53	-7.88	3.65	16.00	38.45
				H	123.80	37.57	-7.88	3.65	26.04	38.45
	848.31	777	E2	V	111.95	25.80	-7.88	3.67	14.25	38.45
				H	122.67	36.47	-7.88	3.67	24.92	38.45

$$ERP = 26.04dBm = 401.791mW$$

$$Power\ Density = ERP * Duty\ Cycle / (4 \pi R^2)$$

$$= 401.791 * 1 / (4 * \pi * 20^2) = 0.0799\ mW/cm^2$$

where Duty Cycle is 1 for CDMA operation and R is 20 cm.

The MPE limit for General Population/Uncontrolled Exposure is shown in the FCC OET Bulletin 65 Supplement C and can be calculated as follows:

$$MPE\ limit = 824/1500 = 0.55\ mW/cm^2$$

As we can see the resulted power density is below the MPE limit, therefore MO6092 in cellular band is compliant with the FCC rules on RF exposure.

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Operation in PCS band (1850 – 1910 MHz)

The EIRP of MO6092 in PCS band is 27.58 dBm. max. The resulted EIRP can be expressed as follows:

EUT Mode	Frequency (MHz)	CH	EUT Pol.	Antenna Pol.	SPA Reading (dBuV)	S.G. Output (dBm)	Antenna Gain (dBi)	Cable Loss (dB)	EIRP (dBm)	Limit (dBm)
CDMA 2000 PCS	1851.25	25	E2	V	112.38	8.00	9.90	5.56	12.33	33.00
				H	119.33	15.15	9.90	5.84	19.21	33.00
	1880.00	600	E2	V	114.30	9.94	9.99	5.61	14.32	33.00
				H	127.35	23.21	9.99	5.61	27.58	33.00
	1908.75	1175	E2	V	112.05	7.72	10.07	5.66	12.13	33.00
				H	125.55	21.44	10.07	5.66	25.85	33.00

$$EIRP = 27.58 \text{ dBm} = 572.796 \text{ mW}$$

$$\begin{aligned} \text{Power Density} &= EIRP * \text{Duty Cycle} / (4 \pi R^2) \\ &= 572.796 * 1 / (4 * \pi * 20^2) = 0.1140 \text{ mW/cm}^2 \end{aligned}$$

where Duty Cycle is 1 for CDMA2000 operation and R is 20 cm.

The MPE limit for General Population/Uncontrolled Exposure is shown in the FCC OET Bulletin 65 Supplement C and can be calculated as follows:

$$MPE \text{ limit} = 1.0 \text{ mW/cm}^2$$

As we can see the resulted power density is below the MPE limit, therefore MO6092 in PCS band is compliant with the FCC rules on RF exposure.

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The Derivation of Maximum Allowable Gain

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.

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Limitation

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

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,

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

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Maximum Linear Gain Determination using ERP/EIRP

As per 22.913a) and 24.232 (c), ERP is limited as 7W and EIRP is limited as 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

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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	32.30	32.10	30.80	27.60	32.80	32.60	30.60	27.40
836.6	190	32.60	32.10	30.70	27.40	32.90	32.60	30.50	27.30
848.8	251	31.90	32.10	30.50	27.40	32.40	32.20	30.40	27.20
1850.2	512	29.30	29.20	29.40	26.20	29.30	29.20	29.30	26.00
1880.0	661	29.50	29.40	29.60	26.30	29.40	29.30	29.40	26.60
1909.8	810	29.40	29.30	29.30	26.00	29.30	29.20	29.10	25.90

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	32.80	32.50	29.20	29.10	32.10	31.90	30.50	27.20
836.6	190	32.80	32.60	29.30	29.20	32.20	31.90	30.30	27.10
848.8	251	32.30	32.10	29.20	29.00	31.80	31.90	30.30	27.00
1850.2	512	29.20	29.10	29.30	26.00	29.60	29.40	29.20	25.80
1880.0	661	29.30	29.20	29.40	26.00	29.60	29.50	29.30	26.00
1909.8	810	29.20	29.00	29.10	25.70	29.40	29.20	29.00	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	8-PSK Mode	GMSK Mode	8-PSK Mode
		AV Power (dBm)	AV Power (dBm)	AV Power (dBm)	AV Power (dBm)
824.2	128	23.07	18.60	26.58	21.38
836.6	190	23.07	18.37	26.58	21.28
848.8	251	23.07	18.37	26.18	21.18
1850.2	512	20.17	17.17	23.18	19.98
1880.0	661	20.37	17.27	23.28	20.58
1909.8	810	20.27	16.97	23.18	19.88

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	28.24	24.84	28.89	24.19
836.6	190	28.34	24.94	28.89	24.09
848.8	251	27.84	24.74	28.89	23.99
1850.2	512	24.84	21.74	26.39	22.79
1880.0	661	24.94	21.74	26.49	22.99
1909.8	810	24.74	21.44	26.49	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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Maximum Source-based Time Average power for WCDMA mode:

EUT Mode	Frequency (MHz)	CH	Peak Power (dBm)	Avg. Power (dBm)
WCDMA Band II	1852.4	9262	25.08	21.67
	1880.0	9400	25.43	21.73
	1907.6	9538	24.80	21.35

EUT Mode	Frequency (MHz)	CH	Peak Power (dBm)	Avg. Power (dBm)
WCDMA Band V	826.4	4132	25.83	22.25
	836.6	4183	25.84	22.12
	846.6	4233	25.63	21.97

EUT Mode	Frequency (MHz)	CH	Avg. Power (dBm)	Peak Power (dBm)
CDMA 2000 Cellular	824.70	1013	23.82	23.75
	836.52	384	23.84	23.75
	848.31	777	23.77	23.67

EUT Mode	Frequency (MHz)	CH	Avg. Power (dBm)	Peak Power (dBm)
CDMA 2000 PCS	1851.25	25	23.25	23.18
	1880	600	23.10	22.85
	1908.75	1175	22.98	22.77

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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 28.89dBm, and MPE limit as 0.55 mW/cm².

Therefore, antenna gain is calculated as 5.53dBi

Operation in PCS band (1850 – 1910 MHz)

Given the maximum source-based time-averaged power as 26.49dBm, and MPE limit as 1 mW/cm².

Therefore, antenna gain is calculated as 10.52dBi

Operation in WCDMA Band II (1850 – 1910MHz)

Given the maximum source-based time-averaged power as 21.73dBm, and MPE limit as 1.0 mW/cm².

Therefore, antenna gain is calculated as 15.28dBi

Operation in WCDMA Band V (824 – 850MHz)

Given the maximum source-based time-averaged power as 22.25dBm, and MPE limit as 0.55 mW/cm².

Therefore, antenna gain is calculated as 12.17dBi

Operation in CDMA2000 Cellular (824-850MHz)

Given the maximum source-based time-averaged power as 23.84dBm, and MPE limit as 0.55 mW/cm².

Therefore, antenna gain is calculated as 10.58dBi

Operation in CDMA2000 PCS (1850-1910MHz)

Given the maximum source-based time-averaged power as 23.25dBm, and MPE limit as 1.0 mW/cm².

Therefore, antenna gain is calculated as 13.76dBi

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

Operation in cellular band (824 – 849 MHz)

Given the maximum burst power as 32.90dBm, and ERP limit as 7W

Therefore, antenna gain is calculated as 5.55dBi

Operation in PCS band (1850 – 1910 MHz)

Given the maximum burst power r as 29.60dBm, and EIRP limit as 2W

Therefore, antenna gain is calculated as 3.41dBi

Operation in WCDMA Band II (1850 – 1910MHz)

Given the maximum burst averaged power as 25.43dBm, and EIRP limit as 2W

Therefore, antenna gain is calculated as 7.58dBi

Operation in WCDMA Band V (824 – 850MHz)

Given the maximum burst power as 25.84dBm, and ERP limit as 7W

Therefore, antenna gain is calculated as 12.61dBi

Operation in CDMA2000 Cellular (824-850MHz)

Given the maximum burst power as 23.18dBm, and ERP limit as 7W

Therefore, antenna gain is calculated as 14.70dBi

Operation in CDMA2000 PCS (1850-1910MHz)

Given the maximum burst power as 23.75dBm, and EIRP limit as 2W

Therefore, antenna gain is calculated as 9.83dBi

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