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Environmental Evaluation for RF Exposure for the DM20A

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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 DM20A transmitter. The analysis below demonstrates that the DM20A 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.

This report serves as the technical basis for the statement of compliance and a request for an exclusion from routine SAR environmental evaluation submitted with the application for certification for the DM20A, FCC ID: AXATR-409.

1.2. Description of the DM20A Device

The DM20A Transceiver has been designed as an OEM module for use by various OEM integrators. The transmitter section delivers up to 4 watts ERP (burst) of output power when in AMPS mode. The transmitter operates in the band designated for cellular telephone use, from 824 to 849 MHz and 1850 to 1910 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, eight power levels, PL0 – PL7)
2. CLASS 4 Dual Mode & Band Transceiver (AMPS/DAMPS/PCS, 11 power levels, PL0 – PL10, PL0=PL1=PL2)

The CLASS 1 burst modem transceiver is designed to send a burst of data as a CLASS 1 AMPS cellular mobile, with 3.2 Watts at the antenna connector (PL0). The module is shipped without an antenna, and the actual ERP in practice may vary somewhat with the application. The Interface Manual that is supplied to our customers (system integrators) specifies the use of an antenna with maximum system gain of 1 dBd (3.15 dBi), which is derived from the use of an antenna with 2.5 dBd (4.65dBi) gain in conjunction with 1.5 dB cable loss. With 1 dBd (3.15 dBi) of antenna system gain, the PL0 3.2 watts at the antenna connector is boosted to 4W ERP.

Typical applications will trigger registrations of less than 120 ms in duration at most every 15 minutes. Once the DM20A determines that data is to be sent, the transceiver initiates a call and then transmits an 8-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. Normally, the cellular system network connection time is about seven to eight seconds; it is spec'd to be no longer than 15 seconds. Once the network has connected the modem, the 8 second data burst is sent.

The burst modem operation is described as follows: The DM20A transmits at full power (4W ERP, PL0) for 0.08 seconds, followed by 0.45 W ERP (PL2) for 0.4 seconds, then repeats. This sequence continues until the network connection is established, up to the end of the 44^{th} PL2 segment (total sequence duration is 21.12 seconds), after which time the call is terminated. {Note: as soon as a modem connection is established the sequence is instantaneously halted and the data burst is sent}. Once the data burst is sent, the burst transmitter is disabled by the software for 40 seconds in order to protect the hardware that has been designed to dissipate heat appropriately for this duty cycle.

The second mode of operation is as a CLASS 4 terminal, dual mode dual band (AMPS, DAMPS, and PCS TDMA), 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 DM20A 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 DM20A 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 DM20A device will be in fixed locations, the transmitter is designed to be used in mobile applications. In general, the applications for DM20A are such that there is a separation distance of greater than 20 centimeters. Some applications of the DM20A device will involve operation in a residential environment. (Examples include wireless local loop, security alarm and electrical meter reading applications).

2.2. 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."

The DM20A transmitter output power is rated at 4 watts ERP. The DM20A operates at this output power *only* in a non-continuous burst mode. Continuous transmission is not permitted to prevent overheating of the burst power amplifier. SAR evaluation is not feasible because the PA device does not have a normal operating mode that would support the duration of a specific absorption rate (SAR) RF exposure evaluation. On this basis, Ericsson requests an exclusion from routine RF exposure evaluation. This exclusion is supported in the following paragraphs with analysis of the maximum RF exposures from a DM20A transmitter under worst-case and typical conditions which clearly demonstrates compliance with the FCC regulations.

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 **$S = EIRP / 4*\pi*R^2$**, 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. Note that the 30 minute time-averaging factor is not allowed for uncontrolled exposure per 47 CFR 2.1091 (d) (2).

3. Worst-case exposure analysis

3.1. Transmission duration & averaging time

The CLASS 1 burst modem has a variable duration dependent on the system response. The maximum duty cycle corresponds when no network connection is established after the 44th burst sequence. For this scenario there are 3.52 seconds (44*0.08) at PL0, and 17.6 seconds (44*0.4) at PL2 over a total 21.12 second period.

The CLASS 4 dual mode transceiver transmission duration can be continuous.

3.2. Maximum exposures

To complete the worst-case scenario, we must determine the peak ERP delivered by the device. The DM20A CLASS 1 burst modem is calibrated to deliver 3.2 watts to the antenna connector. There is 1 dBd (3.15 dBi) antenna system gain as described in section 1.2. The transmitter output tolerance is specified as +2 / -4 dB so the maximum output power is 6.3 W ERP at PL0 and 0.71W at PL2.

This transmitter sequence corresponds to a worst case maximum average output power of 1.64 W ERP.

Using a separation of 20 centimeters (per the definition of mobile device as discussed in section 2.1), a duration of 3.52 seconds at 6.3W and 17.6 seconds at 0.71W, 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 * 6.3 / (4*π*20^2)) * 3.52/21.12 + (1.64 * .71 / (4*π*20^2)) * 17.6/21.12
= 0.34 + .19 = **0.53 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 (3.15 dBi) 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 well below the MPE limit of 0.567 mW/cm^2 derived in section 2.3.

The DM20A 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) corresponding to 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 infrequent communication with the cellular system when data transmission is required. Using the typical cellular system network connection time of 7.5 seconds, the typical

exposure will involve transitioning to burst data 0.3 seconds into the 16th PL2 sequence, corresponding to a total of 9.28 seconds (1.28 + 8) at 4W, 6.22 seconds at 0.45W, over a total 55.5 second period (including a 40 second off time).

For the situation where the For the CLASS 4 mode, the typical application maximum usage scenario is continuous transmission at full power (0.45W ERP).

4.2. Maximum exposures

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 9.28 seconds at 4W, 6.22 seconds at 0.45W, and an averaging time of 55.5 seconds, 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 * 4 / (4*π*20^2)) * 9.28/55.5 + (1.64 * .45 / (4*π*20^2)) * 6.22/55.5
= 0.22 + .02 = **0.24 mW/cm^2**

Note that this exposure is well 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 (3.15 dBi) 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:

$\mathbf{S_{avg}}$ = (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 demonstrates that exposure to RF from the DM20A device is well below the limits imposed by the FCC regulations.

In order to minimize RF exposure, applications developers (i.e. Ericsson's customers) will receive guidelines for use and installation of the DM20A device to reduce the possibility of even inadvertent exposure. 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 user's manual (DM20A FCC filing - Exhibit 8 Interface Manual).