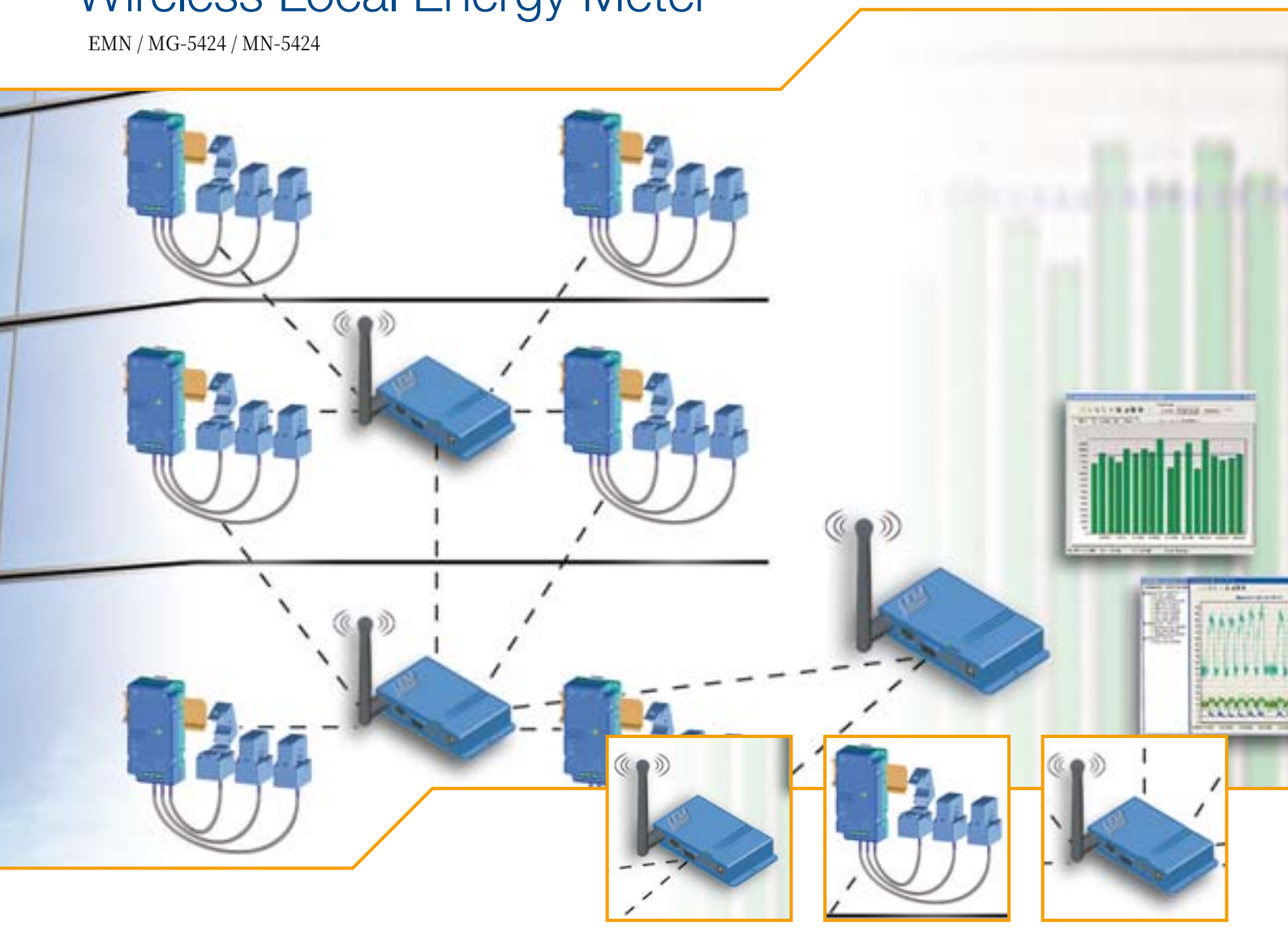
User Manual

Wi-LEM

Wireless Local Energy Meter

EMN / MG-5424 / MN-5424



Doc. No: CH 26102
Version: 1.0
Date: 29.01.07

LEM®

I. IDENTIFICATION

I.1 DOCUMENT

Wireless Local Energy Meter (Wi-LEM) User Manual

Software Version : 1.0

Nb. : CH 26102

Last Modifications : 29.01.2007

I.2 MANUFACTURER

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1 NOTICES

1.1 Certification directives

The present product is designed to fully agree with the following directives:

CE, FCC, IC and JAPAN

- Federal Communication Commission Interference Statement

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 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 of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that

  to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

FCC Caution: Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment. (15.21)

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. (15.19)

IMPORTANT NOTE:

FCC Radiation Exposure Statement:

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20cm between the radiator & your body.

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

- Industry Canada statement:

This device complies with RSS-210 of the Industry Canada 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.

IMPORTANT NOTE:

Radiation Exposure Statement:

This equipment complies with IC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20cm between the radiator & your body.

For more information, contact LEM's customer service.

1.2 Safety instructions

1.2.1 Introduction

1.2.1.1 Principle

The user must have read and understood this chapter before undertaking any action with / in the system.

For all information considered inadequate, please contact the manufacturer or your local representative.

⚠CAUTION **FAILURE TO FOLLOW THESE INSTRUCTIONS MAY CAUSE SERIOUS ACCIDENTS !**

All device users, such as :

- owners;
- installers, maintenance and service personnel, or any other person in related job functions;
- managers, operators, setters, programmers, foremen, mechanics;

must read and strictly follow the safety instructions in this document.

These regulations also pertain to options, components, installations, devices and systems related to the machine.

1.2.1.2. Importance of safety indications

All the safety and protection instructions given in this manual must be respected to prevent reversible or irreversible bodily injuries, material damages or environmental pollution. Similarly, legal regulations, accident prevention and environment protection measures, as well as recognized technical regulations, aimed at appropriate risk-free work methods in force in the country and in the machine workspace must be respected.

1.2.1.3. Failure to respect safety regulations

Any non-respect of the safety and protection rules, as well as existing legal and technical regulations, could cause reversible or irreversible bodily injuries, material damages or environmental pollution.

1.2.2 General rules for all users

⚠ WARNING **READ AND FOLLOW THE USER INSTRUCTIONS AND MANUALS DELIVERED WITH THIS SYSTEM. ONLY PEOPLE TRAINED FOR MANIPULATIONS AND ACQUAINTED WITH THESE INSTRUCTIONS CAN WORK ON THE DEVICE.**

1.2.3. User manuals

- User instructions and manuals delivered by the manufacturer with the system or at a later date must be brought to the attention of all people operating on the device or responsible for it in any way;
- These people must read and strictly follow the user instructions and manuals;
- After the reception of updates, if any, the user will update the documentation.
- Anyone likely to work on the device must have access to the user instructions and manuals.

⚠CAUTION **DOCUMENT TO BE KEPT TO REFER TO IT LATER ON.**

1.2.4 Differentiation of degrees of risk

1.2.4.1 General risks

⚠ DANGER WARNS AGAINST A DIRECT DANGER OF DEATH OR SERIOUS INJURY.

⚠CAUTION INDICATES INCORRECT ACTIONS WHICH MAY CAUSE MINOR HUMAN INJURY OR MAJOR MATERIAL DAMAGE TO THE SYSTEM AND ENVIRONMENT.

⚠ WARNING FOR INFORMATION, INDICATES HANDLING ERRORS OR NEGLIGENCE WHICH MAY CAUSE MATERIAL DAMAGE ON THE DEVICE.

1.2.4.2 Electric cabinet or live components

⚠ DANGER ONLY A QUALIFIED PERSON IS AUTHORIZED TO INTERVENE INSIDE THE ELECTRIC CABINETS OR ON A LIVE COMPONENT.

2. WI-LEM AND NETWORK DESCRIPTION

2.1 About the Wi-LEM (Wireless Local Energy Meter)

The Wi-LEM is a complete data acquisition platform to measure and transmit electrical parameters used for Energy Management application. As it is an open architecture, this platform can be easily interfaced with existing data logger and energy monitoring software.

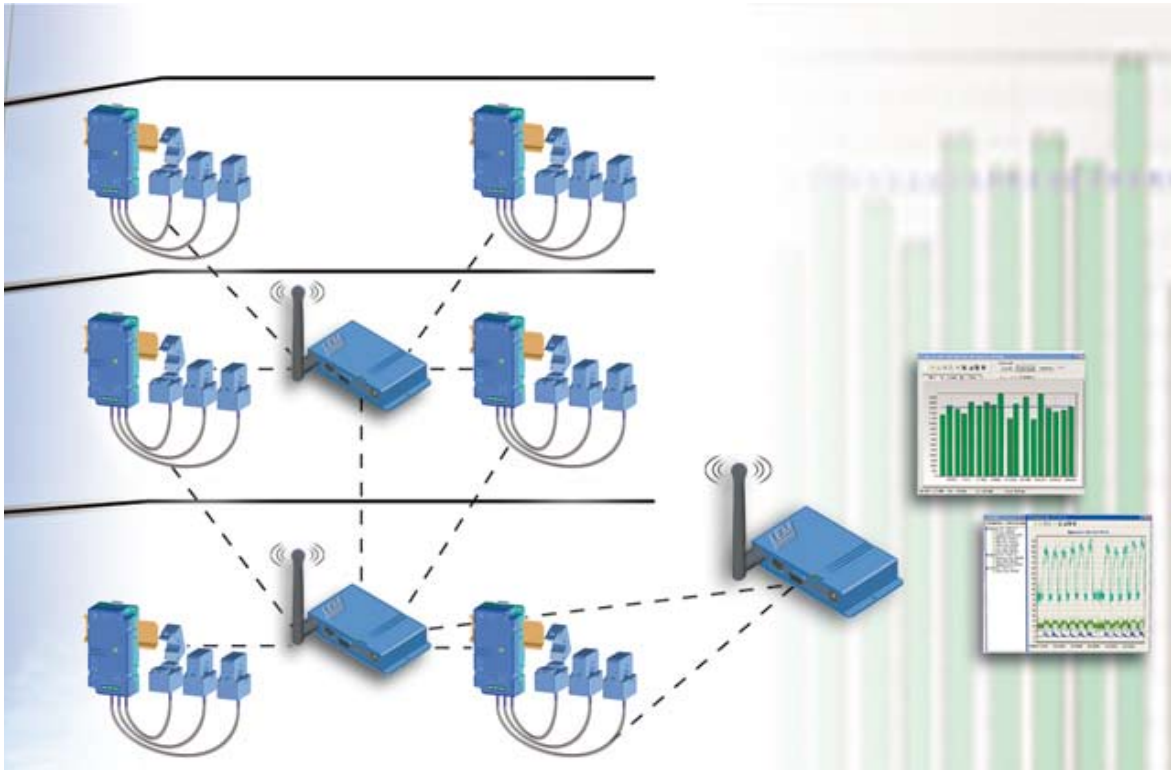


Fig. 2-1: Principle of Wireless Local Energy Meter (Wi-LEM)

The Wi-LEM is constituted by 3 mains parts:

- **Energy Meter Node (EMN)**: sub-meter which calculates several electrical parameters with pre-wired split core current transformers (CT) and embedded wireless data transmission (for more information, see next page).

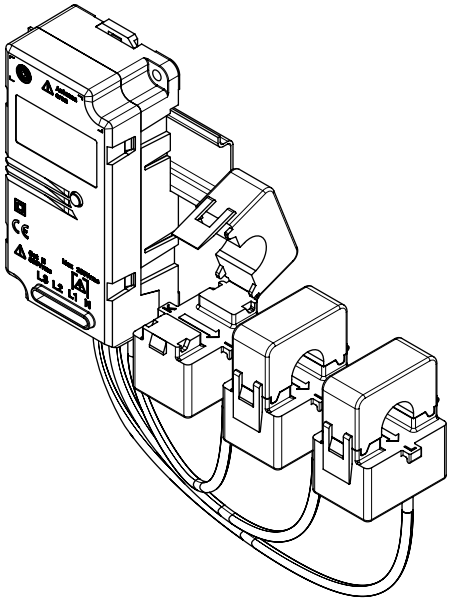


Fig. 2-2: Energy Meter Node

- **Mesh Gate (MG)**: stand alone gateway which manages the wireless network and collect the data periodically sent by the EMN. The MG can be accessed by the data logging system for analysis.

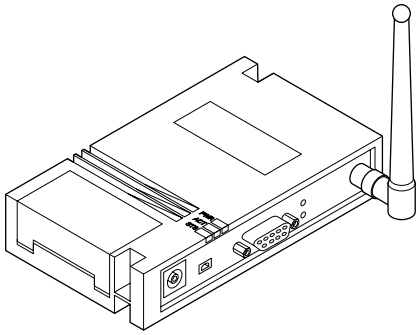


Fig. 2-3: Mesh Gate

- **Mesh Node (MN)**: repeater extending the distance of the transmission between the EMN and the MG when needed.

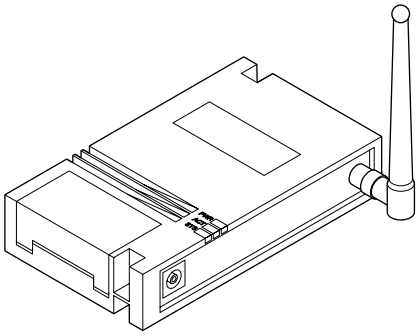


Fig. 2-4: Mesh Node

2.2 Energy Meter Node (EMN)

The Energy Meter Node (EMN) is a 3-phase electric meter with a wireless (radio) communication.

1. Led indicator

For more information about the LED indicator, see chapter 3.4.5.

2. Antenna
3. Clipping fixture for DIN Rail
4. Identification label (ID)
5. Current Transformer (CT)
6. Voltage input

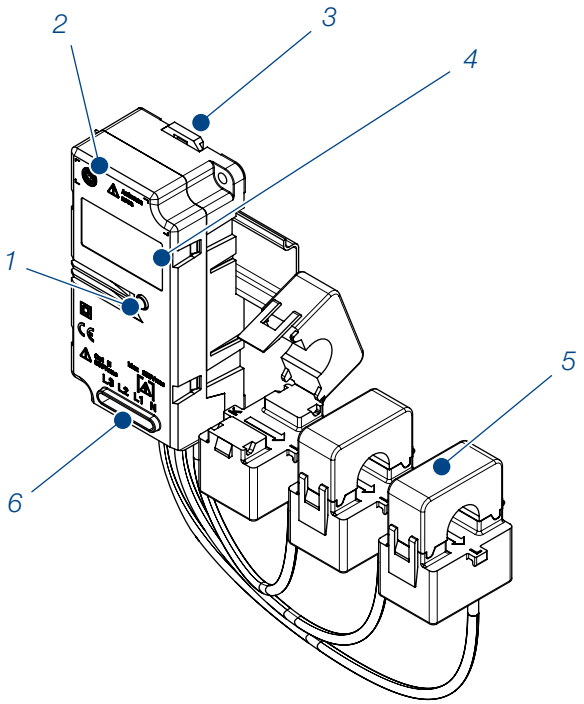


Fig. 2-5: Energy Meter Node

2.2.1 Detailed Description

Data from the meter is sent to the gateway for user access periodically.

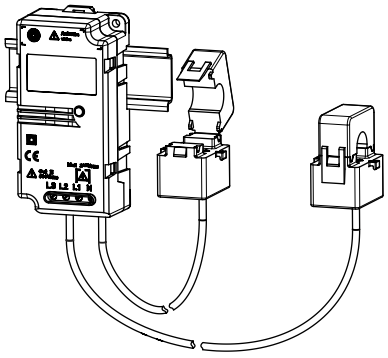
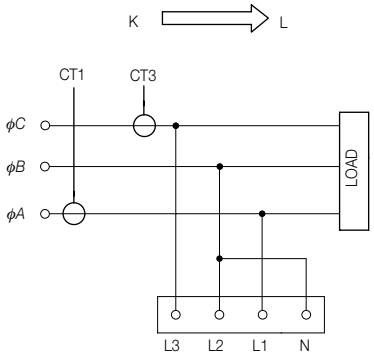
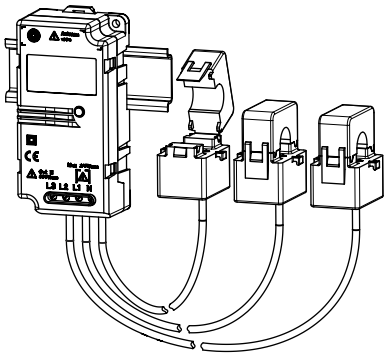
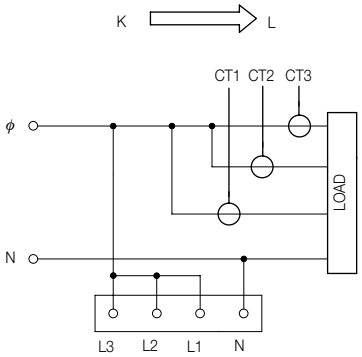
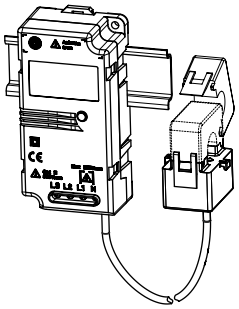
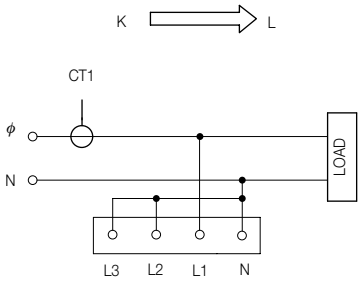
The meter data is split into three sections:

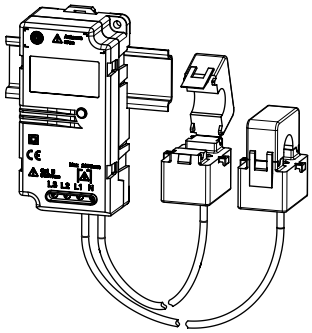
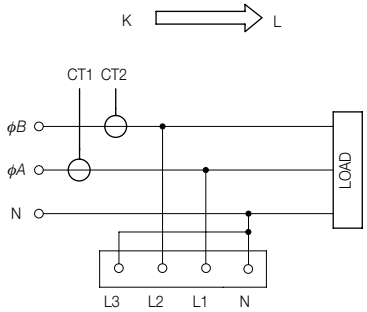
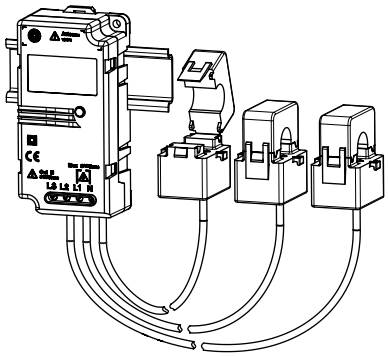
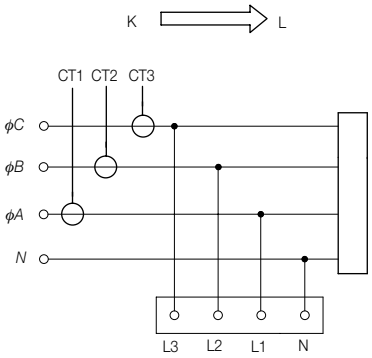
- **Energy Meter:** Active, reactive and apparent energy per phase and sum with a time-stamp.
- **Recording Interval Meter:** Active, reactive and apparent energy per phase and sum with a time-stamp of the end of the recording interval; minimum voltage per phase and maximum current per phase during recording interval; frequency
- **Meter Identification and Configuration:** Meter configuration and version; recording interval time setup, command and status word.

2.2.2 Models Description

The following table lists the different models of Energy Meter Node available.

Table 2-1: Model Description

Model*	Wiring Diagram
EMNxxxD3 (Delta - 3 wires)	  *As the maximum voltage is 265 V_{RMS}, this model can not be used on 400 or 480V_{RMS}. Delta Network.* V_{BA} *and* $V_{BC} \leqslant 265\ V_{RMS}$
EMNxxxW0 (3 single phases on same voltage)	  $V_{N\phi} \leqslant 265\ V_{RMS}$
EMNxxxW2 (Single phase - 2 wires)	  $V_{N\phi} \leqslant 265\ V_{RMS}$

Model*	Wiring Diagram
EMNxxxW3 (Wye - 3 wires)	  V_{NA} and $V_{NB} \leqslant 265\ V_{RMS}$
EMNxxxW4 (Wye - 4 wires)	  V_{NA} , V_{NB} and $V_{NC} \leqslant 265\ V_{RMS}$

* for more information about model names, see chapter 4.2.9 "product identification"

2.2.3 Main Characteristics

- Primary Nominal Current (I_{pN}): ..... 5A / 20A / 50A / 100A (according to the model)
- Primary Current Measuring Range: ..... 10% . . .120% x I_{pN}
- Primary Voltage Measuring Range (V_p): ..... 90 to 265 V_{RMS}
- Frequency (f):..... 50 / 60 Hz
- Maximum power consumption ..... 2 W
- Maximum supply current (N-L1)..... 0.2 A_{RMS}
- Ambient operating temperature (90% rH) (T_A)... - 10 .. + 55 °C
- Mass (m) ..... 400 g
- Protection Index IP2X
- Isolation ..... ⧈ Isolation class II
IEC 61010-1 CAT III V rms

For more details about technical characteristics, refer to the datasheets about the EMN series.

2.3 Mesh Gate description

1. LED indicators (see table hereunder)
2. Power supply 9 V DC
3. Mini USB connector "CONSOLE"
4. RS232 connector
5. Antenna

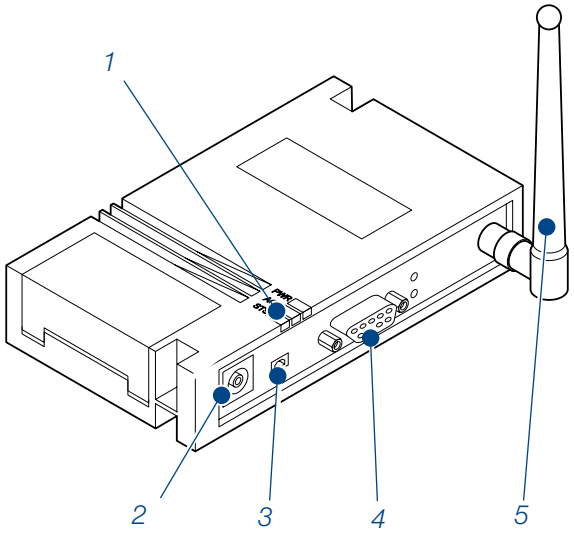


Fig. 2-6: Mesh Gate

Table 2-2

LED	LED Status	Description
PWR	ON	Connection with host device detected.
	Blinking	No host device detected or MeshScape Network Monitor not running.
	OFF	Power has been removed.
ACT	Flashing	Gateway detects RF activity. The activity LED will flash when detecting valid packets (packets destined for device) and may also flash when detecting invalid packets (packets destined for other devices) or environmental noise. Only valid packets are processed by the device.
	OFF	
STS	*(Reserved for future use.)*	

2.4 Mesh Node description

1. LED indicators (see table hereunder)
2. Power supply 9 V DC
3. Antenna

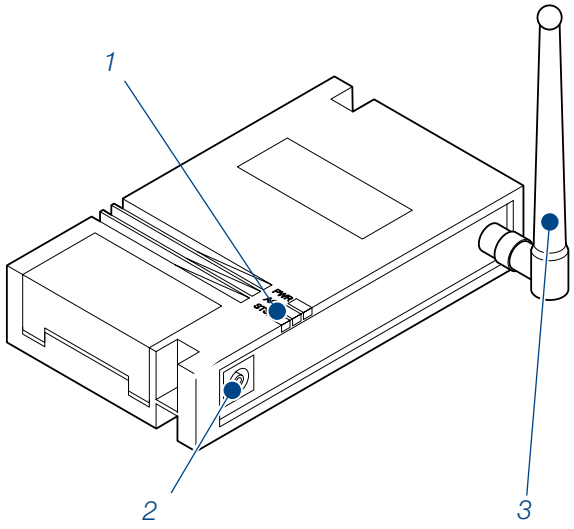


Fig. 2-7: Mesh Node

Table 2-3

LED	LED Status	Description
PWR	ON	Power ON
	OFF	No Power
RF Activity	Flashing	Mesh Node detects RF activity. The RF activity LED will flash when detecting valid packets (packets destined for device) and may also flash when detecting invalid packets (packets destined for other devices) or environmental noise. Only valid packets are processed by the device.
	OFF	No RF activity detected.
STS	ON	The Mesh Node has established two single northbound pathways to the Mesh Gate.
	Blinking	The Mesh Node has established a single northbound pathway to the Mesh Gate.
	OFF	The Mesh Node is not on the MeshScape network

2.5 Network

2.5.1 Network Characteristics

- Radio standard: 802.15.4
- Protocol ..... Millennial.Net
- RF Band: .....2.4 GHz
- RF Power: ..... 1 mW (0 dBm)
- Operating range between
  EMN and MG or MN.....20 m (65 ft)
  MG and MN .....30 m (100 ft)

2.5.2 Introduction

The radio network is self-configuring. The nodes IDs are factory programmed and usually do not need to be changed.

In a mesh network, there are often several different routes possible for a message from a EMN to the MG through Mesh Nodes. The path with the least **hops** (RF steps between 2 nodes) to routers will be used if available.

More routers can be used for long distances or to add routes from a EMN to the MG in areas with a changing environment.

Different topologies are available (See figures).

2.5.3 Description

Each EMN and the MG are equipped with a radio module.

The measurement values of the EMN are buffered in the gateways RAM.

The MG is updated by each EMN periodically depending on the network configuration.

When addressing a EMN Modbus slave, the MG responds directly. As the MG contains an image of the EMN values, there is no need to pass the message on to the EMN.

A write command, however, is forwarded to the EMN, a delay of 2 to 4 minutes can occur for the response message.

Refer to «Modbus interface» on Chapter 4.4.1. for more information.

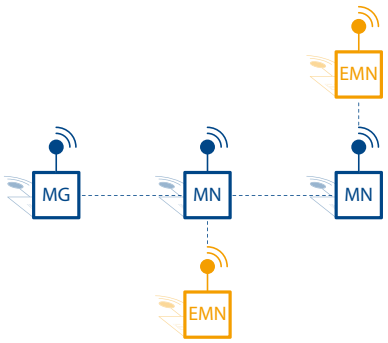


Fig. 2-8: Single path between MG, MN and EMN (Linear)

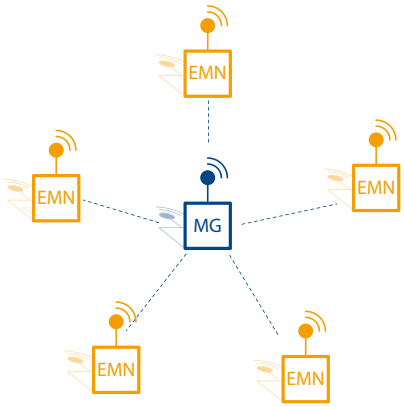


Fig. 2-9: Combination of low power EMN with a MG (Simple Star)

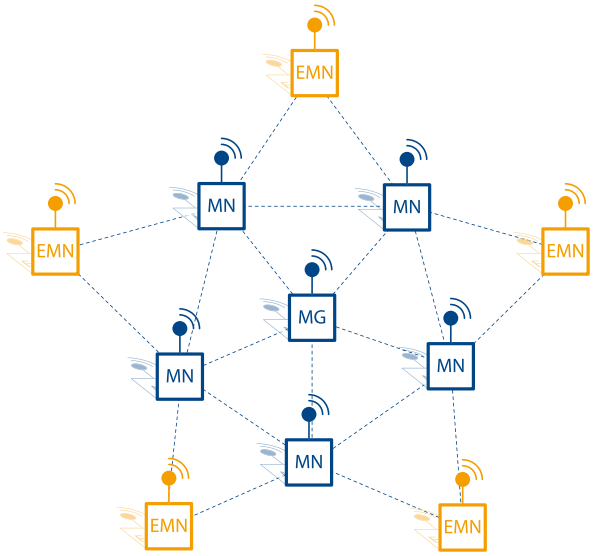


Fig. 2-10: Network with a combination of reliability and low power (Star Mesh Network Topology)

3. HARDWARE INSTALLATION AND CONTROL

This chapter describes how to install the hardware to set up the Wireless Mesh Sub-meter Network.

3.1 Important warning and notices

DANGER RISK OF ELECTRICAL SHOCK: THIS EQUIPMENT CONTAINS HAZARDOUS VOLTAGE THAT MAY CAUSE SERIOUS INJURY OR DEATH TO PERSONS IF PRECAUTIONS WITHIN THIS GUIDE ARE NOT FOLLOWED. DO NOT REMOVE ANY PART OR CUT SENSOR CABLE OF THE EMN.

⚠CAUTION THIS ELECTRIC EQUIPMENT MUST BE USED IN ELECTRIC / ELECTRONIC EQUIPMENT WITH RESPECT TO APPLICABLE STANDARDS AND SAFETY REQUIREMENTS IN ACCORDANCE TO THE MANUFACTURER'S OPERATING INSTRUCTIONS.

⚠ WARNING INSTALLATION AND SERVICE MUST BE DONE BY QUALIFIED PERSONNEL ONLY ON POWER LOCKED CABINET

⚠CAUTION EMN AND ITS PREWIRED CURRENT TRANSFORMER ARE DESIGNED FOR USE IN RESTRICTED ACCESS CABINET.

- Do not install the equipment in cabinet which does not provide a sufficient protection level according to the datasheet
- Do not remove or change any part of the product, it may damage it or other equipment or cause serious injury or death.
- In case of accidental degradation of enclosure or other part, do not install the equipment or remove it from installation and carry out its replacement.
- Do not degrade or cut any part of the enclosure and cables.

3.2 Before You Start

- Check carefully that the EMN Model received is appropriate for the system to be monitored. Otherwise, wrong or incomplete data may be sent to the Mesh Gate (MG).
- Read carefully this manual and take care of the warning notes.

3.3 Network deployment recommendations (Mesh Node and Mesh Gate installation)

Prior to define your network and the elements location, read the following informations.

⚠ WARNING **FOR A CORRECT DEPLOYMENT OF A NEW NETWORK, THE MESH GATE MUST BE POWERED BEFORE ALL OTHER NODES.**

3.3.1 Site Planning and data collection

- Number of floors, layout;
- Network topology – dense versus spread out/ serial;
- Type of building material;
- Power availability for nodes not attached to meters;
- Any known obstacles or RF interferences; (Heating pipes, electrical room, etc.);
- “Bridge” Mesh Node Placement;
- Detect other 2.4 GHz interference.

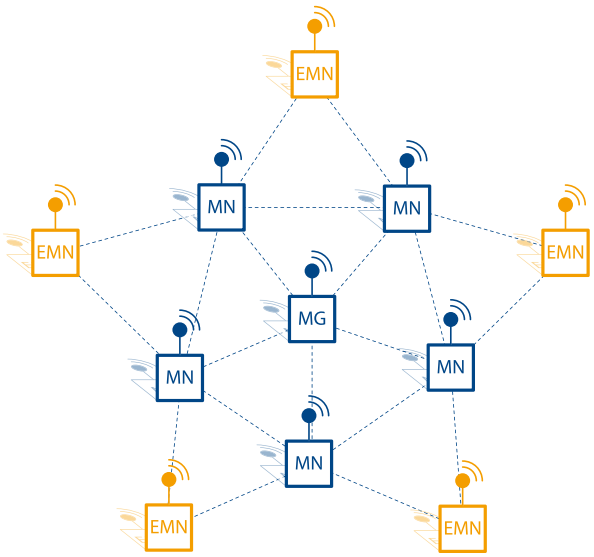


Fig. 3-1: Network with a combination of reliability and low power (Star Mesh Network Topology)

3.3.2 EMN location

To obtain the best effectiveness of the network, apply the following recommendations.

- Do not install EMN in front of or close to metallic parts. That may reduce the efficiency of the embedded antenna.
- Avoid proximity of Electromagnetic Induction.
- Respect the illustrated layout to insure an optimized orientation of the antenna.

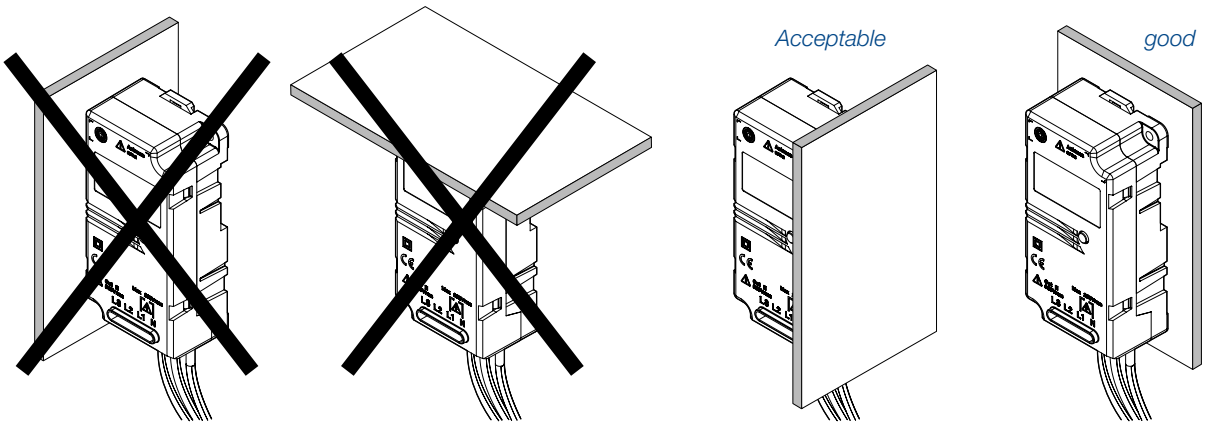


Fig. 3-2: Avoid the proximity of the antenna with metal parts

3.3.3 Mesh Gate location and connection

- It is always preferable to place the Mesh Gate in middle of network.
- Need for PC (start-up/diagnostic/troubleshooting)

A Power on the Mesh Gate by plugging the power **supply adaptor 9V**.

B Connect the Data Port **RS232** to the COM port of the computer. If the **Meshscape Monitor** is not required, the Modbus Master can also be connected to the **RS485** port situated inside the cover of the **Mesh Gate**

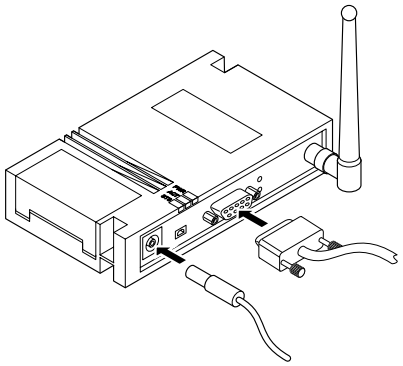


Fig. 3-3: Connect the Mesh Gate RS232 port to the PC

3.3.4 Mesh Node location and connection

- RF waves radiate out from antenna in doughnut shape
- Communicating antennas should be parallel to each other
- Avoid placing Mesh Node right under an EMN.

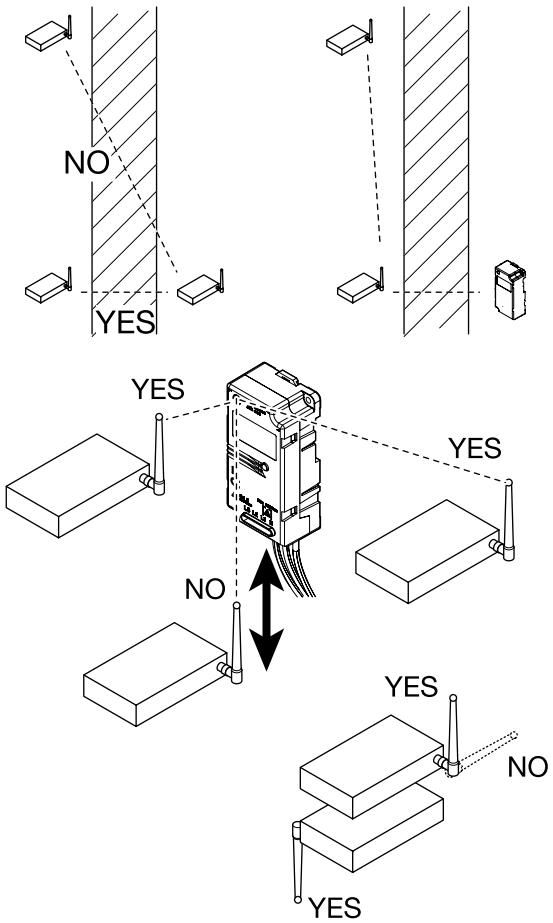


Fig. 3-4: location advising

A Power on the Mesh Node by plugging the power supply adaptor 9V **(1)**.

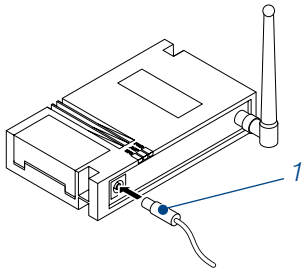


Fig. 3-5: Connect the Mesh Node power supply

3.4 Energy Meter Node Mounting

⚠ DANGER **MAKE SURE THAT THE LOCATION WHERE THE ENERGY METER NODE HAS TO BE FIXED IS POWERED OFF.**

3.4.1 Wall and panel Mounting

A Prepare the mounting holes.

B Fix the EMN to the wall or the panel with the screws **(1)**.

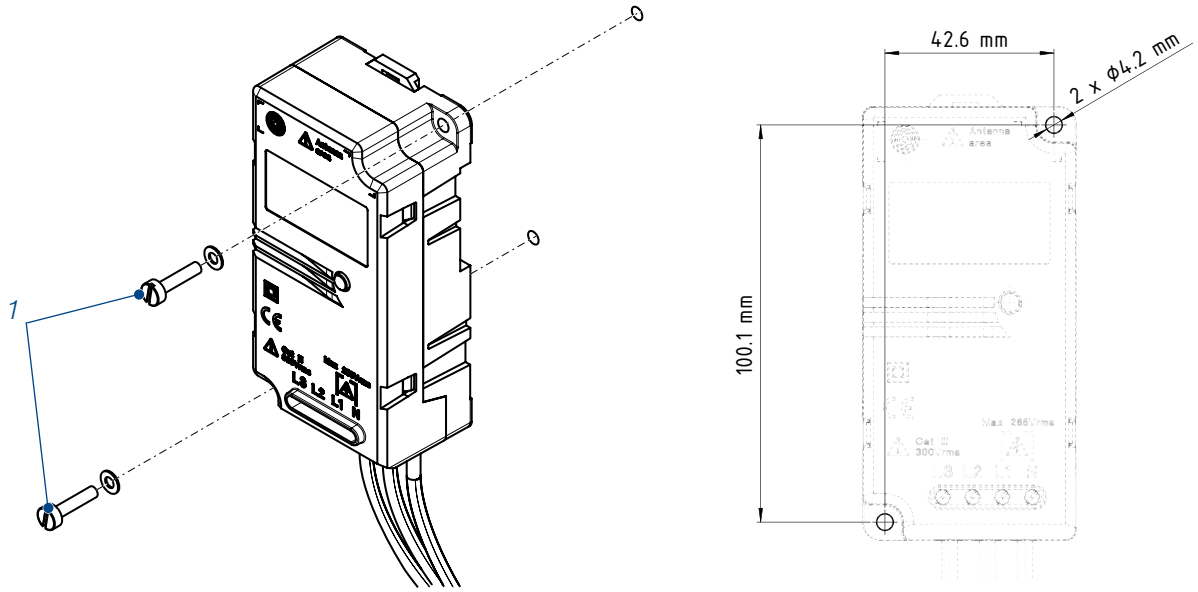


Fig. 3-6: Fixing the EMN on a wall or panel

Note: *Use max fastening torque 2.8 Nm (2 Lb.-Ft)*

3.4.2 DIN Rail Mounting

A Clip the EMN on the DIN Rail **(3)**.

B Pull up the clipping fixture **(2)** to remove the EMN from the DIN Rail.

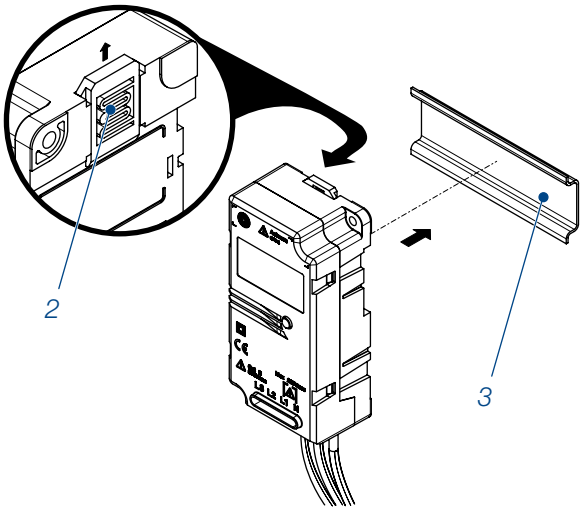


Fig. 3-7: Fixing the EMN on the DIN Rail

3.4.3 Current Transformer mounting

DANGER MAKE SURE THAT THE POWER CABLE ON WHICH THE CURRENT TRANSFORMER IS ATTACHED IS POWERED OFF.

⚠CAUTION THESE CURRENT TRANSFORMERS ARE DESIGNED FOR LESS THAN 50 OPEN/CLOSE CYCLES, DO NOT USE AS A CLAMP ON METER.

⚠ WARNING KEEP THE MATING SURFACES (2) PARTICLE FREE OTHERWISE ACCURACY MAY BE DEGRADED.

⚠CAUTION THESE CURRENT TRANSFORMERS HAVE BEEN DESIGNED FOR ISOLATED CABLE USE ONLY.

A Respect the Current Transformer phase allocation according to Voltage phase allocation.

If the phase allocation is wrong, the EMN will send incorrect energy data.

Refer to chapter 2.2.2 for more details about the phase allocation.

B Make sure that the arrow **(3)** shows the way of the positive current flow from the generator to the load. In this case, the label **(6)** is facing the load.

This allows the EMN to calculate Active Energy with the right sign.

C Close the Current Transformer around the cable **(1)**.

D Use the mounting clip **(5)** to attach the Current Transformer on the cable **(4)**.

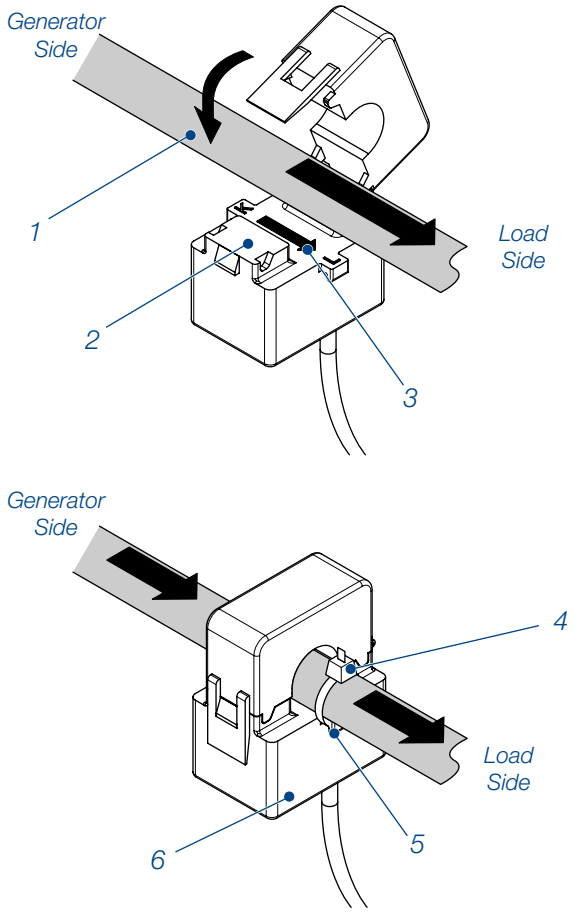


Fig. 3-8: Current Transformer mounting

3.4.4 Voltage Input connection

⚠ WARNING **A CIRCUIT BREAKER OR SIMILAR DEVICE MUST BE INSTALLED BETWEEN THE MAIN SUPPLY AND THE ENERGY METER NODE FOR LINE PROTECTION. REFER TO THE COUNTRY REGULATIONS AND EMN CHARACTERISTICS TO DEFINE THE APPROPRIATE PROTECTION TO BE USED.**

⚠ DANGER **MAKE SURE THAT THE WIRES THAT YOU CONNECT TO THE VOLTAGE INPUT ARE POWERED OFF.**

3.3.4.1 Procedure

Refer to «Model Description» on Chapter 2 for more details about the Wiring Diagram of the Energy Meter Node.

A Connect the wires from the line to the right Input Voltage connecting points **(1)**.

Use 2.5 mm² wire for single wire and 1 mm² wire for 2 wires.

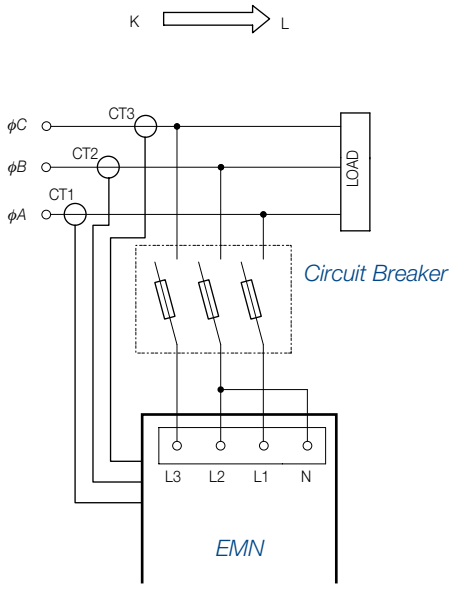


Fig. 3-9: Example of Circuit Breaker connection

3.4.5. LED indicator description

The LED Indicator (2) has the following status:

1 blink, wait 2 seconds:
Normal operation:

2 blinks, wait 1 second:
Radio module communication error: EMN is unable to send data.

3 blinks, wait 1 second:
Meter not synchronized to 50/60Hz: Frequency out of range of 50Hz - 10% to 60Hz + 10%.

4 blinks, wait 1 second :
Comm- & Synch error together:

5 blinks, wait 1 second:
Checksum Error: If a reset-meter command followed by an OFF/ON sequence does not reset this error, the calibration memory is corrupt and the device needs to be sent back to LEM.

6 blinks, wait 1 second:
Direct serial communication mode (factory use only).

7 blinks, wait 1 second:
Internal hardware failure.

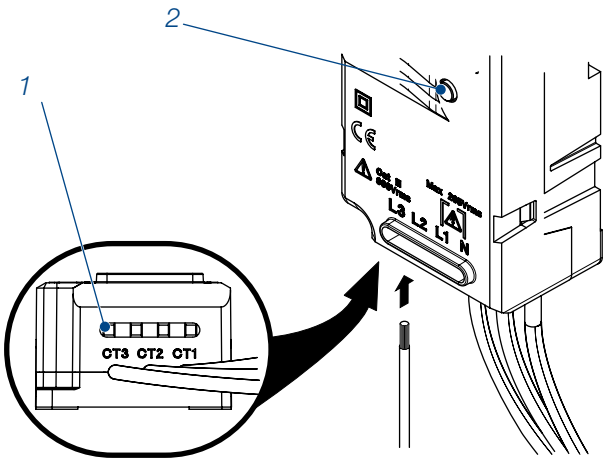


Fig. 3-10: Connecting the wires to the Input Voltage

3.5 Network installation

By default, the Mesh Gate is configured for **MODBUS** mode.

The network installation might need the MeshScape Monitor application which requires the Mesh Gate to be in **STANDARD** mode. In this case, configure the data port for **RS232** at a baud-rate of **115200**, **no flow control**

This **STANDARD** mode provides more information on the network status.

3.5.1 Mesh Gate connection

The Mesh Gate configuration such as baud rates, flow control etc. , can be set through the **CONSOLE** interface. It can be used with any serial terminal such as **HyperTerminal** on Windows operating systems.

A Power on the Mesh Gate by plugging the **power supply adaptor 9V (1)**.

B Connect the **CONSOLE** (mini USB **(2)**) interface to the COM port of the computer (SUBD).

- Use cable ref. : XXX

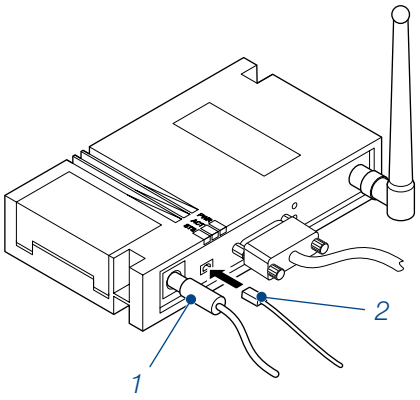


Fig. 3-11: Mesh Gate to PC connection

Table 3-1: Pin-out for the Mesh Gate terminal block

RS485			PWR OUT		RS232				PWR IN	
RTN	A	B	3.3V	GND	RTS	CTS	RX	TX	GND	+

The function of each Mesh Gate block pin is described as follows:

Table 3-2: Mesh Gate terminal block pin assignments

Pin	Label	Input / Output	Function
1	RTN	Reference	Reference connection for RS485
2	A	I/O	RS485 signal +
3	B	I/O	RS485 signal -
4	3.3V	Output Power	3.3V Output power
5	GND	Power	Digital ground
6	RTS	Input	RS232 Request to send
7	CTS	Output	RS232 Clear to send
8	RX	Output	RS232 Receive data
9	TX	Input	RS232 Transmit data
10	N/A	N/A	Not used
11	GND	Power	Digital Ground
12	+	Power	Input power (4.5V to 30V)

3.5.1.1 Fixed CONSOLE port configuration

- Baud Rate 115200
- Data Bits 8
- Parity . . . . . None
- Stop Bits 1
- No flow control

3.5.1.2 Standard or MODBUS modes selection

The HyperTerminal displays the message "**Starting SAG-Lite Mesh Gate Interface**".

Fig. 3-12: Mesh Gate Console Interface Main Menu

A Press **"ENTER"** to start the application.

B Press **"a"** to enter the **"Administration"** menu.

C Press **"a"** to change the Mesh Gate application.

- The **Standard (MACS)** needs to be set for use with the **MeshScape** network monitor.
- The **Modbus Data Logger** should be set for access to the **EMN in Modbus mode**.

Fig. 3-13: Mesh Gate Console Interface Administration Menu

D The Data Port setting for the **RS-232/RS485** interface are accessed from the Administration menu, by pressing **"h"** for **"Configure Data Port"**.

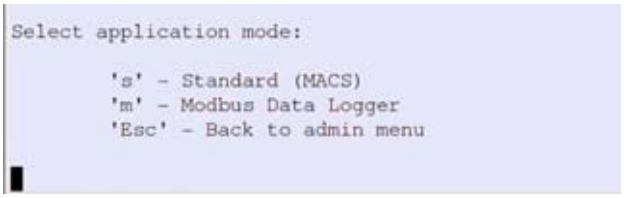


Fig. 3-14: Mesh Gate Console Interface Application Menu

3.5.1.3 Data port configuration (default RS232)

DB-9 style connector :

RS-232 Data Port connector with standard DCE connections for transmit data, receive data, RTS input, and CTS output.

- Baud Rate 115200
- Data Bits 8
- Parity None
- Stop Bits 1

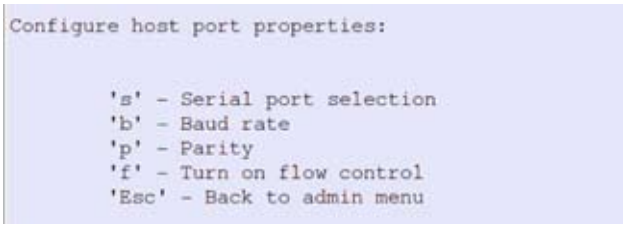


Fig. 3-15: Mesh Gate Console Interface Port Settings Menu

3.5.2 MeshScape Monitor

With the Mesh Gate switched to **Standard Application**, the **MeshScape Monitor** software can be used to view the network.

1. Menu bar
2. Mesh Gate details
3. Network details
4. Mesh Node, End Node and EMN details (EMN contains an End Node)

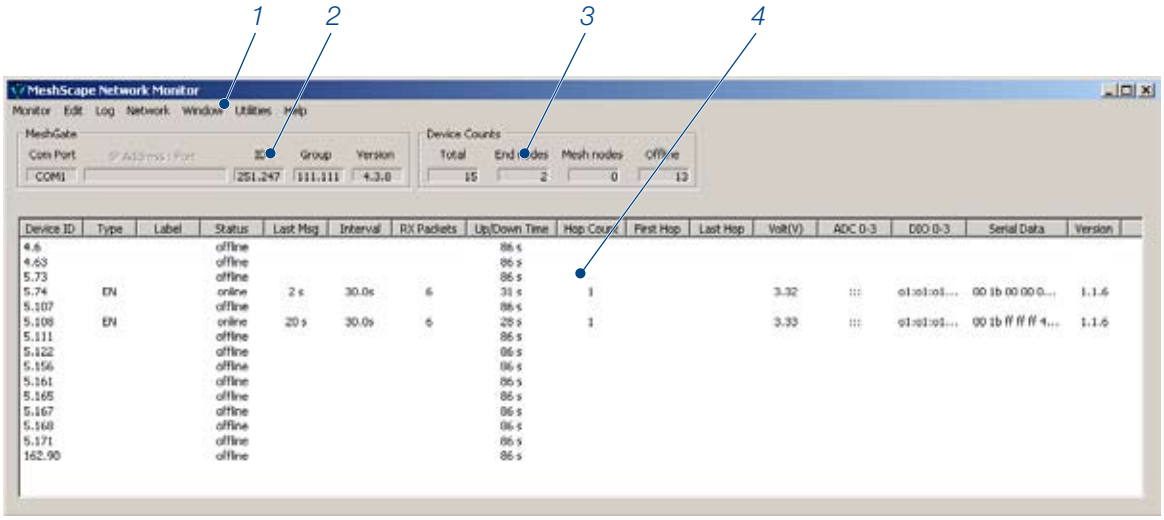


Fig. 3-16: MeshScape Monitor main screen

3.5.2.1 Network Initialisation and control

The network starts building itself once the Mesh Gate is powered on.

Depending on the physical topologies, a network may take up to 5 minutes to be formed.

- Each router (Mesh Node) or EMN that is powered on should be seen in the monitor application.
- The Hop count can help to determine if additional routers are necessary.
- If a transducer is not “seen” by the Mesh Gate (monitor), verify the distances to the next Mesh Node/Mesh Gate. An additional Mesh Node should be placed between the transducer and the nearest Mesh Node.
- To verify the functioning of the EMN, observe the serial data of the corresponding line. At regular intervals there will be new data written. The interval is not changeable and is between 5 and 30 seconds.
- None of the EndNode (in EMN) parameters should be changed!

3.5.2.2 Addressing a Node

The nodes are already addressed at factory.

However, in case of addition of nodes in an existing network, it can be necessary to change the ID address of the node.

The Group ID and the Device ID are printed on the label on the front cover of the EMN or Mesh Node **(1)**.

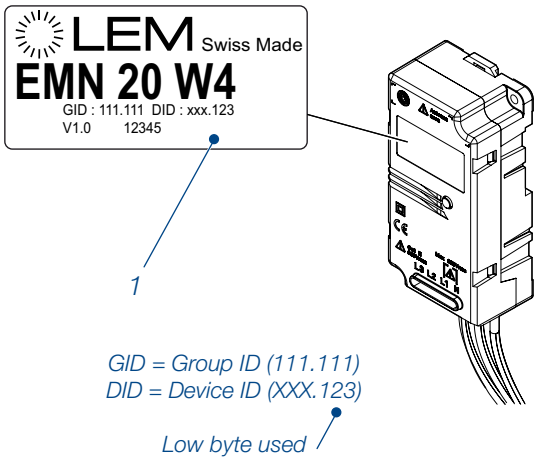


Fig. 3-17: ID labels

A Select **Utilities,** then the command **"Update Network Identity"**.

The window beside is displayed.

B Enter the new ID of the node in the field **(2)**.

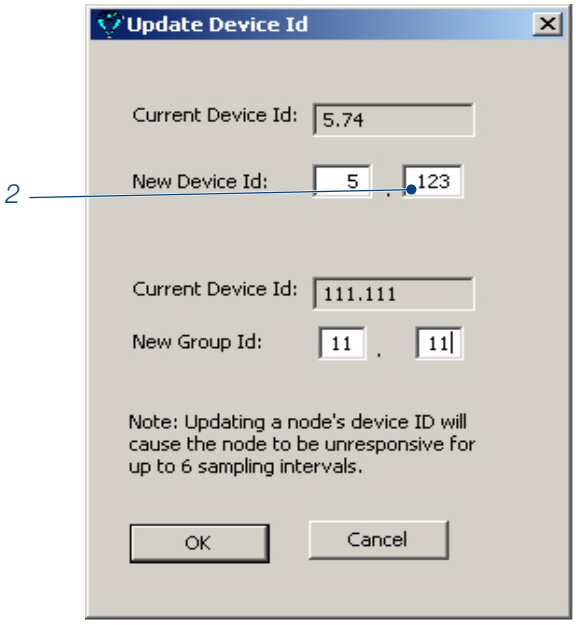


Fig. 3-18: Update Device ID

⚠ WARNING **DO NOT MODIFY THE GROUP ID.**
MODIFYING THE GROUP ID OF A NODE, WILL MAKE IT INVISIBLE ON THE NETWORK. IN THIS CASE, CONTACT LEM CUSTOMER SERVICE.

4. SOFTWARE INTERFACE

4.1 Introduction

This chapter describes the parameters and the registers available for software development.

4.2 Energy Meter Node

4.2.1 Modbus Register Table

Table 4-1 Modbus Register Map

Modbus Register	Description	Type / length	Storage	Unit after scaling	Access
0	Active Energy Consumption, Phase 1 MSW	S32	NV	Wh	R
1	Active Energy Consumption, Phase 1 LSW		NV	Wh	R
2	Active Energy Consumption, Phase 2 MSW	S32	NV	Wh	R
3	Active Energy Consumption, Phase 2 LSW		NV	Wh	R
4	Active Energy Consumption, Phase 3 MSW	S32	NV	Wh	R
5	Active Energy Consumption, Phase 3 LSW		NV	Wh	R
6	Active Energy Consumption, Phase Sum MSW	S32	NV	Wh	R
7	Active Energy Consumption, Phase Sum LSW		NV	Wh	R
8	Reactive Energy Consumption, Phase 1 MSW	S32	NV	VAh	R
9	Reactive Energy Consumption, Phase 1 LSW		NV	VAh	R
10	Reactive Energy Consumption, Phase 2 MSW	S32	NV	VAh	R
11	Reactive Energy Consumption,Phase 2 LSW		NV	VAh	R
12	Reactive Energy Consumption, Phase 3 MSW	S32	NV	VAh	R
13	Reactive Energy Consumption, Phase 3 LSW		NV	VAh	R
14	Reactive Energy Consumption, Phase Sum MSW	S32	NV	VAh	R
15	Reactive Energy Consumption, Phase Sum LSW		NV	VAh	R
16	Apparent Energy Consumption, Phase 1 MSW	U32	NV	VARh	R
17	Apparent Energy Consumption, Phase 1 LSW		NV	VARh	R
18	Apparent Energy Consumption, Phase 2 MSW	U32	NV	VARh	R
19	Apparent Energy Consumption, Phase 2 LSW		NV	VARh	R
20	Apparent Energy Consumption, Phase 3 MSW	U32	NV	VARh	R
21	Apparent Energy Consumption, Phase 3 LSW		NV	VARh	R
22	Apparent Energy Consumption, Phase Sum MSW	U32	NV	VARh	R
23	Apparent Energy Consumption, Phase Sum LSW		NV	VARh	R
24	Energy Counter Timestamp, Min / Sec	U16	V		R
25	Energy Counter Timestamp, Day / Hour	U16	V		R
26	Energy Counter Timestamp, Year / Month	U16	V		R
27	Line Frequency	U16	V	Hz	R
28	Recording Interval Timestamp, Min / Sec	U16	V		R
29	Recording Interval Timestamp, Day / Hour	U16	V		R
30	Recording Interval Timestamp, Year / Month	U16	V		R
31	Recording Interval Active Energy, Phase 1	S16	V	Wh	R
32	Recording Interval Active Energy, Phase 2	S16	V	Wh	R
33	Recording Interval Active Energy, Phase 3	S16	V	Wh	R
34	Recording Interval Active Energy, Phase Sum	S16	V	Wh	R

Modbus Register	Description	Type / length	Storage	Unit after scaling	Access
35	Recording Interval Reactive Energy, Phase 1	S16	V	VAh	R
36	Recording Interval Reactive Energy, Phase 2	S16	V	VAh	R
37	Recording Interval Reactive Energy, Phase 3	S16	V	VAh	R
38	Recording Interval Reactive Energy, Phase Sum	S16	V	VAh	R
39	Recording Interval Apparent Energy, Phase 1	U16	V	VARh	R
40	Recording Interval Apparent Energy, Phase 2	U16	V	VARh	R
41	Recording Interval Apparent Energy, Phase 3	U16	V	VARh	R
42	Recording Interval Apparent Energy, Phase Sum	U16	V	VARh	R
43	Maximum Current in Interval, Phase 1	U16	V	A	R
44	Maximum Current in Interval, Phase 2	U16	V	A	R
45	Maximum Current in Interval, Phase 3	U16	V	A	R
46	Minimum Voltage in Interval, Phase 1	U16	V	V	R
47	Minimum Voltage in Interval, Phase 2	U16	V	V	R
48	Minimum Voltage in Interval, Phase 3	U16	V	V	R
49	LEM Product ID (bits 7-10) Current caliber (bits 3-6) Connection schema (bits 0-2)	U16	NV		R
50	Software Version (bits 8-15) Software Revision (bits 0-7)	U16	NV		R
51	Status Word	U16	NV		R
52	Command Word	U16	V		R/W
53	Recording Interval Time Setting	U16	NV	min	R/W

Notes on table:
NV: *Non-Volatile, restored after power-cycle;* **V:** *Volatile.*
S: *Signed;* **U:** *Unsigned;*
R: *Read;* **W:** *Write;*

4.2.2 Scaling factors

Scaling Factor Table				
	Divide the result by:			
Current range	**5A**	**20A**	**50A**	**100A**
Active Energy Wh [Intvl]	64	16	6.4	3.2
Active Energy Wh [Counter]	8	2	0.8	0.4
Reactive Energy VARh [Intvl]	64	16	6.4	3.2
Reactive Energy VARh [Counter]	8	2	0.8	0.4
Apparent Energy VAh[Intvl]	64	16	6.4	3.2
Apparent Energy VAh[Counter]	8	2	0.8	0.4
Vrms	25	25	25	25
Irms	1200	300	120	60
Frequency	16	16	16	16

Note on table: Intvl : *Interval*

4.2.3 Energy counters

These objects contain the total consumed energy measured by the EMN. Writing the reset command to the command word resets the energy counters, the recording interval counters as well as the on-going interval accumulated values.

The time-stamp of the energy counters is written into the register when the data is sent to the gateway.

The energy counters will count positive for energy consumed, negative for energy generated and pushed into the grid.

Active, reactive and apparent energy consumption values are stored as 32-bit values, thus using 2 Modbus registers. The lower register address contains the high word (MSW), the higher register contains the low word value (LSW).

- Registers 0 to 26

Notes:
MSW: *Most Significant Word.*
LSW: *Least Significant Word*

0	1
16-bits	16-bits
MSW	LSW

4.2.4 Recording Interval based energy

Energy is integrated over a recording time interval, which is configurable.

The nominal energy is calculated over the period of five minutes with nominal current and nominal input voltage. The last completed interval values are stored in the register map.

The timestamp is set in the **Timestamp** Register at the end of the integration interval.

- Registers 28 to 48

4.2.5 Recording Interval Time (register 53)

The recording interval time is a **configurable parameter** that defines the recording interval in **minutes**.

It can take the values 5, 6, 10, 12, 15, 20, 30.

The start of such an interval is at the hour + n* interval.

When writing a value other than the ones listed to this parameter it will be discarded and the EMN will continue to use the previous set value.

Not that the **Mesh Gate** will respond with an **"ACK"** to a write of a non-valid value as it **does not check** the contents of the message sent to the **EMN.**

When changing the interval time, the EMN will calculate the end of the next recording interval time while keeping the current interval measurements. This means that at the end of the Recording interval, the timestamp will be correct with respect to the new setting, but the first interval values are not guaranteed to be integrated over the set interval time and thus should be discarded by the master application software.

4.2.6 Time-stamp

The **Time-stamp** of the energy counters and the recording interval have the same format using three Modbus registers. Each of the registers is split into two parts as shown in the following table.

Register		High byte	Low byte
24	28	Minute	Second
25	29	Day	Hour
26	30	Year	Month

4.2.7 Frequency

The **Line Frequency** is measured on the phase of the power supply only (phase 1).

Last value of the recording interval is kept in this register.

4.2.8 Maximum Current

The RMS current is averaged over 10 line periods (200ms in a 50Hz system). The max current average of the recording interval is kept in the register.

4.2.9 Minimum Voltage

The RMS voltage is averaged over 10 line periods (200 ms in a 50 Hz system). The minimum voltage value of the recording interval is kept in the register.

Parameter	Description
Scaling	$U_{Nominal}$ (230Vrms) = 5750(d)
Access/Type	User, Read, Volatile

4.2.10 Product Identification

The **Product Identification** identifies the LEM product, the meter configuration and the current calibre.

Connection Diagram.

The corresponding code is in the **Product ID** register, Bits **[0-2]**.

Description	Model	Code	Number of Current Sensors
Wye 4-wire	W4	0 0 0	3
1-Phase 2-wire	W2	0 1 0	1
2-Phase 3-wire	W3	0 1 1	2
3 single Phase on same voltage	W0	1 0 1	3
Delta 3-wire	D3	1 1 1	2

Current Calibre

The current calibre of the connected current transducers and thus the nominal current can be read from the **Product ID** register, bit **[3-6]**.

Current Caliber	Code
5A	000
20A	010
50A	011
100A	100

LEM Product ID (0001)

The LEM **Product ID** is a 4-bit product identification code, bits **[7-10]**.

All of the EMN will share the same product ID.

4.2.11 Software Version

The software version reflects the major release number of the EMN software

The MSB of this register contains the version number.

The LSB of this register contains the revision number.

4.2.12 Status Word

The status of the EMN can be read from a read-only register

Bit	Status Description
0	Set when synchronized to 50/60Hz
1	Set if a checksum error has been detected at power-up
2,3,4,5,6,7	Not Used
8	Internal use only
9	Internal use only
10	Not Used
11	Internal use only
12	Internal use only
13,14,15	Not Used

4.2.13 Command Word

The EMN is able to execute commands after a write to a command **word**, which is mapped to a **R/W** register. Setting a bit in the command **word** executes the command.

Bit	Command
0	Reset Meter. This resets the device counters and the Interval counters
7	Place EMN in direct serial communication mode. Used during manufacturing. Do not place EMN in this mode, otherwise the EMN will not be able to communicate via radio module. If this is done, turn device OFF and ON again to reset the mode to normal radio communication
1,2,3,4,5,6,8,9,10,11, 12,13,14,15	Not Used / Ignored

Reset Meter

This command resets the energy counters to zero in both RAM and non-volatile RAM

This command does not affect the reporting interval values.

Direct serial word

This able radio-communication to restore radio-communication mode, power cycle EMN (Switch OFF, then ON).

4.3 Mesh Gate

4.3.1 Mesh Gate Register table

The registers hold information about the gateway as well as the MeshScape network

Modbus Register	Description	Type
0	Group ID	U16
1	Gateway Device ID (XXX.247)	U16
2 – 17	Active Endnode Device List Bit Map*	U16
18	Total online device count (MG, EN and EMN)	U16
19 – 20	UTC Time Stamp**	U16
21-36	Active Meshnode ID List Bit Map	U16
37-44	System Revision Number: eq.v1.1.x	ASCII

4.3.2 Read Device Identification

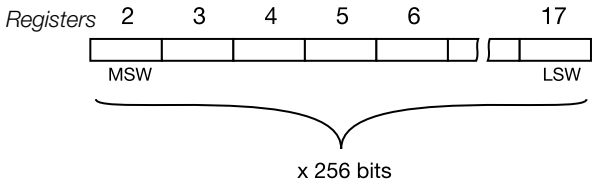
This **Read Device Identification** objects are listed below:

Object ID	Object Name / Description	Type	Max Byte Size	Value / Note
0x00	Vendor Name (GW only)	ASCII String	32 Bytes	“Millennial Net Inc.”
0x01	Product Code (GW only)	ASCII String	16 Bytes	“RK-5424-XX”
0x02	Major Minor Revision (GW only)	ASCII String	16 Bytes	“v1.1.X”
0x03	Vendor URL (GW only)	ASCII String	32 Bytes	«www.millennial.com»
0x04	Product Name (GW only)	ASCII String	16 Bytes	“MeshScape”
0x05	Model Name (GW only)	ASCII String	16 Bytes	“5424”
0x06	User Application Name (GW only)	ASCII String	32 Bytes	“To be determined”

* Each bit of the 16 registers corresponds to a Modbus slave address. The Modbus address corresponds to bit number as follows:

Examples: EMN N° 25: register 16, bit 9 = 1

EMN N°16: register 16, bit 0 = 1



** 32-bits value, R/W, Volatile MN and EMN will be synchronized with this value (MG)

Write the time value in this register

Mesh Gate UTC time registers: 19 (MSW) and 20(LSW). Concatenate to have a 32-bit UTC value

4.3.3 Setting of Mesh Gate Network Time

The Mesh Gate holds the reference time for the entire network.

Mesh Nodes and EMNs will synchronize their internal RTCs after power-up, then at periodic intervals (2-4 minutes).

The initial synchronisation can take up to 6 minutes. Depending on the network configuration /number of hops from Mesh Gate to EMN.

The Mesh Gate is not equipped with a battery, so the internal time is not kept when power is removed. It is thus necessary to set the Mesh Gate time immediately after power-up of the Mesh Gate.

The time drift according to Millenial is up to several seconds/day. Synchronizing the Mesh Gates time periodically with the Master-applications time is necessary.

⚠ WARNING **WHEN SETTING THE TIME IN THE MESH GATE, BOTH UTC REGISTERS NEED TO BE WRITTEN IN ONE COMMAND.**

The ongoing recording intervals in the EMNs will be disrupted by a change of the Mesh Gate time.

4.4 Network

4.4.1 Modbus Interface

The Wireless Mesh Network uses the Modbus RTU (Remote Terminal Unit) framing mode.

ASCII mode is not supported.

The gateway can act in two ways:

- Modbus Slave with Mesh Gate data
- EMN Slave proxy with EMN data

4.4.1.1 Modbus slave

The following commands are known:

- Read Holding Registers (0x03)
- Write Multiple Registers (0x10)
- Read Device Identification (0x2B/0x0E)

4.4.1.2 EMN slave Mesh Gate

The Mesh Gate responds to Modbus requests with Modbus slave addresses corresponding to a EMN. Available Modbus commands are:

- Read Holding Registers (0x03)
- Write Multiple Registers (0x10)

*Response of a write command will always be "**acknowledge**" response.*
To verify if a write command is successfull, poll the register that writtten to.

4.4.2 Network Identification of EMN

Each of the EMNs has a unique **MeshScape 16-Bit ID** (DID) which is printed on the EMN in the form of **[High Byte].[Low Byte]**.

As the Modbus supports only 8-Bit addresses, only the **Low Byte** of the MeshScape address is used for Modbus communications.

4.4.3 Modbus Communication

For more information about Modbus protocol, see: **www.modbus.org**

The EMNs are seen as Modbus slaves through the Mesh Gate.

The maximum size of a **Modbus RTU** frame is 256 bytes.

A Modbus request has the following general format.

Description	Slave Address	Function Code	Request Data	CRC
Byte Count	1	1	4 (typical, see below)	2 (LSB I MSB)

4.4.3.1 Read Holding Registers (Function code 0x03)

Master Request Format

Description	Slave Address	Function Code	Request Data	CRC
Hex	0xID	0x03	0xXX ... 0x7D	0xLSB 0xMSB

Slave Request Format

Description	Slave Address	Function Code	Request Data	CRC
Hex	0xID	0x03	0xXX 0xYY	0xLSB 0xMSB

The following is a Modbus master read request packet. A request is referred to as a packet sent from the Modbus master application to the gateway slave. This has a function code value of 0x03.

The **Request Data** includes a 2 byte starting address offset value and a 2 byte length value specifying the length of data to be returned in a 16 bit word (number of Holding Registers, 1 to 125 (0x7D)).

4.4.3.2 Examples

Read the frequency from EMN with ID 63

- Modbus address 0x3F
- Starting register ..... 0x1B (register 27 decimal)
- Length.....0x01

```
[3F 03 00 1B 00 01 F0 D3]
```

Read all IRMS and URMS values from EMN with ID 63

- Modbus address 0x3F
- Starting register ..... 0x2B (register 43 decimal)
- Length.....0x06

```
[3F 03 00 2B 00 06 B1 1E]
```

5. GLOSSARY

- **EMN** Energy Meter Node
- **RTC** Real Time Clock
- **UTC** Coordinated Universal Time. Number of seconds passed since 1.1.1970
- **Mesh Gate** Millennialnet gateway that controls the RF network and provides a serial interface for the customer.
- **Mesh Node** Millennialnet RF router/repeater
- **End Node / Node** Millennialnet RF communication module integrated in the EMN
- **Hop Count** Number of network node hops taken by a packet delivered from a node to the Mesh Gate.

  For example: End Node — Mesh Gate = 1 hop,

  End Node — Mesh Node — Mesh Gate = 2 hops

  (each additional Mesh Node will add another hop).

- **Modbus** Communications protocol using RS232/RS485 used by the Mesh Gate.

Further information and protocol specifications can be found on http://www.modbus.org.

GLOSSARY