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Environmental Evaluation of RF Exposure for the GSM/WCDMA Radio Module RD-2

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 LJPRD-2 transmitter. The following analysis demonstrates that the LJPRD-2 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 LJPRD-2 Terminal

The LJPRD-2 Transceiver has been designed as M2M terminal. LJPRD-2 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 LJPRD-2 User Guide.

The module has four functional modes of operation:
(1) GSM 850 mode - Class 4 terminal
(2) GSM 1900 mode - Class 1 terminal
(3) WCDMA 850 mode – Class 3 terminal
(4) WCDMA 1900 mode – Class 3 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) and 0.25 Watts continuous output power in WCDMA mode of operation. 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) and 0.25 Watts continuous output power in WCDMA mode of operation.

This transceiver is designed primarily to be integrated into laptops.

2. CLASSIFICATION OF DEVICE / APPLICABILITY OF RULES

2.1 Mobile terminal

The LJPRD-2 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 LJPRD-2, 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 (LJPRD-2 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 LJPRD-2 transceiver is rated at 2 Watts of output power in GSM 850 mode, and for Class 3 operation, the transceiver is rated at 0.25 Watts of output power in WCDMA 850 mode. The User's Manual supplied to customers specifies the use of an antenna with maximum system gain of 3dBi. The following sections analyze the maximum RF radiation exposures from a LJPRD-2 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 LJPRD-2 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/cm^2.**

In all systems calculations for the LJPRD-2 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.

$\mathbf{ERP = P_{out} \times D = S \times 4\pi R^2}$

If a distance of R = 20 cm is selected, then the ERP can be found as follows:

Cellular Band (850MHz):

= .549 mW/cm^2 x 4π x (20 cm) ^{2}
= 2.76 Watts

PCS Band (1900MHz):

= 1 mW/cm^2 x 4π x (20 cm) ^{2}
= 5.03 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. The User's guide assumes the use of an antenna with 3dBi 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 mW x 1.22)/(4π x (20 cm) ^{2})
= 0.12 mW/cm^2

3.3 Class 3 Operation – WCDMA 850

For Class 3 WCDMA 850 operation, the unit is calibrated to deliver 24 dBm to the antenna connector. 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 mW x 1.22)/(4π x (20 cm) ^{2})

= 0.06 mW/cm^2

3.4 Class 4 Operation – GSM 1900

For Class 4 GSM 1900 operation, 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 mW x 1.22)/(4π x (20 cm) ^{2})
= 0.06 mW/cm^2

3.5 Class 3 Operation – WCDMA 1900

For Class 3 WCDMA 1900 operation, the unit is calibrated to deliver 24 dBm to the antenna connector. 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 mW x 1.22)/(4π x (20 cm) ^{2})
= 0.06 mW/cm^2

3.6 Conclusion

Calculated RF exposure is below the MPE limits of 0.549 mW/cm^2 (for Cellular Band) derived in section 2.3 and 1.0mW/cm^2 (for PCS Band). In practice there is also some cable loss between antenna and terminal, and actual RF exposure is even lower.

4. CONCLUSIONS

The preceding analysis makes it clear that any exposure to RF from the LJPRD-2 terminal is below the limits imposed by FCC regulations as long as a minimum separation distance of 20 centimeters is maintained. Furthermore, this product is intended to be installed by professionals only, who will receive guidelines for installation of the LJPRD-2 device to ensure exposures do not exceed MPE limits.