HAYSYS

FEEDERNET SYSTEM – LV MONITORING

USER MANUAL

H00216 and H00217

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POINT OF CONTACT

Enquiries regarding the content of this document should be addressed to:

HAYSYS Limited
Pembroke House
Spring Meadow Business Park
Spring Meadow Road
Rumney
Cardiff
United Kingdom
CF3 2ES

Tel: +44 (0)2920 736276
Fax: +44 (0)2920 735949
E-mail: info@haysys.co.uk

I. AMENDMENT RECORD

Previous Document No	Date of Issue	Reason for Change	Change Note
N/A	July 2019	First Issue	N/A
TS00192	March 2021	Updated for new style Rogowski Coils	90/0206

II. ABBREVIATIONS

Abbreviation	Meaning
3G	Third Generation
4G	Fourth Generation
A	Amperes
AC	Alternating Current
DDR	Double Data Rate
DoC	Declaration Conformity
IP	Internet Protocol
kW	Kilo-watts
LV	Low Voltage
PPE	Personal Protective Equipment
TCP	Transmission Control Protocol
THD	Total Harmonic Distortion
V	Volts
VA	Volt Amperes
W	Watts

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1 INTRODUCTION

The FeederNet System is used to measure the Low Voltage (LV) parameters connected to Power Network Distribution Assets. The system makes direct measurements of both Voltage and Currents and processes the information to provide the various LV parameters.

This document provides a description of the FeederNet System components, the safety warnings that must be adhered to, the installation method, the commissioning method and finally the procedure for confirming operation.

1.1 Safety Warnings

1.1.1 Safety, Hazard Categories and Symbols

Table 1 - Safety, Hazard Categories and Symbols

Symbol	Description
	**Warning** – follow precautions to avoid injury or causing equipment malfunction.
	Do not install, maintain or remove the system in HAZARDOUS LIVE substations without applying additional protective measures. Additional protective measures can be: • De-energising the circuits • Use of personal protective equipment (PPE) suitable for high voltage work and adoption of safe operating procedures.
	**Warning** – follow precautions to avoid electric shock injury
	Approved Safety Boots are to be worn during Installation
	Approved Insulated Sole Footwear are to be worn during Installation
	Approved Safety Headgear is to be worn during Installation
	Approved High Visibility Jacket is to be worn during Installation
	Approved Safety Gloves are to be worn during Installation
	Approved Safety Overalls are to be worn during Installation
	Approved Safety Eyewear are to be worn during Installation

Table 1 - Safety, Hazard Categories and Symbols

Symbol	Description
	Do not dispose as unsorted waste
CAT IV	The Feedernet equipment is an Over-Voltage Category IV equipment as defined in EN61010-1:2010
	This equipment is for professional use and must only be installed, operated, maintained and uninstalled by suitably trained and competent persons. Appropriate working practices must be established and personal protective equipment must be defined in accordance with Health and Safety at Work legislation for the environment in which the system is installed. Instruction and training on the HAYSYS LV Monitoring System is available.
	The Feedernet Control Unit should be fitted with a suitable external isolator or circuit breaker which meets all the relevant IEC 60947-1 and IEC 60947-3 requirements, and during installation it should be located and labelled to meet EN 61010-1 requirements.
	Follow safe electrical work practices as specified in local and national work instructions and codes. Use appropriate personal protective equipment and gloves as required.
	Always use this product in the manner specified or the protection provided by the product may be impaired. The equipment contains no user serviceable parts.
	Disconnect the system from the supply before performing any maintenance action.
	Always connect the neutral supply before connecting any phase. Always disconnect the neutral supply last.
	The working voltage line to neutral is 230VAC. Do not apply the Feedernet LV Monitoring System to circuits having nominal AC line to neutral voltage greater than 230V. The system may be safely used in installations where the phase to phase voltage is 415VAC.
	If using a GSM / GPRS interface the Feedernet Control Unit will communicate periodically during usual system operation. Maintain a minimum distance of 20cm between the antenna and your body.
	NOTE: This product is to be used for providing information only and is not intended for use in safety-critical applications.

Electrical equipment should be installed, operated, serviced, maintained and uninstalled only by suitably qualified personnel.

No responsibility is assumed by HAYSYS Ltd for any consequences arising out of the misuse of this equipment.

Death or serious injury may result from failure to observe the instructions in this manual.

Beneath the covers of the Control Unit exist the voltage connections made via plug/socket components. These voltages can be up to 440V RMS depending upon the particular installation. The connections made to the plug (See Figure 1 below, ringed in red), should only be undertaken with the voltage removed.

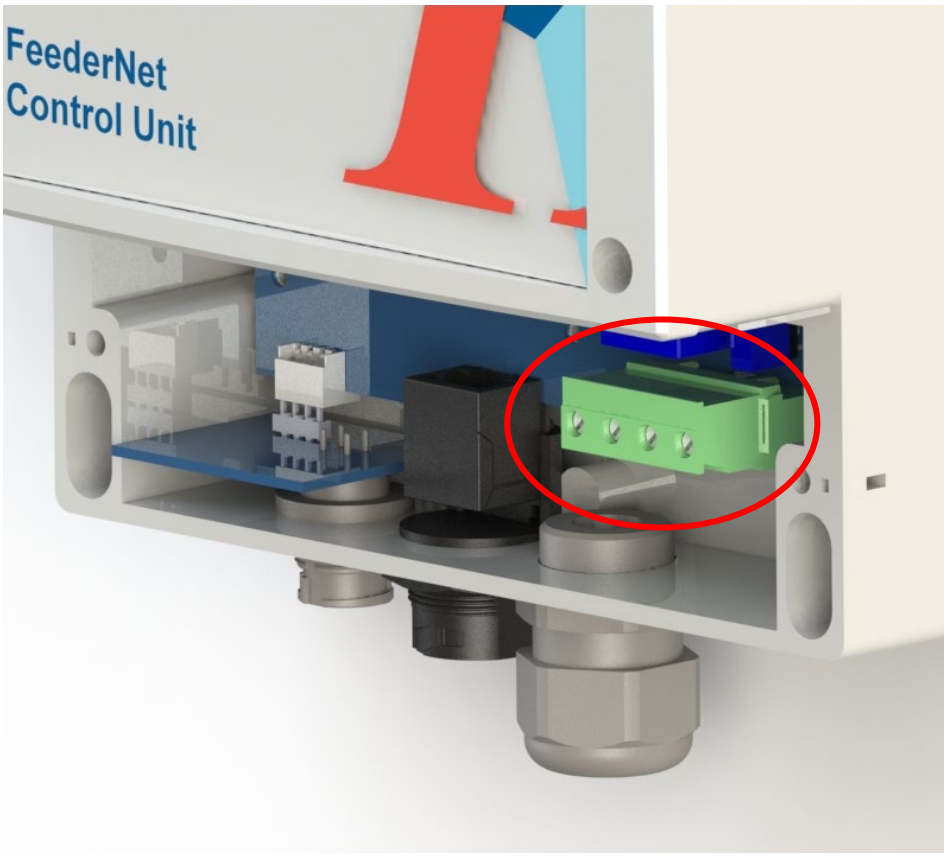


Figure 1 – LV Voltage (3 phase and Neutral – 415V/240V) Plug and Socket connectivity

1.2 General Safety Considerations

The FeederNet System has been designed, through the physical size and use of non-metallic external parts, to accommodate installation inside most Low Voltage (LV) Substation Pillars.

It is recommended that a suitable survey of the installation site is carried out prior to deciding if the FeederNet units can be installed within the pillar, or not, along with if this installation should be completed while the Pillar remains in an energised state.

It is recommended that the survey includes a risk assessment and identifies suitable risk reduction measures.

1.2.1 Installation into an energised LV Pillar

	**Warning –** follow precautions to avoid electric shock injury
	Approved Safety Boots are to be worn during Installation
	Approved Insulated Sole Footwear are to be worn during Installation
	Approved Safety Headgear is to be worn during Installation
	Approved High Visibility Jacket is to be worn during Installation
	Approved Safety Gloves are to be worn during Installation
	Approved Safety Overalls are to be worn during Installation
	Approved Safety Eyewear are to be worn during Installation

General hazards are hazards that would be expected when undertaking any installation of this kind within 'live' equipment and are not specific to the FeederNet units. These hazards include:

a. Inadvertent contact with either the Low Voltage system, resulting in electric shock or burns.

b. Flashover resulting in burns or eye damage.

c. Introduction of debris, conductor strands etc. causing a risk of flashover.

It is recommended that suitable Personal Protection Equipment (PPE), be worn by all staff installing the equipment. As a minimum, this should include:

a. LV rubber gloves.

b. A full face visor.

c. Flame and Arc resistant coveralls.

The installation of the FeederNet units should only be undertaken using site approved toolkits and by authorised personnel. The installation should never be undertaken by a 'lone-worker'.

The mounting of the FeederNet Control Unit, within the Pillar, can be achieved using several different methods. Where the installation is within a steel pillar, drilling the fabric of the Pillar is not recommended but instead should be through the use of the supplied magnetic mountings.

A suitable safe space for the control unit should be identified prior to the installation. The FeederNet units have no exposed conducting parts.

If there is any doubt regarding any risk at all, then it is recommended that the LV Pillar be de-energised for the installation activity.

2 INSTALLATION

2.1 Example 3-Feeder Installation

Figure 2 below shows a typical FeederNet installation, where the LV Substation/Pillar, uses three LV Feeders. The design of the FeederNet architecture has been optimised to enable a simple and straight-forward installation and minimising both cables and connections.

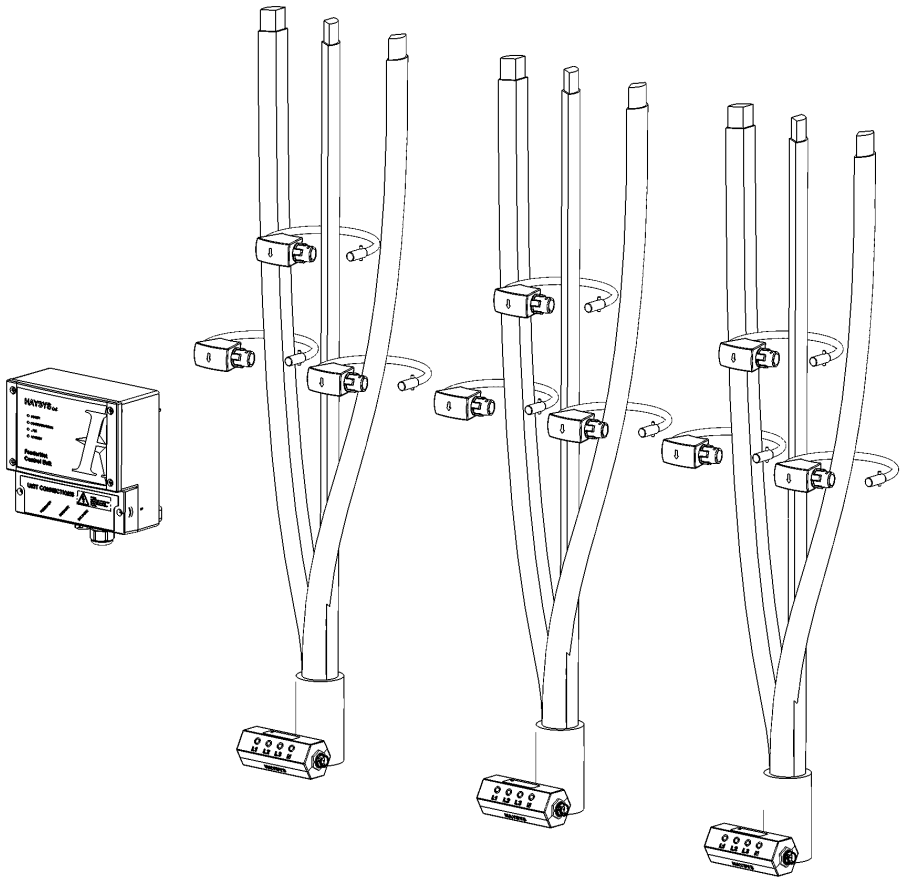


Figure 2 - Example 3-Feeder Installation (cables omitted for clarity)

The example installation shown above, requires the following components:

a. 9 x Rogowski Coils; one for each phase of each feeder – neutral currents are normally calculated from the measured three phase currents and not measured directly.

b. 3 x FeederNet Measurement modules; one for each feeder. The Measurement modules are normally positioned at the base of the feeder. Each of the Rogowski coils is cabled to its corresponding Measurement Module. Each of the Measurement modules are connected together, to form the FeederNet 'daisy chain' network, with only a single cable connecting to the Control Unit.

c. 1 x FeederNet Control Unit. This can be mounted either external to the LV Pillar or within. The Control unit is also connected, using the supplied fused measurement leads, to the three-phase voltage supply. The Control unit is powered from any of the phases and no further connection is required.

2.2 FeederNet System Components

2.2.1 The Rogowski Coils

The Rogowski Coils, one for each phase to be monitored, are very flexible and separate to be wrapped around the conductor and then joined together again to make a complete circle. The output of the coil is a small AC voltage that is directly proportional to the current flowing through the conductor that the coil is wrapped around.

The Rogowski Coils are available from HAYSYS in a variety of Coil lengths, to allow their installation in almost any site with very tight space constraints. The standard Main coil length is 300mm. The coils also come with a variety of Measurement Lead length (not shown). The standard Measurement Lead length is 0.5 metres.

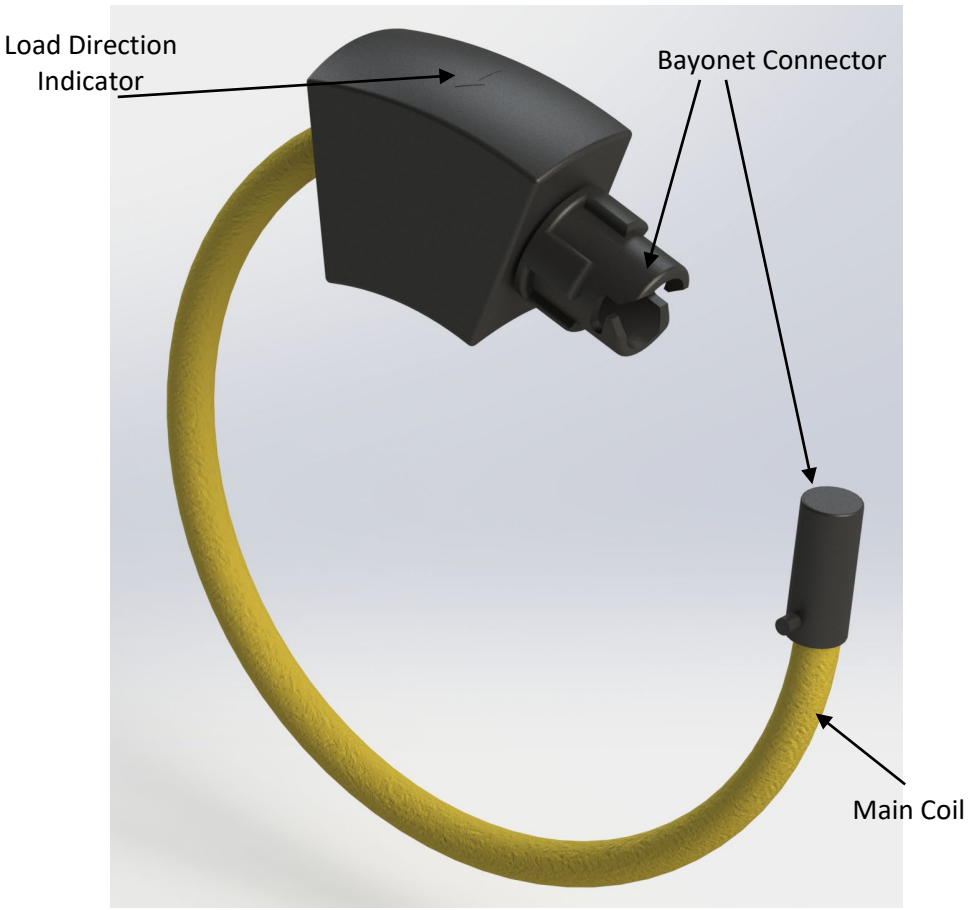


Figure 3 - The Rogowski Coil

The AC voltage corresponding to the current through the conductor being monitored, appears on two of the cores of the measurement lead, with the third being the screen for the measurement lead. The measurement lead is factory wired into the Measurement Module to ensure correct calibration of the unit. **Note**: Swapping of the coil connections in the measurement module may have a detrimental effect on the calibration of the Measurement Module. However, swapping Measurement Modules with Control Units has no effect on the calibration. Each of the coils are marked with their respective Phase.

2.2.2 The Measurement Module

The FeederNet Measurement Module digitises the analogue AC voltages received from the Rogowski Coils. The Rogowski coils are connected to the Measurement Module at the factory where they are also digitally calibrated.

The Rogowski coils cannot be interchanged on the Measurement Module without an impact on the system calibration.

There is one Measurement Module required per three phase Feeder to be monitored, with the ability to connect multiple Measurement Modules together, in a chain, to form a Feeder Network being monitored.

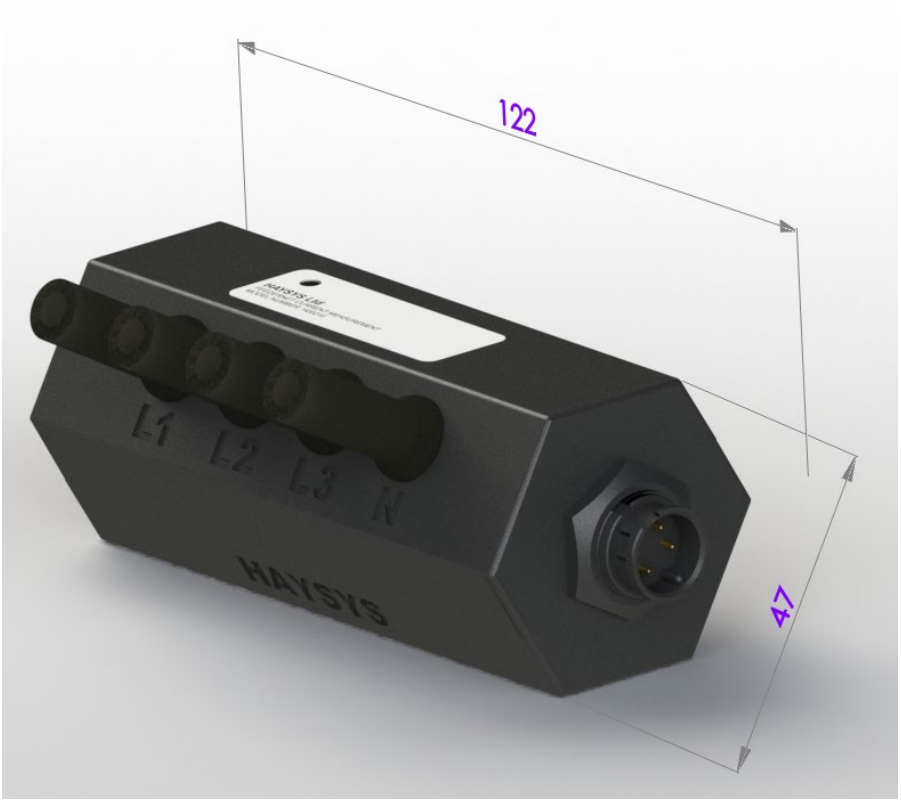


Figure 4 - The Measurement Module

The Measurement Module connectors, at either end of the housing both contain four connection pins. Two pins are the supply voltage for the modules, provided by the Control Unit, and the other two pins being digital data (one Transmit and one Receive). The plug (Male socket) is connected in the chain towards the Control Unit, whilst the socket (Female socket) is connected to the next Measurement Module in the chain (if any).

The Current Measurement Module has the capacity to measure all three phase currents and the neutral current (although the Neutral current is normally calculated by the Control Unit).

Figure 5 - The Measurement Module - Front View

The Measurement unit also contains a small tri-colour LED, providing colour indication on the status of the Measurement Unit and the communications with the Control Unit.

- A flashing LED indicates that measurements are being taken and the unit is running and communicating with the controller.
- A flashing green LED indicates that all is ok and that current flow is being detected.
- A flashing amber LED indicates that no current flow has been detected (because there is none or it is very low (< 2A))
- A deep red LED indicates that a fault or error has been detected in the current module.

2.2.3 The Control Unit

The FeederNet Control unit has been designed using a powerful ARM® Processor, running an embedded Linux Operating System. The unit also contains a Real-Time Clock, Ethernet Connectivity and internal storage contained on a flash chip and a MicroSD Memory card. The unit also contains Double Data Rate (DDR) Memory.

The Control Unit provides the means for the Phase Voltages to be digitised, measured and receives the current measurement data along the FeederNet network from the connected Measurement Modules. The data is processed within the Control Unit to provide the various LV parameters.

The Control Unit controls the Measurement Modules and provides the communications with the System data servers. For the OpenLV units, the communication is provided to the LVCap® Platform.

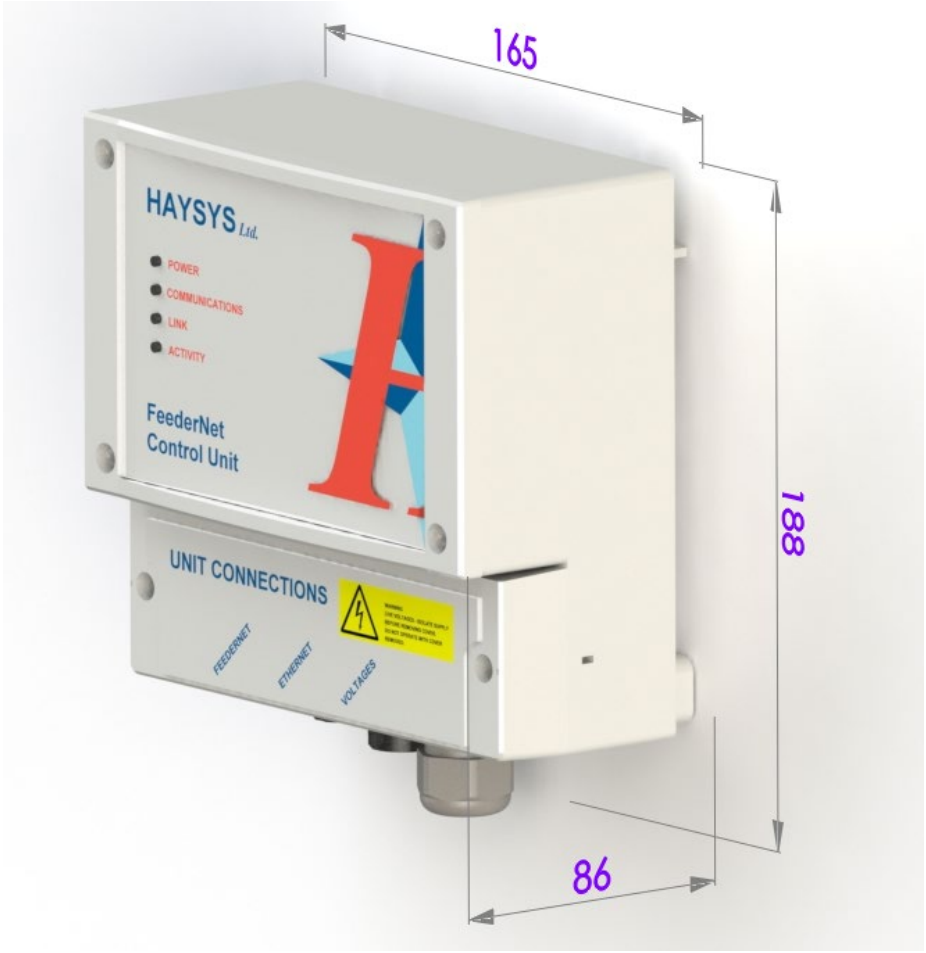


Figure 6 - The Control Unit

The Control Unit enclosure is manufactured from Polycarbonate material and has dimensions of 165 x 188 x 86, as shown in Figure 6 above. The weight of the Control unit is 1kg. The Control Unit has an Ingress Protection (IP) rating of IP65 and is suitable for mounting outside externally and open to the elements.

The unit also has a UV resistance of UL 508 and Flammability Rating of UL 746C.

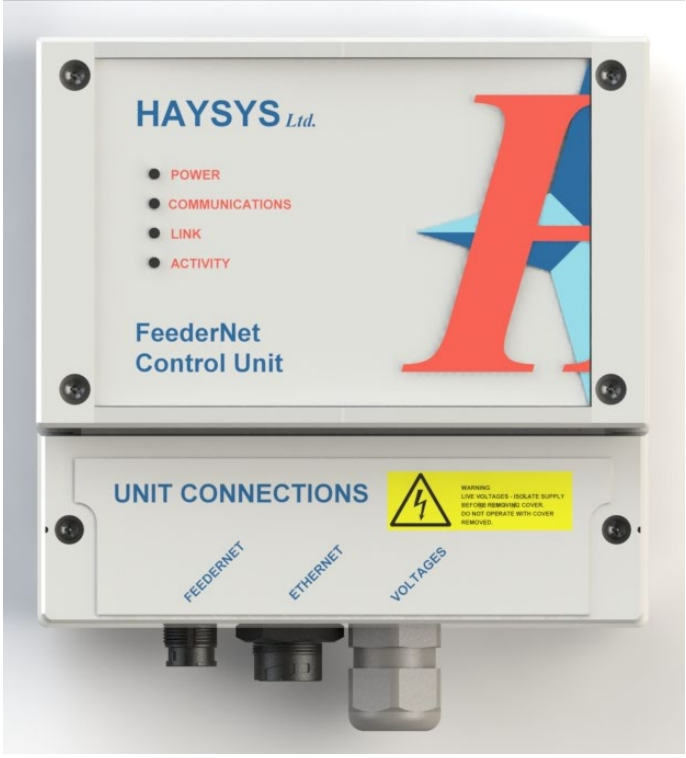


Figure 7 - The Control Unit - Front View

The Control Unit has three wired connections:

a. FeederNet socket connection – provides the connectivity to the FeederNet Measurement Module chain.

b. Standard Ethernet RJ45 Connection – Provides wired connectivity to the Data Servers.

c. Voltages – Provides wired connectivity to the three phase and neutral voltages to be measured. (These voltages and neutral also provide the power supply to the Control Unit which only requires any one phase to be powered).

2.2.4 Voltage Leads

The FeederNet Control Unit measures the three-phase voltages and a set of fused connection leads are available (optional at additional cost) that meet IEC 61010 CAT IV as shown in Figure 8 below.

Figure 8 - Voltage connection Leads

Should alternative lead sets be used, then they are also required to meet the requirements of IEC 61010 CAT IV.

2.3 Installing the Rogowski Coils and Measurement Modules

As shown in Figure 3 above, the Rogowski Coils come apart to enable them to be wrapped around the phase or neutral conductor. Once wrapped around the conductor, the ends of the Rogowski Coil are then re-connected using the bayonet connector.

As shown in Figure 3 and Figure 9 below, the Rogowski Coils are fitted with an orientation label showing the direction of current flow through the conductor/Rogowski Coil. It is important that all Rogowski coils are fitted such that the direction of the arrows on the Rogowski coils correspond to the direction of the current through the conductor being monitored.

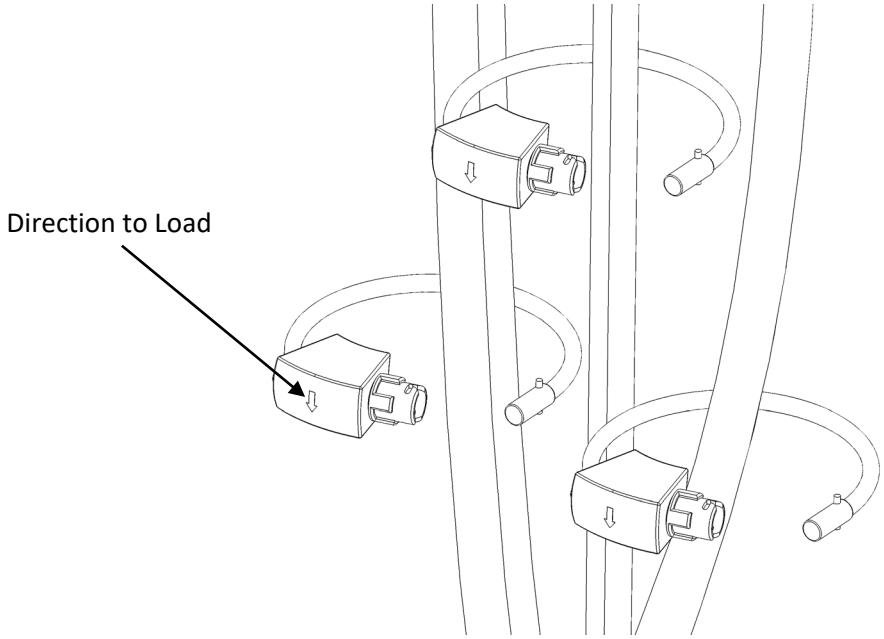


Figure 9 - Coil Orientation Indication

Greater accuracy can be achieved if the coils are positioned so that the conductor is in the centre of the Rogowski Coil and as far as possible away from any other adjacent conductor.

The Rogowski coils are connected directly to the Measurement Modules at the factory and cannot be interchanged without a detrimental impact on the System Calibration Accuracy. Each of the coils are labelled with either L1, L2, L3 or N.

Figure 10 – Phase Identification Label

The Measurement Modules can be installed 'floating' as it is not necessary to physically mount them. However, mounting brackets are available if required.

2.3.1 Connecting the Measurement Modules

Connection between the Measurement Modules and also between Measurement Module and the Control Unit, is via a single four-pin plug and socket circular connector. The connector is twisted clockwise to lock and anti-clockwise to un-lock. Only a single cable is required between each Measurement Module and only one cable is required between Measurement Module and the Control Unit.

2.3.2 Installing the Rogowski Coils around Feeder Cables

Figure 11 below, details the installation of three Rogowski Coils around a typical three phase Feeder cable. The figure also shows the recommended position for the FeederNet Measurement module at the base of the cable where the cable enters the LV Pillar.

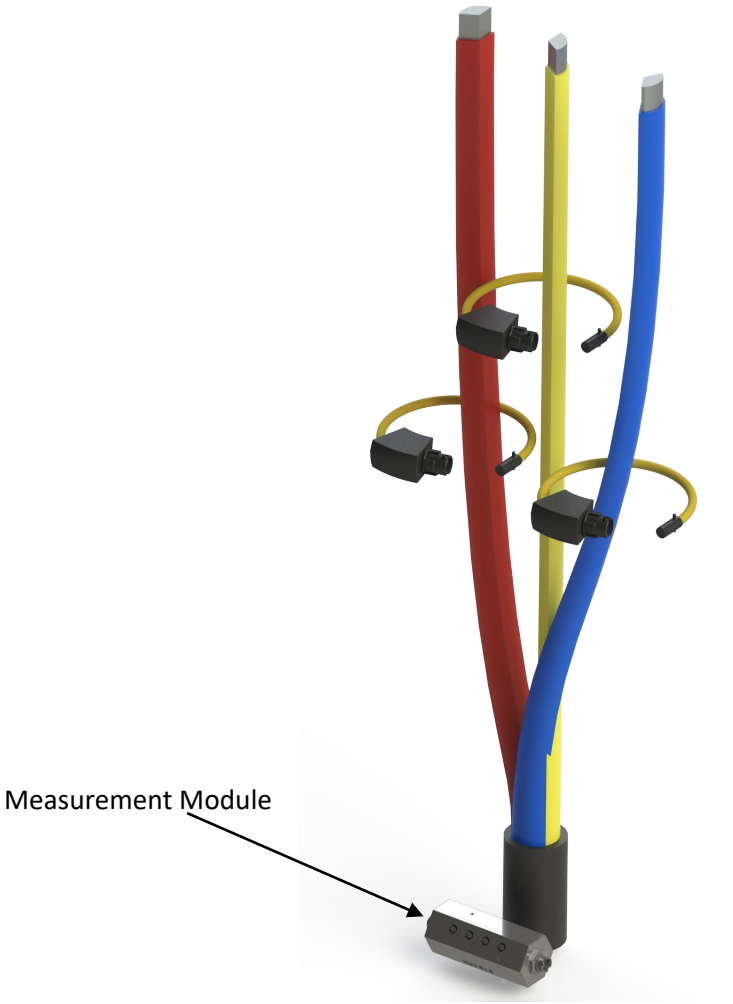


Figure 11 - Fitting the Coils to the Feeder (Leads omitted for clarity)

This installation is repeated for each of the Feeders to be monitored. Each of the measurement leads from each of the Rogowski Coils are routed to the Measurement Module, in a neat and safe manner.

Each of the Measurement Modules are then connected together, in a daisy chain, to form the Feeder Network. The first Measurement Module of the daisy chain, is then connected to the FeederNet port of the Control Unit (see section 2.2.3 for further details).

2.4 Installing the Control Unit

The Control Unit can be mounted using either magnetic mountings, standard 35mm DIN Rail or surface mounted. The mounting holes to be used are shown in Figure 12 below. The side mounting holes are accessed by removing the connection cover, while the Centre Mounting is a standard 'keyhole' that requires the mounting screw to be in place so that the Control Unit can hook onto it.

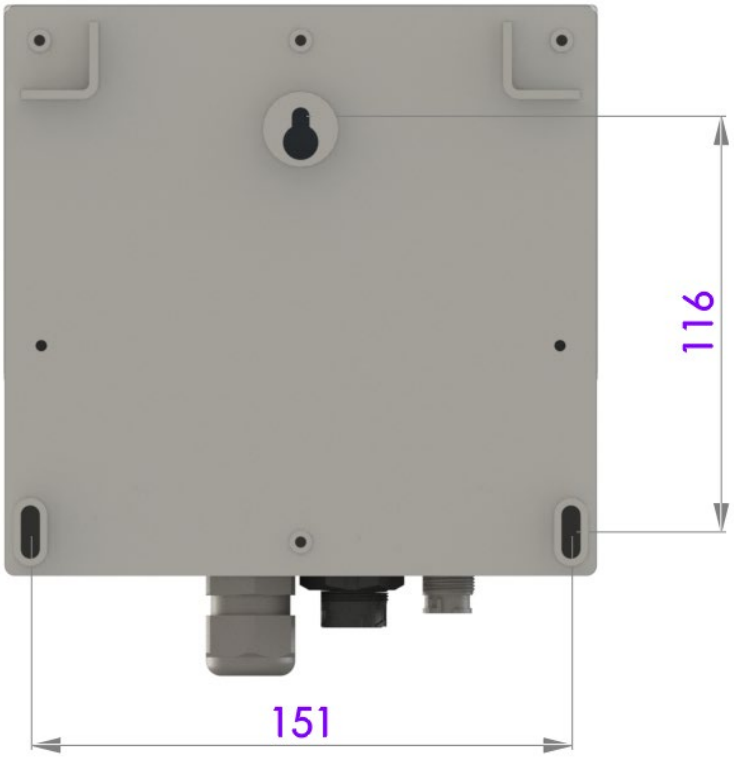


Figure 12 – Control Unit Mounting Positions

With the Control Unit surface mounted, the design of the enclosure is such that that rear face will not be flush against the surface. This provides additional protection from damp walls etc.

2.4.1 Mag-Mounting the Control Unit

The FeederNet Control Unit can also be supplied with Magnetic Mountings, as shown in Figure 13 below.

Figure 13 - Mag-Mounted Control Unit

There is a total of three rubber coated permanent magnets that provide a pull-strength of 3.8 Kgs each. This then attaches the Control Unit to a steel surface with a total pull-strength of 11.4 Kgs.

2.4.2 Connecting the Three Phase Voltages

The three phase voltages are connected to the Control unit using the screw terminal plug/socket. These are accessed by removing the 'UNIT CONNECTIONS' Cover. The connections can accommodate a cable cross sectional size of up to 2.5 mm^2. The voltage wiring must be passed through the cable gland on the bulkhead of the Control Unit enclosure prior to the connection to the screw terminal plug. Once the voltage wires are connected, the plug can be inserted into the socket within the FeederNet Control Unit as shown in Figure 14 below. See section 2.2.4 for details of recommended Voltage Lead sets.

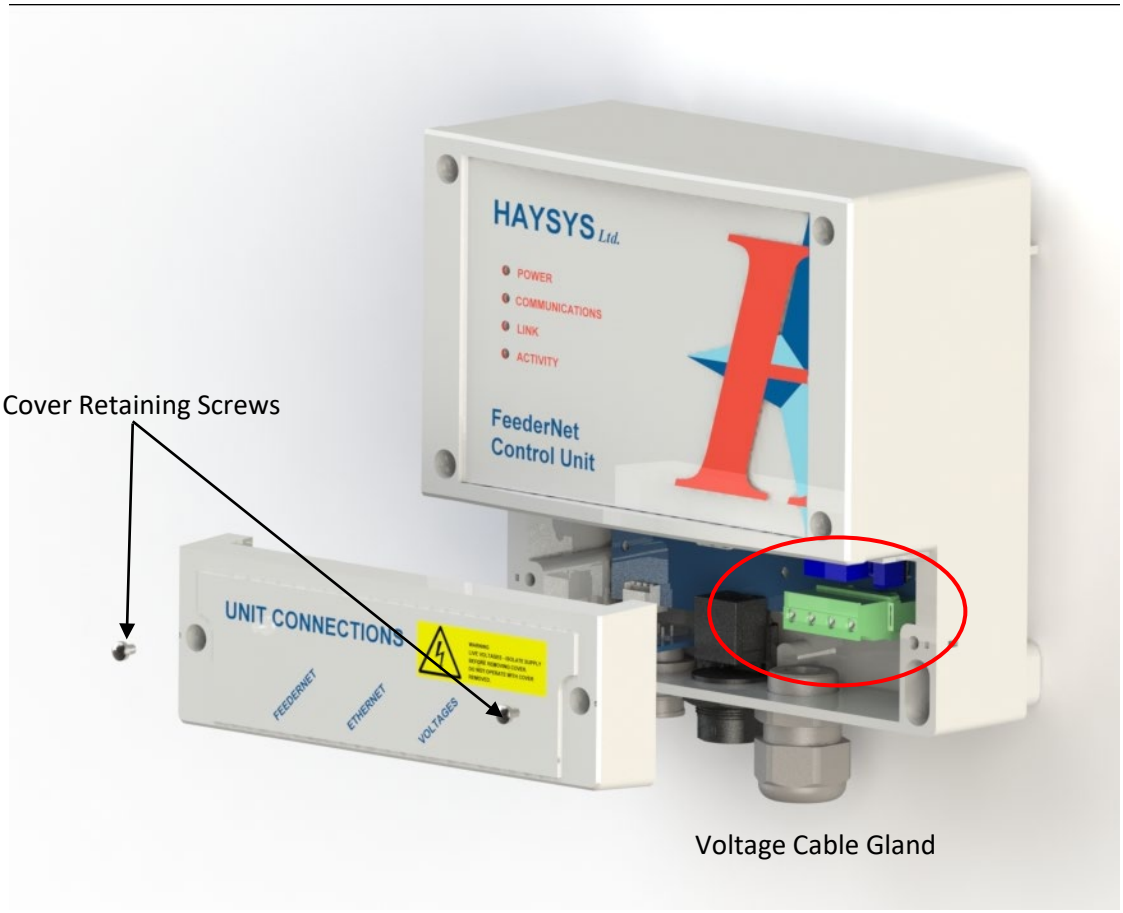


Figure 14 - Control Unit Voltage Connections

The Voltage connection plug/socket screw terminals are highlighted in Figure 14 above. The terminals are accessed by removing the Unit Connections cover. This is achieved by removing the two retaining screws either side of the cover.

WARNING: The Voltage plug, circled in Red above, must be wired, plugged in and the Connections Cover in place, prior to applying the three phase voltages. The three-phase cable, must be routed through the voltage cable gland.

Each of the voltage connections are protected by internal fuses. These are not field replaceable, but can be replaced at a suitable workshop. Spare fuses are available from HAYSYS.

2.4.3 Voltage Isolation and Protection

The FeederNet Control unit contain three fuses, one for each phase, that provide protection from overcurrent caused by a fault within the Control Unit.

The Control unit is also protected from Over-Voltage, through internal devices working with the internal fuses.

2.5 Communicating with the FeederNet System

The FeederNet System communication is standard with either Ethernet RJ45 connection or Mobile communications.

The mobile communication is delivered using standard 4G communications, over the O_2 mobile network. The SIM cards fitted are global SIM cards and will connect to any available mobile network.

The mobile communications hardware is integral to the Control Unit, including the Antenna. Should a customer require, the Control Unit can be supplied with an external connector, suitable for connecting a standard external mobile network antenna.

3 DIGITAL INTERFACES

The FeederNet System provides the required data using several interfaces including the MODBUS, DNP3 and on-line via the HAYSYS FeederNet Portal.

3.1 Control Unit IP Address

The Internet Protocol (IP) address of the Control Unit is currently set at the factory. There is no provision to change this IP address in the field as yet, however any address can be accommodated when ordering the units.

3.1.1 MODBUS Port

The Control Unit is configured using the standard MODBUS Server Port number 502.

A list of the MODBUS registers in excel and / or JSON file format is available from HAYSYS.

3.1.2 FeederNet Azure Portal

Should the customer wish, the FeederNet data can also appear on the on-line FeederNet Portal, as shown in Figure 15 below.

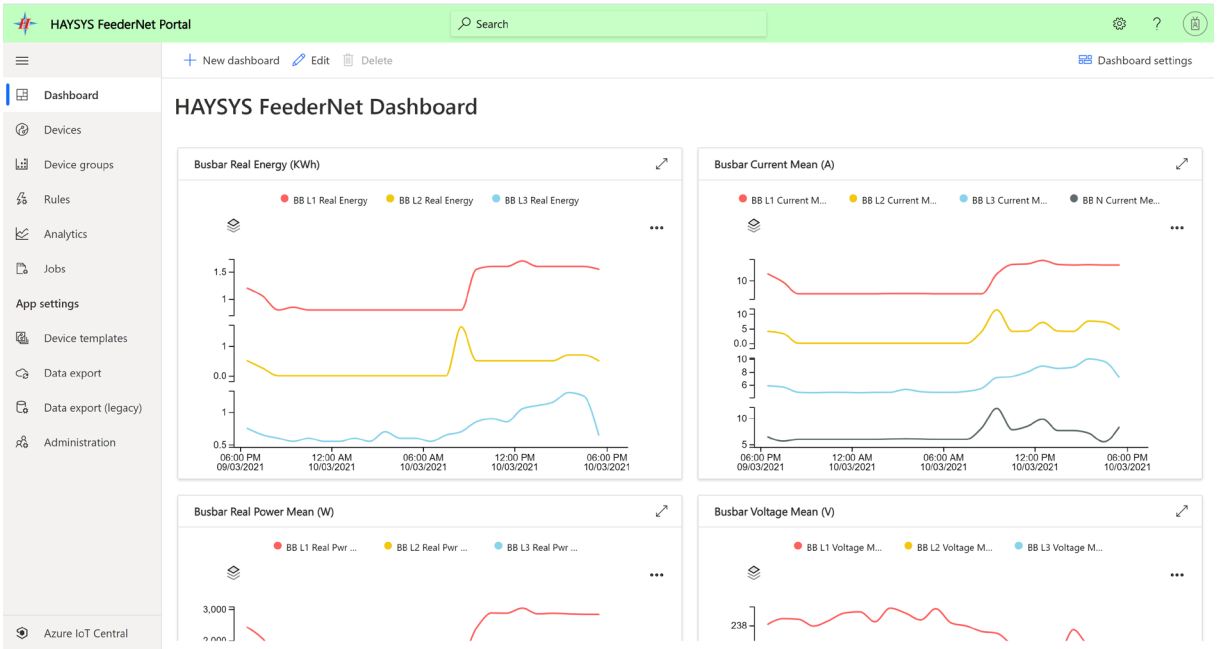


Figure 15 - FeederNet Portal

The portal provides access to all the supplied data from the Control Unit and in addition, the customer can make adjustments to the hardware configuration.

3.2 FeederNet Dataset

Currently the following measurements can be returned by the FeederNet Control Unit via its data interface:

a. Instantaneous, Minimum, Maximum and Mean Values for all three phases for the following:

1. Voltages
2. Fundamental Voltage
3. Voltage Total Harmonic Distortion (THD)
4. Frequency

b. Instantaneous, Minimum, Maximum and Mean Values for all individual feeder three phases and neutral for the following:

1. Current
2. Fundamental Current
3. Current THD
4. Phase Angle
5. Real Power
6. Reactive Power
7. Apparent Power
8. True Power Factor
9. Real Energy (Watt/hr)
10. Reactive Energy (Watt/hr)
11. Apparent Energy (Watt/hr)

c. All the values for section b. are also available as summated busbar values.

4 COMMISSIONING

4.1 Power Up

Once the Measurement Units and Control Unit have been installed and with the Control Unit covers all in place, the Control Unit can be powered.

The Control unit will go through its power-up sequencing and when completed, display the LED states as detailed in section 4.2 below.

4.2 Confirming Operation

Confirmation of both the Measurement Modules and the Control Unit on-site, is achieved by examining the status of the following LED indications:

a. Measurement Module LED – flashing green.

b. Control Unit Power LED – flashing blue.

c. Control Unit Communications LED – no indication or solid green

d. Active LED – flashing green

e. Link LED - Amber

The correct status of the LEDs detailed above demonstrate to the local user/installer, that the units are powered, alarm free and sampling both Voltages and Currents.

5 EU DECLARATION OF CONFORMITY (DOC)

EU Declaration of Conformity (DoC)

We:

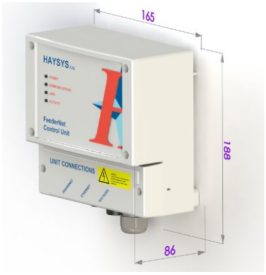
Company Name: **HAYSYS Ltd**

Company Address: Pembroke House
Spring Meadow Industrial Estate
Rumney
Cardiff CF3 2ES

Declare that this DoC is issued under our sole responsibility and belongs to the following product:

Product Name: Feedernet
Product Type: Voltage and Current Measurement and reporting system

Model Number(s): **H00217 Control Module** **H00216 Measurement Module**



The objects of the declaration described above are in conformity with the relevant Union harmonisation legislation.

2011/65/EU (RoHS2 Directive):	All Component parts are supplied to HAYSYS Ltd under a valid EU Declaration of Conformity.
2012/19/EU (WEEE Directive):	Producer Registration WEE/CX3839XD
2014/35/EU (Low Voltage Directive):	EN61010-1:2010 EN61010-2-30:2010
2014/30/EU (EMC Directive):	EN61000-6-2:2005 EN61000-6-4:2007 +A1:2011
2014/53/EU (Radio Equipment Directive):	EN301 489-1 V2.1.1 EN301 489-17 V3.1.1 EN300 328 V2.1.1 EN301-511 V12.5.1
Date of Issue:	1st July 2019
Place of Issue:	Cardiff, United Kingdom

Signature:

Name: Joseph Hayden - Director

Declaration Reference TS00191

Figure 16 - EU Declaration of Conformity