

**Environmental Evaluation
of RF Exposure for
the Embedded GSM Terminal TME-4**

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1. INTRODUCTION

1.1 Purpose of the Report

This technical report is a detailed environmental evaluation of the radio frequency exposure expected from use of the TME-4 transmitter. The following analysis demonstrates that the TME-4 terminal is in compliance with the requirements for maximum permissible exposure (MPE) to radiofrequency exposure as defined in the FCC Rules, 47 CFR 2.1091, as amended.

1.2 Description of the TME-4 Terminal

The TME-4 Transceiver has been designed primarily as machine-to-machine terminal, where the unit is located within the application. TME-4 terminal includes internal antenna or possibility to use external antenna. All calculations related to MPE are made using antenna gain guidelines provided in customer documentation such as the TME-4 User Guide.

The module has two functional modes of operation:

- (1) GSM 850 mode - Class 4 terminal
- (2) GSM 1900 mode - Class 1 terminal

In the GSM 850 band (824 to 849 MHz), the transmitter section delivers up to 2 Watts burst output power in GPRS mode of operation (max two TX slots per frame). In GSM 1900 band, the transmitter section delivers up to 1 Watt burst output power in GPRS mode of operation (max two TX slots per frame).

2. CLASSIFICATION OF DEVICE / APPLICABILITY OF RULES

2.1 Mobile terminal

The TME-4 terminal is properly defined as a mobile terminal per 47 CFR 2.1091 (b), which states that “mobile devices are defined as transmitters designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between radiating antennas and the body of the user or nearby persons.”

2.2 Excludability from routine environmental evaluation

47 CFR 2.1091(c) states that “mobile devices that operate in the Cellular Radiotelephone Service...are subject to routine environmental evaluation for RF exposure prior to equipment authorization or use if...their effective radiated power (ERP) is 1.5 Watts or more.”

For Class 4 operation, the TME-4 transceiver is rated at 2 Watts of output power in GSM 850 mode. The User's Manual supplied to customers specifies the use of an antenna with maximum system gain of 9dBi. The following sections analyze the maximum RF radiation exposures from a TME-4 transmitter under maximum and typical conditions. This analysis will clearly demonstrate compliance with the amended FCC rules.

2.3 Applicable limits for exposure to radio frequency exposure

The following paragraphs analyze the maximum RF radiation exposures from a TME-4 transmitter. This analysis will clearly demonstrate compliance with the amended FCC rules.

The table below is excerpted from Table 1(B) of 47 CFR 1.1310 titled Limits for Maximum Permissible Exposure (MPE), Limits for General Population/Uncontrolled Exposure:

Frequency Range (MHz)	Power Density (mW/cm ²)	Averaging Time (minutes)
300 - 1500	f/1500	30

where f = frequency in MHz.

The lowest frequency of operation in the cellular band is 824 MHz, so the MPE limit is $f/1500 = 824/1500 = 0.549 \text{ mW/cm}^2$.

In all systems calculations for the TME-4 terminal the following assumptions are made:

Customer supplied antenna gain = 9 dBi (Internal antenna gain is lower than 9 dBi)

Antenna gain of standard dipole = 2.14 dBi

Given power density $S = P_{\text{out}} \times D / 4\pi R^2$, where P_{out} = transmitter output power from connector (Watts)
D = directive gain of antenna relative to std. dipole
R = spherical surface distance from origin

The effective radiated power (ERP) is defined as the product of the measured transmitter output power and the specified antenna system gain, relative to a half-wave dipole, in the direction of interest. If a distance of R = 20 cm is selected, then the ERP can be found as follows:

$$\begin{aligned} \text{ERP} &= P_{\text{out}} \times D = S \times 4\pi R^2 \\ &= .549 \times 4\pi \times 20^2 \\ &= 2.76 \text{ Watts} \end{aligned}$$

The maximum radiated power of 2.76 W represents the maximum average power that produces MPE limit levels at 20 cm over a 30 minutes period. It should be noted that this power density equation is only accurate in the far-field and that at 20 cm distance, the MPE will be overestimated.

3. RF EXPOSURE ANALYSIS

3.1 Power Output

To complete the calculations, the peak ERP delivered by the device must be determined. In GSM 850 mode, the TME-4 is a class 4 terminal calibrated to deliver 2 Watts to the antenna connector. The User's guide assumes the use of an antenna with 9dBi gain.

3.2 Class 4 Operation – GSM 850

For Class 4 GSM 850 operation (burst), the unit is calibrated to deliver 33 dBm to the antenna connector. Due to nature of GSM signal, time averaged power is 27 dBm (in GPRS mode duty cycle is 2/8 = 6dB). After the antenna system gain is included, the field strength density becomes:

$$\begin{aligned} S &= P_{\text{out}} \times D / 4\pi R^2 \quad \text{where} \quad P_{\text{out}} = 27\text{dBm} = 501 \text{ mW} \\ &\quad D = 9\text{dBi} - 2.14\text{dBi} = 6.86\text{dB} = 4.85 \text{ (antenna gain relative to dipole)} \\ &\quad R = 20 \text{ cm} \\ &= (501 \times 4.85) / (4 \times \pi \times 20^2) \\ &= 0.483 \text{ mW/cm}^2 \end{aligned}$$

Calculated RF exposure is below the MPE limit of 0.549 mW/cm² derived in section 2.3. In practice there is also some cable loss between antenna and terminal, and therefore actual RF exposure is even lower.

4. CONCLUSIONS

The preceding analysis makes it clear that any exposure to RF from the TME-4 terminal is below the limits imposed by FCC regulations as long as a minimum separation distance of 20 centimeters is maintained. Due to the nature of telemetry and telematics applications using this terminal, close proximity of humans to the antenna during transmission is highly unlikely. In order to comply with the FCC RF exposure guidelines, customers are instructed in the user guide to install TME-4 so that a minimum distance of 20 centimeters is maintained between antenna in use and all persons, with external antenna (if used) gain not exceeding 9dBi.

Nokia requests an exclusion from routine RF exposure evaluation based on the calculations presented in this report. The results clearly demonstrate compliance with the amended FCC rules.