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Environmental Evaluation of RF Exposure for the Embedded GSM Terminal RX-9

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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 RX-9 transmitter. The following analysis demonstrates that the RX-9 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 RX-9 Terminal

The RX-9 Transceiver has been designed as M2M terminal. RX-9 terminal uses only external antenna, which is attached into terminal. All calculations related to MPE are made using antenna gain guidelines provided in customer documentation such as the RX-9 Installation Manual.

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 bursted 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 bursted output power in GPRS mode of operation (max two TX slots per frame). This device includes also EGPRS mode, but its output is considerably lower than in GPRS mode.

This transceiver is designed primarily for applications where the unit is located within the application

2. CLASSIFICATION OF DEVICE / APPLICABILITY OF RULES

2.1 Mobile terminal

The RX-9 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.”

For most applications of the RX-9, there is typically a separation distance of greater than 20 centimeters. The discussion below will demonstrate that the maximum likely exposures in these applications are significantly below the maximums permitted. However, whenever possible, the transmitter should be installed in such a manner as to make it unlikely that a human body can be maintained in close proximity (i.e. less than 20 centimeters) to the radiating antenna. A statement to this effect is included in the manual supplied to the customers using this device (RX-9 User Guide). This statement should make it clear that Nokia does not mean to imply that proximities of less than 20 centimeters are unsafe. Rather, maintaining a separation of at least 20 centimeters simply ensures that the analysis below is valid and that the margins with respect to the maximum permissible exposures that are demonstrated below are maintained.

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 RX-9 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 3 dBi. The following sections analyze the maximum RF radiation exposures from a RX-9 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 RX-9 transmitter under extreme and typical conditions. This analysis will clearly demonstrate compliance with the amended FCC rules.

The table below is excerpted from Table 1B 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
1500 – 100,000	1.0	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 mW/cm2.**

For operation in the PCS band is 1850 MHz, the MPE limit is **1.0 mW/cm2.** As this is considerably higher than in cellular band, no further calculations are done.

In all systems calculations for the RX-9 terminal the following assumptions are made:
Customer supplied antenna gain = 3 dBi
Antenna gain of standard dipole = 2.14 dBi

Given power density $\mathbf{S = P_{out} \times D / 4\pi R^2}$, 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:

$$\mathbf{ERP = P_{out} \times D = S \times 4\pi R^2}$$
$$\mathbf{= .549 \times 4\pi \times 20^2}$$
$$\mathbf{= 2.76\ Watts}$$

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 RX-9 is a class 4 terminal calibrated to deliver 2 Watts to the antenna connector, and in GSM 1900 mode, this device is a class 1 terminal calibrated to deliver 1 Watt. The User's guide assumes the use of an antenna with 3 dBi gain.

3.2 Class 4 Operation – GSM 850

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

$S = P_{out} \times D / 4\pi R^2$ where P_{out} = 27dBm = 501 mW
D = 3dBi – 2.14dBi = 0.86dB = 1.22 (antenna gain relative to dipole)
R = 20 cm

$= (501 \times 1.22)/(4 \times \pi \times 20^2)$
= 0.122 mW/cm2

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 actual RF exposure is even lower.

3.3 Class 1 Operation – GSM 1900

For Class 1 GSM 1900 operation (bursted), the unit is calibrated to deliver 30 dBm to the antenna connector. Due to nature of GSM signal, time averaged power is 24 dBm (duty cycle 2/8 = 6dB). After losses and the antenna system gain are included, the field strength density becomes:

$S = P_{out} \times D / 4\pi R^2$ where P_{out} = 24dBm = 251 mW
D = 3dBi – 2.14dBi = 0.86dB = 1.22 (antenna gain relative to dipole)
R = 20 cm

$= (251 \times 1.22)/(4 \times \pi \times 20^2)$
= 0.061 mW/cm2

4. CONCLUSIONS

The preceding analysis makes it clear that any exposure to RF from the RX-9 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 provide an even greater margin of comfort, customers will receive guidelines for use and installation of the RX-9 device to ensure exposures do not exceed MPE limits.

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.