ERICSSON

INTERNAL DM15 TECHNICAL REPORT

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ANNA-JANE 4 FACTORY TEST SPECIFICATION FOR THE DM15

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1 INTRODUCTION

1.1 PURPOSE OF THE REPORT

This technical report is a detailed environmental evaluation of the radiofrequency exposure expected from use of the DM15 transmitter. 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-400.

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 an 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 4 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 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 4 terminal, dual mode (AMPS and DAMPS), with nominally 0.355 Watts 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 transmitter is designed to be used in mobile applications. In general, the applications for DM15 are such that there is a separation distance of greater than 20 centimeters. Some applications of the DM15 device will involve operation in a residential environment. (Examples include 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 20 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 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."

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."

The DM15 transceiver is rated at 3 watts of output power. The module is shipped without an antenna, and the actual ERP in practice may vary somewhat with the application. The User's Manual that is supplied to our 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). Some customers will be using a 0dB dipole antenna. For the purposes of the worst case analysis below, an ERP of 7 watts, corresponding to the maximum ERP allowed under Part 22 of the FCC rules is assumed. The peak ERP for the DM15 exceeds 1.5 watts, however, a worst-case analysis (detailed below) shows a maximum 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 7 watts (again an improbably high level for this device) yields an *average* ERP of 1.27 Watts, which is below the 1.5-watt threshold for excludability. It is extremely improbable that this duty factor is maintained at this high a level for any 30-minute period (FCC rules indicate an averaging time of 30 minutes is appropriate for use in analyzing this device). 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.

These case explained above for excludability notwithstanding, the following paragraphs analyze the maximum RF radiation exposures from a DM15 transmitter under worst-case and typical conditions. This analysis will clearly demonstrate compliance with the amended FCC rules.

2.3 APPLICABLE LIMITS FOR EXPOSURE TO RADIOFREQUENCY EXPOSURE

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=20 cm** and **S=MPE=0.567 mW/cm^2**, we find that **the maximum EIRP is 2.85 W** in order to produce exposure levels below the MPE at 20 centimeters. (Note that EIRP=1.64*ERP, where 1.64 is the gain of a dipole antenna. Therefore **the maximum ERP is 1.74 W**, that is, the maximum *average* power that produces MPE limit levels at 20 cm.). It should be noted that this power density equation is only accurate in the farfield; at 20 cm distance, it will overestimate the MPE.

The above-calculated limits for ERP and EIRP represent average power levels over a 30 minute period, 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 WORST-CASE 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 4 dual mode transceiver transmission duration can be continuous.

3.2 AVERAGING TIME

For the CLASS 1 burst modem, the worst case scenario maximum transmission duration is 7.5 seconds over a 41.5-second period. For the CLASS 4 mode, the worst case scenario is continuous transmission.

3.3 MAXIMUM EXPOSURES

To complete the worst-case scenario, 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. For the purposes of a worst-case analysis, we'll use the maximum transmitter power of 7 watts ERP (the maximum allowed by the FCC under part 22 of the rules).

For the purposes of worst-case 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 non-existent.

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 7 watts we come up with the following expression for the average field strength density in a worst-case scenario:

$\mathbf{S_{avg}}$ = (1.64*ERP / (4*π*R^2)) * duration / time = (1.64 * 7 / (4*π*20^2)) * 7.5/41.5 = **0.41 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.

For Class 4 operation (continuous), the unit is calibrated to deliver .355 mW 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 worst case maximum transmitter power in CLASS 4 mode is 0.71 watts ERP. The (average) field strength density in the worst-case scenario is:

$\mathbf{S_{avg}}$ = (1.64*ERP / (4*π*R^2)) * duration / time = (1.64 * .71 / (4*π*20^2)) * 1/1 = **0.23 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.

The DM15 can independently operate in either CLASS 1 or CLASS 4 mode. When considering a combination of consecutive operational modes, the worst case exposure would occur in the CLASS 1 mode operation (only) when continually repeating the 41.5 second data burst sequence described above.

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, making it possible for three transmissions to fall within a 30-minute window (the averaging time permitted in uncontrolled environments). This results in a total transmission duration of 360 milliseconds in a 30 minute window. For the CLASS 4 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. The CLASS 1 burst modem is calibrated to deliver a 3 watts to the antenna connector. With 1 dBd of system antenna gain, the peak ERP is 4 watts. While 4 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 20 centimeters, a duration of 360 milliseconds, an averaging time of 30 minutes, and a maximum ERP of 4 watts we come up with the following expression for the average field strength density in a typical scenario:

S_{avg} = (1.64*ERP / (4*π*R^2)) * duration / time = (1.64 * 4 / (4*π*20^2)) *.36/(30*60) = **0.26 microWatts/cm^2**

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

For Class 4 operation (continuous), a maximum of 0.355 watts is delivered to the antenna connector. With the 1 dBd antenna system gain, the maximum transmitter power in the Class 4 mode is 0.45 watts ERP. The (average) field strength density in this scenario is:

S_{avg} = (1.64*ERP / (4*π*R^2)) * duration / time = (1.64 * 0.45 / (4*π*20^2)) *1/1 = **0.15 mW/cm^2**

Note that this exposure is well 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 well below the limits imposed by the new FCC regulations. Even in the extremely contrived "worst-case" example given above, exposures are below the MPE guidelines. In a typical application, proximity of humans to the device during transmission is not likely, and even if it does occur (under worst case analysis), exposures do not exceed MPE limits.

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 reduce the possibility of even inadvertent exposure.

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 burst modem mode, the resultant worst case *average* ERP of 1.27 Watts (which is below the 1.5-watt threshold for excludability), and the analysis of the maximum RF exposures from a DM15 transmitter under worst-case and typical conditions which clearly demonstrates compliance with the amended FCC rules.

