



**Kenya Power**

**PROTECTIVE RELAYS, CONTROLS DEVICES AND  
INSTRUMENTS - SPECIFICATION**

A Document of the Kenya Power & Lighting Co. Ltd

**JUNE 2018**

TITLE:	PROTECTIVE RELAYS, CONTROLS DEVICES AND INSTRUMENTS- SPECIFICATION	Doc. No.	KP1/6C/4/1/TSP/13/001
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#### 0.1 Circulation List

COPY NO.	COPY HOLDER
1	Manager, Standards
Electronic copy (pdf) on Kenya Power server ( <a href="http://172.16.1.40/dms/browse.php?FolderId=23">http://172.16.1.40/dms/browse.php?FolderId=23</a> )	

#### REVISION OF KPLC STANDARDS

To keep abreast of progress in the industry, KPLC Standards shall be regularly reviewed. Suggestions for improvements to approved standards, addressed to the Manager, Standards department, are welcome.

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## 0.2 Amendment Record

Rev No.	Date (YYYY-MM-DD)	Description of Change	Prepared by (Name & Signature)	Approved by (Name & Signature)
Issue 1	2018-06-28	Replaces Issue 1 rev 0 of 2013-08-29	S. Nguli	Dr. Eng. P. Kimemia
Rev 1				

Issued by: Head of Section, Standards Development

Signed:

Date: 2018-06-28

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## FOREWORD

This specification has been prepared by Network Maintenance (Power System Protection Section) of the Network Management Division in collaboration with Standards Department and lays down specifications for Design, Manufacture and Testing of Protective Relays, Control devices and Accessories, Measuring and Indicating Instruments.

This specification is intended for procurement of materials and does not include provision of contract.

This specification stipulates the minimum requirements for protective relays, control devices and measuring and Indicating Instruments acceptable for use in the company and it shall be the responsibility of the suppliers and manufacturer to ensure that the offered design is of the highest quality and guarantees excellent service to KPLC, good workmanship and good engineering practice in the manufacture of these equipment for KPLC.

There are no other specifications in this series.

Users of these Kenya Power specifications are responsible for their correct interpretation and application.

This specification supersedes all previous specifications for Protective Relay and Control and Measuring and Indicating Instruments.

The following are members of the team that developed this specification.

Name	Department
Eng. Paul Mwangi	Network Maintenance
Eng. Stephen Nguli	Standards
Eng. Raphael Ndolo	Standards
Mr Bernard Rotich	Standards

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## 1. SCOPE

This specification is for Protective Relays, Controls devices and Instruments.

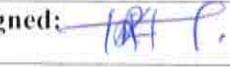
## 2. NORMATIVE REFERENCES

The following standards contain provision which, through reference in this text, constitute provisions of this specification. For dated editions the cited edition will apply; for undated editions the latest edition of the referenced document shall apply: -

- IEC 60255: Measuring relays and protection equipment – Part 1: Common requirements
- IEC 60688: Electrical measuring transducers for converting a.c. and d.c. electrical quantities to analogue or digital signal.
- IEC 61000-4-13: Part 4-13: Electromagnetic compatibility (EMC) - Testing and measurement techniques: Harmonics and inter harmonics including mains signalling.
- IEC 61850-8-1:2011: Communication networks and systems for power utility automation
- IEC 60051-1:2016: Direct acting indicating analogue electrical measuring instruments and their accessories - Part 1: Definitions and general requirements common to all parts
- IEC 60870-5:103: Telecontrol equipment and systems - Part 5-103: Transmission protocols - Companion standard for the informative interface of protection equipment
- IEC 60055: Paper-insulated metal-sheathed cables for rated voltages up to 18/30 kV (with copper or aluminium conductors and excluding gas-pressure and oil-filled cables) - Part 1: Tests on cables and their accessories
- BS 142-2-2.2:1990: Electrical protection relays. Requirements for the principal families of protection relays. Specification for general requirements for measuring relays used for protection.
- ISO/IEC 17025: General requirements for the competence of testing and calibration laboratories
- ISO 9001:2008/2015: Quality management systems - Requirements

## 3. DEFINITIONS AND ABBREVIATIONS

For the purpose of this specification the definitions and abbreviations given in the reference standards shall apply together with the following:

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### **3.1. ABBREVIATIONS**

**KPLC**- Kenya Power and Lighting Company Limited

**IEC** – International Electro technical Commission

**ISO** – International Organization for Standardization

## **4. REQUIREMENTS**

### **4.1. SERVICE CONDITIONS**

The equipment shall be tropicalized, designed and constructed for continuous indoor operation in areas with the following atmospheric conditions: -

Altitude: From sea level up to 2200m above mean sea level.

Humidity: High at the Coast, up to 90% and lower inland, up to 50%.

Temperatures: Average ambient temperature of +35°C with a minimum of -1°C and a maximum of +40°C.

Maximum Indoor temperature inside the Relay Panels is +50 ° C.

Pollution: Heavy saline with severe corrosive effects in coastal lands and generally clean air inland.

### **4.2. GENERAL REQUIREMENTS**

- 4.2.1. All Relays shall be designed for operations in the severe tropic climate conditions and fully comply with climatic aging tests as per IEC 60932-class 2.
- 4.2.2. In choosing materials and their finishes, due regard shall be given to the humid tropical conditions under which the Relay will be called upon to work.
- 4.2.3. Iron and Steel are generally to be painted or galvanized as appropriate. Indoor parts may alternatively have chromium or copper-nickel plated or other approved protective finish.
- 4.2.4. Small iron and steel parts (other than stainless steel) of all Relays and instruments, the cores of electromagnets and the metal parts of relays and mechanisms shall be treated in an appropriate manner to prevent rusting.
- 4.2.5. The use of Iron and steels shall be avoided in instruments and electrical relays wherever possible. Steel screws shall be zinc, cadmium or chromium plated or where plating is not possible owing to tolerance limitations; it shall be of corrosion resisting steel.

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- 4.2.6. Instrument screws (except those forming part of a magnetic circuit) shall be of brass or bronze.
- 4.2.7. Springs shall be of non-rusting material, e.g., phosphor-bronze or nickel silver, as far as possible.
- 4.2.8. Neoprene and similar synthetic compounds, not subject to deterioration due to the climatic conditions, shall be used for gaskets.
- 4.2.9. Power supply modules for Relays and Measuring instruments:
  - a. All equipment and apparatus including protective relays and control and measuring devices shall be capable of satisfactory operation at 80% to 125% of the rated supply voltage.
  - b. The Rated DC supply voltage shall be inscribed on the device.

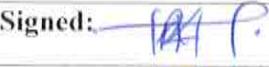
### **4.3. SPECIFIC REQUIREMENTS**

#### **4.3.1. Materials**

- 4.3.1.1. All materials supplied under this tender shall be new and of the best quality and of the class most suitable for working under the conditions specified.
- 4.3.1.2. They shall withstand the variations of temperature and atmospheric conditions arising under working conditions without distortion, deterioration or undue stresses in any parts or heating.
- 4.3.1.3. All the devices shall be suitable for installation in relay panels inside control rooms without air conditioning.
- 4.3.1.4. The heat generated by the relays and other measuring devices shall therefore be minimal to ensure that the temperature inside the panels does not rise beyond the rating of the relays and other devices.

#### **4.3.2. Instruments**

- 4.3.2.1. All measuring instruments, including the energy meters, shall be of flush-mounted, back-connected, dust-proof and heavy-duty switchboard type and in accordance with the requirement of IEC 60051.
- 4.3.2.2. For analogue type instruments, scale plates shall be of a permanent white circular or rectangular finish with black pointer and markings. The scale range shall be provided as given in the detailed specifications.
- 4.3.2.3. All measuring instruments of analogy type shall be approximately 96 X 96 mm enclosures and shall be provided with clearly readable long scale, approximately 240 degrees. The maximum error shall not be more than one and a half (1.5%) percent of full-scale range.

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#### 4.3.3. Protective Relays

- 4.3.3.1. All Measurement relays shall be flush mounted and of Numeric Design, with event recording, disturbance recording, power measurement, and shall be in accordance to IEC 60255.
- 4.3.3.2. Besides the communication port, the relays shall have a human – machine interface facility (HMI) comprising a keypad and an LCD screen, where one can easily access relay information and manually program the parameter settings.
- 4.3.3.3. Relay contacts shall be suitable for making and breaking the maximum currents, which they are required to control in normal service.
- 4.3.3.4. The Relay Trip contacts shall be capable of interrupting without damage the Circuit Breaker Trip Coil Current should the Circuit Breaker Auxiliary Contacts fail to open. Relay trip contacts shall be rated for 130V DC and switching capacity of 1000W/VA make, and 30W/VA break. Permissible current shall be 5A continuous and 15A for 3 seconds.
- 4.3.3.5. Where contacts of the protective relays are not sufficient for Circuit Breaker Tripping and interrupting the Trip Current, this shall be clearly stated by the manufacturer.
- 4.3.3.6. Relay contacts shall make firmly without bounce and the relay mechanism shall not be affected by Panel vibration or external magnetic fields.
- 4.3.3.7. Relays shall be suitable for operation on the rated D.C. Auxiliary supply without use of dropping resistors or diodes.
- 4.3.3.8. The relay Thermal rating shall be such that the fault clearance times on any combination of current and time multiplier settings shall not exceed the thermal withstand capability of the relay. (Max. fault current = 31.5kA).
- 4.3.3.9. The relays, control devices and instruments shall be supplied complete with all screws, bolts, brackets and all other accessories necessary for mounting/installation in panels and terminating all external wiring connections.
- 4.3.3.10. Plug –in auxiliary relays for DIN rail mounting shall be supplied complete with the bases.

#### 4.4. DETAILED SPECIFICATIONS FOR RELAYS, INSTRUMENTS AND CONTROL DEVICES

These specifications indicate the required performance characteristics for each of the Protection Relays.

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#### 4.4.1. Ratings for Protection Relays and Control Devices:

Unless other stated, all protection relays and control devices shall have the following rated values:

- (a) The power system where the relays are to be installed has nominal frequency of 50HZ
- (b) The rated CT secondary current is 1A
- (c) The rated VT secondary voltage is 110V AC, phase to phase (63.5V AC phase to ground)
- (d) DC auxiliary rating is 110V DC.
- (e) Relay trip operation shall be indicated by a red LED, for measurement relays. Red mechanical flags are acceptable for transformer mechanical protection – auxiliary

#### 4.4.2. Distance Protection Relay Type I:

4.4.2.1. The Distance relay is for use on Transmission Lines, to provide fast and highly dependable selective fault clearance on both overhead and underground feeders.

4.4.2.2. The Relay shall be for application in a substation with 1&1/2 circuit breaker configuration, hence shall be suitable for tripping of two circuit breakers, monitoring the status of two circuit breakers and automatic reclosure of two circuit breakers. The relay shall be used for re-trofit to replace existing old static & electromechanical relays.

#### 4.4.2.3. This shall have the following functions and features: -

- i. The relay shall have four analogue current input channels and five voltage input channels for connection of CT & VT secondary analogue signals as a minimum.
- ii. The relay shall be suitable for Flush mounting on the protection panel
- iii. The relay shall be of Numeric/Digital Design and employ complete digital signal processing of measured values.
- iv. The Relay offered must have been in Service in Kenya Power System and operated successfully for the last Eight years.
- v. Improved designs of previous relays are acceptable. Relay offers from Manufacturers who have not supplied relays before are not acceptable for this tender.
- vi. Relays that have failed in service or mal-operated shall not be acceptable
- vii. Full Scheme distance protection, with parallel calculation and monitoring of all the fault loops.
- viii. The relay shall have selective single phase and/or three phase tripping Logic

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- ix. Under Impedance Starting criteria. Other starting criteria in addition to the under impedance starting are acceptable.
- x. Five zones of phase distance protection (for Phase-phase faults) with selectable Mho and quadrilateral characteristics. Parameters (resistive reach, reactive reach and time delay) for each zone to be independently set.
- xi. As a minimum five zones of ground distance protection, (for Phase- Ground/Phase-Earth Faults) with selectable Mho and Quadrilateral characteristics with residual current compensation. Parameters (resistive reach, reactive reach and time delay) for each Zone to be independently set.
- xii. The Distance Protection Zones direction shall be independently set as forward or reverse or non-direction.
- xiii. Operating time for Distance Zone 1 set at 0 seconds delay shall not exceed 30ms
- xiv. Communication channel Aided Scheme logic for phase and ground distance protection with the following schemes
  - (a) Permissive Under Reach Transfer scheme (PUTT)
  - (b) Permissive Overreach Transfer scheme(POTT) and
  - (c) Blocking Schemes.
  - (d) Direct Transfer Tripping Scheme

**Note:** The Tele-protection scheme shall be suitable for hardwiring connection between the relay and the telecommunication multiplexer cabinet.

- xv. Load encroachment Discrimination Feature, to guarantee reliable discrimination between load operation and short circuits for long highly loaded lines, to prevent inadvertent trips.
- xvi. Parallel line compensation to cancel the effect of mutual inductance.
- xvii. Measuring voltage monitoring/ Fuse failure supervision Logic.
- xviii. The distance relay shall be blocked from operating in the event of failure of the measuring voltage or when the auxiliary switch of the Voltage transformer secondary MCB trips.
- xix. Weak in-feed Protection: Echo and/or Trip, to allow effective operation of permissive schemes when there is no in-feed on one end of the line.
- xx. Current Reversal Guard Feature – for use on parallel lines
- xxi. Power Swing detection feature for blocking Distance operation for moderate power swings and to trip for out of step conditions

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- xxii. Voltage Memory Feature for use by the distance comparators
- xxiii. Automatic Switch on to Fault Feature(SOTF), enabled when the line is de-energised and only active for a set time delay after the line circuit breaker is closed
- xxiv. Directional Earth Fault Protection, with communication channel aided scheme with the following schemes: -
  - (a) Directional Comparison Scheme(POTT)
  - (b) Blocking Scheme
  - (c) Selectable final time tripping for use when the communication channel is not in use, or for use on radial feeder. It shall be possible enable/disable the final time trip feature.
- xxv. Back up three phase overcurrent & Earth fault protection, with the following protection functions:
  - a) High set element for Phase and Earth fault overcurrent with selectable definite time delay
  - b) Low set element for Phase and Earth fault overcurrent with inverse current-time characteristics as per IEC 60255.
- xxvi. Stub Bus overcurrent protection enabled via binary input when the bay disconnector is open
- xxvii. Under frequency and rate of change of frequency Protection
- xxviii. Overvoltage protection
- xxix. Circuit Breaker Failure Protection
- xxx. Circuit Breaker Contact wear feature
- xxxi. Broken Conductor detection for Alarm purposes.
- xxxii. Auto-reclose function for One Phase and/or three phases, suitable for use with the following selections made via external switch:
  - (a) **Auto reclose Block:** No Auto-reclose: Trip to Lockout
  - (b) **Single Pole Autoreclose:** (Single pole Trip and Auto-reclose for Distance Zone 1- phase to ground faults only). Other faults types shall lead to three phase trip and lock out.
  - (c) **Single Pole + Three Phase Auto-reclose (SPAR + DAR):** Single pole trip and auto-reclose for Distance Zone 1 phase to ground faults only, followed by three pole trip and

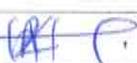
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auto-reclose for the next phase to ground fault or phase to phase fault within the reclaim time). If the first fault is phase to phase, then the scheme will perform three phase trip and auto-reclose only and lock out if a second fault of any type occurs during the reclaim time. Three phase faults shall lead to Trip and Lockout.

(d) **Three Phase Autoreclose (DAR):** three phase Trip and auto-reclose only for phase to ground faults or Phase to Phase faults. Lock out for three phase faults.

(e) It shall be possible to initiate autoreclose in the distance relay from the line current differential relay in the neighbouring panel protecting the same transmission line.

xxxiii. Synchro-check Function for use with three phase auto-reclose

xxxiv. Fault Locator; with automatic display on the Relay LCD Screen of the distance to fault in terms of Line percentage or distance in km. This information is for use by other operational staff to guide the maintenance/repair teams. The last distance to fault will always be displayed on the screen, for ease of access by the Operational Personnel.

**Note 1:** In the bid submission the bidder shall demonstrate that the requirement of this clause is fully met. Requirement to use the keypad to access this information is **not acceptable**

**Note 2:** Distance Relays which do not meet this requirement shall **not be accepted**

The accuracy of Distance to fault location shall be ±2% as a minimum.

The following information shall be provided with fault location:

- (a) The short-circuit loop which was used to determine the fault reactance
- (b) The reactance X per phase in Ohms Primary and secondary
- (c) The reactance R per phase in Ohms Primary and secondary
- (d) The distance to fault in percentage and km of line length

xxxv. The relay shall be able to display of Fault details on the LCD such as Fault- Loop or Faulty phases, the Zone, and the Relay Operate time.

xxxvi. Disturbance recorder with capacity to record ten analogues and twelve digital signals. The relay shall have capacity to store the latest, twenty (20), disturbance records.

xxxvii. Storage of at least one hundred (100) event records

xxxviii. Storage of at least Twenty (20) Trip records. The following fault data will be available:

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- a) Magnitude and phase angle of phase currents and voltages before the fault
  - b) Magnitude and phase angle of phase currents and voltages during the fault
  - c) The sequence of events of digital signals, start and operate (Trip) signals involved in fault detection and clearance. The events shall me time tagged to 10ms level.
- xxxix. Events and fault records shall not be erased even when the auxiliary DC supply is switched off.
- xl. Metering and display on the LCD screen of the following Power system instantaneous parameters including;
- a) Voltage
  - b) Load current
  - c) Active Power
  - d) Reactive Power
  - e) Apparent Power
  - f) Power Factor and
  - g) Frequency
- NB: Simultaneous Maximum demand values of Active Power, Reactive Power and Apparent Power shall be available in the relay.
- xli. At least Twenty-Four (24) Binary inputs.
- xlii. At least Thirty-two (32) Binary outputs
- Note: Two pairs of the binary output relays shall be rated to directly energise the circuit breaker trip coil. These output relays shall provide phase segregated outputs for each phase. This is to allow single phase tripping and auto-reclose. This trip output relays shall have fast operating times of less than 5 ms*
- xliii. Stability against switching inrush currents and reverse faults.
- xliv. Clear faulted phase indication.
- xlv. Clear fault identification even for boundary conditions.
- xlvi. At Least twelve (12) LEDs for indication of the following; - Relay trip, Phase L1, Phase L2, Phase L3, Zone 1, Zone 2, Zone 3, DEF, Channel aided trip, SOTF, etc.

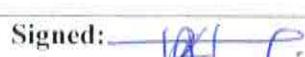
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- xlvii. Relay healthy LED
- xlviii. Relay self-supervision, with LED for healthy status indication(green) and Error indication (red) and watchdog contact
- xlix. Protocol applicable: Full IEC 61850-8-1 compliant & IEC 60870-5- 103. Appropriate communication ports to be provided for local and remote communication.
  - i. Relay Terminals-shall be screw type terminals large enough to accommodate at least 2 x 2.5 mm<sup>2</sup> cable and shall be located at the back of the relay
  - ii. Front Serial RS232 or USB or Optical or Ethernet Port shall be provided for relay configuration and parameter setting and download of Data using a Laptop Computer.
  - iii. Software for Programming the configuration and Relay Settings and also downloading and analysing the Relay Data shall be provided.
  - iv. Relay to Laptop connection cable shall be provided.
  - iv. **Relay configuration:** The Manufacturer shall carry out relay configuration at the Factory to suit installation in existing transmission substations in KPLC Network. Existing Protection and control drawings for the substations shall be handed over to the manufacturer/supplier for relay configuration. The FATS shall be carried out once the relays have been configured. Correct functionality of all relay Protection and Control Functions shall checked during the FATS, including correct operation of the single pole auto reclose scheme where applicable.

#### 4.4.3. Distance Protection Relay Type II

- 4.4.3.1. The Distance relay shall be used for protection of Sub transmission and Distribution Lines, both overhead lines and underground cables of different characteristic impedances and lengths. The relay shall be used for fault location on the protected feeders.
- 4.4.3.2. To achieve this, the relay shall automatically display the distance to fault in km on the LCD screen upon fault interruption. *This requirement is critical and the offered relays that are not able to meet this requirement will not be considered.*
- 4.4.3.3. The ability to Access the distance to fault details using the Keypad or a laptop is of secondary value and shall not be considered as a solution for the above requirement.
- 4.4.3.4. **The relay shall have the following functions and features: -**
  - i. The relay shall have four analogue current input channels and four voltage input channels for connection of CT & VT secondary analogue signals

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- ii. Shall be suitable for Flush mounting on the protection panel
- iii. The relay shall be of Numeric/Digital Design and employ complete digital processing of measured values
- iv. The Relay offered must have been in Service in Kenya Power System and operated successfully for the last Six years. Improved designs of previous relays are acceptable. Relays offers from Manufacturers who have not supplied relays before are not acceptable for this tender.
- v. Relays that have failed in service or mal-operated shall not be acceptable
- vi. Full distance Protection Scheme, i.e., non-switched
- vii. Under Impedance Starting criteria. Other starting criteria in addition to the under impedance starting are acceptable.
- viii. The relay shall employ three phase tripping criteria, since it shall be used on sub-transmission and distribution lines
- ix. Four zones of Phase distance protection (for Phase-phase faults) with selectable Mho and Quadrilateral characteristics. Parameters (resistive reach, reactive reach and time delay) for each Zone independently set.
- x. Four zones of Ground distance protection, (for phase- Ground/Phase-Earth Faults) with selectable Mho and Quadrilateral characteristics with residual current compensation. Parameters (resistive reach, reactive reach and time delay) for each zone shall be independently set.
- xi. The distance Zones direction shall be independently set as forward or reverse or non-direction. Minimum operating time shall not exceed 40ms.
- xii. Communication channel Aided Scheme logic for the distance protection with the following schemes:
  - a. Permissive Under-reach Transfer scheme
  - b. Permissive Overreach Transfer scheme and
  - c. Direct Transfer Tripping Scheme
- Note:** The tele-protection shall be achieved by hard wiring between the relay and the telecommunication equipment
- xiii. Load encroachment Discrimination Feature, to increase the possibility to detect high resistive faults on heavily loaded lines.
- xiv. Fuse failure supervision Logic
- xv. Voltage Memory Feature for use by the distance comparators

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- xvi. Automatic Switch on to Fault Feature(SOTF), enabled when the line is de-energised and only active for a set time delay after the line circuit breaker is closed
- xvii. Directional Earth Fault Protection, with communication channel aided scheme as follows
  - a. Directional Comparison Scheme
  - b. Blocking Scheme

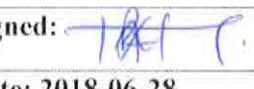
*Note: Selectable final time tripping for use when the communication channel is not in use, or for use on radial feeder.*

- xviii. Back up three phase overcurrent & Earth fault protection, with the following protection functions:
  - (a) High set element for Phase and Earth fault overcurrent with selectable definite time delay
  - (b) Low set element for Phase and Earth fault overcurrent with inverse current-time characteristics as per IEC 60255.

***Other Functions, include:***

- xix. Sensitive Earth Fault Protection
- xx. Stub Bus overcurrent protection
- xxi. Circuit Breaker Failure Protection
- xxii. Under-frequency and rate of change of frequency protection
- xxiii. Overvoltage protection
- xxiv. Broken conductor detection for Alarm purposes.
- xxv. Auto-reclose function for three phases, suitable for high speed and delayed auto-reclose.
- xxvi. The Auto-reclose scheme will be selectable as enabled or disabled preferably on the relay LCD screen;
- xxvii. Only the selected functions in the distance relay shall initiate auto-reclose
- xxviii. The auto-reclose function shall be capable of two auto-reclose shots, with separately set dead times.

*Note: It shall be possible to initiate auto-reclose in the distance relay from an external backup overcurrent and earth fault relay on the same Panel.*

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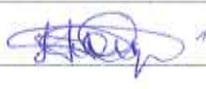
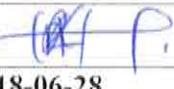
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- xxix. Fault Locator; with automatic display on the Relay LCD Screen of the distance to fault in terms of Line percentage or distance in km. This information is for use by other operational staff to guide the maintenance teams. The last distance to fault shall always be displayed on the screen.

**Note:** In the bid submission the bidder shall demonstrate that the requirement of this clause is fully met. Requirement to use the keypad or laptop to access this information is OK, as a secondary option, but will not be considered on its own to fulfil the requirements above.

***Distance Relays Offered which do not meet the above requirement shall not be accepted***

- xxx. The accuracy of Distance to fault location shall be  $\pm 2\%$  as a minimum.
- xxxi. The following additional information shall be provided with fault location:
- a) The short-circuit loop which was used to determine the fault reactance
  - b) The reactance X per phase in Ohms Primary and secondary
  - c) The reactance R per phase in Ohms Primary and secondary
  - d) The distance to fault in percentage and km of line length:
- This detailed information
- xxxii. The relay shall be able to display Fault details on the LCD Screen such as Fault- Loop or Faulty phases, the Zone, and the Relay Operate time.
- xxxiii. Internal Disturbance recorder with capacity to record eight analogue and twelve digital signals. The relay shall have capacity to store the latest, twenty (20), disturbance records.
- xxxiv. Storage of at least Fifty (50) event records
- xxxv. Storage of at least twenty (20) trip records. The following fault data will be available:
- (a) Magnitude and phase angle of phase currents and voltages before the fault
  - (b) Magnitude and phase angle of phase currents and voltages during the fault
  - (c) The sequence of events of digital signals, start and operate (Trip) signals involved in fault detection and clearance. The events shall be time tagged to 10ms level.
- xxxvi. Events and fault records shall not be erased even when the auxiliary DC supply is switched off.
- xxxvii. Metering and display on the LCD screen of the following Power system instantaneous parameters including;

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- (a) Voltage
- (b) Load current
- (c) Active Power
- (d) Reactive Power
- (e) Apparent Power
- (f) Power Factor and
- (g) Frequency

**Note:** Simultaneous Maximum demand values of Active Power, Reactive Power and Apparent Power shall be available in the relay.

- xxxviii. As a minimum the relay shall have ten (10) Binary inputs.
- xxxix. As a minimum the relay shall have twelve (12) Binary outputs.

**Note:** Two pairs of the binary output relays shall be rated to directly energise the circuit breaker trip coil. These contacts shall be able to safely interrupt the Circuit Breaker trip Coil current.

- xl. Stability against switching inrush currents and reverse faults.
- xli. Clear faulted phase indication.
- xlii. Clear fault identification even for boundary conditions.
- xliii. At least twelve (12) LEDs for indication of the following; - Relay trip, Phase L1, Phase L2, Phase L3, Zone 1, Zone 2, Zone 3, DEF, Channel aided trip, SOTF, etc.
- xliv. Relay healthy LED
- xlv. Relay self-supervision, with LED for healthy status indication(green) and Error indication (red) and watchdog contact
- xlvi. Protocol applicable: IEC 61850-8-1. Appropriate communication ports to be provided on the relay.
- xlvii. Relay Terminals-shall be screw type terminals large enough to accommodate at least 2 x2.5mm<sup>2</sup> cable and shall be located at the back of the relay.
- xlviii. Front Serial RS232 or USB or Optical or Ethernet Port shall be provided for relay configuration and parameter setting and download of Data using a Laptop Computer.
- xlix. Software for Programming the configuration and Relay Settings and also downloading and analysing the Relay Data shall be provided.
  - 1. Relay to Laptop connection cable

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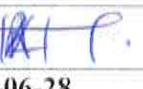
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- ii. **Relay configuration:** The Manufacturer shall carry out relay configuration at the Factory to suit installation in existing transmission substations in KPLC Network. Existing Protection and control drawings for the substations shall be handed over to the manufacturer/supplier for relay configuration. The FATs shall be carried out once the relays have been configured. Correct functionality of all relay Protection and Control Functions shall checked during the FATs.

#### 4.4.4. Line Current Differential Relay Type I:

The differential relay shall be used to protect an overhead transmission line. The actual line length will be indicated in the technical schedules. The lines to be protected are of varying lengths. The specific requirements in terms of length of line to be protected will be stated in the scope of supply or Price schedule.

- 4.4.4.1. Each relay is expected to interface directly with a single mode optical fibre (OPGW).
- 4.4.4.2. Each Relay should come with 20 metre fibre patch cords with ST connectors to connect with optical fibre cable at the ODF.
- 4.4.4.3. In addition to performing the differential function the relay shall incorporate back up distance protection and three phase overcurrent and earth fault back-up protection functions.
- 4.4.4.4. The Differential relay is for use on Transmission Lines, to provide fast and highly dependable selective fault clearance on overhead lines.
- 4.4.4.5. The Relay shall be for application in a substation with 1&1/3 circuit breaker configuration, hence shall be suitable for tripping of two circuit breakers, monitoring the status of two circuit breakers and automatic reclosure of two circuit breakers.
- 4.4.4.6. The relay shall be used for re-trofit purposes to replace existing old static & electromechanical relays.
- 4.4.4.7. **The relays should also incorporate the following protection features.**
  - i. Full numerical design with at least two groups of settings.
  - ii. The Relay offered must have been in Service in Kenya Power System and operated successfully for the duration of service. Improved designs of previous relays are acceptable.
  - iii. Relays that have failed in service or mal-operated shall not be acceptable
  - iv. The relay shall be suitable for Flush mounting on the panel.

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- v. Single pole and three pole tripping logic
- vi. The relays at the two ends shall operate under directly connected fiber optical cable
- vii. Simultaneous tripping of relays at both ends even if there is little or no in-feed from one end.
- viii. Phase segregated current differential measurement of both magnitude and phase angle.
- ix. High speed discriminative Protection for all fault types.
- x. High sensitivity for detection of high resistive phase to earth faults
- xi. Integrated Distance protection with at least three Zones of selectable Quadrilateral/mho comparator characteristics, with load encroachment discrimination, SOTF, Power Swing Block, Fuse Failure Protection and Directional earth fault Protection.
- xii. The distance protection and the Directional Earth Protection shall have unit protection schemes such as those covered in the specifications for Distance Protection Type I.
- xiii. In case of Loss of communication for the differential protection, the distance protection will automatically be enabled.
- xiv. Back up Overcurrent and earth fault protection with Definite Time and Inverse IEC Time-current Characteristics
- xv. Selective Single phase and three phase tripping suitable for single pole trip and auto-reclose for phase to ground faults and three phase trip and lock out for other faults.
- xvi. The relay shall be capable of initiation of auto-reclose on an external autoreclose relay. The relay shall achieve the following functionality via an external selector switch:
  - a. **Autoreclose Block;** No Autoreclose/Trip to Lockout
  - b. **Single Pole Autoreclose** (Single pole Trip and Autoreclose for phase to ground faults only)
  - c. **Single pole + Three Phase Autoreclose (SPAR + DAR):** Single pole trip and autoreclose for Phase to ground faults followed by three pole trip and auto-reclose for the next phase to ground or phase to phase fault within the reclaim time). Where the initial fault is a phase to phase fault, then only one shot of three phase trip and auto-reclose will be performed.

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- d. **Three Phase Autoreclose (DAR):** three phases and autoreclose only for phase to ground faults
- e. It shall be possible to initiate autoreclose in a distance relay in the neighbouring protection panel for protection of the same transmission line.
- xvii. The relay shall have communication channel supervision facilities.
- xviii. The relay shall have high stability under transient conditions.
- xix. The relay shall have high stability for heavy through faults and CT saturation effects.
- xx. The relay shall be insensitive to DC Components and Harmonics.
- xxi. The relay shall be capable of communication between the two ends via directly connected Optical fibre cable.
- xxii. Direct Transfer tripping via the optical fibre cable, independent of differential scheme.
- xxiii. Line capacitive charging current compensation and withstand.
- xxiv. CT ratio (Amplitude) and phase angle correction in built in the relay
- xxv. Selectable minimum operating current, 10-150% of in for low set differential element.
- xxvi. High set differential operating element
- xxvii. Relay Operate time: less than 30ms.
- xxviii. Transformer inrush restraint
- xxix. The differential Relay shall restrain upon the loss of the communication channel and block the differential scheme and enable emergency overcurrent protection.
- xxx. Relay terminals shall be provided at the back and shall be suitable for termination of 2.5 mm<sup>2</sup> cable. The terminal screws shall be design of star/flat type.
- xxxi. Distance to fault measurement, with automatic display on the Relay LCD Screen, where the distance to fault can be directly read/seen.
- xxxii. Display of Fault details on the LCD such as Fault Loop or Faulty phases, the Zone, and the Relay Operate time.
- xxxiii. Storage of at least Five (5) disturbance(oscillograph)
- xxxiv. Storage of at least Twenty (20) event records
- xxxv. Storage of at least Five (5) Trip records including value of phase and earth fault

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- xxxvi. currents and the relay tripping times
- xxxvii. Events and fault records shall not be erased even when the auxiliary DC supply is switched off.
- xxxviii. Status indications of all input, output and internal functions.
- xl. Programmable binary inputs, which can be configured to perform, customized functions.
- xli. Programmable relay outputs (trips and alarm contacts) that can be configured to perform various tasks.
- xliv. Metering, including; U, I, P, Q, S, F & Cos Φ
- xlv. At least Sixteen (16) Binary inputs.
- xlvi. At least twenty (20) Binary outputs
- xlvii. Human – Machine interface with visual display of measurements and internal operations of the relays. Facilities for scrolling should be provided. Default display should be programmable. It should be possible and convenient to program Relay
- I. settings from the HMI.
- li. The bias and operate current on a phase basis in both magnitude and phase for both
- lii. local and remote ends should be accessible through the MMI.
- liii. 9 pins – RS232 port for connection to laptop PC should be available on the front of the relay or any other suitable serial communication port.
- liv. Protocol applicable: Full IEC 61850-8-1 compliant & IEC 60870-5- 103. Appropriate
- lv. communication ports to be provided for local and remote communication.
- lvii. Self – supervision with fault diagnosis and watchdog contact.
- lviii. LED indications for: Relay healthy(Green), relay faulty(Amber) and Protection operated (Red)
- lviii. Shall have twelve (12) LEDs for various indications
- lix. Password Protection for relay settings.
- ix. Independent Latching of Trip commands, to prevent CB reclose.
- lx. Except for the latched commands, all other relay Operations should be resettable with the Relay covers on.

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- Ixii. Upon Operation, the Relay will indicate the Faulted Phase(s), Time taken to Trip and Fault Current on the MMI. Additionally, the faulted phases, Issuance of Trip Command, and Communication failure between the two Relays should be indicated using Red LEDs.
- Ixiii. Fault Locator with automatic display on the Relay LCD Screen of the differential relay distance to fault in terms of Line percentage or distance in km. This information is for use by other operational staff to guide the maintenance/repair teams. The last distance to fault will always be displayed on the screen.

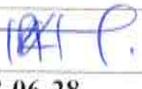
**Note:** In the bid submission the bidder shall demonstrate that the requirement of this clause is fully met. Requirement to use the keypad to access this information is not acceptable.

- Ixiv. **Binary Output Relays:** Two pairs of the binary output relays shall be rated to directly energise the circuit breaker trip coil. This output relays shall provide phase segregated outputs for each phase. This is to allow single phase trip and auto-reclose. This trip output relays shall have fast operating times of less than 5 ms.
- Ixv. **Relay configuration:** The Manufacturer shall carry out relay configuration at the Factory to suit installation in existing transmission substations in KPLC Network. Existing Protection and control drawings for the substations shall be handed over to the manufacturer/supplier for relay configuration.
- Ixvi. The FATs shall be carried out once the relays have been configured. Correct functionality of all relay Protection and Control Functions shall checked during the FATs, including correct operation on the single pole auto reclose scheme where applicable.

#### 4.4.5. Line Current Differential Relay Type II:

The differential relay shall be used to protect a 66kV underground/Overhead Line.

- 4.4.5.1. The actual length of overhead Line or Under-ground cable to be protected shall be stated in the Scope of Supply or Price Schedule.
- 4.4.5.2. An underground all dielectric fibre cable to be laid in the same trench as the 66kV underground single-phase power cables will provide the communication channel for the Line current differential Protection Scheme.
- 4.4.5.3. Each relay shall interface directly with the underground single mode optical fibre cable.
- 4.4.5.4. Each Relay should come with 20 metre fibre patch cords with ST connectors to connect with optical fibre cable at the ODF.

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- 4.4.5.5. In addition to performing the differential function the relay should incorporate back up distance protection and three-phase overcurrent and earth fault back-up protection functions.
- 4.4.5.6. The Relay offered must have been in Service in Kenya Power System and operated successfully for the duration of service. Improved designs of previous relays are acceptable
- 4.4.5.7. **The relays should incorporate the following Protection Features: -**

- i. Fully numerical design with at least two groups of settings.

**Note:** Relays offers from Manufacturers who have not as yet supplied relays to Kenya are not acceptable for this tender.

- ii. Relays that have failed in service or mal-operated shall not be acceptable
- iii. The relay shall be suitable for Flush mounting on the panel.
- iv. Three phase tripping logic
- v. Simultaneous tripping of relays at both ends even if there is little or no in-feed from one end.
- vi. Phase segregated current differential measurement of both magnitude and phase angle.
- vii. High speed discriminative Protection for all fault types.
- viii. High sensitivity for detection of high resistive phase to earth faults
- ix. Integrated Distance protection with at least three Zones of selectable Quadrilateral/mho comparator characteristics, with load encroachment discrimination.
- x. Back up Overcurrent and earth fault protection with Definite Time and Inverse IEC Time-current Characteristics
- xi. Three-phase auto reclose Function
- xii. Communication channel supervision facilities.
- xiii. High stability under transient conditions.
- xiv. High stability for heavy through faults and CT saturation effects.
- xv. Insensitive to DC Components and Harmonics.
- xvi. Be capable of communication between the two ends via directly connected Optical fibre cable.

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- xvii. Direct Transfer tripping via the optical fibre cable, independent of differential scheme.
- xviii. Cable capacitive charging current compensation and withstand.
- xix. CT ratio (amplitude) and phase angle correction in built in the relay
- xx. Selectable minimum operating current, 10-150% of In.
- xxi. Relay Operate time: less than 30ms.
- xxii. Transformer inrush restraint
- xxiii. The differential Relay shall restrain upon the loss of the communication channel and block the differential scheme and enable Emergency backup overcurrent and Earth fault protection. Relay terminals shall be provided at the Back and shall be suitable for termination of 2.5 mm<sup>2</sup> cable. The terminal screws shall be of star or flat type.
- xxiv. Distance to fault measurement, with automatic display on the relay LCD screen, where the distance to fault can be directly read/seen.
- xxv. Display of Fault details on the LCD such as Fault Loop or Faulty phases, the Zone, and the Relay Operate time.
- xxvi. Storage of at least five (5) disturbance(oscillographic)
- xxvii. Storage of at least twenty (20) event records
- xxviii. Storage of at least five (5) Trip records including value of phase and earth fault currents and the relay tripping times
- xxix. Events and fault records shall not be erased even when the auxiliary DC supply is switched off.
- xxx. Status indications of all input, output and internal functions.
- xxxi. Programmable binary inputs, which can be configured to perform, customized functions.
- xxxii. Programmable relay outputs (trips and alarm contacts) that can be configured to perform various tasks.
- xxxiii. Metering, including; U, I, P, Q, S, F & CosΦ
- xxxiv. At least Twelve (12) Binary inputs.
- xxxv. At least Twelve (12) Output Relays/Contacts
- xxxvi. Human – Machine interface with visual display of measurements and internal operations of the relays. Facilities for scrolling should be provided. Default display should be programmable. It should be possible and convenient to program Relay settings from the MMI.

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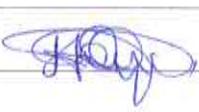
- xxxvii. The bias and operate current on a phase basis in both magnitude and phase for both local and remote ends should be accessible through the MMI.
- xxxviii. Protocol applicable: Full IEC 61850-8-1 compliant. Appropriate communication ports to be provided for local and remote communication.
- xxxix. 9 pin – RS232 port for connection to laptop PC should be available on the front of the relay or any other suitable serial port.
  - xl. Self – supervision with fault diagnosis.
  - xli. LED indications for; Relay healthy(Green), relay faulty(Amber) and Protection Operated(Red)
  - xlii. Additional at least twelve (12) LEDs for various indications
  - xliii. Password Protection for relay settings.
  - xliv. Independent Latching of Trip commands, to prevent CB reclose.
  - xlv. Except for the latched commands, all other relay Operations should be resettable with the Relay cover on.
  - xlvi. Upon Operation, the Relay will indicate the Faulted Phase(s), Time taken to Trip and Fault Current on the MMI. Additionally, the faulted phases, Issuance of Trip Command, and Communication failure between the two Relays should be indicated using Red LEDs.
  - xlvii. Relay configuration: The Manufacturer shall carry out relay configuration at the factory to suit installation in existing transmission substations in KPLC Network. Existing Protection and control drawings for the substations shall be handed over to the manufacturer/supplier for relay configuration. The FATS shall be carried out once the relays have been configured. Correct functionality of all relay Protection and Control Functions shall be checked during the FATS.

#### **4.4.6. Biased Differential Protection Relay for a Two or Three Winding Power Transformer:**

*Note: The relay offered must have been in service in Kenya Power for at Least 8 years and offered satisfactory service. Improved designs of previous relays are acceptable.*

##### **4.4.6.1. The Relay shall have the following Functions and Features: -**

- i. Suitable for protection of a two or three winding power transformer, with a power rating of up to 90 MVA, with HV winding rated up to 245kV. Specific requirements will be stated in the Scope of supply or Price schedules.
- ii. Relay must be of Numerical design
- iii. Flush mounting design

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- iv. Pick up setting range, for IDIFF >; 0.1 to 1.0 x rated current, as a minimum
- v. Pickup on switch-on (factor of IDIFF>) 1.0 to 2.0
- vi. High-set Element (IDIFF>>) with a setting range of 1.0 to 20.0 x rated current
- vii. Independent definite time delay setting for IDIFF> and for IDIFF>> of 0.00 to 30.00 seconds as a minimum
- viii. Magnetizing current inrush restraint feature, using 2nd harmonic restraint and /or zero crossing on the sine wave
- ix. Setting range of I<sub>2fN</sub>/I<sub>fN</sub> of 10 to 50% as a minimum
- x. Compensation for zero sequence currents that may appear on only one winding of the power transformer
- xi. Measurement and indication on the LCD screen, of phase – HV&LV currents and relay differential and bias currents
- xii. Storage of at least Five (5) Fault records and Ten (10) Event records
- xiii. Events and fault records shall not be erased even when the auxiliary DC supply is switched off
- xiv. The Fault flags shall be visible on the LCD screen, and provide details of the phases that have operated and the fault current values.
- xv. Over-fluxing protection function with at least two stages of alarm and trip functions
- xvi. 5th harmonic restraint feature on the differential Element to prevent unnecessary tripping due to CT saturation or transformer over-excitation.
- xvii. Over-excitation Protection with both alarm and trip elements
- xviii. Stabilized against transient and steady-state fault currents caused e.g. by over-excitation of transformers, using fifth harmonic.
- xix. Insensitive against DC offset currents and current transformer saturation.
- xx. High stability also for different current transformer saturation
- xxi. High-speed instantaneous trip on high-current transformer faults.
- xxii.
- xxiii. Independent of the conditioning of the star point(s) of the power transformer.
- xxiv. High earth-fault sensitivity by detection of the star point current of an earthed transformer winding
- xxv. Integrated matching of the transformer connection group

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- xxvi. Integrated matching of the transformation ratio including different rated currents of the transformer windings
- xxvii. Dual Bias characteristics with two slopes to ensure relay stability for heavy through faults. The start and end of the two slopes shall be settable, in terms of the rated current.
- xxviii. Unbalanced Load Protection
- xxix. Thermal Overload Protection
- xxx. Back up Overcurrent and Earth Fault protection for HV and/or LV winding

4.4.6.2. The following measurements shall be available in the relay:

- i. Magnitudes and phase angles of the phase currents for the three phases on the HV side of Transformer
- ii. Magnitudes and phase angles of the phase currents for the three phases on the LV side of Transformer
- iii. Magnitude of differential current and restraining current for the three phases
- iv. The disturbance recorder function shall have a capacity for eight (8) analogue and twelve (12) digital signals. The last four disturbance records will be available in the relay.
- v. Red L.E.D to indicate that the relay has operated/issued trip command
- vi. Relay Self diagnostic, with LED to indicate Relay failure and a contact for remote indication of relay failure status
- vii. The relay shall have at least eight (8) LEDs for trip and alarms and at least four (4) binary inputs.
- viii. The relay shall have at least our (4) outputs relays with normally open contacts for circuit breaker tripping and alarm annunciation. Two pairs of contacts shall be rated to directly energise the circuit breaker tripping coil.
- ix. The relay shall have the ability to select output contacts to latched or non-latched status and the LCD screen where the settings and measurands can be read.
- x. The relay shall have keypad for manual programming of settings and data access.
- xi. The relay shall have front serial RS232 or USB or Ethernet Port for Relay communication with a laptop computer for relay configuration and parameter settings and download of fault records, events records and disturbance record.
- xii. Relay terminals-shall be screw type terminals large enough to accommodate at least 2x2mm<sup>2</sup> cable and shall be located at the back of the relay.

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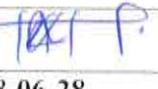
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- xiii. Four (4) sets of installation, commissioning, operation and maintenance manuals shall be provided.
- xiv. Relay to Laptop connection cable shall be provided.
- xv. Software for relay configuration and settings programming using Laptop computer shall be provided.

#### 4.4.7. Restricted Earth Fault Relay:

NB: The relay Offered must have been in service in Kenya Power for at Least 8 years and offered satisfactory service. Improved designs of previous relays are acceptable.

- 4.4.7.1. This relay shall be used for protection of one winding of a power transformer.
- 4.4.7.2. This relay shall have the following functions and features: -
  - i. Relay shall be of Numerical, static type or Electro-Mechanical type.
  - ii. The Relay shall operate on high impedance principle.
  - iii. The relay shall be of numeric design.
  - iv. The relay shall be suitable for flush mounting on panel front.
  - v. The relay shall be of an independent relay and not a function in the differential relay.
  - vi. Relay shall reject harmonics produced by the system particularly third harmonics.
  - vii. Stabilising resistor and voltage dependent resistor (metrosil) of suitable rating shall be offered with the Relay based on maximum through Fault of 31kA.
  - viii. The relay current setting range shall be 0.05- 0.8 x rated current ( $I_n$ ) as a minimum and an operating time < 25ms at 5 times the setting.
  - ix. The relay shall have four (4) LEDs for relay status indication and for trip and alarms annunciation as a minimum and two (2) binary inputs as a minimum
  - x. The relay shall have four (4) Binary Outputs as a minimum with LCD screen where the settings and measurands can be read
  - xi. The relay's REF operate current shall be displayed on the LCD screen and keypad for manual programming of settings and data access
  - xii. The relay shall have serial RS232, USB or Ethernet Port for relay configuration and programming of parameter settings and data download using a laptop computer.
  - xiii. The relay shall have an event recorder with capacity to store the last fifty (50) events
  - xiv. The relay shall have fault recorder with capacity to store the last ten (10) fault records

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- xv. The relay shall have a disturbance record with capacity to store the last four (4) disturbance records
- xvi. The relay terminals shall be screw type terminals large enough to accommodate at least 4 mm<sup>2</sup> cable and shall be located at the back of the relay

#### 4.4.8. Stabilizing Resistor

Each REF relay shall be supplied with an adjustable stabilizing resistor. For dimensioning of the stabilizing resistor consider maximum through fault phase –earth current of 31.5kA.

#### 4.4.9. Voltage Dependent Resistor (Metrosil)

- 4.4.9.1. Each REF relay shall be supplied with a voltage dependent resistor (VDR) or metrosil to limit voltage across the REF high impedance circuit. The basis for the rated voltage of the VDR is the maximum phase-earth through fault of 31.5kA.

*Note: The Stabilising resistor and the Voltage dependent resistor shall preferably be housed in a box with terminals that allow connection of the REF relay to the resistor and VDR in the box. Several terminals will be provided to allow selection of required stabilizing resistor. The single box will be suitable for panel mounting.*

#### 4.4.10. Feeder Protection and Bay Control Relay

NB: The relay Offered must have been in service in Kenya Power for at Least 8 years and offered satisfactory service. Improved designs of previous relays are acceptable.

- 4.4.10.1. This relay shall have the following functions and features: -

- i. The Feeder Protection and bay control relay shall be of Numeric Design
- ii. The relay shall be suitable for flush mounting
- iii. The relay will have a large LCD screen measuring at least 7cm X 7cm where a mimic of the switchgear arrangement and status of the switchgear for the bay shall be displayed.
- iv. The position of the Circuit Breaker, i.e. racked-in or withdrawn shall be indicated.
- v. Circuit Breaker close and open push key buttons with symbols and colour codes as per the IEC standards shall be provided on the relay as well as switchgear selection key.
- vi. A Local/Remote key selector switch shall be provided on the relay and the selected status of the selector switch indicated by means of an LED.

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vii. The Relay offered shall have at least the following protection functions; -

- (a) Three Phase Overcurrent and Earth Fault
- (b) Sensitive earth fault
- (c) Broken Conductor detection
- (d) Autoreclose
- (e) Circuit breaker contact wear
- (f) Circuit breaker Failure protection
- (g) Under and over frequency protection as well as rate of change protection
- (h) Over voltage protection

**Note 1:** All the protection functions shall meet the requirements of each function as included in this specification.

**Note 2:** Earth Fault and Sensitive Earth Fault Protection elements shall be separate to allow independent settings to be applied.

**Note 3:** Earth Fault and Sensitive earth fault shall have separate CT inputs.

**Note 4:** Detailed specifications for three phase overcurrent, earth fault and sensitive earth fault functions are included elsewhere in these specifications.

viii. The relay shall have a circuit breaker contact wear counter/monitor.

ix. The Relay shall measure and display (Metering) on the LCD screen the following power system parameters; Current (I), Voltage (V), Active Power (P), Reactive Power (Q), Frequency (HZ) and power factor (P.F).

x. The relay shall store at least twenty (20) fault records, Fifty (50) events and ten (10) disturbance records. The disturbance record shall have capacity to monitor Eight (8) analogue and ten (10) digital channels.

xi. It shall be possible to display instantaneous measurands on the screen alongside the bay mimic.

xii. The unit shall have an L.E.D to indicate relay healthy status (green colour) and relay faulty status (red colour). A separate Red L.E.D to indicate operation (Trip) of the protection functions.

xiii. The relay shall have at least Eight (8) programmable LEDs for displaying Protection function operations and other alarms.

xiv. The template for writing the alarm labels shall be provided with the relay

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- xv. The relay shall have at least twelve (12) binary inputs
- xvi. The Relay shall have at least six (6) output relays
- xvii. The relay shall be provided with IEC 61850-8-1 Communication protocol, and the corresponding communication port.
- xviii. The Relay terminals shall be of screw type terminals large enough to accommodate at least 2x2.5mm<sup>2</sup> cable and shall be located at the back of the relay.
- xix. Front Serial RS232 or USB or Ethernet Port for relay communication with a laptop computer for relay configuration and parameter settings and download of fault records, events records and disturbance record for analysis.

#### **4.4.11. Auto reclose relay Function in the Feeder Protection Relay.**

This autoreclose function shall be housed within the feeder protection relay and shall have the following features: -

- i. Selectable 1 – 3 auto-reclose shots
- ii. Independently set dead time for each shot
- iii. Autoreclose inhibit after manual close both from external CB close switch and from control key on the Relay front face.
- iv. Each autoreclose shot shall be initiated by the selected protection function(s). Operation of protection function not selected to initiate a particular shot of autoreclose shall lead to lock-out of the relay, hence circuit breaker.
- v. Autoreclose inhibition for over current high set element.

**Note:** The Protection Functions Offered shall satisfy the detailed specifications as included elsewhere in this specification for each of the protection and control functions.

#### **4.4.12. Feeder Protection Relay:**

- ##### **4.4.12.1. The Relay shall have the following protection functions and features in a single casing as a minimum: -**
- i. Three phase overcurrent
  - ii. Earth fault
  - iii. Sensitive Earth Fault
  - iv. Broken Conductor detection
  - v. Autoreclose function for three phase autoreclose.

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vi. Under- and Over-Frequency Protection, including rate of change frequency protection

**Note 1:** *Earth Fault and Sensitive Earth Fault Protection elements shall be separate to allow independent settings to be applied. These functions will have separate CT inputs*

**Note 2:** *Earth Fault and Sensitive earth fault elements shall have separate CT Inputs.*

**Note 3:** *Detailed specifications for three phase overcurrent, earth fault and sensitive earth fault functions are included elsewhere in this specification. All requirements must be met.*

- 4.4.12.2. There shall be independent CT input for Earth Fault and for Sensitive Earth Fault Protection to allow independent connection of the Sensitive Earth Fault Protection Function to a separate Core type CT
- 4.4.12.3. Relay must be of Numerical design.
- 4.4.12.4. Relays that have failed in service or mal-operated shall not be acceptable
- 4.4.12.5. The relays shall be suitable for flush mounting on the front of the panel
- 4.4.12.6. Current setting range for overcurrent function shall be 0.5In-2.0In as a minimum
- 4.4.12.7. Current setting range for earth fault function shall be 0.05In-0.8In as a minimum
- 4.4.12.8. Two stages of High Set Element for both overcurrent and earth fault protection function, with a setting range of 1-20In as a minimum and a definite time delay setting of 0 – 60 seconds as a minimum.
- 4.4.12.9. I.D.M.T characteristics for overcurrent and Earth fault protection function according to BS142 or IEC60255 i.e. Standard Inverse (SI), Very Inverse (VI), Extremely Inverse (EI), Long Time Inverse (LTI), including definite time for the high-set Elements.
- 4.4.12.10. Time setting multiplier 0.05 – 1.0 as a minimum
- 4.4.12.11. Current setting range for sensitive earth fault function 0.01In - 0.8In as a minimum
- 4.4.12.12. Definite time delay characteristic for Sensitive earth fault function; setting range, 0- 30 seconds as a minimum.
- 4.4.12.13. Requirements for the auto reclose function:
  - i. Three phases auto reclose
  - ii. Selectable 1 – 3 autoreclose shots
  - iii. Independently set dead time for each shot
  - iv. Autoreclose inhibit after manual close

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v. Each autoreclose shot shall be initiated by the selected Protection Function(s). Operation of Protection Function not selected to initiate a particular shot of Autoreclose shall lead to Lock-out.

vi. Autoreclose inhibition for over current high set element

**4.4.12.14. Data Storage:**

- i. Storage of at least five (5) fault/trip records
- ii. Ten (10) event records
- iii. Five (5) disturbance records

**Note:** *Events and fault records shall not be erased even when the auxiliary DC supply is switched off*

**4.4.12.15. Configurable output relays for protection element pick up (start) and Trip outputs which can be used to back-trip upstream circuit breakers and for implementing blocking schemes for busbar protection.**

**4.4.12.16. Red L.E.D to indicate that the protection functions have operated and issued a trip output to Trip the circuit breaker.**

**4.4.12.17. Relay self-diagnostic, with LED to indicate relay healthy status (green colour) and relay failed status (red colour) and a watch dog contact for remote alarm**

**4.4.12.18. LEDs:** The relay shall have a minimum eight (8) LEDs for alarms annunciation.

**4.4.12.19. Binary Outputs:** The relay shall have as a minimum twelve (12) Binary inputs.

**4.4.12.20. Binary Outputs:** The relay shall have a minimum four (4) outputs Relays. One (1) of the output relays shall be adequately rated to directly operate the circuit breaker trip coil.

**4.4.12.21. LCD screen where the settings and measurands can be read**

**4.4.12.22. Keypad for manual programming of settings and data access**

**4.4.12.23. Relay Terminals-**shall be screw type terminals large enough to accommodate at least 4mm<sup>2</sup> cable and shall be located at the back of the relay

**4.4.12.24. The relay applicable protocol shall be IEC 61850-8-1**

**4.4.12.25. Front Serial RS232 or USB or Ethernet Port for relay communication with a laptop computer for relay configuration and parameter settings and download of fault records, events records and disturbance records for analysis.**

**4.4.12.26. Software for configuration and relay parameter settings and also downloading and analysing the relay fault data shall be provided.**

**4.4.12.27. Relay to Laptop connection cable shall be provided**

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4.4.12.28. Auto reclose relay Function in the feeder protection relay. This auto reclose function shall be housed within the feeder protection relay: -

- i. Selectable 1 – 3 auto reclose shots
- ii. Independently set dead time for each shot
- iii. Auto-reclose inhibit after manual close
- iv. Each auto-reclose shot shall be initiated by the selected protection function(s). Operation of protection function not selected to initiate a particular shot of auto-reclose shall lead to lock-out of the relay.
- v. Auto-reclose inhibition for over current high set element.

#### 4.4.13. Three- Phase Directional Overcurrent and Earth Fault Relay:

NB: The relay Offered must have been in service in Kenya Power for at Least 8 years and offered satisfactory service. Improved designs of previous relays are acceptable.

The relay shall have the following functions and features: -

- i. Relay must be of Numerical design.
- ii. Shall be suitable for flush mounting on the front of the panel
- iii. The Relay Offered must have been in Service in Kenya Power System and operated successfully for the eight (8) years. Improved designs of previous relays are acceptable. Relays that have failed in service or mal-operated shall not be acceptable
- iv. The relay shall have a red L.E.D to indicate that the relay has operated to trip
- v. Relay Self diagnostic, with LED to indicate relay healthy status (green colour) and relay failed status (red colour) and a watch dog contact for remote alarm shall be provided.
- vi. Current setting range for overcurrent relay 0.5In-2.4x rated current (In), as a minimum
- vii. Current setting range for earth fault relay 0.05In-0.8xrated current (In), as a minimum
- viii. Quadrature connection for polarizing voltage
- ix. Applicable on the LV side of a Dyn1 transformer
- x. Overcurrent high set Element, with a setting range of 1-20 x rated current (In) as a minimum.
- xii. Earth fault high set element, with a current setting range of 1-20 x rated current as a minimum.

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- xiii. All stages of the Phase and Earth Fault elements shall be freely assigned the directional feature, as forward, reverse or non-directional.
- xiv. Inverse Current-Time characteristics according to BS 142 or IEC 60255 and Definite time characteristics. The characteristic for each protection function shall be selectable.
- xv. The normal operating boundary shall be +/-90 degrees from relay characteristic angle.
- xvi. Relay sensitivity shall be 1% of rated value of current and polarizing voltage at an angle equal to the relay characteristic angle.
- xvii. Time setting multiplier 0.05 – 1.0, as a minimum
- xviii. Broken conductor detection feature
- xix. Circuit breaker contact wear monitor
- xx. Storage of at least five (5) fault records and ten (10) event records

*Note: Events and fault records shall not be erased even when the auxiliary DC supply is switched off.*

- xxi. Storage of the last two disturbance records as a minimum.
- xxii. Configurable output relays with ability to output starting elements to control tripping of other upstream protection relays.
- xxiii. The relay shall have as a minimum eight (8) LEDs for alarms annunciation
- xxiv. The relay shall have as a minimum four (4) binary inputs.
- xxv. The Relay shall have as a minimum four (4) output relays and an LCD screen where the settings and measurands can be read.
- xxvi. Keypad for manual programming of settings and data access
- xxvii. Relay Terminals-shall be screw type terminals large enough to accommodate at least 4mm<sup>2</sup> cable and shall be located at the back of the relay
- xxviii. Front Serial RS232 or USB or Ethernet port for relay communication with a laptop computer for relay configuration and parameter settings and download of fault records, events records and disturbance records for analysis.

#### 4.4.14. Three Phase Overcurrent and Earth Fault Relay:

NB: The relay offered must have been in service in Kenya Power for at least 8 years and offered satisfactory service. Improved designs of previous relays are acceptable.

The relay shall have the following Functions and Features: -

- i. Relay must be of Numerical Design

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- ii. Relays shall be suitable for Flush mounting on the panel front and current setting range for overcurrent relay shall be 0.5In-2.0In as a minimum
- iii. Current setting range for earth fault relay shall be 0.05In-0.8In as a minimum
- iv. I.D.M.T characteristics for overcurrent and earth fault protection function according to BS142 or IEC60255 i.e. Standard Inverse (SI), Very Inverse (VI), Extremely Inverse (EI), Long Time Inverse (LTI), including definite time for the high-set Elements.
- v. The relays 'time setting multiplier 0.05 – 1.0, as a minimum and under frequency protection feature shall be provided.
- vi. Relays Broken conductor detection protection feature shall be provided.
- vii. High set element for both overcurrent and earth fault protection, with a setting range of 1-20 x rated current (In) and a definite time delay setting of– 60 seconds shall be provided.
- viii. Circuit breaker contact wear monitor: Ability to store at least five (5) fault records and ten (10) event records
- ix. Events and fault records shall not be erased even when the auxiliary DC supply is switched off.
- x. Means of identifying fault type and stage of protection that has operated either by
- xi. use of LEDs or by automatic display of the fault records details on the relay LCD.
- xii. Trip and start contacts shall be freely configurable to the output relays with drop off /pickup ratio >90% and low transient overreach < 10%.
- xiii. Red L.E.D to indicate that the relay protection functions have operated/tripped and relay self-diagnostic, with LED to indicate relay healthy status (Green colour) and relay failed status (Red colour) and a watch dog contact for remote alarm shall be provided.
- xiv. The relay shall have as a minimum eight (8) LEDs for alarms annunciation
- xv. The relay shall have as a minimum four (4) binary inputs.
- xvi. The Relay shall have as a minimum four (4) output relays
- xvii. LCD screen where the settings and measurands can be read.
- xviii. Relay Terminals-shall be screw type terminals large enough to accommodate at
- xix. least 4mm<sup>2</sup> cable and shall be located at the back of the relay.
- xx. LCD screen Keypad for manual programming of settings and data access.

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- xxi. The relay shall have front serial RS232 or USB or Ethernet Port for relay communication with a laptop computer for relay configuration and parameter settings and download of fault records, events records and disturbance records for analysis.
- xxii. Relay to Laptop connection cable shall be provided

#### 4.4.15. Earth Fault Relay:

The Relay shall have the following functions and Features: -

- i. Relay must be of Numerical Type
- ii. Current setting range 0.05In-0.8In
- iii. The Relay must have been in operation in Kenya Power System and operated successfully for the last eight (8) years. Improved designs of previous relays are acceptable.
- iv. Shall be suitable for flush mounting on the front of the panel
- v. Inverse Current – Time characteristics for Earth fault protection function according to BS142 or IEC60255 i.e. Standard Inverse (SI), Very Inverse (VI), Extremely Inverse (EI), Long Time Inverse (LTI), including definite time for the high-set Elements.
- vi. Time setting multiplier 0.05 – 1.0 x rated current (In)
- vii. High set Element with a setting range of 1-20 x rated current (In).
- viii. Circuit breaker contact wear monitoring
- ix. Ability to store at least five (5) Fault records, and ten (10) event records
- x. Events and fault records shall not be erased even when the auxiliary DC supply is switched off.
- xi. Trip and Start Contacts shall be freely configurable to the output Relays.
- xii. Drop off /pickup ratio >90% and low transient overreach < 10%
- xiii. Red L.E.D to indicate that the Relay has operated to trip
- xiv. Relay Self diagnostic, with LED to indicate Relay failure and a contact for remote indication
- xv. The relay shall have as a minimum four (4) LEDs for alarms annunciation
- xvi. The relay shall have as a minimum four (4) binary inputs.
- xvii. The Relay shall have as a minimum four (4) output relays
- xviii. LCD screen where the Settings and measurands can be read
- xix. Keypad for manual programming of settings and data access

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- xx. Relay Terminals-shall be screw type terminals large enough to accommodate at least 4mm<sup>2</sup> cable and shall be located at the back of the relay
- xxi. Front Serial RS232 or USB or Ethernet Port for relay communication with a laptop
- xxii. Laptop computer for Relay configuration and parameter settings and download of fault records, events records and disturbance records for analysis.
- xxiv. Relay to Laptop connection cable

#### 4.4.16. Sensitive Earth Fault Relay:

The Relay shall have the following functions and features: -

- i. Relay must be of Numerical Type
- ii. Should be suitable for flush mounting on the front of the panel
- iii. The Relay must have been in operation in the Kenya Power System and operated successfully for the last eight (8) years. Improved designs of previous relays are acceptable.
- iv. Relays that have failed in service or mal-operated shall not be acceptable
- v. Current setting range for earth fault relay 0.0125In- 0.8In
- vi. Definite time delay characteristic shall have setting range 0- 30seconds.
- vii. Fault records, Event Records Events and fault records shall not be erased even when the auxiliary DC supply is switched off, drop off/pickup ratio >90% and low transient overreach < 10%.
- viii. Red L.E.D to indicate that the Relay has operated to trip, relay self-diagnostic, with LED to indicate Relay failure and a contact for remote indication
- ix. The relay shall have as a minimum four (4) LEDs for alarms annunciation
- x. The relay shall have as a minimum four (4) binary inputs.
- xi. The Relay shall have as a minimum four (4) output relays
- xii. LCD screen where the settings and measurands can be read
- xiii. Keypad for manual programming of settings and data access
- xiv. Relay Terminals-shall be screw type terminals large enough to accommodate at least 2 x 2.5 mm<sup>2</sup> cable and shall be located at the back of the relay
- xv. Front Serial RS232 or USB or Ethernet Port for relay communication with a laptop

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computer for relay configuration and parameter settings and download of fault records, events records and disturbance records for analysis.

#### 4.4.17. Electrical Reset – Trip Relay

The manufacturer shall have experience of a minimum of 15 years in the manufacture of trip relays

The relay shall be used to trip circuit breakers and shall have the following features: -

- i. High burden tripping relay, immune to capacitance discharge currents and leakage currents
- ii. At least Four (4) pairs of normally open (NO) and two (2) pairs of normally closed (NC) or 4NO/NC output contacts.
- iii. Instantaneous operation; time <15ms
- iv. The Relay shall be suitable for flush mounting
- v. Flag or target shall be a red; L.E.D, or durable bulb or Red Mechanical flag
- vi. The Relay shall be electrically reset, and the reset button shall be inbuilt on the relay and accessible without opening the relay cover or shall be supplied separately for panel flush mounting, in which case the reset button shall be illuminated with red colour.
- vii. Contact rating – capable of carrying 30Amps for 3 seconds and 10A, continuously
- viii. Relay terminals-shall be screw type large enough to accommodate at least 4mm<sup>2</sup> cable and shall be located at the back of the relay
- ix. Relay terminals shall be clearly marked
- x. Relay contacts configuration shall preferably be drawn on the relay casing.
- xi. Alternatively, a connection drawing shall be supplied with the relay.
- xii. Size not greater than 24x19x6 cm

#### 4.4.18. Self-Reset Trip Relay

The manufacturer shall have experience of a minimum of 15 years in the manufacture of trip relays

The relay shall be used to trip Circuit Breakers. The relay shall have the following features: -

- i. High burden tripping relay, immune to capacitance discharge currents and leakage currents

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- ii. At least Four (4) pairs of normally open (NO) and two (2) pairs of normally closed (NC) or 4NO/NC output contacts.
- iii. Instantaneous operation; time <15ms
- iv. The Relay shall be suitable for flush mounting or for mounting on 35mm DIN rail, in which case the relay shall be supplied complete with the base
- v. Flag or target shall be a red; L.E.D, or durable bulb or Red Mechanical flag
- vi. The Relay shall be self-reset, once the relay initiating the trip resets.
- vii. Contact rating – capable of carrying 30Amps for 3 seconds and 10A, continuously and the Relay terminals shall be clearly marked
- viii. Relay Terminals-shall be screw type terminals large enough to accommodate at least 2 x 2.5 mm<sup>2</sup> cable and shall be located at the back of the relay
- ix. Drawing for relay connection shall be provided with the relay
- x. Relay contacts configuration shall preferably be drawn on the relay casing.
- xii. Alternatively, a connection drawing shall be supplied with the relay.
- xiii. Size not greater than 24x19x6 cm

#### 4.4.19. Trip circuit supervision Relay Type I:

The manufacturer shall have experience of a minimum of 15 years in the manufacture of Trip Circuit Supervision relays

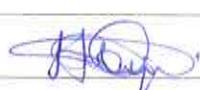
The relay shall have the following features: -

- i. Continuous supervision of trip circuit for circuit breaker in both OPEN & CLOSED positions
- ii. Trip Circuit Healthy – Red/Green L.E.D ON
- iii. Trip circuit fail –Green/Red L.E.D OFF
- iv. Two (2) normally closed (NC) and two (2) normally open(NO) or 2 C/O (change-over) output contacts
- v. The relay shall have a time delay of at least 150mS to avoid transient operations
- vi. Contact ratings – 30 Amps for 3 seconds and 5 Amps continuously.
- vii. Suitable for flush mounting on the relay panel
- viii. Relay Terminals-shall be screw type terminals large enough to accommodate at least 4mm<sup>2</sup> cables and shall be located at the back of the relay and relay terminals shall be clearly marked.

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- ix. Relay shall be supplied complete with the base.
- x. Relay contacts configuration shall preferably be drawn on the relay casing.
- xi. Alternatively, a connection drawing shall be supplied with the relay.
- xii. Size not greater than 16x9x9 cm

#### 4.4.20. Trip circuit supervision Relay Type II:

The manufacturer shall have experience of a minimum of 15 years in the manufacture of Trip Circuit Supervision relays

The relay shall have the following Features: -

- i. Continuous supervision of trip circuit for circuit breaker in both OPEN & CLOSED positions
- ii. Trip Circuit Healthy – Red/Green L.E.D ON
- iii. Trip circuit fail - Green/Red L.E.D OFF
- iv. Two (2) normally closed (NC) and two (2) normally open (NO) or 2C/O (change-over) output contacts.
- v. The relay shall have a time delay of at least 150mS to avoid operation due to transient DC supply interruptions.
- vi. Contact ratings – 30 Amps for 3 seconds and 5 Amps continuously.
- vii. Suitable for DIN Rail (35 mm) Mounting
- viii. Relay Terminals-shall be screw type terminals large enough to accommodate at least 2 x 2.5 mm<sup>2</sup> cable and shall be located at the back of the relay
- ix. Relay terminals shall be clearly marked
- x. Relay shall be supplied complete with the base
- xi. Relay contacts configuration shall preferably be drawn on the relay casing.
- xii. Alternatively, a connection drawing shall be supplied with the relay.

**Note:** The manufacturer for the auxiliary relays below shall have a least 15 years' experience in the manufacture of auxiliary relays for transformer mechanical protection Trip function

#### 4.4.21. Auxiliary relays For Transformer Mechanical Protection Trip Function Type I:

The relays shall be used as repeat relays for power transformer mechanical protection functions.  
The Relay shall have the following features: -

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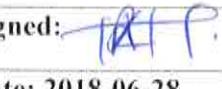
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- i. High speed operation; < 20 ms for tripping
- ii. One (1) element in one casing/relay
- iii. Hand reset contacts
- iv. Manually reset Operation indication/mechanical flag (Red in colour)
- v. Shall be suitable for 35mm DIN rail mounting inside the panel
- vi. At Least Three (3) pairs of normally open (NO) output contacts
- vii. Relay Terminals-shall be screw type terminals large enough to accommodate at least 2.5 mm<sup>2</sup> cables and located at the back of the relay.
- viii. Contact ratings – 30 Amps for 3 seconds and 10 Amps continuously.
- ix. Relay terminals shall be clearly marked, with indelible numbers
- x. Relay shall be supplied complete with base.
- xi. Relay contacts configuration shall preferably be drawn on the relay casing.
- xii. Alternatively, a connection drawing shall be supplied with the relay.
- xiii. Size not greater than 24x18x10 cm

#### **4.4.22. Auxiliary relays For Transformer Mechanical Protection Trip Function Type II:**

The Relay shall have the following features: -

- i. High speed operation < 20 ms for Tripping
- ii. One element (1) in one casing
- iii. Self-reset contacts
- iv. Manually reset Operation Indication flag – Red in colour
- v. Provision of hand operation to close relay contacts for testing
- vi. Shall be suitable for DIN Rail (35mm) mounting at the back of the panel
- vii. At Least Three (3) pairs of normally open(NO) output contacts
- viii. Complete relay including the relay base (socket).
- ix. Contact ratings – 30 Amps for 3 seconds and 5 Amps continuously.
- x. Relay Terminals-shall be screw type terminals large enough to accommodate at least 2.5 mm<sup>2</sup> cable
- xi. The Relay terminals shall be clearly marked.
- xii. Relay contacts configuration shall preferably be drawn on the relay casing.

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- xiii. Alternatively, a connection drawing shall be supplied with the relay.
- xiv. Relay shall be supplied complete with base
- xv. Size not greater than 10x5x5 cm

#### **4.4.23. Auxiliary relays For Transformer Protection Alarm Function Type III:**

The relay shall have the following features: -

- i. Moderate speed of operation < 35ms for Alarm
- ii. One (1) element in one casing/relay
- iii. Self-reset contacts
- iv. Provision of hand operation to close relay contacts for testing
- v. Manually reset operation indication flag – Red in colour
- vi. Shall be suitable for DIN Rail mounting at the back of the panel
- vii. At least Three (3) NO (Normally open) output contacts per element
- viii. Contact ratings - 30 Amps for 3 seconds and 10 Amps continuously.
- ix. Complete relay including the relay base (socket)
- x. Relay Terminals-shall be screw type terminals large enough to accommodate at least 2.5 mm<sup>2</sup> cable
- xi. Relay terminals shall be clearly marked
- xii. Relay contacts configuration shall preferably be drawn on the relay casing
- xiii. Relay supplied complete with base
- xiv. Size not greater than 10x5x5 cm

#### **4.4.24. Bistable Auxiliary relays:**

The Relay shall have the following features: -

- i. The manufacturer shall have at least 10 years' experience in the manufacture of Bistable auxiliary relays for use in Protection and Control Panels.
- ii. Application of alternate control pulses cause the contacts to change from one state to the other.
- iii. If the supply is interrupted, the contacts remain in their previous position even when the voltage is restored.
- iv. Equipped with two DC coils, one for each contact position

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