1. **GENERAL DATA & INFORMATION**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Panel No.**  |  |  | **CT Ratio**  | 800/1A |
| **Relay Type**  | Multi-Function Relay |  | **IN** | 1A |
| **Manufacturer** |  | **VT Ratio**  | 33kV/110V |
| **Serial No** |  | **VN** | 110 V |
| **Order No.** | 1MRK004810-DC | **Draw. & Sh. No.:** |  |
| **Software Version** | 1.2.3 | **Conn. Diag. No.** |  |
| **Frequency Fn**  | 60 HZ | **DC. Aux. Voltage**  | 125 VDC |

1. **MECHANICAL CHECKS AND VISUAL INSPECTION**

 As per TCS –P–105 Rev -1, Item no 4.1& 4.12.1.1

|  |  |  |
| --- | --- | --- |
| **item** | **Description** | **Remarks** |
| 1 | Inspect for any physical damage or defects. | ❑ Yes | ❑ N/A |
| 2 | Verify connections and ferrules as per approved drawings | ❑ Yes | ❑ N/A |
| 3 | Check tightness of all the connections. | ❑ Yes | ❑ N/A |
| 4 | Check Apparatus List | ❑ Yes | ❑ N/A |
| 5 | Check relay version and switching elements on printed circuit board | ❑ Yes | ❑ N/A |

1. **ELECTRICAL TESTS**

 As per TCS –P–105 Rev -1, Item no 4.2& 4.12.1.2

* 1. **FUNCTION TEST**

|  |  |  |
| --- | --- | --- |
| **Item** | **Description** | **Remarks** |
| 1 | Human Machine Interface (HMI) Checked. | ❑ Yes | ❑ N/A |
| 2 | Case Earthing checked. | ❑ Yes | ❑ N/A |
| 3 | LED’s Function Checked. | ❑ Yes | ❑ N/A |
| 4 | Trip Contacts Checked. | ❑ Yes | ❑ N/A |
| 5 | Reset Function Checked | ❑ Yes | ❑ N/A |
| 6 | Group active Functions Checked | ❑ Yes | ❑ N/A |
| 7 | Binary inputs checked. | ❑ Yes | ❑ N/A |
| 8 | Output Relays Checked | ❑ Yes | ❑ N/A |
| 9 | Event Display on HMI Screen Checked | ❑ Yes | ❑ N/A |
| 10 | Test switch / plug checked for correct function. | ❑ Yes | ❑ N/A |
| 11 | Watchdog contacts checked | ❑ Yes | ❑ N/A |
| 12 | Current shorting facility. | ❑ Yes | ❑ N/A |

* 1. **OPERATING DC SUPPLY CURRENT**

|  |  |  |  |
| --- | --- | --- | --- |
| DC voltage(V) | DC current w/o fault (mA) | DC current with fault (mA) | Max. calculated watt (W) |
| 125 |  |  |  |

Limit: DC burden 50 watts. (Refer to the reference technical manual page 391).

* 1. **WATCH DOG CHECK**

SUPPLY OFF

 TERMINALS (CLOSED) - ( X11:2, X11:3) :

 TERMINALS (OPEN) - ( X11:1, X11:3) :

SUPPLY ON

 TERMINALS (CLOSED) - (X11:1, X11:3) :

 TERMINALS (OPEN) - (X11:2, X11:3) :

* 1. **TIME AND DATE CHECK**

To check time & date go to main menu on the display for RED670 then open system time and adjust time & date.

To test keeping time and date setting this, remove the auxiliary supply from the relay for approximately 30 seconds, then restoring the auxiliary supply, the time and date setting should not be lost.

Result: \_\_\_\_\_\_\_\_\_\_\_\_

* 1. **SETTING ADOPTED**

Refer enclosed setting printout

* 1. **SECONDARY INJECTION TESTS**

**DISTANCE PROTECTION**

1. **ZONE REACH MEASUREMENTS:**

|  |  |  |
| --- | --- | --- |
| **Item** | **Description** | **Checked** |
| 1 | Print out from Freja attached. |  |

**PH-E (PE):**

* Resistive reach: RFn (Ω/loop) = RFn (Ω/phase) = RFPE
* Reactive reach: XFn (Ω/loop) = XFn (Ω/phase)

= Xn (Ω/phase) + X1 (Ω/phase)= (2\*X1 + X0) / 3

* Chars. Angle = -15 to 115 at FW Direction



**PH-PH (PP):**

* Resistive reach: RFn (Ω/phase) = ½ RFn (Ω/loop) = ½ RFPP.
* Reactive reach: XFn (Ω/phase) = ½ Xn (Ω/loop) = X1.

RFn: Zone n resistive reach resistance.

XFn: zone n positive sequence reactance.

X0 : line zero sequence reactance.

X1 : line positive sequence reactance.

**3 PH:** Same setting like PH-PH but, note PHS is rotated by 30o at 3PH, Due to that, zones at resistive reach is reduced

**Accuracy:**

± 2.0% static accuracy, ± 2.0 degrees static angular

Accuracy Conditions:

Voltage range: (0.1-1.1) x Ur, Current range: (0.5-30) x Ir, Angle: at 0 degrees and 85

1. **ZONE TIMING TEST**

|  |  |  |
| --- | --- | --- |
| **Item** | **Description** | **Checked** |
| 1 | Print out from Freja attached. |  |

 Limit: 28-33 ms ± 10ms ± 0.5 %.[The relay was tested on final setting]

1. **PHASE SELECTION FUNCTION (PHS)**
	1. **PHS REACH MEASUREMENTS**

|  |  |  |
| --- | --- | --- |
| **Item** | **Description** | **Checked** |
| 1 | Print out from Freja attached. |  |

|  |  |  |
| --- | --- | --- |
| Setting given as (Ω/loop ) not (Ω/phase ) |  |  |
| PHS , with Phase-to-Phase | PHS , with Phase-to-Earth | PHS , with 3 Phase |

**PH-E (PE):**

* Resistive reach: RFphs (Ω/loop) = RFphs (Ω/phase) = RFFwPE.
* Reactive reach: Xnphs (Ω/loop) = Xnphs (Ω/phase)

= (2\*X1 + X0) / 3

**PH-PH (PP):**

* Resistive reach: RFphs (Ω/phase) = ½ RFphs (Ω/loop) = ½ RFFwPP
* Reactive reach: X1phs (Ω/phase) = ½ X1phs (Ω/loop) = X1phs (Ω/phase).

**3PH:**

* Resistive reach: RFphs (Ω/phase) = 1.15 RFphs (Ω/phase).
* Reactive reach: X1phs (Ω/phase) = 1.335 \* X1phs (Ω/phase).

Take in consideration that, although PHS rotate by 30 0,

it still keep directional angle (-15, 115) as its starting boundary.

* 1. **PHS TIMING TEST:**

|  |  |  |
| --- | --- | --- |
| **Item** | **Description** | **Checked** |
| 1 | Print out from Freja attached. |  |

Limit: 28-33 ms ± 10ms ± 0.5 %.

1. **POWER SWING DETECTION (PSD)**

**4.1. PSD REACH TEST MEASUREMENT**

|  |  |  |
| --- | --- | --- |
| **Item** | **Description** | **Checked** |
| 1 | Print out from Freja attached. |  |

Where:

RLdFw = KLdRFw \* RLdOutFw

RLdIn = KLdRRv \* RLdOutRv



* 1. **TIMING TEST:**

* + 1. **Check The Operating Time (TP1)**

|  |  |  |
| --- | --- | --- |
| Type of fault | Tp1 setting ms | Tp1 actual ms |
| 3 phase | 40 |  |

***TP1****:* it is the smallest time can be passing from outer boundary to inner boundary of Power Swing Chars. to detect PSD Start

**FREJA GENERAL MODE, SEQUENCE, 3 STAGES.**

* 1ST STAGE: Normal Load, 3phase Vr & Ir, outside the outer zone area
* 2nd STAGE: 3phase V&I to get the impedance inside the PSD zone (I=Ir & V/I<Zouter and T =Tp1).
* 3RD STAGE: 3phase V&I to get the impedance outside PSD zone and pass the inner boundary (I=Ir & V/I<Zinner and T =1 SEC).

\* Change 2nd stage timing till get PSD operating time exactly.

* + 1. **Check The Blocking Time (tR2):**

|  |  |
| --- | --- |
| **Setting Value**  | **Measured Value** |
|  2 sec. |  |

Limit: ± 10 ms (see the tech. ref. manual page 90).

***tR2****:* if the PSD is detect a 3Phase zone fault for time is longer than tR2, then it Block PSD function.

**FREJA GENERAL MODE**

* 1ST STAGE: 3PHASE healthy V&I (I=Ir, V/I >outer zone setting impedance).
* 2ND STAGE: 3PHASE V&I (I=Ir, V/I <inner zone setting impedance).
* 3RD STAGE inside 3Ph fault for time >= tR2.

\* Change the time of 3rd stage till get trip, which mean blocking of PSD

The relay was tested on final setting

* + 1. **Check of the relay tripping during power swing if a single phase faults Occurred, tR1 [ ]**

|  |  |  |
| --- | --- | --- |
| **Item** | **Description** | **Checked** |
| 1 | Blocking of zone 1, 2 & 3 |  |

Test procedure: same as before only change the time for 3rd stage to be less than tr2 sec. and test that for each zone.

Check of the relay tripping during power swing if a single phase faults Occurred, tR1 [ ]

***tR1:*** if the PSD is detect a single phase fault, so after time equal to tR1, then it Block PSD function

**FREJA GENERAL MODE**

* 1ST STAGE: 3PHASE V&I (I=Ir, V/I > outer zone setting impedance).
* 2ND STAGE: 3PHASE V&I (I=Ir, V/I < inner zone setting impedance).
* 3RD STAGE outside PSD for time < tR2.
* 4RD STAGE inside 1Ph fault for time >= tR1
* Change the time of 4th stage till get trip, which mean blocking of PSD

|  |  |
| --- | --- |
| **Setting Value** | **Measured Value** |
| 300 ms |  |

* + 1. **Check The Fast PSD Time (tP2)**

***tP2****:* it is second operating timer for PSD (Fast PSD), if PSD occur for second time at interval equal to *Tw*.

**FREJA GENERAL MODE**

* 1st STAGE: 3PHASE V&I (I=Ir, V/I >outer zone setting impedance).
* 2nd STAGE: 3PHASE V&I (outer zone > I=Ir, V/I > inner zone setting impedance)

for time >= tP1.

* 3rd stage: 3PHASE V&I (I=Ir, V/I <inner zone setting impedance) for time = 100 ms.
* 4th stage leave PSD and back to normal load for time < Tw.
* 5th stage pass outer PSD for time >= tP2
* 6th stage pass inner PSD

\* Note, you must minimize the TH, which is the holding time for PSD starting signal

* Change the time of 4th stage and 5th stage to get Tw, tP2 timers

|  |  |  |
| --- | --- | --- |
| **Timer** | **Setting Value**  | **Measured Value** |
| Tw | 250 ms |  |
| tP2 | 15 ms |  |

Time limit: ± 10ms ± 0.5 %

* + 1. **Check of the blocking function:**

|  |  |  |
| --- | --- | --- |
| **Item** | **Description** | **Checked** |
| 1 | Blocking of zone 1, 2 & 3 |  |

\* Test procedure: same as before only change the time for 3rd stage to be less than TR2 sec. and test that for each zone.

1. **CURRENT SENSITIVITY TEST:**

Ir = 1.0 A

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Phase** | **Fault type** | **Setting** | **Z1** | **Z2** | **Z3** | **PHS** |
| R | PH-E |  |  |  |  |  |
| R-Y | PH-PH |  |  |  |  |  |
| R-Y-B | 3PH |  |  |  |  |  |
| Y | PH-E |  |  |  |  |  |
| Y-B | PH-PH |  |  |  |  |  |
| R-Y-B | 3PH |  |  |  |  |  |
| B | PH-E |  |  |  |  |  |
| B-R | PH-PH |  |  |  |  |  |
| R-Y-B | 3PH |  |  |  |  |  |

* If test done using 3PZSTD1A at freja, then multiply 3PH measured by √3
* If test done using 3PZSTD2A at freja, then multiply PH-PH measured by (2 / √3)
* Reverse zone pickup at 0.75 of Iminop as per technical ref page 135

\* Note**:** ZM03 IMinOpPE pickup at 100% of ZM03 IMinOpPE setting because PHS IMINOpPE = 0.05 and ZDIR IMINOp = 0.1

1. **DIRECTIONALTEST**

RV

295O

ND

180O

345O

165O

115O

FW

ND

90O

Line characteristic angle:

Relay directional angles: ArgDir (15) and ArgNegRes (115)

a) Forward direction; the operating chs. Area from: to:

b) Reverse direction; the operating chs. Area from: to:

c) The non-directional area from: to:

and from: to:

Test Procedure: -

* Apply Single Phase V & I Under PHS Setting.
* Change the voltage angle from 0 degree up to 360 degrees until the indication of FW, REVESE and non-directional appears as per setting applied.
1. **SCHEMECOMMUNICATION TEST**
* Scheme selected : PERMISSIVE OVER REACH
* Coordination time : ms.
* NO carrier receive + Zone 2 fault

Trip Time :

Indication :

* carrier receive + Zone 2 fault

Trip Time :

Indication :

* Zone 3 fault

Trip Time :

Indication :

* Carrier send time : ms.
* Tsend min. : ms (100 ms setting)

To check the T send min. time; the injection time should be less than T Send min.

Limit: ± 10 ms for operating time (see the tech. ref. manual page 122).

1. **AUTOMATIC SWITCH ON TO FAULT (SOTF)**
2. Operating Time

|  |  |
| --- | --- |
| Distance Protection | indications |
| SOTF – ON | Trip Time (msec) |
| External SOTF with manual Close pulse. |  |  |

Activate the DLD with the internal SOTF function.

Limit: (28-33) ± 10 ms for operating time

1. SOTF Timers:

**tSOFT:** it is the holding time for SOTF start signal .

* Activate the SOFT with DLD
* FREJA GENERAL MODE
* 1ST STAGE: 3PHASE Vr &Ir
* 2ND STAGE 3PHASE Dead (V, I = zero) for time >= tDLD
* 3RD STAGE 3PHASE Dead (V, I = zero) for time <= tSOTF
* 4th STAGE Single Phase Fault.

 \* Change tSOTF till get smallest value cause trip.

tSOTF :\_\_\_\_\_\_\_\_\_\_\_\_ tSOTFsetting =

Note: refer. To configuration of relay there is 250 ms adding as pulse delay to BC input

1. **FUSE FAILURE SUPERVISION FUNCTION (FUSE)**

|  |  |
| --- | --- |
| Setting | Measured Values |
| 3U0>(V) | 3I0<(A) | 3U0>(V) | 3I0<(A) |
|  |  |  |  |

3U0= Ua + Ub + Uc

3I0= Ia + Ib + Ic

Limit: ± 2.5 % of Ur for 3U0> and ± 2.5 % of 3I0r

**General mode**

* 1st stage: 3phase V&I healthy case.
* Decrease one phase voltage till the indication led fuse fail appears.
* Decrease the same phase current till the indication led fuse fail reset.
	1. Fuse failure operating time m sec.
* 1ST stage: 3phase v&i healthy case.
* 2ND stage: put fuse fail condition (take contact fuse fail)
	1. Check the blocking of the relay when the general block functions

(VT MCB TRIP) is activated [ ].

* 1. Check the latching facility of fuse fail function [ ].
	2. V.T supervision lathing time = sec.

Disable opDUDI Mode.

Enable UZsIZs Mode.

**General mode:**

* 1ST stage: 3phases V&I healthy case. (Take time 1 sec)
* 2ND stage: put 3 phase (v) to achieve the DLD and fuse fail for time >= latching time (5 second)
	1. Check the relay operation if a fault occurred during the fuse fail [ ].

**General mode:**

* 1st stage: 3phases V&I healthy case. (Take time 1 sec)
* 2nd stage: fuse fail condition (take time < 5 sec)
* 3rd stage: fault condition

\* Trip for t < 5 sec, Block for t > 5 sec

* 1. Check Reset fuse fail Voltage (USealIN < [ ]).

**General mode:**

* 1st stage: 3phases V&I HEALTHY case. (Take time 1 sec)
* 2nd stage: fuse fail condition (take time >= 5 sec) , till latch condition.
* 3rd stage: 3Phase , V = USealIn , I = Ir

Change V on 3rd stage till get the exact value of USealIn which reset the latched Fuse Failure.

USealIn<: \_\_\_\_\_\_\_\_\_\_\_\_

USealIn<setting = % UBase

1. **SERVICE VALUES FOR MEASUREMENTS**

Ph voltage applied : 110.0 V Ph current applied: 1.0 A.

Phase shift : 0, 240, 120 degrees. Frequency: 60 HZ.

CT Ratio : 800 /1 A VT ratio: 33 kV/110 V

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Values** | **Sec. Values** | **Prim. Values** | **Values** | **Sec. Values** | **Prim. Values** |
| U1 |  |  | I1 |  |  |
| U2 |  |  | I2 |  |  |
| U3 |  |  | I3 |  |  |
| U1 – U2 | - |  | F |  |
| U2 – U3 | - |  |  |  |  |
| U3 – U1 | - |  |  |  |  |

Reading for Active and Reactive Power at different angles: -

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | 0º | 45º | 90º | 135º |
| P (MW) |  |  |  |  |
| Q (MVAR) |  |  |  |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | 180º | 235º | 270º | 315º |
| P (MW) |  |  |  |  |
| Q (MVAR) |  |  |  |  |

1. **POLARIZING VOLTAGE (3U0) PICKUP AND DROP OFF TEST:**

|  |  |  |
| --- | --- | --- |
| 3U0 setting | Operating values at 2\* Is | Indication |
| 1 % of Uph (volts) | Angle | Pick up Volts | Drop off Volts |
| 0.66 V | 65° |  |  |  |

1. **PICKUP AT VARIOUS OPERATIN ANGLES FOR AIDED DEF:**

Iop\_min = (IN>Dir) / (COS(Φ-RCA)

**Note: -** Direction element for Aided Def connected to STFW signal which operate at IN>Dir

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Angle Change** | **Expected value(A)** | **Pickup (A)** | **Drop-off (A)** | **Set Time (S)** | **Op Time (S)** |
| 60 | 0.200 |  |  | 0.070 |  |
| 130 | 0.584 |  |  | 0.070 |  |
| 340 | 1.151 |  |  | 0.070 |  |

**DEF TRIP**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Angle Change** | **Expected value(A)** | **Pickup (A)** | **Drop-off (A)** | **Set Time (S)** | **Op Time (S)** |
| 60 | 0.200 |  |  | 0.8 |  |
| 130 | 0.200 |  |  | 0.8 |  |
| 340 | 0.200 |  |  | 0.8 |  |

1. **SCHEME COMMUNICATION TEST (AID DEF):**

Scheme selected :

Coordination time : ms.

* **NO Carrier Receive + Forward fault**

Trip Time :

Indication :

* **Carrier Receive + Forward fault**

Trip Time :

Indication :

Carrier send time : ms.

Indication :

1. **FOUR STEP RESIDUAL OVER CURRENT (TEF)**
	1. **CHECK THE OPERATING CHARACTERISTIC ANGLE:**

 A - Forward direction : -

 B - Reverse direction : -



Where default for IEC Normal Inverse is:

A = 0.14

P = 0.02

C = 1

B = 0

Step 1 (IN1>)

Kt = 0.2

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Phase | Isetting | Iinjected = 2 \* Isetting | Iinjected = 4 \* Isetting | Iinjected = 10 \* Isetting |
| t expected | t measured | t expected | t measured | t expected | t measured |
| R | 0.2 | 2  |  | 1 |  | 0.6 |  |
| Y | 2 |  | 1 |  | 0.6 |  |
| B | 2 |  | 1 |  | 0.6 |  |

Step 2 (IN2>)

Kt = 0.2

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Phase | Isetting | Iinjected = 2 \* Isetting | Iinjected = 4 \* Isetting | Iinjected = 10 \* Isetting |
| t expected | t measured | t expected | t measured | t expected | t measured |
| R | 0.5 | 2  |  | 1 |  | 0.6 |  |
| Y | 2 |  | 1 |  | 0.6 |  |
| B | 2 |  | 1 |  | 0.6 |  |

**DIFFERENTIAL PROTECTION**

1. **MEASUREMENTS :**

- For Angle Measurement; Set Measurement Ref is IR.

- Inject three phase current with different values and angles.

- For Neutral Current (N) Inject 3 Phase Current with same magnitude and same phase angles.

 So, IN = IR + IB + IY = 0.5 (0 O) + 1.0 (240 O) + 1.5 (120 O) = 0.866 (150 O)

|  |  |  |  |
| --- | --- | --- | --- |
| **Phase** | **Applied Current** | **Display secondary** | **%Error** |
| **Magnitude** | **Angle** | **Magnitude** | **Angle** | **Magnitude** | **Angle** |
| **R** | 0.5 | 0.0 |  |  |  |  |
| **Y** | 1.0 | 240.0 |  |  |  |  |
| **B** | 1.50 | 120.0 |  |  |  |  |
| **N** | 1.0 | 0.0 |  |  |  |  |

 **MEASUREMENTS (LOCAL / REMOTE)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Phase** | **Applied CURRENT** | **Display Primary**  | **LDCM Value** |
| **Magnitude** | **Angle** | **Magnitude** | **Angle** | **Magnitude** | **Angle** |
| **R** | 1.0 | 0.0 |  |  |  |  |
| **Y** | 1.0 | 240.0 |  |  |  |  |
| **B** | 1.0 | 120.0 |  |  |  |  |

 Limits: Amplitude Accuracy; ± 0.5 % Ir

According to the Catalogue for Technical Data – Page: 32

1. **PICK UP & DROP OFF TEST FOR DIFFERENTIAL CURRENT (ID) :**

Use fiber optic communication between ch1& ch2 then test of differential protection element;

Also, **charge current** should be not active in the setting.

Pick Up Value = Idmin A

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Phase** | **Setting****Idmin (A)** | **Injected Current****I bias (A)** | **Measured Pick Up Value (A)** | **Measured Drop Out Value (A)** |
| **R** | 0.2 | 0.2 |  |  |
| 0.6 | 0.6 |  |  |
| **Y** | 0.2 | 0.2 |  |  |
| 0.6 | 0.6 |  |  |
| **B** | 0.2 | 0.2 |  |  |
| 0.6 | 0.6 |  |  |
| **R-Y** | 0.4 | 0.4 |  |  |
| **Y-B** | 0.4 | 0.4 |  |  |
| **B-R** | 0.4 | 0.4 |  |  |
| **R-Y-B** | 0.4 | 0.4 |  |  |

Limits: Pick up & Drop Out ± 2% of Ir According to the Catalogue for Technical Data – Page: 24

1. **OPERATING TIME TEST FOR DIFFERENTIAL CURRENT (ID)**

Set: DT Mode Idmin = 0.4Ibase, AddDelay = on, ImaxDelay > 4 A

|  |  |  |  |
| --- | --- | --- | --- |
| **PHASE** | **Inject current (A)** | **Delay Time (ms)** | **Operating Time (ms)** |
| **R** | 4 | Zero (Inst) |  |
| 4 | 100 |  |
| **Y** | 4 | Zero (Inst) |  |
| 4 | 100 |  |
| **B** | 4 | Zero (Inst) |  |
| 4 | 100 |  |
| **R-Y** | 4 | Zero (Inst) |  |
| **Y-B** | 4 | Zero (Inst) |  |
| **B-R** | 4 | Zero (Inst) |  |
| **R-Y-B** | 4 | Zero (Inst) |  |

Accuracy: Instantaneous Operation: 25 ms typically at 0 to 10\*Id

According to the Catalogue for Technical Data –Page: 24

1. **PICK UP & DROP OFF TEST & OPERATING TIME FOR DIFFERENTIAL CURRENT ALARM**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **PHASE** | **SETTING** **IdAlarm (A)** | **Injected Current A** | **Measured Pick Up Value (A)** | **Measured Drop Out Value (A)** |
| **R** | 0.2 | 0.2 |  |  |
| 0.6 | 0.6 |  |  |
| **Y** | 0.2 | 0.2 |  |  |
| 0.6 | 0.6 |  |  |
| **B** | 0.2 | 0.2 |  |  |
| 0.6 | 0.6 |  |  |
| **R-Y** | 0.4 | 0.4 |  |  |
| **Y-B** | 0.4 | 0.4 |  |  |
| **B-R** | 0.4 | 0.4 |  |  |
| **R-Y-B** | 0.4 | 0.4 |  |  |

1. **DELAY TIME FOR DIFFERENTIAL CURRENT ALARM**

Set IdAlarm = 0.2 IB

|  |  |  |
| --- | --- | --- |
| **PHASE** | **Delay (sec)** | **Operating time in sec** |
| **R** | zero |  |
| 5 |  |
| **Y** | zero |  |
| 5 |  |
| **B** | zero |  |
| 5 |  |
| **R-Y** | zero |  |
| 5 |  |
| **Y-B** | zero |  |
| 5 |  |
| **B-R** | zero |  |
| 5 |  |
| **R-Y-B** | zero |  |
| 5 |  |

1. **BIAS CHARACTERISTIC TESTING**

Use fiber optic communication between ch1&ch2 then test differential protection element; also charging current should be active.as shown figure.

A current is injected into the R phase, which is used as the bias current, and another current is injected into the Y phase, which is used as differential current.

Inject a bias current of 1A in the R phase. The relay will trip and any contacts associated with the R phase will operate.

Slowly increase the current in the Y phase until phase Y trips. Record the phase Y current magnitude and check that it corresponds to the following equation;

**SECTION 1**

When bias current is between:

0 ≤ Ibias ≤ Endsection1\*IBase

Trip= IdminOp \*Ibase

Set End section1 = 1.25\*IBase



|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Slope section 1** | **Idmin set** | **I bias****(A)** | **Id calculated****(Trip)** | **Id Measured** | **Errors %** |
| **R** | **Y** | **B** | **R** | **Y** | **B** |
| **IdminOp** | 0.2 | 0.20 | 0.20 |  |  |  |  |  |  |
| 0.4 | 0.4 | 0.4 |  |  |  |  |  |  |
| 0.6 | 0.6 | 0.60 |  |  |  |  |  |  |

Limits; ± 2 %Ir

According to the Technical Reference Catalogue – Page24

**SLOPE SECTION 2**

When bias current is between:

Endsection1\*Ibase ≤ Ibias ≤ Endsection2\*IBase

Trip = (IdminOp \*Ibase+ slope section2/100 \*(Ibias - End section1\*Ibase )

 Where; Idmin ; The Basic Diff Current Setting.

To check more than one point at the same slope, Change the bias current value and the equation above can be used, and also for other differential settings '' Different slopes, Is1 ''.

Apply the above procedure for each phase.

Set End section1 = 1.25\*IBase

 End section2 = 3.0\*IBase

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Slope section 2** | **Idmin set** | **I bias****A** | **Id calculated****(Trip)** | **Id Measured** | **Errors %** |
| **R** | **Y** | **B** | **R** | **Y** | **B** |
| **30 %** | 0.2 | 1.5 | 0.275 |  |  |  |  |  |  |
| 0.4 | 2.0 | 0.625 |  |  |  |  |  |  |
| 0.6 | 3.0 | 1.125 |  |  |  |  |  |  |
| **50 %** | 0.2 | 1.5 | 0.325 |  |  |  |  |  |  |
| 0.4 | 2.0 | 0.775 |  |  |  |  |  |  |
| 0.6 | 3.0 | 1.475 |  |  |  |  |  |  |

Limits; ± 2 %Ir

According to the Technical Reference Catalogue – Page24

**SLOPE SECTION3**

Repeat the test and check the result with the following equation;

When bias current is more than:

Ibias ≥ End section2\*Ibase

Trip = Ibase\*(IdminOp + slope section2/100\*(End section2 - End section1)) +

(slope section3/100 \* (Ibias- End section2\*Ibase) A

Set End section1 = 1.25\*IBase

 End section2 = 3.0\*IBase

 Slope section2 = 50%

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Slope section3** | **Idmin set** | **I injectedA** | **Id calculated****(Trip)** | **Id Measured** | **Errors %** |
| **R** | **Y** | **B** | **R** | **Y** | **B** |
| **50%** | 0.2 | 4.0 | 1.575 |  |  |  |  |  |  |
| 0.4 | 5.0 | 2.275 |  |  |  |  |  |  |
| 0.6 | 6.0 | 2.975 |  |  |  |  |  |  |
| **80 %** | 0.2 | 4.0 | 1.875 |  |  |  |  |  |  |
| 0.4 | 5.0 | 2.875 |  |  |  |  |  |  |
| 0.6 | 6.0 | 3.875 |  |  |  |  |  |  |

Limits; ± 2 %Ir

According to the Technical Reference Catalogue – Page24

1. **TEST OF 2ND HARMONICS**

Idmin = 0.2 Ib

|  |  |  |  |
| --- | --- | --- | --- |
| **Phase** | **I2 / I1 ratio %** | **I1 ( F =60 Hz )****(Pickup Value)** | **I2 ( F = 120 Hz )** |
| **Expected Blocking** | **Measured** |
| **R** | 10 |  |  |  |
| **Y** | 50 |  |  |  |
| **B** | 100 |  |  |  |

1. **TEST OF 5TH HARMONICS**

|  |  |  |  |
| --- | --- | --- | --- |
| **Phase** | **I5 / I1 ratio %** | **I1 ( F =60 Hz )** | **I5 ( F = 300 Hz )** |
| **Expected Blocking** | **Measured** |
| **R** | 15 |  |  |  |
| **Y** | 30 |  |  |  |
| **B** | 50 |  |  |  |

1. **UNRESTRAINED CURRENT PICKUP TEST**

|  |  |
| --- | --- |
| **Phase** | **Idunrest** |
| **Setting Value ( of IB )** | **Pickup Value** | **Drop Off Value** |
| **R** | 5.0 |  |  |
| 8.0 |  |  |
| **Y** | 5.0 |  |  |
| 8.0 |  |  |
| **B** | 5.0 |  |  |
| 8.0 |  |  |

1. **UNRESTRAINED CURRENT TIME TEST**

|  |  |
| --- | --- |
| **Phase** | **Idunrest** |
| **Setting Value ( of IB )** | **Pickup Time( ms )** | **Error %** |
| **R** | 5.0 |  |  |
| 8.0 |  |  |
| **Y** | 5.0 |  |  |
| 8.0 |  |  |
| **B** | 5.0 |  |  |
| 8.0 |  |  |

1. **ENHANCED DIFFERENTIAL (IDminhigh)**

There are 2 condition during them the relay must decrease its sensitivity: during energized or at external fault, where at that conditions the slope chars. Use the value of IdminHigh instead of Idmin for just a time equal to tIdminHigh. After that slope chars. Back as usual using Idmin as basic setting

* 1. **IDminhigh PICKUP & DROP OFF**

|  |  |
| --- | --- |
| **Phase** | **IdMinHigh** |
| **Setting Value ( of IB )** | **Pickup Value** |
| **R** | 5.0 |  |
| 8.0 |  |
| **Y** | 5.0 |  |
| 8.0 |  |
| **B** | 5.0 |  |
| 8.0 |  |

* 1. **IDminhigh TIME TEST**

|  |  |
| --- | --- |
| **Phase** | **TIdminHigh** |
| **Setting Value** **( second )** | **Pickup Timeseconds** |
| **R** | 5.0 |  |
| 8.0 |  |
| 10.0 |  |
| **Y** | 5.0 |  |
| 8.0 |  |
| 10.0 |  |
| **B** | 5.0 |  |
| 8.0 |  |
| 10.0 |  |

1. **Trip indication test:**

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Type of fault** | **Led Color** | **Check** |
| 01 | Phase R | Red |  |
| 02 | Phase Y | Red |  |
| 03 | Phase B | Red |  |
| 04 | Differential Trip | Red |  |
| 05 | Z1/Aided Trip | Red |  |
| 06 | Z2/Z3 / O.C / E.F Trip | Red |  |
| 07 | I/T Received | Yellow |  |
| 08 | SOTF Trip | Yellow |  |
| 09 | CBF Trip | Yellow |  |
| 10 | Ch1 Comm. Fail | Yellow |  |
| 11 | Ch2 Comm. Fail | Yellow |  |
| 12 | 87L Current Alarm | Yellow |  |
| 13 | FUSE FAIL | Yellow |  |
| 14 | CS | Yellow |  |
| 15 | CR | Yellow |  |

1. Disturbance recorder checked [ ].
2. Binary outputs and inputs checked [ ].
3. TestEquipments Used

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sl. No | Description | Make | Equipment Sl .No | Calibration Date | Calibration Due Date |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |