KBCH 120, 130, 140

Transformer Differential Protection Relay

Service Manual

KBCH/EN M/G11

CURRENT DIFFERENTIAL RELAYS

KBCH 120, 130, 140

CONTENT

ISSUE F			Amendments completed 07.01.2002
ISSUE E			
Chapter	Section	Page	Description
1	2.10	15	**Measurement** Sentence added at end of paragraph
1	5.3.2	40	**Recorder Capture** Note amended
1	8	54	**Technical Data** Frequency tracking range amended to 13-65Hz
1	8.17	62	**Model Numbers** Amend case details P - change Midos case size 8 to "MiCOM Livery Size 8 (40TE)"
ISSUE D			Amendments completed 07.01.2002
2	All	All	Layout of manual amended to corporate standard
ISSUE C			Amendments completed 07.01.2002
3	All	All	Layout of manual amended to corporate standard
ISSUE C			Amendments completed 07.01.2002
4	All	All	Layout of manual amended to corporate standard

SAFETY SECTION

CONTENTS

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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 Energy Automation & Information 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).

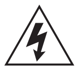
The operating manual for the equipment gives instructions for its installation, commissioning, and operation. However, the manual cannot cover all conceivable circumstances or include detailed information on all topics. In the event of questions or specific problems, do not take any action without proper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

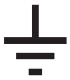
3.1 Symbols

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

CE 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. The following Product Specific Standard was used to establish conformity: EN 50263 : 2000	Compliance demonstrated via the Technical Construction File route.

Where applicable :

Ex II (2) G	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.
ATEX Potentially Explosive Atmospheres directive 94/9/EC, for equipment.	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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CHAPTER 1
Technical Description

CONTENT

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 an 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 front plate, 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 IEC147-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 a 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 R6530.

1.4 Unpacking

Care must be taken when unpacking and installing the relays so that none of the parts are 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°C.

2. DESCRIPTION OF THE RELAY

2.1 Introduction

The relay types covered by this manual are:-

– KBCH120 2 biased inputs per phase Transformer Differential Relay;

– KBCH130 3 biased inputs per phase Transformer Differential Relay;

– KBCH140 4 biased inputs per phase Transformer Differential Relay.

The relay is housed in size 8 Midos modular cases and is physically fully compatible with the existing relays in the range. The Midos system provides compact construction with a metallic case and integral-mounted screw/push-on terminal connections on the rear of the housing. The case is suitable for rack or panel mounting, and makes the relay ideally suited to retrofit applications

The relay contains a number of printed circuit boards as shown in Figure 2-1. Instructions for removing each pcb are given in Section 10.

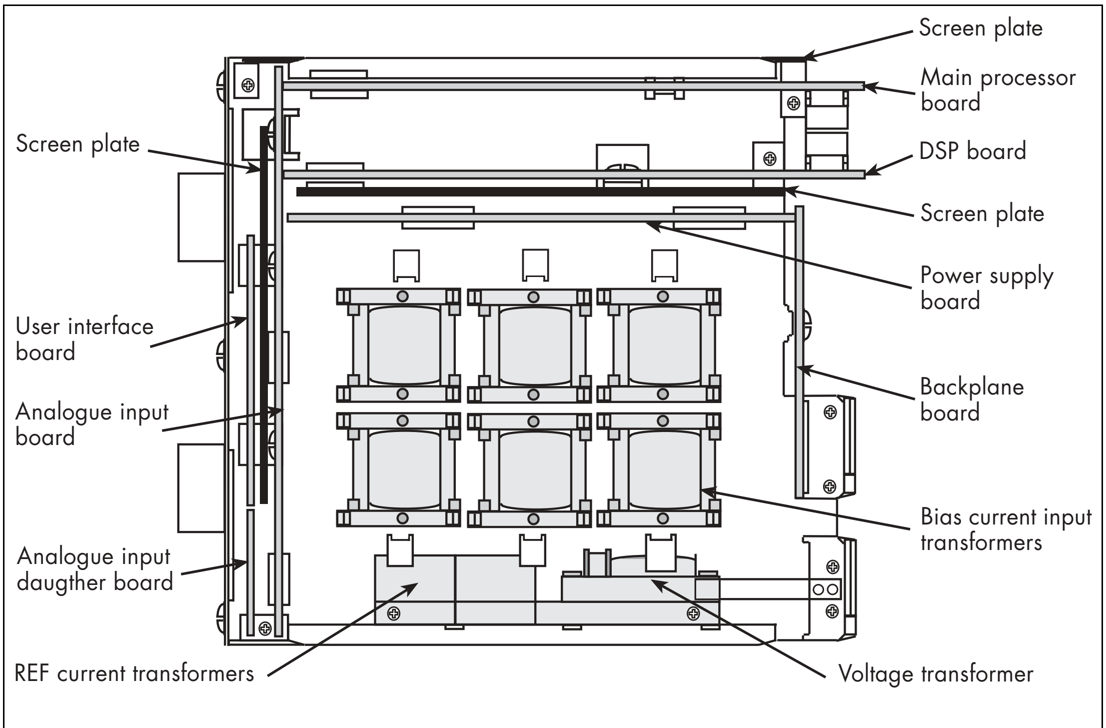


Figure 2-1: Internal layout of relay.

The relay is fully digital containing two microprocessors, a digital signal processor (DSP) and a 80C196 which communicate with each other internally. The 80C196 is responsible for the user interface, serial communications and scheme logic. The DSP is responsible for the protection algorithms. The main functions performed in each are shown in Figure 2-2.

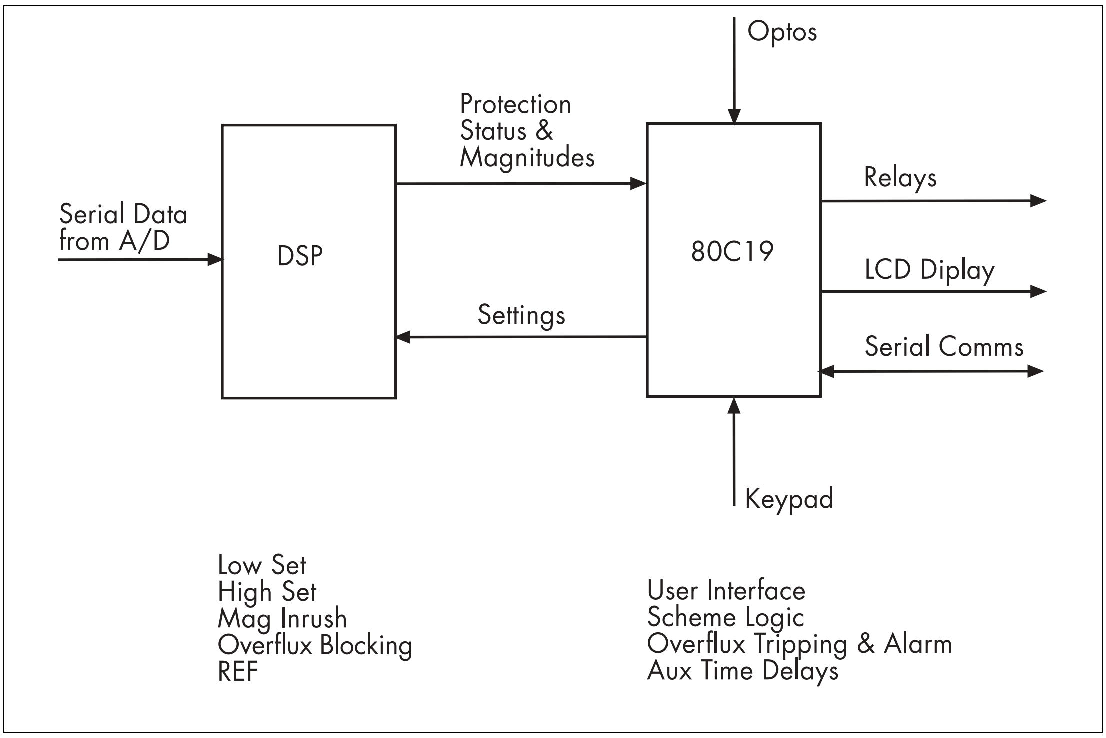


Figure 2-2: Functional block diagram

2.2 Signal Conditioning

2.2.1 Analogue to Digital conversion

The relay has up to sixteen analogue inputs, twelve are bias currents used in the differential protection, three are currents used in the restricted earth fault (REF) protection and one is a voltage used in the overflux protection. Each analogue input is conditioned by a low pass anti-aliasing filter before passing to a 16 bit analogue to digital converter via a 16 channel multiplexer. Each channel is sampled at forty times per cycle, synchronised to the power system frequency. The digital data is passed to a digital signal processor (DSP) which performs the protection algorithms.

2.2.2 Calibration

Calibration of each channel is performed in software, there are no hardware adjustments in the relay. Calibration consists of gain and phase adjustment to compensate for the hardware variations and the sequential sampling effect. Both calibrations are done by adjusting the magnitude of each sample as they are read in to the DSP. Phase calibration is not required for the REF and voltage channels as phase plays no part in these algorithms.

2.2.3 Current Transformer (CT) ratio and phase compensation

Each of the bias current samples are further modified depending on the appropriate relay settings for CT ratio and phase compensation as described in section 5.1.4.

2.2.4 Transformer configuration

The transformer configuration setting is used to set unused channels to zero, to ensure that they play no part in the algorithms. It also affects the relay measurements and disturbance recorder functions as these display the current flowing into each of the transformer windings. In cases where a single CT is used this is the same as the bias current but where two CTs are used the winding current is calculated by summing the two bias currents as shown in Figure 2-3.

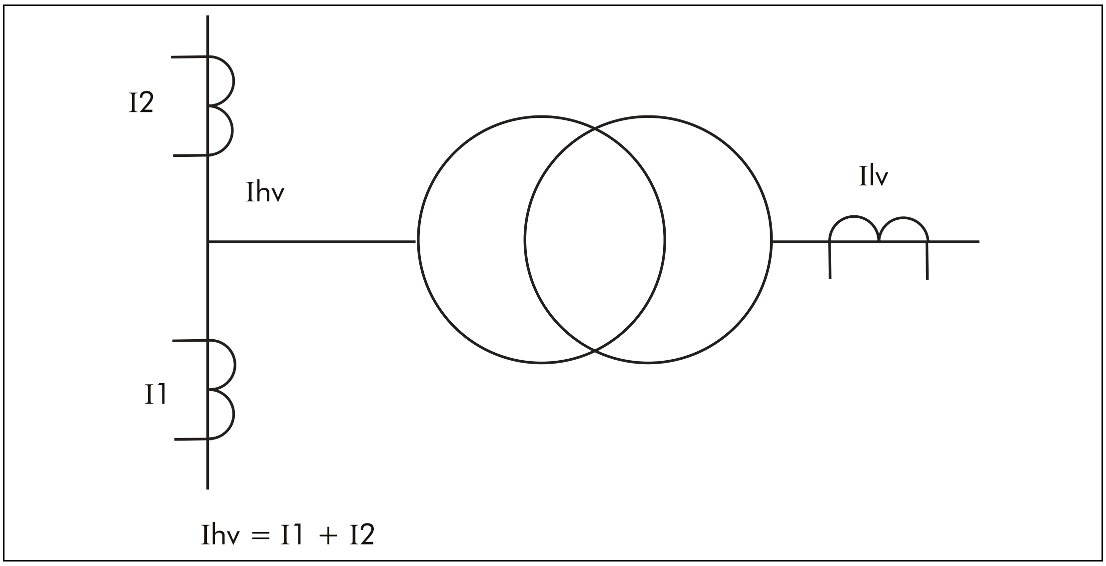


Figure 2-3: Measurements for mesh corner applications

2.2.5 Differential current

The differential current, for each phase, is calculated by summing the four individual bias currents related to that phase.

2.2.6 Fourier

The fundamental frequency magnitude and phase are calculated by a technique which uses fourier transforms. A single cycle fourier is applied to each of the sixteen channels, the three differential channels and the nine winding current channels. Phase angle is not calculated for the three REF channels and the voltage channel as these are not required for the algorithms. The fouriers are calculated eight times per cycle.

2.2.7 Frequency tracking

The bias currents and voltage channels are used to determine the system frequency. This is used to adjust the sample rate to maintain 40 samples per cycle and also in the overflux protection algorithms.

2.3 Biased differential protection function

The relay contains two differential protection algorithms described below. Each algorithm is applied to each of the three phases independently.

2.3.1 Low set protection function

The biased low set differential element characteristic is shown in Figure 2-4. The calculated bias current fourier magnitudes are summed to determine the through bias current. The calculated fourier magnitude of the differential current is also used in the algorithm. The minimum differential current required for operation is adjustable between 0.1PU and 0.5PU based on rated current.

Under normal operation steady state magnetising current and the use of tap changers result in unbalanced conditions and hence differential current. To accommodate these conditions the initial slope is 20% for bias currents of zero up to rated current. This ensures sensitivity to faults whilst allowing for up to 15% mismatch when the power transformer is at the limit of its tap range. At currents above rated, extra errors may be gradually introduced as a result of CT saturation. The bias slope is therefore increased to 80% to compensate for this.

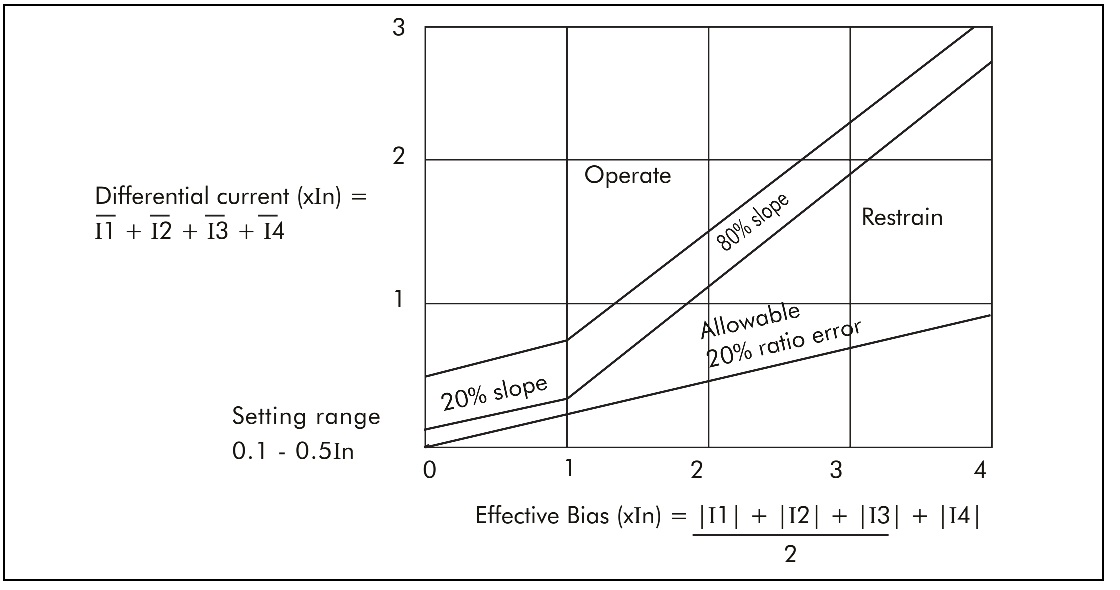


Figure 2-4: Differential low set characteristic

2.3.2 Magnetising inrush current blocking

Particularly high inrush currents may occur on transformer energisation, depending on the point on wave of switching as well as the magnetic state of the transformer core. Since the inrush current flows only in the energised winding differential current results. The use of traditional second harmonic restraint to block the relay during inrush conditions may result in a significant slowing of the relay during heavy internal faults due to the presence of second harmonics as a result of saturation of the line current transformers. To overcome this, the relay uses a waveform recognition technique to detect the inrush condition. The differential current waveform associated with magnetising inrush is characterised by a period of each cycle where its magnitude is very small, as shown in Figure 2-5. By measuring the time of this period of low current, an inrush condition can be identified. The detection of inrush current in the differential current is used to inhibit that phase of the low set algorithm.

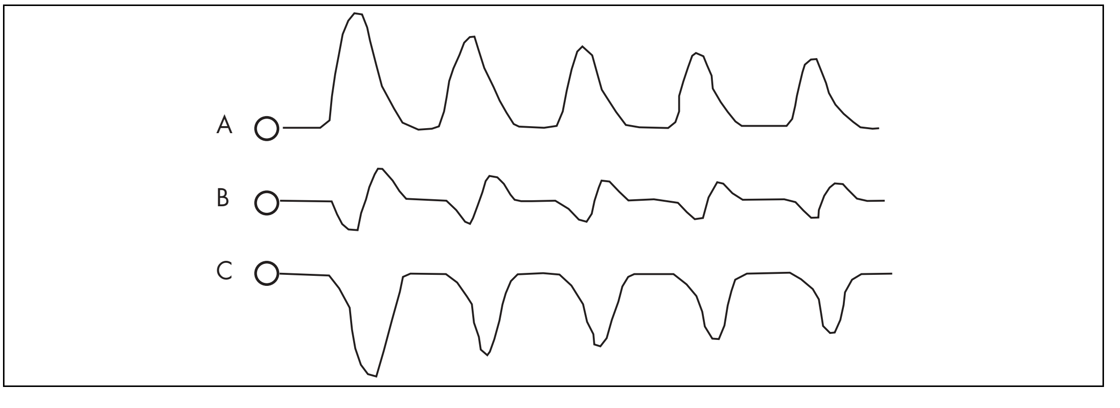


Figure 2-5: Typical magnetising inrush current waveforms

2.3.3 Overflux blocking

When a load is suddenly disconnected from a power transformer the voltage at the input terminals of the transformer may rise by 10-20% of rated value causing an appreciable increase in transformer steady state excitation current. The resulting excitation current flows in one winding only and hence appears as differential current which may rise to a value high enough to operate the differential protection. A typical current waveform is shown in figure 2-6. A waveform of this type is characterised by the presence of fifth harmonic. A fourier technique is used to measure the level of fifth harmonic in the differential current. The ratio of fifth harmonic to fundamental is compared with a setting which if exceeded inhibits the biased differential protection. Detection of overflux conditions in any phase blocks that particular phase of the low set algorithm.

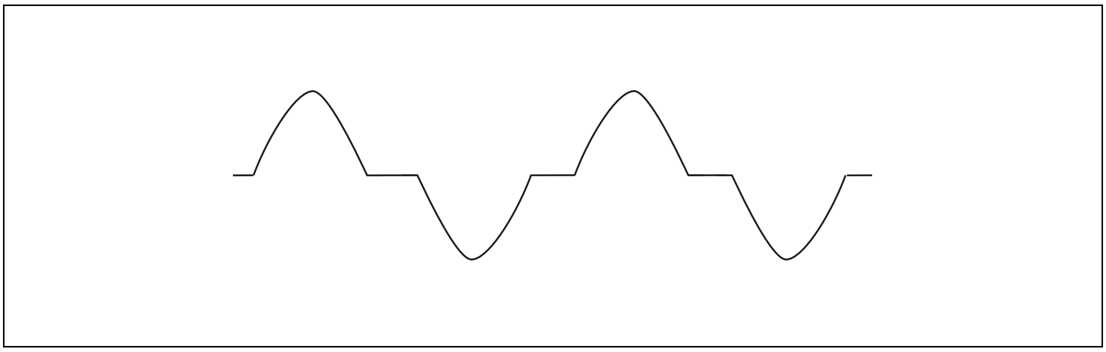


Figure 2-6: Typical overflux current waveforms

2.3.4 High set protection function

An additional unrestrained instantaneous high set differential element is provided to ensure rapid clearance of terminal faults. This element is essentially peak measuring to ensure fast operation for internal faults with saturated CTs. The high set is not blocked under magnetising inrush or over excitation conditions, hence the setting must be set such that it will not operate for the largest inrush currents expected.

2.4 Restricted earth fault (REF) protection function

Restricted earth fault protection is included to give greater sensitivity to earth faults and hence protect more of the winding. A separate element is provided for each winding. An external resistor is required to provide stability in the presence of saturated line current transformers.

The REF protection works on the high impedance circulating current principle as used in the MCAG14 relays. When subjected to heavy through faults the line current transformer may enter saturation unevenly, resulting in unbalance. To ensure stability under these conditions the element uses a voltage operated, high impedance circuit, set to operate at a voltage slightly higher than that developed by the current transformers under maximum external fault conditions i.e. one CT fully saturated. Harmonics, particular third, are rejected by basing the measurement on the fundamental frequency fourier magnitude.

2.5 Overflux protection function

Power frequency overvoltage causes both an increase in stress on the insulation and a proportionate increase in the working flux. The latter effect causes an increase in the iron loss and a disproportionate increase in magnetising current. In addition flux is diverted from the core into the steel structural parts, and in particular under extreme over-excitation into the core bolts. These normally carry very little flux but under these conditions they may be rapidly heated to a temperature which causes their insulation to fail and eventually causes the main insulation to fail.

Over-excitation is caused by an increase in voltage or a reduction in frequency. It follows therefore that transformers can withstand an increase in voltage with a corresponding increase in frequency but not an increase in voltage with a decrease in frequency.

Operation cannot be sustained when the ratio of voltage to frequency, with these quantities expressed as per unit of rated values, exceeds unity by more than a small amount, for instance if V/f > 1.1. The base of "unit voltage" should be taken as the highest voltage for which the transformer has been designed for.

Protection against overflux conditions does not call for high speed tripping, in fact instantaneous tripping is undesirable as it would cause tripping for momentary system disturbances which can be borne safely. Normal conditions must be resumed within a minute or two at the most.

The relay contains two overflux algorithms, alarm and trip. The alarm, normally set to operate at a lower level than the trip, will be used to initiate corrective action. Both operate by comparing the ratio of Voltage to Frequency against a setting. The alarm has a definite time delay, the trip has a choice of definite time delay or inverse definite minimum time characteristic which is shown in Figure 2-7.

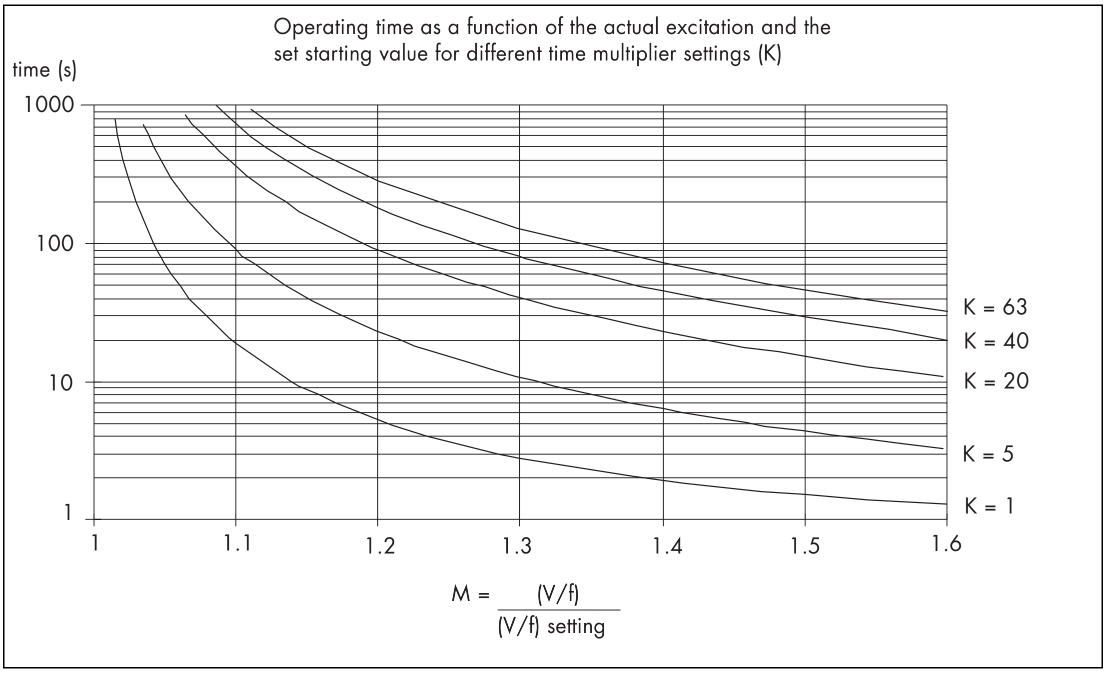


Figure 2-7: Overflux tripping IDMT characteristic

2.6 Opto-isolated control inputs

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

2.7 Output relays

There are eight programmable output relays and these relays can be arranged to operate in response to any, or all, of the available functions by suitably setting the OUTPUT MASKS. In addition there is a watchdog relay for external indication of equipment failure/healthy status.

2.8 Alternative setting group

An alternative group of settings is provided. The alternative settings can be selected at any time, either by energising 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.

2.9 Logic

All the settings for the auxiliary timing functions are located under the LOGIC heading of the menu.

There are eight auxiliary timers in the relays which 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.

2.10 Measurement

All measurement values can be displayed on the front of the relay. The display consists of up to nine phase current values depending on model and configuration. The currents displayed are those measured before the effects of phase compensation. If the primary current transformer ratios are entered in the SETTINGS column the phase current values will be in primary amperes. The default setting for these ratios is 1:1; in which case the displayed measured values are then the secondary quantities as seen by the relay. In the case of "mesh corner" where two current transformers are used the displayed currents are the calculated current which is flowing in the transformer winding. The differential and through bias currents are displayed in secondary terms. The minimum current that is measured by KBCH is 30mA or 150mA for 1A or 5A respectively.

2.11 Fault records

Fault values are recorded for the last fault but the fault flags are recorded for the last five faults. They are stored in non-volatile memory and can be accessed via the user interface. There is provision for clearing these records.

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 de-selected. 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-energised and they can only be accessed via the serial communication port.

2.12 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. 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 energising supply to the relay.

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 seven characters that may be either "1" or "0" to indicate the set and reset states of the alarm. The flags offer the following indications:

Alarm Flags							Indication	
6	5	4	3	2	1	0		
						1	Unconfig	Protection not operational – needs to be configured
					1		Uncalib	Protection is running uncalibrated – calibration error
				1			Setting	Protection is running – possible setting error
			1				No service	Protection is out of service
		1					No opto	Protection not sampling opto inputs
	1						No S/Logic	Protection not operational – scheme logic not running
1							DSP Faulty	Protection not operational – Fault detected in DSP

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.

2.13 Password protection

Password protection is only provided for the configuration settings of the relay. This includes transformer configuration, phase compensation selection, CT ratio correction, CT 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.

2.14 Serial communication

Serial communications are supported over K-BUS, a multidrop network that readily interfaces to IEC870-5 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. Status - an eight bit word that identifies the trip and alarm state, busy state, also the presence of event and disturbance records for collection.

2.14.1 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; 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/IEC870-5 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.

– 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 ±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 RECORDS 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.

2.14.2 Disturbance records

The internal disturbance recorder has sixteen analogue channels plus one to record the status of the eight control inputs and one to record the status of the eight relay outputs. The analogue channels record up to nine phase currents, three per winding, the three differential currents, the three calculated through bias currents and the voltage channel. In the case of “mesh corner” where two current transformers are used the phase currents are the calculated current which is flowing in the transformer winding. 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 disturbance records can only be accessed via the serial communication port.

2.14.3 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 manual tap up/tap down.

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 5.

2.14.4 Notes on serial port

Each relay in the K-Series 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 allows the connection to the bus wiring to be made in either polarity.

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 high level data link control (HDLC) and the data rate is 64kbits/s. Up to 32 units may be connected to any bus at any point with a maximum length of 1000m.

2.14.5 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 time-out 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. Cyclical redundancy checksum (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 re-send a command a set number of times if it does not receive a reply or receives a reply with a detected error.

3. EXTERNAL CONNECTIONS

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
Not Used	-	9	10	-	Not Used
Not Used	-	11	12	-	Not Used
Auxiliary Voltage Input	(+)	13	14	(–)	Auxiliary Voltage Input
Not Used	-	15	16	-	Not Used
Voltage Input (Overflux)	In	17	18	Out	Voltage Input (Overflux)
Not Used	-	19	20	-	Not Used
A Current (1)	In	21	22	Out	A Current (1)
B Current (1)	In	23	24	Out	B Current (1)
C Current (1)	In	25	26	Out	C Current (1)
E/F Current (1)	In	27	28	Out	E/F Current (1)

Function		Terminal			Function
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
Earth Terminal	-	57	58	-	Not Used
Not Used	-	59	60	-	Not Used
Not Used	-	61	62	-	Not Used

Function		Terminal			Function
A Current (4)	In	63	64	Out	A Current (4) (KBCH140 only)
B Current (4)	In	65	66	Out	B Current (4) (KBCH140 only)
C Current (4)	In	67	68	Out	C Current (4) (KBCH140 only)
A Current (3)	In	69	70	Out	A Current (3) (Not on KBCH120)
B Current (3)	In	71	72	Out	B Current (3) (Not on KBCH120)
C Current (3)	In	73	74	Out	C Current (3) (Not on KBCH120)
E/F Current (3)	In	75	76	Out	E/F Current(3) (Not on KBCH120)
A Current (2)	In	77	78	Out	A Current (2)
B Current (2)	In	79	80	Out	B Current (2)
C Current (2)	In	81	82	Out	C Current (2)
E/F Current (2)	In	83	84	Out	E/F Current (2)

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.

3.1 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 front plate of the relay; it is marked (Vx = 24V – 125V) or (Vx = 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.

3.2 Opto-isolated control inputs

The opto-isolated control inputs are rated for 48V dc and energised from the isolated 48V field voltage provided on terminals 7 and 8 of the relay. Terminal 8 (–) must be connected to terminals 52 and 55. The opto-isolated control inputs can then be energised 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 3-1, contact X operates L1 of relay 1 and contact Y operates L0 of relay 1 as well as L0 and L1 of relay 2. L2 is not used on either relay and has no connections made to it.

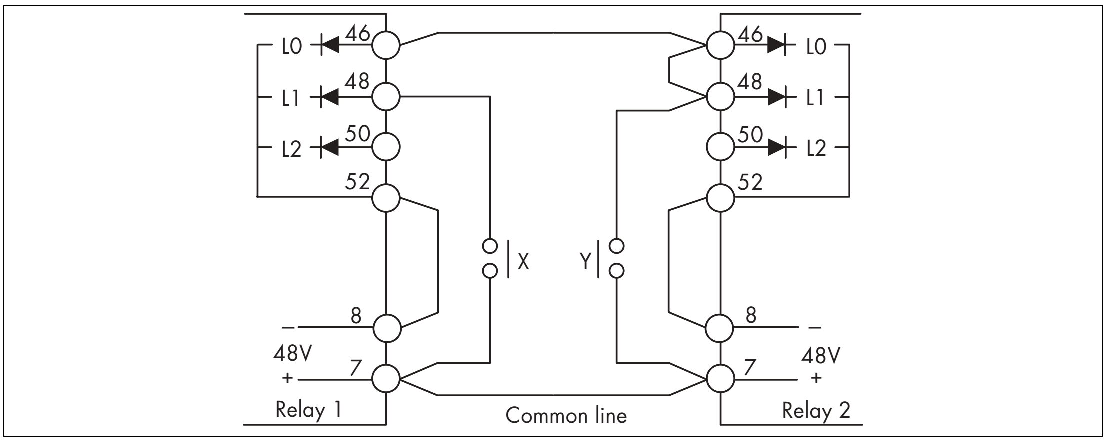


Figure 3-1: Connection to optical isolator control inputs

3.3 Analogue inputs

The relays can have up to sixteen analogue inputs depending on the model. Each is fed via an input transducer and low pass filter to a multiplexer and analogue to digital converter. The analogue signals are sampled forty times per cycle on each channel as the sampling rate tracks the frequency of the input signal.

3.4 Output relays

There are four programmable output relays on the microprocessor board and four on the DSP board. These relays each have two make contacts connected in series to increase their rating. The protection and control functions to which these relays respond are selectable via the menu system of the relay. It is normal practice to allocate RLY3 and RLY7 as trip relays as these relays also control the flagging (see section 6.9).

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.

3.5 Alternative trip arrangements

Normal practice is to use a separate trip contact for each of the circuit breakers associated with the transformer.

3.5.1 DC shunt trip

An auxiliary supply is required 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 energised trip circuits as shown in Figure 3-2.

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 relay trip contact and the trip coil.

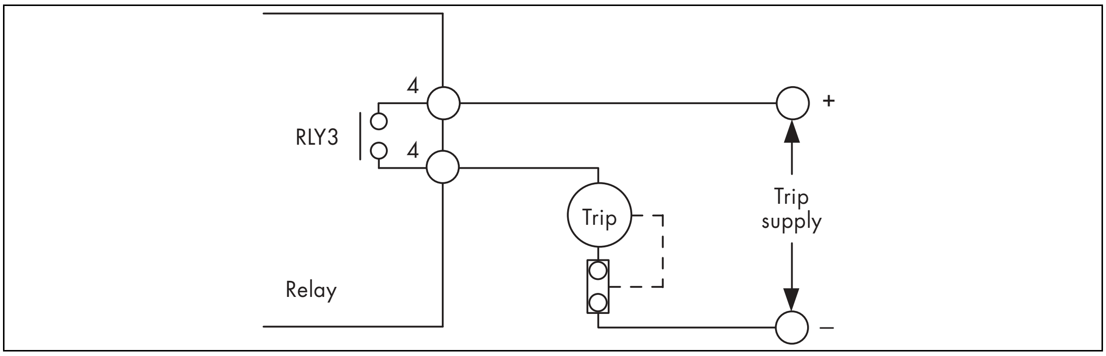


Figure 3-2: DC shunt trip arrangement

3.5.2 AC no-volt trip

For ac tripping it may be considered safer to opt for an no-volt trip release. Tripping from a make contact on the relay is still possible by using the circuit shown in Figure 3-3.

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-energised.

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

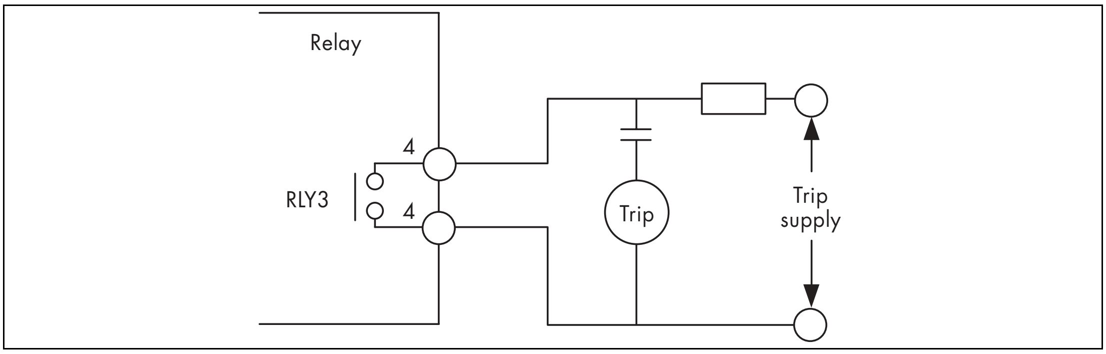


Figure 3-3: AC no volt trip arrangement

3.6 Serial communication port (K-BUS)

Connection to the K-BUS Port is by standard Midos 4mm screw terminals or push-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 3-4). 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/IEC870-5 converter box Type KITZ101/102 and suitable software to run on an IBM or compatible personal computer.

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.

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

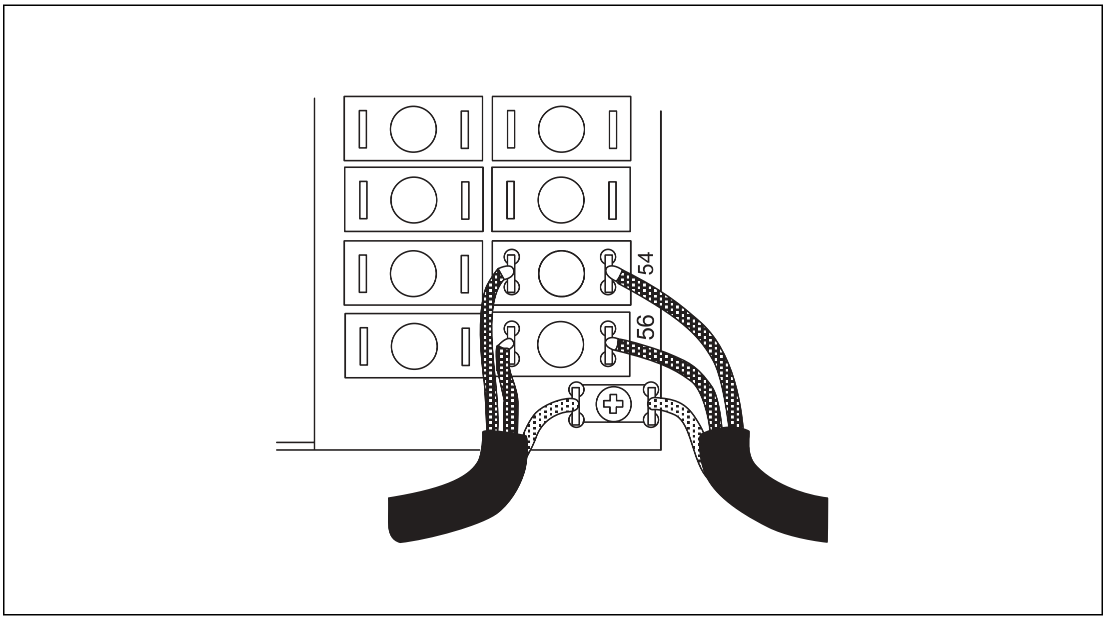


Figure 3-4: Termination arrangement for communications

4. USER INTERFACE

4.1 Front plate layout

The front plate of the relay carries an identification label at the top right hand 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 left hand corner which gives details of the auxiliary voltage Vx, reference voltage Vn and current ratings In (see Figure 4-1).

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

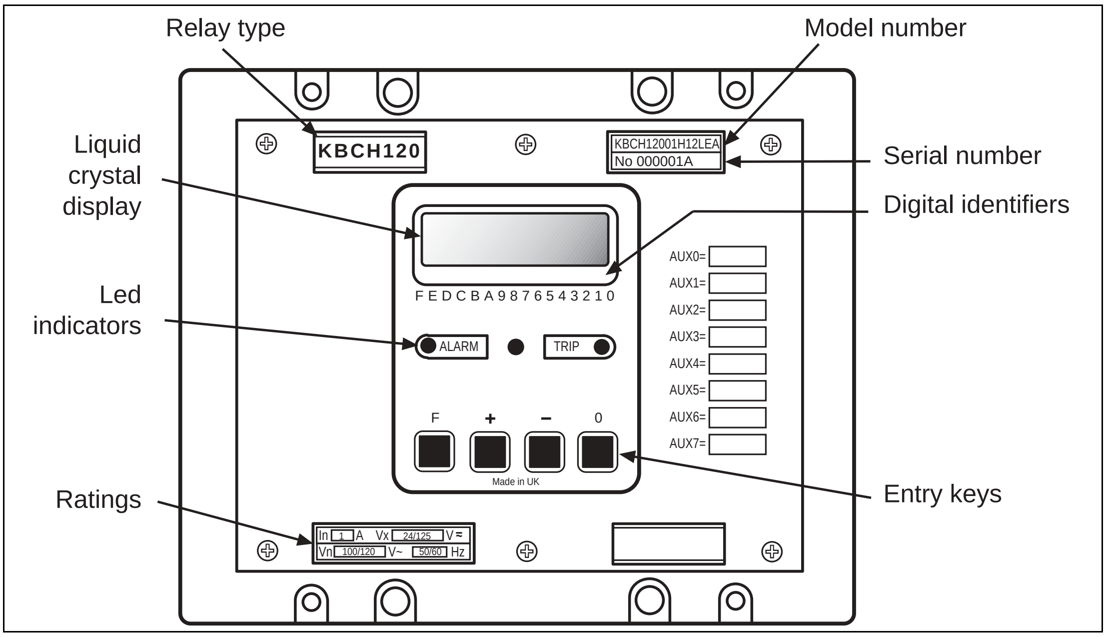


Figure 4-1: Front plate layout

4.2 LED indications

The three LEDs provide the following functions:

GREEN LED	Indicates the relay is powered up and running. It reflects the state of the watchdog relay.
YELLOW LED	Indicates alarm conditions that have been detected by the relay. These may be external alarms via the logic inputs or alarms detected 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. The trip flags give further information.

4.3 Keypad

Four keys on the front plate 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

4.4 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 front plate of the relay is momentarily pressed. This enables the display to be read in all conditions of ambient lighting.

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

5. 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 (see Figure 5-1).

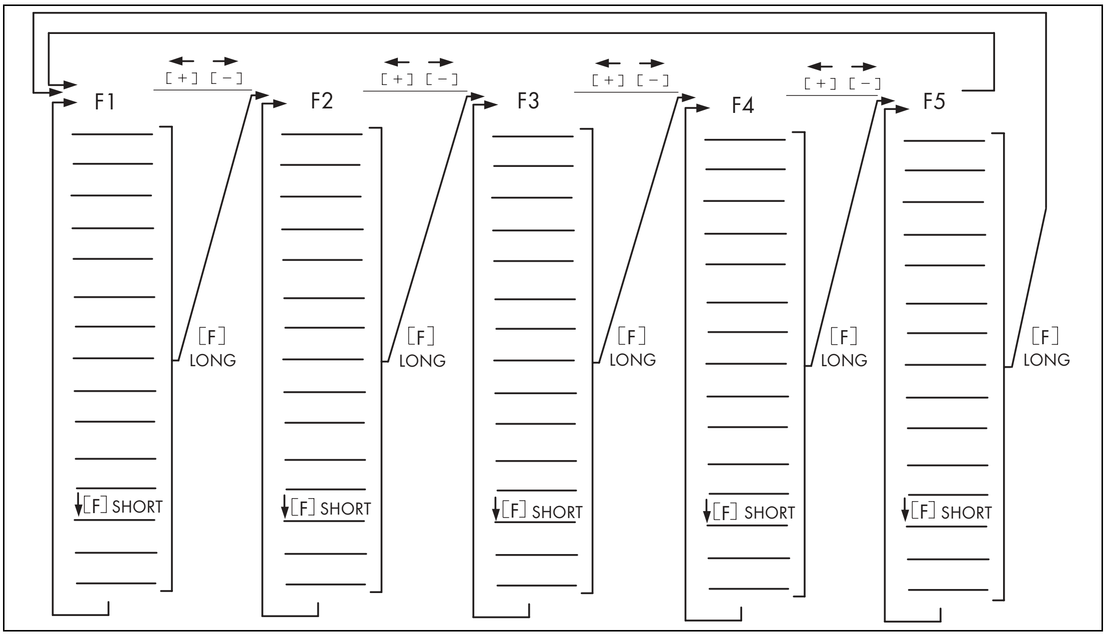


Figure 5-1: Menu system of relay

Four keys on the front plate 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 this Input (Overflux). The trip LED can be reset by holding down the reset key [0] for at least one second.

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). The currents measured during the last fault are also recorded on this page of the menu. To delete all fault records the next cell after

(Fn–4) must be selected. This cell will read "FLT Records Clear = [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 pre-set 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.

For instruction on how to change the various types of settings refer to Section 5.2.

5.1 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 KBCH120 relay would not display any settings related to the tertiary winding (LV2). 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 what values to set them to. 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 SETTINGS(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].

5.1.1 System data

0000 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 Rem Tap Ctrl]	1 = Enable remote control of tap changer
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]
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	Not used [READ]
000D SYS Ctrl Status	Not used [READ]
000E SYS Setting Grp	Setting group in use (1/2) [READ]
0011 SYS S/W Ref 1	Software reference number 1 [READ]
0012 SYS S/W Ref 2	Software reference number 2 [READ]
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]

The following notes describe each setting:

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 numbers 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.

0004 SYS Description [PWP]

This is text that describes the relay type, for example “2 Bias I/P + REF”. 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 front plate and should be quoted in any correspondence concerning the product.

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]

The plant status is not used in these relays.

000D SYS Control Status [READ]

The control status is not used in these relays.

000E SY 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).

0011 SYS S/W Ref 1 [READ]

The version of software for the microprocessor is coded into this number. It cannot be changed.

0012 SYS S/W Ref 2 [READ]

The version of software for the DSP is coded into this number. It cannot be changed.

0020 SYS Logic Stat

Current state of opto-isolated logic control inputs. Note this function is repeated in cell 0D01.

0021 SYS Relay Stat

Current state of relay outputs. Note this function is repeated in cell 0D02.

0022 SYS Alarms

Current state of alarm flags (see Section 5.2.11).

5.1.2 Fault records

01 00	FAULT RECORDS	[READ]
01 01	FLT Ia HV	Fault Current in HV winding A phase
01 02	FLT Ib HV	Fault Current in HV winding B phase
01 03	FLT Ic HV	Fault Current in HV winding C phase
01 05	FLT Ia LV1	Fault Current in LV1 winding A phase
01 06	FLT Ib LV1	Fault Current in LV1 winding B phase
01 07	FLT Ic LV1	Fault Current in LV1 winding C phase
01 09	FLT Ia LV2	Fault Current in LV2 winding A phase
01 0A	FLT Ib LV2	Fault Current in LV2 winding B phase
01 0B	FLT Ic LV2	Fault Current in LV2 winding C phase
01 0D	FLT Ia Diff	Fault Current in Differential circuit A phase
01 0E	FLT Ib Diff	Fault Current in Differential circuit B phase
01 0F	FLT Ic Diff	Fault Current in Differential circuit C phase
01 10	FLT Ia Bias	Fault Current in Bias circuit A phase
01 11	FLT Ib Bias	Fault Current in Bias circuit B phase
01 12	FLT Ic Bias	Fault Current in Bias circuit C phase
01 13	FnowGx	Current state of flags (not latched)
01 14	Fn-Gx	flags for last fault (n) [RESET trip led only]
01 15	Fn–1Gx	flags for previous fault (n–1) - previous fault
01 16	Fn–2Gx	flags for previous fault (n–2)
01 17	Fn–3Gx	flags for previous fault (n–3)
01 18	Fn–4Gx	flags for previous fault (n–4)
01 19	FLT Records Clear = [0]	Clear fault records [RESET]

5.1.3 Measurements(1)

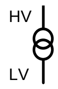
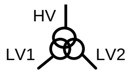
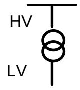
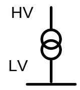
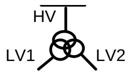
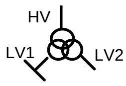
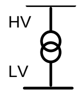
02 00	MEASUREMENTS(1)	[READ]
02 01	MS1 Ia HV	Current in HV winding A phase
02 02	MS1 Ib HV	Current in HV winding B phase
02 03	MS1 Ic HV	Current in HV winding C phase
02 05	MS1 Ia LV1	Current in LV1 winding A phase
02 06	MS1 Ib LV1	Current in LV1 winding B phase
02 07	MS1 Ic LV1	Current in LV1 winding C phase
02 09	MS1 Ia LV2	Current in LV2 winding A phase
02 0A	MS1 Ib LV2	Current in LV2 winding B phase
02 0B	MS1 Ic LV2	Current in LV2 winding C phase
02 0D	MS1 Ia Diff	Current in Differential circuit A phase
02 0E	MS1 Ib Diff	Current in Differential circuit B phase
02 0F	MS1 Ic Diff	Current in Differential circuit C phase
02 10	MS1 Ia Bias	Current in Bias circuit A phase

02 11	MS1 Ib Bias	Current in Bias circuit B phase
02 12	MS1 Ic Bias	Current in Bias circuit C phase
02 13	MS1 F	System frequency

5.1.4 Settings(1)

05 00	SETTINGS(1)	[SET]
05 01	S1 Fn. Links	Setting 1 function links [PWP]
	Link 1 [S1 Enable Id>]	1 = Enable low set
	Link 2 [S1 Enable Id>>]	1 = Enable high set
	Link 3 [S1 Enable Io> HV]	1 = Enable REF on HV winding
	Link 4 [S1 Enable Io> LV1]	1 = Enable REF on LV winding
	Link 5 [S1 Enable Io> LV2]	1 = Enable REF on Tertiary winding (not KBCH120)
	Link 7 [S1 Enable OF Trip]	1 = Enable Overflux Trip
	Link 8 [S1 Enable OF Alm]	1 = Enable Overflux Alarm
	Link 9 [S1 Enable OF Blk]	1 = Enable Overflux Block
05 02	S1 Configuration	See Note below [PWP]
05 03	S1 HV CT Ratio	HV side CT Ratio [PWP]
05 04	S1 LV1 CT Ratio	LV side CT Ratio [PWP]
05 05	S1 LV2 CT Ratio	LV2 side CT ratio (not KBCH120) [PWP]
05 06	S1 HV Ratio Cor	HV side CT correction ratio [PWP]
05 07	S1 HV VectorCor	HV Phase compensation [PWP]
05 08	S1 LV1 Ratio Cor	LV1 side CT correction ratio [PWP]
05 09	S1 LV1 VectorCor	LV1 Phase compensation [PWP]
05 0A	S1 LV2 Ratio Cor	LV2 side CT correction ratio (not KBCH120) [PWP]
05 0B	S1 LV2 VectorCor	LV2 Phase compensation (not KBCH120) [PWP]
05 0C	S1 Id>	Low set setting
05 0D	S1 Id>>	High set setting
05 0E	S1 Io> HV	REF setting HV winding
05 0F	S1 Io> LV1	REF setting LV winding
05 10	S1 Io> LV2	REF setting Tertiary winding (not KBCH120)
05 11	S1 Iof	5th harmonic Overflux setting
05 12	S1 tOF	5th harmonic Overflux detector time delay
05 15	S1 V/f(Trip)Char	Overflux Trip Characteristic
05 16	S1 V/f (Trip)	Setting for Overflux Trip
05 17	S1 tV/f (Trip)	Definite time setting for Overflux Trip
05 18	S1 V/f (Trip)TMS	Time multiplier for Overflux Trip
05 19	S1 V/f (Alarm)	Setting for Overflux Alarm
05 1A	S1 tV/f (Alarm)	Definite time setting for Overflux Alarm

Notes on Configuration setting:

Setting	No of Bias Inputs	Configuration	Applicable to
HV+LV	2 bias inputs		KBCH120/130/140
HV+LV1+LV2	3 bias inputs		KBCH130/140
HV(x2)+LV	3 bias inputs		KBCH130/140**
HV+LV(x2)	3 bias inputs		KBCH130/140
HV(x2)+LV1+LV2	4 bias inputs		Only KBCH140
HV+LV1(x2)+LV2	4 bias inputs		Only KBCH140**
HV(x2)+LV(x2)	4 bias inputs		Only KBCH140
** Not available in In = HV 1A/LV 5A versions of KBCH140			

Notes on VectorCor setting:

Setting	Action	Phase Shift
Yy0	Do nothing	0°
Yd1	$Ia = (IA - IC) / \sqrt{3}$ $Ib = (IB - IA) / \sqrt{3}$ $Ic = (IC - IB) / \sqrt{3}$	30° lag
Yd2	$Ia = (IA + IB)$ $Ib = (IB + IC)$ $Ic = (IC + IA)$	60° lag
Yd3	$Ia = (IB - IC) / \sqrt{3}$ $Ib = (IC - IA) / \sqrt{3}$ $Ic = (IA - IB) / \sqrt{3}$	90° lag
Yd4	$Ia = IB$ $Ib = IC$ $Ic = IA$	120°
Yd5	Yd11 and Invert	150° lag
Yy6	Invert currents	180° lag
Yd7	Yd1 and Invert	150° lead
Yd8	Yd2 and Invert	120° lead

Where Ia is the corrected current and IA is the uncorrected current

Setting	Action	Phase Shift	
Yd9	Yd3 and Invert	90° lead	
Yd10	Yd4 and Invert	60° lead	
Yd11	$Ia = (IA - IB) / \sqrt{3}$ $Ib = (IB - IC) / \sqrt{3}$ $Ic = (IC - IA) / \sqrt{3}$	30° lead	
Ydy0	$Ia = IA - (IA + IB + IC) / 3$ $Ib = IB - (IA + IB + IC) / 3$ $Ib = IC - (IA + IB + IC) / 3$	0°	Zero sequence trap
Ydy6	Ydy0 and Invert	180° lag	Zero sequence trap and invert

5.1.5 Settings(2)

06 00	SETTINGS(2)	[SET]
06 01	S1 Fn. Links	Setting 1 function links [PWP]
	Link 1 [S2 Enable Id>]	1 = Enable low set
	Link 2 [S2 Enable Id>>]	1 = Enable high set
	Link 3 [S2 Enable Io> HV]	1 = Enable REF on HV winding
	Link 4 [S2 Enable Io> LV1]	1 = Enable REF on LV winding
	Link 5 [S2 Enable Io> LV2]	1 = Enable REF on Tertiary winding (not KBCH120)
	Link 7 [S2 Enable OF Trip]	1 = Enable Overflux Trip
	Link 8 [S2 Enable OF Alm]	1 = Enable Overflux Alarm
	Link 9 [S2 Enable OF Blk]	1 = Enable Overflux Block
06 02	S2 Configuration	See Note above [PWP]
06 03	S2 HV CT Ratio	HV side CT Ratio [PWP]
06 04	S2 LV1 CT Ratio	LV side CT Ratio [PWP]
06 05	S2 LV2 CT Ratio	LV2 side CT ratio (not KBCH120) [PWP]
06 06	S2 HV Ratio Cor	HV side CT correction ratio [PWP]
06 07	S2 HV VectorCor	HV Phase compensation [PWP]
06 08	S2 LV1 Ratio Cor	LV1 side CT correction ratio [PWP]
06 09	S2 LV1 VectorCor	LV1 Phase compensation [PWP]
06 0A	S2 LV2 Ratio Cor	LV2 side CT correction ratio (not KBCH120) [PWP]
06 0B	S2 LV2 VectorCor	LV2 Phase compensation (not KBCH120) [PWP]
06 0C	S2 Id>	Low set setting
06 0D	S2 Id>>	High set setting
06 0E	S2 Io> HV	REF setting HV winding
06 0F	S2 Io> LV1	REF setting LV winding
06 10	S2 Io> LV2	REF setting Tertiary winding (notKBCH120)

06 11	S2 Iof	5th harmonic Overflux setting
06 12	21 tOF	5th harmonic Overflux detector time delay
06 15	S2 V/f(Trip)Char	Overflux Trip Characteristic
06 16	S2 V/f (Trip)	Setting for Overflux Trip
06 17	S2 tV/f (Trip)	Time multiplier for Overflux Trip
06 19	S2 V/f (Alarm)	Setting for Overflux Alarm
06 1A	S2 tV/f (Alarm)	Definite time setting for Overflux Alarm

Note: Settings 02 – 0B are common to both Settings groups 1 and 2 as they relate to the transformer and line current transformers.

5.1.6 Logic functions

09 00	LOGIC FUNCTIONS	[SET]
09 02	LOG tAUX0	Time delay associated with AUX0 output
09 03	LOG tAUX1	Time delay associated with AUX1 output
09 04	LOG tAUX2	Time delay associated with AUX2 output
09 05	LOG tAUX3	Time delay associated with AUX3 output
09 06	LOG tAUX4	Time delay associated with AUX4 output
09 07	LOG tAUX5	Time delay associated with AUX5 output
09 08	LOG tAUX6	Time delay associated with AUX6 output
09 09	LOG tAUX7	Time delay associated with AUX7 output
09 0A	LOG tTEST	Test Relay close pulse setting
09 0B	LOG tTapUp	Tap Changer Tap Up closure time
09 0C	LOG tTapDown	Tap Changer Tap Down closing time
09 0D	LOG Default Dsply	Selected default display

Default Display [SET]

0 =	AREVA K-SERIES MIDOS	
1 =	Description (or User Defined Scheme Reference)	
2 =	Plant Reference (User Defined)	
3 =	HV	Ia
	Ib	Ic
4 =	LV1	Ia
	Ib	Ic
5 =	LV2	Ia
	Ib	Ic
6 =	F(now)	

5.1.7 Input masks

0A 00	INPUT MASKS	[PWP]
0A 07	INP Blk V/f Trp	Input to Block Overflux Trip
0A 08	INP Blk V/f Alm	Input to Block Overflux Alarm
0A 09	INP Aux 0	Input to initiate tAUX0
0A 0A	INP Aux 1	Input to initiate tAUX1

0A 0B	INP Aux 2	Input to initiate tAUX2
0A 0C	INP Aux 3	Input to initiate tAUX3
0A 0D	INP Aux 4	Input to initiate tAUX4
0A 0E	INP Aux 5	Input to initiate tAUX5
0A 0F	INP Aux 6	Input to initiate tAUX6
0A 10	INP Aux 7	Input to initiate tAUX7
0A 11	INP Set Grp 2	Input to select setting group

5.1.8 Relay masks

0B 00	RELAY MASKS	[PWP]
0B 01	RLY Id>A	Relay to be operated by A Phase low set trip
0B 02	RLY Id>B	Relay to be operated by B Phase low set trip
0B 03	RLY Id>C	Relay to be operated by C Phase low set trip
0B 04	RLY Id>>A	Relay to be operated by A Phase high set trip
0B 05	RLY Id>>B	Relay to be operated by B Phase high set trip
0B 06	RLY Id>>C	Relay to be operated by C Phase high set trip
0B 07	RLY Io> HV	Relay to close for REF trip HV winding
0B 08	RLY Io> LV1	Relay to close for REF trip LV winding
0B 09	RLY Io> LV2	Relay to close for REF trip Tertiary winding (not KBCH120)
0B 0A	RLY Aux0	Relay to be operated by AUX 0 timer
0B 0B	RLY Aux1	Relay to be operated by AUX 1 timer
0B 0C	RLY Aux2	Relay to be operated by AUX 2 timer
0B 0D	RLY Aux3	Relay to be operated by AUX 3 timer
0B 0E	RLY Aux4	Relay to be operated by AUX 4 timer
0B 0F	RLY Aux5	Relay to be operated by AUX 5 timer
0B 10	RLY Aux6	Relay to be operated by AUX 6 timer
0B 11	RLY Aux7	Relay to be operated by AUX 7 timer
0B 12	RLY Tap Up	Relay to cause Tap Changer to Tap Up
0B 13	RLY Tap Down	Relay to cause Tap Changer to Tap Down
0B 15	RLY OF Alm	Relay to operate when any overflux condition is detected (based on 5th harmonic)
0B 16	RLY V/f Trip	Relay to operate for Overflux Trip(V/f)
0B 17	RLY V/f Alarm	Relay to operate for Overflux Alarm(V/f)

5.1.9 Recorder

0C 00	RECORDER	
0C 01	REC Control	RUNNING/TRIGGERED/STOPPED [SET]
0C 02	REC Capture	SAMPLES/MAGNITUDE/PHASE [SET]
0C 03	REC Post Trigger	Trace length after trigger [SET]
0C 04	REC Logic trig	Select logic input to trigger [SET]

0C 05	REC Relay trig	Select relay output to trigger [SET]

5.1.10 Test/Control

0D 00	TEST/CONTROL	
0D 01	TST Logic Stat	State of control inputs [READ]
0D 02	TST Relay Stat	State of relay outputs [READ]
0D 03	Select Relays To Test	Relay to operate for trip test [SET]
0D 04	Test Relays = [0]	Facility to test relays using Relay Test mask [SET]
0D 05	TST Tap Control	Tap Changer Control No Operation/Tap Up/Tap Down [SET]

5.2 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.

5.2.1 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 the PASSWORD cell and pressing the [0] key for more than one second.

5.2.2 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 5.2.1. 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.

5.2.3 Entering text

Enter the setting mode as described in Section 5.2 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 5.2 to exit from the setting change.

5.2.4 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 the 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 front plate 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.

5.2.5 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 5.2 to exit from the setting change.

Note: When entering CT RATIO the overall ratio should be entered, i.e. 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 x 5 = 2000A.

5.2.6 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 5.2 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.

5.2.7 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 front plate 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.

5.2.8 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 front plate 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.

5.2.9 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.

5.2.10 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 5.2.9 will also reset the TRIP LED indication. Set function link SD5 to "1" for automatic reset of trip led.

5.2.11 Alarm records

The alarm flags are towards the end of the SYSTEM DATA column of the menu and consist of seven 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.

Alarm Flags							Indication	
6	5	4	3	2	1	0		
						1	Unconfig	protection not operational – needs to be configured
					1		Uncalib	protection is running uncalibrated – calibration error
				1			Setting	protection is running – possible setting error
			1				No Service	protection is out of service
		1					No Opto	protection not sampling opto inputs
	1						No S/Logic	Protection not operational – scheme logic not running
1							DSP Faulty	Protection not operational – Fault detected in DSP

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 keypad if the "Unconfigured" alarm is raised because the relay will be locked in a non-operate state.

5.2.12 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 5.1.6

LOGIC FUNCTIONS location LOG Default Display by following the setting procedure given in Section 5.2.5. The display can be returned to the default value, without waiting for the 15 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 must be reset, as described in Section 5.2.10, before the relay returns to the selected default display.

5.3 Disturbance recorders

The disturbance recorder may be triggered by several different methods dependent on the settings in this 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.

5.3.1 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 left-hand 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].

5.3.2 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.

Note: If the disturbance recorder is set to SAMPLES mode the bias currents will indicate zero. This is due to the bias current being calculated from the sample data.

5.3.3 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 increment of 5 between 5 and 505 samples. When recording samples the total trace duration is 510/40 = 12 cycles because the interval between the samples is equivalent to one fortieth of a cycle. However, the Fourier derived values are calculated eight times per cycle and so the total trace length when recording these calculated phase or amplitude values is 510/8 = 63 cycles.

5.3.4 Recorder logic trigger

Any, or all, of the opto-isolated inputs may be used as the stop trigger and the trigger may be taken from either the energisation or the de-energisation 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 5.2.4. 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 energisation and a – will indicate the trigger will occur for de-energisation.

5.3.5 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 energisation or the de-energisation 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 output relay and a "0" will deselect it.

The selection is made using the instructions for setting links in Section 5.2.4. 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 energisation and a – will indicate the trigger will occur for de-energisation.

5.3.6 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 ± 2.5ms at 50Hz (10.4 ± 2.1ms at 60Hz) after the opto-input was energised. The time recorded for the output relays is the time at which the coil of the relay was energised 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 1μs for the samples values.

6. SELECTIVE 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 6-1.

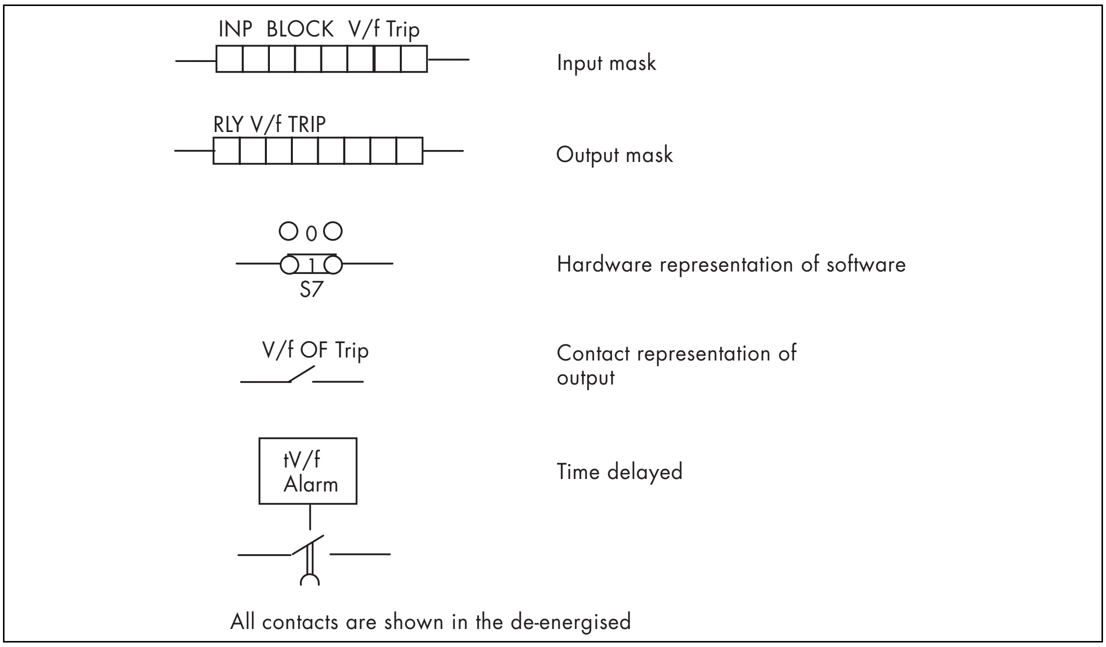


Figure 6-1: Key to symbols used in logic diagrams

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 "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 nput 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 6-2 shows by example how the input and output masks may be used.

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.

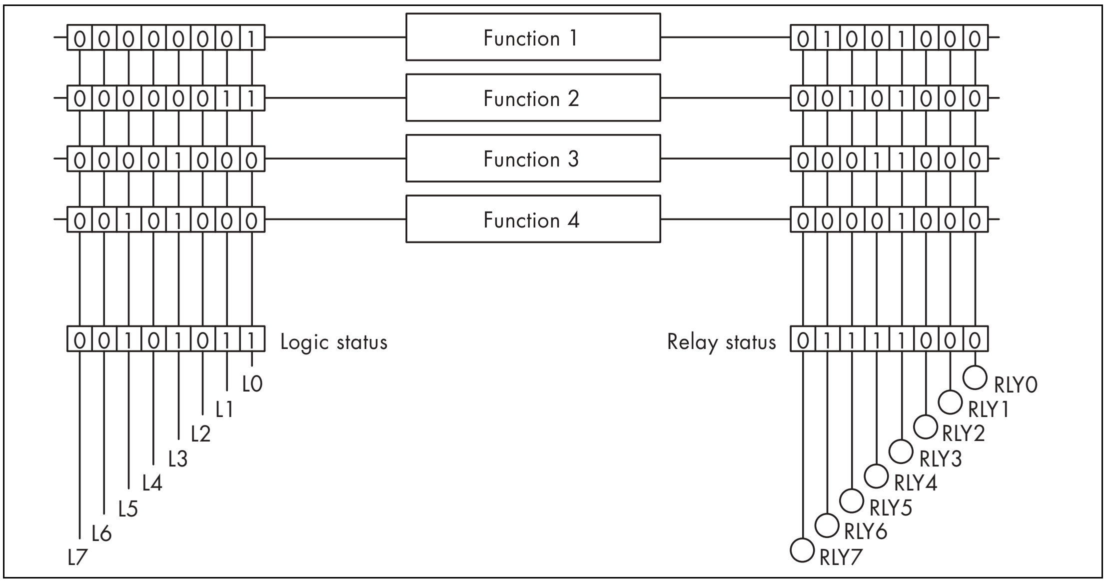


Figure 6-2: Operation of input/output masks

6.1 Biased differential trip logic

The biased differential trip logic is shown in Figure 6-3. If selected by link S1 the output from the differential algorithm Id> sets a latch. The output of the latch is directed to the [Trip Id>] mask. This will result in the output relay(s) designated by the mask being energised. The t100ms timer ensures a minimum dwell time of 100ms.

Operation of the magnetising inrush detector blocks the differential algorithm (integral part of algorithm).

Operation of any 5th harmonic overflux detector, 5th Harmonic, enabled by function link S9 block its own phase differential algorithm (integral part of algorithm).

In addition the 5th harmonic overflux signal starts a timer tOF, the output of which is directed to a [OF Alarm] mask to indicate an overflux condition exists.

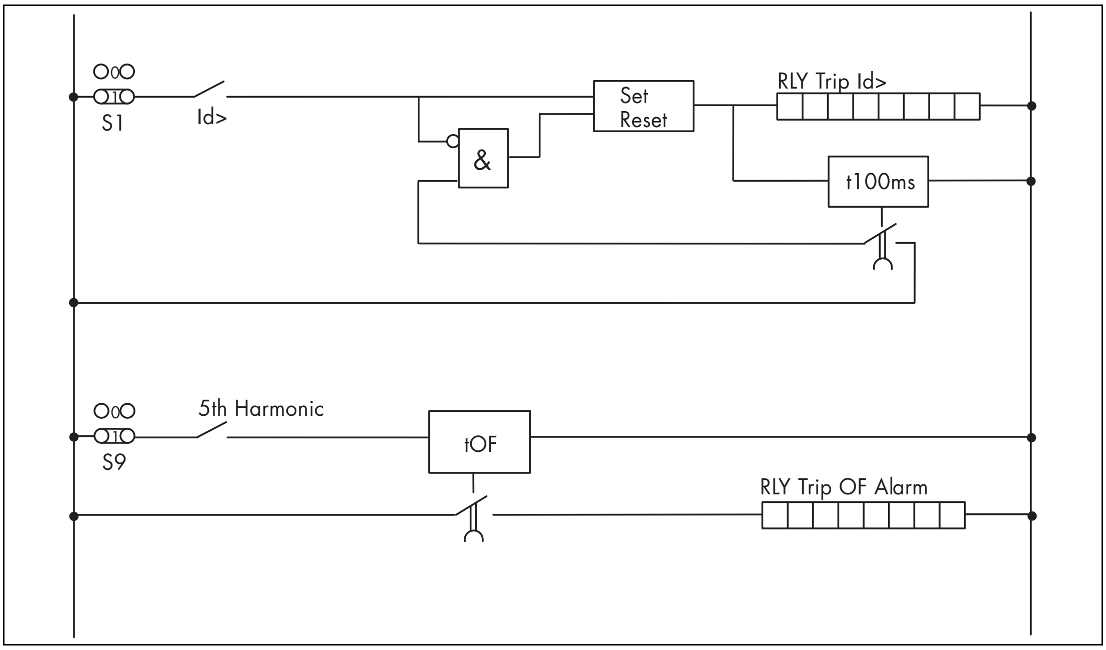


Figure 6-3: Differential low set trip logic

6.2 Differential high set trip logic

The differential high set trip logic is shown in Figure 6-4. If selected by link S2 the output from the differential algorithm Id>> sets a latch. The output of the latch is directed to the [Trip Id>>] mask. This will result in the output relay(s) designated by the mask being energised. The t100ms timer ensures a minimum dwell time of 100ms. The high set is not restrained by the magnetising inrush or over excitation detectors.

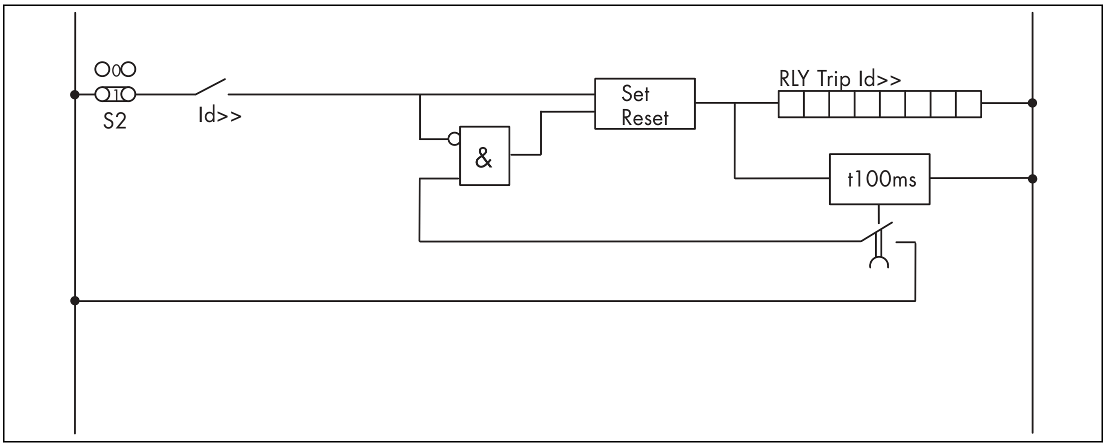


Figure 6-4: Differential high set trip logic

6.3 Restricted earth fault trip logic

The restricted earth fault (REF) trip logic is shown in Figure 6-5. The REF for the HV, LV1 and LV2 windings are enabled by function links S3, S4 and S5 respectively and the outputs are directed to [Trip Io> HV], [Trip Io> LV1] and [Trip Io> LV2] output masks respectively. The t100ms timer ensures a minimum dwell time of 100ms.

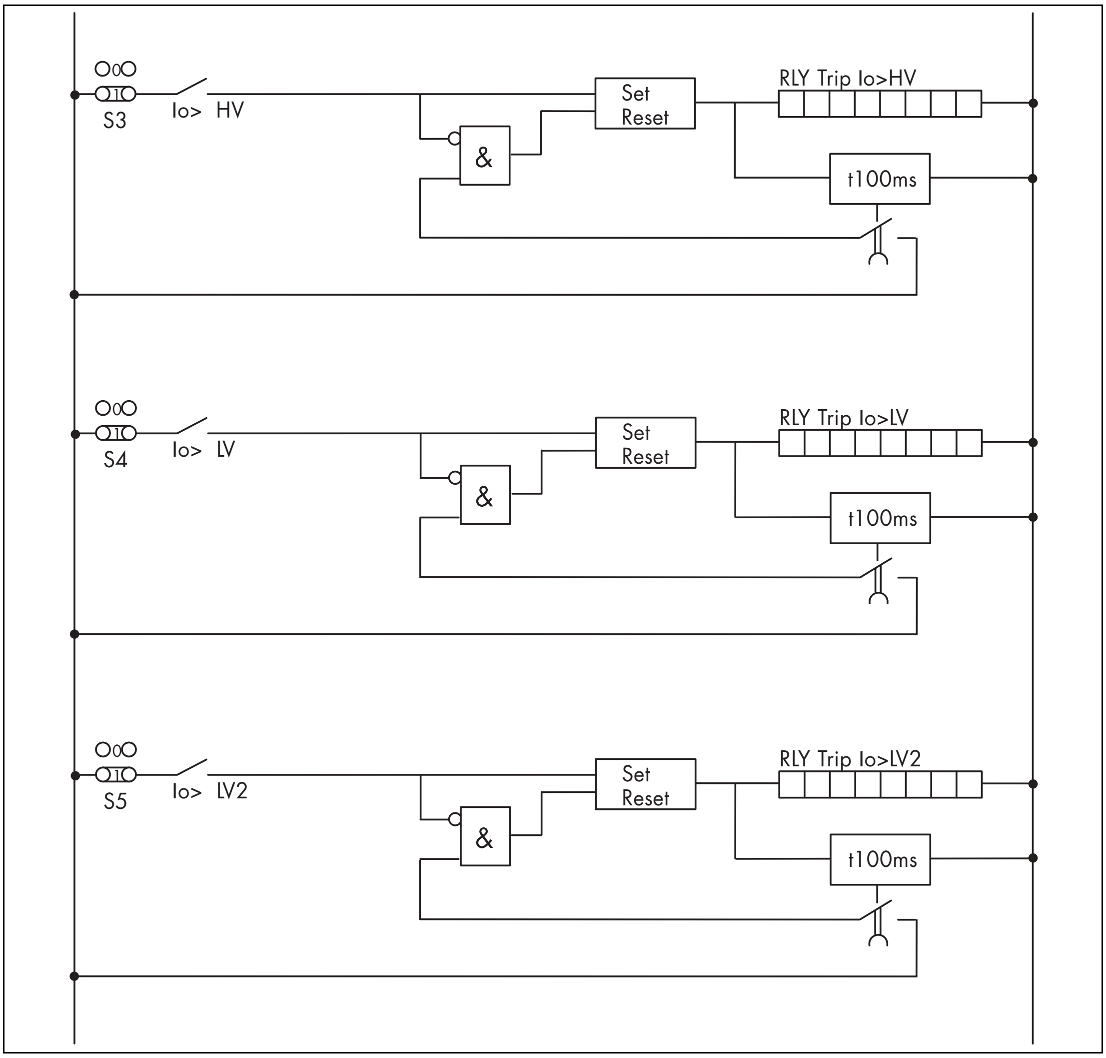


Figure 6-5: REF trip logic

6.4 Overflux trip logic

The overflux trip logic is shown in Figure 6-6. The overflux trip and alarm characteristics operate using the V/f principle and are enabled by function links S7 and S8 respectively and the outputs directed to [V/f Trip] and [V/f Alarm] output masks respectively. The algorithms can be individually blocked by energising the appropriate control input.

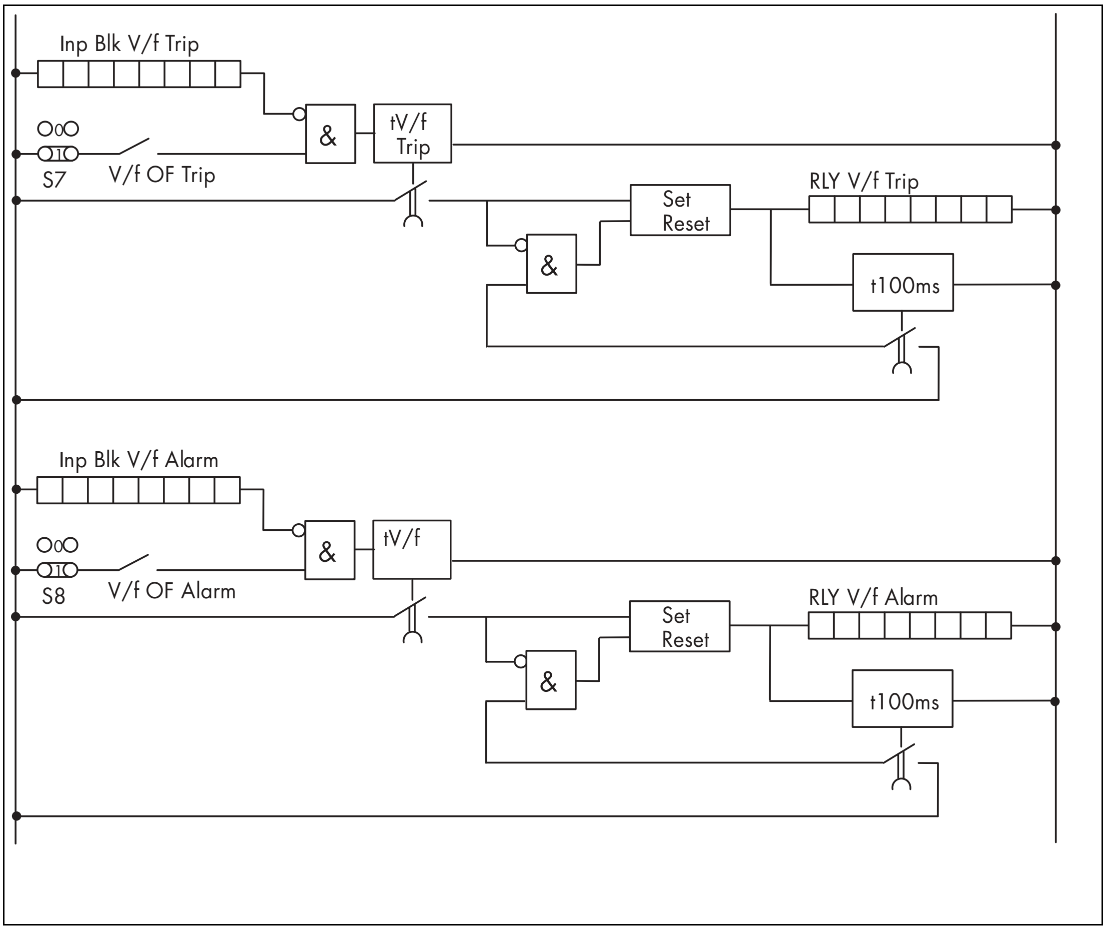


Figure 6-6: Overflux trip & alarm logic

6.5 Auxiliary timers

Figure 6-7 shows eight 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.

These inputs could be used for either tripping or alarm purposes following operation of external protection for example a Buchholz relay or a Temperature relay. In this way the operation of the Buchholz and/or Temperature relay is recorded and time tagged and is then available over the serial communications link.

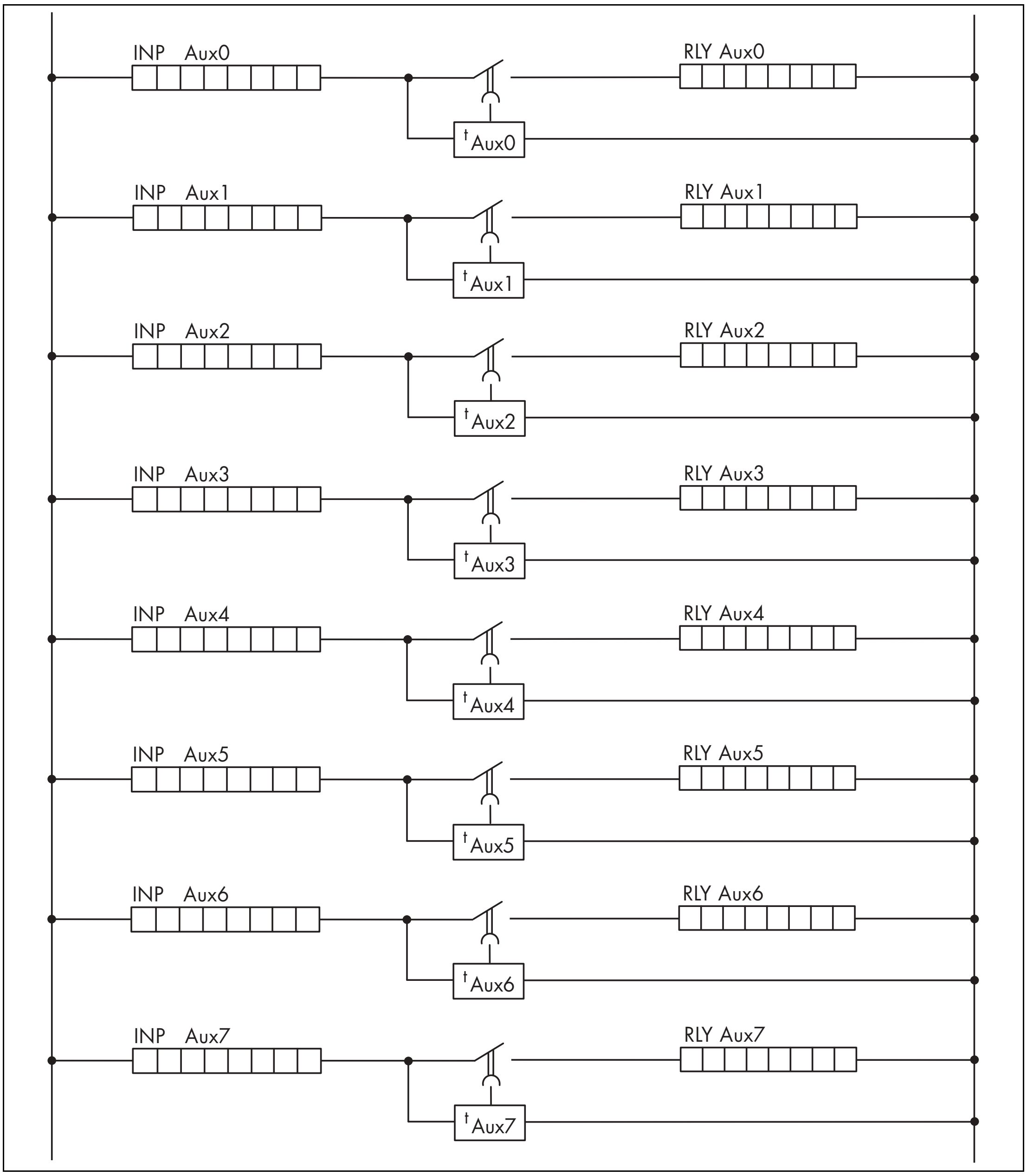


Figure 6-7: Auxiliary time delays

6.6 Change of setting group control

Figure 6-8 shows that 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 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.

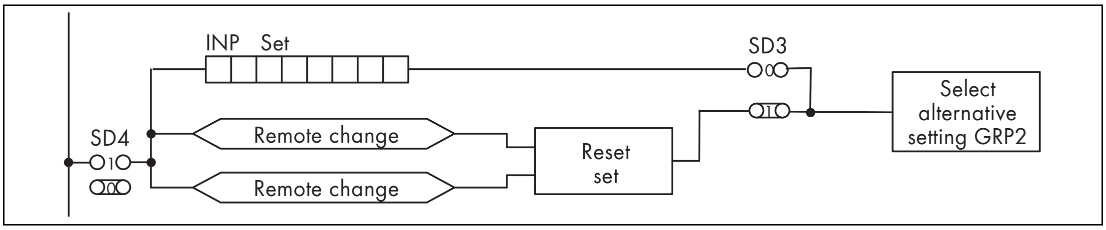


Figure 6-8: Change setting group control logic

6.6.1 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 RECORDS of default display if selected. The setting group remains as selected when the auxiliary supply is interrupted.

6.6.2 Local control of setting group

Local control is asserted via the input mask [INP Set Grp2] and the control input that is set in this mask. The relay will respond to the group 2 settings whilst this input is energised and the setting group 1 when it is de-energised.

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.

6.7 Manual tap changer control

The transformer tap changer can be instructed to raise or lower a tap via commands over the serial communications link or locally via the menu system. Two relay masks [Tap Up] and [Tap Down] are provided for this purpose. On receiving the request to change taps the appropriate relay is operated for a time given by the appropriate setting as shown in Figure 6-9.

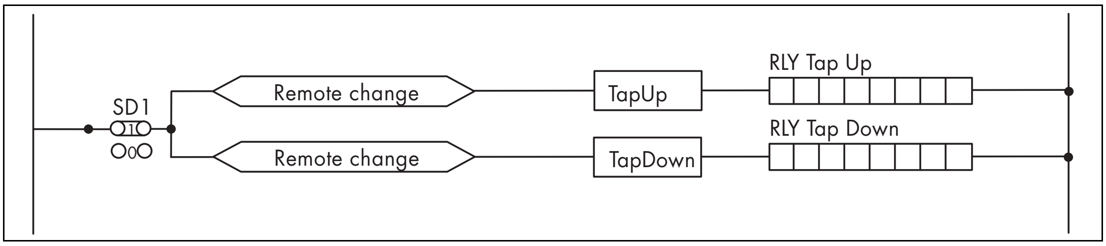


Figure 6-9: Remote control of transformer tap changer

6.8 Trip test facility

As shown in Figure 6-10 a relay test facility allows each output relay to be operated via the menu either individually or in groups as determined by the [RELAY TEST] mask. The timer ensures there is a minimum closure time.

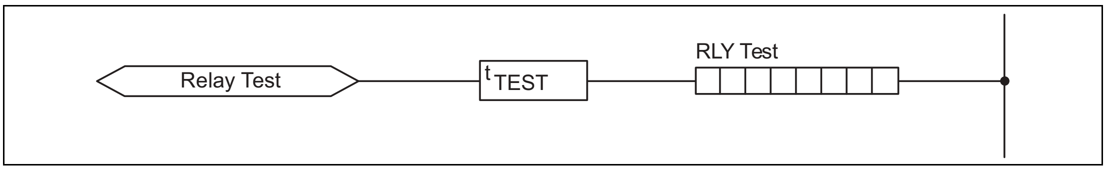


Figure 6-10: Trip test facility

6.9 Trip and external alarm flag logic

Not all protection functions will be used for tripping purposes; some may be used for control or alarm. The trip flag latching has been made programmable so that it can be set to suit the application. Figure 6-11 shows that the trip LED and the trip flags are latched for operation of relays RLY3 and/or RLY7.

To ensure correct flagging RLY3 and RLY7 should not be used for alarm or control functions.

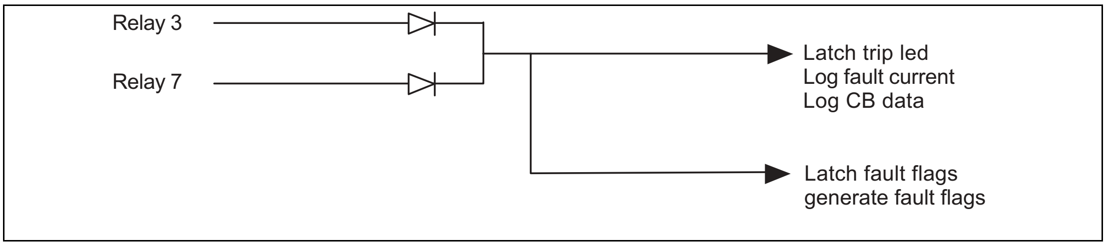


Figure 6-11: Trip and flag logic

The status of external protection routed to the relay via the logic inputs and auxiliary timers may not be required to trip the circuit breakers. In this case RLY3 or RLY7 would not be selected in the auxiliary timer output masks and the trip flag logic just described would not operate. In this case the output from the auxiliary timers is displayed on an additional “External Alarms” display which replaces the default display. The Alarm LED and the flags are latched but are not stored in non volatile memory nor do they effect the fault records. Event records are however generated.

6.10 Trip and external alarm flag display format

Trip display	External alarm displays
Fn-GxA**B**C**F AUXO1234567Io123	External alarms AUXO1234567
FEDCBA9876543210	FEDCBA9876543210

Fnow	=	Current state of flags (not latched)
Fn	=	Flags for last fault
Fn–1	=	Flags for previous fault
Fn–2	=	Flags for previous fault
Fn–3	=	Flags for previous fault
Fn–4	=	Flags for previous fault
Gx x	=	Setting group number
A*	=	Differential Trip on A Phase
A–*	=	High Set Trip on A Phase
A**	=	Differential + High Set Trip on A Phase
F	=	Overflux Trip
AUX 0	=	Auxiliary 0
AUX 1	=	Auxiliary 1
AUX 2	=	Auxiliary 2
AUX 3	=	Auxiliary 3
AUX 4	=	Auxiliary 4
AUX 5	=	Auxiliary 5
AUX 6	=	Auxiliary 6
AUX 7	=	Auxiliary 7
Io 1	=	REF Trip – HV Winding
Io 2	=	REF Trip – LV Winding
Io 3	=	REF Trip – Tertiary Winding (LV2)

7. 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.

7.1 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.

7.2 Initial factory applied settings

7.2.1 Initial protection settings

As received the relay will be configured with all protection elements enabled.

The second setting group will be inhibited and its settings will not appear in the menu. The settings for both setting groups will be set the same as follows:

Fn Links 0110111110

Configuration HV+LV1+LV2 (HV+LV on KBCH120)

HV CT ratio	1:1
LV1 CT ratio	1:1
LV2 CT ratio	1:1
HV Ratio Cor	1.0
HV VectorCor	Yy0 (0 deg)
LV1 Ratio Cor	1.0
LV1 VectorCor	Yy0 (0 deg)
LV2 Ratio Cor	1.0
LV2 VectorCor	Yy0 (0 deg)
Id>	0.2PU
Id>>	10PU
Io>HV	0.1PU
Io> LV1	0.1PU
Io> LV2	0.1PU
Iof	50%
tOF	10s
V/f Trip Char	IDMT
V/f Trip	2.42 V/Hz
V/f (Trip)TMS	1
V/f Alarm	2.31 V/Hz
tV/f (Alarm)	10s

7.2.2 Initial control settings

SYS Fn Links 10001011

Automatic reset of the flags and change of setting group will be inhibited and must be 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 password when the relay leaves the factory will be AAAA.

The disturbance recorder will be set to not automatically reset on restoration of the supply and will be triggered by operation of the trip relays (RLY3 or RLY7).

7.2.3 Initial time delay settings

tAUX0	=	1.0s	tAUX4	=	1.0s
tAUX1	=	1.0s	tAUX5	=	1.0s
tAUX2	=	1.0s	tAUX6	=	1.0s
tAUX3	=	1.0s	tAUX7	=	1.0s
tTEST	=	2.0s	tTapUp	=	1.0s
tTapDown	=	1.0s			

7.2.4 Initial allocation of opto-isolated control inputs

L0 Initiate auxiliary timer 0

L1 Initiate auxiliary timer 1

L2 Initiate auxiliary timer 2

L3 Initiate auxiliary timer 3

L4 Initiate auxiliary timer 4

L5 Initiate auxiliary timer 5

L6 Initiate auxiliary timer 6

L7 Initiate auxiliary timer 7

7.2.5 Initial allocation of output relays

RLY0 Trip (Id>A, B, C, Id>>A, B, C, Io>HV, LV1, LV2, V/f Trip)

RLY1 Trip (Id>A, B, C, Id>>A, B, C, Io>HV, LV1, LV2, V/f Trip)

RLY2 Trip (Id>A, B, C, Id>>A, B, C, Io>HV, LV1, LV2, V/f Trip)

RLY3 Trip (Id>A, B, C, Id>>A, B, C, Io>HV, LV1, LV2, V/f Trip)

RLY4 Tap Up

RLY5 Tap Down

RLY6 V/f Alarm

RLY7 Trip (Id>A, B, C, Id>>A, B, C, Io>HV, LV1, LV2, V/f Trip)

7.3 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, practice 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 6, 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.

7.4 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 and enter any changes.

4. The Description will state the main functions, for example " Bias I/P + REF" 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 5.2.6.

7. Moving to the SETTINGS column of the menu, the function links are first selected. Any protection not required is disabled by setting the appropriate bit t0. This will remove the unrequired settings from the menu.

8. The CT ratios for each winding, may be entered if it is required to display the line currents in primary values of current. Otherwise these ratios should be set at 1:1 when the measured values will be displayed in the secondary quantities applied to the relay terminals.

9. Next, select the configuration appropriate to the transformer being protected. Again unrequired settings will be removed from the menu.

10. Next, the setting related to the vector group compensation and CT ratio mismatch for each winding can be entered.

11. The protection settings can now be entered. (Note these do not require the password to be entered first)

12. The timers in the LOGIC column of the menu should now be set to the required times.

13. The input and output masks are then set. Section 6.9 gives some important notes on the allocation of output relays.

14. Finally the password protection should be established. This will occur automatically fifteen 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.

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 such as "Protection Access Software and Toolkit" from AREVA T&D.

8. TECHNICAL DATA

8.1 Ratings

8.1.1 Inputs

Reference Current (In)

Nominal Rating	Continuous	3s	1s
In = 1A	3In	30In	100A
In = 5A	3In	30In	400A

Reference Voltage (Vn)

Nominal Rating	Nominal Range	Continuous Rating
Vn = 100/120V	0 – 140V phase/phase	180V phase/phase

Auxiliary Voltage (Vx)

Nominal Rating	Operative Range		Absolute
	DC Supply	AC 50/60Hz	Maximum
24 – 125V ac/dc	20 – 150V	50 – 133V	190V crest
48 – 250V ac/dc	33 – 300V	87 – 265V	380V crest

Frequency (Fn)

Nominal Rating	Tracking Range
50 Hz or 60 Hz	13 – 65Hz

Opto-Isolated Inputs Supply

Nominal Rating	Reference Range
50V dc only	25 – 60V dc only

8.1.2 Outputs

Field Voltage 48V dc (Current limited to 60mA)

8.2 Burdens

8.2.1 Bias current circuit

In = 1A	<0.045VA {at rated current
In = 5A	<0.22VA {

8.2.2 REF current circuit

In = 1A	<0.085VA {at rated current
In = 5A	<0.24VA {
	(excludes stabilising resistor)

8.2.3 Voltage circuit

Vn = 100/120V <0.002 VA at 110V

8.2.4 Auxiliary voltage

Auxiliary Supply	Low Voltage Version	High Voltage Version
DC supply	4.8 – 8.0W	4.8 – 12.0W
AC supply	6.7 – 12.0VA	7.0 – 21.0VA

The burden depends upon the power supply rating, the applied voltage, the number of inputs and outputs energised and the status of the backlight.

8.2.5 Opto-isolated inputs

DC supply 0.25W per input (50V 10k½)

8.3 Setting ranges

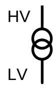
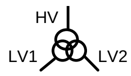
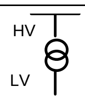
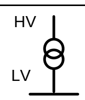
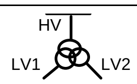
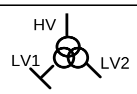
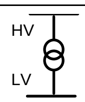
8.3.1 Transformer configuration

External CT ratio

HV CT ratio }		{steps of 0.001 to 10
LV1 CT ratio }	1:1 to 9999:1	{steps of 0.01 to 100
LV2 CT ratio }		{steps of 0.1 to 1000
		{steps of 1 to 9999

Transformer configuration.

The following list shows the options:-

Setting	No of Bias Inputs	Configuration	Applicable to
HV+LV	2 bias inputs		KBCH120/130/140
HV+LV1+LV2	3 bias inputs		KBCH130/140
HV(x2)+LV	3 bias inputs		KBCH130/140**
HV+LV(x2)	3 bias inputs		KBCH130/140
HV(x2)+LV1+LV2	4 bias inputs		Only KBCH140
HV+LV1(x2)+LV2	4 bias inputs		Only KBCH140**
HV(x2)+LV(x2)	4 bias inputs		Only KBCH140
**Note: Not available on In = 1A/LV 5A versions of KBCH 140			

CT ratio mismatch correction

HV Ratio Cor }

LV1 Ratio Cor } 0.05 to 2 in steps of 0.01

LV2 Ratio Cor }

Phase compensation correction

HV VectorCor	}	Yy0 (0deg), Yd1 (–30deg), Yd2 (–60deg), Yd3 (–90deg),
LV1 VectorCor	}	Yd4 (–120deg), Yd5 (–150deg), Yy6 (+180deg),
LV2 VectorCor	}	Yd7 (+150deg), Yd8 (+120deg), Yd9 (+90deg),
	}	Yd10 (+60deg), Yd11 (+30deg),
	}	Ydy0 (0deg), Ydy6 (+180deg).

8.3.2 Protection settings

Differential Protection settings

Protection settings	Setting range	Step size
Id>	0.1 to 0.5PU	0.1
Id>>	5 to 20PU	0.5
Iof	10 to 50%	5
tOF	0.1s to 14.4ks (4 Hours)	0.01

REF Protection settings

Io> HV	}	
Io> LV1	}0.05 to 1.0PU	0.005
Io> LV2	}	

Overflux Protection settings

V/f (Trip)Char	DT, IDMT	
V/f (Trip)	1.5 to 3 V/Hz	0.01
tV/f (Trip)	0.1 to 60s	0.1 (DT selected)
V/f (Trip)TMS	1 to 63	1 (IDMT selected)
V/f (Alarm)	1.5 to 3 V/Hz	0.01
tV/f (Alarm)	0.1 to 60s	0.1

8.3.3 Auxiliary timers

Auxiliary timers		Setting range	Step size	
tAUX0	}		{	
tAUX1	}		{	
tAUX2	}		{0.01 to	100s
tAUX3	}	0 to 14.4ks(4 Hours)	{ 0.1 to	1000s
tAUX4	}		{ 1 to	10,000s
tAUX5	}		{ 10 to	14,400s
tAUX6	}		{	
tAUX7	}		{	

tTEST	0.5 to 10s	0.1
tTapUp	0.5 to 10s	0.1
tTapDown	0.5 to 10s	0.1

8.4 Operating times

Element	Operating time	Disengagement time
I d>	typically 30 to 35ms	typically <50ms**
Id>>	typically 15ms	typically <30ms**
Io>	typically 20 to 40ms	typically <25ms**
V/f	–	typically <30ms**

**Note: A minimum contact dwell time of 100ms is incorporated on the protection trip functions, such that if a fault condition is removed within the 100ms then the disengagement times will be extended by the dwell.

8.5 Accuracy

The accuracy under reference conditions is 7.5%.

8.6 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
Maximum series lead resistance	5kΩ (2 optos in parallel)
Maximum ac induced loop voltage	50Vrms (thermal limit)
Maximum capacitance coupled ac voltage	<250Vrms via 0.1μF

8.7 Contacts

Output relays	Eight single make
Make:	30A and carry for 0.2s
Carry:	5A continuous
Break:	DC: 50W resistive
	25W inductive
	(L/R) = 0.04s
	AC: 1250VA (5A maximum)
	Subject to maxima of 5A and 300V
Watchdog relays	One make and one break
Make:	10A and carry for 0.2s
Carry:	5A continuous
Break:	DC: 30W resistive

15W inductive

(L/R) = 0.04s

AC: 1250VA (5A maximum)

Subject to maxima of 5A and 300V

8.8 Operation indicator

3 Light Emitting Diodes - internally powered.

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

8.9 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)

8.10 Current transformer requirements

See Application section for details

8.11 REF requirements

See Application section for details

8.12 High voltage withstand

8.12.1 Dielectric withstand IEC 255-5: 1977

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

2.0kVrms for one minute between all 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 watch-dog relay.

8.12.2 Impulse IEC 255-5: 1977

5kV peak, 1.2/50μs, 0.5J between

(i) all terminals connected together and case earth

(ii) independent circuits

(iii) terminals of the same circuit (except output contacts)

8.12.3 Insulation resistance IEC 255-5: 1977

The insulation resistance is greater than 100MΩ

8.13 Electrical environmental

8.13.1 DC supply interruptions IEC 255-11: 1979

The relay can withstand a 10ms interruption in the auxiliary voltage with up to 4 inputs energised.

The relay can withstand a 10ms interruption in the auxiliary voltage with 2 inputs and 2 outputs energised at battery (auxiliary) voltages of not less than 48V.

8.13.2 High frequency disturbance IEC 255-22-1: 1988

The relay complies with Class III, 1MHz bursts decaying to 50% of peak value after 3 to 6 cycles, repetition rate 400/second

(i) 2.5kV between independent circuits connected together and case earth

(ii) 2.5kV between independent circuits

(iii) 1kV between terminals of the same circuit (except output contacts)

8.13.3 Fast transient IEC 255-22-4: 1992

Class IV (4kV, 2.5kHz) - applied directly to all inputs.

- applied via a capacitive clamp to the K-Bus port.

8.13.4 Electrostatic discharge IEC 255-22-2:1989 & IEC 801-2: 1991

Class III (8kV) - discharge in air with cover in place

Class III (8kV) - discharge in air with cover removed

Level 2 (4kV) - point contact discharge with cover removed

8.13.5 Conducted emissions EN 55011: 1991

Group 1 class A limits.

Frequency range (MHz)	Limits of conducted Interference	
	Quasi-Peak (dBμV)	Average (dBμV)
0.15 to 0.50	79	66
0.50 to 30	73	60

The lower limit shall apply at the transition frequency.

8.13.6 Radiated emissions EN 5501: 1991

Alternatively EN 55022: 1994

Group 1 Class A limits.

Frequency range (MHz)	Limits of Radiated Interference Field Strength
	Quasi-Peak (dBμV/m) at 30m *
30 to 230	30
230 to 1000	37

The lower limit shall apply at the transition frequency.

* For measurements made at 10m the limits are increased by 10dB.

8.13.7 Radiated immunity IEC 255-22 -3:1989 & IEC 801-3:1984

Reference document is EN 50082-2:1995 Immunity Standard for Industrial Environments.

Frequency	Level/Class	Modulation
20 to 1000MHz*	10V/m, Class III	1kHz, 80% AM
1.7 to 1.9GHz#	10V/m	Keyed Carrier 50% duty cycle, 200Hz prf.

* Note extended frequency range.

Additional range for digital mobile phones.

Additional spot frequency checks at 27MHz, 86MHz, 100MHz, 170MHz, 460MHz, and 934MHz.

8.13.8 Conducted immunity ENV 50141:1993 & IEC801-6

Frequency	Level/Class	Modulation
0.15 to 80MHz	10Vrms, Level 3	1kHz, 80% AM

Additional spot frequency checks at 200kHz, 1MHz, 8MHz and 20MHz.

8.13.9 EMC Compliance

Compliance to the European Commission Directive 89/336/EEC on EMC is claimed via the Technical Construction File route.

Generic Standards EN 50081-2:1994 and EN 50082-2:1995 were used to establish conformity.

8.13.10 Power frequency interference

EA PAP Document, Environmental Test Requirements for Protection relays and Systems Issue I, Draft 4.2.1 1995.

500 V a.c. common mode, 250 V a.c. differential mode, via 0.1μF for 2s applied to all inputs except those for which 50Hz input is normal.

Class 3, 50mV, 0.1% unbalance applied to all communication circuits.

8.14 IEEE/ANSI specifications

8.14.1 IEEE Surge Withstand Capacity (SWC)

ANSI C37.90.1 - 1990: (Reaff 1994)

4 - 5kV fast transient and 2.5kV oscillatory. Applied directly to each input and earth.

Applied directly across the auxiliary power supply, opto isolated input and each output contact.

8.14.2 IEEE Radiated immunity

ANSI C37.90.2 - 1995

25 - 1000MHz, zero and 100% square wave modulated. Field strength 35V/m.

8.15 Atmospheric environmental

8.15.1 Temperature IEC 68-2-1/IEC 68-2-2: 1974

Storage and transit –25°C to +70°C

Operating –25°C to +55°C

8.15.2 Humidity IEC 68-2-3: 1969

56 days at 93% relative humidity and 40°C

8.15.3 Enclosure protection IEC 529: 1989

IP50 (Dust protected)

8.16 Mechanical environmental

8.16.1 Vibration IEC 255-21-1: 1988

Vibration Response Class 2

1g between 10Hz and 150Hz

Vibration Endurance Class 2

2g between 10Hz and 150Hz

8.16.2 Shock and bump IEC 255-21-2: 1988

Shock response Class 2

10g 3 pulses

Shock withstand Class 1

15g 3 pulses

Bump Class 1

10g 1000 pulses

8.16.3 Seismic IEC 255-21-3: 1993

Class 2

Frequency range 1-35Hz

8.16.4 Mechanical durability

Loaded contact - 10,000 operations minimum

Unloaded contact - 100,000 operations minimum

8.17 Model numbers

KBCH140 CO CS RTG A

- Configuration (i.e. settings as supplied) and connection diagram (Sheet. No. varies with external connection arrangement).
- Issue
- Rating }
- Case details } Mechanical assembly
- Relay Type }

KBCH 1X X

0	- First Version
2	- 2 bias inputs per phase
3	- 3 bias inputs per phase
4	- 4 bias inputs per phase
1	- Auxiliary Powered (V)
H	- Inrush proof
C	- current operated
B	- biased differential
K	- K-Series Midos

CO

01	- Standard configuration

CS

1	- Back connected flush mounting (standard mounting) May be used as an additional digit for configuration later
P	- MiCOM Livery Size 8" (40TE)

RTG

E	- Standard (English text)
F	- French text
G	- German text
S	- Spanish text
L	- Vn = 100-120V, In = 1A, 50/60Hz
M	- Vn = 100-120V, In = 5A, 50/60Hz
P	- Vn = 100-120V, In = HV 1A/LV 5A, 50/60Hz**
2	- Vx = 24-125V ac/dc
5	- Vx = 48-250V ac/dc

** Note: Option P (1A/5A rating) is only available on KBCH120 and KBCH140

9. PROBLEM SOLVING

9.1 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 5.2.2.

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 front plate of the relay. If they differ, quote the one in the system data column.

9.2 Protection settings

9.2.1 Settings for protection not displayed

Check the protection is enabled in the function links found in either Settings(1) or Settings(2) which ever is applicable.

9.2.2 Second setting group not displayed

Set function link SD4 to "1" to turn on the group 2 settings.

9.2.3 Function links cannot be changed

Enter the password as these menu cells are protected.

Links are not selectable if associated text is not displayed.

9.2.4 Setting cannot be changed

Check if it is a password protected setting. If so enter the password.

9.3 Alarms

If the watchdog relay operates, first check that the relay is energised 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 10 seconds, or so, 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.

9.3.1 Watchdog alarm

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.

Note: The green LED will usually follow the operation of the watchdog relay.

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 2.12).

9.3.2 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 recognised service centre.

9.3.3 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.

9.3.4 "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.

9.3.5 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 5.2.10.

9.4 Records

9.4.1 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 or RLY7 are operated by one of its trip contacts via an auxiliary input. This will result in the fault values, as measured by the relay, being stored at the instant RLY3 and RLY7 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 a lot of 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 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.

9.4.2 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 current 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 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.

9.5 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.

9.5.1 Measured values do not change

Values in the MEASUREMENTS(1) column 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 the communication manual.

9.5.2 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-energise 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 are 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.

9.5.3 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.

9.6 Output relays remain picked-up

9.6.1 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 energising supply after such changes.

10. MAINTENANCE

10.1 Remote testing

K-Series 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.

10.1.1 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.

10.1.2 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.

10.1.3 Trip test

A trip test can be performed remotely by using the options under the TEST/CONTROL column in the menu.

Note: These are password protected cells

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 5.2.8 for how to set relay masks.

10.2 Local testing

When testing locally, similar tests may be carried out to check for correct functioning of the relay.

10.2.1 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.

10.2.2 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 the section of this manual dealing with commissioning. These tests will prove the calibration accuracy is being maintained.

10.2.3 Trip test

A trip test can be performed remotely by using the options under the TEST/CONTROL column in the menu.

Note: These are password protected cells

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 5.2.8 for how to set relay masks.

10.2.4 Additional tests

Additional tests can be selected from the Commissioning Instructions as required.

10.3 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. Refer to Figure 2-1 in Section 2 for the module layout.

10.3.1 Replacing the user interface board

Withdraw the module from its case.

Remove the six screws on the front plate.

Remove the front plate.

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.

10.3.2 Replacing the analogue input daughter board

Remove the six screws on the front plate.

Remove the front plate.

Lever the top edge of the analogue input daughter 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 analogue input daughter board and assemble in the reverse order.

10.3.3 Replacing the 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.

10.3.4 Replacing the DSP board

This is the second board in from the left hand side of the module.

To replace this board:

Remove the processor board as described above.

Remove the two securing screws that hold the DSP board in place.

Remove the two screws at the rear of the module which secure the screening plate between the power supply and DSP board.

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.

10.3.5 Replacing the analogue input board

It is not recommended to remove this board.

10.3.6 Replacing output relays and opto-isolators

These are located on the main microprocessor board and on the DSP board. To replace remove these boards as detailed above. 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.

10.3.7 Replacing the power supply board

Remove the two screws securing the centre terminal block to the top plate of the module.

Remove the two screws securing the centre terminal block to the bottom plate of the module.

Remove the two screws securing the back plane to the metalwork.

Unplug the back plane from the power supply pcb.

Withdraw the power supply board from the rear, unplugging it from the front bus.

Reassemble in the reverse of this sequence.

10.3.8 Replacing the back plate

Remove the two screws securing the centre terminal block to the top plate of the module.

Remove the two screws securing the centre terminal block to the bottom plate of the module.

Remove the two screws securing the back plane to the metalwork.

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.

10.4 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 engineers and it is recommended that the work is carried out by an authorised 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.

11. LOGIC DIAGRAMS

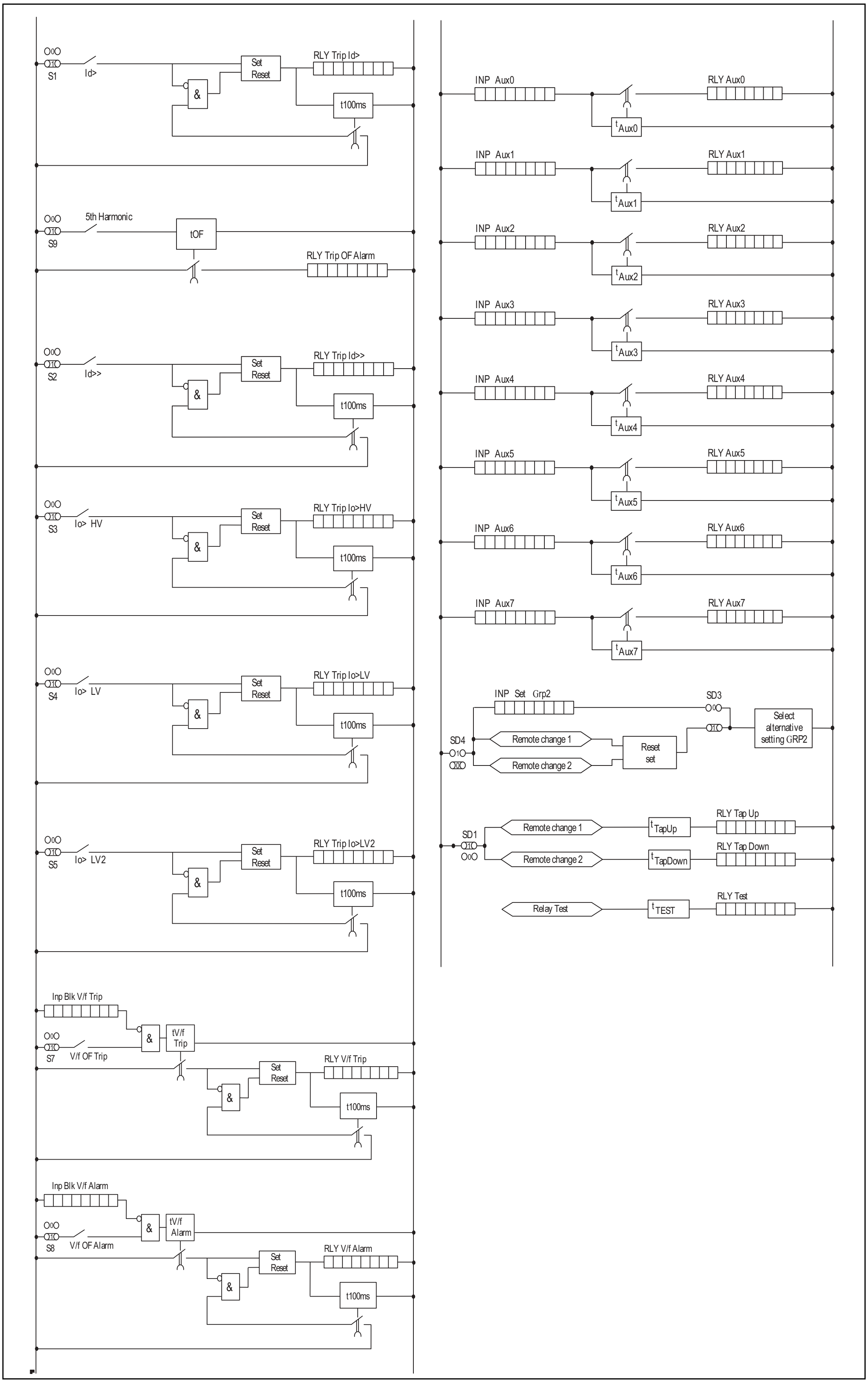
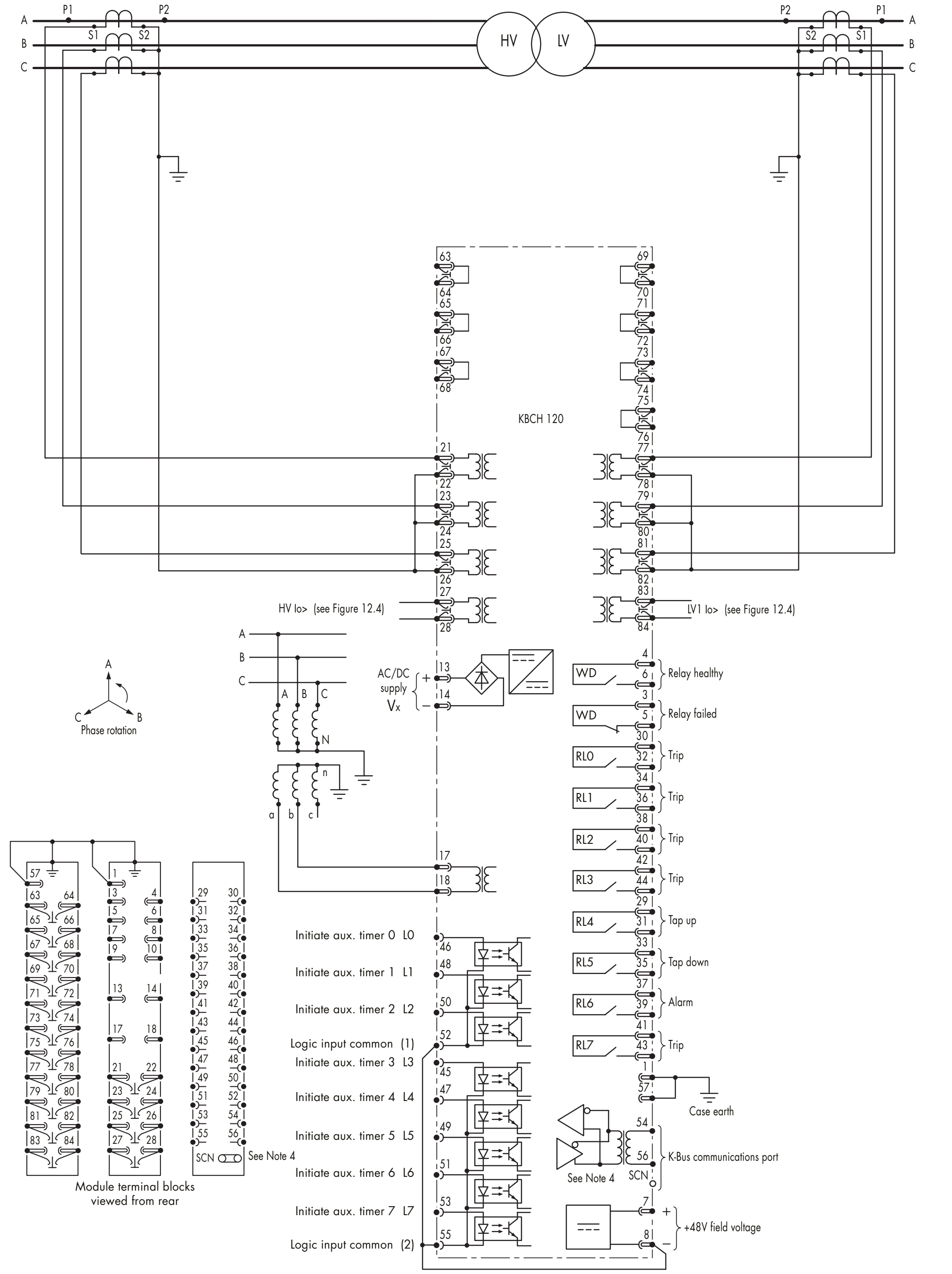


Figure 11-1: KBCH Logic Diagram

12. CONNECTIONS DIAGRAMS

Figures 12-1, 12-2, 12-3 and 12-4 show the external connection for KBCH120, 130 and 140 respectively.



Notes:

1. (a) CT shorting links make before (b) and (c) disconnect.
   (b) Short terminals break before (c).
   (c) Long terminals.
   (d) Pin terminal (PCB type)
2. VT input must be supplied with phase - phase voltage. Connections are typical only.
3. Earth connections are typical only.
4. SCN = Screen connection for K-Bus.

Figure 12-1: Typical external connections for KBCH120

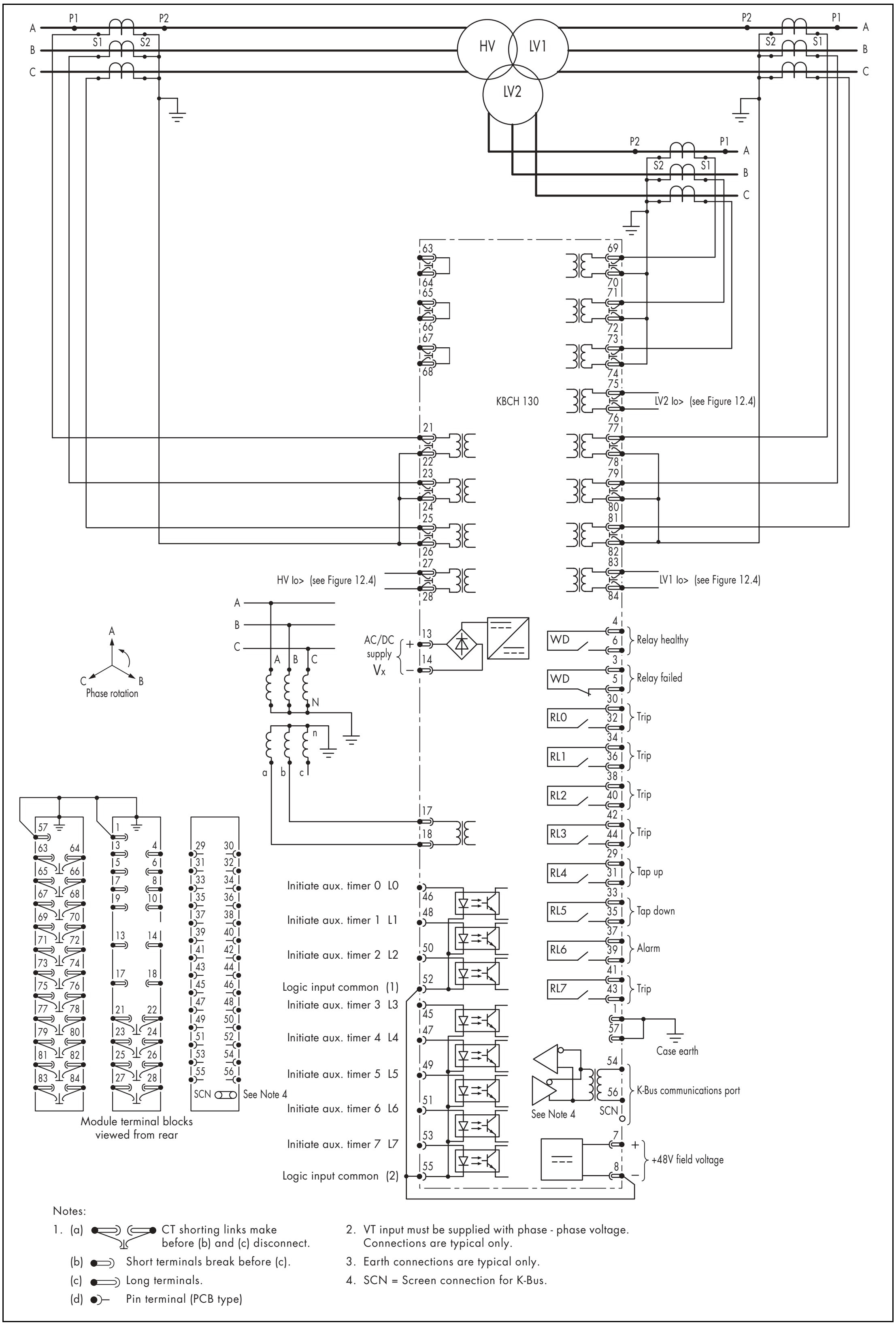


Figure 12-2: Typical external connections for KBCH130

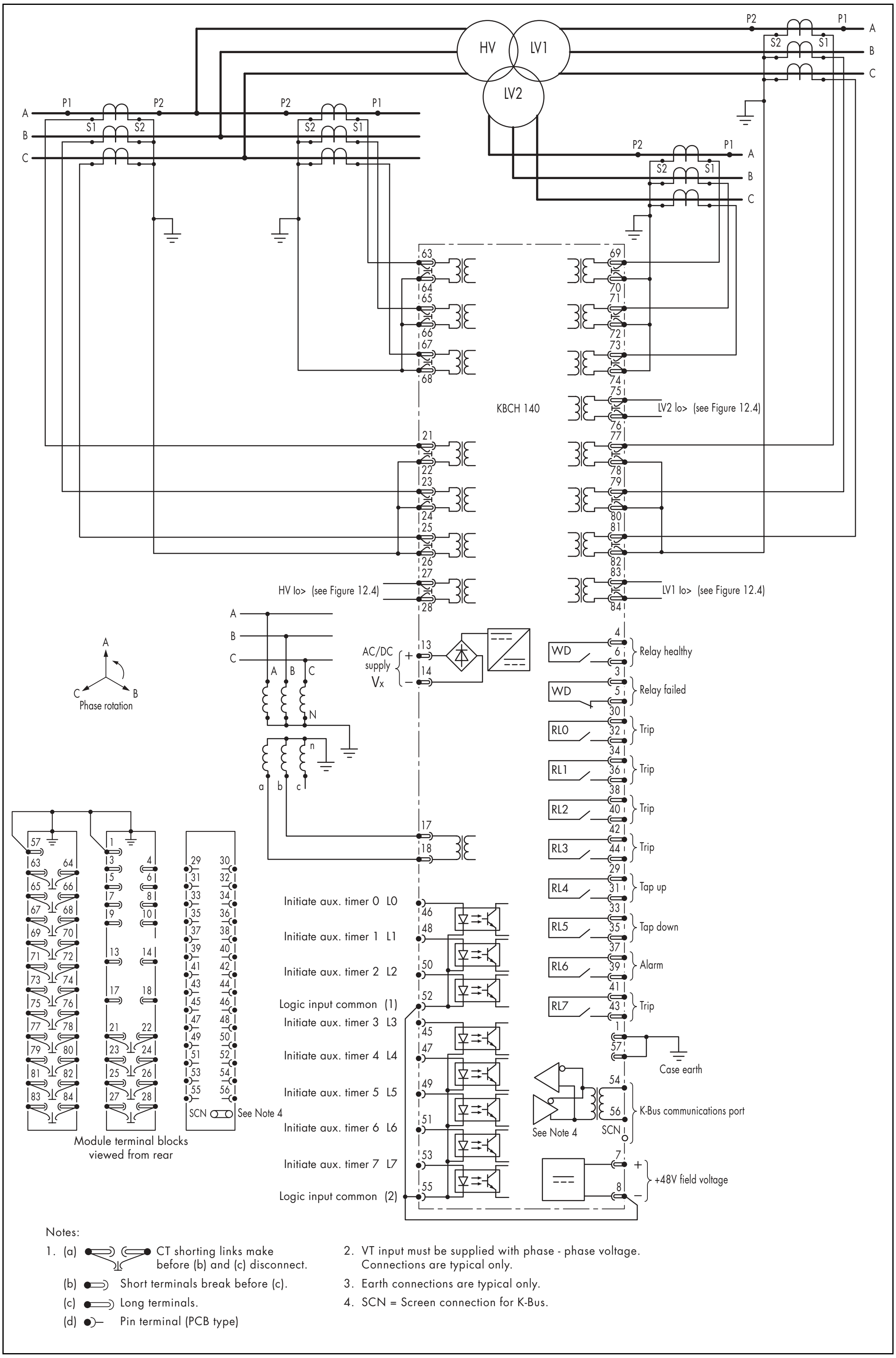
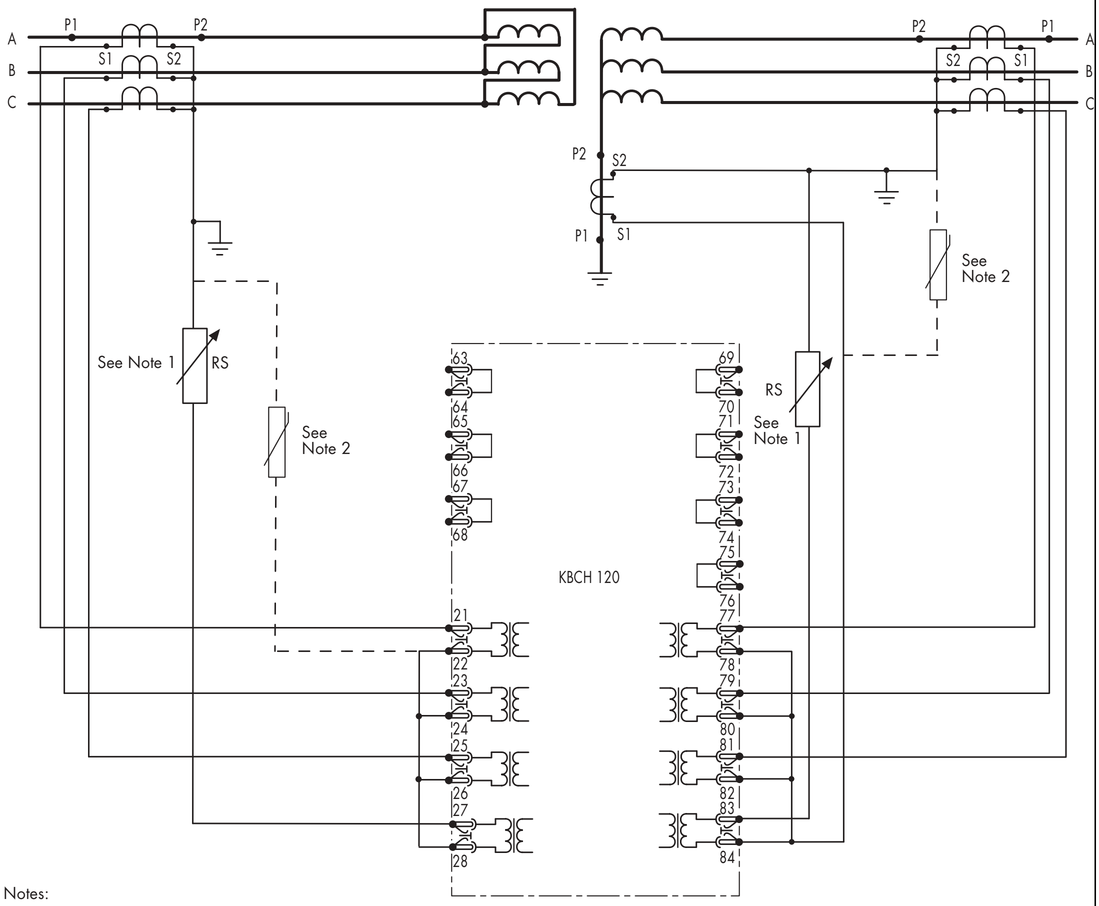


Figure 12-3: Typical external connections for KBCH140



Notes:

1. See Service Manual R8530 for the setting of the external stabilising resistor.
2. Optional voltage limiting non-linear resistor (see Service Manual R8530).

Figure 12-4: Typical restricted earth fault connections for KBCH140

CHAPTER 2
Application

CONTENT

1 INTRODUCTION

1.1 Protection of transformers

The development of modern power systems has been reflected in the advances in transformer design. This has resulted in a wide range of transformers with sizes from a few kVA to several hundred MVA being available for use in a wide variety of applications.

The considerations for a transformer protection package vary with the application and importance of the transformer. To reduce the effects of thermal stress and electrodynamic forces it is advisable for the overall protection package to minimise the time that a fault is present within a transformer.

On smaller distribution transformers effective and economically justifiable protection can be achieved by using either fuse protection or IDMT/instantaneous overcurrent relays. Due to the requirements of co-ordination with the down stream power system protection this results in time delayed fault clearance for some low level faults. Time delayed clearance of major faults is unacceptable on larger distribution, transmission and generator transformers, where the effects on system operation and stability must be considered. High speed protection is desirable for all faults.

Transformer faults are generally classified into four categories:

– Winding and Terminal faults

– Core faults

– Abnormal operating conditions such as over voltage, overfluxing and overload

– Sustained or uncleared external faults

All of the above conditions must be considered individually and the transformer protection package designed accordingly.

To provide effective protection for faults within a transformer and security for normal operation and external faults, the design and application of transformer protection must consider factors such as:

– Magnetising Inrush current

– Winding arrangements

– Winding connections

– Connection of protection secondary circuits

The way that the protection of larger transformers is typically achieved is best illustrated by examining the protective devices associated with common applications.

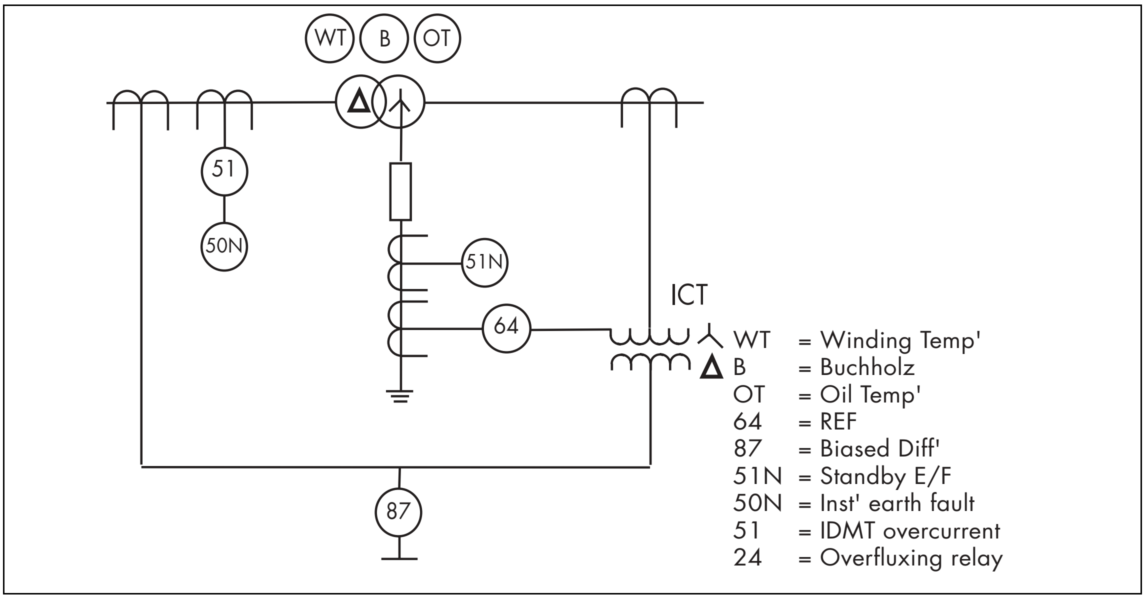


Figure 1: Typical Transformer Protection Package

Overview of existing Practices

Figure 1 shows a typical protection package for a sub-transmission or large distribution transformer.

High speed protection is provided for faults on both the HV and LV windings by a biased differential relay (87). The relay operates on the basic differential principle that HV and LV CT secondary currents entering and leaving the zone of protection can be balanced under load and through fault conditions, whereas under internal fault conditions balance will be lost and a differential current will cause the relay to trip. The zone of protection is clearly defined by the CT locations and, as the protection is stable for through faults, it can be set to operate without any intentional time delay.

Figure 1 illustrates the application of an overall differential relay where an interposing CT is used to provide phase and ratio correction of CT signals in addition to trapping LV zero sequence current to prevent maloperation of the differential element for external LV earth faults.

More sensitive high speed earth fault protection for the LV winding is provided by a high impedance restricted earth fault relay (64). Due to the limitation of phase fault current on the HV side for LV winding earth faults and the fact that any un-restricted earth fault protection in the transformer earth path requires a discriminative time delay, restricted earth fault protection is widely applied. The application of restricted earth fault protection is further discussed in section 2.3.

Earth fault protection is provided on the HV winding by the inherently restricted earth fault element associated with the HV overcurrent CT's (50N). The Delta winding of the transformer draws no HV zero sequence current for LV earth faults and passes no zero sequence current to upstream HV earth faults, hence there is no requirement to grade this element with other earth fault protection and it can be set to operate without any intentional time delay. The high impedance differential principle is used to ensure stability in the event of asymmetric CT saturation for external phase faults and during inrush conditions.

Sustained external LV faults are cleared by the IDMT overcurrent protection on the HV winding (51) or by the standby earth fault relay (51N) in the transformer earth connection. The extent of backup protection employed will vary according to the transformer installation and application.

The protection scheme may be further enhanced by the use of other protective devices associated with the transformer, such as the Buchholz, pressure relief and winding temperature devices. These devices can act as another main protective system for large transformers and they may also provide clearance for some faults which might be difficult to detect by protection devices operating from line current transformers, e.g. winding inter turn faults or core lamination faults. These devices are connected to directly trip the breaker in addition to operating auxiliary relays for flagging purposes.

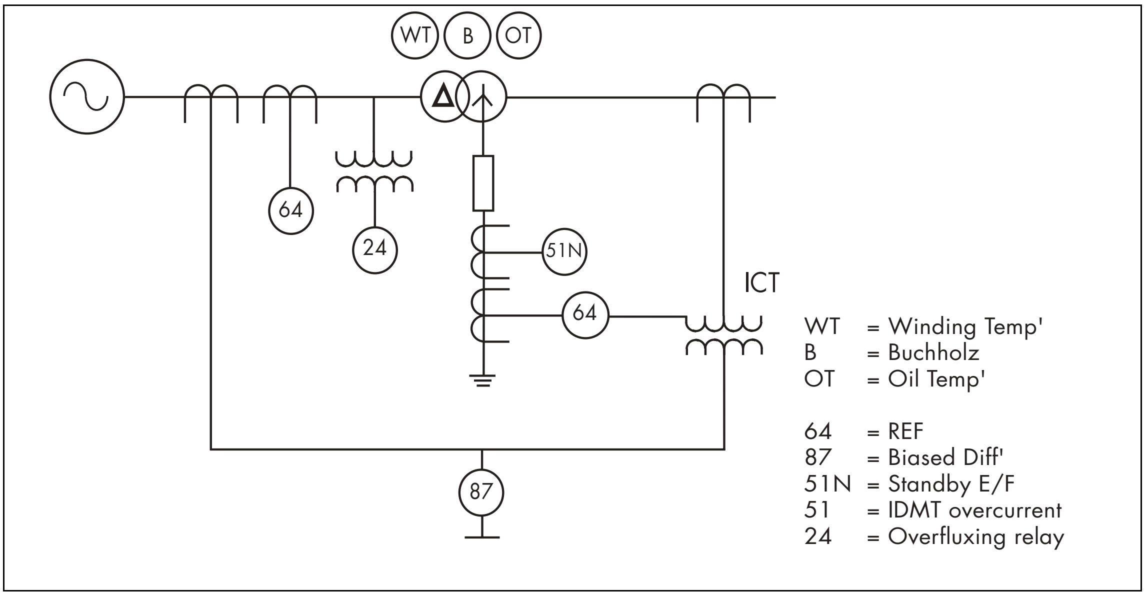


Figure 2: Typical protection package for a Generator transformer

The protection package for a generator transformer is similar to that for any other large transformer.

High speed protection is provided for phase to phase faults by the provision of a biased differential relay. In addition, for large generators, the transformer is commonly included within an overall second main differential arrangement, which incorporates the generator and transformer within the overall zone of protection. Earth fault protection is provided by a restricted earth fault relay on the star winding.

Overfluxing protection is commonly applied to generator circuits to prevent generator or transformer damage from prolonged overfluxing conditions.

Other protection devices will again complement the relay protection package.

Auto-transformers are commonly used to couple EHV and HV power networks if the ratio of their voltages is moderate. The protection arrangements for an auto transformer are similar in most respects to the protection of a two winding transformer. Differential protection can be provided by high impedance relays. Where a delta tertiary winding is present the tertiary winding will not be protected by the high impedance protection for the main windings. Protection of all windings can be offered by a biased differential relay such as the KBCH, this is further discussed in section 3.3.

1.2 KBCH Protection relay

The KBCH relay has been designed to bring the latest digital technology to the protection of power transformers. The increased functionality of digital relays allows an enhanced protection package to be offered for a wide variety of applications, which, when combined with a host of non-protective features, can contribute to system information gathering requirements.

1.2.1 Protection Features

The protection features offered by the KBCH are listed below:

- Biased differential protection
- Restricted earth fault protection for individual transformer windings
- Overfluxing protection
- Instantaneous high set operation
- Magnetising inrush restraint
- 5th Harmonic Overfluxing blocking
- 8 opto-isolated inputs for alarm/trip indication of external devices

The biased differential element has a dual slope bias characteristic to ensure sensitivity, with load current, to internal faults and stability under heavy through fault conditions.

The differential element is blocked for magnetising inrush conditions by utilising the waveform gap detection technique successfully employed in the MBCH relay. In addition, the differential element can be optionally blocked under transient overfluxing conditions by a 5th Harmonic blocking feature. Reduced operating times for heavy internal faults are achieved by the use of a differential instantaneous high set element.

Restricted earth fault protection, based upon the high impedance stability principle, is available for each transformer winding, to offer increased sensitivity to low-level winding earth faults.

The V/f overfluxing element provides protection against damage that may result from prolonged overfluxing. Independent alarm and trip characteristics are provided to enable corrective action to be undertaken prior to tripping being initiated.

Use of the eight available opto isolators as trip repeat and alarm paths for other transformer protection devices, (Buchholz, Oil pressure, winding temperature etc.,) allows operation of these devices to be event-logged. Interrogation of the relay fault, event and disturbance records offers an overall picture of an event or fault, of the transformer protection performance and sequences of operation.

All models of the KBCH are three phase units with internal phase compensation, CT ratio correction and zero sequence filtering, thus eliminating the need for external interposing transformers in virtually all applications. Up to four biased inputs can be provided to cater for power transformers with more than two windings and/or more than one set of CT's associated with each winding, e.g. in mesh or one-and-a-half circuit breaker substation arrangements.

The variety of protective functions offered by the KBCH makes it ideal not only for the protection of power transformers but also for a variety of applications where biased differential or high impedance protection is commonly applied, these include:

- Overall Generator/Transformer protection
- Generators
- Reactors

1.2.2 Non protection features

In addition to providing all of the common relaying requirements for a transformer protection package, the KBCH relay shares many common features with the other relays in the K-range.

The KBCH offers this variety of additional features by virtue of its digital design and standardisation of hardware. These features are listed below:

- Electrical Instrumentation with local/remote display
- Fault records (summary of reasons for tripping etc.)
- Event records (summary of alarms and relay events)
- Disturbance records (record of analogue wave forms and operation of opto isolated inputs / output relays)
- Date and time tagging of all records
- Commissioning aids
- Remote communications with a K-bus network interface
- High level of continuous self monitoring and diagnostic information
- Remote manual Tap changer control
- Relay menu available in English, French, German or Spanish

2 APPLICATION OF INDIVIDUAL PROTECTIVE FUNCTIONS

2.1 Overall Differential Protection (87)

In applying the well established principles of differential protection to transformers, a variety of considerations have to be taken into account. These include compensation for any phase shift across the transformer, possible unbalance of signals from current transformers either side of windings and the effects of the variety of earthing and winding arrangements. In addition to these factors, which can be compensated for by correct application of the relay, the effects of normal system conditions on relay operation must also be considered. The differential element must be blocked for system conditions which could result in maloperation of the relay, such as high levels of magnetising current during inrush conditions or during transient overfluxing.

In traditional transformer differential schemes, the requirements for phase and ratio correction were met by the application of external interposing current transformers, as a secondary replica of the main transformer winding arrangements, or by a delta connection of main CT's (phase correction only). Within the KBCH, software interposing CT's (ICT's) are provided where the same setting criteria apply. The advantage of having replica interposing CT's in software is that it gives the KBCH the flexibility to cater for line CT's connected in either star or delta as well as being able to compensate for a variety of system earthing arrangements.

2.1.1 Biased elements

The number of biased differential inputs required for an application depends upon the transformer and its primary connections. It is recommended that, where ever possible, a set of biased CT inputs is used per set of current transformers.

There are three basic models of the KBCH relay;

– KBCH120:- Two biased differential inputs

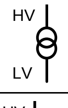
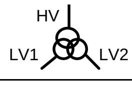
– KBCH130:- Two or Three biased differential inputs

– KBCH140:- Two, Three or Four biased differential inputs

Where a KBCH 140/130 is chosen they can be programmed to provide 2, 3, 4 and 2 or 3 biased windings respectively.

Versions of the KBCH120 and KBCH140 are available with 1A HV CT inputs and 5A LV CT inputs for applications where the CT's either side of a transformer are of different secondary ratings.

Table 1 shows the variety of connections which can be catered for by the range of KBCH relays.

Menu setting	No. of biased inputs	Configuration	Required relay type
HV+LV	2		KBCH120/130/140
HV+LV1+LV2	3		KBCH130/140

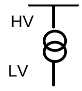
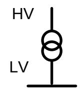
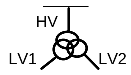
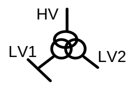
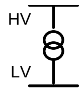
Menu setting	No. of biased inputs	Configuration	Required relay type
HV(x2)+LV	3		KBCH130/140**
HV+LV(x2)	3		KBCH130/140
HV(x2)+LV1+LV2	4		Only KBCH140
HV+LV1(x2)+LV2	4		Only KBCH140**
HV(x2)+LV(x2)	4		Only KBCH140
** Note: Not available on In = HV 1A/LV 5A versions of KBCH140			

Table 1: Biased input configurations available on the KBCH

To ensure that the KBCH looks at the currents into the transformer windings for instrumentation and differential purposes it is important that the correct configuration is chosen on the KBCH relay menu. When applied to a three winding transformer [HV + LV1 + LV2] should be chosen, whereas for a two winding transformer with a requirement for three biased inputs either HV(x2) +LV or HV + (LVx2) should be chosen.

The KBCH relay achieves stability for through faults in two ways, both of which are essential for correct relay operation. The first consideration is the correct sizing of the current transformers as described in Chapter 4, the second is by providing a relay bias characteristic as shown in Fig 3.

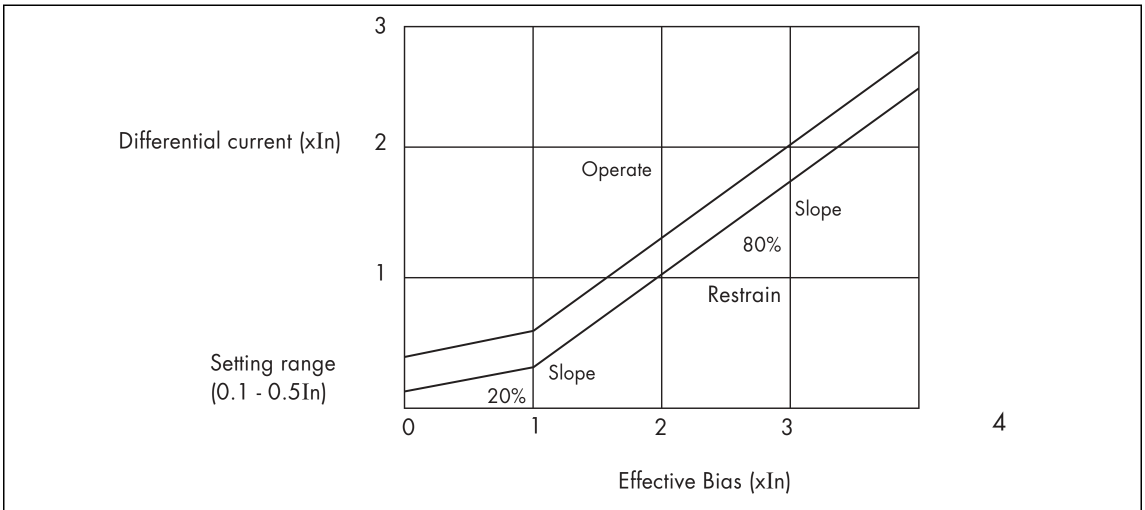


Figure 3: KBCH Fixed Bias Characteristic (Showing setting range)

The differential current on a per phase basis is defined as the vectorial sum of all the input currents after phase, ratio and zero sequence correction has been performed. The bias current on a per phase basis is defined as half the scalar sum of all the input currents after phase, ratio and zero sequence correction.

For KBCH140:-

$$Id = | \bar{I1} + \bar{I2} + \bar{I3} + \bar{I4} | \text{ i.e. vectorial sum}$$

$$Ib = (|\bar{I1}| + |\bar{I2}| + |\bar{I3}| + |\bar{I4}|) / 2 \text{ i.e. scalar sum}$$

The basic pick up level of the low set differential element is variable between 0.1In and 0.5In in 0.1In steps (where In is the rated current of the relay). The setting chosen is dependant upon the item of plant being protected and by the amount of differential current that might be seen during normal operating conditions. A setting of 0.2In is generally recommended when the KBCH is used to protect a transformer.

The initial bias slope, from zero up to rated current, is fixed at 20% to ensure sensitivity to internal faults up to load current. This allows for the 15% mismatch which can occur at the limit of the transformer's tap-changer range and an additional 5% for any CT ratio errors. The slope is then increased to 80% for bias currents above rated current. This ensures stability under heavy through fault conditions which could lead to increased differential current due to asymmetric saturation of CT's.

No adjustment of the bias slopes is provided.

When protecting generators and other items of plant, where shunt magnetising current is not present, a lower differential setting can be used and 0.1 In would be more typical.

The biased low-set differential protection is blocked under magnetising inrush conditions and optionally during transient over fluxing conditions on a per phase basis.

2.1.2 Ratio correction

To ensure correct operation of the differential element it is important that under load and through fault conditions the currents into the differential element of the relay balance. In many cases, the HV and LV current transformer primary ratings will not exactly match the transformer winding rated currents. Ratio correction factors are therefore provided. The CT ratio correction factors are applied to ensure that the signals to the differential algorithm are correct. A ratio correction factor is provided which is adjustable from 0.05 to 2.0 in steps of 0.01, for each set of CT inputs. This range should be adequate for virtually all applications.

To provide instrumentation in primary quantities, the main current transformer ratios can be entered in the locations "HV CT ratio", "LV1 CT ratio" and "LV2 CT ratio" in the settings column. The appropriate number of CT ratios will appear dependent upon the number of in-service biased inputs selected.

Alternatively the CT ratio can be set to 1:1, so that all currents shown on the relay menu will appear as secondary values.

To minimise unbalance due to tap changer operation, current inputs to the differential element should be matched for the mid-tap position.

The CT ratio correction factors are found in the settings column of the KBCH menu. Their use is best illustrated with an example.

Example 1: Two winding transformer (KBCH120)

20MVA Transformer, Dyn1, 33/11kV

HV CT ratio - 400/1

LV CT ratio - 1500/1

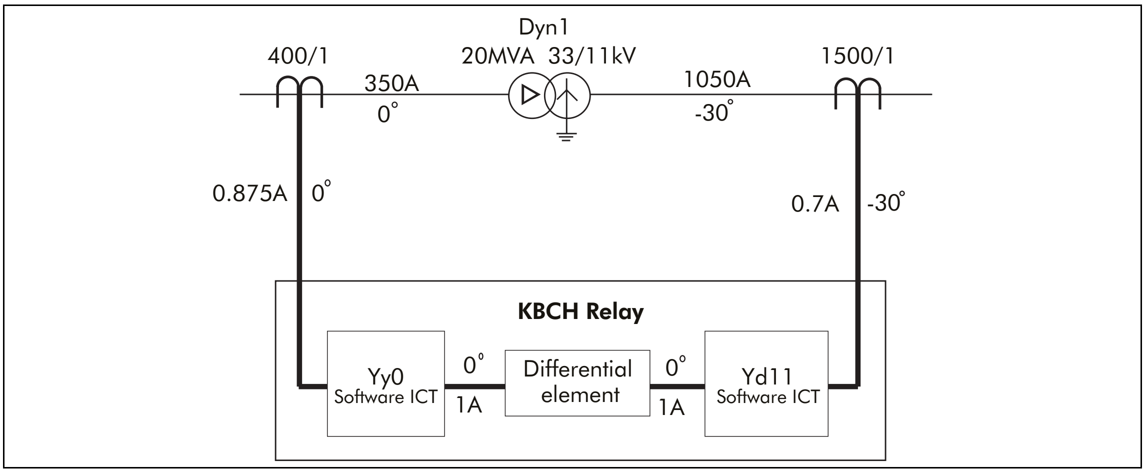


Figure 4: Application of a KBCH120 to a two winding transformer.

Phase correction is applied as detailed in section 2.1.3, with the Yy0 option chosen for the HV CT's and with the Yd11 option chosen for the LV CT's.

$$33\text{kV full load current} = \frac{20\text{ MVA}}{33\text{kV}\sqrt{3}} = 350\text{ Amps}$$

Secondary current = 350 x 1/400 = 0.875 Amps

$$11\text{kV full load current} = \frac{20\text{ MVA}}{11\text{kV}\sqrt{3}} = 1050\text{ Amps}$$

Secondary current = 1050 x 1/1500 = 0.7 Amps

Each of these secondary currents are corrected to relay rated current, in this case 1A.

HV ratio correction factor 1/0.875 = **1.14 [Setting applied to relay]**

LV ratio correction factor 1/0.7 = **1.43 [Setting applied to relay]**

When a Star/Delta software interposing CT is chosen no additional account has to be taken for the $\sqrt{3}$ factor which would be introduced by the delta winding. This is accounted for by the relay.

Further examples for applying ratio compensation in KBCH are given in Appendix C.

2.1.3 Phase correction and zero sequence current filtering.

To compensate for any phase shift between two windings of a transformer it is necessary to provide phase correction. This was traditionally provided by the appropriate connection of physical interposing current transformers, as a replica of the main transformer winding arrangements, or by a delta connection of main CT's.

Phase correction is provided in the KBCH via software interposing CT's for each transformer winding i.e. HV, LV1, LV2 and, as with the ratio correction, the appearance of the facility in the relay menu will depend upon the selected configuration for biased inputs.

The phase correction settings available with KBCH are as follows;

Yy0 (0deg), Yd1 (–30deg), Yd2 (–60deg), Yd3 (–90deg), Yd4 (–120deg),

Yd5 (–150deg), Yy6 (+180deg), Yd7 (+150deg), Yd8 (+120deg), Yd9 (+90deg),

Yd10 (+60deg), Yd11 (+30deg), Ydy0 (0deg), Ydy6 (+180deg).

In addition to mimicking the phase shift of the protected transformer, it is also necessary to mimic the distribution of primary zero sequence current in the protection scheme. The necessary filtering of zero sequence current has also been traditionally provided by appropriate connection of interposing CT's or by delta connection of main CT secondary windings. In the KBCH, zero sequence current filtering is implemented in software when a delta connection is called up for a software interposing CT.

Where a transformer winding can pass zero sequence current to an external earth fault it is essential that some form of zero sequence current filtering is employed. This ensures out of zone earth faults will not cause the relay to maloperate.

An external earth fault on the star side of a Dyn11 transformer will result in zero sequence current flowing in the current transformers associated with the star winding but, due to the effect of the delta winding, there will be no corresponding zero sequence current in the current transformers associated with the delta winding.

In order to ensure stability of the protection, the LV zero sequence current must be eliminated from the differential current. Traditionally this has been achieved by either delta connected line CT's or by the inclusion of a delta winding in the connection of an interposing current transformer.

Selection of the phase correction settings will be dependant on the phase shift required across the transformer and on zero sequence filtering requirements. As with ratio correction factors, the phase correction is applied either side of the relay element. Providing replica interposing CT's in software has the advantage of being able to cater for line CT's connected in either star or delta as well as being able to cater for in-zone earthing transformers. To aid selection of the correct setting on the relay menu, the description of the available phase correction factors has been simplified by the use of the reference system described in Appendix 1.

Phase correction and zero sequence current filtering worked examples.

Example 1:- Transformer connection Ynd1

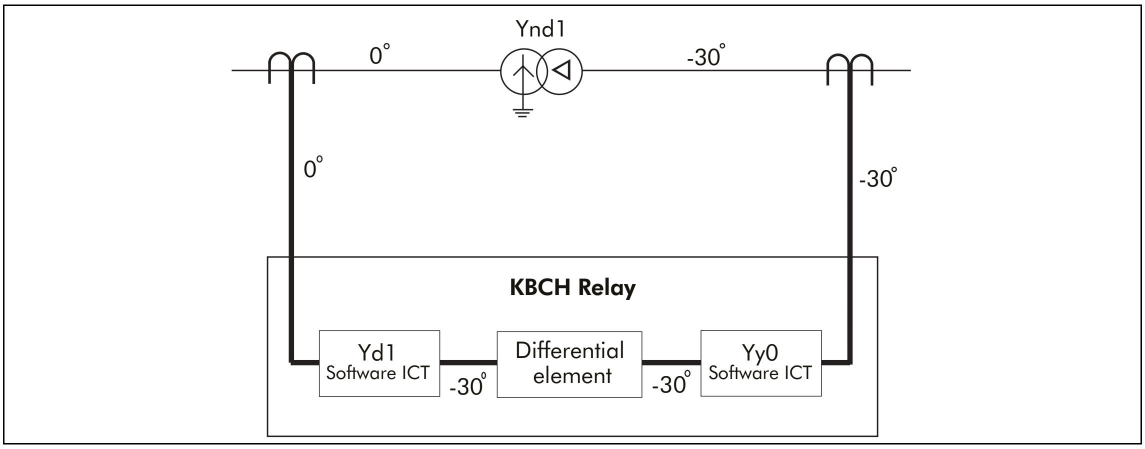


Figure 5:

The transformer connection shows that the delta connected low voltage line current lags the high voltage line current by 30° (–30°phase shift). To ensure that this phase shift does not create a differential current, the same phase shift must be introduced in the secondary circuit. The HV software interposing CT is effectively a winding replica of the main power transformer. It not only provides a -30° phase shift, but also performs the necessary function of filtering out any HV zero sequence current component.

The KBCH has internal zero sequence traps which are selected by the correct selection of software interposing CT's (ICT's) (see table 2).

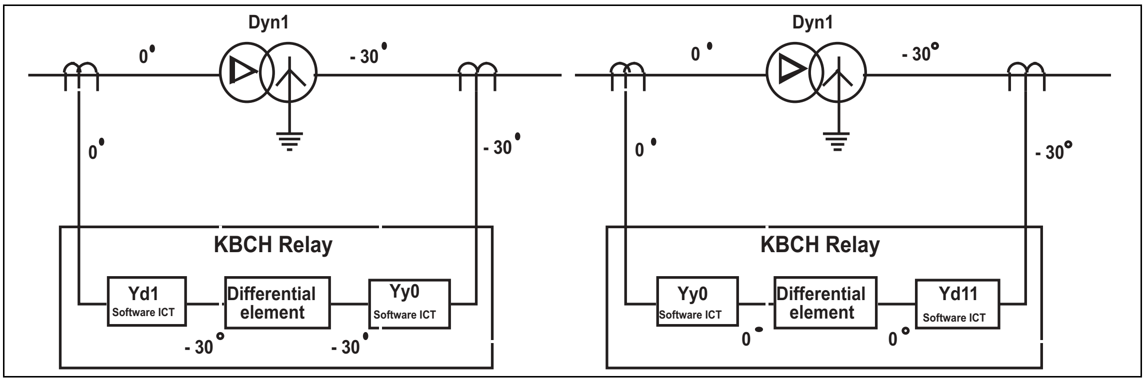


Figure 6: Incorrect software ICT's **Figure 7: Correct software ICT's**

Figure 6 shows an application of the KBCH where the required phase shift has been provided by selecting a Yd1 software interposing current transformer on the HV side. Although phase correction is provided, instability would exist for an LV earth fault as no LV zero sequence filtering is present. Figure 7 shows the correct application of the software ICT's, where the required phase shift and zero sequence compensation is provided by the selection of Yd11 software ICT's.

Further examples for applying zero sequence current filtering in KBCH are given in Appendix 2.

Example 2:- Transformer connection Dyn1yn11

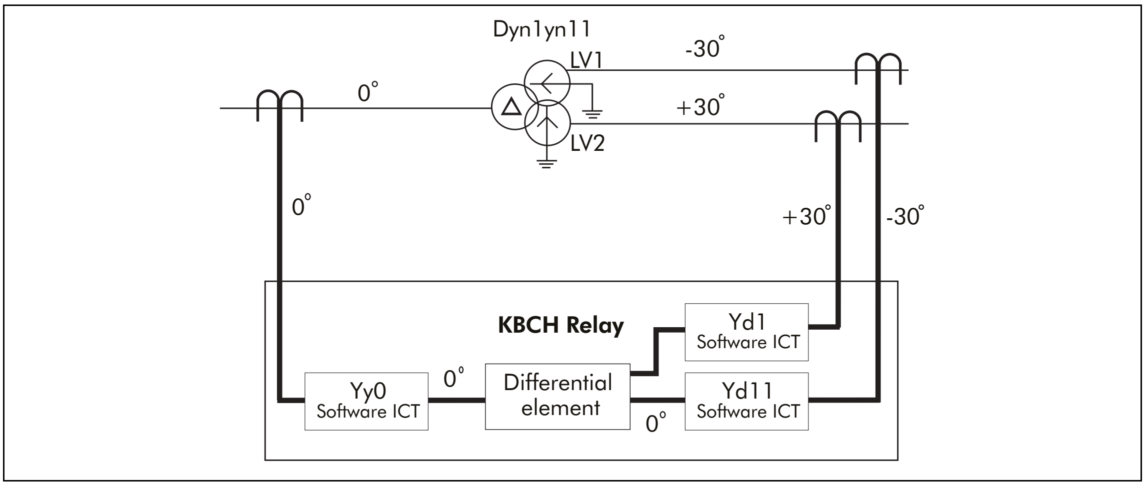


Figure 8: Phase shift compensation and Zero sequence filtering on a three winding transformer.

The transformer connection shows that the first LV winding (LV1) line current lags the HV line current by 30° lag (–30° phase shift), the phase displacement of the second LV winding with respect to the HV winding is 30° lead (+ 30° phase shift). To compensate for these phase shifts the HV phase compensation factor would be uncorrected **[select Yy0, on the relay menu]** the LV1 vector would then be shifted by +30° **[Select Yd11, on the relay menu]** and the LV2 vector would then be shifted by –30° **[Select Yd1, Phase shift on the relay menu].**

Example 3:- Transformer connection Dd10

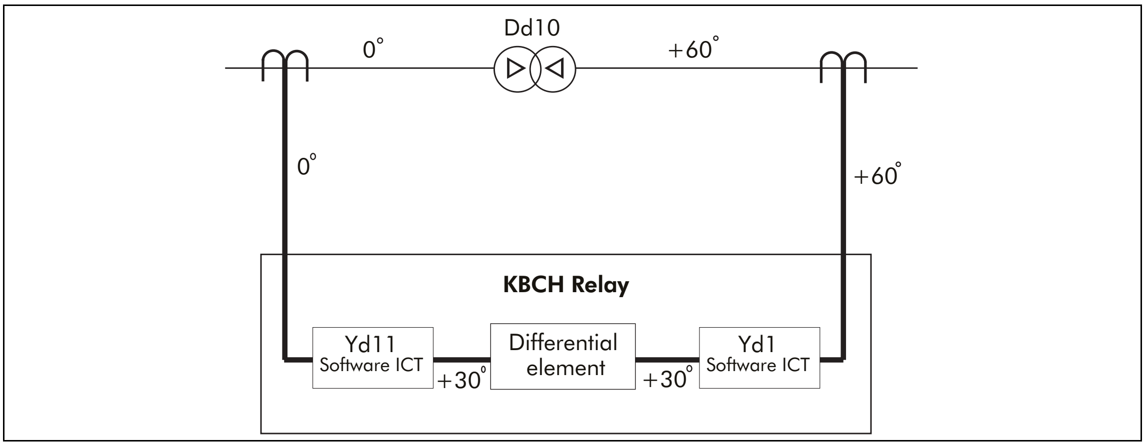


Figure 9: Phase shift compensation and Zero sequence filtering on a d10 transformer.

Where less common transformer connections are encountered a combination of the phase compensation factors provided can be used to achieve the desired phase shift. In the case of a Dd10 transformer the LV current leads the HV current by 60°. By correcting the HV current by +30° (**Select Yd11 on the relay menu**) and the LV current by –30° (**Select Yd1 on the relay menu**) the required 60° phase shift and zero sequence filtering is achieved.

Transformer Connection			Transformer Phase Shift	Phase Compensation Factor (Relay Setting)	
				HV	LV
Dd0	Yy0	Dz0	0°	Y(d)y0	Y(d)y0
Dy1			–30°	Yy0	Yd11
Yd1	Yz1		–30°	Yd1	Y(d)y0
Dd2	Dz2		–60°	Yd1	Yd11
Dd4	Dz4		–120°	Yd11	Yd7
Dy5			–150°	Yy0	Yd7
Yd5	Yz5		–150°	Yd5	Y(d)y0
Dd6	Yy6	Dz6	180	Y(d)y0	Y(d)y6
Dy7			+150°	Yy0	Yd5
Dd8	Dz8		+120°	Yd7	Yd11
Yd9			+90°	Yd9	Y(d)0
Dd10	Dz10		+60°	Yd11	Yd1
Yd11	Yz11		+30°	Yd11	Y(d)y0

Table 2: Selection of phase compensation factors

Table 2 indicates the phase shifts associated with a variety of transformers as well as the suggested phase compensation factors to be employed on KBCH. This assumes that the line current transformers are star connected. The required phase shifts can be achieved using alternative correction factors if desired.

Where an in-zone earthing connection is provided, and no phase shift compensation is necessary with the chosen software ICT, the required zero sequence filtering is provided by selection of a software delta tertiary winding (d) as indicated in table 2.

In some applications the line current transformers are connected in Delta to provide the required phase compensation and a zero sequence trap. If this is the case, and if the phase correction is correct, both the HV and LV phase compensation factors on the KBCH can be set to give a 0° phase shift i.e. Yy0 setting on the relay.

2.1.4 Magnetising inrush

The magnetising inrush phenomenon is associated with a transformer winding which is being energised where no balancing current is present in the other winding(s). This current appears as a large operating signal for the differential protection. Special measures are taken with the relay design to ensure that no maloperation occurs during inrush.

The wave form gap detection method which has been successfully implemented within the MBCH transformer differential relay, and which has gained many relay years of service experience is the basis for KBCH inrush restraint.

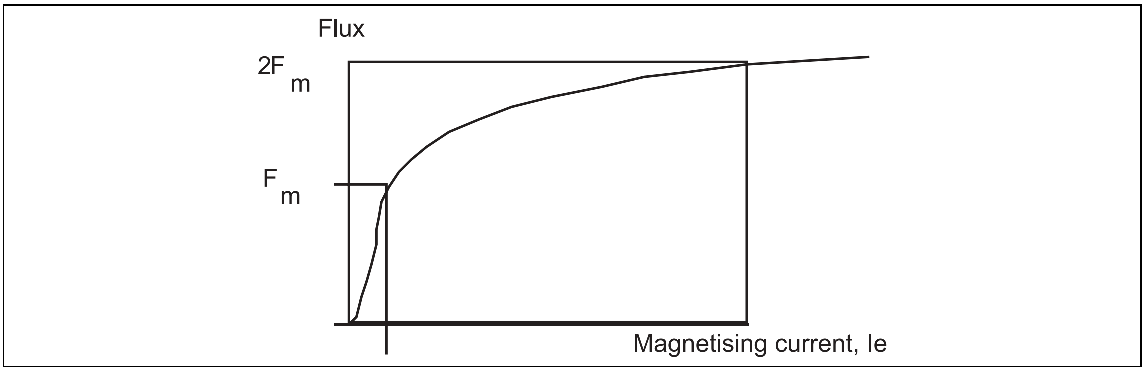


Figure 10: Transformer magnetising characteristic

Figure 10 portrays a transformer magnetising characteristic. To minimise material costs, weight and size, transformers are generally operated near to the "knee point" of the magnetising characteristic. Consequently, only a small increase in core flux above normal operating levels will result in a high magnetising current.

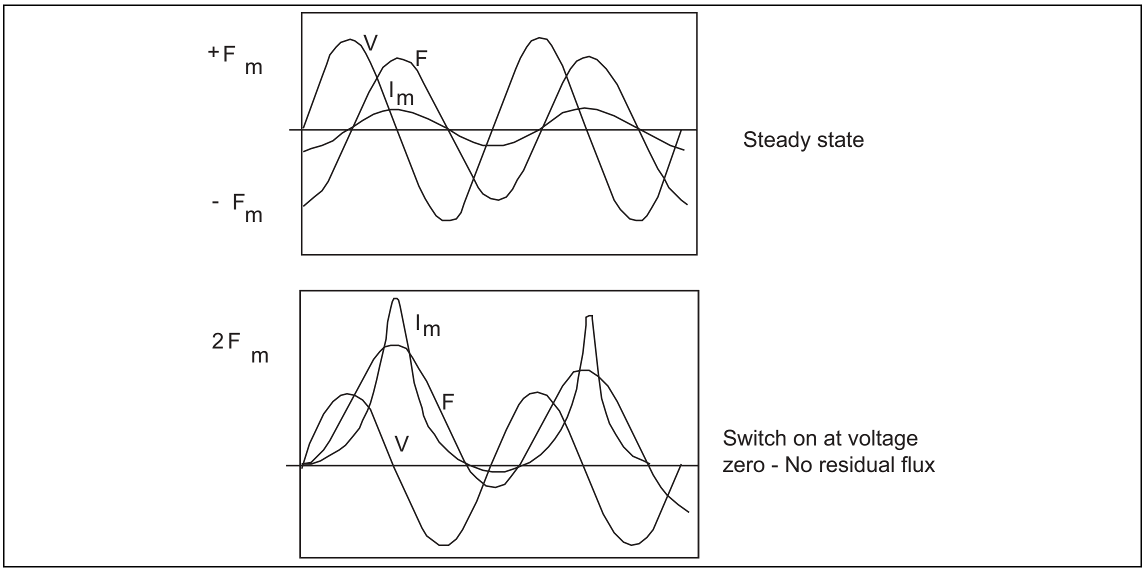


Figure 11:

Under normal steady state conditions, the magnetising current associated with the operating flux level is relatively small (usually less than 1% of rated current). However, if a transformer winding is energised at a voltage zero, with no remnant flux, the flux level during the first voltage cycle (2 x normal max flux) will result in core saturation and in a high, non-sinusoidal magnetising current waveform. This current is commonly referred to as magnetising inrush current and may persist for several cycles.

The magnitude and duration of magnetising inrush current waveforms are dependant upon a number of factors such as transformer design, size, system fault level, point on wave of switching, number of banked transformers etc.

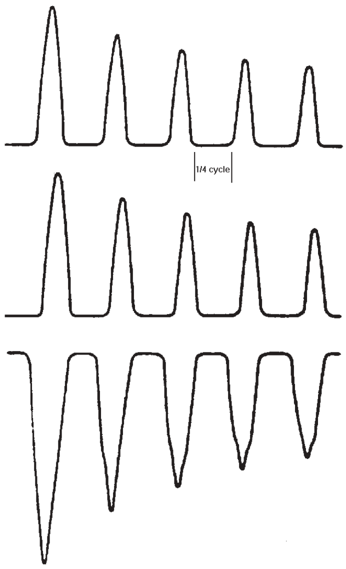


Figure 12: Inrush currents to a transformer star winding seen by differential elements after star/delta phase correction or to a delta winding with no phase correction.

Figure 12 shows typical magnetising inrush wave forms seen by differential protection elements for a three phase transformer. As can be seen from these typical examples, the magnetising inrush wave forms are characterised by the presence of a period during each cycle when relatively little current flows. By measuring the duration of the low current periods in any cycle (quarter of a cycle minimum), the relay is able to determine whether the differential current is due to magnetising inrush or due to a genuine fault. Low set differential element operation is inhibited only with inrush current. This wave form gap measuring technique ensures that operating times remain unaffected even during periods of significant line CT saturation.

2.2 High set operation

The KBCH relay incorporates an independent differential high set element to complement the protection provided by the biased differential low set element. The instantaneous high set offers faster clearance for heavy internal faults and it is not blocked for magnetising inrush or transient overfluxing conditions.

The high set element is a peak measuring device and is not subject to the inherent time delay required for magnetising inrush detection and the delay produced by the fourier filter. Stability is provided for heavy external faults, but the operating threshold of the high set differential element must be set to avoid operation with inrush current.

As described in section 2.1.4 when a transformer is energised, a high magnetising inrush current is drawn. The magnitude and duration of this inrush current is dependant upon several factors which include;

– Size and impedance of the transformer,

– Point on wave of switching,

– Remnant flux in the transformer,

– Number of transformers connected in parallel.

It is difficult to accurately predict the maximum anticipated level of inrush current. Typical waveform peak values are of the order of 8 - 10x rated current. A worst-case estimation of inrush could be made by dividing the transformer full load current by the per-unit leakage reactance quoted by the transformer manufacturer.

A setting range of 5-20In (RMS values) is provided on the KBCH relay. The high set RMS setting should be set in excess of the anticipated or estimated peak value of inrush current after ratio correction.

2.3 Restricted Earth Fault Protection

2.3.1 Basic principles

The KBCH uses biased differential protection to provide fast clearance for faults within the protected zone. The value of earth fault current, however, may be limited by any impedance in the earth path or by the percentage of the winding involved in the fault. The KBCH offers a restricted earth fault element for each winding of the protected transformer to provide greater sensitivity for earth faults which will not change with load current.

The levels of fault current available for relay measurement are illustrated in figures 13 and 14. If an earth fault is considered on an impedance earthed star winding of a Dyn transformer (Fig 13), the value of current flowing in the fault (I_f) will be dependant upon two factors. These are the value of earthing impedance and the fault point voltage, which is governed by the fault location. The value of fault current (I_f) is directly proportional to the location of the fault. A restricted earth fault element (64) is connected to measure I_f directly, to provide more sensitive earth fault protection. The overall differential protection is less sensitive, since it only measures the HV current I_s. The value of I_s is limited by the number of faulted secondary turns in relation to the HV turns.

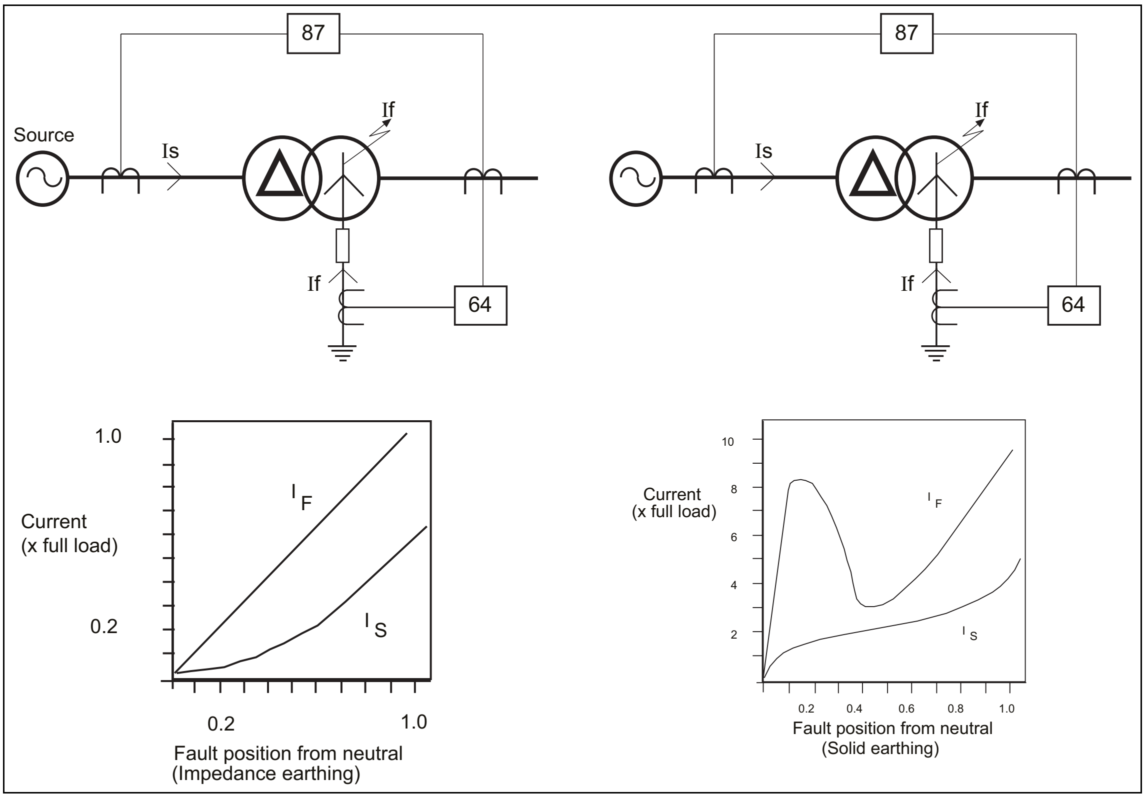


Figure 13: Fault limitation on an impedance earthed system.

Figure 14: Fault limitation on a solidly earthed system.

If a fault on a solidly earthed star winding (Fig 14) is considered, the fault current is limited by the leakage reactance of the winding, any impedance in the fault and by the fault point voltage. The value of fault current varies in a complex manner with fault location. As in the case of the impedance earthed transformer, the value of current available as an overall differential protection operating quantity is limited. More sensitive earth fault protection is provided by a restricted earth fault relay (64), which is arranged to measure I_f directly. Although more sensitive protection is provided by REF, the operating current for the overall differential protection is still significant for faults over most of the winding. For this reason, independent REF protection may not have previously been considered necessary for a solidly earthed winding; especially where an additional relay would have been required. With the KBCH, the REF protection is available at no extra cost if a neutral CT is available.

Restricted earth fault protection is also commonly applied to Delta windings of large power transformers, to improve the operating speed and sensitivity of the protection package to winding earth faults. When applied to a Delta winding this protection is commonly referred to as “balanced earth fault protection”. It is inherently restricted in its zone of operation when it is stabilised for CT spill current during inrush or during phase faults. The value of fault current flowing will again be dependant upon system earthing arrangements and the fault point voltage.

The application of the KBCH Restricted Earth Fault (REF) elements is based on the high impedance differential principle, offering stability for any type of fault occurring outside the protected zone, but operation for earth faults within the zone.

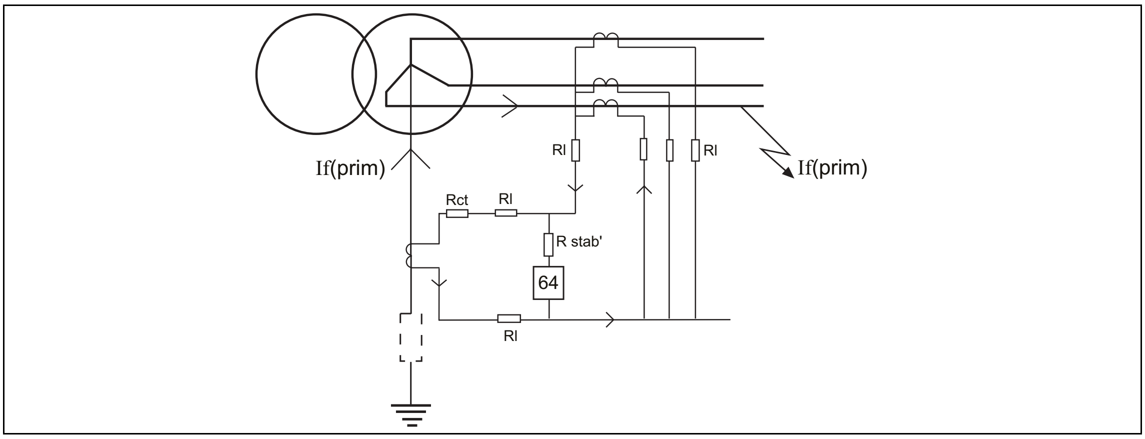


Figure 15: High Impedance principle

2.3.2 Stability requirements

The RMS voltage seen across an infinite impedance relay differential circuit for an external fault, with one CT totally saturated and with the other CT(s) totally unsaturated, is given by equation (1). This assumed state of CT's has been the traditional basis for high impedance protection stability calculations.

$$V_r = I_f(R_{ct} + 2R_l + R_B) \qquad (1)$$

Where:

V_r = Relay circuit voltage

I_f = Secondary external fault current

R_{ct} = CT secondary winding resistance

R_l = Resistance of longest CT lead

R_B = Resistance of other relays/components in CT circuit

For a relay element which is sharply tuned to operate with fundamental frequency current, the stability of the differential protection scheme for an external fault has been, shown by conjunctive tests, to be a function of the RMS differential voltage, given by equation (1).

To achieve through fault stability, the differential relay operating voltage must be increased by adding a stabilising resistor to the relay circuit, as given by equation (2). By increasing the impedance of the relay circuit, most of the spill current resulting from asymmetric CT saturation will be forced to flow through the relatively low impedance of the saturated CT circuit, rather than through the relay circuit. The differential operating voltage required for stability is usually known as the stability voltage setting of the protection

$$V_s = I_s.R_s \qquad (2)$$

Where:

V_s = Stability voltage setting

I_s = Relay current setting

R_s = Stabilising resistance

In equation (2), the resistance of the relay element itself has been ignored, since the resistance of a modern electronic relay is much lower than the external resistance required for through fault stability.

The general stability voltage requirement is described by equation (3), which expresses the required stability voltage setting (V_S) in relation to the relay differential voltage that is given by equation (1) for an external fault. The relationship is expressed in terms of a required stability factor (K).

$$Vs > K.If(Rct + 2Rl + RB) \qquad (3)$$

The assumption that one CT is completely saturated for an external fault does not describe what actually happens when asymmetric CT saturation occurs. The CT that saturates will only saturate during parts of each current wave form cycle. This means that the spill current wave form seen by the restricted earth fault element will be highly non-sinusoidal. The sensitivity of the relay element to non-sinusoidal spill wave forms for through faults will be a function of the relay element frequency response, its operating speed, the differential voltage setting (Vs) and the wave shapes.

Relay frequency response and operating speed are factors which are inherent to the relay design. Spill current wave shapes will be related to the ratio of the CT kneepoint voltage (Vk) to relay circuit impedance. The relay element current setting (Is) will control its susceptibility to given levels of spill current let through the relay circuit impedance (Rs). Since the relay circuit impedance and relay current setting are factors which determine the stability voltage setting (Vs), it is the ratio Vk/Vs which will govern the stability of the restricted earth fault protection for through faults. This ratio, has an influence on the required K factor for stability.

The relationship between the ratio V_K/V_S and the required stability factor K has been found to be of a general form for various relay designs that have undergone conjunctive testing by AREVA. It is the absolute values of V_K/V_S and K that vary in the relationship for different relay designs. Graph 1 displays the relationship that has been found for KBCH restricted earth fault protection by conjunctive testing.

For a selected V_K/V_S ratio, Figure 16 can be used to determine the required factor K so that the stability voltage setting (V_S) can be calculated. Some application complication arises due to the fact that V_S is derived by knowing the required factor K and that the required factor K is dependent on V_S, through the ratio V_K/V_S. An iterative approach is required if the optimum factor K is to be identified for a particular application (figure 17).

The approach with older electromechanical restricted earth fault relays was to use a universally safe K factor of 1.0, but the older relays operated quickly with a lower Vk/Vs ratio (Vk/Vs = 2.0). With more modern relays it is desirable to identify the optimum K factor for stability, so that the required Vk/Vs ratio for stability and operating speed will not make CT kneepoint voltage requirements worse than traditional requirements.

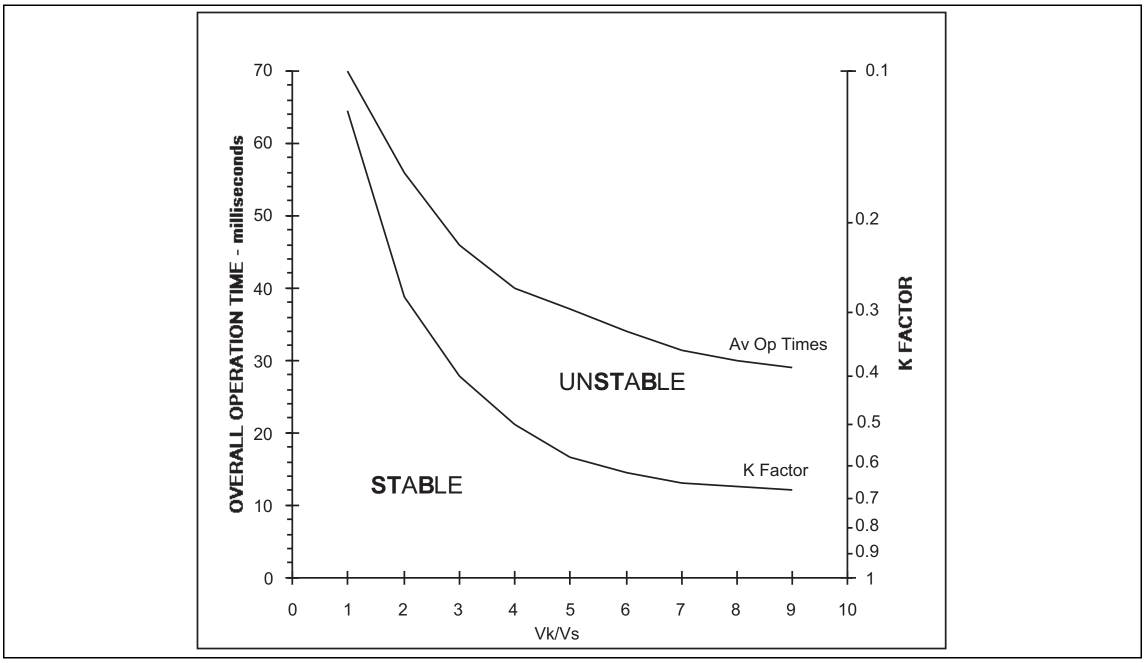


Figure 16: Restricted earth fault operating characteristics

2.3.3 Operating times

Having considered attaining stability of restricted earth fault protection for through faults, the next performance factor to consider is the operating time for internal faults.

The CT kneepoint voltage as a multiple of the protection stability voltage setting (V_K/V_S) will govern the operating time of a differential relay element for heavy internal faults with transiently offset fault current waveforms.

With the aid of the operating time curve derived for KBCH (Figure 16), it is possible to identify the ratio V_K/V_S that is required to achieve a desired average operating speed for internal faults.

2.3.4 Setting procedure

To simplify the procedure for setting a KBCH restricted earth fault element the following flow chart has been produced.

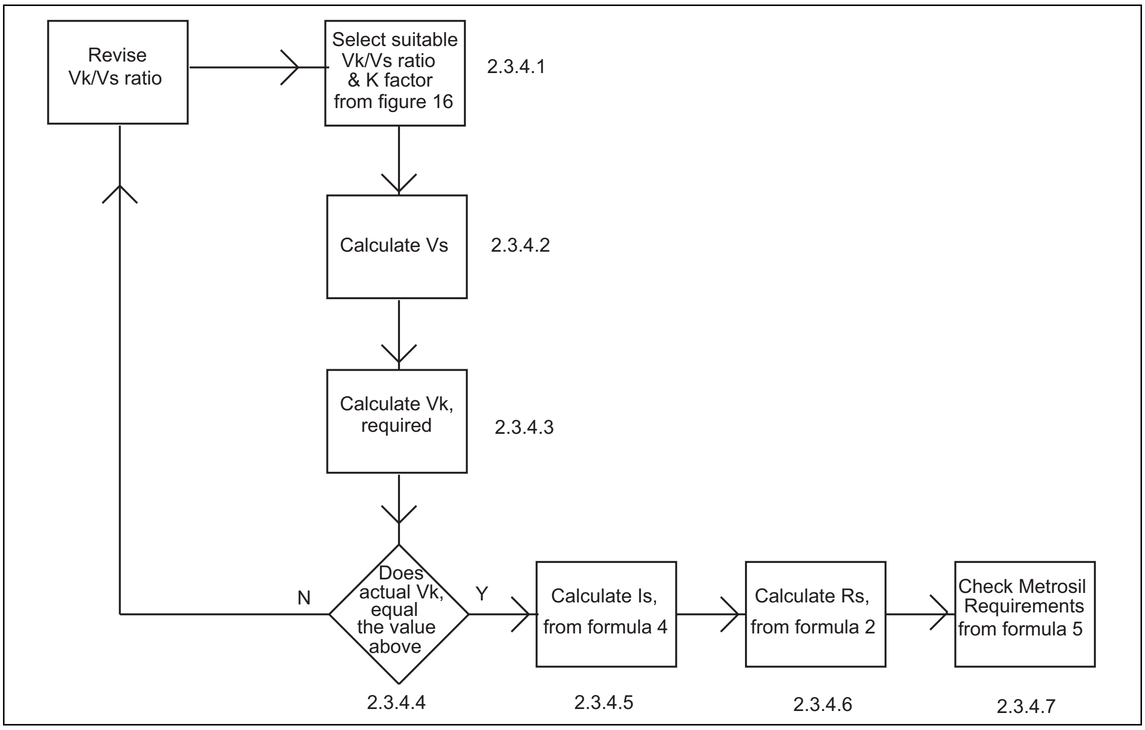


Figure 17: Restricted earth fault setting procedure

2.3.4.1 VK/VS ratio

From the operating time curve (Figure 16), a minimum V_K/V_S ratio should be selected to give satisfactory average internal fault operating times. It is recommended that this ratio should be at least 4.0, to give average operating times of two cycles for a 50Hz system.

2.3.4.2 Stability voltage setting

From figure 16, the required K factor can be read off once the minimum V_K/V_S ratio has been decided. The required K factor will be 0.5 when the target V_K/V_S ratio is 4.0.

Once the required K factor has been established, equation (3) can be applied to determine the required stability voltage setting.

2.3.4.3 CT kneepoint voltage requirement

Once the stability voltage setting has been determined, the REF CT kneepoint voltage requirement can be calculated using the V_K/V_S ratio that was decided upon in section 2.3.4.1.

If the REF CT kneepoint voltage requirement is less than the required voltage for the biased differential protection, see section 4, the CT's must be designed to meet the higher requirement. This means that the REF application procedure, so far, must be repeated using higher V_K/V_S ratios, until the REF CT kneepoint voltage requirement matches the requirement of the biased differential protection. If the required REF CT kneepoint voltage cannot be met for some reason, the application procedure, so far, must be repeated using lower V_K/V_S ratios, until the REF CT kneepoint voltage requirement can be met. This situation might arise when using CT's that are already in situ. The penalty for using a lower V_K/V_S ratio is that the protection average operating times could be longer.

2.3.4.4 Required current setting and CT magnetising current

To achieve the required primary operating current a suitable setting (I_s) must be chosen for the relay.

The recommended primary operating current for REF protection is usually determined by the minimum fault current available for operation.

Typical settings for REF protection are:

Solidly earthed system:-	10 – 60% of winding rated current
Resistance earthed system:-	10 – 25% minimum earth fault current for fault at the transformer terminals.

The primary operating current (I_p), in secondary terms, is a function of the CT ratio, the relay operating current (I_s), the number of CT's in parallel with the relay element (n), and the magnetising current of each CT (I_e) at the stability voltage (V_s).

$$I_p = \text{CT ratio} \times (I_s + nI_e)$$

The required relay current setting (I_s) can be determined by equation (4).

$$I_S < \{I_{OP}/(\text{CT ratio})\} - n.I_e \qquad (4)$$

2.3.4.5 Required stabilising resistor setting

Once the relay current setting has been decided upon, the required stabilising resistor setting can be determined from the relationship described by equation (2).

The stabilising resistors supplied with KBCH are adjustable wire-wound resistors. For 1 Amp rated relays the range of adjustment is 0 – 220Ω, for 5 Amp rated relays the range of adjustment is 0 – 47Ω.

2.3.4.6 Metrosil assessment

For applications where the maximum internal earth fault level is higher than the though fault current used to derive the required stability voltage setting, a check should be made on the peak voltage that might be produced for an internal earth fault, using the traditional formula below. If this voltage to exceeds 3kV peak, a voltage-limiting non-linear resistor (Metrosil) should be applied in parallel with the restricted earth fault relay and stabilising resistor circuit. This requirement should only arise with some applications of restricted earth fault protection for the primary winding of a power transformer on a multiple-earthed system.

The peak voltage can be estimated by using the formula below:

$$Vp = 2\sqrt{2\,Vk\,(Vf - Vk)} \qquad (5)$$

Where; $Vf = If\,(Rct+2Rl+Rs)$

Vk = Actual CT kneepoint voltage

If = maximum internal secondary fault current

Rct = CT secondary winding resistance

Rl = maximum lead burden from CT to relay

Rs = value of stabilising resistor.

The required metrosil for 1Amp relay applications can be chosen as follows,

For stability voltage settings 0 - 125Volts, C = 450

For stability voltage settings >125Volts, C = 900

For 5 Amp applications AREVA T&D should be consulted.

2.4 Overfluxing protection and blocking

2.4.1 Basic principles

The KBCH relay offers an overfluxing protection element which can be used to raise an alarm or initiate tripping in the event of prolonged periods of transformer overfluxing. In addition, a differential current 5th harmonic blocking feature is also provided within the KBCH, which can be used to prevent possible maloperation of the differential element under transient overfluxing conditions.

To make use of the time delayed overfluxing protection, the KBCH relay must be supplied with a voltage signal which is representative of the primary system voltage on the source side of the transformer. The 5th harmonic blocking feature does not require a voltage signal. A 5th harmonic signal is derived from the differential current wave form on each phase and blocking is on a per phase basis.

2.4.2 Transformer overfluxing

Transformer overfluxing might arise for the following reasons:

– High system voltage

Generator full load rejection

Ferranti effect with light loading transmission lines

– Low system frequency

Generator excitation at low speed with AVR in service

– Geomagnetic disturbance

Low frequency earth current circulation through a transmission system

The initial effects of overfluxing will be to increase the magnetising current for a transformer. This current will be seen as a differential current. If it reaches a high level without a waveshape which would cause operation of the inrush blocking system, there would be a risk of differential protection tripping.

Persistent overfluxing may result in thermal damage or degradation of a transformer as a result of heating caused by eddy currents that may be induced in non-laminated metalwork of a transformer. The flux levels in such regions would normally be low, but excessive flux may be passed during overfluxed operation of a transformer.

The following protection strategy is proposed to address potential overfluxing conditions:

– Maintain protection stability during transient overfluxing

– Ensure tripping for persistent overfluxing

In most applications, the recommended minimum differential trip threshold for KBCH, its filtering action and possible operation of the inrush detector will ensure stability of the differential element. If more difficult situations exist, the KBCH relay is offered with a 5th harmonic differential current blocking facility. This facility could be applied with some study of the particular problem.

To ensure tripping for persistent overfluxing, due to high system voltage or low system frequency, the KBCH is provided with time delayed Volts per Hertz protection. Where there is any risk of persistent geomagnetic overfluxing, with normal system voltage and frequency, the 5th harmonic differential current facility could be used to initiate tripping after a long time delay.

2.4.3 Time delayed Overfluxing protection

Two independently adjustable V/f elements are available for overfluxing protection. A definite-time element, with a time setting range of 0.1- 60 seconds, is provided for use as an alarm element. The settings of this element should be such that the alarm signal can be used to prompt automatic or manual corrective action.

Protection against damage due to prolonged overfluxing is offered by a V/f protection element with an inverse time (IDMT) tripping characteristic. The setting flexibility of this element, by adjustment of the time multiplier setting (see figure 18), makes it suitable for various applications. The manufacturer of the transformer or generator should be able to supply information about the short-time over-excitation capabilities, which can be used to determine appropriate settings for the V/f tripping element. The IDMT overfluxing protection would be used to trip the transformer directly.

If preferred, the V/f tripping element can be set with a definite time characteristic.

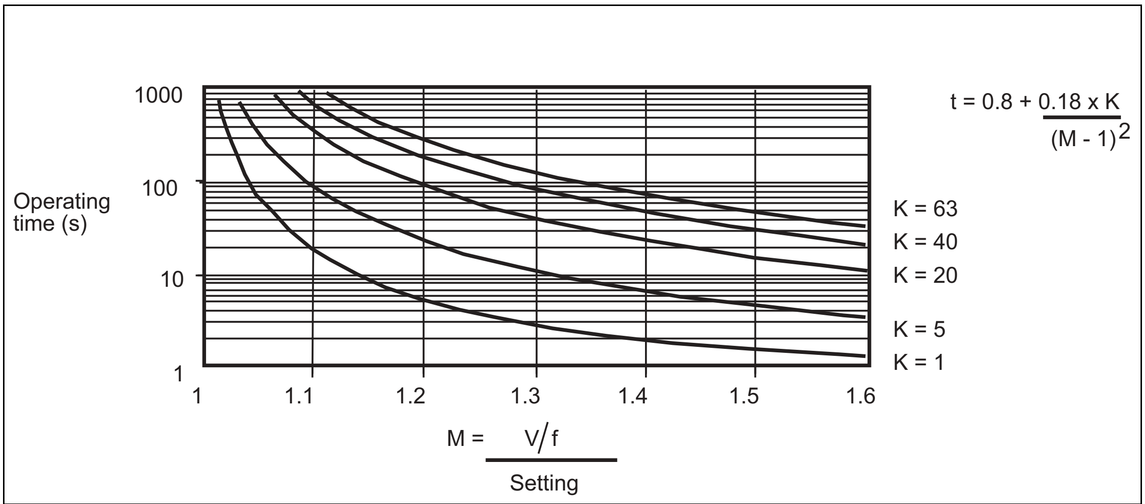


Figure 18: Inverse time (IDMT) Overfluxing protection characteristic

2.4.4 5th Harmonic blocking

The 5th Harmonic blocking feature is available for possible use to prevent unwanted operation of the low set differential element under transient overfluxing conditions.

When overfluxing occurs, the transformer core becomes partially saturated and the resultant magnetising current waveforms increase in magnitude and become harmonically distorted. Such waveforms have a significant 5th harmonic content, which can be extracted and used as a means of identifying the abnormal operating condition.

The 5th harmonic blocking threshold is adjustable between 10 - 50% differential current (Id). The threshold should be adjusted so that blocking will be effective when the magnetising current rises above the chosen threshold setting of the low-set differential protection. Where the magnetising current is just in excess of the differential element setting, the magnetising inrush detection will not be effective in all applications with all types of transformers. AREVA T&D intend to offer some guidance in this respect.

To offer some protection against damage due to persistent overfluxing that might be caused by a geomagnetic disturbance, the 5th harmonic blocking element can be routed to an output contact via an associated timer. Operation of this element could be used to give an alarm to the network control centre. If such alarms are received from a number of transformers, they could serve as a warning of geomagnetic disturbance so that operators could take some action to safeguard the power system. Alternatively this element can be used to initiate tripping in event of prolonged pick up of a 5th harmonic measuring element. It is not expected that this type of overfluxing condition would be detected by the AC overfluxing protection. This form of time delayed tripping should only be applied in regions where geomagnetic disturbances are a known problem and only after proper evaluation through simulation testing.

2.4.5 Required settings

IDMT / DT V/f element

The pick up for the overfluxing elements will be dependant upon the nominal core flux density levels.

Generator transformers are generally run at higher flux densities than transmission and distribution transformers and hence require a pick up setting and shorter tripping times which reflect this. Transmission transformers can also be at risk from overfluxing conditions and withstand levels should be consulted when deciding upon the required settings.

A setting range of 1.5 to 3 Volts/Hz is provided

Example

A required setting of 1.05 pu overfluxing factor with a 110V VT secondary on a 50Hz system would require a setting on the relay of 110/50Hz x 1.05 = 2.31 V/Hz.

3 OTHER PROTECTION CONSIDERATIONS

3.1 Use of auxiliary opto isolated inputs

KBCH provides 8 auxiliary timer circuits, Aux0 – Aux7, as shown in Figure 19. These can be used as timers or, if the time setting is set to zero, as simple auxiliary follower relays, with the advantage that operation of these followers will be event- logged and monitored via the K bus communication link. Operation of any auxiliary timer will illuminate the yellow warning LED on the relay front plate.

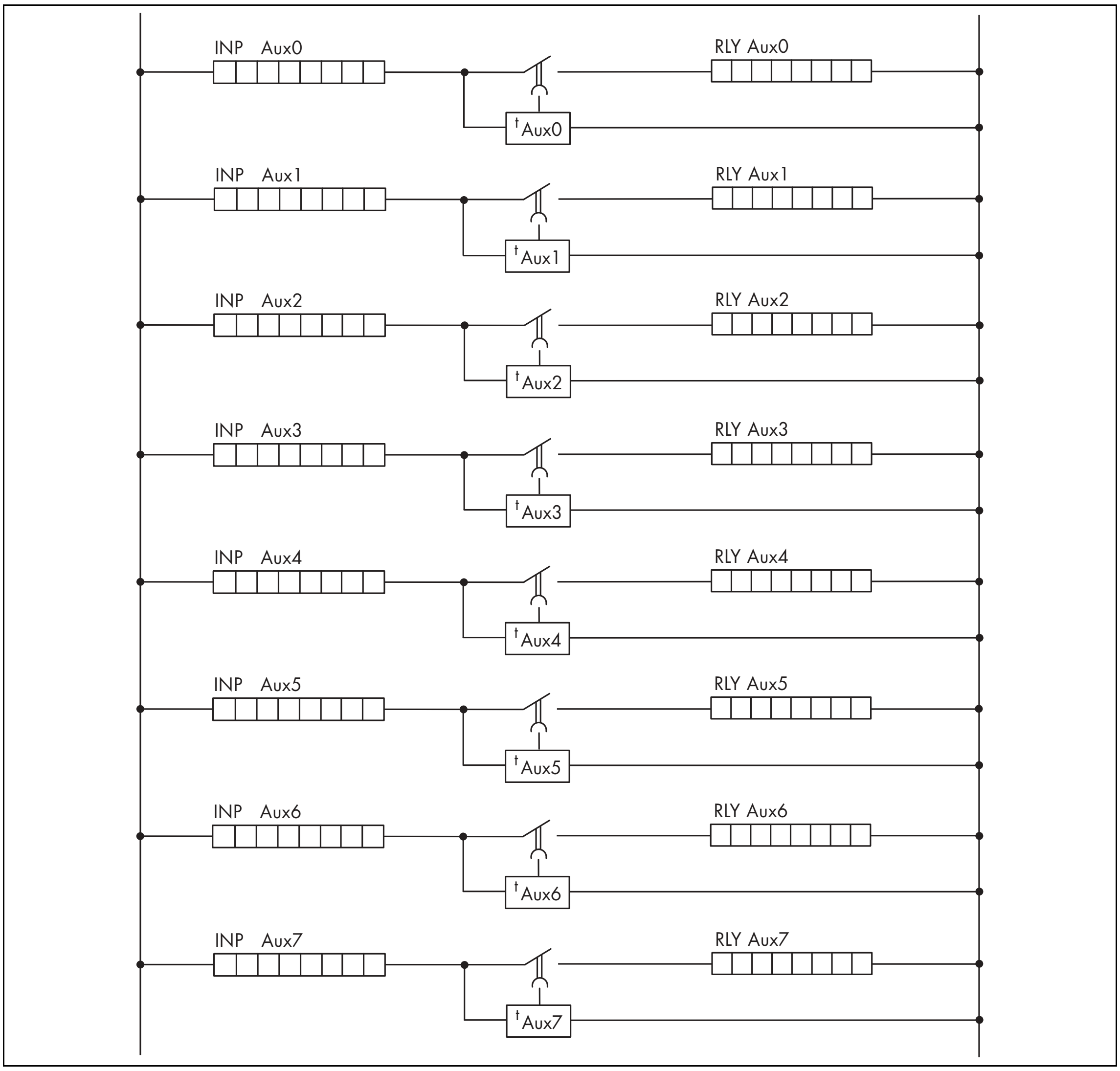


Figure 19:

Buchholz protection could be connected in a protection scheme with a KBCH relay. The Buchholz alarm (gas) contact could energise an opto input which is programmed to operate one of the auxiliary timer paths. Operation of the opto input will be logged as an event in the relay's event record. A replacement alarm output contact can be provided, if required, by using the follower elements output relay mask. The timer could be set to zero.

Since the Buchholz relay provides independent protection it should be able to initiate tripping independently of the KBCH. This means that the Buchholz trip (surge) contact should be wired to trip the transformer circuit breaker(s) directly or via a separate auxiliary relay. Where Buchholz trip operation is to be event-logged by KBCH, the auxiliary relay approach can be adopted so that a volt free contact will be available for KBCH opto control. Alternatively, a group of opto isolators could be fed from the protection auxiliary supply, rather than the 48V field voltage of the relay, as long as suitable series resistors are used (see below Figure 20).

With this approach the Buchholz surge contact could initiate breaker tripping directly, through a suitable diode, as well as through the KBCH auxiliary path (see Figure 20).

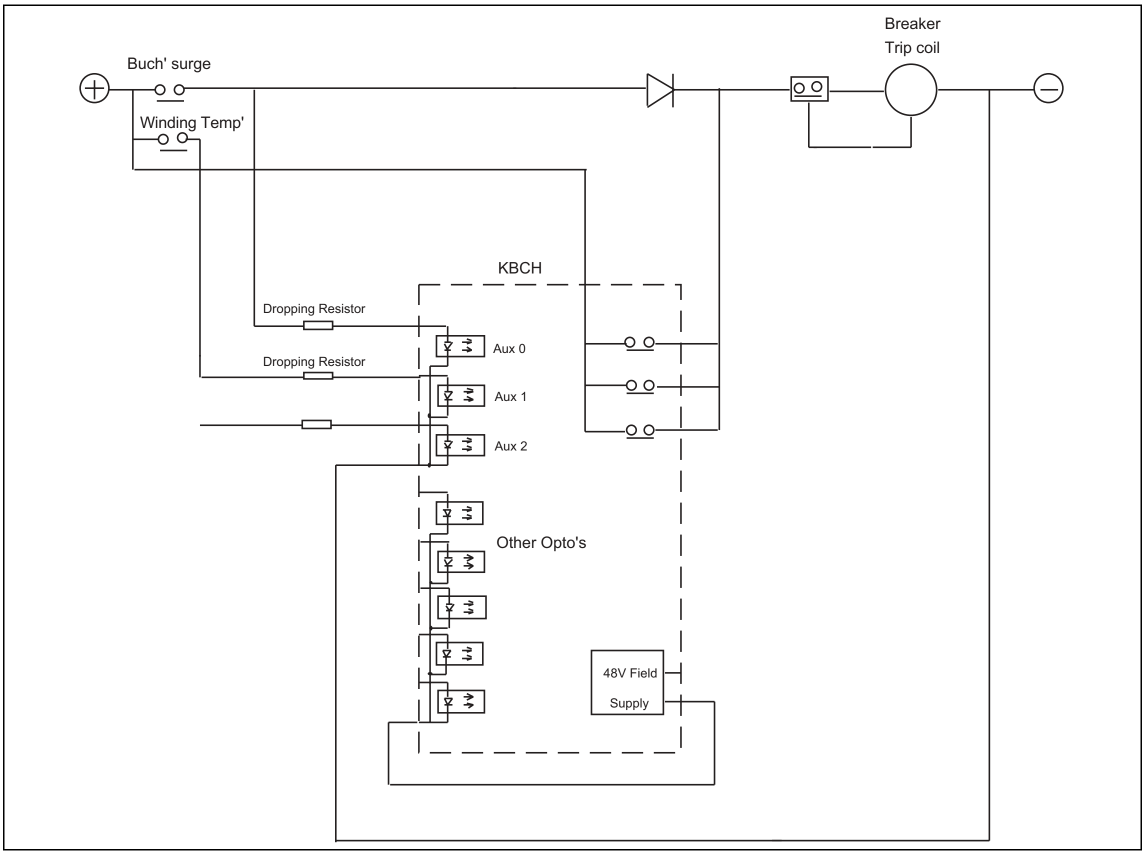


Figure 20: Use of opto isolators with protection Auxiliary supply.

Opto-inputs for the KBCH are 50V, 10kΩ.

Required values of dropping resistor:

Auxiliary supply 110/125V – 10kΩ, 1.0W

220/250V – 33kΩ, 2.0W

A label area is provided on the front of the relay where the function of each KBCH auxiliary element can be described.

Other transformer ancillary protection or alarm devices, e.g. winding/oil temperature, low oil level, pressure relief valves etc, may be connected in a similar fashion to provide event record data. All ancillary trip paths should be independent of the KBCH, as described for Buchholz protection.

3.2 Tap changer control

The KBCH offers the possibility of remote manual tap changer control, via K-bus communication. Remote commands act on KBCH scheme logic timers which can be set up to operate any of the output relays, as illustrated in Fig 21. This remote control facility may be of interest for tapping parallel transformers apart to reduce reactive load current prior to switching out a transformer. This practice is often adopted to minimise step changes in consumer supply voltage when switching out a transformer.

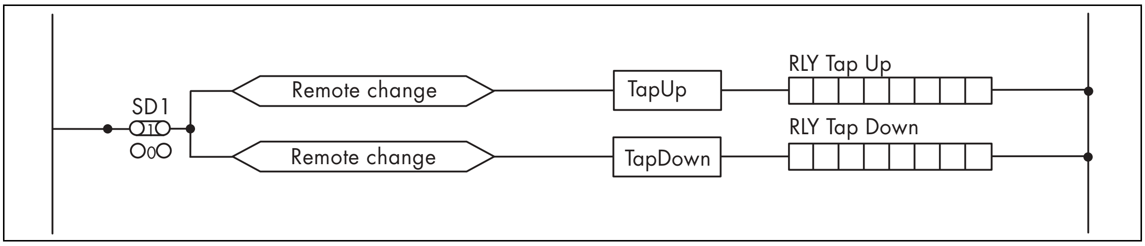


Figure 21: Tap changer controls

3.3 Generator / Reactor / Auto-transformer protection

As with any biased differential relay, the KBCH can be applied as differential protection for any item of plant which has some internal impedance.

Auto-transformers can be adequately protected by a high impedance relay circulating current scheme, but where a delta tertiary winding is present, protection of this winding will not be provided by such a scheme. Application of a biased differential relay in the conventional way will give a measure of inter turn fault protection and it will also detect delta tertiary phase faults. Detection of tertiary earth faults will be dependant on tertiary winding earthing.

For some auto transformer applications, with a loaded tertiary winding, the range of ratio compensation offered by KBCH may not be sufficient for the tertiary CT signals. In rare cases, an external interposing current transformer may be required.

3.4 Generator transformers / Unit transformers

For large generator applications it is common to provide separate differential protection schemes for the generator, main transformer and for the unit transformer. In addition, an overall system differential relay is often employed as back up.

The KBCH compliments the P340 range integrated generator protection package and the P140 digital overcurrent relay range to offer protection for generating plant. Overfluxing protection for the entire plant is provided by the KBCH (see Fig 22).

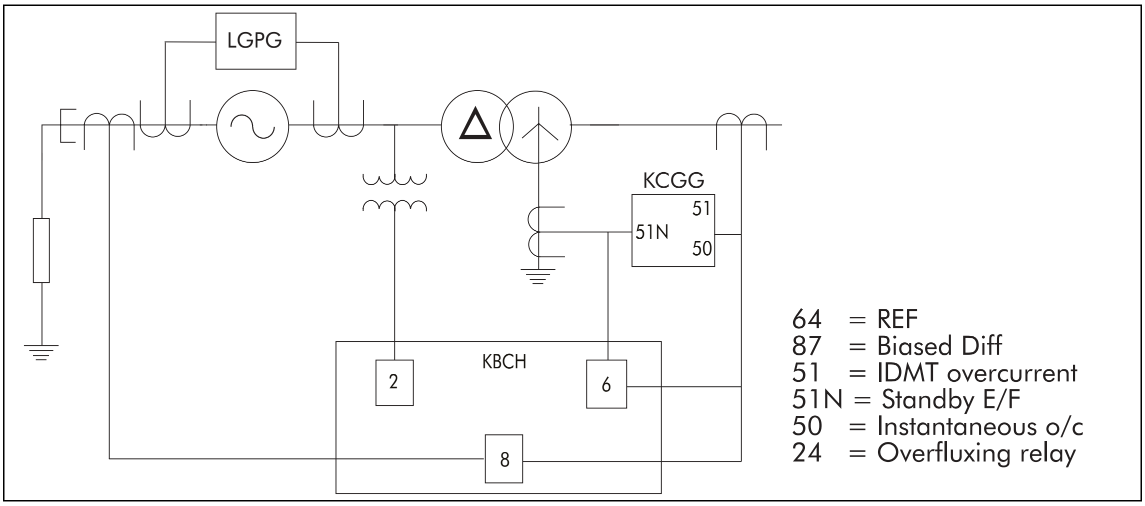


Figure 22: Generator and Generator Transformer protection

If a unit transformer is directly connected at the generator terminals a number of considerations apply.

The unit transformer current for an LV system fault must be eliminated for large unit transformers in the Generator/transformer differential protection by connecting the protection as a three ended scheme. Practice has varied in the past and Figure 23 shows that the unit transformer CTs can be placed on the primary or secondary side of the unit transformer.

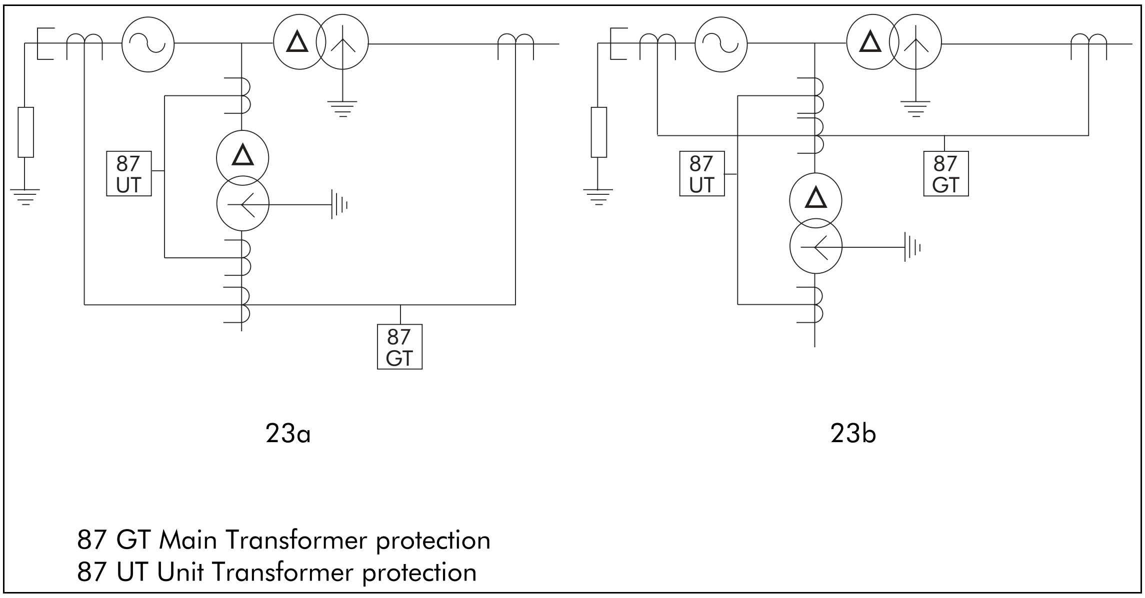


Figure 23: Unit transformer configurations

Placing the unit transformer in-zone, as figure 23a, may not afford adequate protection for the unit transformer. The unit transformer's relatively low rating, and corresponding high impedance, may mean that the main generator/transformer differential protection will not be sensitive to faults within the unit transformer. The degree of ratio compensation required for the unit transformer LV CT's may also be in excess of the KBCH ratio compensation setting range.

The unit transformer should generally have separate protection, for example a dedicated differential relay, and the unit transformer may be placed outside the main generator transformer differential zone to give correct discrimination and relay operation for all faults, as illustrated in figure 23b.

3.5 K-Series and MiCOM schemes

The Midos K-range of relays offers integrated protection modules which cover numerous applications - such as directional and non-directional overcurrent protection, auto-reclose and check synchronising. In combination with the P340 range integrated generator protection package, the KBCH transformer differential protection offers a completely digital protection approach for generating plant as well as for substations (Fig 24).

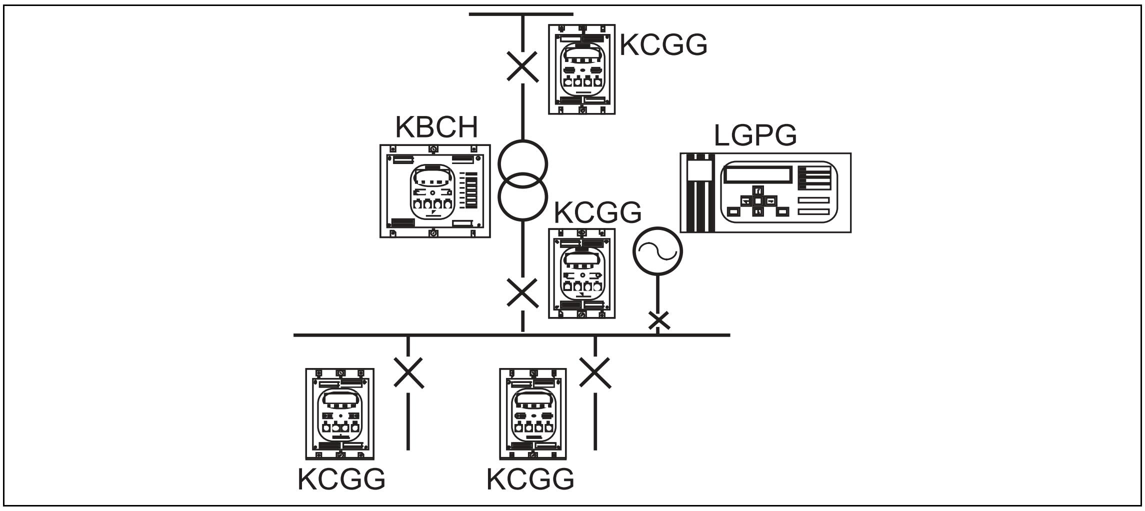


Figure 24: Combined digital protection scheme.

Simple serial communications hardware enables the numerical relays to be accessed locally or remotely from a common point (Fig 25). This allows the user access to a comprehensive array of fault records, event records and disturbance records.

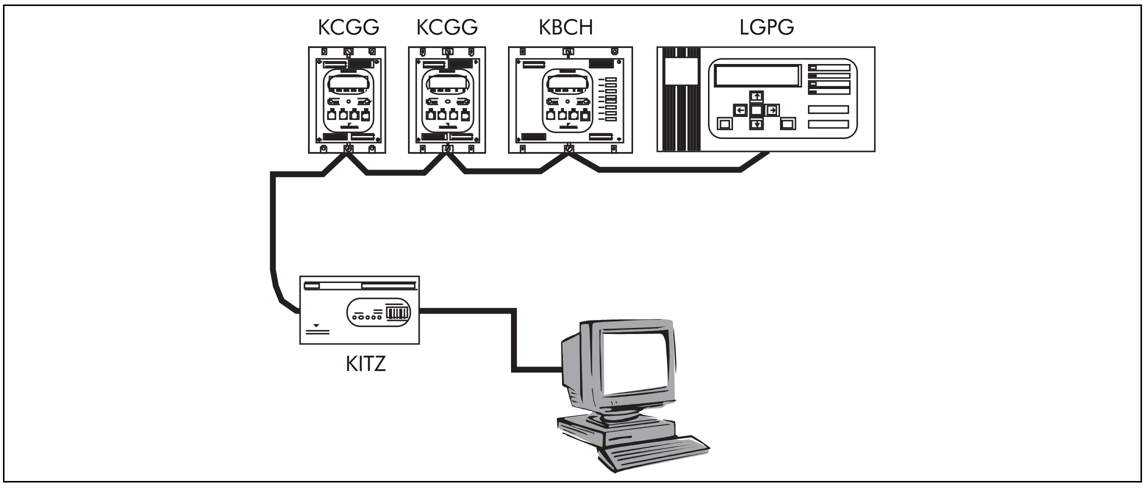


Figure 25: Digital relays on a K-bus communications network

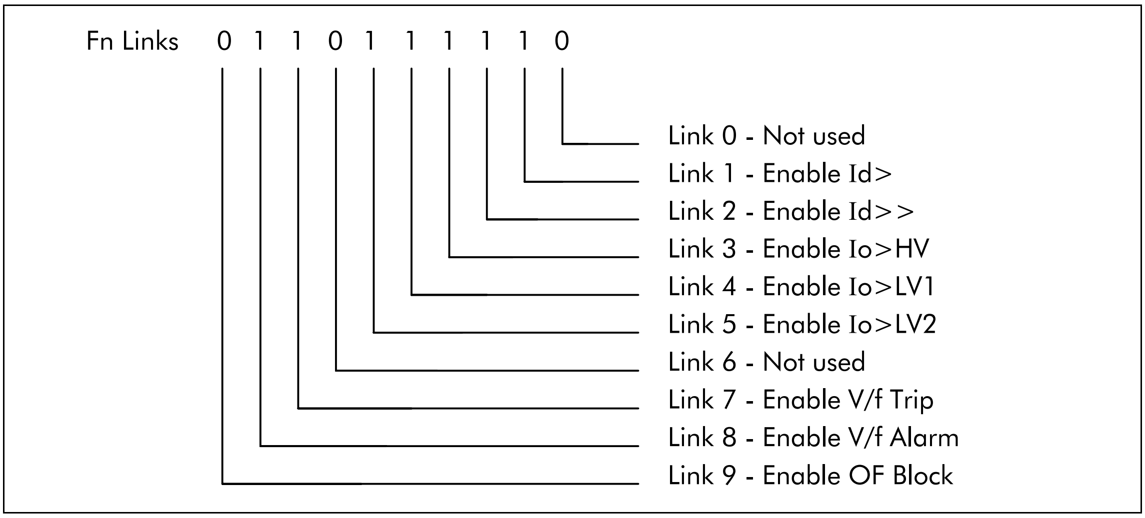
Facilities are not provided within the KBCH to record circuit breaker trip times, number of circuit breaker operations or the summated contact breaking duty that can be recorded by K series overcurrent relays. If this information is required, the overcurrent relay fitted as back-up protection can be utilised. When the KBCH initiates tripping an output contact from the KBCH can be programmed to activate an auxiliary element via an opto-isolated input on the K-series overcurrent relay. The activated auxiliary on the overcurrent relay must have relay 3 or 7 programmed as its output contact to enable it to log the circuit breaker data.

4 RECOMMENDED SETTINGS AND CT/VT REQUIREMENTS

4.1 Recommended settings

The following settings are recommended and are applied to the relay as default settings. The relevant sections of the application notes should be cross referenced prior to applying the settings ensuring they are correct for the application.

Setting Function links



Differential element (Sections 2.1 and 2.2)

– Differential setting of biased differential element, Id>= 0. 2In

– Differential high set setting, Id>> = 10 In

Restricted earth fault element (Section 2.3)

– Restricted earth fault setting HV, Io> = 0.1

– Restricted earth fault setting LV, Io> = 0.1

– Stabilising resistor value , see section 2.3.2

Overfluxing protection and blocking (Section 2.4)

– 5th harmonic blocking % setting = 50%

– 5th harmonic blocking timer, tOF = 10.0s

– V/f overfluxing pick up setting, trip=2.42V/Hz (110V VT on a 50Hz system, 10% overflux)

– V/f (Trip) characteristic = IDMT

– V/f (Trip) TMS = 1.0

– V/f overfluxing pick up setting, alarm=2.31V/Hz (110V VT on a 50Hz system, 5% overflux)

– V/f (Alarm) timer setting = 10s

4.2 CT connection requirements

As with any protection relay the current transformer requirements have to be given careful consideration. This consideration is particularly important when applying differential relays, as the location of the CT's and their performance under through fault conditions can have a significant affect on operation of the protection.

The location of the CT's effectively defines the zone of operation of the protection for both the differential element and for the restricted earth fault element. The number of CT's required is dependant upon the transformer configuration as shown in figure 26.

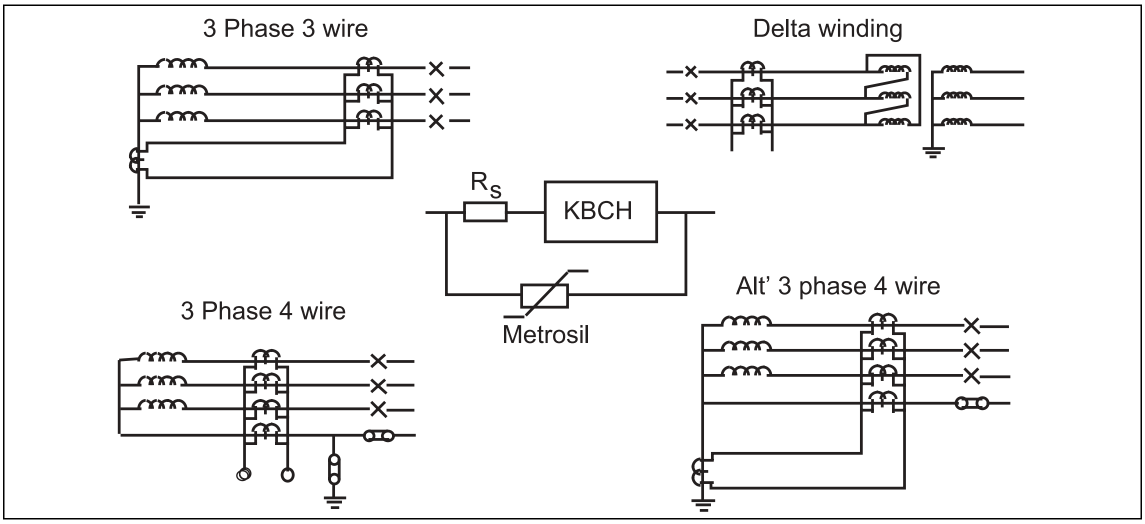


Figure 26: Current transformer location requirements

Since the majority of faults are caused by flashovers at the transformer bushings, it is advantageous to locate the CT's in adjacent switchgear. This also has the advantage of incorporating the LV cables within the zone of protection.

To provide effective protection, CT's should be arranged to overlap other zones of unit protection, so that no blind spots exist.

Where suitable ratio correction or phase compensation can not be provided with the KBCH software interposing CT's, an external interposing CT should be used. A range of suitable interposing CT's are available from AREVA. These should be used wherever possible to ensure proper protection performance.

To guarantee high set stability for very heavy through faults, when using a KBCH 130/140 on a mesh substation connection, the leads from the mesh CT's or one and a half switch bay should be approximately balanced.

To ensure that the quoted operating times and through fault stability limits are met the ratio of $Vk_A/Rtot_A$: $Vk_B/Rtot_B$, at biased inputs either side of the protected impedance, should not exceed a maximum disparity ratio of 3:1. This ensures that during a through fault condition the flux density in the current transformers is not greatly different.

Where; VkA = Knee point voltage of CT at end A

RtotA = Total burden connected to CT at end A = (RCT + 2Rl + RB)

VkB = Knee point voltage of CT at end B

RtotB = Total burden connected to CT at end B = (RCT+ 2Rl + RB)

4.3 C.T Requirements

When deciding upon the current transformer requirements for the KBCH three factors must be taken into account;

– The CT's must meet the minimum requirements for relay operation.

– The CT's must meet the requirements for through fault stability of the differential element.

– The CT's must meet the requirements for operation and through fault stability of the restricted earth fault element(s). (see section 2.3.4.3)

4.3.1 Minimum requirements

The knee point voltage of the CT must meet with the requirements given in sections 4.3.2 and 2.3.4.3 with a minimum value:

Star connected CT's	$\frac{60}{In}$
Delta connected CT's	$\frac{100}{In}$

4.3.2 Requirements for the biased differential protection

Application	Knee point voltage, V_k	Through fault stability limit	
		X/R	If
Transformers	$V_k > 24I_n[R_{ct}+2R_1+R_B]$	40	$15I_n$
Generators, or Generator transformers, or Block Differential (Overall generator, generator transformer and unit/station transformer), or Motors, or Shunt reactors.	$V_k > 24I_n[R_{ct}+2R_1+R_B]$	40	$15I_n$
	$V_k > 48I_n[R_{ct}+2R_1+R_B]$	120	$15I_n$

Application	Knee point voltage, V_k	Through fault stability limit	
Series reactors or Transformers connected to a mesh corner with two sets of CT's supplying separate biased relay inputs.	$V_k>24I_n[R_{ct}+2R_1+R_B]$	40	$15I_n$
	$V_k>48I_n[R_{ct}+2R_1+R_B]$	40	$40I_n$
		120	$15I_n$

Where R_B = Resistance of interposing CT and other relays/components in CT circuit.

In the majority of cases interposing current transformers are not required and the CT requirements should be modified to remove the burden of the ICT (R_B).

Where line CT's are connected in Delta, an additional factor must be taken account of in the CT requirements i.e.

$$Vk\ .\ 24.\ \sqrt{3}.I_n[R_{ct}+2R_l].$$

The above current transformer requirements are based upon results of conjunctive relay/C.T tests performed by AREVA with a heavy current test plant.

It may be necessary on occasions to use CT's where the requirements detailed above for biased differential operation are not met. If this is the case the following should be taken into account when modifying the CT equation.

The degree of CT saturation that could occur for a through fault will be dependant upon the through fault current magnitude and the X/R ratio for the impedance limiting the current (X/R ratio governing the rate of decay of any transient DC component of current waveform). For a transformer differential application, the X/R ratio will be moderate (less than 30) and the through fault current will be fairly high (above 10In). For a generator differential application, the X/R ratio could be fairly high (above 100) but the maximum through fault current could be fairly low (less than 5In). It is more difficult to assure stability for a generator circuit application, due to the fact that the bias current can be fairly small in magnitude compared to the degree of CT saturation that could occur in the presence of a transient DC component with a slow rate of decay. This is why better CT's are required for high X/R applications.

As can be seen, the KBCH CT requirements are specific to two categories; one for X/R ratios up to 40 (representative of transformer differential applications) and the second for X/R ratios up to 120 (representative of generator circuit applications). A reduction in the required CT Vk requirements can not be recommended on the basis of reduced through fault current for the reasons given above. On the assumption that the level of CT saturation will be proportional to If x X/R, the CT Vk factor for a generator circuit can be reduced from 48 depending on the actual X/R in proportion to 120. The following formula would then apply:-

$$Vk > [24 + 24(X/R - 40)/(120 - 40)]\ .\ [Rct + 2R1]$$

4.4 Voltage transformer requirements

When using the V/f overfluxing protection element a voltage transformer signal is required from the source side of the protected transformer; i.e. the side from which the overfluxing condition may be imposed. To cover all applications, a phase to phase connection is used. If phase to neutral volts were used there is a possibility that fast IDMT V/f tripping times could occur due to voltage rises on healthy phases during earth faults. With multiple earthed systems, the healthy phase to neutral voltages are allowed to rise to 80% of the phase to phase voltage. This means that the phase to neutral voltage could rise to 139% on healthy phases during an earth fault.

The V.T input is rated 100 –120V A.C.

APPENDIX A

APPENDIX A

Transformer connection referencing system

The transformer HV windings are indicated by capital letters, and the LV winding by small letters. The numbers refer to positions on a clock face and indicate the phase displacement of balanced 3-phase LV line currents with respect to balanced 3-phase HV line currents. An additional N, Ynd1, (lower case for LV, n) indicates a neutral to earth connection on the respective winding of the power transformer. This bears no relationship to the required phase connection and has been omitted from the relay menu. The presence of an in-zone earth connection does, however, demand a zero sequence current filter, as discussed in section 2.1.3.

Example 1:- A Ynd1 connection indicates a two winding transformer with an earthed, Star-connected, high voltage winding and a Delta-connected low voltage winding. The low voltage balanced line currents lag the high voltage balanced line currents by 30° (–30° phase shift).

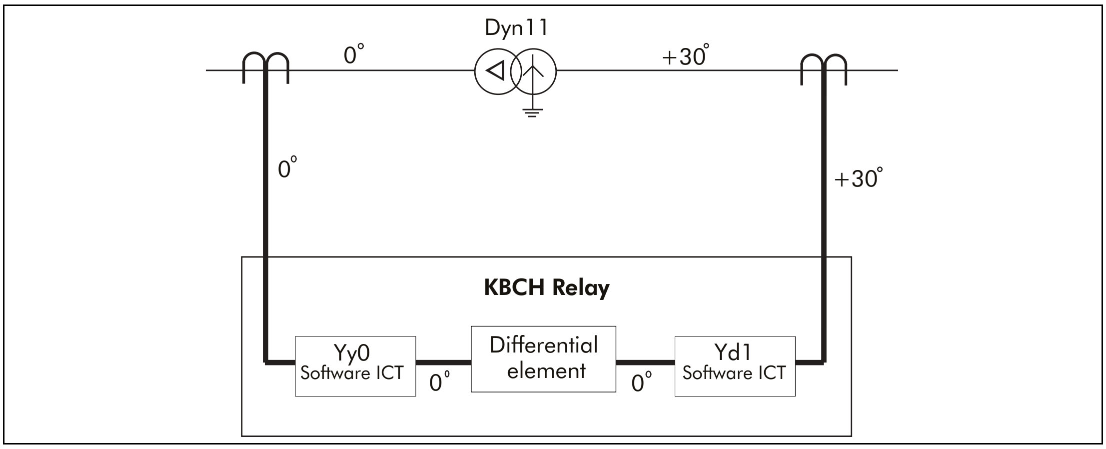
Example 2:- A Dyn1yn11 connection indicates a three winding transformer with a Delta-connected high voltage winding and two earthed Star-connected low voltage windings. The phase displacement of the first LV winding with respect to the HV winding is 30° lag (–30° phase shift), the phase displacement of the second LV winding with respect to the HV winding is 30° lead (+30° phase shift).

APPENDIX B

APPENDIX B

Zero sequence current filtering worked examples.

Example:- Transformer connection, Dyn11



The phase correction for the transformer is provided by the selection of the phase correction factors;

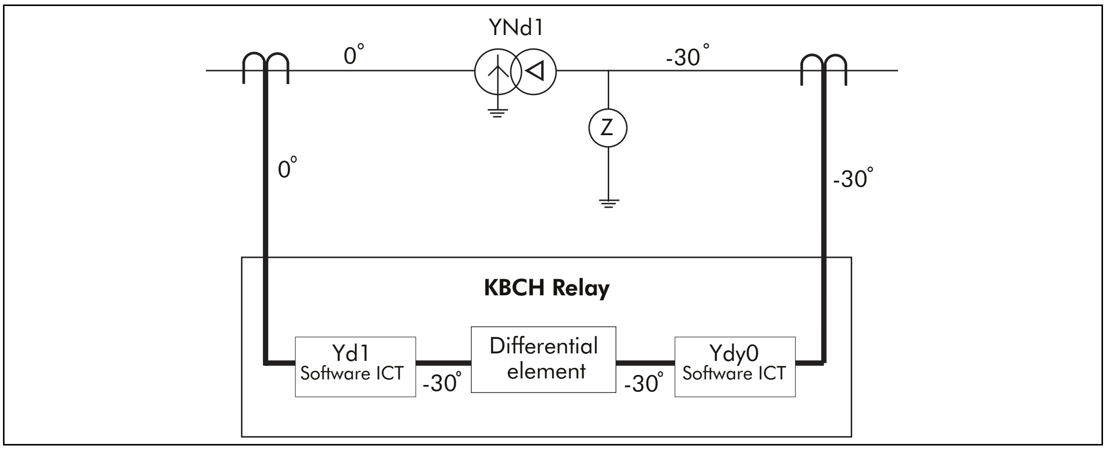
– HV phase correction factor: Yy0

– LV phase correction factor: Yd1

As can be seen, the delta winding introduced with the LV software interposing CT will provide the required zero sequence trap, as would have been the case if the vector correction factor has been provided using an external interposing current transformer.

If, in the above example, the line CTs on the LV side of the transformer are connected in delta then the HV and LV software Interposing CT's could both be set to Yy0, since the required phase shift and zero sequence trap is provided by the line CT's.

Example 2:- Transformer connection, YNd1 with in zone earthing transformer.

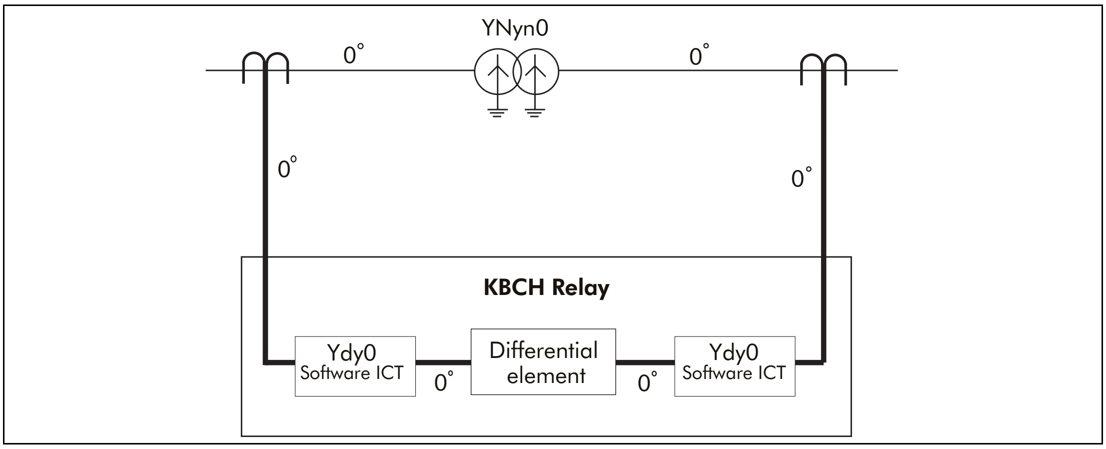


The phase compensation for the transformer is chosen to compensate for the –30° phase shift across the transformer. Before setting the software interposing CT's the earthing arrangements and the requirements for zero sequence traps must be considered.

With the star point of the HV winding earthed there is a possibility that an external HV earth fault could cause relay maloperation as a corresponding zero sequence current would not flow in the LV CT's. This matter can be dealt with by selecting a Yd1 HV software ICT, which also provides the required phase correction.

With the LV earthing transformer connected within the zone of protection, it is also possible for an external earth fault on the LV side of the transformer to cause the differential element to become unstable. A zero sequence trap is therefore also required for the LV side of the transformer. This can be arranged by selecting a Ydy0 LV software interposing current transformer to provide the required zero sequence trap without adding any additional phase shift.

Example 3:- Transformer connection YNyn0



Whenever an in zone earthing connection is provided, a zero sequence trap should always be provided. In this example, there will be some difference between HV and LV zero sequence currents as a result of the zero sequence magnetising current of the transformer. This is normally small, but not if a three limb core is used. To avoid any problems with any application the above rule for zero sequence traps should be applied with earthed windings.

APPENDIX C

APPENDIX C

Setting examples.

Example 1:- Ratio compensation with tap changer.

When deciding upon the required ratio connection factors for the differential element, checks should be made to ensure that the optimum differential setting has been chosen.

For simplicity the following procedure can be followed:-

– Calculate HV full load current at mid tap volts and LV full load current

– Adjust ratio compensation for In to relay on both sides at mid tap

– Calculate HV full load current at both tap extremities

– Determine Idiff at both tap extremities (with mid tap correction)

– Determine Ibias at both tap extremities (with mid tap correction)

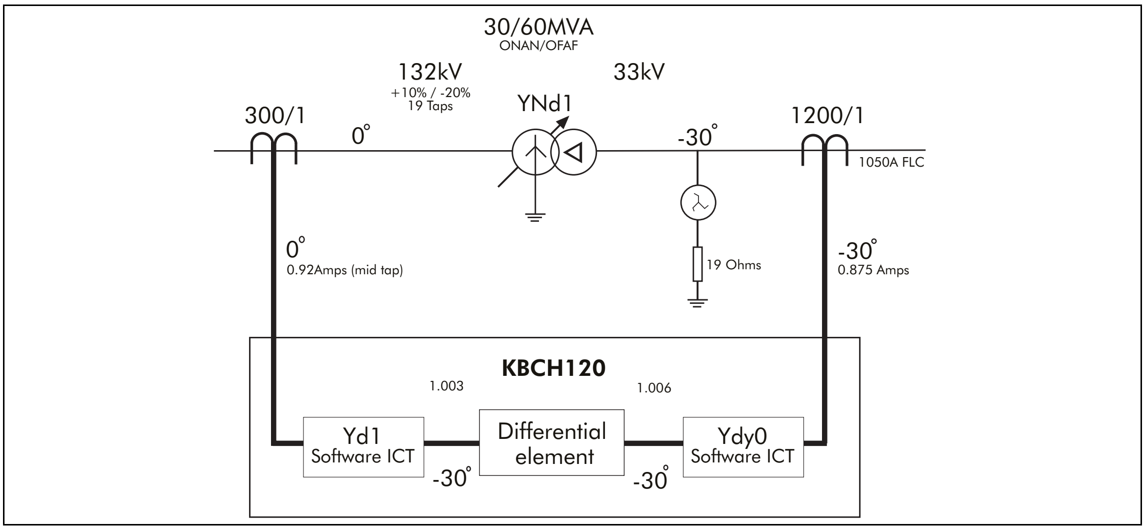
$$\text{Ibias} = (I_{RHV} + I_{RLV}) / 2$$

Where I_R = current to the relay after ratio compensation has been applied.

– Determine relay operating current, $\text{Iop} = I_s + 0.2\ \text{Ibias}$ (Ibias < In)

– Check Idiff , <Iop by a 10% margin for each tap extremity and adjust I_s as necessary

– Calculate HV full load current at mid tap volts and LV full load current



19 Tap positions = 18 Tap increments; Tap 1 = +10%, Tap 19 = –20%

$$\text{Tap increment} = \frac{10\% - (-20\%)}{18} = 1.67\%$$

$$\text{Mid Tap range} = 132\text{kV}\left(\frac{100 + (10 - 20)/2}{100}\right) = 95\% \text{ of } 132\text{kV} = 125.4\text{kV}$$

$$= (\text{Tap No } 10)$$

HV FLC on Tap 10 $= \dfrac{60 \times 10^3}{125.4 \times \sqrt{3}}$ = 276A Primary = 276 x 1/300A Secondary

= 0.92A secondary

LV FLC = $\dfrac{60 \times 10^3}{33 \times \sqrt{3}}$ = 1050A Primary = 1050 x 1/1200A Secondary

= 0.875A secondary

– Adjust ratio compensation for In to relay on both sides at mid tap.

Required HV ratio compensation factor = 1.0/0.92 = 1.087, select 1.09

Required LV ratio compensation factor = 1.0/0.875 = 1.142, select 1.15
(1.14 could be selected for the LV compensation factor but 1.15 gives the lowest spill current).

– Calculate HV full load current at both extremities

HV Full load current on tap 1 (10%) $= \dfrac{60 \times 10^3}{132 \times 1.1\sqrt{3}}$ = 293A Primary

= 239 x 1/300 Amp secondary

= 0.797A secondary

HV corrected current on tap 1 = 1.09 x 0.797 = 0.869 Amps

HV Full load current on tap 19 (–20%) $= \dfrac{60 \times 10^3}{132 \times 0.8\sqrt{3}}$ = 328A Primary

= 328 x 1/300 Amp secondary

= 1.093A secondary

HV corrected current on tap 19 = 1.09 x 1.093 = 1.191 Amps

– Determine Idiff at both extremities (with mid tap correction).

LV corrected current = 0.875 x 1.15 = 1.06 Amps

Idiff at tap 1 = 1.006 – 0.869 = 0.137A

Idiff at tap 19 = 1.191 – 1.006 = 0.185A

– Determine Ibias at both extremities (with mid tap correction).

Ibias = $(I_{RHV} + I_{RLV}) / 2$

Bias current on tap 1 = (0.869 + 1.006) / 2 = 0.9375 Amps

Bias current on tap 19 = (1.191 + 1.006) / 2 = 1.0985 Amps

– Determine relay operating current, Iop

– Operating current at tap 1 with Ibias = 0.9375A, Is = 0.2

Iop = I_s + 0.2Ibias = 0.2 + 0.2 x 0.9375 = 0.3875A

Operating current at tap 19 with Ibias = 1.0985A, Is = 0.2

$$Iop = I_s + 0.2 + (Ibias - 1.0) \times 0.8 = 0.2 + 0.2 + (1.0985 - 1.0) \times 0.8$$

$$= 0.4788A$$

– Check Idiff < Iop by a 10% margin for each tap extremity and adjust Is as necessary.

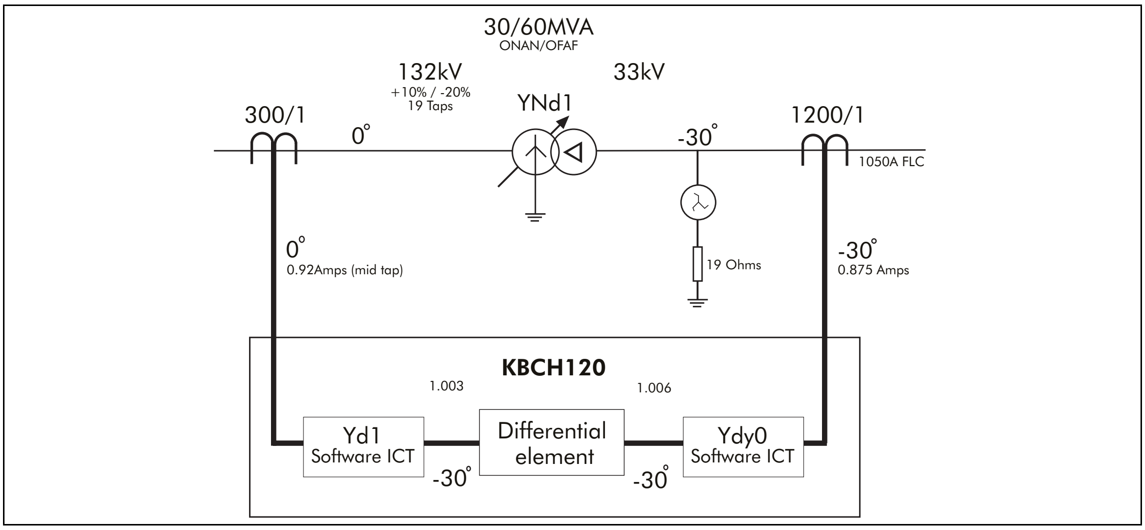
Tap 1:- Since Idiff = 0.137A and 0.9Iop at tap 1 = 0.9 x 0.3875 = 0.349A

Therefore there is sufficient security with Is=0.2

Tap 19:- Since Idiff = 0.185A and 0.9Iop at tap 1 = 0.9 x 0.4788 = 0.431A

Therefore there is sufficient security with Is=0.2

Example 2:- Ratio correction for a three winding transformer with no tap changer.



– Calculate HV and LV full load currents.

The HV full load current of the transformer $= \dfrac{50MVA}{22kV\sqrt{3}}$ = 1312 Amps

= 0.875A secondary

The LV1/2 full load current of the transformer = $\dfrac{50MVA}{11kV\sqrt{3}}$ = 2624 Amps

= 1.75A secondary

It is necessary to calculate the low voltage winding full load currents based on the HV winding MVA rating to ensure secondary currents balance for all conditions.

– Adjust ratio compensation for In to relay on both sides.

The HV ratio compensation factor would be set to 1/0.875 = **1.14**
The LV1 and LV2 ratio compensation factor would be set to 1/1.75 = **0.57**

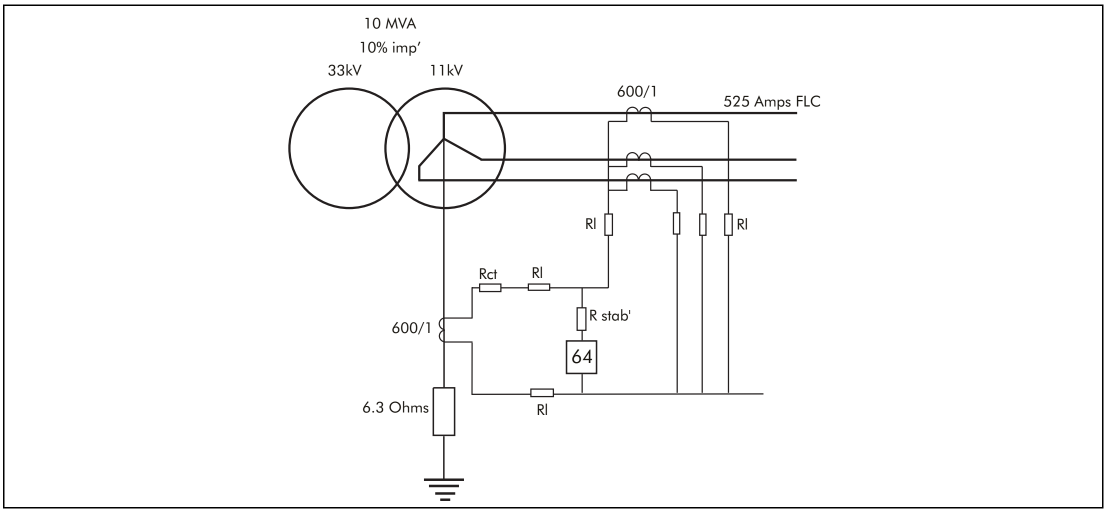
– Determine Idiff, Ibias and Iop (with a 20% setting)

Idiff = (1.14 x .875) – (.57x1.75) = 0
Ibias =(0.9975 + 0.9975)/2 = 0.9975
Iop = 0.2 + 0.2x.9975 = 0.3995
Since Idiff=0 and 0.9Iop = 0.9 x 0.399 =0.36A, there is sufficient security with Is = 0.2

APPENDIX D

APPENDIX D

Restricted earth fault setting example



Where Rct = 3.70, Vk = 91 volts, Rstab = 0 – 220Ω

Max lead length = 50m, Rl = 0.057 (1.14/km)

Following the procedure detailed in Figure 17 a suitable Vk/Vs ratio, K Factor and hence operating speed can be chosen.

– Select suitable Vk/Vs ratio and K Factor.

For general applications a typical operating speed of two cycles is sufficient and a K Factor of 0.5 with a VK/Vs ratio of 4 can be chosen.

– Calculate stability voltage, Vs.

The required stability voltage can be calculated using formula 3

$$Vs = K.If\ (Rct + 2Rl)$$

If = max' secondary through fault current

As the earth fault current in this application is limited to 1000A the maximum through fault current will be an external three phase current. An estimation of the maximum three phase fault current can be estimated by ignoring source impedance;

If = secondary full load current / transformer % impedance.

If = 0.875A / 0.1 = 8.75 Amps

Vs = 0.5 x 8.75 (3.70 + 2x0.057) = 16.7 volts

Calculate and check Vk requirements.

Vk = 4 Vs = 66.8 volts

Actual Vk = 91 volts, which results in a Vk/Vs ratio = 5.5 and, as can be seen from figure 16, with a factor of 0.5 the protection would be unstable. An iterative approach is adopted to achieve the desired settings.

From figure 16 a Vk/Vs ratio = r requires a K Factor = 0.6 for stability.

Vs can now be re-calculated based on these values.

Vs = 0.60 x 8.75 (3.70 + 2 x 0.114) = 20.0 volts

$Vk = 4\ Vs = 80.0$ volts

Actual Vk = 91 volts, which results in a Vk/Vs ratio = 4.55 and, as can be seen from figure 16, with a K Factor of 0.36 the protection is stable.

– Calculate relay setting, Is.

Required primary operating current = 25% of earth fault current

= 6350V/6.3 x 25% = 252Amps

Setting current Is = (Iop/CT ratio) – n Ie

Ie for the chosen CT = 1% at voltage setting (from CT magnetising characteristic)

Is = (252x1/600) – 4 x 0.01 = 0.38 (select this setting on the relay)

– Calculate required stabilising resistance value, Rs

$$Rs = Vs / Is = 20 / 0.38 = 53$$

– Check Metrosil requirements

If the peak voltage appearing across the relay circuit under maximum internal fault conditions exceeds 3000V peak then a suitable non-linear resistor ("metrosil"), externally mounted, should be connected across the relay and stabilising resistor.

The peak voltage can be estimated by the formula:

Where $$Vp = 2\sqrt{2Vk\ (Vf - Vk)}$$

Vk : actual CT knee point voltage

$$Vf = If'\ (Rct + 2Rl + Rstab)$$

Where If': maximum prospective secondary internal fault current

As the earth fault current in this application is limited to 1000A the maximum internal fault current is limited to 1000A;

$$If' = 1000/600 = 1.67$$

$$Vf = 1.67\ (3.70 + 0.114 + 53)$$

$$= 94.88V$$

$$Vp = 2\sqrt{2 \times 91 \times (94.88 - 91)}$$

$$= 53.15V$$

This value is below maximum of 3000V peak and therefore no Metrosils are required with the relay.

CHAPTER 3
Commissioning Instructions

CONTENT

1. COMMISSIONING PRELIMINARIES

When commissioning a K-series relay for the first time the engineer should allow an hour to get familiar with the menu. Please read section 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 (Kitz 101/102) and the Courier access software, then the menu can be viewed one page at a time to display a full column of data and text. Settings are more easily entered and the final settings can be saved as a file on a disk for future reference or for printing a permanent record. The instructions are provided with the Courier access software.

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 and flags reset. No protection or configuration settings can be changed. The table below lists the possible key presses and the relevant functions that they perform. 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.

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	Changes display to first menu column heading “SYSTEM DATA”
	[0]short	Turns on backlight
	[0]long	Resets the trip led if the fault flags are displayed and returns to the selected default display
Column heading	[F]short	Displays the next item of data in the column
	[0]long	Returns to the selected default display without waiting for the 2 minute delay
Anywhere in the menu	[F]short	Turns on backlight
	[F]long	Displays the heading for the next column
	[0]short	Turns on backlight
	[0]long	Resets a cell if it is resettable

Table 1

WITH THE COVER REMOVED FROM THE CASE

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

Current Display	Key Press	Effect of Action
Column heading	[+] [–]	Moves to the previous heading Moves to the next column heading
A settable cell	[+] or [–]	Puts the cell in the setting mode (flashing cursor on bottom line of display) if the cell is password protected the password must be entered first.
Setting mode	[+]	Increments value
	[–]	Decrements value
	[F]	Changes to the confirmation display. If the function links, relay or input masks are displayed then the [F] key will step through them from left to right. Once the end is reached a further key press will change to the confirmation display
	[0]	Escapes from the setting mode without the setting being changed
Confirmation display	[+]	Confirms setting and enters new value
	[–]	Returns prospective value of setting for checking and further modification
	[0]	Escapes from the setting mode without the setting being changed.

Table 2

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 anti-static bag.

There are no user serviceable parts within the module and it is advised that it is not unnecessarily disassembled. Touching the printed circuit boards should be avoided, since complementary metal oxide semiconductors (CMOS) are used, which can be damaged by static electricity discharged from the body.

1.3 Equipment required

1. Continuity tester (multimeter)
2. Overcurrent test set (CFBA) with time interval meter
3. Multifinger test plug type MMLB01 for use with test block type MMLG01

4. Two 8A Variacs
5. 2 variable resistors (0 – 150Ω) of as high a current rating as possible.
6. Timer (if not available on the overcurrent test set)
7. Two pole switch
8. Two 2.5A diodes
9. Two multimeters
10. Frequency counter
11. Test plugs, multi-finger and single finger
12. Primary Injection Test Kit

The following equipment would be useful but is not essential to commissioning.

1. Programmable, synchronised, variable frequency current source capable of producing up to 55% 5th harmonic superimposed on the fundamental, and also two currents in anti-phase (180°out of phase).
2. Portable PC with suitable software and a KITZ101/102 K-bus/IEC870/5 interface unit.

1.4 Inspection

Remove the polycarbonate front cover by unscrewing the four knurled plastic nuts with a small screwdriver. The module can now be withdrawn by pulling the black handles at the top and the bottom. Care should be taken as some force is required to do so and the relay module is heavy.

Once removed carefully examine the module and case to see that no damage has occurred since installation and visually check that 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 and case are identical and that the model number and rating information are correct. The serial number of the relay appears on the label on the inside of the cover and on the front plate of the relay module. The serial numbers marked on these two locations should match. The only time that they may not match is when a faulty relay module has been replaced for continuity of protection.

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.

With the relay removed from its case, check that it is isolated from the voltage and current transformer inputs, and ensure that the terminals listed below in table 3 are closed by checking with a continuity tester.

TERMINALS		
21 & 22	65 & 66	75 & 76
23 & 24	67 & 68	77 & 78
25 & 26	69 & 70	79 & 80
27 & 28	71 & 72	81 & 82
63 & 64	73 & 74	83 & 84

Table 3

1.5 Earthing

Check 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. Check that the local earth bar is solidly connected to the cubicle earth terminal.

1.6 Main current transformers

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

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) with the terminals allocated odd numbers (1, 3, 5, 7 etc.). The auxiliary supply is normally routed via terminals 13 (+) and 15 (–), but check this against the schematic diagram for the installation.

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.

2. COMMISSIONING TEST NOTES

All the tests in these instructions should be carried out unless stated otherwise. Section 5 is applicable to the KBCH 120 model, section 6 to the KBCH 130 and section 7 to the KBCH 140 model. Sections 3, 4, 8, 9, 10, 11, 12, 13 and 14 are applicable to all relay models.

The values quoted in these instructions make no allowance for errors due to tolerances of measuring equipment or site conditions.

Note:-

1. The relay has internal transformer phase compensation which can be set in the SETTINGS menu depending on the transformer winding configuration. As this compensation is based on manipulating three phase currents it is advised that for all secondary injection commissioning tests and checks the cells [HV VectorCor], [LV1 VectorCor] and [LV2 VectorCor] in the SETTINGS(1) or SETTINGS(2) menu are set to Yy0 unless stated otherwise. This is because all the tests are performed with single phase rather than three phase currents. Note that the LV2 VectorCor will only appear on the KBCH 130 and 140 models.

2. All the current settings in the relay are in per unit values and therefore should be multiplied by 5 if the relay is rated at 5 amps (In = 5A), to convert to the equivalent actual value.

3. Once all the commissioning tests are complete the function link cells [S1 Fn. Links] and [S2 Fn. Links] and the vector correction factors should be set back to their calculated application settings. Finally all the calculated application settings should be checked.

2.1 Commissioning the relay with its calculated application settings

After the auxiliary supply tests in section 3, the settings required for the particular application should be entered as described in section 4. It is important that once entered these settings are not changed as the relay should be commissioned at its calculated application settings. If these are not available then the relay should be commissioned at the factory default settings.

2.2 Commissioning the relay with the selective logic functions

The relay should be commissioned with the selective logic settings required for a particular application. Table 4 lists the selective logic schemes and the tests that must be performed on the relay to ensure that these work correctly.

SELECTIVE LOGIC FUNCTION	TEST
Opto Blocking Logic	12.1
Overflux Blocking Function	12.2
Timer Blocking Functions	12.3
Change of Setting Group	12.4
Tap Changer Control	12.5

Table 4

2.3 Resetting fault flags

When the relay trips and the red trip LED is illuminated, this can be reset by pressing [0] long. This should be done each time the relay trips, in order to both reset the LED and to clear the fault indication on the display. The output relays will not latch when they have tripped and will reset when the fault condition has been removed. Note that the LED and the fault display can only be reset when the fault condition has been removed.

2.4 Configuration of output relays

The relay has 8 output relays, each of which can be configured to operate for more than one protection function. Which relay is configured to which protection function can be found in the cells under the RELAY MASKS menu heading. Each protection function has its own cell followed by an 8 bit binary number. Each bit in this binary number corresponds to an output relay as shown in table 5 below.

	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
	RLY7	RLY6	RLY5	RLY4	RLY3	RLY2	RLY1	RLY0
Terminals	41&43	37&39	33&35	29&31	42&44	38&40	34&36	32&30

Table 5

If a bit is set to 1 then the relay which corresponds to that bit will be selected to operate for that particular protection function.

For example, the cell [RLY Id>A] defines which relays are to be operated by the A phase low set trip. If the bits in this cell are set as in table 6 below, this means that relays 7, 3, 2, 1 and 0 will trip when this particular protection function operates. Any one relay can have more than one protection and control function assigned to it.

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
1	0	0	0	1	1	1	1

Table 6

Note that the LCD display will only give a trip indication if the protection and control function is configured to operate either relay 3, terminals 42 and 44, or relay 7, terminals 41 and 43. If relays other than 3 or 7 are selected for a certain function then the display will not give an indication of a trip and the red trip LED will not be illuminated, although the output relay contacts will still close.

It is advised in all cases that a continuity tester be used to monitor the output relay contacts and to ensure that the appropriate output relay has energised. The display should only be used for visual indication of a trip condition.

3. AUXILIARY SUPPLY TESTS

Tests 3.1, 3.2 and 3.3 have to be performed for each relay model.

3.1 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 7. Check that the auxiliary supply voltage is within the range shown below, and where applicable check that it is connected in the correct polarity.

Relay rating (V)	DC operating range (V)	AC operating range (V)	Maximum crest voltage (V) DC/AC
24 / 125	20 – 150	50 – 133	169 / 190
48 / 250	33 – 300	87 – 265	338 / 380

Table 7

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 ENERGISE THE RELAY USING A BATTERY CHARGER WITH THE BATTERY DISCONNECTED.

3.2 Energisation from auxiliary voltage supply

For secondary injection testing using the test block type MMLG, insert test plug 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 8.

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 that the relay is healthy. The relay has a non-volatile memory which remembers the state (ON or OFF) of the red led trip indicator when the relay was last powered, and therefore the indicator may be illuminated. With a continuity tester monitor the state of the watchdog contacts as listed in table 8.

Terminals	With relay not powered	With relay powered
3 and 5	contact closed	contact open
4 and 6	contact open	contact closed

Table 8

3.3 Field voltage

The relay generates a field voltage that should be used to energise the opto-isolated inputs. With the relay energised, 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 9 when no load is connected.

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

Table 9

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 by using a portable PC with a K-Bus connection and recorded 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.

The protection settings for the relay are contained in the SETTINGS (1) and SETTINGS (2) menu columns. SETTINGS (2) is only required if group 2 is used.

The characteristics of the relay can be further changed by setting the FUNCTION LINKS. 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 therefore this is the first place to look if the relay is not configured as required. The FUNCTION LINKS are found in the following menu headings.

SYSTEM DATA heading in the cell [SYS Fn. Links]
SETTINGS(1) heading in the cell [S1 Fn. Links]
SETTINGS(2) heading in the cell [S2 Fn. Links]
INPUT MASKS heading
RELAY MASKS heading

Table 10

The INPUT MASKS are used to assign the opto isolated inputs of the relay to control specific functions.

The RELAY MASKS are used to assign the output relays to operate for a specific protection or control function.

4.1 Changing the settings

Settings and text in certain cells of the menu can be changed using either the keypad on the front of the relay or a PC and the suitable software as described in section 1. When using the keypad, select the menu heading in which the cell to be changed is found by pressing [F]long. Select the cell to be changed by pressing [F]short. To enter the setting mode press either the [+] or [–] key. This will cause the cursor to flash on the bottom line of the display. The contents of the cell can then be changed by pressing [+] to increment the value and [–] to decrement the value.

Some of the settings on the relay are password protected and it is therefore necessary to enter the password before the relay configuration can be changed. The password can be entered in the SYSTEM DATA menu heading. The relay is supplied with a factory default password of AAAA. When the password has been successfully entered, the yellow ALARM led will flash on and off indicating that the relay configuration can now be changed. This will reset after 15 minutes if no further keys are pressed and the password will have to be entered again.

If required, a new password can be entered immediately after the default password is entered by following the same procedure as for entering the default password. If the password has been changed and forgotten or lost a unique recovery password is available which can be supplied by the factory, or service agent, if given details of the relay model and serial number. This will be found in the SYSTEM DATA column of the menu and should correspond to the number on the label on the top right hand corner of the front plate of the relay.

Care should be taken to ensure that no unwanted changes are entered. Refer to Table 2 for details on how to enter a new setting or how to escape from the setting mode without the setting being changed. The following points should be noted:

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 the default value if required.

4.2 Changing the system frequency.

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:

Go to the SYSTEM DATA menu, press [F]short until [SYS FREQUENCY 50Hz] appears on the LCD. Press the [+] key until the display shows [SYS FREQUENCY 60Hz]. Then press [F]short once more followed by the [+] key to confirm the change.

4.3 Relay operation

This test will ensure that each output relay operates correctly and closes on command.

Go to the TEST/CONTROL menu heading and step down until the [Select Relays To Test] cell is displayed. Each bit in this cell corresponds to an output relay. Bit 0 is for relay 0, bit 1 for relay 1 and so on. Select one relay at a time by setting the appropriate bit to 1. Then, step down one to the [Test Relays = [0]] cell. The output relay will close for the duration that the [0] key is pressed plus the time set in the cell [LOG tTest] which is found under the menu heading LOGIC FUNCTIONS.

Operation of the relay can be monitored by indication from the relay contacts, e.g. continuity meter. Test each relay in turn as described above.

RELAY	TERMINALS
Relay 0	30, 32
Relay 1	34, 36
Relay 2	38, 40
Relay 3	42, 44
Relay 4	29, 31
Relay 5	33, 35
Relay 6	37, 39
Relay 7	41, 43

Table 11

5. KBCH 120

The following tests are all applicable to the KBCH 120 model. It is recommended that these tests are performed with both the phase compensation factors [HV VectorCor] and [LV1 VectorCor] set to Yy0.

5.1 Measurement checks

To test the relay measurement functions a current of known value should be injected into each phase input. With the CT ratios in the cells [HV CT Ratio] and [LV1 CT Ratio] in the SETTINGS menu set to the values of the line CT's, the displayed measured values will be in the equivalent primary quantities.

5.1.1 HV and LV1 winding measurement checks

Connect the CT inputs to the relay as shown below.

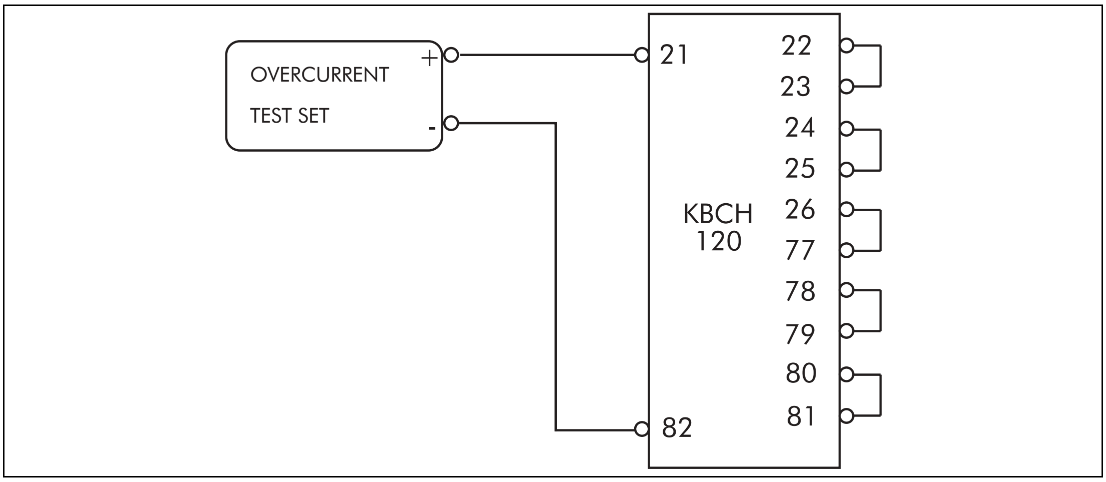


Figure 1: HV and LV1 windings measurement check.

Go to the SETTINGS menu and set all the bits in the cell [S1 Fn. Links] to 0. This disables all the protection elements so that the relay will not trip. Then go to the MEASUREMENTS menu and step down one until the cell [MS1 IaHV] is displayed. Inject rated current and ensure that the displayed value lies within ±10% of the injected value. By pressing [F]short, step down until the cell [MS1 IcLV1] is reached, checking each time that the displayed value lies in this range.

Check that the cells [MS1 Ia Diff], [MS1 Ib Diff] and [MS1 Ic Diff] display the correct values of differential current. In this case it should be

(Injected I)x2±10%

Check that the cells [MS1 Ia Bias], [MS1 Ib Bias] and [MS1 Ic Bias] display the correct values of bias current. In this case it should be

Injected I±10%

5.1.2 Frequency measurement check

Inject a current of known frequency to terminals 21 and 22 of the relay. The frequency must be in the range 15 to 65 Hz. In the MEASUREMENTS menu step down until the cell [MS1F] is displayed. Check that the displayed value lies in the range

Injected frequency ±2%.

5.2 Differential Protection

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

5.2.1 Low set element current sensitivity (Id>)

In the SETTINGS menu go to cell [S1 Fn. Links] and set all bits to 0, except bit 1, {S1 Enable Id>}, which should be set to 1. This will ensure that only the low set protection function is enabled.

The operation of the relay can be monitored as described in section 4.3 Relay operation. The relays selected for the low set differential protection function can be found under the RELAY MASKS heading. The phase A relay will be found in the cell [RLY Id>A], phase B relay in cell [RLY Id>B] and phase C in [RLY Id>C]. Each bit in these cells which is set to 1 corresponds to an output relay which is selected for this function. See section 2.4 for a fuller explanation on the configuration of the output relays.

Connect the equipment so that current can be injected through terminals 21 and 22.

Slowly increase the current from 0 amps and note the pick-up value at which the relay operates. Reduce the current slowly and note the drop off value at which it resets. Check that the pick-up and drop-off are within the range shown in Table 12.

In table 12 below, $$\mathrm{Is} = \frac{1.1\ [\mathrm{Id}>]}{[\mathrm{CT\ Ratio\ Cor}]}$$

Id> is the low set setting which will be found in the cell [Id>] under the SETTINGS menu heading. CT Ratio Cor is the CT ratio correction which is used to compensate for a mismatch in currents due to the line side current transformer ratios. There is one ratio correction factor for the HV side, which is found in the cell [HV Ratio Cor], and one for the LV1 side found in the cell [LV1 Ratio Cor]. Both of these are found under the SETTINGS menu headings. The appropriate CT ratio factor should be used to calculate the current to inject depending upon whether it is being injected into the HV or the LV1 inputs.

	Current Level
Pick-up	0.9 x Is to 1.1 x Is
Drop-off	0.9 x Pick-up to 1.0 x Pick-up

Table 12

Repeat the above test for each of the remaining phases on the HV side, and for all three phases on the LV1 side. These are listed in table 13.

Input	Terminals
IA HV	21 , 22
IB HV	23 , 24
IC HV	25, 26
IA LV1	77, 78
IB LV1	79, 80
IC LV1	81, 82

Table 13

Note: As the CT inputs to each phase have been verified by both the measurement checks and the low set differential trip checks it is only necessary to check the operating time and the high set current sensitivity for each phase element on one side of the transformer only.

5.2.2 Low set element operating time

Connect the relay so that current can be injected through terminals 21 and 22, but in addition connect the relay contacts for this protection function to both trip the test set and to stop a timer. Configure the test set so that when the current is applied to the relay, the timer starts.

Inject 5xIs into the A phase low set element (terminals 21 & 22). Check that the operating time for the relay is within the range

30ms to 40ms

Repeat this test for both of the remaining phases on the HV side, as listed in table 13 above.

5.2.3 High set element current sensitivity (Id>>)

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 checks the instantaneous current sensitivity of the differential high set element relay. This test can only be performed if the test set is able to inject sufficient current into the relay to cause the element to trip at the calculated application setting.

Go to the cell [S1 Fn. Links] in the SETTINGS menu and set bit 2 {S1 Enable Id>>} to 1, thus enabling the high set function. Then disable the low set element by setting bit 1 {S1 Enable Id>} to 0. Ensure that all the other bits are set to 0.

The relays selected to operate for the Id>> trip can be found under the RELAY MASKS heading. The phase A relay will be found in the cell [RLY Id>>A], phase B relay in cell [RLY Id>>B] and phase C in [RLY Id>>C]. Each bit in these cells which is set to 1 corresponds to an output relay which is selected for this function. See section 2.4 for a fuller explanation of the configuration of the output relays.

Operation of the relays can be monitored as described in section 4.3.

The relay should be connected so that current can be injected through terminals 21 & 22. In addition the output relays should be connected to trip the test set and to stop a timer. IT IS IMPORTANT TO TRIP THE TEST SET IN ORDER TO AVOID SUSTAINED APPLICATION OF EXCESSIVE CURRENTS. The timer should be started when the current is applied to the relay.

As 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 have to be performed for his particular protection function. These are listed in table 14.

Id>> (Trip)	Id>>(No Trip)
1.1x Is	0.9x Is

Table 14

The first test to be performed is at the higher current level, to check that the instantaneous element operates.

In table 14 above, $$\mathrm{Is} = \frac{[\mathrm{Id} >>]}{[\text{CT Ratio Cor}]}$$

Id>> is the high set setting which will be found in the cell [Id>>] under the SETTINGS menu heading. CT Ratio Cor is the CT ratio correction which is used to compensate for a mismatch in currents due to the line side current transformer ratios. This is found in the cell [HV Ratio Cor] under the SETTINGS menu heading.

Inject 1.1xIs and ensure that the selected output relay operates.

FOR THE SECOND TEST IT IS IMPORTANT THAT THE CURRENT IS NOT APPLIED FOR LONGER THAN 1 SECOND.

Inject 0.9xIs for 1 second and ensure that the selected output relay does not operate.

Repeat the above two tests for the two remaining elements of the HV side of the transformer as listed in table 13.

5.2.4 High set element operating time

This test can only be performed if the test set is able to inject sufficient current into the relay to cause the element to trip at the calculated application setting.

Connect the relay so that current can be injected through terminals 21 and 22, but in addition connect the relay contacts for this protection function to both trip the test set and to stop a timer. Configure the test set so that when the current is applied to the relay, the timer starts.

Inject 3xIs into the A phase low set element (terminals 21 & 22). Check that the operating time for the relay is within the range

10ms to 20ms

Repeat this test for both of the remaining phases on the HV side, as listed in table 13.

5.3 Restricted Earth Fault Protection

There are two restricted earth fault elements for this relay model, one on the high voltage side of the transformer and one on the low voltage side of the transformer.

5.3.1 REF current sensitivity HV side (Io> HV)

In the SETTINGS(1) menu go to cell [S1 Fn. Links] and set all the bits to 0 except bit 3, {S1 Enable Io>HV} which should be set to 1. This will ensure that only the REF protection on the high voltage side of the transformer is enabled.

The relays selected for the REF protection on the HV side of the transformer can be found under the RELAY MASKS heading in the cell [RLY Io> HV]. Each bit in this cell which is set to 1 corresponds to an output relay for this protection function. See section 2.4 for a fuller explanation of the configuration of the output relays. The operation of the relay can be monitored as described in section 4.3.

Connect the equipment so that current can be injected through terminals 27 & 28.

Slowly increase the current from 0 amps and note the pick-up value at which the relay operates. Reduce the current slowly and note the drop-off value at which it resets. Check that the pick-up and drop-off values are within the range shown in Table 15.

	Current Level
Pick-up	0.9 x Is to 1.1 x Is
Drop-off	0.9 x Pick-up to 1.0 x Pick-up

Table 15

In table 15 above, Is corresponds to the settings for the earth fault elements. These are found in the cells [Io> HV], [Io>LV1] in the SETTINGS menu heading.

5.3.2 REF element HV side operating time

Connect the relay as in section 5.3.1 above, but in addition connect the relay contacts for this protection function to both trip the test set and to stop a timer. Configure the test set so that when the current is applied to the relay, the timer starts.

Inject 5 x Is into the relay and check that the operating time for the relay is within the range,

20ms to 30 ms

5.3.3 REF current sensitivity LV1 side (Io> LV1)

In the SETTINGS menu go to cell [S1 Fn. Links] and set all the bits to 0 except bit 4, {S1 Enable Io> LV1} which should be set to 1. This will ensure that only the REF protection on the low voltage side of the transformer is enabled.

The relays selected for the REF protection on the LV1 side of the transformer can be found under the RELAY MASKS heading in the cell [RLY Io> LV1]. Each bit in this cell which is set to 1 corresponds to an output relay for this protection function. See section 2.4 for a fuller explanation of the configuration of the output relays. The operation of the relay can be monitored as described in section 4.3.

Connect the equipment so that current can be injected through terminals 83 & 84.

Slowly increase the current from 0 amps and note the pick-up value at which the relay operates. Reduce the current slowly and note the drop-off value at which it resets. Check that the pick-up and drop-off values are within the range shown in Table 15.

In this case Is corresponds to the LV1 side earth fault element setting and is found in the cell [Io> LV1] under the SETTINGS menu heading.

5.3.4 REF element LV1 side operating time

Connect the relay as in section 5.3.3 above, but in addition connect the relay contacts for this protection function to both trip the test set and to stop a timer. Configure the test set so that when the current is applied to the relay, the timer starts.

Inject 5 x Is into the relay and check that the operating time for the relay is within the range,

20ms to 30ms

6. KBCH 130

The following tests are all applicable to the KBCH 130 model. It is recommended that these tests are performed with the phase compensation factors [HV VectorCor], [LV1 VectorCor] and [LV2 VectorCor] set toYy0.

6.1 Measurement checks

To test the relay measurement functions a current of known value should be injected into each phase input. With the CT ratios in the cells [HV CT Ratio], [LV1 CT Ratio] and [LV2 CT Ratio] in the SETTINGS menu set to the values of the line CT's, the displayed measured values will be in the equivalent primary quantities.

6.1.1 HV + LV1 + LV2 winding measurement checks

Connect the CT inputs to the relay as shown below

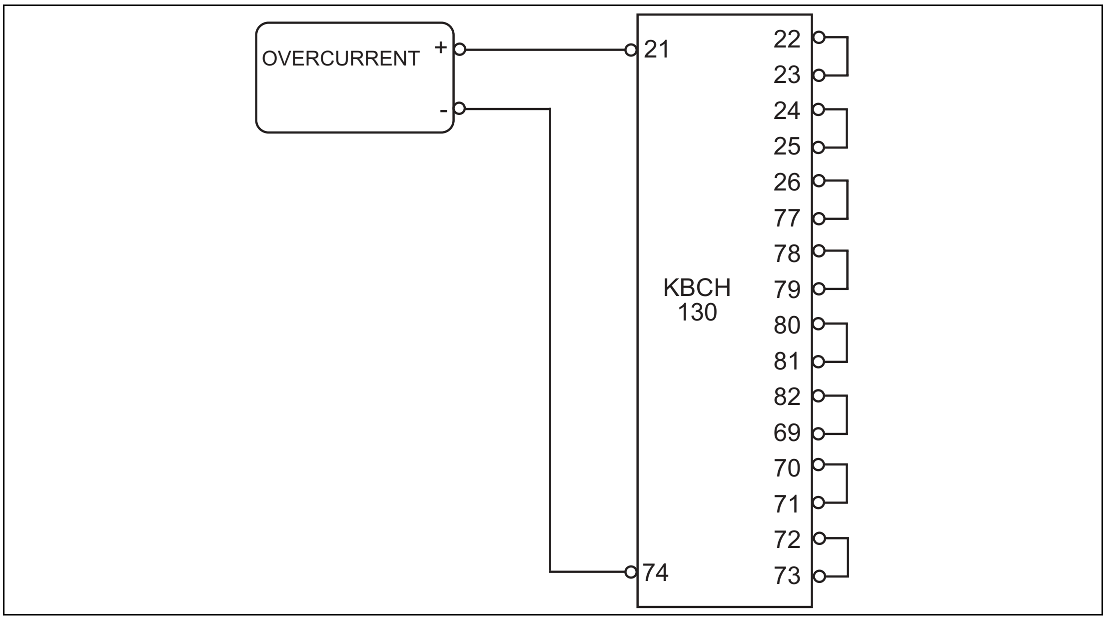


Figure 2: HV, LV1 and LV2 windings measurement check

Go to the SETTINGS menu and set all the bits in the cell [S1 Fn. Links] to 0. This disables all the protection elements so that the relay will not trip. Then go to the MEASUREMENTS menu and step down one until the cell [MS1 IaHV] is displayed. Inject rated current and ensure that the displayed value lies within ±10% of the values listed in table 16. By pressing [F]short, step down until the cell [MS1 Ic Bias] is reached, checking each time that the displayed value lies in this range.

	CONFIGURATION			
CURRENT	HV+LV	HV+LV1+LV2	HV(X2)+LV	HV+LV(X2)
HV – Phase	Iinj	Iinj	2x Iinj	Iinj
LV1 – Phase	Iinj	Iinj	Iinj	2x Iinj
LV2 – Phase	0	Iinj	0	0
Differential	2x Iinj	3x Iinj	3x Iinj	3x Iinj
Bias	Iinj	3/2x Iinj	3/2x Iinj	3/2x Iinj

Table 16

6.1.2 Frequency measurement check

Inject a current of known frequency to terminals 21 and 22 of the relay. The frequency must be in the range 15 to 65 Hz. In the MEASUREMENTS menu step down until the cell [MS1F] is displayed. Check that the displayed value lies in the range

Injected frequency ±2%.

6.2 Differential Protection

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

6.2.1 Low set element current sensitivity (Id>)

In the SETTINGS menu go to cell [S1 Fn. Links] and set all bits to 0, **except** bit 1, {S1 Enable Id>} which should be set to 1. This will ensure that only the low set protection function is enabled.

The operation of the relay can be monitored as described in section 4.3 Relay operation. The relays selected for the low set differential protection function can be found under the RELAY MASKS heading. The phase A relay will be found in the cell [RLY Id>A], phase B relay in cell [RLY Id>B] and phase C in [RLY Id>C]. Each bit in these cells which is set to 1 corresponds to an output relay which is selected for this function. See section 2.4 for a fuller explanation on the configuration of the output relays.

Connect the equipment so that current can be injected through terminals 21 and 22.

Slowly increase the current from 0 amps and note the pick-up value at which the relay operates. Reduce the current slowly and note the drop off value at which it resets. Check that the pick-up and drop-off are within the range shown in Table 17.

In table 17 overleaf, $\mathrm{Is} = \dfrac{1.1\ [\mathrm{Id}>]}{[\mathrm{CT\ Ratio\ Cor}]}$

Id> is the low set setting which will be found in the cell [Id>] under the SETTINGS menu heading. CT Ratio Cor is the CT ratio correction which is used to compensate for a mismatch in currents due to the line side current transformer ratios. There is one ratio correction factor for the HV side, which is found in the cell [HV Ratio Cor], one for the LV1 side found in the cell [LV1 Ratio Cor], and one for the LV2 side found in the cell [LV2 Ratio Cor]. All of these are found under the SETTINGS menu heading. The appropriate CT ratio factor should be used to calculate the current to inject depending upon whether it is being injected into the HV, LV1 or the LV2 inputs.

	Current Level
Pick-up	0.9 x Is to 1.1 x Is
Drop-off	0.9 x Pick-up to 1.0 x Pick-up

Table 17

Repeat the above test for each of the remaining phases on the HV side, and for all three phases on the LV1 side and all three on the LV2 side. These are listed in table 18 below.

Input	Terminals
IA HV	21, 22
IB HV	23, 24
IC HV	25, 26
IA LV1	77, 78
IB LV1	79, 80
IC LV1	81, 82
IA LV2	69, 70
IB LV2	71, 72
IV LV2	73, 74

Table 18

Note: As the CT inputs to each phase have been verified by both the measurement checks and the low set differential trip checks it is only necessary to check the operating time and the high set current sensitivity for each phase element on one side of the transformer only.

6.2.2 Low set element operating time

Connect the relay as in section 6.2.1 above, but in addition connect the relay contacts for this protection function to both trip the test set and to stop a timer. Configure the test set so that when the current is applied to the relay, the timer starts.

Inject 5xIs into the A phase low set element (terminals 21 & 22). Check that the operating time for the relay is within the range

30ms to 40ms

Repeat this test for both of the remaining phases on the HV side listed in table 18 above.

6.2.3 High set element current sensitivity (Id>>)

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 checks the instantaneous current sensitivity of the differential high set element relay. This test can only be performed if the test set is able to inject sufficient current into the relay to cause the element to trip at the calculated application setting.

Go to the cell [S1 Fn. Links] in the SETTINGS menu and set bit 2 {S1 Enable Id>>} to 1, thus enabling the high set function. Then disable the low set element by setting bit 1 {S1 Enable Id>} to 0. Ensure that all the other bits are set to 0.

The relays selected to operate for the Id>> trip can be found under the RELAY MASKS heading. The phase A relay will be found in the cell [RLY Id>>A], phase B relay in cell [RLY Id>>B] and phase C in [RLY Id>>C]. Each bit in these cells which is set to 1 corresponds to an output relay which is selected for this function. See section 2.4 for a fuller explanation of the configuration of the output relays.

Operation of the relays can be monitored as described in section 4.3.

The relay should be connected so that current can be injected through terminals 21 & 22. In addition the output relays should be connected to trip the test set and to stop a timer. IT IS IMPORTANT TO TRIP THE TEST SET IN ORDER TO AVOID SUSTAINED APPLICATION OF EXCESSIVE CURRENTS. The timer should be started when current is applied to the relay.

As 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 have to be performed for his particular protection function. These are listed in table 19.

Id>> (Trip)	Id>>(No Trip)
1.1x Is	0.9x Is

Table 19

The first test to be performed is at the higher current level, to check that the instantaneous element operates.

In table 19 above, $$\text{Is} = \frac{[\text{Id} >>]}{[\text{CT Ratio Cor}]}$$

Id>> is the high set setting which will be found in the cell [Id>>] under the SETTINGS menu heading. CT Ratio Cor is the CT ratio correction which is used to compensate for a mismatch in currents due to the line side current transformer ratios. This is found in the cell [HV Ratio Cor] under the SETTINGS menu heading.

Inject 1.1xIs and ensure that the selected output relay operates

FOR THE SECOND TEST IT IS IMPORTANT THAT THE CURRENT IS NOT APPLIED FOR LONGER THAN 1 SECOND.

Inject 0.9xIs for 1 second and ensure that the relay does not operate.

Repeat the above two tests for the two remaining elements of the HV side of the transformer as listed in table 18.

6.2.4 High set element operating time

This test can only be performed if the test set is able to inject sufficient current into the relay to cause the element to trip at the calculated application setting.

Connect the relay so that current can be injected through terminals 21 and 22, but in addition connect the relay contacts for this protection function to both trip the test set and to stop a timer. Configure the test set so that when the current is applied to the relay, the timer starts.

Inject 3xIs into the A phase low set element (terminals 21 & 22). Check that the operating time for the relay is within the range

10ms to 20ms

Repeat this test for both of the remaining phases on the HV side, as listed in table 18.

6.3 Restricted Earth Fault Protection

There are three restricted earth fault elements for this relay model, one on the high voltage side of the transformer and two on the low voltage side of the transformer.

6.3.1 REF current sensitivity HV side (Io> HV)

In the SETTINGS menu go to cell [S1 Fn. Links] and set all the bits to 0 except bit 3, {S1 Enable Io> HV} which should be set to 1. This will ensure that only the REF protection on the high voltage side of the transformer is enabled.

The relays selected for the REF protection on the HV side of the transformer can be found under the RELAY MASKS heading in the cell [RLY Io> HV]. Each bit in this cell which is set to 1 corresponds to an output relay for this protection function. See section 2.4 for a fuller explanation of the configuration of the output relays. The operation of the relay can be monitored as described in section 4.3.

Connect the equipment so that current can be injected through terminals 27 & 28.

Slowly increase the current from 0 amps and note the pick-up value at which the relay operates. Reduce the current slowly and note the drop-off value at which it resets. Check that the pick-up and drop-off values are within the range shown in Table 20.

	Current Level
Pick-up	0.9 x Is to 1.1 x Is
Drop-off	0.9 x Pick-up to 1.0 x Pick-up

Table 20

In table 20 above, Is corresponds to the settings for the earth fault element. These are found in the cells [Io>HV], [Io>LV1] and [Io>LV2] in the SETTINGS menu depending upon which winding is being tested.

6.3.2 REF element HV side operating time

Connect the relay as in section 6.3.1 above, but in addition connect the relay contacts for this protection function to both trip the test set and to stop a timer. Configure the test set so that when the current is applied to the relay, the timer starts.

Inject 5xIs into the relay and check that the operating time for the relay is within the range,

20ms to 30ms

6.3.3 REF current sensitivity LV1 side (Io> LV1)

In the SETTINGS menu go to cell [S1 Fn. Links] and set all the bits to 0 except bit 4, {S1 Enable Io> LV1} which should be set to 1. This will ensure that only the REF protection on the LV1 side of the transformer is enabled.

The relays selected for the REF protection on the LV1 side of the transformer can be found under the RELAY MASKS heading in the cell [RLY Io> LV1]. Each bit in this cell which is set to 1corresponds to an output relay for this protection function. See section 2.4 for a fuller explanation of the configuration of the output relays. The operation of the relay can be monitored as described in section 4.3.

Connect the equipment so that current can be injected through terminals 83 & 84.

Slowly increase the current from 0 amps and note the pick-up value at which the relay operates. Reduce the current slowly and note the drop-off value at which it resets. Check that the pick-up and drop-off values are within the range shown in Table 20.

6.3.4 REF element LV1 side operating time

Connect the relay as in section 6.3.3 above, but in addition connect the relay contacts for this protection function to both trip the test set and to stop a timer. Configure the test set so that when the current is applied to the relay, the timer starts.

Inject 5xIs into the relay and check that the operating time for the relay is within the range,

20ms to 30ms

6.3.5 REF current sensitivity LV2 side (Io> LV2)

In the SETTINGS menu go to cell [S1 Fn. Links] and set all the bits to 0 except bit 5, {S1 Enable Io> LV2} which should be set to 1. This will ensure that only the REF protection on the LV2 side of the transformer is enabled.

The relays selected for the REF protection on the LV2 side of the transformer can be found under the RELAY MASKS heading in the cell [RLY Io> LV2]. Each bit in this cell which is set to 1 corresponds to an output relay for this protection function. See section 2.4 for a fuller explanation of the configuration of the output relays. The operation of the relay can be monitored as described in section 4.3.

Connect the equipment so that current can be injected through terminals 75 & 76.

Slowly increase the current from 0 amps and note the pick-up value at which the relay operates. Reduce the current slowly and note the drop-off value at which it resets. Check that the pick-up and drop-off values are within the range shown in Table 20.

6.3.6 REF element LV2 side operating time

Connect the relay as in section 6.3.5 above, but in addition connect the relay contacts for this protection function to both trip the test set and to stop a timer. Configure the test set so that when the current is applied to the relay, the timer starts.

Inject 5xIs into the relay and check that the operating time for the relay is within the range,

20ms to 30ms

7. KBCH 140

The following tests are all applicable to the KBCH 140 model. It is recommended that these tests are performed with the phase compensation factors [HV VectorCor], [LV1 VectorCor] and [LV2 VectorCor] set toYy0.

7.1 Measurement checks

To test the relay measurement functions a current of known value should be injected into each phase input. With the CT ratios in the cells [HV CT Ratio], [LV1 CT Ratio] and [LV2 CT Ratio] in the SETTINGS menu set to the values of the line CT's, the displayed measured values will be in the equivalent primary quantities.

7.1.1 HV + LV1 winding measurement checks

Connect the CT inputs to the relay as shown below:

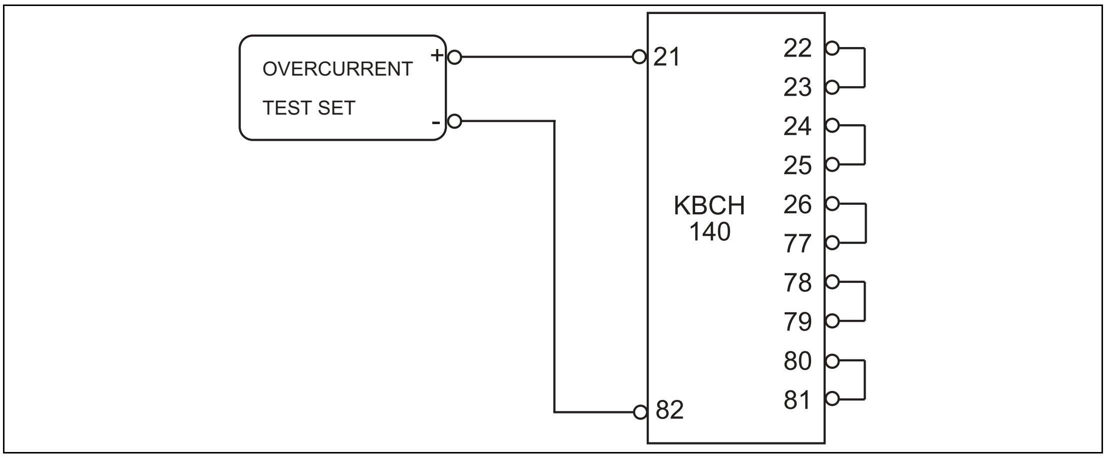


Figure 3: HV, LV1 windings measurement check

Go to the SETTINGS menu and set all the bits in the cell [S1 Fn. Links] to 0. This disables all the protection elements so that the relay will not trip. Then go to the MEASUREMENTS menu and step down one until the cell [MS1 IaHV] is displayed. Inject rated current and ensure that the displayed value lies within ±10% of the injected value. By pressing [F] short, step down until the cell [MS1 IcLV1] is reached, checking each time that the displayed value lies in this range.

Only perform the checks below if the cell [S1 Configuration] is set to {HV + LV}, otherwise go to section 7.1.2.

Check that the cells [MS1 Ia Diff], [MS1 Ib Diff] and [MS1 Ic Diff] display the correct values of differential current. In this case it should be

(Injected I) x2±10%

Check that the cells [MS1 Ia Bias], [MS1 Ib Bias] and [MS1 Ic Bias] display the correct values of bias current. In this case it should be

Injected I±10%

7.1.2 LV2 + LV3 winding measurement check

Connect the CT inputs to the relay as shown below:

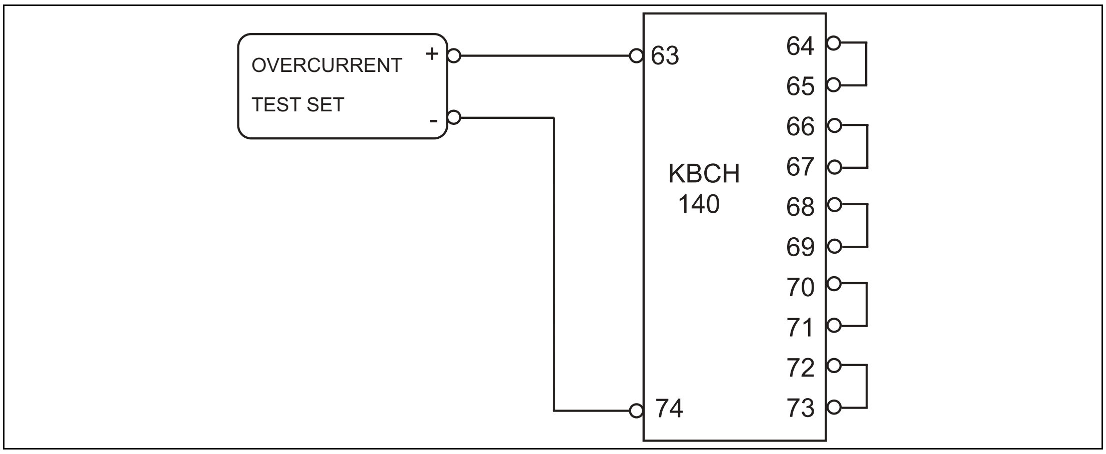


Figure 4: LV2 and LV3 winding measurement check

In the MEASUREMENTS menu step down until the cell [MS1 IaLV2] is displayed. Inject rated current and ensure that the displayed value lies within ±10% of the injected value. By pressing [F] short, step down until the cell [MS1 IcLV2] is reached, checking each time that the displayed value lies in this range.

	CONFIGURATION			
CURRENT	HV+LV1+LV2	HV(x2)+LV or HV+LV(x2)	HV(x2)+LV1+LV2 or HV+LV1(x2)+LV2	HV(x2)+LV(x2)
LV2 – Phase	Iinj	0	Iinj	0
Differential	Iinj	Iinj	2xIinj	2x Iinj
Bias	1/2xIinj	1/2xIinj	Iinj	Iinj

Table 21

7.1.3 Frequency measurement check

Inject a current of known frequency to terminals 21 and 22 of the relay. The frequency must be in the range 15 to 65 Hz. In the MEASUREMENTS menu step down until the cell [MS1F] is displayed. Check that the displayed value lies in the range.

Injected frequency±2%

7.2 Differential Protection

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

7.2.1 Low set element current sensitivity (Id>)

In the SETTINGS menu go to cell [S1 Fn. Links] and set all bits to 0, except bit 1, {S1 Enable Id>} which should be set to 1. This will ensure that only the low set protection function is enabled.

The operation of the relay can be monitored as described in section 4.3 Relay operation. The relays selected for the low set differential protection function can be found under the RELAY MASKS heading. The phase A relay will be found in the cell

[RLY Id>A], phase B relay in cell [RLY Id>B] and phase C in [RLY Id>C]. Each bit in these cells which is set to 1 corresponds to an output relay which is selected for this function. See section 2.4 for a fuller explanation on the configuration of the output relays.

Connect the equipment so that current can be injected through terminals 21 and 22.

Slowly increase the current from 0 amps and note the pick-up value at which the relay operates. Reduce the current slowly and note the drop off value at which it resets. Check that the pick-up and drop-off are within the range shown in Table 22.

In table 22 below, $$Is = \frac{1.1\ [Id >]}{[CT\ Ratio\ Cor]}$$

Id> is the low set setting which will be found in the cell [Id>] under the SETTINGS menu heading. CT Ratio Cor is the CT ratio correction which is used to compensate for a mismatch in currents due to the line side current transformer ratios. There is one ratio correction factor for the HV side, which is found in the cell [HV Ratio Cor], one for the LV1 side found in the cell [LV1 Ratio Cor], and one for the LV2 side found in the cell [LV2 Ratio Cor]. All of these are found under the SETTINGS menu heading. The appropriate CT ratio factor should be used to calculate the current to inject depending upon whether it is being injected into the HV, LV1 or the LV2 inputs.

	Current Level
Pick-up	0.9 x Is to 1.1 x Is
Drop-off	0.9 x Pick-up to 1.0 x Pick-up

Table 22

Repeat the above test for each of the remaining phases on the HV side, and for all three phases on the LV1 side, all three on the LV2 side and the LV3 side. These are listed in table 23.

Input	Terminals
IA HV	21, 22
IB HV	23, 24
IC HV	25, 26
IA LV1	77, 78
IB LV1	79, 80
IC LV1	81, 82
IA LV2	69, 70
IB LV2	71, 72
IV LV2	73, 74
IA LV3	63, 64
IB LV3	65, 66
IC LV3	67, 68

Table 23

Note: As the CT inputs to each phase have been verified by both the measurement checks and the low set differential trip checks it is only necessary to check the operating time and the high set current sensitivity for each phase element on one side of the transformer only.

7.2.2 Low set element operating time

Connect the relay as in section 7.2.1 above, but in addition connect the relay contacts for this protection function to both trip the test set and to stop a timer. Configure the test set so that when the current is applied to the relay, the timer starts.

Inject 5xIs into the A phase low set element (terminals 21 & 22). Check that the operating time for the relay is within the range

30ms to 40ms

Repeat this test for both of the remaining phases on the HV side as listed in table 23 above.

7.2.3 High set element current sensitivity (Id>>)

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 checks the instantaneous current sensitivity of the differential high set element relay. This test can only be performed if the test set is able to inject sufficient current into the relay to cause the element to trip at the customers setting.

Go to the cell [S1 Fn. Links] in the SETTINGS menu and set bit 2 {S1 Enable Id>>} to 1, thus enabling the high set function. Then disable the low set element by setting bit 1 {S1 Enable Id>} to 0. Ensure that all the other bits are set to 0.

The relays selected to operate for the Id>> trip can be found under the RELAY MASKS heading. The phase A relay will be found in the cell [RLY Id>>A], phase B relay in cell [RLY Id>>B] and phase C in [RLY Id>>C]. Each bit in these cells which is set to 1 corresponds to an output relay which is selected for this function. See section 2.4 for a fuller explanation of the configuration of the output relays.

Operation of the relays can be monitored as described in section 4.3.

The relay should be connected so that current can be injected through terminals 21 & 22. In addition the output relays should be connected to trip the test set and to stop a timer. IT IS IMPORTANT TO TRIP THE TEST SET IN ORDER TO AVOID SUSTAINED APPLICATION OF EXCESSIVE CURRENTS. The timer should be started when the current is applied to the relay.

As 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 have to be performed for his particular protection function. These are listed in table 24.

Id>> (Trip)	Id>>(No Trip)
1.1x Is	0.9x Is

Table 24

The first test to be performed is at the higher current level, to check that the instantaneous element operates.

In table 24 above, $$Is = \frac{[Id >>]}{[CT\ Ratio\ Cor]}$$

Id>> is the high set setting which will be found in the cell [Id>>] under the SETTINGS menu heading. CT Ratio Cor is the CT ratio correction which is used to compensate for a mismatch in currents due to the line side current transformer ratios. This is found in the cell [HV Ratio Cor] under the SETTINGS menu heading.

Inject 1.1xIs and ensure that the selected output relay operates

FOR THE SECOND TEST IT IS IMPORTANT THAT THE CURRENT IS NOT APPLIED FOR LONGER THAN 1 SECOND.

Inject 0.9xIs for 1 second and ensure that the relay does not operate.

Repeat the above two tests for the two remaining phases of the HV side of the transformer listed in table 21.

7.2.4 High set element operating time

This test can only be performed if the test set is able to inject sufficient current into the relay to cause the element to trip at the calculated application setting.

Connect the relay so that current can be injected through terminals 21 and 22, but in addition connect the relay contacts for this protection function to both trip the test set and to stop a timer. Configure the test set so that when the current is applied to the relay, the timer starts.

Inject 3xIs into the A phase low set element (terminals 21 & 22). Check that the operating time for the relay is within the range

10ms to 20ms

Repeat this test for both of the remaining phases on the HV side, as listed in table 23.

7.3 Restricted Earth Fault Protection

There are three restricted earth fault elements for this relay model, one on the high voltage side of the transformer and two on the low voltage side of the transformer.

7.3.1 REF current sensitivity HV side (Io> HV)

In the SETTINGS menu go to cell [S1 Fn. Links] and set all the bits to 0 except bit 3, {S1 Enable Io> HV} which should be set to 1. This will ensure that only the REF protection on the high voltage side of the transformer is enabled.

The relays selected for the REF protection on the HV side of the transformer can be found under the RELAY MASKS heading in the cell [RLY Io> HV]. Each bit in this cell which is set to 1corresponds to an output relay for this protection function. See section 2.4 for a fuller explanation of the configuration of the output relays. The operation of the relay can be monitored as described in section 4.3.

Connect the equipment so that current can be injected through terminals 27 & 28.

Slowly increase the current from 0 amps and note the pick-up value at which the relay operates. Reduce the current slowly and note the drop-off value at which it resets. Check that the pick-up and drop-off values are within the range shown in Table 25.

	Current Level
Pick-up	0.9 x Is to 1.1 x Is
Drop-off	0.9 x Pick-up to 1.0 x Pick-up

Table 25

In table 25 above, Is corresponds to the settings for the earth fault element. These are found in the cells [Io>HV], [Io>LV1] and [Io>LV2], in the SETTINGS menu heading depending upon which winding is being tested.

7.3.2 REF element HV side operating time

Connect the relay as in section 7.3.1 above, but in addition connect the relay contacts for this protection function to both trip the test set and to stop a timer. Configure the test set so that when the current is applied to the relay, the timer starts.

Inject 5xIs into the relay and check that the operating time for the relay is within the range,

20ms to 30ms

7.3.3 REF current sensitivity LV1 side (Io> LV1)

In the SETTINGS menu go to cell [S1 Fn. Links] and set all the bits to 0 except bit 4, {S1 Enable Io> LV1} which should be set to 1. This will ensure that only the REF protection on the low voltage side of the transformer is enabled.

The relays selected for the REF protection on the LV1 side of the transformer can be found under the RELAY MASKS heading in the cell [RLY Io> LV1]. Each bit in this cell which is set to 1corresponds to an output relay for this protection function. See section 2.4 for a fuller explanation of the configuration of the output relays. The operation of the relay can be monitored as described in section 4.3.

Connect the equipment so that current can be injected through terminals 83 & 84.

Slowly increase the current from 0 amps and note the pick-up value at which the relay operates. Reduce the current slowly and note the drop-off value at which it resets. Check that the pick-up and drop-off values are within the range shown in Table 25.

7.3.4 REF element LV1 side operating time

Connect the relay as in section 7.3.3 above, but in addition connect the relay contacts for this protection function to both trip the test set and to stop a timer. Configure the test set so that when the current is applied to the relay, the timer starts.

Inject 5xIs into the relay and check that the operating time for the relay is within the range,

20ms to 30ms

7.3.5 REF current sensitivity LV2 side (Io> LV2)

In the SETTINGS menu go to cell [S1 Fn. Links] and set all the bits to 0 except bit 5, {S1 Enable Io> LV2} which should be set to 1. This will ensure that only the REF protection on the LV2 side of the transformer is enabled.

The relays selected for the REF protection on the LV2 side of the transformer can be found under the RELAY MASKS heading in the cell [RLY Io> LV2]. Each bit in this cell which is set to 1corresponds to an output relay for this protection function. See section 2.4 for a fuller explanation of the configuration of the output relays. The operation of the relay can be monitored as described in section 4.3.

Connect the equipment so that current can be injected through terminals 75 & 76.

Slowly increase the current from 0 amps and note the pick-up value at which the relay operates. Reduce the current slowly and note the drop-off value at which it resets. Check that the pick-up and drop-off values are within the range shown in Table 25.

7.3.6 REF element LV2 side operating time

Connect the relay as in section 7.3.5 above, but in addition connect the relay contacts for this protection function to both trip the test set and to stop a timer. Configure the test set so that when the current is applied to the relay, the timer starts.

Inject 5xIs into the relay and check that the operating time for the relay is within the range,

20ms to 30ms

8. PHASE COMPENSATION

This test will verify that the relays internal phase compensation is functioning correctly. In this test, current is injected through the A phase HV and LV1 windings. The phase compensation for both these windings should be set to the same value, which will result no differential current if the magnitudes of the injected currents are equal. The differential currents can be monitored using the MEASUREMENTS menu. One of the phase compensation factors on one of the windings is then changed which should result in differential current. Using the MEASUREMENTS menu the resultant differential current can be noted and compared with the values listed in table 26 below.

Note: It is important in this case that the injected currents are in anti-phase, i.e. 180° out of phase. This is achieved by having two current sources that are in phase and swapping the inputs into terminals 77 and 78 as shown below.

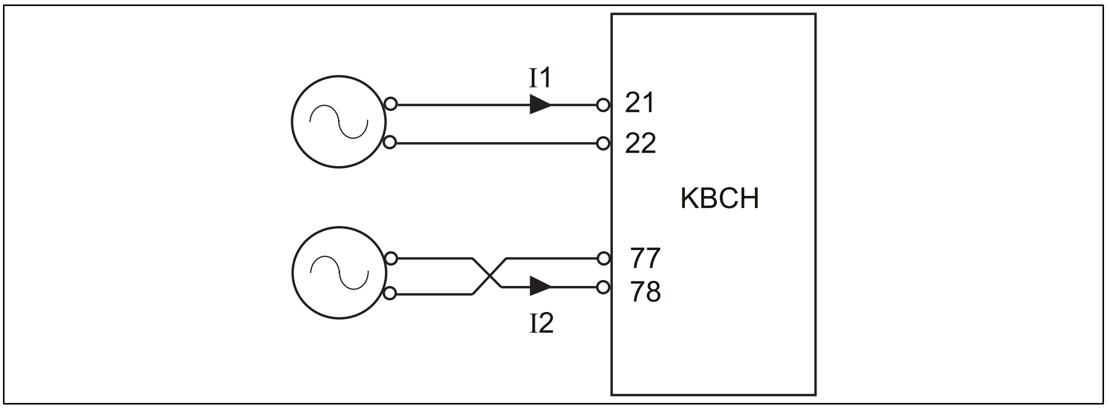


Figure 5: Phase Compensation Test.

Connect the relay as shown in figure 5 above. Go to the SETTINGS menu and set both cells [S1 HV VectorCor] and [S1 LV1 VectorCor] to the same phase compensation setting. Inject rated current, ensuring that the currents injected are effectively 180° out of phase. Go to the MEASUREMENTS menu and ensure that there are no measured values of differential current. The differential current measurements are found in the cells [Ia Diff], [Ib Diff] and [Ic Diff].

Then go to the SETTINGS menu and change the cell [S1 LV1 VectorCor] to the corresponding "opposite" setting listed in table 26. Go to the MEASUREMENTS menu and check that this time there are displayed values of differential current and that the values correspond with those listed in table 26, where Iinj is the value of injected current.

It is not necessary to perform checks on all the possible combinations of settings but it is recommended that the tests should be carried out with those settings that are to be used in the relay application.

Once the checks are complete both the cells [S1 HV Vector Cor] and [S1 LV1 Vector Cor] should be set to Yy0 as the rest of the commissioning checks are performed at this default setting.

HV VectorCor	LV1 VectorCor	Displayed Measured Values		
		Ia DIFF	Ib DIFF	Ic DIFF
Yy0	Yy6	2xIinj	0	0
Yd1	Yd7	2xIinj/$\sqrt{3}$	2xIinj/$\sqrt{3}$	0
Yd2	Yd8	2xIinj	0	2xIinj
Yd3	Yd9	0	2xIinj/$\sqrt{3}$	2xIinj/$\sqrt{3}$
Yd4	Yd10	0	0	2xIinj
Yd5	Yd11	2xIinj/$\sqrt{3}$	0	2xIinj/$\sqrt{3}$
Yd6	Yy0	2xIinj	0	0
Yd7	Yd1	2xIinj/$\sqrt{3}$	2xIinj/$\sqrt{3}$	0
Yd8	Yd2	2xIinj	0	2xIinj
Yd9	Yd3	0	2xIinj/$\sqrt{3}$	2xIinj/$\sqrt{3}$
Yd10	Yd4	0	0	2xIinj
Yd11	Yd5	2xIinj/$\sqrt{3}$	0	2xIinj/$\sqrt{3}$
Ydy0	Ydy6	4/3xIinj	2/3xIinj	2/3xIinj
Ydy6	Ydy0	4/3xIinj	2/3xIinj	2/3xIinj

Table 26

9. LOW SET ELEMENT BIAS CHARACTERISTIC

This test checks the low set element bias characteristic. The relay has a dual slope bias characteristic, therefore this test is performed at two points on the bias curve, one at 20% slope and the other at 80% slope, corresponding with bias currents of 0.5 p.u. and 1.5 p.u. respectively.

In the SETTINGS menu go to cell [S1 Fn. Links] and set all the bits to 0 except bit 1, {S1 Enable Id>}, which should be set to one. This will ensure that only the low set protection function is enabled.

The operation of the relay can be monitored as described in section 4.3 Relay operation. The relays selected for the low set differential protection function can be found under the RELAY MASKS heading. The relay to be monitored in this case is the A phase relay which is found in the cell [RLY Id>A]. Each bit in this cell which is set to 1 corresponds to an output relay which is selected for this function. See section 2.4 for a fuller explanation on the configuration of the output relays.

Note: It is important in this case that the injected currents are in anti-phase, i.e. 180° out of phase. This is achieved by having two current sources that are in phase and swapping the inputs into terminals 77 and 78 as shown below.

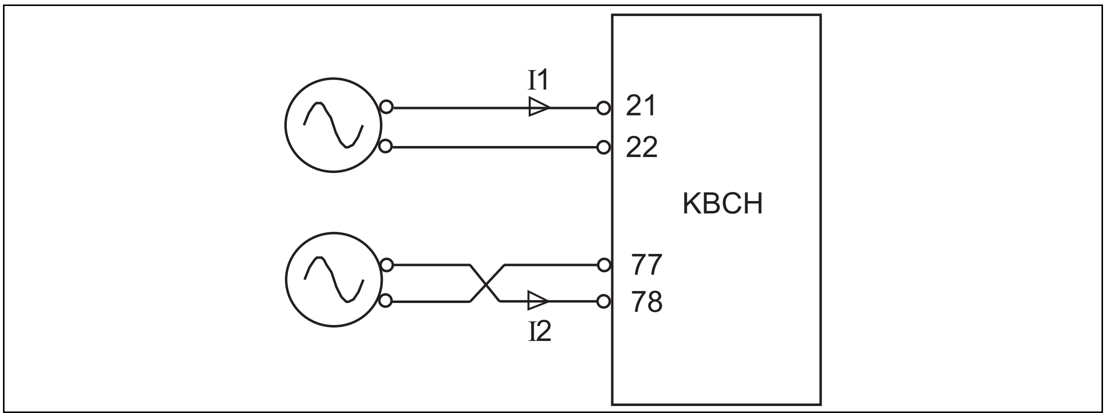


Figure 6: Low set bias characteristic

In total 4 tests should be performed, one to cause the relay to trip and one to not cause the relay to trip, for both sections of the bias curve.

From table 27, select the appropriate values of currents for each test, depending upon the setting and rating of the relay. Using the equations below calculate the values of currents to apply to the relay, (I1' and I2'). In all cases the current should not be applied for longer than 1 second. In all cases the applied current should be within ±5% of the calculated values.

$I1' = \dfrac{I1}{\text{HV CT Ratio Cor}}$	$I1' = \dfrac{I2}{\text{LV1 CT Ratio Cor}}$

		20% Characteristics				80% Characteristics			
In	Id>	Trip		No Trip		Trip		No Trip	
(amps)	(p.u.)	I1 (amps)	I2 (amps)	I1 (amps)	I2 (amps)	I1 (amps)	I2 (amps)	I1 (amps)	I2 (amps)
1	0.1	0.65	0.35	0.55	0.45	1.95	1.05	1.80	1.20
1	0.2	0.70	0.30	0.60	0.40	2.00	1.00	1.85	1.15
1	0.3	0.75	0.25	0.65	0.35	20.5	0.95	1.90	1.10
1	0.4	0.80	0.20	0.70	0.30	2.10	0.90	1.95	1.05
1	0.5	0.85	0.15	0.75	0.25	2.15	0.85	2.00	1.00
5	0.1	3.25	1.75	2.75	2.25	9.75	5.25	9.00	6.00
5	0.2	3.50	1.50	3.00	2.00	10.00	5.00	9.25	5.75
5	0.3	3.75	1.25	3.25	1.75	10.25	4.75	9.75	5.25
5	0.5	4.25	0.75	3.75	1.25	10.75	4.25	10.00	5.0

Table 27

Note: It is important to ensure that the currents I1′ and I2′ when applied to the relay are in anti phase, i.e. 180° out of phase.

10. MAGNETISING INRUSH RESTRAINT

This test checks that the magnetising inrush restraint is functioning by simulating a typical magnetising inrush waveform by half wave rectifying an AC input signal.

In the SETTINGS menu go to cell [S1 Fn. Links] and set all bits to 0 except bit 1, {S1 Enable Id>} which should be set to 1. This will ensure that only the low set protection function is enabled.

The relays selected to operate when the low set protection function operates on phase A will be found in the cell [RLY Id>A]. See section 2.4 for a fuller explanation of the configuration of the output relays. The operation of the relays can be monitored as described in section 4.3.

Connect the relay as shown below, ensuring that the diode is able to withstand the applied current.

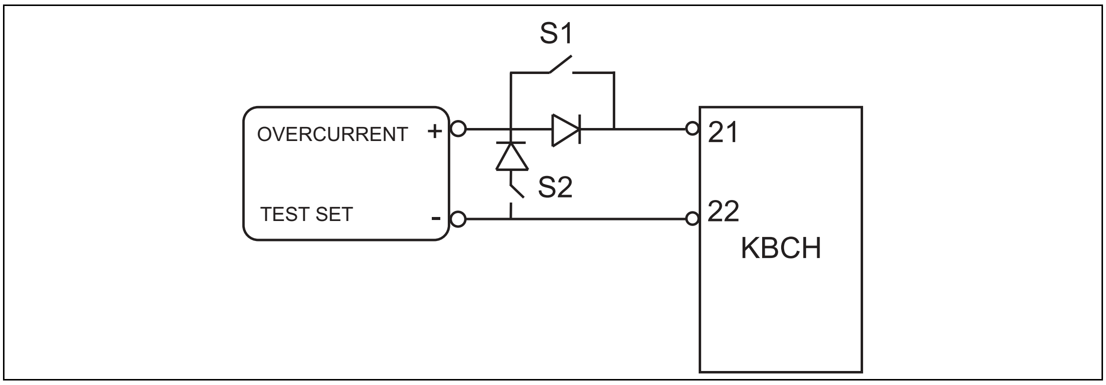


Figure 7: Magnetising inrush restraint circuit

With switch S1 closed and switch S2 open, inject 4xIs, where

$$Is = \frac{1.1\ [Id>]}{[HV\ Ratio\ Cor]}$$

Id> is the low set setting found under the SETTINGS menu heading. HV Ratio Cor is the CT ratio correction factor which is used to compensate for a mismatch in currents due to the line side current transformer ratios. This is found in the cell [HV RatioCor] in the SETTINGS menu heading. Ensure that the relay selected for the low set differential protection trips.

Then open switch S1 and close switch S2 and inject 4xIs. Ensure that the relay selected for the low set differential protection does not trip, thus indicating that the magnetising inrush detector has successfully blocked the low set differential protection.

11. OVERFLUX PROTECTION

The overflux protection has two independent elements, one which is used to give an alarm indication and one which is used to cause a trip. Note that the yellow alarm LED on the relay is used to indicate an internal fault in the relay and not a protection function alarm.

11.1 Overflux alarm sensitivity

In the SETTINGS menu heading, go to cell [S1 Fn. links] and set all bits to 0 except bit 8, {S1 Enable OF Alm} which should be set to 1. This will ensure that only the overflux alarm is enabled.

The relay selected to operate for this protection function can be found under the RELAY MASKS heading in the cell [RLY V/f Alarm]. Each bit in this cell which is set to 1corresponds to an output relay which is selected for this function. For a fuller description of the configuration of output relays see section 2.4.

Configure the equipment so that an AC voltage can be applied to terminals 17 and 18, starting a timer when the voltage is applied, and stopping the timer when the output relay energises.

For a duration greater than the time set in the cell [t V/f (Alarm)], found in the SETTINGS menu heading, apply a voltage of

$$V = \text{setting} \times f \times 0.95 \text{ volts}$$

to terminals 17 and 18, where setting = V/f alarm setting found in the cell [S1 V/f (Alarm)], and f = system frequency.

Ensure that the selected output relay does not energise.

Next, apply a voltage of

$$V = \text{setting} \times f \times 1.05 \text{ volts}$$

to terminals 17 and 18 and ensure that the selected output relay does energise and that the time is within ±20% of the time set in the cell [t V/f (Alarm)] found in the SETTINGS menu heading.

11.2 Overflux trip sensitivity

In the SETTINGS menu go to cell [S1 Fn. Links] and set all the bits to 0 except bit 7, {S1 Enable OF Trip} which should be set to 1. This will ensure that only the overflux trip function is enabled.

The relay selected to operate for this protection function can be found under the RELAY MASKS heading in the cell [RLY V/f Trip]. Each bit in this cell which is set to 1 corresponds to an output relay for this function. For a fuller description of the configuration of output relays see section 4.2.

The timing for this function can be either definite time (DT) or inverse minimum definite time (IDMT). This will be found under the SETTINGS menu heading in the cell [S1 V/f (Trip) Char]. If this cell is set to DT then operation of the output relay should occur in

$$T \pm 10\%$$

Where T is the value in the cell [S1 t V/f (Trip)] which is also found in the SETTINGS menu heading.

If the cell [S1 V/f (Trip) Char] is set to IDMT, then operation should occur in

$$t = 0.8 + \frac{0.18^* K}{(M - 1)^2} \pm 10\%$$

where K = Time Multiplier found in cell [S1 V/f (trip) TMS] in the SETTINGS menu and

$$M = \frac{Vapplied \,/\, f}{\left(V/f \right) \text{setting}}$$

This characteristic is plotted on the graph shown below.

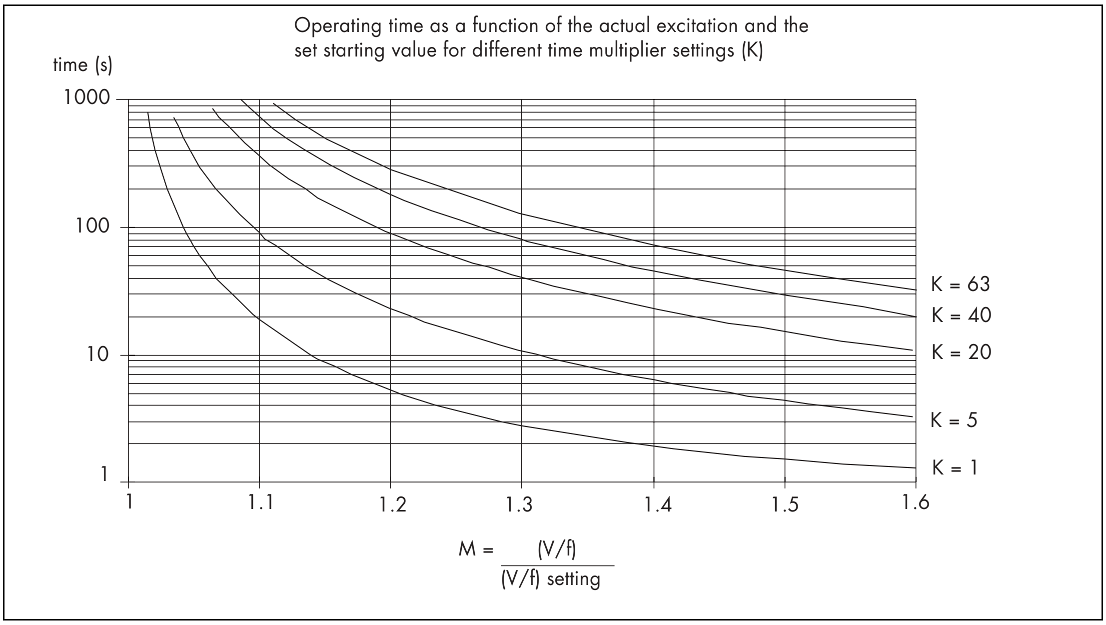


Figure 8

With the relay connected as in section 11.1, for a duration greater than the time t calculated from the equation above, apply a voltage of

V = settingxfx0.95

where setting = V/f trip setting found in the cell [S1 V/f Trip] in the SETTINGS menu, and f = system frequency, and ensure that the selected output relay does not energise.

Next apply a voltage of

V = settingxfx1.05

and ensure that the selected output relay does energise and that the time is within ±20% of the time t above.

11.3 Overflux fifth harmonic

This test checks the overflux fifth harmonic function of the relay. The overflux fifth harmonic function blocks the low set differential protection from operating if fifth harmonic current above setting is detected in the input current. This test can only be performed if the equipment is able to superimpose up to 55% fifth harmonic on the fundamental.

In the SETTINGS menu go to cell [S1 Fn. Links] and set all bits to 0 except bits 1 and 9, which should be set to 1. This will ensure that only the fifth harmonic blocking function of the relay and the low set differential protection are enabled.

The output relay selected to operate for the low set differential protection can be found under the RELAY MASKS heading in the cell [RLY Id>A]. Each bit in this cell which is set to 1 corresponds to an output relay for this function. For a fuller description of the configuration of output relays see section 2.4.

Connect the relay as shown below in Figure 9.

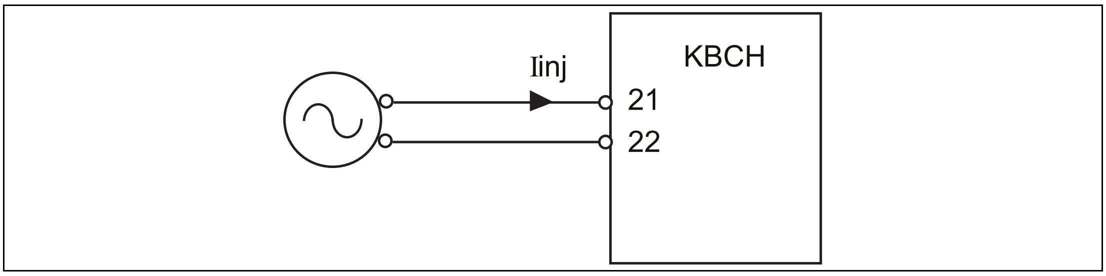


Figure 9: Fifth harmonic blocking circuit

Inject the following current into the relay and ensure that the output relay for the low set differential protection operates.

$$\mathrm{Iinj} = 1.1\left[\frac{\mathrm{Id>}}{\text{HV Ratio Cor}}\right] + [\mathrm{Iof} + 5\%]$$

where,

Id> = low set setting found in the cell [Id>A]

HV Ratio Cor = CT ratio correction found in the cell [HV RatioCor]

Iof = Fifth harmonic current setting found in the cell [S1 Iof]

All of the above settings are found under the SETTINGS menu heading. In this case the fifth harmonic content of the input current is below setting and the low set differential protection should operate.

Next inject the following current and ensure that the output relay for the low set differential protection does not operate.

$$\mathrm{Iinj} = 1.1\left[\frac{\mathrm{Id>}}{\text{HV Ratio Cor}}\right] + [\mathrm{Iof} + 5\%]$$

In this case the fifth harmonic content of the input current is above setting and the low set differential protection should be blocked from operating.

11.4 Overflux fifth harmonic relay operating time

The overflux fifth harmonic detector can be selected to operate an output relay if required. The output relay selected to operate for this function is found under RELAY MASKS heading in the cell [RLY OF Alarm]. Each bit in this cell which is set to 1 corresponds to an output relay for this function. For a fuller description of the configuration of output relays see section 2.4. If there are no bits in this cell set to 1 then there is no need to perform this test.

There is a settable time delay associated with this function which results in a delay between the detection of the fifth harmonic current above setting and operation of the output relay. This time delay is found in the cell [S1 tOF] under the SETTINGS menu heading. This test should only be performed if the timer setting is not so high that testing is impractical. It should be noted that the timer setting can go up to 4 hours.

Connect the relay as in Figure 9, but in addition connect the relay selected to operate for the fifth harmonic detector to stop the timer. Configure the current source such that the timer starts upon application of the current. Apply the following current to the relay:

$$\text{Iinj} = 1.1 \left[\frac{\text{Id>}}{\text{HV Ratio Cor}}\right] + [\text{Iof} + 5\%]$$

Record the operating time and ensure that it lies within the range.

[S1tOF] ± 10%

12. SELECTIVE LOGIC

For the selective logic tests, 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.

12.1 Opto input checks

To enable energisation of the opto inputs, terminal 8 should be linked to terminals 52 and 55. The opto inputs can then be energised by connecting terminal 7 to the appropriate opto input listed in table 28.

Note: The opto isolated inputs may be energised from an external 50V battery in some installations. Check that this has been disconnected before connecting the field voltage to the terminals otherwise damage to the relay may result.

Opto Input Terminal	Number	Bit
L0	46	0
L1	48	1
L2	50	2
L3	45	3
L4	47	4
L5	49	2
L6	51	6
L7	53	7

Table 28

The status of each opto input can be viewed by monitoring the cell [SYS Logic Stat] in the SYSTEM DATA menu heading. When an opto input is energised, the appropriate bit in this cell will be set to 1. Which bit corresponds to which opto-input is listed in table 28. When the opto input is de-energised the bit will be reset to 0.

Test each opto-input in turn by applying a DC voltage from terminal 7 and monitoring the cell [SYS Logic Stat]. Ensure that the correct bit is set to 1 when the corresponding opto-input is energised.

12.2 Controlled blocking of overflux protection

This test need only be done if the relay application requires blocking of the overflux protection. As there are two elements to the overflux protection, there are two possibilities shown in table 29 below.

Input to Block	Input Mask
Overflux trip	INP Blk V/f Trp
Overflux alarm	INP Blk V/f Alm

Table 29

To perform the overflux blocking tests, one or more opto isolated input has to be allocated for each blocking function. When the allocated opto input is energised, as in section 11.1, the appropriate protection function will be blocked.

For the overflux trip function energise the appropriate opto input and repeat test 11.2 at the higher voltage setting (V= fxsettingx1.05) and check that the element is correctly blocked and does not operate.

For the overflux alarm function energise the appropriate opto input and repeat test 11.1 at the higher voltage setting and check that the element is correctly blocked and does not operate.

12.3 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. It should be noted that the timer settings can go up to 4 hours.

Which opto isolated inputs are configured to initiate which timers can be found under the INPUT MASKS menu heading. These are listed in table 30.

Input Mask	Description
INP Aux 0	Input to initiate taux0
INP Aux 1	Input to initiate taux1
INP Aux 2	Input to initiate taux2
INP Aux 3	Input to initiate taux3
INP Aux 4	Input to initiate taux4
INP Aux 5	Input to initiate taux5
INP Aux 6	Input to initiate taux6
INP Aux 7	Input to initiate taux7

Table 30

Each bit in the cells [INP Aux 0] to [INP Aux 7] which is set to1 corresponds to the opto input which, when energised will initiate the appropriate timer.

The time delay associated with each timer can be found in the LOGIC FUNCTIONS menu heading in the cells [LOG tAUX 0] to [LOG tAUX 7]. The relays operated by the auxiliary timers can be found under the RELAY MASKS menu heading in the cells [RLY Aux 0] to [RLY Aux 7].

To test any of the auxiliary time delays, an external switch must be connected to start an external timer and to energise the opto input which activates the relevant auxiliary timer. The external timer must be stopped by the selected relay when it operates.

The measured time delay should be within the range

set time $\pm$10%.

12.4 Change of setting group

This test will check that the setting group i.e. SETTINGS(1) and SETTINGS(2), can be changed remotely, either from the master station or via a local p.c. equipped with the suitable software.

This test need only be performed if bit 4 {SYS Enable Grp2} in the cell [SYS Fn. Links] under the SYSTEM DATA menu heading is set to 1. If bit 4 is set to 0 then there is no need for the tests in this section to be carried out.

If bit 3 {SYS Rem ChgGrp} in the cell [SYS Fn. Links] is set to 0, then the setting group can be changed by energising the opto input allocated in the INPUT MASKS menu heading in the cell [INP Set Grp2]. However, if bit 3 is set to 1, then the setting group can only be changed using the communications channel, either from the master station or a local p.c. equipped with suitable software.

To test the change of setting group, initiate the change described above either by energising the relevant opto input or by a command over the communications channel.

The active setting group can be observed in the SYSTEM DATA column of the menu in the cell [SYS Setting Grp]. This will display the current selected group. The current setting group is stored with 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.

12.5 Remote control of transformer tap changer

The tap changer can be instructed to raise or lower a tap via commands over the serial communications link or locally via the menu system. Two cells in the RELAY MASKS menu heading, [TapUp] and [TapDown], are provided for this purpose. Each bit in these cells which is set to 1 corresponds to an output relay for this function. On receiving the request to change the taps the appropriate relay is operated for a time given by the appropriate setting. The times are found in the LOGIC FUNCTIONS menu in the cells [LOG tTapUp] and [LOG tTapDown].

Go to the TEST/CONTROL menu heading and step down to the cell [TST Tap Control]. Set this to {TapUp}. When the prompt:

Are You Sure?

+ = Yes – = No

is displayed and the [+] button is pressed, the relay selected for the tap up operation will close for the duration set in the cell [LOG tTapUp]. Verify this by configuring the relay so that it both starts and stops a timer. The measured time should be in the range [LOG tTapUp]±10%. The [TST Tap Control] cell will then reset back to the default, {NoOperation}.

Repeat this test for the tap down function by setting the cell [TST Tap Control] to {Tap Down}.

13. FUNCTION LINKS

This check is to make sure that the function links are reset to the calculated application setting.

Go to cell [S1 Fn. Links] in the SETTINGS(1) menu and ensure that it is set to the calculated application setting as recorded at the start of the commissioning test record.

If group 2 is required, go to cell [S2 Fn. Links] in the SETTINGS(2) menu and ensure that it is set to the calculated application setting.

In the SETTINGS(1) and SETTINGS(2) menus, ensure that the phase compensation cells {HV Vector Cor}, {LV1 Vector Cor} and {LV2 Vector Cor} are set back to the calculated application settings. Note that {LV2 Vector Cor} will only appear on the KBCH130 and KBCH140 models.

14. REF PRIMARY INJECTION TESTS

Primary injection tests will be used to check that the current transformers for the restricted earth fault scheme are correctly connected.

14.1 Correct set up check

Before commencing any primary injection tests it is essential to ensure that the circuit is dead, isolated from the remainder of the system and that only those earth connections associated with the primary injection test equipment are in position.

This test should only be performed for each REF input that has a neutral CT connected to it. If there is no neutral CT then there is no need to perform the test on that particular input. Figure 10 shows the connections for the LV1input. This and the other restricted earth fault inputs are listed below.

REF Input	Relay Terminals
HV	27, 28
LV1	83, 84
LV2	75, 76

Table 31

Note that the LV2 winding does not appear on the KBCH120, and will only appear on the 130 and 140 models if they are configured to have the LV2 winding connected.

Connect the relay shown below.

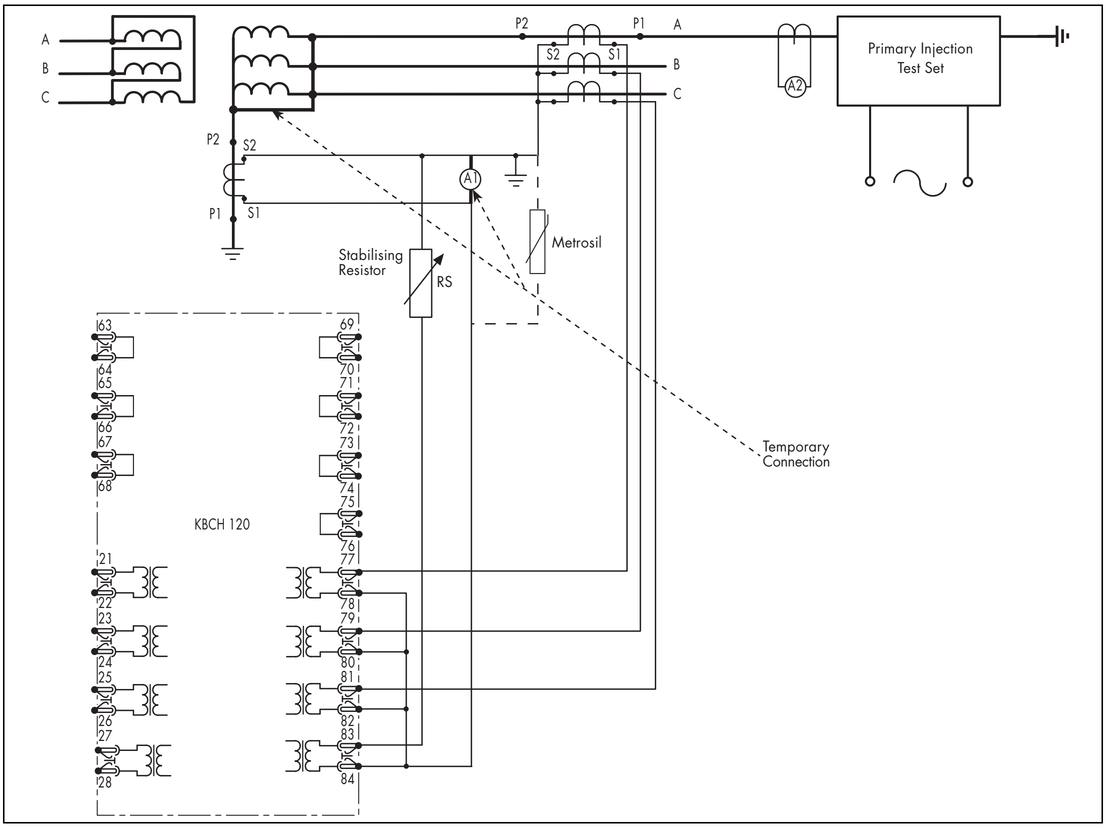


Figure 10: REF Primary injection test set up

During this test it is necessary to measure the spill current in the relay circuit, and short out the relay and stabilising resistor, (if fitted). The current should be increased up to as near full load as possible and the current flowing through ammeter A1 noted. If the connections are correct then this current should be very low, only a few milliamps. A high reading, (twice the injected current, referred through the current transformer ratio) indicates that one of the current transformer connections is reversed.

This test should be repeated for the B-phase CT and neutral CT and then the C-phase CT and neutral CT, and every REF input that has a neutral CT connected to it.

15. ON LOAD TEST

There are some tests that may be carried out with the circuit on-load, provided that there are no operational restrictions in force that prohibit this.

15.1 Correct set up check

The correct connection of CT's and the selection of phase and ratio correction factors are essential to the operation of the relay. This test will check that the relay has been correctly configured with the settings and is correctly wired to the line CT's. These tests should be performed at the transformer tap changer position that the settings calculations were made at. If this is not possible a difference of up to 15% should be allowed for.

When the transformer is under normal steady state load conditions and the relay is configured and wired correctly, then the differential current should be less than 5% of the bias current. Go to the MEASUREMENTS menu and note the current flowing in each of the following cells.

MS1 Ia Diff	MS1 Ia Bias
MS1 Ib Diff	MS1 Ib Bias
MS1 Ic Diff	MS1 Ic Bias

If the differential current is greater than 5% of the bias current then the following should be checked.

Ensure that the phase compensation and ratio correction settings are set to the calculated application settings. These are found under the SETTINGS menu heading in the cells;

HV Ratio Cor	HV VectorCor
LV1 Ratio Cor	LV1 VectorCor
LV2 Ratio Cor	LV2 VectorCor

Note that the LV2 cells do not appear on the KBCH120 model and will not appear on the KBCH130 and KBCH140 models if they are configured as [HV + LV].

If the phase compensation and ratio correction settings are correct, and the differential current is still larger than expected then check that the relay is correctly wired at the relay terminals and that the connections from the line CT's are of the correct polarity.

16. TYPICAL APPLICATION DIAGRAMS

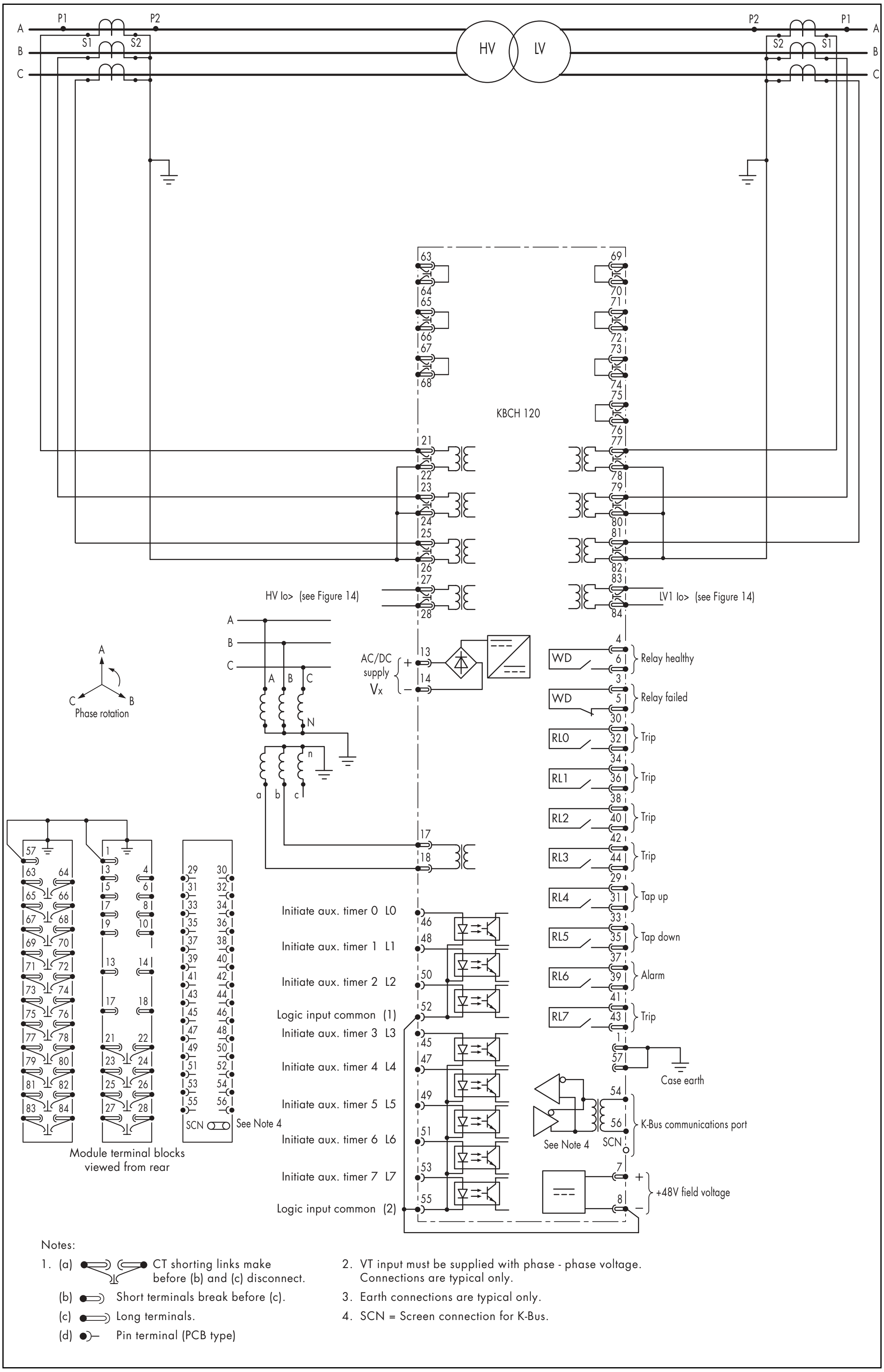


Figure 11: Typical external connections for KBCH 120

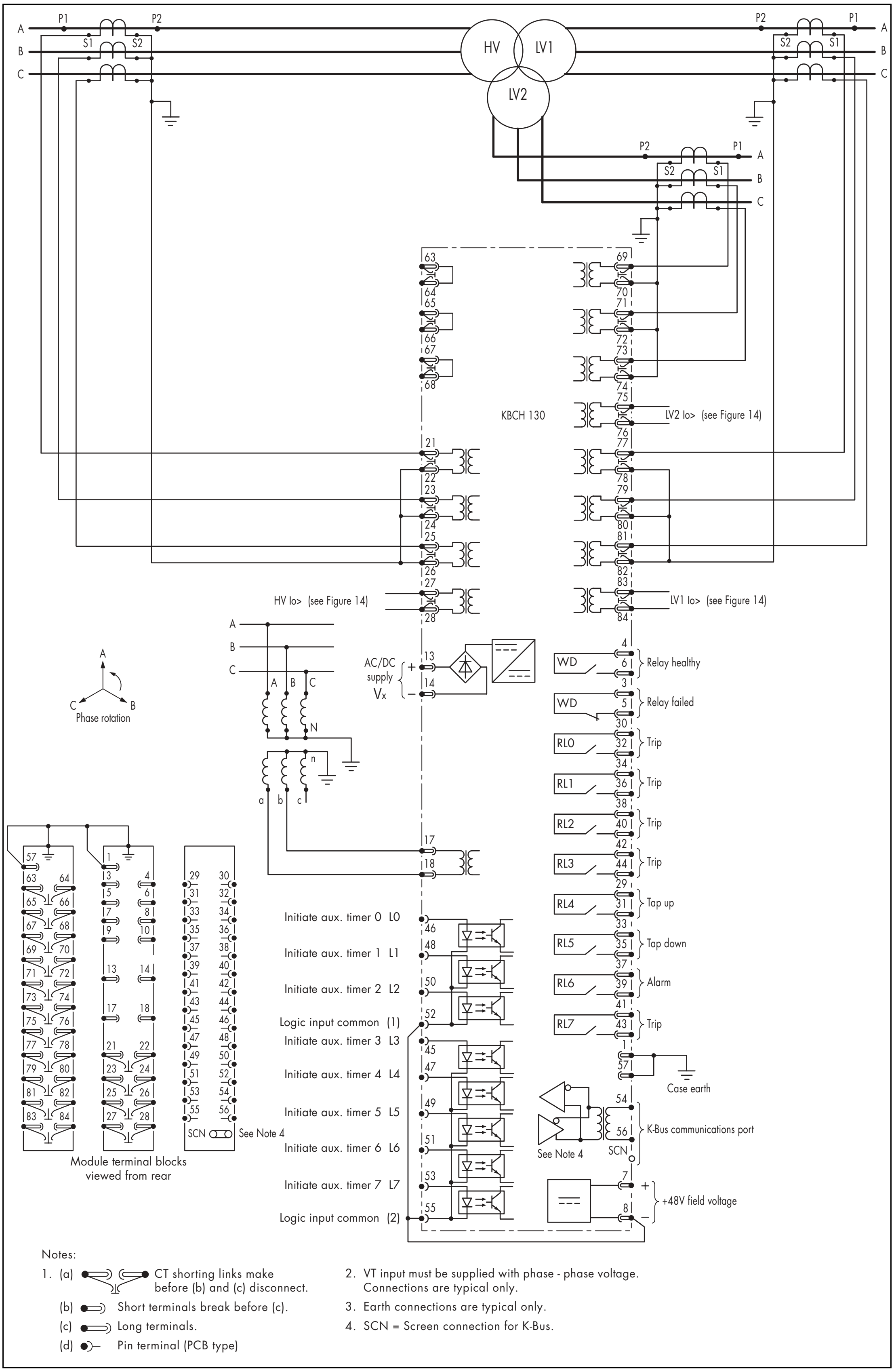
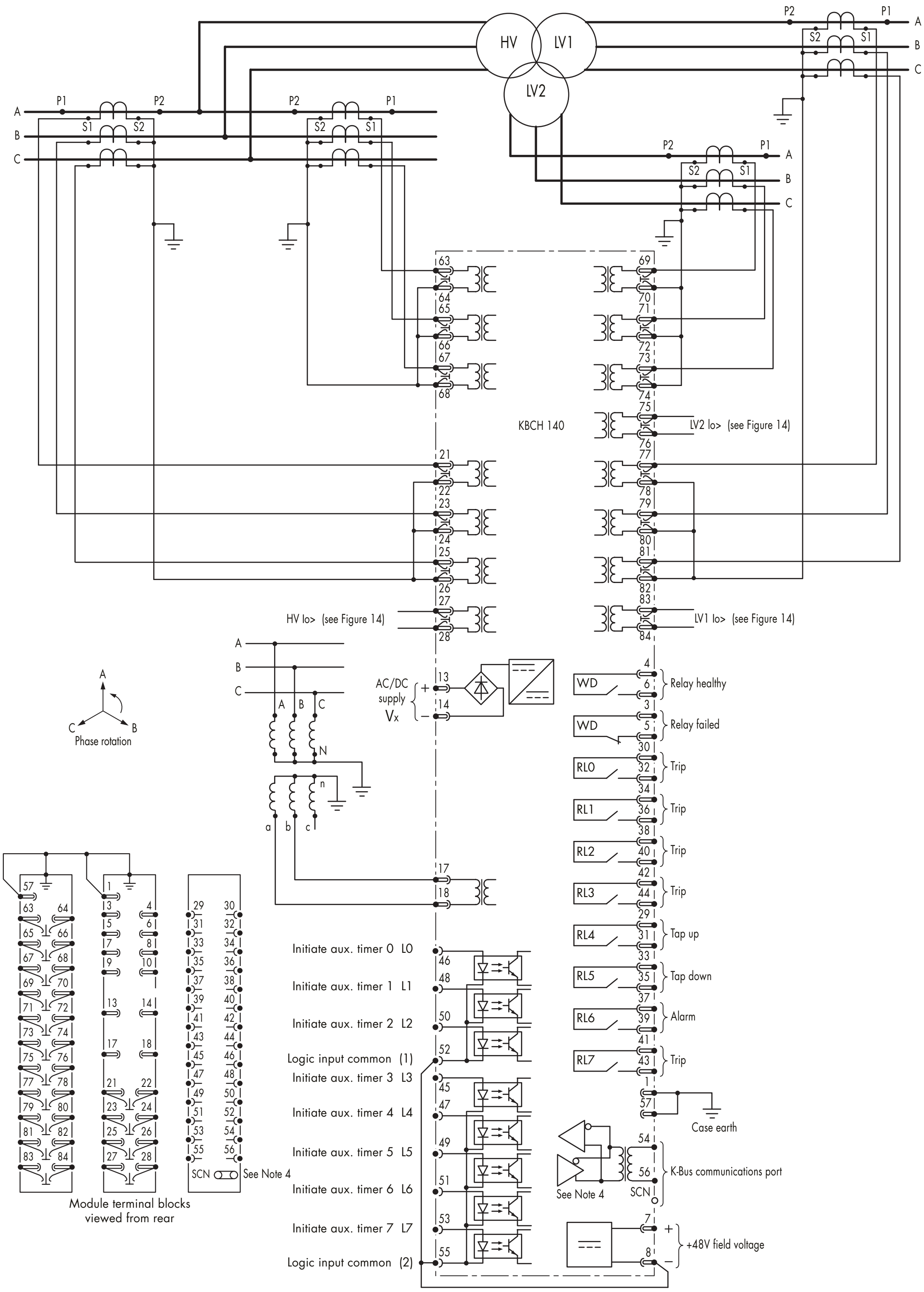


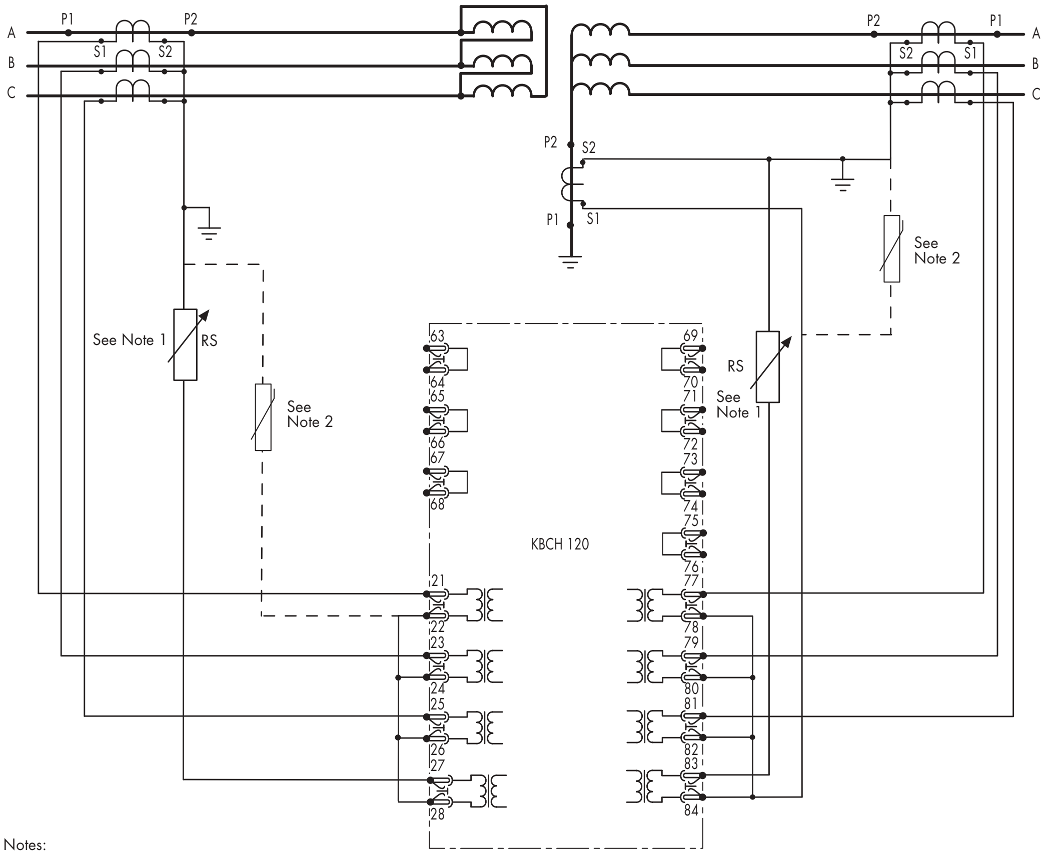
Figure 12: Typical external connections for KBCH130



Notes:

1. (a) CT shorting links make before (b) and (c) disconnect.
   (b) Short terminals break before (c).
   (c) Long terminals.
   (d) Pin terminal (PCB type)
2. VT input must be supplied with phase - phase voltage. Connections are typical only.
3. Earth connections are typical only.
4. SCN = Screen connection for K-Bus.

Figure 13: Typical external connections for KBCH140



Notes:

1. See Service Manual R8530 for the setting of the external stabilising resistor.
2. Optional voltage limiting non-linear resistor (see Service Manual R8530).

Figure 14: Typical restricted earth fault connections for KBCH12

CHAPTER 4
Commissioning Test Result

Transformer Differential Relay **KBCH**

Relay Model Number		Date	
Serial Number			
Station		Circuit	

Front plate information

Transformer Differential Relay Type	KBCH
Model No.	
Serial No.	
Rated Current In	
Aux Voltage Vx	
Voltage Vn	
Frequency	

1.4 Inspection

	tick
Check for damage	
CT shorting switches in case checked	
Serial number on module and case checked	
External wiring checked to diagram (if available)	

Terminals checked for continuity

	tick		tick		tick
21 & 22		65 & 66		75 & 76	
23 & 24		67 & 68		77 & 78	
25 & 26		69 & 70		79 & 80	
27 & 28		71 & 72		81 & 82	
63 & 64		73 & 74		83 & 84	

		tick
1.5	**Earth connection to case checked**	
1.7	**Test block connection checked**	
1.8	**Insulation checked**	

3 AUXILIARY SUPPLY TESTS

3.1 Auxiliary voltage at relay terminals

____________________ Vac/dc

3.2 Energisation from auxiliary voltage supply

Watchdog contacts checked

		tick
Supply off	Terminals 3 & 5 (closed)	
	Terminals 4 & 6 (open)	
Supply on	Terminals 3 & 5 (open)	
	Terminal 4 & 6 (closed)	

3.3 Field Voltage

____________________ Vdc

4 SETTINGS

System Data Settings	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0
SYS Password																
SYS Fn. Links	0	0	0	0	0	0	0	0								
SYS Description																
SYS Plant Ref.																
SYS Model No.																
SYS Serial No.																
SYS Frequency																
SYS Comms Level																
SYS Rly Address																
SYS Setting Grp.																
SYS S/W Ref 1																
SYS S/W Ref 2																

SETTINGS 1	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0
S1 Fn. Links																
S1 Configuration																
S1 HV CT Ratio																
S1 LV1 CT Ratio																
S1 LV2 CT Ratio																
S1 HV Ratio Cor																
S1 HV Vector Cor																
S1 LV1 Ratio Cor																
S1 LV1 Vector Cor																
S1 LV2 Ratio Cor																
S1 LV2 Vector Cor																
S1 Id>																
S1 Id>>																
S1 Io> HV																
S1 Io> LV1																
S1 Io> LV2																
S1 Iof																
S1 tof																
S1 V/f (Trip) Char																
S1 V/f (Trip)																
S1 V/f (Trip) TMS or S1 t V/f (Trip)																
S1 V/f (Alarm)																
S1 t V/f (Alarm)																

SETTINGS 2	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0
S2 Fn. Links																
S2 Configuration																
S2 HV CT Ratio																
S2 LV1 CT Ratio																
S2 LV2 CT Ratio																
S2 HV Ratio Cor																
S2 HV Vector Cor																
S2 LV1 Ratio Cor																

S2 LV1 Vector Cor	
S2 LV2 Ratio Cor	
S2 LV2 Vector Cor	
S2 Id>	
S2 Id>>	
S2 Io> HV	
S2 Io> LV1	
S2 Io> LV2	
S2 Iof	
S2 tof	
S2 V/f (Trip) Char	
S2 V/f (Trip)	
S2 V/f (Trip) TMS or S2 t V/f (Trip)	
S2 V/f (Alarm)	
S2 t V/f (Alarm)	

LOGIC FUNCTIONS

LOG tAUX0	
LOG tAUX1	
LOG tAUX2	
LOG tAUX3	
LOG tAUX4	
LOG tAUX5	
LOG tAUX6	
LOG tAUX7	
LOG tTest	
LOG tTapUp	
LOG t TapDown	
LOG DefaultDsply	

INPUT MASKS	7	6	5	4	3	2	1	0
INP Blk V/F Trp								
INP Blk V/f Alm								
INP Aux 0								
INP Aux 1								

INP Aux 2								
INP Aux 3								
INP Aux 4								
INP Aux 5								
INP Aux 6								
IN Aux 7								
INP Set Grp 2								

RELAY MASKS	7	6	5	4	3	2	1	0
RLY Id>A								
RLY Id>B								
RLY Id>C								
RLY Id>>A								
RLY Id>>B								
RLY Id>>C								
RLY Io>HV								
RLY Io>LV1								
RLY Io>LV2								
RLY AUX 0								
RLY AUX 1								
RLY AUX 2								
RLY AUX 3								
RLY AUX 4								
RLY AUX 5								
RLY AUX 7								
RLY Tap Up								
RLY Tap Down								
RLY Of Alarm								
RLY V/F Trip								
RLY V/f Alarm								

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 Logic trig																

REC Relay trig																

4.3 Relay Operation

	tick		tick
Relay 0		Relay 4	
Relay 1		Relay 5	
Relay 2		Relay 6	
Relay 3		Relay 7	

5 KBCH 120

5.1.1 HV + LV1 Winding Measurements Checks

HV CT Ratio ____________

HV Ratio Correction ____________

HV Phase Compensation ____________

LV1 CT Ratio ____________

LV1 Ratio Correction ____________

LV1 Phase Compensation ____________

PHASE CURRENT

Injected current ____________ A

EXPECTED VALUES			RELAY MEASURED VALUES	
Ia HV	____________	A	____________	A
Ib HV	____________	A	____________	A
Ic HV	____________	A	____________	A
Ia LV1	____________	A	____________	A
Ib LV1	____________	A	____________	A
Ic LV1	____________	A	____________	A

DIFFERENTIAL CURRENT

Theoretical value ____________ A

RELAY MEASURED VALUE

Ia Diff ____________ A

Ib Diff ____________ A

Ic Diff ____________ A

BIAS CURRENT

Theoretical value	________	A
RELAY MEASURED VALUE		
Ia Bias	________	A
Ib Bias	________	A
Ic Bias	________	A

5.1.2 Frequency Measurement

F injected	________	Hz
F measured	________	Hz

5.2 Differential Protection

5.2.1 Low set element current sensitivity (Id>)

	Setting Group 1		Setting Group 2 (if required)	
Setting (Is)	________	A	________	A
Ia HV Pick-up	________	A	________	A
Ia HV Drop-off	________	A	________	A
Ib HV Pick-up	________	A	________	A
Ib HV Drop-off	________	A	________	A
Ic HV Pick-up	________	A	________	A
Ic HV Drop-off	________	A	________	A
Ia LV1 Pick-up	________	A	________	A
Ia LV1 Drop-off	________	A	________	A
Ib LV1 Pick-up	________	A	________	A
Ib LV1 Drop-off	________	A	________	A
Ic LV1 Pick-up	________	A	________	A
Ic LV1 Drop-off	________	A	________	A

5.2.2 Low set element operating time

Expected 30ms to 40ms

Ia HV	________	ms	________	ms
Ib HV	________	ms	________	ms
Ic HV	________	ms	________	ms

5.2.3 High set element (Id>>)

	Setting Group 1		Setting Group 2 (if required)	
Setting (Is)	______	A	Setting (Is) ______	A

	tick	tick
Ia HV Trip		
Ia HV No Trip		
Ib HV Trip		
Ib HV No Trip		
Ic HV Trip		
Ic HV No Trip		

5.2.4 High set operating time

Expected – 10ms to 20ms

Ia HV	______	ms	______	ms
Ib HV	______	ms	______	ms
Ic HV	______	ms	______	ms

5.3.1 REF HV side current sensitivity (Io>HV)

	Setting Group 1		Setting Group 2 (if required)	
Setting (Is)	______	A	______	A
Io HV Pick-up	______	A	______	A
Io HV Drop-off	______	A	______	A

5.3.2 REF HV side operating time

Expected – 20ms to 30ms

Operating time	______	ms	______	ms

5.3.3 REF LV1 side current sensitivity (Io>LV1)

Setting (Is)	______	A	______	A
Io LV1 Pick-up	______	A	______	A
Io LV1 Drop-off	______	A	______	A

5.3.4 REF LV1 side operating time

Expected – 20ms to 30ms

Operating time	______	ms	______	ms

---

6 KBCH 130

6.1.1 HV + LV1 + LV2 measurement checks

HV CT Ratio	______
HV Ratio Correction	______
HV Phase Compensation	______
LV1 CT Ratio	______
LV1 Ratio Correction	______
LV1 Phase Compensation	______
LV2 CT Ratio	______
LV2 Ratio Correction	______
LV2 Phase Compensation	______

PHASE CURRENT

Injected current	______	A

EXPECTED VALUES			RELAY MEASURED VALUES	
Ia HV	______	A	______	A
Ib HV	______	A	______	A
Ic HV	______	A	______	A
Ia LV1	______	A	______	A
Ib LV1	______	A	______	A
Ic LV1	______	A	______	A
Ia LV2	______	A	______	A
Ib LV2	______	A	______	A
Ic LV2	______	A	______	A

DIFFERENTIAL CURRENT

Theoretical value	______	A

RELAY MEASURED VALUE

Ia Diff	______	A
Ib Diff	______	A
Ic Diff	______	A

BIAS CURRENT

Theoretical value ________ A

RELAY MEASURED VALUE

Ia Bias ________ A

Ib Bias ________ A

Ic Bias ________ A

6.1.2 Frequency Measurement

F injected ________ Hz

F measured ________ Hz

6.2 Differential Protection

6.2.1 Low set element current sensitivity (Id>)

	Setting Group 1		Setting Group 2 (if required)	
Setting (Is)	________	A	________	A
Ia HV Pick-up	________	A	________	A
Ia HV Drop-off	________	A	________	A
Ib HV Pick-up	________	A	________	A
Ib HV Drop-off	________	A	________	A
Ic HV Pick-up	________	A	________	A
Ic HV Drop-off	________	A	________	A
Ia LV1 Pick-up	________	A	________	A
Ia LV1 Drop-off	________	A	________	A
Ib LV1 Pick-up	________	A	________	A
Ib LV1 Drop-off	________	A	________	A
Ic LV1 Pick-up	________	A	________	A
Ic LV1 Drop-off	________	A	________	A
Ia LV2 Pick-up	________	A	________	A
Ia LV2 Drop-off	________	A	________	A
Ib LV2 Pick-up	________	A	________	A
Ib LV2 Drop-off	________	A	________	A
Ic LV2 Pick-up	________	A	________	A
Ic LV2 Drop-off	________	A	________	A

6.2.2 Low set element operating time

	Setting Group 1		Setting Group 2 (if required)	
Expected – 30ms to 40ms				
Ia HV	________	ms	________	ms
Ib HV	________	ms	________	ms
Ic HV	________	ms	________	ms

6.2.3 High Set element (Id>>)

Setting (Is)	________	A	Setting (Is)	________	A

	tick	tick
Ia HV Trip		
Ia HV No Trip		
Ib HV Trip		
Ib HV No Trip		
Ic HV Trip		
Ic HV No Trip		

6.2.4 High set element operating time

Expected – 10ms to 20ms

Ia HV	________	ms	________	ms
Ib HV	________	ms	________	ms
Ic HV	________	ms	________	ms

6.3.1 REF HV side current sensitivity (Io>HV)

	Setting Group 1		Setting Group 2 (if required)	
Setting (Is)	________	A	________	A
Io HV Pick-up	________	A	________	A
Io HV Crop-off	________	A	________	A

6.3.2 REF HV side operating time

Expected - 20ms to 30ms

Operating time	______	ms	______	ms

6.3.3 REF LV1 side current sensitivity (Io>LV1)

Setting (Is)	______	A	______	A
Io LV1 Pick-up	______	A	______	A
Io LV1 Drop-off	______	A	______	A

6.3.4 REF LV1 side operating

Expected - 20ms to 30ms

Operating time	______	ms	______	ms

6.3.5 REF LV2 side current sensitivity (Io>LV2)

Setting (Is)	______	A	______	A
Io LV1 Drop-off	______	A	______	A

6.3.6 REF LV2 side operating time

Expected - 20ms to 30ms

Operating time	______	ms	______	ms

7 KBCH 140

7.1.1 HV + LV1 Measurement checks

HV CT Ratio	______
HV Ratio Correction	______
HV Phase Compensation	______
LV1 CT Ratio	______
LV1 Ratio Correction	______
LV1 Phase Compensation	______
LV2 CT Ratio	______
LV2 Ratio Correction	______
LV2 Phase Compensation	______

PHASE CURRENT

Injected current ______________ A

EXPECTED VALUES			RELAY MEASURED VALUES	
Ia HV	______________	A	______________	A
Ib HV	______________	A	______________	A
Ic HV	______________	A	______________	A
Ia LV1	______________	A	______________	A
Ib LV1	______________	A	______________	A
Ic LV1	______________	A	______________	A

7.1.2 LV2 + LV3 measurement check

Ia LV2	______________	A	______________	A
Ib LV2	______________	A	______________	A
Ic LV2	______________	A	______________	A

DIFFERENTIAL CURRENT

Theoretical value ______________ A

RELAY MEASURED VALUE

Ia Diff ______________ A

Ib Diff ______________ A

Ic Diff ______________ A

BIAS CURRENT

Theoretical value ______________ A

RELAY MEASURED VALUE

Ia Bias ______________ A

Ib Bias ______________ A

Ic Bias ______________ A

7.1.3 Frequency Measurement

F injected ______________ Hz

F measured ______________ Hz

7.2 Differential Protection

7.2.1 Low set element current sensitivity (Id>)

	Setting Group 1		Setting Group 2 (if required)	
Setting (Is)	______	A	______	A
Ia HV Pick-up	______	A	______	A
Ia HV Drop-off	______	A	______	A
Ib HV Pick-up	______	A	______	A
Ib HV Drop-off	______	A	______	A
Ic HV Pick-up	______	A	______	A
Ic HV Drop-off	______	A	______	A
Ia LV1 Pick-up	______	A	______	A
Ia LV1 Drop-off	______	A	______	A
Ib LV1 Pick-up	______	A	______	A
Ib LV1 Drop-off	______	A	______	A
Ic LV1 Pick-up	______	A	______	A
Ic LV1 Drop-off	______	A	______	A
Ia LV2 Pick-up	______	A	______	A
Ia LV2 Drop-off	______	A	______	A
Ib LV2 Pick-up	______	A	______	A
Ib LV2 Drop-off	______	A	______	A
Ic LV2 Pick-up	______	A	______	A
Ic LV2 Drop-off	______	A	______	A
Ia LV3 Pick-up	______	A	______	A
Ia LV3 Drop-off	______	A	______	A
Ib LV3 Pick-up	______	A	______	A
Ib LV3 Drop-off	______	A	______	A
Ic LV3 Pick-up	______	A	______	A
Ic LV3 Drop-off	______	A	______	A

7.2.2 Low set element operating time

	Setting Group 1		Setting Group 2 (if required)	
Expected – 30ms to 40ms				
Ia HV	________	ms	________	ms
Ib HV	________	ms	________	ms
Ic HV	________	ms	________	ms

7.2.3 High Set element (Id>>)

Setting (Is)	________	A	Setting (Is) ________	A

	tick	tick
Ia HV Trip		
Ia HV No Trip		
Ib HV Trip		
Ib HV No Trip		
Ic HV Trip		
Ic HV No Trip		

7.2.4 High set element operating time

Expected – 10ms to 20ms

Ia HV	________	ms	________	ms
Ib HV	________	ms	________	ms
Ic HV	________	ms	________	ms

7.3.1 REF HV side current sensitivity (Io>HV)

	Setting Group 1		Setting Group 2 (if required)	
Setting (Is)	________	A	________	A
Io HV Pick-up	________	A	________	A
Io HV Crop-off	________	A	________	A

7.3.2 REF HV side operating time

Expected - 20ms to 30ms

Operating time	________	ms	________	ms

7.3.3 REF LV1 side current sensitivity (Io>LV1)

Setting (Is)	______	A	______	A
Io LV1 Pick-up	______	A	______	A
Io LV1 Drop-off	______	A	______	A

7.3.4 REF LV1 side operating

Expected - 20ms to 30ms

Operating time	______	ms	______	ms

7.3.5 REF LV2 side current sensitivity (Io>LV2)

Setting (Is)	______	A	______	A
Io LV1 Drop-off	______	A	______	A

7.3.6 REF LV2 side operating time

Expected - 20ms to 30ms

Operating time	______	ms	______	ms

8 PHASE COMPENSATION

Injected current ______________ A

VECTOR GROUP SETTINGS		DISPLAYED MEASURED VALUES		
HV Vector Cor	LV1 Vector Cor	Ia DIFF	Ib DIFF	Ic DIFF

9 LOW SET ELEMENT BIAS CHARACTERISTICS

Setting Group 1

	Tick						
Trip 20%		I1		A	I2		A
No trip 20%		I1		A	I2		A
Trip 80%		I1		A	I2		A
No trip 80%		I1		A	I2		A

Setting Group 2 (if required)

	Tick						
Trip 20%		I1		A	I2		A
No trip 20%		I1		A	I2		A
Trip 80%		I1		A	I2		A
No trip 80%		I1		A	I2		A

10 MAGNETISING INRUSH RESTRAINT

	Setting Group 1		Setting Group 2 (if required)	
I injected		A		A
	tick		tick	
Switch S1 Closed, S2 Open Low Set Differential Trip				
Switch S1 Open, S2 Closed Low Set Differential No Trip				

11 OVERFLUX PROTECTION

11.1 Overflux alarm sensitivity

	Setting Group 1		Setting Group 2 (if required)	
Overflux alarm relay no trip		V		V
Overflux alarm relay trip		V		V
Operating time		ms		ms

11.2 Overflux trip sensitivity

	Setting Group 1		Setting Group 2 (if required)	
Overflux alarm relay no trip		V		V
Overflux alarm relay trip		V		V
Operating time		ms		ms

11.3 Overflux fifth harmonic blocking

	Setting Group 1		Setting Group 2	
I injected		A		A
	tick		tick	
Low set differential no trip				
Low set differential trip				

11.4 Overflux fifth harmonic relay operating time

S1 tOF		s	S2 tOF		s
Operating time		s			s

12 SELECTIVE LOGIC

12.1 Opto input checks

	tick		tick
L0		L4	
L1		L5	
L2		L6	
L3		L7	

12.2 Controlled blocking of overflux protection

	tick
Overflux trip successfully blocked	
Oveflux alarm successfully blocked	

12.3 Auxiliary timers

	Setting	Measured value
Auxiliary timer 0		
Auxiliary timer 1		
Auxiliary timer 2		
Auxiliary timer 3		
Auxiliary timer 4		
Auxiliary timer 5		
Auxiliary timer 6		
Auxiliary timer 7		

12.4 Change of setting group

	tick
Change to setting group 2	

12.5 Remote control of transfomer tap changer

Tap up ____________ ms

Tap down ____________ ms

13 FUNCTION LINKS

	Setting Group 1 tick	Setting Group 2 (if required) tick
Relay final settings entered and checked	☐	☐

14 REF PRIMARY INJECTION TEST

		CT Ratio	Primary Current	Spill Current
Inject Into	HV A Phase			
Inject Into	HV B Phase			
Inject Int	HV C Phase			

		CT Ratio	Primary Current	Spill Current
Inject Into	LV1 A Phase			
Inject Into	LV1 B Phase			
Inject Int	LV1 C Phase			

		CT Ratio	Primary Current	Spill Current
Inject Into	LV2 A Phase			
Inject Into	LV2 B Phase			
Inject Int	LV2 C Phase			

15 ON LOAD TEST

MS1 Ia Diff	______	A	MS1 Ia Bias	______	A
MS1 Ib Diff	______	A	MS1 Ib Bias	______	A
MS1 Ic Diff	______	A	MS1 Ic Bias	______	A

Commissioning Engineer	Customer Witness
Date	Date

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: ____________________

AREVA 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

Publication: KBCH/EN M/G11