

RF Exposure evaluation

According to 447498 D04 Interim General RF Exposure Guidance v01

1-mW Test Exemption

A single RF source is exempt RF device (from the requirement to show data demonstrating compliance to RF exposure limits, as previously mentioned) if the available maximum time-averaged power is no more than 1 mW, regardless of separation distance. This exemption applies to all operating configurations and exposure conditions, for the frequency range 100 kHz to 100 GHz, regardless of fixed, mobile, or portable device exposure conditions. This is a standalone exemption, and it cannot be applied in conjunction with any other test exemption.

1-mW Test Exemption for Multiple Sources

The 1-mW exemption intended for single transmitters may be also applied to simultaneous transmission conditions, within the same host device, according one of the following criteria:

a) When maximum available power each individual transmitting antenna within the same time averaging period is ≤ 1 mW, and the nearest parts of the antenna structures of the simultaneously operating transmitters are separated by at least 2 cm.

b) When the aggregate maximum available power of all transmitting antennas is ≤ 1 mW in the same time-averaging period.

This exemption may not be combined with any other exemption.

SAR-Based Exemption

This exemption is applicable to the frequency range between 300 MHz and 6 GHz, with test separation distances between 0.5 cm and 40 cm, and for all RF sources in fixed, mobile, and portable device exposure conditions.

Accordingly, a RF source is considered an RF exempt device if its available maximum time-averaged (matched conducted) power or its effective radiated power (ERP), whichever is greater, are below a specified threshold. This exemption threshold was derived based on general population 1-g SAR requirements.

This method shall only be used at separation distances from 0.5 cm to 40 cm and at frequencies from 0.3 GHz to 6 GHz (inclusive). P_{th} is given by follow Formulas

$$ERP_{20\text{ cm}}(\text{mW}) = \begin{cases} 2040f & 0.3\text{ GHz} \leq f < 1.5\text{ GHz} \\ 3060 & 1.5\text{ GHz} \leq f \leq 6\text{ GHz} \end{cases}, \quad P_{th}(\text{mW}) = \begin{cases} ERP_{20\text{ cm}}(d/20\text{ cm})^x & d \leq 20\text{ cm} \\ ERP_{20\text{ cm}} & 20\text{ cm} < d \leq 40\text{ cm} \end{cases},$$

$$x = -\log_{10} \left(\frac{60}{ERP_{20\text{ cm}} \sqrt{f}} \right)$$

“ f ” is in GHz, “ d ” is the separation distance (cm)

Simultaneous Transmission with SAR-based Exemptions

For these cases, a device with multiple RF sources transmitting simultaneously will be considered an RF exempt device if the condition of following Formula is satisfied.

$$\sum_{i=1}^a \frac{P_i}{P_{th,i}} + \sum_{j=1}^b \frac{ERP_j}{ERP_{th,j}} + \sum_{k=1}^c \frac{Evaluated_k}{Exposure\ Limit_k} \leq 1$$

(SAR-Based Exemption)

0.3 GHz to 1.5GHz(Max Power Limit)

EGPRS B5:

$$P_{th} = ERP_{20cm} * (d/20)^{-\log(60/(ERP_{20cm} * \sqrt{f}))} = 2040 * 0.8242 * (20/20)^{-\log(60/(2040 * \sqrt{0.8242}))} = 1681mW$$

LTE B5:

$$P_{th} = ERP_{20cm} * (d/20)^{-\log(60/(ERP_{20cm} * \sqrt{f}))} = 2040 * 0.8242 * (20/20)^{-\log(60/(2040 * \sqrt{0.8241}))} = 1681mW$$

LTE B12:

$$P_{th} = ERP_{20cm} * (d/20)^{-\log(60/(ERP_{20cm} * \sqrt{f}))} = 2040 * 0.7075 * (20/20)^{-\log(60/(2040 * \sqrt{0.6991}))} = 1426mW$$

LTE B13:

$$P_{th} = ERP_{20cm} * (d/20)^{-\log(60/(ERP_{20cm} * \sqrt{f}))} = 2040 * 0.782 * (20/20)^{-\log(60/(2040 * \sqrt{0.782}))} = 1585mW$$

1.5GHz to 6.0GHz(Max Power Limit)

EGPRS B2:

$$P_{th} = ERP_{20cm} * (d/20)^{-\log(60/(ERP_{20cm} * \sqrt{f}))} = 3060 * (20/20)^{-\log(60/(3060 * \sqrt{1.8502}))} = 3060mW$$

LTE B2:

$$P_{th} = ERP_{20cm} * (d/20)^{-\log(60/(ERP_{20cm} * \sqrt{f}))} = 3060 * (20/20)^{-\log(60/(3060 * \sqrt{1.8501}))} = 3060mW$$

LTE B4:

$$P_{th} = ERP_{20cm} * (d/20)^{-\log(60/(ERP_{20cm} * \sqrt{f}))} = 3060 * (20/20)^{-\log(60/(3060 * \sqrt{1.7101}))} = 3060mW$$

As this equipment:

EIRP = Pm + Gi (if Gi < 0, to treat Gi value as 0)

$$P_t = 10^{(EIRP/10)}$$

Where: Pm = measured transmitter output power in dBm,

Pt = transmitter output power in milliwatts,

Gi = numeric gain of the transmitting antenna (unit-dBi),

GSM B2:

Ant gain Gi= 0dBi

Pm= 30dBm

$$\text{So } P_t = 10^{(30/10)} \text{ mW} = 1000mW < P_{th}(3060mW)$$

GSM B5:

Ant gain Gi= 0dBi

Pm= 32dBm

$$\text{So } P_t = 10^{(32/10)} \text{ mW} = 1584.9mW < P_{th}(1681mW)$$

LTE B2:

Ant gain Gi=0dBi

Pm=25dBm

$$\text{So } P_t = 10^{(25/10)} \text{ mW} = 316.2mW < P_{th}(3060mW)$$

LTE B4:

Ant gain Gi=0dBi

Pm=25dBm

$$\text{So } P_t = 10^{(25/10)} \text{ mW} = 316.2mW < P_{th}(3060mW)$$

LTE B5:

Ant gain Gi=0dBi

Pm=24dBm

So $P_t = 10^{(24/10)} \text{ mW} = 251.2 \text{ mW} < P_{th}(1681 \text{ mW})$

LTE B12:

Ant gain $G_i = 0 \text{ dBi}$

$P_m = 256 \text{ dBm}$

So $P_t = 10^{(25/10)} \text{ mW} = 316.2 \text{ mW} < P_{th}(1426 \text{ mW})$

LTE B13:

Ant gain $G_i = 0 \text{ dBi}$

$P_m = 25 \text{ dBm}$

So $P_t = 10^{(25/10)} \text{ mW} = 316.2 \text{ mW} < P_{th}(1585 \text{ mW})$

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

P = Power input to antenna

G = Antenna Gain

R = distance to the center of radiation of antenna (in meter) = 0.2m

Cat-M and NB-IoT cannot work at the same time, so:

MPE (GSM max) = $PG/4\pi R^2 = 0.3046$

MPE (LTE max) = $PG/4\pi R^2 = 0.0626$

Maximum Simultaneous transmission MPE Ratios for GSM+LTE:

Max MPE Ratio GSM/Limit	Max MPE ratio LTE/Limit	Σ MPE ratios	Limit	Result
0.3153	0.0629	0.3782	1	PASS

Conclusion: the product meets the RF exposure requirements of FCC.