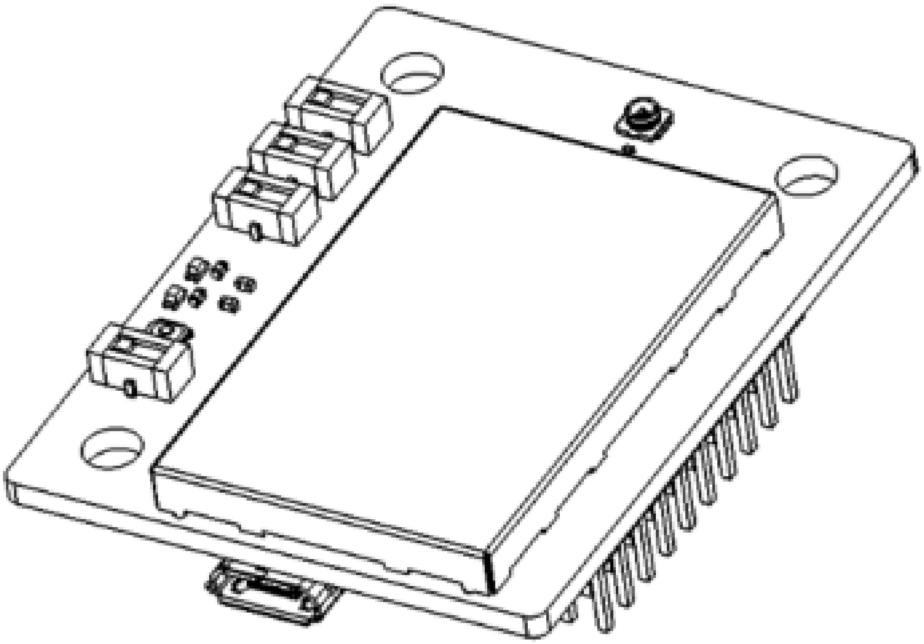
PE IoT Engine

Datasheet



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1. List of Acronyms

Acronym	Description
AES	Advanced Encryption Standard
CMS	Central Management System
GFSK	Gaussian Frequency Shift Key
GPS	Global Positioning System
HDLC	High-Level Data Link Control
IPv6/6LoWPAN	IPv6 over Low-Power Wireless Personal Area Networks
LED	Light Emission Diode
MCU	Microcontroller Unit
NA	Not Applicable
PCB	Printed Circuit Board
PE	Paradox Engineering
RMS	Root Mean Square
RTC	Real Time Clock

2. Product Description

The PE IoT Engine is a Sub 1-GHz IPv6/6LoWPAN hardware radio communication module, as shown in Figure 1 below. The PE IoT Engine is used to build interoperable, fully customized solutions and applications for the Internet of Things (IoT) and Smart Cities. As a communications module, the PE IoT Engine is responsible for handling all network-layer events such as joining the 6LoWPAN mesh network, sending and receiving data, and encrypting the data sent over the network. In order to utilize the capabilities of the PE IoT Engine in an IoT or Smart City application, the PE IoT Engine must be integrated into a 3rd party application board including any external sensors (or actuators) necessary for the application.

Figure 1: The PE IoT Engine

PE Smart Urban Network is Paradox Engineering's flagship platform to enable true Smart City applications, which gives city managers the ability to have bi-directional communication (allowing both remote sensing and remote control) to IoT devices deployed in a city environment and constructing their own private IPv6 wireless network.

An example of some of the many Smart City use cases which can be realized using the PE technologies, including the PE IoT Engine, is shown Figure 2, located below.

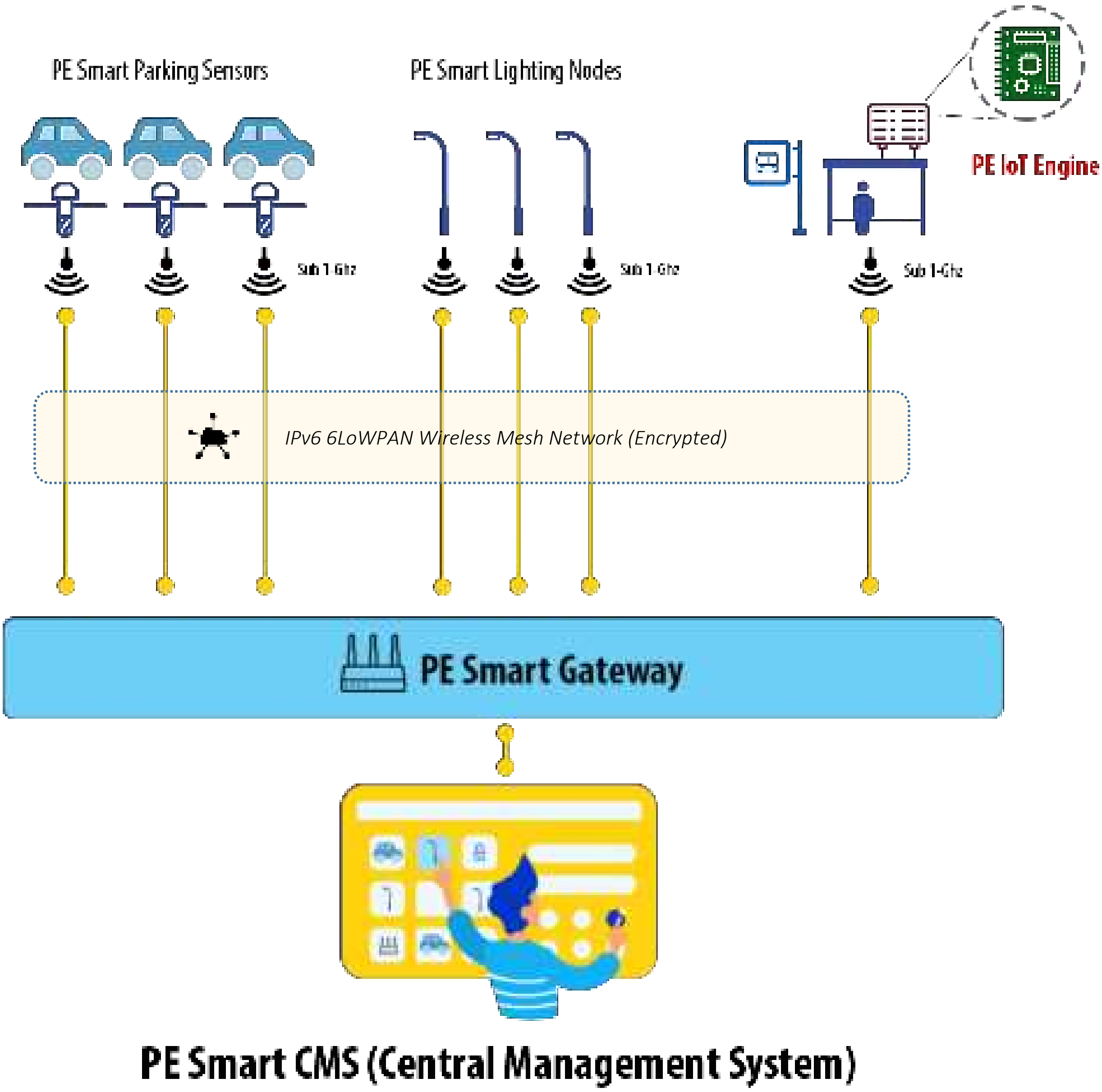

Figure 2: The PE IoT Engine and Other PE Technologies Operating in a Smart City Application

As an open and interoperable platform, the PE IoT Engine adopts the uCIFI standard for Smart City applications. This provides city managers the ability to use an open and standardized data model for sensor data traversing mesh network. The uCIFI standard also ensures that city managers have a well-defined interface to access their data.

As depicted in Figure 2, the PE IoT Engine forms a wireless mesh network with other PE Smart devices (such as the Parking Sensor, the Lighting Node, as well as other PE IoT Engine devices). The PE IoT Engine provides city managers an interoperable, ready-to-use device to connect field objects to their network. Once connected, the IoT devices that leverage the PE IoT Engine are able to exchange data, receive commands, and execute procedures through PE Smart Gateways. All management and control is provided by the PE Smart CMS (Central Management System).

3. Architecture

The PE IoT Engine is a communication module that allows custom, 3rd party IoT applications to have full access to a private, encrypted, self-configuring, self-healing, IPv6/6LoWPAN, wireless mesh network which can easily be deployed in city and urban environments.

One of the core objectives of the PE IoT Engine is to provide hardware engineers a single module that abstracts the networking, mesh topology, IPv6 stack, and Sub 1-GHz radio protocols. Engineers have a versatile data modeling API with the embedded LwM2M engine. The PE IoT Engine supports multiple interfaces such as UART, USB, I2C, Serial, and GPIO to allow external devices to leverage the PE IoT Engine as a network communications module.

PE IoT Engine consists of a single electronic printed circuit board (PCB) that includes the following:

- Microcontroller unit (MCU) and flash memory
- RF transceiver (sub 1-GHz radio) with UFL connector for external antenna (Note: UFL antenna is not provided)
- Micro USB 2.0 connector
- External connectors (located on the bottom side) for interfacing with 3rd-party boards

The electronic PCB and the physical connectors for PE IoT Engine are pictured in Figure 3 below.

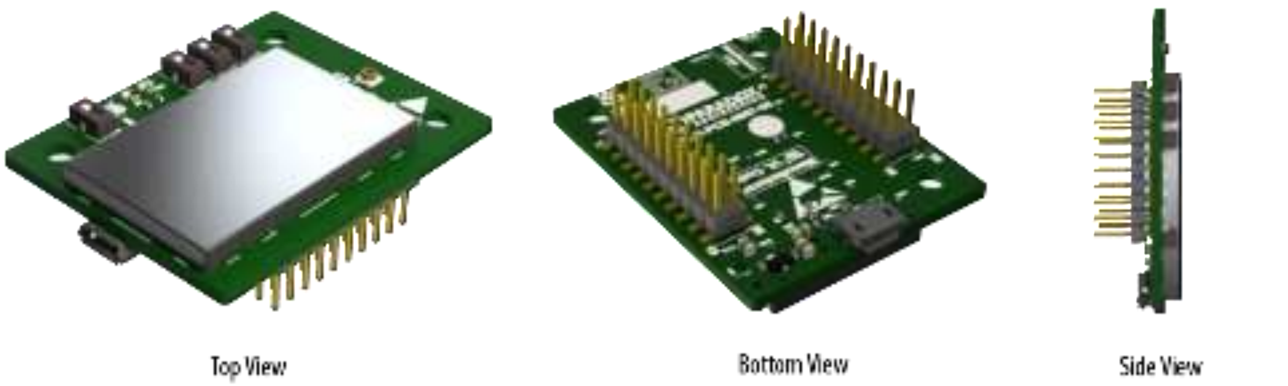

Figure 3: The Top, Bottom, and Side Views of the PE IoT Engine

A high-level block diagram of the PE IoT Engine is pictured in Figure 4, located below.

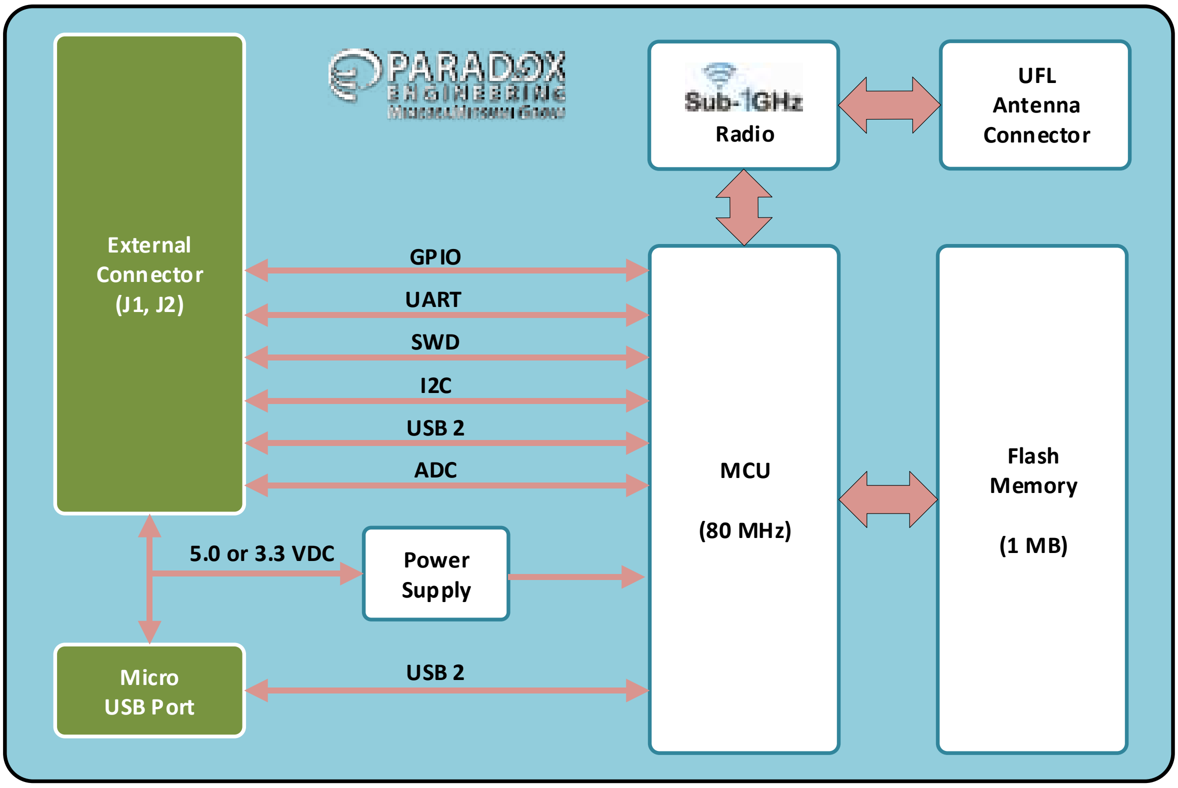

Figure 4: The PE IoT Engine High Level Block Diagram

4. Features

The PE IoT Engine offers the following features:

- Radio communications module providing access to IPv6/6LoWPAN mesh network and highly secure communication infrastructure for bidirectional data transmission
- Dual inline connectors for simple integration with 3rd party boards (such as the Arduino, Raspberry Pi, and Beagle Bone platforms)
- HDLC over UART interface for device configuration and data communications
- Ability to operate in low power mode suitable for use with an (optional) external battery
- LwM2M engine to allow data model definition, data manipulation, and notifications via the IPv6/6LoWPAN mesh network
- Remote OTA firmware upgrade via the IPv6/6LoWPAN mesh network
- 128-bit AES encryption for all data and communications sent over the IPv6/6LoWPAN mesh network

5. Technical specifications

Table 1 – Absolute Maximum Ratings

Symbol	Item	Unit	Min.	Typ.	Max.
V_{DD_2V}	2 V Operating Supply Voltage	VDC	1.9(1)	2	2.2
$V_{DD\_3.3V}$	3.3V Operating Supply Voltage	VDC	2.7	3.3	3.5
V_{DD_5V}	5V Operating Supply Voltage	VDC	3.6	5	6
V_{ANALOG}	IO Pin Voltage	VDC	0	-	V_{REF} +0.3V
$V_{DIGITAL}$	IO Pin Voltage Extended Range	VDC	-0.3	-	V_{DD} +0.3V (5V tolerant UART1)
V_{BAT}	External Power backup for RTC	VDC	1.55	3.3	3.6
V_{RESET}	Reset Pin Voltage	VDC	-0.3	-	V_{DD} +0.3V
T_{OTG}	Operating temperature range	°C	-40	-	70
T_{STG}	Storage temperature range	°C	-40	-	85

(1) Low Power Mode

The power of the source that supplies the product shall be less or equal than 15 W.

Table 2 – I/O Operating Specification

Symbol	Item	Unit	Min.	Typ.	Max.
V_{IL}	I/O input Low voltage	VDC	-	-	0.3 x Min (V_{DD})
V_{IH}	I/O input High voltage	VDC	0.7 x Min (V_{DD})	-	-
$V_{IL(RESET)}$	Reset Low Level Voltage	VDC			0.3 x Min (V_{DD})
$V_{IH(RESET)}$	Reset High Level Voltage	VDC	0.7 x Min (V_{DD})		

Table 3 – Power Consumption

Symbol	Item	Unit	Min.	Typ.	Max.
I_{DD}	Transmission @11 dBm	mA	-	31	-
I_{DD}	Reception	mA	-	28	-
I_{DD}	Sleep Mode	uA	-	-	-

Table 4 – Sub 1-GHz Radio Narrowband Interface

Item	Unit	Description
Radio protocol	-	802.15.4g – 6LoWPAN
Radio modulation	-	GFSK
Data rate	kbps	100
RX sensitivity (BER <1%)	dBm	-104
Tx bandwidth	kHz	≤ 200
RX bandwidth	kHz	260
Data transmission	-	Bi-directional
Data encryption	-	AES-128 bit
Antenna connector	-	External 50 Ω SMA Connector

Table 5 – Sub 1-GHz Radio Narrowband Country Parameters

Country	Frequency band (MHz)[1]	Frequency Hopping / Single channel	Channels	Ch. Spacing (kHz)	TX power (dBm)	Comments
US	902.42 – 927.58	Frequency Hopping	75	340	≤ 14	
EU	868.0 – 868.6	Single channel	-	-	≤ 14	3 ch., 200 kHz spacing (868.1, 868.3 and 868.5 MHz)
EU	869.525 (band P)	Single channel	-	-	≤ 14	1 ch., (869.525 MHz)
JP	920.70 - 923.30	Single channel	-	-	≤ 13	13 ch., 200 kHz spacing (922.3 MHz ch. cannot be used by ARIB STD-T108 tab. 3-12)
TH	920.41 - 924.59	Frequency Hopping	20	220	≤ 14	
KH	923.42 - 924.58	Single channel	-	-	≤ 14	5 ch., 290 kHz spacing, device max TX power is 14 dBm, certification limit is 17 dBm
PH	915.42 - 917.58	Frequency Hopping	9	270	≤ 14	

Table 6 – I/O Operating Specifications

Digital Interfaces

Item	Description
USB	USB 2.0 for Serial Communication and Firmware Upgrade
Serial Port	115200/N/8
SWD	For debugging and programming purposes
GPIO	Up to 14 General Purpose Digital IO
ADC	Up to 2 Analog/Digital Converter Single-ended
UART	Tx / Rx
I2C	I2C (Inter-Integrated Circuit) interface

[1] The values indicate the carrier frequency of the lowest and the highest channels

6. Dimensions

Mechanical dimensions of PE IoT Engine are pictured in Figure 5 below.

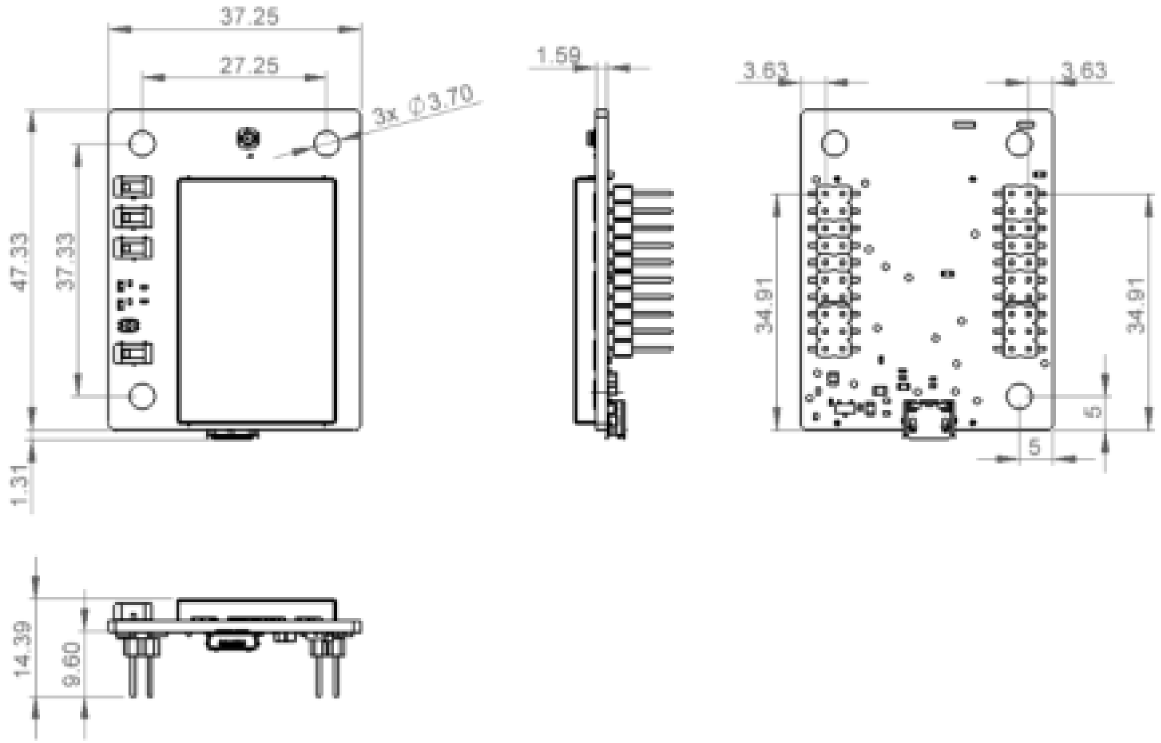

Figure 5: Dimension Views of the PE IoT Engine in Millimeters

7. Connectors and Switches

Table 7 – List of Connectors

Name	Description
J1	2x10 pins male connector, 2.54 mm pitch, mounted on the bottom side
J2	2x10 pins male connector, 2.54 mm pitch, mounted on the bottom side
J3	Micro USB female connector
J18	UFL female connector for RF antenna

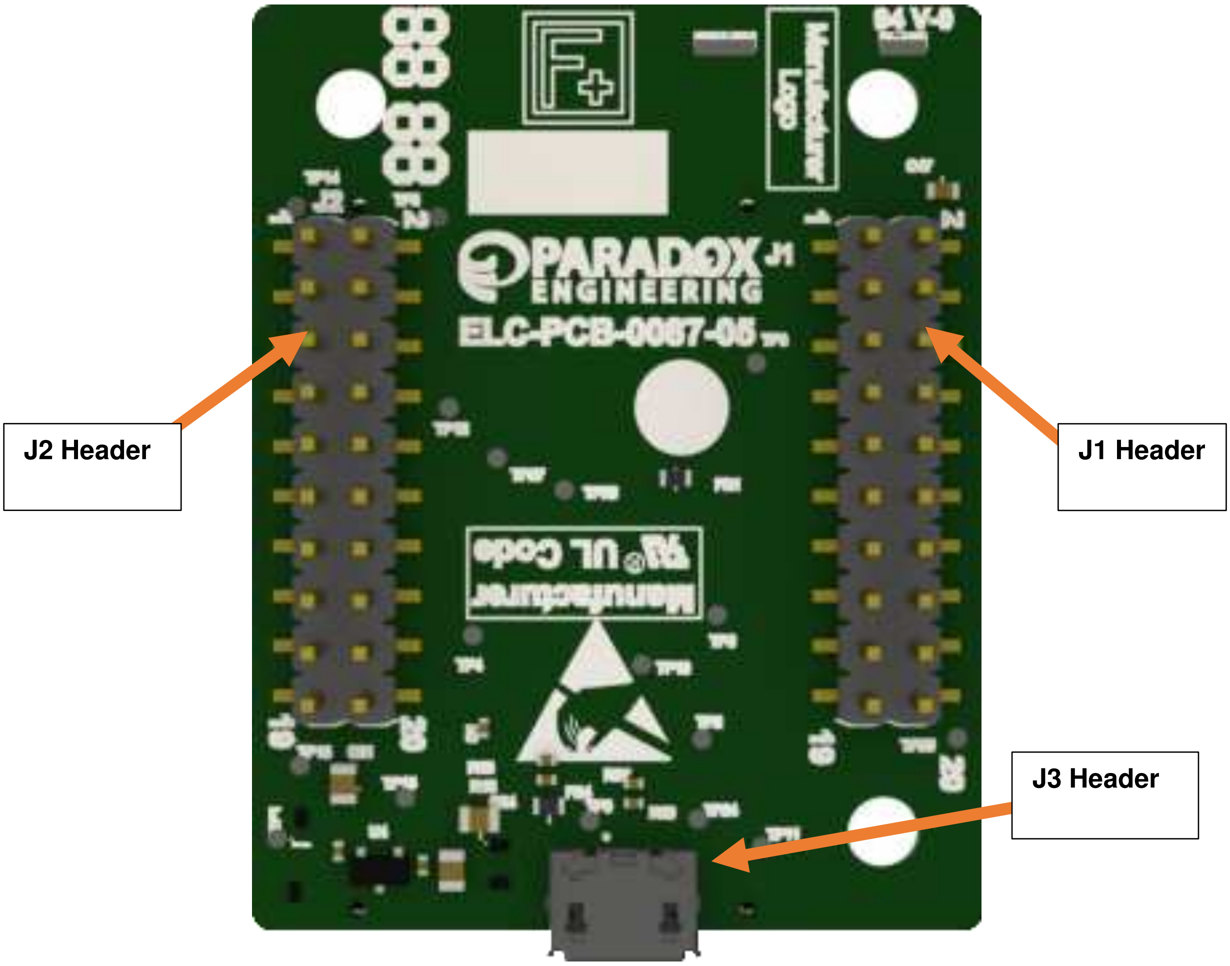

Figure 6: Bottom View with J1, J2, and J3 Headers

Table 8 – List of Switches

Name	Description
SW1	Soft RESET – Push the button to RESET the device
SW2	BOOT0 – Move the switch to the right to activate the bootloader
SW3	V_ADC – Move the switch to the right to supply external power to the ADC. Move the switch to the left to enable VCC to supply power to the ADC.
SW4	VMAIN – Move the switch to the right to enable low power mode and bypass the protection diode
SW5	VBAT - Move the switch to the right to enable the PE IoT Engine to use externally supplied power (such as from a battery). Move the switch to the left to enable VCC to supply power to the VBAT pin

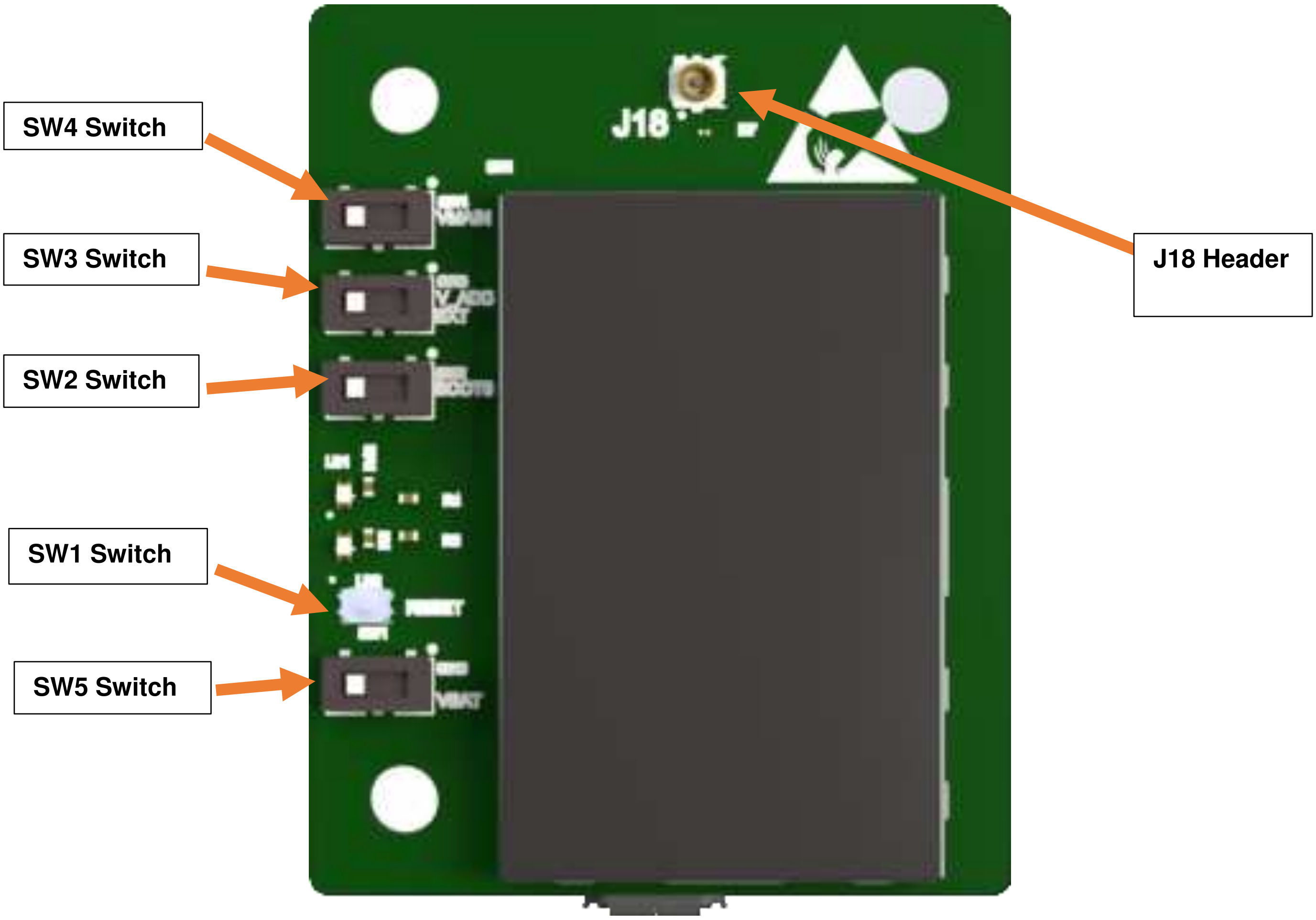

Figure 7: Top View with J18 Header and SW1, SW2, SW3, SW4, and SW5 Switches

Table 9 – List of LEDs

Name	Description
LD1	This LED is always ON if the PE IoT Engine is powered with 5 VDC or USB power. In other power configurations, the LED is OFF to save power.

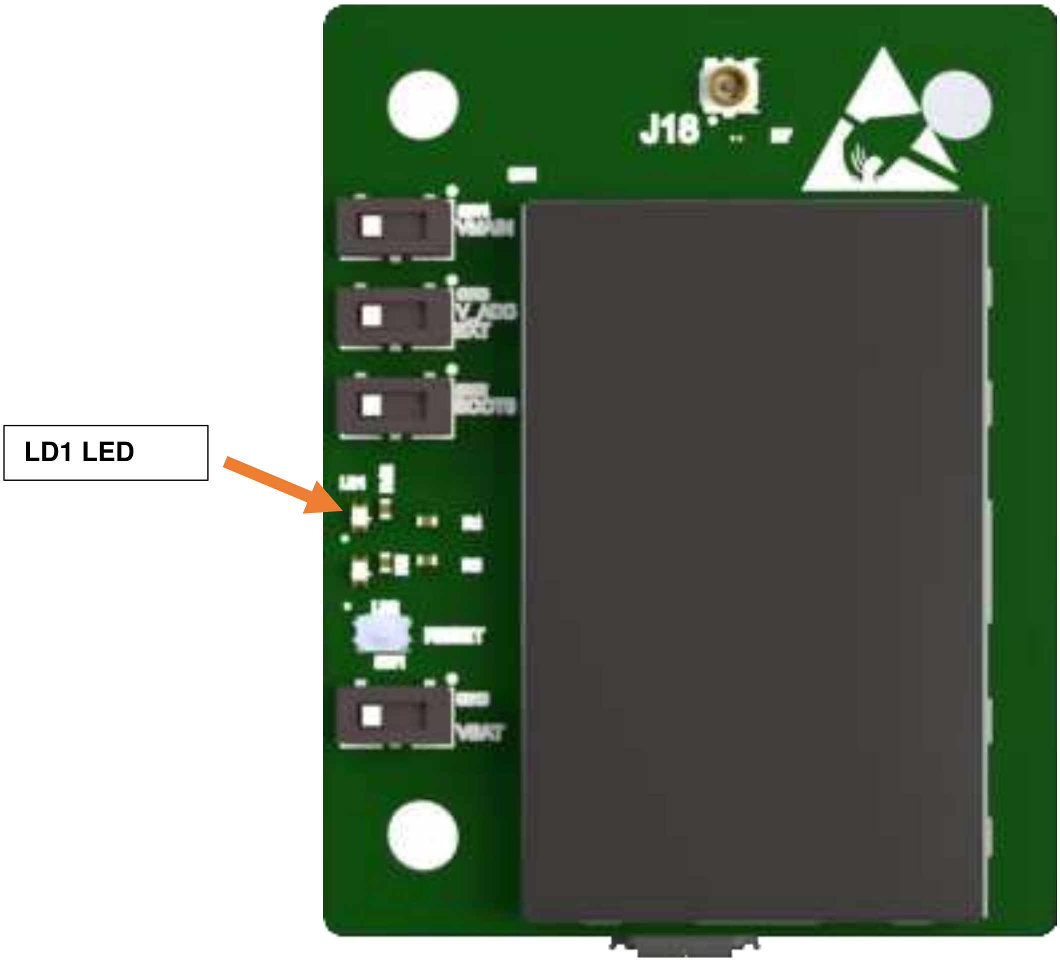

Figure 8: Top View LED LD1

Table 10 – Pinout of J1 Connector

PIN	Name	Type	Description	Reference
1	V_BAT	Power	Optional external backup battery	V_{BAT}
2	GPIO_14	I/O	General purpose input/output	$V_{DIGITAL}$
3	I2C SDL	I/O	I2C data	$V_{DIGITAL}$
4	GPIO_9	I/O	General purpose input/output	$V_{DIGITAL}$
5	GPIO_11	I/O	General purpose input/output	$V_{DIGITAL}$
6	RXD	O	Serial Interface for debugging	$V_{DIGITAL}$
7	GPIO_12	I/O	General purpose input/output	$V_{DIGITAL}$
8	TXD	I	Serial Interface for receiving	$V_{DIGITAL}$
9	GPIO_13	I/O	General purpose input/output	$V_{DIGITAL}$
10	USB_N	I/O	USB data	$V_{DIGITAL}$
11	I2C SDA	I/O	I2C clock	$V_{DIGITAL}$
12	USB_P	I/O	USB data+	$V_{DIGITAL}$
13	USB OTG	I/O	USB OTG	$V_{DIGITAL}$
14	SWDIO	I/O	Serial wire I/O	-
15	GPIO_8	I/O	General purpose input/output	$V_{DIGITAL}$
16	SWCLK	I	Serial wire clock	-
17	GPIO_10	I/O	General purpose input/output	$V_{DIGITAL}$
18	RESET	I	Reset input, active low, internal pull-up	V_{RESET}
19	PWR_MON	O	Power ON monitor, goes high if the module is powered on, goes low if the module is not powered	$V_{DIGITAL}$
20	GND	Power	Ground	-

Table *11* – Pinout of J2 Connector

PIN	Name	Type	Description	Reference
1	+5V_DB	Power	5V Input Voltage from external source	V_{DD_5V}
2	+3.3V_DB	Power	3.3V Input Voltage from external source	$V_{DD\_3.3V}$, V_{DD_2V}
3	GPIO_3	I/O	General purpose input/output	$V_{DIGITAL}$ Not 5 V tolerant)
4	UART1_RX	I/O	HDLC Serial data input	$V_{DIGITAL}$
5	GPIO_7	I/O	General purpose input/output	$V_{DIGITAL}$
6	ON/OFF	I	Input for switching ON or OFF the module	$V_{DIGITAL}$
7	+5V_DB	Power	5V Input Voltage from external source	V_{DD_5V}
8	GPIO_5	I/O	General purpose input/output	$V_{DIGITAL}$
9	ADC_INPUT_02	I/O	ADC input	$V_{DIGITAL}$
10	GPIO_6	I/O	General purpose input/output	$V_{DIGITAL}$
11	RX_AUX	I	Auxiliary serial data input for debug/test	$V_{DIGITAL}$
12	ADC_INPUT_01	I/O	ADC input	V_{ANALOG}
13	GPIO_2	I/O	General purpose input/output	$V_{DIGITAL}$
14	TX_AUX	O	Auxiliary serial data output for debug/test	$V_{DIGITAL}$
15	GPIO_4	I/O	General purpose input/output	$V_{DIGITAL}$
16	DTR	I	Data terminal ready from DTE	$V_{DIGITAL}$
17	GPIO_1	I/O	General-purpose input/output	$V_{DIGITAL}$
18	RI	O	Ring indicator to DTE	-
19	UART1_TX	I/O	HDLC Serial data output	$V_{DIGITAL}$ Not 5 V tolerant)
20	GND	Power	Ground	-

8. Requirements of KDB 996369 D03 – FCC certifications

8.1 Section 2.2 List of applicable FCC rules

The following standard apply to the module:

- 47 CFR FCC part 15.247 , subpart C (radio)
- 47 CFR FCC 47 part 2 - §2.1093 (maximum permissible exposure)
- KDB 558074 D01
- ANSI C63.10:2013
- Title 47 Part 1 Subpart I § 1.1310
- Title 47 Part 2 Subpart J § 2.1091
- ANSI C63.4:2014

8.2 Section 2.3 Summarize the specific operation use conditions

The PE IoT Engine is used in the Internet of Things (IoT) and Smart Cities contexts. As a communications module, the PE IoT Engine is responsible for handling all network-layer events such as joining the 6LoWPAN mesh network. The module is required to be integrated into a 3rd party application equipment.

In its standard use, it is not intended to be used in point-to-point applications. As a consequence, the typical antennas to be used are low-gain antenna.

In addition, the maximum theoretical TX power is physically limited to 14 dBm. The FCC limit in the (902 – 928) MHz band 1 W (30 dBm) and it is not possible to overcome that limit.

8.3 Section 2.4 Limited module procedures

Not applicable.

8.4 Section 2.5 Trace antenna design

Not applicable, the radio module does not have any trace antenna design.

8.5 Section 2.6 RF exposure considerations

The following tables summarize the results of the calculations carried out assuming no co-location or operation in conjunction with any other antenna or transmitter. It is also indicated the minimum distance to keep between antennas and the public:

3. MEASUREMENTS AND CALCULATION RESULTS

3.1 SAR exemption

This device has been excluded from SAR testing based on source-based time-averaged conducted output power and KDB 447498 D01 section 4.3.1 1). This document serves as the RF exposure exhibit in the FCC Form 731 application in lieu of a SAR report.

3.1 Operational Description

The **Module** is a communication device based on 900MHz technology intended to be used in multiple portable applications. It is necessary a calculation for portable use demonstrating that the transmitter can be excluded from SAR testing.

3.2 RF Exposure Conditions

The device is intended for use as portable.

3.3 RF Output Power

TX frequency Range: 902.42MHz – 927.58MHz
Max measured EIRP with PATCH ANTENNA type 2067640100: 14.95dBm (31.2mW)
Max measured EIRP with DIPOLE ANTENNA type ANT-916-CW-HW: 14.95dBm (31.2mW)

3.4 FCC Calculation method and limits

SAR Test Exclusion Thresholds:

[(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm)] · [√f(GHz)] ≤ 3.0 (for 1-g body SAR) or 7.5 (for 10-g extremity SAR)

where respectively

- f(GHz) is the RF channel transmit frequency in GHz
- Power and distance are rounded to the nearest mW and mm before calculation
- The result is rounded to one decimal place for comparison

3.5 FCC Calculation results

Measured Output Power: 31.2mW
Min Test separation distance: 5mm
f: 902.42MHz (as worst case)

Exclusion Threshold Extremity SAR: 7.5 (10-g extremity SAR)

$$\frac{31.2mW}{5mm} * \sqrt{0.90242} = 5.93 \leq 7.5$$

RESULT: The device is excluded from SAR testing.

Notice

Changes or modifications made to this equipment not expressly approved by Paradox Engineering may void the user’s authority to operate this equipment.

Radiofrequency radiation exposure information

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance of 5mm between the radiator and your body.

This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

Product operation is subject to the following two conditions:

1. This device may not cause harmful interference, and

2. This device must accept any interference received, including interference that may cause undesired operation.

8.6 Section 2.7 Antennas

The module has been certified with the following antennas:

- Linx Technologies, ANT-916-CW-HW (ANT-OUT-0027), dipole antenna, 1.2 dBi
- Molex, 2067640100 (ANT-IND-0006), patch antenna, 1.2 dBi

The module is provided by a U.FL connector.

8.7 Section 2.8 Label and compliance information

According KDB 784748 the end-user or the integrator of this module shall use a physical label stating “Contains Transmitter Module FCC ID: 2AKPNDWM005” or “Contains FCC ID: 2AKPNDWM005”.

8.8 Section 2.9 Information on test modes and additional testing requirements

See test report FCCTR_178784_0 and MPETR_178785_0.

In the following table there are the operating conditions adopted during tests identified by an indicator (#) at which has been referred the item "Operating condition of the equipment under test"

OPERATING CONDITION	DESCRIPTION
#1	EUT in the follow configuration: - Powered at 3.6Vdc with patch antenna, type 2067640100. - Continuous transmission, pseudorandom modulated carrier
#2	EUT in the follow configuration: - Powered at 5Vdc with patch antenna, type 2067640100. - Continuous transmission, pseudorandom modulated carrier
#3	EUT in the follow configuration: - Powered at 3.6Vdc with external dipole antenna, type ANT-916-CW-HW. - Continuous transmission, pseudorandom modulated carrier
#4	EUT in the follow configuration: - Powered at 5Vdc with external dipole antenna, type ANT-916-CW-HW. - Continuous transmission, pseudorandom modulated carrier
#5	Continuous transmission, pseudorandom modulated, Hopping mode, without antenna - Powered at 3.6Vdc
#6	Continuous transmission, pseudorandom modulated, Hopping mode, without antenna - Powered at 5Vdc

Special Test Software: Special software by the Applicant to operate the EUT at each channel frequency continuously. For example, the transmitter will be operated at each of the lowest, middle and highest frequencies individually continuously during testing.

Special Hardware Used: None

Transmitter Test Antenna: The EUT has been tested with the antenna fitted in a manner typical of normal intended

8.9 Section 2.10 Additional testing, Part 15 Subpart B disclaimer

Please refer to test report FCCTR_178784_0 and MPETR_178785_0.

The module is FCC Part 15 Subpart B compliant and the modular transmitter is only FCC authorized for the specific rule parts listed on the grant. The host product manufacturer is responsible for compliance to any other FCC rules that apply to the host not covered by the modular transmitter grant of certification. The final host product still requires Part 15 Subpart B compliance testing with the modular transmitter installed.

9. Maximum Permissible Exposure (MPE) Limits

The PE IoT Engine is compliant to Maximum Permissible Exposure (MPE) limits.

9.1 US – United States

See section 8.5 Section 2.6 RF exposure considerations.

9.2 EU – Europe

Table *12* – MPE Limits

9.2.1 Maximum Permissible Exposure (MPE) Limits

RADIATED BY INTERNAL ANTENNA			
EUT CONFIGURATION: powered by 3.6Vdc, mounted antenna model Molex, type 2067640100			
Band (from ETSI EN 300 220-2 V.3.2.1)	M		P
TX Frequency (MHz)	868.10	868.50	869.525
Measured Power (dBm)	13.5	13.5	14.0
Measured Power (mW)	22.39	22.39	25.00
MAXIMUM PERMISSIBLE EXPOSURE (MPE)			
Power density (W/m²)	4.3405	4.3425	4.3476
Evaluation Distance at power density (cm)	2.03	2.02	2.13
VERDICT			
The EUT Radiated Power density at evaluation distance, calculated with the follow expression:			
868.10MHz Evaluation distance at power density = $\sqrt{}$ (EIRP/(4*π*S)) = $\sqrt{}$ (22.39mW / (4*π*4.3405W/m²))= 2.03 cm			
868.50MHz Evaluation distance at power density = $\sqrt{}$ (EIRP/(4*π*S)) = $\sqrt{}$ (22.39mW / (4*π*4.3425W/m²))= 2.02 cm			
869.525MHz Evaluation distance at power density = $\sqrt{}$ (EIRP/(4*π*S)) = $\sqrt{}$ (25.00mW / (4*π*4.3476W/m²))= 2.13 cm			
Is WHITIN THE LIMIT			
Expanded Uncertainty: ± 3,41 dB Level of confidence = 95% (k=2)			

RADIATED BY INTERNAL ANTENNA			
EUT CONFIGURATION: powered by 3.6Vdc, mounted antenna model Linx, type ANT-868-CW-HW			
Band (from ETSI EN 300 220-2 V.3.2.1)	M		P
TX Frequency (MHz)	868.10	868.50	869.525
Measured Power (dBm)	12.9	13.3	13.8
Measured Power (mW)	19.50	21.38	23.99
MAXIMUM PERMISSIBLE EXPOSURE (MPE)			
Power density (W/m²)	4.3405	4.3425	4.3476
Evaluation Distance at power density (cm)	1.89	1.98	2.09
VERDICT			
The EUT Radiated Power density at evaluation distance, calculated with the follow expression: 868.10MHz Evaluation distance at power density = $\sqrt{(EIRP/(4*\pi*S))} = \sqrt{(19.50mW / (4*\pi*4.3405W/m^2))}$ = 1.89 cm 868.50MHz Evaluation distance at power density = $\sqrt{(EIRP/(4*\pi*S))} = \sqrt{(21.38mW / (4*\pi*4.3425W/m^2))}$ = 1.98 cm 869.525MHz Evaluation distance at power density = $\sqrt{(EIRP/(4*\pi*S))} = \sqrt{(23.99mW / (4*\pi*4.3476W/m^2))}$ = 2.09 cm **is WHITIN THE LIMIT**			
Expanded Uncertainty: ± 3,41 dB Level of confidence = 95% (k=2)			

RADIATED BY INTERNAL ANTENNA			
EUT CONFIGURATION: powered by 5Vdc, mounted antenna model Molex, type 2067640100			
Band (from ETSI EN 300 220-2 V.3.2.1)	M		P
TX Frequency (MHz)	868.10	868.50	869.525
Measured Power (dBm)	13.9	13.8	14.0
Measured Power (mW)	24.54	23.99	25.00
MAXIMUM PERMISSIBLE EXPOSURE (MPE)			
Power density (W/m²)	4.3405	4.3425	4.3476
Evaluation Distance at power density (cm)	2.12	2.09	2.13
VERDICT			
The EUT Radiated Power density at evaluation distance, calculated with the follow expression: 868.10MHz Evaluation distance at power density = $\sqrt{(EIRP/(4*\pi*S))} = \sqrt{(24.54mW / (4*\pi*4.3405W/m^2))}$ = 2.12 cm 868.50MHz Evaluation distance at power density = $\sqrt{(EIRP/(4*\pi*S))} = \sqrt{(23.99mW / (4*\pi*4.3425W/m^2))}$ = 2.09 cm 869.525MHz Evaluation distance at power density = $\sqrt{(EIRP/(4*\pi*S))} = \sqrt{(25.00mW / (4*\pi*4.3476W/m^2))}$ = 2.13 cm **is WHITIN THE LIMIT**			
Expanded Uncertainty: ± 3,41 dB Level of confidence = 95% (k=2)			

RADIATED BY INTERNAL ANTENNA			
EUT CONFIGURATION: powered by 5Vdc, mounted antenna model Linx, type ANT-868-CW-HW			
Band (from ETSI EN 300 220-2 V.3.2.1)	M		P
TX Frequency (MHz)	868.10	868.50	869.525
Measured Power (dBm)	13.7	13.5	13.3
Measured Power (mW)	23.44	22.38	21.38
MAXIMUM PERMISSIBLE EXPOSURE (MPE)			
Power density (W/m^2)	4.3405	4.3425	4.3476
Evaluation Distance at power density (cm)	2.07	2.02	1.98
VERDICT			
The EUT Radiated Power density at evaluation distance, calculated with the follow expression: 868.10MHz Evaluation distance at power density = $\sqrt{(EIRP/(4*\pi*S))} = \sqrt{(23.44mW / (4*\pi*4.3405W/m^2))}$ = 2.07 cm 868.50MHz Evaluation distance at power density = $\sqrt{(EIRP/(4*\pi*S))} = \sqrt{(22.38mW / (4*\pi*4.3425W/m^2))}$ = 2.02 cm 869.525MHz Evaluation distance at power density = $\sqrt{(EIRP/(4*\pi*S))} = \sqrt{(21.38mW / (4*\pi*4.3476W/m^2))}$ = 1.98 cm is WHITIN THE LIMIT			
Expanded Uncertainty: ± 3,41 dB Level of confidence = 95% (k=2)			

9.2.2 EU Declaration of Conformity

Paradox Engineering declares that PE IoT Engine is compliant within the 2014/53/EU directive. The full Declaration of Conformity is available at the following link:
hiips://www.pdxeng.ch/certification/t6Ybbh8ojS.pdf

10. Certifications

10.1 US – United States

Table 13 – Reference Standards of the United States

Standard	Title
FCC 47 CFR part 15	FCC 47 CFR Part 15, Subpart C - Intentional Radiators

10.2 EU - Europe

Table 14 – Directives of Europe

Directive	Title
2014/53/EU	Directive on the harmonization of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC
2011/65/EU	DIRECTIVE 2011/65/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment
2015/863/EU	Commission delegated directive amending Annex II to Directive 2011/65/EU of the European Parliament and of the Council as regards the list of restricted substances

Table 15 – Reference Standards of Europe

Standard	Title
ETSI EN 300 220-2	Short Range Devices (SRD) operating in the frequency range 25 MHz to 1 000 MHz; Part 2: Harmonized Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU for non specific radio equipment
ETSI EN 301 489-1	Electromagnetic Compatibility (EMC) standard for radio equipment and services Part 1: Common technical requirements; Harmonized Standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU and the essential requirements of article 6 of Directive 2014/30/EU
ETSI EN 301 489-3	Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 3: Specific conditions for Short-Range Devices (SRD) operating on frequencies between 9 kHz and 246 GHz; Harmonized standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU
IEC EN 62368-1	Audio/video, information and communication technology equipment Part 1: Safety requirements
EN 62311	Assessment of the compliance of low-power electronic and electrical equipment with the basic restrictions related to human exposure to electromagnetic fields (10 MHz to 300 GHz)

10.3 Symbols and Approval Marks

Table *16* – Approval Marks

Approval	Issued by	Certificate No.
CE	PARADOX ENGINEERING MinebeaMitsumi Group	Declaration of Conformity: In progress
FC	In progress	FCC ID: 2AKPQNDWM005

Table *17* – Symbols

Approval	Description
RoHS	RoHS compliant, refer to [OD_1]
	WEEE Directive compliant, refer to [OD_1]

11. Ordering Codes

Table *18* – Ordering Codes

Model Name	Country code	Part No.
NDWM005 US	US - United States	PRD-CMD-0002
NDWM005 EU	EU - Europe	PRD-CMD-0001
NDWM005 CL	CL – Chile	TBD
NDWM005 JP	JP – Japan	TBD
NDWM005 TH	TH – Thailand	TBD
NDWM005 KH	KH – Korea	TBD
NDWM005 PH	PH – Philippines	TBD

12. Related Documents

Table *19* – Related Documents

Item	Document Number	Document Title/Description
[PD_1]	DOC-SW-ETC-2011	PE IoT Engine HDLC Interface Guide
[PD_2]	DOC-SW-AN-2017	LwM2M Reference Application
[OD_1]	EM10507	MinebeaMitsumi Group Green Procurement Standard

13. Revision History

Revision	Document No.	Created by Verified by Approved by	Date	Description
00	DOC-DAT-0023-00	M. Semmoloni R. Palmiero G. Galabro'	21.06.2019	First document release.
01	DOC-DAT-0023-01	B. Hopkins R. Palmiero M. Parnisari	12.11.2019	Updated all sections for PE IoT Engine Changed USB mini to micro Updated J1 and J2 headers for serial use
02	DOC-DAT-0023-02	B. Hopkins R. Palmiero M. Parnisari	12.05.2020	Added additional images
03	DOC-DAT-0023-03	B. Hopkins R. Palmiero M. Parnisari	11.12.2020	Updated all sections for PE IoT Engine for the latest version. Included a new table for switches Updated all photos. Added a new section for the MPEs. Updated table 5, sub 1-GHz params. Added the EU directive. Updated the ordering codes. Updated Tables 1,2,3, 5, 9, 10
04	DOC-DAT-0023-04	B. Hopkins R. Palmiero M. Parnisari	04.03.2021	Added KDB 006360 D03 section to comply FCC certification

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