MEASUREMENT/TECHNICAL REPORT

Intermec Technologies Corporation
EMC Test Laboratory
Cedar Rapids, IA

Intermec Technologies Corporation
Cellular Radio Module
OEM From RIM 802

REPORT NO: 20010120-1

DATE: January 20, 2001

APPENDIX F

APREL LABORATORIES, SAR TEST REPORT

CERTIFICATION REPORT

Subject: **Specific Absorption Rate (SAR) Experimental Analysis**

Product: Wireless handheld Device

Model: Norand 6110

Client: Intermec

Address: Intermec Technologies Corporation
EMC Test Lab Mail Stop: RD01
550 Second St. SE
Cedar Rapids, IA 52401

Project #: ITCC-Intermec Norand 6110 w. RIM 802D-3640

Prepared by APREL Laboratories
51 Spectrum Way
Nepean, Ontario
K2R 1E6

Tested by ____________ Date: JAN, 18, 2001
Kevin W. Benson
Member of Engineering Technical Staff

Submitted by ____________ Date: Jan 18, 2001
Jay Sarkar
Technical Director of Standards & Certification

Approved by ____________ Date: Jan 18/2001
Dr. Jacek J. Wojcik, P. Eng.

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FCC ID: EHAWANRIM802
Applicant: Intermec
Equipment: Wireless handheld Device
Model: Norand 6110
Standard: FCC 96 –326, Guidelines for Evaluating the Environmental Effects of Radio-Frequency Radiation

ENGINEERING SUMMARY

This report contains the results of the engineering evaluation performed on the Intermec Norand 6110 handheld devicewhich incorporates a RIM R802D-2-0 modem. The measurements were carried out in accordance with FCC 96-326. The wireless handheld device was evaluated for its maximum power level (nominally 2W / 33dBm). The duty factor of the radio modem is intrinsically restricted to 25% (See Appendix E).

The wireless handheld device was tested at low, middle and high channels for the keyboard up, right, and left sides. The maximum 10g SAR (0.59 W/kg) was found to coincide with the peak performance RF output power of channel 2000 (low, 806 MHz) for the keyboard of the device. (The hot spot is located on the antenna). Test data and graphs are presented in this report.

Based on the test results and on how the device will be marketed and used, it has been established that the product meets the requirements as specified in the above specifications, for uncontrolled RF exposure environment.

(The results presented in this report relate only to the sample tested.)

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1. INTRODUCTION

Tests were conducted to determine the Specific Absorption Rate (SAR) of the Intermec Norand 6110 handheld device which incorporates a RIM R802D-2-0 modem. These tests were conducted at APREL Laboratories' facility located at 51 Spectrum Way, Nepean, Ontario, Canada. A view of the SAR measurement setup can be seen in Appendix A Figure 1. This report describes the results obtained.

2. APPLICABLE DOCUMENTS

The following documents are applicable to the work performed:

1) FCC 96-326, Guidelines for Evaluating the Environmental Effects of Radio-Frequency Radiation

2) ANSI/IEEE C95.1-1999, IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.

3) ANSI/IEEE C95.3-1992, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields – RF and Microwave.

4) OET Bulletin 65 (Edition 97-01) Supplement C (Edition 97-01), "Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields".

3. DEVICE UNDER INVESTIGATION

- Intermec Norand 6110 handheld device, s/n 4561636, which incorporates a RIM R802D-2-0 modem received on December 19, 2000.

The Intermec Norand 6110 handheld device will be called DUI (Device Under Investigation) in the following.

The DUI is intended to be used as a handheld device which operates in the frequency band of 806 Mhz - 821 MHz. The device was tested with two separate antennas. A half-wavelength end fed whip antenna and a half-wavelength portable wide area network antenna. See the manufacturer's submission documentation for drawings and more design details.

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4. TEST EQUIPMENT

- APREL Triangular Dosimetric Probe Model E-009, s/n 115, Asset # 301420
- CRS Robotics A255 articulated robot arm, s/n RA2750, Asset # 301335
- CRS Robotics C500 robotic system controller, s/n RC584, Asset # 301334
- APREL F-2, flat manikin, s/n 002
- Tissue Recipe and Calibration Requirements, APREL procedure SSI/DRB-TP-D01-033
- HP 438A power meter, s/n 2502A01684, Asset # 301417
- HP 8482A power sensor, s/n 2652A1512B, Asset # 301418
- HP 8920A 0.4 – 1000 MHz RF Communications Test Set , Asset # 301290

5. TEST METHODOLOGY

1. The test methodology utilised in the certification of the DUI complies with the requirements of FCC 96-326 and ANSI/IEEE C95.3-1992.
2. The E-field is measured with a small isotropic probe (output voltage proportional to E^2).
3. The probe is moved precisely from one point to the next using the robot (10 mm increments for wide area scanning, 5 mm increments for zoom scanning, and 2.5 mm increments for the final depth profile measurement).
4. The probe travels in the homogeneous liquid simulating human tissue. Appendix A contains information about the properties of the simulated tissue used for these measurements.
5. The liquid is contained in a manikin simulating a portion of the human body.
6. The DUI is positioned with the surface under investigation against the phantom.

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7. All tests were performed with the highest power available from the sample DUI under transmit conditions.

   More detailed descriptions of the test method is given in Section 6 when appropriate.

6. TEST RESULTS

6.1. TRANSMITTER CHARACTERISTICS

The battery-powered DUI will consume energy from its batteries, which may affect the DUI's transmission characteristics. In order to gage this effect the output of the transmitter is sampled before and after each SAR run. In the case of this DUI, the conducted power was sampled. The following table shows the conducted RF power sampled before and after each of the eight sets of data used for the worst case SAR in this report.

Scan		**Power Readings (dBm)**		**D (dB)**	**Battery #**
Type	**Height (mm)**	**Before**	**After**		
Area	2.5	12.37	12.37	0	4
Area	12.5	11.41	11.41	0	3
Zoom	2.5	11.84	11.66	0.18	3
Zoom	7.5	11.66	11.66	0	1
Zoom	12.5	11.64	11.67	0.03	2
Zoom	17.5	11.58	11.54	0.04	4
Zoom	22.5	11.65	11.64	0.01	3
Depth	2.5 – 22.5	11.64	11.64	0	1

Table 1. Sampled Conducted RF Power

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6.2. SAR MEASUREMENTS

1) RF exposure is expressed as a Specific Absorption Rate (SAR). SAR is calculated from the E-field, measured in a grid of test points as shown in Appendix A Figure 1. SAR is expressed as RF power per kilogram of mass, averaged in 10 grams of tissue for the extremities and 1 gram of tissue elsewhere.

2) The DUI was put into test mode for the SAR measurements via communications software supplied by the radio manufacturer running on a PC to control the channel at the maximum operating power (nominally2W / 33dBm).

3) Figure 3 in Appendix A shows a contour plot of the SAR measurements for the DUI (channel 2000, low, 806 MHz, keyboard, 2W / 33dBm). It also shows an overlay of the DUI's outlines, superimposed onto the contour plot. The presented values were taken 2.5mm into the simulated tissue from the flat phantom's solid inner surface. Figures 1 and 2 show the flat phantom used in the measurements. For the keyboard side measurements, the back edge of the DUI was aligned with x=15 and the antenna of the DUI, with y=5.

   A different presentation of the same data is shown in Appendix A Figure 3. This is a surface plot, where the measured SAR values provide the vertical dimension, which is useful as a visualisation aid.

4) Wide area scans were performed for the low, middle and high channels on the keyboard up, right, and left sides of the DUI. The DUI was operating at maximum output power (2W / 33dBm) and 25% duty factor. The peak single point SAR for the scans were:

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TYPE OF EXPOSURE	DUI side	Antenna Type Long/Short	Antenna distance to phantom (mm)	Channel			Peak Local SAR (W/kg)
				L/M/H	#	Freq (MHz)	
Hand &Bystander Exposure	**Keyboard up side**	**Long**	**15**	**Low**	**2000**	**806**	**1.02**
	Keyboard up side	Long	15	Middle	22D0	815	0.91
	Keyboard up side	Long	15	High	24B0	821	0.88
	Keyboard up side	Short	15	Low	2000	806	0.22
	Right side	Long	25	Low	2000	806	0.31
	Right side	Long	25	Middle	22D0	815	0.35
	Right side	Long	25	High	24B0	821	0.36
	Right side	Short	25	High	24B0	821	0.05
	Right side	Short	25	Middle	22D0	815	0.08
	Right side	Short	25	Low	2000	806	0.05
	Right side	Just the side no antenna	N/A	Low	2000	806	0.02
	Keyboard up side	Just the side no antenna	N/A	Low	2000	806	0.01
	Left side	Just the side no antenna	N/A	Low	2000	806	0.04
	Keyboard down side	Long	53	Low	2000	806	0.09
	Keyboard down side	Long **(device in pouch)**	63	Low	2000	806	0.07

Table 2. SAR Measurements

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7. USER'S HAND EXPOSURE

All subsequent testing for user's hand exposure was performed on channel 2000 (low, 806 MHz), with the keyboard of the DUI facing up against the bottom of the phantom and the antenna 15 mm from the phantom. This relates to the positition and frequency found to provide the maximum measured SAR value.

1) Channel 2000 (low, 806 MHz) was then explored on a refined 5 mm grid in three dimensions. The SAR value averaged over 10 grams was determined from these measurements by averaging the 125 points (5x5x5) comprising a 2 cm cube. The maximum SAR value measured averaged over 10 grams was determined from these measurements to be 0.43 W/kg.

2) To extrapolate the maximum SAR value averaged over 10 grams to the inner surface of the phantom a series of measurements were made at five (x,y) co-ordinates within the refined grid as a function of depth, with 2.5 mm spacing. The average exponential coefficient was determined to be (-0.066 ± 0.005) / mm.

3) The distance from the probe tip to the inner surface of the phantom for the lowest point is 2.5 mm. The distance from the probe tip to the tip of the measuring dipole within the APREL Triangular Dosimetric Probe Model E-009 is 2.3 mm. The total extrapolation distance is 4.8 mm, the sum of these two.

Applying the exponential coefficient over the 4.8 mm to the maximum SAR value averaged over 10 grams that was determined previously, we obtain the **maximum SAR value at the surface averaged over 10 grams**, 0.59 W/kg.

8. BYSTANDER EXPOSURE

All subsequent testing for bystander exposure was performed on channel 2000 (low, 806 MHz), with the keyboard of the DUI facing up against the bottom of the phantom and the antenna 15 mm from the phantom. This relates to the positition and frequency found to provide the maximum measured SAR value.

1) Channel 2000 (low, 806 MHz) was also explored on a refined 5 mm grid in three dimensions. The SAR value averaged over 1 gram was determined from these measurements by averaging the 27 points (3x3x3) comprising a 1 cm cube. The maximum SAR value measured, which is averaged over 1 gram was determined from these measurements to be 0.63 W/kg.

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2) To extrapolate the maximum SAR value averaged over 1 gram to the inner surface of the phantom a series of measurements were made at five (x,y) co-ordinates within the refined grid as a function of depth, with 2.5 mm spacing. The average exponential coefficient was determined to be (-0.066 ± 0.005) / mm.

3) The distance from the probe tip to the inner surface of the phantom for the lowest point is 2.5 mm. The distance from the probe tip to the tip of the measuring dipole within the APREL Triangular Dosimetric Probe Model E-009 is 2.3 mm. The total extrapolation distance is 4.8 mm, the sum of these two.

   Applying the exponential coefficient over the 4.8 mm to the maximum SAR value averaged over 1 gram that was determined previously, we obtain the **maximum SAR value at the surface averaged over 1 gram, 0.86 W/kg**.

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9. CONCLUSIONS

The maximum Specific Absorption Rate (SAR) averaged over 10 grams, determined at 806 MHz (low channel, 2000, keyboard up, 2W / 33dBm) of the Intermec Norand 6110 handheld device, which incorporates a RIM R802D-2-0 modem is 0.59 W/kg. The overall margin of uncertainty for this measurement is ±22.1 % (Appendix B). The SAR limit given in the FCC 96-326 Safety Guideline is 4 W/kg for uncontrolled hand exposure for the general population. This SAR limit reduced by the measurement uncertainty (4.0 - 22.1%) is 3.12 W/kg.

For a bystander or user exposing a part of the body other than the extremities, at a separation distance of 0 cm from the device, the maximum Specific Absorption Rate (SAR) averaged over 1 g is 0.86 W/kg. The SAR limit given in the FCC 96-326 Safety Guideline is 1.6 W/kg for uncontrolled partial body exposure of the general population. This SAR limit reduced by the measurement uncertainty (1.6 - 22.1%) is 1.25 W/kg.

Considering the above, this unit as tested, and as it will be marketed and used, is found to be compliant with the FCC 96-326 requirement.

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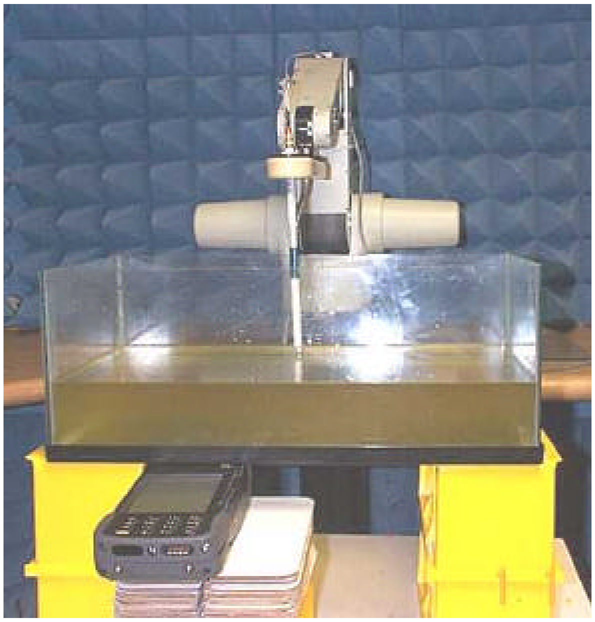
APPENDIX A. Measurement Setup, Tissue Properties and SAR Graphs



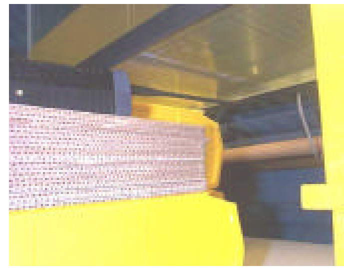


Figure 1. Setup

Simulated muscle Tissue Material and Calibration Technique

The mixture used was based on that presented SSI/DRB-TP-D01-033, "Tissue Recipe and Calibration Requirements". The density used to determine SAR from the measurements was the recommended 1040 kg/m^3 found in Appendix C of Supplement C to OET Bulletin 65, Edition 97-01).

Dielectric parameters of the simulated tissue material were determined using a Hewlett Packard 8510 Network Analyser, a Hewlett Packard 809B Slotted Line Carriage, and an APREL SLP-001 Slotted Line Probe.

	APREL	OET 65 Supplement	Δ (%) (OET)
Dielectric constant, ε_r	53.2	56.11	-5.2%
Conductivity, σ [S/m]	0.99	0.946	4.4%
Tissue Conversion Factor, γ	5.2	-	-

Table 3. Dielectric Properties of the Simulated muscle Tissue at 815 MHz

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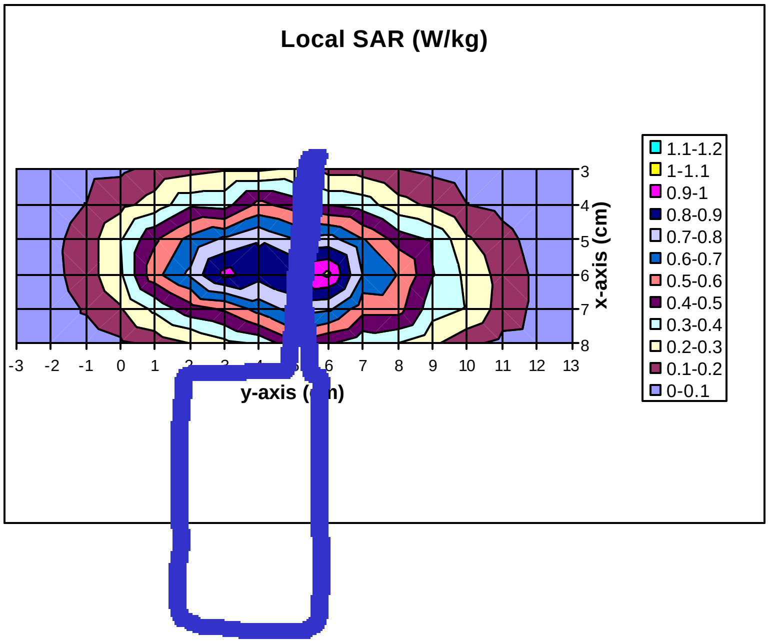

Figure 2. Contour Plot of the Area Scan 2.5mm Above Phantom Surface

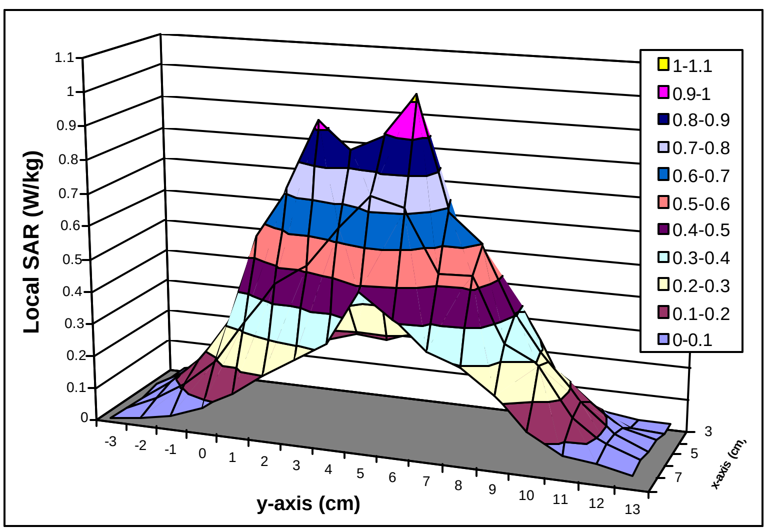

Figure 3. Surface Plot of the Area Scan 2.5mm Above Phantom Surface

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APPENDIX B. Uncertainty Budget

Uncertainties Contributing to the Overall Uncertainty

Type of Uncertainty	Specific to	Uncertainty
Power variation due to battery condition	DUI	0.5%
Extrapolation due to curve fit of SAR vs depth	DUI & Setup	14.4%
Extrapolation due to depth measurement	setup	3.3%
Conductivity	setup	6.0%
Density	setup	2.6%
Tissue enhancement factor	setup	7.0%
Voltage measurement	setup	12.8%
Probe sensitivity factor	setup	3.5%
		22.1% RSS

Table 4. Uncertainty Budget

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APPENDIX C. Validation Scan on a Flat Phantom

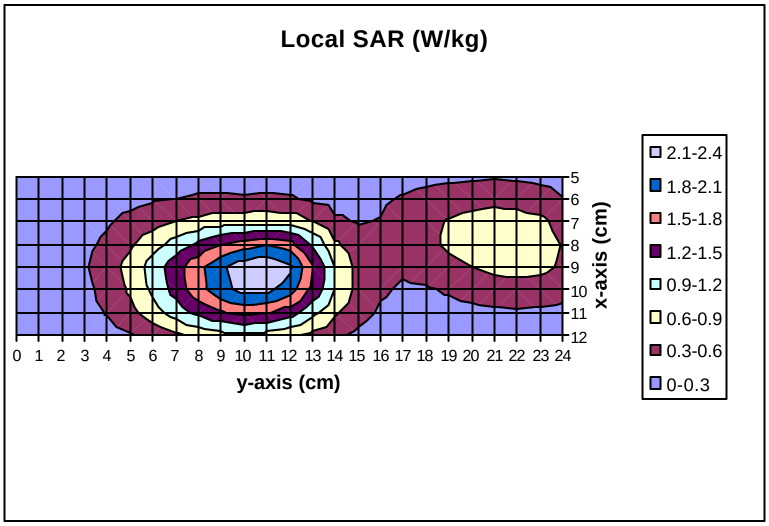

Figure 4. Contour Plot of the Reference Area Scan 2.5mm Above Phantom

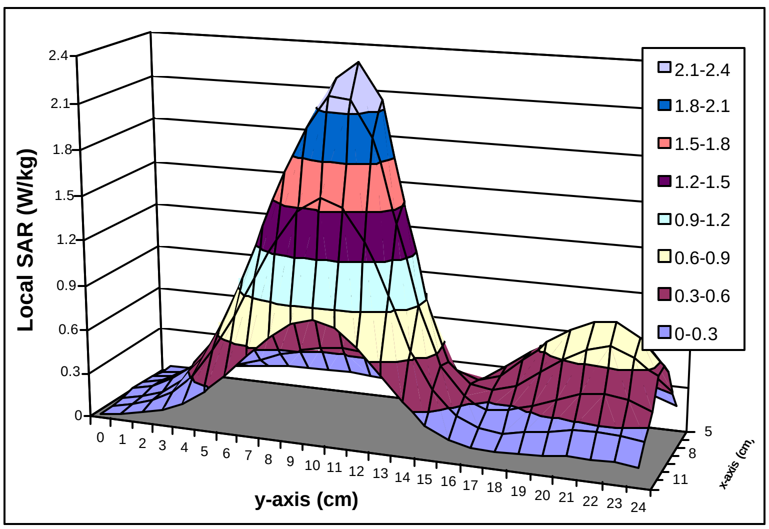

Figure 5. Surface Plot of the Reference Area Scan 2.5mm Above Phantom

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APPENDIX D. Probe Calibration

NCL CALIBRATION LABORATORIES

Calibration File No.: 301420

C E R T I F I C A T E   O F   C A L I B R A T I O N

It is certified that the equipment identified below has been calibrated in the **NCL CALIBRATION LABORATORIES** by qualified personnel following recognized procedures and using transfer standards traceable to NRC/NIST.

Equipment: Miniature Isotropic RF Probe

Manufacturer: APREL Laboratories/IDX Robotics Inc
Model No.: E-009
Serial No.: 115

Customer: APREL
Asset No.:301420

Calibration Procedure: SSI/DRB-TP-D01-032

Cal. Date: 9 November, 2000 Cal. Due Date: 8 November, 2001
Remarks: None

Calibrated By: ______________________________

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APPENDIX E. Duty Factor Limiting Algorithm for the OEM Radio Module R802D-2-O

The duty factor limiting algorithm for the OEM radio module R802D-2-O is a firmware algorithm that directly inhibits the radio firmware that generates transmit pulses. This algorithm will be permanently integrated with the radio firmware and installed at time of manufacture in the production facility. The algorithm cannot be modified or disabled by the user.

The radio module operates on a packet data network. The network controls the timing of most aspects of the radio signalling protocol. The shortest transmit event over which the mobile device has timing control is an entire uplink (transmit) transaction which is a series of transmit pulses. From the perspective of the mobile device this in an “atomic” event, i.e. the network controls the timing of the signalling within the transaction and the transaction can not be broken into smaller independent sub-parts.

Research in Motion Ltd. has implemented and tested a duty factor limiting algorithm for the radio module to comply with the requirement for limiting the duty factor at all times. To limit the duty factor at all times the algorithm controls the timing of when uplink (transmit) transactions are initiated. When an uplink (transmit) transaction occurs the algorithm accrues the actual transmit time. The algorithm ensures that the idle (transmitter off) time is sufficient to ensure the duty factor is less than the limit (25%) before the next uplink (transmit) transaction is initiated. This ensures that the duty factor is limited to the maximum allowable over all times.

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