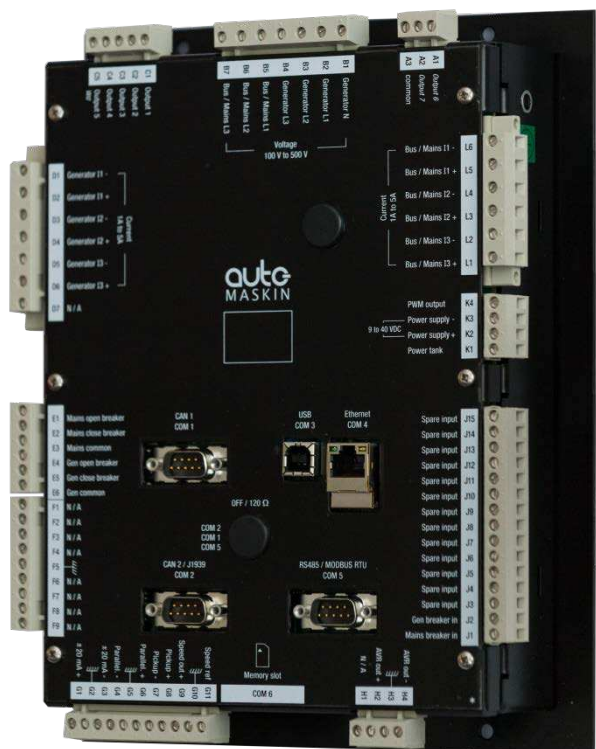


Manual

marine-pro

LSU 408 Load Share and Synchronizer Unit



auto MASKIN

Manual
for
LSU 408 – Load Share and Synchronizer Unit

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|          |              |
|----------|--------------|
| Printed  | October 2015 |
| Revision | 2            |
| Revised  | Not revised  |

[www.auto-maskin.com](http://www.auto-maskin.com)

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# Table of Content

|                                                             |           |                                                      |           |
|-------------------------------------------------------------|-----------|------------------------------------------------------|-----------|
| <b>DOCUMENT INFORMATION .....</b>                           | <b>1</b>  | DURING COMMISSIONING .....                           | 19        |
| ABOUT THIS MANUAL .....                                     | 1         | <b>DEDICATED I/O LINES .....</b>                     | <b>20</b> |
| RESPONSIBILITIES.....                                       | 1         | SPEED GOVERNOR INTERFACE.....                        | 20        |
| ORDERING INFORMATION.....                                   | 1         | ANALOGUE SPEED GOVERNOR OUTPUT.....                  | 20        |
| ABOUT THE LSU .....                                         | 2         | PWM 500 Hz (CATERPILLAR/PERKINS) .....               | 21        |
| UNWRAPPING .....                                            | 2         | SPEED AND VOLTAGE CONTROL WITH CONTACTS/PULSES ..... | 21        |
| <b>INSTALLATION .....</b>                                   | <b>3</b>  | <b>BREAKER CONTROL.....</b>                          | <b>22</b> |
| DIMENSIONS.....                                             | 3         | ANALOGUE LOADSHARING LINES .....                     | 26        |
| ELECTRICAL CONNECTIONS .....                                | 4         | WATCHDOG OUTPUT.....                                 | 26        |
| <i>Terminal connection overview.....</i>                    | 4         | <b>MENU OVERVIEW .....</b>                           | <b>27</b> |
| <i>Connection List .....</i>                                | 5         | MENU INTRODUCTION.....                               | 27        |
| CONFIGURATION .....                                         | 10        | DISPLAY MENU .....                                   | 27        |
| <i>Connecting with LSU 408.....</i>                         | 10        | <i>Generator electrical meter .....</i>              | 27        |
| <i>Configuration.....</i>                                   | 11        | <i>Generator global view .....</i>                   | 28        |
| <i>Saving Configuration .....</i>                           | 11        | <i>Mains / Bus bars electrical meters .....</i>      | 29        |
| WIRING EXAMPLE .....                                        | 12        | <i>Mains / Bus bars Global view .....</i>            | 29        |
| .....                                                       | <b>13</b> | <i>Synchronization .....</i>                         | 30        |
| <b>PREDEFINED CONFIGURATION .....</b>                       | <b>14</b> | <i>Power plant overview.....</i>                     | 31        |
| SINGLE GENERATOR IN CHANGE-OVER MODE.....                   | 14        | <i>Data logging.....</i>                             | 32        |
| GENERATOR PARALLELING WITH DIGITAL BUS .....                | 14        | <i>Generator fuel control.....</i>                   | 32        |
| GENERATOR PARALLELING WITH ANALOGUE PARALLEL LINES.....     | 14        | <i>Generator excitation control.....</i>             | 33        |
| SINGLE GENERATOR IN NO-CHANGE-OVER MODE .....               | 14        | <b>I/O CONFIGURATION .....</b>                       | <b>34</b> |
| GENERATOR PARALLELING AND LOADSHARING .....                 | 15        | <i>Validity .....</i>                                | 35        |
| MULTIPLE GENERATORS WITH STATIC PARALLELING .....           | 15        | <i>Direction .....</i>                               | 35        |
| <i>4 generator sets in parallel, typical sequence .....</i> | 15        | <i>Delay.....</i>                                    | 35        |
| MAINS PARALLELING MODE .....                                | 16        | DIGITAL INPUTS .....                                 | 35        |
| <i>No break change over .....</i>                           | 16        | <i>Input functions.....</i>                          | 36        |
| <i>Permanent mode.....</i>                                  | 16        | <i>Dedicated inputs.....</i>                         | 38        |
| <i>Base load .....</i>                                      | 17        | DIGITAL OUTPUTS .....                                | 38        |
| <i>Peak shaving.....</i>                                    | 17        | <i>Output configurable functions.....</i>            | 38        |
| <i>Power plant paralleled with mains.....</i>               | 17        | <i>Output Polarity.....</i>                          | 41        |
| <b>INSTALLING &amp; COMMISSIONING .....</b>                 | <b>18</b> | <b>PROTECTIONS .....</b>                             | <b>42</b> |
| EARTH GROUNDING.....                                        | 18        | DISABLE .....                                        | 42        |
| WIRING GUIDELINES.....                                      | 18        | GENERATOR ELECTRICAL FAULT .....                     | 42        |
| <i>Power supply circuit breaker .....</i>                   | 18        | MAINS ELECTRICAL FAULT .....                         | 42        |
| <i>Rental fleet &amp; Marine generating sets .....</i>      | 18        | ALARM .....                                          | 42        |
| <i>External power tank capacitor .....</i>                  | 19        | FAULT (SOFT SHUT DOWN).....                          | 42        |
| BEFORE COMMISSIONING .....                                  | 19        | SECURITY (HARD SHUTDOWN) .....                       | 42        |
| <i>Schematic check .....</i>                                | 19        | HELP + FAULT (SOFT SHUT DOWN) .....                  | 43        |
| <i>Check list of inputs-/outputs.....</i>                   | 19        | HELP + GEN. ELECTRICAL FAULT .....                   | 43        |
|                                                             |           | <b>ADDITIONAL FUNCTIONS .....</b>                    | <b>44</b> |
|                                                             |           | LOADSHARING.....                                     | 44        |
|                                                             |           | <i>Introduction.....</i>                             | 44        |
|                                                             |           | <i>Procedure .....</i>                               | 44        |

|                                                                         |           |
|-------------------------------------------------------------------------|-----------|
| <i>Loadsharing suppression</i> .....                                    | 45        |
| <i>ILS synchronization &amp; mains paralleling</i> .....                | 45        |
| <i>Integral inhibition</i> .....                                        | 46        |
| OPERATOR CONTROLLED RETURN TO MAINS.....                                | 47        |
| <i>Explanation</i> .....                                                | 47        |
| <i>How to set this function</i> .....                                   | 47        |
| <i>Summary</i> .....                                                    | 47        |
| <i>Parameters used</i> .....                                            | 47        |
| MAINS & GENERATOR ELECTRICAL FAULT OPTIONS.....                         | 48        |
| <i>Generator electrical fault</i> .....                                 | 49        |
| LSU 408 AND THE EXTERNAL DIESEL CONTROLLER                              |           |
| MODULE .....                                                            | 50        |
| <i>Overview</i> .....                                                   | 50        |
| AUTOMATIC LOAD / UNLOAD .....                                           | 51        |
| <i>Menu Settings</i> .....                                              | 55        |
| NON-ESSENTIAL CONSUMER TRIP (MARINE SEQUENCE) 55                        |           |
| <i>Introduction</i> .....                                               | 55        |
| <i>Procedure</i> .....                                                  | 55        |
| <b>PLC PROGRAMMING .....</b>                                            | <b>56</b> |
| INTRODUCTION .....                                                      | 56        |
| VARIABLE NAMING.....                                                    | 56        |
| TEXT FILE DESCRIPTION .....                                             | 57        |
| <i>Parameter definition block</i> .....                                 | 57        |
| <i>Label definition block</i> .....                                     | 58        |
| <i>Units and accuracy definition block</i> .....                        | 59        |
| <i>Initialization definition blocks</i> .....                           | 64        |
| <i>Equation definition blocks</i> .....                                 | 64        |
| <i>End of file</i> .....                                                | 64        |
| PLC PROGRAMMING LANGUAGE.....                                           | 65        |
| VARIABLES .....                                                         | 67        |
| <i>Variable type and size</i> .....                                     | 67        |
| <i>Locked variables versus dynamic variables</i> .                      | 67        |
| SYNTAX EXAMPLES .....                                                   | 68        |
| <b>COMMUNICATION .....</b>                                              | <b>72</b> |
| CAN BUS GOOD PRACTICES.....                                             | 72        |
| CAN BUS CABLE: .....                                                    | 72        |
| MAXIMAL LENGTH OF A CAN BUS:.....                                       | 73        |
| COM1: LSU 408 CAN BUS.....                                              | 74        |
| <i>CAN bus fault</i> .....                                              | 74        |
| <i>Broadcasting data between multiple LSU 408</i><br><i>units</i> ..... | 75        |
| <i>CAN bus inhibition/Loadsharing suppression</i><br>.....              | 75        |
| <i>COM2 CANopen – Remote I/O units</i> .....                            | 77        |

## Document Information

### About this manual

This manual has been published primarily for professionals and qualified personnel.

The user of this material is assumed to have basic knowledge in load sharing systems, and must be able to carry out related electrical work.

Work on paralleling systems should only be carried out by qualified and experienced personnel.

Installation or work on the power equipment *must only* be carried out by electricians authorized to work with such installations.

### Responsibilities

It is the *sole responsibility of the installer* to ensure that the installation work is carried out in a satisfactory manner, that it is operationally in good order, that the approved material and accessories are used and that the installation meet all applicable rules and regulations.

**Note!** Auto-Maskin continuously upgrades its products and reserves the right to make changes and improvements without prior notice.

All information in this manual is based upon information at the time of printing.

For updated information, please contact your local distributor.

## Ordering information

The **Marine Pro** range includes the 200- and 400 Series of compatible panels.

| Item                                       | Part #  |
|--------------------------------------------|---------|
| DCU 208 - Engine Control Unit              | 1006480 |
| DCU 210 - Engine Control Unit              | 1006481 |
| RP 210 - Remote Panel                      | 1006482 |
| DMU 206 - Engine CANbus Reader             | 1006483 |
| RIO 410 - I/O Expansion Unit               | 1006453 |
| RIO 412 - Exhaust Temp. Monitoring         | 1006454 |
| RIO 425 - Generator Interface              | 1006409 |
| SDU 410 - Safety Unit                      | 1006451 |
| RP 410 - Remote Panel                      | 1006452 |
| Ethernet Switch - 5 channels, 24V          | 1050165 |
| J1939 CANbus Cable                         | 1009110 |
| IP Camera - for RP 210/410 remote panels   | 1121258 |
| MK-14 Relay expansion (400 Series only)    | 1121341 |
| LSU 408 - Load Share and Synchronizer Unit | 1101313 |

## About the LSU

The LSU 408 is a load share, and synchronizer unit. It supplements the DCU by managing synchronizing and load sharing between a genset and bus or mains power source.

It measures current, voltage and phase to both the generator and the external power source, and perform specified tasks selected by the user.

The unit can be used stand-alone, or it can be interfaced with the Auto-Maskin 200- or 400 Series diesel control panels.

For Marine applications where there are specific customer specifications regarding load sharing and tie breaker management, LSU 408 can manage most applications. Please contact us for detailed information.



## Unwrapping

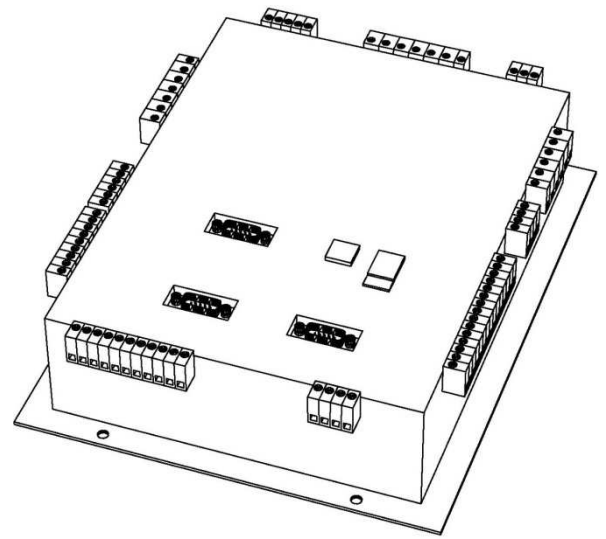
The package includes:

- ❖ This Quick Installation Guide
- ❖ The LSU 408 unit



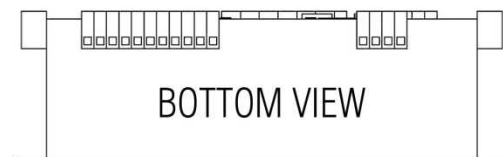
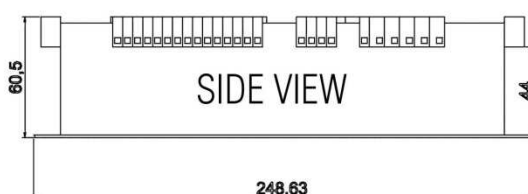
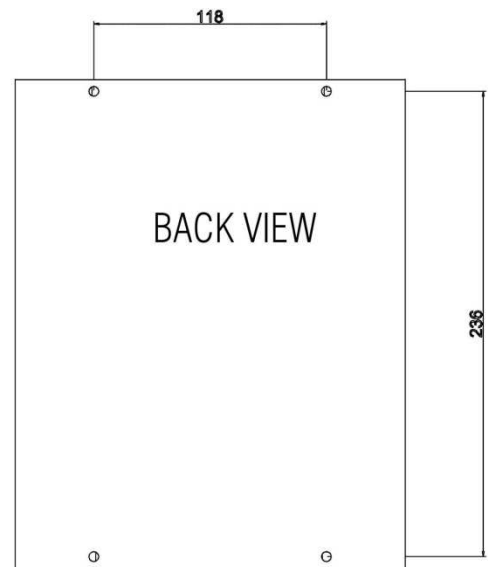
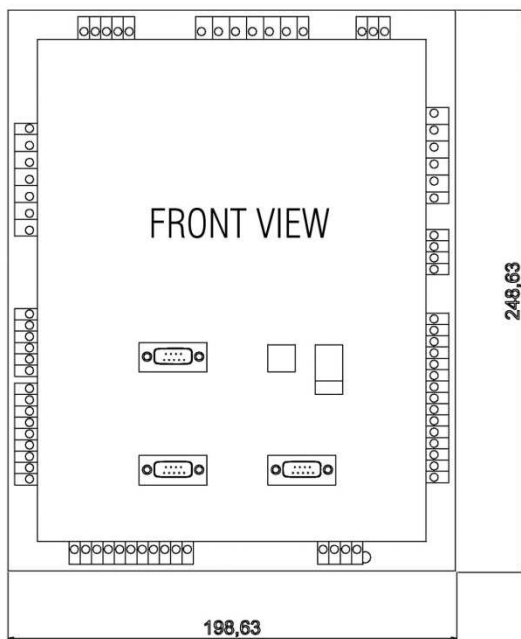
## Installation

The LSU 408 is normally installed in the main control cabinet of a generator. Operating temperature is 0 to +50 °C, and non-condensing humidity shall be less than 95%.



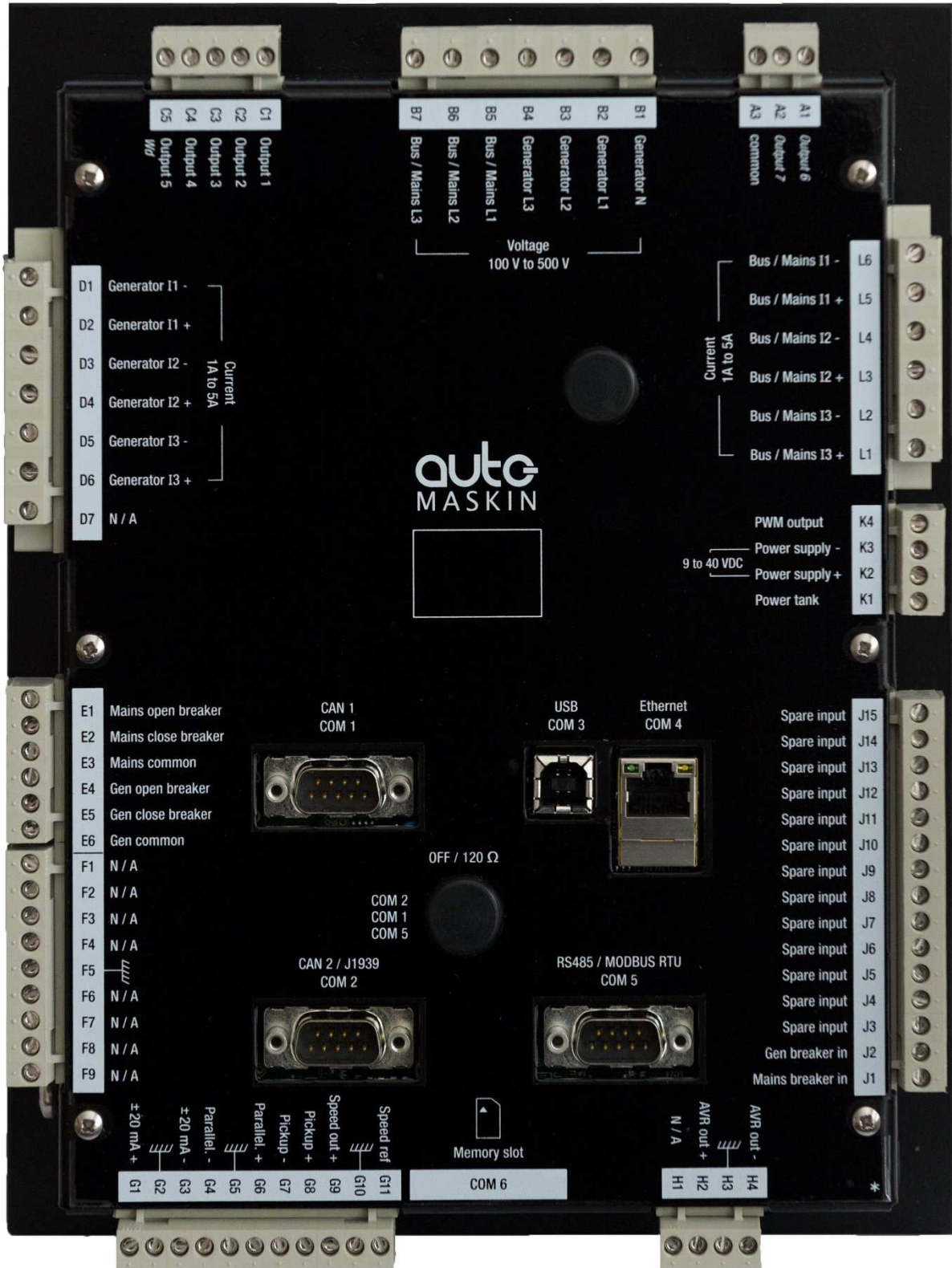
## Dimensions

See unit dimensions below in [mm].



## Electrical Connections

### Terminal connection overview



## Connection List

| Section              | Terminal       | Cond.                | Min      | Typ    | Max    | Unit | Comment                                                         |
|----------------------|----------------|----------------------|----------|--------|--------|------|-----------------------------------------------------------------|
| Power Supply         | K2-K3          |                      | 9        | des.24 | 40     | VDC  |                                                                 |
| Power Consumption    | -              | 9-40V                | -        | 10     | -      | W    |                                                                 |
| Switch Input         | J1-J15         | Disc.=low<br>0V=high | -        | 0      | -      | VDC  | Int. 10kΩ pull-up                                               |
| Current Input        | D1-D7<br>L1-L7 |                      | 1        | -      | 5      | A    | Maximum ratio on ext. transformers is 3250 (3250:1 or 16250:5). |
| Voltage Input        | B1-B7          | 50-60Hz              | 100      | -      | 480    | VAC  | Must be externally protected with 100mA/600V fuses              |
| Analog Input         | G1-G3          | ±20mA                | 0        | -      | 20     | mA   | ±10V (20kΩ input) or ±20mA (50Ω input)                          |
|                      |                | ±10V                 | 0        | -      | 10     | V    |                                                                 |
| Pickup Input         | G7-G8          | 0-40VAC              | 50       | -      | 10 000 | Hz   |                                                                 |
| Relay Output         | A1-A2          |                      | -        | -      | 5A     | A    | Potential free, common on A3                                    |
| Digital Output       | C1-C5          |                      | -        | -      | 350    | mA   | C5 can be used as watchdog                                      |
|                      | G9-G11         |                      | -10      | -      | 10     | V    |                                                                 |
| Speed Out            | K4             |                      | -        | 500    | -      | Hz   | PWM output                                                      |
| Parallel             |                |                      | -        | 5      | -      | V    | Isolated 5V (10kΩ) load sharing and power set level (kW only).  |
| CAN Open             | Com 1-2        |                      | -        | 250    | -      | kbps | Com 1, Isolated CAN protocol                                    |
| Ethernet, Modbus TCP | Com 4          |                      | -        | 100    | -      | Mbps |                                                                 |
| Modbus RTU           | Com 5          |                      | 480<br>0 | 9600   | 19200  | baud |                                                                 |
| USB Port             | Com 3          |                      | -        | -      | -      | -    | Only for production use                                         |
| Memory slot          | Com 6          |                      | -        | -      | -      | -    | SD Card                                                         |

|         |                           |                                                                                                                                                                                                                         |
|---------|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A1      | Output 6                  | Supplied via battery positive or negative (A3), used as configurable relay outputs.<br>5A max.                                                                                                                          |
| A2      | Output 7                  |                                                                                                                                                                                                                         |
| A3      | Common for output 6 and 7 | To battery positive or negative, direct supply to output 6 and 7                                                                                                                                                        |
| B1      | Generator N               | Not necessarily connected.                                                                                                                                                                                              |
| B2      | Generator L1              | Generator voltage measurement.<br>100 to 480 VAC line to line.<br>Frequency: 50 or 60Hz nominal, measurement from 35 to 75Hz.<br>These lines must be protected externally with 100mA/600VAC fuses.                      |
| B3      | Generator L2              |                                                                                                                                                                                                                         |
| B4      | Generator L3              |                                                                                                                                                                                                                         |
| B5      | Mains L1                  | Mains voltage measurement.<br>100 to 480VAC line to line. Frequency: 50 or 60Hz nominal, measurement from 35 to 75Hz.<br>These lines must be protected externally with 100mA/600VAC fuses.                              |
| B6      | Mains L2                  |                                                                                                                                                                                                                         |
| B7      | Mains L3                  |                                                                                                                                                                                                                         |
| C1 - C5 | Output 1 to 5             | Transistor output linked to the power supply voltage (<350mA per output). Over current protected. Reactive load. Each output can be configured with a predefined function.<br>C5 can also be used as a watchdog output. |
| D1      | Generator I1-             | Generator current measurement 0 to 5A. Maximum rating: 15A during 10s. 1VA consumption.<br>External current transformers are normally used.<br>Maximum ratio is 3250 (meaning 3250:1 or 16250:5).                       |
| D2      | Generator I1+             |                                                                                                                                                                                                                         |
| D3      | Generator I2-             |                                                                                                                                                                                                                         |
| D4      | Generator I2+             |                                                                                                                                                                                                                         |
| D5      | Generator I3-             |                                                                                                                                                                                                                         |
| D6      | Generator I3+             |                                                                                                                                                                                                                         |
| D7      | Not connected             |                                                                                                                                                                                                                         |

|    |                                              |                                                                                                                                                                                                                                                                                           |
|----|----------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| E1 | Mains open breaker                           | Two configurable relays with one terminal in common.<br>Factory setting uses one relay for closing and one for opening the mains breaker.<br>Isolated contact. 240VAC/5A.                                                                                                                 |
| E2 | Mains close breaker                          |                                                                                                                                                                                                                                                                                           |
| E3 | Mains common                                 |                                                                                                                                                                                                                                                                                           |
| E4 | Generator open breaker                       | Two configurable relays with one terminal in common.<br>Factory setting uses one relay for closing and one for opening the generating set's breaker.<br>Isolated contact. 240VAC/5A.                                                                                                      |
| E5 | Generator close breaker                      |                                                                                                                                                                                                                                                                                           |
| E6 | Generator common                             |                                                                                                                                                                                                                                                                                           |
| F1 | Not connected                                |                                                                                                                                                                                                                                                                                           |
| F2 | Not connected                                |                                                                                                                                                                                                                                                                                           |
| F3 | Not connected                                |                                                                                                                                                                                                                                                                                           |
| F4 | Not connected                                |                                                                                                                                                                                                                                                                                           |
| F5 | Not connected                                |                                                                                                                                                                                                                                                                                           |
| F6 | Not connected                                |                                                                                                                                                                                                                                                                                           |
| F7 | Not connected                                |                                                                                                                                                                                                                                                                                           |
| F8 | Not connected                                |                                                                                                                                                                                                                                                                                           |
| F9 | Not connected                                |                                                                                                                                                                                                                                                                                           |
| G1 | $\pm 20\text{mA} +$<br>Or $\pm 10\text{V} +$ | $\pm 10\text{V}$ (20k $\Omega$ input) or $\pm 20\text{mA}$ (50 $\Omega$ input).<br>Used as Mains power input measurement with single generator.<br>Used as synchronization input from external analogue synchronizer (ex: in applications with several generators paralleled with mains.) |
| G2 | Shield                                       |                                                                                                                                                                                                                                                                                           |
| G3 | $\pm 20\text{mA} +$<br>Or $\pm 10\text{V} +$ |                                                                                                                                                                                                                                                                                           |
| G4 | Parallel – (shielded cable)                  | Isolated 5V (10k $\Omega$ ) load sharing and power set level (kW only).<br>Compatible with traditional analogue load share lines (often called <b><i>Parallel lines</i></b> ).<br>Compatibility with Wheatstone bridge. Mainly used in applications with mixed equipment.                 |
| G5 | Shield                                       |                                                                                                                                                                                                                                                                                           |
| G6 | Parallel + (shielded cable)                  |                                                                                                                                                                                                                                                                                           |

|          |                            |                                                                                                                                                                                                                                                   |
|----------|----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| G7       | Pickup – (shielded cable)  | 50Hz to 10kHz. Maximum voltage: 40VAC<br>Used for speed regulation.<br>If not wired, engine speed can be measured using alternator voltage.<br>Pickup is recommended.                                                                             |
| G8       | Pickup + (shielded cable)  |                                                                                                                                                                                                                                                   |
| G9       | Speed out +                | G9: ±10V analogue output to speed governor.<br>G11: ±10V reference input from speed governor (ESG).<br>Compatible with most speed governors.                                                                                                      |
| G10      | Shield                     |                                                                                                                                                                                                                                                   |
| G11      | Speed ref                  |                                                                                                                                                                                                                                                   |
| H1       | Not connected              |                                                                                                                                                                                                                                                   |
| H2       | AVR out +                  | Automatic voltage regulator (AVR) control. Compatible with most regulators.                                                                                                                                                                       |
| H3       | Shield                     |                                                                                                                                                                                                                                                   |
| H4       | AVR out –                  |                                                                                                                                                                                                                                                   |
| J1       | Mains breaker feedback     | Digital input with 10kΩ pull-up dedicated to Mains breaker feedback. Accepts NO or NC contact to 0V. Not isolated.                                                                                                                                |
| J2       | Generator breaker feedback | Digital input with 10kΩ pull-up dedicated to generator breaker feedback. Accepts NO or NC contact to 0V. Not isolated.                                                                                                                            |
| J3 – J15 | Spare inputs               | Digital input with 10kΩ pull-up. Inputs can be configured with a specific function or programmed with PLC equations. Accepts NO or NC contact to 0V. Not isolated.                                                                                |
| K1       | Power tank                 | Only used for <b>12V power supply</b> backup during crank time. An externally supplied capacitor can be connected between terminal K1 (+) and K3 (–) for better tolerance to power drops. A 47.000µF capacitor can help accept a 200ms power drop |
| K2       | Power supply +             | 9 to 40V, 10W consumption.                                                                                                                                                                                                                        |

|      |                                              |                                                                                                                                                                                                        |
|------|----------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| K3   | Power supply –                               | Protected against polarity inversion.<br>"Power supply –" must be wired from the speed governor via 4 mm <sup>2</sup> wires.<br>External 5A / 40VDC fuse recommended.                                  |
| K4   | PMW output                                   | 500Hz PWM output.<br>Compatible with Caterpillar and Perkins PWM controlled units. 0–5V protected against short-circuits to 0V.                                                                        |
| L1   | Bus/Mains I3+                                | Bus/Mains current measurement.<br>1 to 5A. Maximum rating: 15A during 10s.<br>1VA consumption.<br>External current transformer is normally used.<br>Maximum ratio is 3250 (meaning 3250:1 or 16250:5). |
| L2   | Bus/Mains I3–                                |                                                                                                                                                                                                        |
| L3   | Bus/Mains I2+                                |                                                                                                                                                                                                        |
| L4   | Bus/Mains I2–                                |                                                                                                                                                                                                        |
| L5   | Bus/Mains I1+                                |                                                                                                                                                                                                        |
| L6   | Bus/Mains I1–                                |                                                                                                                                                                                                        |
| Com1 | LSU Com                                      | Isolated CAN <sup>®</sup> bus.<br>Proprietary protocol to communicate with other LSU 408 units and share data/information.                                                                             |
| Com2 | CAN2 options<br>J1939<br>CANopen<br>MTU MDEC | Isolated CAN bus (125kb/s factory setting).<br>See details in §17.3.<br>Used to communicate with:<br>remote I/O<br>J1939 ECU<br>MTU MDEC protocol                                                      |
| Com3 | USB                                          | Not used                                                                                                                                                                                               |
| Com4 | Ethernet                                     | Web server access for configuration.<br>Modbus TCP                                                                                                                                                     |
| Com5 | RS485<br>Modbus RTU                          | 4800, 9600 or 19200 bps.<br>Used to communicate with SCADA.<br>MODBUS RTU slave. Read (04 and 03) and write (06 and 16) functions, 2 wires.                                                            |
| Com6 | SD card                                      | Firmware upload                                                                                                                                                                                        |



## Configuration

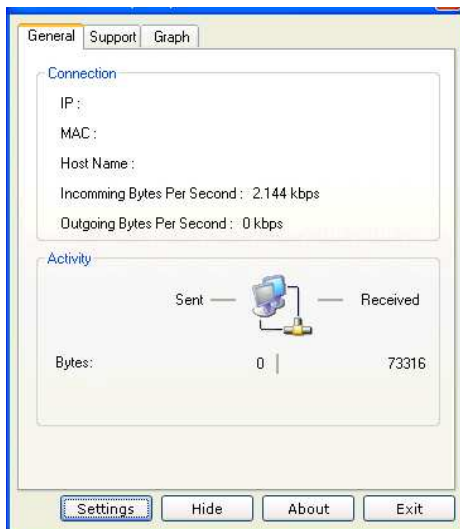
### Connecting with LSU 408

With Windows XP:

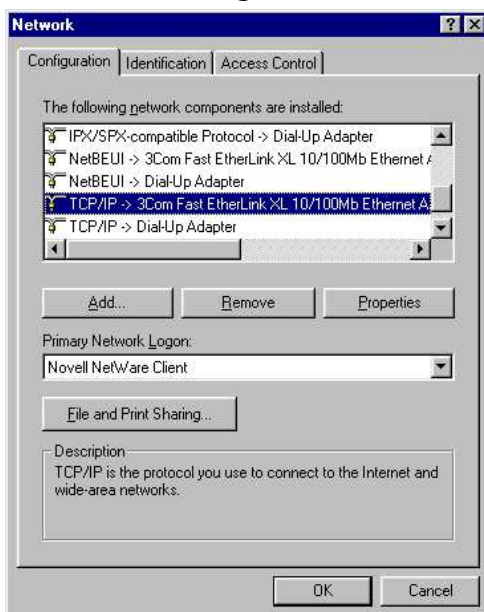
Open the control panel.

Click on network connections.

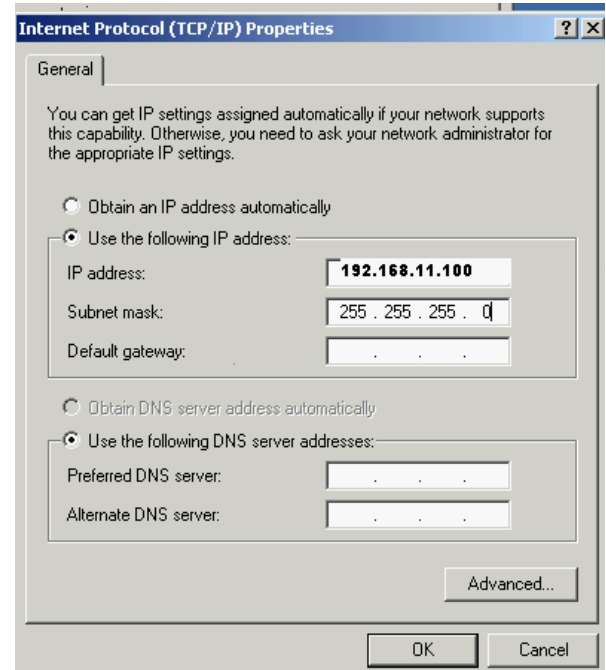
Click on local network.



Click on « Settings ».



Select « Ethernet (TCP/IP) ».  
Properties.



Enter the addresses as shown above.

Note:

IP address 192.168.11.100 shown above can be used if LSU IP address is 192.168.11.1 (factory setting).

Otherwise, computer and LSU IP addresses should match the same subnet mask as shown below.

Example:

Subnet mask:

255.255.255.0

Computer IP address:

AAA.BBB.CCC.XXX

LSU IP address:

AAA.BBB.CCC.YYY



Click on OK.

Close the networking windows.

You can now log into the embedded website using a web explorer and typing the LSU IP as address.

This will start the backup sequence and store all parameters in non-volatile memory so parameters will be kept even in case of a power supply failure.

## Configuration

All the necessary parameters of the LSU 408 can be modified in the embedded web page. The default passwords is:

Lev.0 (read only) – No password

Lev.1 (operator) – 1

(The passwords can be modified by the user.)

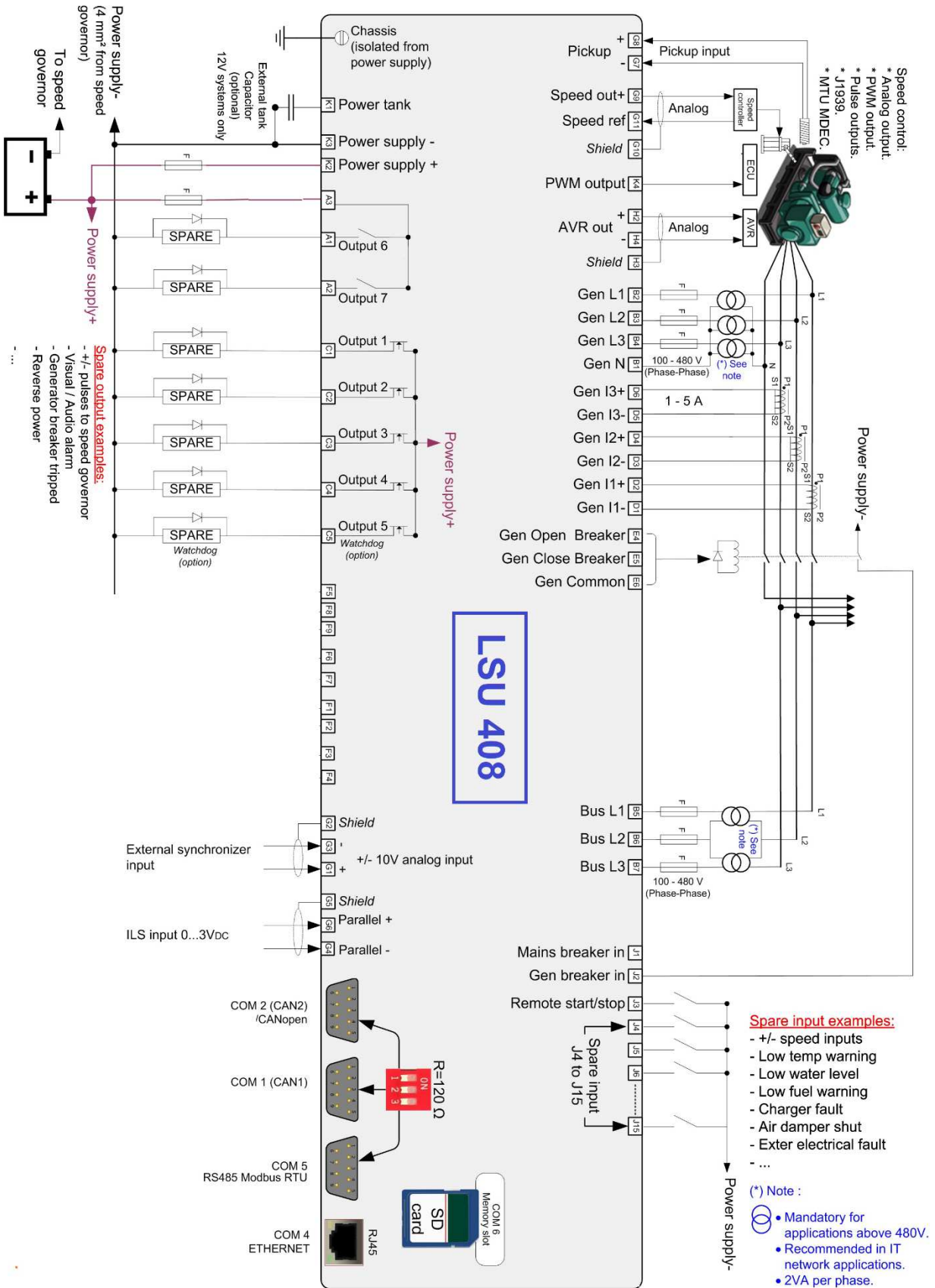
The configuration parameters are arranged in reasonable menus.

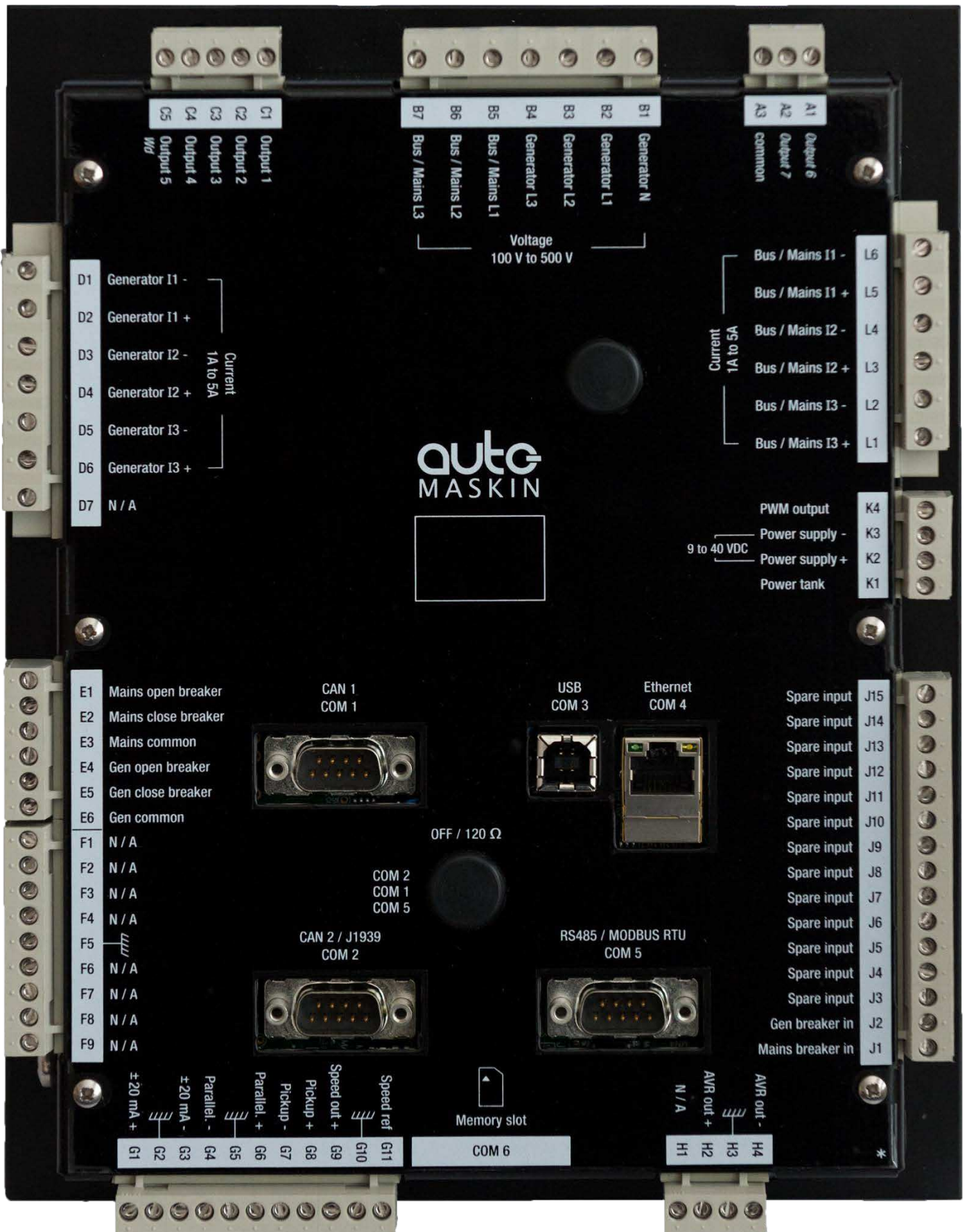
## Saving Configuration

All LSU parameters are stored in a FLASH memory. When a parameter is changed by the user, the new value is stored in a volatile memory: parameter changes take effect as soon as they are entered, but will be lost if the LSU power supply is cut or too low. To permanently save the new parameters to the FLASH memory, use the following method:

Write “1” into parameter E4066 by going into “Configuration/Modification by variable number” of the LSU embedded Web site.

Wiring example





## Predefined Configuration

### Single generator in change-over mode

In Change over mode the generator starts and takes the load when a mains electrical fault occurs. When mains power returns, the generator breaker is opened and the mains breaker is closed after a pre-set delay.

For the generator to start when mains failure occurs, either a protection set to be a remote start output (mains or other), or a digital input has to be configured as a "Mains electrical fault". If remote start is active when mains are present the LSU will send command start engine, and when generator voltage is present it opens the mains breaker, then closes the generator breaker and takes the load.

### Generator Paralleling with digital bus

In this mode, CAN Bus on COM1 is used to manage the different units on the same bus. This mode has better reliability and accuracy than equivalent analogue solutions.

Can Bus can be used to transfer data between the units.

Each unit will detect if any units are missing on the load sharing line and actions are configurable.

### Generator Paralleling with analogue parallel lines

When LSU 408 is configured to analogue load sharing mode, the active power sharing is handled via the analogue parallel lines. You have to disconnect the AVR output (H2-H4) and have an external device control the reactive power (CT droop...). This mode is only recommended for use if you have older devices (which are not compatible with CAN 1 LSU 408), with traditional ILS analogue parallel lines.

### Single generator in no-change-over mode

In "No change over" mode [E1 148] LSU acknowledge start on receiving a remote start signal and doesn't manage the mains breaker. This function can be used if LSU is only managing loadsharing and synchronizing without controlling the breakers.

Typical Marine application.

## Generator paralleling and loadsharing

CAN bus on COM1 is used to manage the different LSU units on the same bus. A maximum of 32 devices can be connected and run in parallel. This mode has better reliability and accuracy than equivalent analogue solutions. In addition it can be used to transfer measurement data between units.

As redundant loadsharing the LSU can be pre-configured to set alarm if one or more units are missing from the bus, and use the traditional analogue paralleling lines instead if an alarm is present.

Each unit can also be configured to run in droop mode if no loadsharing is possible.

In applications where there are several tie breakers and multiple generator sets, each LSU can be pre-configured to loadshare only with specific generators depended on the status of the tie breakers. This function is related to typical marine installations.

The traditional analogue parallel lines can be used if there is one or more engines using older devices with ILS analogue parallel lines.

## Multiple generators with static paralleling

This mode is useful when you urgently need to start a full plant with multiple generators. The generators will be ready to take load in the shortest possible time.

This mode is also very useful when your installation includes high voltage transformers. Starting generators which are paralleled together gives a progressive magnetization without peaks (no transient short-circuit).

*Note: As long as there is voltage reading present on the bus bar, the dynamic paralleling mode will be used even if static paralleling is configured. The static paralleling mode is only usable if all of the generators are stopped and bus bar is dead.*

## 4 generator sets in parallel, typical sequence:

- ❖ Loss of voltage
  - ❖ Loss of voltage
  - ❖ LSU sends command remote start.
  - ❖ At the same time all breakers (CB1, CB2, CB3 & CB4) close as ordered by the corresponding LSU.
  - ❖ DG1, DG2, DG 3, & DG4 start.



- ❖ All generators reach the speed defined by the [E1896] setting (CANBUS synchronization).
- ❖ There is a residual voltage of 80V.
- ❖ All C1 outputs close simultaneously to activate excitation (after dialogue between LSU units).
- ❖ The nominal voltage is reached immediately at the same time on all generators.
- ❖ The plant is available to take up required load within the shortest possible time.

## Advantages

- ❖ Full plant availability in less than 10 seconds.
- ❖ Gradual magnetization of the step-up transformer (no transient short-circuit).

## Mains paralleling mode

### No break change over

When remote start is active, the generator starts, synchronizes and parallels with the mains, then takes the load (ramps up). Once the mains are unloaded, LSU opens the mains breaker.

When remote start is deactivated, the mains take the load in the same way as the generator did previously. If the generator started for a mains failure, when mains power returns the LSU synchronizes the load transfer (ramps down), opens the breaker.

### Permanent mode

When the start is performed and permanent mode is active, LSU see the generator, synchronizes and parallels with the mains, then ramps up load until it reaches its set point. The set point is pre-configured.

There are two modes that can be configured when generator is running in permanent mode:

## Base load

In base load mode (E1153=2), the generator has a constant load and the mains take the utility load variations. If the utility load is less than the generator set point, mains are in reverse power.

## Peak shaving

In the peak shaving mode (E1153=1), the mains have a constant load and the generator takes the utility load variations.

## Power plant paralleled with mains

Two or more generators in parallel with common generator tie breaker and mains breaker.

This application requires additional modules to manage the mains power supply. Contact Auto-Maskin for information regarding the different possibilities.

## Installing & Commissioning

The LSU 408 module has been designed for inside cabinet mounting. Indoor or outdoor installation is possible as long as the following requirements are met:

- ❖ The chosen cabinet must meet the standard safety rules of the workplace.
- ❖ The chosen cabinet must be closed during normal use to prevent the user from coming into contact with power cables.
- ❖ In accordance with the Bureau VERITAS marine agreement, the module must not be installed in areas which are exposed to the weather.

## Earth grounding

Earth grounding of the LSU 408 should be made with two M5 screws & fan washers. Use a short 4mm<sup>2</sup> cable to connect the unit to earth.

## Wiring guidelines

The power cable must be kept separate from the communication cable. The communication cable can be installed in the same conduit as the low level DC I/O lines (under 10 volts). If power and communication cables have to cross, they should do so at right angles.

Correct grounding is essential to minimize noise from electromagnetic

interference (EMI) and is a safety measure in electrical installations. To avoid EMI, shield communication and ground cables appropriately. If several LSU 408 units are used, each of the 0V power supplies (pin K3) must be connected to each other with a 4mm<sup>2</sup> cable. (use an adapter for the 2.5mm<sup>2</sup> connection to the LSU 408 power connector itself).

## Power supply circuit breaker

Terminal K3 (0V) should never be disconnected. The battery circuit should only be opened using a breaker placed between the battery's positive terminal and the K2 terminal (Power supply +).

## Rental fleet & Marine generating sets

CAN bus isolators are fitted inside the LSU 408 unit so it is possible to use it safely in MARINE applications and on rental fleets.



## External power tank capacitor

An external power tank capacitor can be connected between terminal K1 and K3 to help the battery maintaining an adequate power supply when starting the engine (low voltage) or brownouts. This capacitor is optional: LSU 408 is able to operate with a minimum power supply of 9V. This capacitor can be used in case of a **single 12V battery power supply**. Do not connect such power tank on 24V applications.

## Before commissioning

### Schematic check

Be sure you have the latest power plant schematics in order to check the presence on site of the wires (CAN bus, shielded wires, Speed governor / LSU 408 Interface,...)

Be sure that you save your configuration file into an electronic format.

### Check list of inputs-/outputs

Check if the required function is present in the list of preset functions in order to evaluate input/output. If case of doubt, contact your local distributor.

## During commissioning

- ❖ Disconnect the LSU 408 breaker control connector (labeled as « E »).
- ❖ Check your speed governor settings and your AVR control settings.
- ❖ Check important LSU 408 parameters.
- ❖ Ask the technician who wired the power plant to lock the generator breaker open.
- ❖ Check the diesel control system.
- ❖ Check the battery voltage.
- ❖ Check the emergency stop.

Check the 3 minimum protections before carrying out any other tests:

- ❖ Over voltage
- ❖ Emergency stop
- ❖ Reverse kW

Before starting, connect to the LSU 408 using a laptop and enter the monitoring generator menu.

- ❖ Start generator from diesel control.
- ❖ Read values from the LSU and check that they are stable and within the desired values. (Ex: 1500rpm, 50Hz, 400VAC.)
- ❖ Stop generator

## Dedicated I/O lines

Inputs/outputs are associated with functions. Some I/O are dedicated, others are programmable using configuration parameters.

## Speed governor interface

This interface is used to control engine speed.

The Speed governor control is used to manage speed set points, Synchronization, KW Load sharing and KW set points.

The Speed governor interface can be:

- ❖ Analogue output
- ❖ PWM 500Hz digital output (CATERPILLAR/PERKINS)
- ❖ Digital pulse output

## Analogue speed governor output

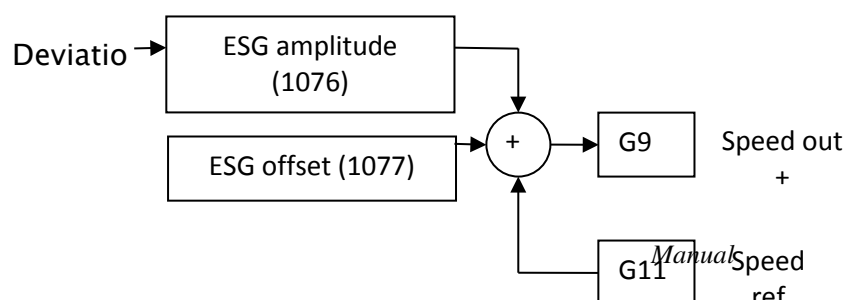
The following procedure must be used to match the interface with the speed governor:

- ❖ Connect the speed ref. wire only (G11).
- ❖ Check that the negative speed governor power supply is shared with all of the LSU 408.

“Configuration/Engine/Speed control settings/Speed governor settings”

- ❖ Start the generator.
- ❖ Measure the voltage on the speed governor terminal and adjust offset [E1077] on LSU 408 in order to get the same voltage on G9–G11 terminals.
- ❖ Connect the speed control *Speed out +* (G9), and refine the nominal frequency by adjusting the offset [E1077].
- ❖ Check the speed variation range by activating [+] and [-] inputs in [Manu] mode. The speed variation range must not exceed  $\pm 3\text{Hz}$  and must not be lower than  $\pm 2\text{Hz}$ . The best settings are reached when the LSU 408 is able to control the frequency with  $\pm 2,5\text{Hz}$  around the nominal frequency.
- ❖ ❖ If the speed variation range is too wide or too narrow, adjust the gain [E1076]

Figure 1 – Speed output



- ❖ Use the laptop to enter the configuration menu.

### PWM 500 Hz (Caterpillar/Perkins)

K4 output is a 500Hz PWM output signal between 0 and 5V. It is protected against short-circuits between the output and the battery negative voltage. To activate this PWM output in order to control speed of Caterpillar or Perkins engines, please check LSU 408 parameters as shown below.

| Variable number | Label         | Value | Description                                                                                                                                             |
|-----------------|---------------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| E1639           | 500 Hz ACT    | 1     | Activates the speed control with 500Hz PWM. In this mode the analogue speed output (G9 / G11) is unavailable.                                           |
| E1077           | ESG offset    | 70%   | PWM duty cycle set for nominal frequency.                                                                                                               |
| E1076           | ESG amplitude | 30%   | Range of the PWM duty cycle to control engine speed. For example, if you have set 20.0%, the PWM will vary +/- 10% around the nominal duty cycle value. |

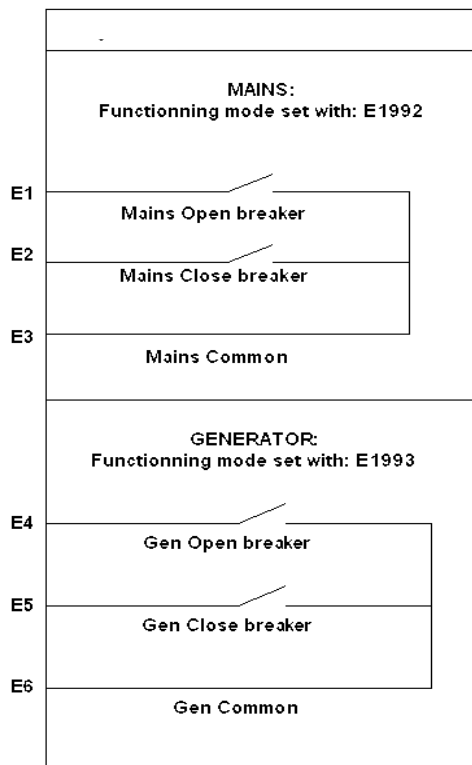
### Speed and voltage control with Contacts/Pulses

Digital outputs can be configured for digital pulses raise-/lower. PID settings for speed and voltage is applicable for the digital outputs.

## Breaker control

LSU 408 is equipped with 4 NO relays (at rest) for breaker control.

- ❖ 2 relays to control the generator breaker, one for opening (E4) and one for closing (E5).
- ❖ 2 relays to control the mains breaker, one for opening (E1) and one for closing (E2).



These outputs allow you to control various types of breaker. This chapter explains the available setups and their associated variables.

## Working modes:

The *Configuration/Enhanced configuration/ gen/mains breaker setup* menu allows you to choose the working mode of these relays via the variables E1992 for the mains and E1993 for the generating set. Table below explains the different functioning modes featured by LSU 408.

## Working modes:

The *Configuration/Enhanced configuration/ gen/mains breaker setup* menu allows you to choose the working mode of these relays via the variables E1992 for the mains and E1993 for the generating set. Table below explains the different functioning modes featured by LSU 408

| Variables |                                                            |
|-----------|------------------------------------------------------------|
| E2000     | Digital input for Generator breaker return                 |
| E2001     | Digital input for Mains breaker return                     |
| E2016     | Genset breaker control                                     |
| E2017     | Mains breaker control                                      |
| E1149     | Delay before breaker opening/closure failure               |
| E1992     | Choice of Genset (Genset) breaker relay work mode          |
| E1993     | Choice of Mains (Mains) breaker relay work mode            |
| E1994     | Time before undervoltage trip coil control contact closure |
| E1995     | Time before a new closure request is authorized            |
| E1893     | Trip coil min. pulse length.                               |

*LSU is shown by the values of E2016 and E2017 changing (1=closure, 2=opening). When the breaker gives the correct feedback, LSU 408 variables E2000 (Mains) or E2001 (Genset) switch to 1.*

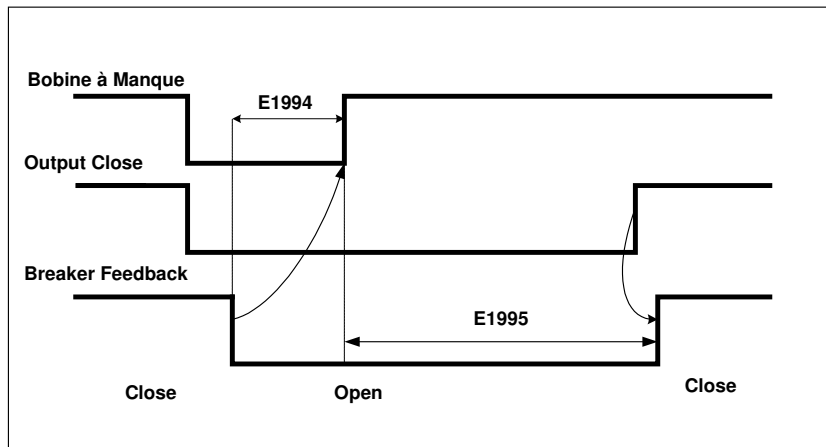
*The delay for a breaker to close before a failure is detected is set to 5 seconds as standard (Configuration/Enhanced configuration/Modification by variable n°/1149).*

| E1992 (Mains)<br>/E1993 (Genset)                                      | Relay output mode                                              | Chronogram |
|-----------------------------------------------------------------------|----------------------------------------------------------------|------------|
| 0                                                                     | Continuous contact to open<br><i>E1 (Mains) / E4 (Genset)</i>  |            |
|                                                                       | Positive pulse to close<br><i>E2 (Mains) / E5 (Genset)</i>     |            |
| 1<br><b>(default setting)</b><br><b>(Contactor)</b>                   | Continuous contact to open<br><i>E1 (Mains) / E4 (Genset)</i>  |            |
|                                                                       | Continuous contact to close<br><i>E2 (Mains) / E5 (Genset)</i> |            |
| 2                                                                     | Undervoltage coil opening<br><i>E1 (Mains) / E4 (Genset)</i>   |            |
|                                                                       | Pulse to close<br><i>E2 (Mains) / E5 (Genset)</i>              |            |
| 3                                                                     | Undervoltage coil opening<br><i>E1 (Mains) / E4 (Genset)</i>   |            |
|                                                                       | Continuous contact to close<br><i>E2 (Mains) / E5 (Genset)</i> |            |
| 4<br><b>(Breakers without</b><br><b>undervoltage</b><br><b>coils)</b> | Pulse to open<br><i>E1 (Mains) / E4 (Genset)</i>               |            |
|                                                                       | Pulse to close<br><i>E2 (Mains) / E5 (Genset)</i>              |            |
| 5                                                                     | Pulse to open<br><i>E1 (Mains) / E4 (Genset)</i>               |            |
|                                                                       | Continuous contact to close<br><i>E2 (Mains) / E5 (Genset)</i> |            |

For control using a pulse or an undervoltage coil, the necessary parameters are:

- ❖ E1893: pulse length.
- ❖ E1994: Undervoltage coil delay. This sets the time between the opening of the breaker and the closing of the undervoltage coil control contact.
- ❖ E1995: Undervoltage coil pause time. Sets the time between the closing of the undervoltage trip coil control contact (E1 or E4) and another breaker close request by the other contact (E2 or E5). This must be longer than the breaker reset time.

These values can be modified in the *Configuration/Enhanced configuration/Modification by variable n°* menu.



**WARNING:**

*Never switch from one mode to another when the plant is in use. An unwanted breaker state modification may occur.*

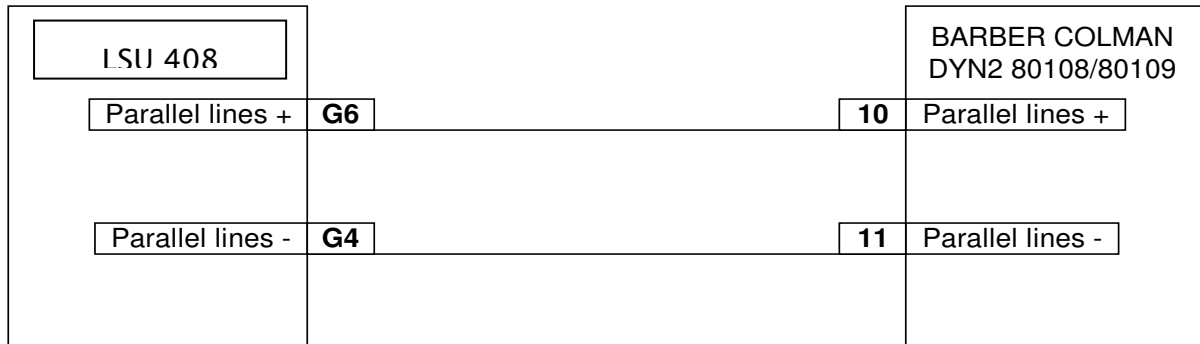
To close the generator breaker the following conditions have to be met:

Voltage must be between 70% (parameter E1432) and 130% (parameter E1433) of the nominal voltage (parameter E1107 or E1108).

Speed must be between 70% (parameter E1434) and 130% (parameter E1435) of the nominal speed (parameter E1080 or E1081).

## Analogue Loadsharing Lines

It is possible to use traditional analogue load share lines (often called Parallel Lines) with the LSU 408 product. The example shown is in association with a BARBER COLMAN product.



Change the following parameters in the "Configuration/Enhanced configuration/powerplant overview" menu to activate parallel lines:

ILS compatible E1158= YES (0)

Deadbus manage. E1515= NON (1)

## Watchdog output

A watchdog option is available using the C5 output. This option must be specified upon ordering your unit so that Auto-Maskin can activate it. For more information concerning this function, please contact Auto-Maskin.



## Menu overview

### Menu introduction

To have access to the menu you need to have an PC connected.

Main menu contains 3 major submenus:

**Display** will give information about the genset, bus-bar or mains, and will display real time information and parameters status.

**Configuration** is only accessible if you have entered a level 1 or 2 password. You will be able to program LSU 408 according to the needs of your plat.

**System** is only accessible if you have entered a level 1 or 2 password. The system menu will let you change parameters that are not related to the plant, but rather to the LSU 408 system.

### DISPLAY Menu

This menu gives access to the following information:

#### Generator electrical meter

These meters are displayed in real time. Scrolling through this menu, you will display the following values:

**Phase to neutral voltage** for each phase [E0000, E0001, E0002]

**Phase to phase voltage** for each phase [E0003, E0004, E0005]

**Current** for each phase [E0006, E0007, E0008]

**Active power** for each phase [E0009, E0010, E0011]

**Reactive power** for each phase [E0012, E0013, E0014]

**Power factor** for each phase [E0015, E0016, E0017]

**Average active and reactive power, frequency and power factor** [E0018, E0019, E0020, E0021]

**Active and reactive energy meters** [E0025, E0026 / E0125, E0126]

The "**Global view**" screen will display all parameters listed above on a single screen. This is particularly useful in pre-commissioning phase.

## Generator global view

### Global view

|     |        |         |         |        |       |
|-----|--------|---------|---------|--------|-------|
| V1= | 0 V    | U31=    | 0 V     | I1=    | 0 A   |
| V2= | 0 V    | U23=    | 0 V     | I2=    | 0 A   |
| V3= | 0 V    | U12=    | 0 V     | I3=    | 0 A   |
| P1= | 0 kW   | Q1=     | 0 kVAR  | cosφ1= | 1.00I |
| P2= | 0 kW   | Q2=     | 0 kVAR  | cosφ2= | 1.00I |
| P3= | 0 kW   | Q3=     | 0 kVAR  | cosφ3= | 1.00I |
| P=  | 0 kW   | F=      | 0.00 Hz |        |       |
| Q=  | 0 kVAR | cos(φ)= | 0.00I   |        |       |

Figure 2 – Generator global view

### Generator phase to neutral voltages

This screen displays the three phase to neutral voltage measurements.

### Generator phase to phase voltages

This screen displays the three phase to phase voltage measurements.

### Generator currents

This screen displays the three current measurements.

### Generator kW

This screen displays the three kW measurements.

### Generator kVAR

This screen displays the three kVAR measurements.

### Generator PF

This screen displays the three power factor measurements.

### All generator parameters

This screen displays all electrical parameters measurements.

### kW meter & kVAR meter

This screen displays KWh and kVARh calculation.

## Mains / Bus bars electrical meters

These meters are displayed in real time. Scrolling through this menu, you will display the following values:

Phase to neutral voltage for each phase [E0793, E0794, E0795]

Phase to phase voltage for each phase [E0796, E0797, E0798]

**Current** for each phase [E0799, E0800, E0801]

**Active** power for each phase [E0802, E0803, E0804]

**Reactive** power for each phase [E0805, E0806, E0807]

Power factor for each phase [E0808, E0809, E0810]

Active and reactive energy meters

The "Global view" screen will display all parameters listed above on a single screen. This is particularly useful in pre-commissioning phase.

## Mains / Bus bars Global view

### Global view

|     |        |         |         |        |       |
|-----|--------|---------|---------|--------|-------|
| V1= | 0 V    | U31=    | 0 V     | I1=    | 0 A   |
| V2= | 0 V    | U23=    | 0 V     | I2=    | 0 A   |
| V3= | 0 V    | U12=    | 0 V     | I3=    | 0 A   |
| P1= | 0 kW   | Q1=     | 0 kVAR  | cosφ1= | 1.00I |
| P2= | 0 kW   | Q2=     | 0 kVAR  | cosφ2= | 1.00I |
| P3= | 0 kW   | Q3=     | 0 kVAR  | cosφ3= | 1.00I |
| P=  | 0 kW   | F=      | 0.00 Hz |        |       |
| Q=  | 0 kVAR | cos(φ)= | 0.00I   |        |       |

Figure 3 – Mains/Busbars global view

## Bus/Mains phase neutral voltages

This screen displays the three phase to neutral voltage measurements.

## Bus/Mains phase-phase voltages

This screen displays the three phase to phase voltage measurements.

## **Bus/Mains currents**

This screen displays the three current measurements.

## **Bus/Mains kW**

This screen displays the three kW measurements.

## **Bus/Mains kVAR**

This screen displays the three kVAR measurements.

## **Bus/Mains PF**

This screen displays the three power factor measurements.

## **All Bus/Mains parameters**

This screen displays all Bus/mains parameter measurements.

## **Bus/Mains kW meter & kVAR meter**

This screen displays kWh and kVARh measurements.

## **Synchronization**

This page will show:

- ❖ Synchroscope (phase difference)

- ❖ Differential frequency (bar graph)
- ❖ Differential voltage (bar graph).
- ❖ Synch check relay status (Phase difference, **frequency** difference, voltage difference, **phase sequence**)
- ❖ **Phase Offset** (shows the parameter [E1929] set for the phase angle shift).

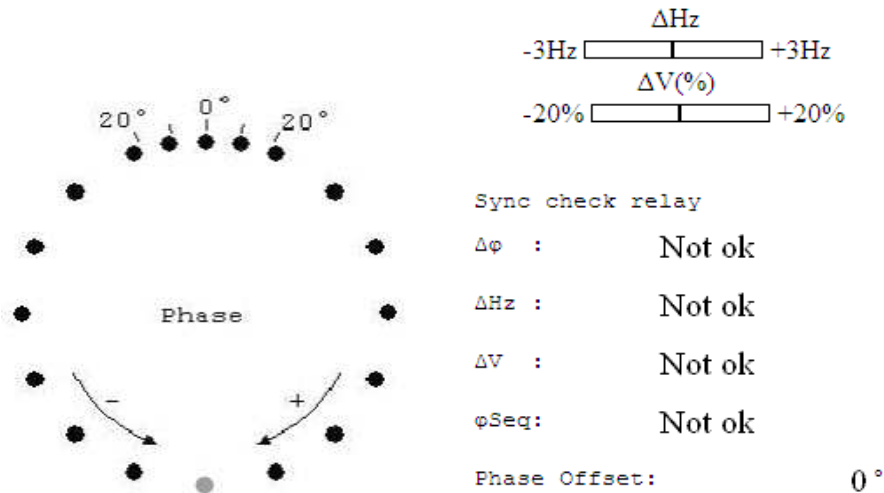


Figure 4 – Synchroscope

## Power plant overview

This menu will show the power plant parameters (parameters shared by different LSU 408 units):

### Generators – kW

This screen will show the percentage of nominal active power supplied by each genset in real time; [E0042 to E0057]

### Generators – kVAR

This screen will show the percentage of nominal reactive power supplied by each genset in real time; [E0132 to E0147]

### Generators – nominal kW

This screen will show the nominal active power of each genset [E0073 to E0088]

### Generator – nominal kVAR

This screen will show the nominal reactive power of each genset [E0089 to E0104]

## Generator – state code

This screen will show the machine status [E2071] of each genset

## Data logging

5 pages will show the **FIFO event data logger** selected in the data logger configuration page.

You can download the **summary file** with a computer connection.

Configuration can be undertaken in: [FIFO data logger](#).

Data login archive can be delete in the menu System/ Date Time meter/. Data login -reset

## Generator fuel control

### Speed/kW settings / control

Whatever the configuration (internal or external speed controller, constant power production or peak shaving...) or the status of the genset (synchronizing, load sharing...) is, all parameters will be displayed. Depending on the configuration some will remain inactive. The percentage values are between – 7000 and + 7000 percent. 7000 % correction is equal to an increase of + 3 Hz.

**Active speed** [E2027]: speed set point of the internal governor. Is equal to the value entered in Configuration/[speed control settings](#) menu.

**Load pulse** [E1074]: is equal to the value entered in Configuration /[speed control settings](#) menu.

**Speed droop** [E1075]: is equal to the value entered in Configuration / [speed control settings](#) menu.

**Active P setpt** [E2048]: Active power set point showed in kW

**Gen synchro** [E2028]: shows the percentage of correction of synchronization signal

**GCR synchro** [E2092]: shows the percentage of correction of external synchronization (with mains)

**kW // mains** [E2029]: shows the percentage of correction of power control when running parallel to the mains.

**Load pulse** [E2030]: shows the percentage of load pulse correction (anticipated impact of load).

**RPM droop** [E2031]: droop correction signal.

**kW sharing** [E2032]: shows the percentage of correction of active load sharing between gensets.

**+/- Hz manu** [E2025]: shows the percentage of correction of manual speed control ([+] and [-] keys of the front panel)

**Speed signals** [E2058]: sum of the speed correction signals.

## Speed/kW meters

**Engine speed** [E0033]: current engine speed in rpm.

**Generator kW** [E0018]: current active power.

## Generator excitation control

### Excitation control settings

**Voltage setpoint** [E2039]: Voltage signal to AVR (usually the set point of the AVR).

**PF // mains** [E1110]: power factor set point when generator is paralleled with mains.

**Volt droop** [E1105]: used when reactive load sharing is not done through the inter LSU 408 CAN bus, in manual mode, and when there is a CAN bus fault.

**U=constant** [E2033]: shows the percentage of correction sent to the AVR to keep voltage set point.

**Volt synchro** [E2034]: shows the percentage of voltage synchronization correction signal sent to the AVR.

**PF control** [E2035]: shows the percentage of correction sent to the AVR to keep power factor set point.

**kVAR sharing** [E2036]: shows the percentage of correction sent to the AVR for reactive load sharing.

**Volt droop** [E2037]: shows the percentage of correction sent to the AVR for droop.

**Manual volt** [E2038]: shows the percentage of correction sent to the AVR by manual control (shift+[+] and shift+[-] keys of the front panel). This value is equal to zero in auto and test modes.

**Excitation** [E2040]: sum of the AVR correction signals.

### Excitation meters

These show the 3 phase voltages and genset kVAR. [E0000, E0001, E0002, E0019]

## I/O Configuration

They are divided into dedicated and configurable inputs.

For Digital inputs 1 to 10 (J6 to J15) the following parameters can be set:

- ❖ Label: can be modified with parameters file.
- ❖ Validity: can be modified using configuration menu or equations.
- ❖ Direction: can be modified using configuration menu or equations.
- ❖ Delay: can be modified using configuration menu or equations.
- ❖ Function: can be modified using configuration menu or equations.

The following table shows all input associated parameters.

|     | Not delayed value | Delayed value | Default label  | Label | Validity | Direction | Delay | Function |
|-----|-------------------|---------------|----------------|-------|----------|-----------|-------|----------|
| J1  | N.A.              | E2000         | Mains breaker  | N.A.  | N.A.     | E1453     | N.A.  | N.A.     |
| J2  | N.A.              | E2001         | Gen breaker    | N.A.  | N.A.     | E1454     | N.A.  | N.A.     |
| J3  | E2787             | E2002         | Spare InputJ3  | N.A.  | N.A.     | E1455     | E1990 | N.A.     |
| J4  | E2788             | E2804         | Spare InputJ4  | L2804 | E4035    | E1456     | E1998 | E1996    |
| J5  | E2789             | E2805         | Spare InputJ5  | L2805 | E4036    | E1457     | E1999 | E1997    |
| J6  | E2790             | E2806         | Spare Input J6 | L2806 | E1287    | E1297     | E1277 | E1267    |
| J7  | E2791             | E2807         | Spare Input J7 | L2807 | E1288    | E1298     | E1278 | E1268    |
| J8  | E2792             | E2808         | Spare Input J8 | L2808 | E1289    | E1299     | E1279 | E1269    |
| J9  | E2793             | E2809         | Spare Input J9 | L2809 | E1290    | E1300     | E1280 | E1270    |
| J10 | E2794             | E2810         | Spare InputJ10 | L2810 | E1291    | E1301     | E1281 | E1271    |
| J11 | E2795             | E2811         | Spare InputJ11 | L2811 | E1292    | E1302     | E1282 | E1272    |
| J12 | E2796             | E2812         | Spare InputJ12 | L2812 | E1293    | E1303     | E1283 | E1273    |
| J13 | E2797             | E2813         | Spare InputJ13 | L2813 | E1294    | E1304     | E1284 | E1274    |
| J14 | E2798             | E2814         | Spare InputJ14 | L2814 | E1295    | E1305     | E1285 | E1275    |
| J15 | E2799             | E2815         | Spare InputJ15 | L2815 | E1296    | E1306     | E1286 | E1276    |

Table 1 - Input parameters



## Validity

Validity input variable numbers (E1287 to 1296) can be set as:

| Num  | Label          | Function                                                             |
|------|----------------|----------------------------------------------------------------------|
| 2330 | Never          | Never active: should be selected if you do not use the input.        |
| 2329 | Always         | Always active: input will be monitored as long as LSU 408 has power. |
| 2331 | Stabilized     | Input will be monitored when genset is ready for use (E2057 = 6).    |
| 2332 | Spare scenario | Input will be monitored as defined in equations.                     |
|      |                |                                                                      |

Table 2 - Input validity domain

## Direction

Direction input variable numbers: (E1297 to 1306)

For each of the ten inputs, two options are available:

| Num | Label      | Function                                                                                               |
|-----|------------|--------------------------------------------------------------------------------------------------------|
| 0   | Norm open  | Should be selected in normal cases unless the input is used for protection.                            |
| 1   | Norm close | Normally closed; should be selected if the input is normally connected to 0V and is opened when active |

Table 3 - Input direction domain

## Delay

Direction input variable numbers: (E1277 to E1286).

For each input, delay can be defined in 100 ms steps between 0 and 6553s.

## Digital inputs

There are several configurable inputs that can be programmed to a specific function.

Beneath is a complete table showing the different functions.

## Input functions

Function input variable numbers (E1267 to 1276) can be set as indicated in the following table.

| Value | Function                       | Description                                                                                                                        |
|-------|--------------------------------|------------------------------------------------------------------------------------------------------------------------------------|
| 0     | Unused                         | Should be selected if you do not use the input.                                                                                    |
| 1     | Used by equations              | If the effect of the input activation is not listed below, choose "used by equations"                                              |
|       |                                |                                                                                                                                    |
| 2205  | Fault reset request            | If an external reset is wired to the input, choose fault reset request. This will automatically reset all faults and alarms        |
| 2227  | Manual start request           | To be selected if a remote start command is to be installed.                                                                       |
| 2233  | Manual +f request              | To be selected if a remote frequency increasing command is to be installed.                                                        |
| 2234  | Manual -f request              | To be selected if a remote frequency decreasing command is to be installed.                                                        |
| 2235  | Manual +U request              | To be selected if a remote voltage increasing command is to be installed.                                                          |
| 2236  | Manual -U request              | To be selected if a remote voltage decreasing command is to be installed.                                                          |
| 2197  | Securities inhibition          | Will inhibit all protections. These alarms and faults remain listed in the faults and alarm logging.                               |
| 2210  | Ext. secu.(Hard shut down)     | If external protections are installed, for immediate stop signal to external diesel controller.                                    |
| 2208  | External alarm                 | If external protections are installed, to report an alarm.                                                                         |
| 2217  | Generator electrical fault     | If external protections are installed, protection will open genset breaker and try to synchronize again.                           |
| 2218  | Mains electrical fault         | If external protections are installed, protection will open mains breaker and try to synchronize again.                            |
| 2681  | Non essential trip alarm       | Remote non essential load.                                                                                                         |
| 2736  | Help + Fault ( Soft shut down) | To be selected to stop the engine after cool down. The LSU 408 will ask another engine to start before stopping itself.            |
| 2737  | Help + Gen Electrical Fault    | To be selected to activate the "gen electrical fault" action. The LSU 408 will ask another engine to start before stopping itself. |
| 2655  | Remote stop horn               | To be selected to stop the external Horn. Useful if one output is set as "Horn". to be used in conjunction with digital outputs    |
| 2336  | Gen. breaker Close manual      | To be selected if manual remote close button for genset breaker is programmed.                                                     |
| 2337  | Gen. breaker Open manual       | To be selected if manual remote open button for genset breaker is programmed.                                                      |
| 2338  | Mains breaker Close manual     | To be selected if manual remote close button for mains breaker is programmed.                                                      |
| 2339  | Mains breaker Open             | To be selected if manual remote open button for mains                                                                              |

|      |                            |                                                                                                                                                                                               |
|------|----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|      | manual                     | breaker is programmed.                                                                                                                                                                        |
| 2001 | Generator breaker Aux      | To be selected if a different input for the generator breaker position is required.                                                                                                           |
| 2000 | Mains breaker Aux          | To be selected if a different input for the mains breaker is required.                                                                                                                        |
| 2002 | Remote start               | To be selected if input for remote start is required.                                                                                                                                         |
| 2241 | Priority generator         | To be selected if load/unload features depend on a priority genset                                                                                                                            |
| 2257 | Synchronization forced     | Will force LSU 408 to synchronize the output with the governing system. AVR will act to synchronize the genset. The "Power mode" (E2088) is forced to Synchronization (1).                    |
| 2258 | Fixed kW forced            | Will force LSU 408 to give constant power delivery. The output governing system will maintain a fixed power output from the genset. The "Power mode" (E2088) is forced to Fixed kW (4).       |
| 2259 | kVAR sharing forced        | The output to AVR will share reactive load with other gensets, using the inter LSU 408 CAN bus. (E.g. to be used in manual mode). The "AVR cont. mode" (E2090) is forced to kVAR sharing (5). |
| 2656 | Voltage Droop forced       | Will force the LSU 408 to apply Droop to the AVR command. Set with [E1105]. The "AVR cont. mode" (E2090) is forced to Voltage droop (1).                                                      |
| 2260 | No manu mode               | Will inhibit the "Manu" mode, LSU 408 will never be in manual mode if input is configured to "Manu"                                                                                           |
| 2261 | External manu mode request | Will put LSU 408 into Manual mode.                                                                                                                                                            |
| 2661 | Running with breaker open  | Allows the engine to run in Auto mode without paralleling or closing its breaker.                                                                                                             |
| 2279 | Select speed 2             | Will select the second speed set point.                                                                                                                                                       |
| 2280 | Select volt 2              | Will select the second voltage set point.                                                                                                                                                     |
| 2281 | Select kW 2                | Will select the second power output set point.                                                                                                                                                |
| 2513 | Select Pnom 2              | Will select the second nominal power (active and reactive).                                                                                                                                   |
| 2766 | Heavy consumer request     | To be selected to activate the "Heavy consumer control" special sequence.                                                                                                                     |
| 5000 | Unload brk1 in             | Order output to close generator breaker n°1 upon startup if the nominal power<E4001                                                                                                           |
| 5001 | Unload brk2 in             | Order output to close generator breaker n°1 upon startup if the nominal power<E4002                                                                                                           |
| 5002 | Unload brk3 in             | Order output to close generator breaker n°1 upon startup if the nominal power<E4003                                                                                                           |
| 5003 | Unload brk4 in             | Order output to close generator breaker n°1 upon startup if the nominal power<E4004                                                                                                           |
| 5004 | Unload brk5 in             | Order output to close generator breaker n°1 upon startup if the nominal power<E4005                                                                                                           |

Table 4 - Input functions

### Dedicated inputs

In the menu list, each input is named after its pin number on the wiring of LSU 408. Polarity can be normally open or normally closed. Program this according to the wiring you will have on site.

As a reminder:

- ❖ J1 is the Mains breaker state.
- ❖ J2 is the Genset breaker state.

### Digital outputs

Output1 to Output5 are wired on the C connector. These outputs are electronically protected, but not isolated.

Outputs 1 to 5 (E1260, E1261, E1262, E1262, E1264): function and polarity can be defined.

Output6 and Output7 relay outputs can be configured. Polarity cannot be changed for these relay outputs.

### Output configurable functions

| Value | Function                  | Description                                                                                                                                                                                        |
|-------|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0     | Unused                    | To be selected if output is not wired.                                                                                                                                                             |
| 1     | Used by equations         | To be selected if output is used by equations.                                                                                                                                                     |
| 2211  | Excitation                | Can be used to activate an external AVR in a static synchronizing configuration [see Configuration -> power plant overview]                                                                        |
| 2212  | Engine (energize to stop) | To be used for command to the external Diesel controller. Will activate an signal [Energize to stop] when engine is running [E0033 > 0] and if there is an engine fault [E2046] or a stop request. |
| 2016  | Generator breaker order   | Can be used to open or close genset breaker. The outputs configured with this function will have exactly the same behaviour as the outputs for the Generator breaker [E4 to E6].                   |
| 2017  | Mains breaker order       | Can be used to open or close mains breaker. The outputs configured with this function will have exactly the same behaviour as the outputs for the Mains breaker [E1 to E3].                        |

|      |                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|------|----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2202 | Alarms summary             | Fault summary: will activate an output when there is at least one "alarm" triggered by LSU 408.                                                                                                                                                                                                                                                                                                                                                                                           |
| 2204 | Securities summary         | Fault summary: will activate an output when there is at least one "Security" triggered by LSU 408.                                                                                                                                                                                                                                                                                                                                                                                        |
| 2203 | Faults summary             | Fault summary: will activate an output when there is at least one "fault" triggered by LSU 408.                                                                                                                                                                                                                                                                                                                                                                                           |
| 2200 | Gen. elec faults summary   | Fault summary: will activate an output when there is at least one "mains elec. fault" triggered by LSU 408.                                                                                                                                                                                                                                                                                                                                                                               |
| 2201 | Mains elec. faults summary | Output will be activated whenever a protection triggers a mains electrical fault.                                                                                                                                                                                                                                                                                                                                                                                                         |
| 2724 | Trip out 1                 | Output activated by the protection in the "Non essential consumer trip" sequence. This is the first trip; Non Essential consumer trip                                                                                                                                                                                                                                                                                                                                                     |
| 2725 | Trip out 2                 | Output activated by the protection in the "Non essential consumer trip" sequence. This is the 2nd trip activated [E1894] seconds after the previous one. Non Essential consumer trip                                                                                                                                                                                                                                                                                                      |
| 2726 | Trip out 3                 | Output activated by the protection in the "Non essential consumer trip" sequence. This is the 3rd trip activated [E1894] sec. after the previous one. Non Essential consumer trip                                                                                                                                                                                                                                                                                                         |
| 2727 | Trip out 4                 | Output activated by the protection in the "Non essential consumer trip" sequence. This is the 4th trip activated [E1894] sec. after the previous one. Non Essential consumer trip                                                                                                                                                                                                                                                                                                         |
| 2728 | Trip out 5                 | Output activated by the protection in the "Non essential consumer trip" sequence. This is the 5th trip activated [E1894] sec. after the previous one. Non Essential consumer trip                                                                                                                                                                                                                                                                                                         |
| 2774 | Trip out direct            | Output activated by the protection in the "Non essential consumer trip" sequence. This one is activated directly. Non Essential consumer trip                                                                                                                                                                                                                                                                                                                                             |
| 2213 | Smoke limiter              | Output to be used if external speed controller has smoke limit input. Will activate an output upon start.                                                                                                                                                                                                                                                                                                                                                                                 |
| 2214 | Warm up                    | This output will activate when engine is warming up. Will activate an output at remote start request from external diesel controller.                                                                                                                                                                                                                                                                                                                                                     |
| 2206 | Horn                       | Can be used for external horn or flashing light relay; output will activate whenever a protection triggers. The output will be activated when a generator electrical fault [E2200], mains electrical fault [E2201], alarm [E2202], fault [E2203] or security [E2204] triggers, and will reset when the LSU 408 horn reset input is activated.<br>Parameter E1991 can be used to select the maximum duration of horn activation (0 means the horn will buzz until being manually stopped). |
| 2215 | Air fans                   | To be wired to fan relay that needs to run when generator is running.                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 2219 | Generator breaker Close    | Can be used to close genset breaker [100 ms pulse]                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 2221 | Generator breaker Open     | Can be used to open genset breaker                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 2220 | Mains breaker Close        | Can be used to close mains breaker.                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

|      |                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|------|------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2222 | Mains breaker Open           | Can be used to open mains breaker.                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 2341 | +f                           | The behaviour will change according to the mode. In Manual mode, if you program the +f function, the output will be on when you activate the LSU 408 configured input for frequency up-/down or voltage up-/.<br>In Auto mode, these functions will control a speed / voltage regulator requiring +/- contacts. You can configure the no action range for the speed [E1598] and for the voltage [E1599], the impulsion delay for the speed [E1600] and for the voltage [E1601]. |
| 2342 | -f                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 2343 | +U                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 2344 | -U                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 2232 | Light test                   | This will activate the output whenever an input programmed for light test is active.                                                                                                                                                                                                                                                                                                                                                                                            |
| 2331 | Generator ready              | Output will be active when start sequence is completed and voltage is present at the generator. In Auto mode, the output will be activated when the engine state is "Gen ready". In Manual mode the output will be activated when the speed [E0033] is positive.                                                                                                                                                                                                                |
| 2240 | Generator stopped            | Output will be active when genset is at rest. In Auto mode, the output will be activated when the engine state is "Waiting". In Manual mode the output will be activated when there is no speed [E0033].                                                                                                                                                                                                                                                                        |
| 2056 | Manu mode                    | Output will be active when LSU 408 is in manual mode.                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 2525 | GE available                 | Will activate when LSU 408 reads gen voltage and is in auto mode - can be used for external logic. The output will be activated when LSU 408 is in Auto mode and the power state [E2071] is not in fault.                                                                                                                                                                                                                                                                       |
| 2767 | Heavy consumer authorization | Output activated when heavy consumer starting is allowed in the "Heavy consumer control" sequence.                                                                                                                                                                                                                                                                                                                                                                              |
| 5000 | Unload brker 1               | Order output to close generator breaker n°1 upon start if the nominal power<E4001                                                                                                                                                                                                                                                                                                                                                                                               |
| 5001 | Unload brker 2               | Order output to close generator breaker n°1 upon start if the nominal power<E4002                                                                                                                                                                                                                                                                                                                                                                                               |
| 5002 | Unload brker 3               | Order output to close generator breaker n°1 upon start if the nominal power<E4003                                                                                                                                                                                                                                                                                                                                                                                               |
| 5003 | Unload brker 4               | Order output to close generator breaker n°1 upon start if the                                                                                                                                                                                                                                                                                                                                                                                                                   |

|      |                             |                                                                                   |
|------|-----------------------------|-----------------------------------------------------------------------------------|
|      |                             | nominal power<E4004                                                               |
| 5004 | Unload brker 5              | Order output to close generator breaker n°1 upon start if the nominal power<E4005 |
| 2320 | Alternator voltage presence | Will activate when the generator is started and generator voltage is OK.          |
| 2883 | GE on load                  | Will activate when generator voltage is OK and GE breaker is closed.              |

## Output Polarity

For each of the five outputs, two options are possible:

- ❖ NE: normally energized; the output will de-energize when required, according to its function.
- ❖ ND: normally de-energized; the output will energize when required.

## Protections

Protections are triggered by different events (digital inputs, and logic sequences). They take action to protect a process, engine or alternator.

When configured, they can take the actions listed hereunder.

### **Disable**

This gives no effect.

### **Generator electrical fault**

This action triggers a “Generator electrical fault”. Protection will open genset breaker and try to synchronize again. Number of attempts can be configured.

### **Mains electrical fault**

This action triggers a “Mains electrical fault”. Protection will open mains breaker and try to synchronize again. Number of attempts can be configured.

### **Alarm**

This action triggers an “Alarm”.

### **Fault (Soft Shut down)**

This action triggers a “Soft shutdown”. Genset breaker will open allowing the engine to cool down sending the stop command to the Diesel control system for the engine.

### **Security (Hard Shutdown)**

This action triggers a “Hard shutdown”. Genset breaker will open and LSU sends the emergency shutdown command to the Diesel control system for the engine.



### **Help + Fault (Soft Shut down)**

This action triggers a “Soft shutdown” with “Help call”. Before the soft shutdown sequence, LSU 408 will call another genset onto load via the LSU CAN bus. When the helping set is connected to the busbar (and not before!) LSU 408 will open the genset breaker, allowing the engine to cool down sending the stop command to the Diesel control system for the engine.

### **Help + Gen. Electrical fault**

This action triggers a “Generator electrical fault” with “Help call”. Breaker(s) to be opened can be configured (genset breaker or mains breaker).

Before opening the corresponding breaker, LSU 408 will call another genset onto load via the LSU 408 CAN bus. When the helping set is connected to the busbar (and not before!) LSU 408 will open the corresponding breaker and try to synchronize again. The number of attempts can be configured.

## Additional functions

### Loadsharing

#### Introduction

This function is for generators in island mode (no mains),

It allows perfect load sharing at the right frequency even if the generators are not the same.

When several generators are on the bus bar, one takes a central role with a fixed frequency of 50Hz. The other generators determine load sharing using an integral so that each one has a perfect share.

The set point of the central frequency is the parameter E1080 (or E1081 if selected).

When the LSU 408 is online with engine running, one genset is elected to be the master (the first one on the bus). The master determines the central frequency and load sharing is without an integral. The other gensets determine the load sharing with an integral, but without using the central frequency.

When you are in state E2071=29 (several generators paralleled with mains), the central frequency is disabled.

#### Procedure

1. In manual mode, using configured input selected for [+] and [-], adjust the speed control output (G9-G11) to obtain the desired frequency +/-2Hz from each genset.
2. Test that load sharing is working properly (default values inhibit the integral).
3. Activation of central frequency with genset 1:
  1. Choose menu: Configuration/modification by variable number, and set E1476 to 2.  
Choose menu: Configuration/Active power regulation:
    - kW sharing GPI
    - G = 50 %( E1102)
    - P = 5 %( E1900)
    - I = 2 %(E1901)
    - Central Hz gain
    - G = 25% (E1902)

4. Adjust genset speed to give 49Hz using the speed governor (LSU 408 in manual mode without load).
  5. Switch to TEST mode setting the configured input high . When the breaker is closed frequency should return to 50.00Hz within 5 seconds. Adjust the Hz central gain (E1902) to adjust the time if needed.
  6. Repeat step 5 for all gensets.
  7. Test the load sharing by changing the nominal frequency of one generator to 49Hz.
- ⇒ Bus frequency should remain at 50 Hz and kW load sharing within 2% of that desired. The stability of load sharing is adjusted with kW sharing GPI / I (E1901)

## Remarks:

- ❖ E1902 = stability of de-drooping (only activated in the master LSU 408). Adjust to recover 1Hz within 5 sec.
- ❖ E1476 = 0 ⇔ Inhibition of central frequency.
- ❖ E1476 = with a high value, response time will be slower (recommended default value =2)
- ❖ E1901 = Load sharing integral, is only active on the slave LSU 408 units.
- ❖ E1102 = Global gain of load sharing is obtained by multiplying the PI and the central Hz gain.
- ❖ E2739 = 1 ⇔ I am the master (I control the frequency).
- ❖ E2739 = 0 ⇔ I am a slave (I share load using the integral)

## Loadsharing suppression

COM1 CAN bus is mainly used by LSU 408 modules to send power management data to each other's. CAN bus inhibition is used to prevent one LSU 408 from taking into account data coming from one or more specific LSU 408 units. This is especially useful when tie breakers are used to change the configuration of the power plant (for example from a 6 generator power plant to two power plants with 3 generators each).

Ask for more detailed applications.

## ILS synchronization & mains paralleling

When using the central frequency (de-drooping) function and paralleling with the mains using an analogue bus (ILS), the central frequency has to be inhibited during synchronization. The following equations should be added in if the synchronization bus is used:

```
@ *****;
@ digital input 1(E2006) is closed during mains synchronization ;
@ mains breaker feedback is connected to terminal J1 ;
@ Don't forget to allow parameter E1476 and E1020 to be ;
@ modifiable by modbus and equations ;
@ *****;
TEST (E2006 EQ 1) AND (E2000 EQ 0) EQ 1 THEN
    BLOC
        E1476:=0;
        E1020:=20000
    BEND
ELSE
    BLOC
        E1476:=2;
        E1020:=0
    BEND
TEND;
```

## Integral inhibition

To disable this type of load sharing and return to the old type, apply the “Disable value” from the table below.

The variables involved in the new type of load sharing are:

| Variable number | Label          | Description                                                                | Default value | Disable value |
|-----------------|----------------|----------------------------------------------------------------------------|---------------|---------------|
| V1102           | Load sharing G | Parameter to set the Global gain.                                          | 50            | 50            |
| V1900           | Load sharing P | Parameter to set the Proportional gain.                                    | 5             | 1             |
| V1901           | Load sharing I | Parameter to set the Integral gain.                                        | 2             | 0             |
| V1902           | Hz centre gain | Parameter to control the central frequency, acting as a frequency standard | 25            | 0             |
| V1476           | XXXXXX         |                                                                            | 2             | 0             |



*Warning:*

*When the CAN bus is not used, you have to disable load sharing (see table above).*

*In the case of a CAN bus failure where E1259 is not set at 6 (load sharing in droop disabled), you also have to disable load sharing.*

## Operator controlled return to mains

### Explanation

Normal operation: In the case of mains failure, the engine starts (LSU sends start request to engine dieselcontroller) and takes the load. When the mains voltage returns, the engine resynchronizes with the mains and automatically gives back the load.

The “Operator controlled return to mains” special function (set with the parameter E1620 = 1) allows the operator to control the moment the engine will return the load to the mains.

The LSU 408 waits for E2584 = 1 (Virtual input 40) before re-synchronizing the engine to the mains.

### How to set this function

The E1620 variable must be set to 1.

The Virtual Input 40 must be set as “used by equations” (E1699=1)

This virtual input can be associated to:

- ❖ a digital input: Ex: E2584= E2006;
- ❖ a CANopen deported digital input: Ex: E2584= E0158;
- ❖ an equation result: E2584= (E2440 GT 1000) AND (E2006 EQ 1)

### Summary

E1620 = 1.

E2584 = Virtual Input 40 to allow the genset to return the load to the mains.

E1699 = 1: (E2584 (VI 40) is "used by equations")

### Parameters used

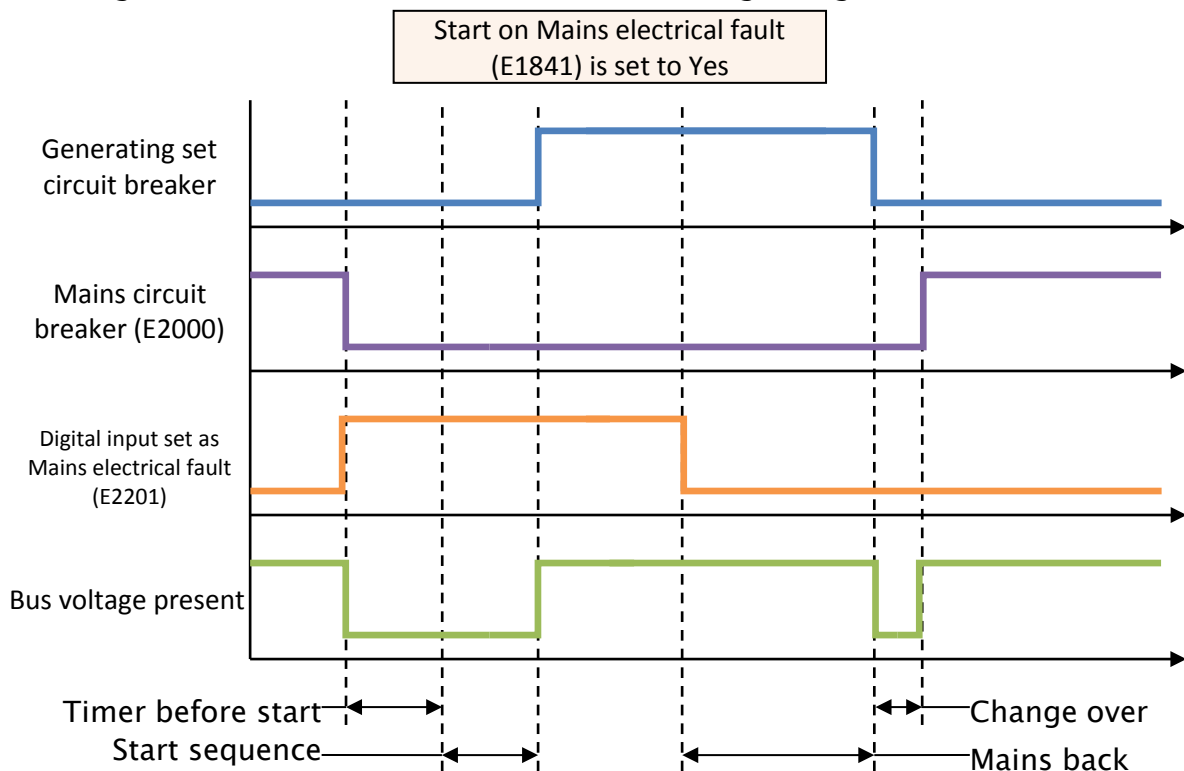
| <b>E1620</b> | <b>Inhibition of Variable 13= Operator return to Mains ( + E2584)</b> |
|--------------|-----------------------------------------------------------------------|
| E2584        | Virtual input Spare 40                                                |
| E1699        | Virtual Input 40 associated function.                                 |

## Mains & Generator electrical fault options

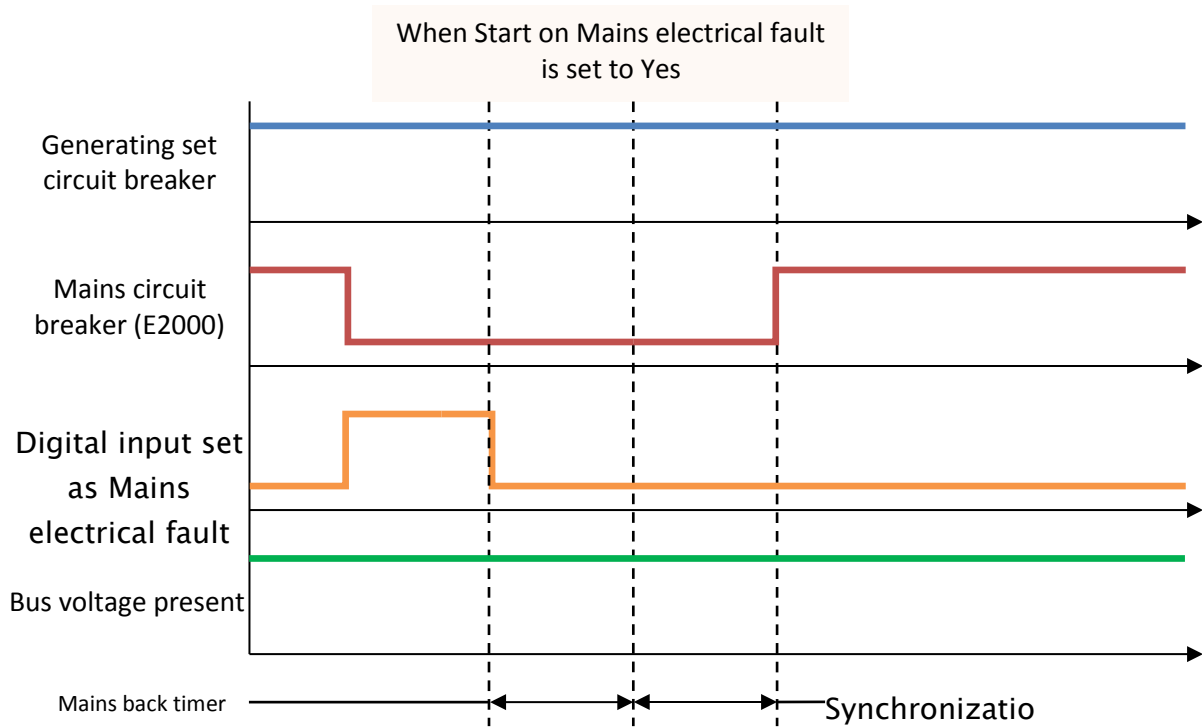
Mains electrical fault management dedicated parameters are shown in the table below:

| Parameter | Default value | Description                                                                                                                                              |
|-----------|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| E1841     | Yes           | Indicates if the generating set should be started on Mains electrical fault appearance.                                                                  |
| E1846     | Mains         | Indicates which circuit breaker should be opened on Mains electrical fault appearance. Choose between Mains, Generating set or Both.                     |
| E1840     | 0.0s          | Delay before start sequence begins on Mains electrical fault appearance.                                                                                 |
| E1842     | 60.0s         | No load delay. Indicates the time to let the engine run without load when generating set circuit breaker is opened. If set to 0, engine will never stop. |

Chronogram below shows the behaviour when using change over mode:



Chronogram below shows the behaviour when using Mains permanent paralleling mode:



**NOTE:**



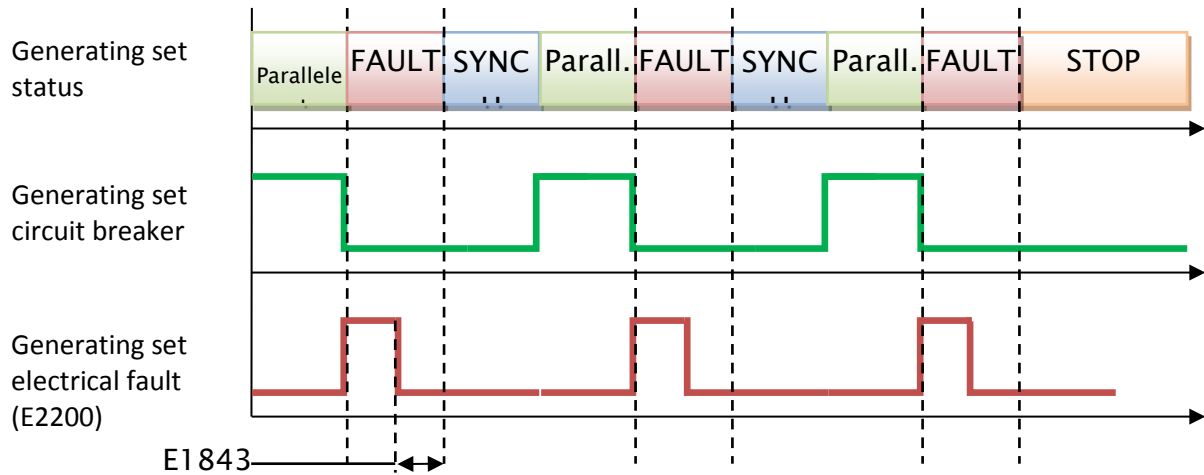
Never use "No start on fault" in conjunction with "open mains on fault" in permanent mode or no break change over mode.

Always use "No start on fault" when "generator breaker" or "both breakers" to open is selected.

## Generator electrical fault

In case of a generator electrical fault, the generator breaker is opened and the alternator is de-excited (if wired) during a certain time (parameter E1265). If the fault is still present after this time has elapsed, a hard shutdown occurs. Otherwise LSU 408 will try to re-synchronize. Associated parameters are listed in the table below.

| Parameter | Default value | Description                                                                              |
|-----------|---------------|------------------------------------------------------------------------------------------|
| E1843     | 30.0s         | Time to wait after a generator electrical fault disappears before trying to synchronize. |
| E1844     | 2             | Attempts to re-synchronize when a generator electrical fault appears and disappears.     |



## LSU 408 and the external diesel controller module

### Overview

This chapter describes how to interface the LSU 408 with an engine and its automatic start module (Diesel Controller DCU 410-/210). The following diagram shows the main functions of each device and how it is to be wired:



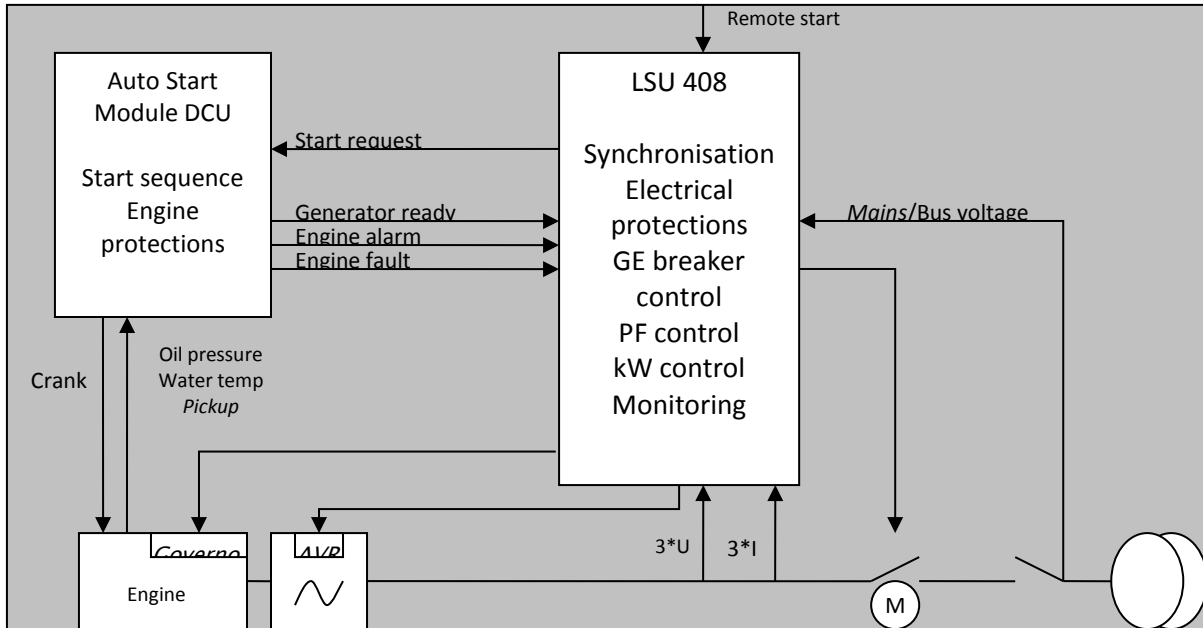
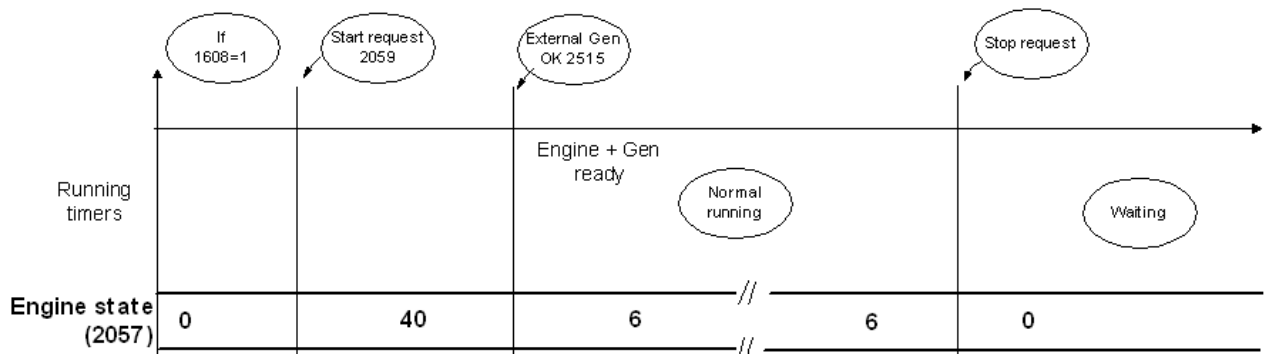


Figure 5 - Wiring LSU 408 ↔ Auto Start Module

| Signal description | Direction    | Auto Start Module (ASM) | LSU 408   |
|--------------------|--------------|-------------------------|-----------|
| Start request      | LSU 408->ASM | Remote start input      | C5        |
| Genset ready (opt) | ASM->LSU 408 | Digital output          | LSU Input |
| Engine Alarm       | ASM->LSU 408 | Digital output          | LSU Input |
| Engine Fault       | ASM->LSU 408 | Digital output          | LSU Input |



### Automatic load / unload

This function automatically controls the start and stopping of several generators of a power plant depending on the load request, whether paralleling with the mains or not. Coordination with the other LSU 408 units is via the CAN bus (COM1).

Required configuration to allow automatic load / unload:

- ❖ All the remote start inputs must be on, on each LSU 408 (connected to 0V).
- ❖ At least 2 generators must have LSU 408 units.
- ❖ If remote start is off, the generator never starts.

A generator can run in "Forced running" mode using a digital input. Select a digital input with the function "Priority generator". Activate this input. This sends the start request to diesel controller and generator starts, synchronizes, closes its breaker and stays on the bus bar until "Remote start/stop" is de-activated.

If there are no generators in "Forced running" mode, the priority generator with "remote start" always starts and closes its breaker on the bus bar, even if there is no load.

When all generators are stopped and have "remote start" activated, upon start-up the "Forced running" generators stay on the bus bar while the others coordinate stopping one by one.

How to determine the priority generator (which starts/stops) by using the variable "Load/Unl. mode" (E1258):

**Load/Unload mode [E1258]** can be:

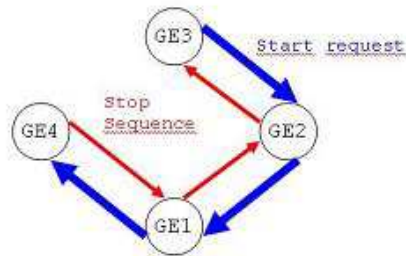
**Inhibited:** [0]; the different LSU 408 units installed on the power plant do not interact to start or stop gensets according to the load demand.

**Digital Input:** [1]; if selected on all the LSU 408 units installed on the power plant, the automatic start/stop sequence will be done by the genset number, which is defined in the power plant overview. If a digital or virtual digital input of one LSU 408 is set as priority generator, this LSU 408 will start first. The next to start will be decided by increasing genset number, which is defined in the power plant overview settings menu. (E.g. if genset 2 has priority, then genset 3 will be the next to be started upon increasing load, then genset 4; by decreasing load demand, genset 4 will be stopped first, then genset 3...).

**Hours run:** [2] the genset to start/stop will automatically be selected according to the LSU 408 hour meter. On increasing load demand, the next genset to be started is the one with fewest hours run; on decreasing load demand, the next genset to be stopped is the one with highest hours run.

**Custom E16:** [3] the genset start/stop sequence will follow the priority number set in each LSU 408 in the variable [E1617].

| GE Numbre | E1617 | Start/stop mode |
|-----------|-------|-----------------|
| 1         | 3     | CUSTOM E16      |
| 2         | 2     | CUSTOM E16      |
| 3         | 1     | CUSTOM E16      |
| 4         | 4     | CUSTOM E16      |



**Load threshold [E1256]:** Percentage of the genset nominal power (defined in the [power plant overview](#) settings menu) at which LSU 408 will ask another genset to start and share the load after the following timer.

**TM before load [E1257]:** Timer for load sharing request.

**Unload dep stp. [E1914]:** Used to select the "unload dependant stop" sequence.

LSU 408 calculates the power that will remain on the bus bar (in % for each engine remaining) if it decides to stop (and open its breaker). If this percentage is under the required threshold (E1915), then LSU 408 will stop. If not it will wait until threshold is reached.

**Unload thresh. [E1254]:** Only used if E1914 is set as NO: load dependent stop not used. It is the percentage of the genset nominal power (defined in the [power plant overview](#) settings menu) at which LSU 408 will ask a genset to stop sharing the load after the following timer.

**Unload dp. thrs [E1915]:** Only used if the E1914 is set as YES: load dependent is used. LSU 408 calculates the power that will remain on the bus bar if it decides to stop. This is the threshold below which LSU 408 decides to stop. It is a percentage of the genset nominal power (defined in the [power plant overview](#)).

**TM bef. unload [E1255]:** Timer used before deciding to reduce the number of gensets in load/unload management.

*Note:*

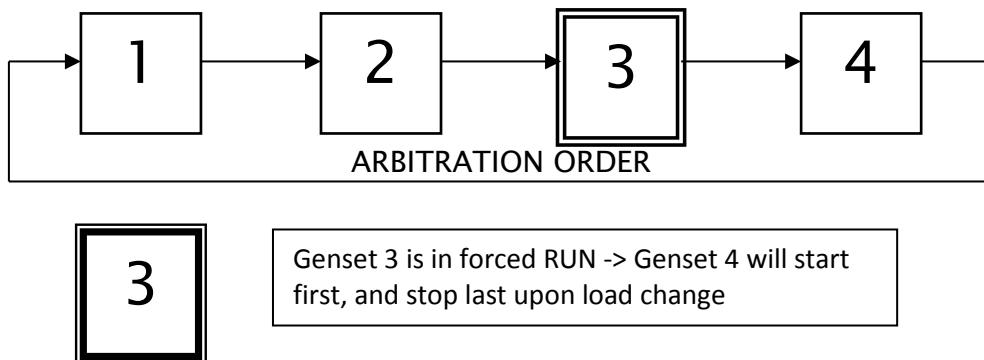
*To force the start of a generator in load / unload mode, during commissioning for example, remote start and digital input (in "Priority generator" mode) must be activated.*

In "Hour run" mode, if a generator starts and goes past the hours run by a generator which is stopped, the first one does not immediately stop and the second one immediately start. Coordination between generators is activated only during a load or unload request, i.e. in the next start/stop on load request.

During a load request, only the stopped and available generators coordinate (auto mode selected; no hard fault).

During an unload request, only the started generators coordinate.

LSU 408 units in manual mode do not take part in start or load sequence.



This function is used in Marine applications.

Certain external parameters must be analysed by the LSU 408 units before accepting heavy consumer load.

- ❖ If Power Plant can accept load, each LSU 408 accepts load.
- ❖ If Power Plant cannot accept load, another engine is started.
- ❖ Analysis of available kW, number of generators on Busbar, or both.
- ❖ One input for each LSU 408 is used to start analysis of power available on plant.
- ❖ One output for each LSU 408 is used to accept heavy Consumer request.
- ❖

## Menu Settings

**Heavy consumer [E1911]:** Power necessary for the heavy consumer.

**Min number of genset [E1912]:** Minimum number of engines in case of heavy consumer request.

**CT Heavy [E1913]:** You can choose between:

- ❖ Disable [0]: Heavy consumer function is not used (default).
- ❖ KWatt [1]: LSU 408 analyses acceptable load on the Power

plant. Engines start request if necessary

- ❖ Min Number [2]: Minimum number of Engines necessary on the power plant for heavy consumer.
- ❖ KWatt & Min number [3]: Analysis of both the power available and minimum number necessary.

Examples that use Heavy Consumer Control: Using of a crane in a harbour, manoeuvring a ship in/out of harbour using bow thrusters, etc .....

## Non-essential consumer trip (marine sequence)

### Introduction

This function is used in Marine applications.

If the generator reaches the overload or under frequency threshold (following timers), LSU 408 triggers outputs to trip non-essential loads.

### Procedure

To set the different thresholds and timers, go to the "Enhanced Configuration/Special functions Non essential consumer trip" menu.

## PLC programming

### Introduction

The CORE system of the LSU 408 is based on a list of predefined variables.

These variables can be used in a proprietary programming language. This language uses simple keywords in an ASCII text file. This text file is downloaded from LSU 408. It is stored as a binary program for use with flash memory. A copy of the source file is also stored on LSU 408 for documentation and readability purposes. This copy can be retrieved at any time to be modified or transferred to another LSU 408.

These equations can be used to add a logic equation and/or conditional function if your application requires non-standard functions. It is also possible to change the predefined behaviour with custom applications.

The PLC provided has a loop time of 100ms, and a special code can be defined to run the first time only (INIT). This chapter provides all resources for PLC programming.

A text file can be transferred to or from the LSU 408 to set or retrieve the whole setup of the LSU 408.

The text file allows you to:

- ❖ Set the value of every parameter.
- ❖ Change the accuracy when displaying analogue values (example: 24V or 24.0V).
- ❖ Change the labels of some custom inputs.
- ❖ Transfer custom equations to the embedded PLC.

### Variable naming

The file named “LSU 408 Variabels.xls” gives an explanation of each variable.

The variable number always uses the same format, the letter “E” followed by 4 digits: EXYYY

The first digit, “X”, is the type of variable:

0 and 5: Measurement or real time value (Ex: Voltage phase 1, CAN Bus Fault ...)

1 and 4: Parameter to be stored in non-volatile memory (Ex: Genset number, Nominal power ...)

2 and 3: General purpose variable (Ex: Alarms, PLC variables ...)

The next 3 digits "YYY" give the number of the variable.

All the parameters (Variable from 1000 to 1999 and from 4000 to 4999) of the LSU 408 are stored in a non-volatile FLASH memory within the module. It is possible to download or upload these parameters with a computer, thus allowing the user to save, modify and reuse these parameters later.

All these values are stored in a text file. The following chapter describes the layout of the file.

The file can be exchanged between a PC and LSU 408.

## Text file description

The text file is made up of 5 parts:

- ❖ Parameter definitions
- ❖ Label definitions
- ❖ Unit definitions
- ❖ Custom PLC Initialization definitions
- ❖ Custom PLC Equation definitions

## Parameter definition block

The starting point of this block is designated by a "{PARAMETERS}" statement.

Each parameter (1xxx or 4xxx variable) can be found as an input in this block. The structure of the input is as follows:

The variable parameter number presented by the letter V (Ex: V1006)

The value

(Ex: 320)

R/W attribute (for MODBUS and PLC equations) (Ex: Y)

The label (only for clarification) (Ex: Gen Nominal kW)

The minimal value (only for clarification) (Ex:  
+00000)

The maximal value (only for clarification) (Ex:  
+65535)

Example:

```
{PARAMETERS}
V1006 320 Y Gen nominal kW +00000 +65535
V1007 1.00 N Gen PT ratio +00000 +65535
```

In the example above, Genset nominal power is set to 320kW. The *Y* attribute shows that this value can be changed by MODBUS or custom PLC equations (for de-rating purposes for example) whereas the *N* attribute in the second line sets Generator PT ratio as "read only" for MODBUS and PLC equations.

It is possible to modify the values directly in the text file before uploading it into the LSU 408. The user must be sure that the modified value is within the minimum / maximum range. Failure to do so will lead to an error message during uploading (*Compilation result: VARIABLE*).

It is also possible to write an incomplete parameter block (not all parameters are displayed in the list). When uploaded, such a file will only modify the parameters which have been entered, the others remain unchanged. This procedure can be used to upload an old text file into a newer LSU 408 or to activate special features independently.

## Label definition block

The beginning of this block is shown by a "{LABELS}" statement.

This block is used to define custom labels.

Only the digital inputs, the virtual digital inputs, the maintenance cycle, can have an input in this block. The table below shows the correspondence between the LABEL number and its associated value:

|                 |             |               |
|-----------------|-------------|---------------|
| Analogue inputs | Cycle label | Virtual input |
|-----------------|-------------|---------------|



|                    |                   |       |             |       |               |       |               |
|--------------------|-------------------|-------|-------------|-------|---------------|-------|---------------|
| L0029              | AI spare. future  | L1442 | Cycle 1 (h) | L2283 | Virtual in 1  | L2565 | Virtual in 21 |
| L0030              | AI spare. future  | L1443 | Cycle 2 (h) | L2284 | Virtual in 2  | L2566 | Virtual in 22 |
| L0031              | AI spare 1 future | L1444 | Cycle 3 (h) | L2285 | Virtual in 3  | L2567 | Virtual in 23 |
| L0032              | AI spare 2 future | L1445 | Cycle 4 (h) | L2286 | Virtual in 4  | L2568 | Virtual in 24 |
| <b>Spare input</b> |                   | L1446 | Cycle 5 (h) | L2287 | Virtual in 5  | L2569 | Virtual in 25 |
|                    |                   | L1447 | Cycle 1 (d) | L2288 | Virtual in 6  | L2570 | Virtual in 26 |
| L2657              | User meter 1      | L1448 | Cycle 2 (d) | L2289 | Virtual in 7  | L2571 | Virtual in 27 |
| L2659              | User meter 2      | L1449 | Cycle 3 (d) | L2290 | Virtual in 8  | L2572 | Virtual in 28 |
| L2804              | Spare Input J4    | L1450 | Cycle 4 (d) | L2291 | Virtual in 9  | L2573 | Virtual in 29 |
| L2805              | Spare Input J5    | L1451 | Cycle 5 (d) | L2292 | Virtual in 10 | L2574 | Virtual in 30 |
| L2806              | Spare Input J6    |       |             | L2293 | Virtual in 11 | L2575 | Virtual in 31 |
| L2807              | Spare Input J7    |       |             | L2294 | Virtual in 12 | L2576 | Virtual in 32 |
| L2808              | Spare Input J8    |       |             | L2295 | Virtual in 13 | L2577 | Virtual in 33 |
| L2809              | Spare Input J9    |       |             | L2296 | Virtual in 14 | L2578 | Virtual in 34 |
| L2810              | Spare InputJ10    |       |             | L2297 | Virtual in 15 | L2579 | Virtual in 35 |
| L2811              | Spare InputJ11    |       |             | L2298 | Virtual in 16 | L2580 | Virtual in 36 |
| L2812              | Spare InputJ12    |       |             | L2299 | Virtual in 17 | L2581 | Virtual in 37 |
| L2813              | Spare InputJ13    |       |             | L2300 | Virtual in 18 | L2582 | Virtual in 38 |
| L2814              | Spare InputJ14    |       |             | L2301 | Virtual in 19 | L2583 | Virtual in 39 |
| L2815              | Spare InputJ15    |       |             | L2302 | Virtual in 20 | L2584 | Virtual in 40 |
|                    |                   |       |             |       |               |       |               |

Table 5- Label definition bloc

Each line of this block contains 2 elements:

- ❖ The variable number of the text, preceded by the letter L for label, and T for page logo.

Ex: L1130

- ❖ The text itself.

### Units and accuracy definition block

The beginning of this block is shown by a "{UNITS}" statement.

This block defines what kind of units and accuracy will be associated with each analogue value input (LSU 408 analogue inputs, virtual inputs, and CANopen analogue inputs).

You only need to define the unit of the analogue input itself. All associated parameters (thresholds for instance) will automatically be modified in accordance. This includes native analogue inputs, extension CANopen analogue inputs, and virtual inputs.

The table below lists the different units supported by LSU 408.

Only the 4 analogue inputs have an entry in this bloc.

The structure of a unit/accuracy definition consists of the variable number preceded by a letter (U for Unit, A for Accuracy definition) and followed by a code as shown in the examples below.

The input is as follows:

```
{UNITS}
U0029 01
U2584 00
A0029 0000032768
```

| Code       | Unit | Code           | Unit  | Code        | Unit | Code   | Unit            | Code         | Unit              |
|------------|------|----------------|-------|-------------|------|--------|-----------------|--------------|-------------------|
| Electrical |      | Power          |       | Pressure    |      | Volume |                 | Time         |                   |
| 00         | “ ”  | 07             | kW    | 13          | Bar  | 20     | L               | 24           | S                 |
| 01         | V    | 08             | kWh   | 14          | mBar | 21     | m <sup>3</sup>  | 25           | H                 |
| 02         | kV   | 09             | kVAR  | 15          | kPa  | 22     | mm <sup>3</sup> | 26           | Days              |
| 03         | mA   | 10             | kVARh | 16          | PSI  | 23     | Gal             | Time related |                   |
| 04         | A    | Rotating speed |       | Temperature |      |        |                 | 27           | Hz/s              |
| 05         | kA   | 11             | rpm   | 17          | °    |        |                 | 28           | m <sup>3</sup> /h |
| Frequency  |      | Percent        |       | 18          | °C   |        |                 | 29           | L/h               |
| 06         | Hz   | 12             | %     | 19          | °F   |        |                 | 30           | Gal/h             |

The tables below give you the list of codes which correspond to the supported units and accuracies. In the examples above, input E2584 has no specific unit while input E0029 will be displayed in Volts (Unit code 01) and with 2 decimal digits (Accuracy code 32768).

| Code Variable number                          | Default unit code | Default accuracy code | Description                               | Label        |
|-----------------------------------------------|-------------------|-----------------------|-------------------------------------------|--------------|
| <b>Native analogue inputs</b>                 |                   |                       |                                           |              |
| 0029                                          | 14                | 00000                 | Analogue measure (0- 400Ohm)              | AI           |
| 0030                                          | 18                | 00000                 | Analogue measure (0-400Ohm)               | AI.          |
| 0031                                          | 00                | 00000                 | Analogue measure of analogue 1 (0-10kOhm) | AI spare 1   |
| 0032                                          | 00                | 00000                 | Analogue measure of analogue 2 (0-10kOhm) | AI spare 2   |
| <b>Analogue inputs for CANopen extensions</b> |                   |                       |                                           |              |
| 0285                                          | 00                | 16384                 | analogue input 1                          | Analog in 01 |
| 0286                                          | 00                | 16384                 | analogue input 2                          | Analog in 02 |
| 0287                                          | 00                | 16384                 | analogue input 3                          | Analog in 03 |
| 0288                                          | 00                | 16384                 | analogue input 4                          | Analog in 04 |
| 0289                                          | 00                | 16384                 | analogue input 5                          | Analog in 05 |
| 0290                                          | 00                | 16384                 | analogue input 6                          | Analog in 06 |
| 0291                                          | 00                | 16384                 | analogue input 7                          | Analog in 07 |
| 0292                                          | 00                | 16384                 | analogue input 8                          | Analog in 08 |
| 0293                                          | 00                | 16384                 | analogue input 9                          | Analog in 09 |
| 0294                                          | 00                | 16384                 | analogue input 10                         | Analog in 10 |
| 0295                                          | 00                | 16384                 | analogue input 11                         | Analog in 11 |
| 0296                                          | 00                | 16384                 | analogue input 12                         | Analog in 12 |
| 0297                                          | 00                | 16384                 | analogue input 13                         | Analog in 13 |
| 0298                                          | 00                | 16384                 | analogue input 14                         | Analog in 14 |
| 0299                                          | 00                | 16384                 | analogue input 15                         | Analog in 15 |
| 0300                                          | 00                | 16384                 | analogue input 16                         | Analog in 16 |

|                                     |    |       |                       |               |
|-------------------------------------|----|-------|-----------------------|---------------|
| 0301                                | 00 | 16384 | analogue input 17     | Analog in 17  |
| 0302                                | 00 | 16384 | analogue input 18     | Analog in 18  |
| 0303                                | 00 | 16384 | analogue input 19     | Analog in 19  |
| 0304                                | 00 | 16384 | analogue input 20     | Analog in 20  |
| 0305                                | 00 | 16384 | analogue input 21     | Analog in 21  |
| 0306                                | 00 | 16384 | analogue input 22     | Analog in 22  |
| 0307                                | 00 | 16384 | analogue input 23     | Analog in 23  |
| 0308                                | 00 | 16384 | analogue input 24     | Analog in 24  |
| 0309                                | 00 | 16384 | analogue input 25     | Analog in 25  |
| 0310                                | 00 | 16384 | analogue input 26     | Analog in 26  |
| 0311                                | 00 | 16384 | analogue input 27     | Analog in 27  |
| 0312                                | 00 | 16384 | analogue input 28     | Analog in 28  |
| 0313                                | 00 | 16384 | analogue input 29     | Analog in 29  |
| 0314                                | 00 | 16384 | analogue input 30     | Analog in 30  |
| 0315                                | 00 | 16384 | analogue input 31     | Analog in 31  |
| 0316                                | 00 | 16384 | analogue input 32     | Analog in 32  |
| 0317                                | 00 | 16384 | analogue input 33     | Analog in 33  |
| 0318                                | 00 | 16384 | analogue input 34     | Analog in 34  |
| 0319                                | 00 | 16384 | analogue input 35     | Analog in 35  |
| 0320                                | 00 | 16384 | analogue input 36     | Analog in 36  |
| 0321                                | 00 | 16384 | analogue input 37     | Analog in 37  |
| 0322                                | 00 | 16384 | analogue input 38     | Analog in 38  |
| 0323                                | 00 | 16384 | analogue input 39     | Analog in 39  |
| 0324                                | 00 | 16384 | analogue input 40     | Analog in 40  |
| 0325                                | 00 | 16384 | analogue input 41     | Analog in 41  |
| 0326                                | 00 | 16384 | analogue input 42     | Analog in 42  |
| 0327                                | 00 | 16384 | analogue input 43     | Analog in 43  |
| 0328                                | 00 | 16384 | analogue input 44     | Analog in 44  |
| <b>Virtual inputs (first block)</b> |    |       |                       |               |
| 2283                                | 00 | 00000 | Virtual input Spare 1 | Virtual in 01 |
| 2284                                | 00 | 00000 | Virtual input Spare 2 | Virtual in 02 |
| 2285                                | 00 | 00000 | Virtual input Spare 3 | Virtual in 03 |
| 2286                                | 00 | 00000 | Virtual input Spare 4 | Virtual in 04 |
| 2287                                | 00 | 00000 | Virtual input Spare 5 | Virtual in 05 |
| 2288                                | 00 | 00000 | Virtual input Spare 6 | Virtual in 06 |

|                                      |    |       |                        |               |
|--------------------------------------|----|-------|------------------------|---------------|
| 2289                                 | 00 | 00000 | Virtual input Spare 7  | Virtual in 07 |
| 2290                                 | 00 | 00000 | Virtual input Spare 8  | Virtual in 08 |
| 2291                                 | 00 | 00000 | Virtual input Spare 9  | Virtual in 09 |
| 2292                                 | 00 | 00000 | Virtual input Spare 10 | Virtual in 10 |
| 2293                                 | 00 | 00000 | Virtual input Spare 11 | Virtual in 11 |
| 2294                                 | 00 | 00000 | Virtual input Spare 12 | Virtual in 12 |
| 2295                                 | 00 | 00000 | Virtual input Spare 13 | Virtual in 13 |
| 2296                                 | 00 | 00000 | Virtual input Spare 14 | Virtual in 14 |
| 2297                                 | 00 | 00000 | Virtual input Spare 15 | Virtual in 15 |
| 2298                                 | 00 | 00000 | Virtual input Spare 16 | Virtual in 16 |
| 2299                                 | 00 | 00000 | Virtual input Spare 17 | Virtual in 17 |
| 2300                                 | 00 | 00000 | Virtual input Spare 18 | Virtual in 18 |
| 2301                                 | 00 | 00000 | Virtual input Spare 19 | Virtual in 19 |
| 2302                                 | 00 | 00000 | Virtual input Spare 20 | Virtual in 20 |
| <b>Virtual inputs (second block)</b> |    |       |                        |               |
| 2565                                 | 00 | 00000 | Virtual input Spare 21 | Virtual in 21 |
| 2566                                 | 00 | 00000 | Virtual input Spare 22 | Virtual in 22 |
| 2567                                 | 00 | 00000 | Virtual input Spare 23 | Virtual in 23 |
| 2568                                 | 00 | 00000 | Virtual input Spare 24 | Virtual in 24 |
| 2569                                 | 00 | 00000 | Virtual input Spare 25 | Virtual in 25 |
| 2570                                 | 00 | 00000 | Virtual input Spare 26 | Virtual in 26 |
| 2571                                 | 00 | 00000 | Virtual input Spare 27 | Virtual in 27 |
| 2572                                 | 00 | 00000 | Virtual input Spare 28 | Virtual in 28 |
| 2573                                 | 00 | 00000 | Virtual input Spare 29 | Virtual in 29 |
| 2574                                 | 00 | 00000 | Virtual input Spare 30 | Virtual in 30 |
| 2575                                 | 00 | 00000 | Virtual input Spare 31 | Virtual in 31 |
| 2576                                 | 00 | 00000 | Virtual input Spare 32 | Virtual in 32 |
| 2577                                 | 00 | 00000 | Virtual input Spare 33 | Virtual in 33 |
| 2578                                 | 00 | 00000 | Virtual input Spare 34 | Virtual in 34 |
| 2579                                 | 00 | 00000 | Virtual input Spare 35 | Virtual in 35 |
| 2580                                 | 00 | 00000 | Virtual input Spare 36 | Virtual in 36 |
| 2581                                 | 00 | 00000 | Virtual input Spare 37 | Virtual in 37 |
| 2582                                 | 00 | 00000 | Virtual input Spare 38 | Virtual in 38 |
| 2583                                 | 00 | 00000 | Virtual input Spare 39 | Virtual in 39 |
| 2584                                 | 00 | 00000 | Virtual input Spare 40 | Virtual in 40 |

## Initialization definition blocks

The beginning of these blocks is shown by the statements "{INIT1}" or "{INIT2}" depending on the level of access (1st or 2nd level password).

A user connected in level 0 (no password) cannot read equations from, or transfer equations to, the LSU 408.

A user connected in level 2 will get access to INIT1 and INIT2 blocks.

A user connected in level 1 will only get access to the INIT1 block.

INIT equations are only run by the PLC when the power supply of the module is turned ON. They won't be run again until power supply is turned OFF and then ON again. The purpose of these blocks is to provide custom equations to the user. They are run during the power up stage.

INIT blocks are typically used to set the initialization values of outputs, timers or counters associated to custom equations or custom parameters.

For further details on the programming language see chapter "PLC programming language".

## Equation definition blocks

The beginning of these blocks is shown by the statements "{EQUATIONS L1}", "{EQUATIONS L2}", depending on the level of access (1st level password or 2nd level password).

A user connected in level 0 (no password) cannot read equations from or transfer equations to the LSU 408.

A user connected in level 2 will get access to *EQUATIONS L1* and *EQUATIONS L2* blocks.

A user connected in level 1 will only get access to *EQUATIONS L1* block.

The purpose of these blocks is to provide custom equations to the user which is run cyclically. These equations are run every 100ms (PLC cycle time).

Non-standard equations can be entered here to handle user defined features like thresholds, Input/Output expansions, PID controls ...

## End of file

Every text file must end with the "{END OF FILE}" statement.

LSU 408 will not try to read data following that statement, so you can place your own comments here.

*Note: it is strongly recommended not to add too many comments after the "End of File" statement because the size of the file must not exceed 126Kbytes.*

*Note: this is a text ONLY file. Do not use word processors (like Microsoft® Word) to edit this file: it would include layout information and corrupt the file. Use text editors only (Notepad for example).*

*The file should not exceed 126kbytes. If you try to transmit a bigger file to a LSU 408, it will be rejected.*



*Warning:*

*Power control and protections are disabled while the LSU 408 is processing a file. When you download or upload a file, you have to disconnect all connectors, except power supply. You must be in manual mode, with engine stopped.*

## PLC programming language

It is strongly advised that you follow training before using custom PLC equations on a power plant. Contact your local dealer for details on training sessions.

The PLC equations use a simple language with a small number of commands. The code is intrinsically linear, each equation being executed one after the other (without any loop). Level 1 equation is executed first, followed by level 2 equations. This way, level 2 equation results can overwrite any conflicting level 1 equation.

The "INIT" part is only executed upon start-up, and the "PROG" part is executed every 100 ms.

All the LSU 408 variables can be used in the equations in the way defined below:

- E0xxx and E5xxx are read only as measurements/inputs. They can't be changed by equations.
- E1xxx and E4xxx parameters can be read by equations. If allowed, they can also be modified using MODBUS or equations downloaded via the text file (see {PARAMETERS} section of the text file chapter).
- E2xxx parameters are PLC outputs. They can be read and written by custom equations.

*Note:*

*-Variables E1xxx/E4xxx is parameters stored in FLASH (non-volatile memory). In level 2 and above, the user can allow the parameters to be written by PLC equations or via MODBUS.*

*-Be very careful when modifying a parameter through equations, as unexpected behaviour (due to an error in your equations for example) may damage your generator.*

-It is advisable to include tests in the equations to verify that the engine is stopped prior to changing a parameter. Otherwise, make modifications in the "INIT" block if possible. These parameter modifications will not be saved in FLASH memory, i.e. parameters will be reset to their previous value if power supply is turned OFF and then ON again, unless the user saves them manually.

-Use document "LSU 408 variables.xls" to get a complete list of all LSU 408 variables.

-Variables E2xxx/E5xxx are outputs from the PLC, they can be read and written by PLC equations without restrictions.

The table below gives a list of all available instructions that can be used in custom PLC equations:

| Instruction family     | PLC instruction                   | Definition                                                                           |
|------------------------|-----------------------------------|--------------------------------------------------------------------------------------|
| Program                | PROG                              | Starting point of PLC equations                                                      |
|                        | INIT                              | Starting point of INIT equations                                                     |
|                        | .                                 | End of equations                                                                     |
| Blocs                  | BLOC                              | Starting and ending points of a block of equations                                   |
|                        | BEND                              |                                                                                      |
| Logical operators      | AND<br>OR<br>XOR                  | Logical operation used on a whole variable (i.e. these are not bit to bit operators) |
| Unary operators        | !                                 | Bit to bit complement                                                                |
|                        | -                                 | Sign change                                                                          |
|                        | >                                 | Right shift                                                                          |
|                        | <                                 | Left shift                                                                           |
|                        | \$                                | Hexadecimal value                                                                    |
| Arithmetical operators | +                                 | Addition                                                                             |
|                        | -                                 | Subtraction                                                                          |
|                        | *                                 | Multiplication                                                                       |
|                        | /                                 | Division                                                                             |
|                        | INC                               | Increment                                                                            |
|                        | DEC                               | Decrement                                                                            |
| Bit operators          | ^                                 | Rotation right                                                                       |
|                        |                                   | Access one bit                                                                       |
|                        | #                                 | Bits mask                                                                            |
| Affectation            | :=                                | Affectation                                                                          |
| Comparison operators   | EQ                                | Equal                                                                                |
|                        | NE                                | Not Equal                                                                            |
|                        | GT                                | Greater Than                                                                         |
|                        | LT                                | Less Than                                                                            |
|                        | GE                                | Greater or Equal                                                                     |
|                        | LE                                | Less or Equal                                                                        |
| Array                  | [...]                             | Array element                                                                        |
| Tests                  | TEST<br>THEN<br>ELIF<br>ELSE TEND |                                                                                      |
| Comments               | @                                 |                                                                                      |



Instructions are separated by a semicolon (;) except before reserved words BEND, ELIF, ELSE and TEND. INIT and PROG blocks are terminated by a dot (.).

Each instruction is terminated by a semicolon (;) except before reserved words (BEND, ELIF, ELSE, TEND).

## Variables

### Variable type and size

The PLC equations only use 16 bit signed integer values. This means that all variables and data should be between -32768 and +32767. This is an important point to keep in mind when comparing values or doing calculations. For example, 20000\*10 will produce a calculation overflow. For the same reason, variables displayed with decimal digits are treated in the equations as if the decimal point wasn't there. For example, a power supply voltage of "24.5 V" will be treated as "245" in the equations.

Be careful when entering values which have digits after the decimal point. If you have one digit after the dot, you have to multiply the number by 10. If you have two digits, multiply by 100.

For instance, the battery voltage measure (variable E0041), is from 0.0 to 6553.5, so you have one digit after the dot. If you want to compare the battery voltage to 25.0 volts, you have to write:

```
TEST E0041 GT 250 THEN...
```

To know the number of digits after the dot, look in the "A53 Z1 9 0030x.xls" file. In the 'Mini' / 'Maxi' columns, the number of digits after dot appears.

### Locked variables versus dynamic variables

The PLC works with two complete sets of variables.

- ❖ The first set is a snapshot of the values before the execution of the equations
- ❖ The second set of variables is the result of the different equations already executed. Before execution of the very first equation, the second set is an exact copy of the first set of variables. It is then altered by the results of the custom equations.

Access to these two sets of variables is differentiated by the way you refer to a variable:

- ❖ Eyyyy means that you want to use the value of variable YYYY before any equation was executed.

- ❖ Xyyyy means that you want the actual value of variable YYYY, which has been modified by previous equations.

When the cycle controller, checks the validity LSU 408 (range min / max) values of variables X2nnn. If the value is legal, it is kept in memory for further operation. If the value is invalid, the internal variable will retain the value it had just before the PLC cycle ( the value E2nnn).

Note that as the first set is a picture of the variables before execution of the equations, it can be viewed as “read only”. This means that when you write the following equation:

```
E2680 := 320;
```

The value “320” will be attributed to variable 2680 in the second set of variables as well.

## Syntax examples

### Test examples:

```
TEST condition THEN instruction TEND;
```

```
TEST condition THEN BLOC instruction; instruction;...;instruction BEND TEND;
```

```
TEST condition THEN BLOC instruction; instruction;...;instruction BEND
ELIF condition THEN BLOC instruction; instruction;...;instruction BEND
ELIF condition THEN BLOC instruction; instruction;...;instruction BEND
ELSE BLOC instruction; instruction;...;instruction BEND
TEND;
```

### Calculation / instruction examples:

```
E2680:=(E2000+E2001+E2002+E2003)/4;
E2000:=2; E2680[E2000+1]:=10;
E2680:=(E0030 GT 1450) AND ((E0030 GT 1500) OR E2680);
```

### Condition examples:

```
TEST E2050 EQ 1 THEN ...
TEST E0030 GT 1500 THEN ...
TEST (!E2046) AND E2055 AND ((E2071 EQ 14) OR (E2071 EQ 15)) EQ 1 THEN ...
```

The following example is a small text file that could be sent to a LSU 408 using a level 2 passwords. In this example, the following variables are used:

- ❖ E0160 is the value of CANopen digital input 1 from an extension module.

- ❖ E1710 is a user parameter. It will be used as the period of a counter.
- ❖ E1711 is another user parameter used as the “duty ratio” of the counter.
- ❖ E2440 is a user variable used as a counter in this example.
- ❖ E2441 and E2442 are two user variables.

```

{INIT L2}
INIT 2
BLOC
    E2440 := E1710;
    E2441 := 0;
    E2442 := 1
BEND
.

{EQUATIONS L2 (every 100ms)}
PROG 2
BLOC
    @ E2440 is used as a counter that decreases from parameter E1710 down to 0;
    TEST E2440 GT 0 THEN
        DEC E2440
    ELSE
        E2440 := E1710
    TEND;
    @ Set the values of E2441 and E2442 depending on digital input 1 (E0160) and
the counter E2440;
    TEST E0160 AND (E2440 LT E1711) EQ 1 THEN
        BLOC
            E2441 := 1;
            E2442 := 0
        BEND
    ELSE
        BLOC
            E2441 := 0;
            E2442 := 1
        BEND
    TEND
BEND
.
{END OF FILE}

```

The INIT block initializes counter E2440 to the value set by the user in parameter E1710. Variable E2441 is set to zero, and variable E2442 is set to one. These initializations are done when the LSU 408 powers up.

The PROG block is executed once every 100ms. In this block, if variable E2440 is not zero, it is decreased by one. Otherwise, it is re-set to the value of parameter E1710. Then we check if CANopen digital input 1 is set to one and counter E2440 is lower than the value set in user parameter E1711. If this is the case, E2441 is set to one and E2442 is set to zero. Otherwise, E2441 is set to zero and E2442 is set to one.

For example if E1710 is set to 100 and E1711 is set to 20, E2441 can be seen as a PWM with a cycle time of 10s ( $100 \cdot 100\text{ms}$ ) and a duty ratio of 20% when CANopen digital input is set to one. Here, E2442 is simply the complement of E2441.

## Communication

### CAN bus good practices

This chapter describes rules to be used to ensure reliable CAN communication. These rules must be applied to all CAN communications; including LSU 408 CAN bus (COM1) and ECU/remote I/O CAN bus (COM2).

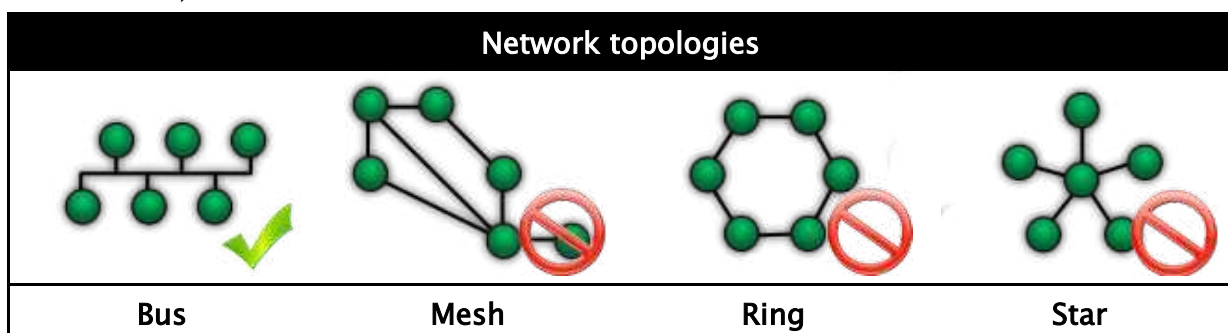
Table below lists the standard CAN DB9 wiring compared to LSU 408 DB9:

| Terminal      | LSU 408       | Standard CAN      | Mandatory |
|---------------|---------------|-------------------|-----------|
| 1             | NC            | Drain             |           |
| 2             | CAN-L         | CAN-L             | X         |
| 3             | GROUND-1      | CAN GND           |           |
| 4             | NC            | Free              |           |
| 5             | GROUND-2      | +24V power supply |           |
| 6             | GROUND-1      | free              |           |
| 7             | CAN-H         | CAN-H             | X         |
| 8             | NC            | free              |           |
| 9             | NC            | 0V power supply   |           |
| <b>SHIELD</b> | <b>GROUND</b> |                   | <b>X</b>  |

Table 6 - DB9 pin out

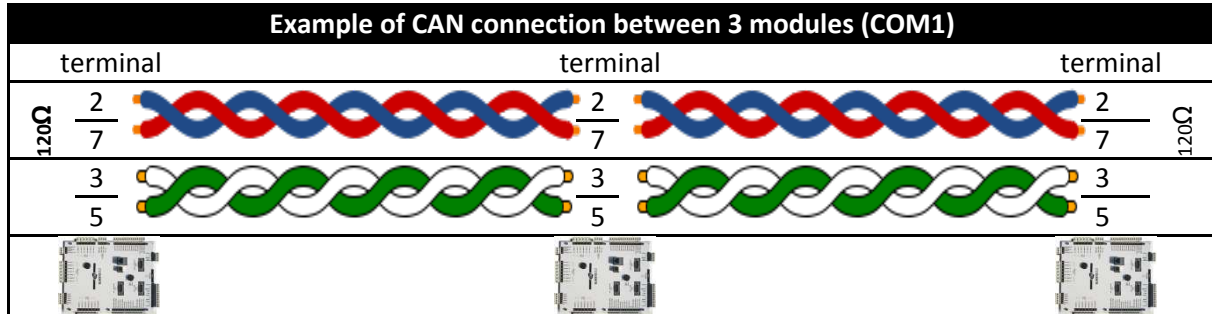
### CAN bus cable:

Cables used must be selected to respond to CAN bus specificities. Always use 120Ω shielded twisted wire pairs. Shield should be connected to the metallic connectors of the cable. CAN bus must be deployed in a single line way (no star, ring or mesh connection) as shown below:



Both ends of the CAN bus must be terminated with 120Ω resistors. Such resistors are fitted into LSU 408 COM1 and COM2 and can be activated using DIP switches at the rear of the module under the “OFF / 120Ω” plug. Termination resistor is connected to the CAN bus when the switch is set to ON (“120Ω” side). When the switch is set to OFF, resistor is disconnected from the CAN bus.

Figure below gives the example of 3 modules connected through CAN bus. Terminal resistors must be activated as shown on the 2 modules located at both ends of the CAN bus.



### Maximal length of a CAN bus:

The maximal length of a CAN bus mostly depends on the communication speed, but also on the quality of wires and connectors used. As said above, 120 Ω termination resistors should also be used appropriately.

Table below indicates the maximal length of a CAN bus depending on the communication speed.

| Communication speed (kbits/s) | Maximal length (metres) |
|-------------------------------|-------------------------|
| 10                            | 5000                    |
| 20                            | 2500                    |
| 50                            | 1000                    |
| 125                           | 500                     |
| 250                           | 250                     |
| 500                           | 100                     |
| 800                           | 50                      |

Next table lists the standard communication speed of each CAN protocol that can be used by your Auto-Maskin module:

| CAN bus | Protocol             | Speed (kbits/s) | Note                                                                                                                  |
|---------|----------------------|-----------------|-----------------------------------------------------------------------------------------------------------------------|
| COM1    | Auto-Maskin protocol | 125             | Fixed                                                                                                                 |
| COM2    | CANopen              | 125             | Can be changed from 10 to 1000 kbps (Parameter E1596 ; Menu <i>Configuration / Enhanced configuration / CANopen</i> ) |
|         | MTU MDEC             | 125             | Fixed                                                                                                                 |
|         | J1939 + CANopen      | 250             | Fixed                                                                                                                 |

## COM1: LSU 408 CAN bus

This CAN bus is used as a communication means between modules (LSU 408/LSU 408) from a single power plant. Features are:

- ❖ Active and reactive load sharing.
- ❖ Automatic load/unload.
- ❖ Static paralleling.
- ❖ Dead bus management.
- ❖ Other data exchange.

Standard CAN bus rules apply here. Please refer to chapter above to connect your modules properly through CAN bus.

### CAN bus fault

CAN communication between LSU 408 modules is continuously checked by each module on the CAN bus. The quantity of modules connected to the CAN bus should always be the same as the quantity of modules declared inside each product (sum of LSU 408). Otherwise a **CAN bus** fault is triggered. This can also be the case if:

- ❖ Two or more units share the same module number (check parameter E1179 on each module).
- ❖ 120Ω termination resistors are not used correctly (see chapter above).
- ❖ CAN bus cable is not properly connected.

This CAN bus fault can only be reset when the correct number of modules is seen on the CAN bus. As with every protection, the way to handle a CAN bus fault can be selected among the list below. This is done using parameter E1259.

| E1259 value | Behaviour when a CAN bus fault is triggered |
|-------------|---------------------------------------------|
| 0           | No action                                   |
| 1           | Generator electrical fault                  |
| 2           | Mains electrical fault                      |
| 3           | Alarm                                       |
| 4           | Soft shutdown (with cool down sequence)     |
| 5           | Hard shutdown (no cool down sequence)       |
| 6           | Droop mode; generates an alarm              |



If a remote start occurs on a LSU 408 working in automatic mode and set up to manage Deadbus situations (E1515 = 0) and a CAN bus fault has already been triggered, LSU 408 will start its engine and close its breaker (if there is no voltage on the bus bar) after a delay that depends on the generator number (E1179). If there is a voltage on the bus bar, LSU 408 will synchronize the generator before connecting to the bus bar.

If the generator is paralleled to the Mains when a CAN bus fault occurs, and error control variable E1259 is set to 6 (Droop mode + Alarm), speed control will be switched to droop and volt control will be switched to power factor regulation. If the Mains are not connected, both speed and voltage droop is applied.

*Note: If you need to disconnect a LSU 408 from the inter LSU 408 CAN bus, you must change the number of generators (parameter E1147) on all other LSU 408 units of the power plant.*

When the power plant is set to load/unload mode (Parameter E1258 set to "Hours run" or "Digital in"), all generators will start using droop mode if a CAN bus error occurs.

## Broadcasting data between multiple LSU 408 units

Custom data can be sent from one unit to the others using simple custom equations. This is very useful to create your own advanced features and adapt your modules to your very specific requirements. It is possible to send up to 10 digital variables and 2 analogue variables from one LSU 408 unit to all other units connected to the same inter module CAN bus (COM 1).

## CAN bus inhibition/Loadsharing suppression

COM1 CAN bus is mainly used by LSU 408 modules to send power management data to each other's. CAN bus inhibition is used to prevent one LSU 408 from taking into account data coming from one or more specific LSU 408 units. This is especially useful when tie breakers are used to change the configuration of the power plant (for example from a 6 generator power plant to two power plants with 3 generators each).

Variables below are used to decide with which modules the LSU 408 should communicate power management data.

| Variable | Description (when variable is set to 1) |
|----------|-----------------------------------------|
| E2691    | Ignore power management data from GE01  |
| E2692    | Ignore power management data from GE02  |
| E2693    | Ignore power management data from GE03  |
| E2694    | Ignore power management data from GE04  |
| E2695    | Ignore power management data from GE05  |
| E2696    | Ignore power management data from GE06  |
| E2697    | Ignore power management data from GE07  |
| E2698    | Ignore power management data from GE08  |
| E2699    | Ignore power management data from GE09  |
| E2700    | Ignore power management data from GE10  |
| E2701    | Ignore power management data from GE11  |
| E2702    | Ignore power management data from GE12  |
| E2703    | Ignore power management data from GE13  |
| E2704    | Ignore power management data from GE14  |

Table 7 - CAN bus inhibition variables

If one of these variables is set to one, power management data from the corresponding LSU 408 will not be taken into account.

*Note: Broadcast data are not influenced by the value of these inhibition variables, so it is still possible to send and receive broadcast values between "inhibited" LSU 408.*

Example below shows a power plant made up of 4 generators that can be split into two power plants of two generators each. LSU 408 units are connected together with a CAN bus on COM1. If it is necessary to split the complete plant using a tie breaker, then it is necessary to modify normal functioning:

- ❖ When the tie breaker is closed, each LSU 408 communicates with the 3 other units.
- ❖ When the tie breaker is open, all LSU 408 units need to know that they have to consider the power plant differently, with two separate bus bars. This is where we will use CAN bus inhibition.

When the tie breaker is closed, all four LSU 408 units should communicate with each other for power management, so variables E2691 to E2694 should be set to 0 (zero) on every LSU 408 unit (no CAN inhibition). When the tie breaker is open, generators DG1 and DG2 should communicate together but ignore data coming from DG3 and DG4. In the same way, generators DG3 and DG4 should communicate together but ignore data coming from DG1 and DG2.

To do so, inhibition variables should be set as shown in table below.

|            | 4 generating sets power plant |       |       |       | 2 * 2 generating sets power plant |       |       |       |
|------------|-------------------------------|-------|-------|-------|-----------------------------------|-------|-------|-------|
|            | Tie breaker is closed         |       |       |       | Tie breaker is open               |       |       |       |
|            | E2691                         | E2692 | E2693 | E2694 | E2691                             | E2692 | E2693 | E2694 |
| <b>DG1</b> | 0                             | 0     | 0     | 0     | 0                                 | 0     | 1     | 1     |
| <b>DG2</b> | 0                             | 0     | 0     | 0     | 0                                 | 0     | 1     | 1     |
| <b>DG3</b> | 0                             | 0     | 0     | 0     | 1                                 | 1     | 0     | 0     |
| <b>DG4</b> | 0                             | 0     | 0     | 0     | 1                                 | 1     | 0     | 0     |

## COM2 CANopen - Remote I/O units

Industrial CANopen extension modules can be used to increase the number of digital/analogue inputs and outputs of LSU 408.

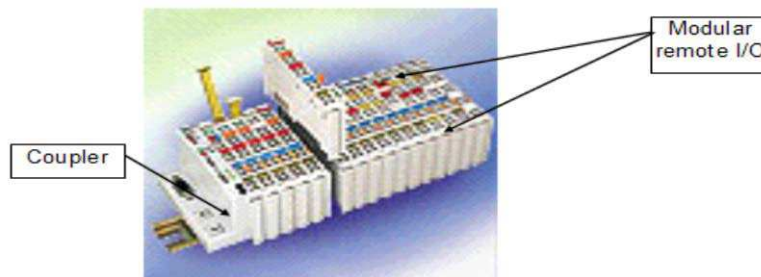


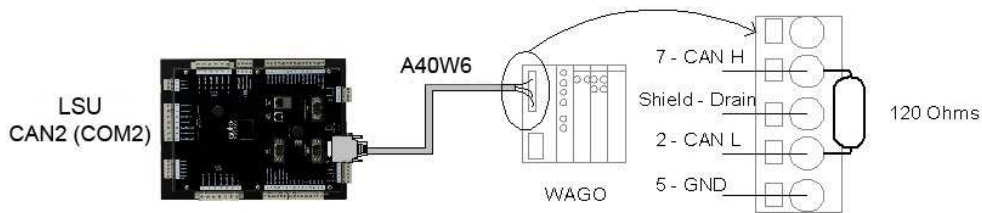
Figure 6 - Modular remote CANopen I/O extension module

The refresh rate of these CANopen inputs and outputs is 100ms.

Wiring of the CAN bus on COM2 should be as described. Also refer to the CANopen extension module's user manual for correct wiring on the CANopen module side.

Modular remote I/O can also be added to LSU 408 using the CANopen© protocol and DB9 connector.

For the remote I/O wiring see the figure below.



- ❖ CAN L must be connected to pin 2 of the DB9.
- ❖ CAN H must be connected to pin 7 of the DB9.
- ❖ CAN GND must be connected to pin 5 of the DB9.
- ❖ Drain must be connected to the shield of the DB9.

An end resistor of 120  $\Omega$  must be connected to each end of the cable between CANH and CANL. This resistor exists inside LSU 408 and can be activated with a switch accessible from the rear of the unit and located under the plug marked “OFF / 120 $\Omega$ ”. COM port is marked on the rear. You need to extract the plug to change the switch. When the switch is ON, resistor is active on bus. When switched the other way, the resistor is not connected to the bus.

Contact your local dealer for a list of recommended CANopen extension modules.

