Type LGPG111
Digital Integrated Generator Protection Relay

Features
- An optimum mix of generator protection functions
- Applicable to a wide range of generators
- User configurable scheme logic
- An alternative setting group
- Wide operative frequency range
- Display of measured values
- Fault, event and disturbance recording
- Integral testing to aid commissioning
- Remote serial communications
- Power-on diagnostics and self-monitoring
- Eight optically isolated logic inputs for monitoring external plant.

Introduction
The LGPG111 is a multi-function relay which integrates a number of common generator protection functions and associated scheme logic into a single relay case.

Models Available
LGPG111
Incorporating 14 separate generator protection functions (see Figure 2).

Application
The LGPG111 can be applied to a wide range of generators. Each of its protection functions can be enabled or disabled to suit individual requirements. This approach avoids the need for application-specific relay versions, and simplifies the tasks of relay specification, evaluation and project planning. The integrated scheme logic eliminates much panel engineering work by reducing the need for auxiliary relays and associated external wiring.

Contacts from external protection and plant monitoring equipment can be connected to any of the eight optically-isolated inputs. This allows external information to be incorporated into the relay’s user-configurable scheme logic. The optically-isolated inputs and relay outputs may be labelled in the software for local or remote monitoring.

These functions can be recorded in the alarm and event recording facilities.

The protection functions provided by the LGPG111 relay are as shown in Figure 2.

Functions
Generator differential (87G)
The generator differential function is for the protection of phase to phase or three-phase stator windings faults which normally involve high fault currents, so that fast fault clearance is required. This function works on a per phase basis and has a dual slope bias characteristic as shown in Figure 3: the lower slope provides sensitivity for internal faults, whereas the higher slope provides stability under through fault conditions, especially if the generator CTs saturate.
Stator earth fault (51N)
The stator earth fault function is current operated and can be typically set to cover up to 95% of the stator windings. It is generally used on resistively earthed generators, but can also be used to respond to current in the secondary circuit of an earthing transformer loaded with a resistor. A time-delayed low set element and an instantaneous high set element are provided.

Neutral displacement (59N)
The neutral displacement function is voltage operated and is used for detecting stator winding earth faults on generators which are earthed via a distribution transformer. Two timer output elements are provided.

Sensitive directional earth fault (67N)
When two or more generators are connected in parallel directly to a busbar, the sensitive directional earth fault function is used to discriminate between internal and external earth faults. A dedicated single-phase CT input is available for the operating current, which can accept the residual current from three line CTs or current from a dedicated core-balance CT. The polarising signal for the directional decision is either the voltage signal applied to the neutral voltage VT input or the current signal applied to the stator earth fault current input.

The stator earth fault, neutral displacement and sensitive directional earth fault functions all have third harmonic rejection built in by means of a software filter.

Voltage dependent overcurrent (51V)
The voltage dependent overcurrent function is used for system backup protection and can trip the generator circuit breaker, if a fault has not been cleared by other protection after a certain period of time. The voltage dependent function can be either voltage controlled or voltage restrained.

When voltage controlled, the current pick-up level is proportionally lowered as the voltage falls below a set value, producing a continuous variation of timing characteristics. This is applicable to generators connected to the busbar, each via a step-up transformer. A voltage vector compensation feature is also available to determine the HV phase-phase voltage signals where a Yd1 or a Yd11 step-up transformer is used.

The timing characteristic can either be definite time or IDMT.

The effects of the voltage level on the current pick-up level for both functions are shown in Figure 4.
Reverse power (32R) and low forward power (32L)

Reverse power protection is used to detect loss of the prime mover. Low forward power protection can be applied to steam turbine generators where sequential shutdown is preferable, under less urgent operations, to avoid over-speeding. Both are balanced conditions, therefore a single phase measurement is sufficient. For this function, the relay calculates $VI\cos\theta$ for the A-phase. In order to provide the required sensitivity, a special current input is used for both of these functions. A compensation angle setting is also available to compensate for phase error of the generator’s CT and VT signals. A delayed drop-off timer is included in the timing logic which acts as an integrating timer. This allows the relay to trip within the predetermined time delay, under pulsating power conditions.

Negative phase sequence (46)

Negative phase sequence function is for the detection of sustained unbalanced load conditions. Under such circumstances double frequency eddy currents are induced in the rotor of a generator and can cause rapid overheating. The function has a thermal replica curve which simulates the effects of pre-fault heating due to low levels of standing negative phase sequence current $I_2$. When the $I_2$ value is well above threshold, the thermal replica approximates to a $t = K/I_2^2$ characteristic, where $K$ is the generator’s per-unit current thermal capacity constant in seconds. The tripping characteristic is shown in Figure 5.

When high values of $K$ are selected and the negative phase sequence currents measured are near to the threshold, the operating time may be too slow. In this case, a maximum time setting $t_{MAX}$ is available to provide a safe trip time.

When $I_2$ is high, the operating time may become too fast and cause loss of discrimination with other power system protection under fault conditions. To reduce this risk, the inverse characteristic is provided with an adjustable minimum operating time setting $t_{MIN}$.

A separate thermal capacity constant setting $K_{reset}$ is also provided for use when the generator is cooling, due to a reduction in $I_2$. This is to cater for rotor components with differing cooling time constants.

An independent alarm element with a definite time output is available for pre-trip warning purposes.

Field failure (40)

Severe loss of excitation caused by field failure can cause a high value of reactive current to be drawn from the power system which can endanger the generator. The field failure protection provided by this relay is a single phase impedance measuring element with an offset mho characteristic, as shown in Figure 6. An integrating timing arrangement, identical to that for the power functions, is also provided. This allows the relay to trip within the predetermined time delay even though the impedance measurement may temporarily fall outside the mho characteristic, eg. under pole-slip conditions.
**Under voltage (27) and over voltage (59)**

An under voltage element and a 2-stage over voltage element are provided. They are primarily used for backing up the speed control governor and the automatic voltage regulator. When severe over voltage occurs, the high set of the over voltage element can be set to provide fast operation. Both elements are 3-phase devices.

**Under frequency (81U) and over frequency (81O)**

Two under frequency elements and one over frequency element are provided. The underfrequency elements are used to detect overloading of the generator caused by various system disturbances or operating conditions.

The overfrequency element is used to back-up the speed control governor if overspeeding occurs.

**Voltage balance (60)**

The voltage balance function is provided to detect VT fuse failure. It compares the secondary voltages of two sets of VTs (or from two separately fused circuits of a single VT) and can be used to block possible incorrect tripping of those protection functions whose performance may be affected by the apparent loss of voltage such as when a VT fuse ruptures.

**Timer held facility**

Both the overcurrent function, the low set element of the stator earth fault function and the neutral displacement function are provided with a timer held facility. The purpose is to enable faster clearance of recurrent intermittent faults, for example, self-sealing insulation faults. This facility allows the relay timer to hold its value when the current drops off, provided that the drop-off period is less than the reset timer setting.

This adjustable reset facility also enables closer co-ordination with electromechanical induction disc relays.

**Integrating timer facility**

Time integration is required for the power function to allow for reciprocating load conditions where the measuring element may pick up briefly and periodically. The same feature is also provided for the field failure function for pole-slipping conditions. Time integration allows the function to operate within its predetermined operating time.

To implement timing integration, an additional delayed drop-off timer is provided. Once the protection measurement element has picked up, the relay will operate after the set time delay, provided that the time interval when the element drops off is within the setting of the delayed drop-off timer tDO.

**Frequency tracking**

The relay tracks the power system frequency and continuously adjusts its internal sampling clock to exact multiples of the system frequency. This provides correct measurements and operation of the protection functions during start-up and run-down of the generator set when the generator unit is operated at abnormal frequency. The operating frequency range is from 25Hz to 70Hz for the differential function and from 5Hz to 70Hz for the other protection functions.

**Configuration**

**Scheme logic**

The protection scheme logic for a generator set normally involves a large number of protection functions combined together to drive a few common trip outputs. Some blocking and interlocking logic may also be required. In order to accommodate different generator applications, the scheme logic is flexible and reconfigurable.

The LGPG111 scheme logic is in the form of logic arrays with an architecture commonly found in programmable logic array devices, having an internal AND-OR structure shown in Figure 7.

The OR functions allow one or more of the AND function outputs to control each output relay, whilst the AND functions provide blocking or interlocking for two or more inputs, or just a through connection for one input. There are 32 inputs to the scheme logic: 19 from the protection functions, 8 optically-isolated inputs and a selection of inverted inputs to allow blocking logic to be created.

The scheme logic controls a total of 15 output relays and has 32 selectable AND functions.

The input and output matrices allow the desired connections to be created. Each intersection of the matrix represents a programmable interconnection. By designing the appropriate interconnections and then entering the information into the relay,
through the scheme logic settings, the required tripping logic can be configured.

The presence of the optically-isolated inputs to the scheme allows external devices such as rotor earth fault relay, temperature sensing devices and mechanical relays to be connected to the scheme, so that the tripping facilities, together with the alarm and remote communication facilities, can be utilised.

The optically-isolated inputs and relay outputs used in a scheme may be allocated to any function required by the application. The relay has a facility to label each of these by providing an identifier. The identifiers are used during the configuration of the scheme logic, by the input and output status displays and by the event, fault and disturbance recording systems.

Alternative setting group
The relay provides an alternative setting group which consists of all the protection and scheme logic settings. It can be used during start-up or rundown of generators or during changes in power system configuration. This setting group can be selected by either energising the appropriate optically-isolated inputs, or via the relay settings menu.

Ancillary Functions

Measurements
The magnitudes of all 17 analogue inputs to the relay are available for display. Other derived quantities are also available. This provides such information as the three-phase, residual and earth currents, the phase to phase voltages, differential and bias currents, negative phase sequence current, phase A active and reactive power plus the phase angle and power system frequency.
All measurements can be displayed in either primary or secondary quantities, selectable by the user.
Primary display quantities are based on the settings for the CT and VT ratios used by the relay.

Event and fault records
Up to 100 event records are available, all of them stored in non-volatile memory. The latest record will automatically overwrite the oldest one. Event records are generated whenever there is a protection function operation, energisation of a status input, operation of an output relay or any hardware failure.
Fault records are also stored as events. Out of the 100 event records, up to 50 fault records can be accommodated. Fault records are initiated when user selected relay outputs operate. The record consists of the date and time of the fault, the state of the optically-isolated inputs, relay outputs and protection functions, together with the measurement values during the fault.

Disturbance records
The internal disturbance recorder can store up to eight analogue channels, together with all the status input and relay output information.
The analogue channels are user selectable from the relay’s 17 inputs.
The data in the analogue channels can be stored as either raw data or as magnitude and phase data. The raw data is sampled at 12 samples per electrical cycle, whereas the magnitude and phase data are calculated once every 20ms. Thus the duration of a record varies with the data type. For raw data, the duration is 64 electrical cycles, but for magnitude and phase data, the duration is 7.68s. The latter set-up allows long duration events such as pole-slip to be captured. In either case, each data entry is time stamped. This is particularly useful for the raw data recording, since the sampling interval varies with the power system frequency, due to the frequency tracking.
The disturbance recorder can be triggered from selected relay outputs and status inputs. A maximum of two records can be stored in volatile memory. A record remains in the buffer area until it is uploaded to a PC, after which the buffer is released. If the two buffers are full, no further recording can be made.

Time synchronisation
The clock for event record time tagging has a resolution of 1ms.
To provide time synchronisation with other equipment in the generator station, the clock can be synchronised by external clock pulses (0.5, 1, 5, 10, 15, 30 or 60 minute period) from an optically-isolated input.

Print functions
Several print functions are provided to allow the relay to provide hard-copy documentation, via the front panel parallel port. This consists of the system settings, protection settings, scheme logic settings, event records and fault records. The scheme logic print-out is formatted so that it can be compared directly with the scheme logic diagram.

Test features
A number of features are provided to enable the relay to be thoroughly tested during commissioning, routine maintenance and fault finding operations:

- The measurement functions allow the analogue input and its associated wiring to be checked.
- Display the on/off states of the status inputs and relay outputs.
- Testing the four indicating LEDs.
- Testing the relay outputs and their associated circuits by operating the relay output contacts.
- Display the operation of each protection function as a percentage of the time-to-trip. This allows the pick-up, progress and operation of each protection function to be checked.

- Testing the set-up of the scheme logic settings by manually entering an input pattern to the scheme, and then examining its logical output. This test can be performed at any time without interfering with the relay’s operation.

Power-on diagnostics and self monitoring

Power-on diagnostic tests are carried out by the relay when it is energised. These tests include checks on the timer, microprocessor, memory and the analogue input module. Continuous self-monitoring, in the form of watchdog circuitry, memory checks and analogue input module tests, is also performed. In the event of a failure, the relay will either lock-out or attempt a recovery, depending on the type of failure detected.

Hardware Description

The relay is housed in a 4U (178mm) high case suitable for either rack or panel mounting. Internally, it consists of a number of plug-in modules which are individually tested and calibrated. The modular hardware architecture is shown in Figure 8.

The microcomputer module consists of a powerful 16-bit microcomputer which controls all of the subsidiary modules through a 64-way ribbon cable called the I/O Bus.

The processor performs all of the major software functions such as input signal processing, protection algorithms, scheme logic, relay output controls and handling of the operator interface.

The analogue input module consists of 12 CTs, 5 VTs and 6 optically-isolated inputs. The CTs and VTs are used to isolate and condition the analogue inputs from the main transformers connected to the generator. Their output signals are then converted into digital data for further processing.

In addition to the 6 optically-isolated inputs on the analogue module, a further 8 are provided by the status input module, making a total of 14 optically-isolated inputs available to the relay. 6 of these have pre-defined functions, such as clock synchronisation, setting group selection, etc., which leaves 8 inputs to be fed into the scheme logic.

All of the optically-isolated inputs operate from an auxiliary supply Vx(2), which is independent of the main auxiliary supply Vx(1). The ratings of Vx(1) and Vx(2) may be different (See Technical Data).

Two relay output modules are provided; each module contains 8 miniature relays. All relays are self-reset. However, a software function is available which allows the user to select outputs to be latched when operated.

The front panel consists of a 2 x 16 character alphanumeric liquid crystal display (lcd) and a 7 push-button keypad. It provides local access to all of the relay’s features. There are also 4 light emitting diodes for visual indication of the relay’s status, a non-isolated IEC870 serial port for connection to a PC, and a parallel port for connection to a printer.

At the rear of the relay, apart from the normal DC supply and plant connections, there is an isolated IEC870 port and a K-Bus port for permanent connection to a remote PC.

The remote communications module is responsible for handling the communications protocol and for controlling the three communication ports.

Figure 8: Hardware architecture
User Interface

Front panel user interface
The features of the relay can be accessed through a user-friendly menu system. The menu is arranged so that related items (menu cells) are grouped into individual sections, each of which is identified by a title. The user navigates around the menu by using the arrow keys, first to select a particular section title and then to select an item within it. The front panel liquid crystal display is limited to displaying one menu cell at a time.

Remote access user interface
The menu can be accessed via the remote communications facility. This allows all of the menu cells in a section to be displayed on the screen of a PC. Changes to the menu cell can be made from the PC keyboard.

Relay interconnection
Three communication ports are available: the front panel, non-isolated IEC870 port; the rear, isolated IEC870 port; and the K-Bus port. The IEC870 ports use RS232 signal levels and allow point-to-point connection. It is applicable when networking is not required or during commissioning.

Alternatively, the relays can be connected via a shielded, twisted pair called K-Bus. Up to 32 relays may be connected in parallel to the bus. K-Bus can be connected through a protocol converter, type KITZ, either directly or via a modem, to the RS232 port of a PC. K-Bus is RS485 based and runs at 64kbits/s. The K-Bus connection is shown in Figure 9.

Software is available with each KITZ to provide access to the relays, to read and change settings. Additional software entitled Protection Access Software and Toolkit is available to give access to the event recorder, together with other additional functions.

Each relay is directly addressable via the bus to allow communication with the PC. It should be noted that protection tripping and blocking signals are not routed via the K-Bus. Separate conventional wiring is used for these functions.

Figure 9: K-Bus terminals connection arrangement
Figure 10: External connection diagram Type LGPG111 (typical scheme)
Figure 11: Type LPG111 scheme logic
## Technical Data

### Ratings

#### Inputs

<table>
<thead>
<tr>
<th>AC Current</th>
<th>In</th>
<th>1A or 5A</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC Voltage</td>
<td>Vn</td>
<td>100V to 120V</td>
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</tbody>
</table>

#### Auxiliary voltage Vx(1)

<table>
<thead>
<tr>
<th>VT ratios</th>
<th>Operative range (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>24/27</td>
<td>19.2 – 32.4</td>
</tr>
<tr>
<td>30/34</td>
<td>24 – 40.8</td>
</tr>
<tr>
<td>48/54</td>
<td>38.4 – 64.8</td>
</tr>
<tr>
<td>110/125</td>
<td>88 – 150</td>
</tr>
<tr>
<td>220/250</td>
<td>176 – 300</td>
</tr>
</tbody>
</table>

#### Auxiliary voltage Vx(2)

<table>
<thead>
<tr>
<th>VT ratios</th>
<th>Operative range (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>24/27</td>
<td>19.2 – 32.4</td>
</tr>
<tr>
<td>30/34</td>
<td>24 – 40.8</td>
</tr>
<tr>
<td>48/54</td>
<td>38.4 – 64.8</td>
</tr>
<tr>
<td>110/125</td>
<td>88 – 150</td>
</tr>
<tr>
<td>220/250</td>
<td>176 – 300</td>
</tr>
</tbody>
</table>

Note: Vx(2) may be different from Vx(1)

#### Frequency

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Fn</th>
<th>50/60Hz</th>
</tr>
</thead>
</table>

### Burdens

#### AC Current

- **Generator differential**
  - <0.05VA per input at In (for 1A relay)
  - <0.20VA per input at In (for 5A relay)
- **Voltage dependent overcurrent, field failure and negative phase sequence**
  - <0.05VA per input at In (for 1A relay)
  - <0.22VA per input at In (for 5A relay)
- **Reverse and low forward power**
  - <0.15VA at In (for 1A relay)
  - <0.30VA at In (for 5A relay)
- **Stator earth fault and sensitive directional earth fault**
  - <0.12VA per input at In (for 1A relay)
  - <0.25VA per input at In (for 5A relay)
- **AC Voltage**
  - <0.005VA per input at Vn
- **DC auxiliary voltage (Vx(1))**
  - 15W quiescent, max. 34W operating.
- **DC auxiliary voltage (Vx(2))**
  - Less than 0.32W on average per input

### Transformer ratios

<table>
<thead>
<tr>
<th>CT ratios</th>
<th>1:1 to 9999:1 in 0.01 steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>VT ratios</td>
<td>1:1 to 9999:1 in 0.01 steps</td>
</tr>
</tbody>
</table>

### CT requirements

#### Generator differential

- **Biased differential settings at I_s1=0.05I_n, k1=0%, I_s2=1.2I_n, k2=150%**
  - $V_k \geq 30I_n (R_{ct} + 2R_L + R_i)$ where maximum through fault current is $10 \times I_n$ and maximum $X/R = 120$
  - $V_k \geq 50I_n (R_{ct} + 2R_L + R_i)$ where maximum through fault current is $10 \times I_n$ and maximum $X/R = 60$

Note: Minimum knee point voltage = 34V
Earth fault protection functions

Sensitive directional earth fault, using three residually connected line CTs

\[ V_k \geq 6I_n (R_{ct} + 2R_L + R_r) \]

where maximum earth fault current = 1 x \( I_n \)

Sensitive directional earth fault, using core balance CT

\[ V_k \geq 6N I_n (R_{ct} + 2R_L + R_r) \]

where maximum earth fault current = 2 x \( I_n \)

Stator earth fault

\[ V_k \geq 6N I_n (R_{ct} + 2R_L + R_r) \]

Ancillary protection functions

Voltage dependent overcurrent, field failure and negative phase sequence

\[ V_k \geq 20I_n (R_{ct} + 2R_L + R_r) \]

where \( V_k \) = Minimum current transformer knee-point voltage for stability
\( I_n \) = Relay rated current (1A or 5A)
\( R_{ct} \) = Resistance of current transformer secondary winding (\( \Omega \))
\( R_L \) = Resistance of a single lead from relay to current transformer (\( \Omega \))
\( R_r \) = Resistance of any other protection functions sharing the current transformer (\( \Omega \))

\( N \) = Maximum earth fault current

Core balanced CT or earth CT rated primary current

Note: \( N \) should not be greater than 2. The core balance CT or earth CT ratio must be selected accordingly.

Power function

For settings >3% \( P_n \) Use correctly loaded class 5P protection CT
For settings \( \leq 3\% P_n \) Use metering class CT. See table below.

Metering CT class recommended for power setting less than 3%\( P_n \)

<table>
<thead>
<tr>
<th>Reverse/low forward Power Setting (%( P_n ))</th>
<th>Metering CT Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>0.6</td>
<td>0.2</td>
</tr>
<tr>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td>0.5</td>
</tr>
<tr>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>1.4</td>
<td></td>
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<tr>
<td>1.6</td>
<td></td>
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<tr>
<td>1.8</td>
<td></td>
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<tr>
<td>2.0</td>
<td>1.0</td>
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<tr>
<td>2.2</td>
<td></td>
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<tr>
<td>2.4</td>
<td></td>
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<tr>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td></td>
</tr>
</tbody>
</table>
**Thermal withstand**
- Continuous withstand CT input 4 x \(I_n\)
- VT input 400V
- Short time withstand CT input 100A for 1s (\(I_n = 1A\))
- 400A for 1s (\(I_n = 5A\))

**Setting ranges**

**Generator differential**
- Basic differential current setting \(I_{s1}\) 0.05\(I_n\) to 0.1\(I_n\) in 0.01\(I_n\) steps
- Threshold for increase bias \(I_{s2}\) 1\(I_n\) to 5\(I_n\) in 0.1\(I_n\) steps
- Bias K1 (I_bias < \(I_{s2}\)) 0% to 20% in 5% steps
- Bias K2 (I_bias > \(I_{s2}\)) 10% to 150% in 10% steps

**Stator earth fault**
- Low set element:
  - Characteristic Standard inverse/Definite time
  - Current setting \(I_{e}> 0.005\) \(I_n\) to 0.5\(I_n\) in 0.005\(I_n\) steps
  - Time multiplier setting TMS 0.05 to 1.2 in 0.05 steps
  - IDMT Operating characteristic \(t = \frac{0.14}{(I/I_e)^{0.032}-1} \times TMS\)
  - Definite time setting \(t> 0.1s\) to 10s in 0.1s steps
  - Reset timer setting \(t_{RESET}\) 0s to 60s in 1s steps
- High set element:
  - Current setting \(I_{e}>> 0.005\) \(I_n\) to 2\(I_n\) in 0.005\(I_n\) steps
  - Time setting \(t>> 0s\) to 5s in 0.1s steps

**Neutral displacement**
- Voltage setting \(V_e> 1V\) to 25V in 1V steps
- Timer 1 setting \(t1\) 0.5s to 5s in 0.5s steps
- Timer 2 setting \(t2\) 1s to 10s in 1s steps
- Timer 2’s reset timer \(t_{2RESET}\) 0s to 60s in 1s steps

**Sensitive directional earth fault**
- Operating current \(I_{res}> 0.005\) \(I_n\) to 0.02\(I_n\) in 0.005\(I_n\) steps
- Polarising voltage \(V_p> 1V\) to 10V in 1V steps
- Polarising current \(I_p> 0.005\) \(I_n\) to 0.02\(I_n\) in 0.005\(I_n\) steps
- Relay characteristic angle RCA \(-95^\circ\) to \(95^\circ\) in \(1^\circ\) steps

**Voltage dependent overcurrent**
- Functions Voltage controlled/Voltage restrained/Simple
- Characteristic Standard Inverse/Definite Time
- Current setting \(I> 0.5\) \(I_n\) to 2.4\(I_n\) in 0.05\(I_n\) steps
- Time multiplier TMS 0.05 to 1.2 in 0.05 steps
- IDMT Operating characteristic \(t = \frac{0.14}{(I/I_e)^{0.032}-1} \times TMS\)
- Definite time setting \(t\) 0s to 10s in 0.1s steps
- Reset timer setting \(t_{RESET}\) 0s to 60s in 1s steps
Voltage settings:

Vs (for voltage controlled) 20V to 120V in 1V steps
Vs1 (for voltage restrained) 80V to 120V in 1V steps
Vs2 (for voltage restrained) 20V to 80V in 1V steps
K factor 0.25 to 1.00 in 0.05 steps
Voltage vector rotate None or Yd

Current pick-up level

<table>
<thead>
<tr>
<th>Voltage Controlled</th>
<th>Voltage Restrainted</th>
</tr>
</thead>
<tbody>
<tr>
<td>I &gt; for V &gt; Vs</td>
<td>I &gt; for V &gt; Vs1</td>
</tr>
<tr>
<td>KI &gt; for V ≤ Vs</td>
<td>KI &gt; + ( I &gt; - KI &gt; \frac{V_{s1} - V_{s2}}{V - V_{s2}} ) for Vs1 ≥ V ≥ Vs2</td>
</tr>
<tr>
<td></td>
<td>KI &gt; for V &lt; Vs2</td>
</tr>
</tbody>
</table>

Reverse power

Power setting \(-P\)

0.2W to 8W in 0.05W steps
(for 1A relay)
1W to 40W in 0.25W steps
(for 5A relay)

Delayed pick-up timer \(t\)

0.5s to 10s in 0.5s steps

Delayed drop-off timer \(t_{DO}\)

0s to 5s in 0.1s steps

Low forward power

Power setting \(P<\)

0.2W to 8W in 0.05W steps
(for 1A relay)
1W to 40W in 0.25W steps
(for 5A relay)

Delayed pick-up timer \(t\)

0.5s to 10s in 0.5s steps

Delayed drop-off timer \(t_{DO}\)

0s to 5s in 0.1s steps

Compensation angle \(\theta_{comp}\)

\(-5^\circ\) to \(+5^\circ\) in 0.1° steps
(for both reverse and low forward power)

Note: The power settings are single phase quantities.

Negative phase sequence trip element

Trip threshold setting \(I_{2>>}\)

0.051n to 0.51n in 0.011n steps

Thermal capacity constant (heating) \(K\)

2s to 40s in 1s steps

Thermal capacity constant (cooling) \(K_{reset}\)

2s to 60s in 1s steps

Operating Characteristic

\(t = \frac{K}{I_{2>>}^2} \log_e \left[1 - \left(\frac{I_{2>>}}{I_2}\right)^2\right]\)

Maximum operating time \(t_{max}\)

500s to 2000s in 10s steps

Minimum operating time \(t_{min}\)

0.25s to 40s in 0.25s steps

Negative phase sequence alarm element

Alarm threshold \(I_{2}\)

0.031n to 0.51n in 0.011n steps

Alarm timer setting \(t\)

2s to 60s in 1s steps
Field failure
Mho offset –Xa
2.5Ω to 25Ω in 0.5Ω steps (for 1A relays)
0.5Ω to 5Ω in 0.1Ω steps (for 5A relays)
Mho diameter Xb
25Ω to 250Ω in 1Ω steps (for 1A relays)
5Ω to 50Ω in 0.2Ω steps (for 5A relays)
Delayed pick-up timer t
0s to 25s in 0.1s steps
Delayed drop-off timer tDO
0s to 5s in 0.1s steps

Under voltage
Voltage setting V<
30V to 110V in 1V steps
Timer setting t
0.1s to 10s in 0.1s steps

Over voltage
Voltage settings V>, V>>
105V to 185V in 1V steps
Timer settings t>, t>>
0s to 10s in 0.1s steps

Under frequency
Frequency settings F1<, F2<
40Hz to 65Hz in 0.05Hz steps
Timer settings t1, t2
0.1s to 25s in 0.1s steps

Over frequency
Frequency settings F>
40Hz to 65Hz in 0.05Hz steps
Timer settings t
0.1s to 25s in 0.1s steps

Voltage balance
Voltage setting Vs
5V to 20V in 1V steps

Digital Inputs
Optically isolated inputs
14 (6 dedicated, 8 available to the scheme logic)

Contacts
Output relays
10 dual make
2 single make
3 change-over
Power supply failure alarm
1 single make
1 single break
Relay inoperative alarm
1 change-over
Contact rating
Make: 30A and carry for 0.2s
Carry: 5A continuous
Break: dc 50W resistive
25W inductive
(L/R = 0.4s)
ac 1250VA
Subject to maxima of 5A and 300V

Durability
Loaded contact
10,000 operations
Unloaded contact
100,000 operations
Communications

Language: Courier

IEC870 port (front/rear)

Transmission mode: Asynchronous
Signal levels: RS232
Message format: IEC870 FT1.2
Data rate: 600 – 19200 bits/s
Connection: Single-ended
Cable type: Screened multi-core
Cable length: 15m
Connector: 25-way D-type female
Isolation: Front (non-isolated) Rear (1kV rms for 1 minute to case earth and other circuits)

K-Bus port

Transmission mode: Synchronous
Signal levels: RS485
Message format: HDLC
Data rate: 64 kbits/s
Connection: Multidrop (32 units)
Cable type: Screened twisted pair
Cable length: 1000m
Connector: Screw terminals
Isolation: 2kV rms for 1 minute

Voltage withstand

Dielectric withstand
IEC255-5: 1977

2.0kVrms for 1 minute between all terminals and case earth
2.0kVrms for 1 minute between terminals of independent circuits, including contact circuits
1.0kVrms for 1 minute across open contacts of output relays
1.0kVrms for 1 minute between IEC870 rear port and earth

Impulse voltage
IEC255-5: 1977

5kV peak, 1.2/50µs, 0.5J between all terminals and all terminals to case earth

Insulation resistance
IEC255-5: 1977

>100MΩ

Electrical environment

DC supply interruptions
IEC255-11: 1979

The relay shall withstand a 10ms interrupt without de-energising

AC ripple on DC supply
IEC255-11: 1979

The relay will withstand 12% ripple

High frequency disturbance
IEC255-22-1: 1988

2.5kV first peak between independent circuits and case
1.0kV first peak across terminals of the same circuit.
No additional tolerances are required for the operating time or the relay’s thresholds
Electrostatic discharge test
IEC255-22-2: 1989

Class III (8kV) – air discharge
Level 3 (6kV) – point contact discharge (IEC801-2: 1991)
No additional tolerances are required for the operating time or the relay’s thresholds

Fast transient disturbance
IEC255-22-4: 1992

Class IV (4kV, 2.5kHz)
Class III (2kV, 5kHz)
No additional tolerances are required for the operating time or the relay’s thresholds

Radio frequency interference
Radiated immunity
IEC255-22-3: 1989

Class III field strength 10V/m
Extended frequency range 20MHz to 1000MHz

Conducted immunity
IEC801-6: 1994
10V rms, 0.15MHz to 80MHz

Radiated emissions
EN55022: 1994
Class A

Conducted emissions
EN55022: 1994
Class A

EMC compliance
89/336/EEC
Compliance with the European Commission Directive on EMC is claimed via the Technical Construction File route. Generic Standards were used to establish conformity

Product safety
73/23/EEC
Compliance with the European Commission Low Voltage Directive.
Compliance is demonstrated by reference to generic safety standards.

Atmospheric environment
Temperature
IEC255-6: 1988
Storage and transit –25°C to +70°C
Operating –25°C to +55°C

Humidity
IEC68-2-3: 1969
56 days at 93% relative humidity at 40°C.

Enclosure protection
IEC529: 1989
IP50 (dust protected)

Mechanical environment
Vibration
IEC255-21-1: 1988
Vibration response Class 2
Vibration endurance Class 2

Shock and bump
IEC255-21-2: 1988
Shock response Class 2
Shock withstand Class 2
Bump Class 1

Seismic
IEC255-21-3: 1993
Class 2
**Case**

The relay is housed in a multi-module MIDOS case as shown in Figure 12.

**Additional Information**

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<thead>
<tr>
<th>Manual/Leaflet</th>
<th>Code</th>
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<tr>
<td>LGPG111 Service Manual</td>
<td>R5942</td>
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<tr>
<td>Courier Communications leaflet</td>
<td>R4113</td>
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**Information Required with Order**

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**Figure 12: Case outlines**

### Rack mounting

- **Front**: 438 x 483 mm
- **Side**: 37 x 252 mm
- **Hinged front panel**: 10.6 x 7 mm
- **Fixing hole detail**: U Scale U = 44.45

### Panel mounting

- **Front**: 438 x 483 mm
- **Side**: 37 x 252 mm
- **Hinged front panel**: 10.6 x 7 mm

### 483mm Rack details

- **Dimensions to IEC 297**
- **Tolerance between any two holes within a distance of 1mm ±0.4**

### Panel cut-out detail

- **Fixing holes Ø5.4**
- **Allow a minimum of 50mm for terminal block and wiring**

All dimensions in mm

Terminal screws: M4 x 8 brass Cheese Head with Lockwashers are provided

Mounting screws are not provided