User Guide, emMesh V1.31(e), FW: 2.147

Document version : A [04/01/19]

Contents

Revision History

Revision	Date	Description
A	April 2019	Creation of document

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Introduction

The "em" series are the long range 868/915 radios (up to 16 km) using the mesh topology to create network availability in areas where traditional networks are not available.

Completely certified, the mesh module allows, thanks to its very low consumption, to be powered only by solar panels and therefore to be used even without supply of electrical network.

They are designed for applications requiring small bandwidth, large number of sensors, ultra-low power consumption, near-realtime control and monitoring and always available response without any requirement for off-cycle.

The emMesh uses Microchip MRF89A chipset which is amplified up to 26db and with reception sensitivity of up to -103 dbm allowing up to 16km distance between two line of sight devices.

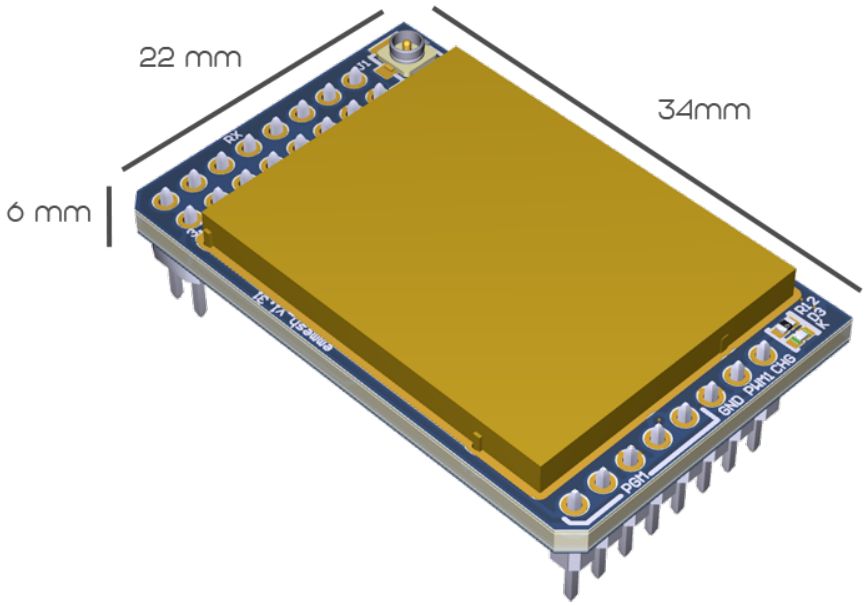
Secured, proprietary Mesh technologies uses fast FHSS patterns with payload encryption allowing fast and reliable communications.

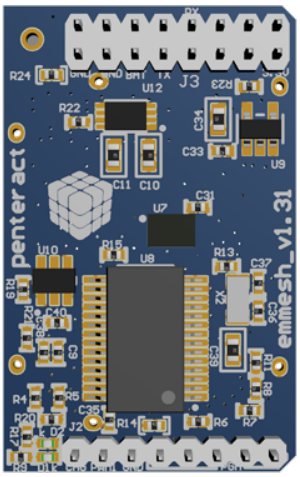
Document related firmware and hardware

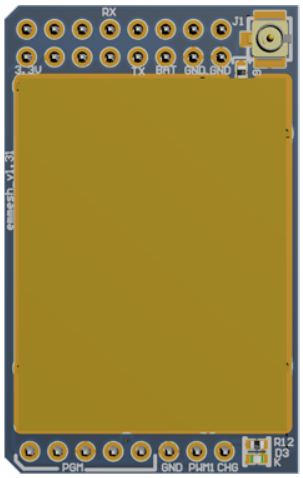
The following document refer to emMesh hardware revision 1.31 and firmware version 2.160.

Technical Specifications

Form factor







General Specifications

Frequencies	Americas: ISM 902-926 Mhz (emMesh v.1.31) Europe: 863 to 870 Mhz (emMesh v.1.31e)
Nombre d'unités	Up to 64006 in a single network
Bandwidth	P2P: 19200 bps
FHSS	15.6 ms, 50 channels
Lithium battery charger	Up to 10 volts of input. Ready for 6 volt solar panels
Internal memory	2 Mbits Flash
Antenna connector	UFL (50 Ohm)

Interfaces

UART 3.3 V	1 communication UART, 1 debug UART
I/O	10 Programmable inputs/outputs
SPI	Up to 1Mbps
USART	I2C
ADC	2-Input 12-bit analog inputs 0-2v
I/O	10 Programmable inputs/outputs
PWM	5 PWM Outputs

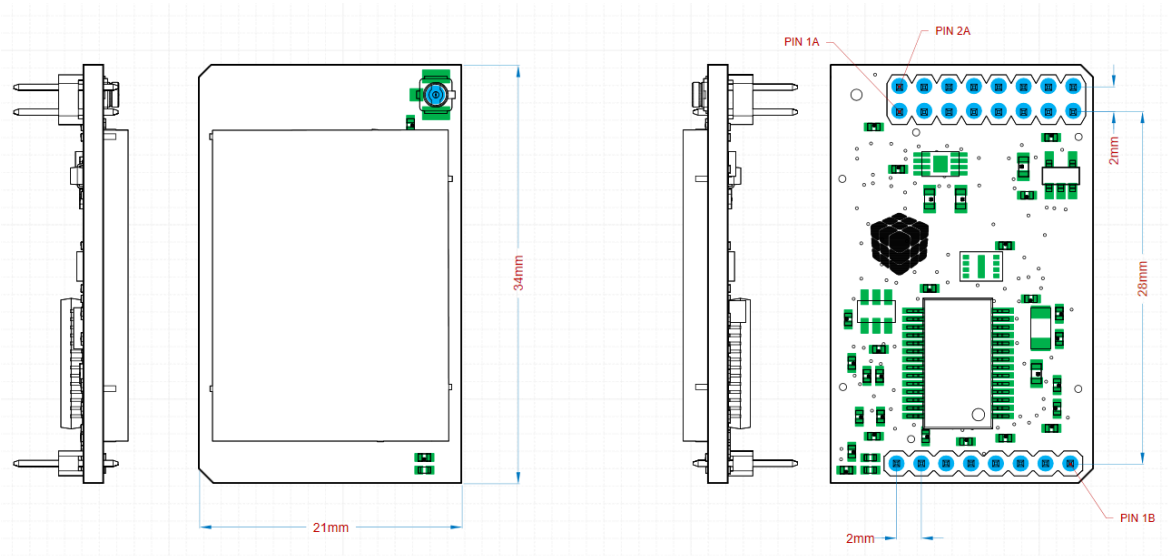
Specifications

Dimensions	34 mm x 21 mm x 10 mm
Operating temperature	-20°C to 70°C
Storage temperature	-40°C to 85°C
Operating voltages	From 3.3 V to 5.5 V
Consumption	Typical: 4 mAh
Antenna connector	Integrated Antenna
Transmitting power	26 dBm
Sensitivity	-103 dBm

Regulatory conformity summary

United States (FCC Part 15.247)	FCC ID : 2ASI4EMMESH emMesh 1.31 FW: 2.160
Canada Innovation, Science and Economic Development Canada (ISED)	IC : 24776-EMMESH emMesh 1.31 FW: 2.160
FCC/IC test transmit power output range	0 to +26dBm
Europe (CE)	Yes emMesh 1.31e FW: 2.160e
RoHS	Compliant

Technical Drawing



GPIOs

16 pins connector

Pins	Name	Type	Description
1	Ground	P	Ground reference for logic and I/O pins
2	PPR	O	Power present state 0V when power present at CHG_IN [open drain]
3	Ground	P	Ground reference for logic and I/O pins
4	TX2	I/O O	I/O pin (0-3.3V) UART TX (0-3.3V)
5	BAT+	P	Positive supply (3.4 to 5.5Vdc)
6	RX2	I/O I	I/O pin (0-3.3V) UART RX (0-3.3V)
7	TX	I/O O I/O	I/O pin (0-3.3V) UART TX (0-3.3V) I2C SDA pin
8	AN1	I/O I	I/O pin (0-3.3V) Analog input (0-3.3V)
9	AN2	I/O I	I/O pin (0-3.3V) Analog input (0-3.3V)
10	RX	I/O I I/O	I/O pin (0-3.3V) UART RX (0-3.3V) I2C SCL pin
11	SDI	I	SPI data input
12	PWM2	I/O	I/O pin (0-3.3V)
13	CHG_IN	P	LI-ION or LI-Po battery charger input power (4.2-10Vdc)
14	SDO	O	SPI serial data output
15	3.3V	P	3.3V DC output (max 200mA)
16	SCK	O	SPI serial data clock

8 pins connector

Pins	Name	Type	Description
1	nMCLR	I	Master reset not (reset emMeah with 0V)
2	3.3V	P	3.3V output (max 200mA)
3	GND	P	Ground reference for logic and I/O pins
4	PGD	I/O	Programmation interface I/O pin (0-3.3V)
5	PGC	I/O	Programmation interface I/O pin (0-3.3V)
6	GND	P	Ground reference for logic and I/O pins
7	PWM1	O	Status LED control pin
8	nCHG	O	0V when charging(open drain)

Design Notes

The following guidelines help to ensure a robust design and allowes regulation conformity.

Power supply design

The emMesh has an integrated voltage regulator. Only a single external supply source is needed. For best performances, make sure the supply voltage is within tolerance. Limit the power supply ripple to 100mV maximum. Also make sure the supply source can withstand peak current of 250mA. Adding a 100uF capacitor at the input will help sustain the peak current demand of the emMesh.

Board layout

The emMesh is designed to be used as a standalone device or integrated in another board, thus, it does not has any board layout requirement other than usual practice for pcb design.

Antenna performance

The following suggestions help you achieve optimal antenna performance.

- Point the antenna up vertically (upright).
- Position the antennas away from metal objects whenever possible.
- If you place the device inside a metal enclosure, use an external antenna.
- Do not place any ground planes or metal objects above or below the antenna.
- For the best results, mount the device at the edge of the host PCB.
- Ensure that the ground, power, and signal planes are vacant immediately below the antenna section.

Serial Communication Protocol

Introduction

The following document refers to Penteract emToo Protocol for Generic implementation.
emToo Protocol works as a global multi-layer, multi-protocol mesh type networking. Allowing multiples protocol such as WiFi, ISM, IP or Bluetooth to interact with each other transparently and be use as a unique transport layer.

The protocol is defined by two mode: Simplified protocol and Advanced Protocol. Description of both mode could be found later in that document.

Choosing the protocol that is more suitable for your needs can lead to simplistic to more complex implantation requirements.

Generic message structure

Both mode, simplified or advanced are using the same base structure. Both are meant to be efficient on any type of transport protocol and secured in both possible encryption and integrity of datas.

Every message sent thru emToo protocol must be packet for the Transport layer structure.
Said transport layer is what is creating the capacity to travel on every type of protocols.

Transport layers such as IP, Serial or Bluetooth are completely transparent and rely on a Mesh reality which held, depending on protocols on a system of relay which allowed a packet to switch from one type of transport to the other without the system needing to know it.

This is coming with some limitation like payload size with is maintained fairly small as it allows smaller capacity type of transport such as emMesh and BLE to be able to participate as said mesh reality. Although said payload could be increased if protocol is only used in IP, knowing which device will be used as relay is fairly important to allows said behaviour and we do not recommend it.

Communication protocol

A message sent must begin with 0x24 0x24 and end with 0x0D 0x0A. In addition, it must contain a size, 8 bits checksum, the message type used and the type of encryption used.

sync	**sync**	**length**	**msg type + encryption**	Payload type	Data	Data	Data	Data
0x24	0x24	0x0F	0x00	0x02	0x41	0x41	0x41	0x41

Data	Data	Data	Data	Data	checksum	**Byte termination**	**Byte termination**
0x48	0x45	0x4C	0x4C	0x4F	0x40	0x0D	0x0A

Table 1: example of a simplified type of message

In the example on **Table 1,** byte[1 & 2] are the sync characters which are alway, whether in simplified or advanced mode, $$.

byte[3] Length:
This byte is a computation of the size of the payload the msgType and itself.

byte[4] Msg Type & Encryptio:
This byte is created by mixing the binary values [MSB 1bits Advanced=1 Simplified=0][LSB 7 bits Encryption Type]

Exemple:
Encryption_Type = 0x01;
Msg_Type = 0x01;
byte[4] = Msg_Type<<7 + Encryption_Type;
byte[4] = 0x81

Please see MsgType and Encryption type section for more infos.

byte[n-3] Checksum:
The checksum is calculated over payload using and 8 bits exclusive or (XOR) sequence. It is done prior to encryption and include payload type.

byte[n-2] & byte [n-1] Ender:
Each message must be terminated by \r\n (0x0D, 0x0A). This allowes both packet end but also correlation of length on which if both values are not equals, message is discarded.

Encryption (6 bits)

Encryption Type <6: 0>	Value	Description
No	0x00	Raw message, no encryption
Polymorphism	0x01	Simple light cypher algorithm based on polymorphism of paraphrase.
Rijndael [CBC]	0x02	Rijndael implentation cypher. (Not on emMesh)
AES 256bits	0x03	AES-256 standard (Not on emMesh)
RSA 2048	0x04	To come
256 bits ECC	0x05	To come
User Defined	0x06 to 0x7F	Supported only by certain devices

Message Type (1 bit)

Message Type <7>	Value	Description
Simplified	0x00	Set following message as being in simplified mode
Advanced	0x01	Set following message as being in advanced mode

Simplified Mode

In simplified mode, the associated device using is acting a a slave accessories. Using that protocol ease the integration by simply allowing

Message types

The difference between the **simplified** and **advanced** type of message is the addition of two headers and types of *payload* possible In the message forward must provide the header of "peer to peer" and "Mesh". **The simplified type of messages can only use the types of payload *dataWithoutAck* and *dataWithAck***

Payload: Simplified Message type

BYTE	Value	Description
0	0x24	Bytetiming
1	0x24	synchronization Byte
2	0-**n**	message size
3	0x00 0x00-0x7F	Message Type < 7> encryption Type <6: 0>
4 n - 4		Payload []
n - 3		Checksum
n - 2	0x0D	ender byte 1
n- 1	0x0A	ender byte 2

Table 2: Structure of a simplified message type

Message Type advanced

BYTE	Value	Description
0	0x24	Bytetiming
1	0x24	synchronization Byte
2	0-**n**	message size
3	0x01 0x00-0x7F	Message Type <7> encryption Type <6: 0>
4-7		destination P2P
8 11		P2P origin
12	0x00-0xFF	Message Type Mesh
13	0x00-0xFF	Message ID Mesh
14	0x00-0xFF	message reception confirmation ID Mesh
15-18		Mesh origin
19-22		Mesh Destination
23	0x00-0xFF	level compared to sending the message
24 to n - 4		Payload []
n - 3		ChkSum
n - 2	0x0D	Ender byte 1
n - 1	0x0A	Ender byte 2

Table 3: Structure of an advanced type of message

Encryption Types

Encryption Type <6: 0>	Value	Description
No	0x00	
Polymorphism	0x01	
RijndaelManaged[CBC]	0x02	
RSA 2048 bits	0x03	

Payload

Payload has a variable maximum size of 38 bytes. The first byte must be the type of *payload* of 5 bit and an encryption index of 3 bit. The byte 0 is therefore never encrypted because it contains the information necessary for decryption.

Payload [0] PayloadType <4: 0>

type payload <4: 0>	value	Description
TypeID	0x00	Return of identification information
Refresh	0x01	Backinformation about theModule
DataWithoutAck	0x02	Back / Send data without receiving confirmation
DataWithAck	0x03	Back / Send data with confirmation of receipt
FileTransfer	0x04	Sends data with afile transfer protocol
undefined	0x05 to 0x1B	
event	0x1C	event Type
return	0x1D	type return
Get	0x1E	type get
set	0x1F	Type set

Table 5: List of types of payload

payload [0] PayloadType <7: 5>

The encryption index is sent on 3 bit at index 0 of the payload.
See the section *Payload* encryption.

TypeID

Returns module identification information within a "CSV"
Structure of the *typeID* varies according to the device name.

See the documentation on the module concerned for details.
Example of "CSV" structure: "**device name, firmware version, hardware version Version EEPROM memory**"

Refresh

Return the module information. The type *refresh* must provide at least 3 information which are: the level relative to the origin of the request, the relay used to communicate with the origin and the ID of the group. The rest of the payload is variable depending on the module, see the documentation on the module concerned for details.

Payload []	Value	Description
0	0x01	Typepayload
1	0x00 - 0x1E (invalid: 0x1F)	level compared to the original
2 to 5		Relay
6	0x00 - 0xFF (default: 0xFF)	Group ID
7 to...		**Module Based.**

Table 6: Structure of the refresh type payload

DataWithoutAck

Back / Sends data without reception confirmation.

DataWithAck

Back / Send data with confirmation of receipt. Upon receipt of a message type *dataWithAck* a message subtype *ackData* will be sent to the origin.

FileTransfer

Sends data with a file transfer protocol.

Event

Type of event, see subtypes events for details.

Return

Return type, see subtypes back for details.

Get

Type of application, see the application subtypes for details.

Set

Type of modification, see subtypes changes for details.

Payload [1]: sub-type <7: 0>

Return Type	Value	Description
AckData	0x03	Receipt Confirmation
RoutingTableInfo	0x20	ID and level of known modules
TableLvl1	0x21	ID of this module in the level table 1
DebugInfos	0x22	
Settings	0x23	Module Settings
RSSI	0x24	signal strength between two modules
MasterID	0x25	master ID
NackInfos	0x2B	Confirmation not received
DecryptionError	0x2C	Error decryption
WrongParameter	0x2D	Invalid Parameter

AckData 0x03

Message receipt Confirmation. The message ID of the header "Mesh" is returned in the payload to indicate which message is confirmed.

RoutingTableInfo 0x20

List ID and level of known modules. For each index 3 requested destination of their associated relay and level will be sent. The possible index values are from 0 to size max / 3, round up if max size / 3 does not give a whole. If the 3 destinations are received 0xFFFFFFFF, it means that the module has not other destinations in its *routingTable* from this index.

0x1D	0x20	Index	Max	Dest [4]	relay [4]	Level

Dest [4]	relay [4]	Level	Dest [4]	relay [4]	Level

TableLvl1 0x21

List ID modules that are present in the level of table 1. For asked each index 8 ID will be send. The possible index values are from 0 to size max / 8, rounding up if size max / 8 does not give a whole.

0x1D	0x21	Index	Max	8 x ID [4]

DebugInfos 0x22

Information on the module. See the documentation on the module concerned for details.

Settings 0x23

Returns module parameters. See the documentation on the module concerned for details.

Rssi 0x24

Returns signal strength. See the documentation on the module concerned for details.

MasterID 0x25

Returns the master ID.

NackInfos 0x2B

Confirmation of non-receipt of the message. The message ID of the header "Mesh" is returned in the payload to indicate which message failed.

DecryptionError 0x2C

Decryption error detected. The message ID of the header "Mesh" is returned in the payload to indicate on what message the error occurred.

WrongParameter 0x2D

Parameter error detected. The message ID of the header "Mesh" is returned in the payload to indicate on what message the error occurred.

Payload [1]: subType <7: 0>

Application Type	value	Description
TypeID	0x00	Request of identifications information
Refresh	0x01	Request information from aModule
RoutingTableInfo	0x20	Request ID and the modules known
TableLvl1	0x21	Request the IDs of the modules present in the level 1 table
DebugInfos	0x22	
settings	0x23	module parameters Application
RSSI	0x24	Request signal strength between two modules
MasterID	0x25	request of the master ID

TypeID 0x00

Request of identifications of the information module. See the documentation on the module concerned for details.

Refresh 0x01

Application of module information. For each index requested 8 ID will be send. The possible index values are from 0 to size max / 8, rounding up if size max / 8 does not give a whole.

RoutingTableInfo 0x20

Application part of the list of known modules. For each index 3 requested destination of their associated relay and level will be sent. The possible index values are from 0 to size max / 3, round up if max size / 3 does not give a whole.

TableLvl1 0x21

Application part of the list of modules that are present in the table level 1. See the documentation on the module concerned for details.

DebugInfos 0x22

Information on the module. See the documentation on the module concerned for details.

Settings 0x23

Request module parameters. See the documentation on the module concerned for details.

Rssi 0x24

Returns signal strength. See the documentation on the module concerned for details.

MasterID 0x25

Request the master ID.

Type of change	value	Description
Settings	0x23	module parameters Modifications
MasterID	0x25	Changing the master ID
ForceRelay	0x26	Changing IDforced relay
Password	0x26	Changing the password
ResetMcu	0x28	RestartModule
CloseDevice	0x29	Module Closing

0x23Settings

Changing the module parameters. See the documentation on the module concerned for details

MasterID 0x25

Changing the master ID. Put into the desired payload ID.

ForceRelay 0x26

Changing the ID of forced relay. Put into the desired payload ID.

Password 0x26

Changing the password. Put in the payload the desired password.

ResetMcu 0x28

Reset the microcontroller.

CloseDevice 0x29

Close the module. Provide the unit of time (see Table 11) on a byte tracking time of 2 bytes (MSB followed by the LSB). Example: 4096 minutes = 0x02 0x10 0x00

Time unit	value
Milliseconds	0x00
Seconds	0x01
minutes	0x02
Hours	0x03

Table 11

Regulatory Informations

United States (FCC)

emMesh 1.31 RF Modules comply with Part 15 of the FCC rules and regulations. Compliance with the labeling requirements, FCC notices and antenna usage guidelines is required. To fulfill FCC Certification, the OEM must comply with the following regulations:

- The system integrator must ensure that the text on the external label provided with this device is placed on the outside of the final product.
- RF Modules may only be used with antennas that have been tested and approved for use with the modules.

OEM labeling requirements

As an Original Equipment Manufacturer (OEM) you must ensure that FCC labeling requirements are met. You must include a clearly visible label on the outside of the final product enclosure that displays the following content:

Contains FCC ID: 2ASI4EMMESH
This device complies with Part 15 of the FCC Rules. 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.

FCC notices

IMPORTANT: emMesh 1.31 RF Modules have been certified by the FCC for use with other products without any further certification (as per FCC section 2.1091). Modifications not expressly approved by Penteract could void the user's authority to operate the equipment.

IMPORTANT: OEMs must test final product to comply with unintentional radiators (FCC section 15.107 & 15.109) before declaring compliance of their final product to Part 15 of the FCC Rules.

IMPORTANT: The RF module has been certified for remote and base radio applications. If the module will be used for portable applications, the device must undergo SAR testing.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules.

These limits are designed to provide reasonable protection Regulatory information United States (FCC) emMesh 1.31 Module User Guide against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications.

However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures: Re-orient or relocate the receiving antenna, Increase the separation between the equipment and receiver, Connect equipment and receiver to outlets on different circuits, or Consult the dealer or an experienced radio/TV technician for help.

FCC-approved antennas

The modules are FCC approved for fixed base station for the channels indicated in the tables below.

If the antenna is mounted at least 25 cm (10 in) from nearby persons, the application is considered a mobile application.

Antennas not listed in the table must be tested to comply with FCC Section 15.203 (Unique Antenna Connectors) and Section 15.247 (Emissions).

The antennas in the tables below have been approved for use with this module.

Cable loss is required when using gain antennas as shown in the tables.

Antennas	Supplier	Part Number	Gain
External	Pulse Electronics	*W1063*	3.0 dBi
Internal	NA	AWG24 Wire 85mm length (1/4 wave monopole)	3.0 dBi

RF exposure

If you are an integrating the emMesh into another product, you must include the following Caution statement in OEM product manuals to alert users of FCC RF exposure compliance:

CAUTION! To satisfy FCC RF exposure requirements for mobile transmitting devices, a separation distance of 20 cm or more should be maintained between the antenna of this device and persons during device operation. To ensure compliance, operations at closer than this distance are not recommended. The antenna used for this transmitter must not be colocated in conjunction with any other antenna or transmitter.

CANADA - ISED
(Innovation, Science and Economic Development Canada)

Labeling requirements

Labeling requirements for Industry Canada are similar to those of the FCC. A clearly visible label on the outside of the final product enclosure must display the following text:

Contains Model emMesh 1.31 Radio, IC: 24776-EMMESH

The integrator is responsible for its product to comply with IC ICES-003 & FCC Part 15, Sub. B - Unintentional Radiators. ICES-003 is the same as FCC Part 15 Sub. B and Industry Canada accepts FCC test report or CISPR 22 test report for compliance with ICES-003.

Detachable antenna

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (EIRP) is not more than that necessary for successful communication.

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire àl'établissement d'une communication satisfaisante.

EUROPE (CE)

The emMesh 1.31e Modules have been tested for use in several European countries.

If emMesh 1.31e Modules are incorporated into a product, the manufacturer must ensure compliance of the final product with articles 3.1a and 3.1b of the Radio Equipment Directive. A Declaration of Conformity must be issued for each of these standards and kept on file as described in the Radio Equipment Directive. Furthermore, the manufacturer must maintain a copy of the emMesh 1.31e Module user guide documentation and ensure the final product does not exceed the specified power ratings, antenna specifications, and/or installation requirements as specified in the user guide.

Maximum power and frequency specifications

Maximum power: 26.5 dBm Equivalent Isotropically Radiated Power (EIRP) at normal condition.

OEM labeling requirements

The “CE” marking must be affixed to a visible location on the OEM product. The following figure shows CE labeling requirements.

The CE mark shall consist of the initials “CE” taking the following form:

If the CE marking is reduced or enlarged, the proportions given in the above graduated drawing must be respected.

The CE marking must have a height of at least 5 mm except where this is not possible on account of the nature of the apparatus. The CE marking must be affixed visibly, legibly, and indelibly.

Penteract customers assume full responsibility for learning and meeting the required guidelines for each country in their distribution market. Refer to the radio regulatory agency in the desired countries of operation for more information.

Declarations of conformity

Penteract has issued Declarations of Conformity for the emMesh concerning emissions, EMC, and safety.

Antennas

Please refer to FCC list of Antennas

Warranty

The only recourse for the customer under this limited warranty is the repair or replacement of the product as described above. Claims based on warranties, including warranties of merchantability or adaptation to a particular use, are limited to the shortest period permitted by law, which can not be less than 3 months. Penteract Consulting Inc. will not be held liable for incidental or consequential damages or material damage.

Any damage resulting in faulty usage or integration of current module could be used against Penteract and will automatically void the warranty. Usage not based in respect of following document will also void the warranty automatically.

Some states do not allow limitations or exemption for incidental or consequential damages or restriction of guarantees. In this case, this limitation or exclusion may not apply. This written warranty gives you specific legal rights. According to the state or province, it is possible that you have other rights.