



K Range – Series 1

Overcurrent and Directional Overcurrent Relays

Service Manual

R8501H

Models available

The following list of models are covered by this manual:

KCGG 110/KCGG 210

KCGG 120

KCGG 130/KCGG 230

KCGG 140/KCGG 240

KCGU 110

KCGU 140/KCGU 240

KCEG 110/KCEG 210

KCEG 130/KCEG 230

KCEG 140/KCEG 240

KCEG 150/KCEG 250

KCEG 160

KCEU 110

KCEU 140/KCEU 240

KCEU 141/KCEU 241

KCEU 150/KCEU 250

KCEU 160

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SAFETY SECTION

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1. INTRODUCTION

This guide and the relevant operating or service manual documentation for the equipment provide full information on safe handling, commissioning and testing of this equipment and also includes descriptions of equipment label markings.

Documentation for equipment ordered from AREVA T&D is despatched separately from manufactured goods and may not be received at the same time.

Therefore this guide is provided to ensure that printed information normally present on equipment is fully understood by the recipient.



Before carrying out any work on the equipment the user should be familiar with the contents of this Safety Guide.

Reference should be made to the external connection diagram before the equipment is installed, commissioned or serviced.

Language specific, self-adhesive User Interface labels are provided in a bag for some equipment.

2. HEALTH AND SAFETY

The information in the Safety Section of the equipment documentation is intended to ensure that equipment is properly installed and handled in order to maintain it in a safe condition.

It is assumed that everyone who will be associated with the equipment will be familiar with the contents of that Safety Section, or this Safety Guide.

When electrical equipment is in operation, dangerous voltages will be present in certain parts of the equipment. Failure to observe warning notices, incorrect use, or improper use may endanger personnel and equipment and cause personal injury or physical damage.

Before working in the terminal strip area, the equipment must be isolated.

Proper and safe operation of the equipment depends on appropriate shipping and handling, proper storage, installation and commissioning, and on careful operation, maintenance and servicing. For this reason only qualified personnel may work on or operate the equipment.

Qualified personnel are individuals who





- are familiar with the installation, commissioning, and operation of the equipment and of the system to which it is being connected;
- are able to safely perform switching operations in accordance with accepted safety engineering practices and are authorised to energize and de-energize equipment and to isolate, ground, and label it;
- are trained in the care and use of safety apparatus in accordance with safety engineering practices;
- are trained in emergency procedures (first aid).

The operating manual for the equipment gives instructions for its installation, commissioning, and operation. However, the manual cannot cover all conceivable circumstances or include detailed information on all topics. In the event of questions or specific problems, do not take any action without proper authorization. Contact the appropriate AREVA technical sales office and request the necessary information.

3. SYMBOLS AND EXTERNAL LABELS ON THE EQUIPMENT

For safety reasons the following symbols and external labels, which may be used on the equipment or referred to in the equipment documentation, should be understood before the equipment is installed or commissioned.

3.1 Symbols

	
Caution: refer to equipment documentation	Caution: risk of electric shock
	
Protective Conductor (*Earth) terminal.	
	
Functional/Protective Conductor Earth terminal	
Note – This symbol may also be used for a Protective Conductor (Earth) terminal if that terminal is part of a terminal block or sub-assembly e.g. power supply.	

*NOTE: THE TERM EARTH USED THROUGHOUT THIS GUIDE IS THE DIRECT EQUIVALENT OF THE NORTH AMERICAN TERM GROUND.

3.2 Labels

See "Safety Guide" (SFTY/4L M) for equipment labelling information.

4. INSTALLING, COMMISSIONING AND SERVICING



Equipment connections

Personnel undertaking installation, commissioning or servicing work for this equipment should be aware of the correct working procedures to ensure safety.

The equipment documentation should be consulted before installing, commissioning or servicing the equipment.

Terminals exposed during installation, commissioning and maintenance may present a hazardous voltage unless the equipment is electrically isolated.

Any disassembly of the equipment may expose parts at hazardous voltage, also electronic parts may be damaged if suitable electrostatic voltage discharge (ESD) precautions are not taken.

If there is unlocked access to the rear of the equipment, care should be taken by all personnel to avoid electric shock or energy hazards.

Voltage and current connections should be made using insulated crimp terminations to ensure that terminal block insulation requirements are maintained for safety.

To ensure that wires are correctly terminated the correct crimp terminal and tool for the wire size should be used.

The equipment must be connected in accordance with the appropriate connection diagram.

Protection Class I Equipment

- Before energising the equipment it must be earthed using the protective conductor terminal, if provided, or the appropriate termination of the supply plug in the case of plug connected equipment.
- The protective conductor (earth) connection must not be removed since the protection against electric shock provided by the equipment would be lost.

The recommended minimum protective conductor (earth) wire size is 2.5 mm² (3.3 mm² for North America) unless otherwise stated in the technical data section of the equipment documentation, or otherwise required by local or country wiring regulations.

The protective conductor (earth) connection must be low-inductance and as short as possible.

All connections to the equipment must have a defined potential. Connections that are pre-wired, but not used, should preferably be grounded when binary inputs and output relays are isolated. When binary inputs and output relays are connected to common potential, the pre-wired but unused connections should be connected to the common potential of the grouped connections.

Before energising the equipment, the following should be checked:

- Voltage rating/polarity (rating label/equipment documentation);
- CT circuit rating (rating label) and integrity of connections;
- Protective fuse rating;
- Integrity of the protective conductor (earth) connection (where applicable);
- Voltage and current rating of external wiring, applicable to the application.

**Equipment Use**

If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

**Removal of the equipment front panel/cover**

Removal of the equipment front panel/cover may expose hazardous live parts which must not be touched until the electrical power is removed.

**UL and CSA Listed or Recognized Equipment**

To maintain UL and CSA approvals the equipment should be installed using UL and/or CSA Listed or Recognized parts of the following type: connection cables, protective fuses/fuseholders or circuit breakers, insulation crimp terminals, and replacement internal battery, as specified in the equipment documentation.

**Equipment operating conditions**

The equipment should be operated within the specified electrical and environmental limits.

**Current transformer circuits**

Do not open the secondary circuit of a live CT since the high voltage produced may be lethal to personnel and could damage insulation.

Generally, for safety, the secondary of the line CT must be shorted before opening any connections to it.

For most equipment with ring-terminal connections, the threaded terminal block for current transformer termination has automatic CT shorting on removal of the module. Therefore external shorting of the CTs may not be required, the equipment documentation should be checked to see if this applies.

For equipment with pin-terminal connections, the threaded terminal block for current transformer termination does NOT have automatic CT shorting on removal of the module.

**External resistors, including voltage dependent resistors (VDRs)**

Where external resistors, including voltage dependent resistors (VDRs), are fitted to the equipment, these may present a risk of electric shock or burns, if touched.

**Battery replacement**

Where internal batteries are fitted they should be replaced with the recommended type and be installed with the correct polarity to avoid possible damage to the equipment, buildings and persons.

**Insulation and dielectric strength testing**

Insulation testing may leave capacitors charged up to a hazardous voltage. At the end of each part of the test, the voltage should be gradually reduced to zero, to discharge capacitors, before the test leads are disconnected.

**Insertion of modules and pcb cards**

Modules and pcb cards must not be inserted into or withdrawn from the equipment whilst it is energised, since this may result in damage.

**Insertion and withdrawal of extender cards**

Extender cards are available for some equipment. If an extender card is used, this should not be inserted or withdrawn from the equipment whilst it is energised. This is to avoid possible shock or damage hazards. Hazardous live voltages may be accessible on the extender card.

**Insertion and withdrawal of integral heavy current test plugs**

It is possible to use an integral heavy current test plug with some equipment. CT shorting links must be in place before insertion or removal of heavy current test plugs, to avoid potentially lethal voltages.

**External test blocks and test plugs**

Great care should be taken when using external test blocks and test plugs such as the MMLG, MMLB and MiCOM P990 types, hazardous voltages may be accessible when using these. *CT shorting links must be in place before the insertion or removal of MMLB test plugs, to avoid potentially lethal voltages.

*Note – when a MiCOM P992 Test Plug is inserted into the MiCOM P991 Test Block, the secondaries of the line CTs are automatically shorted, making them safe.

**Fibre optic communication**

Where fibre optic communication devices are fitted, these should not be viewed directly. Optical power meters should be used to determine the operation or signal level of the device.

**Cleaning**

The equipment may be cleaned using a lint free cloth dampened with clean water, when no connections are energised. Contact fingers of test plugs are normally protected by petroleum jelly which should not be removed.

5. DECOMMISSIONING AND DISPOSAL



Decommissioning:

The supply input (auxiliary) for the equipment may include capacitors across the supply or to earth. To avoid electric shock or energy hazards, after completely isolating the supplies to the equipment (both poles of any dc supply), the capacitors should be safely discharged via the external terminals prior to decommissioning.



Disposal:

It is recommended that incineration and disposal to water courses is avoided. The equipment should be disposed of in a safe manner. Any equipment containing batteries should have them removed before disposal, taking precautions to avoid short circuits. Particular regulations within the country of operation, may apply to the disposal of batteries.

6. EQUIPMENT WHICH INCLUDES ELECTROMECHANICAL ELEMENTS



Electrical adjustments

It is possible to change current or voltage settings on some equipment by direct physical adjustment e.g. adjustment of a plug-bridge setting. The electrical power should be removed before making any change, to avoid the risk of electric shock.



Exposure of live parts

Removal of the cover may expose hazardous live parts such as relay contacts, these should not be touched before removing the electrical power.

7. TECHNICAL SPECIFICATIONS FOR SAFETY

7.1 Protective fuse rating

The recommended maximum rating of the external protective fuse for equipments is 16A, high rupture capacity (HRC) Red Spot type NIT, or TIA, or equivalent, unless otherwise stated in the technical data section of the equipment documentation. The protective fuse should be located as close to the unit as possible.



DANGER - CTs must NOT be fused since open circuiting them may produce lethal hazardous voltages.

7.2 Protective Class

IEC 61010-1: 2001
EN 61010-1: 2001

Class I (unless otherwise specified in the equipment documentation). This equipment requires a protective conductor (earth) connection to ensure user safety.

7.3 Installation Category

IEC 61010-1: 2001
EN 61010-1: 2001

Installation Category III (Overvoltage Category III):

Distribution level, fixed installation.

Equipment in this category is qualification tested at 5kV peak, 1.2/50µs, 500Ω, 0.5J, between all supply circuits and earth and also between independent circuits

7.4 Environment

The equipment is intended for indoor installation and use only. If it is required for use in an outdoor environment then it must be mounted in a specific cabinet or housing which will enable it to meet the requirements of IEC 60529 with the classification of degree of protection IP54 (dust and splashing water protected).

Pollution Degree – Pollution
Degree 2
Altitude – operation up to
2000 m
IEC 61010-1: 2001
EN 61010-1: 2001

Compliance is demonstrated by reference to safety standards.

8. CE MARKING



Marking

Compliance with all relevant European Community directives:

Product safety:
Low Voltage Directive - 73/23/EEC
amended by 93/68/EEC
EN 61010-1: 2001
EN 60950-1: 2001
EN 60255-5: 2001
IEC 60664-1: 2001

Compliance demonstrated by reference to safety standards.

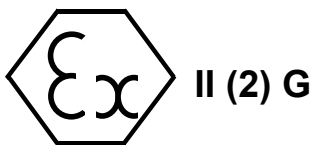
Electromagnetic Compatibility Directive
(EMC) 89/336/EEC amended by
93/68/EEC.

Compliance demonstrated via the Technical Construction File route.

The following Product Specific Standard
was used to establish conformity:

EN 50263 : 2000

Where applicable :



ATEX Potentially Explosive
Atmospheres directive
94/9/EC, for equipment.

The equipment is compliant with Article 1(2) of European directive 94/9/EC. It is approved for operation outside an ATEX hazardous area. It is however approved for connection to Increased Safety, "Ex e", motors with rated ATEX protection, Equipment Category 2, to ensure their safe operation in gas Zones 1 and 2 hazardous areas.

CAUTION – Equipment with this marking is not itself suitable for operation within a potentially explosive atmosphere.

Compliance demonstrated by Notified Body certificates of compliance.

Radio and
Telecommunications Terminal
Equipment (R & TTE)
directive 95/5/EC.

Compliance demonstrated by compliance to the Low Voltage Directive, 73/23/EEC amended by 93/68/EEC, down to zero volts, by reference to safety standards.

9. RECOGNIZED AND LISTED MARKS FOR NORTH AMERICA

CSA - Canadian Standards Association

UL - Underwriters Laboratory of America



– UL Recognized to UL (USA) requirements



– UL Recognized to UL (USA) and CSA (Canada) requirements



– UL Listed to UL (USA) requirements



– UL Listed to UL (USA) and CSA (Canada) requirements



– Certified to CSA (Canada) requirements

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Section 1. HANDLING AND INSTALLATION

1.1 General considerations

1.1.1 Receipt of relays

Protective relays, although generally of robust construction, require careful treatment prior to installation on site. Upon receipt, relays should be examined immediately, to ensure no damage has been sustained in transit. If damage has been sustained during transit, a claim should be made to the transport contractor, and a AREVA T&D representative should be promptly notified.

Relays that are supplied unmounted and not intended for immediate installation should be returned to their protective polythene bags.

1.1.2 Electrostatic discharge (ESD)

The relays use components that are sensitive to electrostatic discharges. The electronic circuits are well protected by the metal case and the internal module should not be withdrawn unnecessarily. When handling the module outside its case, care should be taken to avoid contact with components and electrical connections. If removed from the case for storage, the module should be placed in an electrically conducting antistatic bag.

There are no setting adjustments within the module and it is advised that it is not unnecessarily disassembled. Although the printed circuit boards are plugged together, the connectors are a manufacturing aid and not intended for frequent dismantling; in fact considerable effort may be required to separate them. Touching the printed circuit board should be avoided, since complementary metal oxide semiconductors (CMOS) are used, which can be damaged by static electricity discharged from the body.

1.2 Handling of electronic equipment

A person's normal movements can easily generate electrostatic potentials of several thousand volts. Discharge of these voltages into semiconductor devices when handling electronic circuits can cause serious damage, which often may not be immediately apparent but the reliability of the circuit will have been reduced.

The electronic circuits are completely safe from electrostatic discharge when housed in the case. Do not expose them to risk of damage by withdrawing modules unnecessarily.

Each module incorporates the highest practicable protection for its semiconductor devices. However, if it becomes necessary to withdraw a module, the precautions should be taken to preserve the high reliability and long life for which the equipment has been designed and manufactured.

1. Before removing a module, ensure that you are at the same electrostatic potential as the equipment by touching the case.
2. Handle the module by its frontplate, frame or edges of the printed circuit board. Avoid touching the electronic components, printed circuit track or connectors.
3. Do not pass the module to another person without first ensuring you are both at the same electrostatic potential. Shaking hands achieves equipotential.
4. Place the module on an antistatic surface, or on a conducting surface which is at the same potential as yourself.
5. Store or transport the module in a conductive bag.

If you are making measurements on the internal electronic circuitry of an equipment in service, it is preferable that you are earthed to the case with a conductive wrist strap. Wrist straps should have a resistance to ground between 500k-10M ohms. If a wrist strap is not available, you should maintain regular contact with the case to prevent a build-up of static. Instrumentation which may be used for making measurements should be earthed to the case whenever possible.

More information on safe working procedures for all electronic equipment can be found in BS5783 and IEC 60147-OF. It is strongly recommended that detailed investigations on electronic circuitry, or modification work, should be carried out in a Special Handling Area such as described in the above-mentioned BS and IEC documents.

1.3 Relay mounting

Relays are dispatched, either individually, or as part of a panel/rack assembly. If loose relays are to be assembled into a scheme, then construction details can be found in Publication R7012. If an MMLG test block is to be included it should be positioned at the right hand side of the assembly (viewed from the front). Modules should remain protected by their metal case during assembly into a panel or rack. The design of the relay is such that the fixing holes are accessible without removal of the cover. For individually mounted relays, an outline diagram is normally supplied showing the panel cut-outs and hole centres. These dimensions will also be found in Publication R6501.

1.4 Unpacking

Care must be taken when unpacking and installing the relays so that none of the parts is damaged, or the settings altered and they must only be handled by skilled persons. The installation should be clean, dry and reasonably free from dust and excessive vibration. The site should be well lit to facilitate inspection. Relays that have been removed from their cases should not be left in situations where they are exposed to dust or damp. This particularly applies to installations which are being carried out at the same time as construction work.

1.5 Storage

If relays are not to be installed immediately upon receipt they should be stored in a place free from dust and moisture in their original cartons. Where de-humidifier bags have been included in the packing they should be retained. The action of the de-humidifier crystals will be impaired if the bag has been exposed to ambient conditions and may be restored by gently heating the bag for about an hour, prior to replacing it in the carton.

Dust which collects on a carton may, on subsequent unpacking, find its way into the relay; in damp conditions the carton and packing may become impregnated with moisture and the de-humidifier will lose its efficiency.

Storage temperature -25°C to $+70^{\circ}\text{C}$.

Section 2. INTRODUCTION

2.1 Using the manual

This manual provides a description of the K Range Overcurrent and Directional Overcurrent range of protection relays. It is intended to guide the user through application, installation, setting and commissioning of the relays.

The manual has the following format:

Section 1 Handling and Installation

Guidance on precautions to be taken when handling electronic equipment.

Section 2 Introduction

An introduction on how to use this manual and a general introduction to the relays covered by the manual.

Section 3 Relay Description

A detailed technical description of each relay feature and setting procedure.

Section 4 Applications

An introduction to applications for the relays.

Section 5 Technical Data

Comprehensive details on the ratings, setting ranges and IEC/ANSI specifications to which the relays conform.

Section 6 Commissioning

A guide to commissioning, problem solving and maintenance.

Appendix Appendices include relay characteristic curves, logic diagrams, connection diagrams and commissioning test records.

Index Provides the user with page references for quick access to selected topics.

2.2 An introduction to K Range relays

The K Range range of protection relays brings numerical technology to the successful MIDOS range of protection relays. Fully compatible with the existing designs and sharing the same modular housing concept, the relays offer more comprehensive protection for demanding applications.

With enhanced versatility, reduced maintenance requirements and low burdens, K Range relays provide a more advanced solution to power system protection.

Each relay includes an extensive range of control and data gathering functions to provide a completely integrated system of protection, control, instrumentation, data logging, fault recording and event recording. The relays have a user-friendly 32 character liquid crystal display (LCD) with 4 pushbuttons which allow menu navigation and setting changes. Also, by utilising the simple 2-wire communication link, all of the relay functions can be read, reset and changed on demand from a local or remote personal computer (PC), loaded with the relevant software.

KCGG & KCGU relays provide overcurrent and earth fault protection for power distribution systems, industrial power systems and all other applications where overcurrent protection is required. The relays are used in applications where time graded overcurrent and earth fault protection is required. The KCGU provides sensitive earth fault protection for systems where the earth fault current is limited.

KCEG & KCEU relays provide directional overcurrent and earth fault protection. The overcurrent elements can be selectively directionalised, making the relays a cost effective option where both directional and non-directional protection is required. The directional sensitive earth fault protection provided by the KCEU relay is particularly suitable for systems where the earth fault current is severely limited.

Integral features in the K Range relays include circuit breaker failure protection, backtripping, blocked overcurrent protection for feeders or busbars, cold load pick-up facilities, load shedding capabilities and two alternative groups of predetermined settings. The relays also have integral serial communication facilities via K-Bus.

2.3 Models available

The following list of models are covered by this manual:

KCGG 110/KCGG 210	Earth fault relay
KCGG 120	Two phase overcurrent relay
KCGG 130/KCGG 230	Three phase overcurrent relay
KCGG 140/KCGG 240	Three phase overcurrent and earth fault relay
KCGU 110	Sensitive earth fault relay
KCGU 140/KCGU 240	Three phase overcurrent and sensitive earth fault relay
KCEG 110/KCEG 210	Directional earth fault relay
KCEG 130/KCEG 230	Directional three phase overcurrent relay
KCEG 140/KCEG 240	Directional three phase overcurrent and earth fault relay
KCEG 150/KCEG 250	Directional earth fault and non-directional overcurrent relay
KCEG 160	Directional earth fault relay with dual polarisation
KCEU 110	Directional sensitive earth fault relay
KCEU 140/KCEU 240	Directional three phase overcurrent and sensitive earth fault relay
KCEU 141/KCEU 241	Directional three phase overcurrent and sensitive earth fault relay with wattmetric element
KCEU 150/KCEU 250	Directional sensitive earth fault and non-directional overcurrent relay
KCEU 160	Directional sensitive earth fault relay with dual polarisation

Note: The 100 series of relays are powered by an ac/dc auxiliary supply.

The 200 series of relays are dual powered i.e. powered by an ac/dc auxiliary supply or from the line current transformers in the absence of an auxiliary supply.

Section 3. RELAY DESCRIPTION

3.1 User interface

This interface provides the user with a means of entering settings to the relay and of interrogating the relays to retrieve recorded data.

3.1.1 Frontplate layout

The frontplate of the relay carries an identification label at the top corner. This identifies the relay by both its model number and serial number. This information is required when making any enquiry to the factory about a particular relay because it uniquely specifies the product. In addition there is a rating label in the bottom corner which gives details of the auxiliary voltage, reference voltage (directional relays only) and current ratings. (See Figure 1).

Two handles, one at the top and one at the bottom of the frontplate, will assist in removing the module from the case. Three light emitting diodes (leds) provide status indication and there is also a liquid crystal display and a four-key pad for access to settings and other readable data.

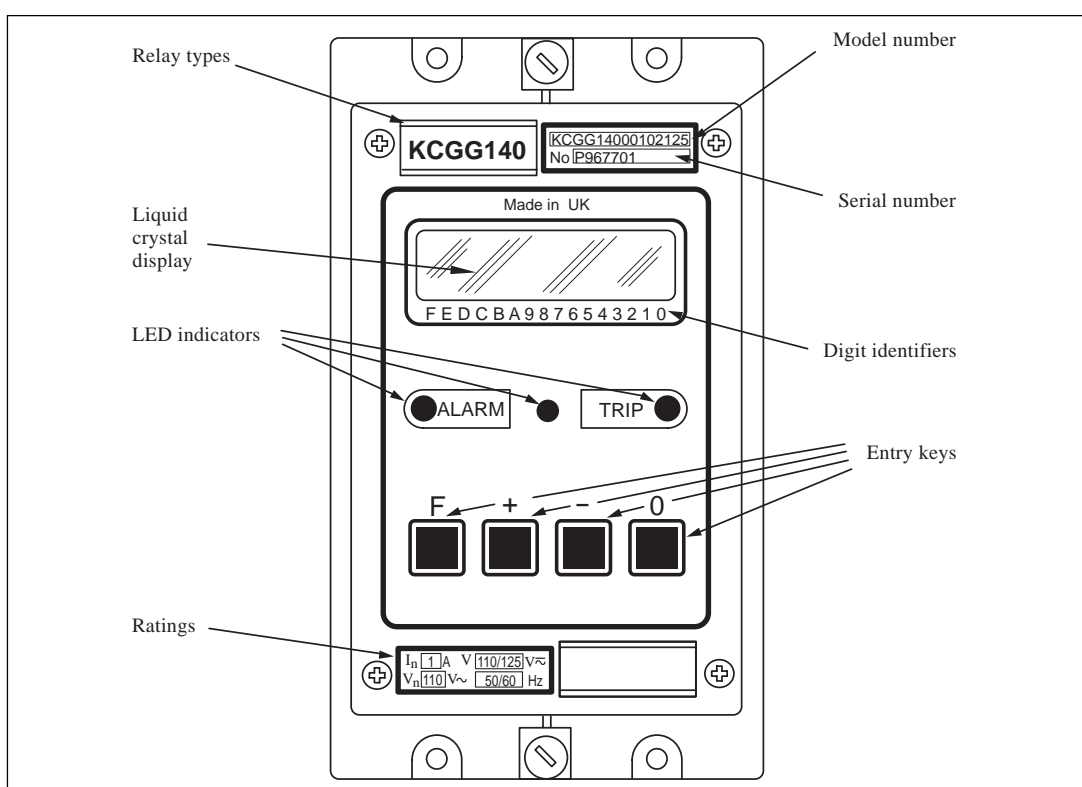


Figure 1. Frontplate layout

3.1.2 LED indications

The three LEDs provide the following functions:

GREEN LED Indicates the relay is powered up and running. In most cases it follows the watchdog relay, but dual powered relays are the exception because the watchdog does not operate for loss of auxiliary supply. Such a condition would be considered a normal operational condition when the relays are energized from line current transformers alone.

- YELLOW LED** Indicates alarm conditions that have been detected by the relay during its self checking routine. The alarm lamp flashes when the password is entered (password inhibition temporarily overridden).
- RED LED** Indicates a trip that has been issued by the relay. This may be a protection trip or result from a remote trip command; the trip flags have to be viewed to decide which.

3.1.3 Keypad

Four keys on the frontplate of the relay enable the user to select the data to be displayed and settings to be changed. The keys perform the following functions:

- [F] – FUNCTION SELECT KEY
- [+] – INCREMENT VALUE KEY
- [-] – DECREMENT VALUE KEY
- [0] – RESET/ESCAPE KEY

Note: Only the [F] and [0] keys are accessible when the relay cover is in place.

3.1.4 Liquid crystal display

The liquid crystal display (LCD) has two lines, each of sixteen characters, that are used to display settings, measured values and records which are extracted from the relay data bank. A backlight is activated when any of the keys on the frontplate of the relay is momentarily pressed. This enables the display to be read in all conditions of ambient lighting.

The numbers printed on the frontplate just below the display, identify the individual digits that are displayed for some of the settings, ie. function links, relay masks etc.

3.1.5 Flag display format

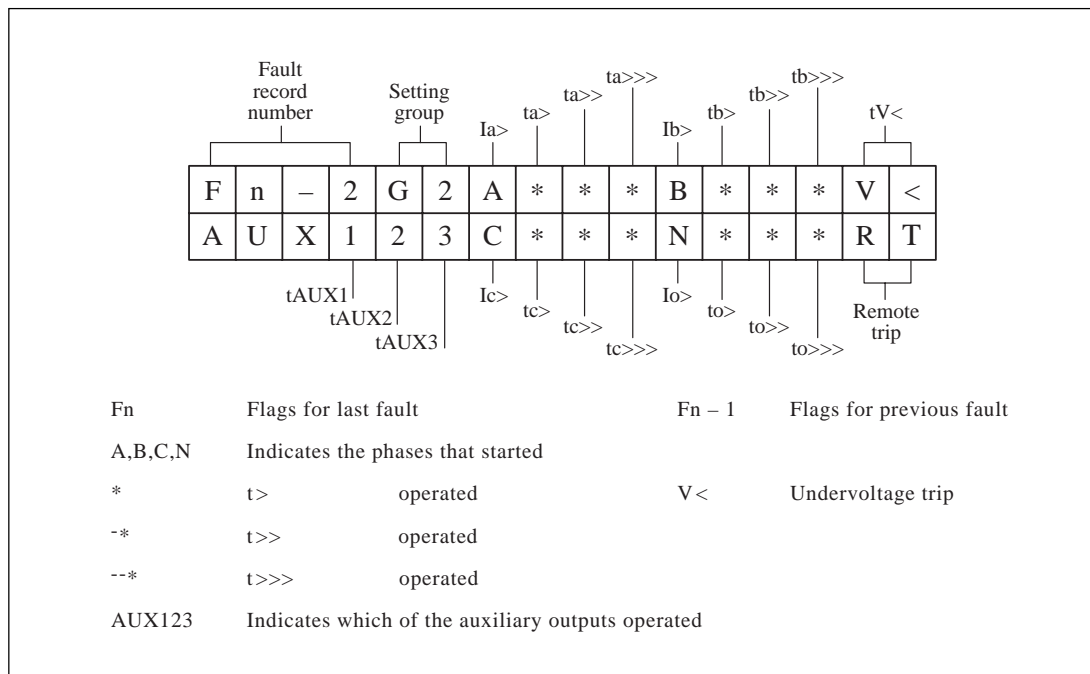


Figure 2. Flag display format

3.2 Menu system

Data within the relays is accessed via a MENU table. The table is divided into columns and rows to form cells, rather like a spreadsheet. Each cell may contain text, values, limits and functions. The first cell in a column contains a heading which identifies the data grouped on that column.

Four keys on the frontplate of the relay allow the menu to be scanned and the contents displayed on the liquid crystal display (LCD). The act of depressing any key will result in the LCD backlight being switched on. The backlight will turn off again if a key is not pressed again within one minute.

The display will normally be the selected default setting and a momentary press of the function key [F] will change the display to the heading for the first column, SYSTEM DATA. Further momentary presses of the [F] key will step down the column, row by row, so that data may be read. If at any time the [F] key is pressed and held for one second the cursor will be moved to the top of the next column and the heading for that column will be displayed. Further momentary presses of the [F] key will then move down the new column, row by row. In this way the full menu of the relay may be scanned with just one key and this key is accessible with the cover in place on the relay.

The other key that is accessible with the cover in place is the reset key [0]. A momentary press of this key will switch on the back light for the LCD without changing the display in any way. Following a protection trip the display will change automatically from the default display to that of the fault flags for that fault and the red trip LED will be lit to draw attention to the fact. The trip LED can be reset by holding down the reset key [0] for at least one second.

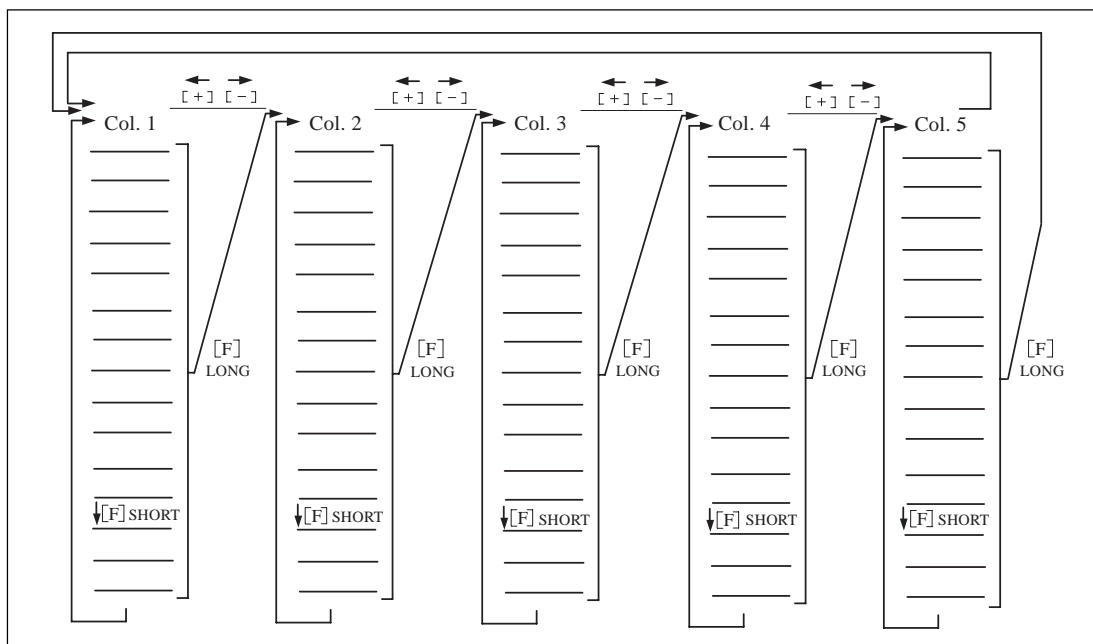


Figure 3. Menu system of relay

The fault information is not lost by this action, it is only cleared from the display. The fault flags can be read by selecting FAULT RECORDS from the column headings and stepping down until the flag data (Fn), the flags for the last fault, are displayed. The red trip LED can be reset by holding the reset key [0] depressed for 1 second whilst this cell is being displayed. The next cell down contains the flags for the previous fault (Fn-1) and so on to (Fn-4); enough for a full four shot autoreclose cycle. The currents and voltages measured during the last fault are also recorded on this page of the menu together with the circuit breaker opening time. To delete all fault records the next cell after (Fn-4) must be selected. This cell will read "FLT clear records = [0]" and to complete the reset action the [0] key must be held depressed for more than 1 second.

The only settings which can be changed with the cover in place are those that can be reset either to zero or some preset value. To change any other settings the cover has to be removed from the relay to gain access to the [+] and [-] keys, that are used to increment or decrement a value. When a column heading is displayed the [-] key will change the display to the next column and the [+] key will change the display to the previous column, giving a faster selection.

When a cell containing a relay setting is displayed the action of pressing either the [+] or [-] keys will indicate to the relay that a value is to be changed and a flashing cursor will appear on the display. To escape from the setting mode without making any change, the [0] key should be depressed for one second.

Password protection is provided for the configuration settings of the relay. This includes time curve selection, set CT and VT ratios, function link settings, opto-input and relay output allocation. Any accidental change to configuration could seriously affect the ability of the relay to perform its intended functions, whereas a setting error may only cause a grading problem. Individual protection settings are protected from change when the relay cover is in place.

For instruction on how to change the various types of settings refer to Section 3.3.

3.2.1 Menu contents

Related data and settings are grouped together in separate columns of the menu. Each column has a text heading that identifies the data contained in that column. Each cell may contain text, values, limits and/or a function. The cells are referenced by the column number/row number. For example 0201 is column 02, row 01.

The full menu is given in the following notes but not all the items will be available in a particular relay. For example, a single pole earth fault relay would not display any phase fault settings and a non-directional relay would not display any settings associated with the directional feature. Those cells that do not provide any useful purpose are not made available in the factory configuration, to avoid the confusion that would occur in deciding at what values to set them. In a similar way certain settings will disappear from the menu when the user de-selects them; the alternative setting group is a typical example. If System Data Link (SD4) is set to "0" alternative settings EF(2) and PF(2) will be hidden and to select them and make them visible, link SD4 must be set to "1". This note is included at this time to explain why some of the items listed below may not appear in the menu for the relay that is being compared with the full list.

The menu cells that are read only are marked [READ] .

Cells that can be set are marked [SET].

Cells that can be reset are marked [RESET].

Cells that are password protected are marked [PWP].

3.2.2

SYSTEM DATA

0001	SYS Language	The language used in the text [READ]
0002	SYS Password	Password [PWP]
0003	SYS Fn Links	Function Links [PWP]
	LINK 0 [SYS Rem ChgStg]	1 = Enable remote setting changes
	LINK 1 [SYS Load Shed T]	1 = Enable global load shed tripping
	LINK 2 [SYS Rem CB Ctrl]	1 = Enable remote circuit breaker control
	LINK 3 [SYS Rem ChgGrp]	1 = Enable remote change of setting group
	LINK 4 [SYS Enable Grp2]	1 = Enable setting group 2
	LINK 5 [SYS Auto Reset]	1 = Enable auto flag reset function
	LINK 6 [SYS Auto Rec]	1 = Enable auto reset of recorder
	LINK 7 [SYS En Log Evts]	1 = Enable event records to be stored
0004	SYS Description	Description or user scheme identifier [PWP]
0005	SYS Plant Ref.	User plant/location identifier [PWP]
0006	SYS Model No.	Model number [READ]
0007	SYS Firmware No.	Firmware number [READ]
0008	SYS Serial No.	Serial number [READ]
0009	SYS Frequency	Frequency [SET]
000A	SYS Comms Level	Communication level [READ]
000B	SYS Rly Address	Communication address [SET]
000C	SYS Plant Status	CB and isolator positions [READ]
000D	SYS Ctrl Status	Not used [READ]
000E	SYS Setting Grp	Setting group in use (1/2) [READ]
000F	SYS LS Stage	Current state of load shedding [READ]
0010	SYS CB Control	CB control NO OPERATION/TRIP/CLOSE [SET]
0011	SYS Software Ref	
0020	SYS Logic Stat	Current state of logic control inputs [READ]
0021	SYS Relay Stat	Current state of output relays [READ]
0022	SYS Alarms	State of alarms [READ]

0001 SYS Language [READ]

The language in which the text is displayed is shown at this location. On these particular relays it is not selectable.

0002 SYS Password [PWP]

The selected configuration of the relay is locked under this password and cannot be changed until it has been entered. Provision has been made for the user to change the password, which may consist of four upper case letters in any combination. In the event of the password becoming lost a recovery password can be obtained on request, but the request must be accompanied by a note of the model and serial number of the relay. The recovery password will be unique to one relay and will not work on any other unless the user set password is the same.

0003 SYS Function Links [PWP]

These function links enable selection to be made from the system options, for example, which commands over the serial link will be acted upon. They are fully detailed in Sections 3.2.2, 3.2.7, 3.2.8, 3.2.9, 3.2.10 and 3.2.11.

0004 SYS Description [PWP]

This is text that describes the relay type, for example “THREE PHASE OVERCURRENT”. It is password protected and can be changed by the user to a name which may describe the scheme configuration of the relay if the relay is changed from the factory configuration.

0005 SYS Plant Reference [SET]

The plant reference can be entered by the user, but it is limited to 16 characters. This reference is used to identify the primary plant with which the relay is associated.

0006 SYS Model Number [READ]

The model number that is entered during manufacture has encoded into it the mechanical assembly, ratings and configuration of the relay. It is printed on the frontplate and should be quoted in any correspondence concerning the product.

0007 SYS Firmware Number [READ]

The version of software and memory components is coded into this number. It cannot be changed.

0008 SYS Serial Number [READ]

The serial number is the relay identity and encodes also the year of manufacture. It cannot be changed from the menu.

0009 SYS Frequency [SET]

The set frequency from which the relay starts tracking on power-up.

000A SYS Communication Level [READ]

This cell will contain the communication level that the relay will support. It is used by master station programs to decide what type of commands to send to the relay.

000B SYS Relay Address [SET]

An address between 1 and 254 that identifies the relay when interconnected by a communication bus. These addresses may be shared between several communication buses and therefore not all these addresses will necessarily be available on the bus to which the relay is connected. The address can be manually set. Address 0 is reserved for the automatic address allocation feature and 255 is reserved for global messages. The factory set address is 255.

000C SYS Plant Status [READ]

Plant status is a 16 bit word which is used to transport plant status information over the communication network. The various bit pairs are pre-allocated to specific items of plant.

000D SYS Control Status [READ]

The control status is not used in these relays but would act like software contacts to transfer data from the relay to the master station controlling communications. For example it may be used by a frequency relay to transfer data to indicate different levels of load shedding that may be initiated by the master station.

000E SYS Setting Group [READ]

Where a relay has alternative groups of settings which can be selected, then this cell indicates the current group being used by the relay. For these relays it is either (Group 1) or (Group 2).

000F SYS LS Stage [READ]

Cell 000F displays the level of load shedding at all times. It has been assumed that load shedding will be initiated either by tripping less essential loads or by voltage reduction, not by both methods simultaneously. Hence there is no arbitration on what is displayed in cell 000F. If the load shed by voltage reduction feature is in use and a command issued to load shed to level 1, then it will display Vreduct1. If a command is then issued to the same relay to load shed trip, this same cell will display that action even if SD1 = 0.

Load shedding by voltage reduction is always responsive to remote commands if output relays are assigned to this function. To inhibit this function, do not assign any output relays in the Vreduct masks.

The command levels received are latched and displayed in this cell.

- Command <Level 0> = "None" – All stages reset
- Command <Level 1> = "V reduct 1" – Relay for stage 1 picked-up
- Command <Level 2> = "V reduct 2" – Relay for stage 2 picked-up
- Command <Level 3> = "V reduct 3" – Relay for stage 3 picked-up

When the auxiliary supply to the relay is interrupted the states of the relays that initiate voltage reduction are remembered. This ensures that the level of load shedding is not caused to change by momentary interruptions of the auxiliary supply.

The master station is expected to take care of any operational changes to the load shed level that may have taken place whilst a relay has been out of service, by resending the last global load shed command.

When link SD1 = 1, it enables load shed tripping in response to commands over the serial port. When SD1 = 0, it prevents load shed tripping in response to such commands over the serial port.

Example: relay set to level 2:

- Command <0> "None" – all load shed circuits restored
- Command <1> "None" – no response command below set level
- Command <2> "LS Trip" – trip in response to command level 2 or greater
- Command <3> "LS Trip" – no response because already tripped
- Command <1> "Restoring" – indication during restoration time
- Command <1> "None" – circuit restored

On loss of the auxiliary supply the memory of having tripped due to a load shed trip command is erased. This ensures that a relay that has been out of service for some time, will not close a circuit breaker in response to a subsequent load shed command, as this could be dangerous.

0010 SYS CB Control [SET]

This cell contains the functions for control of the circuit breaker. Via this cell the circuit breaker can be closed and tripped either from the user interface or over a communication network. To be able to do this, the relay has to have output relays

allocated to circuit breaker control and these relays would normally be routed through the remote/local control switch, arranged to complete the circuits in the remote position.

0020 SYS Logic Stat

Current state of opto-isolated logic control inputs.

0021 SYS Relay Stat

Current state of relay outputs.

0022 Alarms

Current state of alarm flags (see Section 3.3.11).

3.2.3 Fault records [READ]

0101	FLT Ia	Fault current for last trip
0102	FLT Ib	Fault current for last trip
0103	FLT Ic	Fault current for last trip
0104	FLT Io	Fault current for last trip
0105	FLT Vab	Fault line voltage for last trip
0106	FLT Vbc	Fault line voltage for last trip
0107	FLT Vca	Fault line voltage for last trip
0108	FLT Vo	Fault residual voltage for last fault
0109	FLT CB trip time	Circuit breaker operation time for last trip
010A	Fnow	Current state of flags (not latched)
010B	Fn	Flags for last fault (n) [RESET trip LED only]
010C	Fn-1	Flags for fault (n-1) – previous fault
010D	Fn-2	Flags for fault (n-2)
010E	Fn-3	Flags for fault (n-3)
010F	Fn-4	Flags for fault (n-4)
0110	FLT clear record = [0]	Clear fault records (except CB trip time) [RESET]

3.2.4 Measurement (1) [READ]

0201	MS1 Ia (Ip)	Current in phase A (dual polarized)
0202	MS1 Ib	Current in phase B
0203	MS1 Ic	Current in phase C
0204	MS1 Io	Current in neutral N
0205	MS1 Vab	Line voltage A-B
0206	MS1 Vbc	Line voltage B-C
0207	MS1 Vca	Line voltage C-A
0208	MS1 Va	Phase voltage A
0209	MS1 Vb	Phase voltage B
020A	MS1 Vc	Phase voltage C
020B	MS1 Vo	Residual voltage
020C	MS1 F	Frequency

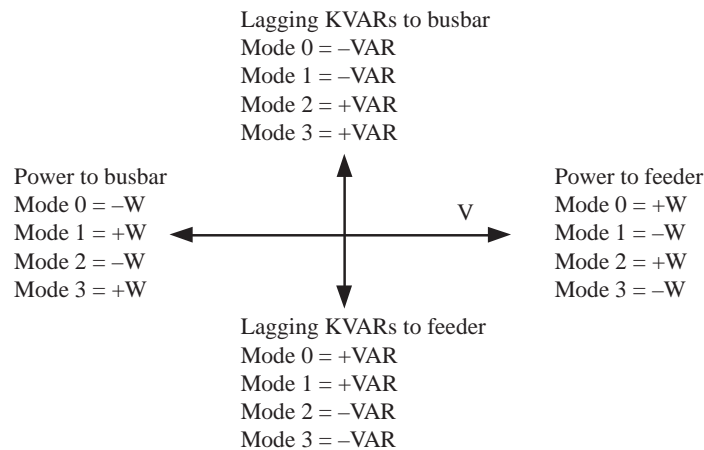
3.2.5 Measurement (2) [READ]

0301	MS2 W	Three phase power
0302	MS2 VA	Three phase VoltAmps
0303	MS2 VAR	Three phase reactive power
0304	MS2 Imax	Highest of the three phase currents

030C	Power Factor	Three phase power factor
0310	MS2 Sum(OPS)	Sum of circuit breaker operations [RESET to 0]
0311	MS2 Sum(Ia)2	Sum of (current phase A broken) ² [RESET to 0]
0312	MS2 Sum(Ib)2	Sum of (current phase B broken) ² [RESET to 0]
0313	MS2 Sum(Ic)2	Sum of (current phase C broken) ² [RESET to 0]
031E	MS2 Mode 0	Mode select [PWP]

3.2.6 Signing direction of power flow

The standard current and voltage connections, shown on connection diagrams, are the convention of forward current flow from the busbar to the feeder. This will correspond to positive values of active power flowing from the busbar to the feeder. However, alternative methods of signing the direction of power flow are provided and may be selected to suit a particular application, or user's standards. The mode for signing the direction of active and reactive power is provided in menu cell 031E in the MEASUREMENTS 2 column of the menu.



When the relay is connected for forward power flow to the feeder then:

- Mode 0 – Nett Export signing : + = nett export of power and negative VARs.
- Mode 1 – Reversed direction : + = nett power flow to busbar in (a+jb) form.
- Mode 2 – Normal direction : + = nett power flow to feeder in (a+jb) form.
- Mode 3 – Nett import signing : + = nett import of power and negative VARs.

As a safeguard against accidental change the mode cell is password protected.

3.2.7 Earth fault (1) [SET]

0501	EF1 Fn. Links	Earth fault function links [PWP]
	Link 1 [EF1 EnableIo>>]	1 = enable Io>>
	Link 2 [EF1 EnableIo>>>]	1 = enable Io>>>
	Link 3 [EF1 Dirn to>]	1 = directional control of Io>
	Link 4 [EF1 Dirn to>>]	1 = directional control of Io>>
	Link 5 [EF1 Dirn to>>>]	1 = directional control of Io>>>
	Link 7 [EF1 Aux 2 = Io<]	1 = enable delayed undercurrent/CLS initiation
	Link 9 [EF1 Io>>NoPeak]	1 = Io>> operates on the Fourier result only
	Link E [EF1 Rev Io>>>]	1 = reverse direction of Io>>>

0502	EF1 CT Ratio	Ratio of CT supplying earth fault current [PWP]
0503	EF1 VT Ratio	Ratio of VT [PWP]
0504	EF1 Charact.	Selectable time characteristic [PWP]
0505	EF1 Io>	Current threshold for selected characteristic
0506	EF1 to>/TMS	Time/time multiplier setting
0507	EF1 toRESET	Hold-up time for timing integration
0508	EF1 Io>>	Second current threshold
0509	EF1 to>>	Time delay for second threshold
050A	EF1 Io>>>	Third current threshold
050B	EF1 to>>>	Time delay for third threshold
050C	EF1 Char. Angle	Characteristic angle for directional feature
050E	EF1 Vop>	Polarizing voltage threshold
050F	EF1 Io<	Undercurrent Setting

Variation for KCEG 160/KCEU 160 relays:

050D	EF1 Ip CT Ratio	Ratio of CT supplying polarizing current
050E	EF1 Ip>	Polarizing current threshold
050F	EF1 Vop>	Polarizing voltage threshold
0510	EF1 Io<	Undercurrent setting

Variation for KCEU 141/KCEU 241 relays:

0510	EF1 Po>	Wattmetric power threshold
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3.2.8 Phase fault (1) [SET]

0601	PF1 Fn. Links	Phase fault function links [PWP]
	Link 1 [PF1 Enable I>>]	1 = enable I>>
	Link 2 [PF1 Enable I>>>]	1 = enable I>>>
	Link 3 [PF1 Dirn t>]	1 = directional control of I>
	Link 4 [PF1 Dirn t>>]	1 = directional control of I>>
	Link 5 [PF1 Dirn t>>>]	1 = directional control of I>>>
	Link 6 [PF1 En V< Trip]	1 = enable delayed undervoltage trip
	Link 7 [PF1 Aux2=I<]	1 = enable delayed undercurrent/CLS initiation
	Link 8 [PF1 I>>=2Ph]	1 = enable 2/3 logic for I>>
	Link 9 [PF1 I>>NoPeak]	1 = I>> operates on the Fourier result only
	Link E [PF1 Rev I>>>]	1 = reverse direction of I>>>
	Link F [ALL 2/3]	1 = 2/3 logic applied to all phase outputs
0602	PF1 CT Ratio	Line CT ratio [PWP]
0603	PF1 VT Ratio	Line VT ratio [PWP]
0604	PF1 Charact.	Selectable time characteristic [PWP]
0605	PF1 I>	Current threshold for selected characteristic
0606	PF1 t>/TMS	Time/time multiplier setting
0607	PF1 tRESET	Hold-up time for timing integration
0608	PF1 I>>	Second current threshold
0609	PF1 t>>	Time delay for second threshold
060A	PF1 I>>>	Third current threshold
060B	PF1 t>>>	Time delay for third threshold
060C	PF1 Char. Angle	Characteristic angle for directional feature
060D	PF1 I<	Undercurrent threshold

060E	PF1 V<	Undervoltage threshold
060F	PF1 tV<	Undervoltage time delay

3.2.9 EARTH FAULT (2) [SET]

0701	EF2 Fn. Links	Earth fault function links [PWP]
	Link 1 [EF2 EnableIo>>]	1 = enable Io>>
	Link 2 [EF2 EnableIo>>>]	1 = enable Io>>>
	Link 3 [EF2 Dirn to>]	1 = directional control of Io>
	Link 4 [EF2 Dirn to>>]	1 = directional control of Io>>
	Link 5 [EF2 Dirn to>>>]	1 = directional control of Io>>>
	Link 7 [EF1 Aux 2 = Io<]	1 = enable delayed undercurrent/CLS initiation
	Link 9 [EF2 Io>>NoPeak]	1 = Io>> operates on the Fourier result only
	Link E [EF2 Rev Io>>>]	1 = reverse direction of Io>>>
0702	EF2 CT Ratio	Ratio of CT supplying earth fault current [PWP]
0703	EF2 VT Ratio	Neutral VT ratio [PWP]
0704	EF2 Charact.	Selectable time characteristic [PWP]
0705	EF2 Io>	Current threshold for selected characteristic
0706	EF2 to>/TMS	Time/time multiplier setting
0707	EF2 toRESET	Hold-up time for timing integration
0708	EF2 Io>>	Second current threshold
0709	EF2 to>>	Time delay for second threshold
070A	EF2 Io>>>	Third current threshold
070B	EF2 to>>>	Time delay for third threshold
070C	EF2 Char. Angle	Characteristic angle for directional feature
070E*	EF2 Vop>	Polarizing voltage threshold
070F*	EF2 Io<	Undercurrent setting
0710	EF2 Po>	Wattmetric power threshold

* for KCEG160/KCEU160 relays these cells are relocated similar to that in Section 3.2.7.

3.2.10 PHASE FAULT (2) [SET]

0801	PF2 Fn. Links	Phase fault function links [PWP]
	Link 1 [PF2 EnableI>>]	1 = enable I>>
	Link 2 [PF2 EnableI>>>]	1 = enable I>>>
	Link 3 [PF2 Dirn t>]	1 = directional control of I>
	Link 4 [PF2 Dirn t>>]	1 = directional control of I>>
	Link 5 [PF2 Dirn t>>>]	1 = directional control of I>>>
	Link 6 [PF2 En V< Trip]	1 = enable delayed undervoltage trip
	Link 7 [PF2 Aux2=I<]	1 = enable delayed undercurrent/Cold Load Start initiation
	Link 8 [PF2 I>>=2Ph]	1 = enable 2/3 logic for I>>
	Link 9 [PF2 I>>NoPeak]	1 = I>> operates on the Fourier result only
	Link E [PF2 Rev I>>>]	1 = reverse direction of I>>>
	Link F [ALL 2/3]	1 = 2/3 logic applied to all phase outputs
0802	PF2 CT Ratio	Line CT ratio [PWP]
0803	PF2 VT Ratio	Line VT ratio [PWP]
0804	PF2 Charact.	Selectable time characteristic [PWP]
0805	PF2 I>	Current threshold for selected characteristic

0806	PF2 t>/TMS	Time/time multiplier setting
0807	PF2 tRESET	Hold-up time for timing integration
0808	PF2 I>>	Second current threshold
0809	PF2 t>>	Time delay for second threshold
080A	PF2 I>>>	Third current threshold
080B	PF2 t>>>	Time delay for third threshold
080C	PF2 Char. Angle	Characteristic angle for directional feature
080D	PF2 I<	Undercurrent threshold
080E	PF2 V<	Undervoltage threshold
080F	PF2 tV<	Undervoltage time delay

3.2.11 LOGIC FUNCTIONS [SET]

0901	LOG Fn Links	Function links for miscellaneous logic [PWP]
	Link 1 [LOG CB Fail]	1 = Enable circuit breaker fail circuit
	Link 2 [LOG Backtrip]	1 = Enable backtrip circuit via Aux1
	Link 3 [LOG Aux3=not I<]	1 = Enable I< to trip via Aux3 and tAUX3
	Link 4 [LOG CLP dly t>>]	1 = Cold load pick-up to delay t>>/to>>
	Link 5 [LOG CLP Chg Grp]	1 = Cold load pick-up to change setting group
	Link 6 [LOG CLP=tAUX2]	1 = CLP initiation delayed by tAUX2
	Link 7 [LOG Latch Start]	1 = Start function to latch flags without trip
	Link 8 [LOG Aux3=not Io<]	1 = Enable Io< to trip via Aux3 and tAUX3
0902	LOG tCLP	Time delay associated with cold load pick-up [SET]
0903	LOG tAUX1	Time delay associated with Aux1 output [SET]
0904	LOG tAUX2	Time delay associated with Aux2 output [SET]
0905	LOG tAUX3	Time delay associated with Aux3 output [SET]
0906	LOG tBF	Circuit breaker fail time setting [SET]
0907	LOG tTRIP	Circuit breaker trip pulse setting [SET]
0908	LOG tCLOSE	Circuit breaker close pulse setting [SET]
0909	LOG LS Group	Load shed trip level 0-7 [SET]
090A	LOG tRESTORE	Load restoration time delay [SET]
090B		
090C		
090D		
090F	LOG Default Display	Selected display for default [SET]

Default Display [SET]

0	Description (or User Defined Scheme Reference)	
1	Plant Reference (User Defined)	
2	F(now)	
3	Ia	Ib
	Ic	Io
4	Ia	Io
	Vab	Vo

3.2.12 INPUT MASKS [PWP]

0A01	INP Blk to>	Input to block to>
0A02	INP Blk to>>	Input to block to>>
0A03	INP Blk to>>>	Input to block to>>>

0A04	INP Blk t>	Input to block t>
0A05	INP Blk t>>	Input to block t>>
0A06	INP Blk t>>>	Input to block t>>>
0A07	INP CB Open CLP	Input to initiate cold load pick-up from CB
0A08	INP Aux1	Input to initiate tAUX1
0A09	INP Aux2	Input to initiate tAUX2
0A0A	INP Aux3	Input to initiate tAUX3
0A0B	INP Stg Grp2	Input to change to setting group 2
0A0C	INP CB Open	Input to indicate circuit breaker open
0A0D	INP CB Closed	Input to indicate circuit breaker closed
0A0E	INP CB to Bus2	Input to circuit breaker connected to bus 2
0A0F	INP LTripp CB	Input to initiate CB trip pulse timer
0A10	INP LClose CB	Input to initiate CB close pulse timer

3.2.13 Relay mask [PWP]

0B01	RLY Io> Fwd	Relay to be operated by Io> FWD/Io> START
0B02	RLY Io> Rev	Relay to be operated by Io> REV
0B03	RLY to>	Relay to be operated by to>
0B04	RLY to>>	Relay to be operated by to>>
0B05	RLY to>>>	Relay to be operated by to>>>
0B06	RLY I> Fwd	Relay to be operated by I> FWD/I> START
0B07	RLY I> Rev	Relay to be operated by I> REV
0B08	RLY t>	Relay to be operated by t>
0B09	RLY t>>	Relay to be operated by t>>
0B0A	RLY t>>>	Relay to be operated by t>>>
0B0B	RLY tV<	Relay to be operated by tV<
0B0C	RLY Aux1	Relay to be operated by Aux1
0B0D	RLY Aux2	Relay to be operated by Aux2
0B0E	RLY Aux3	Relay to be operated by Aux3
0B0F	RLY V Reduct 1	Relay to cause stage 1 voltage reduction
0B10	RLY V Reduct 2	Relay to cause stage 2 voltage reduction
0B11	RLY V Reduct 3	Relay to cause stage 3 voltage reduction
0B12	RLY CB Trip	Relay to provide remote trip of circuit breaker
0B13	RLY CB Close	Relay to provide remote close of circuit breaker

3.2.14 Recorder

0C01	REC Control	RUNNING/TRIGGERED/STOPPED [SET]
0C02	REC Capture	SAMPLES/MAGNITUDE/PHASE [SET]
0C03	REC Post Trigger	Trace length after trigger [SET]
0C05	REC Relay Trig	Select relay output to trigger [SET]

3.3 Changing text and settings

To enter the setting mode

Settings and text in certain cells of the menu can be changed via the user interface. To do this the cover must be removed from the front of the relay to gain access to the [+] and [-] keys. Give the [F] key a momentary press to change from the selected default display and switch on the backlight; the heading SYSTEM DATA will be displayed. Use the [+] and [-] keys, or a long [F] key press, to select the column containing the setting or text cell that is to be changed. Then with the [F]

key step down the column until the contents of the cell are displayed. Press the [+] or [-] key to put the relay into the setting mode, which will be indicated by a flashing cursor on the bottom line of the display. If the cell is a read-only cell then the cursor will not appear and the relay will not be in the setting mode.

To escape from the setting mode

TO ESCAPE FROM THE SETTING PROCEDURE WITHOUT EFFECTING ANY CHANGE: HOLD THE [0] KEY DEPRESSED FOR ONE SECOND, THE ORIGINAL SETTING WILL BE RETAINED.

To accept the new setting

Press the [F] key until the display reads:

Are You Sure?
+ = YES - = NO .

1. Press the [0] key if you decide not to make any change.
2. Press the [-] key if you want to further modify the data before entry.
3. Press the [+] to accept the change. This will terminate the setting mode.

3.3.1 Password protection

Password protection is only provided for the configuration settings of the relay. This includes time curve selection, set CT and VT ratios, function link settings, opto-input and relay output allocation. Any accidental change to configuration could seriously affect the ability of the relay to perform its intended functions, whereas, a setting error may only cause a grading problem. Individual protection settings are protected from change when the relay cover is in place.

Entering passwords

The [+] and [-] keys can be used to select a character at the position of the cursor. When the desired character has been set the [F] key can be given a momentary press to move the cursor to the position for the next character. The process can then be repeated to enter all four characters that make up the password. When the fourth character is acknowledged by a momentary press of the [F] key the display will read:

Are You Sure?
+ = YES - = NO

1. Press the [0] key if you decide not to enter the password.
2. Press the [-] key if you want to modify the entry.
3. Press the [+] to enter the password. The display will then show four stars * * * * and if the password was accepted the alarm LED will flash. If the password is not accepted a further attempt can be made to enter it, or the [0] key used to escape. Password protection is reinstated when the alarm LED stops flashing, fifteen minutes after the last key press, or by selecting a column heading or the PASSWORD cell and pressing the [0] key for more than one second.

3.3.2 Changing passwords

After entering the current password and it is accepted, as indicated by the alarm LED flashing, the [F] key is pressed momentarily to move to the next menu cell. If instead, it is required to enter a new password, the [+] key must be pressed to select the setting mode. A new password can be entered with the same procedure described in Section 3.3.1. Only capital (upper case) letters may be used for the password.

BE SURE TO MAKE A NOTE OF THE PASSWORD BEFORE ENTERING IT. ACCESS WILL BE DENIED WITHOUT THE CORRECT PASSWORD.

3.3.3 Entering text

Enter the setting mode as described in Section 3.3 and move the cursor with the [F] key to where the text is to be entered or changed. Then using the [+] and [-] keys, select the character to be displayed. The [F] key may then be used to move the cursor to the position of the next character and so on. Follow the instructions in Section 3.3 to exit from the setting change.

3.3.4 Changing function links

Select the page heading required and step down one line to FUNCTION LINKS and press either the [+] or [-] to put the relay in a setting change mode. A cursor will flash on the bottom line at the extreme left position. This is link "F"; as indicated by the character printed on the frontplate under the display.

Press the [F] key to step along the row of links, one link at a time, until some text appears on the top line that describes the function of a link. The [+] key will change the link to a "1" to select the function and the [-] key will change it to a "0" to deselect it. Not all links can be set, some being factory selected and locked. The links that are locked in this way are usually those for functions that are not supported by a particular relay, when they will be set to "0". Merely moving the cursor past a link position does not change it in any way.

3.3.5 Changing setting values

Move through the menu until the cell that is to be edited is displayed. Press the [+] or [-] key to put the relay into the setting change mode. A cursor will flash in the extreme left hand position on the bottom line of the display to indicate that the relay is ready to have the setting changed. The value will be incremented in single steps by each momentary press of the [+] key, or if the [+] key is held down the value will be incremented with increasing rapidity until the key is released. Similarly, the [-] key can be used to decrement the value. Follow the instructions in Section 3.3 to exit from the setting change.

Note: When entering CT RATIO or VT RATIO the overall ratio should be entered, ie. 2000/5A CT has an overall ratio of 400:1. With rated current applied the relay will display 5A when CT RATIO has the default value of 1:1 and when the RATIO is set to 400:1 the displayed value will be $400 \times 5 = 2000A$.

3.3.6 Setting communication address

The communication address will normally be set to 255, the global address to all relays on the network, when the relay is first supplied. Reply messages are not issued from any relay for a global command, because they would all respond at the same time and result in contention on the bus. Setting the address to 255 will ensure that when first connected to the network they will not interfere with communications on existing installations. The communication address can be manually set by selecting the appropriate cell for the SYSTEM DATA column, entering the setting mode as described in Section 3.3 and then decrementing or incrementing the address.

It is recommended that the user enters the plant reference in the appropriate cell and then sets the address manually to "0". The master station will then detect that a new relay has been added to the network and automatically allocate the next available

address on the bus to which that relay is connected and communications will then be fully established.

3.3.7 Setting control input masks

An eight bit mask is allocated to each protection and control function that can be influenced by an external input applied to one or more of the opto-isolated control inputs. When an input mask is selected the text on the top line of the display indicates the associated control function and the bottom line of the display shows a series of “1”s and “0”s for the selected mask. The numbers printed on the frontplate under the display indicate the number of the control input (L7 to L0) that is being displayed. A “1” indicates that a particular input will effect the displayed control function and a “0” indicates that it will not. The same input may be used to control more than one function.

3.3.8 Setting relay output masks

An eight bit mask is allocated to each protection and control function. When a mask is selected the text on the top line of the display indicates the associated function and the bottom line of the display shows a series of “1”s and “0”s for the selected mask. The numbers printed on the frontplate under the display indicate the number of the output relay (RLY7 to RLY0) that each bit controls. A “1” indicates that the relay will respond to the displayed function and a “0” indicates that it will not.

The mask acts like an “OR” function so that more than one relay may be allocated to the same function. An output mask may be set to operate the same relay as another mask so that, for example, one output relay may be arranged to operate for all the functions required to trip the circuit breaker and another for the functions that are to initiate autoreclose.

3.3.9 Resetting values and records

Some values and records can be reset to zero or some predefined value. To achieve this the menu cell must be displayed, then the [0] key must be held depressed for at least one second to effect the reset. The fault records are slightly different because they are a group of settings and to reset these the last cell under FAULT RECORDS must be selected. This will display:

FLT clear
records = [0]

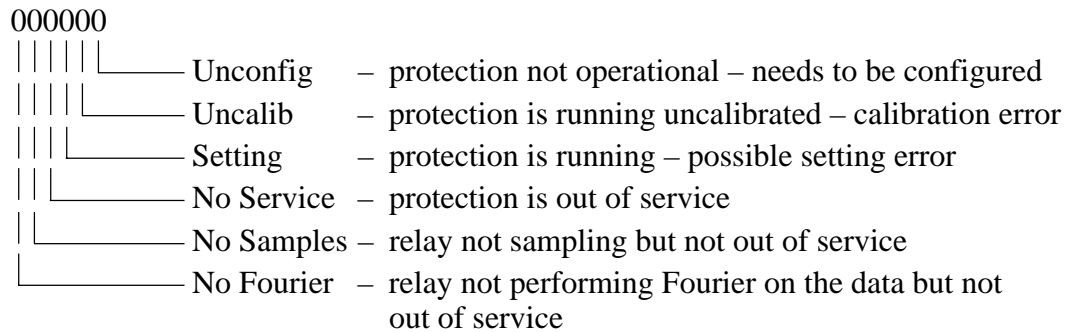
To reset the fault records hold the [0] key depressed for more than 1 second.

3.3.10 Resetting TRIP LED indication

The TRIP LED can be reset when the flags for the last fault are displayed. They are displayed automatically after a trip occurs, or can be selected in the fault record column. The reset is effected by depressing the [0] key for 1 second. Resetting the fault records as described in 3.3.9 will also reset the TRIP LED indication. Set function link SD5 to “1” for automatic reset of trip LED.

3.3.11 Alarm records

The alarm flags are towards the end of the SYSTEM DATA column of the menu and consist of six characters that may be either “1” or “0” to indicate the set and reset states of the alarm. The control keys perform for this menu cell in the same way as they do for Function Links. The cell is selected with the function key [F] and the relay then put in the setting mode by pressing the [+] key to display the cursor. The cursor will then be stepped through the alarm word from left to right with each press of the [F] key and text identifying the alarm bit selected will be displayed.



For the above listed alarms the ALARM LED will be continuously lit. However, there is another form of alarm that causes the ALARM LED to flash and this indicates that the password has been entered to allow access to change protected settings within the relay. This is not generally available as a remote alarm and the alarm flags do not change.

No control will be possible via the key pad if the “Unconfigured” alarm is raised because the relay will be locked in a non-operate state.

3.3.12 Default display (LCD)

The LCD changes to a default display if no key presses are made for 15 minutes. The default display can be selected to any of the options listed in Section 3.2.11 LOGIC FUNCTIONS location 090F by following the setting procedure given in Section 3.2.5. The display can be returned to the default value, without waiting the fifteen minute delay, by selecting any column heading and then holding the [0] reset key depressed for 1 second.

When the protection trips the display changes automatically to display the fault flags. The trip LED indication may be reset by pressing the [0] key whilst they are displayed, otherwise see Section 3.3.10.

3.4 Selective Features and Logic

In this section the scheme logic is broken down into groups which are described individually. The logic is represented in a ladder diagram format and the key to the symbols used is shown in Figure 4.

Contacts have been used to represent the output of the various protection and control functions, even though they are actually implemented in software. The contacts are all shown in the state they would take up with no inputs applied to the protective relay.

The function links are also implemented in software but have been drawn as mechanical links. They are shown in the factory default position for the basic factory configuration. In position “0” the function is deselected and in “1” the function is selected.

Opto-isolated control inputs L7-L0, are represented by an eight bit mask with a thicker line at the top and left hand side of the mask. The control asserted by the input is stated above the mask and the position of the “1”s within the mask will determine the input(s) that assert the control. More than one control input may be assigned by the mask and the same control inputs may be used in several masks.

The output relays RLY7 – RLY0 are represented by an eight bit mask with a thicker line at the bottom and right hand side. A mask is allocated to each protection and control function that can be assigned to an output relay. The function asserted on the mask is stated by the text above it and the position of the “1”s in the mask

determines which relay(s) operate in response. More than one output relay may be assigned by a mask and the same relay may be assigned by several masks.

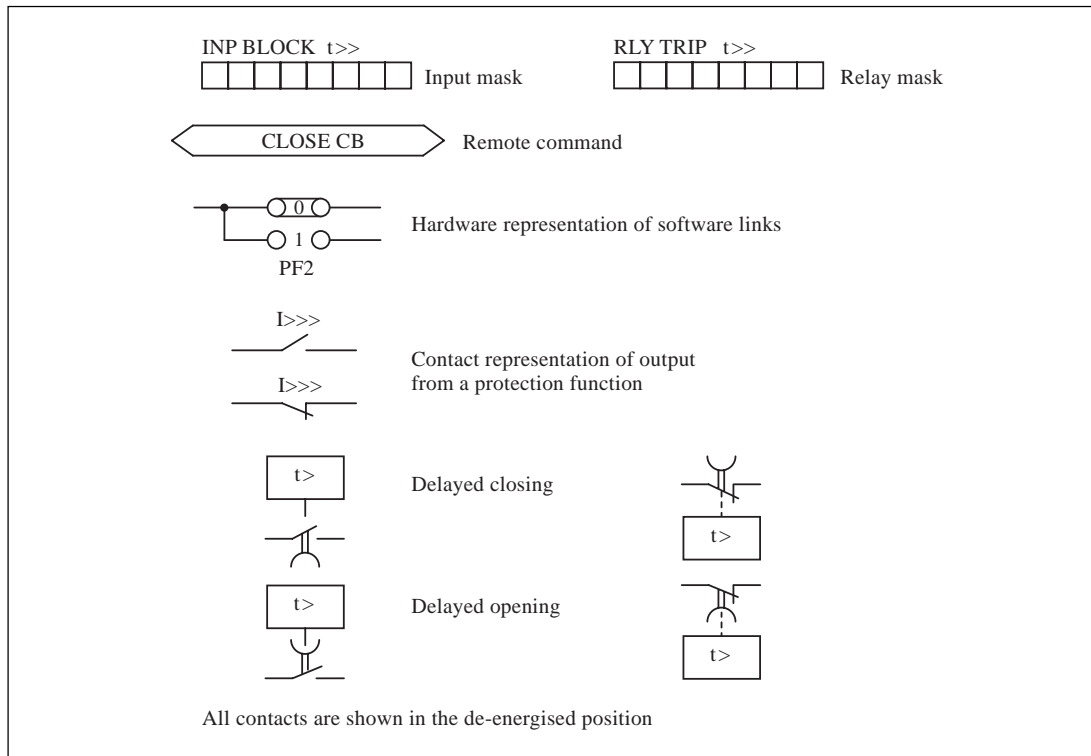


Figure 4. Key to symbols used in the Logic Diagrams

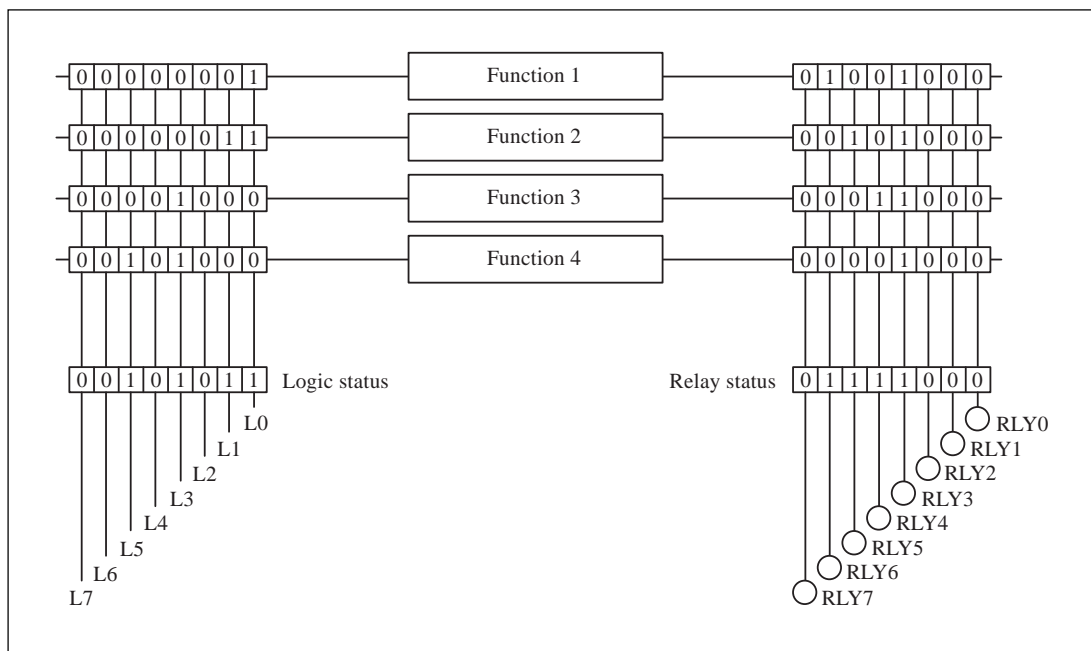


Figure 5. Operation of input/output masks

Function 1 is initiated by L0 as indicated by the position of the “1” in the input mask.

The input masks act as an “OR” gate so that for function 2 it is initiated by either, or both, L0 and L1, but L1 will not initiate function 1.

Both functions 3 and 4 can be initiated by L3, but only function 4 is initiated by L5. Similarly the output masks can be used to direct the output of a function to any relay.

The relay masks also act as “OR” gates so that several functions can be directed to a particular output relay. In the example function 1 operates relays 3 and 6, however, relay 3 is also operated by functions 2, 3, and 4.

3.4.1 Overcurrent function and logic

3.4.1.1 Overcurrent function

There are three overcurrent stages per pole and the settings for each stage are completely independent of each other, within the allowable setting ranges. These elements have settings designated as $I>$, $I>>$ and $I>>>$ for phase faults and the settings of each of these parameters affect all three phase elements equally.

Each threshold has a corresponding following time delay $t>$, $t>>$, $t>>>$. See Figure 6. For earth faults there are separate threshold adjustments $I_{o>}$, $I_{o>>}$, and $I_{o>>>}$ and associated following time delays $t_{o>}$, $t_{o>>}$, $t_{o>>>}$.

$I>/I_{o>}$ elements operate when the power frequency component of the current exceeds the set threshold. These elements may be set as a low set overload protection and may be expected to have relatively long associated time delays. Time delays associated with these elements are respectively $t>/t_{o>}$ and a time/current characteristic may be chosen from a selection of standard curves, or may be set to non-dependent (definite) time.

The time delays for threshold detection stages $I>>$, $I_{o>>}$, $I>>>$, $I_{o>>>}$ may be set to give zero delay for instantaneous operation, if required.

The frequency response for these elements is given in Section 5.15.

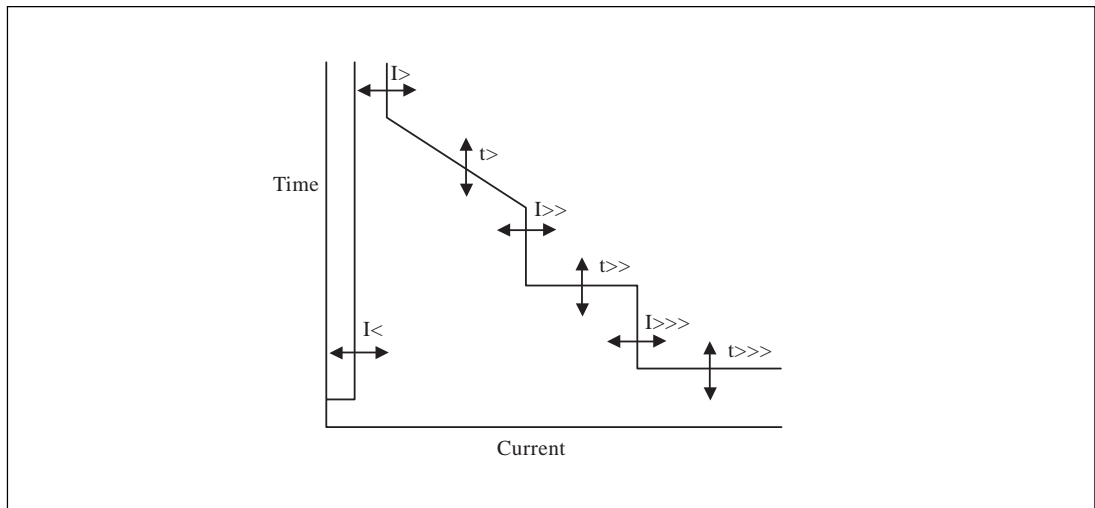


Figure 6. Overcurrent characteristic

3.4.1.2 Start function

All overcurrent relays are provided with separate phase and earth fault START functions which respond when the current exceeds the $I>$ or $I_{o>}$ thresholds. The use of the START outputs in overcurrent blocking schemes is described later in this document.

If any of the elements $I>$, $I>>$, $I>>>$ (or $I_{o>}$, $I_{o>>}$, $I_{o>>>}$) is selectively directionalized then complementary FORWARD START and REVERSE START

functions are provided for the respective phase and earth fault elements. A non directional START indication can be obtained if both the FORWARD START and REVERSE START functions are directed to the same output relay. This relay will then operate when the current threshold is exceeded regardless of the direction of current flow. However, if none of the three elements is directionalized then the FORWARD START becomes non-directional, regardless of polarizing signal, and the REVERSE START becomes inoperative.

3.4.1.3 Undercurrent function

The undercurrent elements $I</I_o<$, shown in Figure 6, respond only to the instantaneous value of the waveform and require the peak value of at least one half cycle to be below the set threshold to indicate an undercurrent condition, thus giving the fast response necessary for the breaker fail applications. However, before an output is given, an undercurrent condition has to be detected by all the undercurrent elements in the relay: the three phase elements and earth element.

An undercurrent condition is assumed not to exist when both the positive and negative peaks of the waveform, on any one phase, exceed the threshold $I<$ or $I_o<$. The requirement for both peaks to exceed the threshold reduces over-reach that would be caused by the exponential component of current. This element has no software filtering and will be responsive to harmonics, but the higher frequencies will receive some attenuation from the anti-aliasing filter, as shown in Figure 37. Time delayed outputs can be obtained from the undercurrent elements via the auxiliary timers. The undercurrent feature can be an indication of loss of critical loads and using an inverted undercurrent signal, an additional fourth overcurrent definite time stage can be arranged.

3.4.1.4 Overcurrent logic

The overcurrent logic is shown in Figure 7. This diagram and the description following applies equally to the earth fault logic. When the current threshold $I>$ is exceeded and output is directed to the [RLY $I>$] mask, this will result in the output relay(s) designated by the mask being energized. Provided no control is being asserted by the input assigned to the [INP Blk $t>$] mask and the $I>$ is exceeded, the timer $t>$ will run. When $t>$ times out the output relay assigned in the [RLY $t>$] mask will be energized and close its contacts. If at any time during the timing cycle the assigned control input is energized, timer $t>$ will be blocked and reset to zero when the reset time has expired.

The second overcurrent function $I>>$ is selected by the phase fault link PF1 (for earth faults $I_o>>$ by EF1). There is no start function associated with the $I>>$ setting, only a trip output from the following timer $t>>$. External control can be asserted over this time delay by the control input assigned by the input mask [INP Blk $t>>$] and the output relay is assigned by mask [RLY $t>>$].

The third overcurrent function $I>>>$ is selected by link PF2 (for earth faults $I_o>>>$ by EF2). The following time delay $t>>>$ has external control assigned by mask [INP Blk $t>>>$] and output relays assigned by [RLY $t>>>$]

Two Out of Three Logic

The $t>>$ element has been provided with a two out of three logic, selected by link PF8. When selected it will ensure operation only occurs for phase/phase faults and double phase to earth faults. It will not operate for single phase earth faults.

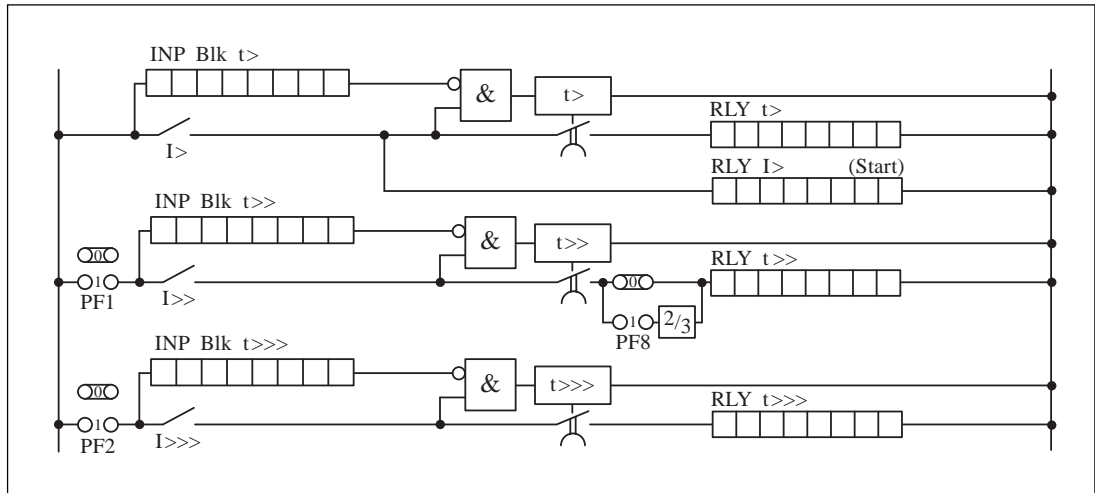


Figure 7. Overcurrent logic

3.4.2 Directional overcurrent function and logic

3.4.2.1 Directional overcurrent and earth fault relays function

Phase fault directional elements are polarized by the quadrature phase/phase voltage, and the earth fault elements are polarized by the zero sequence voltage.

The direction part of the measurement includes a threshold value on the polarizing quantity, and for phase fault measurement this threshold is fixed. However for earth faults an adjustable threshold is provided to allow a setting above any imbalance in the zero sequence polarizing signal to be applied. Control is provided for adjustment of the characteristic angle of the relay.

The directional decision is applied after the current threshold and before the following associated time delay. The directionalization of any element can be selectively overridden by adjusting software links in the relay menu to a suitable setting.

The undercurrent element $I <$ is the exception since this element is not provided with directional control.

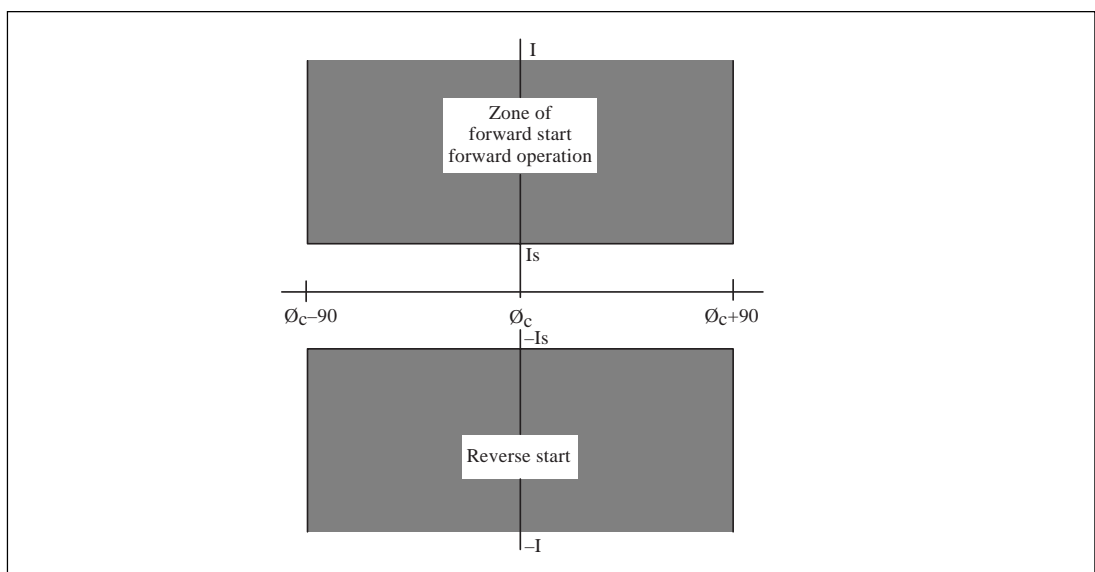


Figure 8. Directional characteristic

3.4.2.2 Directional overcurrent and earth fault relay logic

The directional overcurrent logic is shown in Figure 9 for the phase elements and the following description applies equally to the directional earth fault logic. When the current threshold $I>$ is exceeded and the polarizing signal is above the threshold $Vp>$, an output is directed to the [RLY $I>$ Fwd] mask for forward current flow and to the [RLY $I>$ Rev] for reverse current flow. A non-directional start can be obtained by allocating the same output relay in both start masks so that it operates for forward or reverse current flow. The time delay $t>$ starts timing when the current exceeds the $I>$ setting and link PF3 is set to “0” to give a non-directional trip via the [RLY $t>$] mask. With link PF3 set to “1” the time delay will only run if the current exceeds the $I>$ threshold and is in the forward direction. External control is asserted via input mask [INP Blk $t>$] and when this input is energized the time delay is reset to zero after the reset delay setting.

Selective directionalization of overcurrent elements

If link PF3 (EF3 for EF) is set to “1” time delay $t>$ ($to>$) starts timing when the current exceeds the $I>$ ($Io>$) setting and is in a forward direction. If link PF3 (EF3) is set to “0” $t>$ ($to>$) will start timing when the current exceeds the $I>$ ($Io>$) setting regardless of the direction of flow. The circuits associated with the $I>>/Io>>$ and $I>>>/Io>>>$ elements are not shown, but they also can be selectively directionalized with their respective function links PF4/EF4 and PF5/EF5.

Selective directionalization of the start outputs

The phase fault start outputs will be directionalized if any one of the phase elements is selected to be directionalized and similarly the earth fault start outputs will be directionalized if any one of the earth fault elements is selected to be directionalized. A non-directional start can be obtained by allocating the same output relay in both start masks so that it operates for forward or reverse current flow, but note that no output will be obtained if the voltage is below the polarizing voltage threshold setting $Vp>$ for phase faults and $Vop>$ for earth faults.

Alternatively, if all three phase fault elements are selected to be non-directional then the phase fault forward start mask will respond with a non-directional start without requiring a polarizing voltage to be present. Similarly if all three earth fault elements are selected to be non-directional the earth fault start mask will respond with a non-directional start without requiring a polarizing voltage to be present. In either case the associated reverse start mask will be inoperative.

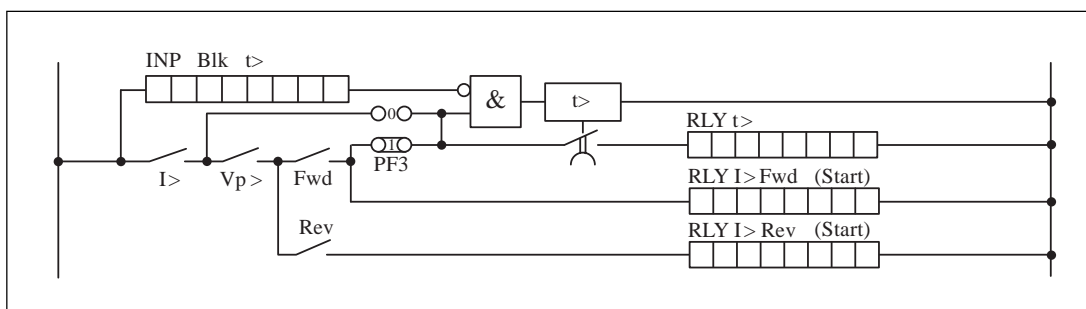


Figure 9. Directional overcurrent logic

3.4.4 Undervoltage function and logic

3.4.4.1 Undervoltage function

Directional phase fault relays have the addition of a three phase undervoltage characteristic that can be arranged to provide a trip command when the supply is lost. It requires the voltage on all three phases to fall below the set threshold $V_{<}$ before an output is obtained. A following adjustable time delay $tV_{<}$ is provided in the trip path for this element to prevent operation during a fault when the voltage may be temporarily depressed.

3.4.4.2 Undervoltage logic

Directional relays have the addition of an undervoltage trip. This can be arranged to operate an output relay via mask [RLY $tV_{<}$], after a set delay ($tV_{<}$), so that the circuit breaker is tripped on loss of all three phase voltages. The circuit breaker or undercurrent element, may then initiate CLP as described in Section 3.4.8.

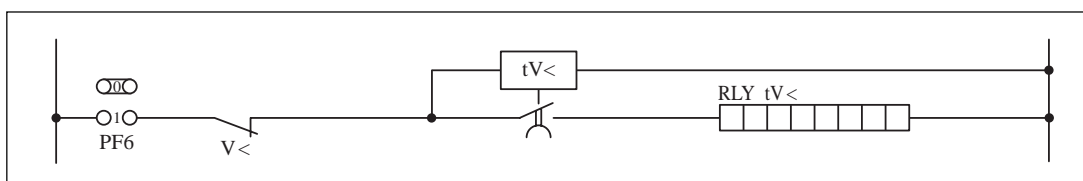


Figure 11. Undervoltage logic

3.4.5 Auxiliary timers (Models A and B)

There are three auxiliary timers in the relays that are sometimes used in the internal scheme logic, as will be discussed later in this document. When they are not used internally they may be used as discrete time delays for external functions. They may be initiated via the opto-isolated control inputs and their outputs directed to any of the output relays by suitably setting the associated RELAY MASKS.

All the settings for the auxiliary timing functions that are used in the logic of the protection are located under the LOGIC heading of the menu. The setting of the Logic Function Links, together with the setting of the input and output masks, control the way in which the optional features are used, thus maximizing the use of the available functions. All function links and input/output masks are password protected to prevent accidental changes being made during the course of minor setting adjustments.

3.4.5.1 Auxiliary timers (Models A and B)

Figure 12a shows three auxiliary timers that may be initiated from external inputs assigned in the respective input masks and which, after the set time delay, operate the relays assigned in the relay masks.

Setting link PF7 to “1”, timer $tAUX2$ will be initiated when the currents for all three phases and earth elements are below the respective undercurrent settings ($I_{<}/I_{o<}$) to give a time delayed undercurrent output.

Setting link LOG3 to “1”, timer $tAUX3$ will be initiated when any of the three phase or earth fault currents rise above their respective undercurrent threshold ($I_{<}/I_{o<}$). This can be used to provide a fourth time delayed overcurrent and earth fault stage.

In the KCEU 141/KCEU 241 the time $tAUX3$ will be initiated from external inputs only.

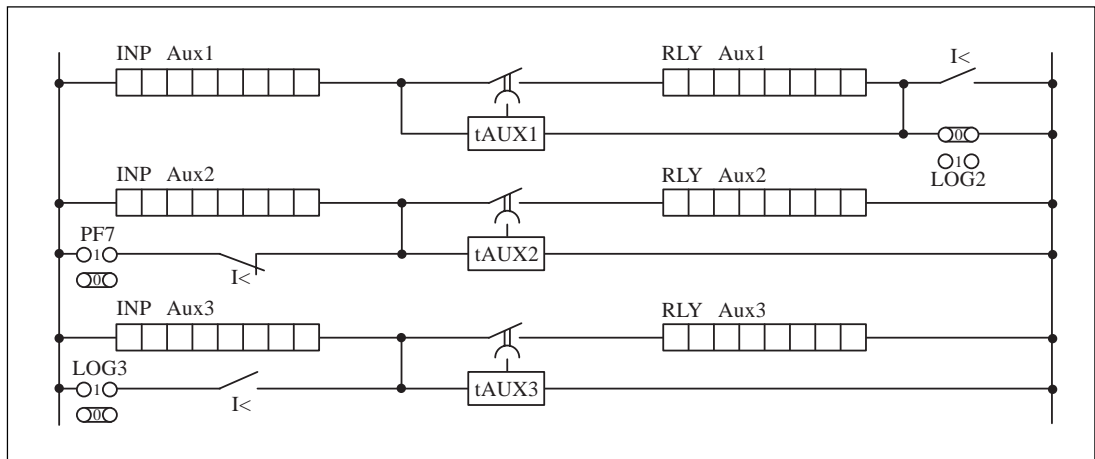


Figure 12a. Auxiliary time delays

3.4.5.2 Auxiliary timers (Models C and onwards)

Figure 12b shows three auxiliary timers that may be initiated from external inputs assigned in the respective input masks and which, after the set time delay, operate the relays assigned in the relay masks.

Setting link PF7 to “1”, timer tAUX2 will be initiated when the currents for all three phases are below the undercurrent settings ($I_{<}$). Setting link EF7 “1”, timer tAUX2 will be initiated when the earth fault current is below the undercurrent setting ($I_{o<}$). The output to the relay assigned in the [RLY Aux2] output mask will be delayed by the time setting tAUX2.

Setting link LOG3 to “1”, timer tAUX3 will be initiated when the current in any of the three phases rises above the undercurrent threshold ($I_{<}$). This can be used to provide a fourth time delayed overcurrent and fault stage. Similarly setting link LOG8 to “1” will produce the same effect when the residual current exceeds the setting ($I_{o<}$).

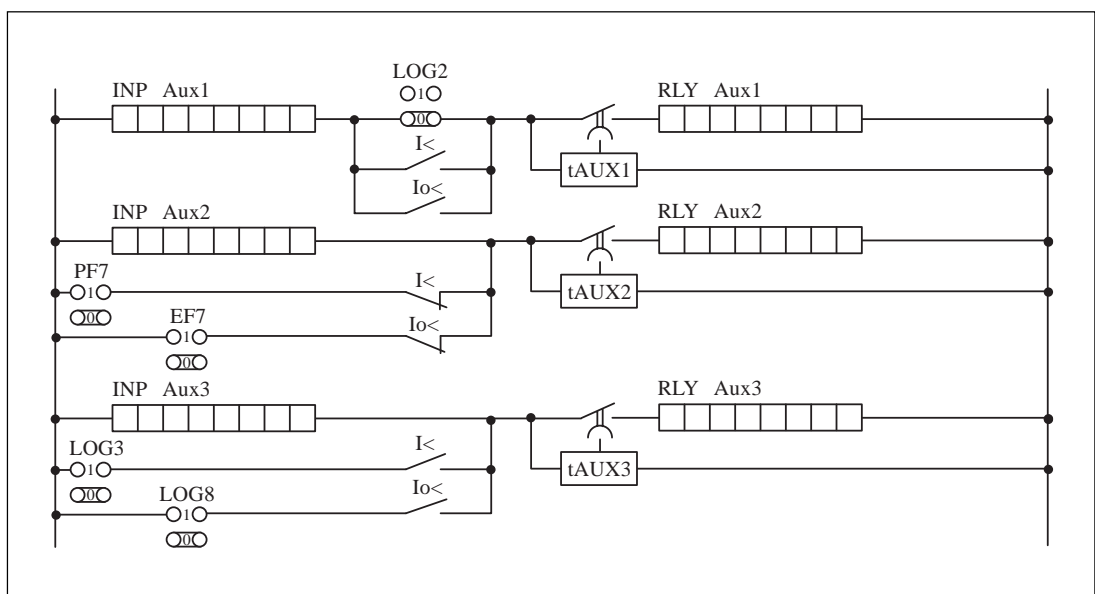


Figure 12b. Auxiliary timers

3.4.6 Breaker fail and backtripping

3.4.6.1 Breaker failure protection

When selected, the breaker fail logic is activated by any protection function that has been selected to operate output relay 3 and is terminated when the command signal to this relay is terminated. This feature is arranged to inhibit the START, FORWARD START, REVERSE START functions if the circuit breaker fails to trip.

3.4.6.2 Breaker failure protection (Models A & B)

Relay RLY3 is designated for the trip functions, as will be explained in Section 3.4.13. When link LOG1 is set to “1” a command to operate RLY3, via any output mask, will also initiate the breaker fail time delay within the relay. If the circuit breaker fails to trip within the set time tBF, the start relays are reset to remove any block which they may be asserting on an upstream relay.

The circuit breaker fail time delay tBF can also be arranged to produce a back trip so that the trip can be transferred directly to the next circuit breaker back in the system. To achieve this Link LOG2 has to be set to “1” and an output relay allocated via the [RLY Aux 1] output mask for backtrip.

The [RLY Aux 1] input mask can be used to assign one of the control inputs to initiate the time delay tAUX1. By this means an externally initiated breaker fail function can be set up. Time delay tAUX1 will be set to the required circuit breaker fail time setting and a backtrip output will be given via the [RLY Aux1] output mask. The backtrip output and the breaker fail timers are checked by the undercurrent element to ensure fast reset.

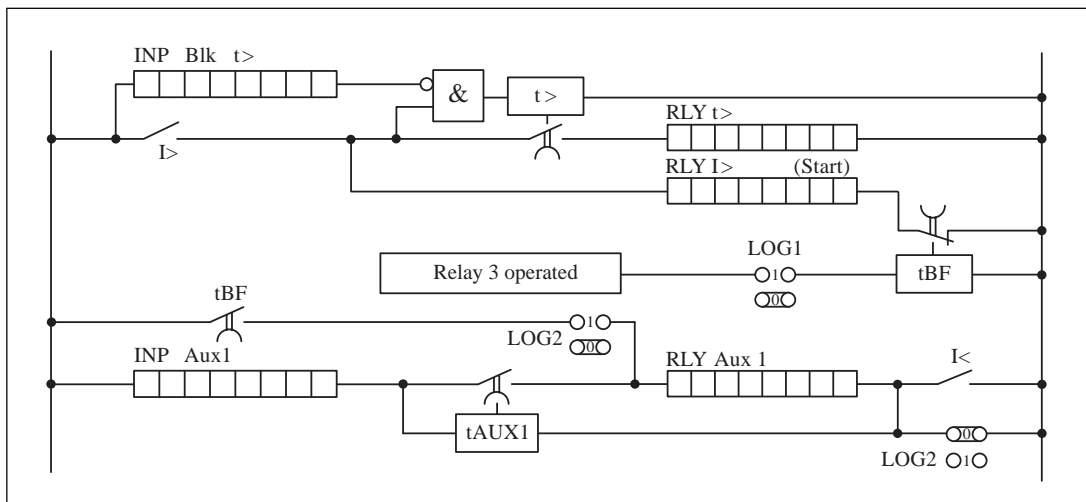


Figure 13a. Breaker fail protection

3.4.6.3 Breaker fail protection (Models C and onwards)

Relay RLY3 is designated for the trip functions, as will be explained in Section 3.4.13. When link LOG1 is set to “1” a command to operate RLY3, via any output mask, will also initiate the breaker fail time delay within the relay. If the circuit breaker fails to trip within the set time tBF, the start relays are reset to remove any block which they may be asserting on an upstream relay.

The circuit breaker fail time delay tBF can also be arranged to produce a back trip; an output to directly trip the next circuit breaker back in the system. To achieve this

Link LOG2 must be set to “1” and an output relay allocated via the [RLY Aux 1] output mask for backtrip.

The [INP Aux 1] input mask can be used to assign one of the control inputs to initiate the time delay tAUX1. By this means an externally initiated breaker fail function can be set up. Time delay tAUX1 will be set to the required circuit breaker fail time setting and a backtrip output will be given via the [RLY Aux 1] output mask. Provided link LOG2 is set to “1” the output relay and the breaker fail timers are checked by the undercurrent element to ensure fast reset.

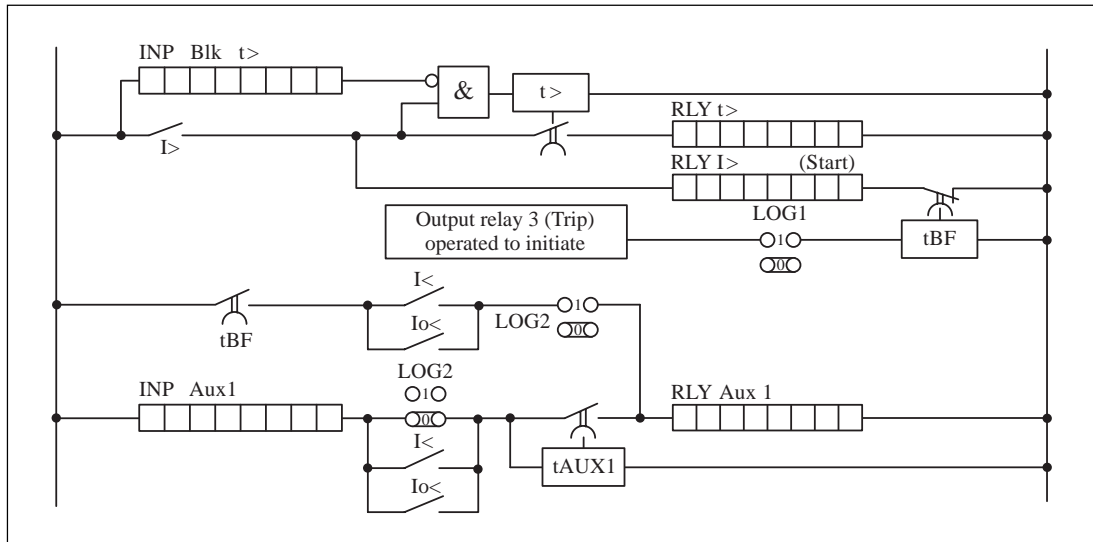


Figure 13b. Breaker fail protection

3.4.6.4 Backtrip

The breaker fail function can be directed to one of the output relays so that in the event of the local circuit breaker failing to trip, the trip signal can be re-routed directly to the upstream circuit breaker. The same backtrip relay can be energized by an external input via one of the auxiliary timers; this timer being set to the required breaker fail delay. In each case the backtrip relay and breaker fail timers will be reset by a current check element.

3.4.7 Alternative setting group

An alternative group of settings is provided for both the phase and earth fault protection functions. The alternative settings can be selected at any time, either by energizing an opto-isolated control input assigned to this function, or by a remote command via the serial communication port of the relay. A decision has to be made during commissioning as to which method is to be used to select the alternative setting group. It is not possible to select by both local and remote control at the same time.

3.4.7.1 Change of setting group control

When link SD4 is set to “0” only the settings for one of the setting groups will be displayed: the other group will be inactive and hidden. To activate the second group of phase fault and earth fault settings link SD4 must be set to “1”. The second group of settings will then appear in the menu and can be set in the usual way.

Group 1 settings are normally in use and switching to the group 2 settings requires either a remote command to be received via the serial communication port or an

external input via one of the opto-isolated control inputs. For reasons of operational safety it has not been made possible to control the setting group change both locally and remotely at the same time. Link SD3 decides which method is to be used; it is set to “1” for remote control of the change and to “0” for local control.

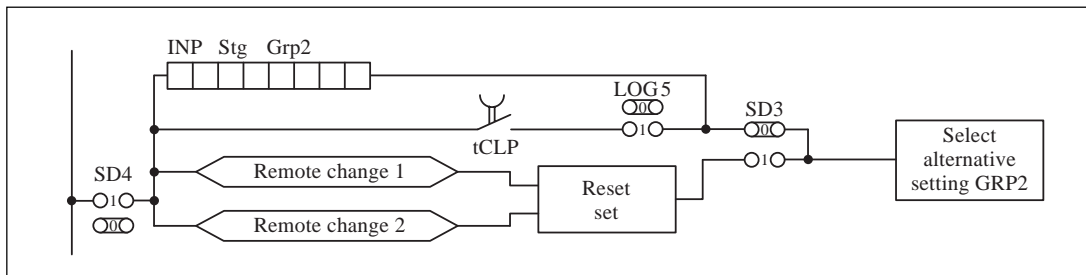


Figure 14. Change of setting group control

3.4.7.2 Remote change of setting group

Remote commands are not maintained, so a set/reset arrangement is used to store the last received command. The setting group that is currently in use can be found by looking at “SYS Setting Grp” in the SYSTEM DATA column of the menu, or “Fnow” in the FAULT RECORD of default display if selected. The setting group remains as selected when the auxiliary supply is interrupted.

3.4.7.3 Local control of setting group

Local control is asserted via the input mask [INP Stg Gp2] and the control input that is set in this mask. The relay will respond to the group 2 settings whilst this input is energized and the setting group 1 when it is de-energized. The setting group can also be changed by the cold load start circuit as described in the next section.

Note: To enable individual settings to be changed remotely System Data Link SD0 must be set to “1”. If instead it is set to “0” then it will not be possible to change individual settings over the communication link.

3.4.8 Cold load pick-up

Cold load pick-up refers to the need to either inhibit the instantaneous low set element of the overcurrent protection or raise the overcurrent settings for a period of time when a circuit is energized. This allows the protection settings to be set closer to the load profile, by increasing settings automatically to cover the transient increases on circuit energization. This feature is not available in the KCEU 141/ KCEU 241 relay.

For systems where the load is predominantly air conditioning there will be large transient currents whilst the blower motors start up. To cater for this type of load it may be sufficient to simply block the instantaneous low-set elements for a short time. However, where the domestic loads are predominantly formed by resistance heating, the second method would be preferable where the fault settings for both the instantaneous low-set and the inverse time overcurrent elements are increased. The cold load pick-up feature can be used to compensate for many transient load conditions including motor starting.

The cold load pick-up timer (tCLP) allows for time delays from zero to 4 hours.

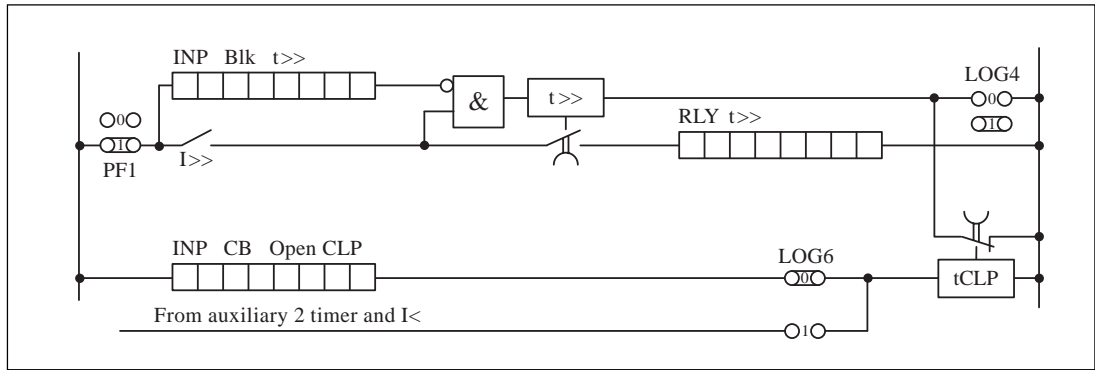


Figure 15. Cold load pick-up increased lowset delay

3.4.8.1 Instantaneous low set element delayed by cold load pick-up

The cold load pick-up logic consists of a timer (tCLP) which picks up without any intentional delay when the protected circuit is de-energized. The initiating contact would be typically an auxiliary contact of the circuit breaker (52b) that is closed when the circuit breaker is open and assigned in the [CB Open CLP] input mask.

The link LOG4 must be set to “1” then the output [RLY t>>] is delayed until the cold load pick-up time delay (tCLP) has timed out. This will delay operation for motor starting currents that may result when the predominant load is air conditioning plant. It may also be used to give additional compensation for transformer inrush currents when I>> is set lower than that recommended for stabilization under transformer inrush conditions, but care should be taken if transformer inrush can occur when the circuit is already energized. Setting link LOG4 to “0” inhibits this option.

The cold load pick-up feature may not be reliable with dual powered relays when energized from current alone, because the initiation may disappear before the relay powers up.

3.4.8.2 Group 2 settings selected by cold load pick-up

Setting link LOG5 to “1” and SD3 to “0” causes the protection to change to the group 2 settings for the cold load pick-up delay (tCLP), but only if the alternative setting group has been activated with link SD4 and selection is set to “local” with link SD3. Link LOG4 must be set to “0” to prevent the short time delay (t>>) being increased. Setting the LOG5 link to “0” inhibits this option.

This feature is useful where the predominant load is resistance type heating because it takes longer for the loading to diversify. Therefore, the overload settings have to be increased for periods of up to four hours. It is also useful for setting the protection to grade with large industrial motors where the starting time may exceed the required protection trip time.

The cold load pick-up may be initiated via the [CB Open CLP] mask as in the previous example. However, where the load is predominantly resistance heating with thermostatic control, the cold load pick-up feature will not be required to take effect unless the circuit has been de-energized for sufficient time for all the thermostats to reset. Delayed initiation can be provided by timer tAUX2.

To select this method, the control input that is to initiate cold load start should be assigned in the [INP Aux2] input mask instead of [CB Open CLP] mask and link LOG6 should be set to 1.

By setting link PF7 to 1, cold load pick-up may be initiated by the phase and earth fault undercurrent elements instead of a circuit breaker contact. A delayed undercurrent output may be provided via the relay assigned in the [RLY Aux2] mask.

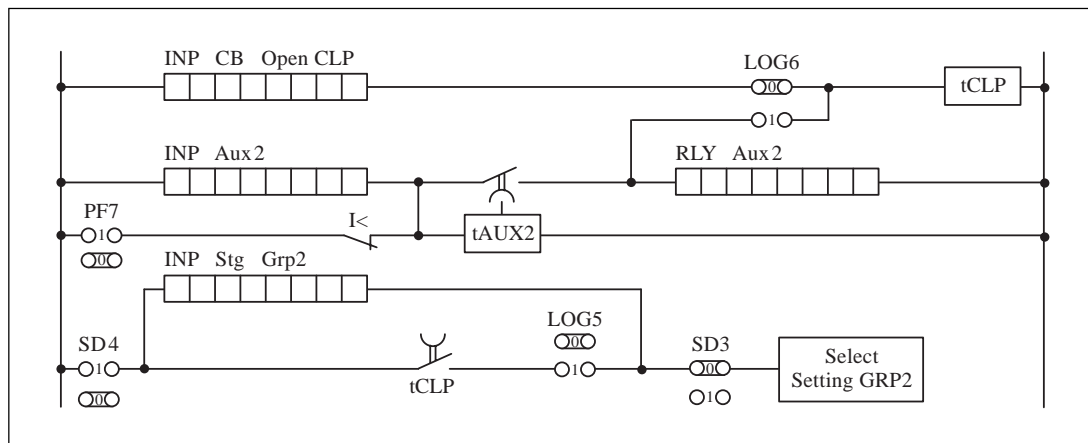


Figure 16. Cold load pick-up increased protection settings

3.4.9 Circuit breaker control

For the relay to respond to remote close and trip commands for the circuit breaker it is necessary to set link SD2 to “1” and allocate output relays via both the [RLY CB Close] and [RLY CB Trip] masks. The commands are not sustained for the closing time of the breaker and so time delays assert the close and trip commands to the circuit breaker for a set period of time (a pulse output of duration set by time delays tTRIP and tCLOSE).

RLY 7 is usually allocated to [RLY CB Trip] and RLY 6 would be used for [RLY CB Close].

Two circuit breaker auxiliary contacts, to indicate the circuit breaker position, must be connected to the control inputs of the relay. The inputs, assigned by the input masks [INP CB Closed] and [INP CB Open], are directed to the appropriate two bits

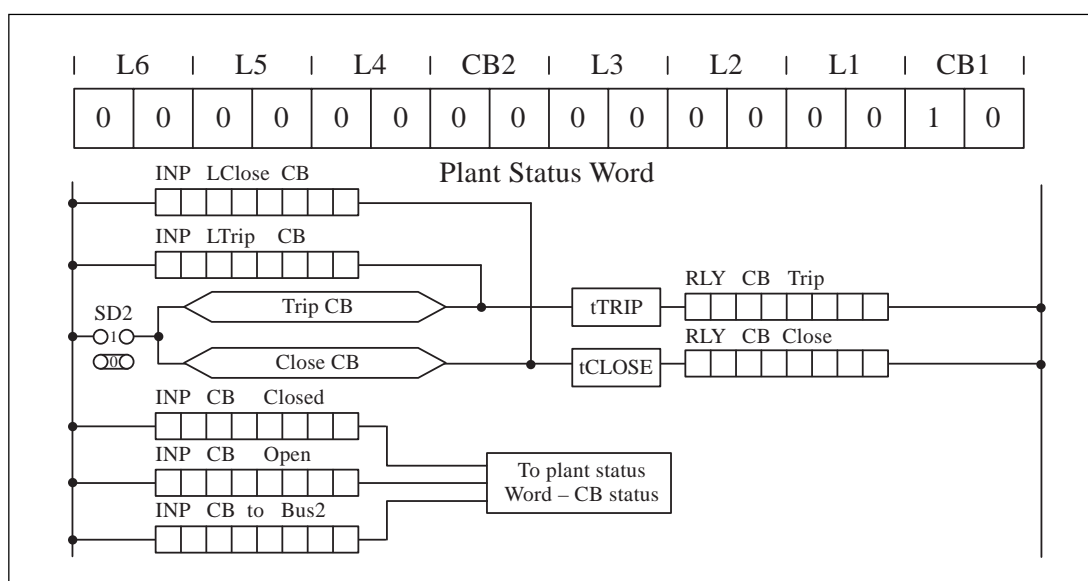


Figure 17. Remote circuit breaker control

in the plant status word for CB1. The Plant Status Word is used by the master station to determine where there are circuit breakers on the system which can be controlled and if they are in the open or closed position. A third opto-input may be used to indicate when the circuit breaker is connected to the second busbar in a two busbar system and is assigned by the [INP CB to Bus2] input mask. When this input is energized the circuit breaker positional information is directed to the two bits in the Plant Status Word for CB2.

The two input masks [INP LClose CB] and [INP LOpen CB] assign control inputs for local initiation of the close and trip pulse timers for the circuit breaker. Manual closure of the circuit breaker via the relay will ensure that closure does not take place unless the relay is operative. It should be noted that by tripping the circuit breaker via this path, a remote trip indication (RT) will be recorded.

3.4.10 Trip and close test facility

If the relay is configured for remote control of the circuit breaker, then a trip or close test can be carried out from the SYSTEM DATA column of the menu. The control buttons on the front of the relay provide an input to the trip and close pulse timers in parallel with the [INP LClose CB] and [INP LTripp CB] masks.

If the relay is not configured for remote control of the circuit breaker then the output relays used for protection trips will need to be assigned in the [RLY CB Trip] mask before the trip test will operate.

3.4.11 Load shedding by tripping less essential loads

The relay is capable of responding to global load shedding commands via the communication port. To select this option link SD1 must be set to "1" and to deselect it link SD1 must be set to "0". Output relays must be selected via the [RLY CB Trip] and [RLY CB Close] masks to perform the circuit breaker control duty. A relay may have already been selected in this mask for remote control of the circuit breaker. If there are no spare output relays for this purpose then the main trip relay may be selected.

An indication is required that the circuit breaker was closed before the trip command was received, otherwise the circuit breaker will not close to restore load when the appropriate command level is received. A control input must therefore be assigned via [INP CB Closed] input mask.

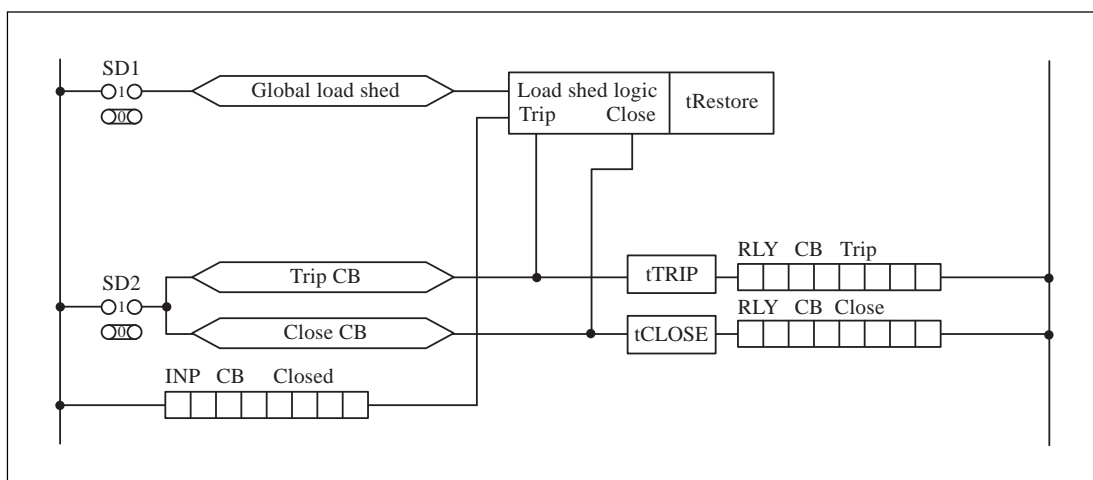


Figure 18. Load shedding by load rejection

3.4.12 Load shedding by voltage reduction

Three of the output relays can be allocated via the [RLY V Reduct 1][RLY V Reduct 2][RLY V Reduct 3] output masks to give three stages of load shedding. Typically these outputs would be used to control the load shedding settings of a voltage regulating relay such as a type MVGC. The relays allocated via these masks will respond to load shedding commands received via the serial communication port and the stage of load shedding to which the relay is responding can be viewed under the SYSTEM DATA heading of the menu (see Section 3.2.2).

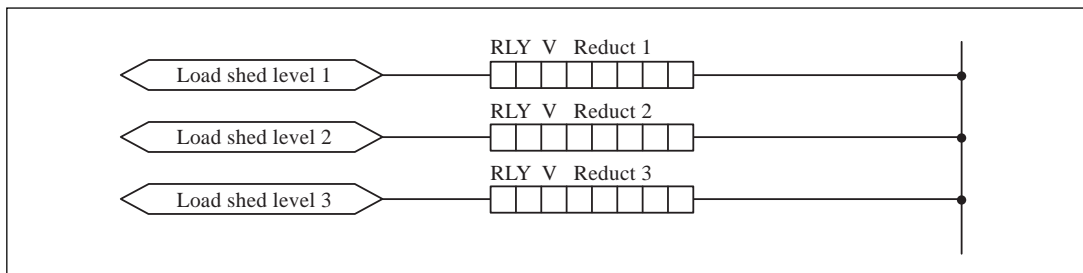


Figure 19. Load shedding by voltage reduction

3.4.13 Trip and flag logic

Not all protection functions will be used for tripping purposes; some may be used for control or alarm. The flag latching has been made programmable so that it can be set to suit the application. Figure 20 shows that the trip LED and the flags are latched for operation of relays RLY3 and RLY7, but the breaker fail is only initiated by the operation of relay RLY3.

To ensure correct flagging RLY3 should not be used for alarm or control functions. RLY7 is used for remote tripping of the circuit breaker and when it is not required for this purpose it may be used as an additional trip relay to provide an extra trip contact.

The flags for the start functions for each phase and for earth elements, that are operated at the time RLY3 or RLY7 is operated, will be latched. In addition it is possible to select an option whereby the start indications are latched even though a trip was not initiated. To do this Logic Link LOG7 must be set to “1” and to inhibit this latch LOG7 must be set to “0”. Note that when this option is selected it does not cause the trip LED to come on because the relay did not trip. The default display does not change to the fault flags when only the start flags are latched, so they can only be read by selecting the FAULT RECORDS column or reading EVENT RECORDS via the communication port.

Note: When LOG7 is set to 1 a fault record will be recorded under start conditions. An event will only be logged if a start contact has been allocated.

Note: On single pole and two pole relays where only four output relays are fitted, it is still possible to allocate relays 4 to 7 in the relay masks. This will not actually cause an output relay to operate but an output to relay RLY7 can be used to initiate the updating circuit breaker maintenance data without initiating a trip or autoreclose sequence. An external signal will need to be routed to RLY7 via an opto-input in mask [INP Aux1], [INP Aux2] or [INP Aux3] with the respective auxiliary time delay set to zero.

An event record will be triggered when the opto-input is energized but a fault record will not result unless relay RLY3 is initiated (If LOG7 is set to 0). The disturbance recorder may also be initiated from the same opto-input if required.

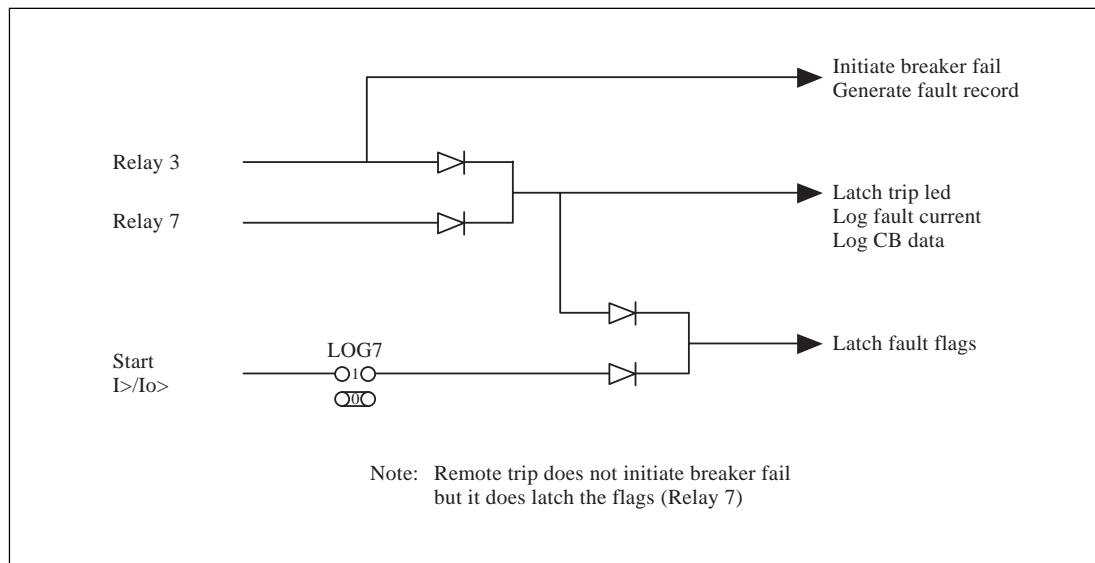


Figure 20. Selectable flag logic

3.5 Configuration

Configuration is the act of selecting from the available options, those that are required for the application. It is also the software equivalent of rewiring a relay to connect the functions together in a different way so that they operate in a new sequence to provide the required composite function. At first this may seem to be a complicated process but it will in fact be found very simple once the basic concept is understood.

3.5.1 Basic configuration – factory settings

The basic configuration contains the factory settings and calibration data. It is not generally accessible, because any incorrect changes would affect the accuracy and performance of the relay. Any detected change to the basic configuration will cause the protection to stop and give an alarm, since incorrect operation could follow.

3.5.2 Initial factory applied settings

3.5.2.1 Initial protection settings

As received the relay will be configured as a basic overcurrent relay with two protection elements per pole, one having a standard inverse time/current characteristic selected and the time multiplier set to 1.0. The reset time setting for this characteristic will be set to zero, the second element having a definite time characteristic set for instantaneous operation. The third measuring element will be inhibited and, if required, the appropriate function links in the phase and earth fault setting columns of the menu will need to be set to “1”.

The second setting group will be inhibited and its settings will not appear in the menu. The breaker fail and cold load start features will also be inhibited.

The threshold settings for both setting groups will be set the same as follows:

Phase Fault	$I_{>} = 1 \times \text{rated current}$	$I_{>>} = 10 \times \text{rated current}$
	$I_{<} = 0.1 \times \text{rated current}$	
Earth Fault	$I_{o>} = 0.2 \times \text{rated current}$	$I_{o>>} = 4 \times \text{rated current}$
	$I_{o<} = 0.1 \times \text{rated current}$	
Sensitive E/F	$I_{o>} = 0.02 \times \text{rated current}$	$I_{o>>} = 0.4 \times \text{rated current}$
	$I_{o<} = 0.01 \times \text{rated current}$	
Directional	$I_{p>} = 0.05 \times \text{rated current}$	$V_{op>} = 2 \text{ volts}$
Char.Angle	$= 0 \text{ degrees}$	

3.5.2.2 Initial control settings

For relays providing phase fault protection, the flags are set to auto-reset three seconds after a line has been successfully re-energized. This feature is not available on relays that respond to residual current only, because there will be no load current to pick up the undercurrent element and so perform the reset function. Relays which have eight output relays will be configured for remote circuit breaker control, but will not function until the link SD2 is set to "1". Load shedding, automatic reset of the flags and change of setting group will be inhibited and must be similarly selected via the SD links if required. Remote change of settings will be possible over the serial communication port so that settings can be downloaded via this path.

The disturbance recorder will be set to automatically reset on restoration of the supply and will be triggered by operation of the trip relay (relay 3).

3.5.2.3 Initial time delay settings

tAUX1	= 1.0 seconds	tCLP	= 8.0 seconds
tAUX2	= 2.0 seconds	tBF	= 0.3 seconds
tAUX3	= 3.0 seconds	tTRIP	= 0.5 seconds
tRESTORE	= 0 seconds	tCLOSE	= 0.5 seconds

3.5.2.4 Initial allocation of opto-isolated control inputs

L0	Change setting group
L1	Block t>>/to>>
L2	Block t>>>/to>>>
L3	Initiate auxiliary timer 1
L4	Initiate auxiliary timer 2
L5	Initiate auxiliary timer 3
L6	CB closed indication
L7	CB open indication

3.5.2.5 Initial-allocation of output relays

RLY0 Start (Fwd Start – directional only)
RLY1 Start (Rev Start – directional only)
RLY2 Trip (t> t>> t>>> to> to>> to>>> + Aux 2&3) [trip]
RLY3 Trip (t> t>> t>>> to> to>> to>>> + Aux 2&3) [main]
RLY4 Trip (t> t>> t>>> to> to>> to>>>) [A/R init]
RLY5 Aux 1
RLY6 Remote CB close
RLY7 Remote CB trip

3.5.3 Configuring for application

Before attempting to change the configuration for a particular application it is strongly recommended that experience is first gained with the initial factory selected options, as supplied. For example, practise moving through the menu and then changing some of the visible individual protection settings.

When familiar with the relay it will be easier to configure it for a specific application. This involves selecting, as described in Section 3.4, those available options that are required for the application. These will then respond in the display; those that are not selected will be inoperative and some of them will be hidden, their current set values being of no concern.

The next stage is to allocate output relays to the chosen functions. This must be done with care because it will determine which functions latch the flags and those which latch the TRIP LED.

3.5.4 Selecting options

1. Select SYSTEM DATA heading from the menu, step down to SYS Password and enter the password. The alarm LED will flash to indicate that the relay is no longer password protected.
2. If required a new password can be entered at this stage.
3. Select the function link settings in the next menu cell down. If SYS AUTORESET is set to “1”, the trip LED will automatically reset after the protected circuit is re-energized and line current is above the undercurrent threshold $I_{<}$ for three seconds. Note that this feature is not available on relays that only give earth fault protection. If the link is set to “0” then the flags have to be manually reset with the [0] key.
4. The description will state the main functions, for example “3PH + EF Dir O/C”. This may be changed to the user configuration reference.
5. The Plant Reference can be used to identify the plant, circuit or circuit breaker that the relay is associated with.
6. The communication address is to be entered manually or by the auto-addressing function of the Master Station as described in Section 3.3.6.
7. Moving to the EARTH FAULT column of the menu, the function links are first selected.
8. The CT and, for directional relays, the VT ratio, may be entered if it is required to set the relay in primary values of current and voltage. Otherwise these ratios

should be set at 1:1 when the settings and measured values will be displayed in the secondary quantities applied to the relay terminals.

9. Next, the time characteristic for $t >$ can be selected.
10. Repeat 7 – 9 for the PHASE FAULT column of the menu to select phase fault options.
11. The function links in the LOGIC column of the menu should now be set to the required functions from the available options.
12. The input and output masks are then set. Section 3.4.13 gives some important notes on the allocation of output relays.
13. Finally the password protection should be established. This will occur automatically two minutes after the last key press, alternatively, select the password cell and hold the reset key pressed until the alarm LED stops flashing. The backlight on the display is turned off one minute after the last key press and will serve as a warning that the password may soon be reinstated.

The relay is now configured for the application and the configuration may be stored on a disc and referenced with a suitable name. The file can then be retrieved and down-loaded to other relays that require the same configuration. This provides a quick method of setting the relay but requires the use of additional equipment, such as a KITZ101 interface unit and a portable PC with suitable software.

3.6 External connections

Standard connection table

Function	Terminal				Function
Earth Terminal	–	1	2	–	Not Used
Watchdog Relay (Break contact)	b –	3 5	4 6	m –	Watchdog Relay (Make contact)
48V Field Voltage	[+]	7	8	[–]	48V Field Voltage
Capacitor Trip Voltage	[+]	9	10	[–]	Capacitor Trip Voltage
Not Used	–	11	12	–	Not Used
Auxiliary Voltage Input	(+)	13	14	(–)	Auxiliary Voltage Input
Not Used	–	15	16	–	Not Used
A Phase Voltage	In	17	18	In	B Phase Voltage
C Phase Voltage	In	19	20	Out	Common Voltage Neutral
A Phase Current	In	21	22	Out	A Phase Current
B Phase Current	In	23	24	Out	B Phase Current
C Phase Current	In	25	26	Out	C Phase Current
Neutral Current	In	27	28	Out	Neutral Current
Output Relay 4	–	29 31	30 32	–	Output Relay 0
Output Relay 5	–	33 35	34 36	–	Output Relay 1
Output Relay 6	–	37 39	38 40	–	Output Relay 2
Output Relay 7	–	41 43	42 44	–	Output Relay 3
Opto Control Input L3	(+)	45	46	(+)	Opto Control Input L0
Opto Control Input L4	(+)	47	48	(+)	Opto Control Input L1
Opto Control Input L5	(+)	49	50	(+)	Opto Control Input L2
Opto Control Input L6	(+)	51	52	(–)	Common L0/L1/L2
Opto Control Input L7	(+)	53	54	–	K-BUS Serial Port
Common L3/L4/L5/L6/L7	(–)	55	56	–	K-BUS Serial Port

Key to connection tables

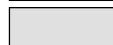
[+] and [–] indicate the polarity of the dc output from these terminals.

(+) and (–) indicate the polarity for the applied dc supply.

In / Out the signal direction for forward operation.



This area is not available on single phase relays.



Not available on two pole overcurrent relays.

Note: All relays have standard Midos terminal blocks to which connections can be made with either 4mm screws or 4.8mm pre-insulated snap-on connectors. Two connections can be made to each terminal.

Connection table for dual polarised relays

Function		Terminal			Function
Earth Terminal	–	1	2	–	Not Used
Watchdog Relay (Break contact)	b –	3 5	4 6	m –	(Make contact)
48V Field Voltage	[+]	7	8	[–]	48V Field Voltage
Capacitor Trip Voltage	[+]	9	10	[–]	Capacitor Trip Voltage
Not Used	–	11	12	–	Not Used
Auxiliary Voltage Input	(+)	13	14	(–)	Auxiliary Voltage Input
Not Used	–	15	16	–	Not Used
Not used	–	17	18	–	Not Used
Zero Sequence Voltage	In	19	20	Out	Zero Sequence Voltage
Not Used	–	21	22	–	Not Used
Not Used	–	23	24	–	Not Used
Polarizing Current	In	25	26	Out	Polarizing Current
CT Neutral Current	In	27	28	Out	CT Neutral Current
Output Relay 4	– –	29 31	30 32	– –	Output Relay 0
Output Relay 5	– –	33 35	34 36	– –	Output Relay 1
Output Relay 6	– –	37 39	38 40	– –	Output Relay 2
Output Relay 7	– –	41 43	42 44	– –	Output Relay 3
Opto Control Input L3	(+)	45	46	(+)	Opto Control Input L0
Opto Control Input L4	(+)	47	48	(+)	Opto Control Input L1
Opto Control Input L5	(+)	49	50	(+)	Opto Control Input L2
Opto Control Input L6	(+)	51	52	(–)	Common L0/L1/L2
Opto Control Input L7	(+)	53	54	–	K-BUS Serial Port
Common L3/L4/L5/L6/L7	(–)	55	56	–	K-BUS Serial Port

Key to connection tables

[+] and [–] indicate the polarity of the dc output from these terminals.

(+) and (–) indicate the polarity for the applied dc supply.

In / Out the signal direction for forward operation.

Note: All relays have standard Midos terminal blocks to which connections can be made with either 4mm screws or 4.8mm pre-insulated snap-on connectors.
Two connections can be made to each terminal.

3.6.1 Auxiliary supply

The auxiliary voltage may be ac or dc provided it is within the limiting voltages for the particular relay. The voltage range will be found on the frontplate of the relay; it is marked $V_x = 24V - 125V$ or $48V - 250V$. An ideal supply to use for testing the relays will be 50V dc or 110V ac because these values fall within both of the auxiliary voltage ranges.

The supply should be connected to terminals 13 and 14 only. To avoid any confusion it is recommended that the polarity of any applied voltage is kept to the Midos standard:

- for dc supplies the positive lead connected to terminal 13 and the negative to terminal 14.
- for ac supplies the live lead is connected to terminal 13 and the neutral lead to terminal 14.

Note: To avoid damage to the relay do not connect any auxiliary supplies to terminals 7 and 8, or 9 and 10.

3.6.2 Dual powered relays

Dual powered relays derive power from the current transformer circuit and may be used with this power source alone. However, the application of an auxiliary ac or dc voltage will enable lower earth fault settings to be used, also settings to be applied and data to be read when the load current is insufficient to power the relay.

It will also allow communications to be maintained at such times.

When powered from the CT circuit alone the 48V field voltage will be available to power the opto-isolated control inputs when the protection starts up. The phase fault current setting range is limited to the minimum current levels at which the power requirements of the relay can be maintained, see Technical Data, Section 5.

This model of relay is rated for an auxiliary voltage $V_x = 100V - 250V$.

Note: The capacitance discharge circuit is not isolated from the auxiliary supply and to prevent the relay from being damaged, no external ground connection should be made to this circuit.

3.6.3 Opto-isolated control inputs

There are a number of opto-isolated control inputs to the relay and these can be arranged to perform alternative functions as determined by the setting of the INPUT MASKS, so making maximum use of the available control inputs. There are three such inputs on the single and two pole relays and eight on all other models.

Software filtering is applied to eliminate the adverse effects of induced ac signals in the external wiring.

The opto-isolated control inputs are rated for 48V and energized from the isolated 48V field voltage provided on terminals 7 and 8 of the relay. Terminal 8 (–) must be connected to terminal 52 and on three and four pole relays terminal 8 must be connected to terminal 55 also. The opto-isolated control inputs can then be energized by connecting a volt-free contact between terminal 7 (+) and the terminal associated with the required input, L0 to L7, given in the above table.

The circuit for each opto-isolated input contains a blocking diode to protect it from any damage that may result from the application of voltage with incorrect polarity.

Where the opto-isolated input of more than one relay is to be controlled by the same contact it will be necessary to connect terminal 7 of each relay together to form a

common line. In the example, shown in Figure 21, contact X operates L1 of relay 1 and contact Y operates L0 and L1 of relay 2. L2 is not used on either relay and has no connections made to it.

The opto-inputs are sampled eight times per cycle and five consecutive samples to indicate that the input is energized, before this is accepted. This ensures that the inputs are relatively immune to spurious operation from induced ac signals in the wiring. thus the capture time is:

$12 \pm 2.5\text{ms}$ at 50 Hz.

$10.4 \pm 2.1\text{ms}$ at 60 Hz.

Note: These inputs will not capture a fleeting contact unless it dwells in the closed state for a time exceeding the above values.

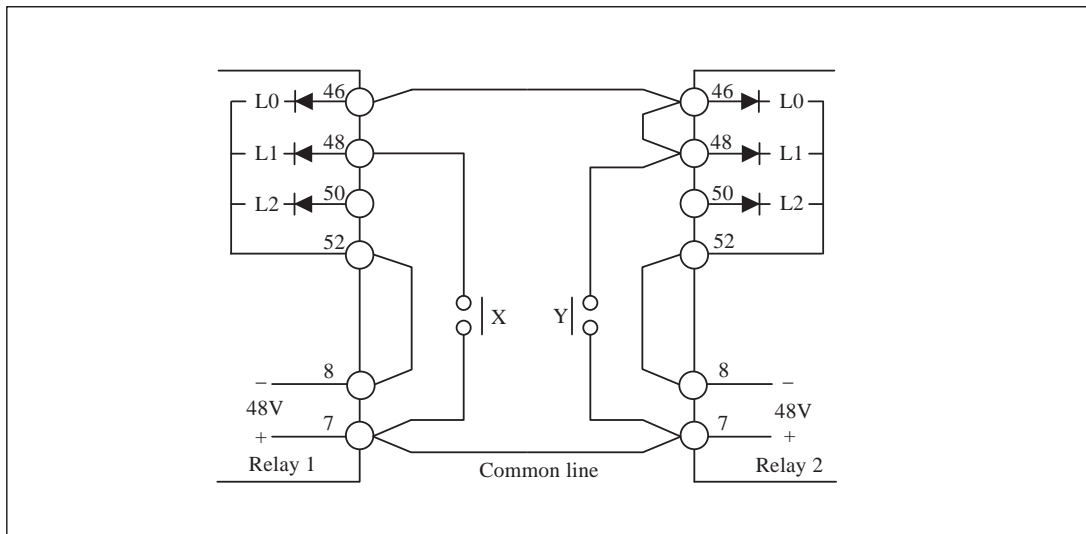


Figure 21. Connection to opto-isolated control inputs

3.6.4 Analogue inputs

The relays can have up to eight analogue inputs, two on the microprocessor board and six on the auxiliary expansion board. Each is fed via an input transducer, a low pass filter and a three range scaling amplifier. The analogue signals are sampled eight times per cycle on each channel as the sampling rate tracks the frequency of the input signal.

The wide setting range provided on the auxiliary powered version of the relays is sufficient to enable the 5A version of the relay to operate from either 1A or 5A current transformers and this version of the relay can be used where dual rated relays are specified. Alternatively, the wide setting range makes the relay suitable for use on circuit breakers that may be applied to a wide range of load circuit ratings with only one current transformer ratio. For example a circuit breaker rated at 2000A and fitted with current transformers rated at 2000/10A (or 2000/2A) and relays rated at 5A (or 1A) could be applied to circuits with load ratings from 100A to 2000A.

The dual powered relays have a narrower setting range and must be used with current transformers that match their current rating. Thermal dissipation is the limitation for the upper end of the setting range and the energy required to power

the relay is the limitation at the lower end. When the relay is powered from an additional auxiliary voltage source, earth fault settings can be applied below that at which the relay can derive sufficient power from the CTs. For this reason the earth fault setting range has not been restricted.

3.6.5 Output relays

Four programmable output relays are provided on relays with no more than two analogue inputs and eight on all other models.

There are four programmable output relays on the microprocessor board and four on the auxiliary expansion board. These relays each have two make contacts connected in series to increase their rating. These relays can be arranged to operate in response to any, or all, of the available functions by suitably setting the OUTPUT MASKS. The protection and control functions to which these relays respond are selectable via the menu system of the relay.

In addition there is a watchdog relay which has one make and one break contact. Thus it can indicate both healthy and failed conditions. As these contacts are mainly used for alarm purposes, single contacts are used and their rating is therefore not quite as high as that of the programmable outputs.

The terminal numbers for the output relay contacts are given in the table at the start of Section 3.6.

3.6.5.1 Output relay minimum dwell time

Outputs from $t>$, $t>>$, $t>>>$, $to>$, $to>>$, $to>>>$ have a minimum dwell of 100ms. This is because they are normally used for trip outputs and the minimum dwell ensures that they will provide a positive trip signal to the circuit breaker.

Circuit breaker control outputs $tCLOSE$, $tTRIP$ have a minimum dwell of 500ms which can be increased to a maximum of 2s. The restoration timer ($tRESTORE$) is followed by the circuit breaker close dwell time.

All other outputs such as $I>$, $Io>$, $tV<$, $Aux1$, $Aux2$ and $Aux3$ have no deliberate dwell time added to them. This is because they are either followed by a timer or used for control purposes which require a faster reset time.

3.6.5.2 Improving reliability of trip and closing contacts

In the event of the circuit breaker failing to trip, the relay contacts are called upon to break the trip coil current. The majority of protective relays are not rated for this duty and their contacts may be damaged as a result. This problem can be eliminated if a relay with heavy duty contacts is interposed between the output contacts of the protective relay and the circuit breaker trip circuit. This can be more economical than the repair costs and the overall fault clearance time need not be increased as a result. If the interposed relay is connected as a shunt repeat relay, the protection will trip the circuit breaker directly and then be backed-up by the contacts of the interposing relay. On breaking, the protective relay will reset first so that the interposing relay performs the actual circuit interruption. (As shown in Figure 22).

Similarly the breaking duty of the relay contacts may not be rated for the circuit breaker closing current and in such cases an interposing relay will be necessary.

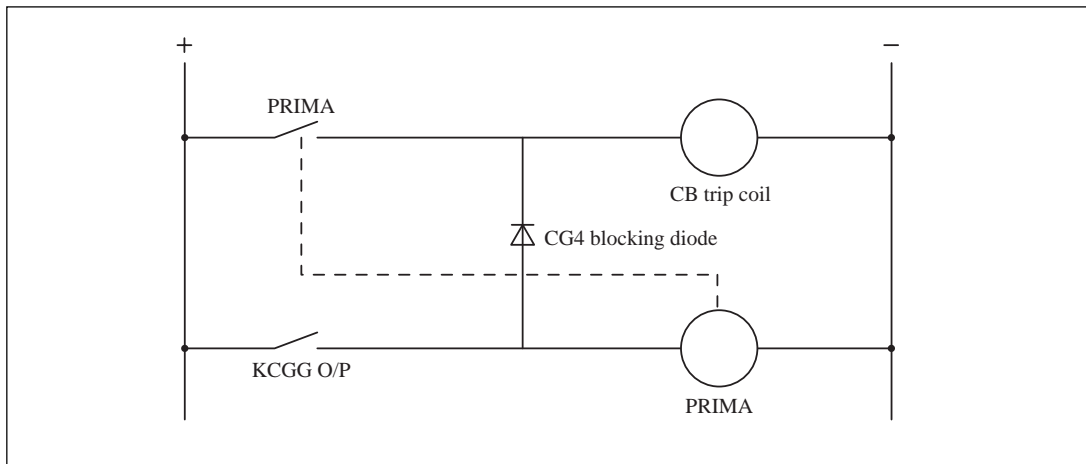


Figure 22. Contact re-inforcing

3.6.6 Alternative trip arrangements

3.6.6.1 DC shunt trip

Auxiliary powered relays require an auxiliary supply to trip the circuit breakers. This will normally be a dc supply which is generally considered to be more secure than an ac supply. It would be usual to use a shunt trip coil for dc energized trip circuits.

The trip circuit current will normally be broken by an auxiliary contact on the circuit breaker once the circuit breaker has opened. If this is not the case then a trip relay with heavy duty contacts must be interposed between the contact of RLY3 and the trip coil. (As shown in Figure 23).

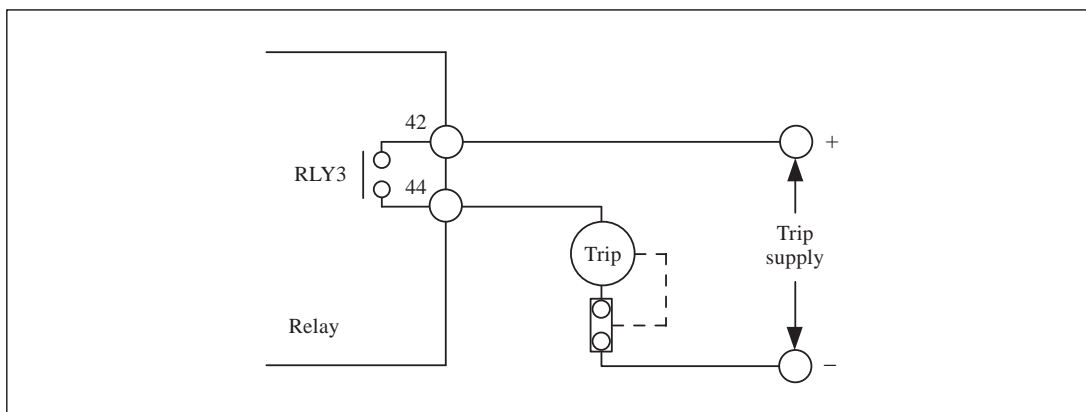


Figure 23. DC shunt trip arrangement

3.6.6.2 AC no-volt trip

For ac tripping it may be considered safer to opt for a no-volt trip release. Tripping from a make contact on the relay is still possible by using the circuit shown in Figure 24.

This arrangement will also trip the circuit breaker when the auxiliary trip supply is lost. If the circuit breaker is fitted with a line VT, then this may be used to provide the trip supply for the circuit breaker and the circuit breaker will then be tripped when the protected circuit is de-energized.

The capacitor is included to reduce the release time and tune the coil to the power frequency. The series resistor then limits the current in the coil to its rated value.

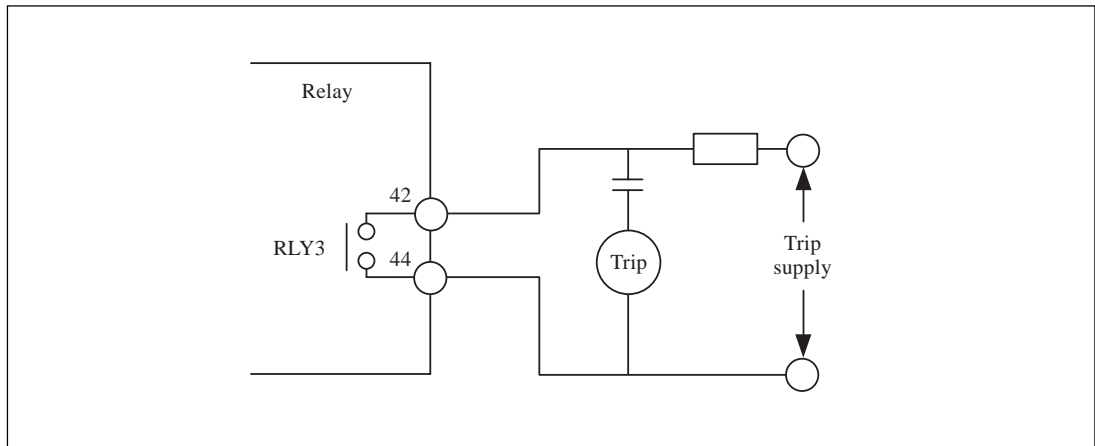


Figure 24. AC no-volt trip arrangement

3.6.6.3 Capacitor discharge trip

Dual powered relays may use either of the above methods. In addition, these particular relays charge an internal capacitor from the current circuit and also from the auxiliary voltage circuit (Figure 25). This capacitor is 680 μ F and it is charged to 50V dc. It may be discharged directly into a suitably sensitive trip coil via one of the programmable output relays. The minimum energy fed to the trip coil is that from the capacitor, but in most cases it will be supplemented by a current from the auxiliary voltage circuit and/or the current circuit.

When energized from current alone the lowest current for which the relay will operate will be that necessary to start up the power supply. To be able to use lower fault settings an auxiliary supply will be required (see Technical Data, Section 5).

The capacitance discharge circuit is not isolated from the auxiliary supply and to prevent the relay from being damaged, no external ground connection should be made to this circuit.

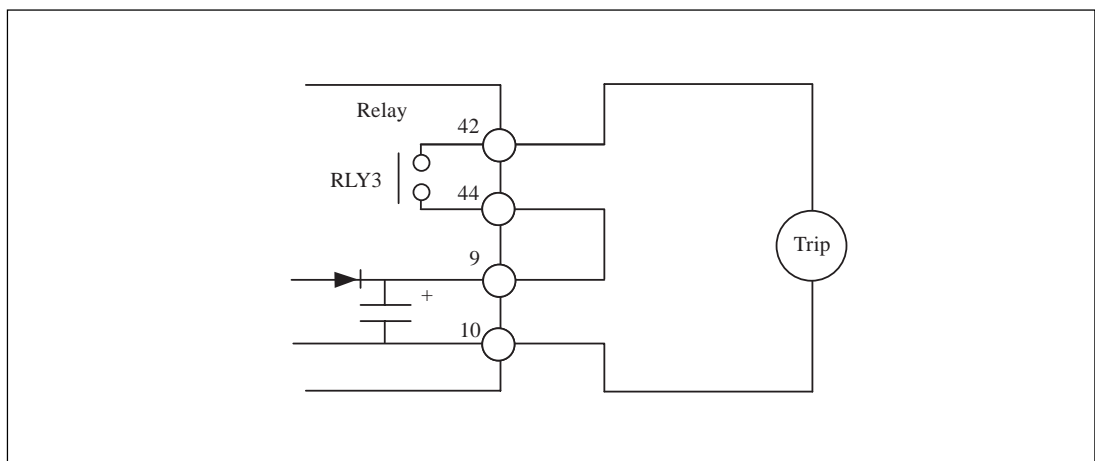


Figure 25. Capacitor discharge trip

3.6.6.4 AC series trip

As an alternative the trip capacitor in the dual powered relays may be discharged into an auxiliary relay. This relay will be de-energized in the quiescent state, with its break contacts short circuiting the trip coils of the circuit breaker (Figure 26).

The trip coils are connected in series with the current transformer secondary circuit so that, when the auxiliary relay is operated, the full secondary current is diverted through the trip coils.

To cover all fault conditions, three trip coils are required and may be necessary to limit the maximum energy that can be fed to each coil, by means of saturating shunt reactors.

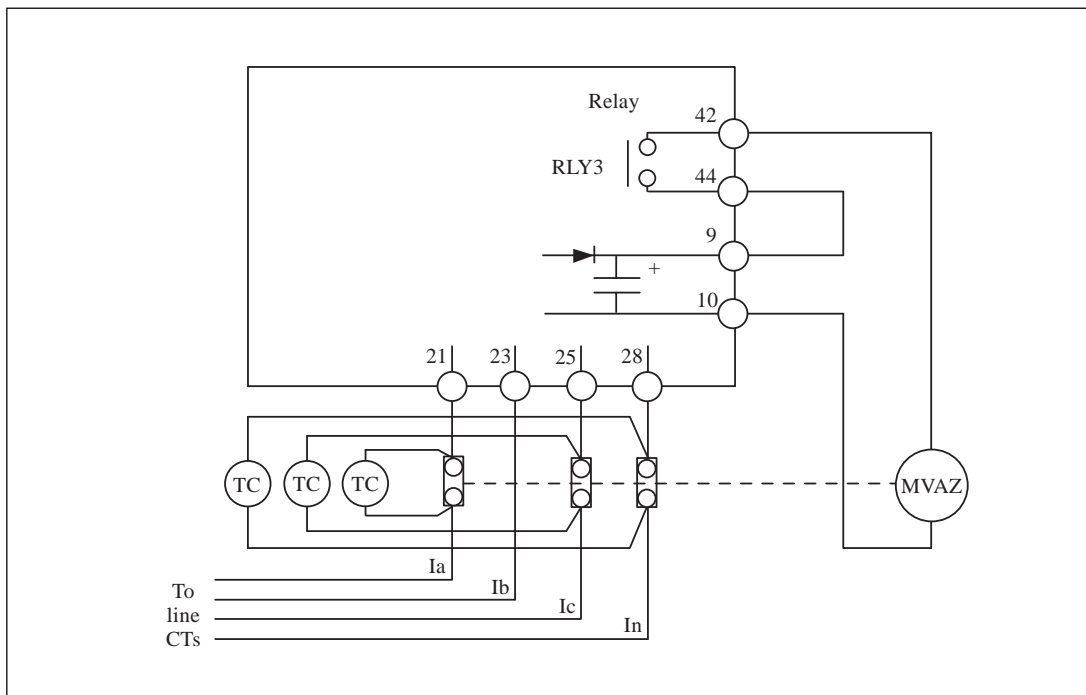


Figure 26. AC series trip arrangement

3.7 Non-protection features and communications

3.7.1 Non-protection features

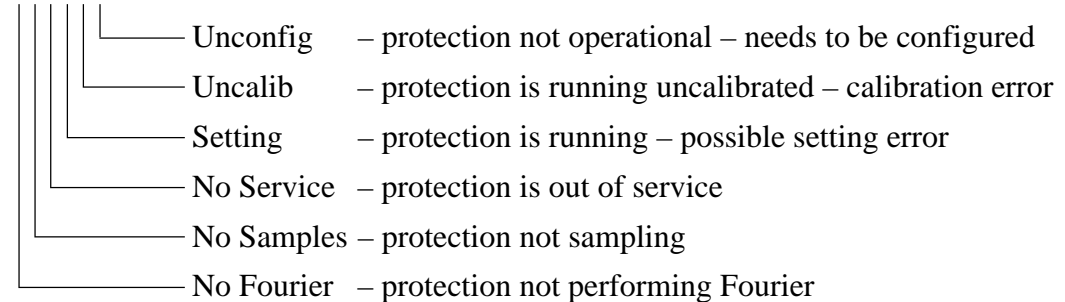
3.7.1.1 Self monitoring and protection alarms

The monitoring circuits within the relay continuously perform a self test routine. Any detected loss of operation in the first instance initiates a reset sequence to return the equipment to a serviceable state. Examples of this are the main processor, the communication processor and the display processor. The voltage rails are also supervised and the processors are reset if the voltage falls outside their working range. Should the main processor fail and not restart, the watchdog relay will provide an alarm. This relay will also signal an alarm on loss of the auxiliary energizing supply to the auxiliary powered relays, but not for the dual powered relays for which the loss of the auxiliary supply may be a normal operational condition.

In addition, the memory of the relay is checked for possible corruption of data and any detected errors will result in an alarm being generated. An ALARM LED

indicates several states which can be identified by viewing the alarm flags that are to be found towards the end of the SYSTEM DATA column of the menu and consist of six characters that may be either “1” or “0” to indicate the set and reset states of the alarm. The flags offer the following indications:

000000



For the above listed alarms the ALARM LED will be continuously lit, the alarm bit will be set in the STATUS word as a remote alarm and the watchdog relay will operate. However, there is another form of alarm that causes the ALARM LED to flash; this indicates that the password has been entered to allow access to change protected settings within the relay and this is not generally available as a remote alarm.

Note: No control will be possible via the key pad if the “Unconfigured” alarm is raised because the relay will be locked in a non-operate state.

3.7.1.2 Measured values

Measurements are divided into two groups: those that are directly measured and those that are calculated from the directly measured quantities. For example, VA is calculated from the product of current and voltage.

All measurement values can be displayed on the front of the relay. The display of measured values will be in primary system values if the current and voltage transformer ratios are entered under PHASE FAULT and EARTH FAULT SETTINGS. The default setting for these ratios is 1:1; the displayed settings and measured values then being in terms of the secondary quantities from the primary transducers.

Included under this heading is the number of circuit breaker trips initiated by the relay and the summated contact breaking duty for each pole of circuit breaker. This feature can be extended to respond when another protection trips the circuit breaker by arranging for one of the opto-inputs to be energized.

3.7.1.3 Remote control functions

Control functions that affect the relay and that can be performed over the serial link include the change of individual relay settings and the change between setting groups. Plant control functions include remote control of the circuit breaker position and load shedding by either voltage reduction or by load rejection.

Note: if it is considered essential that it must not be possible to perform certain of these remote control functions, they can be inhibited by setting software links in the relay. These links are password protected, see Section 3.3.1.

Notes on security of remote control via the serial port

Access to the memory of the relay is restricted to that addressed via the menu system of the relay. In addition, all setting changes are reflexed back to the Master Station

for verification before the EXECUTE command is issued. On reception of the EXECUTE command the new setting is checked against the limits stored in the relay before they are entered. Only then does the relay respond to the new setting.

All remote commands are reflexed back to the Master Station for verification before they are executed and any command left set is automatically rejected if not executed within the timeout period. No replies are permitted for global commands as this would cause contention on the bus; instead a double send is used for verification purposes with this type of command.

Remote control is restricted to those functions that have been selected in the relay's menu table and the selection cannot be changed without entering the password. CRC and message length checks are used on each message received. No response is given for received messages with a detected error. The Master Station can be set to resend a command a set number of times if it does not receive a reply or receives a reply with a detected error.

3.7.1.4 Aids to circuit breaker maintenance

The information gathered by the relay can be of assistance in determining the need for circuit breaker maintenance. The circuit breaker opening time is recorded under FAULT RECORDS. If this value is monitored, any significant increase may be used as an indication that circuit breaker maintenance is required.

Additionally the number of circuit breaker operations is recorded under MEASUREMENTS (2). Also under this heading will be found an indication of the summated contact breaking duty which is recorded separately for each phase.

3.7.1.5 Fault records

Fault values are recorded for the last fault but the fault flags are recorded for the last five faults to give a record of a complete four shot autoreclose cycle. They are stored in non-volatile memory and can be accessed via the user interface. There is provision for resetting these records to zero. In addition, the time taken for the circuit breaker to interrupt the fault current is recorded.

A copy of the fault record is also stored in the event records and up to 50 of these records can be held at any one time, provided all other events are deselected. These records will carry a time tag which is valid for 49 days. However, the event records will be lost if the relay is de-energized and they can only be accessed via the serial communication port.

3.7.1.6 Time tagged event records

An event may be a change of state of a control input or an output relay; it may be a setting that has been changed locally or a protection or control function that has performed its intended function. A total of 50 events may be stored in a buffer, each with an associated time tag. This time tag is the value of a timer counter that is incremented every 1 millisecond.

The event records can only be accessed via the serial communication port when the relay is connected to a suitable Master Station. When the relay is not connected to a Master Station the event records can still be extracted within certain limitations:

- the event records can only be read via the serial communication port and a K-BUS/IEC60870-5 Interface Unit will be required to enable the serial port to be connected to an IBM or compatible PC. Suitable software will be required to run on the PC so that the records can be extracted.

- when the event buffer becomes full the oldest record is overwritten by the next event.
- records are deleted when the auxiliary supply to the relay is removed, to ensure that the buffer does not contain invalid data. Dual powered relays are most likely to be affected.
- the time tag will be valid for 49 days assuming that the auxiliary supply has not been lost within that time. However, there may be an error of $\pm 4.3s$ in every 24 hour period due to the accuracy limits of the crystal. This is not a problem when a Master Station is on line as the relays will usually be polled once every second or so.

Events that are recorded include:

- 1 change in state of logic inputs.
- 2 change in state of relay outputs.
- 3 change to settings made locally.
- 4 fault records as defined in the FAULT RECORD column of the menu.
- 5 alarm messages.

Items 1 and 2 may be deleted from the events so that up to 50 fault records may be stored

3.7.1.7 Disturbance records

The internal disturbance recorder has one channel allocated to each of the measured analogue quantities; one to record the eight control inputs and one to record the eight relay outputs. As with the event recorder, when the buffer is full the oldest record is overwritten and records are deleted if the auxiliary supply to the relay is removed. This ensures that when the buffer is read the contents will all be valid.

The disturbance recorder is stopped and the record frozen a set time after a selected trigger has been activated. For example, a protection trip command could be the selected trigger and the delay would then set the duration of the trace after the fault.

Each sample has a time tag attached to it so that when the waveform is reconstituted it can be plotted at the correct point against the time scale, thus ensuring that the time base is correct and independent of the frequency. The K Range overcurrent relays measure eight samples per cycle but the method of recording allows the analysis program to perform with records that may have a different sample rate.

The disturbance recorder may be triggered by several different methods dependent on the settings in the column of the menu. However, the records have to be read via the serial communication port and suitable additional software is required to reconstruct and display the waveforms. Only one complete record is stored and the recorder must be retriggered before another record can be captured.

Recorder control

This cell displays the state of the recorder :

- a) RUNNING – recorder storing data (overwriting oldest data)
- b) TRIGGERED – recorder stop delay triggered
- c) STOPPED – recorder stopped and record ready for retrieval

When this cell is selected, manual control is possible and to achieve this the relay must be put into the setting mode by pressing the [+] key. A flashing cursor will

then appear on the bottom line of the display at the lefthand side. The [+] key will then select "RUNNING" and the [-] key will select triggered. When the appropriate function has been selected the [F] key is pressed to accept the selection and the selected function will take effect when the [+] key is pressed to confirm the selection. To abort the selection at any stage, press the reset key [0].

Recorder capture

The recorder can capture:

- a) SAMPLES – the individual calibrated samples
- b) MAGNITUDES – the Fourier derived amplitudes
- c) PHASES – the Fourier derived phase angles

The relay has no electro-mechanical adjustments, all calibration is effected in software and all three of the above options are used in the calibration process. For normal use as a fault recorder SAMPLES will be the most useful.

Recorder post trigger

The Post Trigger setting determines the length of the trace that occurs after the stop trigger is received. This may be set to any value between 1 and 512 samples. When recording samples the total trace duration is $512/8 = 64$ cycles because the interval between the samples is equivalent to one eighth of a cycle. However, the Fourier derived values are calculated once per cycle and so the total trace length when recording these calculated phase or amplitude values is 512 cycles.

Recorder logic trigger (available only on models A and B)

Any, or all, of the opto-isolated inputs may be used as the stop trigger and the trigger may be taken from either the energization or the de-energization of these inputs. The bottom line of the display for this cell will show a series of 16 characters, each of which may be set to "1" or "0". A "1" will select the input as a trigger and a "0" will deselect it.

The selection is made using the instructions for the setting links in Section 3.3.4. The opto-isolated input (L0 to L7) associated with each digit is shown on the top line of the display for the digit underlined by the cursor. A + preceding it will indicate that the trigger will occur for energization and a – will indicate the trigger will occur for de-energization.

Recorder relay trigger

Any, or all, of the output relays may be used as a stop trigger and the trigger may be taken from either the energization or the de-energization of these outputs. The bottom line of the display for this cell will show a series of 16 characters, each of which may be set to "1" or "0". A "1" will select the the input and a "0" will deselect it.

The selection is made using the instructions for setting links in Section 3.3.4. The output relay (RLY0 to RLY7) associated with each digit underlined by the cursor is shown on the top line of the display. A + preceding it will indicate that the trigger will occur for energization and a – will indicate the trigger will occur for de-energization.

Notes on recorded times

The times recorded for the opto-isolated inputs is the time at which the relay accepted them as valid and responded to their selected control function. This will be $12.5 \pm 2.5\text{ms}$ at 50Hz ($10.4 \pm 2.1\text{ms}$ at 60Hz) after the opto-input was energized. The time recorded for the output relays is the time at which the coil of the relay was energized and the contacts will close approximately 5ms later. Otherwise the time tags are generally to a resolution of 1ms for events and to a resolution of $1\mu\text{s}$ for the sample's values.

3.7.1.8 Flags available via serial port

Status Byte

This is returned by the relay at the start of every message to signal important data on which the Master Station may be designed to respond automatically. The flags contained are:

- Bit 0 – 1 = Disturbance record available for collection
- Bit 1 – 1 = Plant status changed
- Bit 2 – 1 = Control status changed
- Bit 3 – 1 = Relay busy, cannot complete reply in time
- Bit 4 – 1 = Relay out of service
- Bit 5 – 1 = Event record available for retrieval
- Bit 6 – 1 = Relay alarm indication set
- Bit 7 – 1 = Relay trip indicated set

Relay Alarms

Available in System Data column of the relay menu at location 0022. The value of this cell is a series of binary flags indicating the alarms as follows:

- Bit 0 – 1 = Relay unconfigured
- Bit 1 – 1 = Relay uncalibrated
- Bit 2 – 1 = Setting error detected
- Bit 3 – 1 = No service - protection out of service
- Bit 4 – 1 = No samples
- Bit 5 – 1 = No Fourier

Plant Status

The plant status can be found at menu location 000C and the bits indicate the status of items of plant controlled via the relay; they are defined as follows:

Bit 1 Bit 0

- 0 0 – No CB connected (auxiliary CB1 contacts faulty)
- 0 1 – CB1 open
- 1 0 – CB1 closed
- 1 1 – Auxiliary CB1 contacts or wiring faulty

Bit 8 Bit9

- 0 0 – No CB connected (auxiliary CB1 contacts faulty)
- 0 1 – CB2 open
- 1 0 – CB2 closed
- 1 1 – Auxiliary CB2 contacts or wiring faulty

No other bits in this word are used in KCGG/KCGU/KCEG/KCEU relays

Logic Status

This is located at menu location 0020 and each bit in the word corresponds to the status of the associated opto-isolated input (bit 3 = L3). A "1" indicates that it is recognized by the relay as being energized and "0" indicates that it is de-energized.

Relay Status

This is located at menu location 0021 and each bit in the word corresponds to the status of the associated output relay (bit 3 = relay 3). A "1" indicates that it is operated and "0" indicates that it is reset.

3.7.2 Serial communications

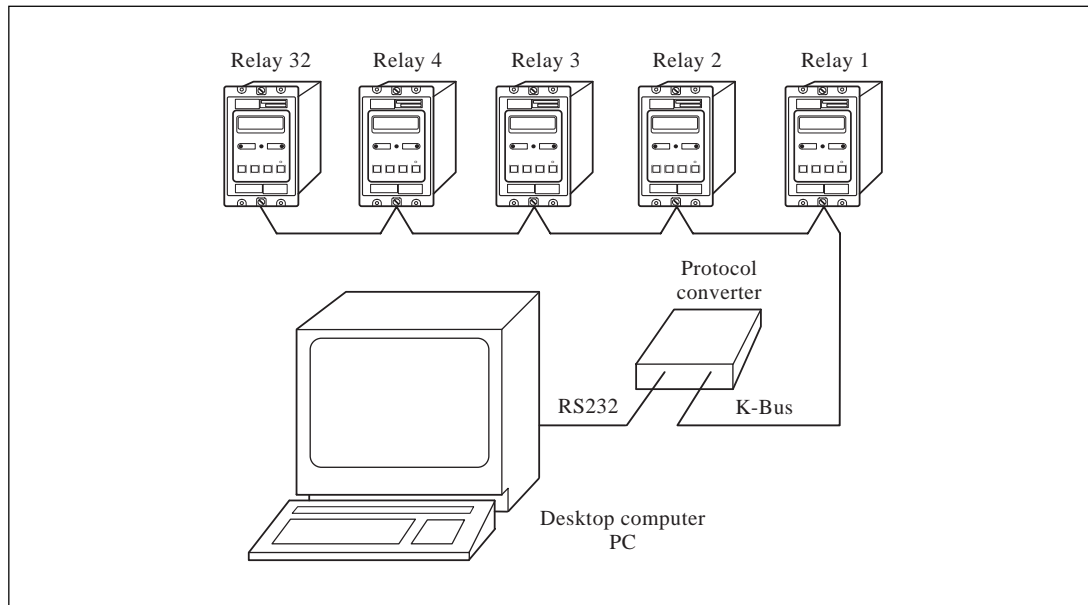


Figure 27. Basic communication system

Serial communications are supported over K-BUS, a multidrop network that readily interfaces to IEC60870-5 FT1.2 Standards. The language and protocol used for communication is Courier. It has been especially developed to enable generic master station programs to access many different types of relay without continual modification to the master station program. The relays form a distributed data base for the Master Station and may be polled for any information required.

This includes:

1. Measured values
2. Menu text
3. Settings and setting limits
4. Fault records
5. Event records
6. Disturbance records
7. Plant status
8. Status – an eight bit word that identifies the trip and alarm state, busy state, also the presence of event and disturbance records for collection.

3.7.2.1 Serial communication port (K-Bus)

Each relay in the K Range has a serial communication port configured to K-Bus Standards. K-Bus is a communication interface and protocol designed to meet the requirements of communication with protective relays and transducers within the power system substation environment. It has to be as reliable as the protective relays themselves and must not result in their performance being degraded in any way. Hence error checking and noise rejection have been major concerns in its design.

The communication port is based on RS485 voltage transmission and reception levels with galvanic isolation provided by a transformer. A polled protocol is used and no relay unit is allowed to transmit unless it receives a valid message, without any detected error, addressed to it. Transmission is synchronous over a pair of screened wires and the data is FM0 coded with the clock signal to remove any dc component so that the signal will pass through transformers. This method of encoding the data results in the polarity of the connection to the bus wiring being unimportant.

With the exception of the Master Units, each node in the network is passive and any failed unit on the system will not interfere with communication to the other units. The frame format is HDLC and the data rate is 64kbits/s. Up to 32 units may be connected to any bus at any point over a maximum length of 1000m.

Connection to the K-Bus Port is by standard Midos 4mm screw terminals or snap-on connectors. A twisted pair of wires is all that is required; the polarity of connection is not important. It is recommended that an outer screen is used with an earth connected to the screen at the Master Station end only. Termination of the screen is effected with the "U" shaped terminal supplied and which has to be secured with a self tapping screw in the hole in the terminal block just below terminal 56 (see Figure 28). Operation has been tested up to 1,000 metres with cable to:

DEF Standard 16-2-2c

16/0.2mm dia

40mΩ/m per core

171pf/m core/core

288pf/m core/screen

The minimum requirement to communicate with the relay is a K-Bus/IEC60870-5 converter box type KITZ and suitable software to run on an IBM or compatible personal computer.

Three versions of the KITZ are available:

KITZ101 – AC Powered version

KITZ102 – DC Powered version

KITZ103 – K-Bus to OPTIMHO Interface unit

These units are further described in publication R6521.

Note: K-Bus must be terminated with a 150Ω resistor at each end of the bus.
The master station can be located at any position, but the bus should only be driven from one unit at a time.

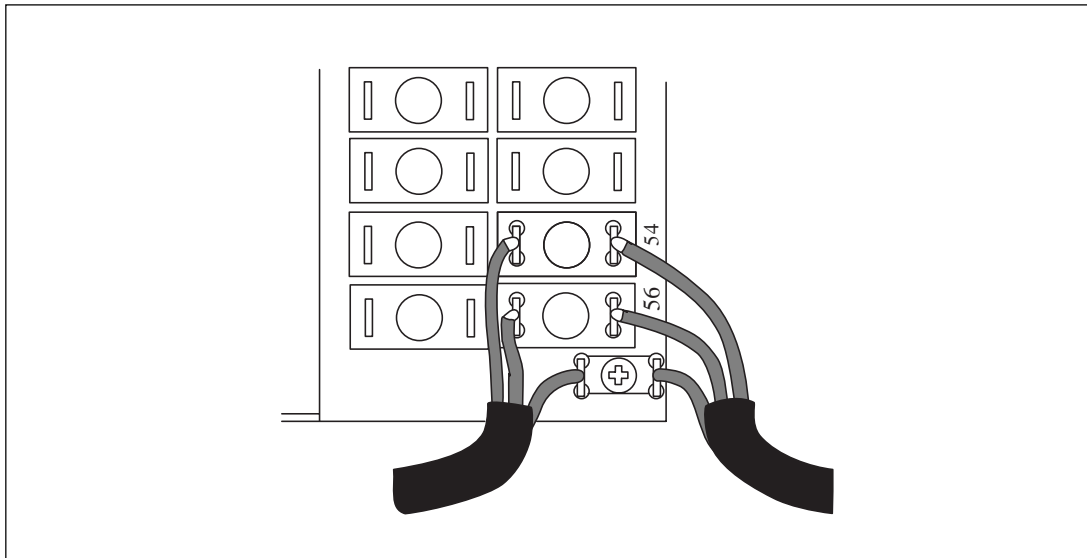


Figure 28. Terminal arrangement for communications

3.7.2.2 Protection Access Software

The Protection Access Software & Toolkit is a dedicated application software package designed to run under DOS on an IBM or IBM compatible personal computer. It provides an interface for remote communication with the AREVA T&D range of relays that implement the Courier Communication Language.

It utilises a standard RS-232 serial port of the PC to communicate using IEC60870 and the Courier language, either directly to IEC60870 based relays or, via an interposing KITZ protocol converter, to K-Bus based relays. It can interface to a maximum of 254 relays, although this is normally restricted to 32 relays at a time (this being the maximum number of relays that can be connected to one spur directly).

User input is via the keyboard using the familiar system of pull down menus and windows to select various options and functions.

Two versions of the software are available:

Protection Access Software & Toolkit (PAS&T) which enables the user to have full access to all functions within the relay including the event and disturbance recording facilities.

Courier Access software which is a reduced version of the PAS&T enabling the user to have access to all settings on the relay via the communication link.

3.7.2.3 PC requirements

To operate correctly, the Protection Access Software & Toolkit requires

- IBM PC/XT/AT/PS2 or true compatible.
- 640 kB of main memory RAM
- Graphics adaptor CGA, EGA, VGA or MDA
- Serial adaptor port configured as COM1 or COM2 (for communication)
- Floppy disc drive 3.5 inch

- MS-DOS 3.2 or later/IBM PC-DOS 3.2 or later
- Parallel printer port for optional printer

Additional equipment

- Printer
- RS-232 link
- KITZ 101 K-Bus/RS232 communication interface
- Modem

3.7.2.4 Modem requirements

AREVA T&D has adapted the IEC60870-5 ft1.2 frame format for transmitting the Courier communication language over RS-232 based systems, which includes transmission over modems.

The IEC60870-5 ft1.2 specification calls for an 11-bit frame format consisting of 1 start bit, 8 data bits, 1 even parity bit and 1 stop bit. However, most modems cannot support this 11-bit frame format, so a relaxed 10-bit frame format is supported by the Protection Access Software & Toolkit and by the KITZ, consisting of 1 start bit, 8 data bits, no parity and 1 stop bit.

Although Courier and IEC60870 both have inherent error detection, the parity checking on each individual character in the 11-bit frame provides additional security and is a requirement of IEC60870 in order to meet the error rate levels it guarantees. It is therefore recommended that modems should be used which support these 11-bit frames. The following modems have been evaluated for use with the full IEC60870 ft1.2 protocol and are recommended for use:

Dowty Quattro (SB2422)

Motorola Codex 3265 or 3265 Fast

Other modems may be used provided that the following features are available; refer to the modem documentation for details on setting these features:

Must support an 11 bit frame (1 start bit, 8 data bits, 1 even parity bit and 1 stop bit). This feature is not required if the 10-bit frame format is chosen.

Must be possible to disable all error correction, data compression, speed buffering or automatic speed changes.

Must save all the settings required to achieve a connection in non-volatile memory. This feature is only required for modems at the outstation end of the link.

- Notes:
1. The V23 asymmetric data rate (1200/75bps) is not supported
 2. Modems made by Hayes do not support 11 bit characters.

Section 4. APPLICATION NOTES

4.1 Application of overcurrent characteristics

Each relay is provided with seven inverse time/current characteristics to cover the range of applications to which the relay may be applied. In addition there is a definite, current independent time characteristic. The full range of curves will be found in Appendix 1.

The various time/current characteristics may find application as follows:

STI30XDT – short time inverse curve (becomes constant time at 30x setting).

For use where relatively short operation times are required to preserve system stability and where grading with downstream relays is not required.

LT30XDT – long time inverse curve (becomes constant time at 30x setting).

Provides protection for starting surges and overloads of short duration, but the cold load start/pick-up feature would be considered the preferable solution for these applications.

Most useful for grading with low voltage system protection devices or for protecting neutral earthing resistors.

DT – definite time characteristic

Useful for achieving constant time grading steps over a wide current range and for offering faster tripping times than inverse time protection at low multiples of current setting. This characteristic is often used where there is no significant variation in fault level between relay locations eg. in the case of earth fault protection of a resistance earthed system, or in the case of low circuit impedance compared to source impedance.

SI30XDT – standard (moderately) inverse curve (becomes constant time at 30x setting).

The standard characteristic for co-ordination of protection on systems where the amount generation varies and for providing back-up protection on transmission systems.

IN30XDT – inverse curve (becomes constant time at 30x setting).

Slightly more inverse than the SI30XDT curve, but also for co-ordination of protection on distribution systems and for back-up protection for relays on other circuits. This curve will allow closer grading with some relays that do not have an IEC standard curve.

VI30XDT – very inverse curve (becomes constant time at 30x setting).

Being very inverse it allows for longer operation times at low currents, or shorter times at high currents, than the previous two curves. This characteristic is especially useful when co-ordinating a number of relays and where there is great variation in fault current between relay locations.

EI20XDT – extremely inverse curve (becomes constant time at 20x setting).

Main use is for grading with downstream fuses and upstream overcurrent relays on distribution and industrial systems. The relay maintains its very inverse characteristic to higher current levels than electro-mechanical relays and therefore, provides for closer grading with the fuse characteristic.

II10XDT – extremely inverse curve (becomes constant time at 10x setting).

This relay is also for use in grading with downstream fuses and upstream overcurrent relays on distribution and industrial systems. However, the change to definite time at the lower current level of 10 times setting will be particularly useful where more than one relay has to be co-ordinated, because it will allow additional time grading steps to be used at the high current levels.

This curve grades more closely with the characteristic of electro-mechanical relays because of the earlier cut-off.

Note: the current measurement is linear to 820 times minimum setting and hence curves that become definite time above 20 times setting may tend to definite time at a lower multiple of setting given by:

$$xI_s = [820 \times (\text{minimum settable value})]/(\text{actual setting selected}).$$

4.1.1 IDTM relay co-ordination

Inverse definite minimum time relays are time graded such that the relay nearer to the fault operates faster than the relays nearer to the source. This is referred to as cascade operation because if the relay nearest to the fault does not operate, the next one back towards the source will trip in a slightly longer time. The time grading steps are typically 400ms, the operation times becoming progressively longer with each stage.

4.2 Blocking Schemes

Adding an extra time graded stage may not always be acceptable, but an additional stage can be added without increasing the number of time steps by implementation of a simple blocking scheme.

4.2.1 Blocked overcurrent protection

Inverse time delay blocking

Non-cascade operation allows closer time grading between relays and is achieved by using the START contact relay of one relay to block the operation of the time delayed element $t_{>}/t_o$ on the relay further back in the system towards the source.

Thus both relays can then have the same current and time settings and grading will be automatically provided by the blocking feature. If the breaker fail protection is selected, it will release the block if the circuit breaker fails to trip. This gives a constant, close time grading, but there will be no back-up protection in the event of the pilots being faulty.

Short time delay blocking

Improved fault clearance times can be obtained by setting the $I_{>}/I_o$ element above the transient load level and setting $t_{>}/t_o$ to 200ms for relays with directional elements or 80ms for non-directional relays. These time delays are for worst case conditions and may be reduced, depending on the system X/R and maximum fault level.

The time delays $t_{>}/t_o$ are arranged to be blocked by the START contacts of the downstream relay when the downstream relay detects a fault current flowing.

The short time delay is essential to ensure that the blocking signal will be received by the upstream relay before operation can occur.

The inverse time overload elements should be graded in the normal way for cascade operation and to provide an overload feature and backup protection. The short time

elements, operating in the non-cascade mode, then provide an instantaneous zone of protection and again the breaker fail feature can be used to advantage.

Overcurrent relays are adequate for non-cascade operation on radial circuits but for ring circuits, or where there are parallel feeds, it will be necessary to use directionalized overcurrent relays.

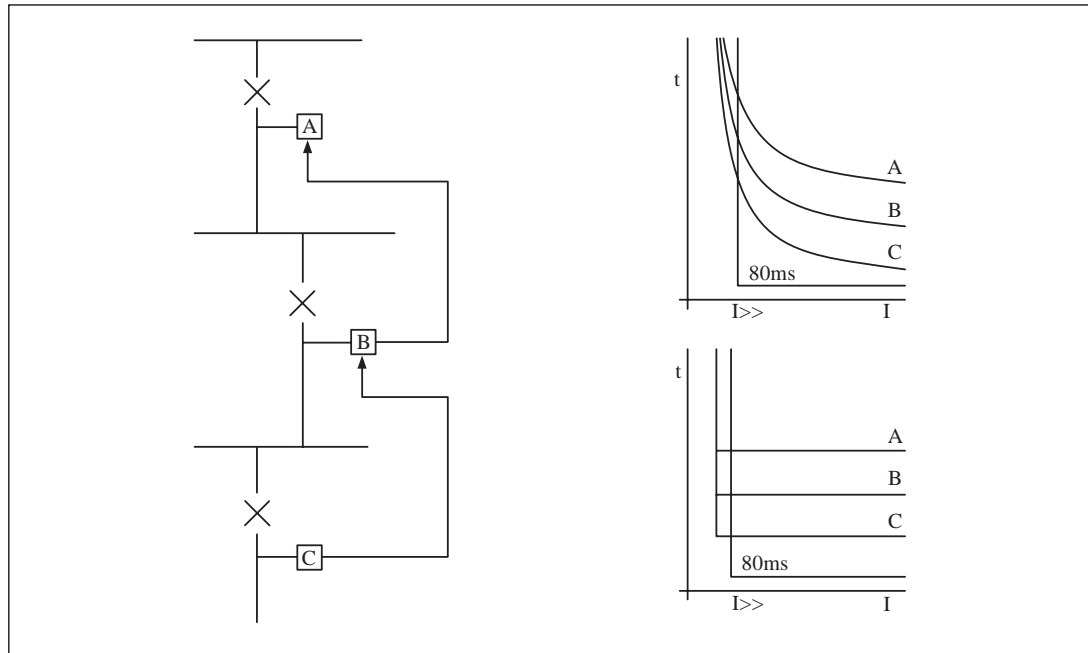


Figure 29. Non-cascade operation

4.2.2 Protection for busbars on radial systems

This is simply achieved on radial circuits by setting the short time lags ($t_{>>}/t_{o>>}$) of the relay on the incoming feeder to the busbar to 200ms for relays with directional elements or 80ms for non-directional relays, and blocking these time delays when the START element of any relay on the load circuits detects fault current flowing from the busbar to a feeder. These time delays are for worst case conditions and may be reduced, depending on the system X/R and maximum fault level. Feedback from regenerative loads must be less than the relay setting.

The protection can be enhanced by arranging for the internal breaker fail circuits of the feeder relays to backtrip the incoming circuit breaker as described in Section 4.5.1 and the transfer back-up tripping described in Section 4.5.2. The use of a KCGG240 relay on the incoming feeder will provide dead substation protection as described in Section 4.4.5.

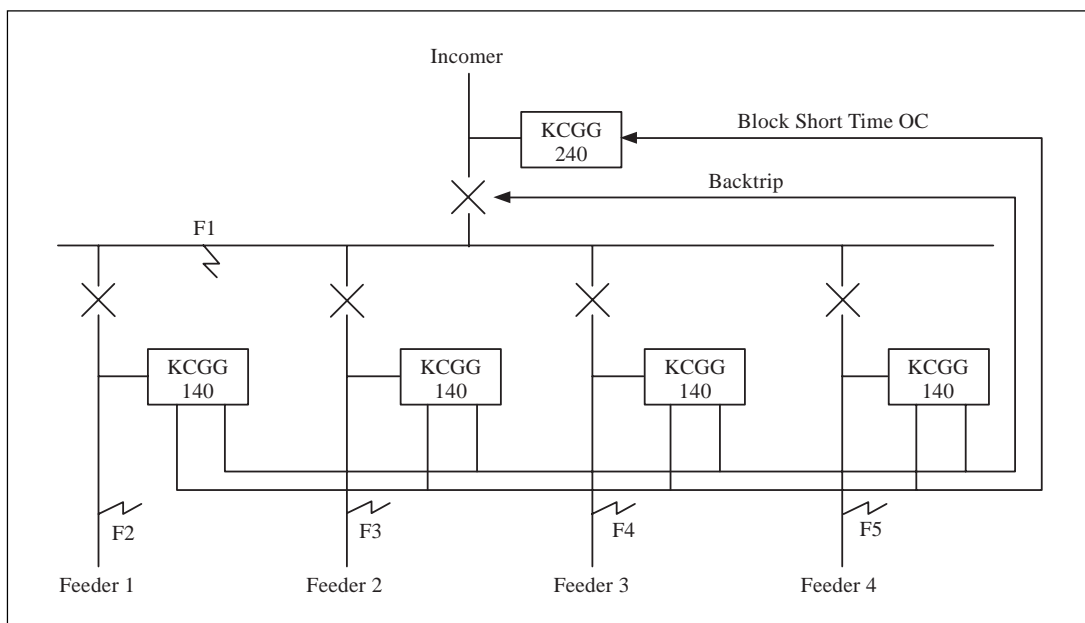


Figure 30. Simple busbar protection

4.2.3 Protection for busbars with multiple infeeds

Where there are multiple feeds to the busbar the START elements must be directionalized such that they will block operation of any relays on circuits feeding current to the busbar when they detect current flowing from the busbar to their associated feeder. Directional relays can be used to provide composite schemes of protection for the feeders and the busbar, using the non-cascade mode of operation.

Application of Midos K Range relays for single and double busbar protection is further described in publications R4112 and R4114.

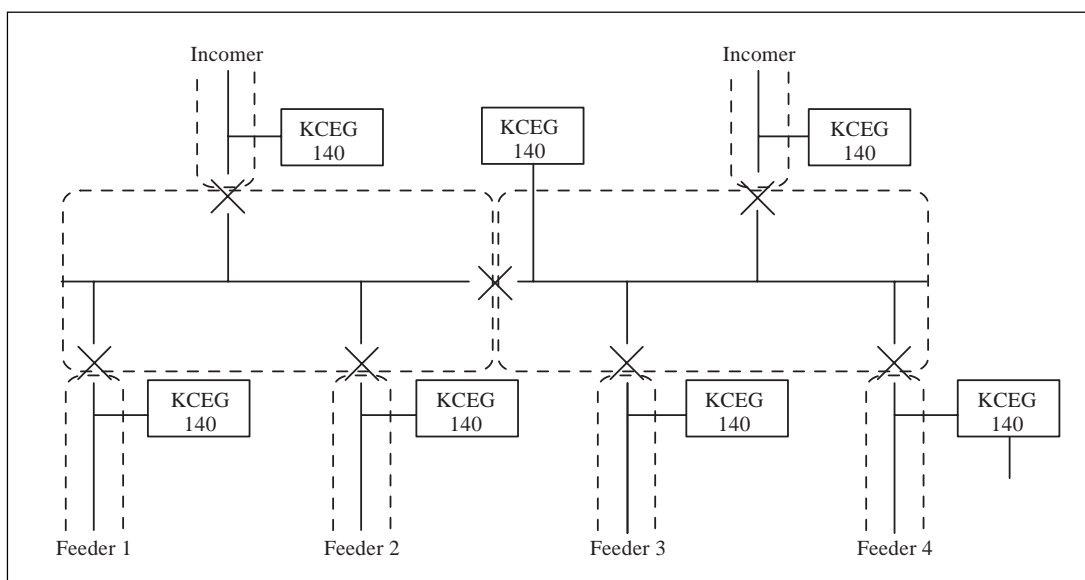


Figure 31. Protection of busbars with multiple infeeds

4.2.4 General points to consider in blocking applications

It is possible to separate the phase and earth fault START outputs and use them to block the respective elements of the upstream relay. However, if this is done then the effect of current transformer saturation during phase faults has to be considered. If the current transformers transiently saturate on one of the circuits, then a spill current is produced in the neutral circuit of the current transformers. This can result in one of two effects:

- 1) the current exceeds the threshold of the earth fault element then it will attempt to trip if it does not receive a blocking signal from a downstream relay. This will be an incorrect operation that may trip more circuits than necessary.
- 2) as a result of spill current, an earth fault element gives a blocking signal to the relay on the infeed for a short duration.

The problem from 1) above can be lessened by increasing the time setting of to>>, but this will reduce the benefits of non-cascade schemes. The solution to consider is to block the phase and earth fault trip elements with the phase and earth fault start elements of the downstream relays, but prevent blocking of the phase fault trip elements under transient current transformer saturation conditions. This will be most easily achieved by setting the earth fault element polarising voltage threshold (Vop) above the maximum expected zero sequence voltage occurring under healthy conditions, thus preventing the earth fault elements on the incoming feeder relay producing a blocking signal under transient CT saturation conditions.

Problem 2) may not be a problem at all if the transient spill current only lasts a short time, as the added delay caused by a spurious blocking signal will stabilize the protection for only a short time. If this is seen as a problem then the use of a stabilizing resistor could be considered.

Note: The response of directional overcurrent relays to power system disturbances will vary with the earthing arrangements. It is not practical to consider all configurations of the power system and so the application notes in this document can only be a general guide. Each application will need to be engineered to suit the system.

4.3 Application notes for directional overcurrent relays

4.3.1 Directional stability

Directional relays are required to withstand a fault in the reverse direction without operating. In addition the directional relay is required to remain stable (ie. not operate) when the reverse fault current is removed and the current falls to zero, or to a load value which is below the overcurrent setting of the relay and in a forward direction. With time delayed protection, directional stability is not usually a problem, but with directionalized instantaneous overcurrent relays it is much more difficult to achieve and momentary operation may occur when the fault is removed.

The software of the KCEG relays has been arranged to reduce transient operation to a minimum, but even so, it may be advisable to set the associated time delay for any directional overcurrent element to between 40 and 200ms, depending on the system X/R ratio and the maximum fault level, to ensure stability under this condition. When KCEG relays are used in blocking schemes they will have sufficient time delay settings applied. Therefore, it is only the instantaneous high set elements where the delay may need to be added and often these particular elements need not be directionalized.

4.3.2 Application of directional phase fault relays

The characteristic angle setting of the relay is the phase angle of the line current with respect to the polarizing voltage, in order to be at the centre of the directional characteristic. For the phase fault elements the fault current will usually be lagging by an angle of -45° to -60° and it is desirable that this is at the centre of the directional characteristic. However, the phase elements are polarized by the quadrature phase/phase voltage. Thus phase A is polarized by V_{bc} , but V_{bc} lags V_a by -90° , so that the effective polarizing angle of the relay for phase faults will be $(\phi_c - 90)^\circ$. Thus for most practical purposes the characteristic angle (ϕ_c) will be set to a leading angle of $+30^\circ$ or $+45^\circ$ for the phase elements.

The minimum operating value of the voltage input to the directional overcurrent relay should be as low as practicable from the aspect of correct directional response of the relay itself. This follows because of the important requirement for the relay to achieve correct directional response during a short circuit fault close to the relay when the voltage input can be below 1% of rated value. Furthermore, there is no restriction on the minimum operating value from the aspect of the power system or voltage transformer performance. Hence the threshold for the phase fault elements of the KCEG relays has been set at 0.5V.

4.3.3 Application of directional earth fault relays

The earth fault element uses the zero sequence voltage as the polarizing quantity. With multi-pole relays this voltage is internally derived from the three phase to neutral voltages applied to the relay. With single pole relays this voltage has to be externally derived from an open delta winding on the line voltage transformers, or via star/open delta interposing voltage transformers.

The characteristic angle setting for earth faults will be as shown on the relay and therefore lagging angles of between 0° and 60° may be used as appropriate, dependent on the system earthing arrangements.

A 0° setting is generally used on resistance earthed systems whereas a -45° setting would be more typical on solidly earthed distribution systems with -60° being typical on solidly earthed transmission systems.

When providing sensitive earth fault protection for an insulated system, a core balance current transformer should be used. Where this is oriented as for an earthed system i.e. with the relay looking down the feeder, the relay characteristic angle should be set to $+90^\circ$. If the current transformer is reversed, anticipating capacitive current flow from the feeder onto the busbar, -90° should be used.

For the protection of arc suppression (Petersen) coil earthed systems, a sensitive setting is required to enable accurate detection of the relatively small currents flowing under fault conditions. Angle settings in the region of $+5^\circ$ (lead), 0° , -5° (lag) are common, with the relays having suitably fine setting adjustments of 1° .

Two options exist within the K Range for protection of arc suppression (Petersen) coil earthed systems; a standard sensitive directional earth fault relay (KCGU110) or alternatively the KCEU141/241. Both relays have an adjustable polarising voltage threshold setting with the KCEU141/241 having an additional wattmetric ($V.I.\cos\phi$) earth characteristic. By virtue of these features either of the above options effectively ignore any residual spill current, resulting from mismatch of line CTs, due to the fact that there is negligible zero sequence voltage present under load conditions.

Where a directional relay is used to prevent sympathetic tripping of the earth fault element, which would otherwise result from the currents flowing via the cable capacitance to earth, an angle setting of $+45^\circ$ (lead) is recommended.

For earth faults the minimum operating value of the residual voltage input to the directional earth fault relay is determined by power system imbalance and voltage transformer errors. The zero sequence voltage on a healthy distribution system can be as high as 1.0%, also the voltage transformer error can be 1.0% per phase which results in a possible spurious residual voltage as high as 2.0% under healthy conditions. In order to take account of both of the foregoing quantities and thus eliminate unwanted relay operation, it is necessary to introduce a minimum operating value of up to 3.5%. In practice, a choice of settings of say 2.0% to 4.0% should be considered, with perhaps 10% and 20% for high resistance and insulated neutral systems respectively. The setting for $V_{op>}$ will be found in the EARTH FAULT setting column of the menu and should be set appropriately, taking the above notes into account.

Note: The KCEG 140 requires a residual voltage in excess of 6.4V before the voltage threshold circuit will function, regardless of the $V_{op>}$ setting. If this is considered to be a problem in a particular application then a KCEG 110 should be used for the earth fault protection and a KCEG 130 for the overcurrent protection.

4.3.4 Application of dual polarized earth fault relays

When the zero sequence voltage under fault conditions is likely to be very small, it may be advisable to use current polarization. In this case the current flowing in the neutral of the power transformer is used to polarize the relay. As for voltage polarization the threshold value of the current polarizing quantity is influenced by the power system unbalance. However, the essential difference is that current polarization is not affected by voltage transformer errors, nor indeed is it affected by neutral current transformer error. Hence, the threshold level for current polarization may be based on the maximum zero sequence current in a healthy system, that is, 0.5% of the neutral impedance rating. However, the neutral impedance rating is often greater than the feeder rating and hence a minimum operating current threshold of 0.5% of relay rating is required. This results in a recommended range of say 0.5% to 5.0% of relay rating.

The characteristic angle adjustment phase shifts the voltage polarizing vector only and therefore has no effect on the characteristic at the time when the relay is polarized from current. The characteristic angle for current polarization is fixed at 0° .

Only voltage polarized and dual polarized relays are available in the Type KCEG range of relays, with the dual polarized version being supplied when current polarization is requested. Dual polarized versions of the relay provide both current and voltage polarization via separate analogue/digital inputs. When the polarizing voltage exceeds the threshold setting $V_{op>}$, the relay will be polarized from the voltage source alone. If the voltage signal is below the threshold, the current signal is used to polarize the relay provided it exceeds the current threshold $I_{p>}$. When neither polarizing signal is above its threshold the relay is blocked from operating.

4.3.5 Directional stability for instantaneous elements

The directional information is calculated every 20ms on the last eight samples of the waveform from the analogue/digital converter. The first directional calculation after

the fault inception may be based on one or more of the samples that were captured before the fault. Hence the phase information will contain an element of uncertainty. However, subsequent calculations will be based on eight samples captured from the fault and operation will be correct.

Therefore, to ensure directional stability of the instantaneous elements during transitional conditions, such as the one described, the associated time delays $t_{>>}$, $t_{>>>}$, $t_{>>}$ and $t_{>>>}$ should be set to give a delay of between 40 and 200ms, depending on the system X/R and maximum fault level. In directional blocking schemes, for example those for providing busbar protection, there will already be other requirements for a delay setting.

4.4 Application notes for dual powered relays

4.4.1 Powered from current transformers alone

When powered from the current transformer circuit alone, the minimum current to operate the relay is that required to establish the power supply rails within the relay. Lowering the design value of this parameter increases the burden on the current transformers and the power dissipated within the relay case. The limits are therefore a compromise based on these factors:

Minimum current to power the relay for phase faults = $0.4I_n$

Minimum current to power the relay for earth faults = $0.2I_n$

However, a combined three phase and earth fault relay will operate with lower earth fault current settings when the load current in the protected circuit is sufficient to power the relay, ie. greater than $0.4I_n$. Settings less than $0.2I_n$ are provided for earth faults but they must be used with discretion. However, settings less than $0.2I_n$ should not be used for single pole earth fault relays that are powered from current alone.

When switching on to a fault, the relay will be delayed in operation by the start up time and this delay will need to be taken into account in any grading exercise.

The delay is the time taken by the processor to initialize its registers, read in settings from non-volatile memory and perform self checks. There will be an additional delay whilst the power supply builds up, but this will be less significant when using

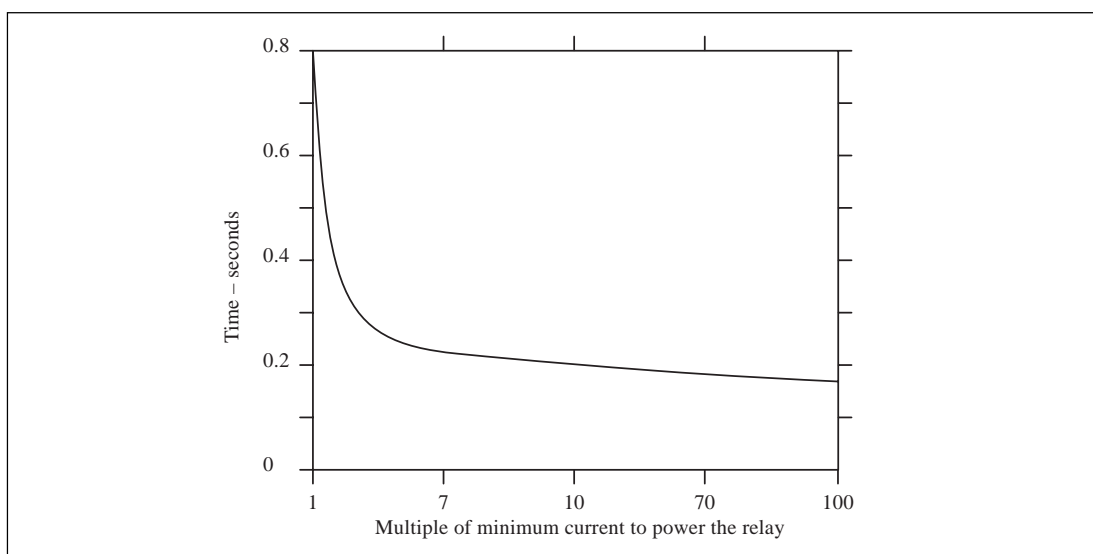


Figure 32. Start-up time delay

an inverse time/current characteristic as the power supply delay similarly varies with current. The start-up time is not reduced by lowering the Time Multiplier Setting. With prefault load current there will be no start-up time and the relays will operate within their normal time settings.

Note: Where the start-up delay cannot be tolerated it is recommended that the relay is also powered from an auxiliary ac voltage supply so that it can be up and running before a fault occurs. It will also make stored disturbance and event records more secure.

4.4.2 Powered from an auxiliary ac voltage and from current transformers

The addition of an auxiliary ac voltage supply to power the relay will:

- 1 enable the settings to be changed when the protected circuit is de-energized.
- 2 enable records to be retrieved and control functions to be carried out over the communication link.
- 3 reduce the burden on the line CTs.

Should the auxiliary voltage be lost during a fault, power will be drawn from the current transformer circuit to maintain the relay in a fully operational state. However, if the source of the auxiliary voltage is carefully chosen it is unlikely to be lost completely during earth faults but it may collapse to 50% of its rated value. Provided the voltage is still above the minimum required to power the relay, very low earth fault settings can be successfully applied. In the absence of the auxiliary voltage the relay is not guaranteed to operate for earth fault currents less than $0.2I_n$.

No alarm is given for loss of the ac auxiliary voltage, unless it is externally monitored by a separate supervision relay.

4.4.3 Special application notes for dual powered relays

Dual powered relays may be fitted with eight opto-isolated inputs and eight relay outputs, but at the claimed minimum operating current they cannot all be energized at the same time. If they are, then the minimum operation current will be increased. However, in applications requiring a dual powered relay it is unlikely that more than two output relays will be energized at any one time. The following table shows how the minimum operating current varies with the number of relays (not including the watchdog) and inputs that are to be energized at the same time.

Number of output relays energized	2	4	6	8
8 opto-inputs energized	$1.3 \times I_{min}$	$1.5 \times I_{min}$	$1.7 \times I_{min}$	$2.0 \times I_{min}$
6 opto-inputs energized	$1.3 \times I_{min}$	$1.4 \times I_{min}$	$1.6 \times I_{min}$	$1.8 \times I_{min}$
4 opto-inputs energized	$1.2 \times I_{min}$	$1.3 \times I_{min}$	$1.5 \times I_{min}$	$1.8 \times I_{min}$
2 opto-inputs energized	$1.1 \times I_{min}$	$1.2 \times I_{min}$	$1.4 \times I_{min}$	$1.6 \times I_{min}$

$I_{min} = 0.4I_n$ for phase faults and $0.2I_n$ for earth faults.

4.4.5 Dead substation protection

The dual powered relays derive power for the electronics and the trip coil of the circuit breaker from the line current transformers and optionally from an auxiliary ac voltage supply. Applying one of these relays on the incoming feeder to the substation will ensure that the substation is still protected in the event of complete failure of the trip battery supply.

The application limitations are that the setting range of these relays is a little more restricted when power is being derived from the current transformers alone and that the circuit breaker must have a suitable trip coil fitted. The tripping energy is provided by a 680 μ F capacitor charged to 50V and the circuit breaker should reliably trip when this capacitor is discharged into its trip coil. (See Section 3.6.6 for alternative trip connections).

4.5 Breaker fail protection, backtripping and back-up transfer tripping

4.5.1 Breaker fail protection and backtripping

If the function links have been set to activate the breaker fail function, then the blocking signals will be removed if the breaker fails to clear the fault within the set time delay (tBF). This will result in the START relays being reset, so allowing any relays that they were blocking to operate. It may be that the current setting of the blocked upstream relay is higher than the available fault current, so it is not able to clear the fault. In this case it would be an advantage to backtrip, sending a signal from the relay that is trying to trip the failed circuit breaker, directly to the next circuit breaker towards the source.

When the backtrip feature is selected the output relay is assigned via the output mask [Aux1] and will be recorded in the fault flags as Aux1. The time delay (tBF) will typically have a setting of 200 to 400 milliseconds.

An externally initiated breaker fail circuit can be arranged as described in Section 3.4.6 where time delay tAUX1 is the breaker fail time delay. This externally initiated breaker fail circuit does not reset the START relays.

Application of Midos K Range relays for circuit breaker fail is further described in publication R4115.

4.5.2 Back-up transfer tripping

Consider the radial feed arrangement shown in Figure 30 and repeated in miniature in Figure 33. The protection relay on the incomer provides two additional time delayed outputs: t>> with an 80ms delay if the downstream feeder relays are non-directional or 200ms if they are directional and t>>> with a delay of t>> plus grading margin. The t>> delay is for worst case conditions and may be reduced, depending on the system X/R and maximum fault level. The t>> output contact is wired through a normally open contact on the watchdog repeat relay, to the trip relay for the circuit breaker on the infeed. The t>>> output is wired directly to the trip relay for the circuit breaker on the infeed.

With all the relays in a healthy state, the watchdog repeat relay will be energized and for a busbar fault the circuit breaker on the incoming circuit will be tripped by t>>. For a fault on any of the outgoing feeders t>> and t>>> of the relay on the incoming circuit will be blocked by the start contact of the overcurrent relay on the outgoing feeder which is carrying the fault current. The circuit carrying the fault current will be tripped by the overcurrent relay on that circuit.

In the event of any relay on the outgoing circuits becoming defective, the watchdog repeat relay drops off to give an alarm and to transfer the t>> trip from the incoming circuit breaker to the buswire connected, via the watchdog break contact of each relay on the outgoing feeders, to the appropriate circuit breaker. Thus the trip will be transferred to the circuit breaker with the failed relay and so a fault on that circuit will be cleared without tripping the busbar. For a busbar fault the incoming circuit breaker will be tripped by t>>> after a short delay. For faults on any healthy outgoing feeder both t>> and t>>> of the incoming feeder will be blocked and correct discrimination will be obtained with only the faulted feeder being tripped.

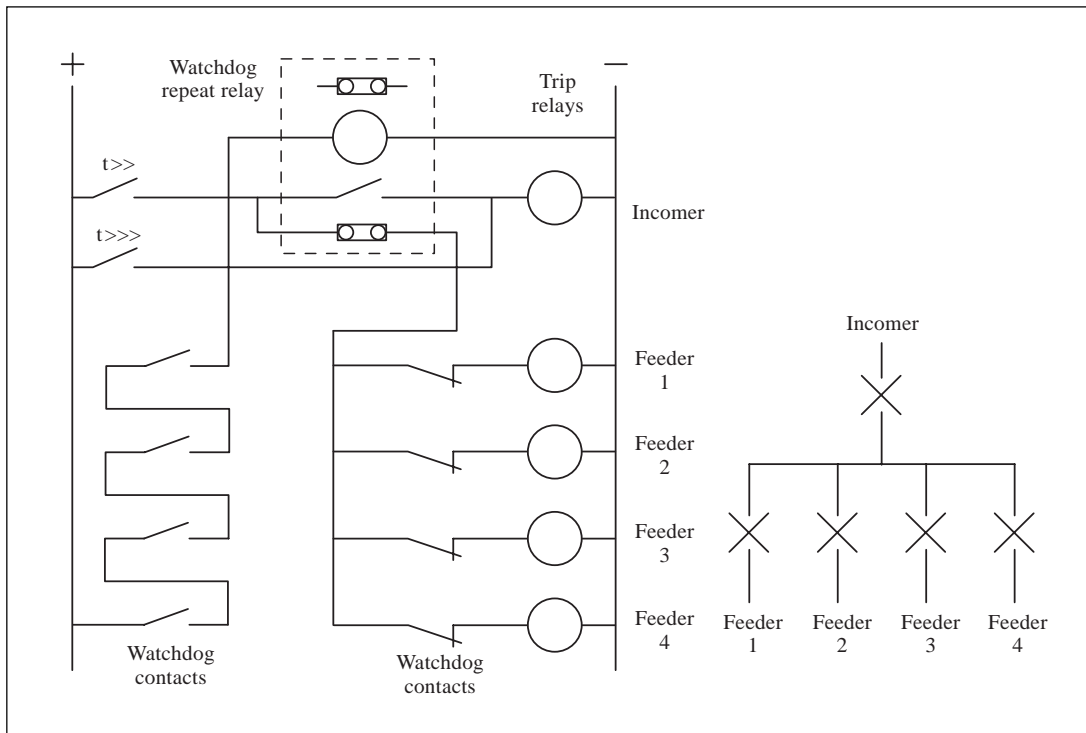


Figure 33. Back-up transfer tripping

4.6 Restricted earth fault

Where back-up overcurrent or differential protection does not provide adequate earth fault coverage of the secondary winding of a transformer, and where the winding of a medium to large transformer is arranged in delta, restricted earth fault protection is often applied. Restricted earth fault protection can be provided by a dedicated electro-mechanical relay, however, the earth fault element of a K Range relay can be arranged to offer comparable protection.

When the earth fault element ($I_{0>>}$) is connected in a restricted earth fault configuration a stabilizing resistor will be required to be connected in series with the neutral input circuit of the relay.

Application of Midos K Range relays for restricted earth fault protection is further described in publication R4120.

4.7 Further applications and control facilities

4.7.1 Protection against intermittent recurrent faults

This type of fault is also sometimes referred to as a pecking or flashing fault. A typical example of an intermittent recurrent fault would be one in a plastic insulated cable where, in the region of the fault, the plastic melts and reseals the cable, extinguishing the fault but after a short time the insulation breaks down again. The process repeats to give a succession of fault current pulses each of increasing duration with reducing intervals between the pulses, until the fault becomes permanent.

When the reset time of the overcurrent relay is less than the interval between the fault current pulses the relay will be continually reset and not be able to integrate up to the trip level until the fault becomes permanent. Having the reset time set to give as long a delay as possible, but less than that which would interfere with normal

operation of the protection and control system, will help to eliminate some less common health and safety problems.

Overcurrent relays in Midos K Range have provision for adjusting the reset delay to values between 0 and 60 seconds for timers $t_{>/to>}$. Reset times of 60 seconds are most suited to cable applications where autoreclose is not generally permitted. For overhead lines with fast reclosing equipment, it can be an advantage to set the reset time to zero; this will ensure that all relays will have fully reset before a reclosure takes place and that some relays will not be held part way towards operation as a result of the last fault.

When grading with electro-mechanical relays which do not reset instantaneously, the reset delay can be used to advantage to gain closer discrimination. In these instances the reset time should be set to a value less than the dead time setting of any autoreclose relays on the system. Sensitive earth fault relays will also benefit from having the reset time set as high as possible so that fault current pulses are summated.

Any reset delay will give an improvement in the detection of intermittent faults.

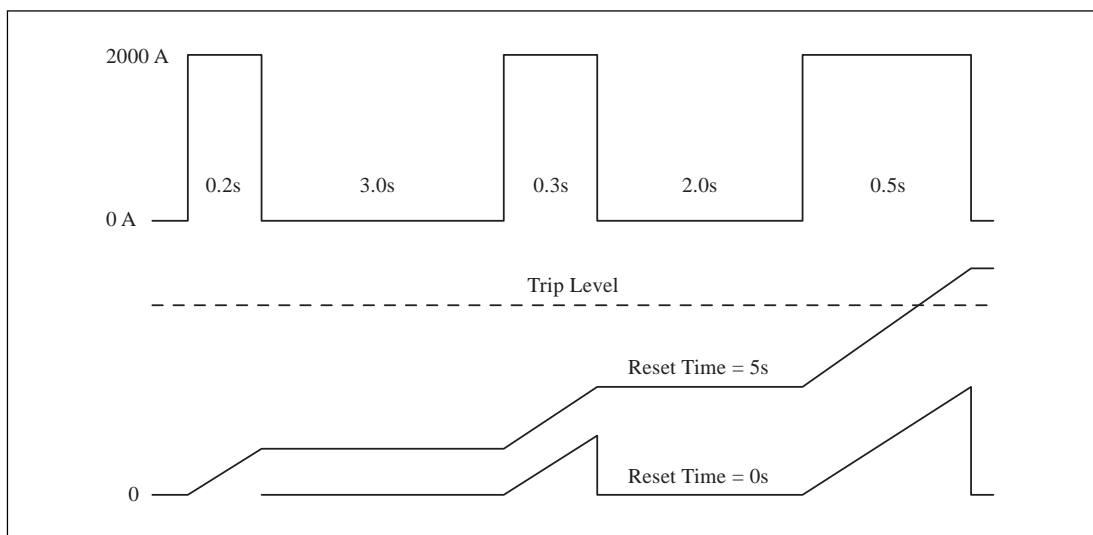


Figure 34. Protection against intermittent faults

4.7.2 Autoreclose inhibition of instantaneous low set

When overcurrent relays from the Midos K Range are used with autoreclose relays the $I_{>>/I_o>>}$ elements may be used as low set instantaneous elements.

The associated time delays $t_{>>/to>>}$ would be set to zero seconds to effect rapid fault clearance. Although the timer is set to zero, its output still may be blocked, via one of the control inputs to the relay, on successive autoreclose cycles to inhibit the instantaneous trip element. Blocking the element, instead of the trip path, with a contact of the autoreclose relay will ensure correct flagging at all times.

Where lightning strikes are frequent, it can be an advantage to make the $I_{>>/I_o>>}$ setting equal to $I_{>/I_o>}$, in order to detect the maximum number of transient faults.

4.7.3 Additional fourth overcurrent stage

As described in Section 3.4.5 auxiliary timer 3 (tAUX3) can be used in conjunction with the undercurrent element to provide a fourth time delayed overcurrent and earth fault stage. If $I_{<}$ is set to a low threshold value the output can be used as an alarm to

indicate current flow in the feeder. With the threshold set above load current, an additional overcurrent stage is available for shaping the overall time current characteristic of the relays. This stage may suffer from transient overreach when very low time settings are applied.

4.7.4 Cold load start/pick-up for grading with motor starting

The cold load pick-up feature may be used to assist in grading overcurrent relays with motor starting currents by lifting the curves above the motor starting characteristic.

In the example shown in Figure 35, the motor starting current encroaches into the operation zone of the overload characteristic provided by $t > t_o$. If this setting is increased by the cold load feature, it will allow the motor to start and then return the protection settings to more appropriate values.

It is not suggested that this arrangement will eliminate the need for motor protection because it does not model the thermal characteristics of the motor. However it can provide some basic overcurrent protection

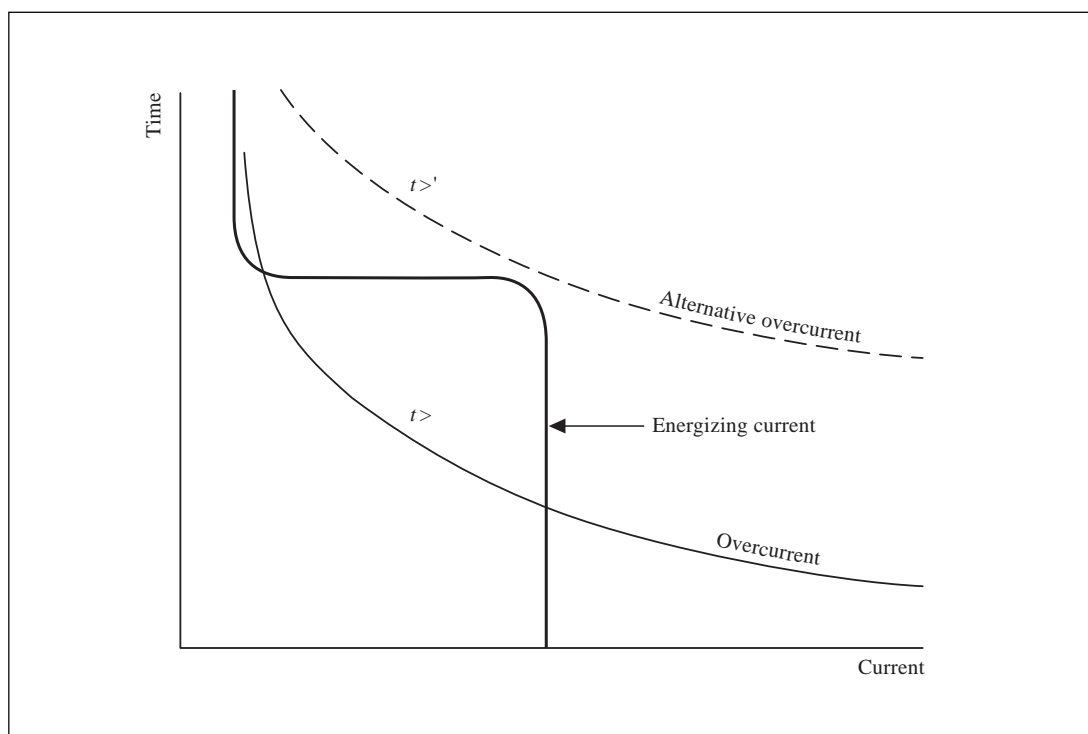


Figure 35. Energizing currents

4.7.5 Sensitivity to transformer inrush currents

Either the $I_{>>}/I_o$ elements, or the $I_{>>>}/I_o$ elements, may be used as high-set instantaneous elements. The design is such that they will not respond to the transient component of the fault current and so may be set closer to motor starting current level.

The principles used should allow the instantaneous elements to be set down to 35% of the anticipated peak transformer inrush current. To a first approximation the peak inrush is given by the reciprocal of the per unit series reactance of the transformer.

Use of the cold load pick up feature, to increase the time setting for the instantaneous elements when energizing the primary circuit, may also be considered as a way of allowing lower current thresholds to be used.

4.7.6 Circuit breaker control

It is generally recommended that separate output relays are allocated for remote circuit breaker control. This enables the control outputs to be selected via a local/remote selector switch mounted on the circuit breaker (sometimes a health and safety requirement). Where this feature is not required the same output relay(s) can be used for both protection and remote tripping.

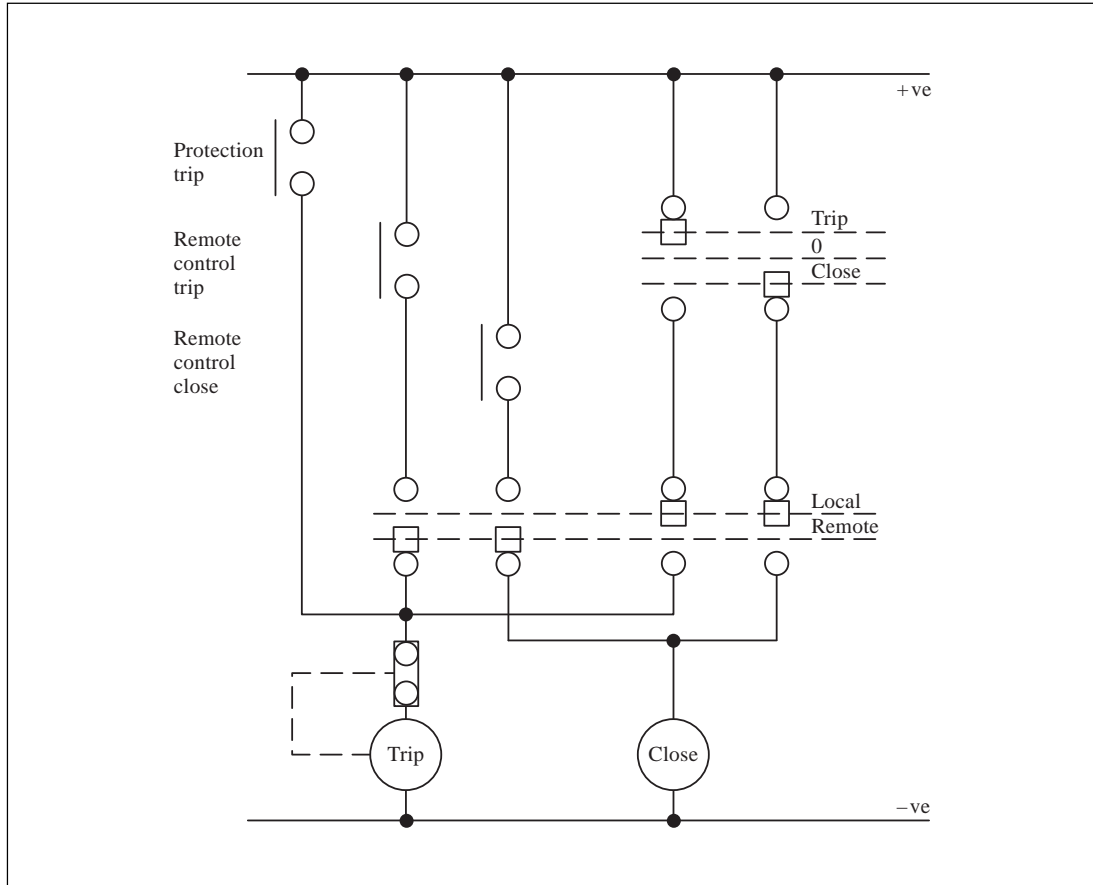


Figure 36. Remote control of circuit breaker

4.7.7 Load shedding

Load shedding by tripping less important loads can also benefit from the control connections shown in the remote control diagram (Figure 36). Where load restoration is being used it will be necessary to provide for both tripping and closing of the circuit breaker via the relay. The time delay ($t_{RESTORE}$) may be set to different values for each circuit so that the reclosures of the circuit breakers are staggered.

Note: If the auxiliary supply to the relay is removed for a short period of time, the relay will not remember that it tripped for a load shed command. This will result in the relay not responding to a restoration command.

Section 5. TECHNICAL DATA

5.1 Ratings

5.1.1 Inputs

Reference Current (In)	Nominal Rating	Continuous	3 Seconds	1 Second
Auxiliary powered	In = 1A	3.2In	30In	100A
	In = 5A	3.2In	30In	400A
Dual powered	In = 1A	2.4In	30In	100A
	In = 5A	2.4In	30In	400A
Reference Voltage (Vn)	Nominal Range	Maximum Withstand Value		
Polarizing voltage	0 – 327V phase/neutral	375V		
Vn = 110V	0 – 327V phase/phase			
	0 – 327V 3x(zero sequence)			
Auxiliary Voltage (Vx)	Nominal Rating	Operative Range		Absolute
		DC Supply	AC 50/60Hz	Maximum
Auxiliary powered	24 – 125V ac/dc	19 – 150V	50 – 133V	190V crest
	48 – 250V ac/dc	33 – 300V	87 – 265V	380V crest
Dual powered	100 – 250V ac/dc	60 – 300V	60 – 265V	380V crest
Frequency (Fn)	Nominal Rating	Reference Range		
Frequency tracking	50 Hz or 60 Hz	45-65Hz		
Non tracking	50 Hz or 60 Hz	47-52.5Hz or 57-63Hz		
Opto-Isolated Inputs	Nominal Rating	Off Voltage	On Voltage	
Supply	60V dc only	≤12V dc	≥35V dc	
Maximum withstand	60V dc			

5.1.2 Outputs

Field Voltage	48V dc (Current limited to 60mA)
Capacitor Trip	50V dc (680 microfarad capacitor) Energy = 0.85J

5.2 Burdens

5.2.1 Reference current circuit

Auxiliary powered	Phase	Earth	SEF	
In = 1A	0.04	0.08	0.18	ohms at In
In = 1A	0.07	0.07	0.07	ohms at 30In
In = 5A	0.006	0.008	0.012	ohms at In
In = 5A	0.006	0.008	0.007	ohms at 30In

Dual powered		Phase	Earth	SEF	
In = 1A		0.58	2.7	2.6	ohms at 0.5 In for V _x = 110V
		0.45	2.3	2.2	ohms at In for V _x = 110V
		0.37	2.0	2.0	ohms at 2 In for V _x = 110V
		0.33	1.9	1.8	ohms at 5 In for V _x = 110V
		0.31	1.9	1.7	ohms at 10 In for V _x = 110V
		0.31	1.9	1.7	ohms at 20 In for V _x = 110V
		0.31	1.7	1.5	ohms at 30 In for V _x = 110V
In = 1A		8.1	27.3	29.9	ohms at 0.5 In for V _x = 0V
		5.4	11.3	12.4	ohms at In for V _x = 0V
		2.1	5.2	5.6	ohms at 2 In for V _x = 0V
		0.8	2.6	2.6	ohms at 5 In for V _x = 0V
		0.46	2.0	2.0	ohms at 10 In for V _x = 0V
		0.35	1.8	1.8	ohms at 20 In for V _x = 0V
		0.32	1.6	1.6	ohms at 30 In for V _x = 0V
In = 5A		0.034	0.106	0.108	ohms at 0.5 In for V _x = 110V
		0.027	0.088	0.089	ohms at In for V _x = 110V
		0.024	0.078	0.079	ohms at 2 In for V _x = 110V
		0.022	0.072	0.071	ohms at 5 In for V _x = 110V
		0.021	0.071	0.068	ohms at 10 In for V _x = 110V
		0.021	0.069	0.066	ohms at 20 In for V _x = 110V
		0.021	0.062	0.064	ohms at 30 In for V _x = 110V
In = 5A		0.333	1.082	1.219	ohms at 0.5 In for V _x = 0V
		0.220	0.454	0.500	ohms at In for V _x = 0V
		0.091	0.207	0.225	ohms at 2 In for V _x = 0V
		0.037	0.103	0.101	ohms at 5 In for V _x = 0V
		0.026	0.078	0.077	ohms at 10 In for V _x = 0V
		0.022	0.073	0.071	ohms at 20 In for V _x = 0V
		0.021	0.070	0.066	ohms at 30 In for V _x = 0V
5.2.2	Polarizing current circuit		Earth	SEF	
	Polarizing current		0.08	0.18	ohms for In = 1A
			0.008	0.012	ohms for In = 5A
5.2.3	Reference voltage circuit				
	Polarizing voltage		0.02 VA at 110V	phase/neutral	
			0.15 VA at 327V	phase/neutral	
5.2.4	Auxiliary voltage				
	DC supply	2.5 – 6.0 W at V _x max with no output relays or logic inputs energized			
		4.0 – 8.0 W at V _x max with 2 output relays and 2 logic inputs energized			
		5.5 – 12 W at V _x max with all output relays and logic inputs energized			
	AC supply	6.0– 12 VA at V _x max with no output relays or logic inputs energized			
		6.0 – 14 VA at V _x max with 2 output relays and 2 logic inputs energized			
		13 – 23 VA at V _x max with all output relays and logic inputs energized			

5.2.5 Opto-isolated inputs

DC supply 0.25W per input (50V 10k Ω)

5.3 Overcurrent setting ranges

5.3.1 Auxiliary powered relays

		Threshold (Is)	Step size
Phase fault	I>	0.08 – 3.2In	0.01In
	I>>	0.08 – 32In	0.01In
	I>>>	0.08 – 32In	0.01In
	I<	0.02 – 3.2In	0.01In
Standard earth fault	Io>	0.02 – 0.8In	0.0025In
	Io>>	0.02 – 8.0In	0.0025In
	Io>>>	0.02 – 8.0In	0.0025In
	Io<	0.005 – 0.8In	0.0025In
Sensitive earth fault	Io>	0.002 – 0.08In	0.00025In
	Io>>	0.002 – 0.8In	0.00025In
	Io>>>	0.002 – 0.8In	0.00025In
	Io<	0.0005 – 0.08In	0.00025In
Reset	General	0.95Is	

5.3.2 Dual powered relays

		Threshold (Is)	Step size
Phase fault	I>	0.4 – 2.4In	0.01In
	I>>	0.4 – 32In	0.01In
	I>>>	0.4 – 32In	0.01In
	I<	0.02 – 3.2In	0.01In
Standard earth fault	Io>	0.02 – 0.8In	0.0025In
	Io>>	0.02 – 8.0In	0.0025In
	Io>>>	0.02 – 8.0In	0.0025In
	Io<	0.005 – 0.8In	0.0025In
Sensitive earth fault	Io>	0.002 – 0.08In	0.00025In
	Io>>	0.002 – 0.8In	0.00025In
	Io>>>	0.002 – 0.8In	0.00025In
	Io<	0.0005 – 0.08In	0.00025In
Reset	General	0.95Is	

Note: Operation is not guaranteed for earth faults below 0.2In, regardless of the actual setting, when the load current is below 0.4In and the auxiliary voltage is not available. See also the special application notes for dual powered relays and the table in Section 4.4.3 regarding the maximum number of outputs and inputs that may be energized at any one time.

5.4 Time setting ranges

5.4.1 Inverse definite minimum time (IDMT)

$$t = \frac{K \times [TMS]}{(I/I_s)^\alpha - 1}$$

Where

t = operation time

K = constant

I = fault current

I_s = current threshold setting

α = constant

TMS = time multiplier (0.025 to 1.2 in steps of 0.025)

Curve description	Name	Constants		Minimum operation
Short time inverse	(STI30XDT)	K = 0.05	α = 0.04	1.05I _s
Standard inverse	(SI30XDT)*	K = 0.14	α = 0.02	1.05I _s
Inverse	(IN30XDT)	K = 9.4	α = 0.7	1.05I _s
Very inverse	(VI30XDT)*	K = 13.5	α = 1	1.05I _s
Extremely inverse	(EI20XDT)*	K = 80	α = 2	1.05I _s
Extremely inverse	(EI10XDT)	K = 80	α = 2	1.05I _s
Long time inverse	(LT30XDT)	K = 120	α = 1	1.05I _s

* IEC standard characteristic

5.4.2 Definite Independent time

		Setting range	Step size
t ₀ >/t>	Definite time	0 to 100 s	0.01s
tRESET	Definite time	0 to 60 s	0.1s
t ₀ >>/t>>	Definite time	0 to 100 s	0.01s
t ₀ >>>/t>>>	Definite time	0 to 10 s	0.01s

5.4.3 Auxiliary time delays

		Setting range	Step size
tV<	Definite time	0 to 10s	0.01s
tAUX1	Definite time	0 to 14.4ks(4Hrs)	0.01, 0.1, 1 or 10s
tAUX2	Definite time	0 to 14.4ks (4Hrs)	0.01, 0.1, 1 or 10s
tAUX3	Definite time	0 to 14.4ks (4Hrs)	0.01, 0.1, 1 or 10s
tCLP	Definite time	0 to 14.4ks (4Hrs)	0.01, 0.1, 1 or 10s
tBF	Definite time	0 to 10s	0.01s
tTRIP	Definite time	0.5 to 2s	0.1s
tCLOSE	Definite time	0.5 to 2s	0.1s
tRESTORE	Definite time	0 to 100s	0.01s

5.4.4 Measurement (Displayed)

Voltage	$(0 - 327) \times VT \text{ ratio}$	volts phase/neutral
Current	$(0 - 64)I_n \times CT \text{ ratio}$	amps per phase
Power	$(0 - 9.999) \times 10^{21}$	Watts
VAr	$(0 - 9.999) \times 10^{21}$	VAr
VA	$(0 - 9.999) \times 10^{21}$	VA
CB Operations	$(0 - 65535)$	
Current ² broken	$(0 - 9.999) \times 10^{21}$	A ²
Frequency	45 – 65	Hz

5.5 Directional settings

Characteristic angle (ϕ_c)	$-95^\circ \dots 0^\circ \dots +95^\circ$	
Operating boundary	$\phi_c \pm 90^\circ$	
Undervoltage ($V <$)	1V to 220V	phase to phase
Voltage threshold $V_{p>}$	0.5V (fixed)	overcurrent directional elements
Voltage threshold	0.5V to 22V	directional earth fault
Current threshold $I_{p>}$	$0.005I_n$ to $0.05I_n$ (dual polarized only)	

Note: The KCEG 140 requires a residual voltage in excess of 6.4V before the voltage threshold circuit will function, regardless of the V_{op} setting. If this is considered to be a problem in a particular application then a KCEG 110 should be used for the earth fault protection and a KCEG 130 for the overcurrent protection.

Additional settings for the KCEU141/241

Voltage threshold $V_{op>}$	0.6V – 22V	
Characteristic angle (ϕ_c)	$-180^\circ \dots 0^\circ \dots +180^\circ$	
$P_{o>}$ (1A)	0 – 20W	50mW steps
$P_{o>}$ (5A)	0 – 100W	250mW steps

5.6 Ratios

CT ratios	9999 : 1	Default = 1 : 1
VT ratios	9999 : 1	Default = 1 : 1

5.7 Accuracy

5.7.1 Reference conditions

Ambient temperature	20°C
Frequency	50Hz or 60Hz (whichever is set)
Time multiplier setting	1.0
Auxiliary voltage	24V to 125V (aux powered) 48V to 250V (aux powered) 100V to 250V (dual powered)
Fault Position	Within $\pm 80^\circ$ of the RCA where appropriate.

5.7.2 Current

Undercurrent	Minimum operation $\pm 10\%$ ($> 4 \times$ minimum setting) $\pm 20\%$ ($< 4 \times$ minimum setting)
--------------	--

	Overcurrent	Minimum operation	±5%	
		Reset	±5%	
		Repeatability	±2.5%	
5.7.3	Time delays			
				Reference range
	Operating time (t>/to>)	ST, SI, IN, VI, LT	±5% + (20 to 40)ms	2Is to 30Is
		Extremely inv (EI)	±7.5% + (20 to 40)ms	2Is to 20Is
		Definite time	±0.5% + (20 to 40)ms	3Is to 30Is
	Operating time (t>>/t>>>)	Definite time	±0.5% + (10 to 45)ms	3Is to 30Is
		(to>>/to>>>)		
	Repeatability	Inverse time	±2% ±40ms	
		Definite time	±0.5% or 10ms	
	Overshoot time	Less than 50ms	when current reduced to zero.	
	Reset time t>/to>	Definite time	±1% ±50ms	
	Disengagement	I<	typically 35ms	
		I>/Io>	typically 30ms	
		t>/to>	typically 30ms*	
		t>>/to>>	typically 50ms*	
		t>>>/to>>>	typically 50ms*	
	* Minimum dwell	[disengagement time is affected if measuring circuit resets within 100ms of pick-up. For further information see Section 3.6.5.1.]		
5.7.4	Directional			
	Characteristic angle ϕc	0°		
	Operating boundary	ϕc ± 90° accuracy ±2°		
	PU – DO differential	less than 3° (typically <1°)		
	Polarizing voltage(Vp>)	±10% (at ϕc ±80°)		
	Polarizing voltage(Vop>)	±10% (at ϕc ±80°)		
	Polarizing current(Ip>)	±10% (at ϕc ±80°)		
	Undervoltage (V<)	±10% (at ϕc ±80°)		
	Undervoltage delay (tV<)	±0.5%+(50 to 70)ms		
5.7.5	Auxiliary timers			
	Operating time	±0.5% or +(15 to 35)ms		
	Disengagement time	0 to 10 ms (for timers alone)		
		15 to 30ms (including output relays and opto-inputs)		
	Breaker Fail Timer tBF	±0.5% or ±10ms		

5.7.6	Measurements	
	Voltage	$\pm 2\% V_n$ (typical) - Reference range = 1 to 320V
	Current	$\pm 2\% I_n$ (typical) - Reference range = setting range
	Power	$\pm 4\% P_n$ (typical)
	VAr	$\pm 4\% P_n$ (typical)
	VA	$\pm 4\% P_n$ (typical)
	Frequency (45-65Hz)	$\pm 1\% F_n$ (typical)
	Wattmetric characteristic	$\pm 4\%$ (typical)

5.8 Influencing quantities

5.8.1	Ambient temperature	
	Operative range	-25 to +55°C
	Current settings	1%
	Voltage settings	0.03% per °C
	Operation times	1%
	Angle measurement	2°
5.8.2	Frequency	
	With frequency tracking	
	Operative range	46 to 65Hz
	Current setting	$\pm 1\%$
	Voltage settings	$\pm 1\%$
	Operating times	1%
	Angle measurement	<1°
	Without frequency tracking (KCGG 110/210, KCGU 110, KCEG 110/210/160 KCEU 110/160)	
	Operative range	47 to 52.5Hz or 57 to 63Hz
	Current setting	$\pm 5\%$
	Voltage settings	$\pm 5\%$
	Operating times	2%
	Angle measurement	2°
5.8.3	Auxiliary supply	
	Nominal	Operative range
		24/125V 19 to 150V dc (aux powered)
		50 to 133V ac (aux powered)
		48/250V 33 to 300V dc (aux powered)
		87 to 265V ac (aux powered)
		100/250V 60 to 300V dc (dual powered)
		60 to 265V ac (dual powered)

	Current settings	0.5%
	Voltage settings	0.5%
	Operation times	0.5%
	Angle measurement	0.5°
5.8.4	System X/R	
	Transient overreach	<5%
	Effect upon directional characteristics	
	Effect upon Operating Times (fault 45° from RCA)	
		<40ms (X/R <30, I ≥ 5Is)
		<75ms (X/R ≤90, I ≥5Is)
	Minimum protection time delay for directional stability (fault 45° from RCA)	
		40ms (X/R ≤ 15, I ≤ 40In)
	Additional time delay incurred for forward direction fault (45° from RCA)	
		≤60ms (X/R ≤ 5, I ≤16In)
		≤100ms (X/R ≤ 15, I ≤40In)
5.9	Opto-isolated inputs	
	Capture time	12.5 ±2.5ms at 50Hz
		10.4 ±2.1ms at 60Hz
	Release time	12.5 ±2.5ms at 50Hz
		10.4 ±2.1ms at 60Hz
	Minimum operating voltage	>35V dc
	Input resistance	10kΩ
	Maximum series lead resistance	2kΩ for single input at 40V min. 1kΩ for 2 inputs in parallel at 40V min. 0.5kΩ for 4 inputs in parallel at 40V min.
	Maximum ac induced loop voltage	50Vrms (thermal limit)
	Maximum capacitance coupled ac voltage	250Vrms via 0.1μF
5.10	Contacts	
	Output relays 0 to 7	
	Type	2 make contacts connected in series
	Rating	
	Make	30A and carry for 0.2s
	Carry	5A continuous
	Break	DC – 50W resistive 25W inductive (L/R = 0.04s) AC – 1250VA (maximum of 5A)
	Subject to maxima of 5A and 300V	

Watchdog

Type	1 make + 1 break
Rating	Make 10A and carry for 0.2s
	Carry 5A continuous
	Break DC – 30W resistive
	DC – 15W inductive (L/R = 0.04s)
	AC – 1250VA (maximum of 5A)
	Subject to maxima of 5A and 300V

Durability

Loaded contact	10,000 operations minimum
Unloaded contact	100,000 operations minimum

5.11 Operation indicator

3 Light Emitting Diodes – internally powered.

16 character by 2 line Liquid Crystal Display (with backlight).

5.12 Communication port

Language	Courier
Transmission	Synchronous – RS485 voltage levels
Format	HDLC
Baud Rate	64k/bit per second
K-Bus Cable	Screened twisted pair
K-Bus cable length	1000m of cable.
K-Bus Loading	32 units (multidrop system)

5.13 Current transformer requirements

CT requirements for use in typical applications are shown below. These CT requirements are based on a maximum prospective fault current of 50x relay rated current (I_n) and the relay having a maximum high set setting of 25x rated current (I_n). The CT requirements are designed to provide operation of the phase and earth fault elements.

Where the criteria for a specific application are in excess of those detailed above or the actual lead resistance exceeds the limiting value quoted, the CT requirements may need to be increased. CT requirements for a variety of further applications are provided in publication R6096.

Auxiliary powered relays

KCGG1--, KCEG1--, KCGU1--, KCEU1--, KMPC

Relay and CT secondary rating (A)	Nominal output (VA)	Accuracy class	Accuracy limit factor (x rated current)	Limiting lead resistance -one way (ohms)
1	2.5	10P	20	1.3
5	7.5	10P	20	0.11

Dual/self powered relays

KCGG2--, KCEG2--, KCGU2--, KCEU2--,

Relay and CT secondary rating (A)	Nominal output (VA)	Accuracy class	Accuracy limit factor (x rated current)	Limiting lead resistance -one way (ohms)
1	7.5	10P	10	0.8
5	10	10P	20	0.17

Where the K Range relays are being used for Restricted Earth Fault protection the CTs must be sized to assure stability as described in publication R4120.

The CT requirements for auxiliary powered relays can be used for the KMPC, but the following points should also be considered:

The accuracy class should be chosen depending upon the required accuracy of measurement.

Limits of error for accuracy class 5P and 10P

Accuracy class	Current error at rated primary current (%)	Composite error (%) at rated accuracy limit
5P	±1	±5
10P	±3	±10

The accuracy limit factors detailed above should be used to ensure full range fault recording.

Where sensitive earth fault protection is required, core balance CTs (Ferranti effect CTs) may be used.

5.14 High voltage withstand

5.14.1 Insulation IEC60255-5: 1977

2.0kVrms for one minute between all terminals and case earth.

2.0kVrms for one minute between terminals of independent circuits, including contact circuits.

1.5kVrms for one minute across open contacts of output relays 0 to 7.

1.0kVrms for one minute across open contacts of the watchdog relay.

5.14.2 Impulse IEC60255-5: 1977

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

5.14.3 Insulation resistance IEC60255-5: 1977

> 100 MΩ

5.15 Electrical Environment

5.15.1 DC supply interruptions IEC60255-11: 1979

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

- 5.15.2 AC ripple on dc supply IEC60255-11: 1979
The relay shall withstand 12% ac ripple.
- 5.15.3 High frequency disturbance IEC60255-22-1: 1988
Class III – 2.5kV peak between independent circuits and case.
– 1.0kV peak across terminals of the same circuit.
No additional tolerances are required for the operating time or the unit's thresholds.
- 5.15.4 Electrostatic discharge
IEC60255-22-2: 1989 Class III (8.0kV) - discharge in air with cover in place.
IEC60801-2: 1991 Level 2 (4.0kV) - point contact discharge with cover removed.
No additional tolerances are required for the operating time or the unit's thresholds.
- 5.15.5 Fast transient disturbance
IEC60255-22-4: 1992 Class IV (4.0kV, 2.5kHz) applied directly to auxiliary supply and watchdog relay.
IEC60801-4: 1988 Level 3 (2.0kV, 5kHz) applied directly to all inputs.
No additional tolerances are required for the operating time or the unit's thresholds.
- 5.15.6 Radio frequency interference
EMC Compliance
89/336/EEC Compliance with the European Commission Directive on
EN50081-2: 1994 EMC is claimed via the Technical Construction File route.
EN50082-2: 1995 Generic standards were used to establish conformity.
- 5.16 Atmospheric Environment**
- 5.161 Temperature
IEC60255-6: 1988 Storage and transit –25°C to +70°C
Operating –25°C to +55°C
IEC60068-2-1: 1990 Cold
IEC60068-2-1: 1974 Dry Heat
- 5.16.2 Humidity
IEC60068-2-3: 1969 56 days at 93% relative humidity and 40°C
- 5.16.3 Enclosure protection
IEC60529: 1989 IP50 (Dust protected)

5.17 Mechanical Environment

5.17.1 Vibration

IEC60255-21-1: 1988 Response Class 1
Endurance Class 1

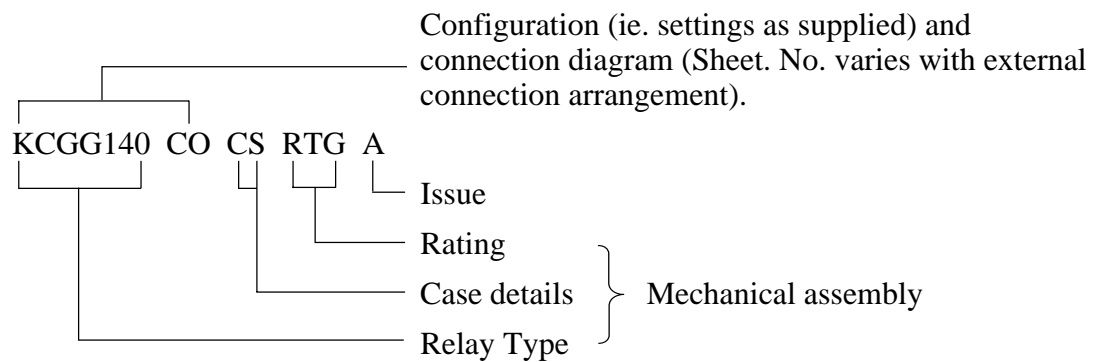
5.17.2 Shock and bump

IEC60255-21-2: 1988 Shock response Class 1
Shock withstand Class 1
Bump Class 1

5.17.3 Seismic

IEC60255-21-3: 1993 Class 1

5.18 Model numbers



KCEG 1XX

- 0 – First Version
- 1 – Single pole E/F
- 2 – Two pole Ph/F
- 3 – Three pole Ph/F
- 4 – Three pole Ph/F + E/F
- 5 – Three pole Ph/F + DEF (only used for KCEG/KCEU)
- 6 – Dual Polarized E/F (only used for KCEG/KCEU)
- 1 – Auxiliary Powered (V)
- 2 – Dual Powered (V&I)
- G – General application
- U – Sensitive E/F
- E – Directional
- G – Overcurrent
- C – Current (measured quantity)
- K – K Range Midos

CO

- 01 – Standard configuration

CS

- 1 – Back connected flush mounting (standard mounting)
May be used as an additional digit for configuration later
- D – Midos case size 4
- F – Midos case size 6
- H – Midos case size 8

RTG

- E – Standard (English text)
- A – $V_n = 0V$ $I_n = 0A$
- C – $V_n = 0V$ $I_n = 1A$ 50/60Hz
- E – $V_n = 0V$ $I_n = 5A$ 50/60Hz
- F – $V_n = 0V$ $I_n = 5A$ (equal PF and EF sensitivity) 50/60Hz
- G – $V_n = 0V$ $I_n = 5A$ (PF) + $1A$ (EF) 50/60Hz
- J – $V_n = 57 - 120V$ $I_n = 0A$
- L – $V_n = 57 - 120V$ $I_n = 1A$ 50/60Hz
- M – $V_n = 57 - 120V$ $I_n = 5A$ 50/60Hz
- N – $V_n = 57 - 120V$ $I_n = 5A$ (equal PF and EF settings) 50/60Hz
- P – $V_n = 57 - 120V$ $I_n = 5A$ (PF) + $1A$ (EF) 50/60Hz
- 2 – $V_x = 24 - 125V$ ac/dc (Auxiliary powered version)
- 5 – $V_x = 48 - 250V$ ac/dc (Auxiliary powered version)
- 9 – $V_x = 100 - 250V$ ac/dc (Dual powered version)

Note: Initial production relays will have the reference voltage rating marked as $V_n = 110V$ and for later models this will be marked 57-120V. The voltage rating and operational range is the same for both marked ratings and the only difference is in the label affixed to the relay.

5.19 Frequency response

The operating criteria for each element have been chosen to suit the applications for which it is most likely to be used. Knowing how these elements respond under operating conditions will help to apply them effectively.

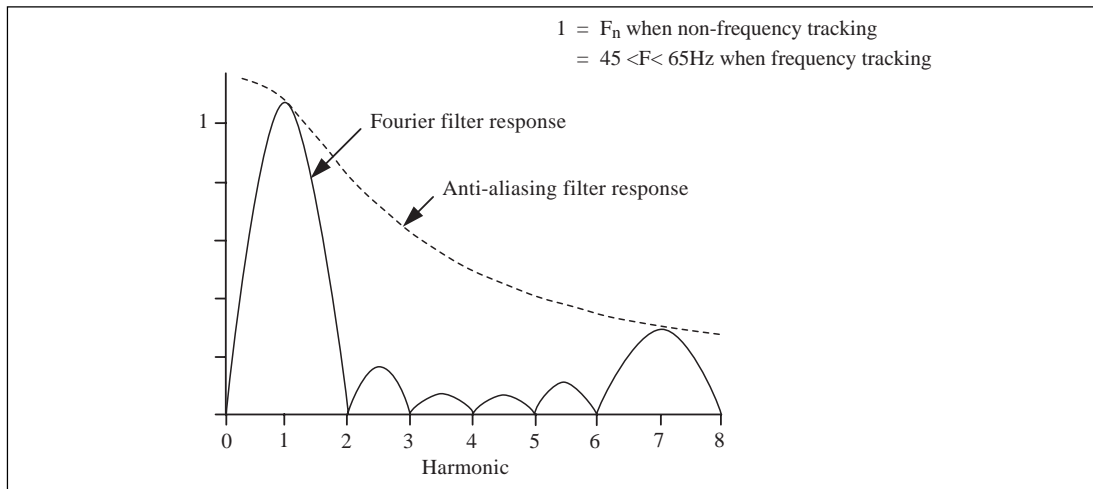


Figure 37. Response of Fourier filtering

Measurement is based on the Fourier derived value of the fundamental component of current and Figure 37 shows the frequency response that results from this filtering. The "1" on the horizontal scale relates to the selected rated frequency of the relay and the figures "2", "3", "4" etc. are the second, third and fourth harmonic frequencies respectively. It can be seen that harmonics up to and including the 6th are suppressed, giving no output. The 7th is the first predominant harmonic and this is attenuated to approximately 30% by the anti-aliasing filter. For power frequencies that are not equal to the selected rated frequency ie. the frequency does not coincide with "1" on the horizontal scale, the harmonics will not be of zero amplitude. For small frequency deviations of $\pm 1\text{Hz}$, this is not a problem but to allow for larger deviations, an improvement is obtained by the addition of frequency tracking.

With frequency tracking the sampling rate of the analogue/digital conversion is automatically adjusted to match the applied signal. In the absence of a signal of suitable amplitude to track, the sample rate defaults to that to suit the selected rated frequency (F_n) for the relay. In presence of a signal within the tracking range (45 to 65Hz), the relay will lock on to the signal and the "1" on the horizontal axis in Figure 37 will coincide with the measured frequency of the measured signal. The resulting output for 2nd, 3rd, 4th 5th and 6th harmonics will be zero. Thus Figure 37 applies when the relay is not frequency tracking the signal and also if it is tracking a frequency within the range 45 to 65Hz.

Power frequency signals are predominant in phase quantities and are therefore used in the frequency tracking routine, whereas earth fault quantities often contain a high proportion of harmonic signals. The earth fault element of multi-pole relays will generally be locked to the power frequency as the relay tracks it using the phase quantities. If the relay were to track a frequency above 65Hz then it would try to lock on to a sub-harmonic frequency and the response would then be as shown in Figure 38. The horizontal axis of this graph is in Hz, the units of frequency, and a substantial output is produced for the 2nd harmonic of the system frequency and also for the 3rd, etc. Hence it is for this reason the relays are restricted to tracking the phase quantities and do not track earth fault signals.

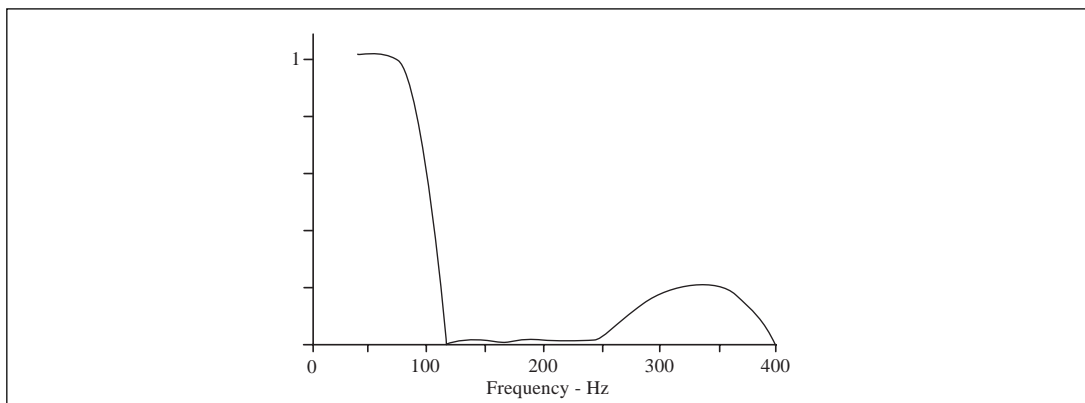


Figure 38. Response when tracking a single frequency

Transient overreach

The $I_{>>}/I_{o>>}$ and $I_{>>>}/I_{o>>>}$ elements are often required for instantaneous high set and/or low set functions and for these applications they need to be unaffected by offset waveforms, which may contain a large dc exponential component and by transformer inrush currents. To achieve this, two criteria for operation are applied independently. The first is that the Fourier derived power frequency component of the fault current is above the set threshold, as for $I_{>}/I_{o>}$. The second is that the peak of any half cycle of current exceeds twice the set threshold value and is provided to reduce the operation time to less than that which could be obtained with the Fourier measurement alone.

For directional overcurrent relays see also Section 5.19.1

Another point to be aware of is that the second criterion uses peak values and these are only filtered by the anti-aliasing filter. However, the peak measurements are still based on sampled values and the position of the samples relative to the peak of the harmonic will depend on the phase relationship. The frequency response will therefore be modified for the $I_{>>}/I_{o>>}$ and $I_{>>>}/I_{o>>>}$ elements for which Figure 39 is typical only.

For certain applications it may be necessary to set the $I_{>>}$ or $I_{o>>}$ element to a low setting, possibly lower than that for the $I_{>}$ or $I_{o>}$ elements. In these situations the modified frequency response shown in Figure 39 may not be acceptable because of the lack of harmonic rejection. To overcome this problem a software link is provided to select or deselect the peak detection feature for the $I_{>>}$ and $I_{o>>}$ overcurrent elements.

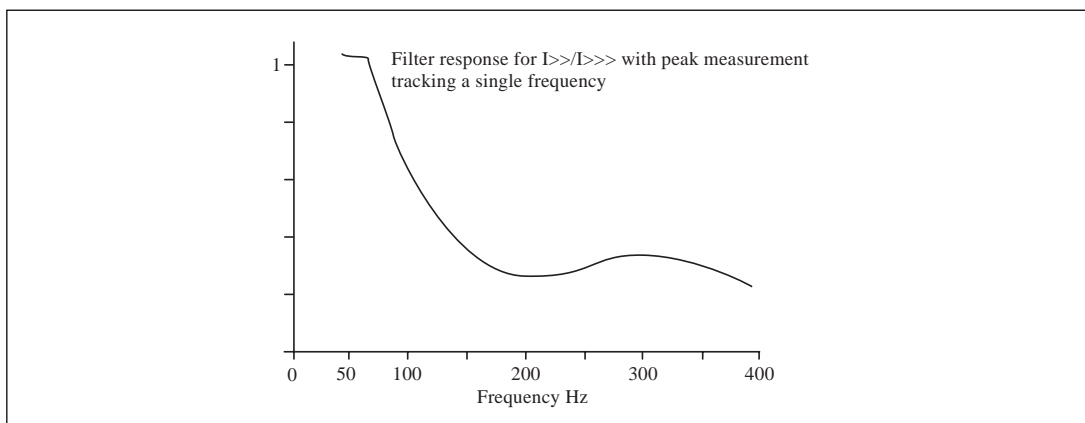


Figure 39. Typical composite frequency response

5.19.1 Frequency response of directional elements

The peak measurement is not used for the $I_{>>}/I_{o>>}$ and $I_{>>>}/I_{o>>>}$ elements of directional overcurrent relays. This is to ensure that the overcurrent and directional measurement is made from the same data to ensure decisive operation. Figure 39 will then no longer apply and the frequency response of these elements will be as shown in Figures 37 and 38.

The phase directional elements are provided with synchronous polarization which is maintained for 320ms after the voltage collapses so that decisive operation is ensured. During the period of synchronous polarization the relay tracks the frequency on a current signal so that the phase correction is kept as close as possible, even with some deviation in frequency.

Section 6. COMMISSIONING

6.1 Commissioning preliminaries

When commissioning a K Range relay for the first time the engineers should allow an hour to get familiar with the menu. Please read Section 6.1.1.1 which provides simple instructions for negotiating the relay menu using the push buttons [F] [+] [-] and [0] on the front of the relay. Individual cells can be viewed and the settable values can be changed by this method.

If a portable PC is available together with a K-Bus interface unit and the courier access software, then the menu can be viewed a page at a time to display a full column of data and text. Settings are also more easily entered and the final settings can be saved to a file on a disk for future reference or printing a permanent record. The instructions are provided with the Courier Access software.

6.1.1 Quick guide to local menu control

With the cover in place only the [F] and [0] push buttons are accessible, so data can only be read or flag and counter functions reset. No protection or configuration settings can be changed. In the table [F]long indicates that the key is pressed for 1s and [F]short for less than 0.5s. This allows the same key to perform more than one function.

6.1.1.1 With the cover fitted to the case

Current display	Key press	Effect of action
Default display or fault flags after a trip	[F]short or [F]long [0]short [0]long	Display changes to first menu column heading "SYSTEM DATA". Backlight turns ON. If the fault flags are displayed the trip LED will be reset and the display will return to the selected default display.
Column heading	[0]short [0]long	Backlight turned ON. Returns to the selected default display without waiting for the time-out delay.
Anywhere in menu	[F]short [F]long [0]short [0]long	Displays the next item of data in the column. Displays the heading for the next column. Turns the backlight ON. If a resettable cell is displayed it will be reset.

Table 6.1

6.1.1.2 With the cover removed from the case

The key presses listed in 6.1.1.1 still apply and in addition the [+] and [-] keys are accessible:

Current display	Key press	Effect of action
Column heading	[-] [+]short	Move to next column heading. Move to previous column heading
A settable cell	[+] or [-]	Puts relay in the setting mode (flashing cursor on bottom line of display) if the cell is not password protected.
Setting mode	[+] [-] [F] [0]	Increments value. Decrements value. Changes to the confirmation display. If function links, relay or input masks are displayed then the [F] key will step through them from left to right. A further key press will change to the confirmation display. Escapes from the setting mode without setting being changed.
Confirmation display	[+] [-] [0]	Confirms setting and enters new value. Returns prospective value of setting for checking and further modification. Escapes from the setting mode without the setting being changed.

Table 6.2

6.1.1.2 Terminal allocation

Reference should be made to the diagram supplied with every relay. The diagram number will be found on the label fixed inside the case to the left-hand side. Section 3.6 of this document provides useful notes on connections to the relay.

6.1.1.3 Electrostatic discharge (ESD)

See recommendations in Section 1 of this user manual before handling module outside its case.

6.1.1.4 Inspection

Carefully examine the module and case to see that no damage has occurred since installation and visually check the current transformer shorting switches in the case are wired into the correct circuit and are closed when the module is withdrawn. Check that the serial number on the module, case and cover are identical and that the model number and rating information are correct.

Check that the external wiring is correct to the relevant relay diagram or scheme diagram. The relay diagram number appears inside the case on a label at the left hand side. The serial number of the relay also appears on this label, the inside of the cover and on the front plate of the relay module. The serial numbers marked on these three items should match; the only time that they may not match is when a failed relay module has been replaced for continuity of protection.

With the relay removed from its case, ensure that the shorting switches between terminals listed below are closed by checking with a continuity tester.

Terminals: 21 and 22; 23 and 24; 25 and 26; 27 and 28.

6.1.1.5 Earthing

Ensure that the case earthing connection, above the rear terminal block, is used to connect the relay to a local earth bar and where there is more than one relay the copper earth bar is in place connecting the earth terminals of each case in the same tier together.

6.1.1.6 Main current transformers

DO NOT OPEN CIRCUIT THE SECONDARY CIRCUIT OF A LIVE CT SINCE THE HIGH VOLTAGE PRODUCED MAY BE LETHAL TO PERSONNEL AND COULD DAMAGE INSULATION.

6.1.1.7 Test block

If the MMLG test block is provided, the connections should be checked to the scheme diagram, particularly that the supply connections are to the live side of the test block (coloured orange) and with the terminals allocated odd numbers (1, 3, 5, 7 etc.). The auxiliary supply is normally routed via terminals 13 (+) and 15 (–), but check against the schematic diagram for the installation.

6.1.1.8 Insulation

Insulation tests only need to be done when required.

Isolate all wiring from the earth and test the insulation with an electronic or brushless insulation tester at a dc voltage not exceeding 1000V. Terminals of the same circuits should be temporarily strapped together.

The main groups on the relays are given below but they may be modified by external connection as can be determined from the scheme diagram.

- a) Current transformer circuits.
- b) Voltage transformer circuits.
- c) Auxiliary voltage supply (and capacitor discharge circuit on 200 series relays).
- d) Field voltage output and opto-isolated control inputs.
- e) Relay contacts.
- f) Communication port.
- g) Case earth.

Note: Do not apply an insulation test between the auxiliary supply and the capacitor discharge terminals because they are part of the same circuit and internally connected.

6.1.2 Commissioning test notes

6.1.2.1 Commissioning the relay with its calculated application settings

Relay Model	Auxiliary powered Test 6.1.3.1	Dual powered Test 6.1.3.2	Earth fault element Test 6.1.6	Sensitive earth fault element Test 6.1.6	Phase fault element Test 6.1.7	Directional earth fault element Tests 6.1.8 & 6.1.11.2.1	Directional phase fault element Tests 6.1.9 & 6.1.11.2.2	Dual polarized earth fault element Tests 6.1.6 & 6.1.11.2.1	Wattmetric element Tests 6.1.12
KCGG 110	P		1						
KCGG 120	P				2				
KCGG 130	P				3				
KCGG 140	P		1		3				
KCGG 210		P	1						
KCGG 230		P			3				
KCGG 240		P	1		3				
KCGU 110	P			1					
KCGU 140	P			1	3				
KCGU 240		P		1	3				
KCEG 110	P					1			
KCEG 130	P						3		
KCEG 140	P					1	3		
KCEG 150	P				3	1			
KCEG 160	P							1	
KCEG 210		P				1			
KCEG 230		P					3		
KCEG 240		P				1	3		
KCEG 250		P			3	1			
KCEU 110	P					1			
KCEU 140	P					1	3		
KCEU 141	P					1	3		1
KCEU 150	P				3	1			
KCEU 160	P							1	
KCEU 240		P				1	3		1
KCEU 241		P				1	3		1
KCEU 250		P			3	1			

Table 6.3

Table 6.3 lists the relay types and the tests that must be performed on the relay power supply, overcurrent, earth fault and directional elements.

A “P” in a column indicates which type of power supply each particular relay has.

A number in a column indicates how many elements of that type each particular relay has.

After the auxiliary supply tests the settings required for the particular application should be entered as described in Section 6.1.4.

After the settings have been entered the measurements checks described in Section 6.1.5 should be carried out.

None of the current, voltage and time ranges given in these instructions make any allowance for instrument errors.

6.1.2.2 Commissioning the relay with the logic required for a particular application

The relay should be commissioned with the selective logic settings required for the particular application. Table 6.4 lists the selective logic schemes and the tests that must be performed on the relay to ensure these work correctly.

Selective logic function	Test
Opto-input blocking logic	6.1.10.1
Timer blocking functions	6.1.10.2
Undervoltage logic	6.1.10.3
Auxiliary timers (Aux1, Aux2, Aux3)	6.1.10.4
Breaker fail and backtripping	6.1.10.5
Change of setting group	6.1.10.6
Cold load start / pickup	6.1.10.7
Circuit breaker control	6.1.10.8

Table 6.4

Selective logic features listed below require K-Bus remote commands and are not covered by the commissioning instructions:

Remote setting change

Remote group change

Remote circuit breaker control

Remote load shedding control

6.1.2.3 Equipment required

For KCGG and KCGU relays the following equipment is required :

Overcurrent test set with time interval meter.

Multifinger test plug type MMLB01 for use with test block type MMLG.

Continuity tester.

For KCEG and KCEU relays the following additional equipment is required :

440/110V star/star phase shifting transformer.

AC voltmeter 0-440V

DC voltmeter 0-250V

AC multi-range ammeter

Suitable non-inductive potentiometer to adjust polarizing voltage level.

Phase angle meter or transducer. If necessary suitable current shunt(s) for use with the phase angle meter.

For KCEG160 and KCEU160 only:

Resistor for controlling the polarizing current signal.

Additional multi-range ammeter for the polarizing current.

A 110/3V step-down transformer for use with the phase shifter to obtain the polarizing current source (only necessary if the phase shifter cannot provide sufficient current directly).

A portable PC, with suitable software and a KITZ101 K-Bus/IEC60870-5 interface unit will be useful but in no way essential to commissioning.

6.1.3 Auxiliary supply tests

6.1.3.1 Auxiliary powered relays (100's)

6.1.3.1.1 Auxiliary supply

The relay can be operated from either an ac or a dc auxiliary supply but the incoming voltage must be within the operating range specified in Table 6.5.

Relay rating (V)	DC operating range (V)	AC operating range (VAC)	Maximum crest voltage (V)
24/125	19 – 150	50 – 133	190
48/250	33 – 300	87 – 265	380

Table 6.5

CAUTION: The relay can withstand some ac ripple on a dc auxiliary supply. However, in all cases the peak value of the auxiliary supply must not exceed the maximum crest voltage. Do not energize the relay using the battery charger with the battery disconnected.

6.1.3.1.2 Energization from auxiliary voltage supply

For secondary injection testing using the test block type MMLG, insert test plug type MMLB01 with CT shorting links fitted. It may be necessary to link across the front of the test plug to restore the auxiliary supply to the relay.

Isolate the relay trip contacts and insert the module. With the auxiliary disconnected from the relay use a continuity tester to monitor the state of the watchdog contacts as listed in Table 6.6.

Connect the auxiliary supply to the relay. The relay should power up with the LCD showing the default display and the centre green LED being illuminated; this indicates the relay is healthy. The relay has a non-volatile memory which remembers the state (ON or OFF) of the LED trip indicator when the relay was last powered, and therefore

the indicator may be illuminated. With a continuity checker, monitor the state of watchdog contacts as listed in Table 6.6.

Terminals	With relay de-energized	With relay energized
3 and 5 4 and 6	contact closed contact open	contact open contact closed

Table 6.6

6.1.3.1.3 Field voltage

The relay generates a field voltage that should be used to energize the opto-isolated inputs. With the relay energized, measure the field voltage across terminals 7 and 8. Terminal 7 should be positive with respect to terminal 8 and should be within the range specified in Table 6.7 when no load is connected.

Nominal dc rating (V)	Range (V)
48	45 – 60

Table 6.7

6.1.3.2 Dual powered relays (200's)

6.1.3.2.1 Auxiliary Supply

The relay can be operated from either an ac or a dc auxiliary supply but the incoming voltage must be within the operating range specified in Table 6.8.

Relay rating (V)	DC Operating range (V)	AC Operating range (V)	Maximum crest voltage (V)
100/250	60 – 300	60 – 265	380

Table 6.8

CAUTION: The relay can withstand some ac ripple on a dc auxiliary supply. However in all cases the peak value of the dc supply must not exceed the maximum specified operating limits.

Do not energize the relay using the battery charger with the batteries disconnected.

Note: The application of the auxiliary voltage supply reduces the burden that is imposed by the relay on the current injection equipment. For the secondary injection tests in Sections 6.6 to 6.9 inclusive, it is recommended that the relay should be powered from an auxiliary supply rather than from the current circuit.

6.1.3.2.2 Energization from auxiliary voltage supply

For secondary injection testing using the test block type MMLG, insert test plug type MMLB 01 with CT shorting links fitted. It may be necessary to link across the front of the test plug to restore the auxiliary supply to the relay.

Isolate the relay trip contacts and insert the module. With the auxiliary disconnected from the relay, use a continuity tester to monitor the state of the watchdog contacts as listed in Table 6.9.

Reconnect the auxiliary supply to the relay. The relay should power up with the LCD showing the default display and the centre green LED being illuminated; this indicates the relay is healthy. The relay has a non-volatile memory which remembers the state (ON or OFF) of the LED trip indicator when the relay was last powered, and therefore the indicator may be illuminated. With a continuity checker, monitor the state of watchdog contacts as listed in Table 6.9.

N.B. These contacts only change state for an internal fault within the relay.

Terminals	With relay de-energized	With relay energized
3 and 5	contact closed	contact closed
4 and 6	contact open	contact open

Table 6.9

6.1.3.2.3 Field voltage

The relay generates a field voltage that should be used to energize the opto isolated inputs.

With the relay energized measure the field voltage across terminals 7 and 8. Terminal 7 should be positive with respect to terminal 8 and should be within the range specified in Table 6.10 when no load is connected.

Nominal dc rating (V)	Range (V)
48	45 – 60

Table 6.10

6.1.3.2.4 Capacitor trip voltage

Measure the supply to trip coil voltage across terminals 9 and 10. Terminal 9 should be positive with respect to terminal 10 and should be within the range specified in Table 6.11 when no load is connected.

Nominal capacitor trip voltage (V dc)	DC range (V)
50	45 – 55

Table 6.11

6.1.3.2.5 Energization from line CTs

With the auxiliary supply disconnected from the relay inject current into the relay terminals listed in Table 6.12. In each case the relay should power up correctly with the LCD showing the default display and the centre green LED being illuminated. Repeat tests 6.1.3.2.3 and 6.1.3.2.4 with the relay powered from the injected current.

Injected current (x In)	Terminals
0.4 x In	Inject into terminals 21 and 23. Link terminals 22 and 24.
0.4 x In	Inject into terminals 25 and 21. Link terminals 26 and 22.
0.4 x In	Inject into terminals 23 and 25. Link terminals 24 and 26.
0.2 x In	Inject into terminals 23 and 28. Link terminals 24 and 27.

Table 6.12

For $0.2 \times I_n$ the relay may chatter. This is due to the loading effect of the output relays and is overcome by disabling the relevant output relay masks (Start and Trip).

6.1.4 Settings

The commissioning engineer should be supplied with all the required settings for the relay. The settings should be entered into the relay via the front keypad or using a portable PC with a K-Bus connection.

The protection settings for the relay are contained in PHASE FAULT (1), EARTH FAULT (1), PHASE FAULT (2) and EARTH FAULT (2) menu columns. The last two columns are only required if setting group 2 is used.

The time characteristics for the first overcurrent stages are selectable and it is not necessary to select the same curve for both phase and earth faults. The selection is made in the menu columns for phase and earth fault settings, but the password must first be entered before the characteristic can be changed.

The following abbreviations are used for the relay characteristic curves:

STI30XDT	Short time inverse characteristic goes definite time after $30 \times I_s$	
SI30XDT	Standard inverse characteristic goes definite time after $30 \times I_s$	* IEC
I30XDT	Inverse characteristic goes definite time after $30 \times I_s$	
VI30XDT	Very inverse characteristic goes definite time after $30 \times I_s$	* IEC
EI20XDT	Extremely inverse characteristic goes definite time after $20 \times I_s$	* IEC
EI10XDT	Extremely inverse characteristic goes definite time after $10 \times I_s$	
LTI30XDT	Long time earth fault characteristic goes definite time after $30 \times I_s$	
DT	Definite time characteristic	

The characteristics of the relay can be further changed by setting function links as described in Section 3.4.1. These links change the logic within the relay so that the auxiliary functions can be used for alternative tasks. They can also turn OFF or block some of the unwanted functions and so this is the first place to look if the relay is not configured as required.

SYSTEM DATA	SYS Fn Links
EARTH FAULT (1)	EF1 Fn Links
PHASE FAULT (1)	PF1 Fn Links
EARTH FAULT (2)	EF2 Fn Links
PHASE FAULT (2)	PF2 Fn Links
LOGIC FUNCTIONS	LOG Fn Links
INPUT MASKS	An eight bit mask is allocated to each protection and control function that can be influenced by an external input applied to one or more opto-isolated inputs.

RELAY MASK An eight bit mask is allocated to each protection and control function that can operate one or more outputs.

It is necessary to enter the password before the functions link, time curve, masks, VT and CT ratios can be changed.

For each protection and control function input required, at least one opto-input must be allocated in the INPUT MASK menu.

For each protection and control function output required, at least one output relay must be allocated in the RELAY MASK menu.

When the relay leaves the factory it is configured with a set of default relay masks, input masks and protection settings. Any of these settings can be left at these default values if required.

When the relay settings have been entered into the relay, they should be noted down on the commissioning test record sheet. If the K-Bus communications are being used then the master station can download the settings to the relay, record any relay settings on disc and download recorded settings to other relays.

All relays will leave the factory set for operation at a system frequency of 50Hz. If operation at 60Hz is required then this must be set as follows:

From 'SYSTEMS DATA' menu, press the 'F' key until 'SYS Frequency 50Hz' appears on the LCD. Press the '+' key until the display shows 'SYS Frequency 60Hz'. Then press the 'F' key once more followed by the '+' key to confirm the change.

6.1.5 Measurement checks

To test the relay measurement functions a known current should be injected into each phase input and the neutral input. For directional relays the polarizing voltage(s) should be applied to the VT inputs as per the application diagram. The phase to neutral voltage should be measured with a voltmeter, or for single pole relays the open delta winding voltage from the line VTs.

With the CT and VT ratio settings of the PHASE FAULT and EARTH FAULT headings set to the values of the line CTs and VTs the displayed, measured values and settings will be in the equivalent primary quantities.

All measured values have a tolerance of $\pm 5\%$ except power which is the product of two quantities and therefore has a tolerance of $\pm 10\%$.

The maximum displayed measured value for SEF element is 1.638A with a CT ratio of 1:1.

6.1.6 Earth fault/sensitive earth fault element

[KCGG110/210, KCGG140/240, KCGU110, KCGU140/240]

The relay should be commissioned with the settings calculated for the application.

For dual powered relays it is recommended that the relay is energized from an auxiliary voltage supply as this will reduce the burden imposed by the relay on the current injection test set.

Ensure that the main system current transformers are short circuited before isolating them from the relay in preparation for secondary injection tests. Also isolate the relay trip contacts.

6.1.6.1 Test connections

Connect the auxiliary supply to the relay and record the voltage at terminals 13 (+ve) and 14 (–ve).

Ensure that the line CTs are short circuited and disconnected from the relay.

If relay has simple overcurrent elements then connect the current injection test set to terminals 27 and 28 of the relay. If the earth fault elements are directionalized then go to Section 6.1.8.

6.1.6.2 Current sensitivity for Io>

This test checks the current sensitivity of the relay. Operation of the relay can be monitored in three ways:

- 1 By indication from the relay contacts.
- 2 Viewing the [SYS Relay Stat] display under the SYSTEM DATA heading of the menu.
- 3 Setting the display to [Fnow] which will be found in the fault record column.

Note: The default display can be set to [Fnow] if preferred.

If the display is [Fnow], the current state of the flags, a letter is displayed to indicate which phase has started and an * will indicate which element has tripped. See Section 3.1.5 for more information on the flag display.

Inject single phase current into the earth fault current input of the relay (terminals 27 and 28) and slowly increase the current, noting the pick-up value at which the START relay operates. Reduce the current slowly and note the drop-off value at which the START relay resets. Check the pick-up and drop-off current is within the range shown in Table 6.12.

	Current level
Pick-up	$0.95 \times I_s - 1.05 \times I_s$
Drop-off	$0.9 \times \text{pick-up} - 1.0 \times \text{pick-up}$

Table 6.12

6.1.6.3 Time characteristic for to>

The relay selected for the to> trip can be found under the RELAY MASKS heading in [RLY to>]. The terminals for each relay are shown in the application diagram. Connect the relay contacts for the to> trip to both trip the test set and to stop a timer. Inject single phase current into the earth fault current input (terminals 27 and 28) at 2 x setting current. If the test set used can inject sufficient current, repeat the test again at 10 x setting current.

Check that the operating time for the relay is within the range shown in the table below.

Curve description	Operating time at specified current (seconds) x TMS			
	2 x Is		10 x Is	
	Nominal	Range	Nominal	Range
STI30XDT	1.780	1.68 – 1.87	0.52	0.49 – 0.55
SI30XDT	10.03	9.52 – 10.53	2.97	2.82 – 3.12
I30XDT	15.05	14.30 – 15.81	2.34	2.23 – 2.46
VI30XDT	13.5	12.82 – 14.18	1.50	1.43 – 1.58
EI20XDT	26.67	24.66 – 28.67	0.81	0.74 – 0.87
EI10XDT	26.67	24.66 – 28.67	0.81	0.74 – 0.87
LTI30XDT	120.0	121 – 126	13.33	12.66 – 14
DT	[Set time to>] $\pm 5\%$ + [0.02 to 0.04 seconds]			

Table 6.13

Note: The operating times given above are for TMS = 1. Therefore to obtain the operating time for any other TMS setting the relay's actual TMS setting must be multiplied by the time given in the table above.

For all curves there is an additional tolerance of between 0.02 and 0.04 seconds.

All the operating times given have no allowance for errors in the measuring instruments.

6.1.6.4 Current setting for Io>> and Io>>>

WARNING:

THE RELAY MAY BE DAMAGED BY APPLYING EXCESSIVE CURRENT FOR LONG DURATIONS DURING TESTING, OR IN RECURRENT BURSTS WITHOUT ALLOWING TIME FOR THE RELAY TO COOL DOWN.

This test is to check that the instantaneous current level of the Io>> and Io>>> is correct. If the Io>> element is to be used by the customer then the EARTH FAULT function link 1 must be set to "1". This test can only be performed if the test set available can inject sufficient current into the relay to cause the element to operate at the customer's current setting. The relay selected for the Io>> trip can be found under the RELAY MASKS heading in [RLY to>>].

To prevent sustained application of excessive current the trip output contacts for to>>> should be connected to trip the test set. The time delay to>>> should be set to less than 0.1 second for the test and restored to its original value when the test has been completed.

When the setting is above the continuous current rating of the relay DO NOT INCREASE THE CURRENT SLOWLY since this may damage the relay before it can operate. Instead the current level should be set and then suddenly applied.

Two tests are specified in Table 6.14 for the particular current setting required for the application. Initially the higher current level should be applied to check that the instantaneous element operates and then the lower current level should be applied to check that no trip occurs.

TRIP $I_{o>>>}$ / $I_{o>>>>}$	NO TRIP $I_{o>>>}$ / $I_{o>>>>}$
1.05 x current setting	0.95 x current setting

Table 6.14

If the $I_{o>>>>}$ threshold is to be used by the customer then the EARTH FAULT function link 2 should be set to “1”. Test 6.1.6.4 can then be repeated for $I_{o>>>>}$, but only if the test set available can inject sufficient current into the relay to cause the element to operate at the customer’s current setting. The relay selected for the $I_{o>>>>}$ trip can be found under the RELAY MASKS heading in [RLY to>>>>].

The instantaneous trip output contacts must be connected to trip the test set.

To prevent sustained application of excessive current the time delay to>>>> should be set to less than 0.1 second for this test, the original setting being restored when the test has been completed.

6.1.6.5 Special note for sensitive earth fault relays

The actual minimum operation current for the sensitive earth fault settings will be affected by the magnetizing current that is taken by the core balance CT. The effect that the CT has on the relay setting can be assessed if the primary circuit is de-energized, by reconnecting the CTs to the relay and repeating the setting test 6.1.6.2. The effective setting may be more than doubled in some cases.

6.1.7 Phase fault elements

[KCGG120, KCGG130/230, KCGG140/240, KCEG150/250, KCGU140/240, KCEU150/250]

The relay should be commissioned with the settings calculated for the application.

For dual powered relays it is recommended that the relay is energized from an auxiliary voltage supply as this will reduce the burden imposed by the relay on the current injection test set.

Ensure that the main system current transformers are short circuited before isolating the relay from the current transformers in preparation for secondary injection tests. Also isolate the relay trip contacts.

6.1.7.1 Test connections

Connect the auxiliary supply to the relay and record the voltage at terminals 13 (+ve) and 14 (–ve).

Ensure that the line CTs are short circuited and disconnected from the relay.

If any of the phase elements are directionalized refer to Section 6.1.9 for the test instructions.

6.1.7.2 Current sensitivity for $I_{>}$

This test checks the current sensitivity of the relay. Operation of the relay can be monitored in three ways:

- 1 By indication from the relay contacts.
- 2 Viewing the [SYS Relay Stat] display under the SYSTEM DATA heading of the menu.
- 3 Setting the display to [Fnow] which will be found in the fault record column.

Note: The default display can be set to [Fnow] if preferred.

If [Fnow], the current state of the flags is displayed, indication that a phase has picked up is given by a letter and an * will indicate which element has tripped. See Section 3.1.5 for more information on the flag display.

Where there is a star point on the relay, it is advantageous to inhibit the operation of the earth fault elements (inhibit to>, to>> and to>>>) in order to avoid confusion with trip signals and indications.

Inject single phase current into one of the phase inputs to the relay and slowly increase the current, noting the pick-up value at which the START relay operates. Reduce the current slowly and note the drop-off value at which the START relay resets. Check the pick-up and drop-off current is within the range shown in Table 6.15.

	Current level
Pick-up	$0.95 \times I_s - 1.05 \times I_s$
Drop-off	$0.9 \times \text{pick-up} - 1.0 \times \text{pick-up}$

Table 6.15

The test must be repeated on all the phase elements of the relay. Table 6.16 lists the terminals that current should be injected into for each of the phases.

Phase	Terminals
A	21 – 22
B	23 – 24
C	25 – 26

Table 6.16

In addition, with some site wiring, it may be necessary to inject A-N, B-N, C-N.

6.1.7.3 Time characteristic for t>

The relay selected for the t> trip can be found under the RELAY MASKS heading in [RLY t>]. The terminals for each relay are shown in the application diagram. Connect the relay contacts for the t> trip to both trip the test set and to stop a timer. Inject single phase current of 2 x setting current into one of the phase fault current inputs listed in Table 6.16. If the test set used can inject sufficient current, repeat the test at 10 x setting current. Check that the operating time for the relay is within the range shown in the Table 6.17 below.

Curve description	Operating time at specified current (seconds) x TMS			
	2 x I_s		10 x I_s	
	Nominal	Range	Nominal	Range
STI30XDT	1.780	1.68 – 1.87	0.52	0.49 – 0.55
SI30XDT	10.03	9.52 – 10.53	2.97	2.82 – 3.12
I30XDT	15.05	14.30 – 15.81	2.34	2.23 – 2.46
VI30XDT	13.5	12.82 – 14.18	1.50	1.43 – 1.58
EI20XDT	26.67	24.66 – 28.67	0.81	0.74 – 0.87
EI10XDT	26.67	24.66 – 28.67	0.81	0.74 – 0.87
LTI30XDT	120.0	114 – 126	13.33	12.66 – 14
DT	[Set time to>] $\pm 5\%$ +[0.02 to 0.04 seconds]			

Table 6.17

Note: The operating times given above are for TMS = 1. Therefore to obtain the operating time for any other TMS setting the relay's actual TMS setting must be multiplied by the time given in the table above.

For all curves there is an additional tolerance of between 0.02 and 0.04 seconds.

The operating times given make no allowance for errors in the measuring instruments.

6.1.7.4 Current setting for I>> and I>>>

WARNING

THE RELAY MAY BE DAMAGED BY APPLYING EXCESSIVE CURRENT FOR LONG DURATIONS DURING TESTING, OR IN RECURRENT BURSTS WITHOUT ALLOWING TIME FOR THE RELAY TO COOL DOWN.

This test is to check that the instantaneous current level of the I>> and I>>> is correct. If the I>> element is to be used by the customer then the PHASE FAULT function link 1 must be set to "1". This test can only be performed if the test set available can inject sufficient current into the relay to cause the element to operate at the customer's current setting. The relay selected for the I>> trip can be found under the RELAY MASKS heading in [RLY t>>]. Table 6.16 shows which terminals are used for each relay element.

To prevent sustained application of excessive current the trip output contacts for t>>> should be connected to trip the test set. The time delay t>> should be set to less than 0.1 second for the test and restored to its original value when the test has been completed.

When the setting is above the continuous current rating of the relay DO NOT INCREASE THE CURRENT SLOWLY since this may damage the relay before it can operate. Instead the current level should be set and then suddenly applied.

Two tests specified in Table 6.20 are for the particular current setting required for the application. Initially the higher current level should be applied to check that the instantaneous element operates and then the lower current level should be applied to check that no trip occurs.

TRIP I>> / I>>>	NO TRIP I>> / I>>>
1.05 x current setting	0.95 x current setting

Table 6.20

If the I>>> threshold is to be used by the customer then the PHASE FAULT function link 2 should be set to "1". Test 6.1.7.4 can then be repeated for I>>>, but only if the test set available can inject sufficient current into the relay to cause the element to operate at the customer's current setting. The relay selected for the I>>> trip can be found under the RELAY MASKS heading in [RLY t>>>].

The instantaneous trip output contacts must be connected to trip the test set.

Table 6.16 shows which terminals to use for current injection into the individual phase elements.

To prevent sustained application of excessive current the time delay for the I>> current threshold should be set to operate in zero seconds for this test. The setting can be restored to the original value when the test has been completed.

6.1.8 Directional earth/sensitive earth fault elements
[KCEG110/210, KCGG140/240, KCEG150/250, KCEG160]
[KCEU110, KCEU140/240, KCEU150/250, KCEU160]

The relay should be commissioned with the settings calculated for the application.

For dual powered relays it is recommended that the relay is energized from an auxiliary voltage supply as this will reduce the burden imposed by the relay on the current injection test set.

Ensure that the main system current transformers are short circuited before isolating them from the relay in preparation for secondary injection tests. Also isolate the relay trip contacts.

To test the directional earth fault element, it is necessary to set some function links to directionalize the earth fault overcurrent element. Table 6.21 shows which EARTH FAULT function links must be set to “1” to enable directional control of each of the earth fault elements.

Earth fault element	EARTH FAULT function link
$I_{o>}$	3
$I_{o>>}$	4
$I_{o>>>}$	5

Table 6.21

6.1.8.1 Test connections for directional earth fault relays

If the relay being commissioned has directional earth fault elements then the relay and the overcurrent test set and phase shifting transformer must be set up as shown in Figure 40. Taking positive phase angles as the current leading the voltage and negative phase angles as the current lagging the voltage, adjust the phase shifting transformer so the phase angle meter reads ($180^{\circ} +$ set earth fault characteristic angle). Once the phase angle has been set and the current input of the phase angle meter has been short circuited with a wire link, the overcurrent tests can be performed.

The correct polarity of connection for operation with forward current flow is shown in the two tables at the beginning of Section 3.6. The test arrangement will depend on the type of relay being tested.

KCEG140/240, KCEU140/240

The residual voltage is internally derived from the summation of the three phase to neutral voltages and for these relays a three phase voltage should be applied to the relay. The residual voltage is then produced by collapsing one of the phase voltages with a potentiometer, as shown in Figure 40; the residual voltage being equal to the actual amount by which the phase voltage is reduced.

KCEG110/210, KCEG150/250, KCEG160 KCEU110, KCEU150/250, KCEU160

The earth fault elements of other relays in the range require the residual polarizing voltage to be derived from an external source and so the connections should be as shown in Figure 41.

6.1.8.2 Polarizing voltage sensitivity V_{op}

To test the sensitivity of the polarising voltage the relay must be connected as shown in Figures 40 or 41 according to relay type.

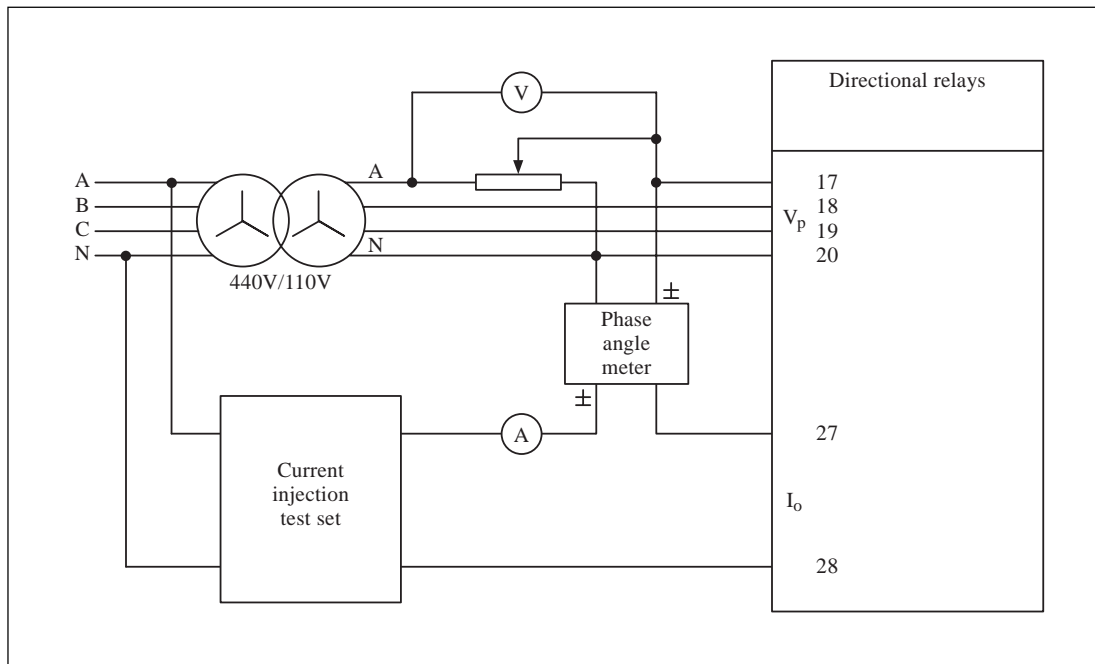


Figure 40. Connection diagram for KCEG140/240 and KCEU140/240

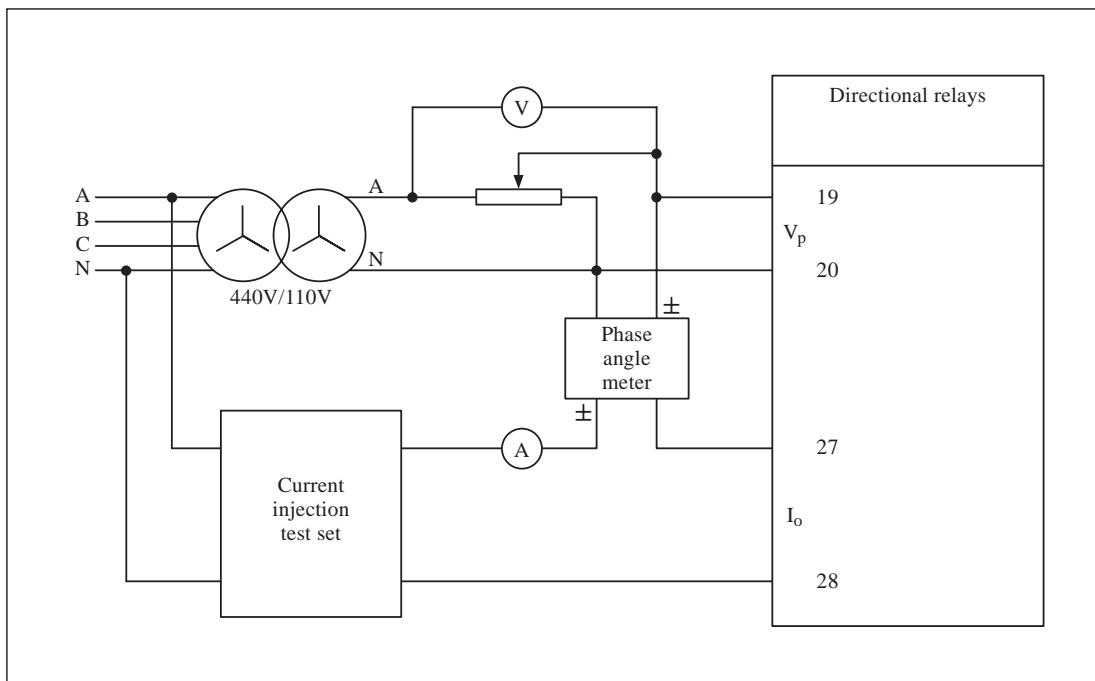


Figure 41. Connections for KCEG110/210, KCEG150/250, KCEG160, KCEU110, KCEU150/250, KCEU160

When using the connections shown in Figure 40 the full three phase voltage should be applied and the voltage output from the potential divider adjusted to vary the residual voltage; the voltage measured across the top half of the potentiometer should agree with the value of V_o displayed on the relay under MEASUREMENTS (1). When using the connections shown in Figure 41 the single phase voltage being applied is the residual quantity and should agree with the value of V_o displayed on the relay under MEASUREMENTS (1).

Set the current from the secondary injection test set to a value within the rating of both the relay and the phase angle meter. Then taking positive angles as the current leading the voltage and negative angles as the current lagging the voltage, adjust the phase shifting transformer so the phase angle meter reads the set earth fault characteristic angle. Once the phase angle has been set the current input to the meter should be short circuited.

While monitoring the forward start contact, selected by the [RLY $I_o >$ Fwd] relay mask, current above twice the $I_o >$ setting should be injected into terminal 27 and the polarizing voltage should be reduced to the minimum. In this condition the forward start contact should be open. The polarizing voltage should be then slowly increased until the forward start contact [RLY $I_o >$ Fwd] operates; this value should be the set value for $V_{op} > \pm 10\%$.

Note: for the KCEG140, where the residual voltage is generated internally, the $V_{op} >$ settings cannot be guaranteed below 7V when the low gain range is selected by the healthy phases.

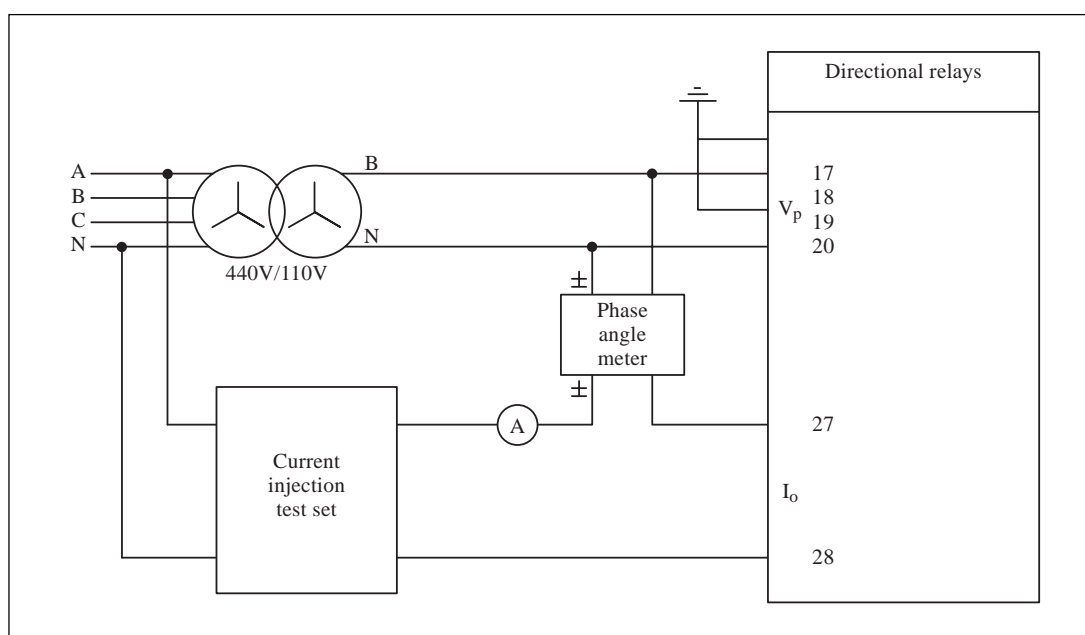


Figure 42. Connections for current polarization check of KCEG160 and KCEU160

6.1.8.3 Angular boundary of operation for $V_{op} >$

Apply polarizing voltage above the threshold voltage $V_{op} >$ and operating current above the setting $I_o >$ to the relay under test. From the EARTH FAULT heading make a note of the relay characteristic angle (RCA).

The forward start contact selected by the [RLY $I_o >$ Fwd] relay mask under the RELAY MASKS heading and the reverse start contact selected by the

[RLY Io> Rev] relay mask should be monitored to indicate when the relay is in the operate region.

Taking positive angles as leading and negative angles as lagging, adjust the phase shifting transformer so the phase angle meter reads $(180^\circ + \text{RCA})$. Check that the reverse start contacts selected by the [Io> Rev Start] relay mask have closed and the forward start contacts selected by the [Io> Fwd Start] relay mask are open.

Rotate the phase shifting transformer so the phase lag is decreasing or the phase lead is increasing on the phase angle meter and continue until the forward start contacts close and the reverse contacts open. Note the angle on the phase angle meter and check it is within the limits stated in Table 6.23.

Continue rotating the phase shifting transformer until the forward start contacts open and the reverse start contacts close. Note the angle on the phase meter and check it is within the limits stated in Table 6.23.

Relay in operate region: Phase angle meter indication	Tolerance
$(\text{RCA} - 90^\circ)$ lag through to $(\text{RCA} + 90^\circ)$ lead	$\pm 5^\circ$

Table 6.23

6.1.8.4 Current sensitivity for Io>

This test checks the current sensitivity of the relay. Operation of the relay can be monitored in three ways:

- 1 By indication from the relay contacts.
2. Viewing the [SYS Relay Stat] display under the SYSTEM DATA heading of the menu.
3. Setting the display to [Fnow] which will be found in the fault record column.

Note: The default display can be set to [Fnow] if preferred.

If the display is [Fnow], the current state of the flags, a letter is displayed to indicate which phase has started and an * will indicate which element has tripped.

See Section 3.1.5 for more information on the flag display.

With the applied polarizing voltage set above twice the threshold level and the phase shifter adjusted to the characteristic angle of the relay, inject current into the earth fault current input of the relay (terminals 27 and 28). Slowly increase the current and note the pick-up value at which the [RLY Io> Fwd] relay operates. Reduce the current slowly and note the drop-off value at which the START relay resets. Check the pick-up and drop-off current is within the range shown in Table 6.24.

	Current level
Pick-up	$0.95 \times I_s - 1.05 \times I_s$
Drop-off	$0.9 \times \text{Pick-up} - 1.0 \times \text{pick-up}$

Table 6.24

6.1.8.5 Time characteristic for to>

The relay selected for the to> trip can be found under the RELAY MASKS heading in [RLY to>]. The terminals for each relay are shown in the application diagram. Connect the relay contacts for the to> trip to both trip the test set and to stop a timer.

With the applied polarizing voltage set above twice the threshold level and the phase shifter adjusted to the characteristic angle of the relay, inject a single phase current into the earth fault current input (terminals 27 and 28) at 2 x setting current. If the test set used can inject sufficient current, repeat the test at 10 x setting current. Check the operating time against Table 6.25.

Curve description	Operating time at specified current (seconds) x TMS			
	2 x Is		10 x Is	
	Nominal	Range	Nominal	Range
STI30XDT	1.780	1.68 – 1.87	0.52	0.49 – 0.55
SI30XDT	10.03	9.52 – 10.53	2.97	2.82 – 3.12
I30XDT	15.05	14.30 – 15.81	2.34	2.23 – 2.46
VI30XDT	13.5	12.82 – 14.18	1.50	1.43 – 1.58
EI20XDT	26.67	24.66 – 28.67	0.81	0.74 – 0.87
EI10XDT	26.67	24.66 – 28.67	0.81	0.74 – 0.87
LTI30XDT	120.0	114 – 126	13.33	12.66 – 14
DT	[Set time to>] $\pm 5\%$ +[0.02 to 0.04 seconds]			

Table 6.25

Note: The operating times given above are for TMS = 1. Therefore to obtain the operating time for any other TMS setting the relay's actual TMS setting must be multiplied by the time given in the table above.

For all curves there is an additional tolerance of between 0.02 and 0.04 seconds.

The operating times given make no allowance for errors in the measuring instruments.

6.1.8.6 Current setting for Io>> and Io>>>

WARNING

THE RELAY MAY BE DAMAGED BY APPLYING EXCESSIVE CURRENT FOR LONG DURATIONS DURING TESTING OR IN RECURRENT BURSTS, WITHOUT ALLOWING TIME FOR THE RELAY TO COOL DOWN.

This test is to check that the instantaneous current level of the Io>> and Io>>> is correct. If the Io>> element is to be used by the customer then the EARTH FAULT function link 1 must be set to "1". This test can only be performed if the test set available can inject sufficient current into the relay to cause the element to operate at the customer's current setting. The relay selected for the Io>> trip can be found under the RELAY MASKS heading in [RLY to>>].

To prevent sustained application of excessive current the trip output contacts for to>> should be connected to trip the test set. The time delay to>> should be set to

less than 0.1 second for the test and restored to its original value when the test has been completed.

When the setting is above the continuous current rating of the relay DO NOT INCREASE THE CURRENT SLOWLY since this may damage the relay before it can operate. Instead the current level should be set and then suddenly applied.

With the applied polarizing voltage set above twice the threshold level and the phase shifter adjusted to the characteristic angle of the relay, inject the higher of the two currents specified in Table 6.26, check that the output relay operates and the correct flags are displayed. Reset the flags and repeat for the lower value of current and check that the relay does not operate, the trip LED is not lit and no flags are fault displayed.

TRIP $I_{o>>}$ / $I_{o>>>}$	NO TRIP $I_{o>>}$ / $I_{o>>>}$
1.05 x current setting	0.95 x current setting

Table 6.26

If the $I_{o>>>}$ threshold is to be used by the customer then the EARTH FAULT function link 2 should be set to “1”. Test 6.1.8.6 can then be repeated for $I_{o>>>}$, but only if the test set available can inject sufficient current into the relay to cause the element to operate at the customer’s current setting. The relay selected for the $I_{o>>>}$ trip can be found under the RELAY MASKS heading in [RLY to>>>]. The instantaneous trip output contacts must be connected to trip the test set.

6.1.8.7 Special note for sensitive earth fault relays

The actual minimum operation current for the sensitive earth fault settings will be affected by the magnetizing current that is taken by the core balance CT. The effect that the CT has on the relay setting can be assessed if the primary circuit is de-energized, by reconnecting the CTs to the relay and repeating the Setting Test 6.1.6.2. The effective setting may be more than doubled in some cases.

6.1.8.8 Polarizing current sensitivity $I_{p>}$

When the relay is current polarized this test must be carried out to check the sensitivity $I_{p>}$. Connect the test circuit as shown in Figure 40. Set the currents to a value within the ratings of both the relay and the phase angle meter and adjust the phase shifter such that the two currents are in phase. Then leave the phase angle set and short out the terminals of the phase angle meter.

While monitoring the forward start contact selected by the [RLY $I_{o>}$ Fwd] relay mask, current above twice the $I_{o>}$ setting should be injected into terminal 27 and the polarizing current should be reduced to the minimum. In this condition the forward start contact should be open. The polarizing current should be then slowly increased until the forward start contact [RLY $I_{o>}$ Fwd] operates; this value should be the set value for $I_{op>}$ $\pm 10\%$.

6.1.8.9 Angular boundary for $I_{op>}$

Check the test connections to the relay are as shown in Figure 40 . Ensure the polarities of all of the connections are correct, particularly where variable or step-down transformers are used, and that the phase shifting transformer is connected star/star. Apply polarizing current above the threshold $I_{op>}$ and operating current above the setting threshold $I_{o>}$ to the earth fault circuit under test.

Note that the relay characteristic angle for current polarized directional operation is always taken to be 0° .

The forward start contact selected by the [RLY Io> Fwd] relay mask under the RELAY MASKS heading and the reverse start contact selected by the [RLY Io> Rev] relay mask should be monitored to indicate when the relay is in the operate region.

Adjust the phase shifting transformer until the phase angle measured on the phase angle meter is 180°. Check that the reverse start contacts have closed and the forward start contacts are open. If the reverse start relay has not operated then check both current polarities conform with the diagram.

Adjust the phase shifting transformer until the angle measured on the phase angle meter is 0°. Check that the reverse start contacts are open and the forward start contacts have closed.

Rotate the phase shifting transformer into the lead quadrant on the phase angle meter and continue until the forward start contacts open and the reverse start contacts close. Note the angle on the phase angle meter and check it is within the limits stated in Table 6.27.

Reverse rotation and slowly wind the phase shifting transformer until the forward start contacts open and the reverse start contacts close. Note the angle on the phase meter and check it is within the limits stated in Table 6.27 .

Relay in operate region : Phase angle meter indication	Tolerance
90° lag through to 90° lead	±5°

Table 6.27

6.1.9 Directional phase fault element

The relay should be commissioned with the settings calculated for the application.

For dual powered relays it is recommended that the relay is energized from an auxiliary voltage supply as this will reduce the burden imposed by the relay on the current injection test set.

Ensure that the main system current transformers are short circuited before isolating them from the relay in preparation for secondary injection tests. Also isolate the relay trip contacts.

To test the directional phase fault element, it is necessary to set some function links to directionalize the phase fault overcurrent elements. Table 6.28 shows which PHASE FAULT function links must be set to “1” to enable directional control of each of the phase fault elements.

Phase fault element	PHASE FAULT function link
I>	3
I>>	4
I>>>	5

Table 6.28

6.1.9.1 Test connections

If the relay being commissioned has directional phase fault elements then the test equipment should be wired to the relay as shown in Figure 43. Care should be taken to ensure that the correct polarities are connected to the phase angle meter. With the phase shifter set to 0° the phase angle meter should read 0° .

6.1.9.2 Angular boundary of operation

With the test connections as detailed in Section 6.1.9.1 apply current and rated volts to the phase under test. The current should be set above the setting threshold to $I>$. Make a note of the relay characteristic angle (RCA) which can be found under the PHASE FAULT (1) heading of the relay menu.

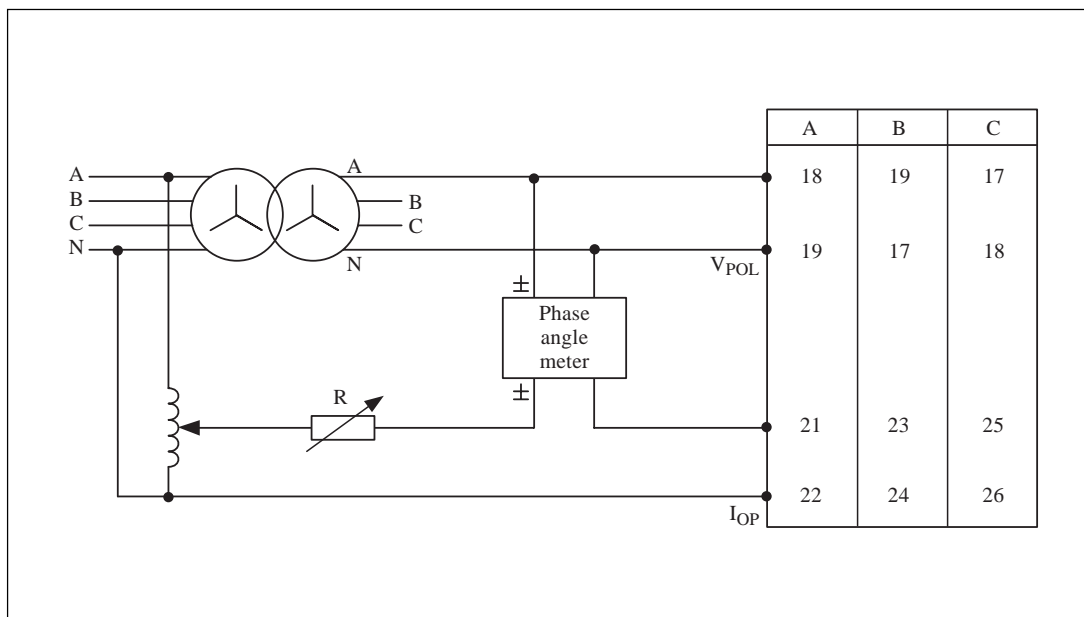


Figure 43. Connection for directional overcurrent relays KCEG 130/230, KCEG 140/240, KCEU 140/240

The forward start contact selected by the [RLY I> Fwd] relay mask under the RELAY MASKS heading and the reverse start contact selected by the [RLY I> Rev] relay mask should be monitored to indicate when the relay is in the operate region.

Taking positive angles as leading and negative angles as lagging, adjust the phase shifting transformer so the phase angle meter reads $(180^\circ + \text{RCA})$. Check that the reverse start contacts selected by the [I> Rev Start] relay mask have closed and the forward start contacts selected by the [I> Fwd Start] relay mask are open.

Rotate the phase shifting transformer so the phase lag is decreasing or the phase lead is increasing on the phase angle meter and continue until the forward start contacts close and the reverse contacts open. Note the angle on the phase angle meter and check it is within the limits stated in Table 6.29. Rotate the phase shifting transformer in the opposite direction to check the other operating boundary.

Relay in operate region : Phase angle meter indication	Tolerance
(RCA – 90°) lag through to (RCA + 90°) lead	$\pm 5^\circ$

Table 6.29

6.1.9.3 Current sensitivity for I>

This test checks the current sensitivity of the relay. The start contact selected by the [RLY I>] relay mask (or by [RLY I> Fwd] for directional phase fault relays) under the RELAY MASKS heading should be monitored to indicate when the input current exceeds the setting current I_s . This can be by either monitoring the relay contacts or viewing the [SYS Relay Stat] display in the SYSTEM DATA heading.

Where there is a star point on the relay, it is advantageous to inhibit the operation of the earth fault elements (inhibit to>, to>>, to>>>) in order to avoid confusion with trip signals and indications.

Inject single phase current into a convenient phase current input on the relay and slowly increase the current, noting the pick-up value at which the START relay operates. Reduce the current slowly and note the drop-off value at which the START relay resets. Check the pick-up and drop-off current is within the range shown in the Table 6.29.

	Current level
Pick-up	$0.95 \times I_s - 1.05 \times I_s$
Drop-off	$0.9 \times \text{pick-up} - 1.0 \times \text{pick-up}$

Table 6.30

The test must be repeated on all the phase elements of the relay.

Table 6.31 lists the terminals into which current should be injected for each of the phases.

Phase	Terminals
A	21 – 22
B	23 – 24
C	25 – 26

In addition, with some site wiring, it may be necessary to inject A-N, B-N, C-N.

Table 6.31

6.1.9.4 Time characteristic for t>

The relay selected for the t> trip can be found under the RELAY MASKS heading in [RLY t>]. The terminals for each relay are shown in the application diagram. Connect the relay contacts for the t> trip to both trip the test set and to stop a timer.

With the rated three phase polarizing voltage applied to the relay, set to twice the threshold level and the phase shifter adjusted to the characteristic angle of the relay, inject a 2 x rated current into one phase of the relay (terminals numbers are given in Table 6.31 for each phase) and measure the operation time. If the test set used can inject sufficient current, repeat the test at 10 x setting current. Check the operating time against Table 6.32.

Note: The operating times given above are for $TMS = 1$. Therefore to obtain the operating time for any other TMS setting the relay's actual TMS setting must be multiplied by the time given in the table above.

For all curves there is an additional tolerance of between 0.02 and 0.04 seconds.

The operating times given make no allowance for errors in the measuring instruments.

Curve description	Operating time at specified current (seconds) x TMS			
	2 x Is		10 x Is	
	Nominal	Range	Nominal	Range
STI30XDT	1.780	1.68 – 1.87	0.52	0.49 – 0.55
SI30XDT	10.03	9.52 – 10.53	2.97	2.82 – 3.12
I30XDT	15.05	14.30 – 15.81	2.34	2.23 – 2.46
VI30XDT	13.5	12.82 – 14.18	1.50	1.43 – 1.58
EI20XDT	26.67	24.66 – 28.67	0.81	0.74 – 0.87
EI10XDT	26.67	24.66 – 28.67	0.81	0.74 – 0.87
LTI30XDT	120.0	114 – 126	13.33	12.66 – 14
DT	[Set time to>] ±5% +[0.02 to 0.04 seconds]			

Table 6.32

6.1.9.5 Current setting for I>> and I>>>

WARNING

THE RELAY MAY BE DAMAGED BY APPLYING EXCESSIVE CURRENT FOR LONG DURATIONS DURING TESTING, OR IN RECURRENT BURSTS WITHOUT ALLOWING TIME FOR THE RELAY TO COOL DOWN.

This test is to check that the instantaneous current level of the I>> and I>>> is correct. If the I>> element is to be used by the customer then the PHASE FAULT function link 1 must be set to “1”. This test can only be performed if the test set available can inject sufficient current into the relay to cause the element to operate at the customer’s current setting. The relay selected for the I>> trip can be found under the RELAY MASKS heading in [RLY t>>].

When the setting is above the continuous current rating of the relay DO NOT INCREASE THE CURRENT SLOWLY since this may damage the relay before it can operate. Instead the current level should be set and then suddenly applied.

With the applied polarizing voltage set above twice the threshold level and the phase shifter adjusted to the characteristic angle of the relay, inject the higher of the two currents specified in Table 6.33 and check that the output relay operates and the correct flags are displayed. Reset the flags and repeat for the lower value of current and check that the relay does not operate, the trip LED is not lit and no flags are fault displayed.

TRIP I>> / I>>>	NO TRIP I>> / I>>>
1.05 x current setting	0.95 x current setting

Table 6.33

If the I>>>> threshold is to be used by the customer then the EARTH FAULT function link 2 should be set to “1”. Test 6.1.9.5 can then be repeated for Io>>>>, but

only if the test set available can inject sufficient current into the relay to cause the element to operate at the customer's current setting. The relay selected for the Io>>> trip can be found under the RELAY MASKS heading in [RLY to>>>]. The instantaneous trip output contacts must be connected to trip the test set.

6.1.10 Selective logic

For the selective logic checks only the features that are to be used in the application should be tested. Relay settings **must not** be changed to enable other logic functions that are not being used to be tested. For detailed descriptions of the selective logic please refer to Section 3.4 of this manual.

6.1.10.1 Opto-input checks

This test is to check that all the opto-inputs are functioning correctly. The state of the opto-isolated input can be viewed from the [SYS Logic Stat] display under the SYSTEM DATA heading. Relays of the type 110, 120 and 210 only have 3 opto-inputs (L0, L1 and L2). All other relay types have the full 8 opto-inputs (L0, L1, L2, L3, L4, L5, L6 and L7).

To enable energization of the opto-inputs, terminal 8 should be linked to terminals 52 and 55. The opto-inputs can then be individually energized by connecting terminal 7 to the appropriate opto-input listed in Table 6.34.

Opto-input number	Terminal
L0	46
L1	48
L2	50
L3	45
L4	47
L5	49
L6	51
L7	53

Table 6.34

The status of each opto-input can be viewed by displaying [SYS Logic Stat], which will be found towards the end of the SYSTEM DATA column of the menu. When each opto is energized one of the characters on the bottom line of the display will change to indicate the new state of the inputs. The number printed on the frontplate under the display will identify which opto each character represents. A "1" indicates an energized state and a "0" indicates a de-energized state.

Note: The opto-isolated inputs may be energized from an external 50V battery in some installations. Check that this is not the case before connecting the field voltage otherwise damage to the relay may result.

6.1.10.2. Controlled blocking of time delay elements

These tests should only be done if the particular relay application requires blocking of one or more of the time delay settings associated with the overcurrent elements. Typically this will occur in autoreclose schemes when blocking of the instantaneous element is required for certain parts of the autoreclose cycle, or in blocking schemes used to provide unit protection such as that to protect a busbar.

To perform the earth fault element blocking tests, opto-isolated inputs must have been allocated for each blocking function. Table 6.35 lists which input masks must have inputs allocated to them to enable blocking of earth fault elements. It is not necessary for opto-inputs to be assigned in masks to elements which do not require blocking.

Earth fault element	Input mask
to>	[INP Blk to>]
to>>	[INP Blk to>>]
to>>>	[INP Blk to>>>]

Table 6.35

To perform the phase fault element blocking tests, opto-isolated inputs must have been allocated for each blocking function. Table 6.36 lists which input masks must have inputs allocated to them to enable blocking of phase fault elements. It is not necessary for opto-inputs to be assigned in masks to elements which do not require blocking.

Phase fault element	Input mask
t>	[INP Blk t>]
t>>	[INP Blk t>>]
t>>>	[INP Blk t>>>]

Table 6.36

Repeat Tests 6.1.8.5 and 6.1.8.6 for earth faults and Tests 6.1.9.4 and 6.1.9.5 for phase faults, with appropriate opto-inputs energized and check that the element is correctly blocked and does not operate.

The test should be repeated on each element that has been allocated a blocking input.

6.1.10.3 Undervoltage logic

Only directional relays have the undervoltage trip facility. To enable this facility PHASE FAULT Function Link 6 must be set to “1”.

To test the undervoltage logic, a single phase voltage must be applied to the relay. When the voltage falls below the threshold setting $V<$ the timer $tV<$ will be energized and when it times out, the selected output relay in relay mask [RLY $tV<$] will pick up. When the applied voltage exceeds the threshold setting $V<$, the output relay will instantaneously reset. The setting value for $V<$ and $tV<$ can be found in the PHASE FAULT heading of the menu.

The length of the delay measured should be within $tV< \pm 0.5\% + (0.02 \text{ to } 0.05)$ seconds and the voltage at which the relay operates should be within $\pm 10\%$ of the $V<$ setting.

Note: If a three phase voltage is applied to the relay, then all three phase to neutral voltages will need to be reduced below the set voltage threshold $V<$ before the output relay can operate and any one phase voltage exceeding the threshold will cause reset.

6.1.10.4 Auxiliary timers

The auxiliary timers present in the relay should only be tested if they are to be used in the intended application and if the timer settings are not so high that testing is impractical.

6.1.10.4.1 Timer AUX1

To test the tAUX1 time delay an external switch must be connected to start an external timer interval meter and energize the opto input that activates tAUX1. The time interval meter must be stopped by the contacts of the relay allocated in relay mask [RLY tAUX1] when it operates.

If the LOGIC function link LOG2 is set to “1” then current must be injected into the relay above the undercurrent threshold $I_{<}$ during the test, otherwise the timer will be blocked from operating. If LOGIC function link LOG2 is set to “0” the current does not need to be injected into the relay during the test.

The measured time delay should be within the set time $tAUX1 \pm 0.5\% + (0.02 \text{ to } 0.05) \text{ seconds}$.

6.1.10.4.2 Timer AUX2

If the PHASE FAULT function link PF7 is set to “1” or the input mask [INP Aux2] has been allocated an input, then auxiliary timer 2 should be tested. There are two ways of testing the timer depending on the relay’s settings.

- * If the input mask [INP Aux2] has been allocated then an external time interval meter must be connected so that it starts when the opto-isolated input is energized and stops when the relay allocated by the relay mask [RLY tAUX2] operates.
- * If the PHASE FAULT function link PH7 is set to “1” then the timer will be energized via the undercurrent element when an undercurrent condition exists. The time interval meter must therefore be started when the current is removed and it must be stopped when the relay selected by the mask [RLY Aux2] operates.

The measured time delay should be within the set time $tAUX1 \pm 0.5\% + (0.02 \text{ to } 0.05) \text{ seconds}$.

6.1.10.4.3 Timer Aux3

If the LOGIC function link LOG3 is set to “1” or the input mask [INP Aux3] has been allocated an input, then auxiliary timer 3 should be tested. There are two ways of testing the timer depending on the relay’s settings.

- * If the input mask [INP Aux3] has been allocated then an external time interval meter must be connected so that it starts when the opto-isolated input is energized and stops when the relay allocated by the relay mask [RLY tAUX3] operates.
- * If the LOGIC function link LOG3 is set to “1” then the timer tAUX3 will be energized via the undercurrent element when the undercurrent threshold is exceeded (ie. an overcurrent condition). The time interval meter must therefore be started when the current is applied and it must be stopped when the relay selected by the mask [RLY Aux2] operates.

The measured time delay should be within the set time $tAUX1 \pm 0.5\% + (0.02 \text{ to } 0.05) \text{ seconds}$.

6.1.10.5 Breaker fail

When LOGIC function link LOG1 is set to “1” the breaker fail function should be tested. Operation of relay 3, initiated via any relay mask, will initiate the breaker fail timer tBF.

The relay should be connected to an overcurrent test set as described in Section 6.1.7.1 for overcurrent relays, or Section 6.1.8.1 for directional overcurrent relays. A time interval meter should be connected so that it starts when current is injected into the relay and arranged to stop by one of two functions:

- * If the function link LOG2 is set to “0” the time interval meter should be arranged to stop when a relay allocated by the mask [RLY I>]; [RLY Io>]; [RLY I> Fwd]; or [RLY Io> Fwd] is reset (dropped off) by the breaker fail timer.
- * If function link LOG2 is set to “1” then the time interval meter should be arranged to stop when the relay allocated via relay mask [RLY Aux1] operates.

The measured time delay should be within the set value of tBF $\pm 0.5\%$ + (0.02 to 0.05) seconds.

6.1.10.6 Change of setting group

Test the change of setting group if SYSTEM DATA function link SD4 is set to “1” as this will enable control of the setting group. If link SD4 is set to “0” then there is no need for the tests in this section to be carried out.

If SYSTEM DATA function link SD3 is set to “0” and link LOG5 is set to “0” the setting group can be changed by energizing the opto-input allocated by input mask [INP Stg Grp2]. However, if link LOG5 is set to “1” and no relay is allocated in input mask [INP Stg Grp2] the setting group will have to be tested as described under cold load pick-up in Section 6.1.10.7.

If link SD3 is set to “1” then the setting group can only be changed by a command over the communication channel, either from the master station or a local PC via suitable software.

To test the change of setting group initiate the change as described above. The active setting group can be observed in the SYSTEM DATA column of the menu under [SYS Setting Grp] where the current selected group is displayed. The active setting group is stored with the flags for each fault record.

If necessary some of the earlier setting tests can be repeated on setting group 2 to verify the settings in that group.

6.1.10.7 Cold load start/pick-up

The cold load start feature can operate in either of two ways.

The first method of operation is by inhibiting the instantaneous low set element for an additional time delay, equivalent to the setting of the cold load pick-up timer tCLP, when the circuit is first energized. The relay will operate in this way if LOGIC function link LOG4 is set to “1”. The I>> element must be enabled by setting PHASE FAULT function link PF1 to “1” and if link LOG6 is set to “0” an opto-input must be allocated in the input mask [INP CB Open CLP]. If link LOG6 is set to “1” then an opto-input must be allocated in mask [INP Aux2] or else link PF7 set to “1”.

To test the cold load start in this configuration the relay must be connected to an overcurrent test set as described in Sections 6.1.6.1; 6.1.7.1; 6.1.8.1 and 6.1.9.1 for the appropriate type of relay. The current should be set to a value above the current

threshold setting I>> (or Io>>) and then switched to the relay. The time interval meter should be connected so that it starts when current is applied to the relay and stops when the output relay selected in the [RLY I>>] [RLY Io>>] mask operates. The measured time should be increased by an amount equal to setting for tCLP when the cold load pick-up function is activated.

To activate the cold load pick-up timer energize the opto-input allocated in [INP CB Open CLP] or [INP Aux2] as appropriate. If link PF7 and LOG6 are both set to “1” then tCLP will be initiated automatically when the current is switched off.

Note: When timer tAUX2 is in circuit there will be a delay before the cold load pick-up function is activated.

The second method of operation is by selecting setting group 2 for a period of time after the circuit is energized. To operate in this way the function links must be set as follows:

LOGIC function link LOG5 = “1”

SYSTEM DATA function link SD3 = “0”

SYSTEM DATA function link SD4 = “1”

LOGIC function link LOG4 = “0”

Input masks [INP CB Open CLP] or [INP Aux2] must be allocated an input.

The cold load start can be initiated by either energizing the input set by the [INP Aux2] mask or by energizing the input set by the [INP CB Open CLP] mask. When cold load pick-up is initiated by energizing the input set by [INP Aux2] mask an additional time delay (tAux2) is introduced before setting group 1 is returned to.

To test the cold load start the relay should be injected with current above its setting during the cold load start period. The trip flags can then be examined to ensure that it was setting group 2 which initiated the trip during the cold load start period.

6.1.10.8 Circuit breaker control

Provided the relay is wired to control a circuit breaker a manual test can be performed via the user interface of the relay as a check that the connection is functioning correctly.

6.1.10.8.1 CB trip test

The relay mask [CB Trip] must be assigned to the output relays that are to trip the circuit breaker. This will not enable the remote control of the circuit breaker provided system data links 1 and 2 are set to “0”. The circuit breaker trip time delay (tTRIP) under the LOGIC heading, should be set to a value appropriate to the application.

Select the SYSTEM DATA heading from the menu.

Step down the column with short [F] key presses until the display reads:

SYS CB Control

No Operation

Press the [+] key and the cursor will flash on the bottom line of the display.

Press the [+] key once again and the bottom line of the display will change to TRIP.

Press the [F] key and the prompt will be displayed:

Are You Sure?

+ = YES – = NO

Press either the [0] key to abort.
[-] key to change option.
[+] key to execute command.

After executing the open command the output relay assigned to trip the circuit breaker by the [CB Open] relay mask, will operate for the trip time (tTRIP). During the trip test the status of this relay should be monitored to ensure it operates correctly.

6.1.10.8.2 CB close test

The relay mask [CB Close] must be assigned to the output relays that are to trip the circuit breaker. This will not enable the remote control of the circuit breaker provided the System Data Link 2 is set to "0". The circuit breaker close time delay (tCLOSE), under the LOGIC heading, should be set to a value appropriate to the particular application.

Select the SYSTEM DATA heading from the menu.

Step down the column with short [F] key presses until the display reads:

SYS CB Control
No Operation

Press the [+] key and the cursor will flash on the bottom line of the display.

Press the [+] key once again and the bottom line of the display will change to TRIP and press again to display CLOSE.

Press the [F] key and the prompt will be displayed:

Are You Sure?
+ = YES - = NO

Press either the [0] key to abort.
[-] key to change option.
[+] key to execute command.

After executing the close command the output relay assigned to close the circuit breaker by the [CB Close] relay mask, will operate for the close time delay (tCLOSE). During the close test the status of this relay should be monitored to ensure it operates correctly.

6.1.11 On-load tests

There are some tests that may be carried out with the circuit on-load provided there are no operational restrictions in force that prohibit this.

6.1.11.1 On-load measurement checks

Measure the secondary CT currents and if applicable, the secondary VT voltages. Compare the values of the secondary quantities with the relay's measured values, which can be found in MEASUREMENTS (1). If the CT and VT ratios are set to 1:1 then the values will be within $\pm 5\%$ of the secondary quantities, if the CT and VT ratios are not set to 1:1, then the measurement values will be equal to the secondary values multiplied by the appropriate transformer ratios.

6.1.11.2 On load directional check

Check the relay is wired correctly to the system diagram.

Measure that the secondary VT voltage is correct, and check with a phase rotation meter that the system phase rotation is correct.

Check that the CT polarities are correct and that the current flowing in the neutral circuit of the current transformers is negligible.

6.1.11.2.1 Phase fault directional elements – KCEG 130/140 and KCEU 130/140

Check the magnitude and direction of flow of the load current.

Check the relay characteristic angle for the phase fault elements is correct.

Note the current setting of the overcurrent setting $I>$ (this will be found under the PHASE FAULT(1) column heading of the menu). Then temporarily reduce this setting to a value less than the level of load current that is flowing at the time. The direction of the relay can then be determined from operation of either the forward or reverse start relays.

Should the operation of the relay be the reverse of what is expected, recheck the direction of current flow against the settings of the relay before making any changes to the external connections.

Restore all settings to their application values.

Note: These tests alone are not conclusive that the phase connections to the relay are correct. A phase angle measurement is required for conclusive testing.

6.1.11.2.2 Earth fault directional relay – KCEG/KCEU 140/240

Earth fault directional relays are not energized under normal load conditions and it is therefore necessary to simulate operating conditions.

For relays that also have directional phase elements the earth fault polarizing voltage is derived from the VT phase inputs.

To carry out an on-load test, we recommend the temporary connections shown in Figure 44 which simulate a phase A to neutral fault.

If load current is flowing in the operating direction then, providing that the correct phase relationships of the CTs and VTs have been proven and the artificially generated earth fault current is above setting, the forward start contacts will be closed.

Should the load current happen to be in the reverse direction then the current connections should be temporarily reversed, to check the operation of the relay, and then restored.

Note: These tests alone are not conclusive that the phase connections to the relay are correct. A phase angle measurement is required for conclusive testing.

6.1.11.2.3 Earth fault directional relay – KCEG/KCEU 110/150/160/210/250

Earth fault directional relays are not energized under normal load conditions and it is therefore necessary to simulate operating conditions.

For relays with only earth fault elements the relay should be connected to an open delta winding of a voltage transformer and the residual circuit of the current transformers.

There are many ways of making the special connections on the CT and VT circuits to carry out an on-load test, but we recommend the temporary connections shown in Figure 45 which simulate a phase A to neutral fault.

If load current is flowing in the operating direction then provided that the correct phase relationships of the CTs and VTs have been proven and the artificially

Note: These tests alone are not conclusive that the phase connections to the relay are correct. A phase angle measurement is required for conclusive testing.

6.1.12 KCEU141/241 Wattmetric element

6.1.12.1 Test connections and settings

Connect the auxiliary supply to the relay and record the voltage at terminals 13(+ve) and 14(-ve).

Ensure that the line CTs are short circuited and disconnected from the relay.

The relay to be commissioned should be set up as shown in Figure 46.

Terminals 17 and 19 should both be connected to earth.

To test the wattmetric element it is necessary to set some function links to directionalise the earth fault elements. Table 6.37 shows which EARTH FAULT function links must be set to “1” to enable directional control of each of the earth fault elements.

Earth fault element	Earth fault function link
Io>>	1
Io>>>	2
Dirn to>	3
Dirn to>>	4
Dirn to>>>	5

Table 6.37

To test the Wattmetric element the following settings should be applied to the relay;

EF1 Po> 30W (5Amp relay), 6W (1 Amp relay)
EF1 Char angle 0°
to> 0s
tREST 0s

6.1.12.2 Power setting for Po>

Apply 60V to terminals 18 and 20, with the neutral being connected to 20. Inject a current of 450mA (5A relay) or 90mA (1A relay) and gradually increase until the relay operates.

Operation should occur in the region of 500mA (5A relay) or 100mA (1A relay). The value of operate current should be noted.

The relay fault flags will show operation of the earth element N* in group 1.

The above test, to prove operation of the wattmetric element, relies on the injected current being in phase with the applied voltage.

Alternatively the required operating current can be calculated from the following formula

$$Po = Vo \times Io \times \cos(\emptyset - \emptyset_c)$$

Where Po = zero sequence power threshold
 Vo = residual voltage (3 x zero sequence volts)
 Io = residual current
 \emptyset = Phase angle between applied volts and current
 \emptyset_c = Relay characteristic angle

Reverse the polarity of the 60V voltage supply and check that the relay restrains.

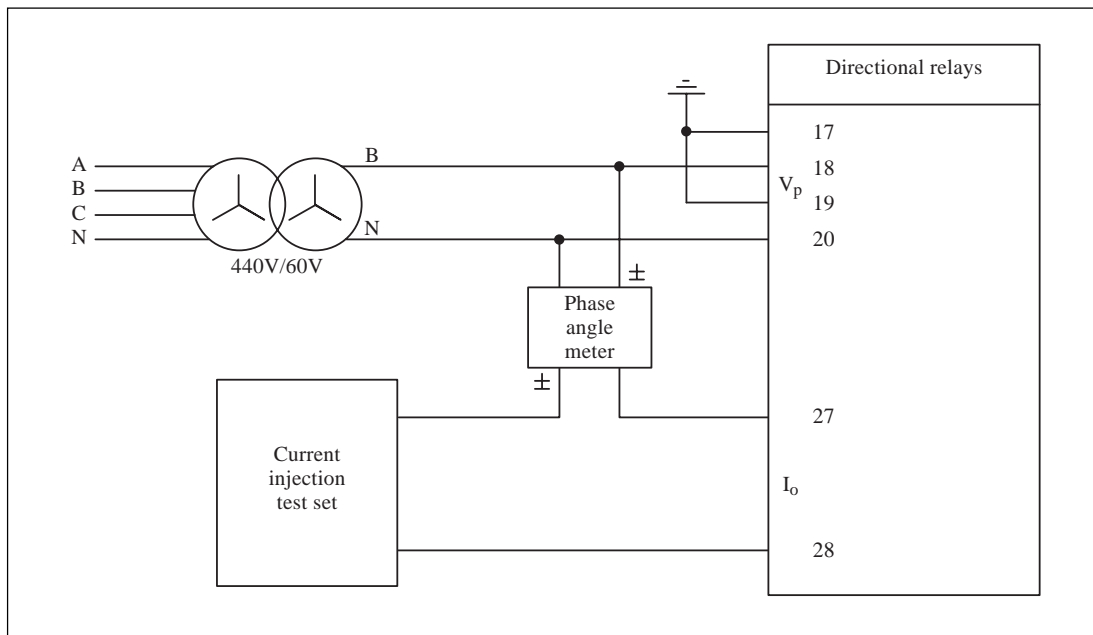


Figure 46. Connection diagram for KCEU141/241

6.2. Problem solving

6.2.1 Password lost or not accepted

Relays are supplied with the password set to AAAA.

Only uppercase letters are accepted.

Password can be changed by the user, see Section 3.3.

There is an additional unique recovery password associated with the relay which can be supplied by the factory, or service agent, if given details of its serial number.

The serial number will be found in the system data column of the menu and should correspond to the number on the label at the top right hand corner of the frontplate of the relay. If they differ, quote the one in the system data column.

6.2.2 Protection settings

6.2.2.1 Settings for highsets not displayed

Set function link PF1 to “1” to turn on settings I>>/t>>.

Set function link PF1 to “1” to turn on settings I>>>/t>>>.

Set function link EF1 to “1” to turn on settings Io>>/to>>.

Set function link EF1 to “1” to turn on settings Io>>>/to>>>.

6.2.2.2 Second setting group not displayed

Set function link SD4 to “1” to turn on the group 2 settings.

6.2.2.3 Function links cannot be changed

Enter the password as these menu cells are protected.

Links are not selectable if associated text is not displayed.

6.2.2.4 Curve selection cannot be changed

Enter the password as these menu cells are protected.

Curves may not have been made selectable in the particular relay.

6.2.3 Alarms

If the watchdog relay operates, first check that the relay is energized from the auxiliary supply. If it is, then try to determine the cause of the problem by examining the alarm flags towards the bottom of the SYSTEM DATA column of the menu. This will not be possible if the display is not responding to key presses.

Having attempted to determine the cause of the alarm it may be possible to return the relay to an operable state by resetting it. To do this, remove the auxiliary power supply for approximately 10 seconds and if it is powered from the CT circuit as well, remove this source of supply, possibly by withdrawing the module from its case. Then re-establish the supplies and the relay should in most cases return to an operating state.

Recheck the alarm status if the alarm LED is still indicating an alarm state.

The following notes will give further guidance.

6.2.3.1 Watchdog alarm

Auxiliary powered relays: the watchdog relay will pick up when the relay is operational to indicate a healthy state, with its “make” contact closed. When an alarm condition that requires some action to be taken is detected, the watchdog relay resets and its “break” contact will close to give an alarm.

Dual powered relays: the watchdog relay operates in a slightly modified way on this version of the relay, because it does not initiate an alarm for loss of the auxiliary power, as this may be taken from an insecure source, or it may be powered solely from the current circuit. In either case it will not be required to indicate an alarm for loss of the auxiliary power source, as this may be a normal operational condition. Operation of the watchdog is therefore inverted so that it will pick-up for a failed condition, closing its “make” contact to give an alarm and in the normal condition it will remain dropped-off with its “break” contact closed to indicate that it is in a healthy state.

Note: The green LED will usually follow the operation of the watchdog relay in either of the above two cases.

There is no shorting contact across the case terminals connected to the “break” contact of the watchdog relay. Therefore, the indication for a failed/healthy relay will be cancelled when the relay is removed from its case.

If the relay is still functioning, the actual problem causing the alarm can be found from the alarm records in the SYSTEM DATA column of the menu (see Section 3.7.1).

6.2.3.2 Unconfigured or uncalibrated alarm

For a CONFIGURATION alarm the protection is stopped and no longer performing its intended function. For an UNCALIBRATED alarm the protection will still be operational but there will be an error in its calibration that will require attention. It may be left running provided the error does not cause any grading problems.

To return the relay to a serviceable state the initial factory configuration will have to be reloaded and the relay recalibrated. It is recommended that the work be carried out at the factory, or entrusted to a recognized service centre.

6.2.3.3 Setting error alarm

A SETTING alarm indicates that the area of non-volatile memory where the selected protection settings are stored, has been corrupted. The current settings should be checked against those applied at the commissioning stage or any later changes that have been made.

If a personal computer (PC) is used during commissioning then it is recommended that the final settings applied to the relay are copied to a floppy disc with the serial number of the relay used as the file name. The setting can then be readily loaded back into the relay if necessary, or to a replacement relay.

6.2.3.4 “No service” alarm

This alarm flag can only be observed when the relay is in the calibration or configuration mode when the protection program will be stopped.

6.2.3.5 Fault flags will not reset

These flags can only be reset when the flags Fn are being displayed or by resetting the fault records, see Section 3.3.10.

6.2.4 Records

6.2.4.1 Problems with event records

Fault records will only be generated if RLY3 is operated as this relay is the trigger to store the records.

Fault records can be generated in response to another protection operating if RLY3 is operated by one of its trip contacts via an auxiliary input. This will result in the fault values, as measured by the K-Relay, being stored at the instant RLY3 resets. The flag display will include a flag to identify the auxiliary input that initiated the record.

Fault currents recorded are lower than actual values, as the fault is interrupted before measurement is completed.

Few fault records can be stored when changes in state of logic inputs and relay outputs are stored in the event records. These inputs and outputs can generate many events for each fault occurrence and limit the total number of faults that can be stored. Setting System Data Link 7 to “0” will turn off this feature and allow the maximum number of fault records to be stored.

The event records are erased if the auxiliary supply to the relay is lost for a period exceeding the hold-up time of the internal power supply.

Events can only be read via the serial communication port and not on the LCD.

Any spare opto-inputs may be used to log changes of state of external contacts in the event record buffer of the K-Relay. The opto-input does not have to be assigned to a particular function in order to achieve this.

The oldest event is overwritten by the next event to be stored when the buffer becomes full.

When a master station has successfully read a record it usually clears it automatically and when all records have been read the event bit in the status byte is set to “0” to indicate that there are no longer any records to be retrieved.

6.2.4.2 Problems with disturbance records

Only one record can be held in the buffer and the recorder must be reset before another record can be stored. Automatic reset can be achieved by setting function link SD6 to 1. It will then reset the recorder 3 seconds after a current, greater than the undercurrent setting has been restored to the protected circuit.

The disturbance records are erased if the auxiliary supply to the relay is lost for a period exceeding the hold-up time of the internal power supply.

Disturbance records can only be read via the serial communication port. It is not possible to display them on the LCD.

No trigger selected to initiate the storing of a disturbance record.

Disturbance recorder automatically reset on restoration of current above the undercurrent setting for greater than 3 seconds. Change function link SD6 to 0 to select manual reset.

Post trigger set to maximum value and so missing the fault.

When a master station has successfully read a record it will clear it automatically and the disturbance record bit in the status byte will then be set to "0" to indicate that there is no longer a record to be retrieved.

6.2.5 Circuit breaker maintenance records

When a replacement relay is fitted it may be desirable to increment the CB maintenance counters to the values of that on the old relay. The current squared counters can be incremented by applying a number of secondary injection current pulses to the current inputs of the relay, but note that the counter will increment rapidly for large current values. The counter for the number of circuit breaker operations can be incremented manually by operating the relay the required number of times.

The circuit breaker trip time for the last fault cannot be cleared to zero. This is to enable the master station to interrogate the relay for this value as a supervisory function.

The circuit breaker maintenance counters are not incremented when another protection trips the circuit breaker. Add a trip input from the protection to an auxiliary input of the relay and arrange for relay RLY3 or RLY7 to operate instantaneously in response to the input.

6.2.6 Communications

Address cannot be automatically allocated if the remote change of setting has been inhibited by function link SD0. This must be first set to "1", alternatively the address must be entered manually via the user interface on the relay.

Address cannot be allocated automatically unless the address is first manually set to 0. This can also be achieved by a global command including the serial number of the relay.

Relay address set to 255, the global address for which no replies are permitted.

6.2.6.1 Measured values do not change

Values in the MEASUREMENTS (1) and MEASUREMENTS (2) columns are snap-shots of the values at the time they were requested. To obtain a value that varies with the measured quantity it should be added to the poll list as described in R8514, the User Manual for the Protection Access Software & Toolkit.

6.2.6.2 Relay no longer responding

Check if other relays that are further along the bus are responding and if so, power down the relay for 10 seconds and then re-energize to reset the communication processor. This should not be necessary as the reset operation occurs automatically when the relay detects a loss of communication.

If relays further along the bus are not communicating, check to find out which are responding towards the master station. If some are responding then the position of the break in the bus can be determined by deduction. If none is responding then check for data on the bus or reset the communication port driving the bus with requests.

Check there are not two relays with the same address on the bus.

6.2.6.3 No response to remote control commands

Check that the relay is not inhibited from responding to remote commands by observing the system data function link settings. If so reset as necessary; a password will be required.

System data function links cannot be set over the communication link if the remote change of settings has been inhibited by setting system data function link SD0 to 0. Reset SD0 to 1 manually via the user interface on the relay first.

Relay is not identified in the Circuit Breaker Control Menu of the Courier Master Station if two auxiliary circuit breaker contacts have not been connected to opto-inputs of the relay, to indicate its position via the Plant Status Word. Check input mask settings and the connections to the auxiliary contacts of the circuit breaker.

6.2.7 Output relays remain picked-up

6.2.7.1 Relays associated with auxiliary timers

Relays with software issue A to F ie. relays with model numbers suffixed by A or B will have logic arranged as shown in Publication R8501. Some problems have occasionally been experienced with these relays when using the timer tAUX2 in earth fault only relays Type KCGG110/210, KCGG120, KCGG160, KCGU110, KCEG110/210, KCEG160, KCEU110 and KCEU160. It is unlikely that this timer will be in use because of the limited I/O, but if it is to be used and you are experiencing a problem please contact our sales department at AREVA T&D.

If an output relay is allocated in the output mask [RLY Aux2] on any of the listed relays and it is in a continually operated state after the timer tAUX2 has timed out, it can be reset by fitting an alternative EPROM supplied from the factory. This will remove the hidden link that is latching the operation, but will not in itself make the full modification available to the user.

To make the modification fully operational the relay will require re-configuring to turn on the additional function links EF7 and LOG8 before they can function. To do this, special equipment will be required and the relay should be returned to the factory.

6.2.7.2 Relays remain picked-up when de-selected by link or mask

If an output relay is operated at the time it is de-selected, either by a software link change or by de-selecting it in an output mask, it may remain operated until the relay is powered down and up again. It is therefore advisable to momentarily remove the energizing supply after such changes.

6.3. Maintenance

6.3.1 Remote testing

K Range Midos relays are self-supervising and so require less maintenance than earlier designs of relay. Most problems will result in an alarm so that remedial action can be taken. However, some periodic tests could be done to ensure that the relay is functioning correctly. If the relay can be communicated with from a remote point, via its serial port, then some testing can be carried out without actually visiting the site.

6.3.1.1 Alarms

The alarm status LED should first be checked to identify if any alarm conditions exist. The alarm records can then be read to identify the nature of any alarm that may exist.

6.3.1.2 Measurement accuracy

The values measured by the relay can be compared with known system values to check that they are in the approximate range that is expected. If they are, then the analogue/digital conversion and calculations are being performed correctly.

6.3.1.3 Trip test

If the relay is configured to provide remote control of the circuit breaker then a trip test can be performed remotely in several ways:

1. Measure the load current in each phase and reduce the phase fault setting of the relay to a known value that is less than the load current. The relay should trip in the appropriate time for the given multiple of setting current.

The settings can then be returned to their usual value and the circuit breaker reclosed.

Note: If the second group of settings is not being used for any other purpose it could be used for this test by having a lower setting selected and issuing a command to change the setting group that is in use to initiate the tripping sequence.

2. If the relay is connected for remote control of the circuit breaker then a trip/close cycle can be performed. This method will not check as much of the functional circuit of the relay as the previous method but it will not need the settings of the relay to be changed.

If a failure to trip occurs the relay status word can be viewed, whilst the test is repeated, to check that the output relay is being commanded to operate. If it is not responding then an output relay allocated to a less essential function may be reallocated to the trip function to effect a temporary repair, but a visit to site may be needed to effect a wiring change. See Section 3.3.8 for how to set relay masks.

6.3.1.4 CB maintenance

Maintenance records for the circuit breaker can be obtained at this time by reading the appropriate data in the MEASUREMENT(2) and the FAULT RECORDS columns.

6.3.2 Local testing

When testing locally, similar tests may be carried out to check for correct functioning of the relay.

6.3.2.1 Alarms

The alarm status LED should first be checked to identify if any alarm conditions exist. The alarm records can then be read to identify the nature of any alarm that may exist.

6.3.2.2 Measurement accuracy

The values measured by the relay can be checked against own values injected into the relay via the test block, if fitted, or injected directly into the relay terminals. Suitable test methods will be found in Section 6.1 of this manual which deals with commissioning. These tests will prove the calibration accuracy is being maintained.

6.3.2.3 Trip test

If the relay is configured to provide a “trip test” via its user interface then this should be performed to test the output trip relays. If the relay is configured for remote control of the circuit breaker the “trip test” will initiate the remote CB trip relay and not the main trip relay that the protection uses. In which case the main trip relay should be tested by injecting a current above the protection setting so that operation occurs.

If an output relay is found to have failed, an alternative relay can be reallocated until such time as a replacement can be fitted. See Section 3.3.8 for how to set relay masks.

6.3.2.4 CB maintenance

Maintenance records for the circuit breaker can be obtained at this time by reading the appropriate data in the MEASUREMENT(2) and the FAULT RECORDS columns.

6.3.2.5 Additional tests

Additional tests can be selected from the Commissioning Instructions as required.

6.3.3 Method of repair

Please read the handling instructions in Section 1 before proceeding with this work. This will ensure that no further damage is caused by incorrect handling of the electronic components.

6.3.3.1 Replacing a pcb

a) Replacement of user interface

Withdraw the module from its case.

Remove the four screws that are placed one at each corner of the frontplate.

Remove the frontplate.

Lever the top edge of the user interface board forwards to unclip it from its mounting.

Then pull the pcb upwards to unplug it from the connector at its lower edge.

Replace with a new interface board and assemble in the reverse order.

b) Replacement of main processor board

This is the pcb at the extreme left of the module, when viewed from the front. To replace this board:

First remove the screws holding the side screen in place. There are two screws through the top plate of the module and two more through the base plate.

Remove screen to expose the pcb.

Remove the two retaining screws, one at the top edge and the other directly below it on the lower edge of the pcb.

Separate the pcb from the sockets at the front edge of the board. Note that they are a tight fit and will require levering apart, taking care to ease the connectors apart gradually so as not to crack the front pcb card. The connectors are designed for ease of assembly in manufacture and not for continual disassembly of the unit.

Reassemble in the reverse of this sequence, making sure that the screen plate is replaced with all four screws securing it.

c) Replacement of auxiliary expansion board

This is the second board in from the left hand side of the module.

Remove the processor board as described above in b).

Remove the two securing screws that hold the auxiliary expansion board in place.

Unplug the pcb from the front bus as described for the processor board and withdraw.

Replace in the reverse of this sequence, making sure that the screen plate is replaced with all four screws securing it.

6.3.3.2 Replacing output relays and opto-isolators

PCBs are removed as described in Section 6.3.3.1 b and c. They are replaced in the reverse order. Calibration is not usually required when a pcb is replaced unless either of the two boards that plug directly on to the left hand terminal block are replaced, as these directly affect the calibration.

Note that this pcb is a through hole plated board and care must be taken not to damage it when removing a relay for replacement, otherwise solder may not flow through the hole and make a good connection to the tracks on the component side of the pcb.

6.3.3.3 Replacing the power supply board

Remove the two screws securing the right hand terminal block to the top plate of the module.

Remove the two screws securing the right hand terminal block to the bottom plate of the module.

Unplug the back plane from the power supply pcb.

Remove the securing screw at the top and bottom of the power supply board.

Withdraw the power supply board from the rear, unplugging it from the front bus.

Reassemble in the reverse of this sequence.

6.3.3.4 Replacing the back plane (size 4 and 6 case)

Remove the two screws securing the right hand terminal block to the top plate of the module.

Remove the two screws securing the right hand terminal block to the bottom plate of the module.

Unplug the back plane from the power supply pcb.
Twist outwards and around to the side of the module.
Replace the pcb and terminal block assembly.
Reassemble in the reverse of this sequence.

6.3.4 Recalibration

Whilst recalibration is not usually necessary it is possible to carry it out on site, but it requires test equipment with suitable accuracy and a special calibration program to run on a PC. This work is not within the capabilities of most people and it is recommended that the work is carried out by an authorized agency.

After calibration the relay will need to have all the settings required for the application re-entered and so it is useful if a copy of the settings is available on a floppy disk. Although this is not essential it can reduce the down time of the system.

6.3.5 Digital test equipment

If commissioning testing is carried out using a digital secondary injection test set there may be an apparent erratic operation at the boundaries of the directional characteristic. This will be particularly noticeable when observing the operation of the start relay contacts, which is the method described in the commissioning instructions in Section 6.1. This is caused by the transitional errors when changing direction or applying signals instantaneously.

The problem is easily overcome by using the $t>$, $t>>$, $t>>>$, $to>$, $to>>$, or $to>>>$ outputs for indication of relay operation instead of $I>$, or $Io>$. These time delays should then be set to a minimum of 20ms. See also the notes in Section 4.3.5 of this manual.

The slight directional indecision of the start relays should not cause any problem as it will be covered by the short time delays that are applied in the blocking schemes.

**Appendix 1. CHARACTERISTIC CURVES FOR KCGG, KCGU, KCEG
and KCEU RELAYS**

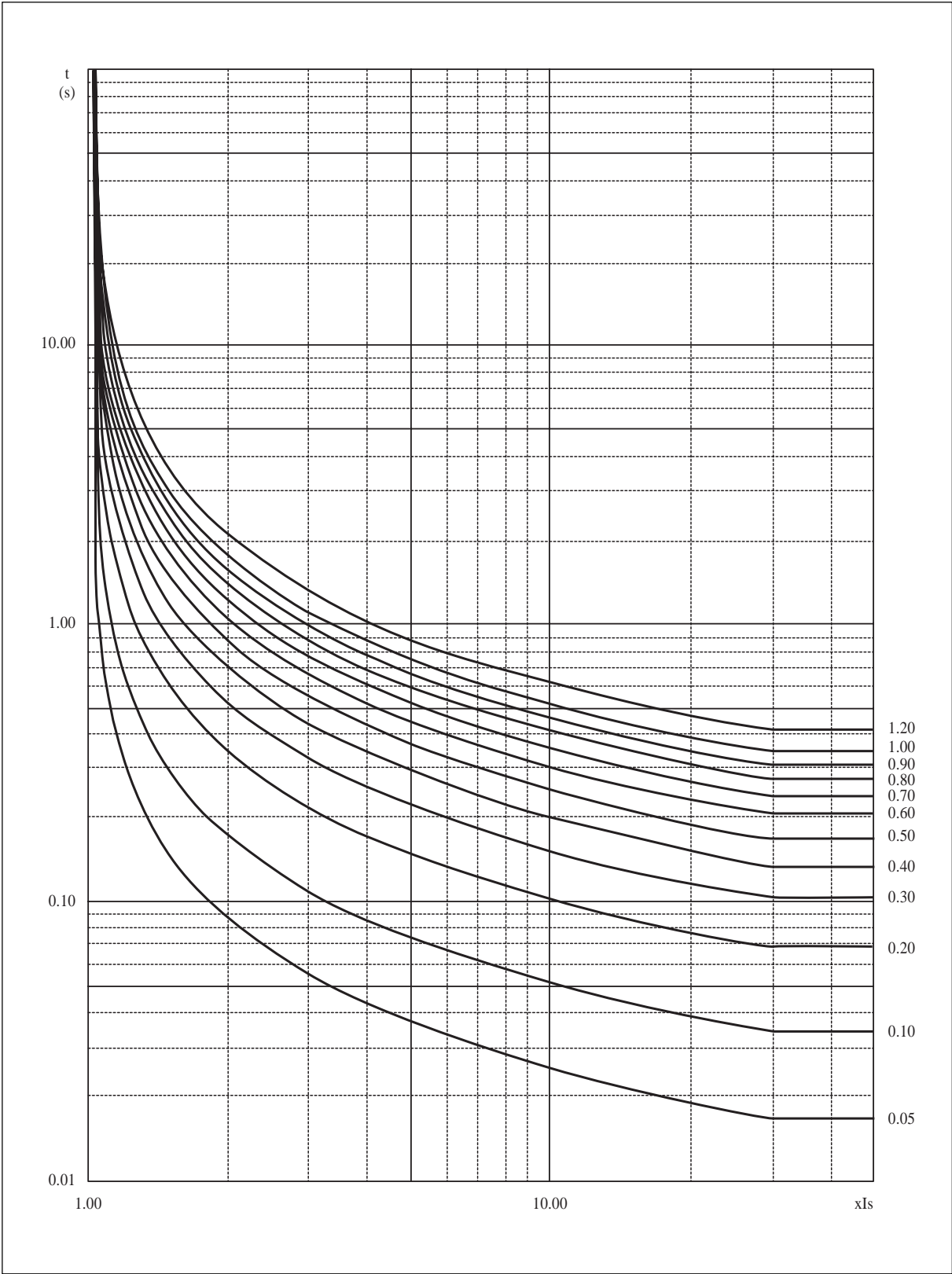


Figure 47. Characteristic curve ST30XDT short time inverse – definite time above 30xIs

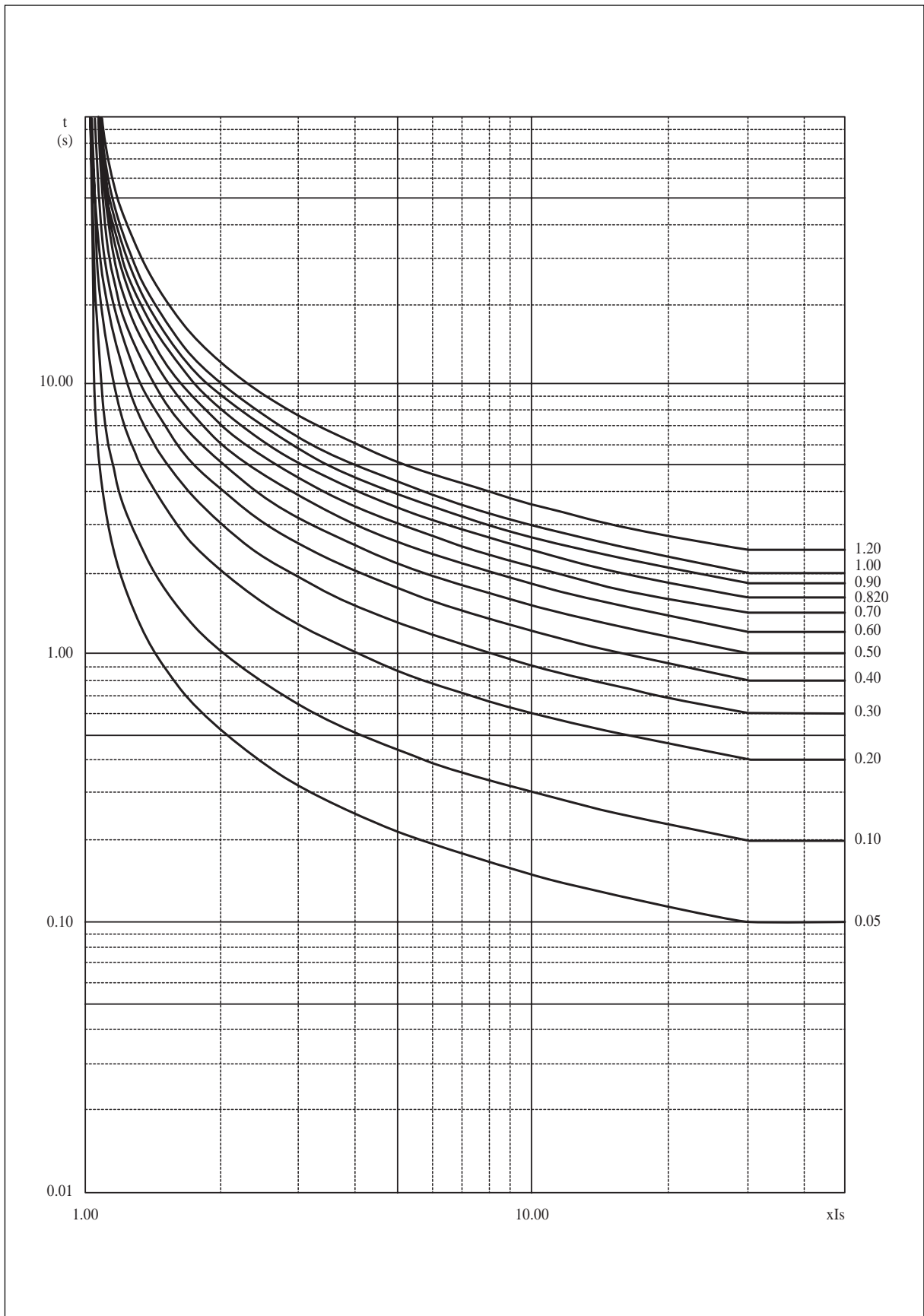


Figure 48. Characteristic curve SI30XDT standard inverse (moderately inverse) – definite time above $30xI_s$

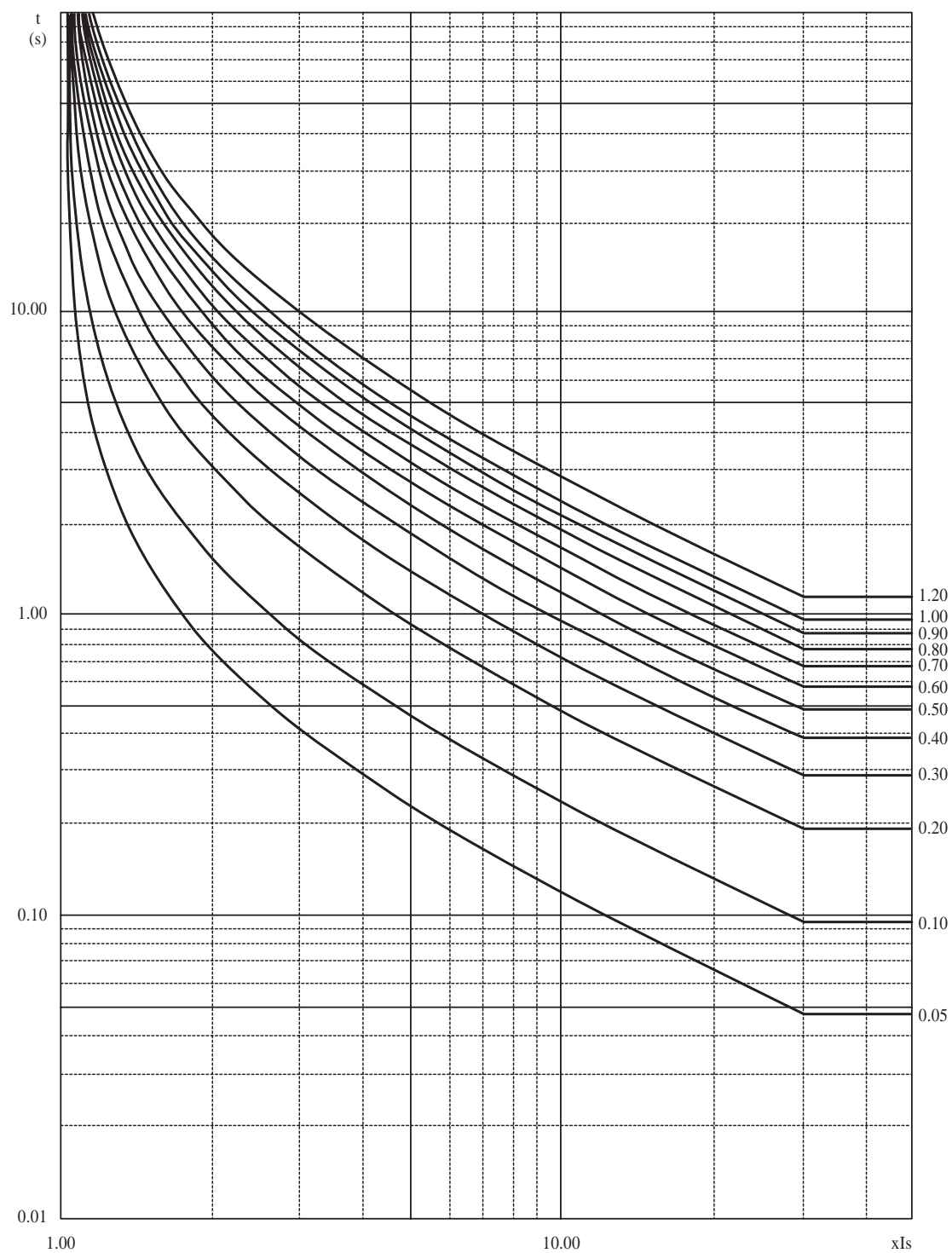


Figure 49. Characteristic curve IN30XDT inverse – definite time above 30xIs

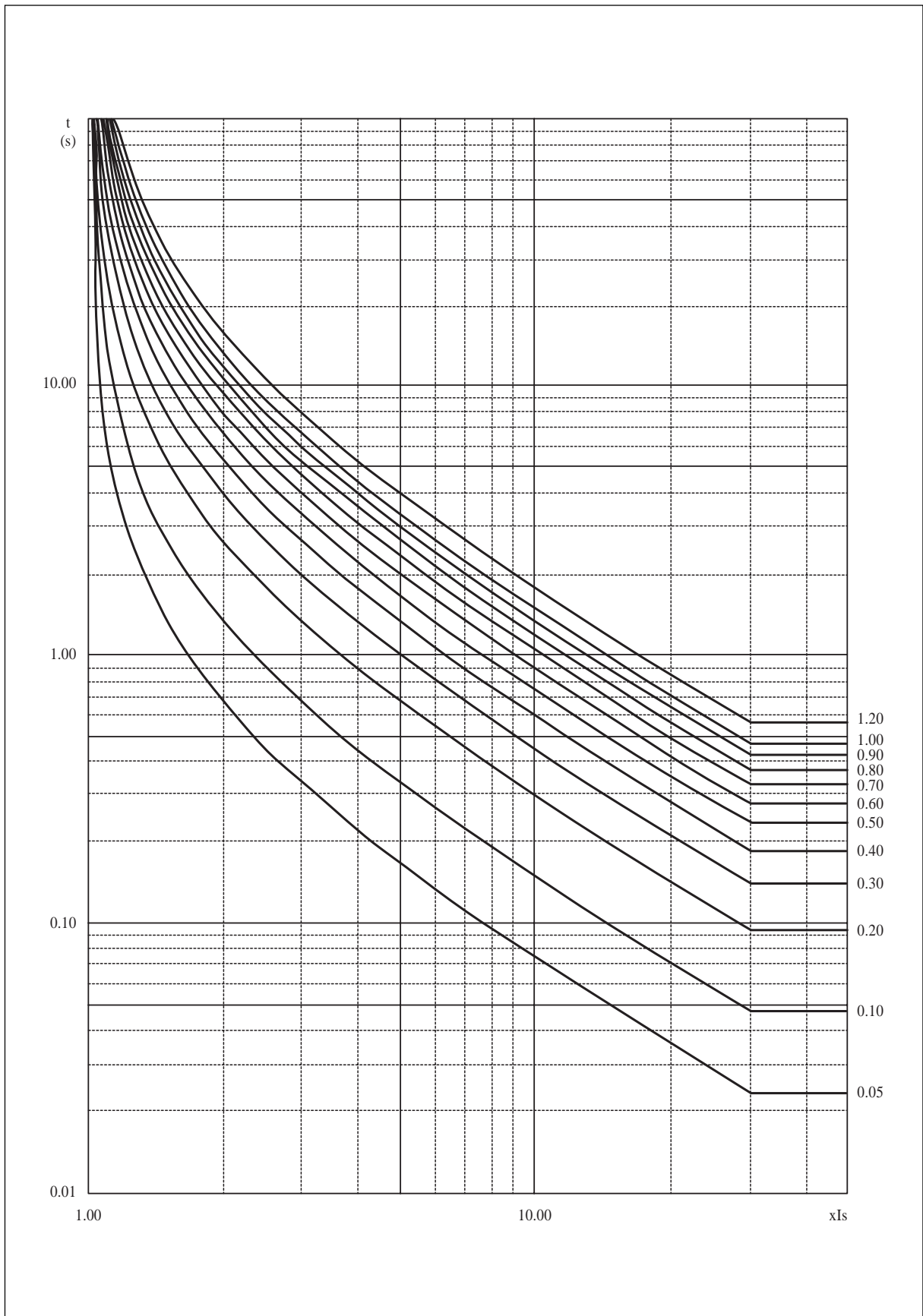


Figure 50. Characteristic curve VI30XDT very inverse – definite time above $30xI_s$

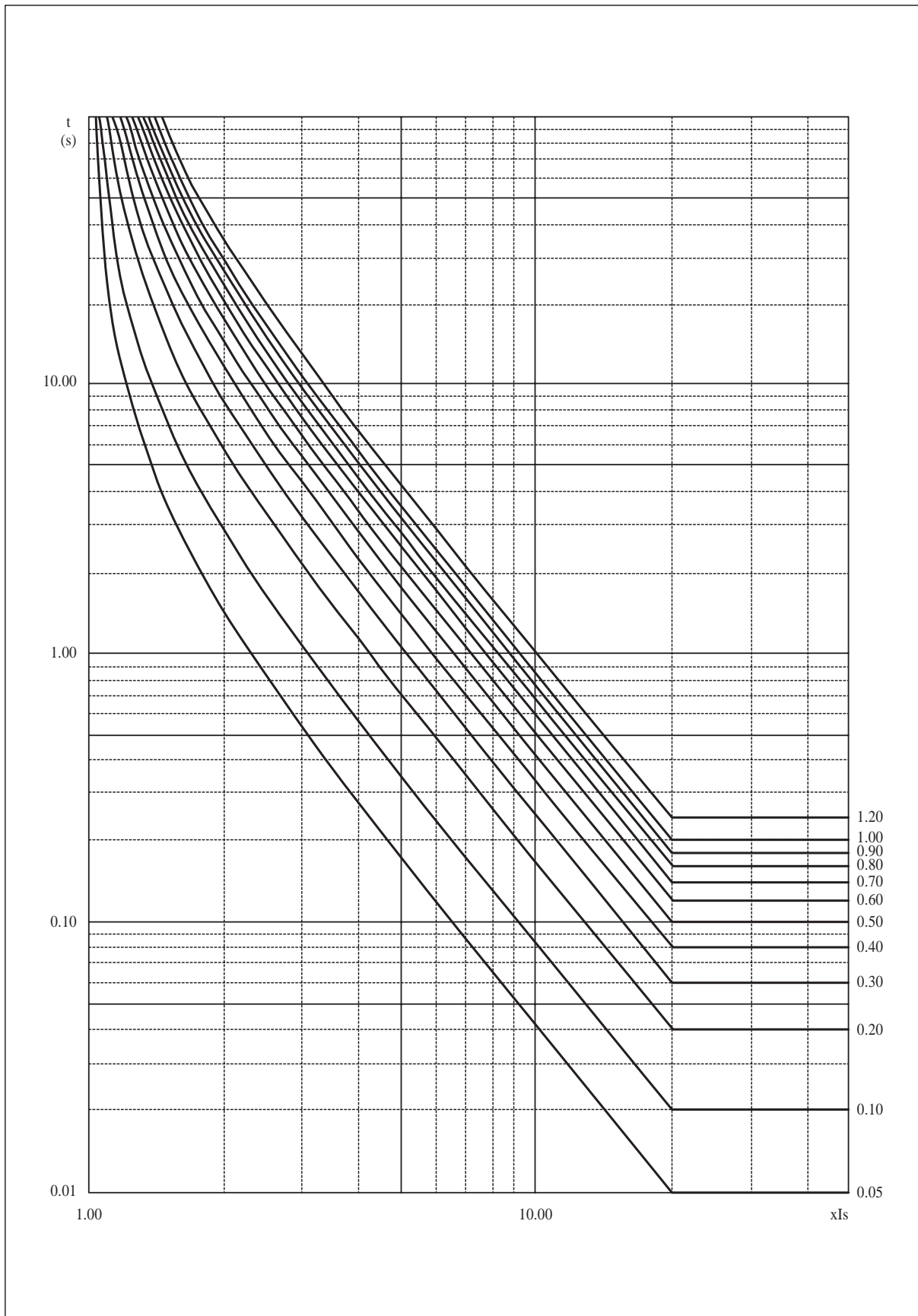


Figure 51. Characteristic curve EI20XDT extremely inverse – definite time above 20xIs

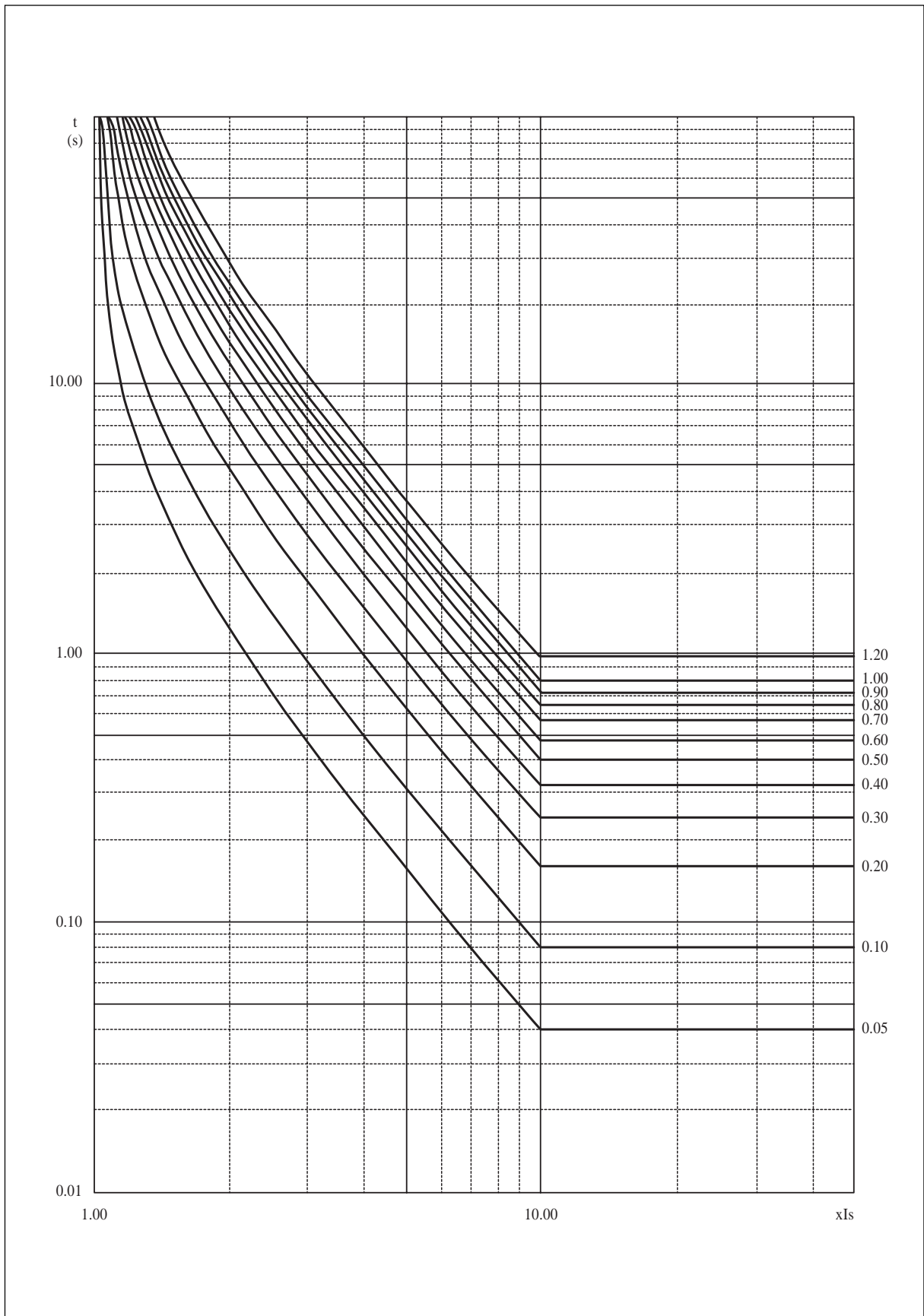


Figure 52. Characteristic curve EI10XDT extremely inverse – definite time above 10xIs

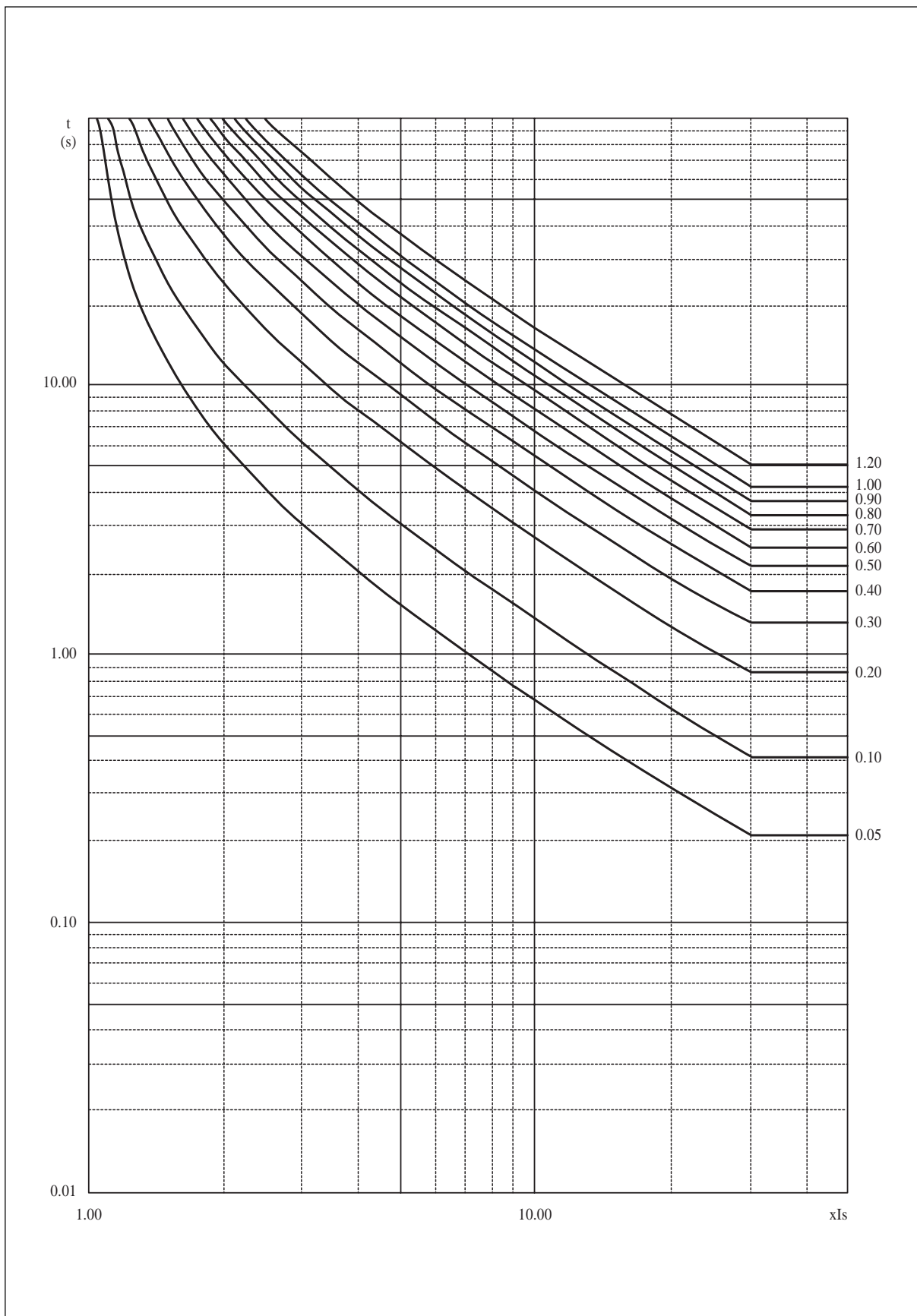


Figure 53. Characteristic curve LT30XDT long time inverse – definite time above 30xIs

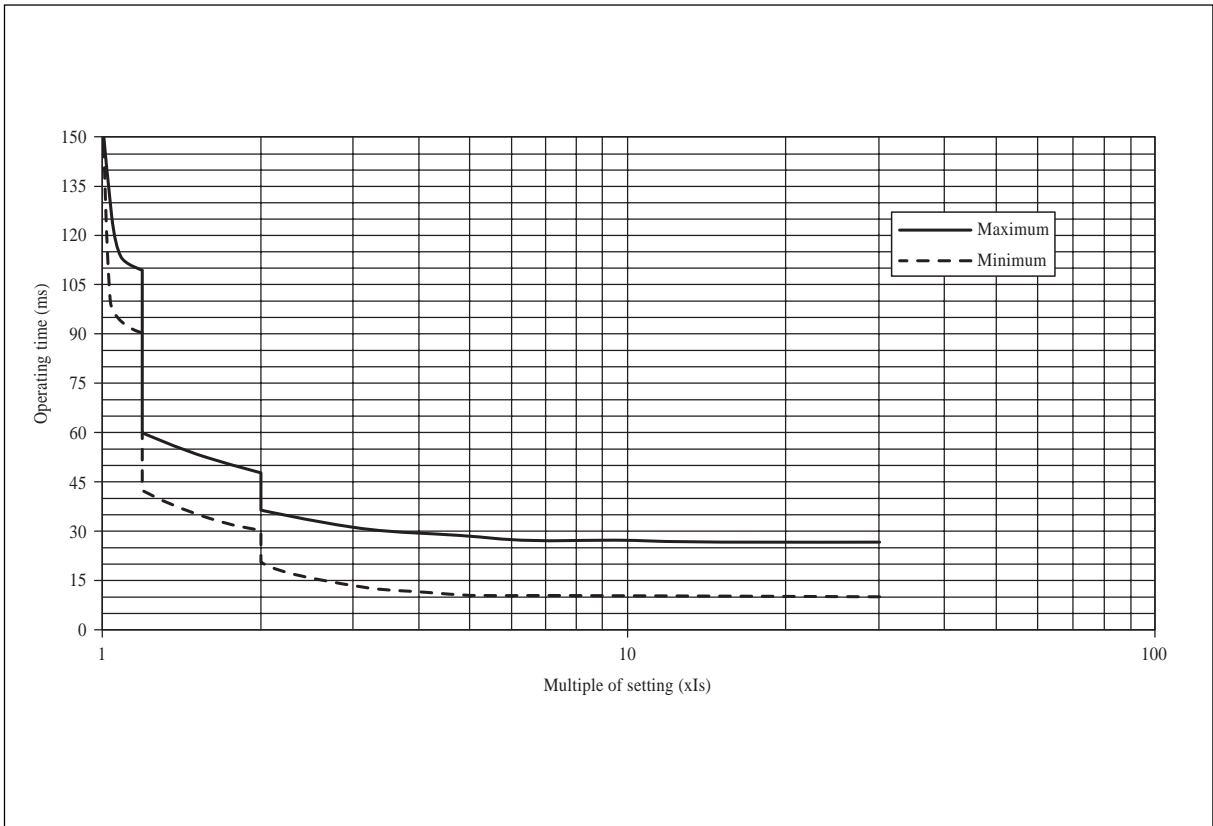


Figure 54. Operating times KCGG $I_{>>}$, $I_{>>>}$ and $I_{o>>>}$

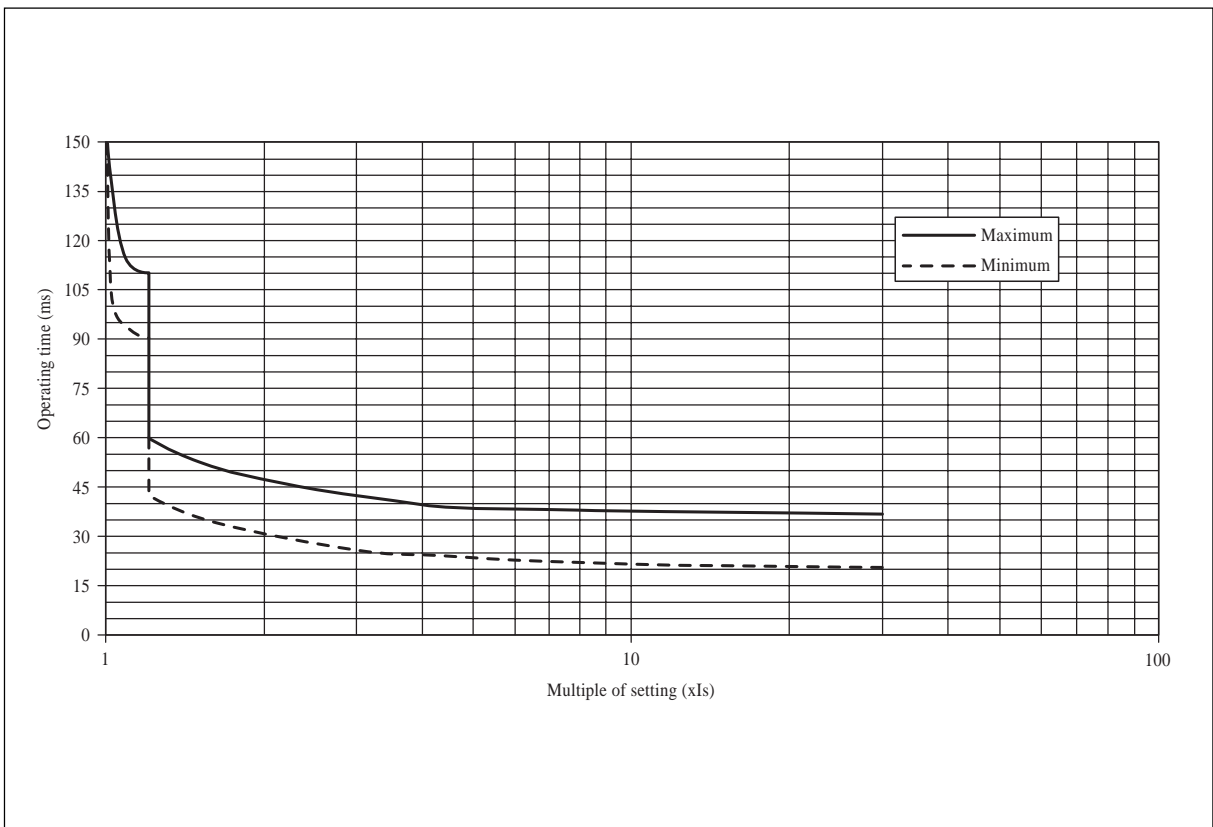


Figure 55. Operating times KCEG $I_{>>}$, $I_{>>>}$ and $I_{o>>>}$

Appendix 2. LOGIC DIAGRAMS FOR KCGG, KCGU, KCEG and KCEU RELAYS

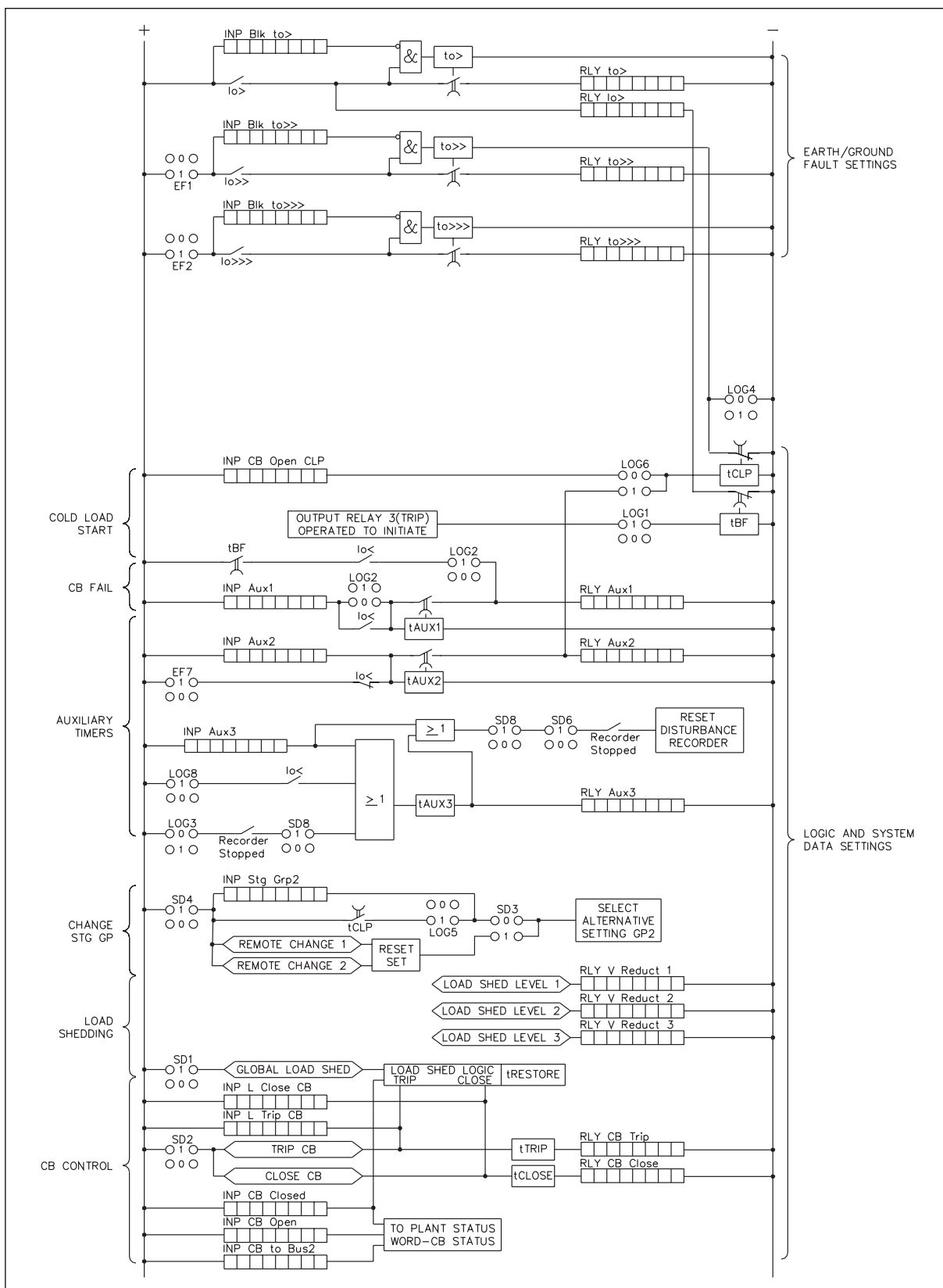


Figure 56. Logic diagram: earth fault relays Types KCGG 110 and KCGU 110

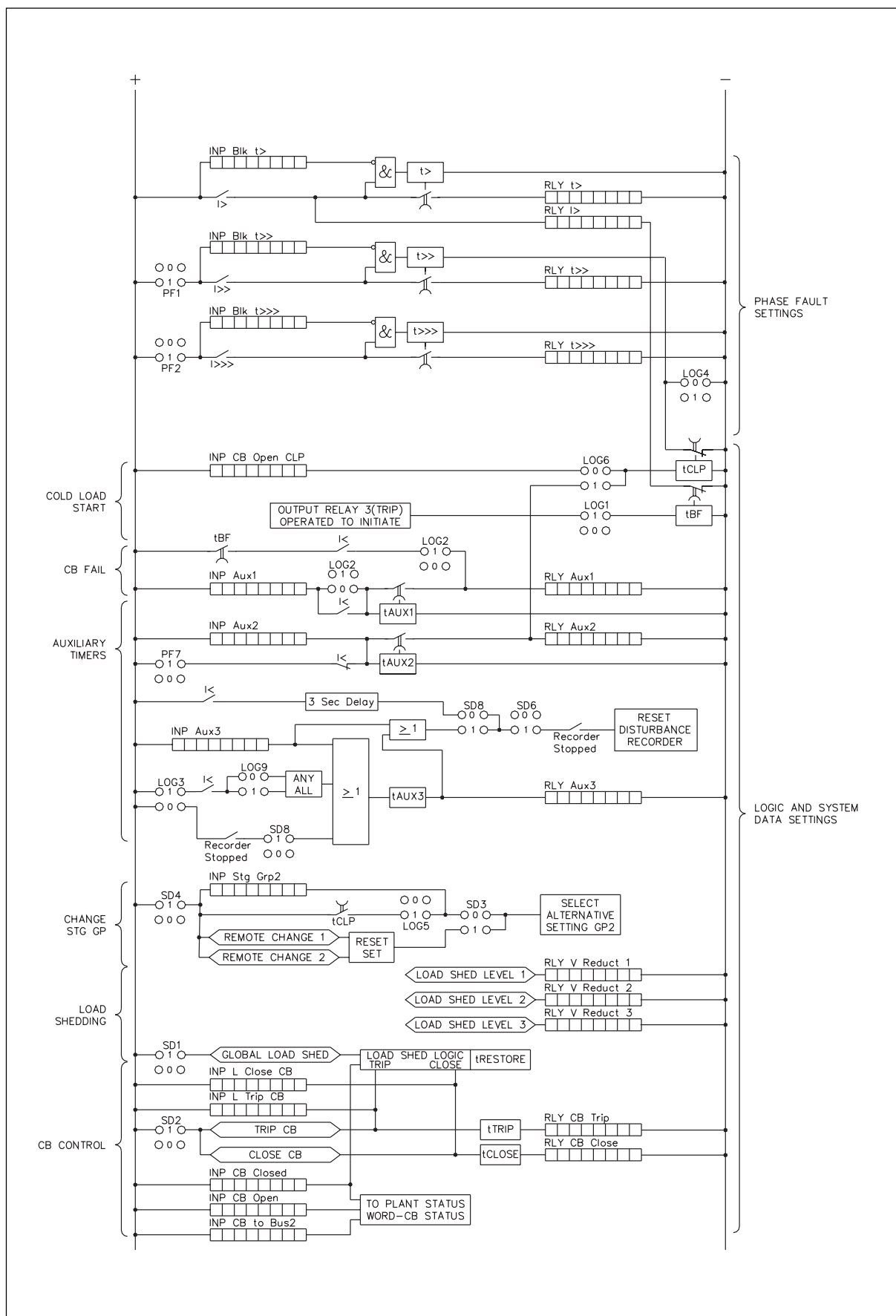


Figure 57. Logic diagram: two phase overcurrent relay Type KCGG 120

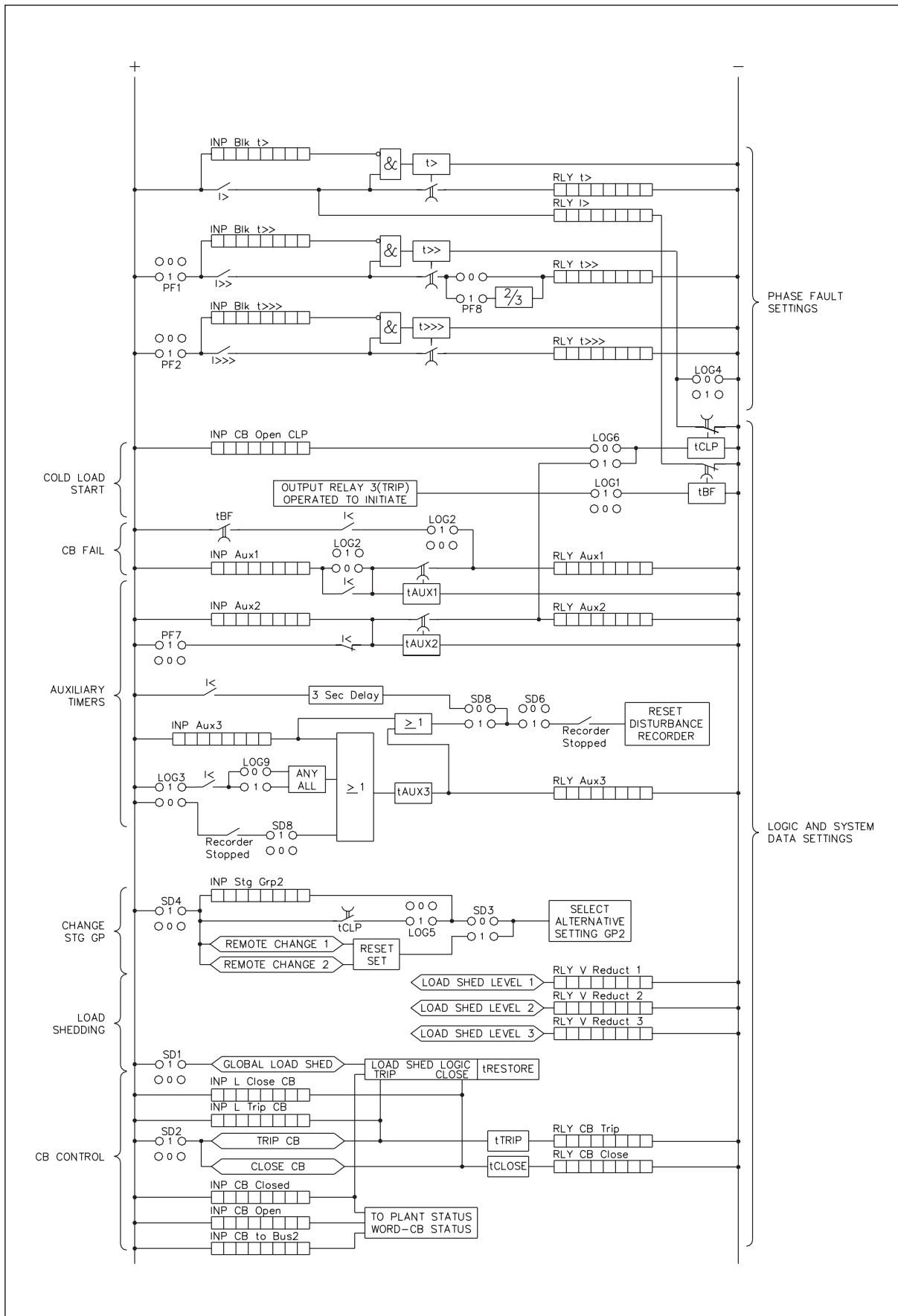


Figure 58. Logic diagram: three phase overcurrent relay Type KCGG 130

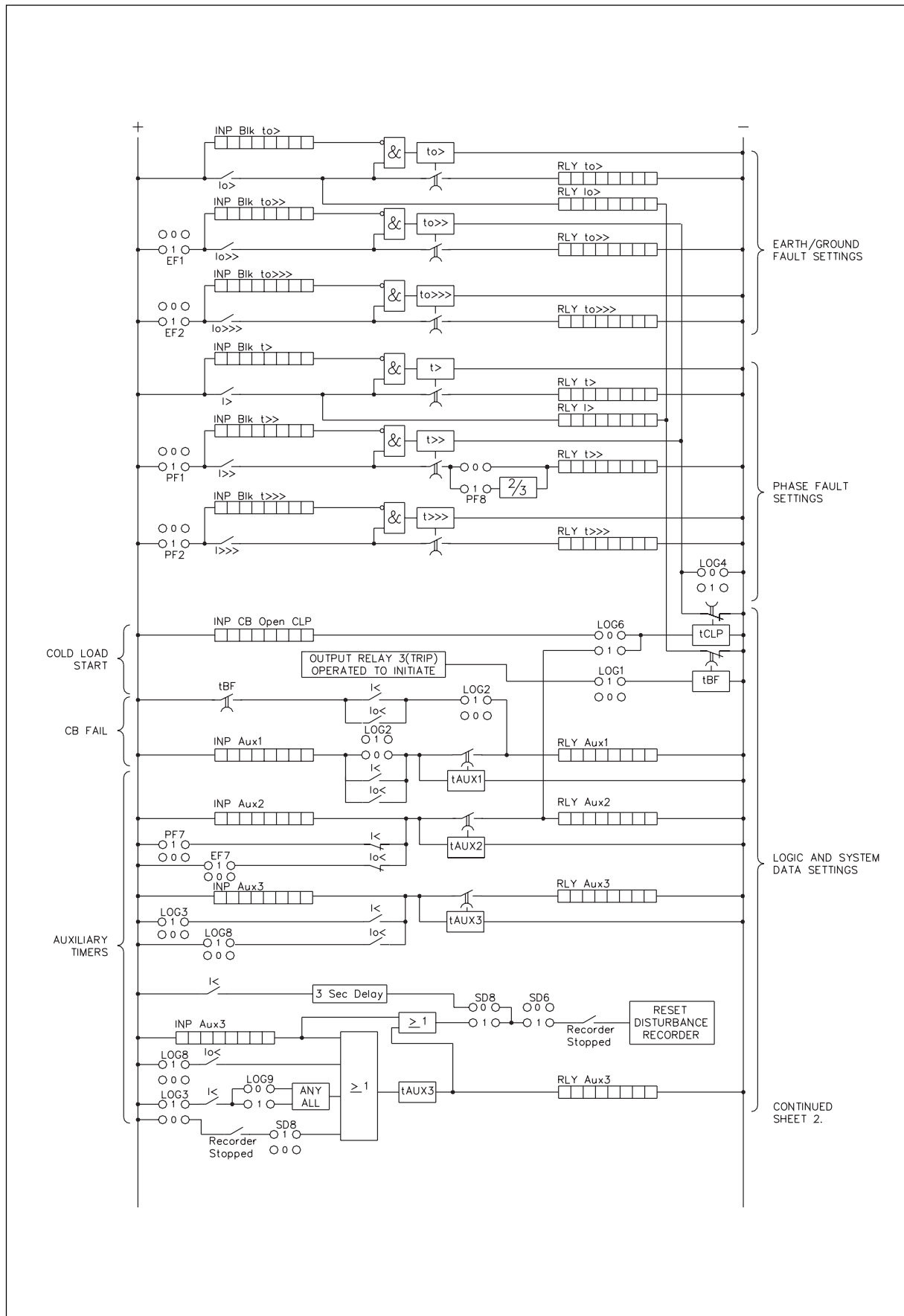


Figure 59a. Logic diagram: three phase overcurrent and earth fault relays Types KCGG 140 and KCGU 140 (Sheet 1)

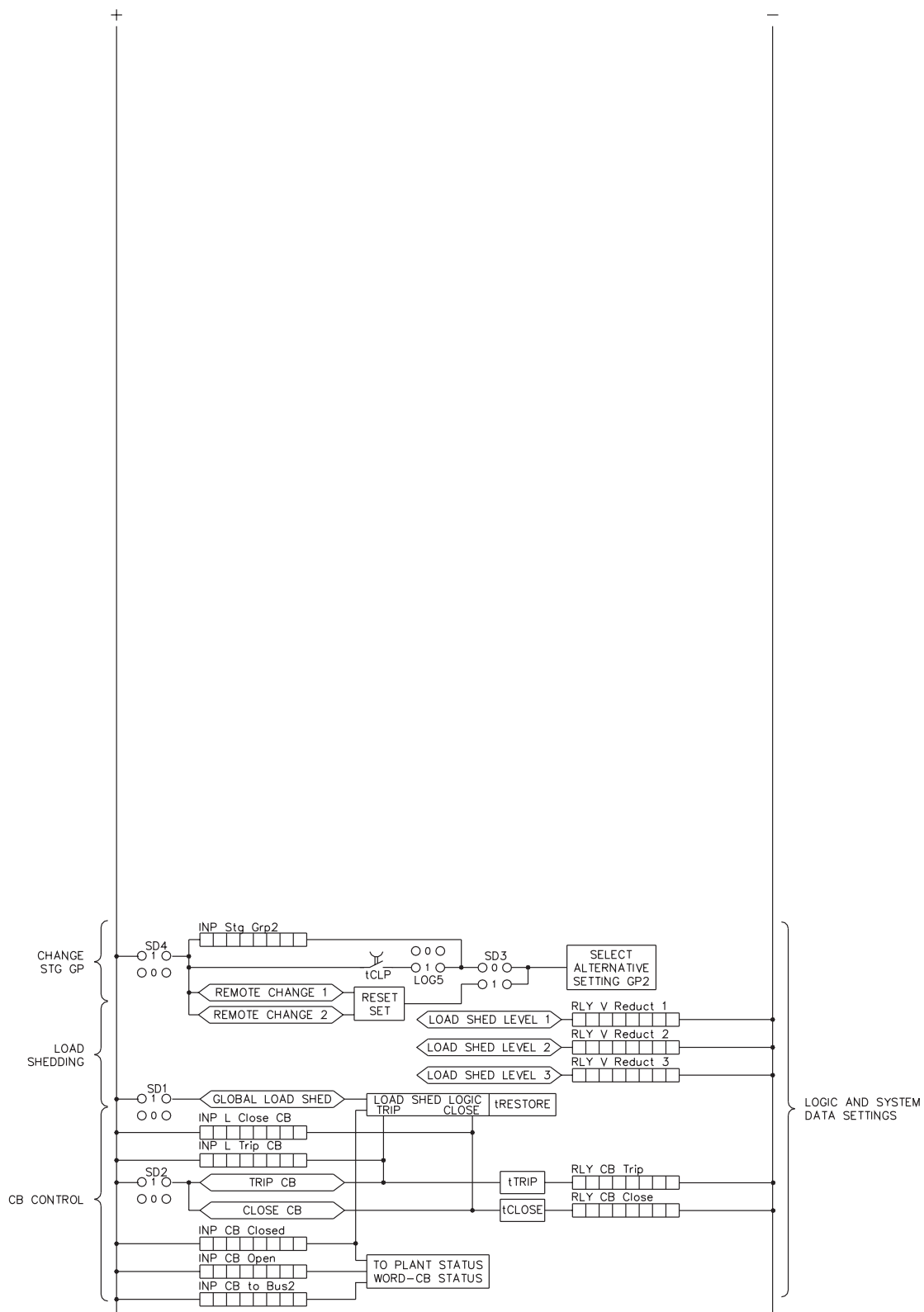


Figure 59b. Logic diagram: three phase overcurrent and earth fault relays Types KCGG 140 and KCGU 140 (Sheet 2)

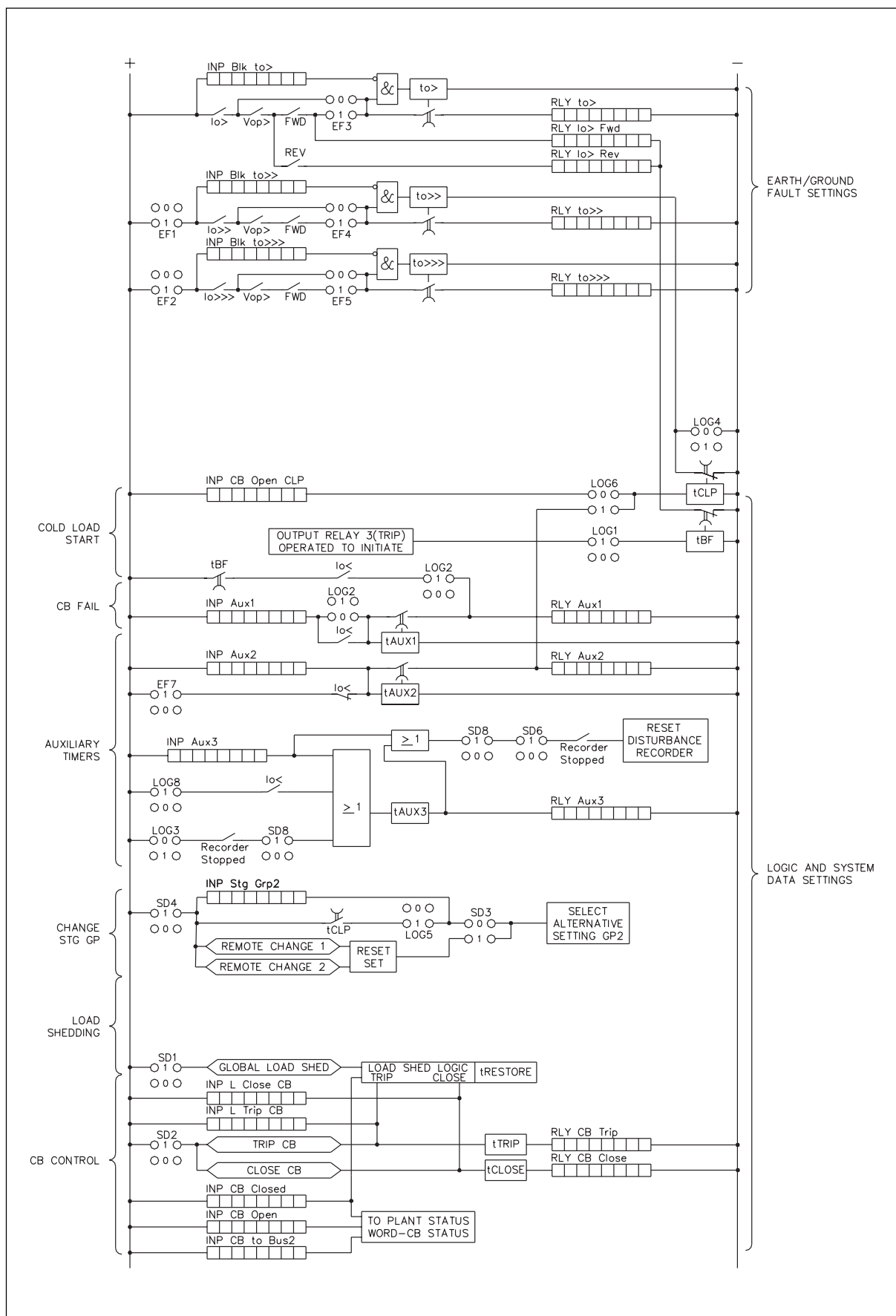


Figure 60. Logic diagram: directional earth fault relays Types KCEG110 and KCEU 110

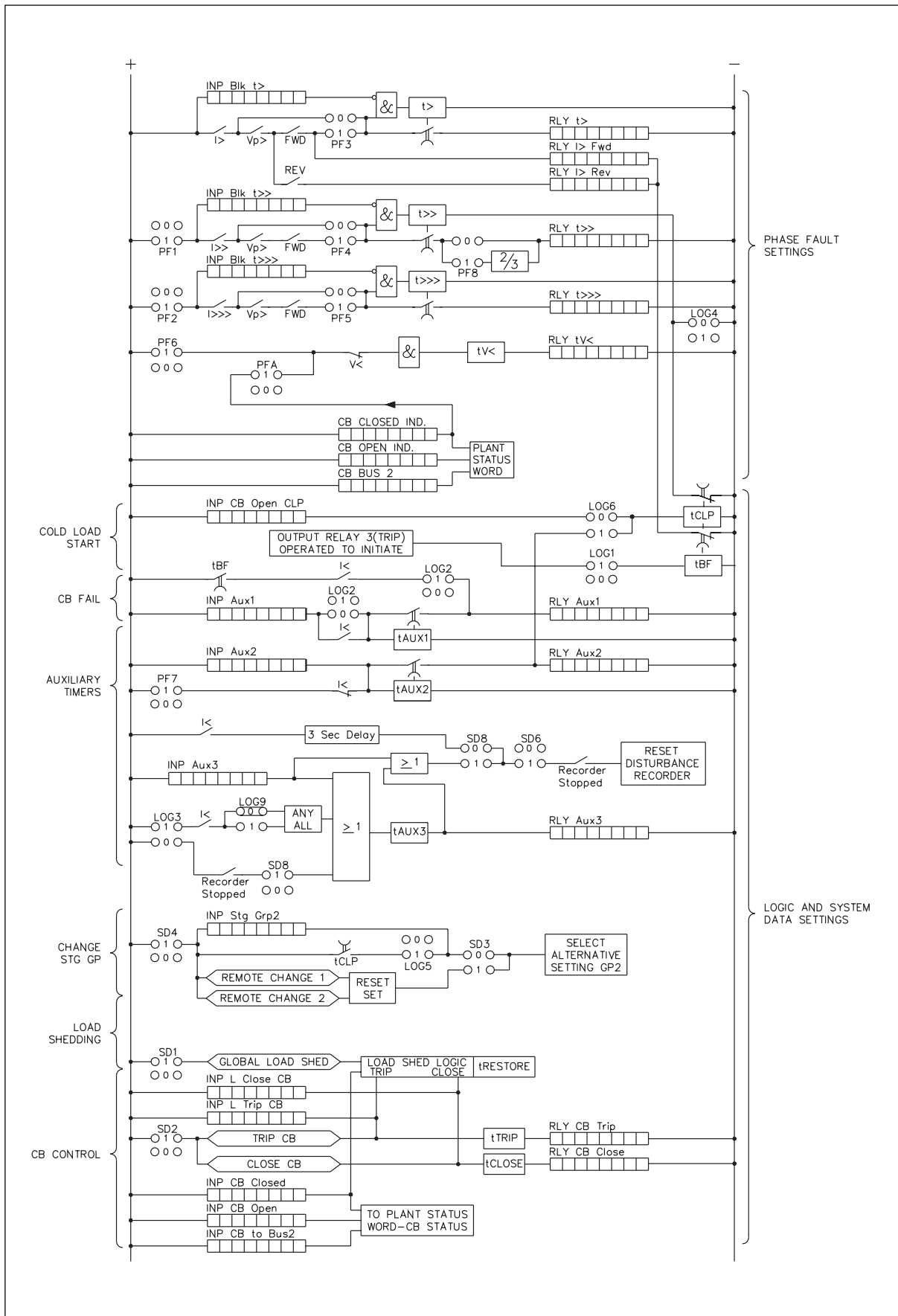


Figure 61. Logic diagram: three phase directional overcurrent relay Type KCEG 130

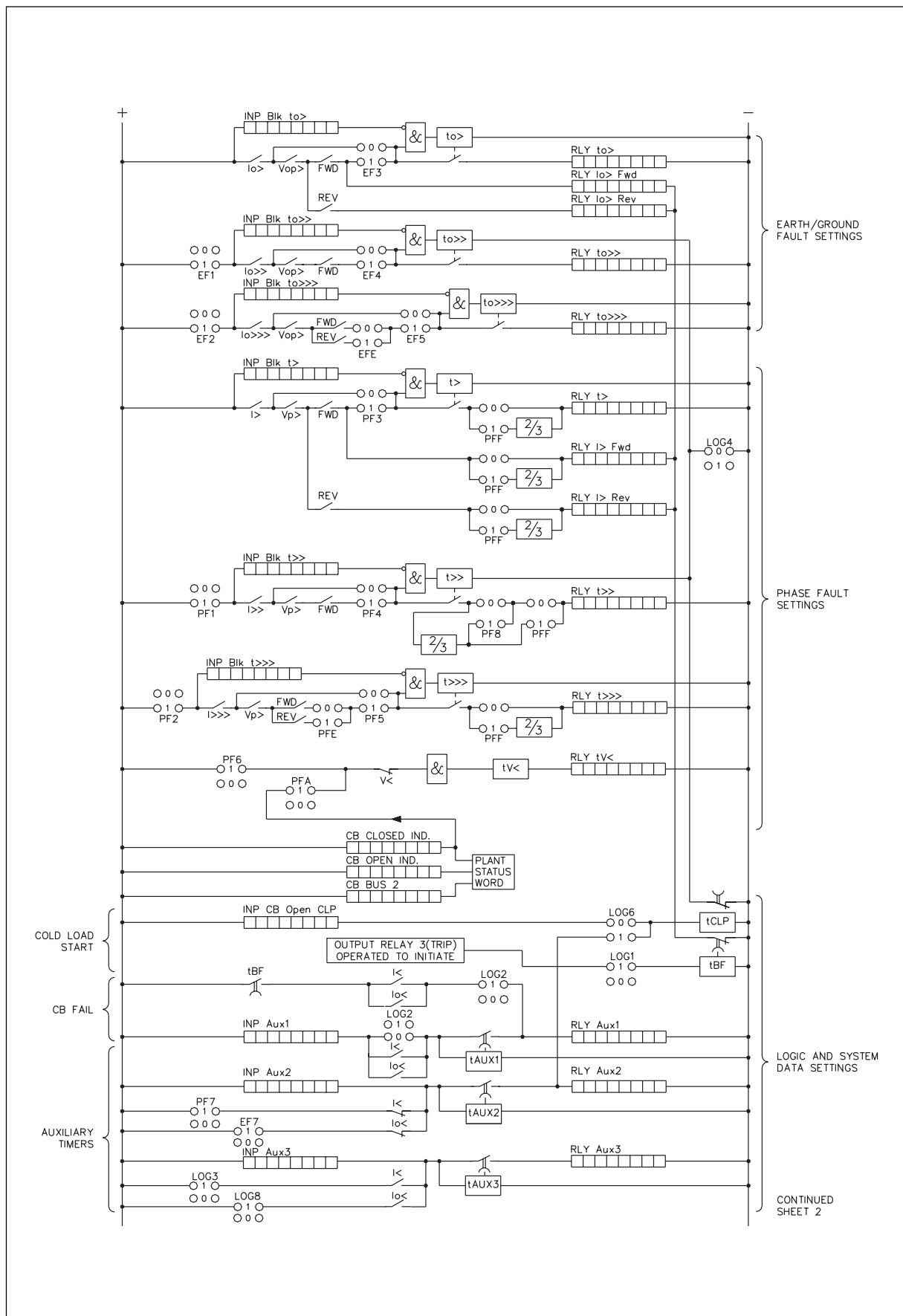


Figure 62a. Logic diagram: three phase directional overcurrent and earth fault relays
Types KCEG 140 and KCEU 140 (Sheet 1)

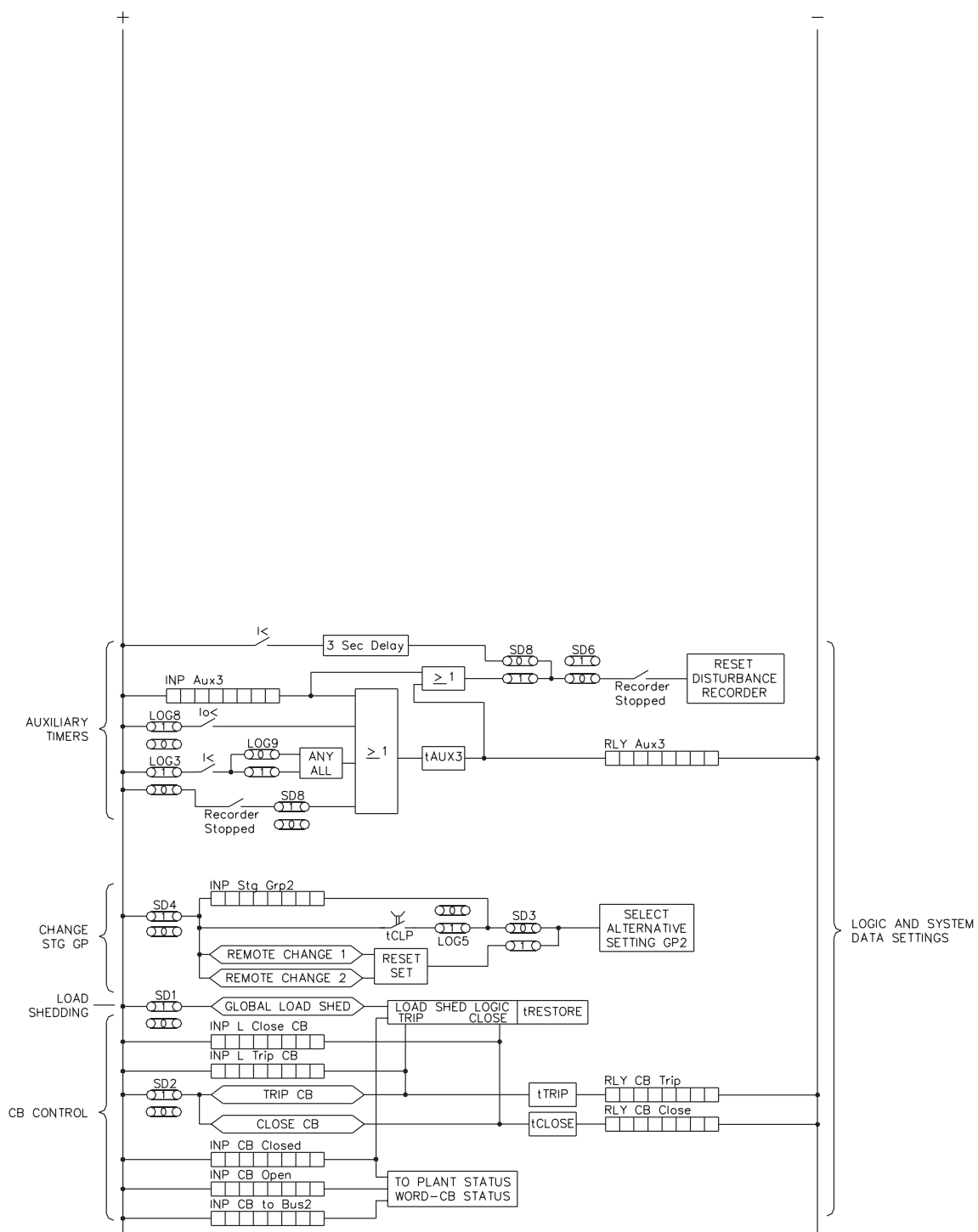


Figure 62b. Logic diagram: three phase directional overcurrent and earth fault relays
Types KCEG 140 and KCEU 140 (Sheet 2)

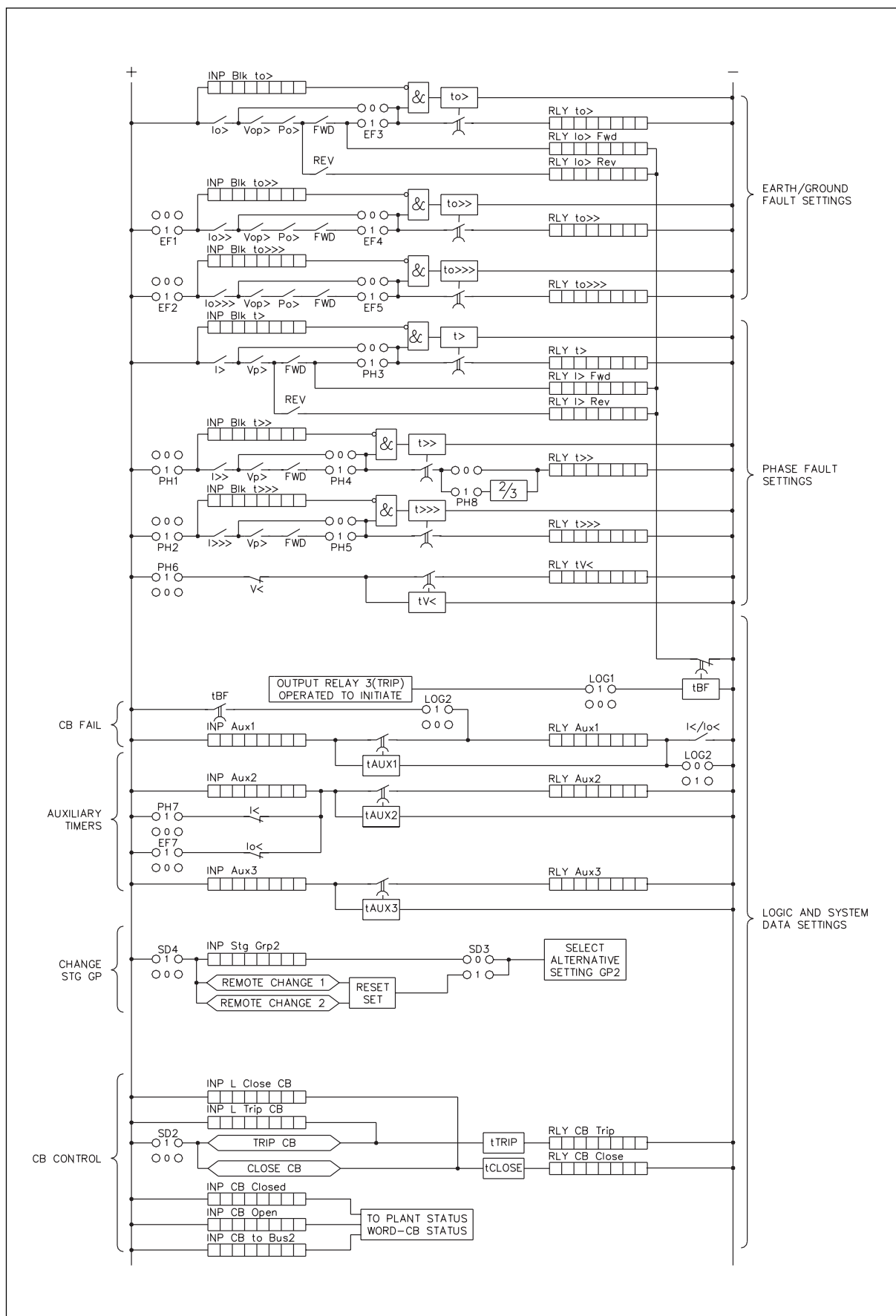


Figure 63. Logic diagram: directional three phase overcurrent and sensitive wattmetric earth fault relay Type KCEU 141

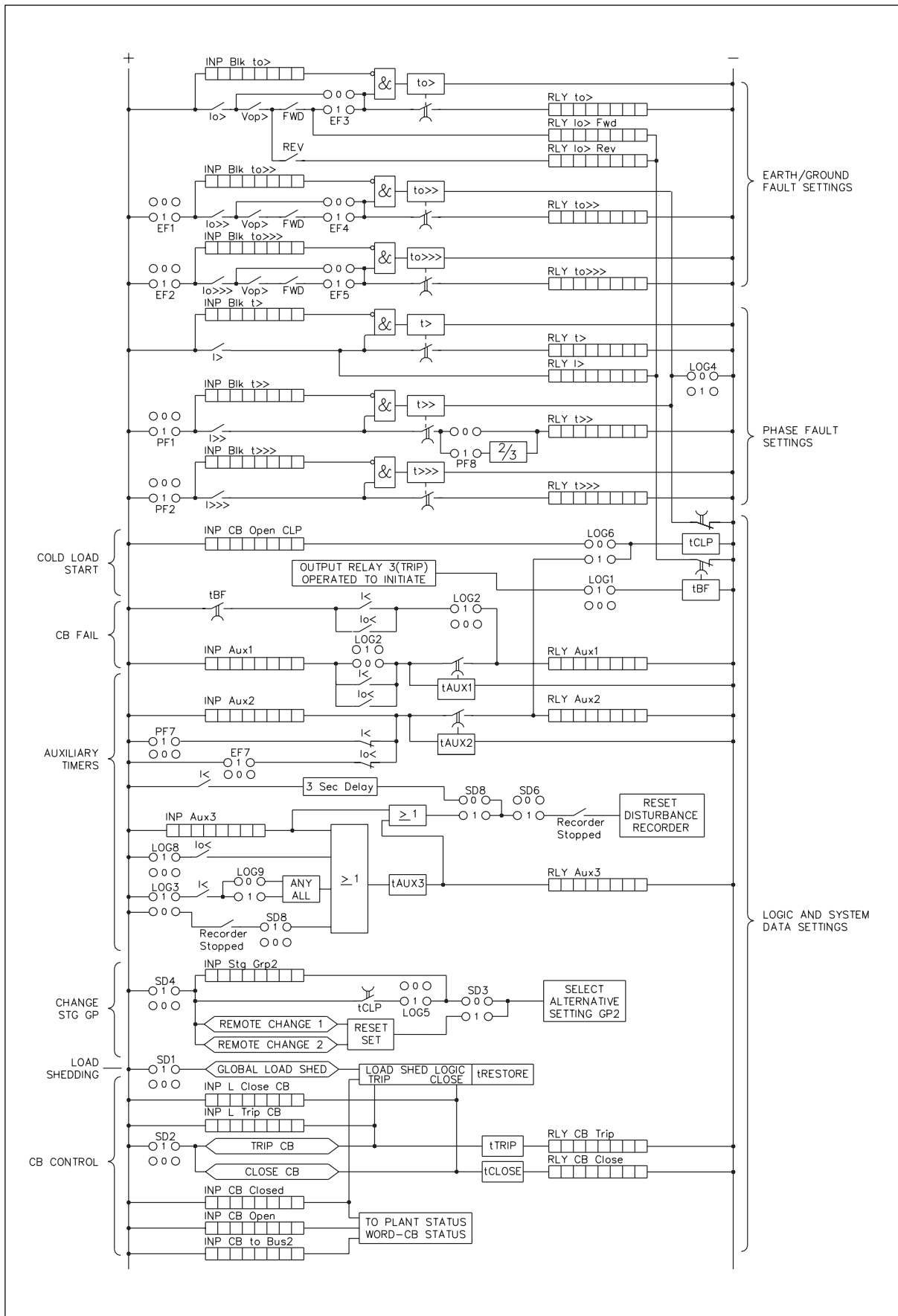


Figure 64. Logic diagram: three phase overcurrent and directional earth fault relays
Types KCEG 150 and KCEU 150

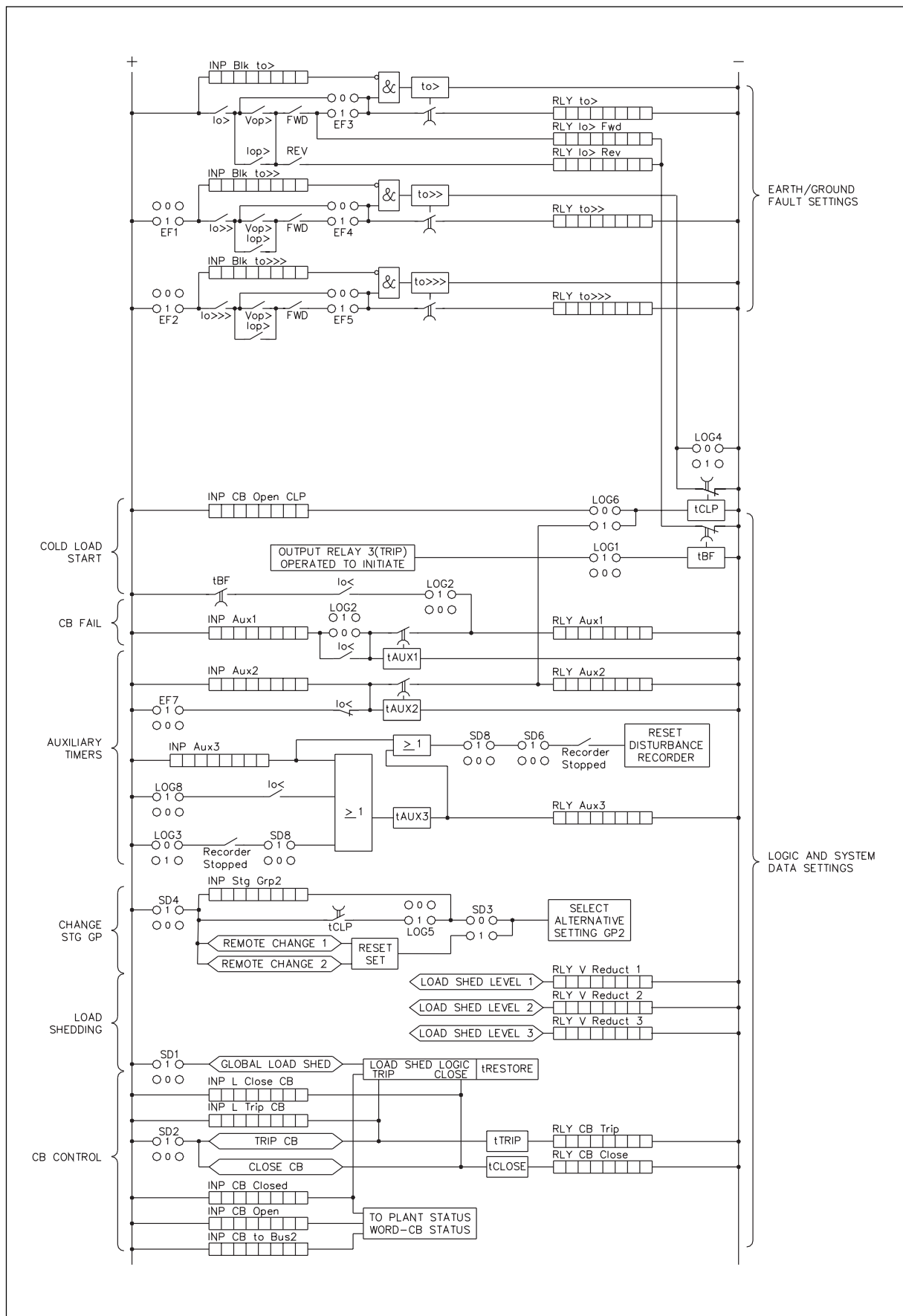


Figure 65. Logic diagram: dual polarized directional sensitive earth fault relays Types KCEG 160 and KCEU 160

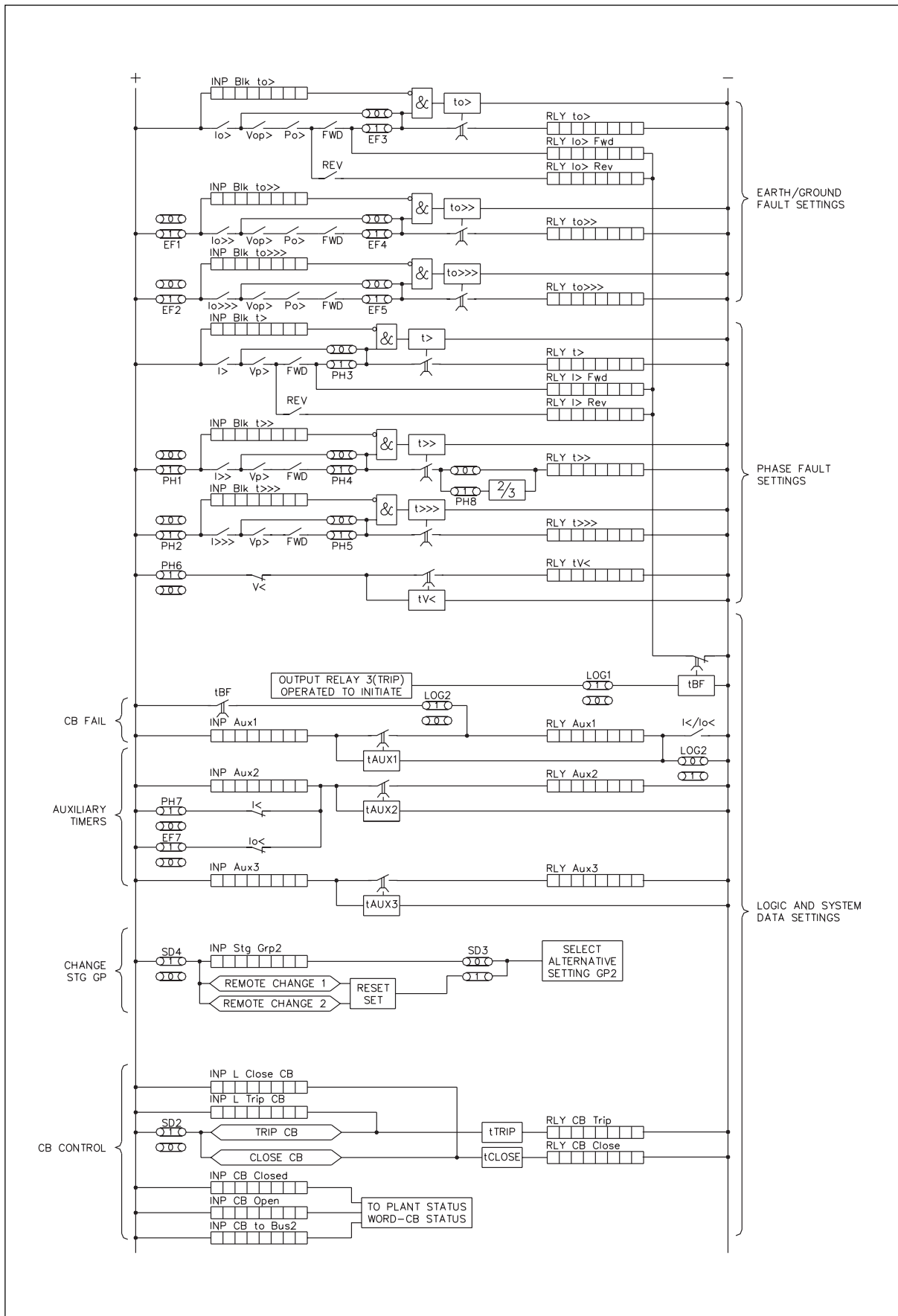


Figure 66. Logic diagram: Dual powered directional three phase overcurrent and sensitive wattmetric E/F relay Type KCEU 241

Appendix 3. CONNECTION DIAGRAMS FOR KCGG, KCGU, KCEG and KCEU RELAYS

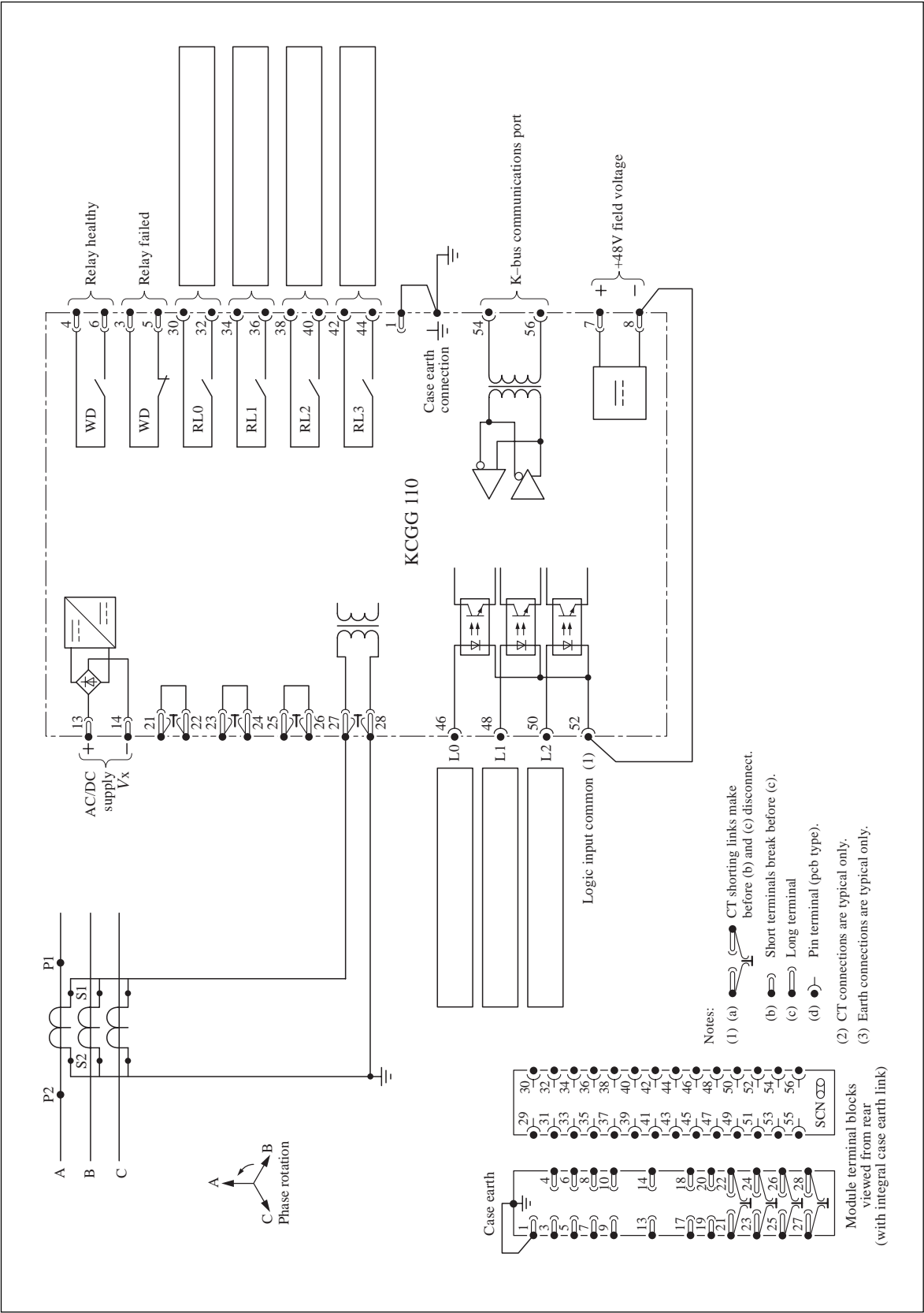


Figure 67. Typical application diagram: earth fault relay Type KCGG 110

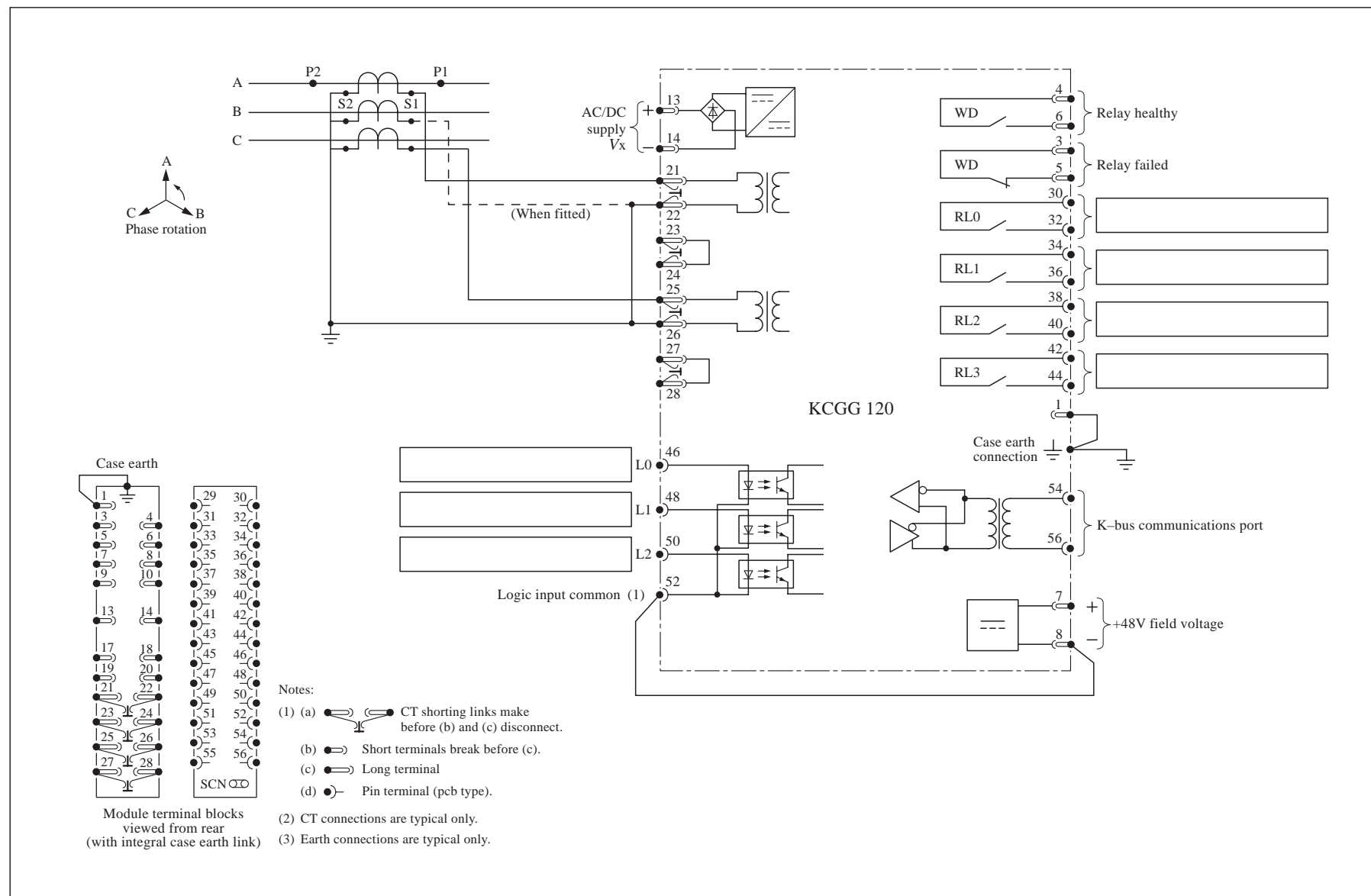


Figure 68. Typical application diagram: 2 phase overcurrent relay Type KCGG 120

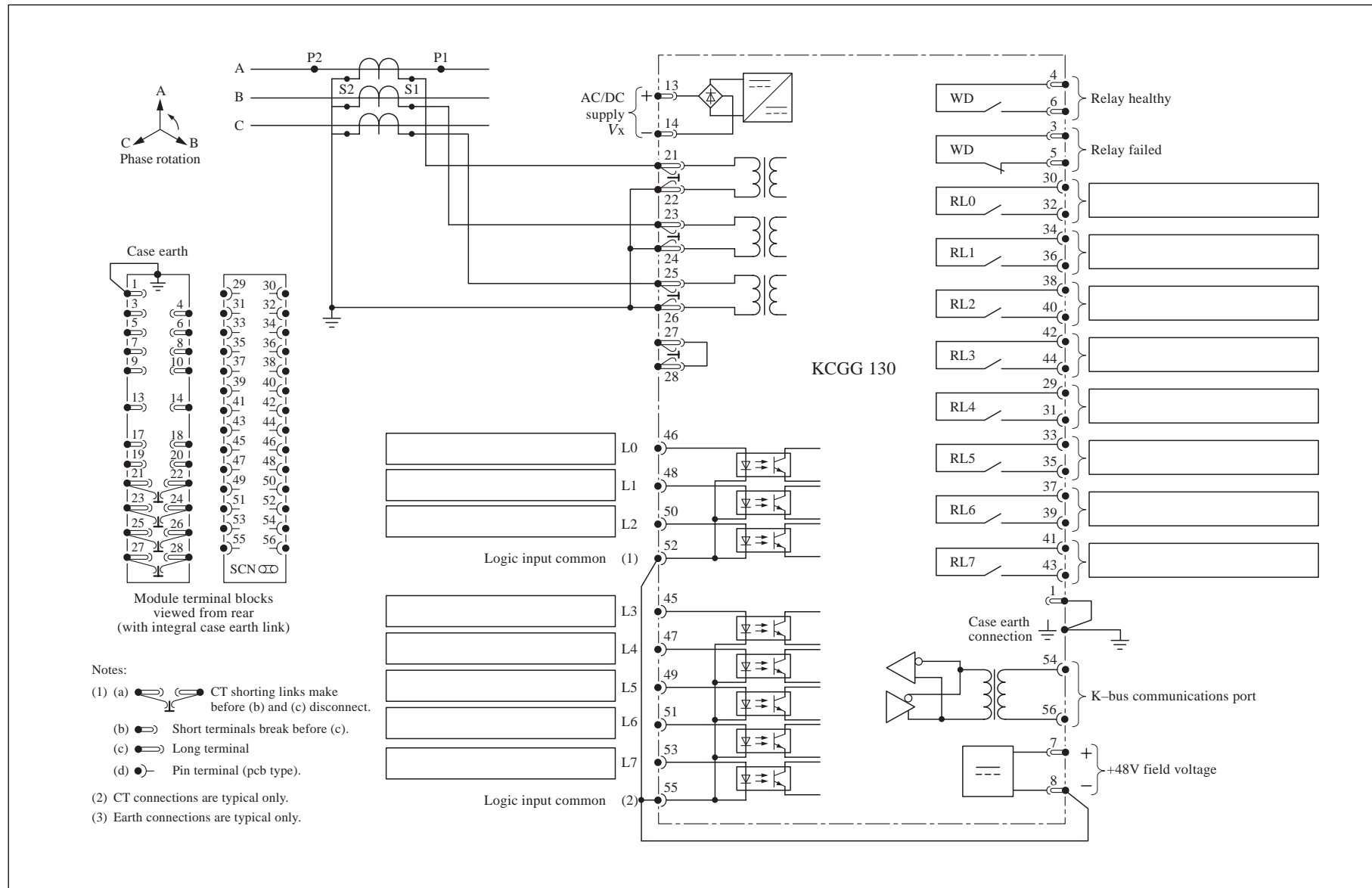


Figure 69. Typical application diagram: 3 phase overcurrent fault relay Type KCGG 130

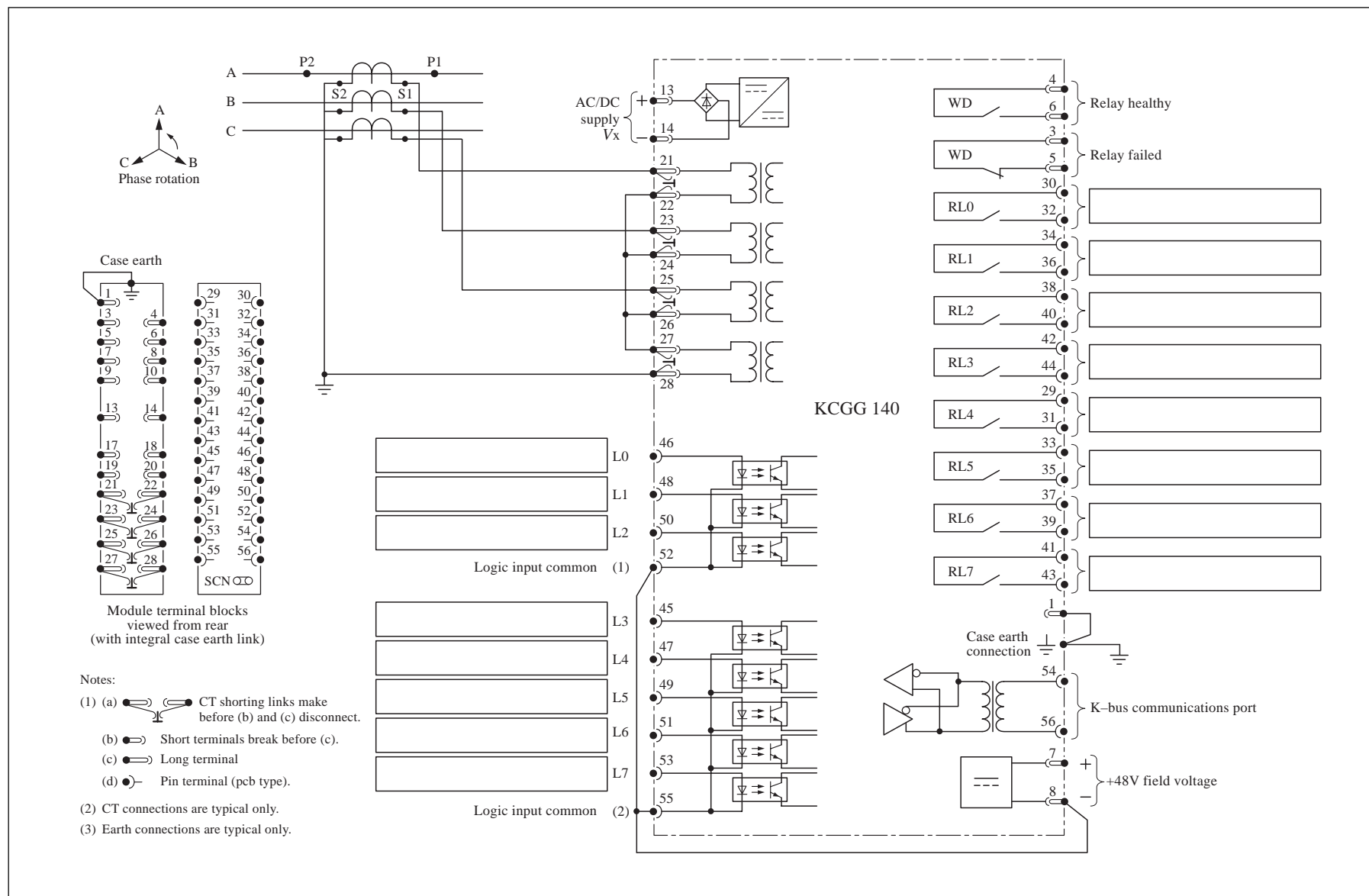
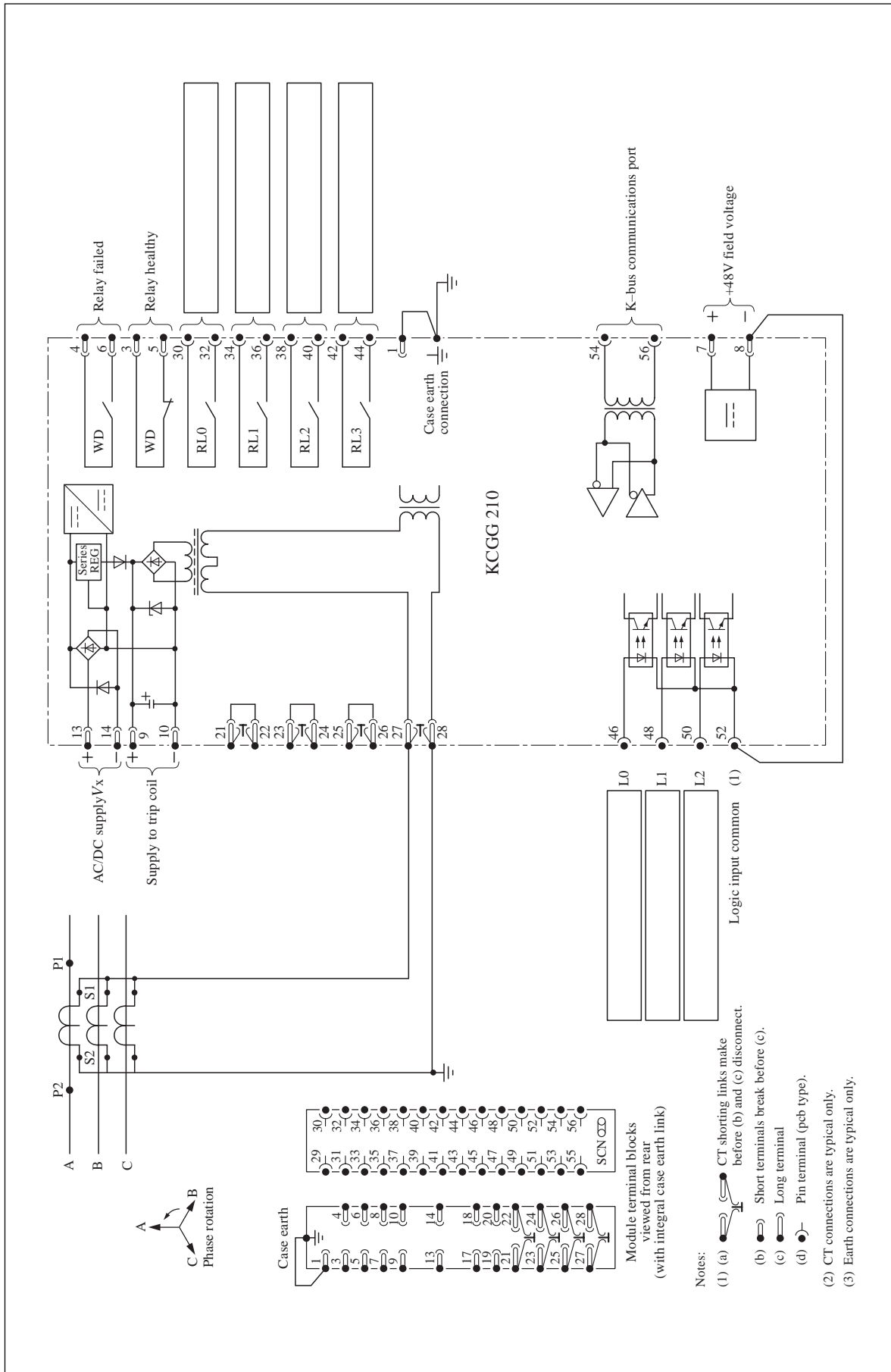


Figure 70. Typical application diagram: 3 phase overcurrent and earth fault relay Type KCGG 140



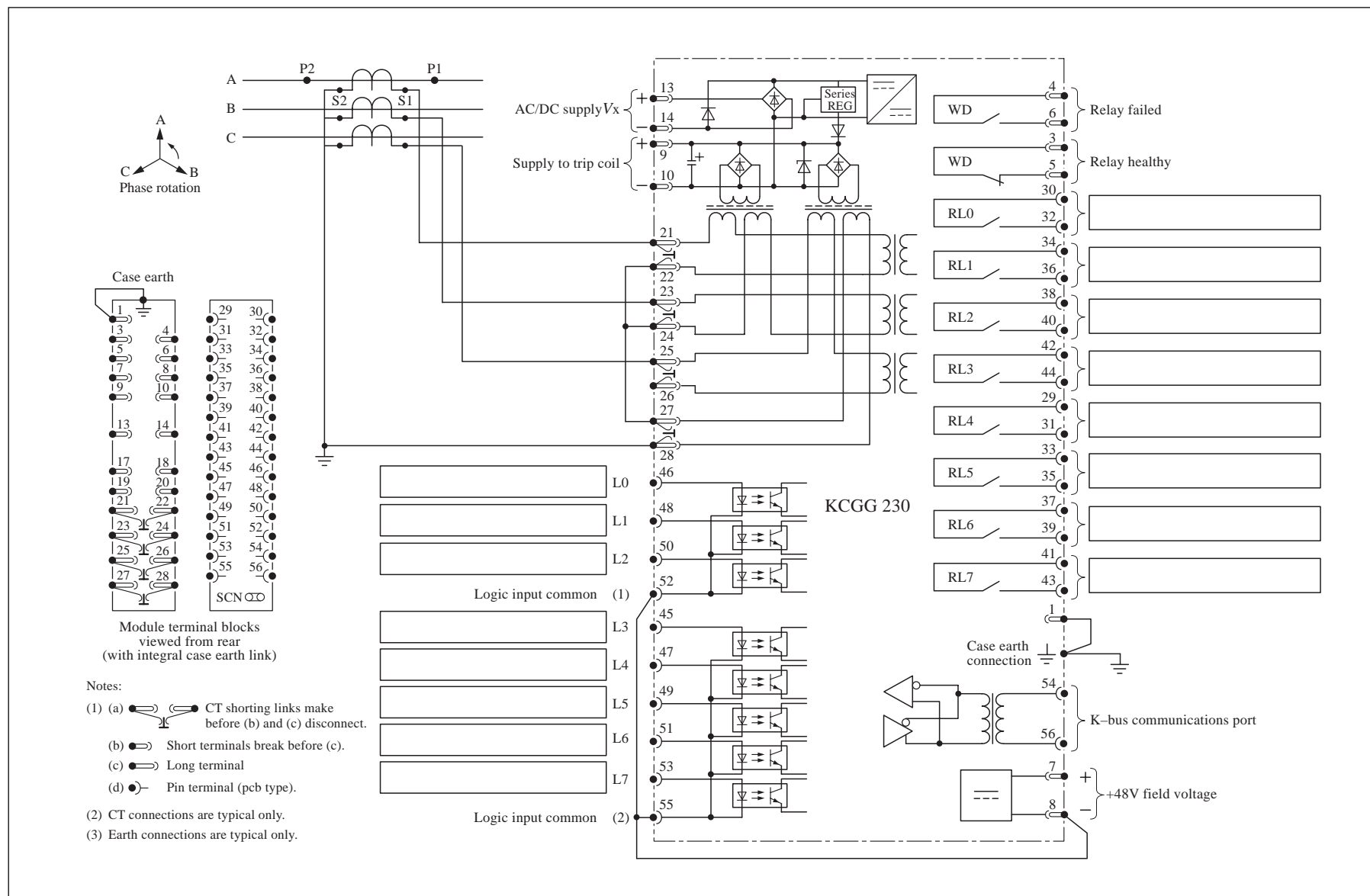


Figure 72. Typical application diagram: dual powered 3 phase overcurrent relay Type KCGG 230

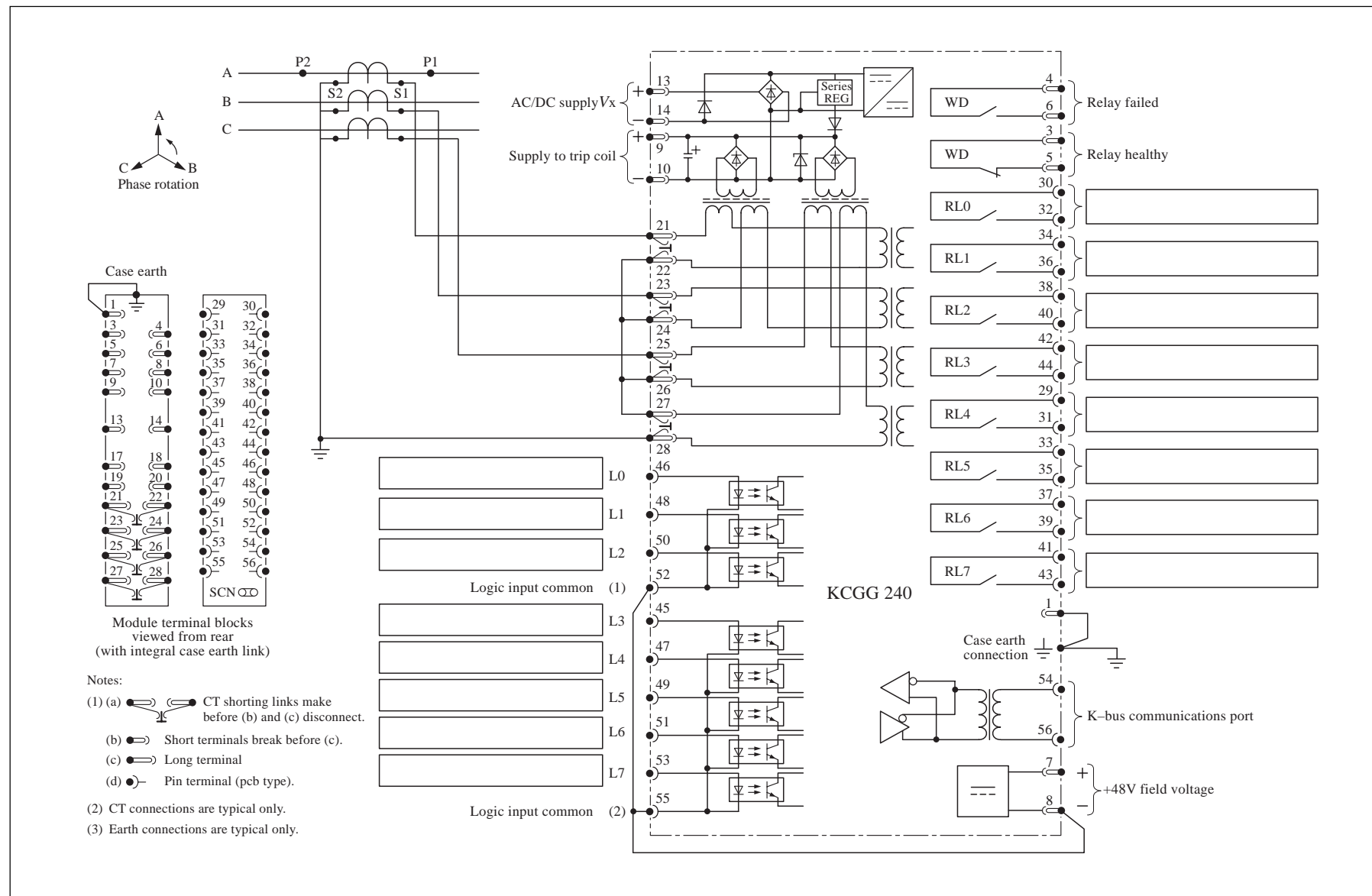


Figure 73. Typical application diagram: dual powered 3 phase overcurrent and earth fault relay Type KCGG 240

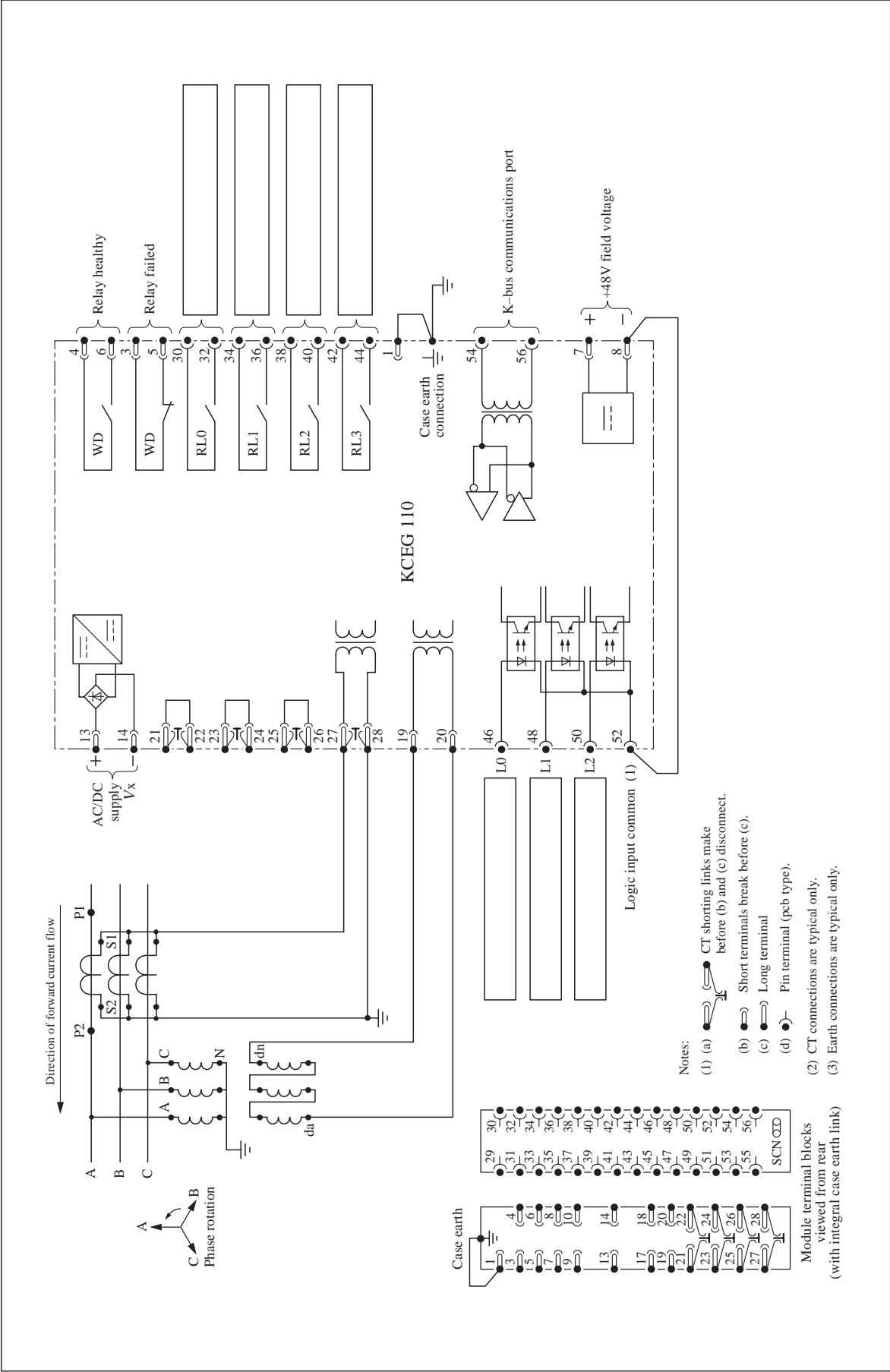


Figure 74. Typical application diagram: directional earth fault relay Type KCEG 110

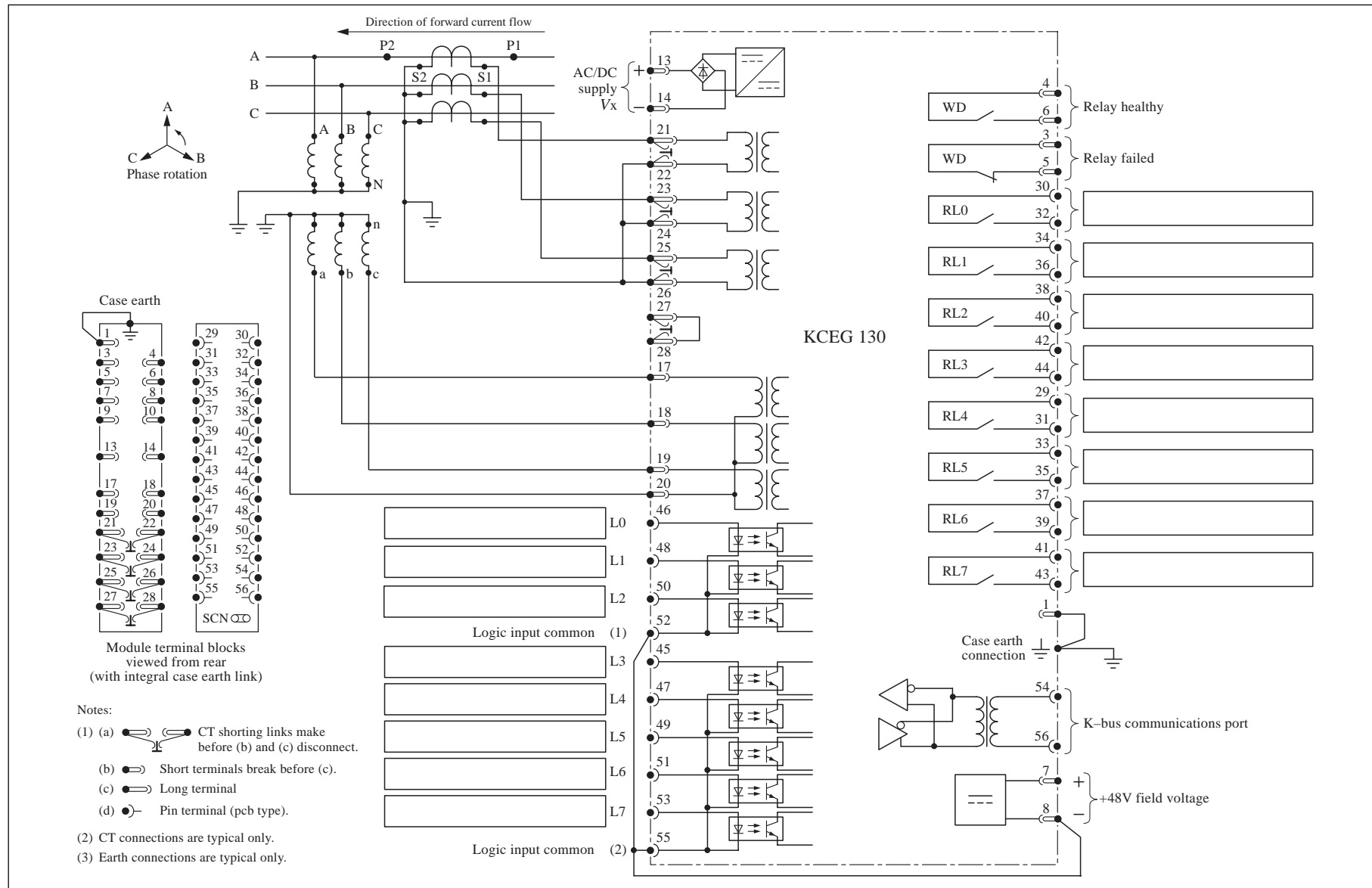


Figure 75. Typical application diagram: 3 phase directional overcurrent relay Type KCEG 130

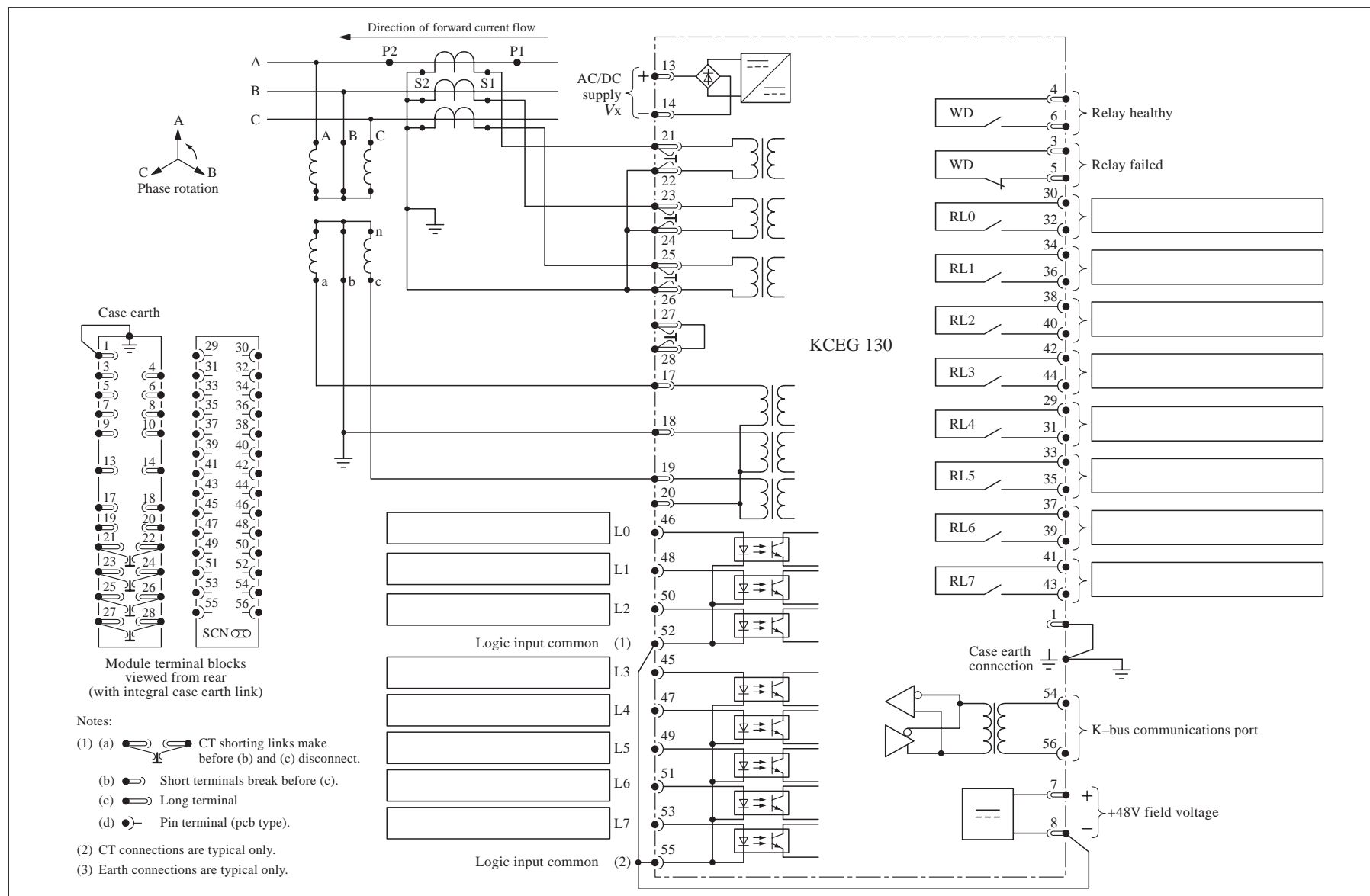


Figure 76. Typical application diagram: 3 phase directional overcurrent relay Type KCEG 130. “V” connected 2 phase input

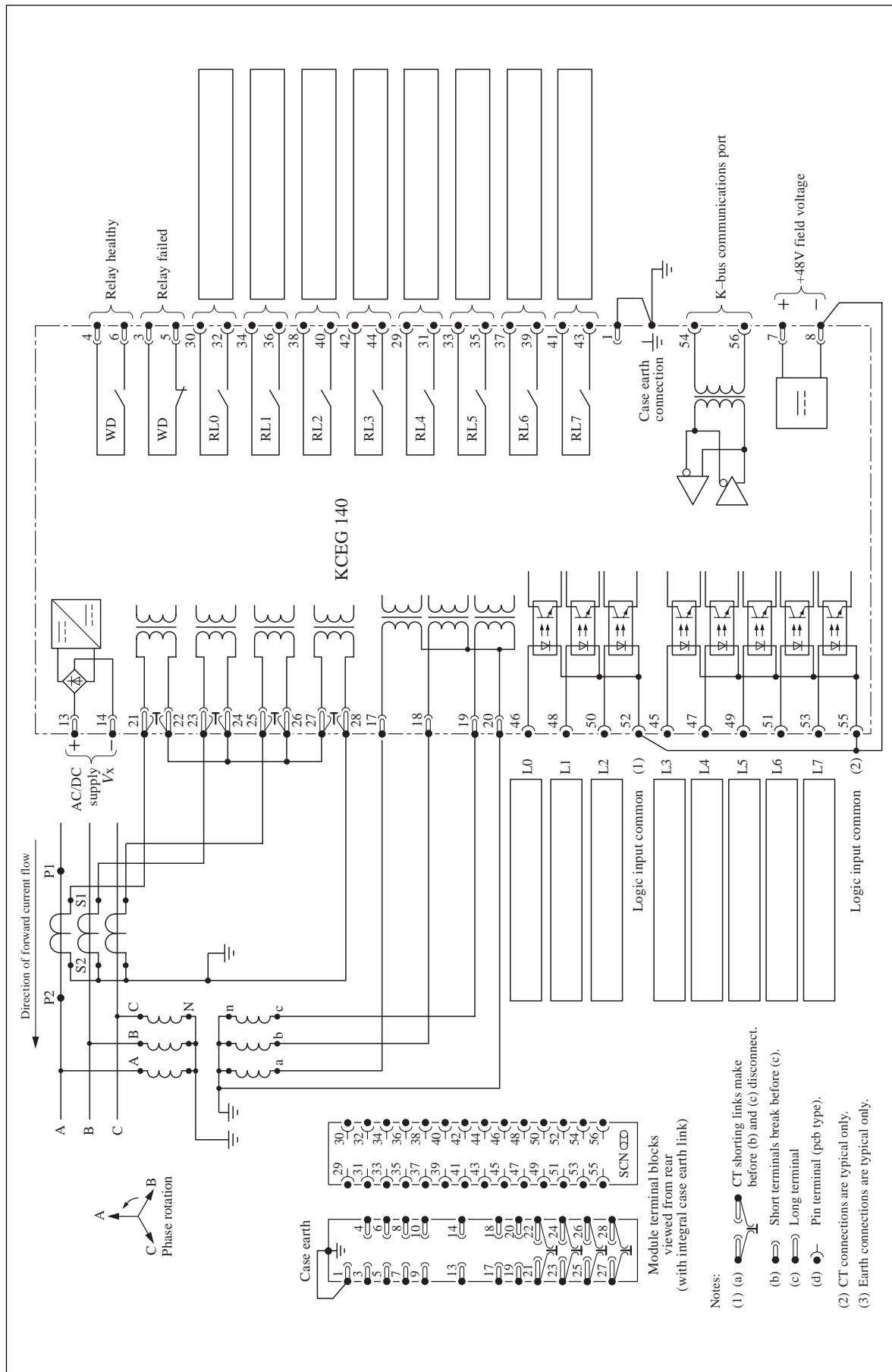


Figure 77. Typical application diagram: 3 phase directional overcurrent and earth fault relay Type KCEG 140

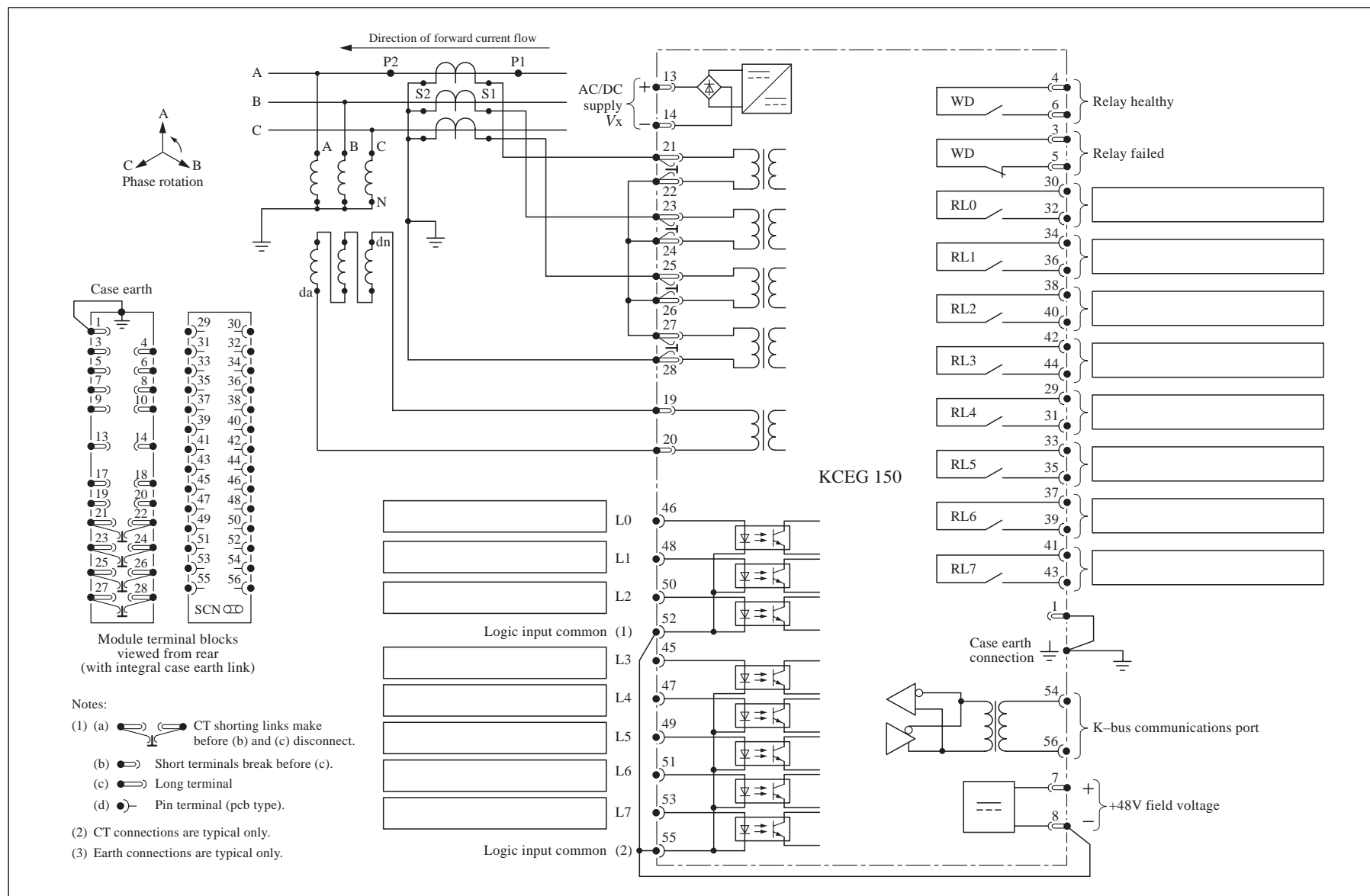


Figure 78. Typical application diagram: 3 phase overcurrent and directional earth fault relay Type KCEG 150

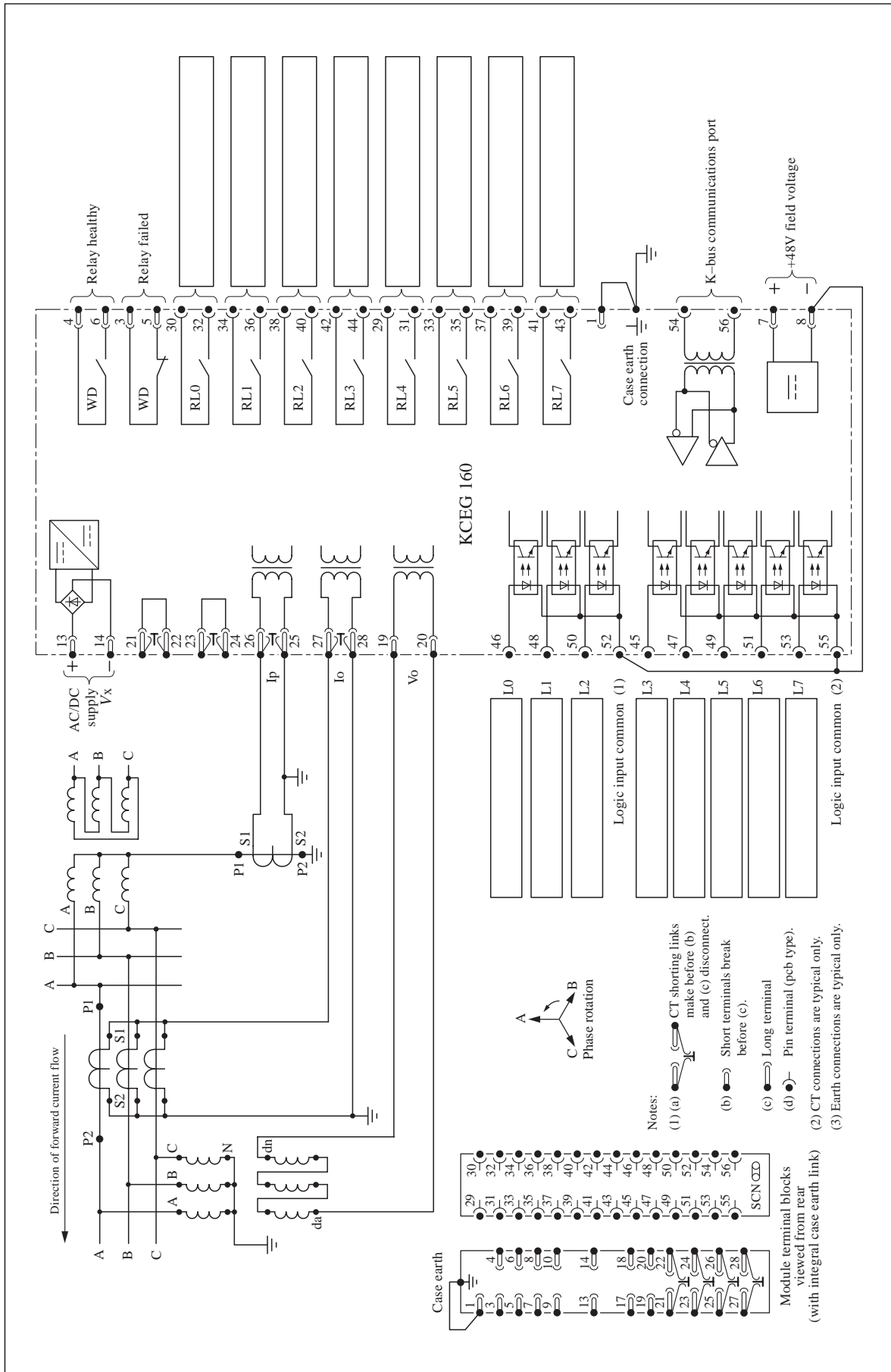


Figure 79. Typical application diagram: directional earth fault relay Type KCEG 160

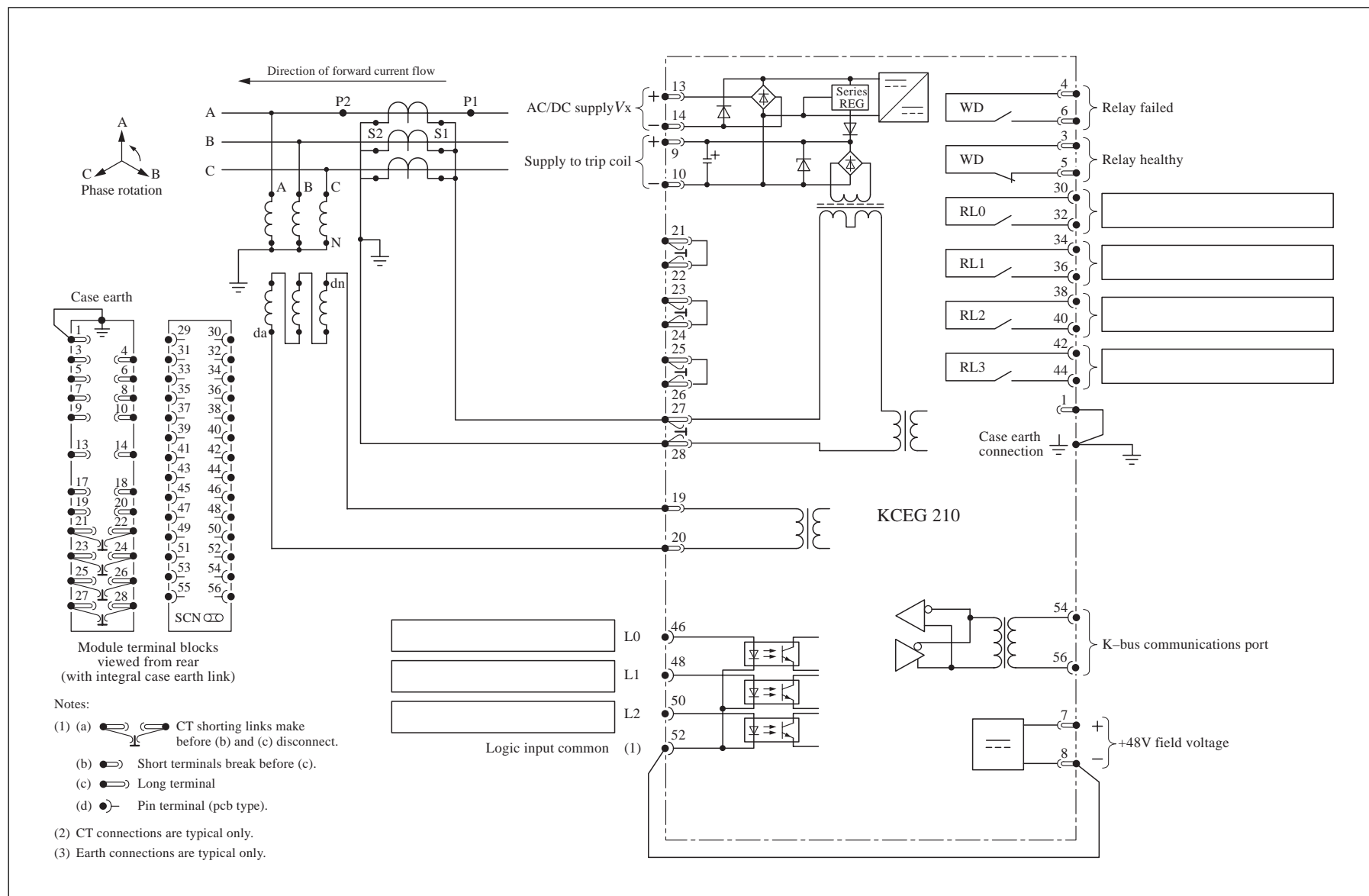


Figure 80. Typical application diagram: directional earth fault relay Type KCEG 210

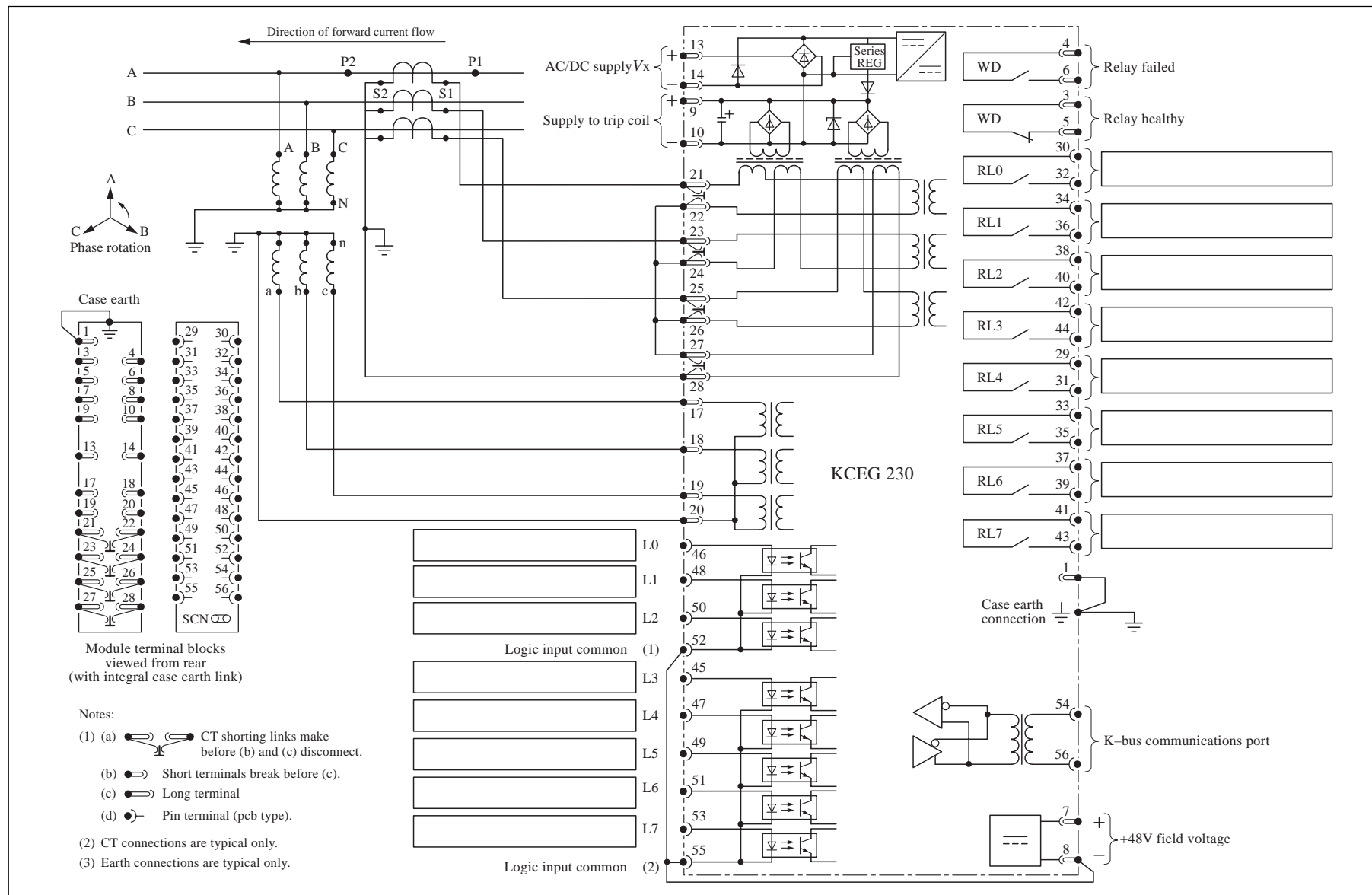


Figure 81. Typical application diagram: dual powered 3 phase directional overcurrent relay Type KCEG 230

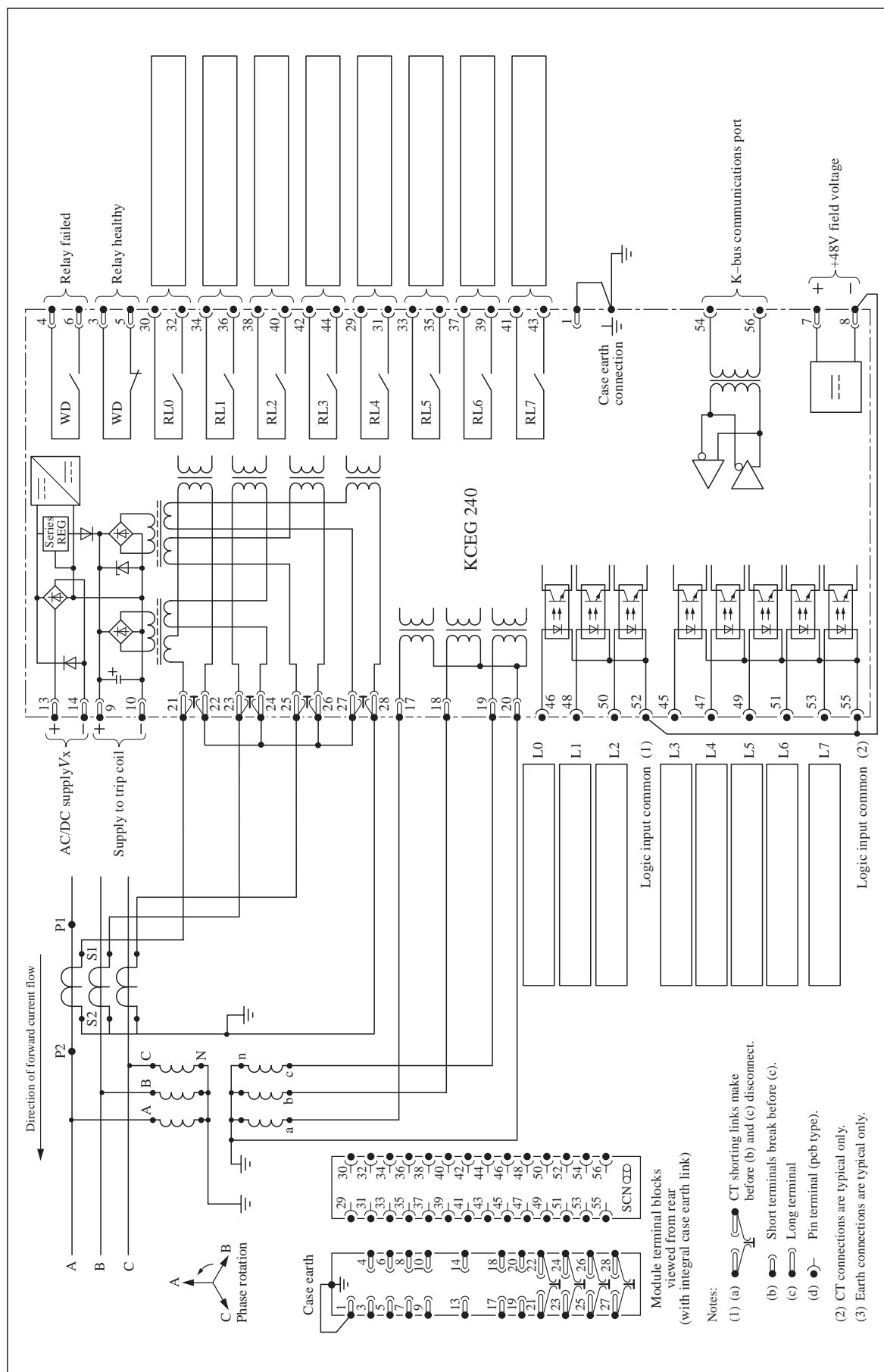


Figure 82. Typical application diagram: dual powered 3 phase directional overcurrent and earth fault relay Type KCEG 240

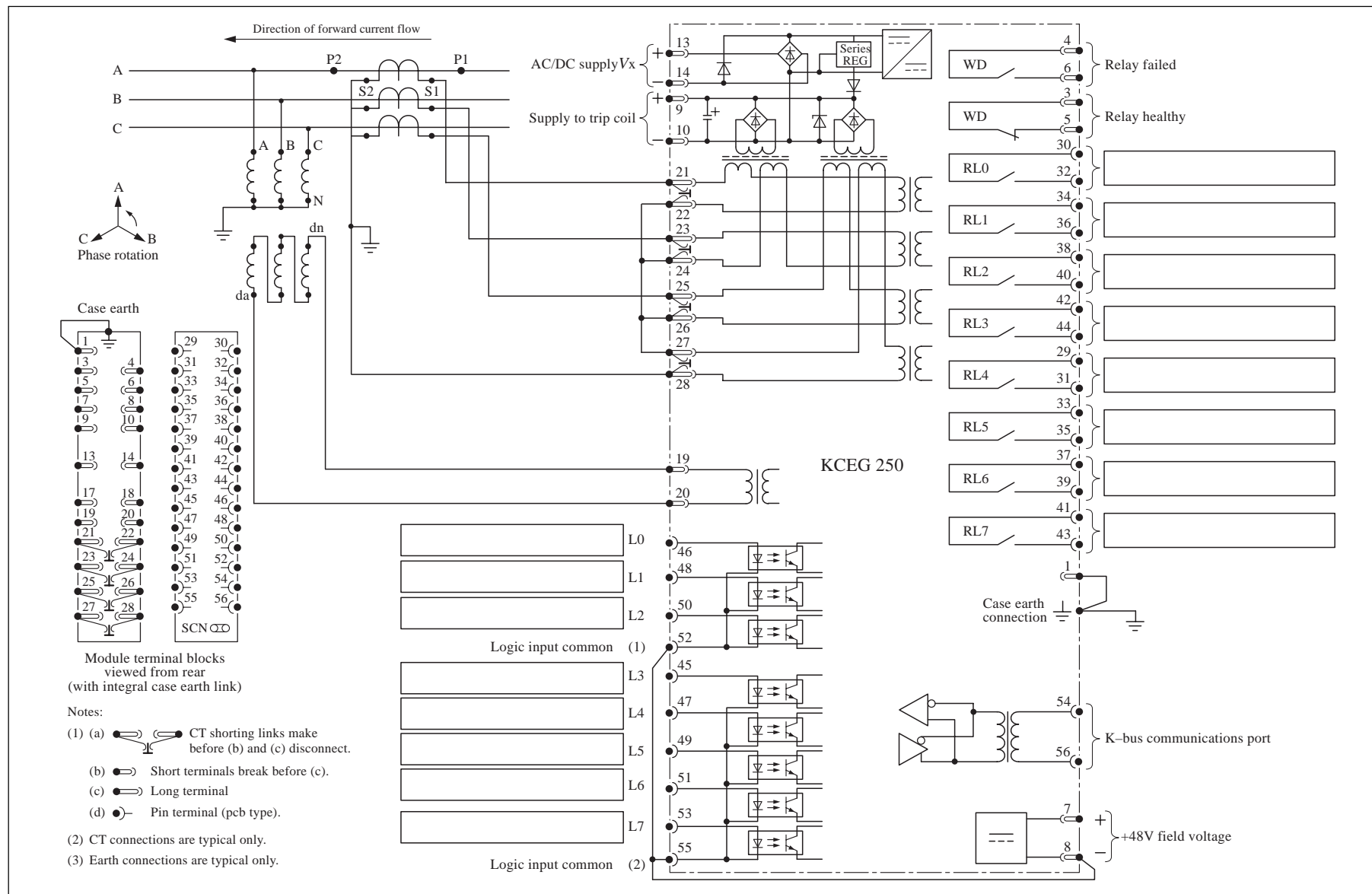


Figure 83. Typical application diagram: dual powered 3 phase overcurrent and directional earth fault relay Type KCEG 250

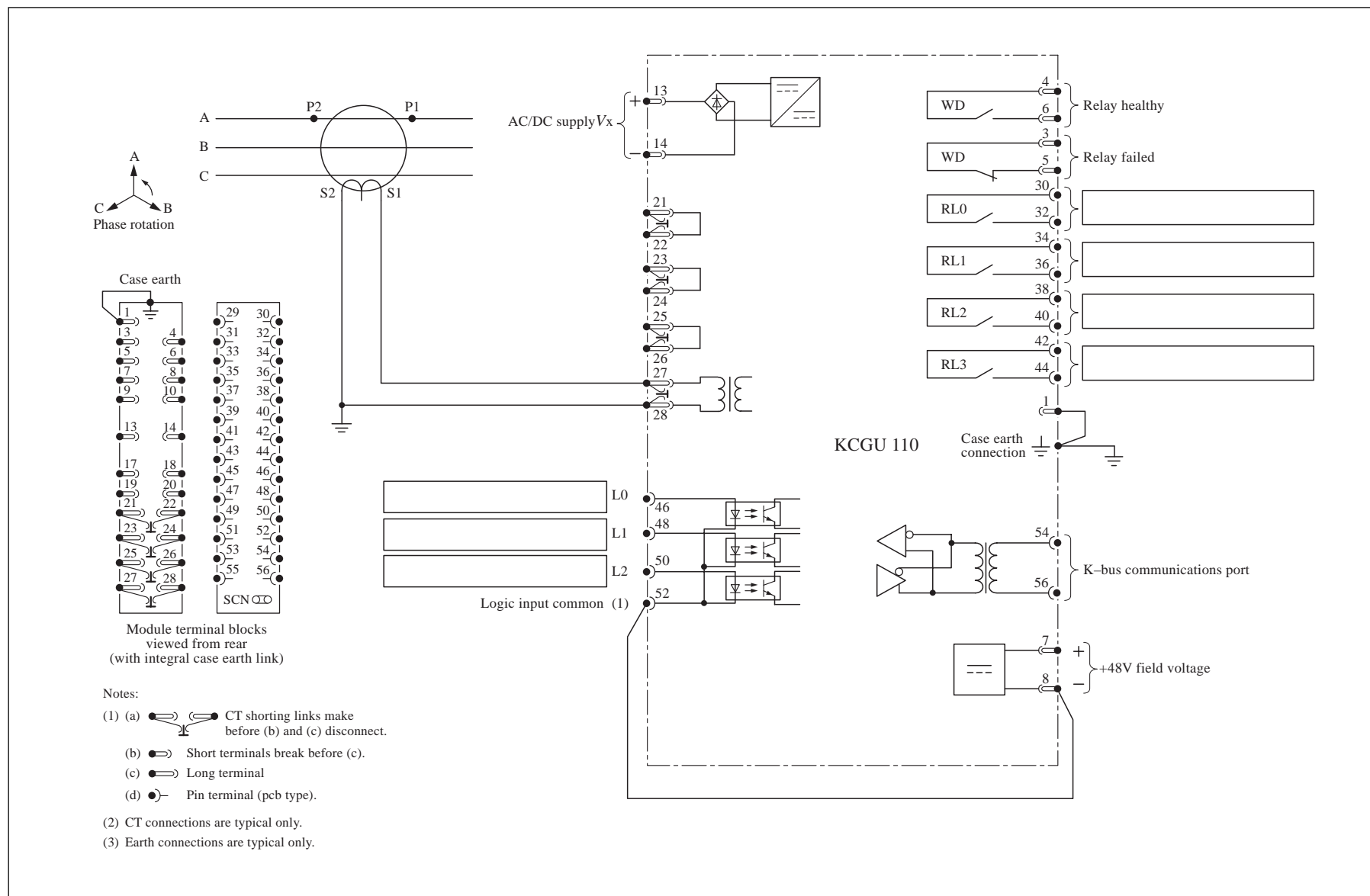
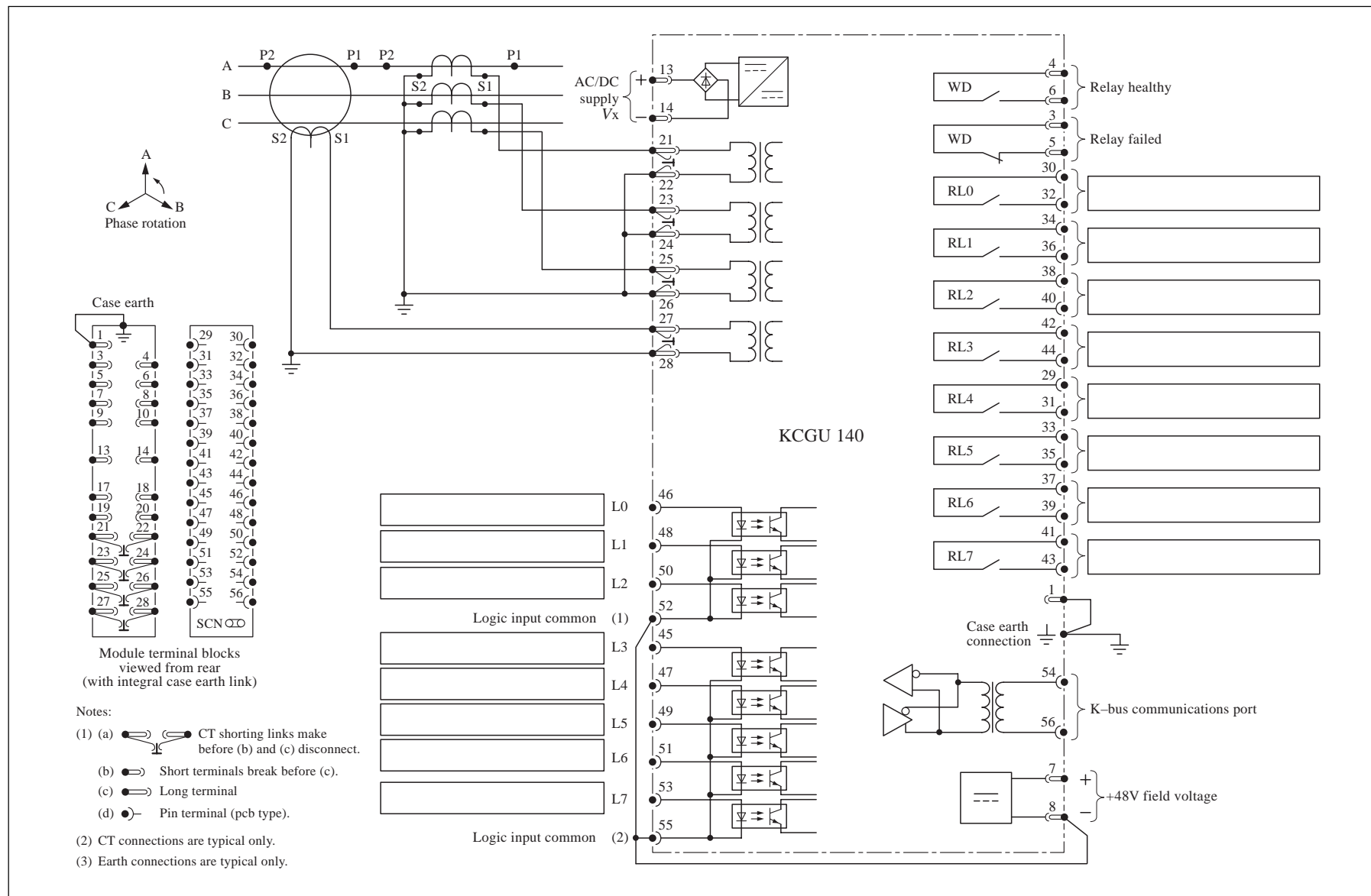


Figure 84. Typical application diagram: sensitive earth fault relay Type KCGU 110



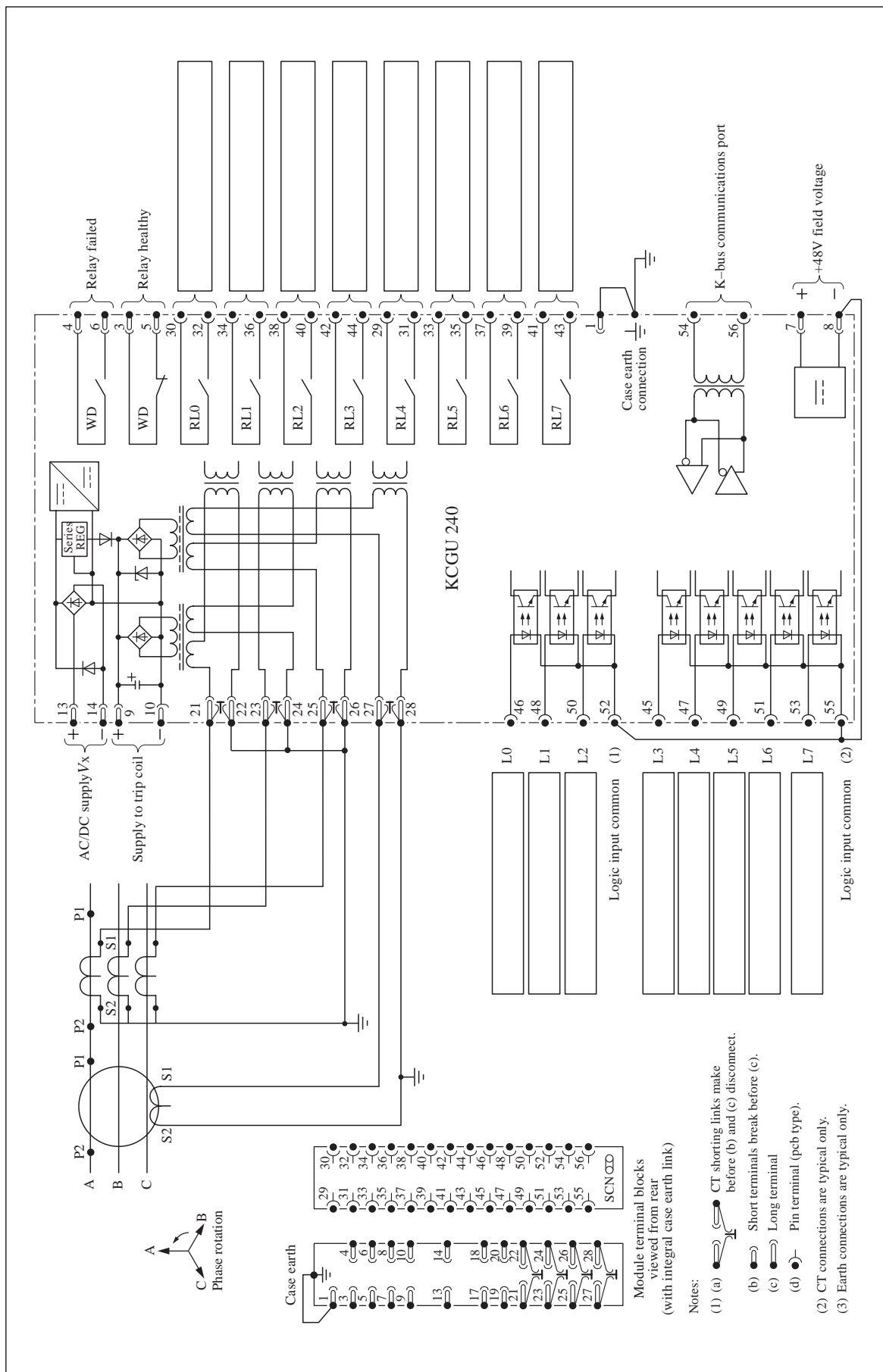


Figure 86. Typical application diagram: dual powered 3 phase overcurrent and sensitive earth fault relay Type KCGU 240

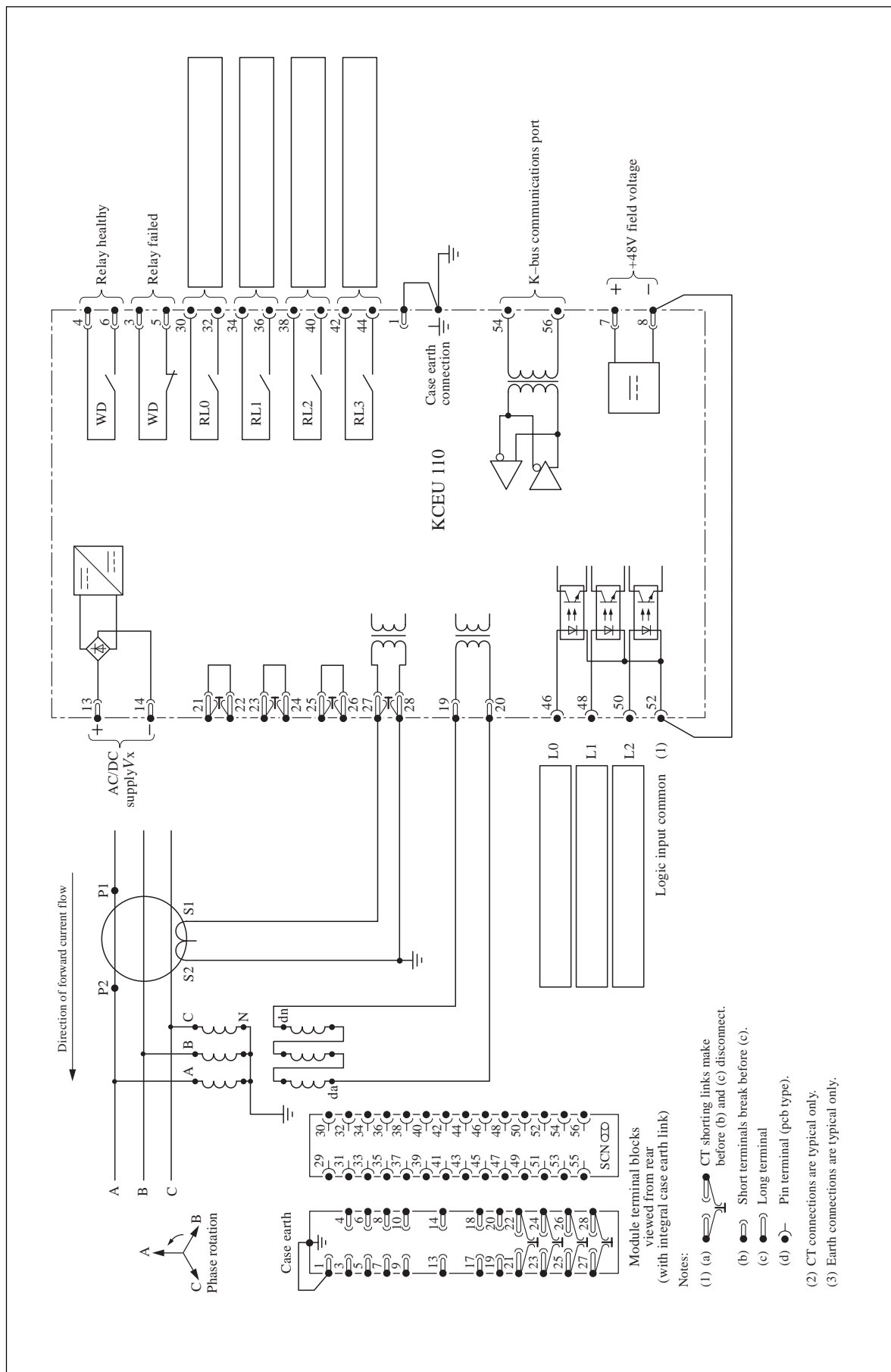


Figure 87. Typical application diagram: directional sensitive earth fault relay Type KCEU 110

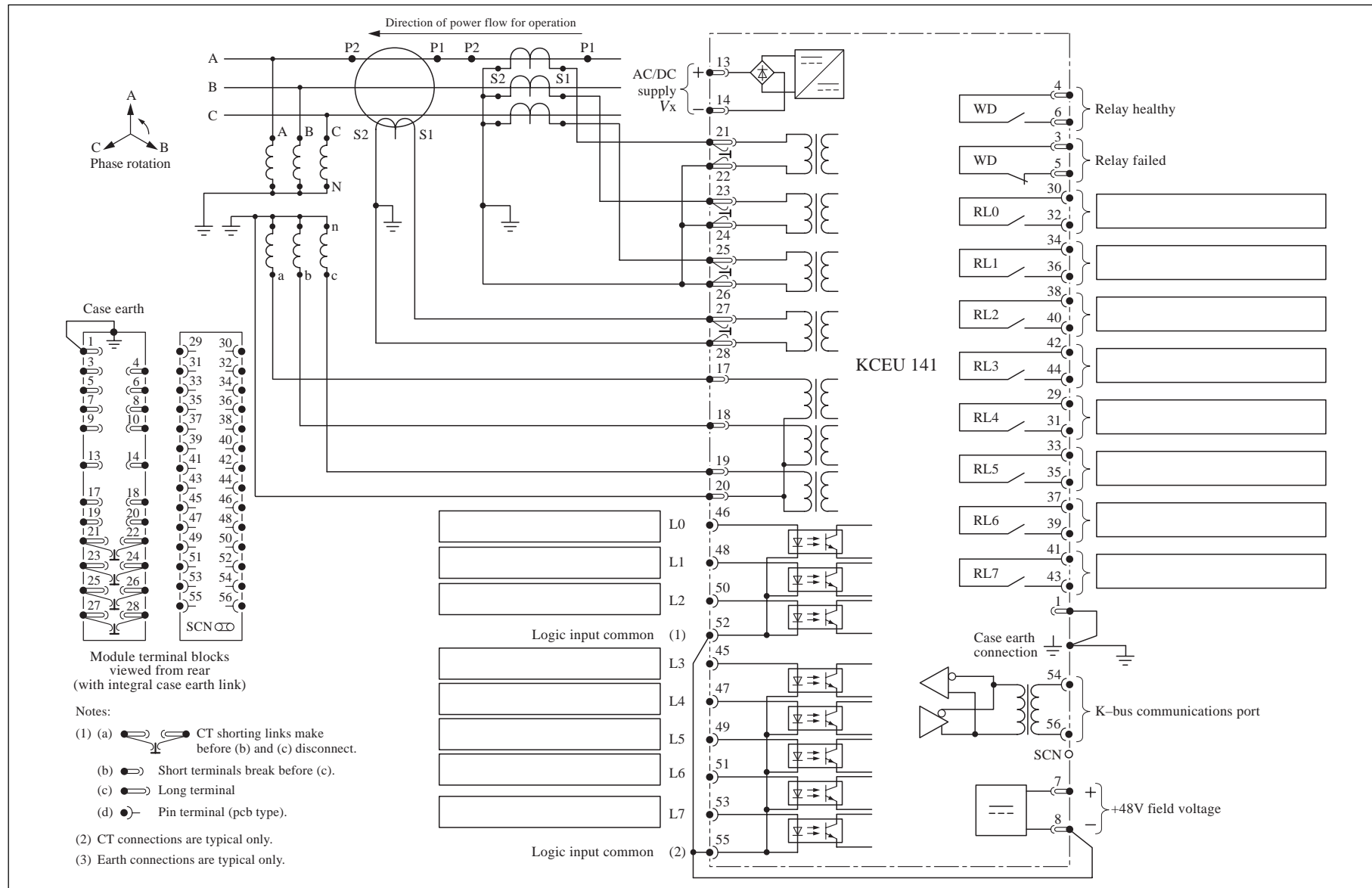


Figure 89. Typical application diagram: directional 3 phase overcurrent and sensitive wattmetric earth fault relay Type KCEU 141

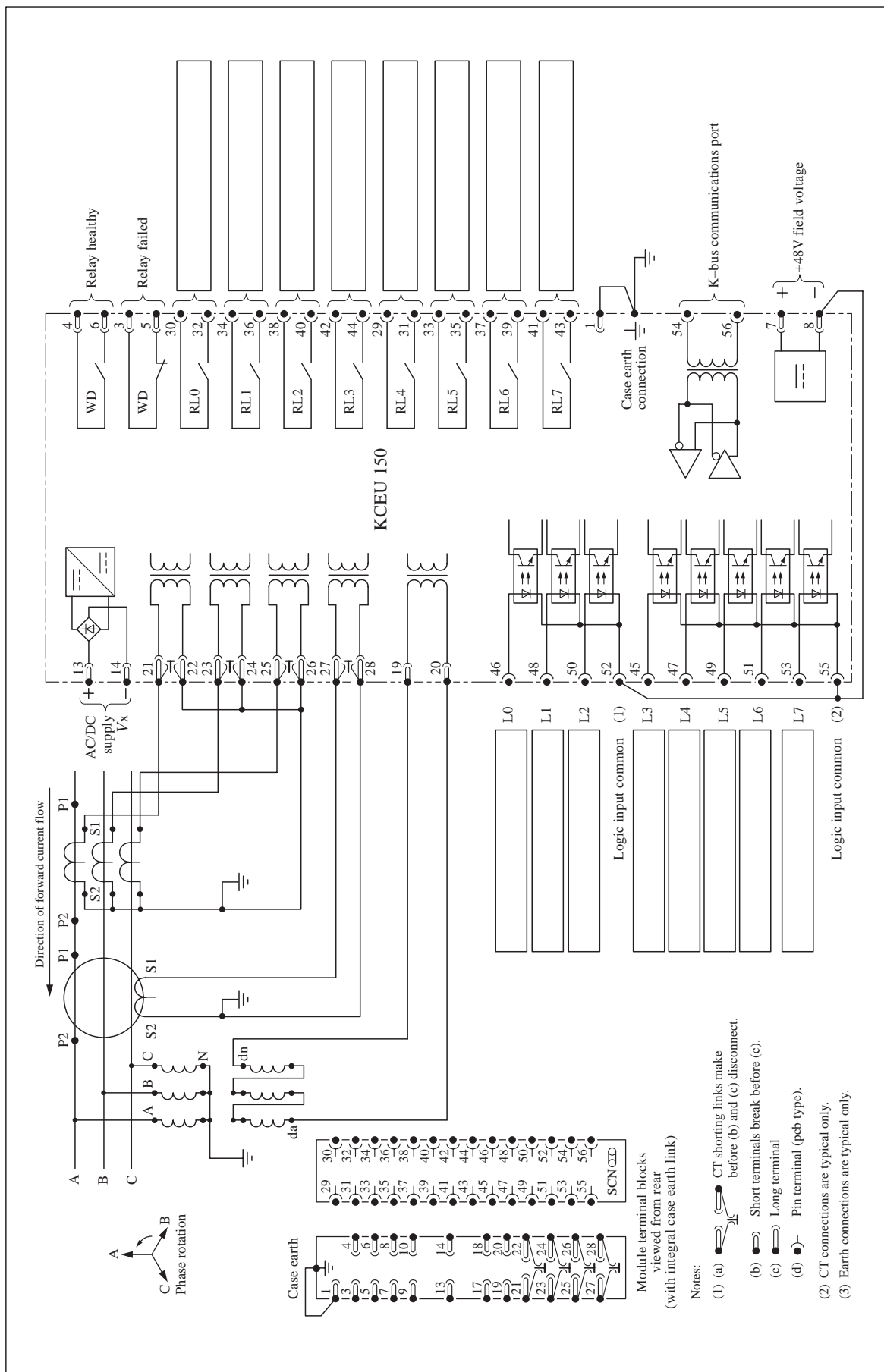


Figure 90. Typical application diagram: 3 phase overcurrent and directional sensitive earth fault relay Type KCEU 150

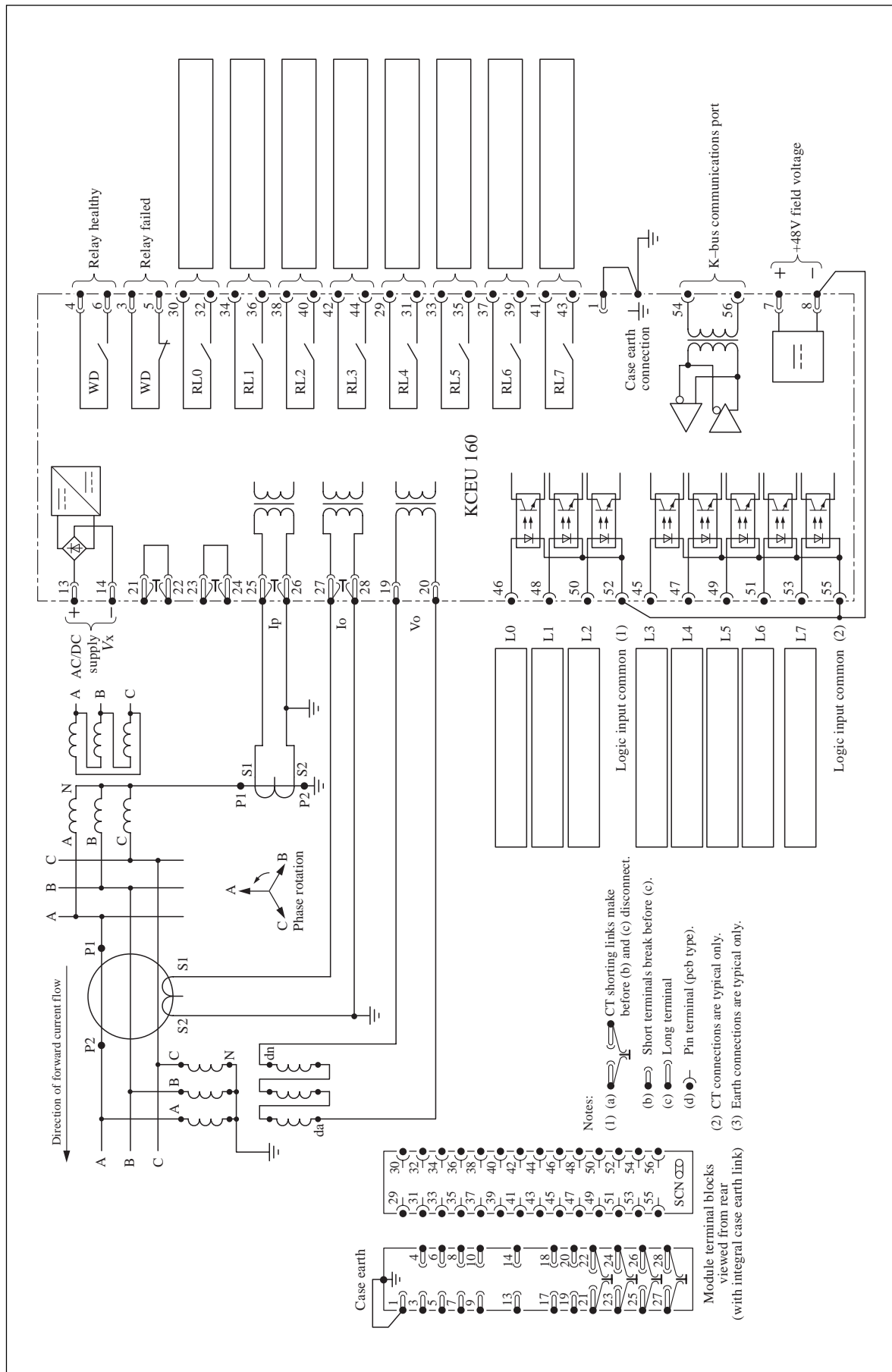


Figure 91. Typical application diagram: dual polarized directional overcurrent sensitive earth relay Type KCEU 160

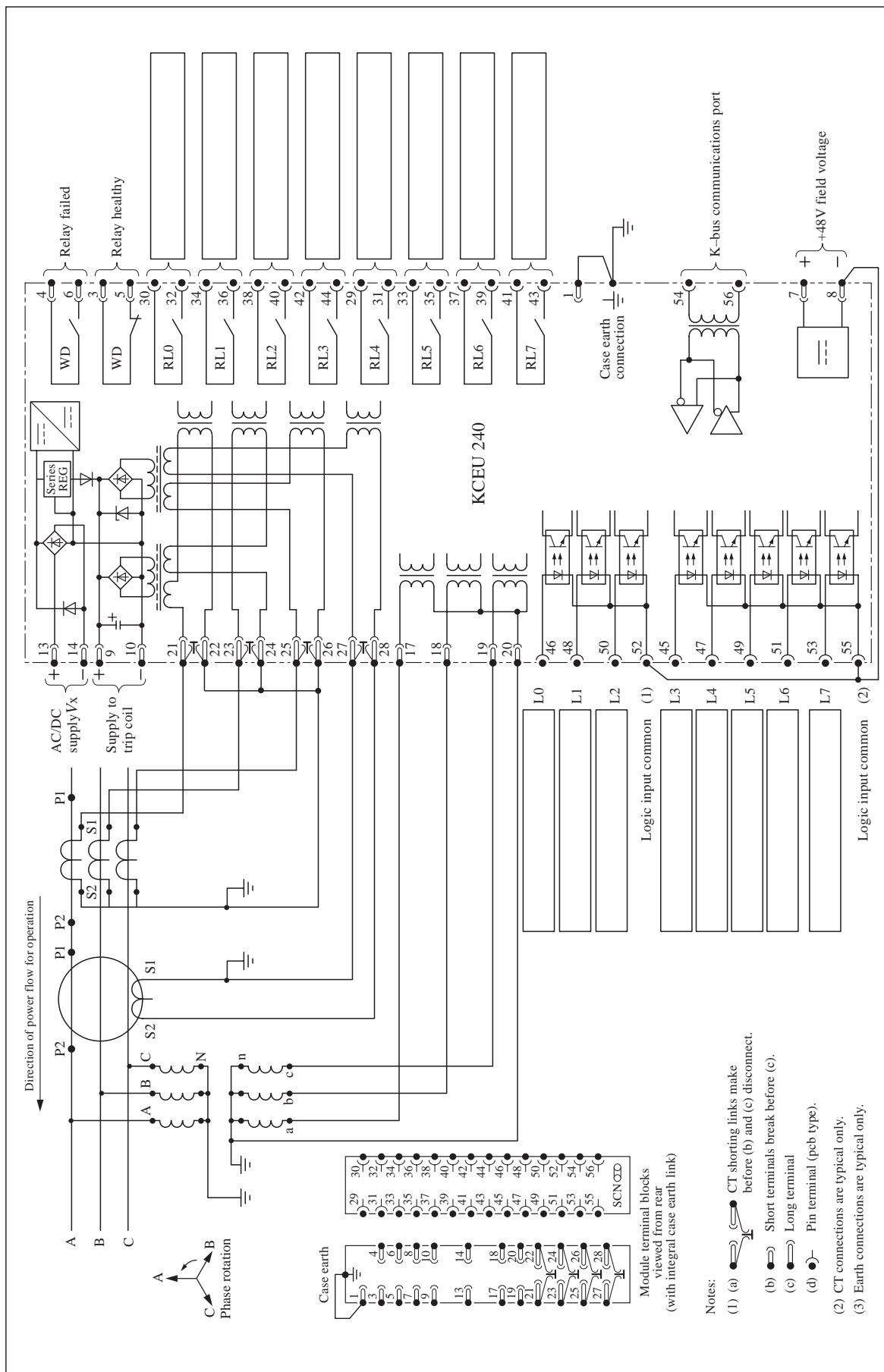


Figure 92. Typical application diagram: dual powered 3 phase directional overcurrent and sensitive earth fault relay Type KCEU 240

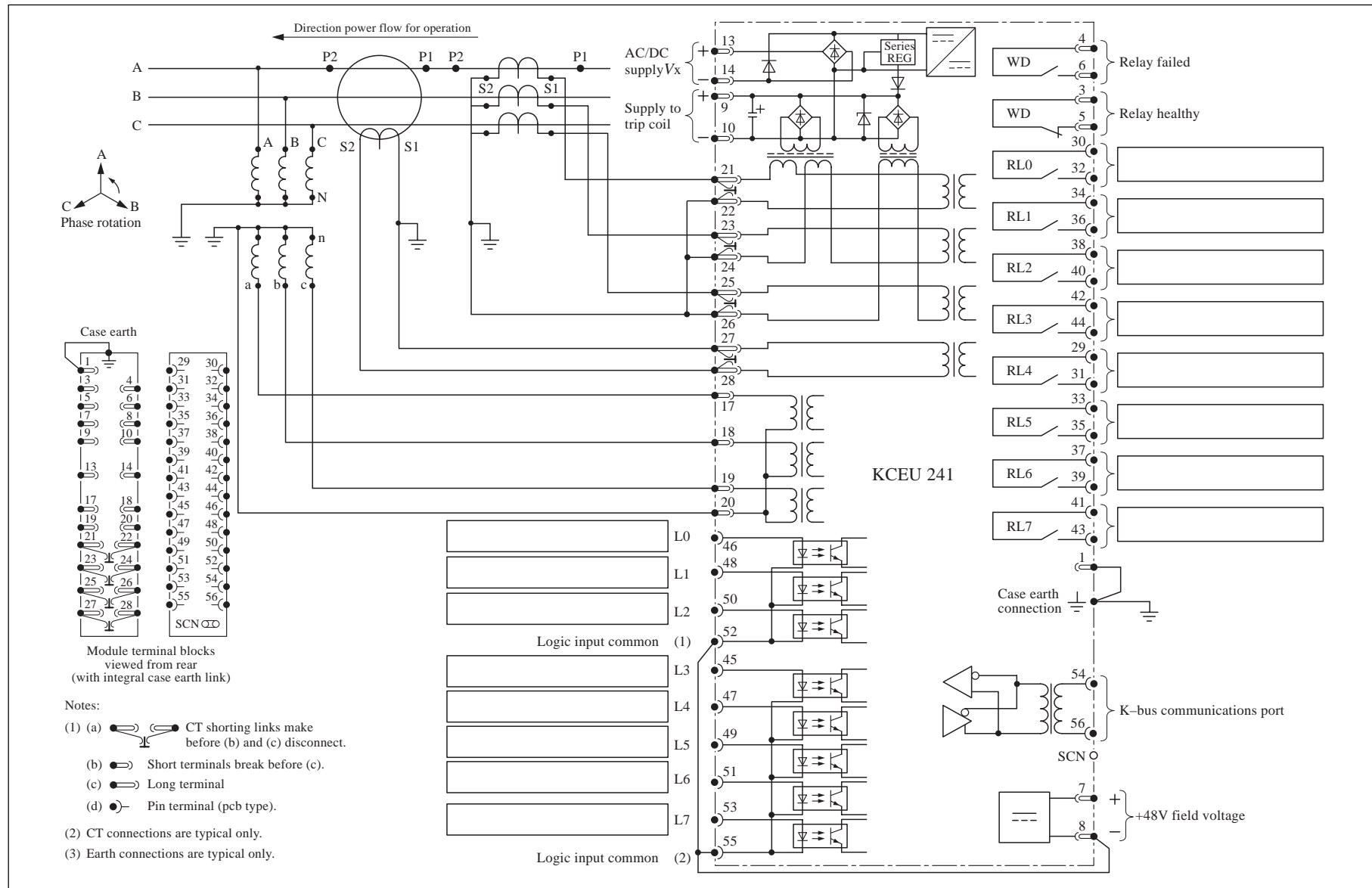


Figure 93. Typical application diagram: dual powered 3 phase overcurrent and sensitive wattmetric earth fault relay Type KCEU 241

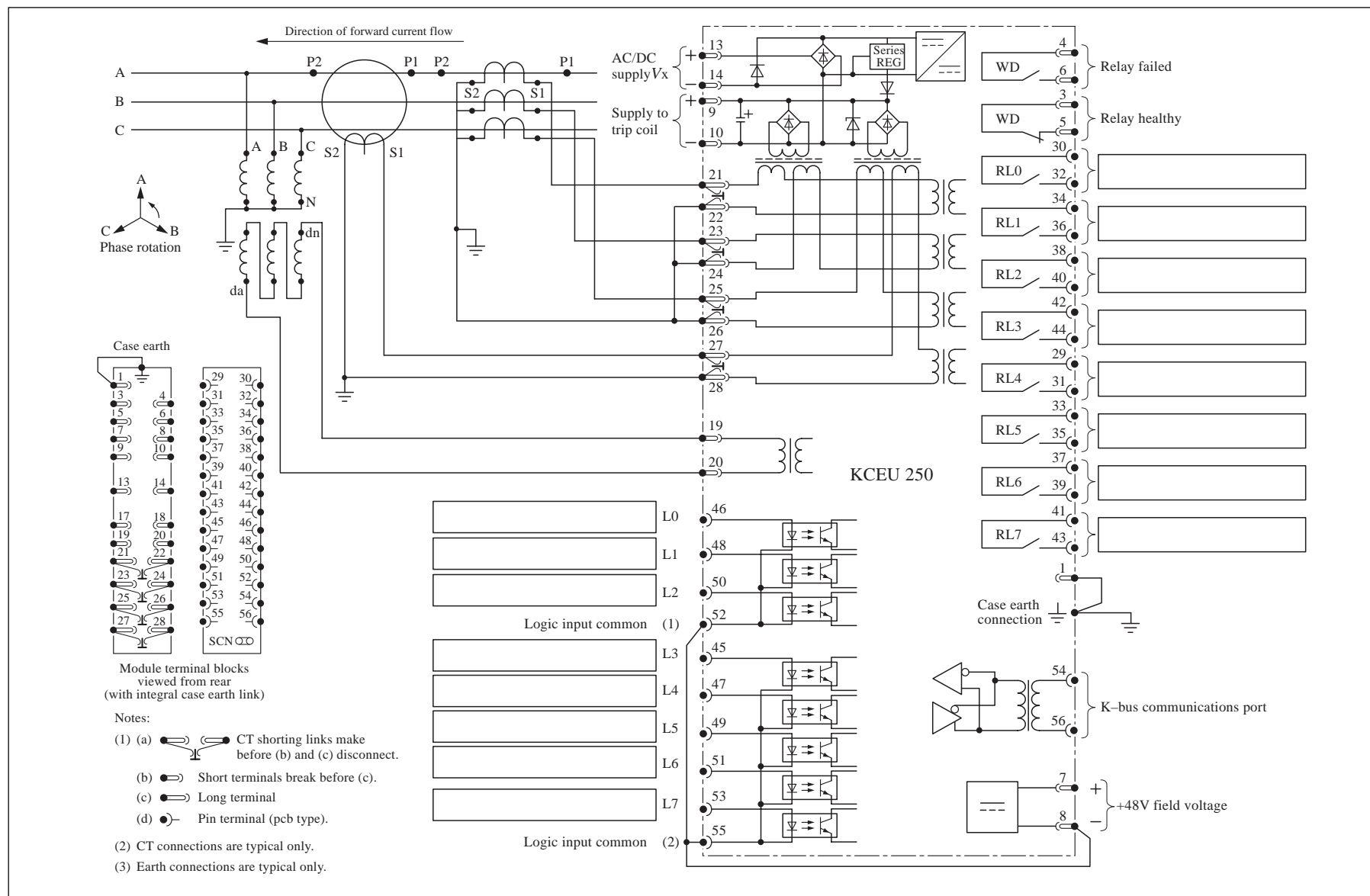


Figure 94. Typical application diagram: dual powered 3 phase overcurrent and directional sensitive earth fault relay Type KCEU 250

Appendix 4. COMMISSIONING TEST RECORD

Multifunctional Overcurrent Relay Type _____ KC _____

Relay model number _____ Date _____

Relay firmware number _____ Serial number _____

Station _____ Circuit _____

Front plate information

Multifunctional overcurrent relay type	KC
Model No.	
Serial No.	
Rated current In	
Aux Voltage Vx	
Pol Voltage Vn	
Frequency	

System data settings

	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0
SYS Password																
SYS Fn. Links																
SYS Description																
SYS Plant ref.																
SYS Model No.																
SYS firmware Ref.																
SYS Frequency																
SYS Comms Level																
SYS Relay Address																
SYS Software Ref.																

Earth fault 1

	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0
EF1 Fn. Links	0	0	0	0	0	0										
EF1 CT Ratio																
EF1 VT Ratio																
EF1 Charact.																
EF1 Io>																
EF1 to>/TMS																
EF1 toRESET																
EF1 Io>>																
EF1 to>>																
EF1 Io>>>																
EF1 to>>>																
EF1 Char. Angle																
EF1 Ip>																
EF1 Vop>																
EF1 Io<																

Phase fault 1

	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0
PF1 Fn. Links	0	0	0	0	0	0										
PF1 CT Ratio																
PF1 VT Ratio																
PF1 Charact.																
PF1 I>																
PF1 t>/TMS																
PF1 tRESET																
PF1 I>>																
PF1 t>>																
PF1 I>>>																
PF1 t>>>																
PF1 Char. Angle																
PF1 I<																
PF1 V<																
PF1 tV<																

Earth Fault 2

	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0
EF2 Fn. Links	0	0	0	0	0	0										
EF2 CT Ratio																
EF2 VT Ratio																
EF2 Charact.																
EF2 Io>																
EF2 to>/TMS																
EF2 toRESET																
EF2 Io>>																
EF2 to>>																
EF2 Io>>>																
EF2 to>>>																
EF2 Char. Angle																
EF2 Ip>																
EF2 Vop>																
EF2 Io<																

Phase fault 2

	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0
PF2 Fn. Links	0	0	0	0	0	0										
PF2 CT Ratio																
PF2 VT Ratio																
PF2 Charact.																
PF2 I>																
PF2 t>/TMS																
PF2 tRESET																
PF2 I>>																
PF2 t>>																
PF2 I>>>																
PF2 t>>>																
PF2 Char. Angle																
PF2 I<																
PF2 V<																
PF2 tV<																

Logic functions

	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0
LOG Fn. Links	0	0	0	0	0	0	0	0								0
LOG tCLP																
LOG tAUX1																
LOG tAUX2																
LOG tAUX3																
LOG tBF																
LOG rTRIP																
LOG tCLOSE																
LOG LS GROUP																
LOG tRESTORE																
LOG Default Dsply																

Input masks

	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0
INP Fn Links																
INP Blk to>	0	0	0	0	0	0	0	0								
INP Blk to>>	0	0	0	0	0	0	0	0								
INP Blk to>>>	0	0	0	0	0	0	0	0								
INP Blk t>	0	0	0	0	0	0	0	0								
INP Blk t>>	0	0	0	0	0	0	0	0								
INP Blk t>>>	0	0	0	0	0	0	0	0								
INP CB Open CLP	0	0	0	0	0	0	0	0								
INP Aux1	0	0	0	0	0	0	0	0								
INP Aux2	0	0	0	0	0	0	0	0								
INP Aux3	0	0	0	0	0	0	0	0								
INP Set Grp 2	0	0	0	0	0	0	0	0								
INP CB Opened	0	0	0	0	0	0	0	0								
INP CB Closed	0	0	0	0	0	0	0	0								
INP Bus Posn 2	0	0	0	0	0	0	0	0								
INP LTripp CB	0	0	0	0	0	0	0	0								
INP LClose CB	0	0	0	0	0	0	0	0								

Relay masks

RLY In Links	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0
RLY Io> Fwd	0	0	0	0	0	0	0	0								
RLY Io> Rev	0	0	0	0	0	0	0	0								
RLY to>	0	0	0	0	0	0	0	0								
RLY to>>	0	0	0	0	0	0	0	0								
RLY to>>>	0	0	0	0	0	0	0	0								
RLY I> Fwd	0	0	0	0	0	0	0	0								
RLY I> Rev	0	0	0	0	0	0	0	0								
RLY t>	0	0	0	0	0	0	0	0								
RLY t>>	0	0	0	0	0	0	0	0								
RLY t>>>	0	0	0	0	0	0	0	0								
RLY tV<	0	0	0	0	0	0	0	0								
RLY Aux1	0	0	0	0	0	0	0	0								
RLY Aux2	0	0	0	0	0	0	0	0								
RLY Aux3	0	0	0	0	0	0	0	0								
RLY V Reduct1	0	0	0	0	0	0	0	0								
RLY V Reduct2	0	0	0	0	0	0	0	0								
RLY V Reduct3	0	0	0	0	0	0	0	0								
RLY CB Close	0	0	0	0	0	0	0	0								
RLY CB Trip	0	0	0	0	0	0	0	0								

Recorder

	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0
REC Control																
REC Capture																
REC Post Trigger																
REC Relay Trigger																

Power mode (measurements)

Mode	
------	--

10.1 Commissioning preliminaries

(tick)

10.1.4 Serial number on case, module and cover checked

CT shorting switches in case checked

Terminals 21 and 22; 23 and 24; 25 and 26; 27 and 28 checked for continuity with module removed from case

External wiring checked to diagram (if available)

10.1.5 Earth connection to case checked

10.1.7 Test block connections checked

10.1.8 Insulation checked

10.3 Auxiliary supply checked

10.3.1 Auxiliary power checked

10.3.1.1 Auxiliary voltage at the relay terminals _____ V ac/dc

10.3.1.2 Watchdog contacts checked

Supply off

Terminals 3 and 5

Terminals 4 and 6

Supply on

Terminals 3 and 5

Terminals 4 and 6

10.3.1.3 Field voltage _____ V dc

10.3.2 Dual auxiliary powered relays _____

10.3.2.1 Auxiliary voltage at the relay terminals _____ V ac/dc

10.3.2.2 Watchdog contacts checked

Supply off

Terminals 3 and 5

Terminals 4 and 6

Supply on

Terminals 3 and 5

Terminals 4 and 6

10.3.2.3 Field voltage _____ V dc

10.3.2.4 Capacitor trip voltage _____ V dc

10.3.2.5 Minimum current injection to power the relay

Terminals 21 and 23 Terminals 22 and 24 linked _____ A

Terminals 25 and 21 Terminals 26 and 22 linked _____ A

Terminals 23 and 25 Terminals 24 and 26 linked _____ A

Terminals 23 and 28 Terminals 24 and 27 linked _____ A

10.5 Metering checks

	Actual value injected	Relay metered value
CT ratio	_____	
Phase A current	_____ A	_____ A
Phase B current	_____ A	_____ A
Phase C current	_____ A	_____ A
VT ratio	_____	
Phase A voltage	_____ V	_____ V
Phase B voltage	_____ V	_____ V
Phase C voltage	_____ V	_____ V

10.6 Test results for earth fault/sensitive earth fault elements

	Setting group 1	Setting group 2 (if required)
Setting	_____	_____
Pick-up current $I_{0>}$	_____ A	_____ A
Drop-off current $I_{0>}$	_____ A	_____ A
Curve	_____	_____
$t_{0>}/TMS$	_____ seconds	_____ seconds
Operate time at x2	_____ seconds	_____ seconds
Operate time at x10	_____ seconds	_____ seconds

Io>> current setting	_____	A	_____	A
Current to trip Io>>	_____	A	_____	A
Current no trip Io>>	_____	A	_____	A
Io>>> current setting	_____	A	_____	A
Current to trip Io>>>	_____	A	_____	A
Current no trip Io>>>	_____	A	_____	A

10.7 Test results for phase fault elements

	Setting group 1		Setting group 2 (if required)	
Setting	_____		_____	
Pick-up current for I> Phase A	_____	A	_____	A
Drop-off current for I> Phase A	_____	A	_____	A
Pick-up current for I> Phase B	_____	A	_____	A
Drop-off current for I> Phase B	_____	A	_____	A
Pick-up current for I> Phase C	_____	A	_____	A
Drop-off current for I> Phase C	_____	A	_____	A
Curve	_____		_____	
to>/TMS	_____	seconds	_____	seconds
Phase A operate time at x2	_____	seconds	_____	seconds
Phase B operate time at x2	_____	seconds	_____	seconds
Phase C operate time at x2	_____	seconds	_____	seconds
Phase A operate time at x10	_____	seconds	_____	seconds
Phase B operate time at x10	_____	seconds	_____	seconds
Phase C operate time at x10	_____	seconds	_____	seconds

Phase A current setting I>>	_____	A	_____	A
Phase A current to trip I>>	_____	A	_____	A
Phase A current to no trip I>>	_____	A	_____	A
Phase B current setting I>>	_____	A	_____	A
Phase B current to trip I>>	_____	A	_____	A
Phase B current to no trip I>>	_____	A	_____	A
Phase C current setting I>>	_____	A	_____	A
Phase C current to trip I>>	_____	A	_____	A
Phase C current to no trip I>>	_____	A	_____	A
Phase A current setting I>>>	_____	A	_____	A
Phase A current to trip I>>>	_____	A	_____	A
Phase A current to no trip I>>>	_____	A	_____	A
Phase B current setting I>>>	_____	A	_____	A
Phase B current to trip I>>>	_____	A	_____	A
Phase B current to no trip I>>>	_____	A	_____	A
Phase C current setting I>>>	_____	A	_____	A
Phase C current to trip I>>>	_____	A	_____	A
Phase C current to no trip I>>>	_____	A	_____	A

10.8 Test results for directional earth/sensitive earth fault elements

V_p> setting _____ V

Actual V_p> threshold _____ V

Setting group	E/F relay characteristic angle	Lag	Lead
1	_____	_____	_____
2	_____	_____	_____

Additional test results for dual polarized elements when current polarized

Lag _____ Lead _____

10.9 Test results for directional phase fault elements

Setting group	E/F relay characteristic angle	Phase A	Phase B	Phase C
1	_____	_____ Lag/Lead	_____ Lag/Lead	_____ Lag/Lead
2	_____	_____ Lag/Lead	_____ Lag/Lead	_____ Lag/Lead

10.10 Test results for selective logic

10.10.1 Opto input checks

Opto input number	(tick)
L0	<input type="checkbox"/>
L1	<input type="checkbox"/>
L2	<input type="checkbox"/>
L3	<input type="checkbox"/>
L4	<input type="checkbox"/>
L5	<input type="checkbox"/>
L6	<input type="checkbox"/>
L7	<input type="checkbox"/>

10.10.2 Controlled logic blocking of time delay elements

Earth fault element	Input mask	Input mask setting								Operation
to>	[INP Blk to>]									
to>>	[INP Blk to>>]									
to>>>	[INP Blk to>>>]									

Phase fault element	Input mask	Input mask setting								Operation
t>	[INP Blk t>]									
t>>	[INP Blk t>>]									
t>>>	[INP Blk t>>>]									

10.10.3 Undervoltage logic

Relay setting of $tV<$ _____ seconds

Measured value of $tV<$ _____ seconds

Relay setting of $V<$ _____ V

Measured value of $V<$ _____ V

10.10.4 Auxiliary timers

	Relay setting of auxiliary timer	Measured value of auxiliary timer
Timer Aux1	_____ seconds	_____ seconds
Timer Aux2	_____ seconds	_____ seconds
Timer Aux3	_____ seconds	_____ seconds
Setting	_____	_____

10.10.5	Breaker fail	Relay setting	Measured values
		_____ s	_____ s

10.10.6	Change setting group	(tick)
	Change to setting group 2	<input type="checkbox"/>

10.10.7	Cold load start/pick-up	
	Initiate cold load start	<input type="checkbox"/>

10.10.8	Circuit breaker control	
	Trip test	<input type="checkbox"/>
	Close test	<input type="checkbox"/>

Commissioning Engineer

Customer Witness

Date

Date

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REPAIR FORM

Please complete this form and return it to AREVA T&D with the equipment to be repaired. This form may also be used in the case of application queries.

AREVA T&D
St. Leonards Works
Stafford
ST17 4LX,
England

For: After Sales Service Department

Customer Ref: _____

Model No: _____

Contract Ref: _____

Serial No: _____

Date: _____

1. What parameters were in use at the time the fault occurred?

AC volts _____ Main VT/Test set

DC volts _____ Battery/Power supply

AC current _____ Main CT/Test set

Frequency _____

2. Which type of test was being used? _____

3. Were all the external components fitted where required? Yes/No
(Delete as appropriate.)

4. List the relay settings being used

5. What did you expect to happen?

continued overleaf



6. What did happen?

7. When did the fault occur?

Instant Yes/No Intermittent Yes/No

Time delayed Yes/No (Delete as appropriate).

By how long? _____

8. What indications if any did the relay show?

9. Was there any visual damage?

10. Any other remarks which may be useful:

Signature

Title

Name (in capitals)

Company name



