C2i

EnCompass 868

Wireless Data Collector (Network Node)

Data and Instruction Manual

Utilivista

BSRIA Member

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1. Introduction

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1.2 - Symbols

Indicates something to be noted by the user

Indicates important information

Indicates high voltage

1.3 - Conventions for Cautions and Warnings

CAUTION

Cautions advise the user to proceed with care. They alert users to situations wherein there is potential that they might perform an action which could result in an unexpected outcome or the loss of data which could be permanent. Cautions contain an explanation of why the action is potentially problematic.

WARNING!

Warnings advise the user to proceed with *extreme* care. They alert users to situations wherein there is potential that they might perform an action which could result in personal injury or damage to equipment. Warnings contain an explanation of why the action is potentially dangerous.

1.4 – Risk Avoidance

To avoid the risk of personal injury and damage to equipment the **EnCompass** must be operated in accordance with the guidelines and specifications detailed in this manual, as well as all statutory requirements and regulations. Take special heed to all Cautions and Warnings. Refer to Section 3 for Safety information and Section 8.2 for I/O limitations.

2. Introduction to the EnCompass

2.1 – Device Overview

The **EnCompass** is the world's first wireless performance monitor. Covering every type of input with tremendous functionality, this battery-powered device is the all-encompassing solution for wireless sensor and power monitoring. The easy-to-deploy **EnCompass** can capture data from *any* sensor *and* power source, convey it securely and reliably over our wireless network to the **Entranet** gateway/receiver where you can instantly see it, or connect it effortlessly to/via any other program, platform or protocol; a seamless stream of innovation taking data to its full potential.

An astonishing array of applications awaits the **EnCompass**, from agricultural applications such as grain temperature monitoring or greenhouse humidity monitoring, and ecological applications such as soil sampling and flow metering, to industrial applications including power metering, pressure monitoring, voltage optimisation and load shedding. However, with both power *and* sensor inputs in one low-cost device, the performance of plant, equipment, machinery and systems (PEMS) can be seen like never before. With performance data, profound opportunities can be unearthed, using Condition-Based Maintenance to prevent costs and, by comparing actual performance with its potential, discovering significant savings.

Using a smart integrated system, the **EnCompass** provides a simple and easy-to-interpret interface between complex systems and the user. It provides many options and advanced features which offer state-of-the-art monitoring of building services or industrial processes. The varied I/O configurations and universal connectivity enable the device to be customized for each user's requirements.

2.2 – Features Overview

- 21 inputs - including serial, digital and analogue - and 1 digital output.
- Using a 868MHZ self-healing mesh network and a protocol designed for superior penetration, low power consumption, high reliability and excellent security ensures unhindered data transfer, with fewer repeaters, even in industrial environments.
- Devices can be set as node, repeater or combined node/repeater.
- Powered by battery or USB mains adapter. The processor can be powered from the mains supply when connected for voltage monitoring.
- Ultra-low power consumption gives battery life of up to 10 years (depending on use). Batteries replaceable.
- Serial connection to enable constant, high resolution reading of all data.
- Local or remote (www) configuration options.
- Manage your data and devices easily with GATEWAY, the device/data management hub installed onboard.
- Data can be reviewed on the dashboards on GATEWAY
- Sampling and reporting fully customizable.
- Firmware can be upgraded automatically over-the-air.
- Simple setup with LED range indicator and clear configuration pages.
- Spring loaded terminals giving increased connection reliability and security.
- CE approved. IP67 rated.

2.3 – Network Overview

The C2i network allows measurements to be taken over a large area and reported via radio frequency (RF) to a single gateway/receiver unit – the **Entranet**.

The **EnCompass** operates with the **Entranet** in one of three configurable modes. When the **EnCompass** is in node setting it is capable of taking measurements and transmitting the information via RF. When in repeater setting it receives data from nodes further away from the **Entranet** and then retransmits the data, thus extending the range of the system. (To ensure that transmission, and therefore battery usage, is efficient, the maximum number of repeaters between a node and the **Entranet** is two.) The third mode combines the node and repeater functionality.

The network works effectively with a handful of nodes (or even just one) in use, but comes into its own when used in large, complex scenarios as it conveys vast amounts of data to the **Entranet** rapidly, reliably and efficiently. This makes it ideal for monitoring all plant, equipment, machinery and systems (PEMS) across a large site, as all the data converges to one central point.

The **Entranet** acts as an Ethernet device, providing web access to C-trac GATEWAY, the integrated device/data management hub. All devices on the network can be configured here as well as the onward data connections to other systems and platforms via protocols such as BACnet and oBIX. Data can also be downloaded directly or viewed right there on a dashboard.

The **EnCompass** may be also be accessed locally via the serial port connection to enable constant, high resolution reading of data from all inputs.

2.4 - Monitoring Capabilities

- **Power Meter** - 3 voltage connections and 1 neutral plus 4 current inputs allow for the termination of electrical supplies and current transformers (CT's) that can monitor the electrical consumption of entire buildings or individual items of plant.
- **Non-Invasive Metering –** If only the electrical current is monitored via the CT's, an assumed constant voltage, or a local (same distribution transformer supply) common reference voltage can be used to calculate power (using continuous current sampling, if the node is sufficiently powered). The reference voltage can be obtained from any standard wall-plug on the same distribution. This facility provides accurate power monitoring without having to make 230V connections at each remote meter point.
- **Pulsed Output –** The triac digital output can be configured to send a 100ms active pulse on every kWh consumed for sending electricity consumption data live to any existing Building Energy Management System (BEMS).
- **Temperature Monitoring** - Five temperature inputs enable many thermistor-type sensors to be connected and monitored. This can be useful for efficiency monitoring of process and building Heating, Ventilation and Air Conditioning systems (HVAC). Again the use of temperature monitoring can be vital in determining the state and condition of specific equipment. These can also be configured as digital inputs (See Digital Status below).
- **Digital Status and Logger** – Two/seven (see above) digital inputs provide utility and/or maintenance data. Each can be configured to count pulses, regularly sample the status, or log the exact time of each change of status.
- **Humidity and Environmental Monitoring** - One humidity and three 4-20mA connections provide the application of any process or environmental transducer to allow analysis of specialist conditional monitoring. The 4-20mA inputs can be configured to interpret data from many kinds of sensor, including temperature, humidity, pressure, light, vibration and fluid dynamics.
- **Serial Connection** - The serial connection enables constant, high resolution reading of data from all inputs, using an attached computer.

2.5 – Inputs and Outputs

4 Current, 3 Voltage + Neutral

1- and 3-Phase Power Metering

Voltage Optimisation
Power Factor Analysis
Load Shedding
Maximum Demand Alarms

3 4-20mA Analogue Inputs
(Loop Powered)

Humidity
Pressure
Vibration
Flow
Light
Tank Level
Chemical

C2i EnCompass

2 Digital Inputs + 1 Output

Status Input
Pulsed Counter
Alarm Input
Pulsed Output (BMS)

Serial
(RS485 and RS232)

Vibration
Temperature/Humidity
LonWorks
BacNet
MeterBus
ModBus

5 Temperature Inputs
(Thermistor)

Space Temp
Ambient Temp
Clamp-on Temp
Immersion Temp
Duct Temp
Bearing Temp

WARNING!

Some of the inputs may be connected to hazardous voltages.
Disconnect the power before working on this equipment.

Input wiring must be installed in accordance with national and local regulations/requirements. All wiring types must be selected appropriately, according to their function and operating constraints.

The inputs for the EnCompass require glands or conduit entries in the gland plate at the bottom of the EnCompass. Care needs to be taken to ensure the IP rating remains intact. See Electrical Installation methods in Section 7.

Each input can take a wide range of readily available sensor types. All inputs and outputs are protected against electrostatic discharge (ESD).

2.5.1 - Connection Details

The connections to the EnCompass are via cable entry holes in the bottom of the case, where cables pass through glands and terminate into the spring loaded plug-in terminals mounted on the edge of the printed circuit board. The case has a detachable plate that is screwed, complete with seal. This plate can be replaced with a blank or with 4 or 8 holes. The cover over the terminal compartment is screwed complete with seal.

3. Safety

3.1 – Important Safety Information

Be sure to heed the following warnings to prevent personal injury or damage to equipment.

WARNING!

The voltage range of the V1, V2, V3 & N terminals are rated at 240/415v AC and are dangerous if connected to the mains. Incorrect installation may cause death, serious personal injury or damage to the equipment. Consequently, the instructions in this manual, as well as national and local rules and safety regulations, must always be complied with.

WARNING!

The circuit powering the EnCompass is 3.6v (battery), 5-24vdc or 5v (USB mains adapter), depending on the power module being used. Disconnect power before installation or servicing to prevent electrical shock or damage to equipment. Make all connections in accordance with national and local electrical codes. Use copper conductors only. To reduce the risk of fire or electrical shock, install in a controlled environment relatively free of contaminants. The EnCompass is only intended for use as a monitoring device. To prevent loss of data or damage to equipment, DO NOT USE IT FOR ANY OTHER PURPOSE.

Static charges produce voltages high enough to damage electronic components. The microprocessors and associated circuitry within an EnCompass device are sensitive to static discharge.

Follow these precautions when installing, servicing, or operating the system:

- **Work in a static-free area.**
- **Discharge any static electricity you may have accumulated.**
- **Discharge static electricity by touching a known, securely grounded object.**
- **Do not handle the printed circuit board (PCB) without proper protection against static discharge.**
- **Use a wrist strap when handling PCBs. The wrist strap clamp must be secured to earth ground.**

WARNING!

All electrical installation work must be undertaken by a suitably qualified and competent person and must be carried out in full accordance with all relevant Statutory Requirements and Regulations.

3.2 – Before Commencing Repair Work

WARNING!

1. Disconnect/Isolate the mains 220/250v supply, if connected.
2. Ensure that all safety and operational measures have been implemented.

3.3 – 3-Phase Power

WARNING!

The metering capability of the **EnCompass** means that it could potentially have 3 phase power connected. Extreme care must be taken when the existence of 300-415vac is present.

3.4 – Battery Replacement

CAUTION

Battery polarity must be correct 3.6v: Red wire = +, Black Wire = −.
The battery cannot and must not be charged and must not be short-circuited.
Used batteries must be disposed of in the appropriate and approved manner.

3.5 – Battery Leakages

WARNING!

Lithium batteries rarely leak but if they do the utmost care must be taken to avoid injury. Clean any leakages with water only, using a cotton cloth, and wear protective clothing, including gloves and safety goggles. DO NOT attempt to clean the batteries themselves; they must be disposed of immediately in a hazardous waste collection. If you get a rash on your skin or you feel a burning sensation in your nose or eyes, contact your doctor as soon as possible.

It is recommended to check the battery for discoloration, swelling or leaking annually.

4. Powering the EnCompass

4.1 - Battery Power

The EnCompass 868 can be powered by two types of non-rechargeable battery, both of which are lithium–thionyl chloride (3.6v).

AA Battery – A 2700mAh AA battery can be used. This is sufficient to give a battery life approaching or sometimes exceeding ten years for devices acting as nodes (excl. repeaters and node/repeaters) in most situations.

C-Type Battery – A 8600mAh C-Type battery is required for devices acting as repeaters or node/repeaters, and is recommended for nodes in certain situations, for example when every possible input is being sampled with a sampling interval of under 30 seconds, or when a node is often going out of range and having to send numerous retransmissions for each report (though this suggests a poorly commissioned network).

The voltage of a lithium battery is almost constant throughout the whole lifetime of the battery (approx. 3.65v). Therefore, it is not possible to determine the remaining capacity by measuring the voltage. However, an estimate of remaining capacity, based on an EnCompass's monitoring and reporting activity, is regularly updated and displayed via the Entranet.

Optimal battery life is obtained by keeping the battery temperature below 30°C.

4.2 - Using a 5-24vdc PSU or USB Mains Power Adapter

As an alternative to battery power, the EnCompass 868 can be powered by 230V mains power. This can be provided by a 5-24vdc PSU, 5vdc USB power adapter or by a direct connection to a computer's USB port. This option allows for continuous power consumption calculations to take place when just the current is attached (see sections 2.4 and 11.3) It also means the EnCompass can be set as a repeater or node/repeater without any need for a C-Type battery.

CAUTION

Under no circumstances should PSU/USB and battery power be connected simultaneously.

4.3 - Drawing Power from Voltage Input V1

When Voltage Input V1 is being measured, the power going through this input will be used for the CPU, enabling continuous power consumption measurement. This will mean the battery or USB adapter will only be used to power the transceiver.

The voltage threshold required on Voltage Input V1 for this to occur is between 45-230V AC.

4.4 - Table of Power Options

	Battery	Battery (with V1 connected to Mains Voltage)	USB Powered (whether or not V1 is connected)
Standard Sampling of all Inputs	Yes	Yes	Yes
Repeater or Node / Repeater Mode	Yes (C-Type battery recommended)	Yes (C-Type battery recommended)	Yes
Continuous Power Metering	No	Yes	Yes *
Using the Optional 5 Extra Digital Inputs in Place of the Thermistor Inputs	No	Yes	Yes

** With option to use an assumed constant voltage, or voltage data from another source (See Section 2.4 – Non-Invasive Power Meter).*

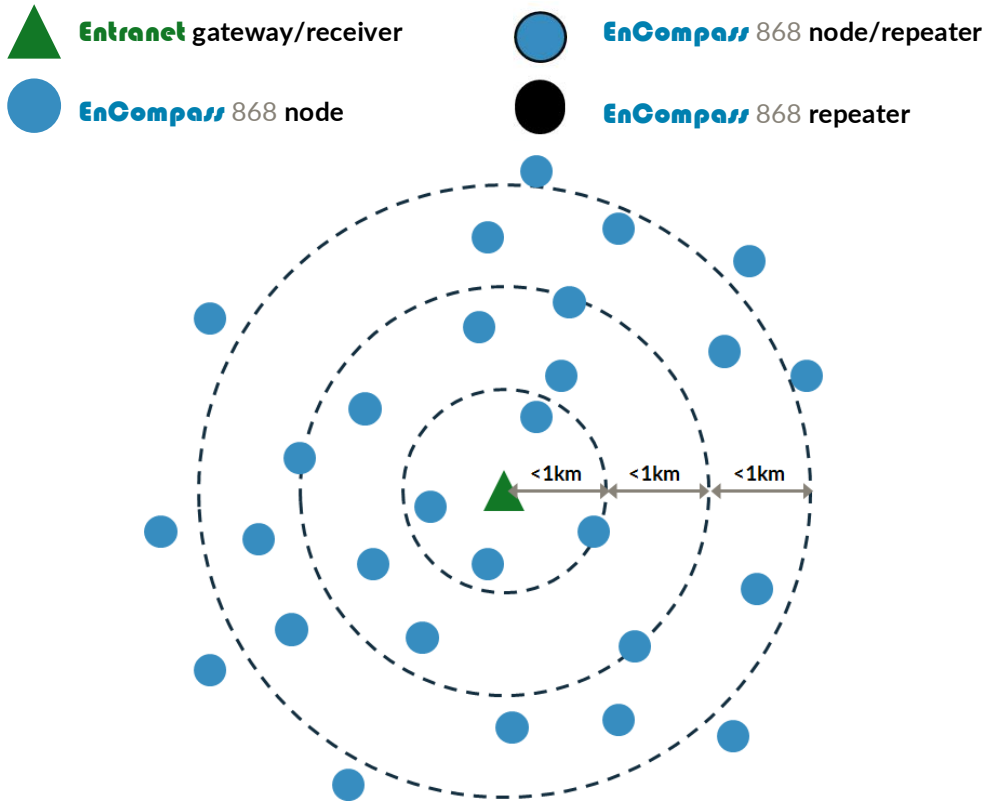
5. Planning and Commissioning a Network

5.1 - Establishing your Requirements

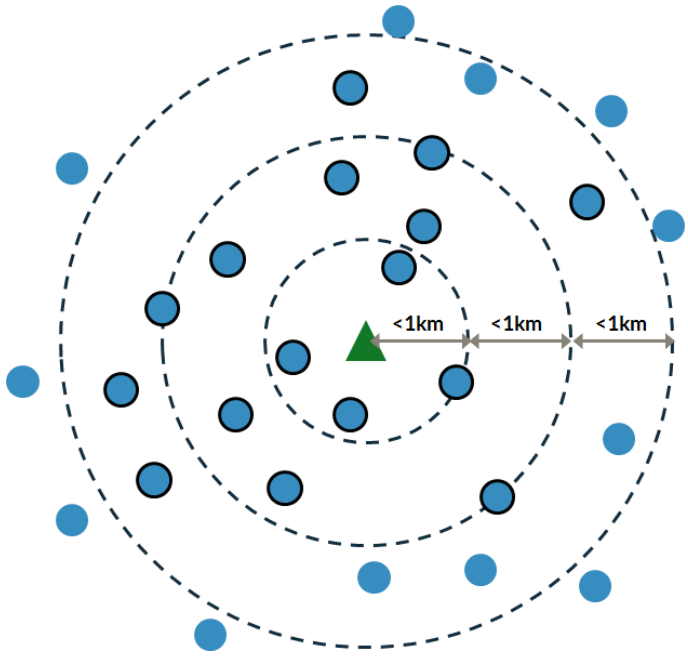
The number of **EnCompass** devices needed for use as monitoring nodes should be easy to establish, based on your monitoring requirements. Estimating the number of repeaters necessitates a strategy as outlined below.

To help estimate the number of repeaters required:

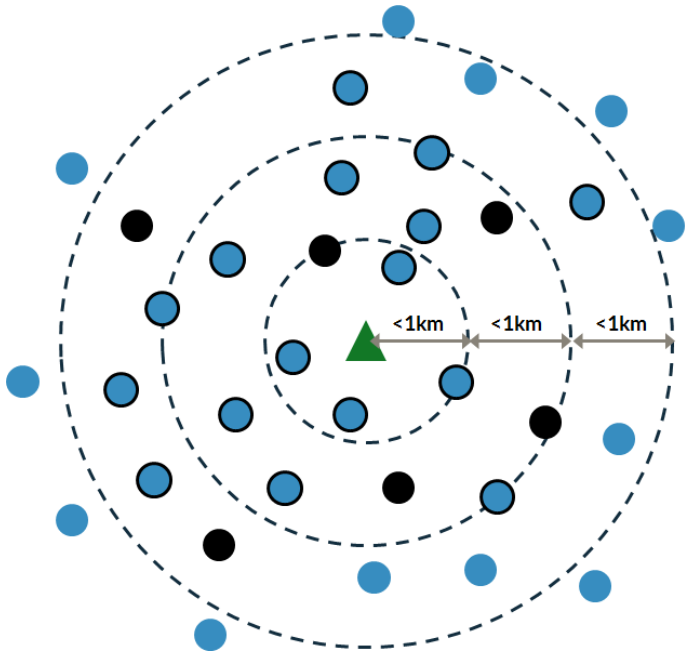
1. **Mark the location of all nodes on a site or building plan. Draw rings up to 1000m apart to include all nodes, with the Entranet gateway/receiver at the centre.**



2. **Mark all nodes except the outermost as node/repeaters.**



3. **Place repeaters where there are gaps exceeding the range of the EnCompass to ensure every node and node/receiver has at least one path to the Entranet.**



The exact position of all nodes, node/repeaters and repeaters will always need to be fine-tuned in-situ using the LED signal indicator on the front of the EnCompass. Detailed instructions for the positioning and fixing of devices can found in Section 6 and Appendix A.

5.2 - Setting-Up the C2i Network

Step 1: Initial Setup

- Install the Entranet 868 gateway/receiver in a suitable location.
- Access the local device management portal (*see* Entranet 868 *manual, Section 4.1*).
- Set the Entranet to allow new nodes (*see* Entranet 868 *manual, Section 5.2*).

Step 2: Setup the nodes and repeaters

See Section 6.

Step 3: Connect the Inputs / Output

See wiring diagrams in Section 7.

Step 4: Commission each EnCompass

See Entranet 868 manual, Section 5.

6. Positioning and Fixing

6.1 - Before Positioning the EnCompass

Read this guide before installing. If the EnCompass is installed incorrectly, Utilivista's guarantee obligations will no longer apply. If in doubt, contact us.

The EnCompass must be mounted in a suitable environment in a position that allows safe access and good clearance for wiring, servicing, removal, battery replacement and connection of all the I/O.

Environmental Considerations

- **Do not operate outside the ambient temperature range (-20°C to +60°C).**
- **Do not cover. Allow air circulation.**
- **Protect from direct contact with steam or any other harmful substances.**
- **The device is battery-powered and thus it's advisable not to locate it in direct sunlight.**

Where possible keep away from the following:

- **Steel poles, pipes, RSJ's, cladding and other large metal surfaces.**
- **Electric motors or high frequency drives.**
- **Other strong wireless signalling systems, dishes or antenna's.**
- **High voltage electric cables or transmission lines.**
- **Any equipment that transmits high levels of interference (high EMC / RF).**
- **Areas where there is the potential for mechanical damage or obvious obstruction to normal operational behaviour.**

To maximise signal strength:

- **Mount the EnCompass in its upright position (it can be mounted in any orientation).**
- **Minimise the number of structural obstacles and the distance between the EnCompass and the Entranet.**
- **Fix the EnCompass as high as practically possible.**

For more detailed information and advice, see Appendix A.

6.2 - Positioning the EnCompass

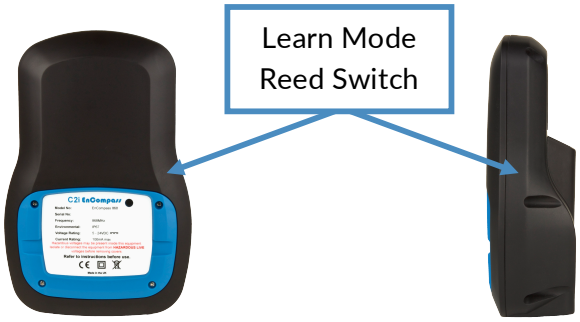
The signal strength indicator has been designed to simplify the installation process. When Learn Mode is activated by placing a magnet momentarily at the correct place on the EnCompass 868 (see page 13) an LED can be viewed on the front of the device. The following describes the different LED signals:

Slow Blink (4 seconds)	No Signal.
Fast Blink (< 1 second)	Weak Signal (avoid if possible).
Solid Light	Good Signal.

The LED is only operational during the two minutes that the EnCompass stays in Learn Mode. However, it can be activated again immediately if necessary.

CAUTION

DO NOT put an EnCompass into Learn Mode at the same time as another device on the network.



Install the Entranet and power it up before deploying an EnCompass 868.

Once the Entranet is operating and running in Learn Mode (*see* Entranet *Manual, Section 5*) the EnCompass devices should be deployed in the following sequence:

1. Start by deploying the devices nearest to the Entranet and work outwards according to the network plan (see Section 5.1), setting them all up as node/repeaters with the exception of those furthest from the Entranet. Deploy each device according to the guidelines outlined in this manual.
2. If, when deploying a device, the LED indicates a poor signal which cannot be improved by adjusting the position, deploy another EnCompass as a repeater at an intermediate location (according to your network plan) ensuring that it has good signal first before checking the other.
3. If a poor signal persists after installing a repeater, move the repeater to different locations until both devices have good signal. Make efficient use of each repeater where possible by moving it around within its 'good signal' area to accommodate more than one node if necessary.
4. Ensure the devices furthest away from the Entranet are deployed as nodes, not node/repeaters.

To ensure that transmission, and therefore battery usage, is efficient, the maximum number of repeaters or node/repeaters between any node and the Entranet gateway/receiver is two.

As a self-healing mesh network, one repeater or node/repeater is able to retransmit the data from any number of other nodes. Thus, given a transmission failure at one, alternative routes to the Entranet, through one or more other repeaters, would be attempted.

6.3 - Fixing the EnCompass

The EnCompass should be fixed to a wall or other permanent structure by attaching a screw or bolt to the building or equipment framework, and hanging the node via the keyhole fixing on the back of the unit. Allow 300mm between the EnCompass and any other fixed equipment or services that may cause mechanical / electrical damage or interference.

Take care not to drill materials that may be harmful. Also ensure that there are no hidden services etc. in or near the path of the drill.

To avoid any danger in fixing as described above, alternative fixings could be used such as cable strap, Velcro, "No-Nails" or similar.

7. Electrical Installation

7.1 - How to Connect

All cables and wiring must comply with national and local regulations and standards.

It may be more convenient to make all the connections before mounting the node, especially if it needs to be positioned at a higher level to gain good reception. In this case ensure long enough tails are provided to enable tidy clipping/fastening to the building fabric/cable tray.

Remove the front access cover and route the cables through the gland plate and connect to the appropriate terminals.

The **EnCompass** comes with three cable gland plate options, Blank, 8 x10mm holes and 4 x 16mm holes. Whichever option is chosen the installer must ensure that the cable glands or entry system is sealed to IP67 standard to maintain the IP protection category. If the necessary steps are not taken and an **EnCompass** is damaged because of ingress of water or other particulates and corrosive vapours, Utilivista will not be obliged to replace the unit within the warranty period. See wiring and connection diagrams below.

Ensure all cable entries are used or plugged with the appropriate gland/plug.

7.2 - Mains Input Wiring Instructions

WARNING!

The voltage range of the V1, V2, V3 & N terminals is rated at 45-230v AC so connecting to the mains can be dangerous. Incorrect installation may cause death, serious personal injury or damage to the equipment. Consequently, the instructions in this manual, national and local rules, as well as safety regulations, must all be complied with.

The voltage and neutral inputs are used solely for the measurement of power consumption and some power quality analysis. These inputs are rated at 230 volts although if connected to a three phase supply there may be upwards of 400-415v present. Connections must therefore only be carried out by a suitably qualified and competent person.

THE MAINS SUPPLY MUST ALWAYS BE ISOLATED BEFORE WORKING ON THIS EQUIPMENT.

Fused protection must be incorporated when connecting the EnCompass to mains, with 250mA quick blow fuses.

The voltage range to enable consumption etc. is between 45-230Vac therefore the user can connect a voltage of 45Vac and still maintain a consumption reading. Please see the commissioning and configuration instructions for more details.

7.3 – CT Installation Instructions

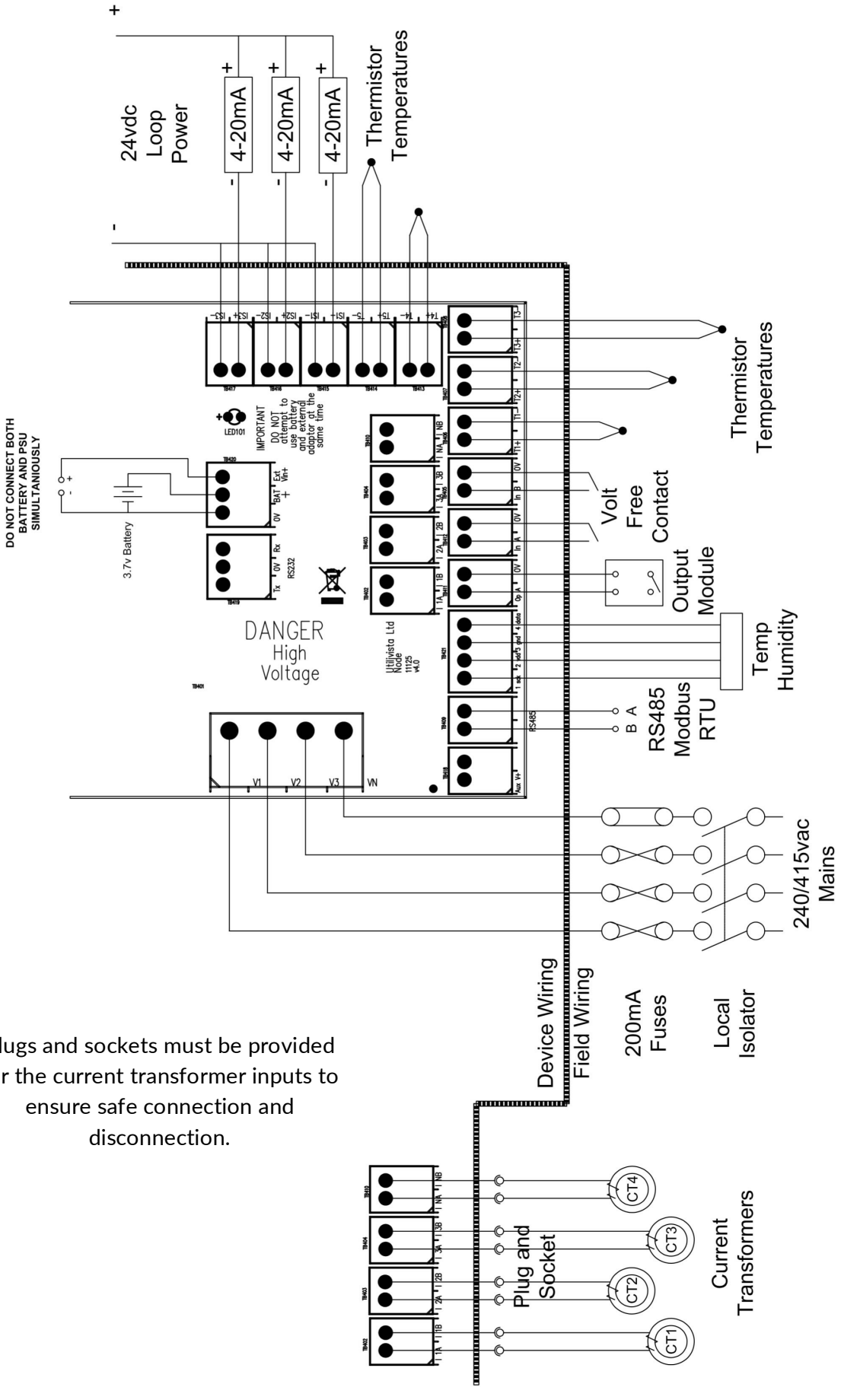
These installation & application notes refer to 1-5A secondary CTs NOT 0.333vac CTs.

It is essential with certain instrumentation that the CT is correctly orientated on the conductor, or P1 must face the supply and L or P2 must face the load. It is also important to ensure that the secondary connections are made in accordance with the instrument connection diagram.

The secondary terminals of the CT must NOT make open circuit on load as dangerously high voltages may occur under these conditions. During installation the secondary terminals must be shorted and during operation it is recommended that one side of the secondary winding is earthed.

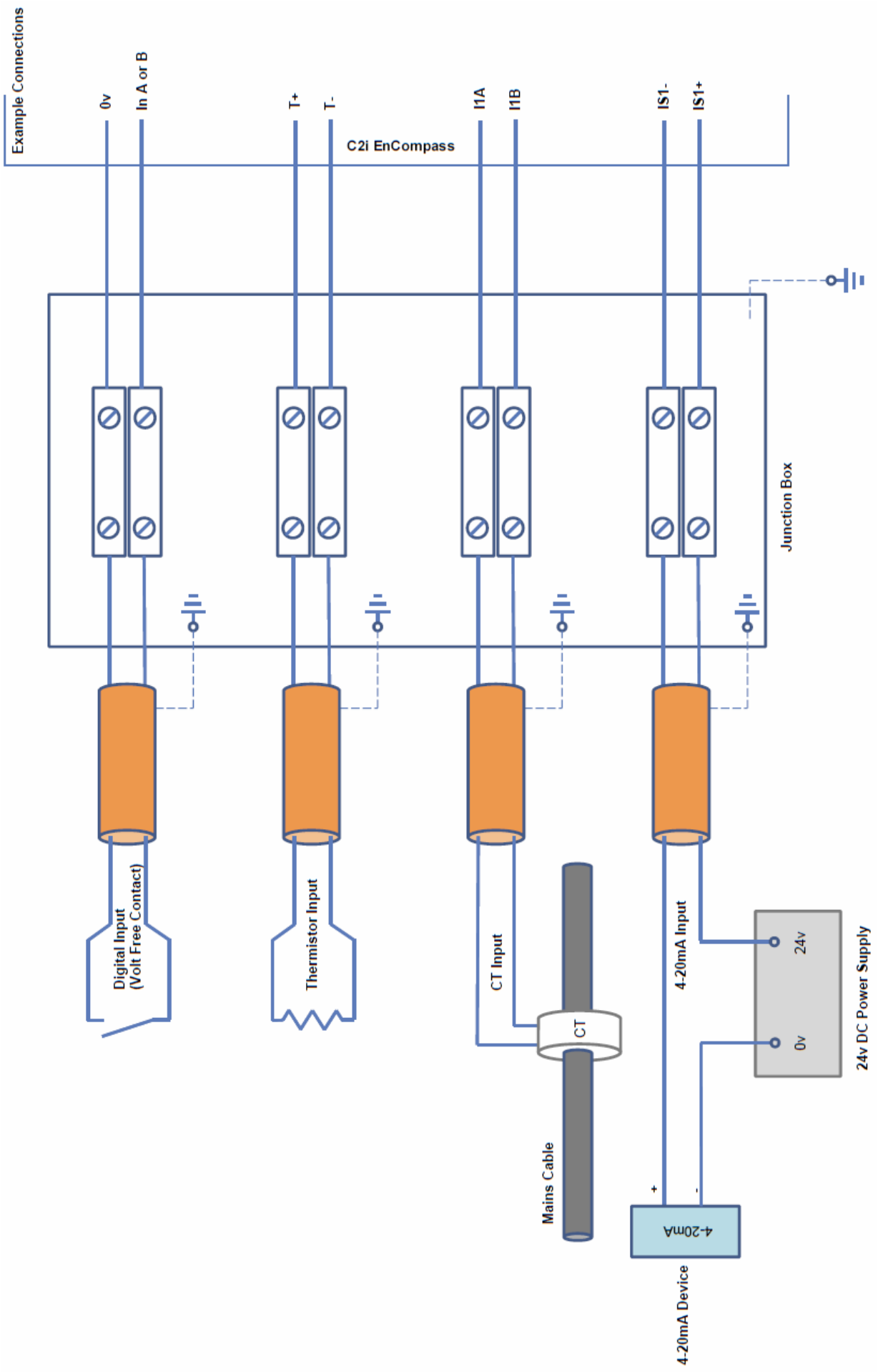
On all current transformers it is possible to reduce the CT ratio by passing multiple turns of the primary conductor cable through the aperture. The resultant CT ratio will be CT primary rating divided by the number of through turns e.g. a 100/5A CT with the primary conductor passed through the aperture twice will produce a CT with a ratio of 50/5A.

7.4 - Wiring Diagram

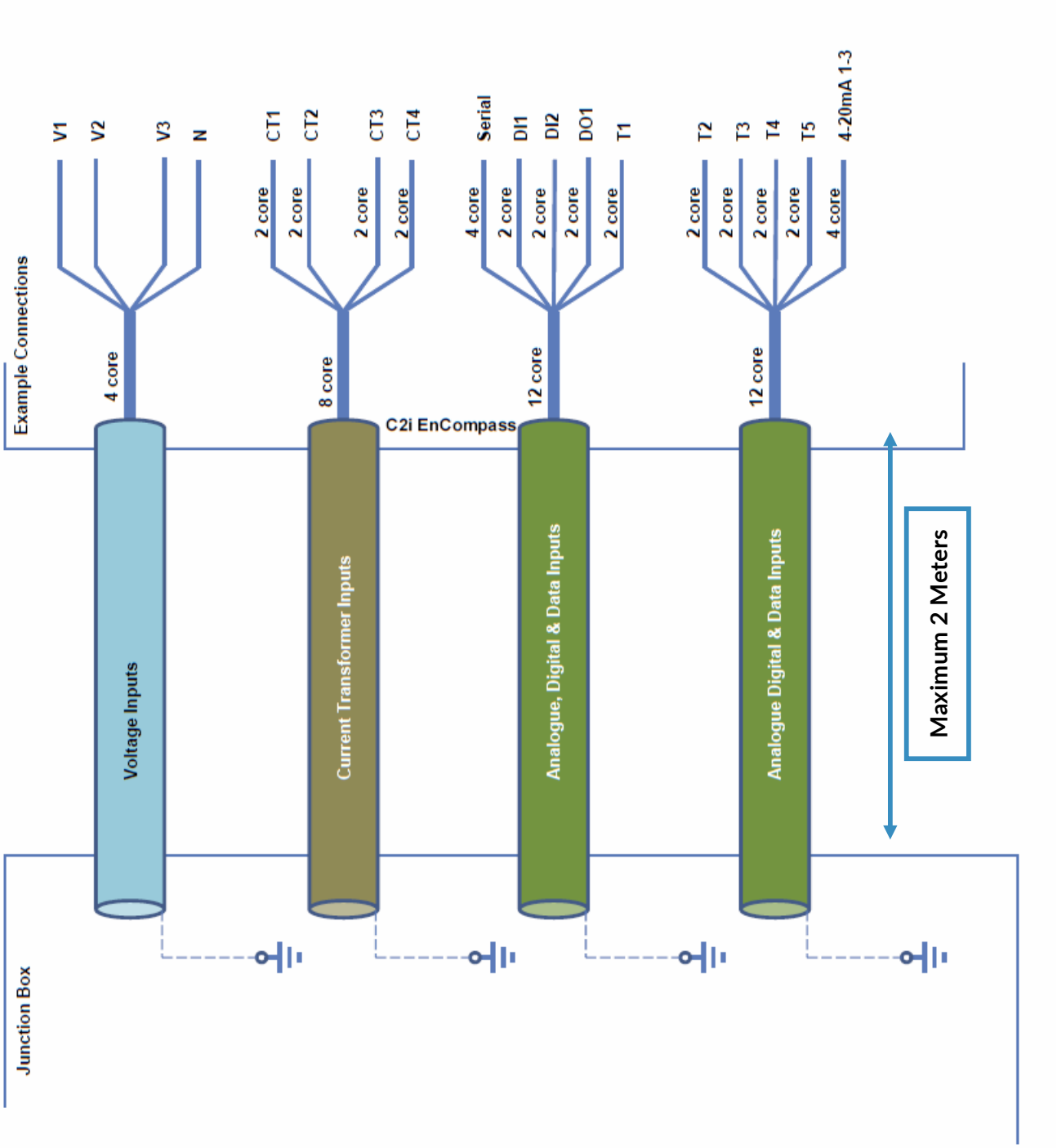


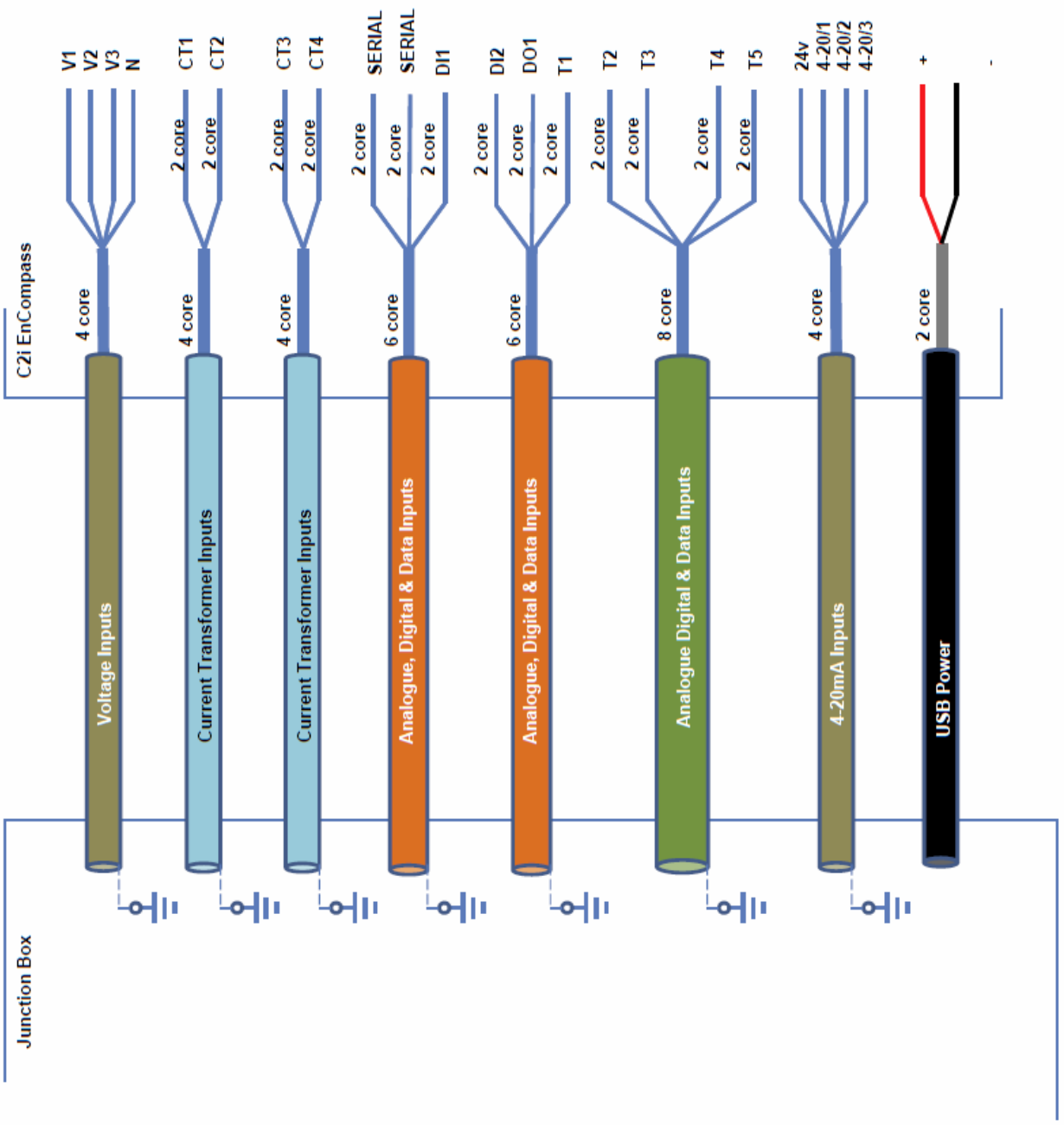
Plugs and sockets must be provided for the current transformer inputs to ensure safe connection and disconnection.

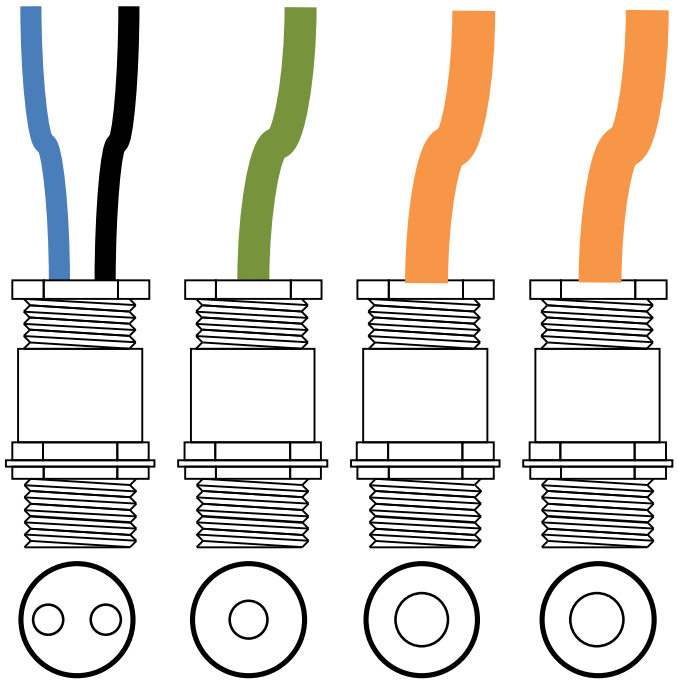
7.5 - I/O Connection Diagram

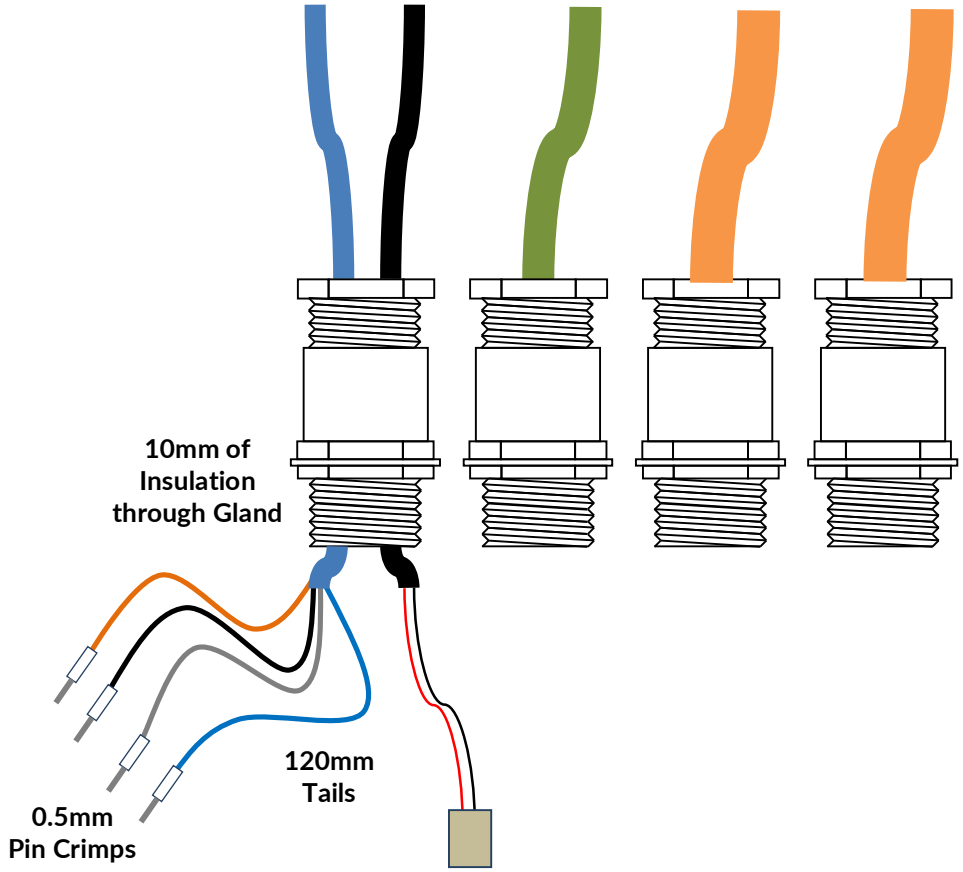


7.6 - Wiring Configurations





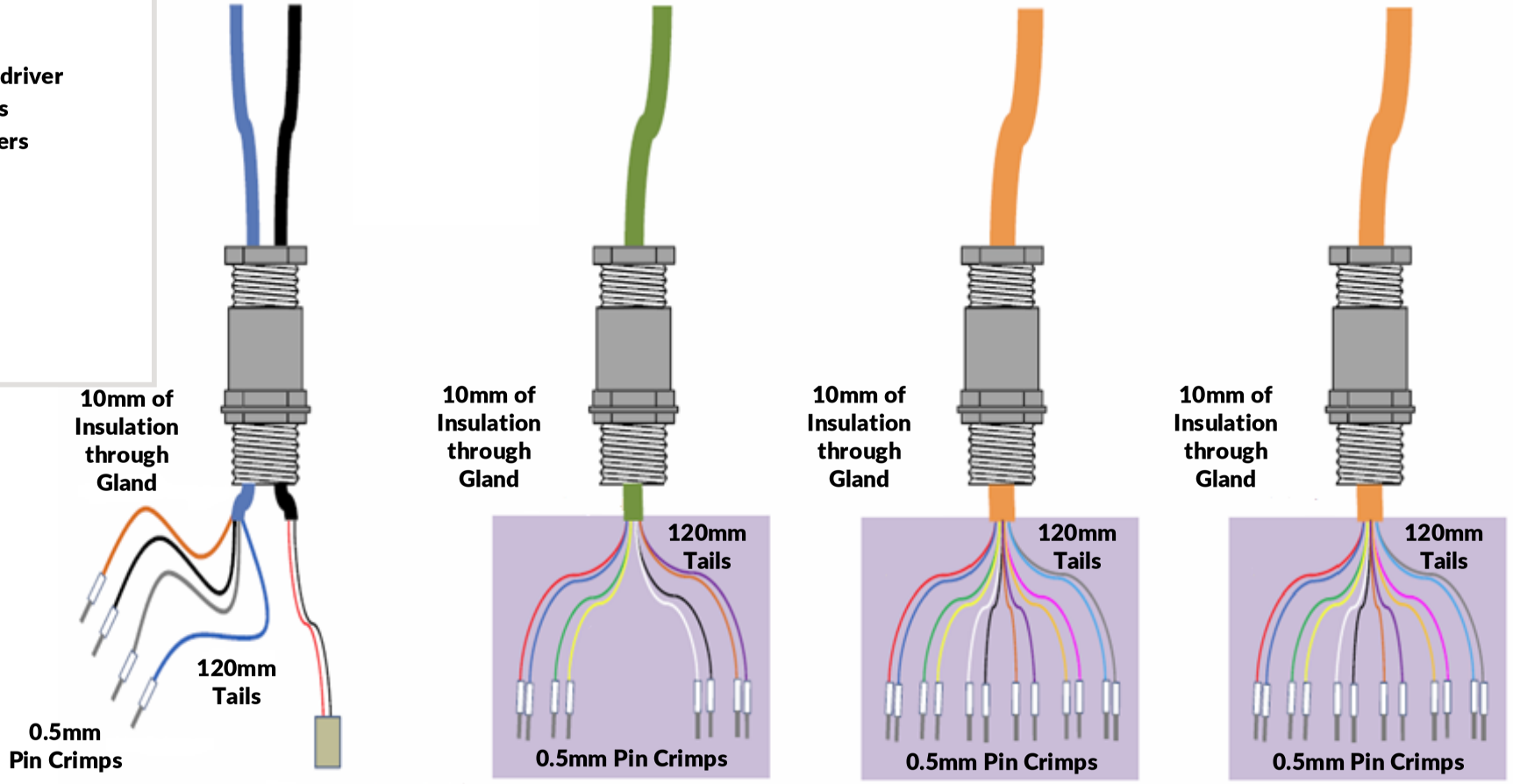




USB Power Connector.
To be fitted after the cable has been fed through the gland.
(*See Instructions*).

Recommended Tools
(Excluding Fixing Method)

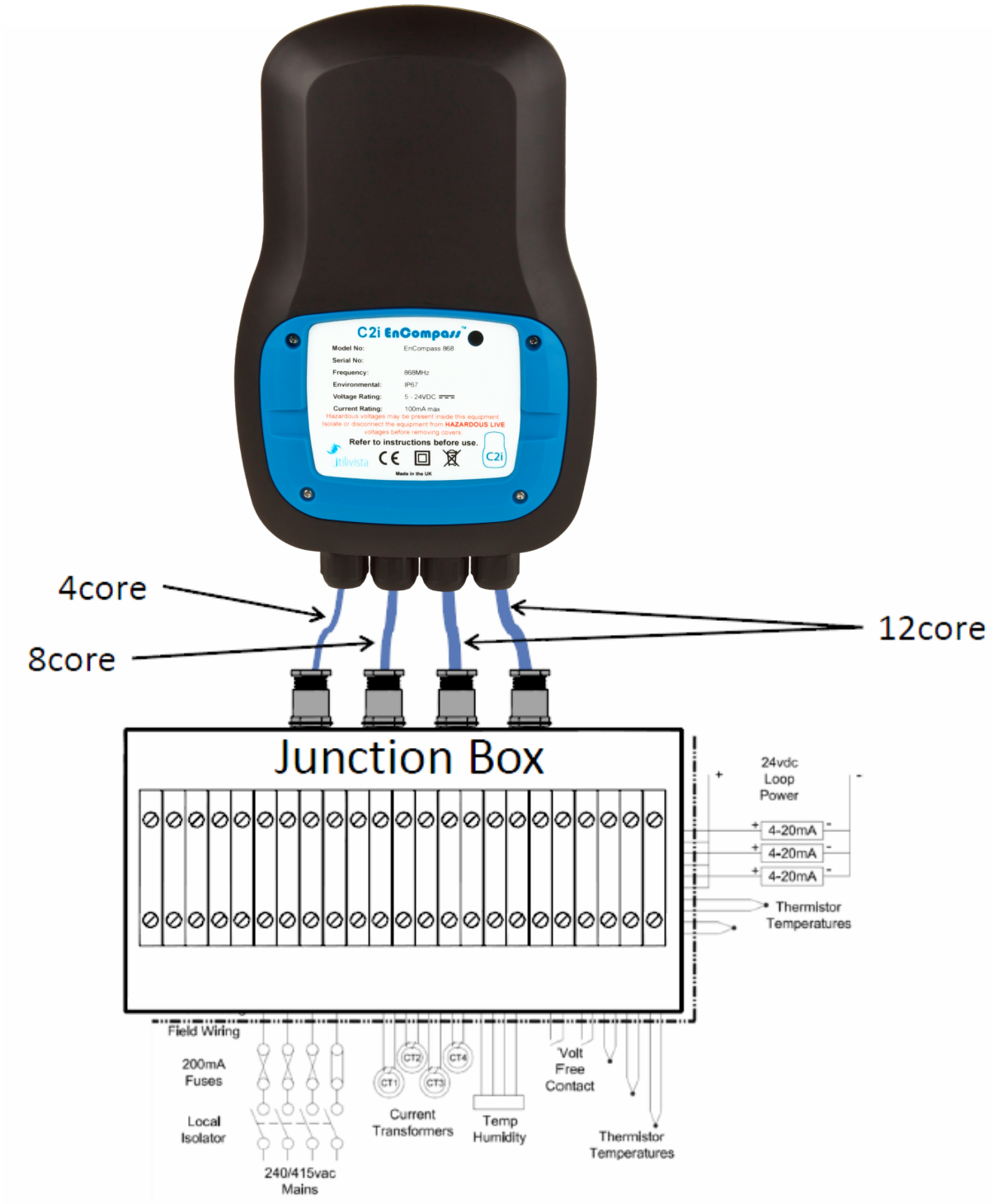
- Long Reach Socket & Wrench (10mm and 16mm Glands)
- M3 Allen Key
- Terminal Screwdriver
- Thin Nose Pliers
- Small Side Cutters
- Knife
- Cable Strippers
- Crimpers
- Testers
- Magnet
- Tape Measure

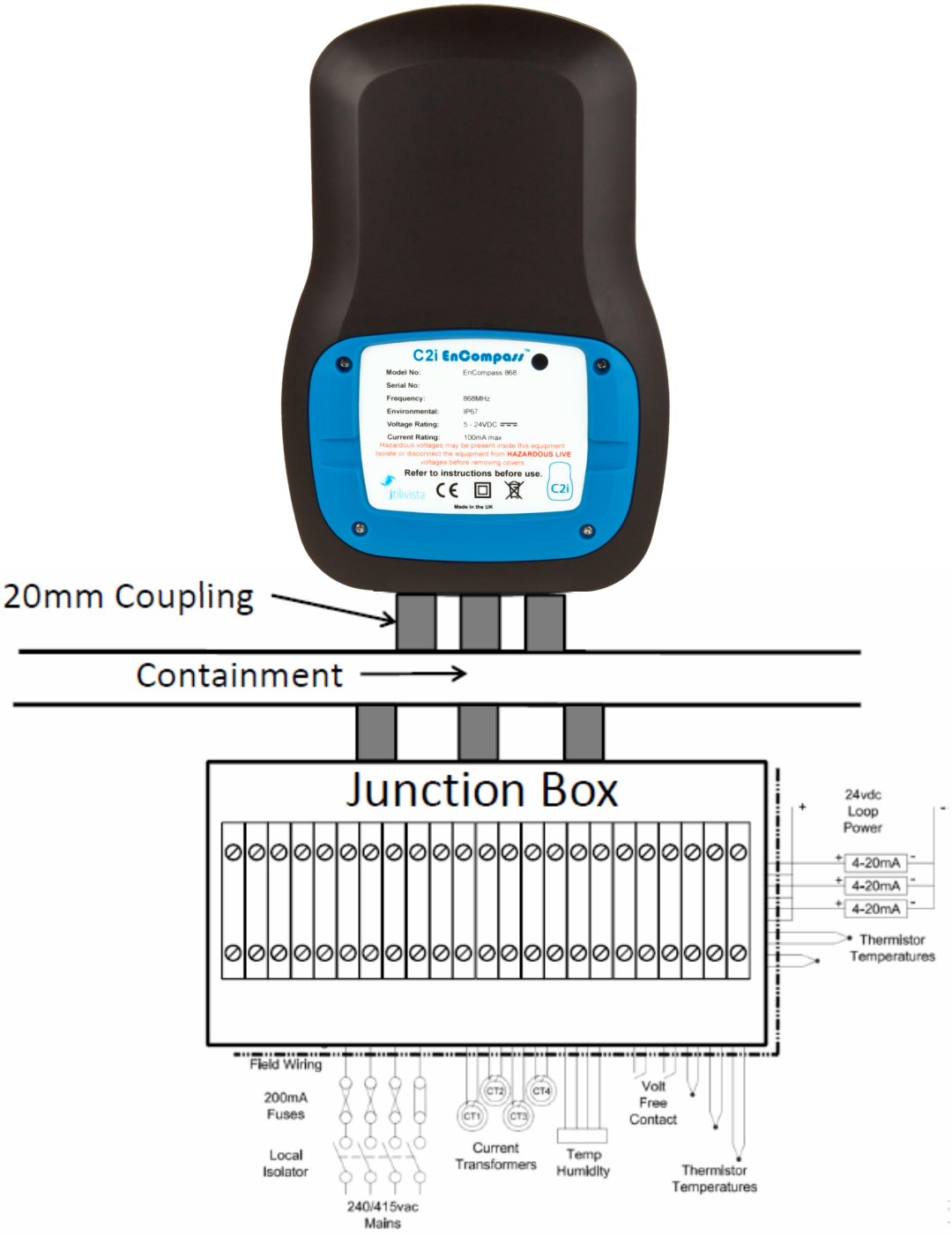


USB Power Connector.
To be fitted after the cable has been fed through the gland.
(*See Instructions*).

Alternative

Connection Methods




C2i EnCompass
Model No: EnCompass 868
Serial No:
Frequency: 868MHz
Environmental: IP67
Voltage Rating: 5 - 24VDC
Current Rating: 100mA max
Hazardous voltages may be present inside this equipment.
Isolate or disconnect the equipment from HAZARDOUS LIVE voltages before removing covers
Refer to instructions before use.
Made in the UK
20mm Coupling
Containment
Junction Box
24vdc Loop Power
4-20mA
4-20mA
4-20mA
Thermistor Temperatures
Field Wiring
200mA Fuses
Local Isolator
240/415vac Mains
CT1
CT2
CT3
CT4
Current Transformers
Temp Humidity
Volt Free Contact
Thermistor Temperatures

8. Specifications

8.1 - General Specifications

POWER

Power Supply	AA or C type Battery (3.6vdc) or USB/PSU (5/24vdc) mains adapter
Mains Input Voltage	Voltage 1-3 range 45vac – 230vac. 50/60Hz Isolated from other I/O
Wiring (Mains)	Cage-Clamp terminals rated at 630v 12Amp Suitable for cables 0.14mm^2 to 2.5mm^2
Wiring (Other)	Cage Clamp terminals rated at 250v 2Amp Suitable for cables 0.5mm^2 to 1.5mm^2
See Wiring Diagram on Page 16	
Current Consumption (Transmitting)	85mA
Current Consumption (Receiving)	20mA
Current Consumption (Sleep Mode)	250nA
Type	Lithium-Thionyl Chloride
Life	Up to 10 years
Power	2700mAh (Nodes) 8500mAh (Repeaters/Combined)
Dimensions	50.5 x 14.5mm
Operating Temperature	-60 to + 85 °C
Nominal Voltage	3.6V
Typical Weight	19g

WIRELESS

Communications Range	Up to 1000m Line-of-Sight
Operating Frequency	868Mhz/915kHz
Channel Spacing	12.5kHz / 25kHz
Receiver Sensitivity	-115dbm
Maximum Link Budget	135dbm
Functionality	Bi-directional
Data Rate	2400 Baud
Bandwidth	Narrow Band FM
Transmit Power	+20dbm (100mW)
Firmware Upgrades	Transmitted over-the-air
Access to Interface	Local or Remote (www) if enabled

CASING

Material	Acrylonitrile Butadiene Styrene (ABS)
Dimensions (H,W,D)	235.00 x 154.06 x 73.22 mm
Volume	$3.5x10^{16}$ Ωcm
Weight	1.1kg approx.
Colour	Black
IP Rating	67
Approvals	CE
Maximum Operating Temperature	60°C
Temperature Range	-20°C to +60°C
Thermal Conductivity	0.2W/m°C
Specific Heat	1.47kJ/kg°C
Thermal Ignition Resistance	HB @ 1.5mm
Coefficient of Thermal Expansion	$10.1x10^{-5}$ m/m°C
Impact Strength	240J/m
Ultimate Tensile Strength @ 20°C	40Mpa
Elongation at Break @ 20°C	50%
Instantaneous Flexural Modulus @20°C	2200Mpa
Compressive Strength @ 20°C	42Mpa
Specific Gravity	$1.05x10^{3}$ kg/m^3
Poisson's Ratio	0.35
Surface Resistance	< 10^{9} Ω
Vicat Softening Point	95

8.2 – Inputs and Outputs

SUMMARY

Voltage Measurement	3 x Voltage Inputs rated @ 45 – 230 VAC
Neutral	1 x Neutral Input Rated @ 45 – 230 VAC
Current Measurement	4 x CT Inputs 0.333 v or 75 mA
Status or Pulsed Count	2 x Digital Inputs (Volt Free Contact) or 7 x Digital Inputs (if selected in place of Temp. inputs)
Status of Totaliser Output	1 x Digital Triac Output for Alarms or BMS Pulsed Meter Input
Temperature and Humidity	5 x 10K3A1 Thermistor Inputs (or 5 extra Digital inputs)
4-20mA	3 x 4-20 mA Inputs for various Transducers (Loop Powered)
Dual Input Interface	Used for Temp/RH Input
Serial	RS232 and RS485

AC VOLTAGE INPUTS

Voltage Rating	230 V AC
Min Operating Voltage	45V AC
Full scale max Voltage	380V AC
No-Load Loss (typical)	1.30W
Frequency	50/60Hz
Error	±1% Typical

CURRENT TRANSFORMER INPUTS

Voltage Rating Max	500mV AC
Secondary Current Rating Max	73mA
Frequency	50/60Hz
Load Resistor	6.8Ω
Error	±1% Typical

DIGITAL INPUTS

Voltage Rating	5V DC
Input Logic Low Voltage (typical)	<0.7V
Input Logic High Voltage (typical)	>2.25V
Input Type	Logic level
Operating Logic	Open circuit = 1, Closed circuit = 0
Pulsed Input	Fast Counter
Max	220ms

DIGITAL OUTPUT

Output Type	Open collector with 10K pull up to Aux-in terminal
Output Resistance	10 Ohm
Current Sink (max)	25mA

TEMP/HUMIDITY INPUT

Voltage Rating	3.3V
Available Current Rating	0.55mA
Operating Range (Temperature)	-40 to 123.8°C
Operating Range (Humidity)	0 to 100% RH
Error (Temperature)	±0.3°C
Error (Humidity)	±1.8%

THERMISTOR INPUTS

Operating Voltage	3.3V DC
Short Circuit Current (typical)	280uA
Input Type	Thermistor 10K, 20K
Operating Logic	Open circuit = 1, Closed circuit = 0
Pulsed Input	Fast Counter
Max	220ms
Error	± 0.1 °C when < 50 °C, dependant on sensor used

4-20mA INPUTS

Voltage when sensing (Max)	5V DC
Current Rating	20mA
Sense Resistor	240 Ω
8/12 bit Resolution	0.1mA/0.025mA (firmware dependant)

24V DC

Input Voltage (max)	36V
Input Voltage (min)	5V

8.3 - Special Conditions

No testing has been carried out in any of the following environments:

- High altitudes.
- Pressurised cabins or containers.
- Explosive atmospheres.

8.4 - Approvals

- CE approvals on the node ensure safety measures are integrated successfully.
- IP67 protection, where 6 means total protection against dust and 7 means protection against immersion between 15cm and 1m of water for 30 minutes.
- Operating temperature range: -20 to +60 °C.

C2i only recommends and sells approved sensors. It is the responsibility of the customer to ensure that all sensors used with the EnCompass have the appropriate approvals.

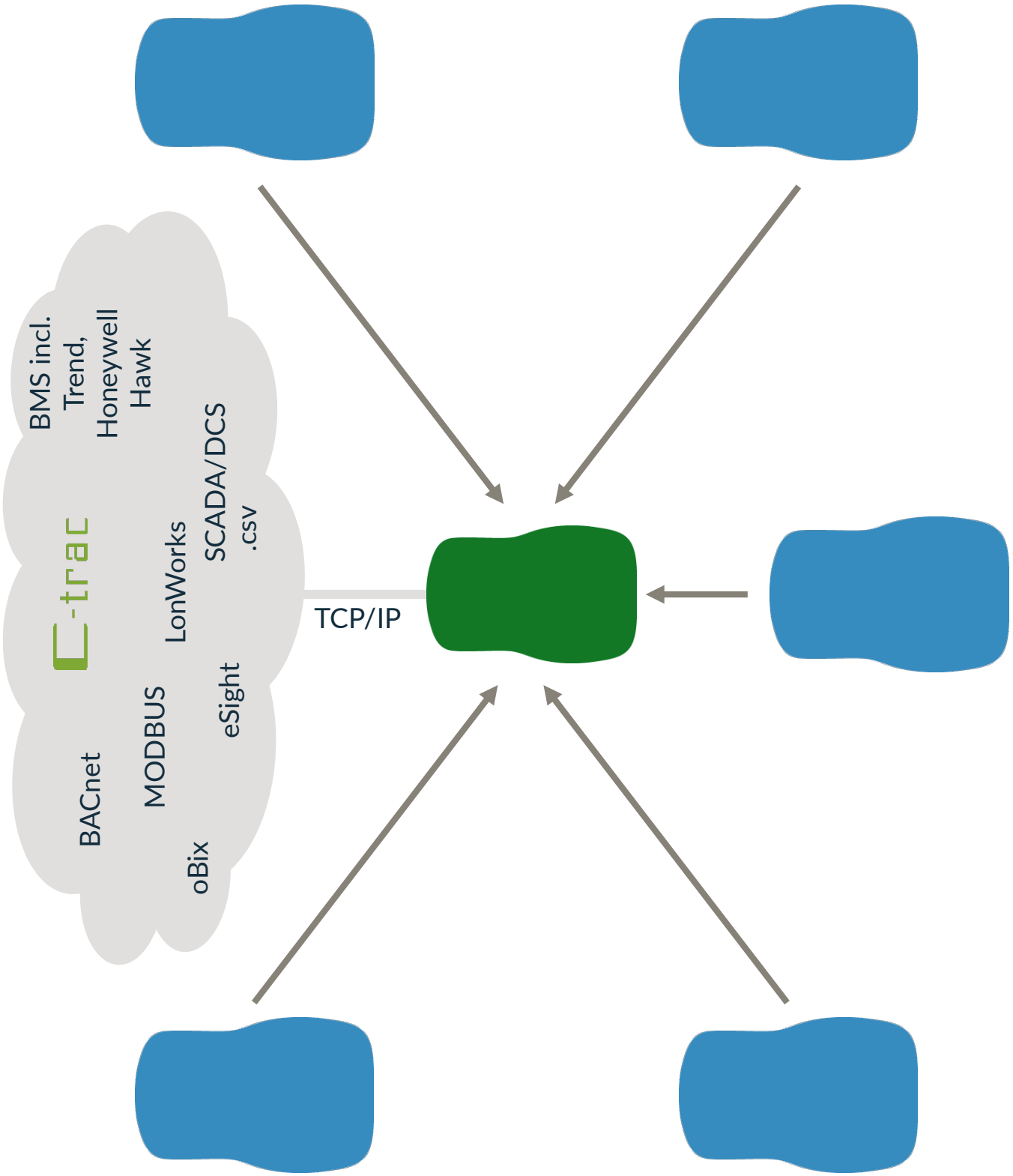
9. Application Examples

Below are application examples of the comprehensive monitoring capability of a single EnCompass when used to monitor utility systems.

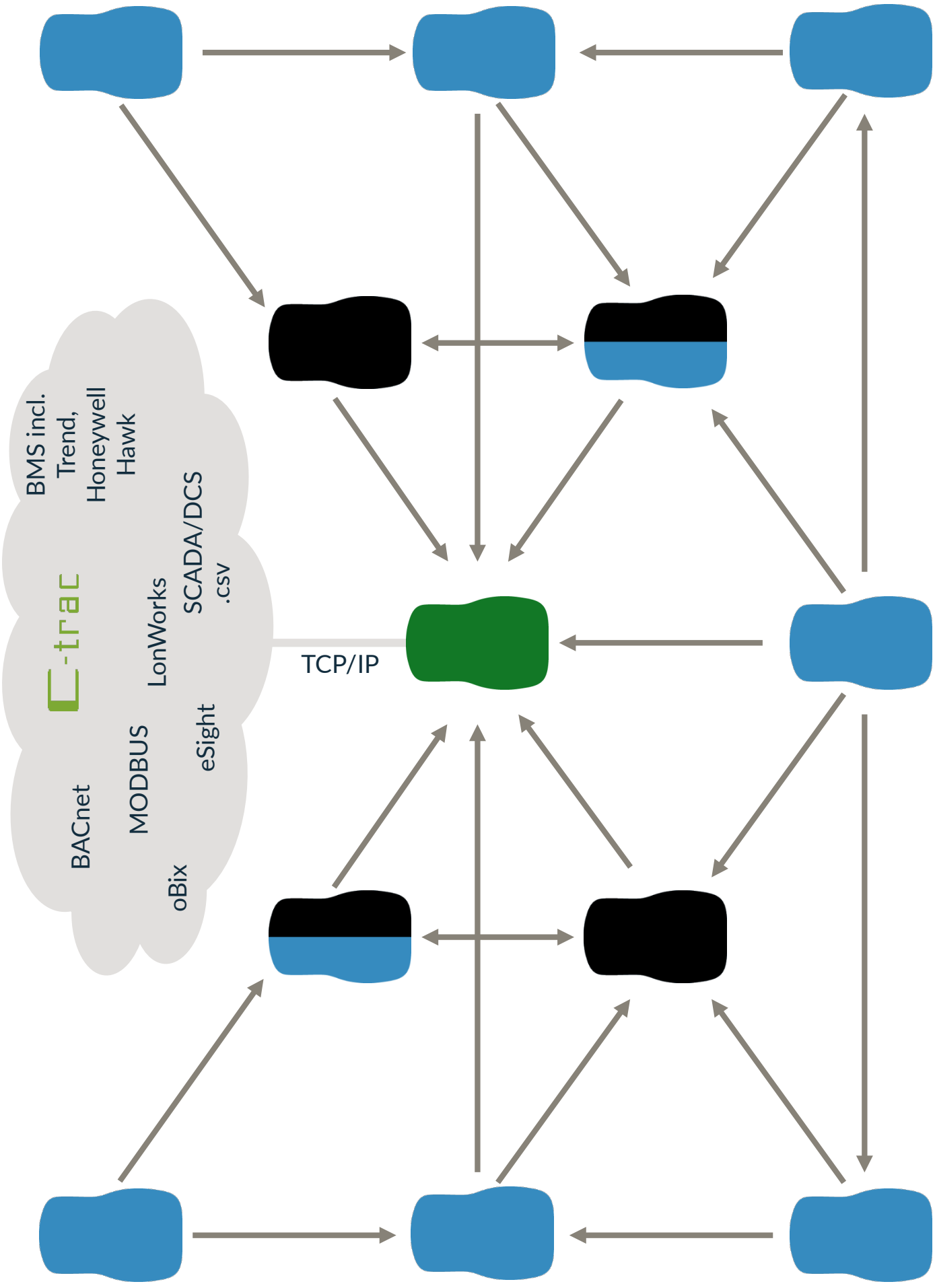
INPUT	MOTOR/PUMP	CHILLER	BOILER	COOLING SYSTEM
Power 3 x Voltage, 1 x Neutral	Main Drive	Compressor	Forced Draft Fan	Recirculation Pumps or Fans
Power 4 x Current Transformers	Main Drive	Compressor	Forced Draft Fan	Recirculation Pumps or Fans
Temperature 1	Bearing Temperature	Chilled Water Flow	Supply Temperature	Supply Temperature
Temperature 2	Stator/Winding Temperature	Chilled Water Return	Return Temperature	Return Temperature
Temperature 3	Ambient	Condenser Water Flow	Flue Gas Temperature	Exit Air Temperature
Temperature 4	Process	Condenser Water Return		Motor Bearing Temperature
Temperature 5		Evaporator Refrigerant Temperature		
4-20mA Input 1	Bearing Vibration	Refrigerant Pressure	Gas/Oil Consumption	Cooling Water Flow
4-20mA Input 2	Speed/Flow Rate	Chilled Water Flow Rate	Steam Flow/Pressure	Fan Speed/ Air Flow
4-20mA Input 3	Pump Discharge Pressure	Compressor Vibration	Oil/Water Tank Level	Pump/Fan Motor Vibration
Digital Input 1	Motor Status	Chiller Status	Boiler Status	Tower Fan Status
Digital Input 2		Purge Unit Runtime	Alarm	
Serial Input		Ambient Temperature & Humidity	Ambient Temperature & Humidity	Ambient Temperature & Humidity

10. Network Examples

10.1 – Simple Network



10.2 – Network Including Repeaters and Node/Repeaters



Appendix A - Positioning to Maximise Range

A.1 – Signal Propagation and Penetration

Use this Appendix as a guide to maximising the range and efficiency by careful positioning of the EnCompass nodes and Entranet gateway/receivers.

Wireless data is transmitted via radio waves. As a radio wave propagates from transmitter to receiver its strength/magnitude/amplitude decreases proportionally to the inverse of the distance and its intensity decreases proportionally to the inverse of the distance squared. Therefore, for every doubling of the distance between transmitter and receiver, intensity reduces to a quarter and strength is halved, thus limiting the effective range.

$$A \propto \frac{1}{d} \qquad I \propto \frac{1}{d^2}$$

Moreover, radio waves receive many losses in typical situations due to obstructions which reduce the effective range even further. The common solution is to increase power; however, using the latest technology to extend the range and improve the link budget, the EnCompass and Entranet have excellent penetration and range without the inconvenience of poor battery life.

A.2 – Typical Range-Reducing Obstructions

Position the signal path to avoid the following where possible:

- **Reinforced Concrete.**
- **Steel Cladding.**
- **Thermal insulation with metallised foil.**
- **Treated Glass.**
- **Equipment prone to emit radio interference.**
- **High Power and overhead power lines.**

TYPICAL MATERIAL DATA

Description	Penetration
Wood, Uncoated Glass, Gypsum	90 – 100%
Brick, Pressboard	65 – 95%
Reinforced Concrete (depending on the density or rebar)	10 – 90%
Metal, Metal Coated Insulation	0 – 10%

TYPICAL RANGE DATA

Description	Range
Line of Sight	Up to 1000m
Wood, Uncoated Glass, Gypsum (through 4 walls)	250m
Brick, Pressboard (through 2 walls)	150m
Reinforced Concrete (through 1 wall or ceiling)	100m
Metal, Metal Coated Insulation (through 1 wall)	Up to 30m

A.3 – Examples

Placement of the **EnCompass** needs to be planned to ensure a system with maximum efficiency and effectiveness.

KEY:

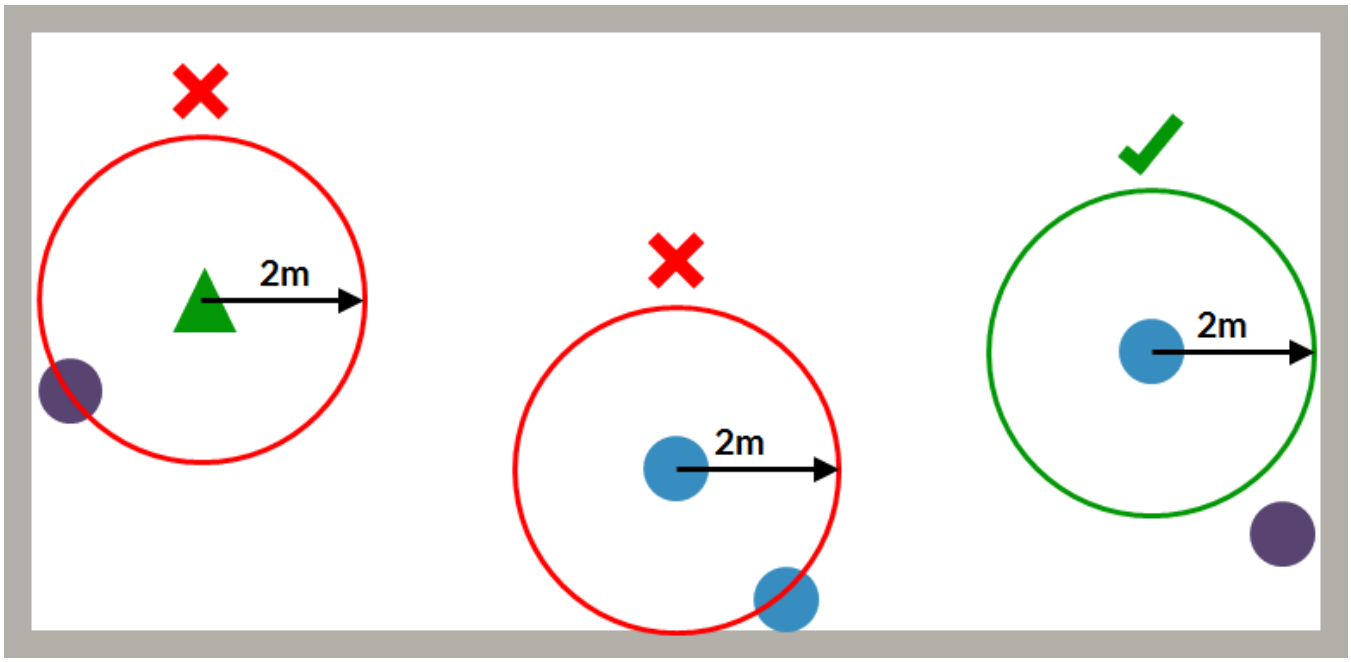
Entranet receiver

EnCompass node

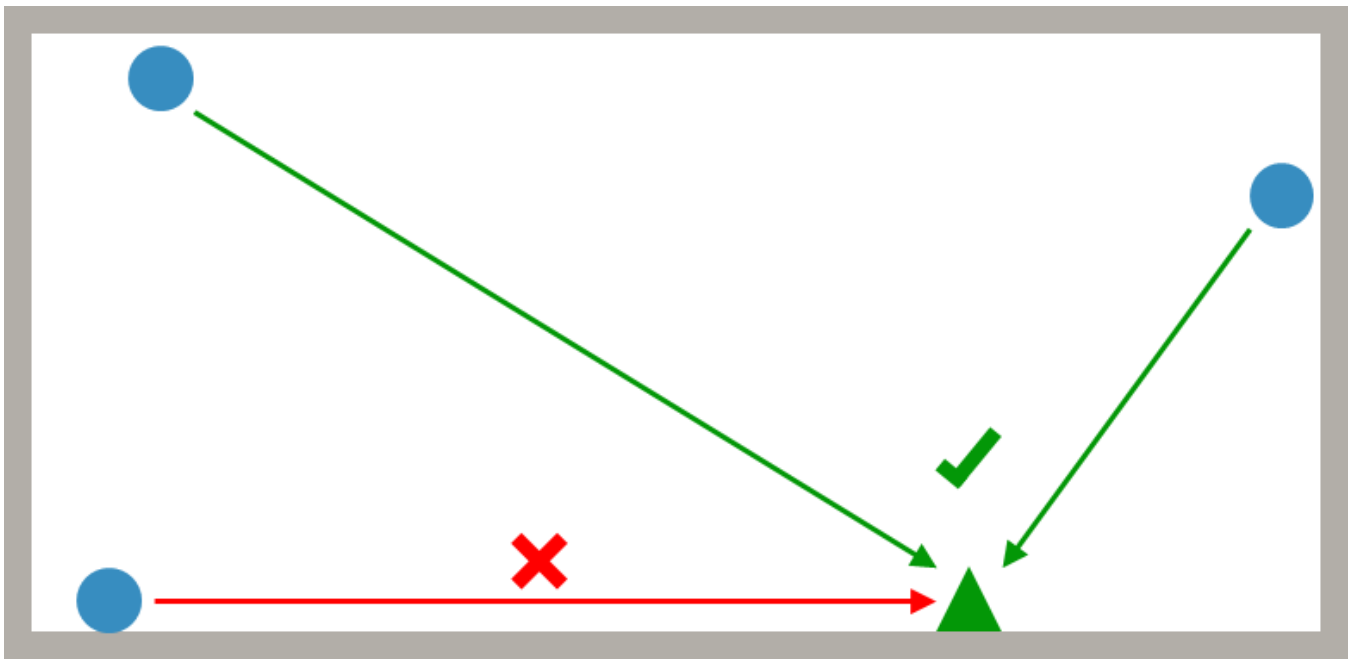
EnCompass node/repeater

Other transmitter

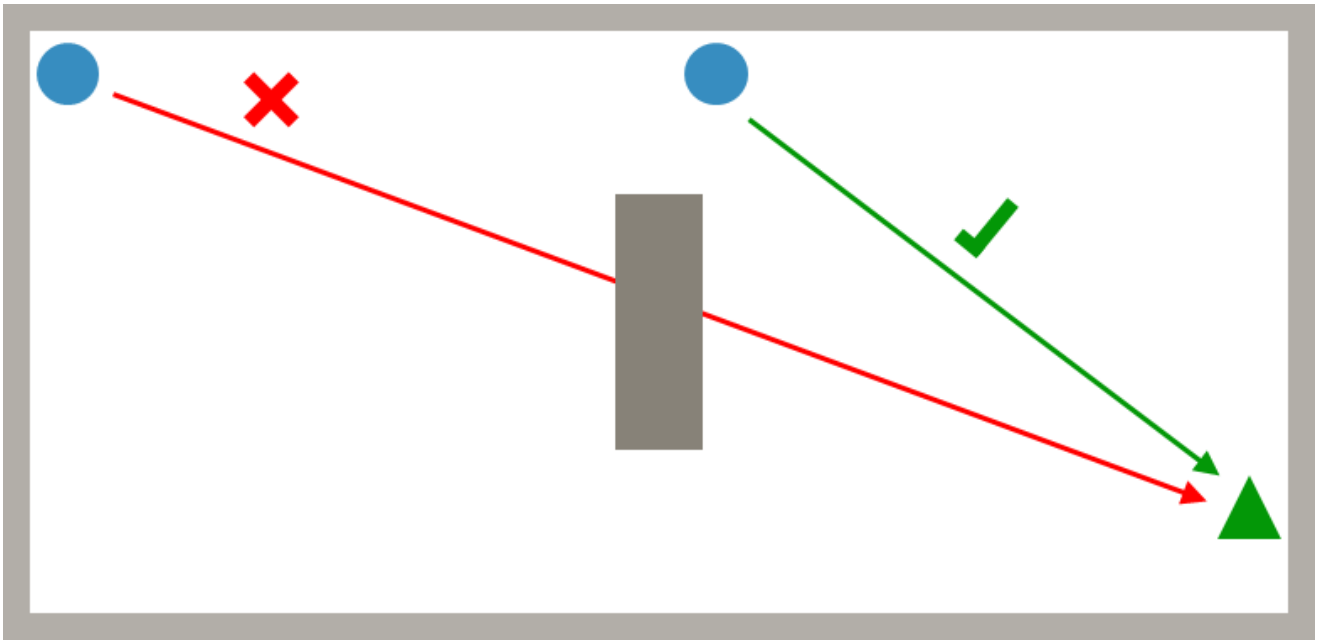
No **EnCompass** or **Entranet** must be less than 2 metres from each other or another transmitter.



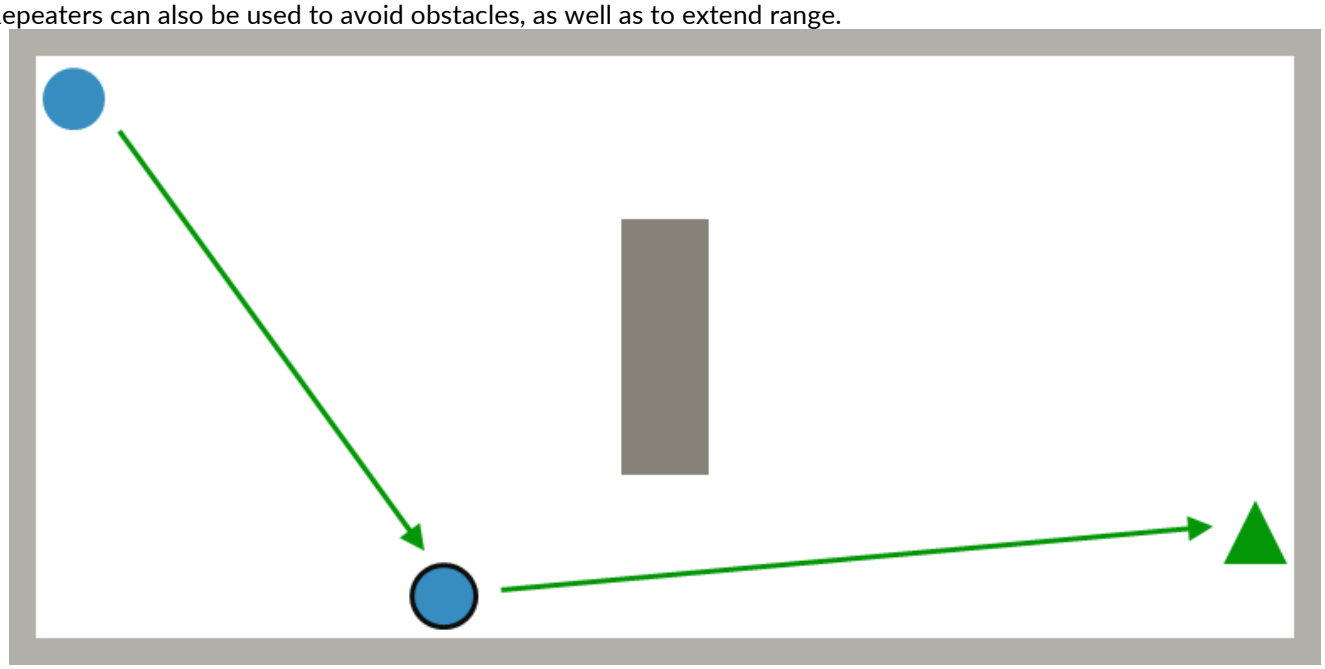
When mounting an **EnCompass** within the same internal vicinity as the **Entranet** or a repeater (with no obstructions), the **EnCompass** should be mounted on the opposite or adjacent wall, not on the same wall as a repeater or the **Entranet**.

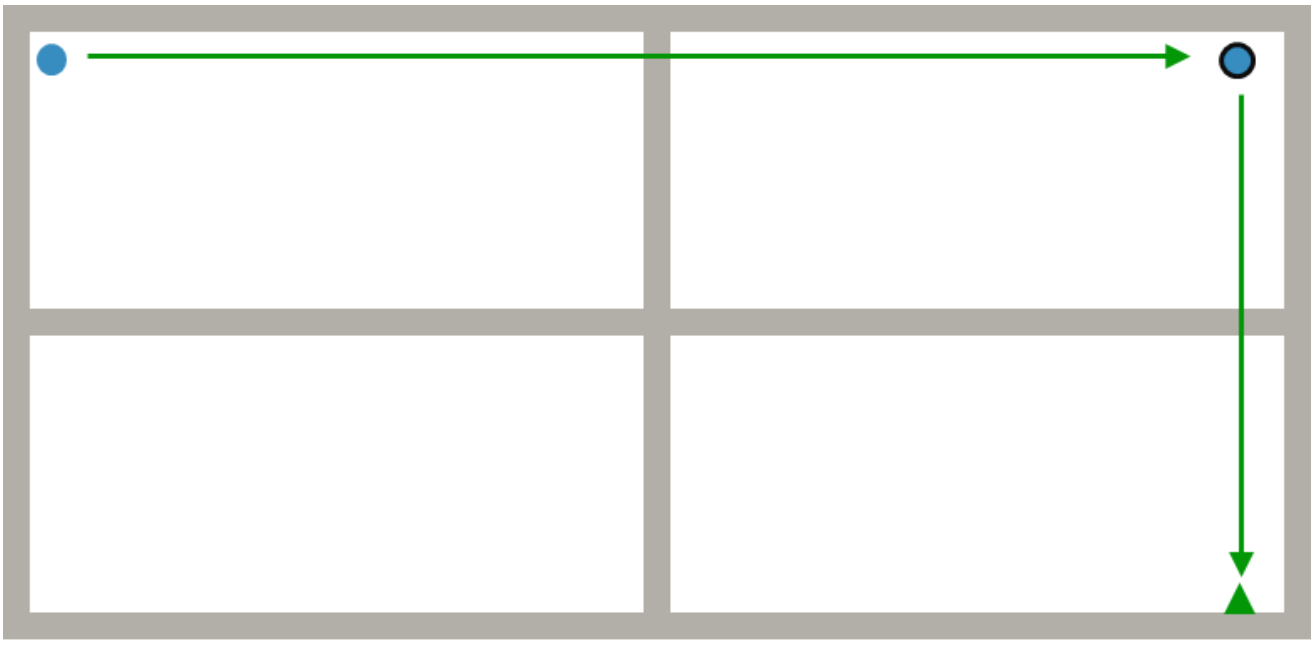


If possible, obstructions should be avoided.

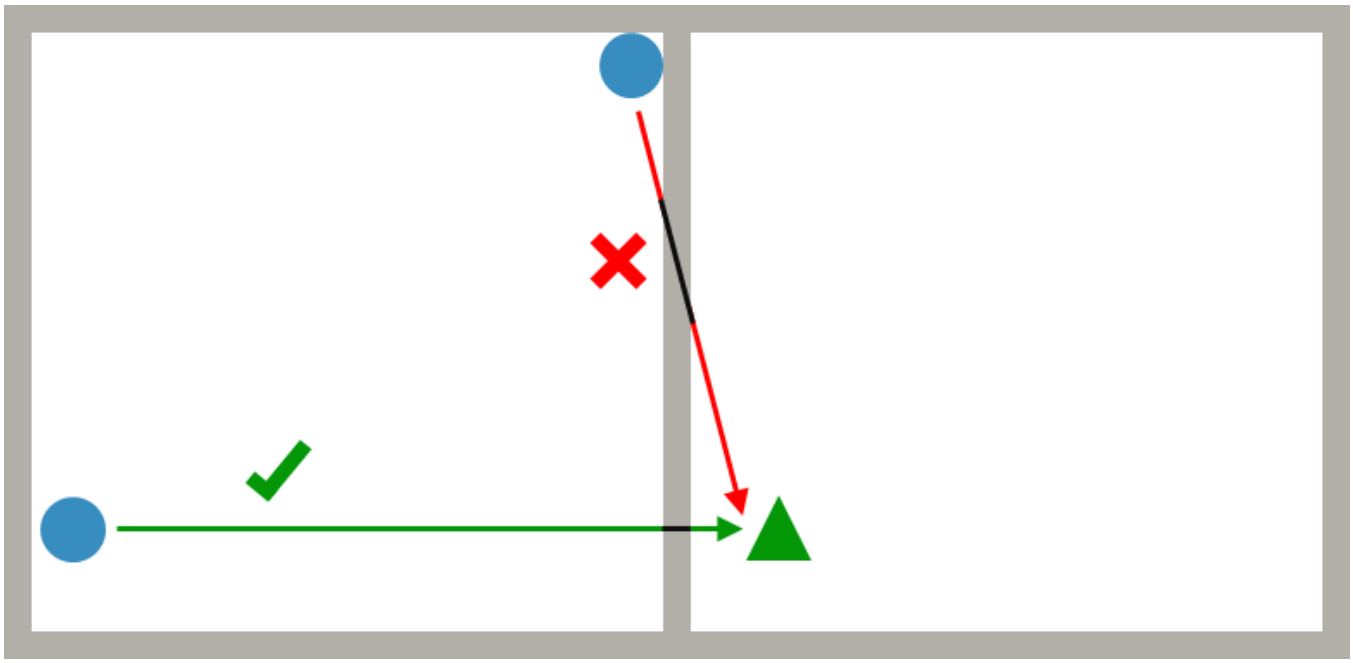


Repeaters can also be used to avoid obstacles, as well as to extend range.

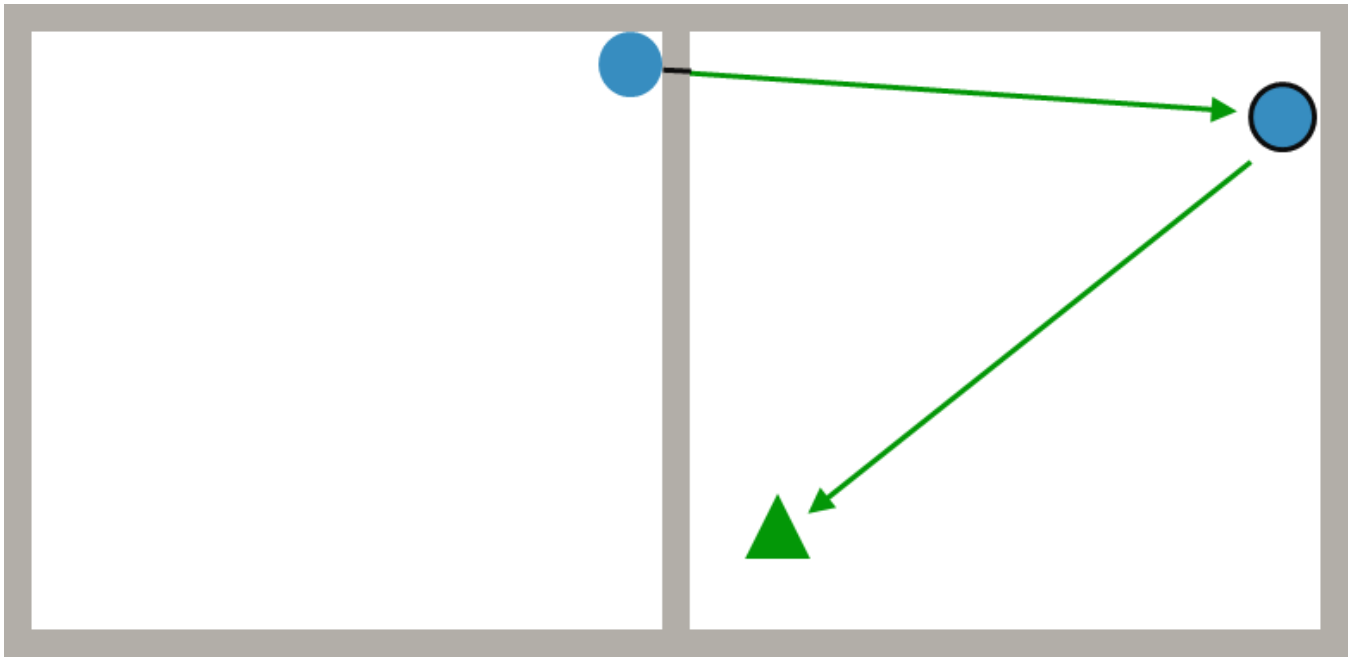




To minimise signal losses when passing through an obstruction such as a wall, position **EnCompass** nodes and repeaters and **Entranet** gateway/receivers such that the signal passes through as close to 90° as possible, reducing the distance through it.



Alternatively, to avoid passing through a wall or other obstruction at a poor angle use a repeater.



Appendix B – Further Network Information

B.1 - Method Used for Optimal Repeater Efficiency

For every logged input a node has an opportunity to transmit its sampled values every 15 minutes, which it will do if the setting for reporting interval demands it to be sent, or if the buffer is approaching maximum capacity. A repeater operates by remembering when a node may wake up to perform transmission and ensuring that it wakes up momentarily beforehand in order to repeat the packets. Repeaters can be at one of two logical levels. Level 1 is a repeater that is within direct range of the **Entranet**, while Level 2 means the path to the **Entranet** is via a Level 1 repeater. Each repeater therefore stores a list of nodes for which it is repeating packets. Normally the repeater is completely powered down and waiting for the correct time to wake up for the next node transmission. At all times where possible, the repeater will completely power down when it can. For example, if a Level 2 repeater forwards a packet, then based on the packet size and the transmission bit-rate there is a physical minimum time at which a response can possibly arrive back. During this time the repeater will power down.

In order for a node to register itself with a repeater, it is necessary to communicate with it outside of a predetermined time window. To allow this, each repeater wakes up every 5 seconds and checks for 2 milliseconds for the presence of a preamble signal of alternating 1's and 0's. If this is detected the **Entranet** is left on until either a valid packet is received, or the preamble ends and no packet is received immediately afterwards. For a node to transmit a packet at any time to a repeater, it simply has to transmit preamble for 5 seconds followed immediately by the packet. This uses a large amount of power on the node, but is something that would not occur very often, possibly no more than once. The repeater can operate this way continuously even from battery due to the very low average power consumption this requires.

In Learn Mode (or when rerouting due to loss of communications), a node attempts to talk directly to the **Entranet** first. If this isn't possible then it attempts to register with a Level 1 repeater. Again, if this fails then it attempts to register with a Level 2 repeater. Once communications are established, the acknowledgement from the **Entranet** will have the list of repeater IDs inserted into it. The node then remembers this path (in reverse) and inserts this into the header of each packet it subsequently transmits in order to have the packet follow the learned route.

B.2 - Method Used for Mesh Routing

Each packet transmitted contains an optional 'required route'. This is a list of 24-bit serial numbers of all the repeaters that are required to pass the packet. Currently the list is two elements long, meaning that there can be at most two repeaters between any node and the **Entranet**.

If no repeaters are required, then all the addresses in the list should be set to 0. If only one is required, then the first element should be set to the required address and the remaining elements set to 0 and so on. The actual route address is used to record the route a packet has actually taken, rather than its desired route.

The process of automatically learning a route between a node and the **Entranet**, or of bypassing a faulty repeater, uses a combination of these tables along with the retry counter. When a node is first installed, it doesn't have any routing information and will always transmit the required and actual routes as zero. When the node sends a report, if the **Entranet** is within range it will send a response as normal. However, each time the node sends a report and doesn't receive a response, the retry counter is incremented.

There is a maximum number of retries that will be attempted before the node gives up, which is programmable and would normally be 10.

Assuming the node and the **Entranet** are out of range, the node will transmit a packet and fail to hear any response. However, if there is a repeater in range then the repeater will monitor these packets and wait until the retry counter reaches 3. At that point it assumes that the node is unable to communicate with the **Entranet** and it should therefore step in to assist. So, the repeater adds its own address into the unused actual route address and re-transmits the packet.

If the **Entranet** then receives this packet, it sees that the actual route taken was different to the required route. The **Entranet** then remembers that in order to send a packet to this node, it must send it via the repeater specified in the actual route list, but in reverse order.

The ACK packet will then be received back at the node, and upon inspection the node will see the route taken by the ACK and will remember the reverse pattern for next time. So, the next packet it sends will have the required route table set.

When a repeater receives a packet that has its own serial number in the required route table, it must repeat it, but only if it hasn't already repeated it before. So, if the repeater's own address appears in the actual route table then it does NOT repeat the packet. But, if its address does not appear then it adds its address to the actual route table and then retransmits it. This is done regardless of the retry count to ensure that packets following the required route are sent first time.

B.3 - Sampling Frequencies

B.3.1 - Continuous sampling

When the **EnCompass** is powered by a combination of the battery and mains voltage on input V1, or when it is powered by the USB adapter, current and (if applicable) voltages are sampled at a very high rate to calculate power consumption. All other inputs can be sampled at this rate, though data at this frequency would be too voluminous to transmit, and therefore this would only be useful when the **EnCompass** is connected to a computer via the serial connection.

B.3.2 - Regular sampling

For all inputs, the sampling rate for the data reported over the network is configurable at node level. The options for this setting range from 10 seconds up to 4 hours. When more than 2 inputs are reporting, a sampling rate of 10 seconds is liable to cause a buffer overload, resulting in lost data. Likewise when more than 4 inputs are reporting, the same would be true of a sampling rate of 20 seconds. For sampling intervals over (and including) one minute, this issue is avoided, regardless of how many inputs are reporting. Sampling times of a certain number of minutes must be numbers that are divisible by 60, as the **EnCompass** ensures that sampling is timed such that it always takes place on the hour.

B.3.3 - Digital event recording

When a digital input is configured to report all changes of status, it will recognize and log every time the input changes, regardless of the sampling rate.

B.4 – Reporting Frequencies

The network functions such that every node has an allocated time, every 15 minutes, when it can transmit data if required. When a node's buffer has filled to the extent that it is unlikely to contain enough data for another 30 minutes of sampling, it will transmit this data at the next available timeslot (thus having to wait no longer than 15 minutes). In addition to this principle, an **EnCompass** has a minimum reporting interval, configurable from 15 minutes up to 4 hours, so the user can ensure that all unreported data for each input is reported at least at that frequency, regardless of the state of the buffer.

Appendix C – Further Specification

C.1 – Resin Fill Information

A large part of the circuitry is resin potted. This provides structural and thermal stability to the internal workings of the node. The components are protected from any physical and most chemical risks. The resin also provides UV absorption.

Robnor Resins EL171H
A semi rigid, room temperature curing, flame retardant polyurethane resin system.

DESCRIPTION

Basic	Two-component polyurethane system
Resin	RL171H
Hardener	HL171H

Application	Key Properties
Encapsulation of Transformers	Non-toxic
Cable Joints	UL94-V0 @ 6mm
Wide range of substrates	Excellent adhesion
Low to medium voltage electrical and electronic applications	High thermal conductivity
	Economical

PHYSICAL DATA (APPROX. VALUES)

Description	Resin	Hardener	Mixed
Colour	Black	Amber	Black
Colour	Beige	Amber	Beige
Specific Gravity	1.72	1.24	1.65
Viscosity (mPas) @ 25°C	19000	200	6000

CURE SCHEDULE (150ML SAMPLE)

Temperature	Working Life (minutes)	Gel Time (minutes)	Light Handling (hours)	Full Cure (hours)
RT (20-25°C)	20	40	24	48
60°C	-	-	2	4
80°C	-	-	1	2

TYPICAL PROPERTIES

Test	Result	Unit
Operating Temperature	-40 - +125	°C (application & geometry dependant)
Flammability	6mm	UL94-V0
Peak Exotherm (250g @ 20°C)	40	°C
Shrinkage	0.5	%
Volume Resistivity	12^{10}	Ohm.cm
Surface Resistivity	$12 - 14^{10}$	Ohm.cm
Dielectric Strength	16	kV/mm
Permittivity (ϵ)	4.6	50Hz
Loss Tangent (Tanδ)	0.04	50Hz
Hardness	90	Shore A
Heat Deflection Temperature	Flexible	
Water Absorption (30 days @ 25°C)	0.54	%
Thermal Conductivity	0.75	W/mK
Coefficient of Linear Expansion	60 – 80	Ppm/°C
Elongation at Break	~30	%
Comparative Tracking Index	>600	v

APPROVALS

RoHS Compliant	Yes
UL94-V0	6mm
REACH (SVHC Concentration)	0%

C.2 – Safety Features

C.2.1 – Mains Safety

Mains inputs are electrically isolated from all other inputs and outputs.

C.2.2 - Cage Clamp Terminals

Cage clamp type terminals ensure the wires are secure and held reliably, thus the connections have an increased durability and stability.
Power terminals conductor size is equal to 0.75mm^2 and low voltage terminals conductor size is equal to 0.5mm^2. Recommend using 0.5mm^2 pin ferrule crimps for easier termination.

C.2.3 - ABS Casing Material

The casing material used for the **EnCompass** is acrylonitrile butadiene styrene (ABS) a compound which has been formulated to meet the static dissipative requirements of the ATEX Directive, thus meeting specific safety requirements. The Casing has high impact strength and ductility, good chemical resistance and abrasion resistance. The material is nontoxic, thus handling of the node has no inherent safety risks. The casing material has high strain tolerance and good resistance to ultraviolet light.

C.2.4 – Electrical Static Discharge (ESD)

All inputs and outputs are protected against ESD.

C.3 – Flammability Ratings

The ratings are as follows:

- 5VA: burning stops within 60 seconds on a vertical specimen with no drips; specimens do not develop a hole.
- 5VB: burning stops within 60 seconds on a vertical specimen with no drips; specimens may develop a hole.
- V-0: burning stops within 10 seconds on a vertical specimen; non-inflamed particles may drip.
- V-1: burning stops within 30 seconds on a vertical specimen; non-inflamed particles may drip.
- V-2: burning stops within 30 seconds on a vertical specimen; flaming particles may drip.

Enclosure Material (UL-94 1.5mm)	V-0
Enclosure Material (UL-94 2.0mm)	5VB
Enclosure Material (UL-94 3.0mm)	5VA
Resin (UL-94 6.0mm)	V-0

C.4 - Description of Wiring Terminal Connections

Terminal Number	Input	Label	Connection	Description
1	45/230 VAC Voltage Ref	Phase 1	V1	Electricity Monitoring
2	45/230 VAC Voltage Ref	Phase 2	V2	Electricity Monitoring
3	45/230 VAC Voltage Ref	Phase 3	V3	Electricity Monitoring
4	45/230 VAC Voltage Ref	Neutral	N	Electricity Monitoring
5	Current Transformer	CT Phase 1	I1A	Electricity Monitoring
6	Current Transformer	CT Phase 1	I1B	Electricity Monitoring
7	Current Transformer	CT Phase 2	I2A	Electricity Monitoring
8	Current Transformer	CT Phase 2	I2B	Electricity Monitoring
9	Current Transformer	CT Phase 3	I3A	Electricity Monitoring
10	Current Transformer	CT Phase 3	I3B	Electricity Monitoring
11	Current Transformer	CT Neutral	INA	Electricity Monitoring
12	Current Transformer	CT Neutral	INB	Electricity Monitoring
13	Serial	Ack	1 Ack	Serial Data/Hum-Temp
14	Serial	Vdd	2 Vdd	Serial Data/Hum-Temp
15	Serial	Ground	3 Gnd	Serial Data/Hum-Temp

16	Serial	Data	4 Data	Serial Data/Hum-Temp
17	Digital Output	Output	Op A	Triac On-Off / Pulsed
18	Digital Output	Output	0V	Triac On-Off / Pulsed
19	Digital Input No1	Input	In A	Status / Counter
20	Digital Input No1	Input	0V	Status / Counter
21	Digital Input No2	Input	In B	Status / Counter
22	Digital Input No2	Input	0V	Status / Counter
23	Thermistor Input No1	10K3A1 (10k,20k,Pt)	T1+	Temperature
24	Thermistor Input No1	10K3A1 (10k,20k,Pt)	T1-	Temperature
25	Thermistor Input No2	10K3A1 (10k,20k,Pt)	T2+	Temperature
26	Thermistor Input No2	10K3A1 (10k,20k,Pt)	T2-	Temperature
27	Thermistor Input No3	10K3A1 (10k,20k,Pt)	T3+	Temperature
28	Thermistor Input No3	10K3A1 (10k,20k,Pt)	T3-	Temperature
29	Thermistor Input No4	10K3A1 (10k,20k,Pt)	T4+	Temperature
30	Thermistor Input No4	10K3A1 (10k,20k,Pt)	T4-	Temperature
31	Thermistor Input No5	10K3A1 (10k,20k,Pt)	T5+	Temperature
32	Thermistor Input No5	10K3A1 (10k,20k,Pt)	T5-	Temperature
33	4-20mA Input No1	4-20mA	IS1+	Any Loop Powered 4-20
34	4-20mA Input No1	4-20mA	IS1-	Any Loop Powered 4-20
35	4-20mA Input No2	4-20mA	IS2+	Any Loop Powered 4-20
36	4-20mA Input No2	4-20mA	IS2-	Any Loop Powered 4-20
37	4-20mA Input No3	4-20mA	IS3+	Any Loop Powered 4-20
38	4-20mA Input No3	4-20mA	IS3-	Any Loop Powered 4-20

C.5 – Cable Specifications

Input / Output Type	Unit	Min/Max	Cable Type	Size mm^2	No. Cores	Overall Diameter	Environment
Voltage	AC Volt	45/230			4	4.0mm	Internal Non-Armoured
Voltage	AC Volt	45/230			4	4.0mm	Internal Armoured
Voltage	AC Volt	45/230			4	4.0mm	External
Voltage	AC Volts	45/230			4	4.0mm	External Armoured
Voltage	AC Volts	45/230			4	4.0mm	Hazardous
Current Transformer	mA/mV	75/333			8	5.0mm	Internal
Current Transformer	mA/mV	75/333			8	5.0mm	External
Current Transformer	mA/mV	75/333			8	5.0mm	External Armoured
Current Transformer	mA/mV	75/333			8	5.0mm	Hazardous
Thermistor Inputs					8	5.0mm	Internal
Thermistor Inputs					8	5.0mm	External
Thermistor Inputs					8	5.0mm	External Armoured
Thermistor Inputs					8	5.0mm	Hazardous
Digital Inputs	Contact	VoltFree			8	5.0mm	Internal
Digital Inputs	Contact	VoltFree			8	5.0mm	External
Digital Inputs	Contact	VoltFree			8	5.0mm	External Armoured
Digital Inputs	Contact	VoltFree			8	5.0mm	Hazardous
4-20mA	mA	4-20			4	5.0mm	Internal
4-20mA	mA	4-20			4	5.0mm	External
4-20mA	mA	4-20			4	5.0mm	External Armoured
4-20mA	mA	4-20			4	5.0mm	Hazardous