Environmental Evaluation for RF Exposure for the DM15

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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 DM15/MM15 transmitters. Since both the DM15 and MM15 are identical hardware configurations and differ only in software functionality, all further discussions will only solely reference the DM15 but the analysis and conclusions apply to both. The analysis below demonstrates that the DM15 device 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.

This report serves as the technical basis for the statement of compliance and a request for an exclusion from routine environmental evaluation submitted with the application for type acceptance for the DM15 FCC ID: AXATR-420-A2.

1.2. Description of the DM15 Device

The DM15 Transceiver has been designed as an OEM module for use by various OEM integrators. The transmitter section delivers up to 3 watts (burst) of output power to a RF connector designed for attachment to a customer-supplied antenna. The transmitter operates in the band designated for cellular telephone use, from 824 to 849 MHz. The transceiver is designed with a form factor suitable for integration into a variety of applications, such as meter reading, security alarm communications, location-on-demand systems, fixed wireless local loop, and vehicular emergency communications.

There are two modes of operation:

1. CLASS 1 Burst Modem Transceiver (AMPS only)
2. CLASS 2 Dual Mode Transceiver (AMPS and DAMPS)

The CLASS 1 burst modem transceiver is designed to send a burst of data as a CLASS 1 AMPS cellular mobile, with 3 Watts of RF power at the antenna connector. Typical applications will trigger registrations of less than 120 ms in duration at most every 15 minutes. Once the DM15 determines that data is to be sent, the transceiver initiates a call and then transmits a 4.5-second data burst, which includes a training sequence and V.27 data. The entire transmitter burst duration varies depending on the cellular system network connection time. When the burst modem call is initiated, the DM15 transmits for 1.5 seconds and then powers down for 4 seconds, and then transmits for 1.5 seconds and then powers down for 4 seconds; this process continues until a tone is detected, up to a *maximum* of eight cycles of 1.5 seconds ON, 4 seconds OFF. The tone is normally detected between two to seven seconds (depending on the cellular system network connection time). Once the tone is detected, the 4.5 second data burst is sent, after which the burst transmitter is disabled by the software for 30 or 50 seconds in order to protect the hardware that has been designed to dissipate heat appropriately for this duty cycle. The disable time is 30 seconds for a sequence of two or less 1.5-second bursts, and 50 seconds for three to eight 1.5-second bursts.

The second mode of operation is as a CLASS 2 terminal, dual mode (AMPS and DAMPS), with nominally 1.5 Watts of RF power at the antenna connector. The usage would vary from a low duty cycle with a meter reading application, to a high duty cycle with a fixed telephony application.

The DM15 is capable of operating in either of the modes described above, and can “switch” between modes by reregistering with the cellular system (identifying its CLASS type and technology).

2. Classification of Device / Applicability of Rules

2.1. Mobile devices

The DM15 is properly defined as a mobile device 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."

While some applications of the DM15 device will be in fixed locations, the device is designed to be used in mobile applications. For applications of the DM15, there is typically a separation distance of greater than 27 centimeters. Some applications of the DM15 device will involve operation in a residential environment with examples including wireless local loop, security alarm and electrical meter reading applications. The discussion below should clearly 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 27 centimeters) to the radiating antenna. A statement to this effect is included in the manual supplied to the Original-Equipment-Manufacturers (OEMs) developing applications using this device (DM15 FCC filing - exhibit 8 User's Manual). This statement should make it clear that Ericsson does not mean to imply that proximities of less than 27 centimeters are unsafe. Rather, maintaining a separation of at least 27 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."

47 CFR 2.1091 (d) (2) states "however, "sourced-based" time-averaging based on an inherent property or duty-cycle of a device is allowed."

For Class 1 operation, the DM15 transceiver is rated at 3 Watts of output power in AMPS mode. The module is shipped without an antenna so the actual ERP in the field will vary somewhat with different antennas and different applications. The User's Manual supplied to customers specifies the use of an antenna with maximum system gain of 1 dBd (2.5 dBd antenna gain and 1.5 dB cable loss). For the purposes of calculating the maximum exposure below, an ERP of 6 watts is assumed (3W + 2dB variation + 1 dB antenna gain). Although the peak ERP for the DM15 exceeds 1.5 watts, the device has an operational duty factor of 18.1% for the CLASS 1 burst modem, over a 41.5-second period. Applying this duty factor to a maximum ERP of 6 watts yields an <u>average</u> ERP of 1.08 Watts, which is below the 1.5-watt threshold for excludability. The nature of the application (short bursts of data) makes it extremely improbable that this duty factor is maintained at this high a level for any 30-minute period.
Furthermore, due to hardware limitations of the
burst modem (continuous transmission is not permitted to prevent overheating of the burst power amplifier), MPE or SAR evaluation is not feasible because the PA device does not have a normal operating mode that would support the duration of an RF exposure evaluation.

For Class 2 operation, the DM15 transceiver is rated at 1.5 Watts of output power in AMPS and DAMPS mode. The same assumptions as to the application and antenna can be made. For the purposes of calculating the maximum exposure, an ERP of 3 watts is assumed (1.5W + 2dB variation + 1 dB antenna gain). Although the peak ERP for the DM15 exceeds 1.5 watts, the device has an operational duty factor of 33% for the CLASS 2 TDMA operation. Applying this duty factor to a maximum ERP of 3 watts yields an <u>average</u> ERP of 1.0 Watts, which is below the 1.5-watt threshold for excludability. Since the AMPS mode is continuous operation, maximum exposure calculations must be used to determine a minimum separation distance.

2.3. Applicable limits for exposure to radio frequency exposure

The previous explanation for excludability notwithstanding, the following paragraphs analyze the maximum RF radiation exposures from a DM15 transmitter under extreme 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

* f = frequency in MHz

So, given the highest frequency of operation of 850 MHz, the MPE limit is f/1500 = 850/1500 = **0.567 mW/cm^2.**

Given that power density **S = EIRP / 4*** p**$*R^2$**, and using **R=27 cm** and **S=MPE=0.567 mW/cm^2**, we find that **the maximum EIRP is 5.193 W** in order to produce exposure levels below the MPE at 27 centimeters. (Note that EIRP=1.64*ERP, where 1.64 is the gain of a dipole antenna. Therefore **the maximum ERP is 3.166 W**, that is, the maximum *average* power that produces MPE limit levels at 27 cm.). It should be noted that this power density equation is only accurate in the farfield; at 27 cm distance, it will overestimate the MPE.

The above-calculated limits for ERP and EIRP represent average power levels with time averaging included. The analysis below will start with peak ERP levels, apply the appropriate time-averaging factor, and then compare the results with the MPE limit of 0.567 mW/cm^2.

For the typical scenarios outlined below, an averaging time of 30 minutes is used as prescribed in Table 1B of 47 CFR 1.1310. However to demonstrate the extent to which the potential exposures from DM15 fall below the MPE, the worst-case analysis for CLASS 1 mode operation is performed using an averaging time of 41.5 seconds.

3. Maximum Exposure Analysis

3.1. Transmission duration

The CLASS 1 burst modem has a variable duration dependent on the system response. The maximum duty cycle corresponds to the occurrence of tone detect immediately after the second Tx burst of 1.5 seconds. The sequence is 1.5 seconds Tx on, 4 seconds Tx off, 1.5 seconds Tx on, 4.5 seconds Tx on for data burst, 30 seconds Tx off. As outlined in the introduction, typical applications will trigger registrations of less than 120 ms in duration at most every 15 minutes. Obviously, the typical situation results in an extremely low duty factor.

The CLASS 2 dual mode transceiver transmission duration has a 33% duty cycle in DAMPS mode and 100% duty cycle in AMPS mode.

3.2. Averaging time

For the CLASS 1 burst modem, the extreme case scenario maximum transmission duration is 7.5 seconds over a 41.5-second period. For the CLASS 2 mode, the maximum exposure occurs for continuous transmission in AMPS mode.

3.3. Maximum exposures

To complete the calculations, we must determine the peak ERP delivered by the device. The DM15 CLASS 1 burst modem is calibrated to deliver 3 watts to the antenna connector. The User's manual specifies the use of an antenna with system gain of 1 dBd (2.5 dBd antenna gain and 1.5 dB cable loss). The transmitter output tolerance is specified as +2 / -4 dB. Therefore the maximum transmitter power is 6 Watts (3 W + 2dB variation + 1 dB antenna gain).

3.3.1 Class 1 Operation – 3 W Burst Mode

For the purposes of this analysis, a transmission of 7.5 seconds duration over a 41.5 second period is assumed, even though the probability of repetitive transmissions over a 30 minute period is virtually zero.

Using a separation of 27 centimeters (per the definition of mobile device as discussed in section 2.1), a duration of 7.5 seconds, an averaging time of 41.5 seconds, and a maximum ERP of 6 Watts we come up with the following expression for the average field strength density in a maximum exposure scenario:

$\mathbf{S_{avg}}$ = (1.64*ERP / (4*π*R^2)) * duration / time = (1.64 * 6000 / (4*π*27^2)) * 7.5/41.5 = **0.194 mW/cm^2**

Note that this worst case exposure is well below the MPE limit of 0.567 mW/cm^2 derived in section 2.3.

3.3.1 Class 2 Operation – 1.5 W AMPS Mode

For Class 2 AMPS operation (continuous), the unit is calibrated to deliver 1.5 W to the antenna connector. The transmitter output tolerance is specified as +2 / -4 dB. Along with the 1 dBd system antenna gain described above, the maximum transmitter power in CLASS 2 mode is 3 Watts ERP. The (average) field strength density becomes:

$\mathbf{S_{avg}}$ = (1.64*ERP / (4*π*R^2)) * duration / time = (1.64 * 3000 / (4*π*27^2)) * 1/1 = **0.537 mW/cm^2**

Note that this worst case exposure is below the MPE limit of 0.567 mW/cm^2 derived in section 2.3.

Since the DM15 can independently operate in either CLASS 1 or CLASS 2 mode. When considering a combination of consecutive operational modes, the maximum exposure would occur in CLASS 2 operation when operating continuously in AMPS mode.

4. Typical exposure analysis

4.1. Transmission duration & averaging time

For the CLASS 1 burst modem, the typical application will involve registration with the cellular system at 15 minute intervals, resulting in the duration of a registration burst of just under 120 milliseconds, For the CLASS 2 mode, the typical application maximum usage scenario is continuous transmission.

4.2. Maximum exposures

To complete the typical scenario analysis, we must determine the peak ERP delivered by the device.

4.2.1 Class 1 Operation – 3 W Burst Mode

The CLASS 1 burst modem is calibrated in the factory to deliver a maximum of 3 watts to the antenna connector. With 1 dBd of system antenna gain, the peak ERP is 3.8 watts. While 3.8 Watts is used in the analysis below, it should be noted that cellular systems across the country have been optimized for portable use. The typical application will not be transmitting at full power except in rural areas or in the fringe areas of

cellular systems. Using a separation of 27 centimeters, and a maximum ERP of 3.8 Watts, we come up with the following expression for the average field strength density in a typical scenario:

$\mathbf{S_{avg}}$ = (1.64*ERP/(4*π*R^2)) *duration / time = (1.64*3.8 /(4*π*27^2)) * 7.5/41.5 **= 0.123mW/cm^2**

This exposure is significantly below the MPE of 0.567 mW/cm^2 derived in section 2.3.

4.2.2 Class 2 Operation – 1.5 W AMPS Mode

For Class 2 AMPS operation (continuous), the device is calibrated in the factory to deliver a maximum of 1.5 Watts to the antenna connector. With the 1 dBd antenna system gain, the peak ERP is 1.9 Watts. The (average) field strength density in this scenario is:

$\mathbf{S_{avg}}$ = (1.64*ERP / (4*π*R^2)) * duration / time = (1.64 * 1.9 / (4*π*27^2)) *1/1 = **0.340 mW/cm^2**

Note that this exposure is below the MPE limit of 0.567 mW/cm^2 derived in section 2.3.

5. Conclusions

The preceding analysis makes it clear that any exposure to RF from the DM15 device is below the limits imposed by FCC regulations as long as a minimum separation distance of 27cm is maintained. Due to the nature of telemetry and telematics applications using this device, close proximity of humans to the antenna during transmission is highly unlikely and the minimum separation distance is much greater than 27cm. In order to provide an even greater margin of comfort, applications developers (i.e. Ericsson's customers) will receive guidelines for use and installation of the DM15 device to ensure exposures do not exceed MPE limits.

Ericsson requests an exclusion from routine RF exposure evaluation based on the reasoning presented in this report. Specifically, the inherent duty cycle properties of the 3 Watt burst modem mode with the resultant *average* ERP of 1.087 Watts (which is below the 1.5-watt threshold for excludability) and the analysis of the maximum RF exposure of 0.340 mW/cm^2 from a DM15 transmitter operating in AMPS mode while maintaining the 27cm minimum separation distance. Taken together, these results clearly demonstrate compliance with the amended FCC rules.

