EPower™ MC Controller

- Fully software configurable
- Predictive Load Management
- Current rating 800A to 4000A
- Voltage up to 690V ac
- All types of firing modes
- Measurement accuracy <1%
- Large integral four row display
- Remote display option
- Multi-channel unit
- Event Log
- Optional I/O
- Modbus RTU comms
- Profibus DP comms
- DeviceNet® comms
- Ethernet (Modbus TCP) comms
- EtherNet/IP comms
- CC-Link comms
- Profinet IO comms
- Voltage, current and power control
- Complete diagnostics
- Energy counter
- Single phase Load Tap Changer

EPower™ MC Controller is the Eurotherm® series of power management and control units. Combining the advantages of the latest technologies and innovations to produce a truly impressive performance for your process.

Ratings
The EPowerr current ratings cover the range from 800 Amps up to 4000 Amps. Ratings are designed at 40°C, but operation can be defined up to 50°C with associated deratings. The voltage rating can go up to a maximum of 690 volts in air cooled units (800 Amps to 2000 Amps) and 600 volts in water cooled units (2000 Amps to 4000 Amps).

Predictive Load Management (Patented)
You can reduce your energy costs across your plant by utilising the Predictive Load Management functionality within EPower. This innovative feature provides a better distribution of energy across different loads in your installation by managing the priority and if necessary, load shedding.

Multi Channel Unit
EPower includes seven different power configurations within one unit, depending on the number of power modules fitted. From single phase configuration to two times two phase control, the unit is perfectly modular and configurable to your process requirements. Multiple zones can be controlled with one unit.

Many more features are available (Log file management, advanced alarm strategy, optional I/O…) to provide you with the best of the technology for your process.

Display and Remote Display
EPower is fitted with a 4 line x 10 character display with indication of the process values, and diagnostic information, along with an alarm and event message centre. Optionally, the EPower has a 32h8e remote display to allow for the process values and alarm information to be presented front of panel in a clear and unambiguous way. Secure access to the local setpoint is also provided to allow for local control when needed. The remote display, as an indicator, can also provide over temperature policeman functionality removing the need for additional panel instrumentation.

imagine having the power to save energy
**General**

<table>
<thead>
<tr>
<th>Specification</th>
<th>MC unit (Driver Module + one power module per power stack)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Module of control (MC) = driver module + firing interface modules</td>
</tr>
<tr>
<td></td>
<td>The product is designed and produced to comply with EN60947-4-3 (low voltage switch gear and control gear). Other applicable standards are cited where appropriate.</td>
</tr>
</tbody>
</table>

**Installation Categories**

<table>
<thead>
<tr>
<th>Installation Category</th>
<th>Rated impulse withstand voltage (Uimp)</th>
<th>Rated insulation voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communications</td>
<td>0.5kV</td>
<td>50V</td>
</tr>
<tr>
<td>Standard I/O</td>
<td>0.5kV</td>
<td>50V</td>
</tr>
<tr>
<td>Driver Module power</td>
<td>2.5kV</td>
<td>230V</td>
</tr>
<tr>
<td>Relays</td>
<td>4kV</td>
<td>230V</td>
</tr>
<tr>
<td>Power Modules (up to 600V)</td>
<td>6kV</td>
<td>600V</td>
</tr>
<tr>
<td>Power Modules (690V)</td>
<td>6kV</td>
<td>690V</td>
</tr>
<tr>
<td>Auxiliary (Fan) supply</td>
<td>2.5kV</td>
<td>230V</td>
</tr>
</tbody>
</table>

**Module of control (MC) = driver module + firing interface modules**

<table>
<thead>
<tr>
<th>MC unit (Driver Module + one power module per power stack)</th>
<th>Voltage range</th>
<th>Frequency range</th>
<th>Power requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage range</td>
<td>100 to 240V ac (+10% - 15%)</td>
<td>47 to 63 Hz</td>
<td>600V</td>
</tr>
<tr>
<td>Frequency range</td>
<td>47 to 63 Hz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power requirement</td>
<td>600V</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Environment**

<table>
<thead>
<tr>
<th>Environment</th>
<th>Operating</th>
<th>Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>0°C to 50°C (32°F to 122°F) (see graph for derating information)</td>
<td>-25°C to 70°C (-13°F to 158°F)</td>
</tr>
</tbody>
</table>

**Warning**

Supply and drain water pipes must be of non-conductive material for at least 1 metre from the Thyristor stack and each element of metal piping in the cooling circuit must be individually bonded to safety earth.

**Protection**

Thyristor drive: High-speed fuses and RC circuits

Pollution degree: Pollution degree 2 (EN60947-1)

Installation category: Installation category II or category III (see Table 1 above)

**Power network**

Installation category II or category III assuming nominal phase voltage with respect to earth is ≤3000V rms (see Table 1 above)

**Thyristor stack weights**

<table>
<thead>
<tr>
<th>Nominal current of the Stack</th>
<th>1 Phase</th>
<th>2 Phase</th>
<th>3 Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000A</td>
<td>0.9</td>
<td>1.6</td>
<td>2.0</td>
</tr>
<tr>
<td>1500A</td>
<td>1.3</td>
<td>2.1</td>
<td>2.5</td>
</tr>
<tr>
<td>2000A</td>
<td>1.7</td>
<td>2.5</td>
<td>3.0</td>
</tr>
</tbody>
</table>

**Thyristor stacks**

IP 00 (EN60529)

Type 1 (fuses)

Single or multiphase control of resistive loads (low/high temperature coefficient and non-ageing/ageing types) and transformer primaries.

**EMC**

Standard: EN60947-4-3 Emissions class A

This product has been designed for environment A (industrial). Use of this product in environment B (domestic, commercial and light industrial) may cause unwanted electromagnetic disturbances in which cases the user may be required to take adequate mitigation measures.

**Immunity criteria**

Immunity criterion 1 (criterion 3 for voltage dips and short-time interruptions)
Operator Interface

Display: 4 lines of up to 10 characters each. Display pages can be used to view process variable values and to view and edit the configuration of the unit. (Editing of the configuration is better carried out using configuration software (iTools). In addition to the standard displays, up to 4 ‘custom’ pages can be defined which allow bargraph displays, text entry etc.

Character format: 7 high x 5 wide yellow-green LCD dot matrix array.

Push buttons: 4 push buttons provide page and item entry and scroll facilities.

LED indicators (beacons): 3 indicators (PWR LOC and ALM) are supplied to indicate that power is applied, that Local Control is selected and that there is one or more active alarm respectively.

Standard Inputs/Outputs (SK1)

All figures are with respect to driver module 0V, unless otherwise stated.

Number of inputs/outputs:
- No of analogue inputs: 2
- No of digital inputs/outputs: 1

10V (Potentiometer) supply: 1

No of analogue outputs: 1

No of digital outputs: 2 (each configurable as an input or an output)

Update rate: Twice the mains frequency applied to power module 1. Defaults to 83.2 Hz (12 ms) if no power applied to power module 1 or if supply frequency lies outside the range 47 to 63Hz.

Termination: Removable 10-way connector. (5.08 mm. pitch)

Analogue Inputs

Performance: See Tables 4 and 5

Input types: Each input is configurable as one of:
- Performance: See Tables 6 and 7

Table 4 Analogue input specification table (voltage inputs)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Typical</th>
<th>Max/Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total voltage working input span</td>
<td>-0.25V to +12.5V</td>
<td></td>
</tr>
<tr>
<td>Resolution (noise free) (Note 2)</td>
<td>13 bits</td>
<td>&lt;0.5%</td>
</tr>
<tr>
<td>Calibration error (Notes 3 and 4)</td>
<td>&lt;0.25%</td>
<td>±0.1%</td>
</tr>
<tr>
<td>Ambient temperature error (Note 3)</td>
<td>&lt;0.01%/°C</td>
<td></td>
</tr>
<tr>
<td>Input resistance (+ve terminal to 0V)</td>
<td>&gt;140KΩ</td>
<td></td>
</tr>
<tr>
<td>Input resistance (-ve terminal to 0V)</td>
<td>150Ω</td>
<td>±1V</td>
</tr>
<tr>
<td>Allowable voltage (+ve terminal to 0V)</td>
<td>&gt;-1V</td>
<td></td>
</tr>
<tr>
<td>Series mode rejection of mains interference</td>
<td>46dB</td>
<td>&gt;30dB</td>
</tr>
<tr>
<td>Common mode dc rejection</td>
<td>46dB</td>
<td>&gt;40dB</td>
</tr>
<tr>
<td>Hardware response time</td>
<td>5ms</td>
<td></td>
</tr>
</tbody>
</table>

Note 1: w.r.t. to the relevant -ve input
Note 2: w.r.t. total working span
Note 3: % of effective range (0 to 5V, 0 to 10V)
Note 4: After warm up. Ambient = 25°C

Table 5 Analogue input specification table (current inputs)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Typical</th>
<th>Max/Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total current working input span</td>
<td>-1mA to +25mA</td>
<td></td>
</tr>
<tr>
<td>Resolution (noise free) (Note 1)</td>
<td>12 bits</td>
<td>&lt;0.5%</td>
</tr>
<tr>
<td>Calibration error (Notes 2 and 3)</td>
<td>&lt;0.25%</td>
<td>±0.1%</td>
</tr>
<tr>
<td>Ambient temperature error (Note 2)</td>
<td>&lt;0.01%/°C</td>
<td></td>
</tr>
<tr>
<td>Input resistance (+ve terminal to 0V)</td>
<td>235Ω</td>
<td></td>
</tr>
<tr>
<td>Input resistance (-ve terminal to 0V)</td>
<td>150Ω</td>
<td></td>
</tr>
<tr>
<td>Allowable voltage (+ve terminal to 0V)</td>
<td>&lt;±1V</td>
<td></td>
</tr>
<tr>
<td>Series mode rejection of mains interference</td>
<td>46dB</td>
<td>&gt;30dB</td>
</tr>
<tr>
<td>Common mode dc rejection</td>
<td>46dB</td>
<td>&gt;40dB</td>
</tr>
<tr>
<td>Hardware response time</td>
<td>5ms</td>
<td></td>
</tr>
</tbody>
</table>

Note 1: w.r.t. total working span
Note 2: % of effective range (0 to 20mA)
Note 3: After warm up. Ambient = 25°C

Analogue outputs

Performance: See Tables 6 and 7

Output types: Each output is configurable as one of:
- 0 to 10V, 1 to 5V, 2 to 10V, 0 to 5V, 0 to 20mA, 4 to 20mA
- Absolute maxima + terminal: -0.7V to +300mA or (+16V or +40mA)
- 0V terminal: ±2A

Table 6 Analogue output specification table (voltage outputs)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Typical</th>
<th>Max/Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total current working span</td>
<td>-24mA</td>
<td>to +24mA</td>
</tr>
<tr>
<td>(within -0.3V to +12.5V voltage span)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open circuit voltage</td>
<td>&lt;16V</td>
<td></td>
</tr>
<tr>
<td>Resolution (noise free) (Note 1)</td>
<td>12.5 bits</td>
<td></td>
</tr>
<tr>
<td>Calibration error (Notes 2 and 3)</td>
<td>&lt;0.25%</td>
<td>&lt;0.5%</td>
</tr>
<tr>
<td>Ambient temperature error (Note 2)</td>
<td>&lt;±0.1%</td>
<td>&lt;0.01%/°C</td>
</tr>
<tr>
<td>Maximum load resistance</td>
<td>&gt;800Ω</td>
<td></td>
</tr>
<tr>
<td>DC output impedance</td>
<td>&lt;2Ω</td>
<td></td>
</tr>
<tr>
<td>Hardware response time (10% to 90%)</td>
<td>20ms</td>
<td>&lt;25ms</td>
</tr>
</tbody>
</table>

Note 1: w.r.t. total working span
Note 2: % of effective range (0 to 5V, 0 to 10V)
Note 3: After warm up. Ambient = 25°C

Table 7 Analogue output specification table (current outputs)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Typical</th>
<th>Max/Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total current working span</td>
<td>-0.7V</td>
<td>to +300mA or (+16V or +40mA)</td>
</tr>
<tr>
<td>(within 0V terminal: ±30V or ±25mA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open circuit voltage</td>
<td>&lt;24mA</td>
<td></td>
</tr>
<tr>
<td>Resolution (noise free) (Note 1)</td>
<td>12.5 bits</td>
<td></td>
</tr>
<tr>
<td>Calibration error (Notes 2 and 3)</td>
<td>&lt;0.25%</td>
<td>&lt;0.5%</td>
</tr>
<tr>
<td>Ambient temperature error (Note 2)</td>
<td>&lt;±0.1%</td>
<td>&lt;0.01%/°C</td>
</tr>
<tr>
<td>Maximum load resistance</td>
<td>&gt;800Ω</td>
<td></td>
</tr>
<tr>
<td>DC output conductance</td>
<td>&lt;1μA/V</td>
<td></td>
</tr>
<tr>
<td>Hardware response time (10% to 90%)</td>
<td>20ms</td>
<td>&lt;25ms</td>
</tr>
</tbody>
</table>

10V supply (Potentiometer supply)

Output voltage: 10.0V ± 0.3V @ 5.5mA

Short circuit o/p current: 15mA max.

Ambient temperature drift: ± 0.012%/°C (typ); ±0.04%/°C (max.)

Absolute maxima Pin 1: -0.7V or -300mA or (+16V or +40mA)

Digital I/O

Hardware response time: 100μs

Voltage inputs:
- Active level (high): 4.4V<Vin<30V
- Non-active level (low): -30V<Vin<-2.3V

Input impedance: 10kΩ

Contact closure input
- Source current: 10mA min; 15mA max
- Open contact (non-active) resistance: >500Ω
- Closed contact (active) resistance: <1500Ω

Current source output
- Source current: 9mA<ICs<14mA @ 14V
- 10mA<ICs<15mA @ 0V
- 9mA<ICs<14mA @ -15V

Open circuit voltage: <14V

Internal pull-down resistance: 10kΩ (to 0V)

Absolute maxima + terminal: ±20mA or ±10V

Absolute maxima - terminal: -30V or ±25mA

Notes:
1. Absolute maximum ratings refer to externally applied signals
2. The 10V potentiometer supply is designed to supply two 5kΩ potentiometers connected in parallel with one another.
3. The maximum current for any 0V terminal is ±2A.
Relay Specification

The relays associated with this product have gold plated contacts applicable to ‘dry circuit’ (low current) use.

Note: Normally closed and normally open refer to the relay when the coil is not energised.

Contact life
Resistive loads: 100,000 operations (de-rate with inductive loads as per figure)
High power use Current: <3A (resistive loads)
Voltage: <264V RMS
Low power use Current: >1mA
Voltage: <1V
Contact configuration: Single pole change-over (One set of Common, Normally Open and Normally Closed contacts)

Termination
Relay 1 (standard): 3-way connector on underside of Driver Module (see Electrical Installation)
Watchdog relay (standard): 3-way connector on underside of Driver Module (see Electrical Installation)
Relays two to four (option): 12-way option module connector (see Electrical Installation)

Installation Category
Installation category III, assuming that the nominal phase to earth voltage is ≤ 300V RMS. Isolation between different relays’ contacts is double isolation, in accordance with the installation category and phase to earth voltage specified above.

Absolute max switching capability: <2A at 240V RMS (resistive loads)

Optional Input/Output Modules (SK3, SK4, SK5)

Up to three input/output modules can be fitted, each containing the inputs and outputs detailed below. Unless otherwise stated below, the specification for the optional I/O (including relays) is as given above for the standard I/O.

Termination
Number of modules: Up to 3
Number of inputs: 1 analogue input and 2 digital inputs per module
Number of outputs: 1 analogue output per module
Number of relays: 1 set of common, normally open and normally closed contacts per module
10V potentiometer supply output voltage: 10.0V ±0.3V at 5.5mA

Mains Network Measurements

All network measurements are calculated over a full mains cycle, but internally updated every half-cycle. For this reason, power control, current limits and alarms all run at the mains half-cycle rate. The calculations are based on waveform samples, taken at a rate of 20Hz. Measurements on each phase are synchronised to its own phase and if the line voltage cannot be detected, the measurements stop for that phase. It should be noted that, depending on the configuration, the phase voltage referred to is one of:

a. the line voltage referenced to neutral in four star,
b. the line voltage referenced to neutral or another phase for single phase or
c. the line voltage referenced to the phase applied to the next adjacent power module for three phase star or delta configurations.

The parameters below are directly derived from measurements for each phase.

Accuracy (20 to 25°C) (Excludes errors due to Current Transformer (CT)). Error = max 0.5% for class 0.5 CTs
Line RMS voltage (Vline):
Load RMS voltage (V):
Thyristor RMS current (Ims):
Load RMS voltage squared (Vsq):

Further parameters (S, PF, Q, Z, Iavg, VsqMax, Vavg, Vsq Burst, VsqMax and Pburst) are derived from the above, for each network (if relevant). See EPower MC Controller User guide (Meas submenu) for further details.

External Current Transformer

| Ratio | Chosen such that the full scale output from the current transformer is 5 Amps. Table 8 shows details for suitable Current Transformers, including the Ext Scaling required for Network Setup configuration |

<table>
<thead>
<tr>
<th>Module</th>
<th>Part</th>
<th>I/O Current</th>
<th>Description</th>
<th>Extral dimensions (L x W x H)</th>
</tr>
</thead>
<tbody>
<tr>
<td>800A CO030232</td>
<td>800A-SA</td>
<td>800</td>
<td>169 x 92 x 72 (6.65 x 3.62 x 2.83)</td>
<td></td>
</tr>
<tr>
<td>1000A CO030233</td>
<td>1000A-SA</td>
<td>1000</td>
<td>169 x 92 x 72 (6.65 x 3.62 x 2.83)</td>
<td></td>
</tr>
<tr>
<td>1250A CO030234</td>
<td>1250A-SA</td>
<td>1250</td>
<td>169 x 92 x 72 (6.65 x 3.62 x 2.83)</td>
<td></td>
</tr>
<tr>
<td>1750A CO030235</td>
<td>1750A-SA</td>
<td>1750</td>
<td>190 x 137 x 80 (7.48 x 5.39 x 3.15)</td>
<td></td>
</tr>
<tr>
<td>2000A CO030236</td>
<td>2000A-SA</td>
<td>2000</td>
<td>190 x 137 x 80 (7.48 x 5.39 x 3.15)</td>
<td></td>
</tr>
<tr>
<td>3000A CO030237</td>
<td>3000A-SA</td>
<td>3000</td>
<td>195 x 156 x 88 (7.72 x 6.14 x 3.46)</td>
<td></td>
</tr>
<tr>
<td>4000A CO030238</td>
<td>4000A-SA</td>
<td>4000</td>
<td>221 x 145 x 90 (8.67 x 5.69 x 3.54)</td>
<td></td>
</tr>
</tbody>
</table>

All current transformers to be accuracy class 0.5.
All current transformers to be able to operate continuously at up to 120% of specified input current.

The precision of the current transformer (CT) affects I, I² and P control modes. To compute the minimum expected overall accuracy of a unit operating in these control modes, the CT accuracy must be taken into account. MC EPowers are delivered with class 0.5 CTs as standard.

Assuming the current transformer phase lag to be negligible, then for ‘I’ and ‘P’ modes, overall accuracy is calculated by adding the CT accuracy figure to the corresponding control mode accuracy figure (above). For ‘I²’ control mode, add twice the CT precision to the accuracy figure.

Communications

CC-Link:
Connector: 5-way
Indicators: RIUN and ERR
DeviceNet:
Connector: 5-way
Indicators: Network Status and Module Status
Ethernet:
Connector: RJ45
Indicators: Tx activity (green) and communications activity (yellow)
EtherNet/IP:
Connector: RJ45
Indicators: NS (Network status), MS (module status and LINK (Link status)
Modbus RTU:
Connector: 5-way
Transmission standard: 3-wire EIA485
Connector: RJ45
Indicators: Tx activity (green) and Rx activity (yellow)
Isolation (EN60947-4-3):
Connector: Link status
Terminals to ground: 50V RMS or dc to ground (double isolation)

Profinet:
Connector: Profibus DPV1
Indicators: 9-way D type
Protocol: Profinet IO
Connector: RJ45
Indicators: NS (Network status), MS (Module status) and LINK (Link status)
**Thyristor Stack**

**Conductor cross section (s)**

<table>
<thead>
<tr>
<th>Stack nominal current</th>
<th>Conductor cross section (s)</th>
<th>Metric (imperial)</th>
<th>Safety earth details Metric (imperial)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Busbar fixing details</strong></td>
<td><strong>Cross section</strong> (Note 1)</td>
<td><strong>Bolts per busbar</strong></td>
<td><strong>Torque</strong></td>
</tr>
<tr>
<td><strong>800A</strong></td>
<td>2 x 10mm x 15mm (5000mm)</td>
<td>M10 (5/8 AF)</td>
<td>2</td>
</tr>
<tr>
<td><strong>1000A</strong></td>
<td>2 x 25mm x 15mm (6000mm)</td>
<td>M10 (5/8 AF)</td>
<td>2</td>
</tr>
<tr>
<td><strong>1300A</strong></td>
<td>2 x 10mm x 15mm (10000mm)</td>
<td>M10 (5/8 AF)</td>
<td>1 or 2 Phase = 2</td>
</tr>
<tr>
<td><strong>1700A</strong></td>
<td>3 x 100mm x 15mm (15000mm)</td>
<td>M10 (5/8 AF)</td>
<td>6</td>
</tr>
<tr>
<td><strong>2000A (air)</strong></td>
<td>3 x 150mm x 15mm (20000mm)</td>
<td>M10 (5/8 AF)</td>
<td>6</td>
</tr>
</tbody>
</table>

**Conductor connection details**

- **Bolts per busbar:**
  - **800A:** 2
  - **1000A:** 2
  - **1300A:** 1 or 2 Phase = 2, 3 Phase = 4
  - **1700A:** 6

- **Torque:**
  - **800A:** 40Nm (30lb-ft)
  - **1000A:** 40Nm (30lb-ft)
  - **1300A:** 40Nm (30lb-ft)
  - **1700A:** 40Nm (30lb-ft)

- **Safety earth connection details:**
  - **800A:** 2500nm (11lb-ft)
  - **1000A:** 3000nm (11lb-ft)
  - **1300A:** 2500nm (11lb-ft)
  - **1700A:** 3750nm (16lb-ft)

**Note:**
1. The ratio (e.g. 1/2) between the cross-sections of the Line/Load and Safety earth conductors is defined in EN60439-1.
2. Water cooled units should be fitted with ‘solid’ load conductors but the line voltage must be supplied using flexible conductors of the relevant cross-sectional area as stated above.
Communications

DeviceNet Connector Pinout

<table>
<thead>
<tr>
<th>Pin</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>V (negative bus supply voltage)</td>
</tr>
<tr>
<td>2</td>
<td>CAN +</td>
</tr>
<tr>
<td>3</td>
<td>CAN -</td>
</tr>
<tr>
<td>4</td>
<td>CAN H</td>
</tr>
<tr>
<td>5</td>
<td>CAN L</td>
</tr>
</tbody>
</table>

Notes:
1. See DeviceNet specification for power supply specification.
2. During startup, an LED test is performed, satisfying the DeviceNet standard.

Profibus Connector Pinout

<table>
<thead>
<tr>
<th>Pin</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>N/C</td>
</tr>
<tr>
<td>8</td>
<td>A (Rx+–Tx+1)</td>
</tr>
<tr>
<td>9</td>
<td>N/C</td>
</tr>
<tr>
<td>5</td>
<td>+5 V (1)</td>
</tr>
</tbody>
</table>

Notes:
1. Isolated 5 Volts for termination purposes. Any current drawn from this terminal affects the total power consumption.
2. The cable screen should be terminated to the connector housing.

CC-Link Connector Pinout

<table>
<thead>
<tr>
<th>Pin</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DA (Rx+–Tx+)</td>
</tr>
<tr>
<td>2</td>
<td>DB (Rx––Tx+)</td>
</tr>
<tr>
<td>3</td>
<td>DG (signal ground)</td>
</tr>
<tr>
<td>4</td>
<td>SLD (Cable shield)</td>
</tr>
<tr>
<td>5</td>
<td>FG (Protective ground)</td>
</tr>
</tbody>
</table>

Notes:
1. A 110 Ohm (±5% 1/2 watt) terminating resistor should be connected across pins 1 and 2 of the connectors at each end of the transmission line.
2. The cable shield should be connected to pin 4 of each CC-Link connector.
3. The shield and Protective earth terminals (pins 4 and 5) are internally connected.

EtherNet/IP Connector Pinout

<table>
<thead>
<tr>
<th>Pin</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tx+</td>
</tr>
<tr>
<td>2</td>
<td>Rx+</td>
</tr>
<tr>
<td>3</td>
<td>Rx–</td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>N/C</td>
</tr>
<tr>
<td>6</td>
<td>N/C</td>
</tr>
<tr>
<td>7</td>
<td>N/C</td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1. Used by engineering tools to identify the node on the network.
2. No power or the module is in ‘SETUP’ or ‘NW–INIT’ state
3. One or more Diagnostic Event present (CIP class 1 or 3)
4. The Expected Identification differs from the Real Identification
5. The Station Name is not set
6. No error or no power

Profinet IO Connector Pinout

<table>
<thead>
<tr>
<th>Pin</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>N/C</td>
</tr>
<tr>
<td>6</td>
<td>N/C</td>
</tr>
<tr>
<td>7</td>
<td>N/C</td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1. Isolated 5 Volts for termination purposes. Any current drawn from this terminal affects the total power consumption.
2. During startup, an LED test is performed, satisfying the DeviceNet standard.

Modbus RTU Pinout

<table>
<thead>
<tr>
<th>Pin</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Reserved</td>
</tr>
<tr>
<td>2</td>
<td>N/C</td>
</tr>
<tr>
<td>3</td>
<td>N/C</td>
</tr>
<tr>
<td>4</td>
<td>N/C</td>
</tr>
<tr>
<td>5</td>
<td>Isolated 0V</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
</tr>
</tbody>
</table>

Internal connections:
Pin 1 to 5 Volts via 10k, pin 2 to 0V via 10k

LEDs:
- Green = Tx activity
- Yellow = Rx activity
- Connectors in parallel

Modbus TCP (Ethernet 10baseT) Pinout

<table>
<thead>
<tr>
<th>Pin</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

LEDs:
- Green = Tx activity
- Yellow = Network activity

Network Status LED Indication

- Off: No power
- Steady green: Normal operation
- Flashing green: Major fault (Exception-state, fatal error etc.)
- Steady red: Exception error
- Flashing red: Recoverable fault

Module Status LED Indication

- Off: No power
- Steady green: Operating normally
- Flashing green: Missing or incomplete configuration
- Steady red: Unrecoverable fault
- Flashing red: Recoverable fault

Operation Mode LED Indication

- Off: Off-line or no power
- Steady green: On-line, clear
- Flashing green: On-line, data exchange
- Red single flash: Parameterisation error
- Red double flash: Profibus configuration error

Status LED Indication

- Off: No power
- Steady green: On-line, one or more connections established (CIP class 1 or 3)
- Flashing green: On-line to 1 or more units
- Red double flash: Profibus configuration error

LINK LED Indication

- Off: No Link, no activity
- Steady green: Link established
- Flashing green: Activity in progress

Network Status LED Interpretation

- Off: Off-line or no power
- Steady green: On-line to 1 or more units
- Flashing green: On-line, no connections
- Steady red: Critical link failure
- Flashing red: 1 or more connections timed out

Module Status LED Interpretation

- Off: No power
- Steady green: Operating normally
- Flashing green: Missing or incomplete configuration
- Steady red: Unrecoverable fault
- Flashing red: Recoverable fault
Fixing Details

Note: Units are shown with individual mounting brackets. Multi-phase units come supplied with 2, 3 or 4 phase brackets as appropriate. See table below for details.

Dimension mm (inches)

<table>
<thead>
<tr>
<th>No of phases</th>
<th>Overall Widths</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>149.5 (5.89)</td>
</tr>
<tr>
<td>2</td>
<td>234.5 (9.23)</td>
</tr>
<tr>
<td>3</td>
<td>319.5 (12.58)</td>
</tr>
<tr>
<td>4</td>
<td>404.5 (15.93)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Door closed</th>
<th>Door open</th>
</tr>
</thead>
<tbody>
<tr>
<td>211.0 (8.31)</td>
<td>270.0 (10.65)</td>
</tr>
<tr>
<td>351.0 (13.82)</td>
<td>466.0 (18.35)</td>
</tr>
</tbody>
</table>

2-phase: Use A & B
3-phase: Use A, B & C
4-phase: Use A, B, C & D

Recommended fixing bolt size = M6

Safety Earth (M6) Recommended tightening torque = 5 Nm (3.7 ft lb)

Thyristor Stack Fixing Details

800/1000/1300 Amp 1 or 2 Phase Units

Dimension mm (inches)

Eurotherm Part No. HA030475 Issue 3 June 10
Thyristor Stack Fixing Details (continued)

800/1000 Amp 3 Phase Units

Dimension mm (inches)

1300 Amp 3 Phase Units
Thyristor Stack Fixing Details (continued)
1700/2000 Amp Air Cooled 1 or 2 Phase Units
Dimension mm (inches)

![Diagram of Thyristor Stack Fixing Details](image-url)

- **Phase 1**
  - EPower connector (1 per phase)
  - Cooling Fan Supply
  - Safety Earth M8 (1/4AF)

- **Phase 2**
  - EPower connector (1 per phase)
  - Cooling Fan Supply
  - Safety Earth M8 (1/4AF)

**Fixings:**
- M10 x 45mm (3/8 x 13/4) (6 per phase)

**Line** (1 per phase)
- Load

- **Dimension mm (inches):**
  - 382 (15.04)
  - 169 (6.65)
  - 432 (16.98)
  - 722 (28.37)
  - 390 (15.35)
  - 330 (13.03)
  - 200 (7.87)
  - 61 (2.4)
  - Ø8.5 (0.33)
  - Ø11 (0.43)

**Busbar drilling details:**
- 10 (0.39)
- 11 (0.43)
- 25 (0.98)
- 37.5 (1.48)
Thyristor Stack Fixing Details (continued)

1700/2000 Amp Air Cooled 3 Phase Units

Dimension mm (inches)

![Diagram of thyristor stack with dimensions and labels]

- ** Ø8.5 (0.33) **
- ** Safety Earth M8 (1/4AF) **
- ** EPower connector (3 places) **
- ** Cooling Fan Supply (2 places) **
- ** Line (3 places) **
- ** Fixings: M10 x 45mm (5/16 x 1-3/4) (6 per phase) **
- ** Load (3 places) **

Eurotherm Part No. HA030475 Issue 3 June 10
Thyristor Stack Fixing Details (continued)

2000/3000/4000 Amp Colored Units

Dimension mm (inches)

Load busbar drilling details

Example (2000A) load bus bar fixing details

Fuse and line supply fitting

Thyristor Stack Fixing Details (continued)

2000/3000/4000 Amp Colored Units

Dimension mm (inches)
Order codes

EPower for MC Unit

<table>
<thead>
<tr>
<th>Phase/Amps</th>
<th>Voltage</th>
<th>Fan Supply</th>
<th>Warranty</th>
</tr>
</thead>
<tbody>
<tr>
<td>1PH-800A.AC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>1PH-1000A.AC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>1PH-1300A.AC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>1PH-1700A.AC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>1PH-2000A.AC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>1PH-2000A-WC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>1PH-3000A-WC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>1PH-4000A-WC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>2PH-800A.AC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>2PH-1000A.AC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>2PH-1300A.AC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>2PH-1700A.AC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>2PH-2000A.AC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>2PH-2000A-WC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>2PH-3000A-WC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>2PH-4000A-WC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>3PH-800A.AC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>3PH-1000A.AC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>3PH-1300A.AC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>3PH-1700A.AC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>3PH-2000A.AC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>3PH-2000A-WC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>3PH-3000A-WC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>3PH-4000A-WC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>4PH-800A.AC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>4PH-1000A.AC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>4PH-1300A.AC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>4PH-1700A.AC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>4PH-2000A.AC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>4PH-2000A-WC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>4PH-3000A-WC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
<tr>
<td>4PH-4000A-WC</td>
<td>690V</td>
<td>No fan</td>
<td>Standard</td>
</tr>
</tbody>
</table>

2 Voltage

600V
690V
690V (for water cooled stacks)
XXX

3 Fan Supply

XXX
No fan

4 Warranty

XXX
Standard
WLL05
5 Year
USWL3
US Extended
**Order codes**

**External Triacistor Stack (HPower)**

<table>
<thead>
<tr>
<th>Phase/Amps</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1PH-800A-AC</td>
<td>1 Phase unit 800 Amps air cooled version</td>
</tr>
<tr>
<td>1PH-1000A-AC</td>
<td>1 Phase unit 1000 Amps air cooled version</td>
</tr>
<tr>
<td>3PH-800A-AC</td>
<td>3 Phase unit 800 Amps air cooled version</td>
</tr>
<tr>
<td>4PH-800A-AC</td>
<td>4 Phase unit 800 Amps air cooled version</td>
</tr>
<tr>
<td>1PH-1000A-AC</td>
<td>1 Phase unit 1000 Amps air cooled version</td>
</tr>
<tr>
<td>3PH-1000A-AC</td>
<td>3 Phase unit 1000 Amps air cooled version</td>
</tr>
<tr>
<td>4PH-1000A-AC</td>
<td>4 Phase unit 1000 Amps air cooled version</td>
</tr>
<tr>
<td>1PH-1300A-AC</td>
<td>1 Phase unit 1300 Amps air cooled version</td>
</tr>
<tr>
<td>3PH-1300A-AC</td>
<td>3 Phase unit 1300 Amps air cooled version</td>
</tr>
<tr>
<td>4PH-1300A-AC</td>
<td>4 Phase unit 1300 Amps air cooled version</td>
</tr>
<tr>
<td>1PH-1700A-AC</td>
<td>1 Phase unit 1700 Amps air cooled version</td>
</tr>
<tr>
<td>3PH-1700A-AC</td>
<td>3 Phase unit 1700 Amps air cooled version</td>
</tr>
<tr>
<td>4PH-1700A-AC</td>
<td>4 Phase unit 1700 Amps air cooled version</td>
</tr>
<tr>
<td>1PH-2000A-AC</td>
<td>1 Phase unit 2000 Amps air cooled version</td>
</tr>
<tr>
<td>3PH-2000A-AC</td>
<td>3 Phase unit 2000 Amps air cooled version</td>
</tr>
<tr>
<td>4PH-2000A-AC</td>
<td>4 Phase unit 2000 Amps air cooled version</td>
</tr>
<tr>
<td>1PH-2500A-AC</td>
<td>1 Phase unit 2500 Amps air cooled version</td>
</tr>
<tr>
<td>3PH-2500A-AC</td>
<td>3 Phase unit 2500 Amps air cooled version</td>
</tr>
<tr>
<td>4PH-2500A-AC</td>
<td>4 Phase unit 2500 Amps air cooled version</td>
</tr>
<tr>
<td>1PH-4000A-AC</td>
<td>1 Phase unit 4000 Amps air cooled version</td>
</tr>
<tr>
<td>3PH-4000A-AC</td>
<td>3 Phase unit 4000 Amps air cooled version</td>
</tr>
<tr>
<td>4PH-4000A-AC</td>
<td>4 Phase unit 4000 Amps air cooled version</td>
</tr>
</tbody>
</table>

**Spare fuse for power modules**

<table>
<thead>
<tr>
<th>Stack nominal current</th>
<th>Fuse (switch part number)</th>
</tr>
</thead>
<tbody>
<tr>
<td>800A/1000A</td>
<td>CS030440U002 CS030444U002 CS030442U002</td>
</tr>
<tr>
<td>1300A</td>
<td>CS030440U002 CS030444U002 CS030442U002</td>
</tr>
<tr>
<td>1700A/2000A (air)</td>
<td>CS030443U002 CS030443U002 CS030443U002</td>
</tr>
<tr>
<td>2000A (water)</td>
<td>CS030615U002 CS030615U002 CS030616U002</td>
</tr>
<tr>
<td>3000A</td>
<td>CS030615U002 CS030615U002 CS030616U002</td>
</tr>
<tr>
<td>4000A</td>
<td>Water-cooled units are available as single phase only</td>
</tr>
</tbody>
</table>

Notes:
1. Stack not included.
2. The maximum nominal current selectable is the current rating selected in Field 1.
3. Only available if 499V selected in Field 2.
4. Selection dependent on number of Phases selected in Field 1.
   - 1PH = IP only
   - 2PH = IP or 2P only
   - 3PH = IP or 3P only
5. Selection dependent on number of Phases selected in Field 1.
   - 1PH = IP only
   - 2PH = IP, 35 or 3D only
   - 3PH = Any
6. PA not selectable if 2P selected in Field 22.
7. HC not selectable if TR selected in Field 24.
8. XX the selection in Fields 28 and 30 cannot be the same.

**Fan Supply**

- 115V
- 115V ac
- 230V
- 230V ac
- No fan. For water cooled stacks.
32h8e EPower Remote Panel

Model number 32h8e is a horizontal 1/8DIN indicator and alarm unit that performs the dual function of remote display for EPower and independent 'policeman'. The latter is intended to disconnect should an overtemperature (or other excess process condition) occur.

32h8e communicates with EPower using Modbus protocol via the EIA485 RJ45 connector located on the underside of the EPower controller.

The remote panel is normally ordered as an option with EPower units. It is a fixed hardware build consisting of a relay output in OP1 and an analogue output in OP3. There are no user communications since this is used to communicate with EPower and the supply is high voltage only (100-240Vac). The unit is configured using 'QuickStart' code on initial start up.

The 32h8e is based on a 32h8i indicator and has the same and additional features as this instrument. For features not covered please refer to HA029005.

The 32h8e displays EPower Current, Voltage, Power and Setpoint parameters for each EPower Network. The Setpoint of the EPower networks can be adjusted via the 32h8e HMI. Indication of selected setpoint is included: local or remote.

Wire sizes
The screw terminals accept wire sizes from 0.5 to 1.5mm (16 to 22AWG). Hinged covers prevent hands or metal making accidental contact with live wires. The rear screws should be tightened to 0.4Nm (3.3lb in).

Ensure that the supply to the unit does not exceed 240V ac +10%

Example Wiring Diagram

*R General notes about relays and Inductive Loads

When switching inductive loads such as contactors or solenoid valves, wire the 22nF/100 'snubber' supplied across normally open relay terminals.

This will prolong contact life and reduce interference.

Snubbers pass 0.6mA at 110V and 1.2mA at 230V ac, which may sufficient to hold on high impedance loads.
**Specification - 32h8e Remote display**

### General

**Environmental performance**
- **Temperature limits**
  - Operation: 0 to 55°C
  - Storage: -10 to 70°C
- **Humidity limits**
  - Operation: 5 to 85% RH non-condensing
  - Storage: 5 to 85% RH non-condensing
- **Panel sealing**: IP65, Nema 4X
- **Shock**: BS EN61010
- **Vibration**: 2g peak, 10 to 150Hz
- **Altitude**: <2000 metres
- **Atmospheres**: Not suitable for use in explosive or corrosive atmosphere

**Electromagnetic compatibility (EMC)**
- **Emissions and immunity**: BS EN61326

**Electrical safety**
- (BS EN61010): Installation cat. II; Pollution degree 2

**INSTALLATION CATEGORY II**
The rate impulse voltage for equipment on nominal 230V mains is 2500V.

**POLUTION DEGREE 2**
Normally, only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation shall be expected.

### Physical
- **Panel mounting**: 1/8 DIN, horizontal
- **Dimensions and weight**:
  - 96mm (3.78”) W x 48mm (1.89”) H x 90mm (3.54 inches) D, 350g (0.77lbs)
- **Panel cut-out dimensions**:
  - 92mm (1.77 inches) W x 45mm (3.62 inches) H
- **Operator interface**:
  - **Type**: LCD TN with backlight
  - **Main PV display**: 5 digits, green or red
  - **Lower display**: 9 character starburst, green
- **Status beacons**: Units, outputs, alarms

**Power requirements**
- **Voltage**: 100 to 240V ac, -15%, +10%, max 9W
- **Frequency**: 48 to 62Hz

**Approvals**
- CE, cUL listed (file E57766)

### Communications
- **Serial communications option**
- **Protocol**: Modbus RTU Master
- **Isolation**: 264V ac, double insulated
- **Transmission standard**: EIA485 (2 wire)

The 32h8e has Modbus Master RS485 Comms with a fixed set of EPower Modbus addresses. Power up the display for the first time, configure the QuickStart code for the standard indicator functions, and the process values displayed as 3 phase or as several times single phase as defined by the EPower configuration.

### Software features

**Alarms**
- **Number**: 4
  - **Type**: Absolute high & low, Rate of change (rising or falling)
- **Latching**: Auto or manual latching, non-latching, event only
- **Output assignment**: Up to four conditions can be assigned to one output
- **EPower Alarms**: Missing mains, Thyristor short circuit, Open thyristor, Fuse blown, Over temperature, Voltage dips, Frequency fault, Power module faults, Load Unbalance, Volt module, wdog fault, Power module comms error, Power module timeout, Closed loop, Output fault

The pre-set alarms have a fixed medium priority enables indicator alarms to be configured as lower, the same or higher priority. EPower alarms can be globally acknowledged via the 32h8e HMI.

**Other status outputs**
- **Functions**: Including sensor break, power fail, new alarm, pre-alarm
- **Output assignment**: Up to four conditions can be assigned to one output

**Custom messages**
- **Number**: 15 scrolling text messages
- **No of characters**: 127 characters per message max
- **Languages**: English, German, French, Spanish, Italian
- **Selection**: Active on any parameter status using conditional command

**Recipes**
- **Number**: 5 recipes with 19 parameters

**Other features**
- **Display colour**: Upper display selectable green or red or green, lower display selectable red or green or red
- **Display filter**: Off to zero last 2 digits
- **Peak monitor**: Stores high and low values

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**Eurotherm Part No. HA030475 Issue 3 June 10 15 EPower MC Controller Specification Sheet**
32h8e Initial configuration

At first switch on, after the start-up sequence, the initial configuration page is displayed.

Note: the following ‘quickstart’ description applies only to new (not previously configured) instruments. If the instrument has previously been configured (either at the factory or subsequently) the instruments starts up showing the relevant process value.

The initial display shows ‘Set1’ on the top line, with a coded display below with its first item flashing. The lower line is decoded as shown in table.

The ‘mode’ (up/down arrows) are used to scroll through the available choices for each item. Once the required value is displayed, the scroll key is used to select the next character for editing. Once all five characters have been edited, further operations of the scroll key call the range high display (allowing the high range value to be edited using the mode keys), then the range low display (allowing the low range value to be edited). A further operation calls the Set2 display, which is decoded in the table below.

After Set2 parameters have been edited, a further operation of the scroll key invites the user to Exit. Operating the scroll key returns to the Set1 display, operating a mode key to display ‘yes’ quits the quickstart menu and causes the unit to enter operating mode.

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