EQUALIZER & ACTIVAR

Introduction, Installation, Operation & Troubleshooting

Revision 9

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1. GETTING STARTED

How to Use This Manual

Elspec's *EQUALIZER* and *ACTIVAR* are transient-free power factor compensation systems. The *EQUALIZER* is a real-time system (RTPFC – Real Time Power Factor Compensation), which compensates reactive energy within typically 5 to 20 milliseconds (16.7 milliseconds at 60 Hz).

The *ACTIVAR* achieves full compensation in 3 to 4 seconds.

Before working with the system, please read this User Manual carefully and follow the safety precautions contained in this chapter. The manufacturer will not be responsible for any incorrect usage. **These precautions must be used in conjunction with local or national health and safety regulations.**

Here is how you should use the manual to assist in system set up and operation:

If you wish to:	**Read:**
Learn about system performance and options	This chapter
Learn about system structure	Chapter 2
Prepare the system for initial commissioning by the technician	Chapter 3
Perform system commissioning (qualified personnel only)	Chapter 4
Operate the controller	Chapter 5
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Monitor the system from a remote PC	Chapter 7
Perform routine preventative maintenance	Chapter 8
Troubleshoot the system	Chapter 9

Table 1: How to Use This Manual

Terminology

Phrase	**Meaning**
CT	Current Transformer (singular)
CTs	Current Transformers (plural)
System	The Equalizer or Activar entire system, including all panels, assemblies, and internal set of CTs
System CTs	Set of two CTs, located inside the system and used for measuring system current
Mains CTs	Set of CTs, located outside the system and used for measuring the network current. This phrase is used also when the Mains CTs measure the Load only (Page 18).

Table 2: This Manual Terminology

Product Versions

This manual includes all existing system functionality. Additional functions may be included in future versions, and earlier versions may not have all functionality. Table 3 summarizes the existing versions.

Item	**Latest Version**
SCR/SCR Equalizer/Activar controller firmware	3.8.6
SCR/Diode Equalizer/Activar controller firmware	2.4.2
Equalizer/Activar controller Boot Loader	1.6
PowerIQ Professional / Network	2.7.7

Table 3: Product Versions

System Benefits

Elspec's *EQUALIZER* or *ACTIVAR offer the following benefits*:

- Transient-free capacitor group switching, using electronic switching elements
- No damage to sensitive electronic equipment
- Energy savings
- Harmonic filtration
- Accurate power factor control, even in the presence of harmonics
- Dramatically increased life expectancy of switching elements and capacitors
- Considerably lower temperature rise of capacitors and inductors thanks to a unique scan feature
- Built-in three-phase network analyzer, measuring all network parameters including harmonics
- Unique self-testing and comprehensive reporting features

The only difference between the *EQUALIZER* and the *ACTIVAR* lies in the total acquisition time: 5 to 20 milliseconds for the *EQUALIZER* as compared with 3 to 4 seconds for the *ACTIVAR*. The *EQUALIZER* therefore offers two additional benefits:

- Prevents voltage drops and flickering, which typically occurs in real-time applications (e.g. spot welding and motor start-up)
- Enhanced utilization of local generation equipment, such as wind turbines and diesel generators

Specifications

Design	Steel-sheet cabinet
Enclosure finish	Epoxy powder coated, grey (RAL 7032),
Internal parts	Rust-proof aluzinc
Rated Voltage	380/400/415V/50Hz, 480V/60Hz, 690V/50Hz and 600V/60Hz Other voltage values are available on request
Capacitors	Low-loss, self-healing, IEC 831-1/2
Ambient temperature	+40°C max short time +35°C average in 24 hours +20°C annual average -10°C low limit
Protection class	IP 20 Other IP ratings are available on request
Standards:	
Electromagnetic Compatibility	EN50081-2, EN50082-2, EN55011, EN61000-4-2/3/4/5, ENV50204, ENV50141
Safety Standards	EN61010-1, EN60439-1, UL508 (option)

Table 4: System Specifications

Old Part Numbering & System Options (up to the year 2004)

EQ300/5-2-400.50-P7-XY-ZZ

System type:
EQ: Equalizer
AR: Activar

Total output in **kVAr** at nominal voltage and frequency

Number of steps. E.g. 3,4,5…12

Switching sequence:
1: 1:1:1
2: 1:2:2
3: 1:2:2:4:4
4: 1:2:4:4
5: 1:2:4:8
6: 1:2:2:6:12:12

Network phase to phase voltage
Such as: **400, 440, 480, 525, 600, 690**

Network frequency:
50: 50 Hz
60: 60 Hz

Tuning frequency:
Standard systems:
P0: inrush limiting inductors
Detuned systems:
P#: # is the detuned harmonic number
For example:
P5.7, P7, P14 (for 50 Hz), P6 (60 Hz)

Measurement Level:
1 through **3**
(3 = Most Advanced)

Communication:
0: None
1: RS-485 Elcom Protocol
2: RS-485 ModBus/RTU protocol
Note: Other options upon request

System Options (see below)

Figure 1: Old System Part Numbering

New Part Numbering & System Options (from the year 2004)

EQ300:60:3-400.50-P7-WFSA

System type:
EQ: Equalizer
AR: Activar

Total output in **kVAr** at nominal voltage and frequency

Smaller group size in KVAr

Number of groups

Network phase to phase voltage
Such as: **400, 440, 480, 525, 600, 690**

Network frequency:
50: 50 Hz
60: 60 Hz

Tuning frequency:
Standard systems:
P0: inrush limiting inductors
Detuned systems:
P#: # is the detuned harmonic number
For example:
P5.7, P7, P14 (for 50 Hz), P6 (60 Hz)

Network topology:
D – Delta 3 wires
W – Wye 4 wires
V – Wye 3 wires
S – Single phase

Group protection:
F – Groups protected by fuses
M – Groups protected by MCCBs.

Cable connection:
C – Single point with MCCB
S – Single point
M – Multiple connection points

Cable entry:
T – Top cable entry
B – Bottom cable entry
A – Top and bottom cable entry
L – Left side cable entry
R – Right side cable entry

Figure 2: New System Part Numbering

The controller part numbering is derived from the system part number (Figure 3).

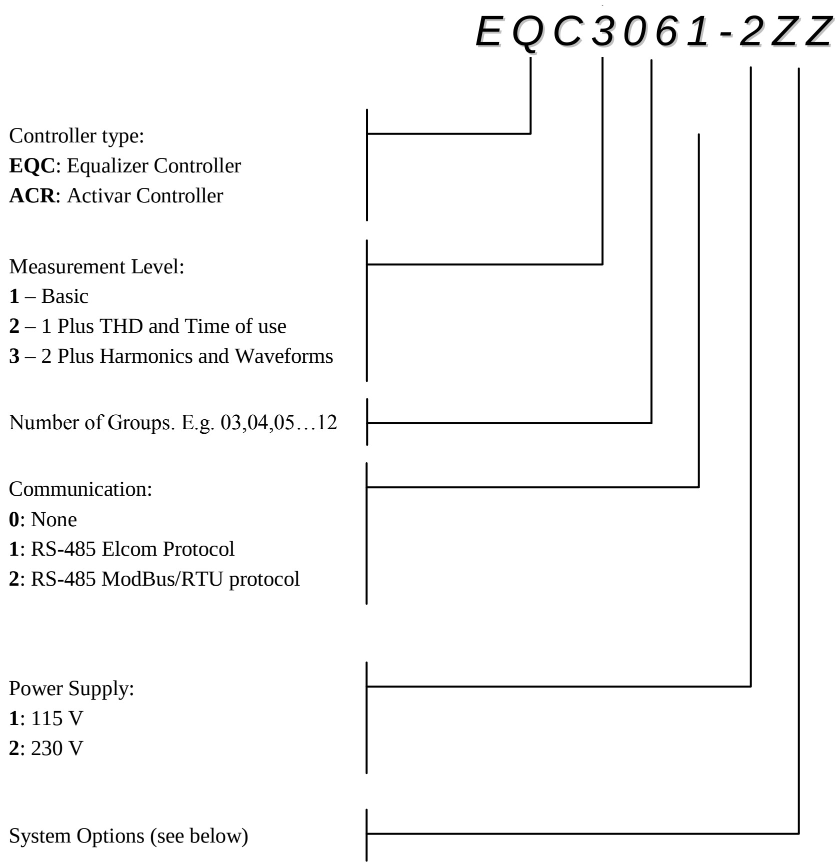


Figure 3: Controller Part Numbering

The system part number may have one or two of the following suffixes, which indicates individual system options as shown in Table 5. Each system may include more than one option, such as "WT" (Wind generator with Transformer).

Option	Name	Desctiprion
M	Medium Voltage	Used for MV compensation system (MV capacitors)
P	Pulse	Synchronized compensation, using external signal
S	Single Phase	Single phase network with single phase capacitors
T	Transformer	MV compensation using LV capacitors and step-down transformer
U	Unbalanced	Three phase network with single phase capacitors. This configuration utilizes three controllers. Each controller compensates assuming the other two exists
V	Voltage Control	In excessive voltage levels the controller connects or disconnects steps according to programmed voltage levels
W	Wind Generator	Special version for wind generator applications
G	Generator	Allows two power factor targets dependent on the generator mode of operation.
D	Motor starter	Solution for the challenges related to large motor start up

Table 5: System Options

Safety Precautions

The following general safety guidelines apply to system installation, operation and commissioning. Always observe these safety precautions and any local or national safety regulations when performing any work on the system.

- The instructions contained in this manual are designed for implementation only by qualified personnel. To avoid personal injury, do not perform any procedure other than as contained in this manual, unless you are qualified to do so.
- Before connecting power cables to the equipment, verify that the mains supply is disconnected.
- The equipment contains potentially harmful voltage when connected to the designated power source. Never open the cabinet door or remove any covers except for maintenance purposes.
- Before removing covers or panels from the equipment, verify that the mains power has been de-energized. Close and/or secure doors and covers before energizing the equipment.
- Accessible metal parts are grounded to prevent shock or fire hazards from lightening and other sources. Ground conductors must not be removed.
- To prevent shock or fire hazards, do not expose the equipment to rain or moisture.
- Avoid making unauthorized modifications to the equipment, sub-assemblies or circuitry.
- Always operate the equipment within the specified power tolerances.
- Before attempting any operation inside a cabinet, disconnect all power supplies from the distribution board and all capacitor groups within the cabinet, and allow the capacitors ten (10) minutes to discharge completely. Verify that the DC voltage over the capacitors and over the Switching Module is less than 20V (DC). ***Failure to comply with this instruction may result in life threatening situations***.
- Before attempting to connect or disconnect capacitors, verify that system’s power supply is disconnected.
- The output of CTs may be affected by high voltage due to cut out on the secondary coil. Throughout installation, make sure that all transformer outputs are connected. ***Failure to comply with this instruction may result in life-threatening situations***.
- To use and operate the equipment, follow the specifications of this manual strictly. ***The manufacturer will not be responsible for any damage or injury resulting from equipment misuse and/or unsafe work practices***.

2. GETTING TO KNOW THE SYSTEM

System Overview

Each system comprises main elements as listed and described below (see drawings in the pocket of this manual back cover or in the documents pouch inside the system):

Controller

The controller (Figure 4) is the brain of the system. Based on an advanced VLSI device and a Digital Signal Processor (DSP), it carries up to 9 channels (4 voltages, 3 network currents and 2 system currents).

The controller also features a large LCD display and 5 function keys. Controller operation is accomplished through easy-to-use menus and on-line help.

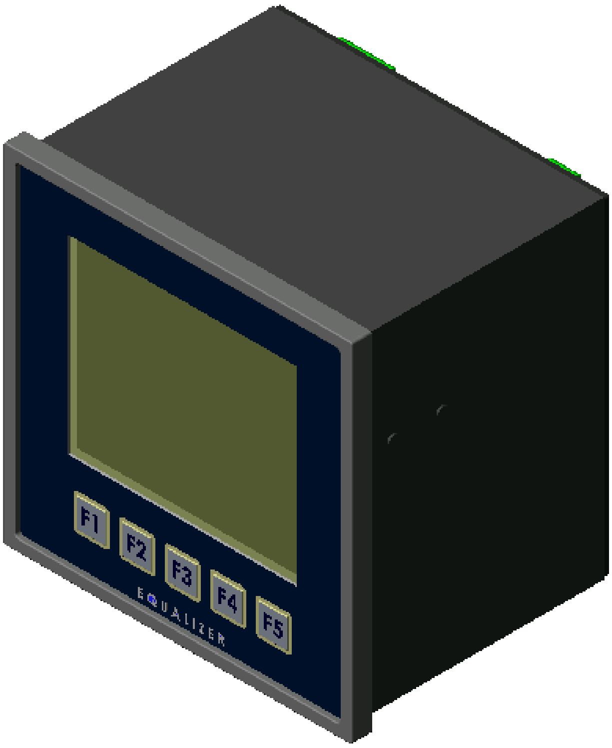


Figure 4: Controller

The controller performs two major functions:

Control

The control function of the controller constantly samples the currents and voltages and analyses the precise capacitor groups required to obtain an accurate power factor or kVAr and in system options "W" or "V" also to adjust the voltage level. This function uses a unique real-time load variation analysis for accurate analysis within approximately 1 millisecond.

In addition, the control function runs system tests to analyze unit condition, provide malfunction indications and adjust unit operation as required.

The controller generates precise firing pulses for the switching module as required to connect or disconnect capacitor groups.

Measurement

The controller features advanced measurement capabilities, including harmonic analysis and waveforms.

Readings are provided for three sections (Figure 5):

- Mains reading as indicated by the M symbol, displaying the measurement of the total network including the compensation system.
- Load centre reading as indicated by the L symbol, displaying the measurement of the load without the compensation system.
- Capacitor system reading as indicated by the C symbol, displaying the measurement of the system only.

The three sections are measured by two sets of CTs only: one fitted within the capacitor system and the other fitted either at the mains or at the load. The controller calculates the third section from the other two.

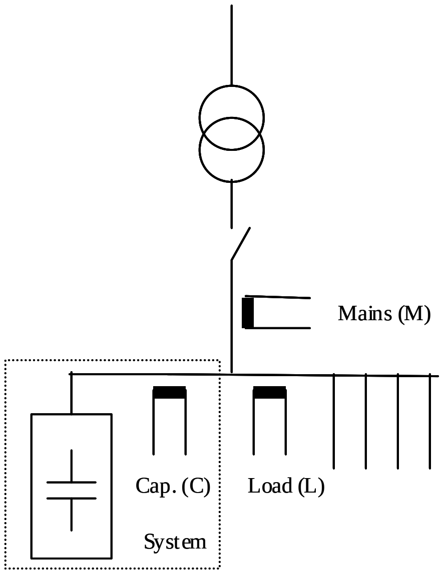


Figure 5: Measured Sections

Switching Modules

Comprising switching elements (SCRs and diodes or SCRs only) and firing circuits (Figure 7 through Figure 9).

There are different types of Switching Modules as illustrated in

Figure 6, which utilizing outside circulation cooling (except types AL and AR). The maximum number of single phase steps is twice as much as for 3-phase with the same Switching Module.

SWMn 230/1C

Switch Elements:

SWM: SCR / Diode

SWM**n**: SCR / SCR

Power Supply Voltage:

115 – 115V

230 – 230V

Max. Number of Groups:

1 - Single group switch

2 – 2 unbalanced groups switch

3 - 3 groups switch

Switch Module Type:

A - SCR/Diode or SCR/SCR, 480V Max., up to 200A per Switch, one or three groups.
B - SCR/Diode or SCR/SCR, 480V Max., up to 200A groups 1-2, 290A group 3.
U - SCR/SCR, 480V Max., up to 200A per Switch, 2 groups for unbalanced systems.
C - SCR/Diode or SCR/SCR, 690V Max., up to 350A
G – SCR/SCR, 690V Max., up to 350A, single phase switch.
AG - SCR/SCR, 480V Max., up to 200A, single phase switch.
D - SCR/Diode or SCR/SCR, 480V Max., up to 350A
AL - 1 group internal, SCR/Diode or SCR/SCR up to 200A for left side of cabinet.
AR - 1 group internal, SCR/Diode or SCR/SCR up to 200A for right side of cabinet.

Figure 6: Switching Modules Part Numbering

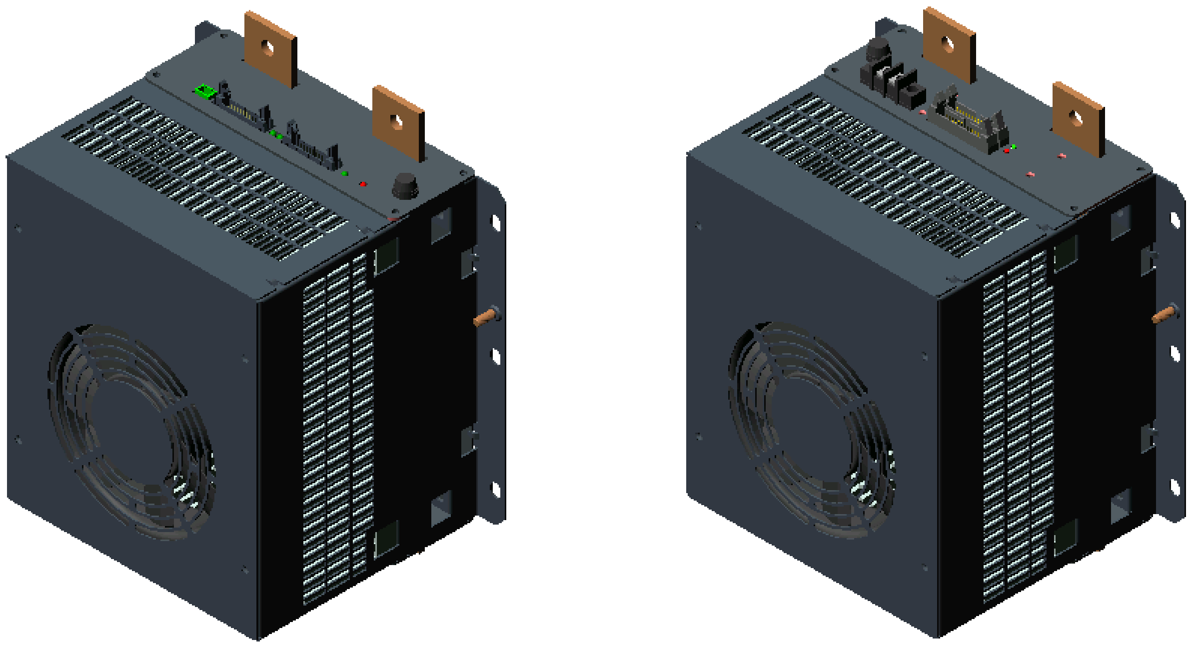


Figure 7: Switching Modules types SWM-1C/D (left) and SWMn-1A/C/D (right)

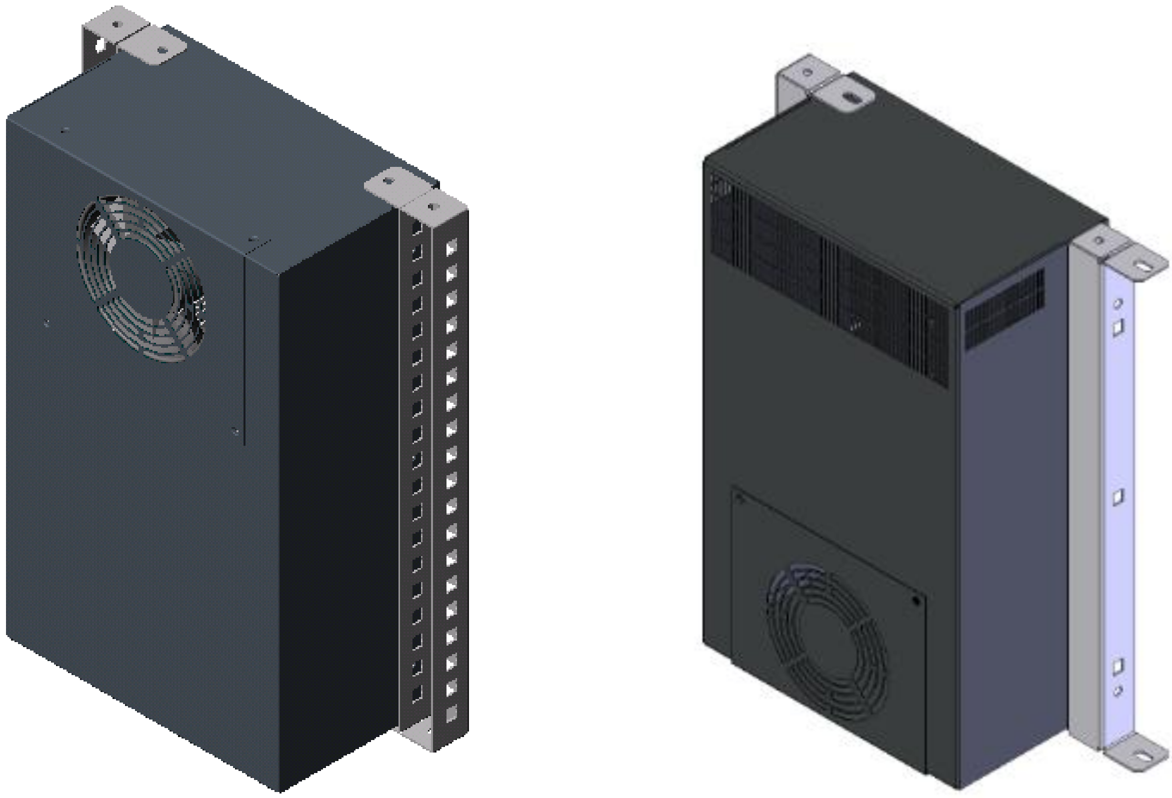


Figure 8: Switching Module types SWM-3A/B (left) & SWMn-3/A/B/U (right)

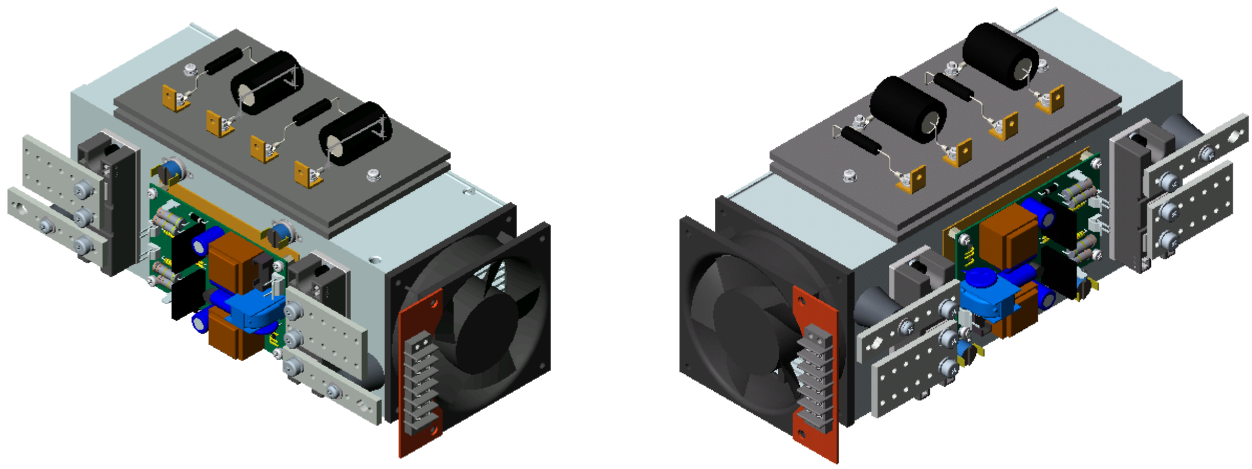


Figure 9: Switching Modules types SWM-1AL (left) & SWM-1AR (right)

Protection

Fuses or circuit breakers offer short circuit and over-current protection to the Capacitor Groups, while the main control switch protects the controller.

Capacitor-Inductor Modules

Each capacitor group consists of one or two inductors and several capacitors.

Main Breaker (Optional)

The system may incorporate an optional main breaker as a disconnect device and for short circuit protection.

PowerIQ Software (Optional)

The optional Power IQ software is used for remote control, system status display and network monitoring. The software works under Microsoft Windows 2000 or XP, and is connected to the system through the controller's RS-422/RS-485 port or to RS-232 port using a converter (see Chapter 7).

3. SYSTEM INSTALLATION

General

The system is factory wired. On-site installation in limited to:

- Positioning and mounting of the equipment,
- Installation of CTs for network measurement (either mains or load - see Figure 5),
- Connection of CT secondary wires to the CT Terminal Block,
- Connection of power cables to the main lugs,
- Adjustments of the controller,
- Installation of the PowerIQ software and communication cables (optional).

WARNING

In case that the instructions below contradict local, national or other applicable regulations you must consult with Elspec before the installation.

Location

The system is not designed for operation in hazardous locations. The area chosen should be well ventilated, free of excessive humidity, dust and dirt. The temperature in the area should be no lower than -10ºC (14ºF) or higher than 40ºC (104ºF). Suitable protection from moisture or water ingress must be provided.

For full door swing, the system should be located in an area, which will allow a minimum of 90 cm (3 ft) of free space in front of each door. A minimum clearing of 5 cm (2”) should be provided between the back of the system and the wall (15 cm in damp locations).

When selecting a location for system installation, careful attention should be paid to accessibility, overhead clearances, and future expansions. Consideration of these factors will eliminate possible difficulties that may otherwise arise during installation or future expansions.

The system is assembled in the factory on a smooth, leveled surface to ensure that all sections are properly aligned. The customer should provide a similar smooth and level surface for installation. An uneven foundation may cause misalignment of shipping blocks, units and doors. The surface under the system must be of a non-combustible material, unless bottom plates are installed in each vertical section.

Sizing Over-current Protective Device

A circuit breaker must be provided upstream of the system to protect the feeder cables from short circuit and overload.

The circuit breaker rating shall be at least 150% of the system current rating.

Power Cables and Earth Connections

Power connections from the main distribution board to the cabinets shall comprise three phases, neutral (if included) and ground. The cable-rating of all conductors shall be higher than the circuit breaker rating as indicated above. For example, 2500A can be connected with set of 7×150mm^2 cable per phase, depends on the actual routing of the cables.

WARNING

Before attempting any operation inside a cabinet, switch off all power supplies from the distribution board and allow another ten (10) minutes for the capacitors to discharge.

Connect the three-phase power supply cables to the bus bars fitted above the fuses. To connect, follow the procedure below:

(1) Check and identify output phases on distribution board circuit breakers. Verify correct phase sequence (L1, L2, L3 clockwise), using a rotary field indicator.

(2) Disconnect all power supply to the main distribution board.

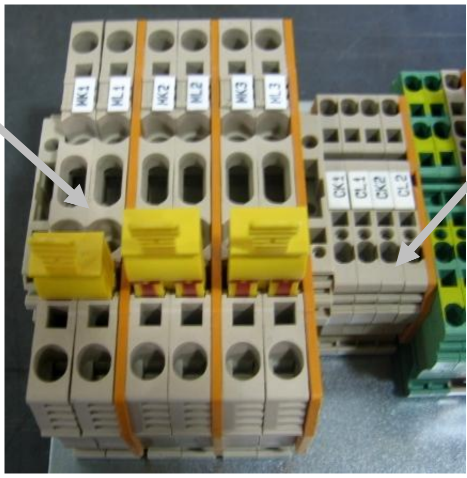
(3) Mark the phases and connect the circuit breaker for the system.

(4) Check the system and site grounding using an earth bonding tester

Mains CTs Connection

The system has a terminal block for connecting both system and mains CTs (Figure 10). The terminal block includes five sets of two shorting terminals with shorting bar each. The two system CTs are factory installed on system input and three are field installed, remotely, on the service mains. Up to the moment when required for system commissioning, all shorting bars should be pushed to the “down” position and secured in place to short the CT secondary circuits safely.

Mains CTs Connection Terminals, the circuit is shorted while both terminals are in “down” position



System Internal CTs Connection Terminals.

Figure 10: CT Connection Terminals

To connect, follow the procedure below:

(1) Install three …/5A CTs with a minimum accuracy rating of 1% and sized 120% (or higher) the maximum mains current. Recommended CTs have 0.5% accuracy, bandwidth of 4kHz and 10VA or higher burden. Connect mains CTs to the output of the main circuit breaker and upstream of any other load as may be connected on the mains bus bars (see Figure 11).

(2) Connect 6×2.5 mm² wires between the mains CTs and the input terminals of the system CTs. Mark the phases on both ends of each wire. The maximum distance between the mains CTs and the input terminals depends on the maximum CTs allowed burden.

WARNING

Throughout installation, verify that all CTs terminals are shorted at the system CTs terminal block.

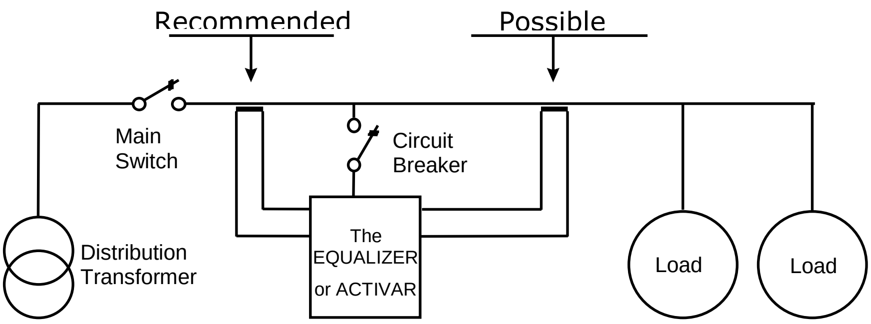


Figure 11: Position of Mains Current Transformers

Communication Cable Connection (optional)

To allow remote communication with the system, a communication link must be established between the system and a PC. To connect, follow the procedure below:

CAUTION
The controller power supply must be turned off during connection and disconnection of communication cable

(1) Verify that the controller power supply is off.

(2) Install a communication cable (2 twisted pairs, shielded) between the PC and the system.

(3) Connect an RS-422/485 to RS-232C converter (e.g. ATEN model IC-485/SI) to the computer end of the communication cable. Set converter's DIP switches to TxON/RxON (i.e. Transmit and Receive always on) and DCE (i.e. connecting directly to the PC).

(4) Connect a PHOENIX contact KGG-MSTB 2.5/4-ST connector to system end of the communication cable as illustrated in Figure 12

(5) To connect multiple systems, use a PHOENIX connector in parallel for each system.

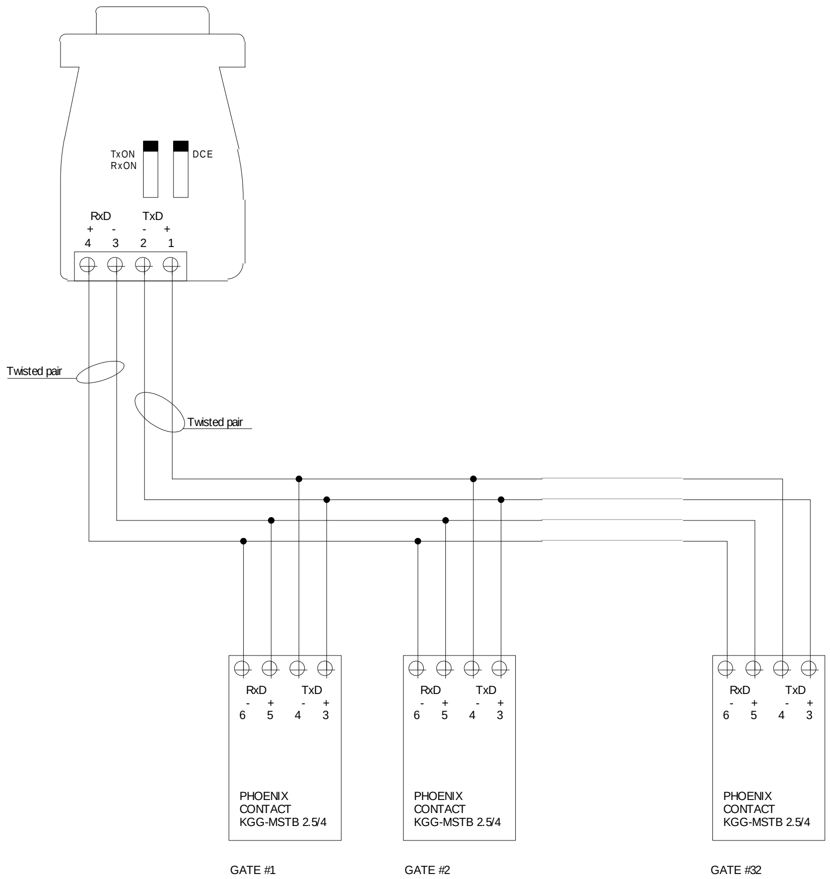


Figure 12: RS-485 Connection Diagram

To allow remote communication with the system, a communication link must be established between the system and the computer. To connect, follow the procedure below:

(1) Install a communication cable (2 twisted pairs, shielded) between the TAC controller and the system (Figure 12).

(2) Connect an RS-422 to RS-232C converter to the TAC end of the communication cable.

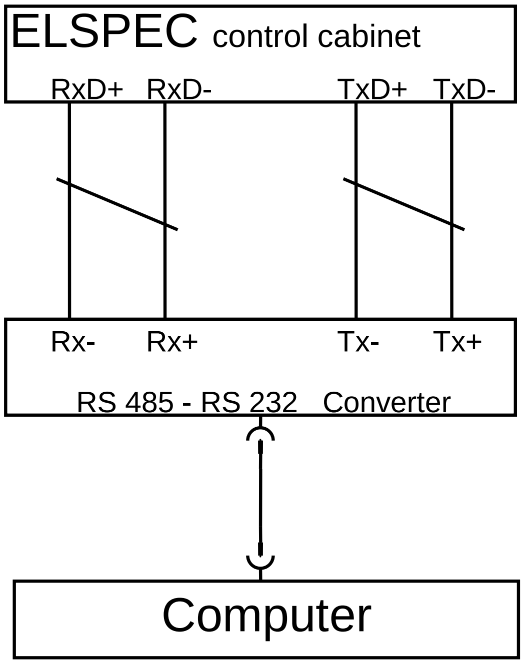


Figure 13: Communication Connection Diagram\

4. ELECTRICAL SYSTEM TESTS

Preliminary Inspection

To prepare the system for initial power-up, run preliminary inspections as listed below:

(1) Check that the system is disconnected from the main supply.

(2) Inspect all electrical and mechanical connections visually for mechanical damage and for integrity of components and accessories.

(3) Check that the enclosure has been positioned as required under "Location" on Page 16.

(4) Inspect incoming cables to ensure proper phase sequence (L1-L2-L3 clockwise).

(5) Inspect Mains CTs wiring for proper phase and polarity marking and for proper connection into the terminal block as required under "Mains CTs Connection" on Page 18.

(6) Pull-test all control wiring to ensure secure seating in terminals.

System Start-up

Before attempting system startup, familiarize yourself with controller's concept of operation as described in Chapter 5.

To start the system up, follow the procedure below:

(1) Verify that system's main breaker or upstream disconnect device is open and that no voltage is present in the system cabinet.

WARNING

Before any work is performed inside the system, ensure that all power sources are disconnected, locked and tagged out. In addition, capacitors must be allowed ten (10) minutes to discharge fully.

(2) Disconnect all internal fuses and circuit breakers.

(3) Using an ohmmeter, check the resistance between all phases (L1-L2, L2-L3, L3-L1) and between all phases to neutral (if exists in the system) and to ground (L1-G, L2-G, L3-G and in Wye network also L1-N, L2-N and L3-N) to ensure that they are not shorted. Resistance should be minimum 100 MΩ (Mega Ohms).

(4) Connect the main control switch circuit breaker and all the control fuses.

(5) Close the system's main breaker or the disconnect device upstream.

(6) Verify that controller's front panel lights up and that the display shows a stable reading.

(7) Use **F4** (▲) and **F5** (▼) to check phase-to-phase (L-L) voltages, as well as frequency readings for all three phases, to obtain valid and stable readings. In Wye network configuration check also the phase to neutral (L-N) voltages.

System Initialization

System initialization comprises system programming and capacitor group tests. To program the system, use the wizard, which will guide you through all the necessary steps. The system will automatically prompt you only for those parameters, which apply to the specific system type and structure.

On completion of system programming, test each capacitor group in sequence as described under "Testing of Other Groups" on Page 62.

Preparation for Site Installation

(1) Switch the cabinet's power supply off.

(2) Connect fuses (or circuit breakers) of capacitor group 1 only. Note that it is a single set of three (3) fuses and that they may **not** be positioned one near to the other. See drawings in the pocket of this manual back cover or in the documents pouch inside the system for fuses location.

WARNING

Fuses should only be installed or removed after all power sources are disconnected, locked and tagged out. In addition, capacitors must be allowed ten (10) minutes to discharge fully before commencing any work within the enclosure.

(3) Close and latch enclosure doors, then switch cabinet power ON.

(4) If the word "INSTALL" appears at the top of the screen (status line), press **F2** (Setup). Otherwise, press **F3** (Menu) and use **F4** (▲) and **F5** (▼) to select the "System Setup" option, and then press **F3** (Enter). Now select "Site Installation", using **F4** (▲) and **F5** (▼), and press **F3** (Enter).

(5) The display will show a "System Structure Summary" window, which is the first stage in the "Site Installation" procedure.

Site Installation Procedure

The Site Installation Procedure is performed by using Wizard. This Wizard helps to install the system quickly and easily. At the beginning the system displays the system structure parameters, which were set at the factory for the specific system. Normally, it is not required to change these parameters.

During installation, the screens displayed will depend on system configuration (e.g. if this is a single-phase system, you will not be prompt for WYE or DELTA feeder type, etc). Each screen is numbered in square brackets (e.g. [17]). At the end of each step's description please continue to the next screen according to entered value and the system type (Table 5).

[1] System Structure Review

Figure 13 displays a typical system structure summary window.

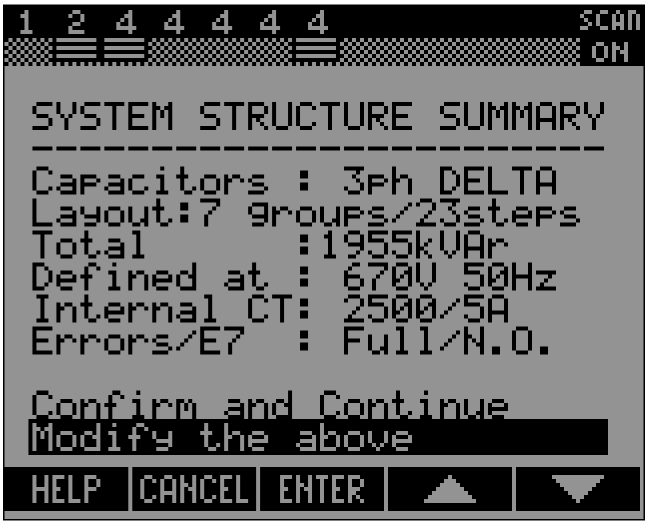


Figure 13: System Structure Summary

The information displayed includes the following:

<u>Capacitors:</u> Display of capacitors' type – single or three-phase (Delta). There are two single-phase configurations: between line and neutral (1ph L-N) or line-to-line (1ph L-L).

<u>Layout:</u> Display of the number of groups installed and the number of system steps as a function of the number and arrangement of the groups. For example, 3 groups in an arrangement of 1:2:2 make up 5 steps (1, 2, 1+2, 2+2, 1+2+2).

<u>Total:</u> Display of the system's total capacity in kVAr, at nominal voltage and frequency.

<u>Defined at:</u> Display of the nominal voltage and frequency.

<u>Internal CT:</u> Display of system internal CTs' ratio transform value.

<u>Errors/E7:</u> Display of the error detection status. "Full" indicates that the error detection mechanism is fully operable while "Partial" indicates that some of the errors are disabled. To find out which errors are disabled, select the "Modify the above" function. Also indicated is the polarity of Error 7 detection (over-temperature) - either N.O. (normally open) or N.C. (normally close).

If all the information in this screen is correct, select "Confirm and Continue" and continue to step [15]. However, if the voltage is more than 500V or the errors are not "Full", it is important to select "Modify the above" to examine the PT secondary or the error setup. Selecting "Modify the above" will open a detailed screen for each parameter and enable value modifications. For system options "S" continue to the next step, for option "U" continue to step Figure 15 and for all other system options continue to step [4].

Caution: **Only a qualified technician may modify these parameters.**

On modification of any of the parameters, a warning message will be displayed to indicate that the system structure programming is about to be changed.

[2] Capacitor Connection – [S] Systems

Use this parameter to set either Phase to Phase or Phase to Neutral connection; Only in Single Phase [S] systems. Continue to step [4].

Figure 14: Capacitor Connection

[3] Controlled phases and Capacitor Connection – [U] Systems

Use the parameter of Figure 15 to set either three or single phase control.

In Figure 16, set if the capacitor connection is neutral to phase or phase to phase.

For three phase systems, set (Figure 17) the number of internal CTs the system has and where they are located. After using the parameter in Figure 18 to set that either the internal CTs are reading values of the input line current to the system, or between line to line inside it.

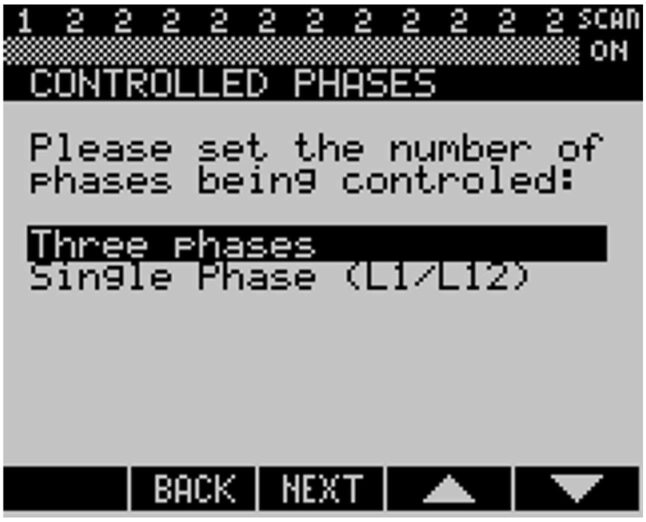


Figure 15: Controlled phases (Unbalanced)

Figure 16: Capacitor Connection (Unbalanced)

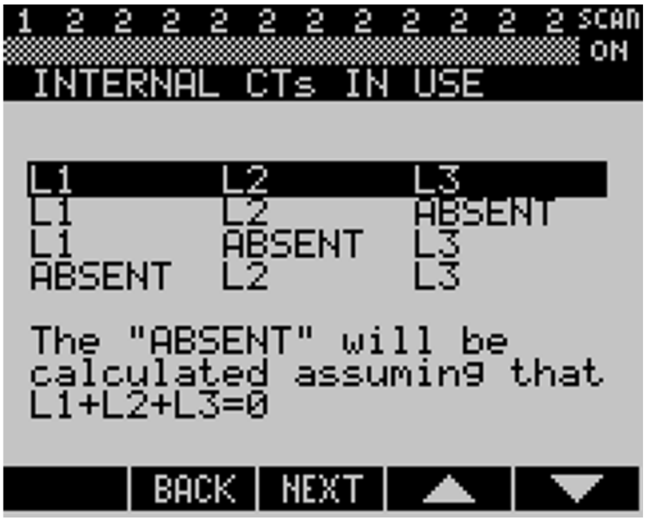


Figure 17: Internal CTs in use

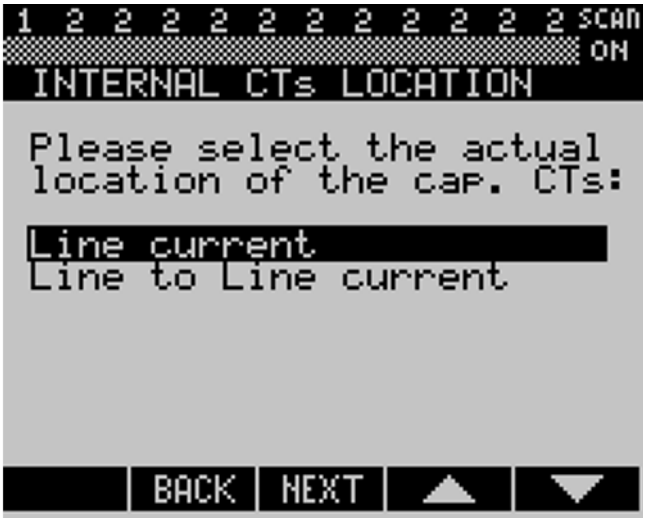


Figure 18: Internal CTs Location

[4] Nominal Voltage

Use this parameter to set the system's nominal voltage. In a three-phase system, the voltage is line-to-line.

For system option "T", continue to the next step. For other systems, if the nominal voltage is more than 500v, continue to step [6]. Otherwise, continue to step [7].

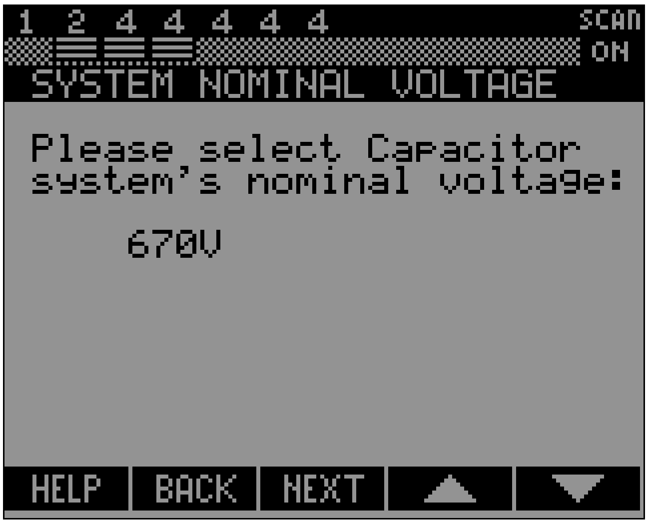


Figure 19: System Nominal Voltage

[5] Voltage Measurement

Systems with option "T" are designed to measure high voltage. The voltage measurement inputs (Appendix C) can be connected either to the system busbars (recommended) or to the MV voltages. Figure 20 shows the setup screen for the voltage measurements.

For "Internal busbar system" and nominal voltage of more than 500V, continue to the next step. Otherwise continue to step [7]. For MV transformer the PT secondary is set during the site installation (step [18]).

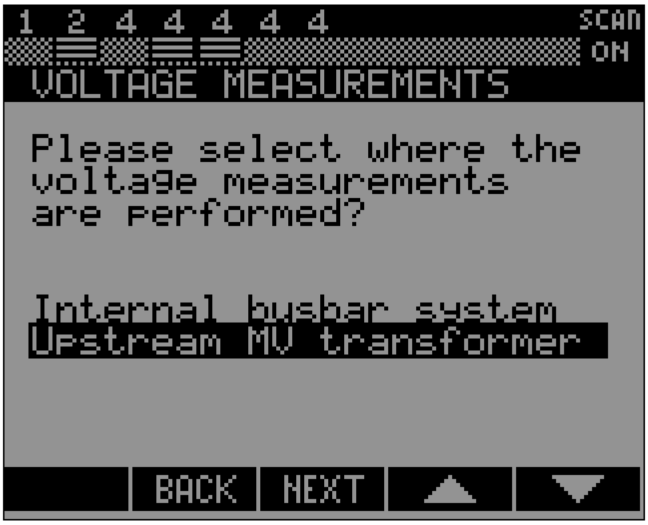


Figure 20: Voltage Measurements

[6] PT Secondary

Use this parameter to set the system's PT secondary voltage. In a three-phase system, the voltage is line-to-line.

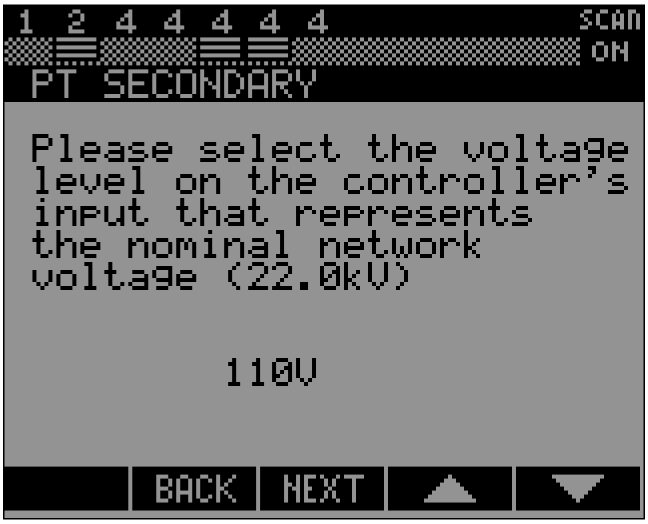


Figure 21: PT Secondary

[7] Nominal Frequency

Use this parameter to set the system's nominal frequency.

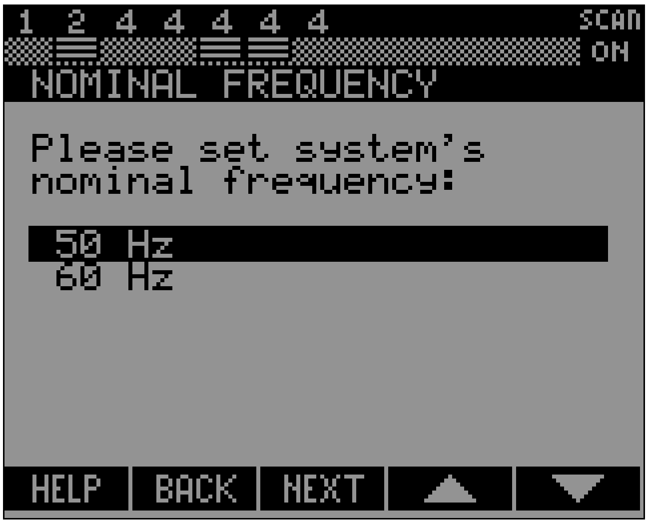


Figure 22: Nominal Frequency

[8] Number of Groups

Use this parameter to set the total number of groups in the system.

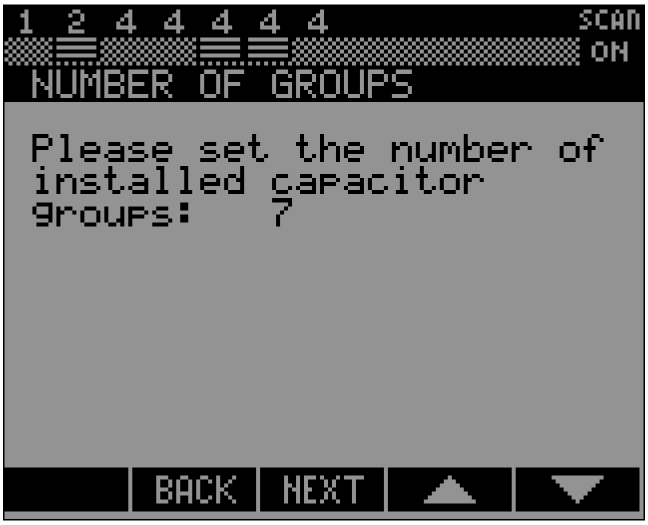


Figure 23: Number of Groups

[9] Group Arrangement

Use this parameter to set the arrangement of the capacitor group. The numbers represents the ratio the group size to the smallest group size (step size).

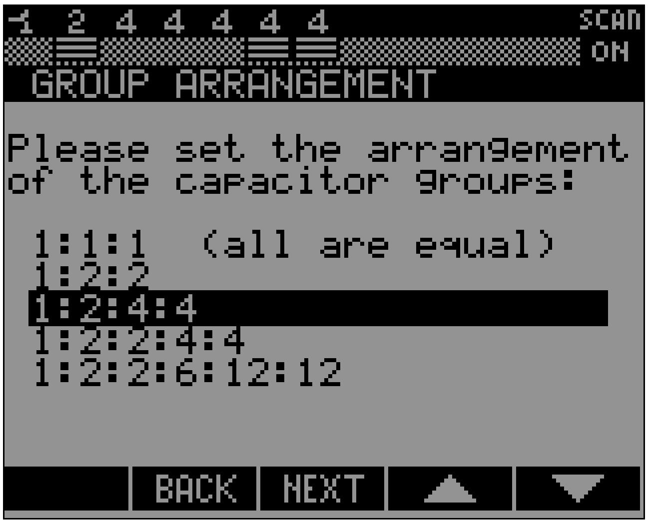


Figure 24: Group Arrangement

[10] Step Size

Use this parameter to define the capacity (in kVAr) of each step.

Figure 25: Step Size

[11] Capacitor System's CT

Use this parameter to set the ratio of the system's CTs (E.g. 2000/5A).

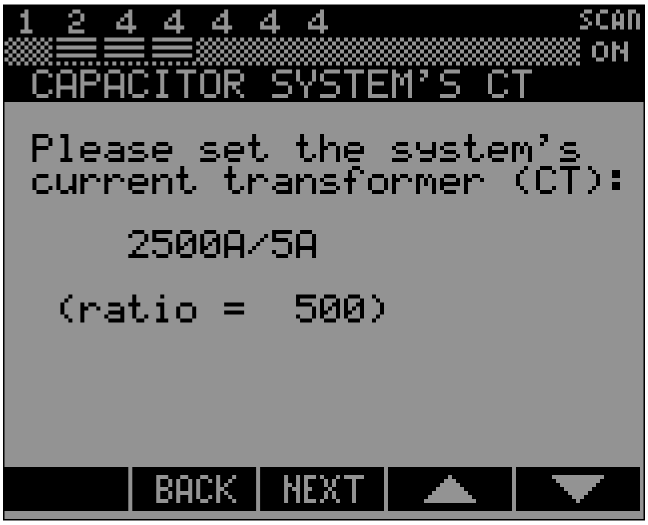


Figure 26: Capacitor System's CT

[12] Over Temperature Detector

Use this parameter to set the polarity (N.C./N.O.) of the over-temperature detector.

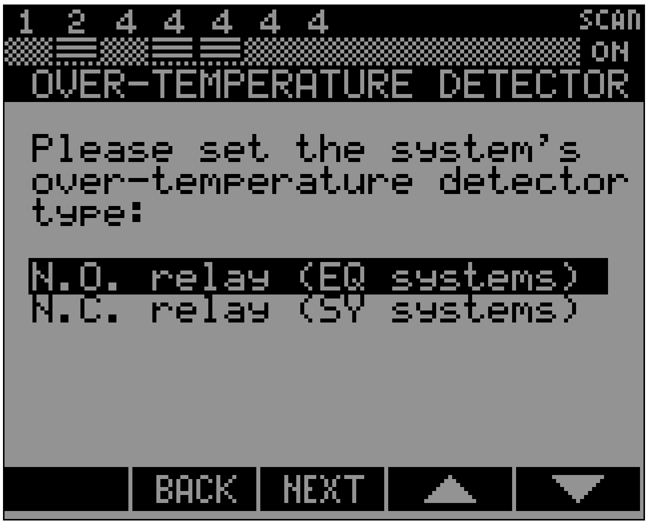


Figure 27: Over-Temperature Detector

[13] Error Detection

Use this parameter to temporarily inhibit detection of certain errors.

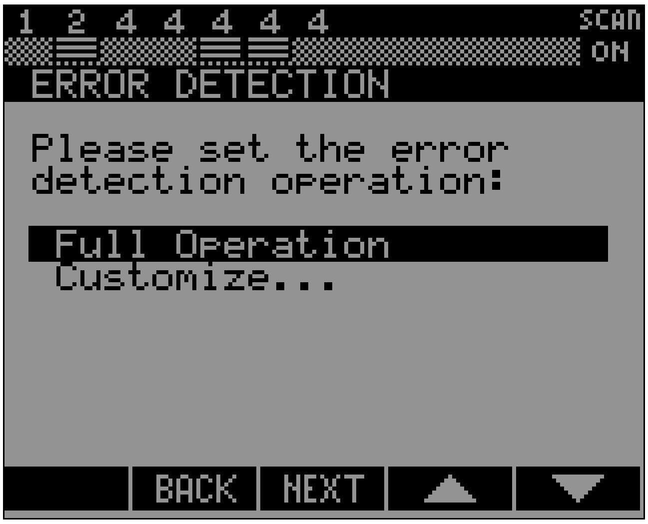


Figure 28: Error Detection

[14] System Structure Finalized

On completion, use this screen to either continue, or stop the Site Installation procedure.

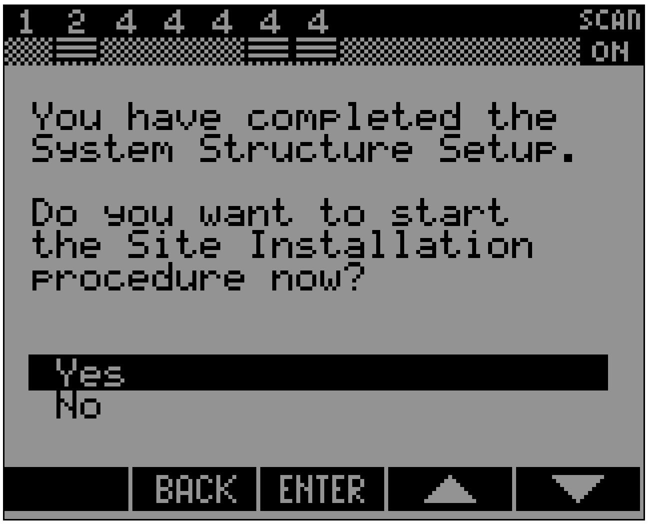


Figure 29: System Structure Setup Completion

[15] Welcome to the Site Installation

Figure 30 shows the first screen of the Site Installation.

If the Site Installation has already been completed before, there are two alternative for the site installation (Figure 31):

Review/Modify parameters: Allow viewing all parameters, and modifying only parameters that do not require activation of the self-diagnosis (e.g., Scan Mode, Target Power Factor). On changing a parameter that requires self-diagnosis a warning screen (Figure 32) prompts to start the complete Site Installation.

Repeat the installation Perform the complete Site Installation wizard.

Figure 30: Site Installation Welcome Screen

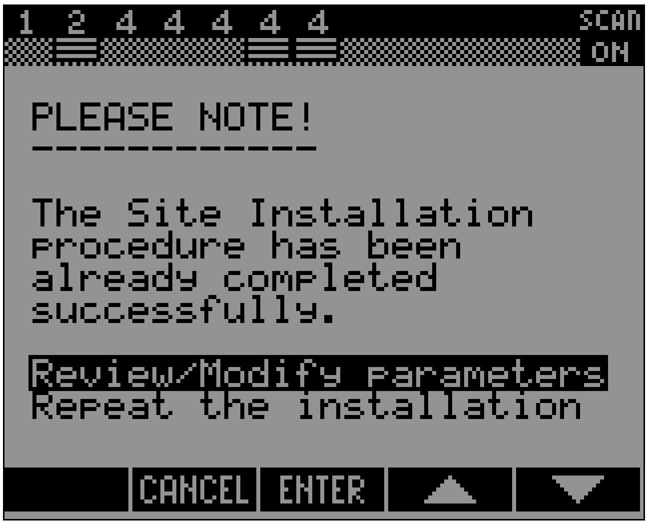


Figure 31: Site Installation Type Selection

Figure 32: Run Site Installation Warning Screen

[16] Date & Time Setting

Use this parameter to modify the current setting of the date and the time.

On system option "S" continue to step [22]. On system option "T" continue to the next step or continue to step [20] for all other options.

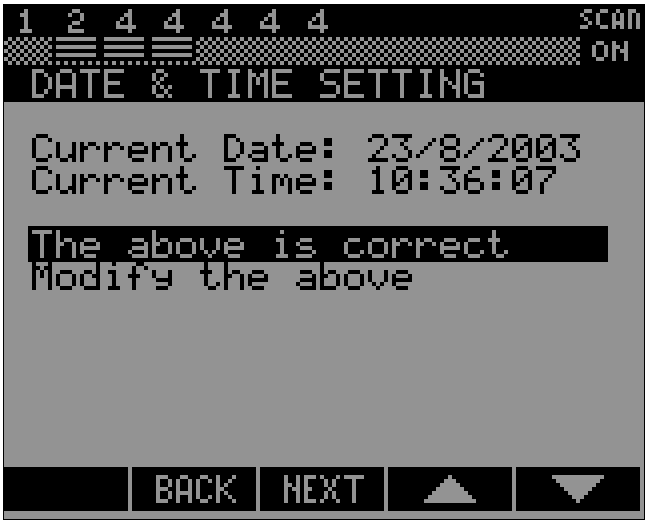


Figure 33: Date & Time Setting

[17] Network Nominal Voltage

Use this parameter to set network nominal voltage. If "Upstream MV transformer" was set at step [5] (page 26), continue to the next step. Otherwise skip to step [19].

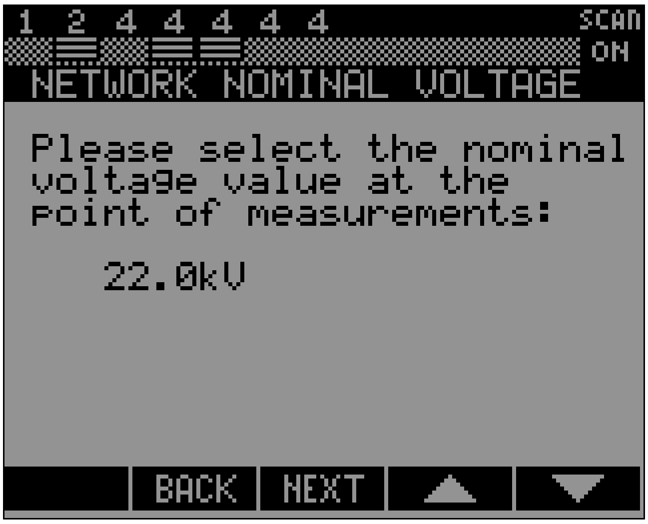


Figure 34: Network Nominal Voltage

[18] PT Secondary

Use this parameter to set the system's PT secondary voltage. In a three-phase system, the voltage is line-to-line.

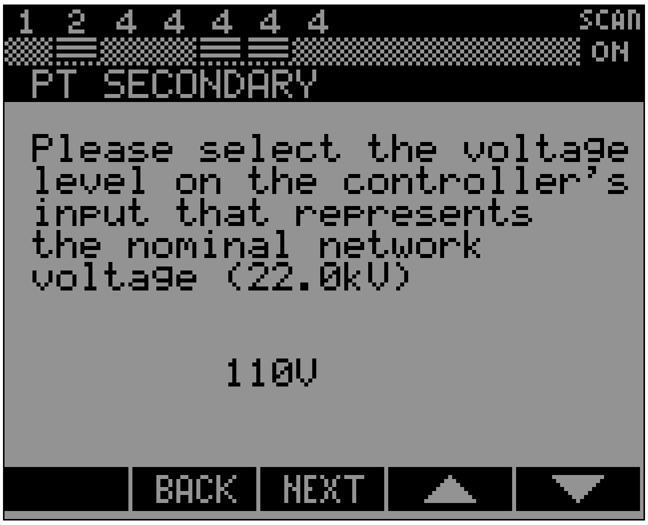


Figure 35: PT Secondary

[19] Sampling Configuration

It is possible to shift all input channels by different phases. Typically, phase shifts are created by transformers, such as Delta/Wye.

WARNING

Changing the phase shifts affects all system performance and must only be done after an express instruction from Elspec.

Each channel has its own shift parameter, but all three phases of same channel share the same shift value: voltages, mains current and capacitors current. There is no need to shift all three channels simultaneously so at least one of the values shall be set to 0. The value is in degrees and positive value represents delay in the phase. For example, for Delta/Wye transformer with mains current connected at the primary but voltages and capacitor currents connected at the secondary, set mains current shift to -30.94 (the values are in steps of 2.8° and -30.94 is the closest value to -30.0) and voltage and capacitor current phase shift to 0. If also the voltages are connected at the primary, set the voltages and mains current phase shift to 0 and capacitor current phase shift to 30.94.

Figure 36 is used to enable (“Special”) or disable (“Standard”) the shift function. If “Standard” is selected, Figure 37 through Figure 39 are skipped.

Figure 36: Sampling Configuration

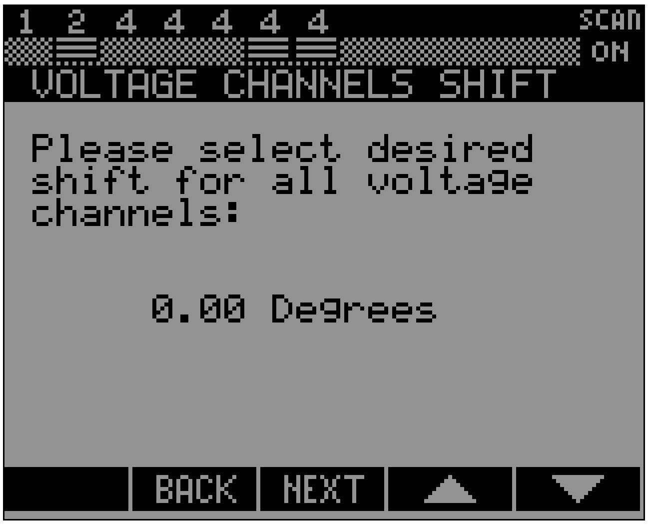


Figure 37: Voltage Channels Shift

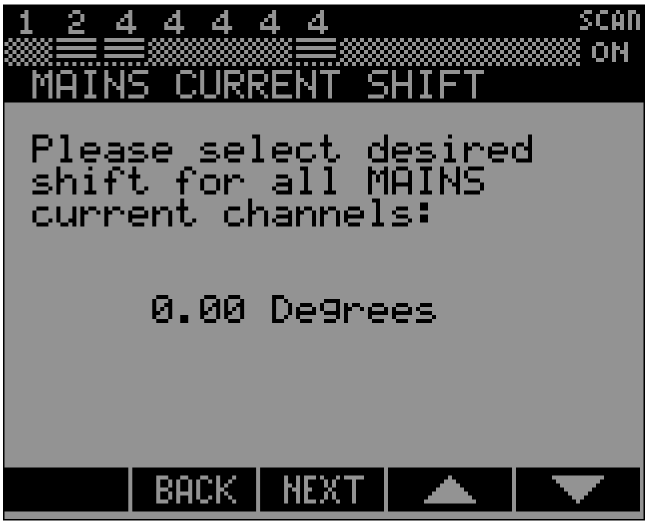


Figure 38: Mains Current Shift

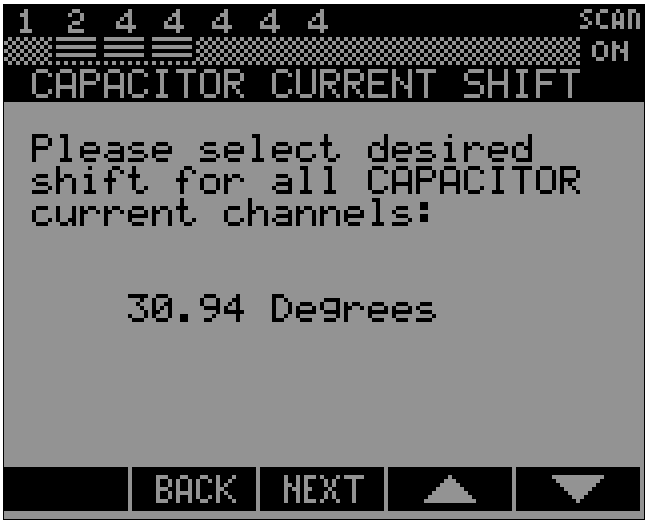


Figure 39: Capacitors Current Shift

[20] Main Feeder Type

Use this parameter to select feeder type, according to the transformer's secondary structure of the feeder transformer - either WYE (star) or DELTA. Continue to step [22] for Wye secondary or continue to the next step for Delta secondary.

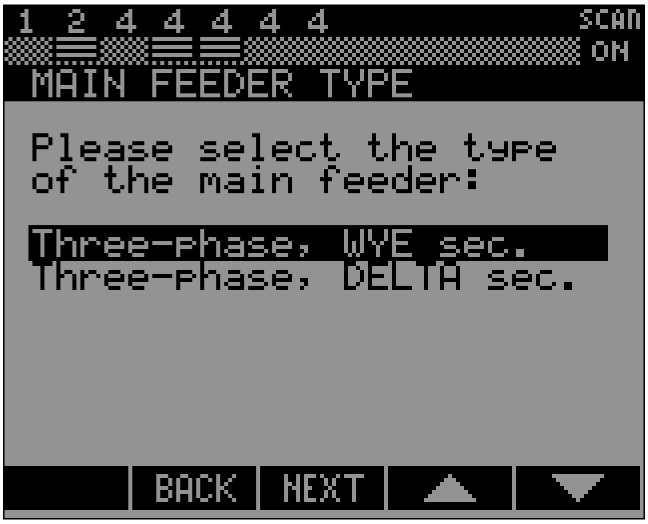


Figure 40: Main Feeder Type

[21] Main CT Connections

Use this parameter to define the number and location of CTs on the Mains. In 2 CTs configuration the third phase is calculated by assuming that the total current of all three phases is zero.

Figure 41: Main CT Connections

[22] Network CT Type

Use this parameter to define whether the Main CTs read the current of both the system and the load or of the load only.

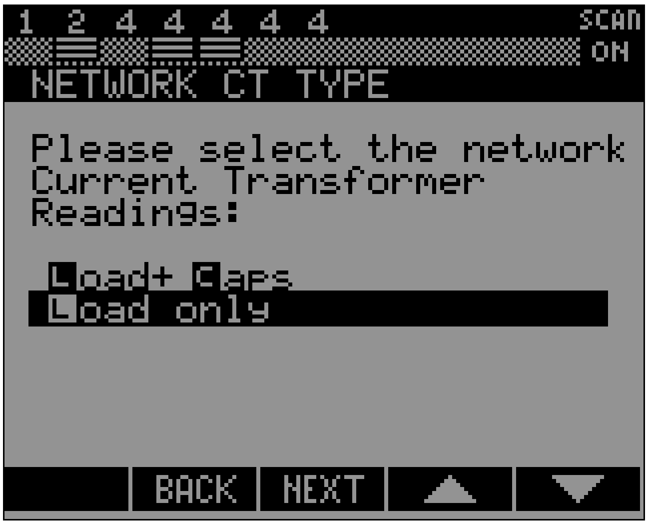


Figure 42: Network CT Type

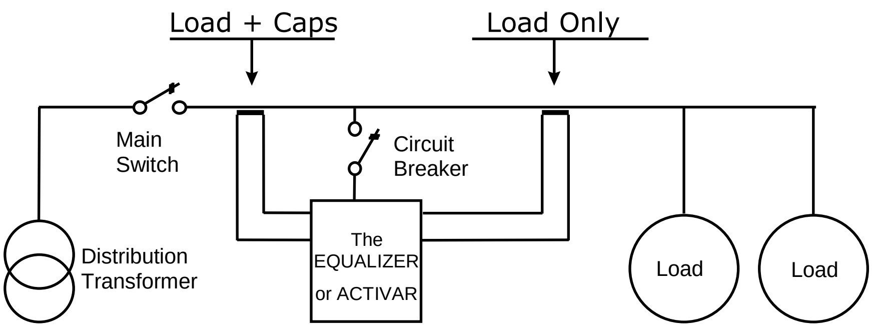


Figure 43: Network CT Type

[23] Self-Diagnosis

The Site Installation procedure runs a self-diagnosis routine, in which all the groups are connected, one by one, and all network information is observed (Figure 45 through Figure 48). If the Site Installation is in "Review/Modify" mode (step [15]) it is possible to skip the self-diagnosis step (Figure 44).

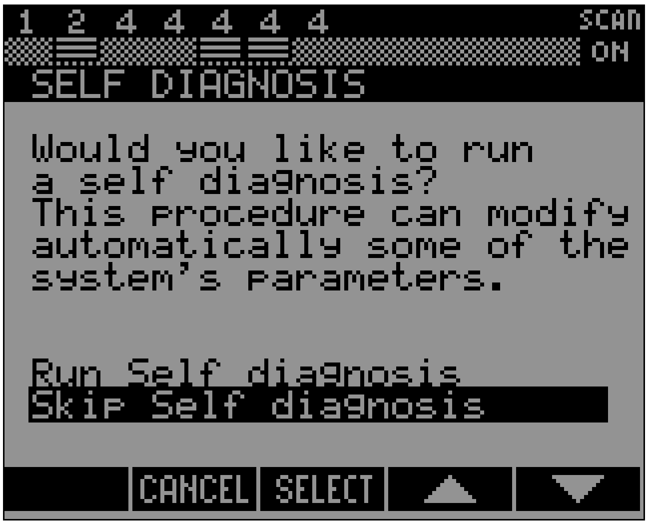


Figure 44: Self Diagnosis

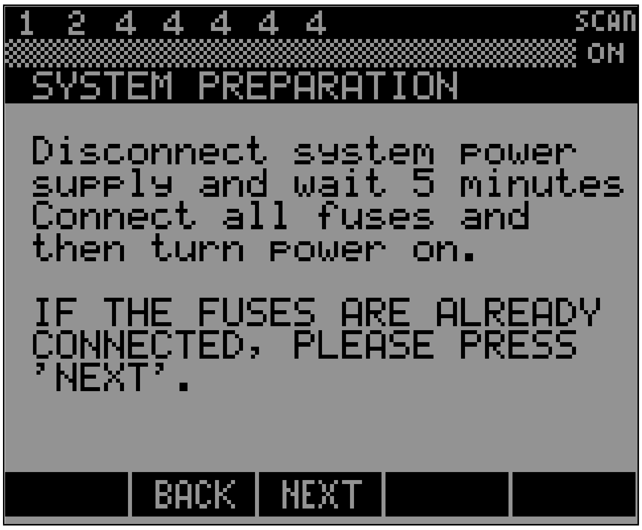


Figure 45: System Preparation

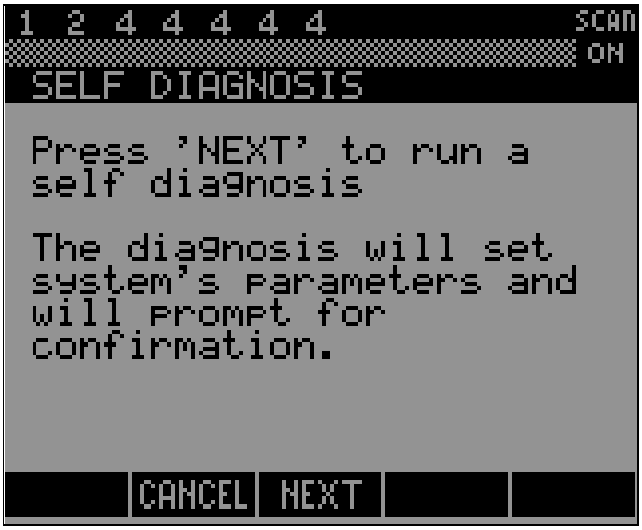


Figure 46: Self Diagnosis Launch

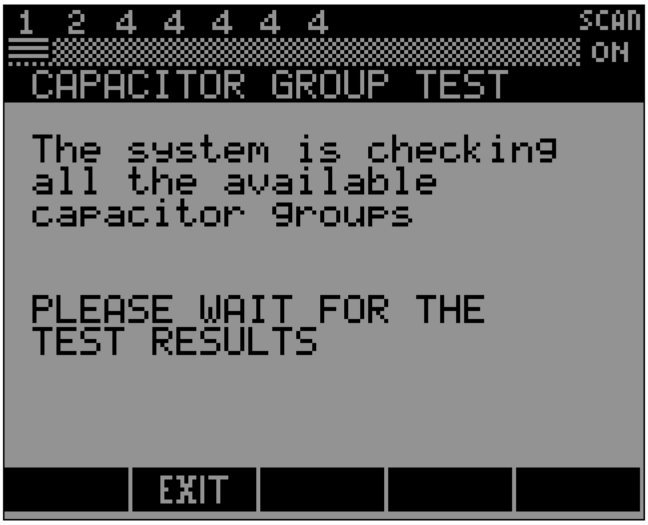


Figure 47: Capacitor Group Test

The self-diagnosis routine verifies voltages, frequency, number of groups, groups' arrangement and capacity (kVAr), as well as CT connection and setting (in Load+Caps network CT type only).

Since only the fuses of the first group are connected at this point, the self-diagnosis function will open a screen as shown in Figure 48, indicating that some groups are not OK. Select "See Test Results" and verify that the first group is of the correct capacity. Then exit the "Test Result" screen and select "Continue Installation" to proceed.

If the system does not detect any valid group, an error message will appear (see Chapter 9 – Troubleshooting).

Figure 48: Faulty Capacitor Groups were found

[24] Setting of Mains CTs

Use this parameter to set the Mains CTs input. If you wish to use a …/1A CTs, set the CTs ratio, however this will have an adverse effect on system accuracy.

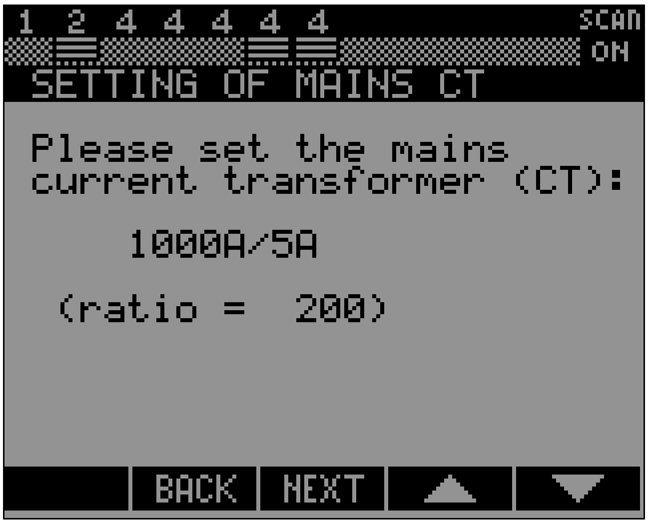


Figure 49: Setting of Mains CT

[25] Mains CTs Polarity

Use this parameter to set the polarity of the Mains CTs. The objective is to see positive active energy readings (kW) on all 3 phases. Any of the three phases that will show a negative reading can be corrected by scrolling to the corresponding row, using **F4** (▲) and **F5** (▼), and pressing **F3** (Select). If there is significant difference between the phases (e.g. more than 20%), it is more likely that there is problem with the phases than with the polarity (refer to Chapter 9 - Troubleshooting).

This parameter can be set when there is load connected and consuming power, so there are power readings and the polarity is observed. In a situation like shown in the figure below, where there is no power consumption, the polarity should be arbitrarily set to "Normal" on all 3 phases (assuming a correct polarity connection of the CTs on the mains). At a later stage, before activating the system, the right polarity should be verified when there is load, by viewing the 3-phase active power readings on "Main", to see that all 3 phases show positive reading. If any of the phases show a negative reading, run "Site Installation", get to "Mains CTs Polarity" parameter setting again and reverse the polarity of the relevant CT(s).

For system types "S" or "U" continue to step [34].

Figure 50: Main CT Polarity

[26] Automatic Operation Mode:

Automatic power factor compensation is normally based on the normal average of all three phases of the entire load. Use this menu to enable other modes (e.g. ignoring one phase or compensating 50% of the load). The "Other…" option depends on system type.

On selecting the first item, continue to step [33] for system option "P" or to step [34] for other system options. On selecting the second item, continue to the next step for system option "W" or continue to step [30] for all other options.

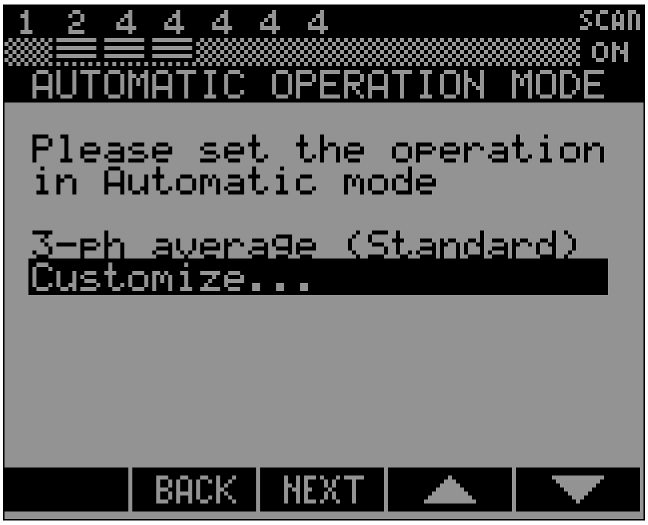


Figure 51: Automatic Operation Mode Setup

[27] Generator version [G], secondary power factor

This version has a secondary power factor needed when the demand is supplied by a generator. Generators operate with a lower power factor (around 0.8).

On the screen shown in Figure 52, you can disable the auxiliary target power factor or enable it. When you choose "Enable – NC", the system works with auxiliary power factor mode when the controller has 24V DC on its inhibit signal connector.When you choose "Enabled – NO", the system works at normal or primary target power factor when the controller has 24V DC.

In Figure 53, you see the screen where to set the auxiliary target power factor value.

Each time the system is switched from primary to auxiliary target PF or vice versa, one event is recorded in the controller.

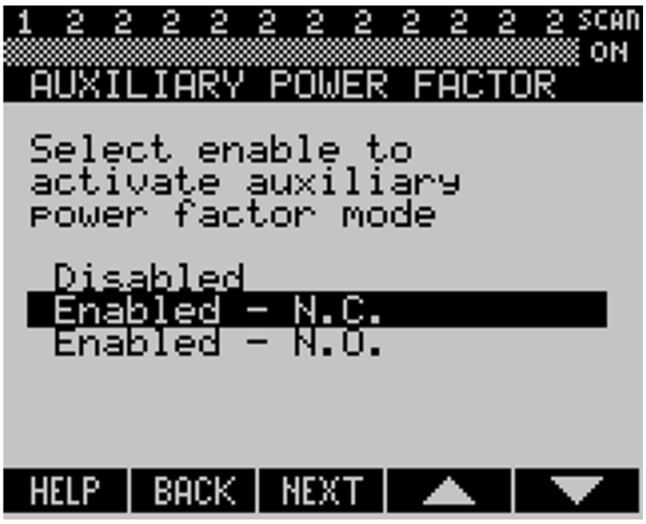


Figure 52: Auxiliary power factor mode

Figure 53: Auxiliary power factor target

[28] Equalizer ST system – Large motor start up

The next screens are only available in the "D" version. The target for this version is to help the network to withstand the large motor start up demand. *<u>This system is not designed to work continuosly like common Equalizer systems.</u>*

The parameter in Figure 54 is in accordance with the motor start up time that the system is going to compensate. After working during the motor start up time, the system needs to wait to cool itself during the time that you have configured in Figure 55. This system is designed to work with a duty cycle of 5%. This means that if the ON time for motor start is 10 seconds, the system must wait a minimum time of 190 seconds until the next operation cycle.

These two parameters ("Maximum Caps ON Time" and "Minimum Cooling Time") are configured in the plant at the final test time and they can't be changed afterward. Therefore, it is very important to order the correct device with the appropriate start up time of the motor.

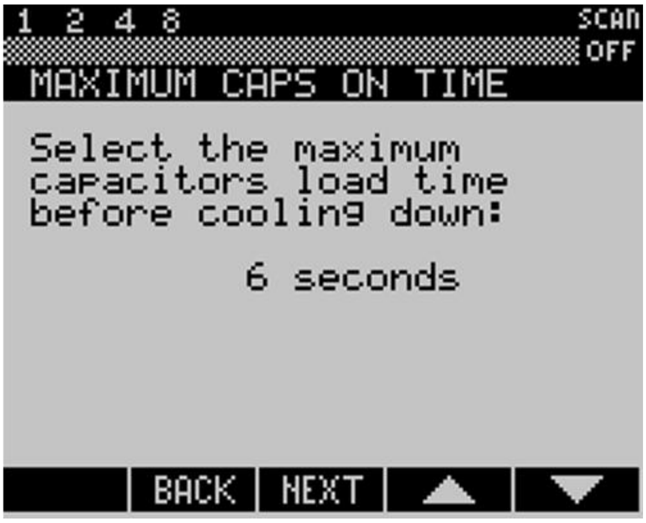


Figure 54: Maximum Caps On Time

Figure 55: Minimum Cooling time

The system has two modes of operations as shown in Figure 56:

KVAr Threshold; when the network demands more reactive energy than it is configured in Figure 57, then the system compensates the load. The system will cease compensating upon reaching 90% of the threshold value.

By external signal; this mode requires one communication card with inhibit signal entry. The system will start to operate upon receiving the inhibit signal, provided however that there will be a demand for reactive power compensation. The inhibit signal must be active during the above mentioned “Maximum Caps ON Time”.

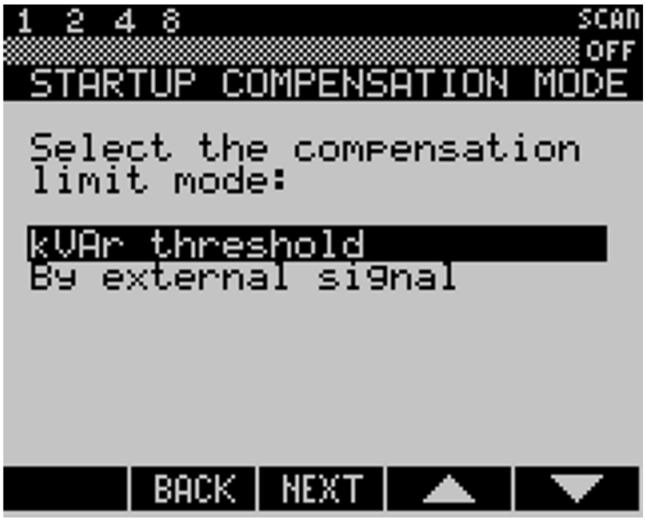


Figure 56: Start up Compensation Mode

Figure 57: KVAr Threshold

For example in the threshold mode, after the system has been working 20 seconds (this value must be set to the MAXIMUM CAPS ON TIME screen). It will show for 380 seconds (as set in the MINIMUM COOLING TIME step in relation with the 5% duty cycle) the screen shown in Figure 57. On this screen there is information about the time left until the next operation cycle (last line).

The system will stop when the load is below 90KVAr or when the MAXIMUM CAPS ON TIME value has been reached, whichever occurs first.

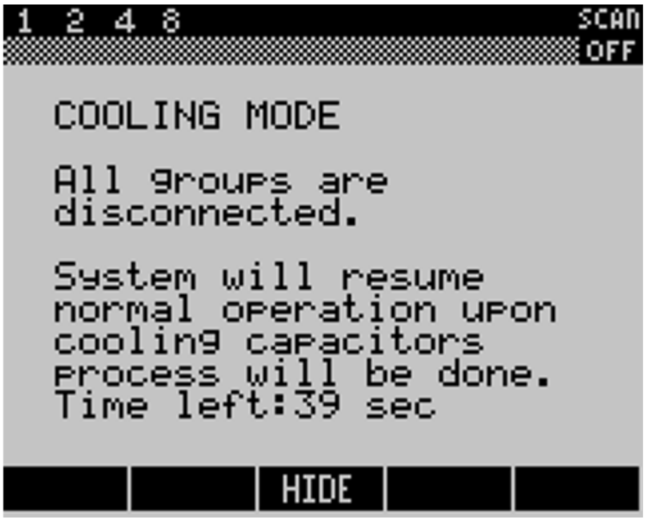


Figure 58: Cooling Mode

[29] Control Operation Mode

Use this parameter to select between different compensation control modes. (Only for [W] and [V] software versions).

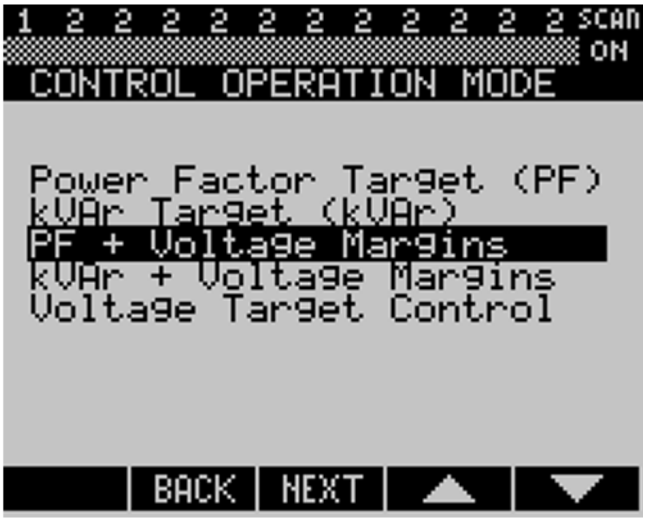


Figure 59: Control Operation Mode

[30] Compensation Mode

Use this parameter to select between different configurations of single and multiple system compensation.

Full load control means that it is a stand alone system, while the other two options are when more than one system reads the same current and voltage. In this case, each system should compensate part of the load. For this purpose there are two modes:

Load Sharing Each system compensates its part, regardless of the other system/s. If another system fails, the system continue the same and only part of the load is compensated.

Cascade Each system compensates its part, and if another system fails the system increase its compensation to recover the other system, up to maximum full system reactive energy is connected. However, the control logic in this mode is 1 cycle average, compared to 1 cycle maximum in other modes.

On selecting the first item, continue to step [32], otherwise continue to the next step.

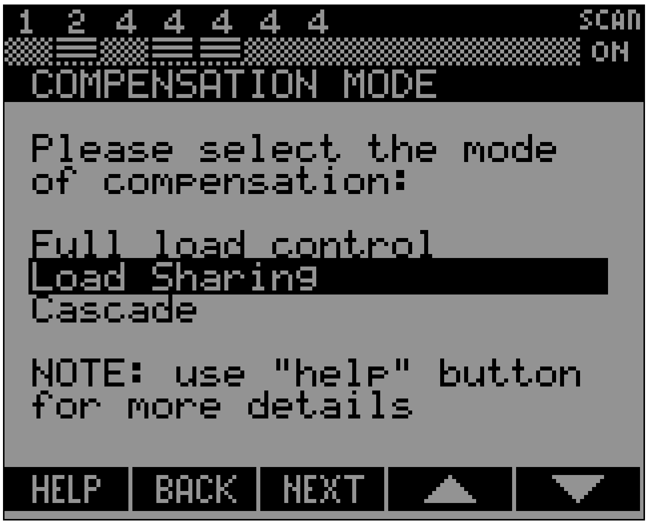


Figure 60: Compensation Mode

[31] Partial Load Compensation

Use this parameter to set the relative part the system will compensate in a multiple system configuration.

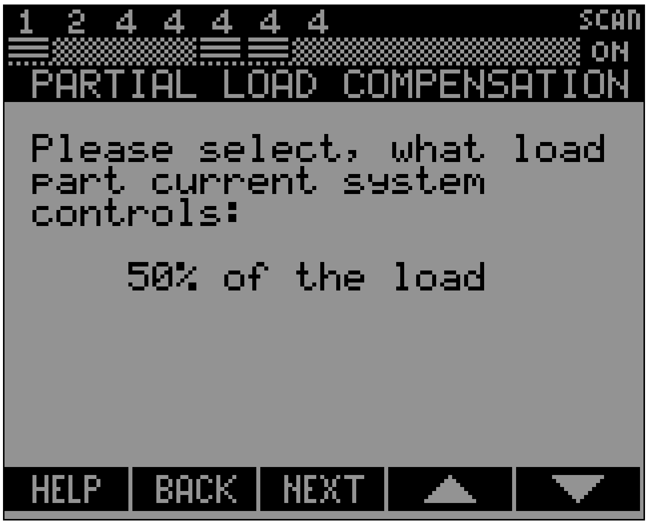


Figure 61: Partial Load Compensation

[32] Active Phases for Control

Use this parameter to determine which of the measured phases will be a part of the control mechanism.

For system option "P" continue to the next step; Otherwise continue to step [34].

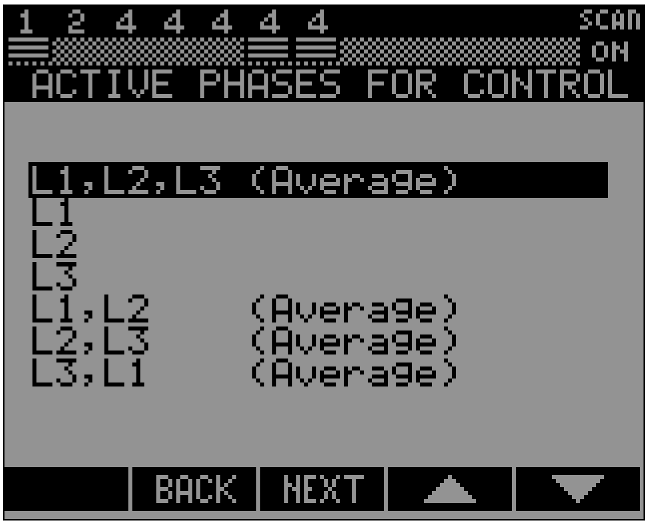


Figure 62: Active Phases for Control

[33] Pulse Synchronized Compensation

Used for close to zero-delay reactive control of the single welder equipment.(Requires welding start and stop signal provided by an involved welding controller). The 24V DC active high signal goes active at a fixed time before every welding batch starts and goes inactive prior to the batch stop. The time delay must be more than 20 ms and should be synchronized with the voltage lines. This means at least 20 ms from the same phase.

The operational theory is based on the fact that the welding cycles/batches for the same welder and the same conditions are more or less similar to each other; it is possible to "study" the single process shape and to connect capacitors according to preset previous batch without actual measurement of the actual reactive demand. The operation can be triggered by an external signal which will signal upcoming welding processes. Upon detection of the external trigger, the compensator can connect the number of capacitors steps calculated from the previous operation. In this case the "measurement" delay will be omitted and only the "connection" delay will play a role.

<u>The compensation accuracy depends only on the signal received from the welder machine.</u>

The "P" option may come with "S" single phase option for single (phase to neutral or phase to phase) applications.

Hardware Requirements: Communication Card is mandatory with 24V digital input (inhibit signal).

The options are:

No Synchronization	The system compensates as a standard system, without a synchronizing pulse.
Sync. To Start and length	Only special cases. Don’t use without Elspec advice.
Sync. To Start and Stop	The signal will be ON during all the welder cycle.

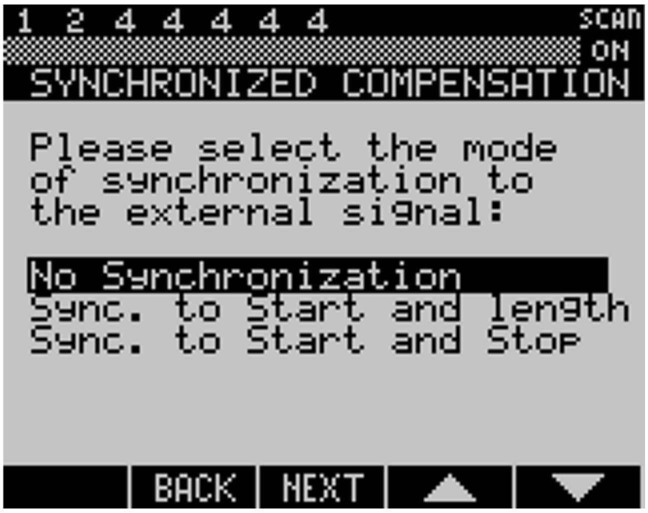


Figure 63: Synchronized Compensation

[34] Scan Mode

Use this parameter to activate or de-activate the Scan mode.

With Scan mode activated, all capacitor groups are connected and disconnected continuously. This mode enables uniform utilization of the capacitor groups and therefore reduces the average current of each group by the ratio of the number of groups connected to the total number of groups.

For example, for a six-capacitor group bank with a nominal current of 100 A per group, the actual current is 120 A per group because of the harmonics present. With Scan mode inactivated, the groups that are on will be loaded by 120%. Assuming that only 3 groups are required, each one of the six groups will carry an average current of

$120A \times \frac{3groups}{6groups} = 60A$, which is 40% less than the nominal.

Note that, when the system connects and disconnects groups in automatic mode, the Scan Mode is temporarily disabled since the automatic mode connects and disconnects the groups in a circular order (FIFO, first in, first out), thus achieving the same functionality.

Figure 64 shows a typical scanning routine of three capacitor groups with a six-group capacitor bank.

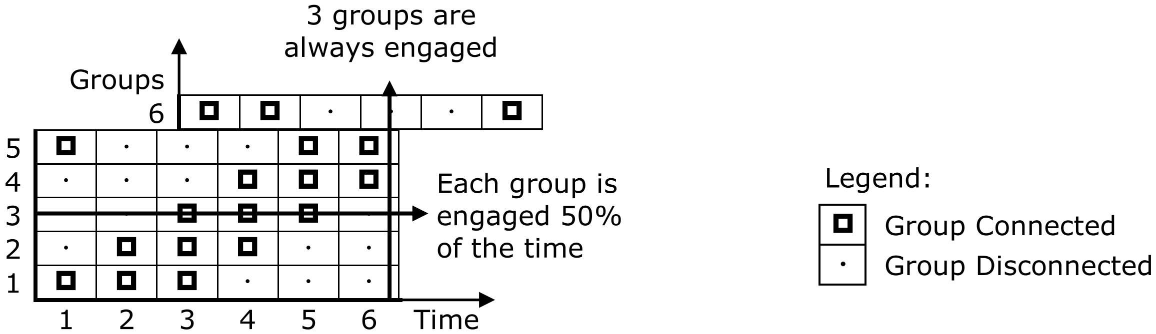


Figure 64: SCAN Sequence Example

Important note: in SCR/SCR system configuration the connection and disconnection of groups is NOT performed at the same time, which results with short time of both groups are connected. Since that, in applications where voltage flickering is important, set SCAN mode to “off”.

Figure 65: Scan Mode

[35] Target Power Factor / Target kVAr

Use this parameter to set the Target Power Factor or kVAr in Automatic mode compensation (this parameter is also directly accessible through “System Setup” menu). kVAr compensation is available in system options "W" and “V” selecting between PF and kVAr control is done at step [27].

For Power Factor, the value is displayed in percent (e.g. 97.5% for 0.975), and a value greater than 100% represents capacitive load (leading), i.e. a value of 102% is 98% leading (or 0.98 capacitive).

For kVAr, positive value means supplying reactive energy to the network (over-compensation).

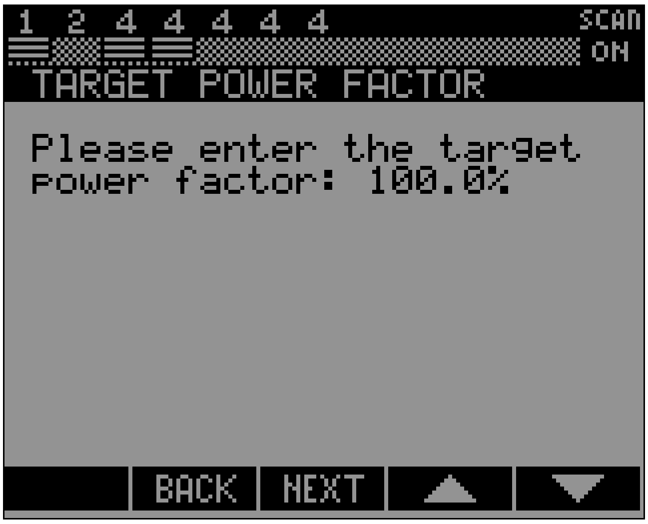


Figure 66: Target Power Factor

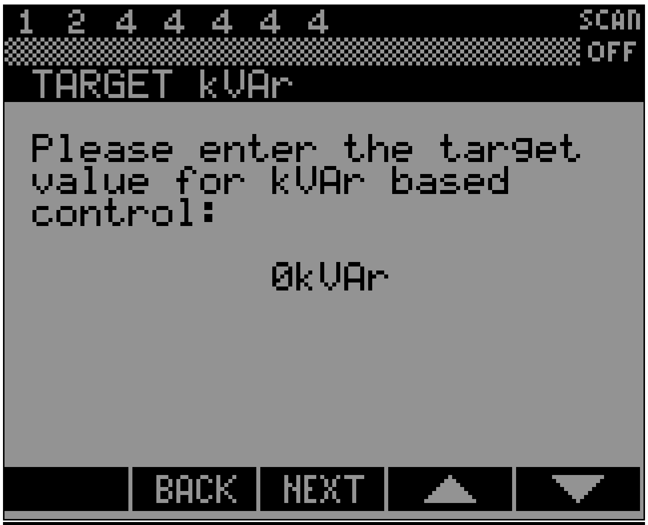


Figure 67: Target kVAr

[36] Step In and Out concept

The compensation system connects and disconnects step-wise, while the network Power Factor and Reactive Energy is continues. The In/Out algorithm controls the connection and disconnection of steps, with regards to the operator preferences.

This includes two parameters:

In/Out Threshold

Insignificant fluctuations in the reactive energy demand, as well as inaccuracy of the CTs' reading, may cause the system to connect or disconnect a step when it is not required. This parameter defines the minimal change between connection and disconnection of a step, in percents from step size.

Power Factor Mode

This parameter determines whether the Target Power Factor is kept as a maximum, minimum, or average as follows:

Minimum mode: The Power Factor will generally be the same or higher than the programmed value. The actual kVAr will be less than the required by maximum "In/Out threshold" and more by maximum one step size.

Maximum mode: The Power Factor will generally be the same or lower than the programmed value and will never overcompensation. The actual kVAr will be less than that required by maximum one step size and more by maximum "In/Out threshold".

Average mode: The Power Factor will be as close as possible to the programmed value, either from below or above. The actual kVAr will be less than that required and more than that required by maximum half step size plus half "In/Out threshold".

Figure 68 through Figure 72 show example of a network with four different configurations. The system step size is 100kVAr and the requirement increases from 100 kVAr to 215 kVAr, than back to 150 kVAr and remains at 150 kVAr with minor changes due to CT inaccuracy. The calculated kVAr (amount of kVAr to connect calculated by the control mode) is marked as ♦, the actual connected kVAr are marked as ■ and the difference between them (compensation variation) is marked as ▲. The light vertical lines show the margins between connection and disconnection of a step.

The difference between Figure 68, Figure 69 and Figure 70 is the value of the In/Out threshold. With the 50% value there are minimal changes is the connected capacity but larger differences between the target value and the actual. With the 5% threshold there are useless connections and disconnection at the end while the 20% works best in this example.

The difference between Figure 70, Figure 71 and Figure 72 is the Power Factor mode. In the first the connected capacity is more or less the required, in the second it is always higher (with regards to the In/Out threshold) while in the third it is always less.

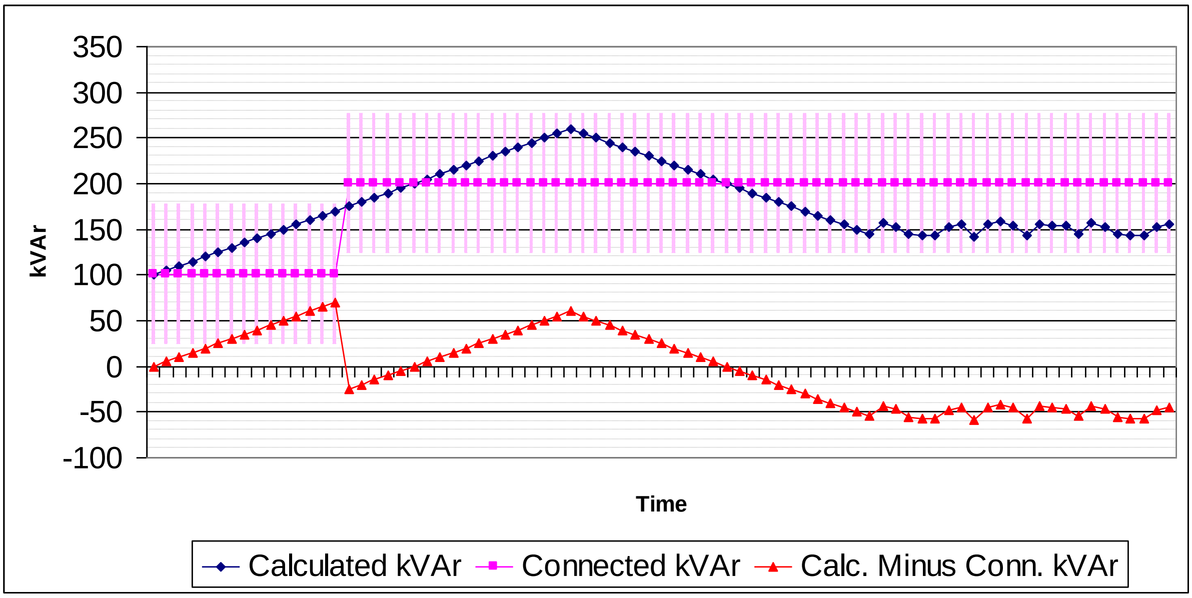


Figure 68: PF Mode <u>Average</u> with <u>50%</u> Threshold example

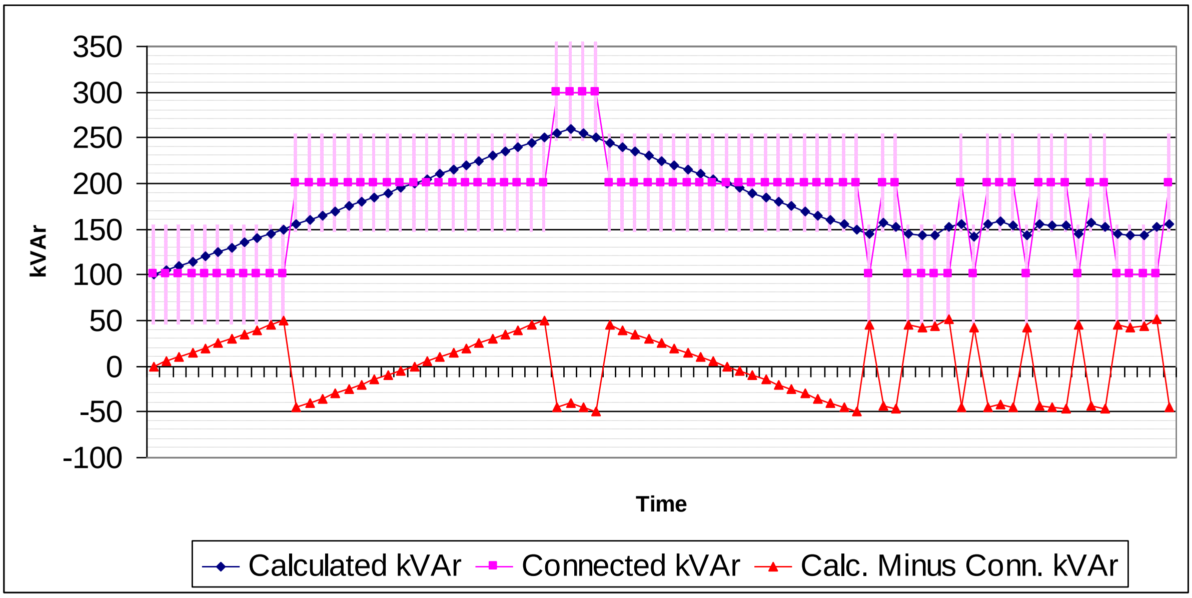


Figure 69: PF Mode <u>Average</u> with <u>5%</u> Threshold example

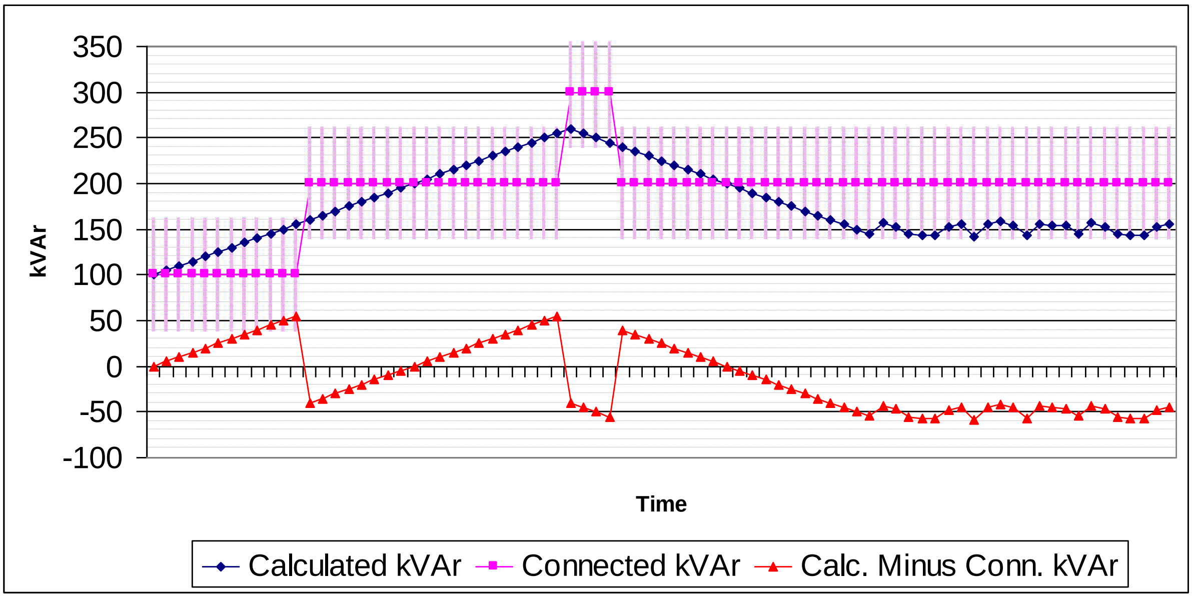


Figure 70: PF Mode <u>Average</u> with <u>20%</u> Threshold example

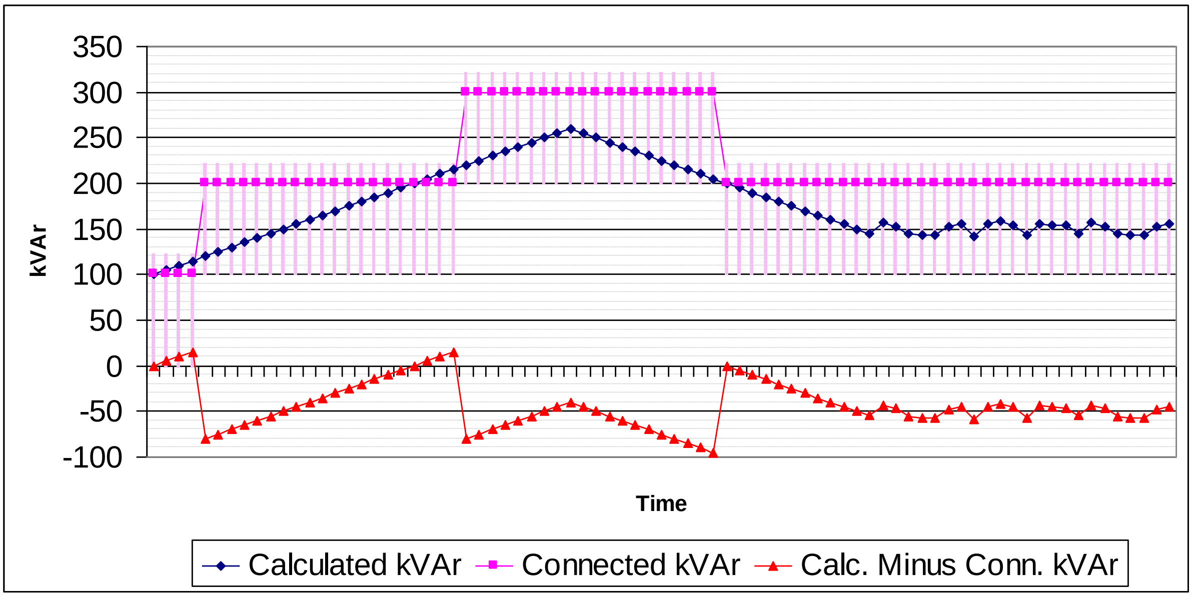


Figure 71: PF Mode Minimum with 20% Threshold example

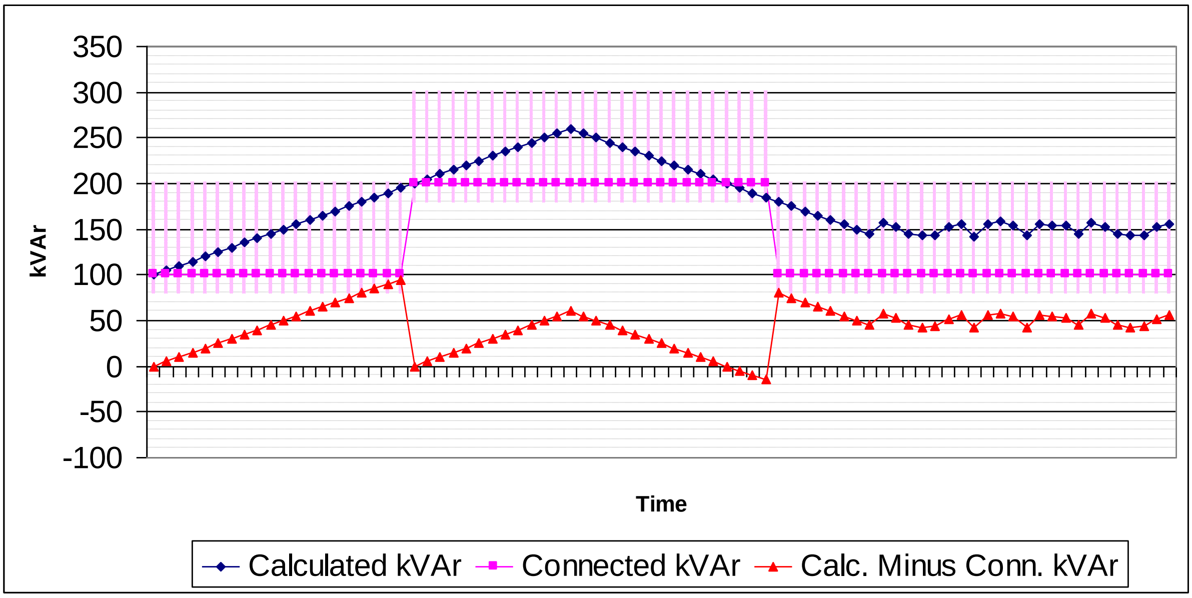


Figure 72: PF Mode Maximum with 20% Threshold example

The In/Out threshold setting, as shown in Figure 73, depends on the CT accuracy, step size comparing to the CT full scale and, possibly, small changes in the load that should be ignored. Higher threshold will cause larger maximum deviations from programmed value and smaller threshold will potentially cause more unwanted connections and disconnections.

The Power Factor mode, as shown in Figure 74, should be set to Average for most installations.

In firmware version 2.X (SCR/Diode Switching Module) the In/Out Threshold is fixed to 50% and only minimum and maximum PF modes are available.

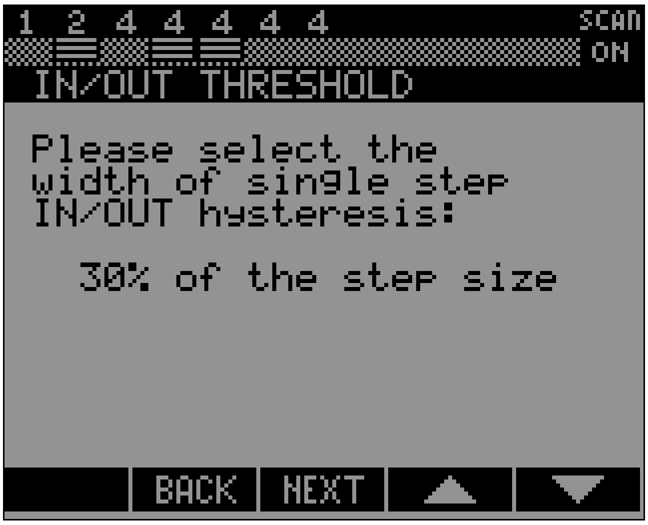


Figure 73: In/Out Threshold

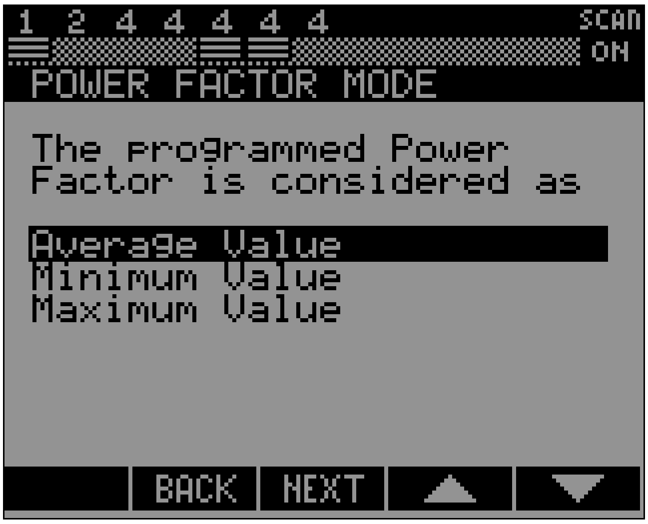


Figure 74: Power Factor Mode

For system option “W” continue to the next step, for system option “V” continue to step [39] or continue to step [48] for other options.

[37] Upstream Compensation

Upstream compensation is used for compensating the upstream transformer in addition to the normal Target Power compensation. The controller multiplies the active power (KW) by the compensation factor and adds the result to the amount of KW to compensate, and compensate it together. This function is useful for making up voltage drops due to active consumption.

Setting of upstream compensation is showed in Figure 75 and Figure 76.

Figure 75: Upstream Compensation

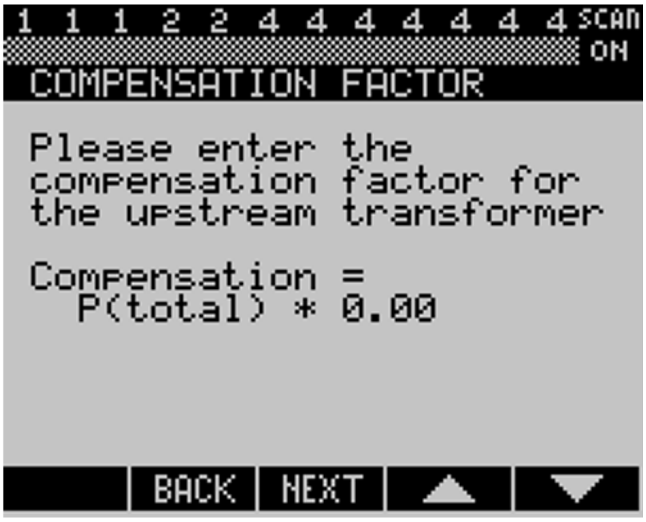


Figure 76: Compensation Factor

For system option “W” continue to the next step, for system option “V” continue to step [39] or continue to step [48] for other options.

[38] Inhibit Signal

Use this parameter to enable or disable the “Inhibit signal” function. The “Inhibit signal” is an external 24Vdc signal that allows external pause of system operation in Automatic mode.

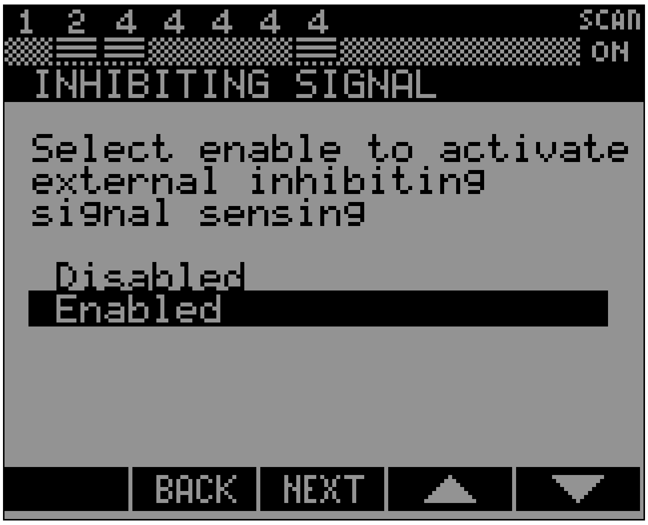


Figure 77: Inhibit Signal

[39] Voltage Control

During power factor control and grid drop mode, voltage control is necessary to limit the grid voltage to a safe limit. If the voltage exceeds the overvoltage parameter value, the power factor shall shift towards the inductive immediately.

If the voltage drops below the undervoltage parameter, the power factor shall shift towards the capacitive, hereby decreasing the voltage drop in the inductive part of the grid impedance.

The voltage control is complementary to the normal Power Factor or kVAr correction mode of operation. During normal voltage condition it is not in operation, while voltage levels goes too high or too low it adjusts the number of connected groups to reach safer voltage level, while the normal PF/kVAr control is still functional. Figure 78 shows the voltage control set points and their default values.

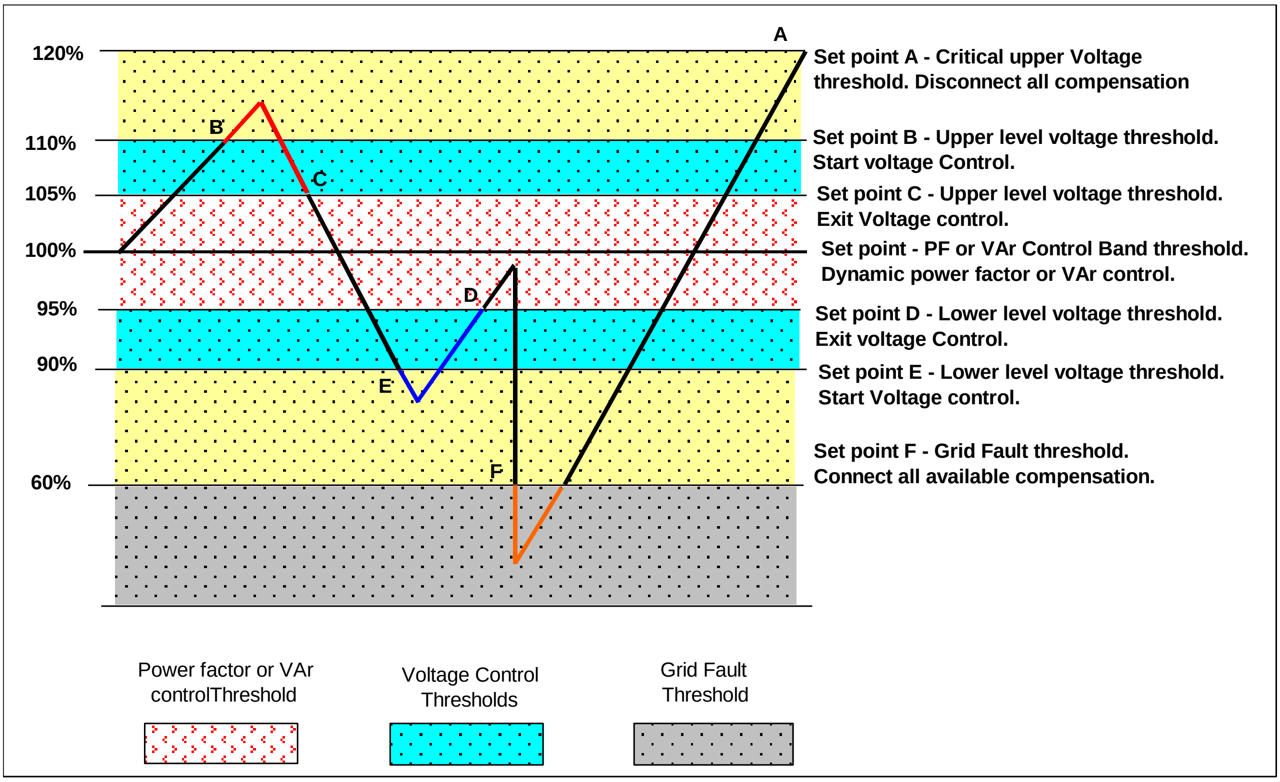


Figure 78: Voltage Control Set Points

The control algorithm calculates the number of steps to connect based on the following formula: $N = \frac{kVAr_{MEASURED} - kVAr_{PROGRAMMED}}{StepSize}$.

The $kVAr_{PROGRAMMED}$ is either the kVAr set value or

$kVAr_{PROGRAMMED} = kW_{MEASURED} \times TAN(\phi)_{PROGRAMMED}$.

The voltage control algorithm adds to the above value offset which adds or removes steps from the actually connected ones: Connected Steps = N + Offset.

The voltage control algorithm is divided into 7 sections, which are defined by 6 parameters. All these parameters can be set either from the system front panel or through the communication.

Voltage Condition	Control Operation	Firmware Operation
Exceeds maximum permitted level	Disconnect all steps	Offset = -∞
Maximum Safe Voltage Level (default = 120%)		
Too High	Deduct 1 from the number of steps to connect	Offset = Offset -1
Start Upper Voltage Control Level (Default = 110%)		
Slightly Too High	Continue previous state	Offset = Offset
Stop Upper Voltage Control Level (Default = 105%)		
Ok	Progressive Stop voltage adjustments	Offset = Offset ± 1
Stop Under Voltage Control Level (Default = 90%)		
Slightly Too Low	Continue previous state	Offset = Offset
Start Under Voltage Control Level (Default = 80%)		
Too Low	Add 1 to the number of steps to connect	Offset = Offset +1
Grid Drop Level (Default = 60%)		
Exceeds minimum permitted level	Connect all steps (after pre-defined number of cycles)	Offset = +∞

Figure 79: Voltage Control Parameters and Operations

The voltage control algorithm only operates in cycles in which there is no change in the normal control results, since typically load changes cause voltage level changes but they are compensated by the normal control.

Following is an example of the operation with step size of 25 kVAr and default voltage control levels (start at 80%, stop at 90%).

kVAr Demand Marked with ♦ with reference to the right axis in kVAr.

Voltage (%) Marked with ■ with reference to the right axis in percent from nominal.

Required Steps The number of steps calculated by the normal control operation. Marked with ■ with reference to the left axis.

Voltage Control Offset the offset of steps calculated by the voltage control algorithm. Marked with ▲ with reference to the left axis.

Total Connected Steps the actual number of steps connected to the network. (Total Connected Steps = Required Steps + Voltage Control Offset). Marked with * with reference to the left axis.

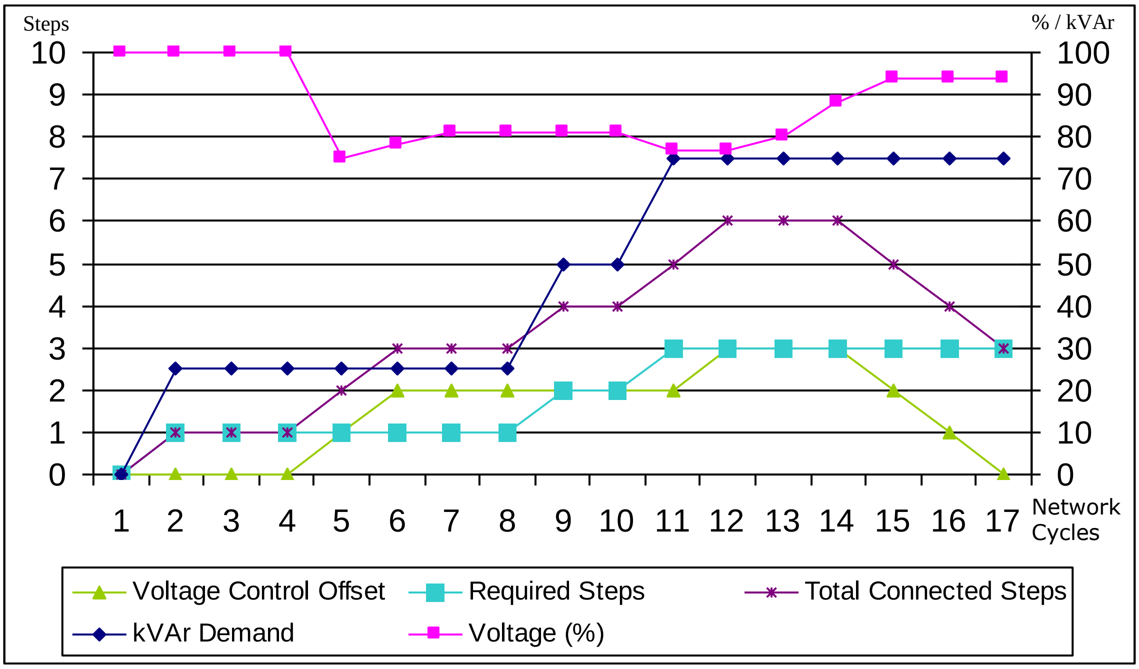


Figure 80: Voltage Control Example

All voltage control parameters, as described above, are set in the following setup screens (Figure 81 through Figure 90):

[40] Grid Voltage Control

Enables or disables all voltage control functionality (Figure 81). If the voltage control is enabled and the system type is "WT", continue to the next step. If voltage control is enabled on other system types continue to step [42] or continue to step [48] otherwise.

Figure 81: Grid Voltage Control

[41] Primary Voltage Control

System type "WT" allows additional voltage control for primary voltage. The readings of the voltage are done by external meter and sent to the controller via communication. The controller activates the voltage control algorithm, as described in step [39], once new voltage measurement set is sent to it (rather than once per cycle). When the primary voltage control in enabled, the upper and lower voltage control is performed comparing to the primary voltage while the maximum safe voltage and grid drop levels are controlled based on the normal voltage. Figure 82 activates or deactivates this function and Figure 83 sets the primary voltage value.

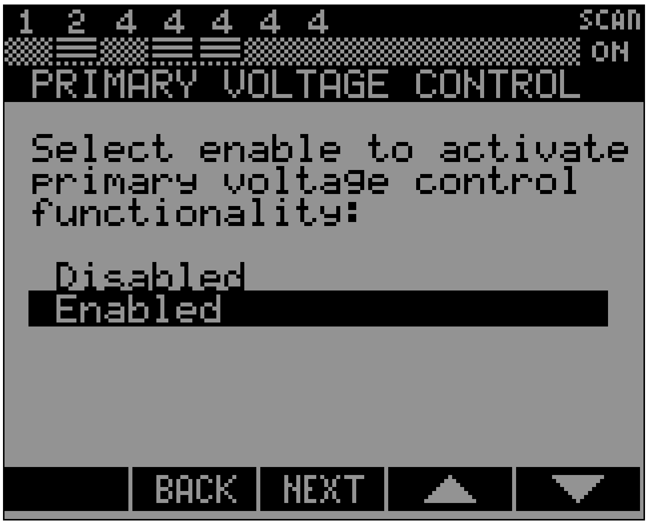


Figure 82: Primary Voltage Control

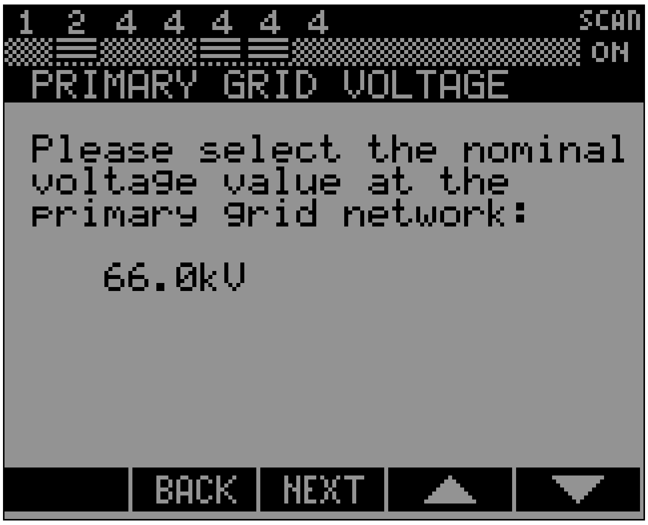


Figure 83: Primary Grid Voltage

[42] Maximum Safe Voltage

Allows setting of the maximum voltage in percent from the nominal voltage (Figure 84). The default value is 120% from the nominal voltage and the effective value is automatically calculated and displayed as well. When the network exceeds this voltage all capacitor groups are disconnected immediately. The system resumes to normal operation when the voltage reaches "Stop Upper Voltage Control" level.

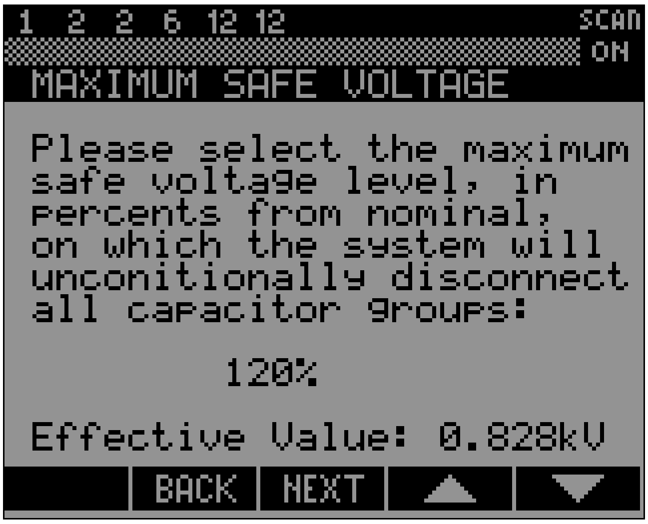


Figure 84: Maximum Safe Voltage

[43] Start Upper Voltage Control

Allows setting of the upper voltage level in which the system will activate voltage control (Figure 85). The value is in percent from the nominal voltage and the default value is 110% from the nominal voltage. The effective value is automatically calculated and displayed as well. Above this level the system will attempt to decrease the voltage level by disconnecting capacitor steps one by one (one step each cycle) until the voltage go below this value or all the steps are disconnected.

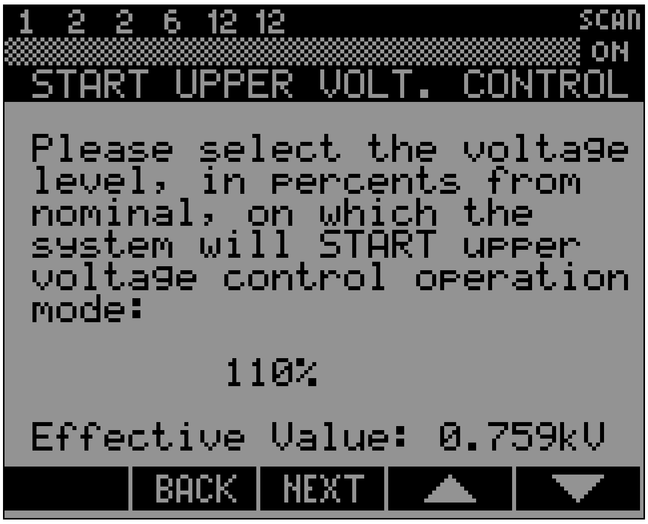


Figure 85: Start Upper Volt. Control

[44] Stop Upper Voltage Control

Allows setting of the voltage level in which the system will stop the voltage control (Figure 86). The value is in percent from the nominal voltage and the default value is 105% from the nominal voltage. The effective value is automatically calculated and displayed as well. Below this level the system will stop the voltage control and resume normal operation. This is done by connecting back the capacitor steps that were disconnected one by one (one step each cycle).

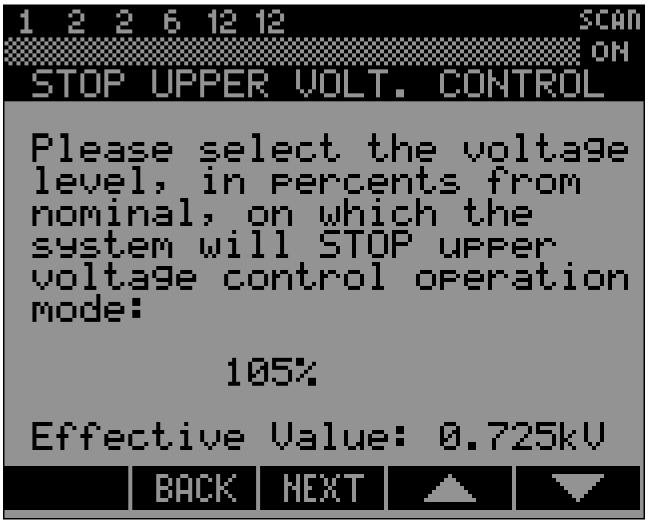


Figure 86: Stop Upper Volt. Control

[45] Grid Fault Level & Delay

Allows setting of the minimum voltage in percent from the nominal voltage (Figure 87). The default value is 60% from the nominal voltage and the effective value is automatically calculated and displayed as well. When the network exceeds this voltage for few network cycles (Figure 88), all capacitor groups are connected. The system resumes to normal operation when the voltage reaches "Stop Lower Voltage Control" level.

Figure 87: Grid Fault Level

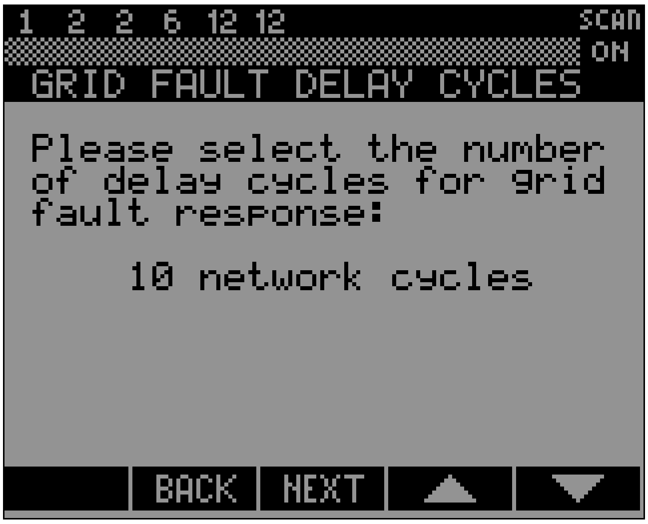


Figure 88: Grid Fault Delay Cycles

[46] Start Lower Voltage Control

Allows setting of the lower voltage level in which the system will activate voltage control (Figure 89). The value is in percent from the nominal voltage and the default value is 80% from the nominal voltage. The effective value is automatically calculated and displayed as well. Below this level the system will attempt to increase the voltage level by connecting capacitor steps one by one (one step each cycle) until the voltage goes above this value or all the steps are connected.

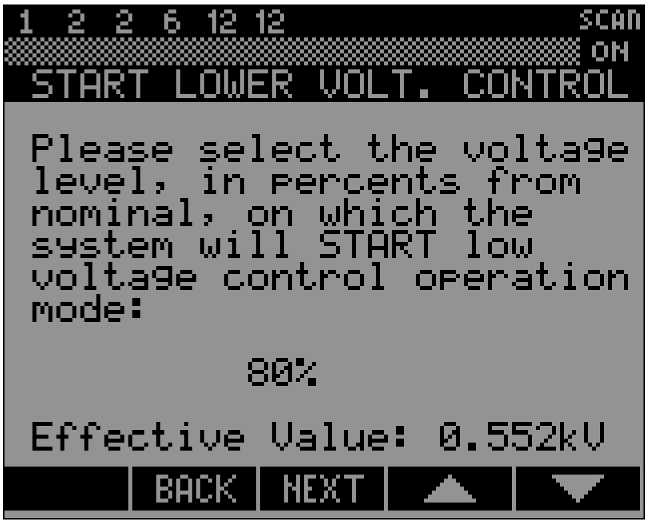


Figure 89: Start Lower Volt Control

[47] Stop Lower Voltage Control

Allows setting of the voltage level in which the system will stop the voltage control (Figure 90). The value is in percent from the nominal voltage and the default value is 95% from the nominal voltage. The effective value is automatically calculated and displayed as well. Above this level the system will stop the voltage control and resume normal operation. This is done by disconnecting back the capacitor steps that were connected one by one (one step each cycle).

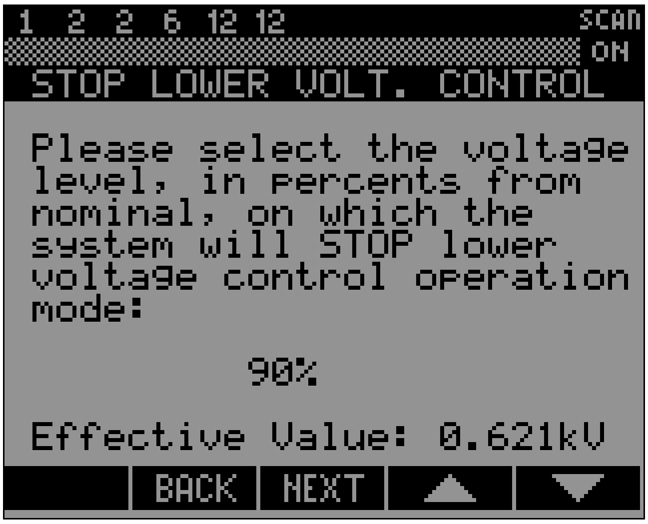


Figure 90: Stop Lower Voltage Control

[48] End of Site Installation

Informs a successful completion of the site installation:

Figure 91: End of Site Installation Screen

Testing of Other Groups

Run this procedure for each capacitor group:

(1) Disconnect cabinet's power supply voltage.

(2) Connect the fuses of the next capacitor group. See drawings in the pocket of this manual back cover or in the documents pouch inside the system for fuses location.

(3) Close and latch enclosure doors, then switch cabinet power up.

(4) Press **F1** (Mode) and use **F4** (▲) and **F5** (▼) to highlight "Perform System Test" option. Press **F3** (Select). The system will perform a built-in test (indicated by the word "TESTING" on the status line).

(5) On test completion, a Group Test Report will be displayed as shown in Figure 92.

(6) Use **F4** (▲) and **F5** (▼) to highlight the group under test. Press **F3** (Enter) and verify that the values detected match those expected. On any mismatch, troubleshoot according to instructions as listed in Chapter 9, "Troubleshooting".

(7) Repeat the "Testing of Other Groups" procedure for all other groups.

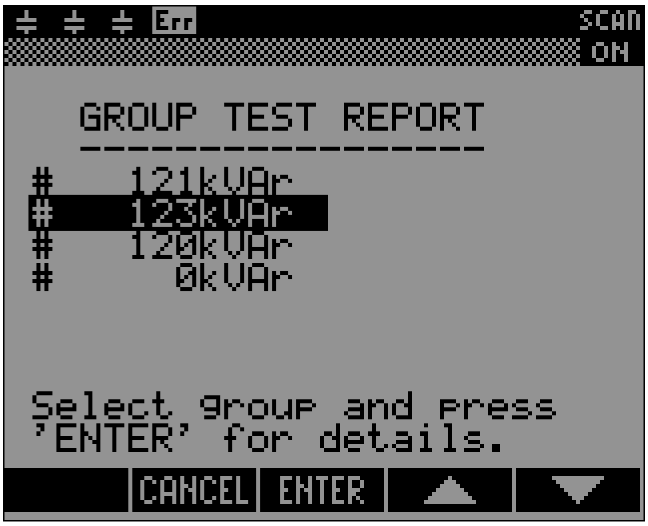


Figure 92: Group Test Report Screen (example)

Measurement Testing Procedure

Prior to setting the controller to the "Automatic Mode" & only once the system has successfully completed the "System Test" for all the groups during the "Manual Mode", you will need to verify whether or not the controller is in actual fact reading the measurements. This is done by completing the Measurement Testing Procedure:

- On the controller proceed to **LCM Total kVAr Meters & select the "F3 Menu"**
- Select **LCM Combined ➜ F3 Enter ➜ Total kVAR Meters ➜ F3 Enter**
- The **LCM Total kVAr Meter** screen (Figure 93) will now appear:

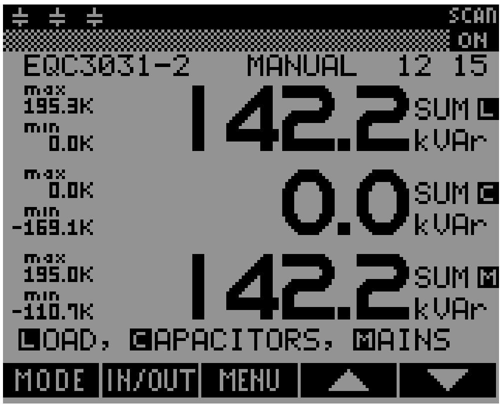


Figure 93 - LCM Screen Without Caps

- Ensure that the Loads & Mains read approximately the same value
- Connect one group ("In/Out" together with "In"):

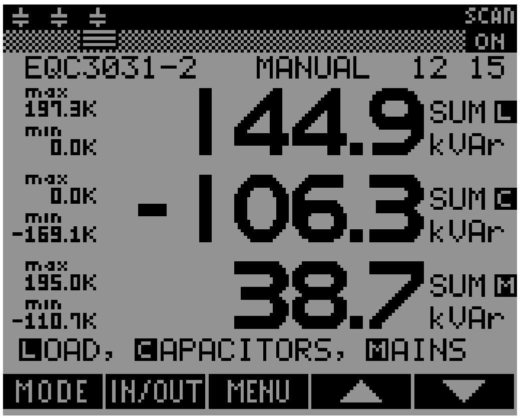


Figure 94 - LCM Screen With Caps

- Correct Measurement Readings:
  - The new loads will increase simultaneously (to a slighter degree) with incrase in compensation, voltage & power,
  - The Caps (negative value) will display the size of the connected groups,
  - The correct Main value needs to equal the Load Size minus the Cap's Size.
- Once you have completed the Testing Procedure & verified that all the system reads the correct measurements, you may set the Controller to **"Automatic Mode".**

CAUTION

Refer to the Troubleshooting Chapter should the measurements differ or read incorrectly. DO NOT SET THE CONTROLLER TO AUTOMATIC MODE UNTIL THE MEASUREMENTS ARE CORRECT.

5. CONTROLLER

Front Panel

The Controller’s front panel is divided into three functional areas (Figure 95):

- Header
- Main Display
- Function keys and tags

The functions of the first and last items are as described in the sections below. The main display is described in details in chapter 6.

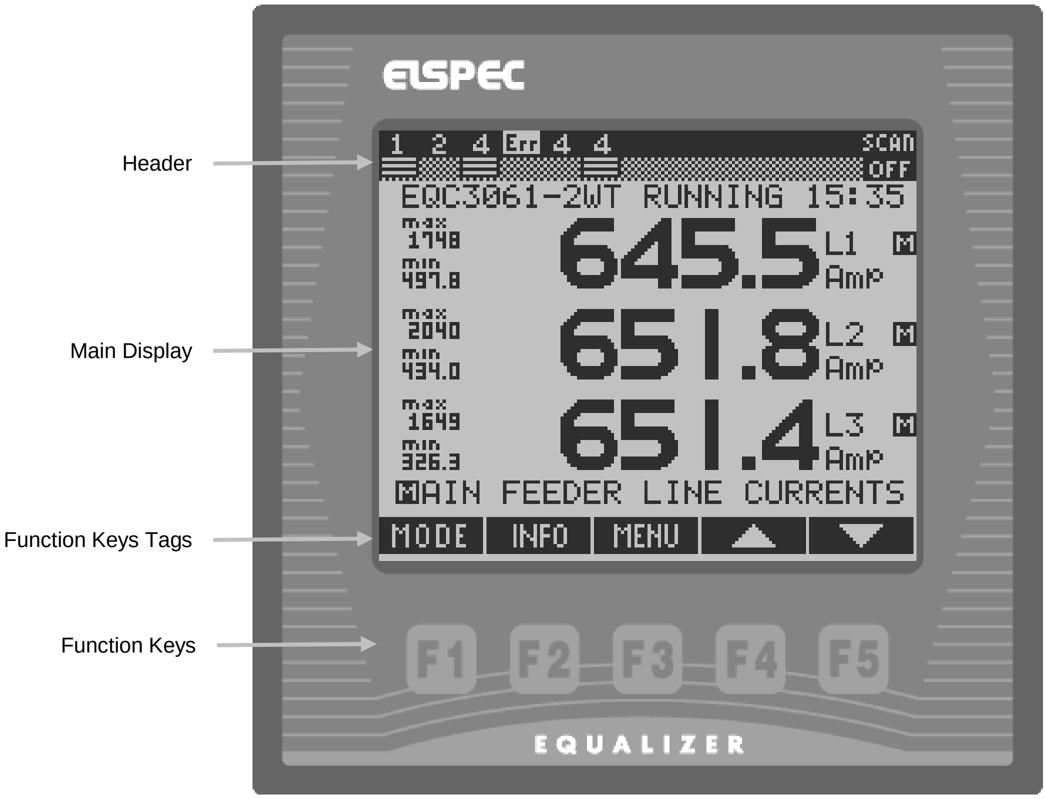


Figure 95: Functional Display Areas

*<u>Before connecting/disconnecting the communication or firing cable to/from the controller connector, **turn the controller off**.</u>*

Header

Displayed at the top of the screen, the header comprises sections as listed and described below:

<u>Capacitor Groups Status</u>

The Capacitor Groups Status display's a list of the available groups and their relative capacity arrangement (see "Site Installation Procedure" on Page 23), as well as the current status of each group.

The upper line displays a number for each defined group. In a group arrangement of 1:1:1 each group is indicated as while in all other arrangements each group is indicated by the number of steps it includes. For example, 4 groups with 1:2:4 arrangement would be 1 2 4 4. If the group is malfunctioning its indication is replaced by Err (for details about the malfunction, see "*Group Test Report*" on Page 83). The programmed group arrangement must correspond with the actual build of the system.

If the group is connected it is marked as below its indication or left empty () if it is not connected.

In Figure 95 the system has 6 groups in 1:2:4:4 configuration. Currently, 9 steps are connected, which are built from group 1 (1 step) and groups 3 & 6 (4 steps each). The 4th group is malfunctioned.

Scan Mode Status

Scan Mode Status - On or off, is displayed at the upper-right corner of the screen.

Scan Mode serves to reduce over-current on the capacitor group, as may be caused by harmonics and over-voltage conditions, to group’s nominal current value. For more details, see "Scan Mode" under "Site Installation Procedure" on Page 48.

Status Line

The Status line is displayed below the Capacitor Groups Status. This line will not be shown while menus are displayed.

The Status line comprises three sections, listing the controller model number, current mode of operation, and time.

System Mode of Operation may be one of the following:

INSTALL	Site Installation Procedure incomplete; the system requires installation (Page 23).
WARM UP	The system is warming up (after power-on), with all capacitors disconnected. After the 10-second warm-up period, the system will resume normal operation.
TESTING	The system is testing the capacitor groups.
RUNNING	The system is in Automatic mode of operation and will connect or disconnect groups automatically.
MANUAL	The system is in Manual mode of operation. Connection or disconnection of groups is manually performed by the operator.
PAUSED	The system is inhibited by a remote signal (Page 54).
ERROR #	The controller has found an error in the system and disconnected all the groups. For more details, press **F2** (INFO or IN/OUT). For error detection and troubleshooting, see Chapter 9.

Function Keys and Tags

All controller functions are accessible from five function keys at the bottom of the front panel. The keys' functions may change and their current function is displayed on the bottom of the screen, by the function keys tags.

Three different display modes are available (see also Chapter 6):

- Numeric display, comprising three large-set numbers with minimum and maximum values for the current measurement,
- Graphic display, comprising waveforms or harmonics' bars.
- Text display, comprising menus, system information, energy meters or events.

Table 6 summarizes the various functions of the keys in each display mode and sub-mode. The function of **F2** depends also on the system’s mode of operation.

Note that in Energy Meters display mode (see Page 76), key functions are identical to those in Numeric Display mode.

Key	Display	Tag	Function	Page
F1	Numeric	MODE	Opens the operation mode set up screen	71
	Graphic	MODE	Opens the operation mode set up screen	71
	Text	HELP	Displays a short help text for the screen, where available	68
F2	Numeric	INFO	In automatic mode - displays the system information screen	70
		IN/OUT	In manual mode - enables manual connection and disconnection of groups	69
	Graphic	INFO	In automatic mode - displays the system information screen	70
		IN/OUT	In manual mode - enables manual connection and disconnection of groups	69
	Text	CANCEL	Cancels the last operation and returns to the previous state	68
		CLOSE	Closes the current window and returns to the previous one	68
		BACK	Moves back one step in a set up procedure	68
F3	Numeric	MENU	Opens system’s main menu	68
	Graphic	MENU	Opens system’s main menu	68
	Text	ENTER	Opens the selected item	68
		CLOSE	Closes the current window and returns to the previous one	68
		NEXT	Accepts the value entered moves to the next step in a set up procedure	68
F4	Numeric	▲	Moves to the previous window on the favourites list	68
	Graphic	◀	Moves the cursor one step to the left	74
	Text	▲	Moves the selection line one line up	68
F5	Numeric	▼	Moves to the next window on the favourites list	68
	Graphic	▶	Moves the cursor one step to the right	74
	Text	▼	Moves the selection line one line down	68

Table 6: Key Functions in Different Display Modes

The Favourites List

The controller contains a pre-defined list of favourite display windows (Table 7). In Numeric Display mode, **F4** and **F5** function as ▲ (up) and ▼ (down) keys, respectively, serve to scroll up or down a display screens from the Favourites list. Screen position on the list will remain unchanged, therefore these keys will always move to the next or previous screen on the Favourites list whether the currently displayed screen was selected from the list or from another menu.

Screen Content	**Wye Configuration**	**Delta Configuration**
Mains Feeder Power Totals	√	
Load Center Power Totals	√	√
Average Volts, Mains Currents and Frequency	√	√
Mains Feeder Currents	√	√
Line-to-line Voltages	√	√
Line-to-neutral Voltages	√	
Control Results kVAr	√	√
Control Results Number of Steps	√	√
Load, Main and Cap kVAr Summary	√	√

Table 7: Favourites List Screens

Menu Key

The system's main "Menu" serves both to select display screens and to program the system. To open, use **F3** in one of the reading modes.

See full Menu description in **Error! Reference source not found.**.

Menu operations are effected through key functions as listed below:

HELP Function

Use **F1** to activate the HELP function, where a help screen is available for the menu displayed. Where no help screen is available, this key is disabled.

CANCEL & BACK Functions

Use **F2** to activate the CANCEL or the BACK functions. CANCEL will close the menu and return to the previous display mode without making a selection, while BACK will close the current window and will accept any changes that were made.

ENTER, NEXT, SELECT & CLOSE Functions

Use **F3** to ENTER, NEXT, SELECT or CLOSE. All these functions are similar, serving to accept the information entered.

ENTER will open a submenu and select a menu item. In the Installation Wizard, NEXT will accept the data entered and move to the next screen. SELECT will toggle between selected inputs (see CT Polarity screen), and CLOSE will accept data and close the screen.

UP & DOWN Functions

Use **F4** and **F5** to activate the ▲ (up) and ▼ (down) functions (for ▲ and ▼ functions in the reading modes, see Chapter 6).

In data entry windows, ▲ (up) will increase the value presented by a unit, while ▼ (down) will decrease it by a unit. Hold down either of the keys to change the values in steps of 10 units.

In all other windows, ▲ (up) will move the selection bar one line up and ▼ (down) will move it one line down.

INFO, IN/OUT and SETUP Functions (F2 key)

In a measurement mode, use **F2** to set for INFO (if the system is in automatic mode), IN/OUT (if the system is in manual mode), or SETUP (if the system has not been installed yet).

The function of this key changes with system status (see "Status Line" on Page 66) as follows:

INSTALL	Use **F2** to activate the SETUP function and run the Site Installation procedure (Page 23).
WARM UP	During the warm up stage, use **F2** to monitor system status (INFO function) or disconnect all groups (IN/OUT function). However, group connection is not allowed at this stage.
RUNNING	Use **F2** to activate the INFO function and display a summary of the current System Information (Page 70).
MANUAL	Use **F2** to activate the IN/OUT function for manual connection or disconnection of groups (see next section for more details).
PAUSED	Pressing **F2** will open a message denoting the system is paused due to activation of the inhibit signal (Page 54), even though the key tag shows different functionality.
ERROR#	Use **F2** to display a description of the existing error (see Chapter 9, “Troubleshooting”, for more details), even though the key tag shows different functionality.

Alarm Output Relay

The relay terminals for the alarm are located on the back of the controller. There are 3 relay terminals consiting of 2 x N.O. Relays (Normally Open) & 2 x N.C Relays (Normally Closed). The Alarm is triggered in the event of a critical error or when the system is not operating in the Automatic Mode. The time delay for the Alarm Trigger is based on the following configuration:

- All the alarm errors (E3, E5, E6, E7 & E10) are triggered when the system is in Manual / Self-Test Mode or as mentioned above when the system is partially / completely inoperative.
- The time delay for errors E6/E7 & E10 is calculated at 1,000 cycles (20 sec. at 50 Hz & 16.66 sec. at 60 Hz).
- The time delay for errors E3 & E5 (usually occuring when the system is partially inoperative) is calculated at 20,000 cycles (400 sec. at 50Hz & 333.33 sec. at 60Hz).
- All the aforementioned time delay caculations are formulated as:
  - $Time\_Delay_{n,N} = 1000 + (n-1) * 19000 \,/\, (N-1)\ cycles$
  - $Time\_Delay_{n,N}$ - The time delay for n disabled groups in a system with N groups
  - Wheras n - The number of disabled groups
  - N - The number of groups in the system

For Example:

The time delay for a system consiting of 5 groups with a network frequency of 50 Hz, with 3 faulty groups will be calculated as:

- $Time\_Delay_{3,5} = 1000 + (3-1) * 19000 \,/\, (5-1) = 10500\ cycles$
- $10500\ cycles \,/\, 50Hz = 210\ seconds$

- The time delay for the deactivation period (initiated when the error condition has been resolved) equals the time delay for the activation period.

System Information

To display the System Information screen as shown in Figure 96, press **F2** (INFO) in Automatic mode or select "System Information" from the main menu.

The System Information screen lists information as described below:

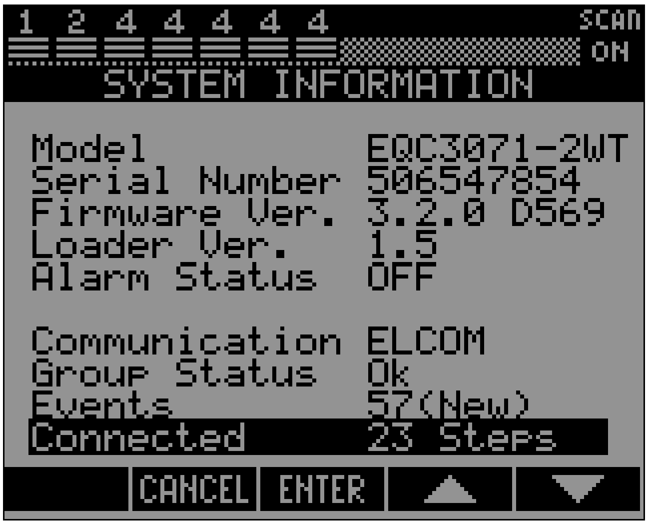


Figure 96: System Information Screen

Model Controller’s model type.

Serial Number Controller’s serial number.

Firmware Ver. Firmware (internal software) version built code.

Loader Ver. The Loader is the fundamental firmware that loads the controller firmware at startup and also used for firmware upgrading.

Alarm Status Alarm relay status - activated (on) or de-activated (off). The Alarm is activated if the system is not in Automatic Mode or if any failure occurred in the system. The alarm activation and de-activation is delayed by 1 to 10 minutes, depends on the severity of the failure that is detected (i.e., 1 group failure out of 12 is less severe than 1 group out of 3).

Communication Communication protocols (where a communication card is installed). Select this option to display a communication information screen with the current baud rate, protocol and communication statistics.

Group Status "OK" if all the installed groups are OK, or a blinking "Error" if an error has been detected in any or all groups. Select this item to display detailed description of the Group Status.

Events The number of New logged Events (unread). Select this option to display more details on the events (see "Figure 105" on Page 77).

Connected The number of steps currently connected. Select this option to display more information on the calculation of the number of steps to connect (Figure 97). It displays the actual and programmed value of the Power Factor (or kVAr in kVAr control mode), Voltage and Primary Voltage. For each value it displays the number of steps to connect or disconnect for this value control, and the total of steps to connect.

Figure 97: Control Logic Results

IN/OUT Function

Use this function to connect or disconnect groups in Manual Mode. First press **F2** to change the functions of **F4** and **F5** to **IN** and **OUT** respectively. Hold down **F2** while pressing either **F4** (In) or **F5** (Out) to connect or disconnect groups.

Press **IN** (**F2** + **F4**) to connect one step, or **OUT** (**F2** + **F5**) to disconnect one step. Connection and disconnection are accomplished in steps rather than by groups, and in a circular pattern (FIFO - First In First Out), i.e. that group which was connected for the longest period of time will be the first one to be disconnected, and vice versa. Therefore, in a system with 1:2:2 configuration and group 1 connected, press **OUT** once and then **IN** twice to connect group 2 only.

Figure 98 shows an example of a capacitor group in/out sequence.

	Groups				Explanation
	1	2	2	2	
Command:	·	·	·	·	Initial State
IN	◘	·	·	·	The 1st group (one step) is connected.
IN	·	◘	·	·	1+1=2 steps. The 1st group is disconnected and the 2nd is connected.
IN	◘	◘	·	·	2+1=3 - both 1st group (1 step) and 2nd group (2 steps) are connected.
IN	·	◘	◘	·	3+1=4 – 2nd and 3rd groups are connected (2 steps each).
OUT	◘	·	◘	·	4-1=3 - the 2nd group, the earlier connected 2-step group disconnects.
OUT	·	·	◘	·	3-1=2 – the 1st group disconnects.
OUT	◘	·	·	·	2-1=1 - the 2-step group disconnects, while the 1st group connects.
IN	·	·	·	◘	1+1=2 – the 2-step group that wasn't used yet connects.

Legend:

◘ Group Connected

· Group Disconnected

Figure 98: Capacitor Groups In/Out Sequence Example

Mode function

Use **F1** (Mode) from measurement mode window, to activate the MODE function. The system will immediately disconnect all the groups, regardless of the mode of operation. This function is therefore useful for fast system disabling. Pressing **F1** (Mode) will display the screen shown in Figure 99. Note that if the "Site Installation" procedure has not been completed yet, a warning message will be displayed to prompt you to run the "Site Installation" procedure.

In "Automatic" mode, the system monitors the power factor and connects or disconnects capacitor groups as required to adjust the power factor to the programmed value (the programmed value and the compensation mode are displayed on this screen).

In "Manual" mode, the operator controls the connection or disconnection of groups manually.

The "Perform System Test" function enforces a self-test. On test completion, a Group Test Report is displayed (see Figure 109 on page 83) and the system returns to its previous mode (Automatic or Manual).

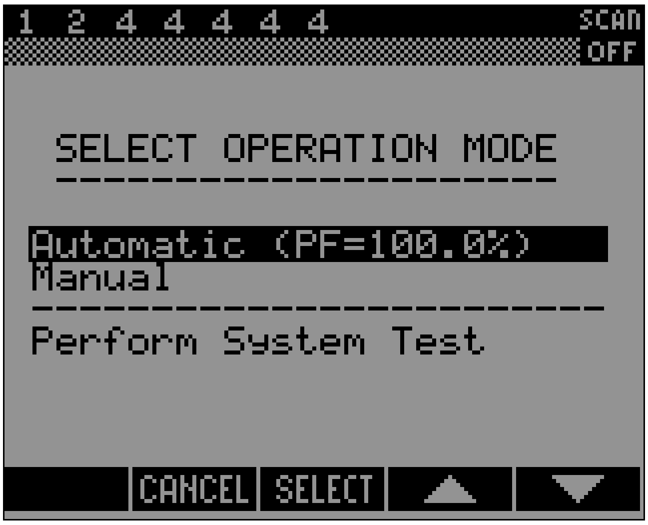


Figure 99: Select Operation Mode

System Setup Menu

The "System Setup" menu, shown in Figure 100, includes some operator related parameters, as well as quick access to changing the Target Power Factor. It is also the menu from which "Site Installation" procedure is launched to make changes in an already installed system. To get to the "System Setup" menu, press **F3** (Menu) on measurement mode window, then select "System Setup".

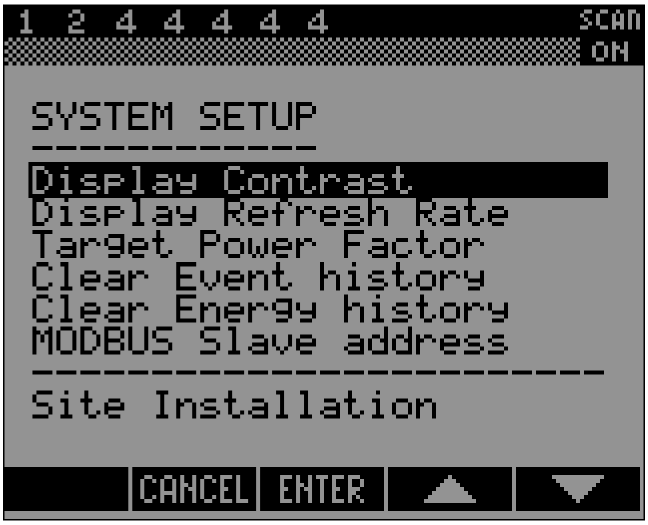


Figure 100: System Setup Menu

Display Contrast	Select this option to set the display contrast. The ambient temperature, lighting condition and viewing angle, affect the contrast.
Display Refresh Rate	The controller measures all the data once per cycle and displays an average over several cycles, for easier reading. Set this parameter to set up the number of cycles to be used for averaging. Note that the minimum and maximum values are checked every cycle, regardless of the refresh rate value.
Target Power Factor	Select this option to set the Target Power Factor for automatic power factor compensation, without having to go through the whole "Site Installation" procedure. The value is displayed in percent (e.g. 97.5% for 0.975), and a value greater than 100% represents capacitive load (leading), i.e. a value of 102% is 98% leading (or 0.98 capacitive). In system option "W" it is possible to set the target also in kVAr. Selecting between kVAr and PF control is done using the Site Installation (Page 45). If kVAr control is selected this menu item is replaced by "**Target kVAr for Control**". Set the target kVAr, while positive value means generating reactive energy ("over compensation").
Clear Event history	Select this option to entirely delete the "Event" log.
Clear Energy history	Select this option to delete the data accumulated by the "Energy Meters". The meters will show zero readings and start accumulate data from the time they were cleared.
ModBus Slave Address	In ModBus communication the slave ID of each unit must be set. This is a value between 1 to 32 (Appendix E). This menu item appears only if ModBus option is included in the controller (see Figure 3 on Page 10).
Site Installation	Select this option to invoke the "Site Installation" procedure. For more details, see Page 23.

6. MONITORING PROCEDURES

The controller has advanced measurement capabilities, including harmonic analysis and waveforms.

Three measurement section readings are available (see also Figure 101):

- Mains reading, as indicated by the M symbol, displaying the measurement of the total network including the compensation system.
- Load centre reading, as indicated by the L symbol, displaying the measurement of the load without the compensation system.
- Capacitor system reading, as indicated by the C symbol, displaying the measurement of the system alone.

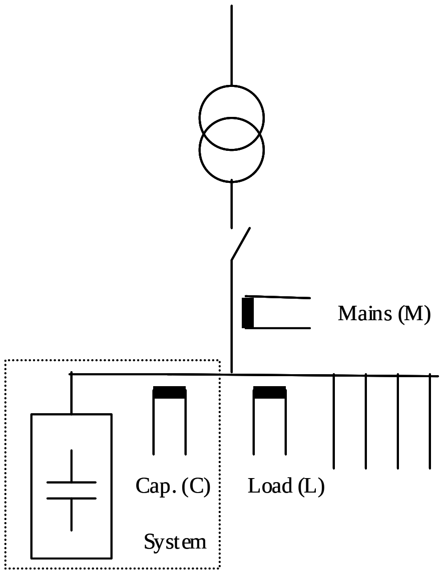


Figure 101: Measured Sections

Select a display screen either from the Favourites list (page 67) or from the main menu. Open the main menu by pressing **F3** (Page 68).

The menu is organized by measurement sections (including combined sections), with the most commonly used screens shown first in each section. Other screens open under the "More…" menu item.

Display Types

Three different display types are available:

- Numeric display, comprising three large-set numbers with their minimum and maximum values (Figure 102).
- Graphic display, covering harmonics (Figure 103) and waveforms (Figure 104).
- Text display, covering menus, System Information (Figure 96 on page 70), Energy Meters (Figure 105) and Events (Figure 106).

Numeric Display

The controller's Numeric Display consists of three values. For each value, a large-set number is displayed with the current value (1) and its minimum and maximum (2). The minimum and maximum values are reset whenever the display is changed. For each reading the relevant phase, parameter's units and load (Mains, Load or Caps) are indicated (3). At the bottom there is a description (4) of the display.

Use **F4** (▲) and **F5** (▼) to scroll to the next or previous display screen from the Favourites list (Page 67).

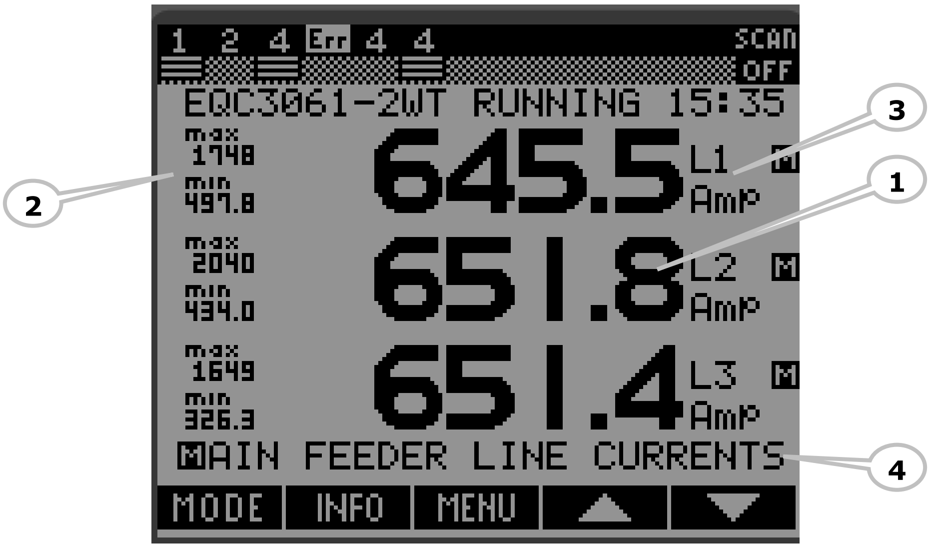


Figure 102: Numeric Display

Graphic Display

Harmonics Spectrum

In a typical Harmonic Spectrum Display, small specific harmonic information box (1), on the upper right corner, shows the type, phase and number of the harmonic, as well as its level (in amperes/volts and in percent), angle and frequency.

Use **F4** (◀) and **F5** (▶) to scroll to the desired harmonic for which the data will be displayed in the information box (2). A cursor will mark the selected harmonic. The harmonics are divided into two separated displays: 1st through 31st harmonic and 32nd through 62nd. The displays are switched automatically according to the number of the selected harmonic. For example, when the cursor is on the 31st harmonic, click F5 (▶) to move the cursor to the 32nd harmonic and display the 32nd through 62nd harmonics.

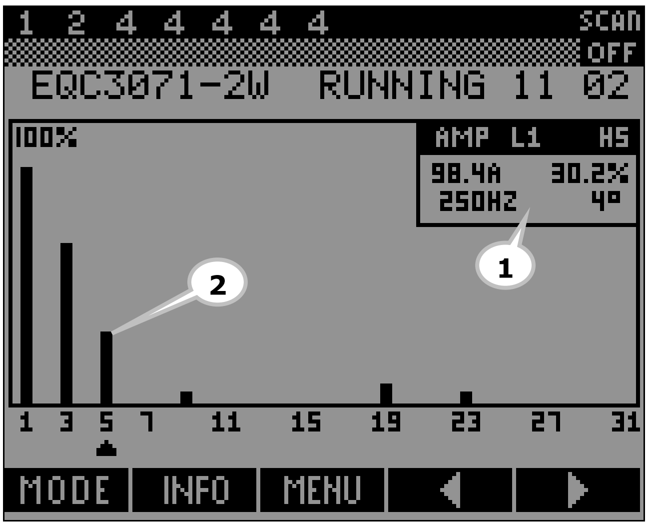


Figure 103: Harmonic Spectrum Display

Waveform Display

The Waveform Display includes a cursor (1), the waveform's momentary value where the cursor is positioned (2), waveform type (3), and lower and upper peak values (4). In addition, specific waveform information (5) shows the phase information, RMS value, THD and angle at the cursor's position.

The starting position (0°) is at the zero crossing on the beginning of the half positive cycle of the Voltage waveform L12.

Use **F4** (◀) and **F5** (▶) to move the cursor's position.

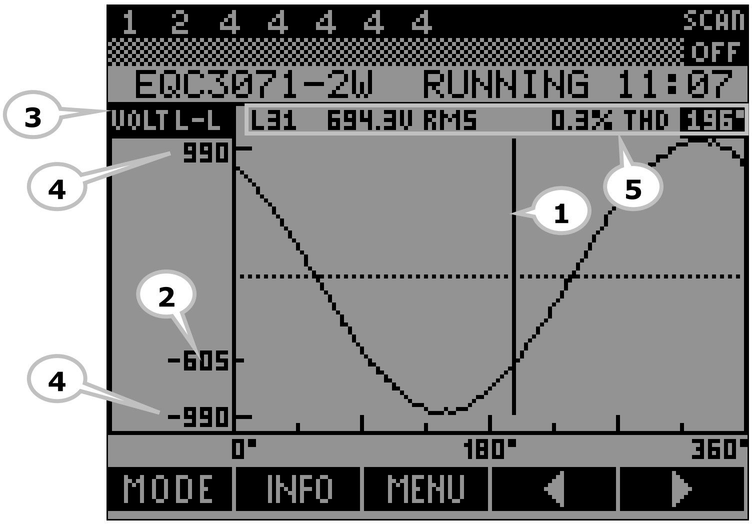


Figure 104: Waveform Display

Text display

Introduction

System’s Text Display comprises menus, System Information, Energy Meters and Events.

See detailed menu navigation description (under "Menu Key") on Page 68 and System Information on Page 70.

Energy Meters Display

The Energy Meters display comprises 15-minute meters and monthly total meters, each showing the previous period total (15-minute or monthly) and the value accumulated since the start of current period. The values include active energy (kWh) and reactive energy (kVArh) for both imported (in) and exported (out) energy. The information is stored in a flash memory device in the controller every 15 minutes, and PowerIQ software can retrieve the information for graphic display and calculation of Time-Of-Use.

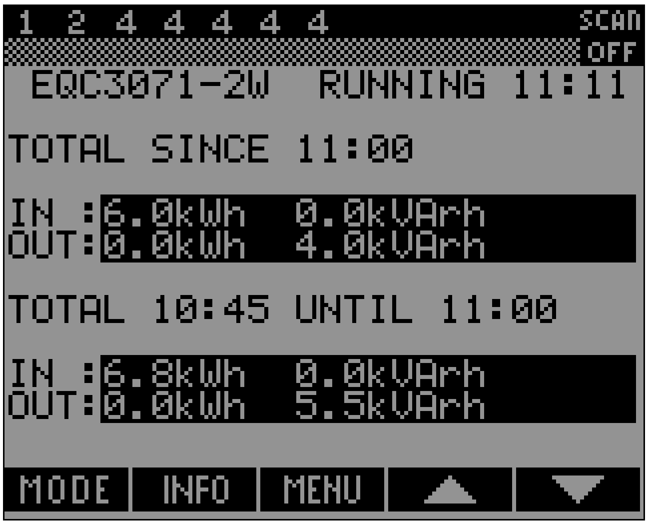


Figure 105: Energy Meters Display

Events

The number of New Events (which were not displayed on the screen) is displayed on the System Information screen (Page 70). When selected, "Summary of Events" window (Figure 106) opens, displaying the number of "New" and "Old" events. "New" events are events that were not displayed yet on the controller.

Figure 106: Event Display

Selecting "New Events" will open the most recent event that is new, while selecting "Old Events" will open the most recent event that is old. The most recent new event is not necessarily the most recent event, as explained in Figure 107. Each event information includes event number, code, date, time, short description of the event and whether it is new or old. Use **F4** (▲) and **F5** (▼) to scroll to the previous or next recorded event by numerical order, regardless of its old/new status. After an event is displayed its status is changed to "old" and the next time it is displayed it will be indicated as such.

The entire Event log is downloadable through PowerIQ software ("Events" icon) to a PC, for easy reading, sorting and filtering.

Appendix D includes complete list of possible events.

Step	**Operation**	**Events**
1	3 events are logged	Events 1 to 3 are new
2	Selecting "New Events"	Event 3 is displayed and changed its status to "old"
3	Pressing "Close"	Events 1 & 2 are new (total 2 new) and 3 is old (total 1)
4	Selecting "New Events"	Event 2 is displayed, although it is newer than #3.

Figure 107: New and Old Events

7. PowerIQ SOFTWARE

General

The PowerIQ software is an application run under Microsoft Windows 2000/XP/Vista (not on Windows 7), providing a graphical user interface for Elspec products.

To use PowerIQ, equipment is required as listed below:

- ❖ Computer system: Pentium 166 MHz or higher, with minimum of 64 MB of memory and 50 MB of free space on the hard disk.
- ❖ Operating system: Microsoft Windows 2000, XP or Vista, with TCP/IP component installed.
- ❖ Communications: A communication cable between the PC and the units. See detailed description of hardware connection and unit set up in Chapter 3.
- ❖ Software: PowerIQ.

For best performance, use Pentium 4 1.6 GHz or higher, with 256 MB of memory and Microsoft Windows XP Professional.

Before connecting/disconnecting the communication to/from the controller connector, ***turn the controller off.***

Packages

The Power IQ comes in either one of two packages:

PowerIQ Professional Including the entire PowerIQ functionality for a single computer.

PowerIQ Network Including the entire PowerIQ functionality for multiple computers connected on a TCP/IP network or modem, as illustrated in Figure 108.

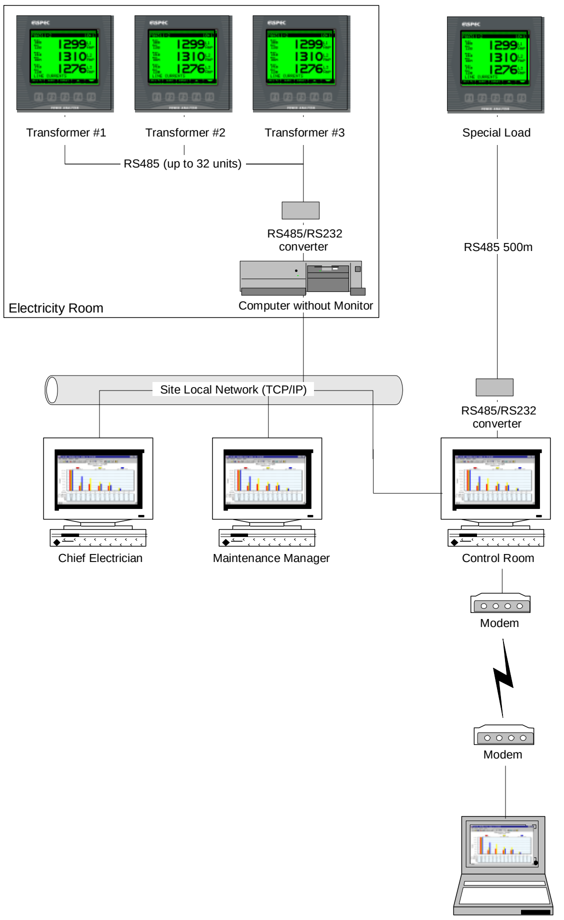


Figure 108: PowerIQ Network Installation Example

Installation

To install PowerIQ, follow the procedure below:

(1) PowerIQ uses Windows' TCP/IP both for network and for stand-alone installations. If your system does not have the TCP/IP installed, see Windows Help under "TCP/IP protocol, installing", to install.

(2) If you have another version of PowerIQ installed on your computer, reboot the computer before starting the installation procedure.

(3) Insert the installation CD-ROM into a CD-ROM drive.

(4) Click "Start" and select submenu "Run..."

(5) Type "D:SETUP", and then click OK. Replace D: with your CD-ROM drive letter.

(6) Follow installation program instructions as they appear on the screen.

Operation

The software includes an application toolbar and client applications. The application toolbar also serves as a communication server for the clients and for other computers (in the network version). The server collects all the data requests from all clients and delivers the required information to all the clients. It is possible to simultaneously open unlimited number of clients, including from the same type (for example opening three instances of Gauge).

All clients are accessible through the PowerIQ Main Taskbar.
To activate, select "Start" » "Programs" » "PowerIQ" » "PowerIQ".

Help System

For additional information on PowerIQ, seek PowerIQ on-line help.

To access on-line help, do one of the following:

(1) Use **F1** to open the Help system for the specific function.

(2) Select "Help" from the PowerIQ Main Taskbar.

(3) Select "Start" » "Programs" » "PowerIQ" » "Help".

8. ROUTINE PREVENTATIVE MAINTENANCE

Safety

All maintenance operations must be pursued in strict compliance with applicable safety codes and under the supervision of competent personnel.

Before attempting any maintenance operation on the system, ensure electrical isolation by opening the circuit breaker or fused disconnect protecting the system. Always follow applicable lock-out/tag-out procedures. For isolation devices installed within the system, exercise extra caution to protect from live terminals and conductors on the line side of the isolation device.

On completion of the maintenance operation, run commissioning procedures (Chapter 4) to ensure that the equipment is in proper working order.

Cleaning Precautions

Do not use a high-pressure insulating solvent spray to clean these units. This type of cleaning will void the warranty.

Fuses

The system carries fuses of two types – control fuses and power electronic fuses. ***To replace, always use fuses of the same type and ratings***. Note that semiconductor fuses have very critical I^2t and I_p let through values. ***Fuses should only be replaced by qualified maintenance personnel***.

Monthly Maintenance

On a monthly basis, check:

- Controller for normal operation.
- Controller display for error messages.
- Capacitor groups for Err indications (Page 65).

In addition, inspect the system visually for:

- Signs of overheating of cables, electronic switch elements and other such components.
- Proper operation of fans.
- Overall cleanliness of the equipment – avoid accumulation of dust and other contaminants inside the equipment.

Annual Maintenance

Once annually, check:

- All control and protective devices.
- All power connections for tightness.
- Measurement system calibration.

9. TROUBLESHOOTING

The secret to troubleshooting is to collect as much information as possible and eliminate problems in a methodical way.

The system contains sophisticated built-in troubleshooting algorithms capable of detecting possible causes of failures. These algorithms operate in thorough mode on system initialization or on detection of a potential problem. Otherwise, they operate in standard mode that doesn't influence system's performance.

Whenever the system suspects that something is not in order, it displays an error or warning message and suggests a possible solution. If a problem only occurs in one group, system operation continues with the groups available.

System Test

System test is carried out in the following instances:

- Power-up (only if the system is in Manual mode with at least one step connected or in Automatic mode).
- During the Site Installation procedure (Page 23).
- On detection of a potential problem.
- On operator selection of "Perform System Test" from the Mode menu (Page 71).

Fault Indication

On detection of a problem, the front panel displays a notification screen explaining the problem. If two faults are detected simultaneously, the display will indicate the number of the more critical error.

If an error is detected in one of the groups, the associated location is marked with Err. To identify the exact problem, see details in the Group Test Report.

Group Test Report

To view the last system test, select “Group Status” from the System Information menu (Page 70). A Group Test Report screen will open, as shown in Figure 109. In this example, group #4 is malfunctioning. This screen will open automatically for system tests run from the Mode menu.

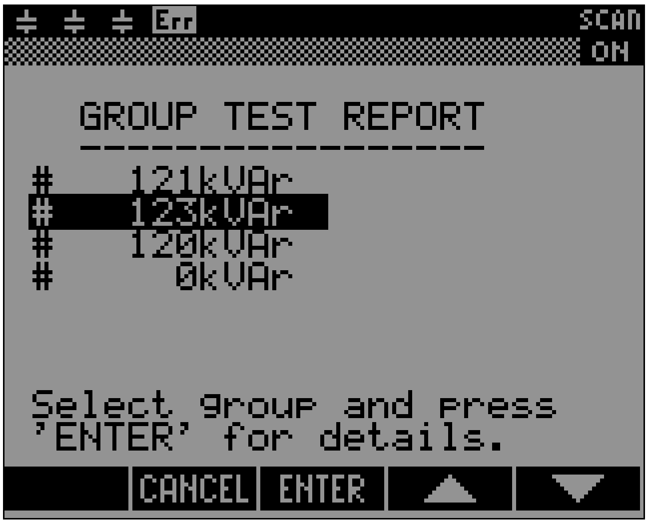


Figure 109: Group Test Report Screen

Use **F4** (▲) and **F5** (▼) to select a group. Now press **F3** (Enter) to open a Group Details screen (Figure 110 and Figure 111) listing information on the reactive energy measured (kVAr), <u>normalized to the nominal voltage and frequency</u> will be displayed (e.g. for nominal values of 400v 50Hz 120kVAr and measured values 390v 50.3Hz 110kVAr,

$\left(\frac{400}{390}\right)^2 \times \frac{50.0}{50.3} \times 110 = 115$ kVAr is displayed).

In addition, the percent value is calculated from the nominal one to yield a status indication – group OK or ERROR.

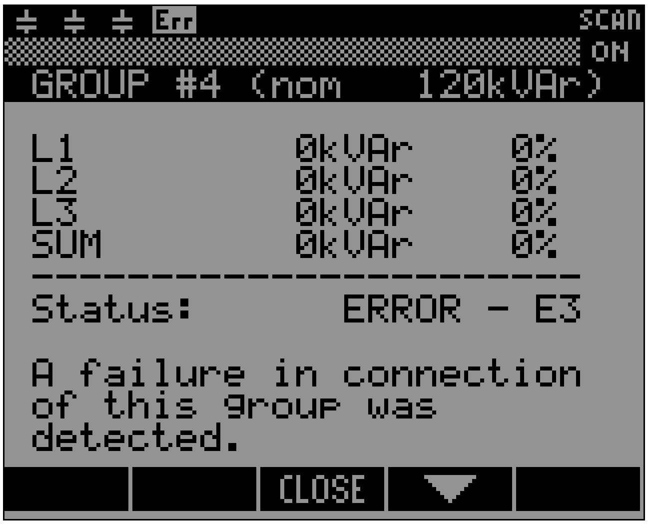


Figure 110: Group Details Screen - Group with Error 3

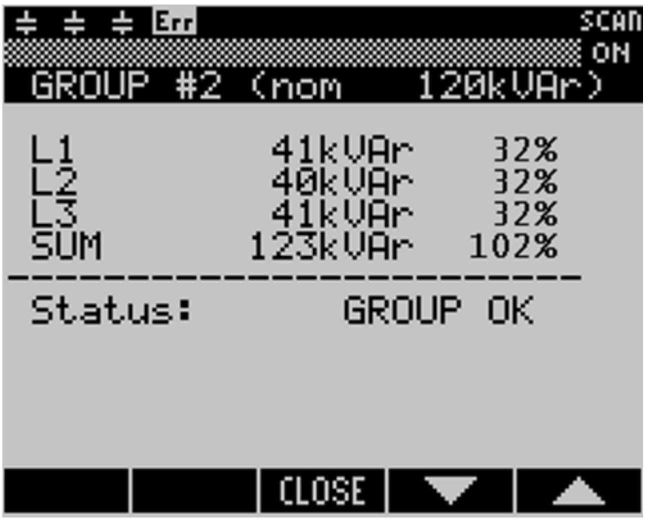


Figure 111: Group Details Screen - Group OK

When Group #1 information is displayed, pressing **F5** (▼) will display background readings (Figure 112). This is the system internal kVAr readings when all the capacitor groups are disconnected. Normally, all values should be zero. However, if one of the groups is malfunctioned with a burned SCR, it may cause a short circuit and turn on a group (or all or part of the phases) and the kVAr readings will be non-zero. This will also cause E3 on this group.

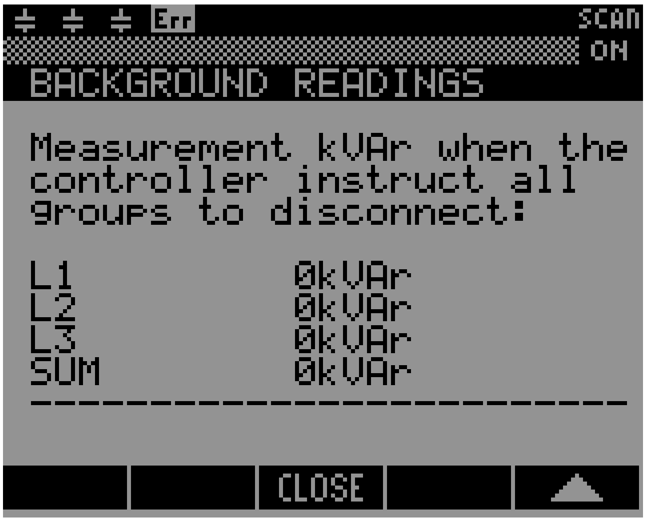


Figure 112: Background Readings

Measurement Test

The “L C M Test” is **not** being displayed:

1) The Loads value should remain almost the same value regardless whether or not the capacitors are connected,
2) The Caps value should indicate the kVAr value of the connected group as a minus value,
3) The Mains value should approximately equal the Loads value minus the Caps value.

(The Caps & Loads indicators are located opposite the [W] firmware).

Should any of the aforementioned points be absent, the cause may be due to:

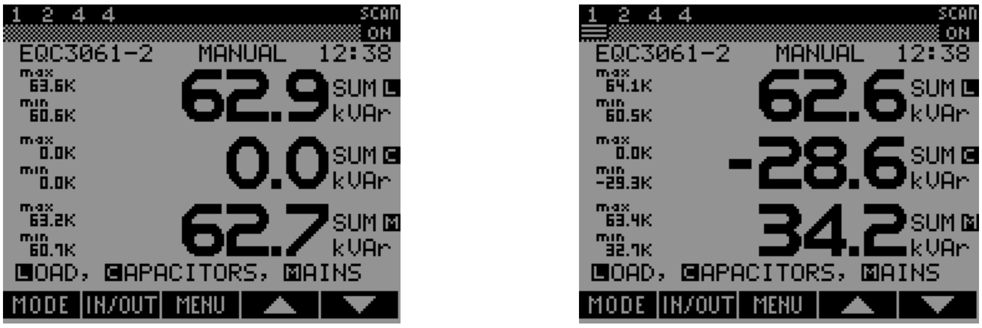
1) The power supplying the system is not at the correct phase order, & / or
2) The power supplying the system is not in the phase as that of the Mains’ CT’s, & / or
3) The Mains’ CTs are connected incorrectly, & / or
4) The polarity of the Mains CT’s is reversed, & / or
5) The CT ratio on the controller itself has been setup incorrectly.

Issues due to changes made to the **external** system CT’s after Elspec has concluded their final testing procedure:

1) The CT ratio in the system is setup incorrectly,
2) The system or Cap CT’s are incorrectly connected,
3) The polarity the system CT’s is reversed,
4) The system CT’s phases are not synchronized with the Mains CT’s phases.

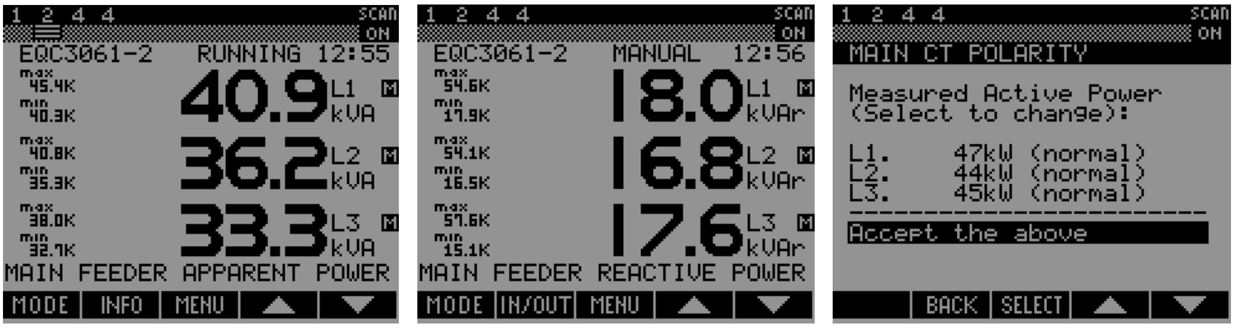
<u>Correct System Connection Screen Displays:</u>

1. <u>L C M Test With & Without Group Connection:</u>



- *Access the menu by selecting: Menu → L C M Combined → Total kVAr Meters*

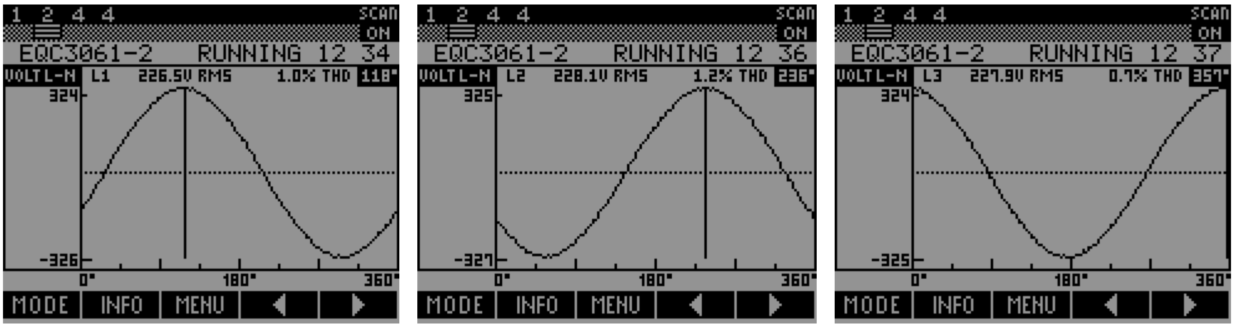
Mains Measurements (kVA, kVAr, & Polarity):



- *Access the menu by selecting: Menu → Main Feeder readings → More → KVA o KVAr phase meters*

NOTE: All the values are positive values (with no group connected) & approximately equal to each phase value.

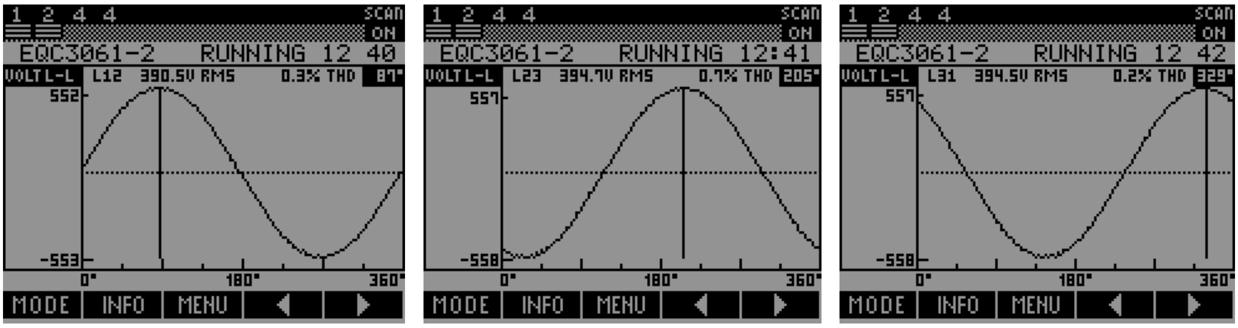
3. <u>Mains -</u> <u>L to N Voltage Waveforms</u> (Applicable only to WYE Topologies)



- *Access the menu by selecting: Menu → Main Feeder Readings → Waveforms → More → Lx – N Voltage*

NOTE: The shift from phase to phase has an angle of 120º.

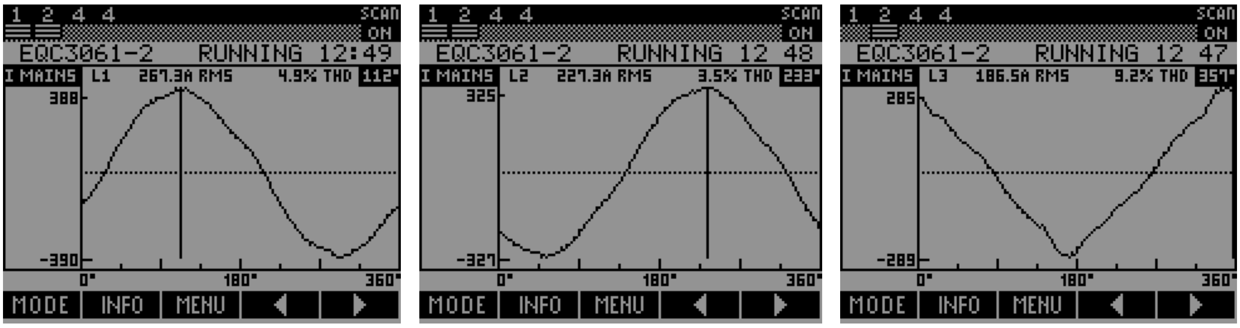
4. <u>Mains -</u> <u>L to L Voltage Waveforms</u> (All Topologies)



- *The menu is accessed by selecting: Menu → Main Feeder Readings → Waveforms → Lx – Ly Voltage*

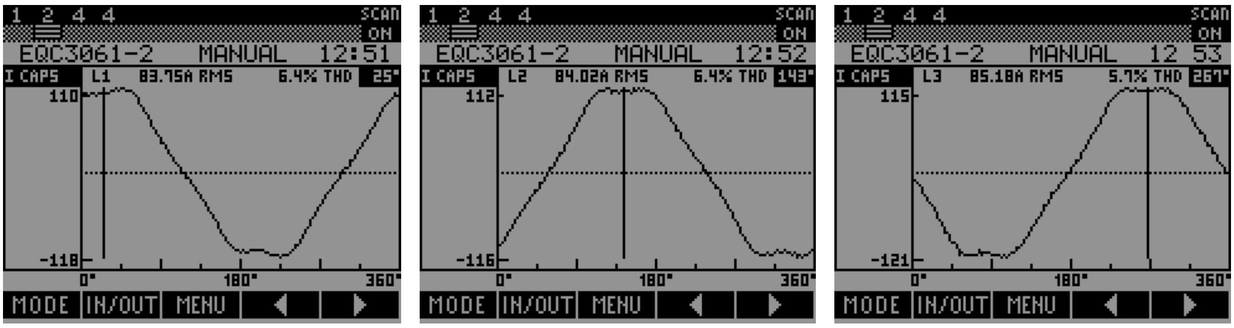
  NOTE: The shift from line to line has an angle of 120º & there are a 30 º difference between the corresponding L – N voltage waveforms. Use Voltage L12 as the starting reference.

5. <u>Mains - Current Waveforms:</u>



- *The menu is accessed by selecting: Menu → Main Feeder Readings → Waveforms → Lx Current*
- NOTE: The shift from phase to phase is at a 120º angle & corresponds approximately (depending on the Power Factor) with the L-N voltage waveforms.

6. <u>Caps – Current Line Waveforms</u>

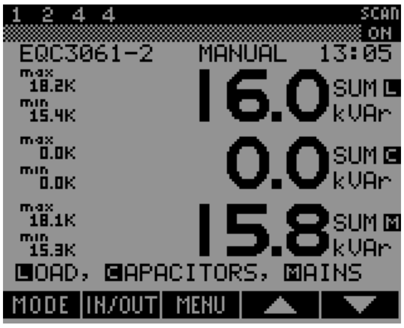


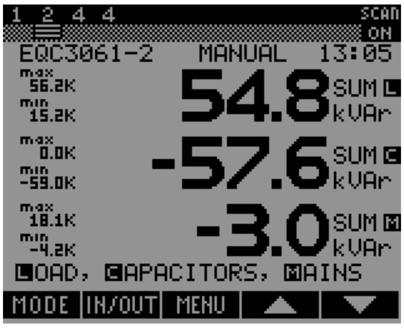
- *Access the menu by selecting: Menu → Cap system readings → Waveforms → Lx Current*
- NOTE: The shift from phase to phase has an angle of 120º with a 90º difference with the corresponding L-N voltage waveforms.

Problematic Displays – Mains CT With An Incorrect Polarity At L3

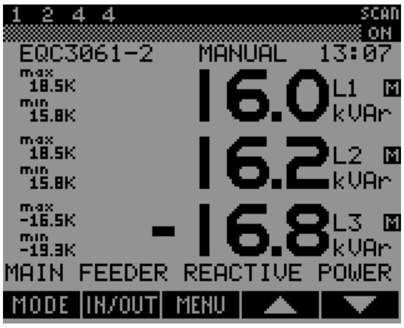
In this example we are using the same Waveform Voltages (L – L & L – N) & Caps Current.

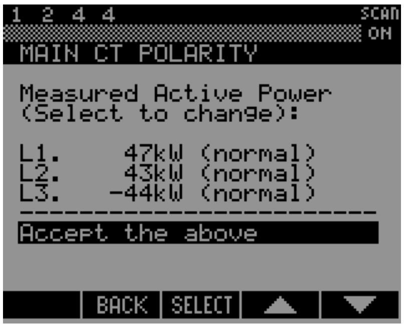
1. The L C M test indicates drastic changes in the loads value when the capacitors are connected:



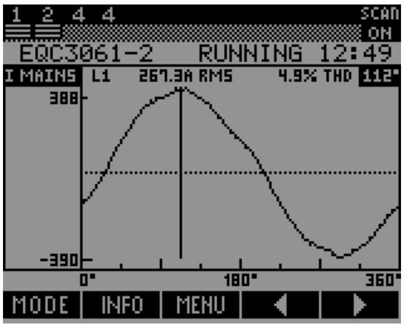


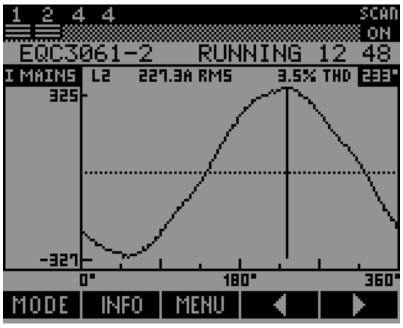
2. The Mains KVAr reading displays an opposite value (+/-), also on the polarity screen:

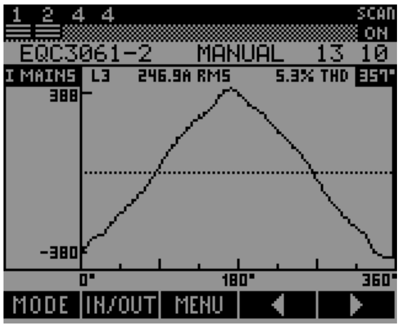


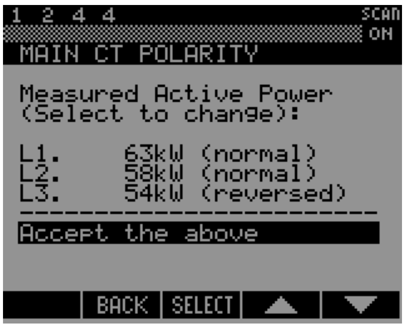


3. The Main's Current Waveforms displays a shift of 120º from L1 to L2 & from L2 at the next peak an additional 120º running however in the negative or in the opposite direction. <u>This is a main indication of an inccorect polarity at the Main CT L3</u>:







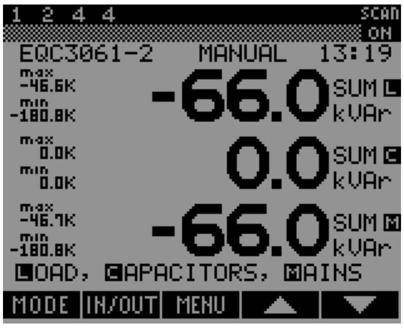


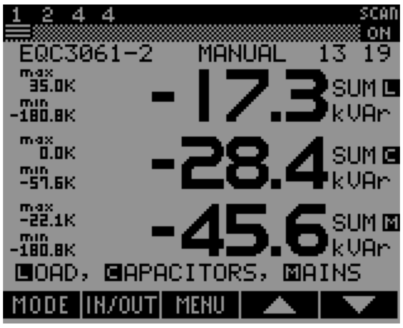
On the L3 polarity screen change the settings from "normal" to "reverse". On thorough inspection of the system should the measurements for all the parameters read correctly, alter the physical connection & change the settings from "reverse" to "normal".

Problematic Displays – Incorrect Order of the Mains' CT's (L2, L1, L3)

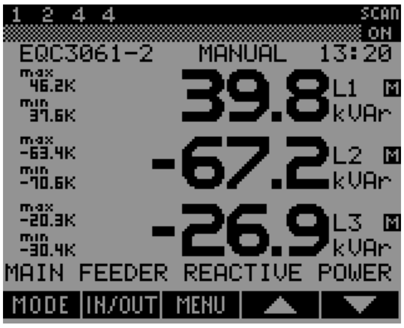
In this example we are using the Cap's Currents are L-L & L-N.

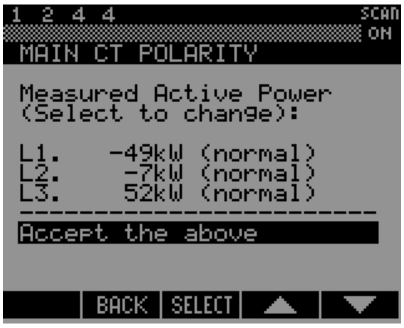
1. The value of the loads fluctuate drastically during an LCM test when the capacitors are connected :





2. The value for each phase will differ in size with an incorrect value (+/-) on the Mains KVAr as well on the polarity screen:

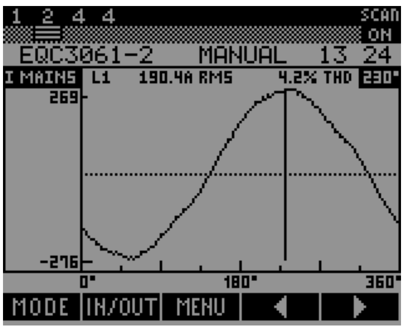


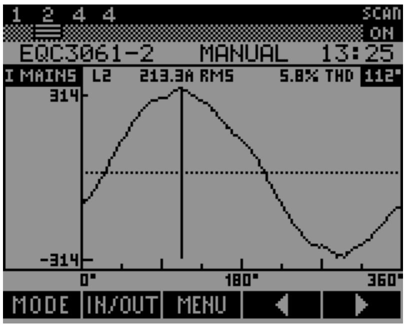


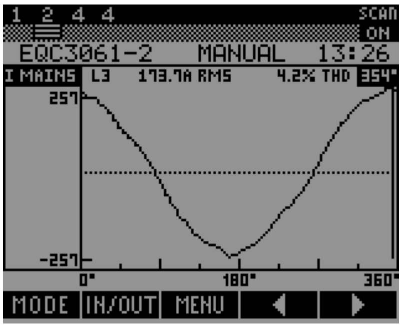
3. The phase angle from L1-L2 will be at 120º & in the incorrect direction on Main's Current waveforms screen. In addition L2-L3 will increase at an angle of 240º & increases at another 240º from L3-L1, instead of a 120º.

You will also notice that I_3 remains in approximately the same position as V_{3-N} voltage (or V_{31} + 30°),

- I_2 remains in approximately in the same position as V_{1-N} voltage (or V_{12} + 30°),I_1 remains in approximately in the same position as V_{2-N} voltage (or V_{23} + 30°),
- The problem is corrected when changes are made to the current measurements of L1 & L2:

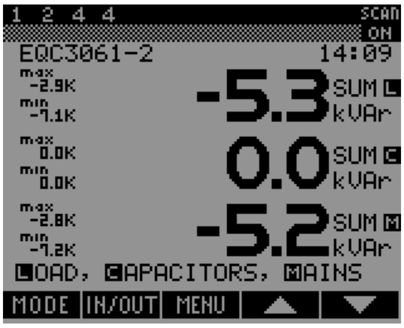






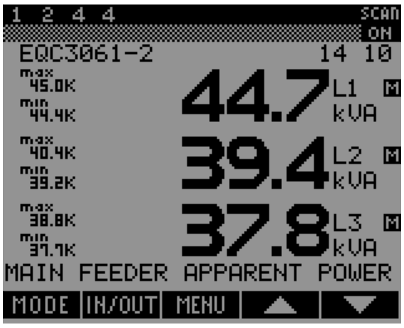
Problematic Displays – Incorrect Voltage Phase Order (L2, L1, L3)

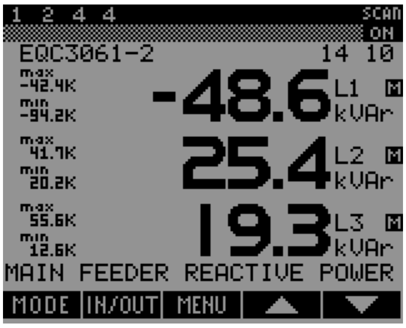
Main's Waveform Currents are in the correct case measurements as per the example above:

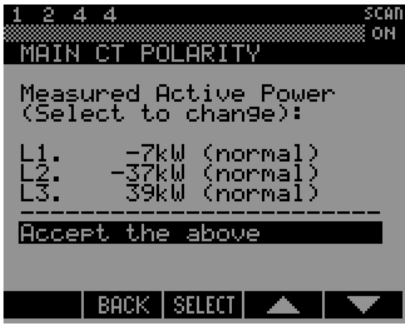


Although the Loads & Mains display a similar value, it still differs from the norm & with an incorrect value (+/-). The value of the loads fluctuate drastically when the capacitors are connected.

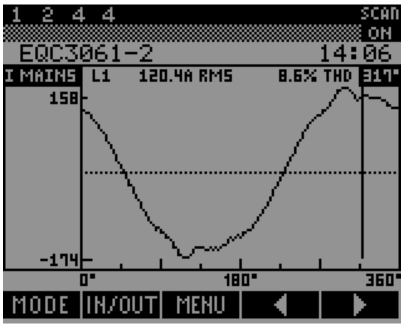
The value for each phase will differ in size with an incorrect value (+/-) on the Mains KVAr as well on the polarity screen:

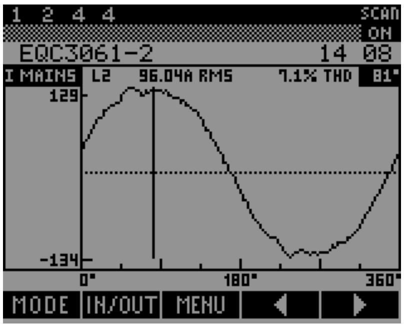


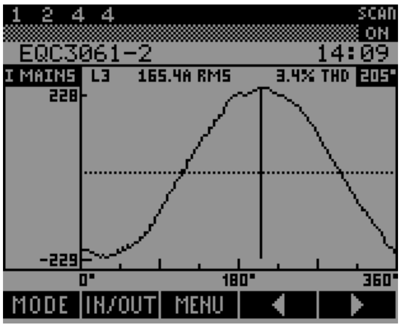




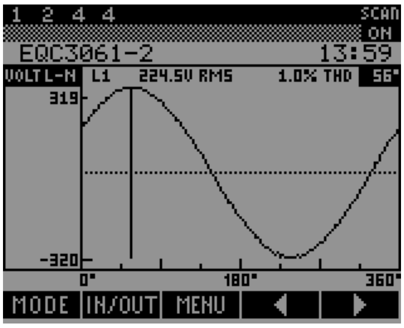
The phase to phase seems that it is on a correct angle of 120º on the Main's waveform currents display:

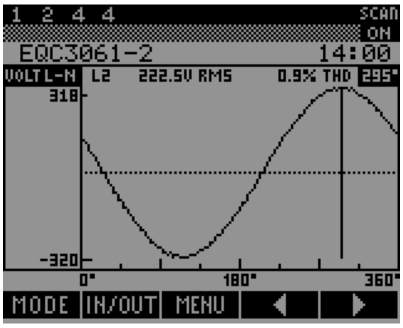


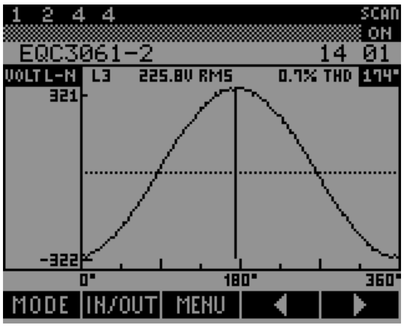




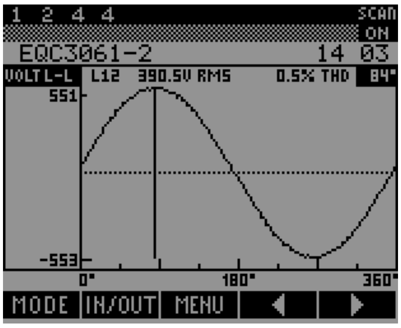
L-N Waveform Voltage angles are at 240º from L1-L2, & at 120º from L1-L3:

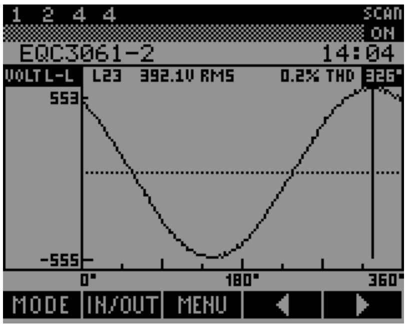


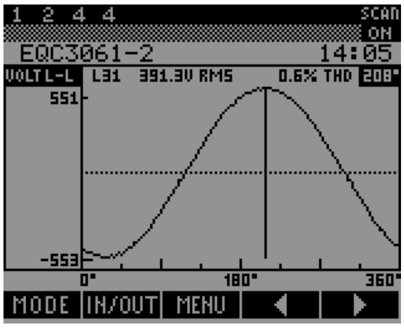




The L-L Waveform voltages displays similar differences as L-N, however shifts another 30º:







At this stage you will need to compare Voltage (L-N) & Current phases of the Mains & access whether or not they are at approximately at the same angle. The reference point is L3 & once you interchange L1-L2, the problem is resolved.

Problems Occurring Due Incorrect Rate of the CT's

The Load & Mains' values are approximately at the same value when the capacitors are disconnected. Once you connect the capacitor, these values change drastically. Therefore, verify that ratio on the CT's data is correct.

Summary;

Voltage Test

- The best & easiest way to know what the exact phase order is is to look at the voltage waveforms. Simply: Select **Menu → Main feeder readings → Waveforms**
- In the event the Topology is WYE, select: **More → Lx-N Voltage**
- Should the Topology be Delta, select **Lx-Ly Voltage**
- With the Left and Right arrows move the bar to the maximum positive value,
- Ensure that you allow for a difference of minus 30º between line to line & line to neutral,
- Make the same allowance for each phase & make a note of the value,
- The end result should be 120º from phase to phase, starting either at L1 / L12,
- Any adjustments & corrections to the phase order should be made when the phase are connected to the system.

Mains Currents Test

In order to test the Currents on the mains, you need to toggle the Mains' CT Polarity as per procedure outlined on page 39.

- Should the active power (with loads) be with a negative value, the polarity is incorrect & the CT is connected in the opposite direction (if you are using the "W" Firmware version, the polarity should be toggled in the opposite direction),
- You will now need to repeat the same step with the line currents,
- Select Menu → Main feeder readings → Waveforms → Lx Current,
- With the Left and Right arrows move the bar to the maximum positive value,
- Make a note of the shift value for each phase,
- With Power Factor 1 (ideal) you need to see the same shift for Mains Voltage & Currents on each phase, if the power factor is 0.8 the shift between voltage and current should be approximately 36º (current after voltage)

Caps Currents Test

Whenever any changes are made to the Caps CT or they are fitted externally (due to customer specifications) you will need to follow the testing procedure:

- Select **Menu → Cap system readings → Waveforms → Lx Current**
- With the Left and Right arrows move the bar to the maximum positive value,
- Make a note of the shift value for each phase,
- Ensure that the Current shift is approximately 90º before the Voltage (L-N).

NOTE: Follow the steps outlined above in the event that the system compensate on MV by a step up transformer, also see "Sampling Configuration".

The main object of the exercise is to ensure that the voltage angles are concurrent with the current measurements.

Should you fail to resolve the problem, send all the screen prints as outlined above, to your local Elspec representative. Include your system's serial number, network data & system connection. In the event that you are using a Step-Up Transformer, included screen prints as per "Sampling Configuration".

Safety

All troubleshooting operations must be pursued in strict compliance with applicable safety codes and under the supervision of competent personnel and safety information on 11.

Before attempting any troubleshooting operation on the system, ensure electrical isolation by opening the circuit breaker or fused disconnect protecting the system. Always follow applicable lock-out/tag-out procedures. For isolation devices installed within the system, exercise extra caution to protect from live terminals and conductors on the line side of the isolation device.

On completion of the troubleshooting operation, run commissioning procedures (Chapter 4) to ensure that the equipment is in proper working order.

Troubleshooting Procedure

Troubleshooting is pursued at four levels, according to the nature of failure:

- System does not work well but has no failure indication.
- General system failure, indicated by a notification text or blinking 'ERROR' in the status line (Page 65).
- Single capacitor failure, indicated by Err on the capacitor indicator.
- Communication failure.

System does not work well but has no failure indication

The first step in troubleshooting is to check the interior of the system cabinet visually. To check, follow the procedure below:

(1) Inspect components for evidence of overheating or arcing.

(2) Check cables for good physical connections. Look for indicators such as broken wires, evidence of overheating and/or loose leads.

If you have not been able to solve the problem, check all connections for secure seating in the correct connectors. If the problem persists, contact Elspec.

General System Failure

Groups are Connected and Disconnected, but there is Nothing on the Display

The controller is set to minimum contrast level. Do one of the following:

(1) Turn the power off and then on. Press F3, F4, F3, and F3 again and then many times on F4 until the display appears.

(2) Using PowerIQ remote control select the display contrast in the system setup and set it to 50%.

(3) Switch controller's power down, press **F1** and hold while switching the power back up again. This will erase all the parameters and require repeated Site Installation, including system structure configuration. This is the LEAST recommended solution, since it requires repeat of all programming.

The Controller Doesn't Power Up

(1) Make sure that the controller is connected to the power supply. Note that power supply connection is separated from the measurement voltage connection and all 5 left most connectors on the rear of the controller should be in use (Appendix C).

(2) Confirm that there is no mismatch between the Phase and Neutral (i.e. the phase is connected to the neutral and vice versa). Do this by measuring the voltage between the phase and the ground.

(3) Switch controller's power down, press **F1** and hold while switching the power back up again. This will erase all the parameters and require repeated Site Installation, including system structure configuration.

(4) Switch controller's power down, press **F3** and **F5** simultaneously and hold while switching the power back up again. If the screen in Figure 113 appears, upload new firmware (see Appendix B).

```
ELSPEC Boot Loader Ver 1.5

 Waiting for communication


--------------------------
Total Received     :     0
Total Okay         :     0
Okay Ratio         :  ---%
Percentage Complete:  ---%
--------------------------
```

Figure 113: Boot Loader Screen

The Controller Switches On and Off

Refer to "The Controller Doesn't Power Up" above.

The Controller Displays a Zero Current Reading

Check CT connections. Make sure that the cable or busbar measured carries current.

Tip: The controller may be measuring the edge of the bus bar where no current is flowing (Figure 114).

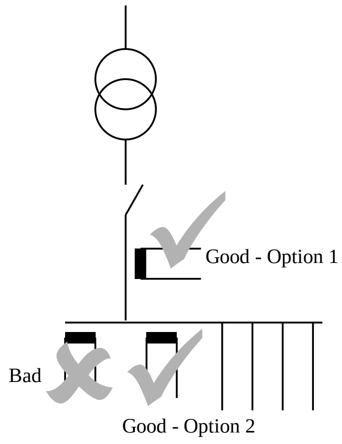


Figure 114: CTs connection example

The Current RMS Readings of All Phases Are Similar, But They Are Different From Those Expected

Check for improper setting of the CT ratio, or verify that ALL the power input is surrounded by the CTs. A typical bad connection is one with two parallel transformers or multiple feeders. For example, in Figure 115, if the CT is set to positions "A" or "B", the current will read 50% of the actual value.

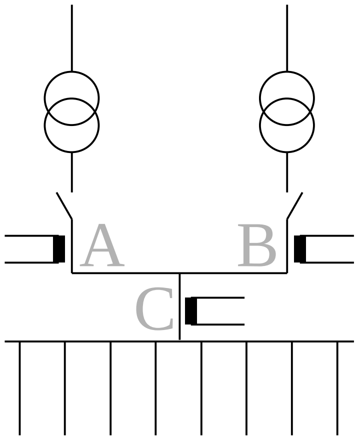


Figure 115: Parallel Transformer CTs connection

The Voltage and Current Readings Are Ok, But The Power and The Power Factor Are Not

Check for a mismatch between the phases of the voltage connections and the CT.

In most cases to fix the mismatch, switch between phases L1 and L3 on either the voltage or the CT (but not on both).

The Unit Displays Negative Active Power

Negative active energy indicates that the load supplies energy back to the network.

If the energy flows to the load, the connection of one or more of the CTs is reversed, or the set-up parameter of CT polarity is not properly set.

To fix, either change CT polarity or repeat the installation procedure.

No Capacitors Connected in Automatic Mode

(1) Repeat Site Installation (Page 23).

(2) Check Target Power Factor (Page 73).

(3) Check current for too low a value, in which case a single group may cause over compensation.
Example: Programmed power factor=1.00, P=20kW, Q=20kVAr, step size 100kVAr. Before capacitors are connected, the power factor is 0.70 inductive. If a step is connected, the power factor will be 0.24 capacitive.

The controller doesn't see firing card

If the unit is a SCR/Diode controller and you check that the card is in place, check the firmware version. This error occurs when you put a SCR/SCR firmware on a SCR/Diode unit. If the controller is connected and working in the system you can be sure if you check the frequency reported by the controller. If the controller reports the frequency with an error larger than five, then you need to change the controller firmware.

You can download from our site the last version for SCR/Diode.

The controller doesn't read the correct voltage values

Check Neutral connection from the system. If the system was designed to receive Neutral, this connection must be there.

Single Capacitor Failure

(1) Repeat Site Installation (Page 23).

(2) Disconnect all the groups and check system current. If it is not zero, replace that switching module to which the malfunctioning group is connected.

(3) Review malfunctioning group data (see "Group Test Report" on Page 83).

(4) If Error 5 is reported, replace the Switching Module (see more details below).

(5) If Error 3 has been detected in three or more adjacent groups, for Switching Module types “A” or “B” (

(6) Figure 6 on page 14), check switching module’s fuse (see more details below).

(7) Check malfunctioning group’s fuse (see more details below).

General Error Message

(1) If the failure occurs only once, allow five minutes for the failure to correct itself or switch system’s supply voltage off and on.

(2) If a blinking ERROR indication appears in the status line, press **F2** (INFO or IN/OUT) to display full error description.

(3) Table 8 lists all possible error messages and their possible solution. The error message on the controller also includes recommendation for correction of the error message. It may also include help screen for additional information. First try to resolve the problem as written on the unit's display, since it may be more relevant to the exact situation.

Error	***Meaning***	***Possible Solution***
E2	Failure to synchronize to phase voltage L1	Verify proper connection of L1 and Neutral
E3	Unable to connect capacitor group	Check fuses, switching module, fire cable
E4	Unable to disconnect capacitor group	Replace switching module
E5	Misfiring	Replace switching module
E6	Network Synchronization Error	Filter harmonics
E7	Over temperature	Replace cooling fan, cool the system
E8	Phase shift error/Phase drop	Fix phases failure
E10	System Resonance	Add inductors, change inductors value

Table 8: List of Error Codes and Possible Solutions

Failure to Synchronize to Phase Voltage L1 (E2)

Possible Causes

The controller synchronizes to the phase voltage of phase L1. In order to be able to synchronize it must have phase L1 voltage and Neutral connected. In systems without neutral the neutral connector should be grounded.

How to Repair

(1) Verify that the Phase L1 and Neutral connectors are connected.

(2) Confirm that there is no mismatch between the Phase and Neutral (i.e. the phase is connected to the neutral and vice versa).
Do this by measuring the voltage between the phase and the ground.

Additional Information

The same procedure is useful in cases that the unit doesn't turn on or it turns on and off repeatedly.

Unable to Connect Capacitor Group (E3)

Possible Causes

Whenever the controller connects a group of capacitors it verifies there is current at the system in all three phases, in order to verify the operation. If the measured current in one or more of the phases is too low, **E3** is reported.

How to Repair

For Switching Module types "A" or "B" (

Figure 6 on page 14):

(1) If the error occurs at three adjacent groups, they probably share the same switching module, which is the source of the problem.
Check the following items in the switching module, or replace it with another one:

- Fuse
- Power supply
- Connection of firing cable

(2) If there is more than one switching module in the system, try firing this group using another switching module by changing the wiring of the firing cable. If the faulty group number is changed, change the switching module. In some cases it may be enough to change only the appropriate SCRs inside the switching module.

(3) Check the capacitors

For Switching Module types "C" or "D" (

Figure 6 on page 14):

(1) Check "Power" indication on the switching module. If it is not "on" check:

- This group inductor/s for over-heating and thermistors wiring.
- Power supply
- Switching Module fuse

(2) Try firing this group using another switching module by changing the wiring of the firing cable. If the faulty group number is changed, change the switching module. In some cases it may be enough to change only the appropriate SCRs inside the switching module.

(3) Check the capacitors

Unable to Disconnect Capacitor Group (E4)

Possible Causes

When all the groups are disconnected the controller verifies that there is no current at the system in any of the phases. If there is current in one or more of the phases, **E4** is reported.

How to Repair

(1) Turn the system power down and measure the impedance between the two edges of each SCR of the malfunctioned group. If the impedance is less than 100Ω, either replace the SCR or replace the Switching Module.

Misfiring (E5)

Possible Causes

Misfiring is detected by spikes on the capacitors current. The sources for such spikes can be the firing card (inside the switching module), an SCR or even a fuse.

How to Repair

(1) If there is more than one switching module in the system, try firing this group using another switching module by changing the wiring of the firing cable. If the faulty group number is changed, change the switching module. In some cases it may be enough to change only the appropriate SCRs inside the switching module. If the faulty group number is not changed, replace the firing cable and/or the controller.

(2) Replace the switching module.

(3) Replace the controller.

(4) Replace the group's fuses.

Network Synchronization Error (E6)

Possible Causes

The system has sophisticated algorithm for synchronizing with the electrical network. In some cases the network is extremely unstable and even this excellent technique cannot synchronize to it.

How to Repair

(1) Verify a satisfactory connection of phase L1 voltage and Neutral.

Over Temperature (E7)

For Switching Module types "A" or "B" (
Figure 6 on page 14):

Possible Causes

Over temperature failure occurs due to the following reasons:

(1) The ambient temperature is too high.

(2) The 1A fuse at the rear panel of the Switching Module is burned or the switching module doesn't receive power supply.

(3) The switching module fan is not functioning, due to either defective fan or internal malfunctioning thermistor (55° N.O.). This will result in over-heating of the switching module.

(4) Internal malfunctioning thermistor (85° N.O.). This will result in wrong fault indication.

(5) One of the inductors' thermistor (120° N.C.) is malfunctioning, or the wiring of the inductors thermistor is not correct. Note that each cabinet (in multi-cabinet system) has its own inductors wiring to its switching module Alarm IN (marked as Ext. Temp. Alarm N.C.).

How to Repair

(1) If the error appears upon the system power on:

- Check the 1A fuse that located on the rear side of the switching module. Check continuity with ohmmeter.
- Check the firing cables, and the wiring between the thermistors that are located on the inductors for good physical connections.
- Verify that the Alarm Input on each switching module is wired to inductors' thermistor and that it is normally close.
- Short the Alarm Input on one of the switching modules. If the error disappears, check the wiring of this switching module alarm input. If not, continue on the next switching module.
- Disconnect the two wires from the terminal of the ALARM N.C, which located on the back of the switching module, and verify with ohmmeter between the two wires (that coming from the loop of the serial thermostat) is short circuit zero impedance. If it isn't, check which thermostat is open and change to new one. This should be done in each cabinet in a multi-cabinet system.
- Verify with voltmeter that the supply for each switching module is 230V (or 115V for 115v model). The terminals are located at the switching module's rear panel.
- Open the left rear panel of the switching module and disconnect one wire which connected to the thermostat (type 85°c, N.O) and verify with ohmmeter that its impedance is infinity (open mode), if not change to a new one. Important: Make sure that the temperature near the thermostat (85°c) is lower than 80°c.
- If the system includes more than one switching module, it is possible to isolate the source for the fault using the following procedure: Disconnect the firing cable that connects between the last switching module (typically it is the one which located farther from the cabinet of the controller) and check if fault indication disappears. In case that it disappears, the reason for fault indication is the unconnected cabinet. If it not, connect the firing cable and continue to the next switching module, return on the procedure that narration above. NOTE: there will showed error 3 on the display after you disconnect firing cable.

(2) Verify that there are no obstacles in the air ways.

(3) Verify that the ambient temperature is not above the system specifications. If it is too high, reduce it by improving the ventilation of the site or adding cooling to the site.

(4) If the switching module is above 60°c and the cooling fan is not working, open the right rear panel of the switching module and short the thermistor. If the fan starts to work, replace the thermistor. Otherwise, replace the fan.

(5) Change the firing card that located in the controller.

For Switching Module types “C” or “D” (
Figure 6 on page 14):

Possible Causes

Over temperature failure occurs due to the following reasons:

(1) The ambient temperature is too high.

(2) The switching module fan is not functioning, due to either defective fan or internal malfunctioning thermistor (55° N.O.). This will result in over-heating of the switching module.

(3) Internal malfunctioning thermistor (85° N.O.). This will result in wrong fault indication.

How to Repair

(1) Check the “Alarm” led on each one of the switching modules. If one of them is “on”:
   - If the switching module is above 60°c and the cooling fan is not working, open the right rear panel of the switching module and short the thermistor. If the fan starts to work, replace the thermistor. Otherwise, replace the fan.
   - Open the rear panel of the switching module and disconnect one wire which connected to the thermostat (type 85°c, N.O) and verify with ohmmeter that its impedance is infinity (open mode), if not change to a new one. Important: Make sure that the temperature near the thermostat (85°c) is lower than 80°c.

(2) Verify that there are no obstacles in the air ways.

(3) Verify that the ambient temperature is not above the system specifications. If it is too high, reduce it by improving the ventilation of the site or adding cooling to the site.

(4) Change the firing card that located in the controller.

Phase Shift Error/Phase Drop (E8)

Possible Causes

The controller verifies that all three phases are connected and that they are in correct order (L1-L2-L3 clockwise).

How to Repair

(1) If one of the phases is missing, verify the connection of this phase to the controller.

(2) If the phase order is wrong, change the wiring of the incoming cables to the unit. Important: the measuring phases MUST be consistent with the phases of the power section. Do NOT change the wiring of the controller voltage measurement inputs.

System Resonance (E10)

Possible Causes
The capacitor increase the harmonic pollution of the network, compared to the load only, by more than 50% from capacitor current.

How to Repair
Check the inductors value. It may be required to change the inductors. Please contact Elspec.

Communication Failure

Cannot Establish Communication

Use "Communication Info" screen (Figure 116) from the "System Information" (Figure 96 on page 70) for additional information on the communication status. The "Received" means the total packets that were received, including bad ones and packets that are not for this unit. "Transmitted" counts the total packets that were transmitted. Since each packet that was received correctly to this unit initiates one transmit packet, this counts the total received ok to this unit. Frame Errors indicate either wrong baud rate or bad link and CRC Errors are usually indication for bad link.

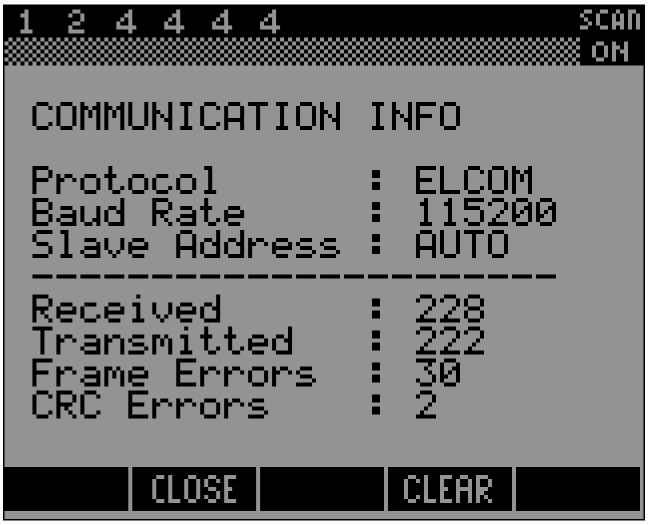


Figure 116: Communication Info Screen

(1) Verify the hardware connection to the unit, including RS-232 to RS-485 converter, power supply to the converter and the position of the converter dip switches.
(2) Make sure that the COM port is not in use by other application.
(3) Add the unit manually, using the Add Unit function.
(4) Use a lower baud rate.

The Remote Control Do Not Display Any Information or Updates Very Slow

Decrease the baud rate using the Unit Properties.

The Auto Setup Adds Too Many Units

Add the unit manually or use controller version 1.3.0 or higher. The version is displayed in the System Information screen (see page 70). See Appendix B for version upgrading.

Message "No Valid Parameters found for the selected unit"

Use controller version 1.3.1 or higher. The version is displayed in the System Information screen (see page 70). See Appendix B for version upgrading.

The PowerIQ Doesn't Have Remote Control Application

Use controller version 1.3.2 or higher. The version is displayed in the System Information screen (see page 70). See Appendix B for version upgrading.

Receiving Wrong Values in ModBus Protocol

Use controller version 1.3.3 or higher. The version is displayed in the System Information screen (see page 70). See Appendix B for version upgrading.

The PowerIQ Doesn't Have Energy Application

Use controller version 2.0.0 or higher. The version is displayed in the System Information screen (see page 70). See Appendix B for version upgrading.

APPENDIX A: DETAILED MENU DESCRIPTION

3-phase WYE Configuration or Unbalanced Network with 3-phase Capacitors

- **Main Menu**
  - **Main Feeder Readings**
    - **Line Currents**
    - **Line to Line Voltages**
    - **Volt-Amp-Hz Meters**
    - **kVA-kW-PF Meters**
    - Energy Meters
      - Monthly totals
      - 15 minute meters
    - Harmonic Analysis
      - Line Current THD
      - L-L Voltage THD
      - L-N Voltage THD
      - Line Current Spectrum
        - L1 Current Spectrum
        - L2 Current Spectrum
        - L3 Current Spectrum
      - L-L Voltage Spectrum
        - L1-L2 Voltage Spectrum
        - L2-L3 Voltage Spectrum
        - L3-L1 Voltage Spectrum
      - L-N Voltage Spectrum
        - L1-N Voltage Spectrum
        - L2-N Voltage Spectrum
        - L3-N Voltage Spectrum
      - Neutral Line Spectrum
        - Neutral Voltage
        - Neutral Current
    - Waveforms
      - L1 Current
      - L2 Current
      - L3 Current
      - L1-L2 Voltage
      - L2-L3 Voltage
      - L3-L1 Voltage
      - More...
        - L1-N Voltage
        - L2-N Voltage
        - L3-N Voltage
        - Neutral Voltage
        - Neutral Current
    - **More...**
      - **Power Factor Meters**
      - **kVAr Phase Meters**
      - **kVA Phase Meters**
      - **kW Phase Meters**
      - **L-N Voltage Meters**
      - **Neutral Conductor**
  - **Load Center Readings**
    - **Line Currents**
    - **Line to Line Voltages**
    - **Volt-Amp-Hz Meters**
    - **kVA-kW-PF Meters**
    - Harmonic Analysis
      - Line Current THD
      - L-L Voltage THD
      - L-N Voltage THD
      - Line Current Spectrum
        - L1 Current Spectrum
        - L2 Current Spectrum
        - L3 Current Spectrum
      - L-L Voltage Spectrum
        - L1-L2 Voltage Spectrum
        - L2-L3 Voltage Spectrum
        - L3-L1 Voltage Spectrum
      - L-N Voltage Spectrum
        - L1-N Voltage Spectrum
        - L2-N Voltage Spectrum
        - L3-N Voltage Spectrum
    - Waveforms
      - L1 Current
      - L2 Current
      - L3 Current
      - L1-L2 Voltage
      - L2-L3 Voltage
      - L3-L1 Voltage
      - More...
        - L1-N Voltage
        - L2-N Voltage
        - L3-N Voltage
    - **More...**
      - **Power Factor Meters**
      - **kVAr Phase Meters**
      - **kVA Phase Meters**
      - **kW Phase Meters**
      - **L-N Voltage Meters**
  - **Cap. System Readings**
    - **Line Currents**
    - **L-L Voltages**
    - **kVAr Meters**
    - **Auto Mode Calc. Groups**
    - **Auto Mode Calc. kVAr**
    - Harmonic Analysis
      - Line Current THD
      - L-L Voltage THD
      - Line Current Spectrum
        - L1 Current Spectrum
        - L2 Current Spectrum
        - L3 Current Spectrum
      - L-L Voltage Spectrum
        - L1-L2 Voltage Spectrum
        - L2-L3 Voltage Spectrum
        - L3-L1 Voltage Spectrum
    - Waveforms
      - L1 Current
      - L2 Current
      - L3 Current
      - L1-L2 Voltage
      - L2-L3 Voltage
      - L3-L1 Voltage
  - **L C M combined**
    - **Average Line Currents**
    - **Total kVAr meters**
    - **Total kVA meters**
    - **Average PF meters**
  - **System Information**
  - **System Setup**
    - **Display Contrast**
    - **Display Refresh Rate**
    - **Target Power Factor**
    - **MODBUS Slave Address (option)**
    - --------------------
    - **Site Installation**

Legend:

Bold Text - All measurement levels

Normal Text - Measurement level 2 and higher

Greyed Text - Measurement level 3 and higher

3-phase DELTA Configuration

Main Menu

- **Main Feeder Readings**
  - **Line Currents**
  - **Line to Line Voltages**
  - **Volt-Amp-Hz Meters**
  - **kVA-kW-PF Meters**
  - Energy Meters
    - Monthly totals
    - 15 minute meters
  - Harmonic Analysis
    - Line Current THD
    - L-L Current THD
    - L-L Voltage THD
    - Line Current Spectrum
      - L1 Current Spectrum
      - L2 Current Spectrum
      - L3 Current Spectrum
    - L-L Current Spectrum
      - L1-L2 Current Spectrum
      - L2-L3 Current Spectrum
      - L3-L1 Current Spectrum
    - L-L Voltage Spectrum
      - L1-L2 Voltage Spectrum
      - L2-L3 Voltage Spectrum
      - L3-L1 Voltage Spectrum
  - Waveforms
    - L1 Current
    - L2 Current
    - L3 Current
    - L1-L2 Voltage
    - L2-L3 Voltage
    - L3-L1 Voltage
    - More...
      - L1-L2 Current
      - L2-L3 Current
      - L3-L1 Current
  - **More...**
    - **Power Factor Meters**
    - **kVAr Phase Meters**
    - **kVA Phase Meters**
    - **kW Phase Meters**
    - **Line to Line Currents**
- **Load Center Readings**
  - **Line Currents**
  - **Line to Line Voltages**
  - **Volt-Amp-Hz Meters**
  - **kVA-kW-PF Meters**
  - Harmonic Analysis
    - Line Current THD
    - L-L Current THD
    - L-L Voltage THD
    - Line Current Spectrum
      - L1 Current Spectrum
      - L2 Current Spectrum
      - L3 Current Spectrum
    - L-L Current Spectrum
      - L1-L2 Current Spectrum
      - L2-L3 Current Spectrum
      - L3-L1 Current Spectrum
    - L-L Voltage Spectrum
      - L1-L2 Voltage Spectrum
      - L2-L3 Voltage Spectrum
      - L3-L1 Voltage Spectrum
  - Waveforms
    - L1 Current
    - L2 Current
    - L3 Current
    - L1-L2 Voltage
    - L2-L3 Voltage
    - L3-L1 Voltage
    - More...
      - L1-L2 Current
      - L2-L3 Current
      - L3-L1 Current
  - **More...**
    - **Power Factor Meters**
    - **kVAr Phase Meters**
    - **kVA Phase Meters**
    - **kW Phase Meters**
    - **Line to Line Currents**
- **Cap. System Readings**
  - **Line Currents**
  - **L-L Voltages**
  - **kVAr Meters**
  - **Auto Mode Calc. Groups**
  - **Auto Mode Calc. kVAr**
  - Harmonic Analysis
    - Line Current THD
    - L-L Voltage THD
    - Line Current Spectrum
      - L1 Current Spectrum
      - L2 Current Spectrum
      - L3 Current Spectrum
    - L-L Voltage Spectrum
      - L1-L2 Voltage Spectrum
      - L2-L3 Voltage Spectrum
      - L3-L1 Voltage Spectrum
  - Waveforms
    - L1 Current
    - L2 Current
    - L3 Current
    - L1-L2 Voltage
    - L2-L3 Voltage
    - L3-L1 Voltage
- **L C M combined**
  - **Average Line Currents**
  - **Total kVAr meters**
  - **Total kVA meters**
  - **Average PF meters**
- **System Information**
- **System Setup**
  - **Display Contrast**
  - **Display Refresh Rate**
  - **Target Power Factor**
  - **MODBUS Slave Address (option)**
  - **--------------------**
  - **Site Installation**

Legend:
Bold Text - All measurement levels
Normal Text - Measurement level 2 and higher
Greyed Text - Measurement level 3 and

Single-phase Configuration

- **Main Menu**
  - **Main Feeder Readings**
    - **Volt-Amp-PF Meters**
    - **kVA-kW-kVAr Meters**
    - **THDv-THDi-Hz Meters**
    - Voltage Waveform
    - Current Waveform
    - Voltage Spectrum
    - Current Spectrum
    - Energy Meters
      - Monthly totals
      - 15 minute meters
  - **Load Center Readings**
    - **Volt-Amp-PF Meters**
    - **kVA-kW-kVAr Meters**
    - **THDv-THDi-Hz Meters**
    - Voltage Waveform
    - Current Waveform
    - Voltage Spectrum
    - Current Spectrum
  - **Cap. System Readings**
    - **Volt-Amp-kVAr**
    - **THDv-THDi-kVAr**
    - **Auto Mode Requirements**
    - Voltage Waveform
    - Current Waveform
    - Voltage Spectrum
    - Current Spectrum
  - **L C M combined**
    - **Line Currents Meters**
    - **kVAr meters**
    - **kVA meters**
    - **Power Factor meters**
  - **System Information**
  - **System Setup**
    - **Display Contrast**
    - **Display Refresh Rate**
    - **Target Power Factor**
    - **MODBUS Slave Address** (option)
    - --------------------
    - **Site Installation**

Legend:

Bold Text - All measurement levels

Normal Text - Measurement level 2 and higher

Greyed Text - Measurement level 3 and

Unbalanced Network with Single-phase Capacitors

- **Main Menu**
  - **Main Feeder Readings**
    - **Line Currents**
    - **Line to Line Voltages**
    - **Volt-Amp-Hz Meters**
    - **kVA-kW-PF Meters**
    - Energy Meters
      - Monthly totals
      - 15 minute meters
    - Harmonic Analysis
      - Line Current THD
      - L-L Voltage THD
      - L-N Voltage THD
      - Line Current Spectrum
        - L1 Current Spectrum
        - L2 Current Spectrum
        - L3 Current Spectrum
      - L-L Voltage Spectrum
        - L1-L2 Voltage Spectrum
        - L2-L3 Voltage Spectrum
        - L3-L1 Voltage Spectrum
      - L-N Voltage Spectrum
        - L1-N Voltage Spectrum
        - L2-N Voltage Spectrum
        - L3-N Voltage Spectrum
      - Neutral Line Spectrum
        - Neutral Voltage
        - Neutral Current
    - Waveforms
      - L1 Current
      - L2 Current
      - L3 Current
      - L1-L2 Voltage
      - L2-L3 Voltage
      - L3-L1 Voltage
      - More...
        - L1-N Voltage
        - L2-N Voltage
        - L3-N Voltage
        - Neutral Voltage
        - Neutral Current
    - **More...**
      - **Power Factor Meters**
      - **kVAr Phase Meters**
      - **kVA Phase Meters**
      - **kW Phase Meters**
      - **L-N Voltage Meters**
      - **Neutral Conductor**
  - **Load Center Readings**
    - **Line Currents**
    - **Line to Line Voltages**
    - **Volt-Amp-Hz Meters**
    - **kVA-kW-PF Meters**
    - Harmonic Analysis
      - Line Current THD
      - L-L Voltage THD
      - L-N Voltage THD
      - Line Current Spectrum
        - L1 Current Spectrum
        - L2 Current Spectrum
        - L3 Current Spectrum
      - L-L Voltage Spectrum
        - L1-L2 Voltage Spectrum
        - L2-L3 Voltage Spectrum
        - L3-L1 Voltage Spectrum
      - L-N Voltage Spectrum
        - L1-N Voltage Spectrum
        - L2-N Voltage Spectrum
        - L3-N Voltage Spectrum
    - Waveforms
      - L1 Current
      - L2 Current
      - L3 Current
      - L1-L2 Voltage
      - L2-L3 Voltage
      - L3-L1 Voltage
      - More...
        - L1-N Voltage
        - L2-N Voltage
        - L3-N Voltage
    - **More...**
      - **Power Factor Meters**
      - **kVAr Phase Meters**
      - **kVA Phase Meters**
      - **kW Phase Meters**
      - **L-N Voltage Meters**
  - **Cap. System Readings**
    - **Volt-Amp-kVAr**
    - **THDv-THDi-kVAr**
    - **Auto Mode Requirements**
    - Voltage Waveform
    - Current Waveform
    - Voltage Spectrum
    - Current Spectrum
  - **L C M combined**
    - **Average Line Currents**
    - **Total kVAr meters**
    - **Total kVA meters**
    - **Average PF meters**
  - **System Information**
  - **System Setup**
    - **Display Contrast**
    - **Display Refresh Rate**
    - **Target Power Factor**
    - **MODBUS Slave Address (option)**
    - --------------------
    - **Site Installation**

Legend:

Bold Text - All measurement levels

Normal Text - Measurement level 2 and higher

Greyed Text - Measurement level 3 and

APPENDIX B: FIRMWARE UPGRADE

Controller's flash memory comprises sections as listed below:

- Boot loader, handling firmware (internal software) loading - this section can only be updated using a special hardware card.
- The firmware running the unit – this section is updated through the communication port.
- Unit parameters - these are not changed by the upgrades, however, since new firmware may have additional parameters, Site Installation must be repeated on completion of each software upgrade.
- Stored data (events, time-of-use, logging) – these are not changed by the upgrades, however, since new firmware may have different logging capabilities, all necessary information must be backed up before upgrading.

The upgrading procedure may include one or two steps, as instructed by Elspec:

- Boot Loader upgrade, normally accomplished in conjunction with firmware upgrading (with or without product code).
- Firmware upgrade, with or without product code, of the internal software. Optionally, the product code may also be modified.

Before You Start

Since the upgrade may corrupt parameters and logged data, run Site Installation and write down all system data. Also, if you have relevant information stored, synchronize it to the PowerIQ software.

Boot Loader Upgrading

(1) Switch the power down, remove the service door on the back of the controller, and slide the Boot Loader Upgrade card into the upper slot. If the slow is occupied, temporarily remove the existing card.

(2) Switch the power back up. On display of the welcome message, press **F1**. On completion, switch the power down and remove the Boot Loader Card. If you have removed a card to insert the Boot Loader Card, reinstall.

(3) Fit service door back in position and switch the power back up. The boot loader upgrading procedure is now complete.

Firmware Upgrading

(1) Connect the controller to the mains and to a computer. Make sure that PowerIQ is NOT running on this computer (if the target unit does not include a communication port, install a communication card temporary in the upper slot).

(2) Open the System Information screen and verify that the controller is of a firmware version and serial number as listed in the firmware upgrade information received from Elspec.

(3) Run the firmware upgrade application, normally named EFU_???.exe where ??? is the new version number.

(4) If you only wish to upgrade the firmware and not the product code, proceed to step 8.

(5) Press the Shift key on the keyboard and then (without releasing the Shift key) click "OK" with the mouse.

(6) The application will start to communicate with the unit until the unit is reset. On display of this message: "Cannot establish communication", do the following and then repeat this procedure:

  a. Switch unit power down.
  b. Press **F3** and **F5** simultaneously.
  c. Switch unit power back up (while still holding **F3** and **F5**).
  d. Hold the keys until the boot loader screen appears.

(4) A window will open and display the serial number and version, also prompting for product and authorization code. Fill in the product code and authorization number as indicated in the firmware upgrade information received from Elspec, then click OK.

(5) The communication progress bar will go up to 100% and then the system will reset. On display of the message: "Cannot establish communication", proceed to step 6.

(6) The controller is now ready for operation - select "System Set up", then "Site Installation" and finally "Modify the above" to set all the parameters.

APPENDIX C: CONTROLLER MOUNTING AND CONNECTION

Mounting

The Controller is designed for mounting in a 140×140 mm hole on a cabinet door. To mount, secure to the door with two fixing clamps as shown in Figure 117.

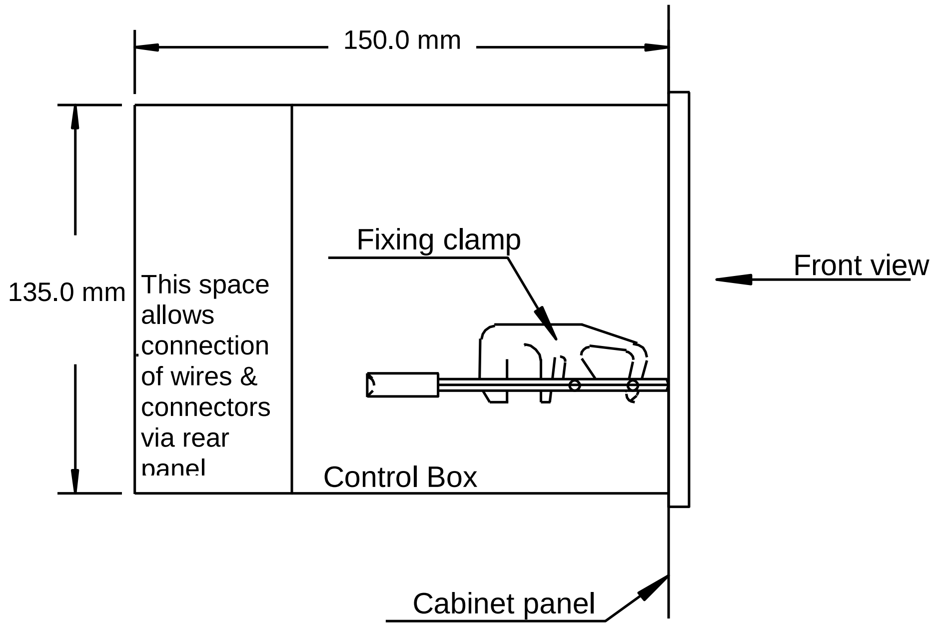


Figure 117: Controller Mounting Diagram (Left Side View)

Connection

Controller rear panel (Figure 118) contains all the connectors required for interface. It carries 12 group *Equalizer/ACTIVAR* firing and RS-485 communication cards. The functions of all rear panel connectors are as described below.

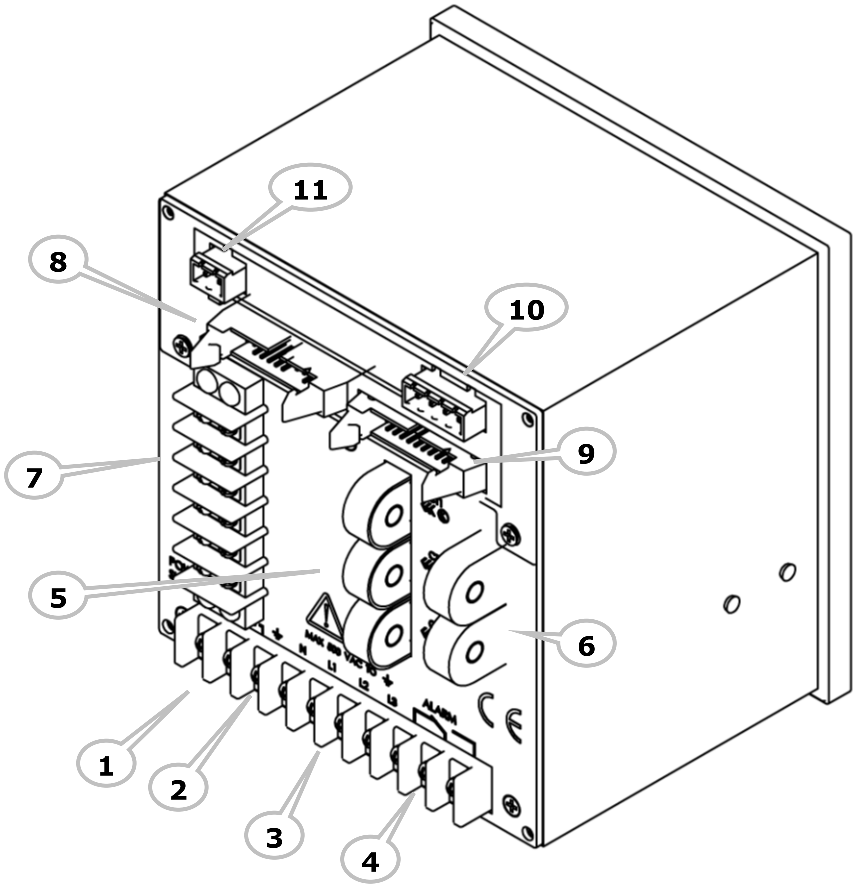


Figure 118: Controller - Rear View

Power Supply (1)	Single-phase power supply. Connect to 230v - 50 or 60 Hz.
GND (2).	Connection to protective earth.
Voltage Measurements(3).	Connection of measured voltages. In delta networks, there is no need to connect the neutral (N). In single-phase networks, connect either L1 and N, or L1 and L2.
Alarm Relay Outputs (4)	Alarm relay outputs. Maximum rating: 250VAC, 24VDC, 2A.
Mains CT (5)	Connection of the network CTs, made without electrical contact. To connect, insert cable through the hole in the red ring. The phases are sequenced from top to bottom: L1, L2, L3.
Caps. CT (6)	Connection of system's internal CTs, made without electrical contact. To connect, insert cable through the hole in the red ring. The phases are sequenced from top to bottom: L1, L2. The bottom ring is not used.
Supporting Connectors (7)	These connectors have no electrical connection to the controller. They serve to support the connection of the CTs, which is normally made by means of two cables (K and L). To connect, insert one cable through the red ring and tie both cables with one of the supporting connectors.
FIRING Connector A (8)	Providing firing pulses to the switching modules and receiving temperature detector's information on capacitor groups 1 through 6.
FIRING Connector B (9)	Providing firing pulses to the switching modules and receiving temperature detector's information on capacitor groups 7 through 12. Groups 7-10 of J3 can be used for groups 5-8, depending on the configuration.
RS-485 (10)	RS-422/RS-485 serial communication port, comprising differential Transmit and Receive ports (connector type: Phoenix MSTB-2.5/4-ST).
Digital Input 1 (11)	Isolated digital input (connector type: Phoenix MSTB-2.5/2-ST). For system option "W" this input operates as "Inhibit Signal": When the Inhibit Signal is enabled, the system operates in running (automatic) mode only when this input has an active signal (Figure 77). For system option "P" this input operates as "Synchronization Signal": This is an input from the load to synchronize the control system (Figure 63).

APPENDIX D: EVENTS LOG

Table 9 lists of all possible events and their description.

ID	Description	Cause
I0001	Power On.	The system was powered on
I0002	Modified Parameter set was rewritten to the flash memory.	One or more of the parameters were changed by the user
I0003	Event history cleared.	The operator cleared the events' history
I0004	Energy history cleared.	The operator cleared the energy records
I0005	E7 Over Temperature error sequence activated.	The system detected over temperature
I0006	E7 Over Temperature error sequence deactivated.	Over temperature error was ended
I0007	Capacitor group test has been performed. Group #**(1)** Found faulty by: Er **(2)**	System test was ended with some faulty capacitors, indicating the faulty groups **(1)** and errors found **(2)**
I0008	Capacitor group test has been performed. No group errors found.	System test was ended and all the groups are ok
I0009	CCT polarity was changed automatically during installation procedure.	The system automatically changed the system internal CT polarity during site installation
I0010	E6 synchronization error. Measurement system was disabled.	The system could not synchronize
I0011	E6 synchronization error has been Cleared.	The system reengaged synchronization
I0012	Time settings were changed.	The operator changes the system time
I0013	Date settings were changed.	The operator changes the system date
I0014	System failed to recover from parameter CRC error. Factory default parameter set was activated.	Both copies of the parameters were corrupted and the system automatically loaded default values
I0015	Automatic operation mode has been set.	User selected automatic mode of operation
I0016	Manual operation mode has been set.	User selected manual mode of operation
I0017	System was shut down. Alarm signal was set ON.	The system was powered off
I0018	Parallel resonance has been detected at H**(1)**. Capacitors are disabled for the next **(2)** sec while **(3)** steps were connected.	The system detected resonance in the network. The lower harmony is displayed **(1)** and the groups that were connected **(3)**. The system is disabled for **(2)** seconds.

Table 9: List of Events Log and Their Meaning

I0019	Alarm signal was set ON.	Alarm signal was activated
I0020	ALARM signal was cleared.	Alarm signal was de-activated
I0021	Power Factor Control has been activated.	The user selected Power Factor mode of operation
I0022	Reactive Energy Control (kVAr) has been activated.	The user selected kVAr mode of operation
I0023	Target Power Factor set point was changed to **(1)** %	The user set the target power factor to **(1)**
I0024	Target kVAr set point was changed to **(1)** kVAr	The user set the target kVAr to **(1)**
I0025	Deep voltage drop control function has been ENABLED.	The user enabled voltage control mode
I0026	Deep voltage drop control function has been DISABLED.	The user disabled voltage control mode
I0027	Deep voltage drop was detected All available capacitor groups will be connected.	The system activated the voltage control grid drop mode
I0028	Deep voltage drop mode has been deactivated Resuming normal operation.	The system de-activated the voltage control grid drop mode
I0029	Firmware version was upgraded from **(1)** to **(2)** **(3)**	The user changed the firmware version from **(1)** to **(2)** with code **(3)**

Table 9: List of Events Log and Their Meaning (cont.)

APPENDIX E: COMMUNICATION

General

The system supports two communication protocols:

Elcom Elspec's unique high-speed communication protocol, enabling the fastest serial communication using PowerIQ software.

ModBus Standard communication protocol, used for communicating with software other than the PowerIQ. This protocol requires a controller with the EQC/ACR □□□**2**-□ option.

Since the system contains a "self-configuration" function, no protocol type and baud rate settings are required. The only setup is Salve ID for Modbus protocol.

ModBus Protocol

The system communicates using MODBUS/RTU with 8 data bits, No Parity and 1 stop bit. The baud rate is set automatically between 9600 to 115200 bps and the Slave ID is set from the front panel

All the parameters are 4x registers and read using either function 3 (Read Holding Registers) or function 4 (of the same functionality). The format of all data is float in real values (e.g. Volts, Amperes) using the standard ModBus byte order. In some applications it is necessary to set the byte order.

Certain applications do not support float format. Converting from four bytes to float, according to IEEE 754 floating point, can be done as in the following procedure (0x indicates hexadecimal numbers):

> If the value is 0x7F800000, it is positive infinity.
> If the value is 0xFF800000, it is negative infinity.
> If the value is in the range 0x7F800001 through 0x7FFFFFFF or in the range 0xFF800001 through 0xFFFFFFFF, it is NaN
> In all other cases, let S, E, and M be three integer values that can be calculated from the following bits:
> If bit 31 is 0, S is 1. Else S is -1.
> E is bits 23 to 30.
> If E is 0, M is bits 0 to 22, multiplied by 2. Else M is bits 0 to 22 plus 0x800000.
> Then the floating-point result equals the value of the mathematical expression $S \times M \times 2^{(E-150)}$

Major parameters are as listed below. Other parameters are available for more detailed information. An address starting with "0x" represents a hexadecimal address. Note that the addresses are listed as PLC addresses (base 1). For protocol addresses (base 0) deduct 1 from each value.

Ir1 represents the Mains current in phase R (L1), Ir2 represents Capacitor System current in phase R, Ir3 represents Load Centre current in phase R (see Chapter 6) and In represents the mains neutral current.

VrH1 represents the value of first phase-to-neutral harmonic in phase R. The following harmonics are in the consecutive address (in steps of 2), i.e., the 2nd harmonic is in address 0x303.

Status & Control Variables

Parameter	Address	R/W	Format	Notes
System Status	0x2AB4	R	16bit	0=System Ok. See details below.

System Status Bits:

Bit	Parameter	Values
Bit 0	Operation mode	0=Auto, 1=Manual
Bit 1	Stand-By mode	0=Running, 1=Stop
Bit 2	Installation	0=Completed 1=not yet
Bit 3	Test Status	0=No test 1=Test in Progress
Bit 4	Faults	0=No Faults 1=some general faults
Bit 5	Inhibiting signal	0=Not Activated 1=Activated
Bit 6	Cooling mode	0=Not Activated 1=Activated
Bits 7-15	RESERVED	

Parameters Addresses

r, s, t	L1, L2 and L3
rs, st, tr	L12, L23 and L31
I	current
V	voltage
Number **1**	Mains
Number **2**	Caps
Number **3**	Load
P	Active power
Q	Reactive power
S	Apparent power
Cos	Power factor
THDI	THD distortion at current
THDV	THD distortion at voltage
n	Neutral
H1	Harmonics

Parameter	Addr
Fault	0x2101
Frequency	17
VrRMS	1
VsRMS	3
VtRMS	5
VavgRMS	7
VrsRMS	9
VstRMS	11
VtrRMS	13
VVavgRMS	15
Ir1RMS	21
Is1RMS	23
It1RMS	25
I1avgRMS	27
Ir2RMS	29
Is2RMS	31
It2RMS	33
I2avgRMS	35
Ir3RMS	37
Is3RMS	39
It3RMS	41
I3avgRMS	43
Pr1RMS	51
Ps1RMS	53
Pt1RMS	55
Ptot1RMS	57
Qr1RMS	59
Qs1RMS	61
Qt1RMS	63
Qtot1RMS	65
Sr1RMS	67
Ss1RMS	69
St1RMS	71
Stot1RMS	73

Parameter	Addr
Qr2RMS	89
Qs2RMS	91
Qt2RMS	93
Qtot2RMS	95
Pr3RMS	111
Ps3RMS	113
Pt3RMS	115
Ptot3RMS	117
Qr3RMS	119
Qs3RMS	121
Qt3RMS	123
Qtot3RMS	125
Sr3RMS	127
Ss3RMS	129
St3RMS	131
Stot3RMS	133
CosR1RMS	141
CosS1RMS	143
CosT1RMS	145
CosTot1RMS	147
THDVr	201
THDVs	203
THDVt	205
THDV_max	207
THDVrs	209
THDVst	211
THDVtr	213
THDVV_max	215
THDIr1	221
THDIs1	223
THDIt1	225
THDI1_max	227

Parameter	Addr
THDIr2	231
THDIs2	233
THDIt2	235
THDI2_max	237
THDIr3	239
THDIs3	241
THDIt3	243
THDI3_max	245
VrH1	0x0301
VsH1	0x0401
VtH1	0x0501
VrsH1	0x0601
VstH1	0x0701
VtrH1	0x0801
Ir1H1	0x0901
Is1H1	0x0A01
It1H1	0x0B01
Ir2H1	0x0C01
Is2H1	0x0D01
It2H1	0x0E01
Ir3H1	0x0F01
Is3H1	0x1001
It3H1	0x1201
VnRMS	281
InRMS	283
THDVn	285
THDIn	287

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