International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 05 | May - 2023 SJIF 2023: 8.176 ISSN: 2582-3930

DESIGN OF DIFFERENTIAL PROTECTION SYSTEM AND ITS SETTINGS FOR 20MVA INDUSTRIAL TRANSFORMER

Deepashree K, Rashmi D, Shravya K M, Anusha B S, Govindappa R
Department of Electrical & Electronics Engineering
DAYANANDA SAGAR ACADEMY OF TECHNOLOGY & MANAGEMENT
Udayapura, Kanakapura main Road, Opp. Art of Living, Bangalore– 82

ABSTRACT: The design of a differential protection system and its settings for a 20MVA industrial transformer are discussed in this study. Transformers are crucial in power systems for scaling up or stepping down power. Any transformer fault that results in significant equipment damage raises the cost of replacement. In order to safeguard the transformer from fault, it must have an adequate protective system.

Differential protection is the most often employed protection strategy for internal problems in transformers [17]. Using CT secondary impedance, this differential protection is divided into two categories. Both the low and high impedance differential protection schemes fall under this category. The differential protection is impacted by the harmonics generated in the transformer [9].

This paper explains low impedance transformer differential protection design while taking the intelligent electronic device (IED)-7UT613 into consideration.

KEYWORDS: Current Transformer (CT), Differential Protection, Electronic Intelligent Device (IED), High Impedance, Internal Fault, Low Impedance, Power System, Secondary Impedance, Transformer.

I.INTRODUCTION:

Various transient disturbances, including internal fault, magnetizing inrush, and external fault, can affect power transformers.

Sometimes the presence of differential current cannot distinguish clearly between a fault and an inrush. Therefore, differential protection using differential relay circuits is one of the most efficient methods of protection for the power transformer. This system is founded on the idea that the transformer's power input and output are equal under normal circumstances. Under typical circumstances, the relay coil won't have any current flowing through it with the secondary's of the current transformer connected properly. However, when a fault condition arises, the current's balance condition will no longer exist, causing the relay contacts to close and sending a trip command to the circuit breaker (CB) to operate, isolating the defective equipment[13].

When powering up the transformer, the primary and secondary sides will have very high currents under normal circumstances. Additionally, the system will have high levels of the 2nd and 5th harmonics introduced by inrush current and overexcitation. As a result, the core becomes saturated, and because the secondary winding is considerably closer to the core than the primary side, inrush and over-excitation have a greater impact on it [9].The secondary side will produce currents that are significantly stronger than those on the primary side. Due to this, the differential protection will trip for a brief period of time.

We choose to disable the protection or change the setting in order to prevent the gadget from travelling inadvertently.

Differential protection is one of the transformer's main defenses against phase to ground and phase to phase fault. To protect the transformer, the transformer differential protection relay's settings must be precise. Incorrect settings can result in the transformer being severely damaged by internal faults or accidentally tripping outside the transformer, which cuts off power to a functioning system [17].

Transformers are one of the most critical and expensive components of any distribution system. It is an enclosed static device usually drenched in oil, and hence faults occurring to it are limited. But the effect of a rare fault can be very dangerous for the transformer, and the long lead time for repair and replacement of transformers makes things even worse. Hence power transformers protection becomes very crucial.

Faults occurring on a transformer are mainly divided into two types, which are, external faults and internal faults, to avoid any danger to the transformer, an external fault is cleared by a complex relay system within the shortest possible time. The internal faults are mainly based on sensors and measurement systems. It is important to understand that there are many types of transformer protection.

There are two types of differential protection scheme. They are:

a) High Impedance Differential Protection

A straightforward solution called the high impedance differential protection scheme calls for all the current transformers (CTs) to have similar magnetising properties, the same CT ratio, and a reasonably high knee point voltage. The protected gadget will have these CTs fitted on every end.

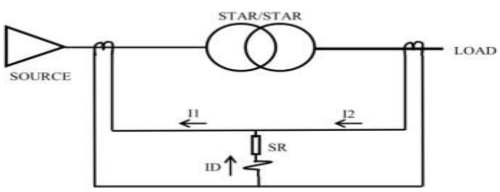


Fig-1.1: high impedance differential protection

Fig-1.1 shows a typical high impedance differential protection scheme of two winding transformer. The differential current ID is given by,

$$ID=I1-I2$$

The relay will activate and send the trip command to the circuit breakers of a transformer if the differential current ID is greater than the preset value **[10]**.

B) Low Impedance Differential Protection

Low Impedance Differential Protection scheme is more advantageous when compared to high impedance differential protection as it does not require the CT's with identical characteristics **[9]**.

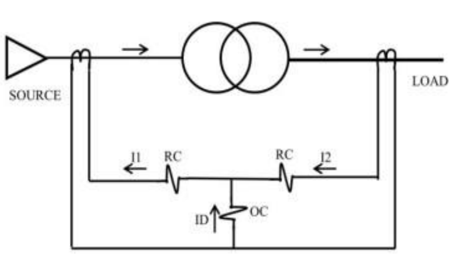


Fig 1.2: low impedance differential protection

Fig 1.2 shows a typical low impedance differential protection scheme of two winding transformerThis kind of relay has an operational coil and a restraining coil. If the differential current crosses the bias current, this protection activates and issues the trip command. So, "Biassed Differential Protection" is another name for this type of defence.

Evolution of protection relay:

The purpose of an electrical power system is to generate and supply electrical energy to consumers. The system should be designed to deliver this energy both reliably and economically. Frequent or prolonged power outages result in severe disruption to the normal routine of modern society, which is demanding ever-increasing reliability and security of supply. As the requirements of reliability and economy are largely opposed, power system design is inevitably a compromise.

The electromechanical relay in all of its different forms has been replaced successively by static, digital and numerical relays, each change bringing with it reductions in size and improvements in functionality. Reliability levels have also been maintained or even improved and availability significantly increased due to techniques not available with older relay types. This represents a tremendous achievement for all those involved in relay design and manufacture.

The definitions that follow are generally used in relation to power system protection:

a. Protection System: a complete arrangement of protection equipment and other devices required to achieve a specified function based on a protection principle (IEC 60255-20)

b. Protection Equipment: a collection of protection devices (relays, fuses, etc.). Excluded are devices such as Current Transformers (CTs), Circuit Breakers (CBs) and contactors

c. Protection Scheme: a collection of protection equipment providing a defined function and including all equipment required to make the scheme work (i.e. relays, CTs, CBs, batteries, etc.)

Relays may be classified according to the technology used:

1. Electromechanical
2. Static
3. Digital
4. Numerical

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 05 | May - 2023 SJIF 2023: 8.176 ISSN: 2582-3930

Tripping characteristics of low impedancedifferential protection:

Fig. 1.3 displays the whole tripping characteristic of the differential protection. The branch 'a' displays the differential protection's sensitivity threshold (setting I-DIFF>), which also considers constant error currents like magnetising currents.

Branch 'b' accommodates for current-proportional mistakes that might be caused by out-of-phase main CTs, out-of-phase relay input CTs, or erroneous current caused by the location of the voltage regulators tap changer. Misaligned main CTs may also be to blame for these errors.

Branch 'c' results in a stronger stabilisation in the range of high currents that could lead to current transformer saturation. Differential currents above the branch d cause an immediate trip regardless of the restraining quantity or harmonic content (setting I-DIFF>>). Here is where you'll find the "Fast Unstabilized Trip with High-Current Faults" region.

The area of "Add-on stabilisation" is the operation zone of the saturation indicator, as previously described under the term "Add-on Stabilisation during External Fault." As shown in Fig. 1.3, the operational feature of the differential protection compares the values IDiff and IRest. If the amounts result in a locus in the tripping area, a trip signal is sent. If the current conditions IDiff/IRest are close to the fault characteristic, trips may still happen even if the trip characteristic has been much improved due to add-on stabilisation, startup, or DC current detection. (90% of the slope of the fault characteristic). [2](pg: 73- 80)

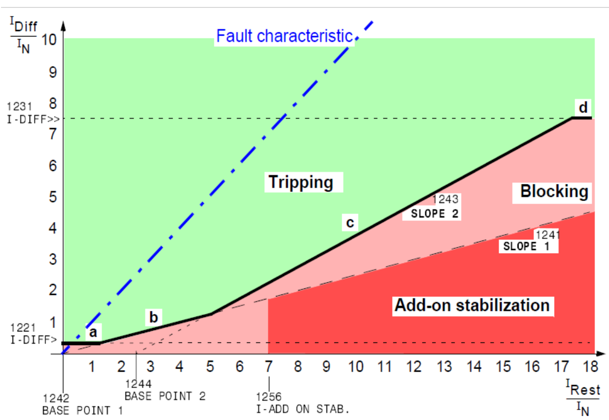


Fig 1.3: Tripping characteristic of differential protection

To clarify the situation, three important operatingconditions should be examined

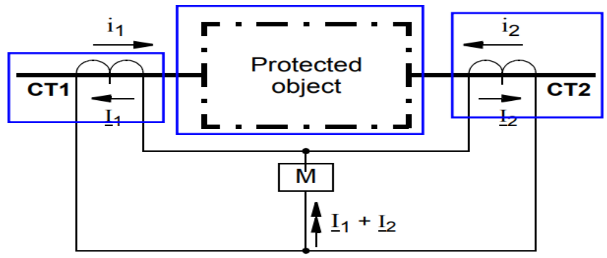


Fig 1.4: definition of current direction

a) Through-flowing current under healthy conditions or on an external fault:

I1 flows into the protected zone, I2 leaves the protected zone, i.e. thus has opposite sign, i.e. I2 = –I1, and consequently |I2| = |I1|

IDiff = |I1 + I2| = |I1 – I1| = 0

IRest = |I1| + |I2| = |I1| + |I1| = 2·|I1|

no tripping effect (IDiff = 0); restraint (IRest) corresponds to twice the through-flowing current.

b) Internal fault, fed from each end e.g. with equal currents:

In this case, I2 = I1, and consequently |I2| = |I1|

IDiff = |I1 + I2| = |I1 + I1| = 2·|I1|

IRest = |I1| + |I2| = |I1| + |I1| = 2·|I1|

tripping effect (IDiff) and restraining (IRest) quantities are equal and correspond to the total faultcurrent.

c) Internal fault, fed from one side only:

In this case, I2 = 0

IDiff = |I1 + I2| = |I1 + 0| = |I1|

IRest = |I1| + |I2| = |I1| + 0 = |I1|

tripping effect (IDiff) and restraining (IRest) quantities are equal and correspond to the fault currentfed from one side.

FAULT DETECTION, DROPOUT:

Since the condition for a fault detection is the same as the trip condition, differential protection typically does not need a "pickup" or "fault detection" function. However, 7UT6, like all SIPROTEC® 4 devices, offers a fault detection feature that is tasked with defining the fault inception instant for a number of additional features, including: A fault event in the system starts when a fault is detected. The trip log buffer and the RAM for oscillographic fault record data must be opened in order to do this. However, even in cases of external faults, internal functions also require the moment the fault first appeared. For instance, the saturation indicator must function properly in cases of external faults.

The protection increases if the restraining current reaches 85% of the additional stabilisation area or the fundamental wave of the differential current exceeds about 85% of the predetermined value (Fig. 1.5). The quick high-current stage's pickup also results in fault detection.

If the harmonic restraint is successful, the harmonic analysis is run (about one AC cycle) to check the conditions of the constraint. If not, tripping happens as soon as the tripping requirements are met.

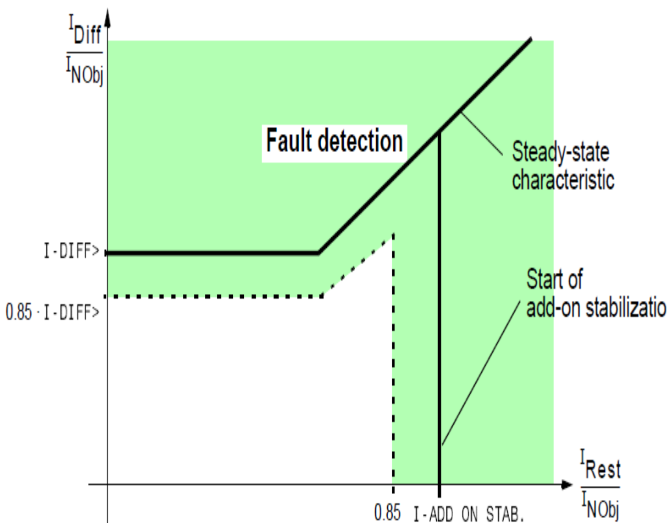


Fig 1.5: Fault detection area of the differential Protection

II. TRANSFORMER DETAILS:

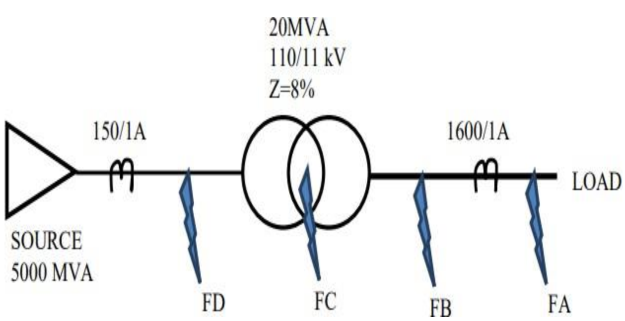


Fig 2.1: transformer with different fault locations

Table 1: transformer rating

PARAMETER	RATING	UNIT
Transformer	20	MVA
Primary voltage	110	kV
Secondary voltage	11	kV
Impedance Z	8%	
LV CT Ratio	150/1	A
HV CT Ratio	1600/1	A

FULL LOAD CURRENTS AT HV AND LV:

Table 2: full load currents

parameter	Current in Amps(A)
Primary full load current	104.9728A
Secondary full load current	1049.728A

NORMAL OPERATING CONDITION OFRELAY:

As per above calculation the differential current, Id=0.04A.In normal condition Id should be equal to zero (0).

To achieve this condition, relay manufacturer provided two matching factors i.e K1 and K2.

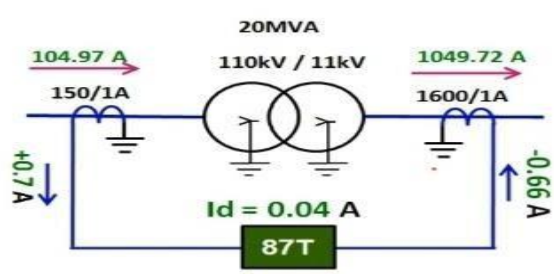


Fig 2.2: Normal condition when Id=0.04

Calculation of K1 and K2:

K1= transformer HV full load current/ HV CT primary rated current

K2= transformer LV full load current/ LV CT primary rated current

By using above two formulas we obtain K1=0.70A

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 05 | May - 2023 SJIF 2023: 8.176 ISSN: 2582-3930

and K2=0.66A

Then the secondary currents are multiplied with thefactors K1 and K2.

I $_{HV(sec)}$ =K2 * actual current=0.66 x

0.7=0.46AI $_{LV(sec)}$ =K1 * actual current=0.7 x

0.66=0.46A

Hence now the Id is equal to zero and in normal condition relay will not operate.

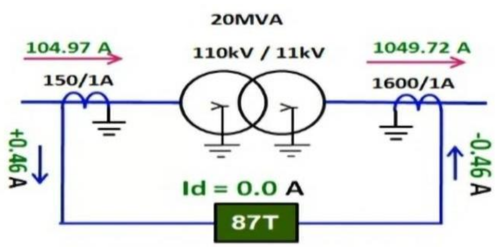


Fig 2.3: After matching factor

Setting calculation and its slope characteristics:

- 20MVA
- Primary CT-150/1A
- Secondary CT-1600/1A
- Star-Star connection

Primary current rating = (20*10^6)/ (√3 x110x10^3)

= 104.9A

Secondary current rating= 1049.72A

150/1= 104.9/x

∴ x=0.699 1600/1=

1049.72/x

∴ x=0.656

0.699-0.65=0.049

- CT error(10%)+tap changing error/CT lead error(5%)+relay margin error(5%)=safety margin(5%)+no load error(2%)=27%

✓ Calculating current on primary and secondary by considering these errors:

1. CT error
   0.699-(0.699 x 10%) = 0.629
2. CT lead error
   0.629-(0.629 x 5%) = 0.597
3. Safety margin error
   0.597-(0.597 x 5%) = 0.567
4. No load error
   0.567-(0.567 x 2%) = 0.5556

∴Primary current flowing =0.556

Similarly, secondary current = -0.799

✓ Calculation of Id(differential current) & Ib(bias current):

Id= 0.55-0.799

Id=0.24+ (-5%) = 0.228

Id= 0.228/0.69

Id(min)=0.32 .... (1)

Slope 1:

Id=0.32

Ib= 0.55+|-0.79| = 0.55+0.79 = 1.34

Ib= 1.34-(1.34 x 5%)

Ib= 1.273

Ib=1.273/0.699 = 1.82

Slope=Id/Ib = 0.3/1.82 = 0.164 or 16.4%

Slope 1= 0.164 or 16.4%

Consider, Base point 1=0

✓ Idiff current:

100% fault 110kV=104.91/8% = 1311.37

150/1 = 1311.37/x

∴x=8.74A

100% fault 11kV= 1049.1/8% = 13113.75

1600/1 = 13113.75/x

x= 8.18A

With CT errors

8.19- 60% (8.19) = 3.27

Id=8.74-3.27 = 5.47

Id (max)=5.47/0.699 = 7.8 ≈ 8................ (2)

Ib= (8.74+3.27)/0.699 = 17.18

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 05 | May - 2023 SJIF 2023: 8.176 ISSN: 2582-3930

During full load, Ib= 0.699+0.699 = 1.39

Slope 2

m = (y2-y1)/(x2-x1)

= (8-0)/ (17.18-2)

= 0.527 or 52.7%

Slope 2=0.527

Base point 2= 2pu

III. HARDWARE & SOFTWARE COMPONENTS

1. 7UT613:

For quick and precise fault clearing of short-circuits in transformers of all voltage levels as well as in rotating electric devices like motors and generators, for short linesand busbars, the SIPROTEC 7UT6 differential protectionrelays are utilised..**[3](pg: 321-353)**

Fig 3.1: SIPROTEC 7UT6 differential protection relay for transformers

PROTECTION FUNCTIONS:

- Differential protection with phase-segregated measurement
- Sensitive measuring for low-fault currents
- Fast tripping for high-fault currents
- Restraint against inrush of transformer
- Phase /ground overcurrent protection
- Overload protection with or without temperature measurement
- Negative-sequence protection
- Breaker failure protection
- Low/high-impedance restricted ground fault (REF)
- Voltage protection functions (7UT613/633)

CONTROL FUNCTIONS:

- Commands for control of circuit-breakers and isolators
- 7UT63x: Graphic display shows position of switching elements, local/remote switching by key- operated switch
- Control via keyboard, binary inputs, DIGSI 4 or SCADA system.
- User defined logic with CFC

MONITORING FUNCTIONS:

- Self-supervision of the relay
- Trip circuit supervision
- Oscillographic fault recording
- Permanent differential and restraint current measurement, extensive scope of operational values

COMMUNICATION INTERFACES:

- PC front port for setting with DIGSI 4
- System interface
  - ✓ IEC 61850 Ethernet
  - ✓ IEC 60870-5-103 protocol
  - ✓ PROFIBUS DP
  - ✓ MODBUS or DNP 3
- Service interface for DIGSI 4 (modem)/ temperature monitoring (thermo-box)
- Time synchronization via IRIG-B/DCF 77

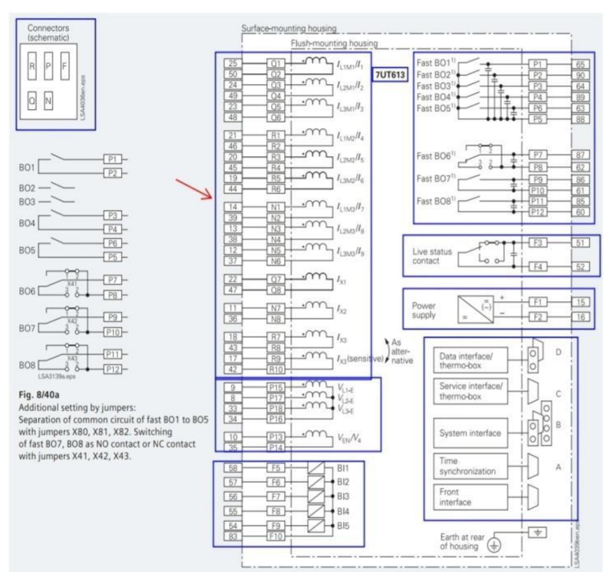


Fig 3.2: connection diagram of 7ut613

CONSTRUCTION:

The 7UT6 is available in three housing widths referred to a 19" module frame system. The height is 243 mm.

– ⅓ (7UT612)

– ½ (7UT613)

– ½ (7UT633/635) of 19"

Cable ring lugs are optional for connecting any cables. The use of premade cable harnesses is possible because plug-in terminals are an option. The connection connections, which take the shape of screw-type terminals, are positioned above and below in the case of surface mounting on a panel. On the same sides of the housing as the communication interfaces.

Fig 3.3: Rear view of flush mounting housing

2. DIGSI-4:

DIGSI 4 is software which has to be installed on your computer for configuring the settings of relay. **[4](pg: 5- 18)**

THE CENTRE OF DIGSI 4:

The DIGSI 4 Manager is the ultimate central element in DIGSI 4. You will need it for managing individual components of your power supply system.

A. Components include:

- SIPROTEC 4 protection devices and bay controllers
- V3/V2 protection devices
- Communication connections among devices and between devices and DIGSI 4

B. A power supply system includes:

- All required components
- The topology of describing the classification of these components into,e.g. substations, feeders, etc.

C. Managing includes:

- Simulating your power supply system's topology or other topology components while archiving various informational data.

THERMAL MONITORING OF TRANSFORMERS:

Fig 3.4: Temperature measurement and monitoring with external thermo-boxes

The significance of monitoring the thermal state of transformers has grown as a result of the necessity to lower the costs of energy transmission and distribution by optimising the system load. One of the duties of the monitoring systems created for medium and big transformers is this monitoring. Differential protection systems have long included overload prevention that is based on a straightforward thermal model and evaluates simply the observed current.

By serially connecting a temperature monitoring box, also known as a thermo-box or RTD-box, the 7UT6's ability to monitor the thermal condition can be enhanced (Fig.3.4). With the connection of two boxes, the temperature of up to 12 measuring sites can be recorded. For each measuring point, a different sensor type (Pt100, Ni100, or Ni120) can be chosen. Each measuring point has two warning phases that are derived when the appropriate specified threshold is exceeded.

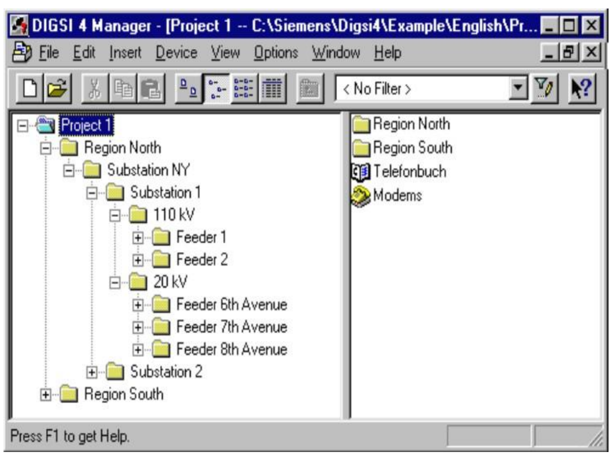
The relay also has the ability to deliver a hot-spot calculation in accordance with IEC 60345, which is an alternative to the standard overload protection. The multiple transformer cooling modes are taken into account in the hot-spot calculation, which is done independently for each leg of the transformer.

Installation and setting of software:

Following these general but necessary explanations we will now tackle .You will create a new project, add a folder to the project, and into a folder a SIPROTEC 4 device.

- Click File→New. In the New dialog box enter as project name Manhattan. If, however, you feel that you are not that deeply rooted in the East, you can of course use any other region in the US as project name. Whatever your decision, click OK afterwards. After allowing itself a

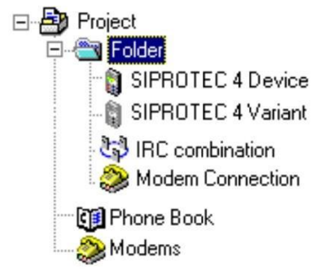
brief time to reflect on this, the DIGSI 4 Manager opens a new project window.



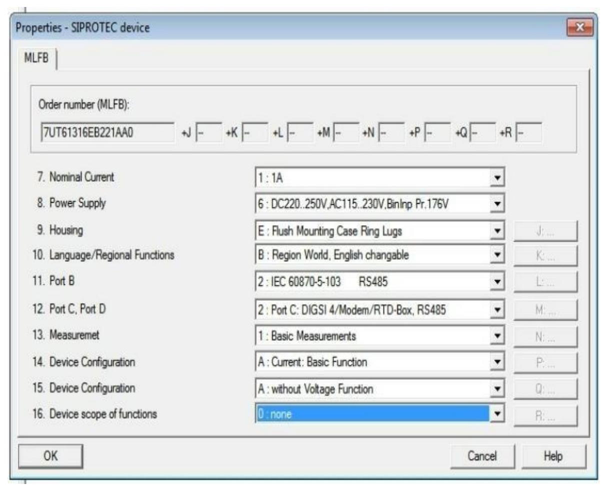
.

- Quite comfortably, the list view already includes a folder with the suitable name Folder. Since any further folder you insert will be named accordingly, we will exhibit some individuality in naming them. Double-click the name and change it to North Region.

- Now right-click the folder. Upon that, the context menu opens from which you select Folder. As you will have no trouble guessing, this command will create another folder within the first folder. If you want to create a folder on the same hierarchy level as the first folder, you must right-click the symbol for the project and proceed correspondingly (but that is surely old hat for you). Now give the newly added folder the name Substation 1.



Now right-click the folder created most recently. Select Insert New SIPROTEC 4 device in the context menu. You see a folder with the name "SIPROTEC 4 devices".

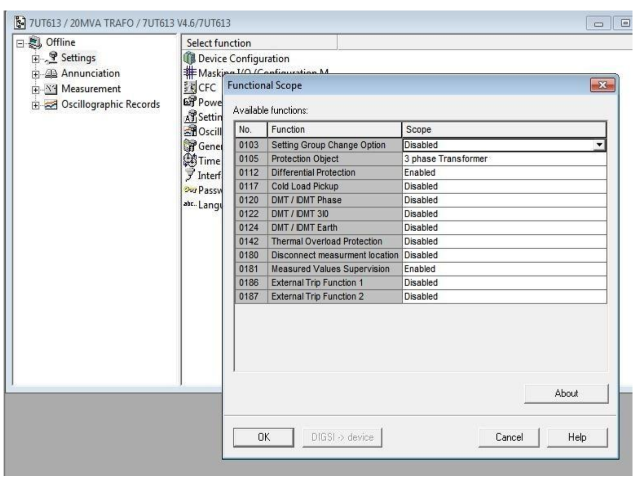


- The dialog box Open Object make sure that the option Offline is enabled. Click OK. This done, DIGSI 4 Configure device is displayed.

Double-click Settings in the list view and then Device Configuration. In the topmost line of the Device Configuration dialog box you see the Settings Group Change Option. Now select the value enabled from the dropdown list and click OK. The list view now shows objects for four settings groups.

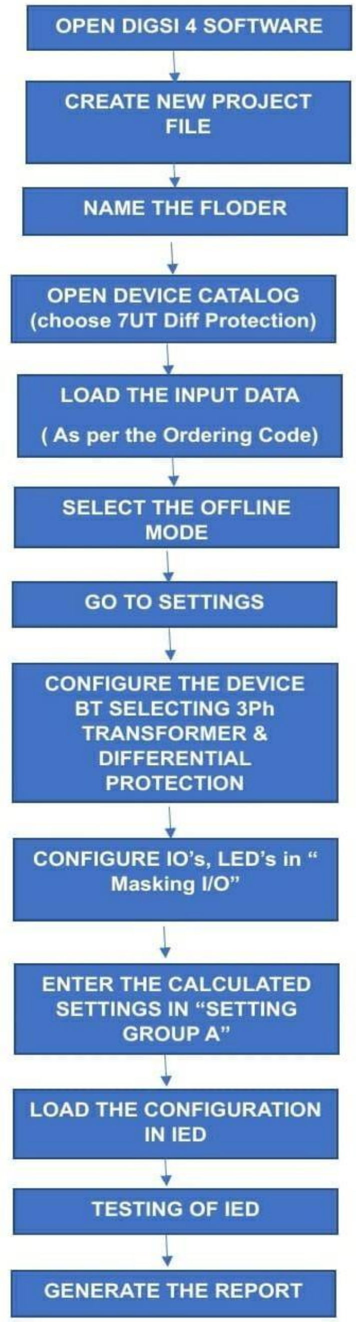
International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 05 | May - 2023 SJIF 2023: 8.176 ISSN: 2582-3930

After you have determined that settings groups can be switched, you must indicate how the switching will be accomplished. For this purpose, double-click Settings Group Change Option. Depending on which one of the six possible values is selected, the parameter Change to another setting group allows switching of the settings groups in three different ways. The cause of the switching can also be the pressing of a function key, an internally generated indication or the result of a logic function. Since our exercise determines that the switching of the settings group is to be accomplished due to different conditions (which we are going to link via logic functions), you must select via binary input. Subsequently, click OK.



All changes you have made are only temporary until you save them explicitly. Thus click File→ Save.

FLOW OF PROGRAM:



3. OMICRON KIT & SOFTWARE:

The CMC 356 is a component of the OMICRON Test Universe, which also includes test software for a computer running Windows and, as necessary, external voltage and/or current amplifiers, GPS or IRIG-B synchronisation units, or other peripherals. **[5](pg: 10-37)**

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 05 | May - 2023 SJIF 2023: 8.176 ISSN: 2582-3930

SYSTEM COMPONENTS:

To set the CMC 356 into operation you need thefollowing components:

- CMC 356 with (mains) power cable
- Connecting cable CMC 356 ↔ PC
- Connecting cable CMC 356 ↔ test object
- PC equipped with an Ethernet port and the OMICRON Test Universe software

STARTING THE TEST SYSTEM:

The ventilation apertures must stay free of obstruction when assembling the CMC 356.

Connecting the System Components:

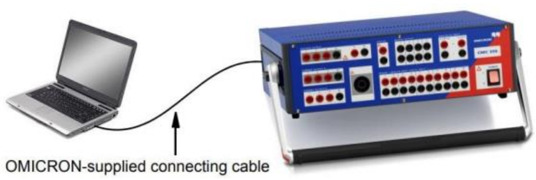


Fig 3.5: Connecting the CMC 356 to the computer

1) Connect the CMC 356 to the PC with the supplied connecting cable1:
   - CMC 356: Connector ETH1 at the rear side of the test set
   - PC: Ethernet port (labelled “Ethernet”, “LAN” or similar)
2) Connect the CMC 356 test set to the mains.
3) Turn on both devices.
4) Start the OMICRON Test Universe software.

IV. TESTING AND RESULTS

1. TESTING PROCEDURE:

- Hardware connection
- Injection testing

i. Measurement testing

ii. 2nd harmonic testing

iii. Differential testing report

2. DIFFERENTIAL CURVE FORMATION:

1. In omicron software there are sub software open test modules and tools(quick CMC)
2. Select differential operating characteristics
3. A new window will appear with a default graph
4. To get the graph that we have set for our transformer, load PTL file
5. Then select test object
6. Click on files and then import
7. By default omicron would have created a folder, open it
8. A new window will appear
9. Click on files
10. Import the relay settings (that is in section II)
11. A window will open
12. Select xrio files
13. Select the 7ut613V4.6 folder
14. A pop up will be displayed that 18 parameters has been imported with zero errors
15. Click ok
16. Then a graph with our setting characteristics willbe displayed

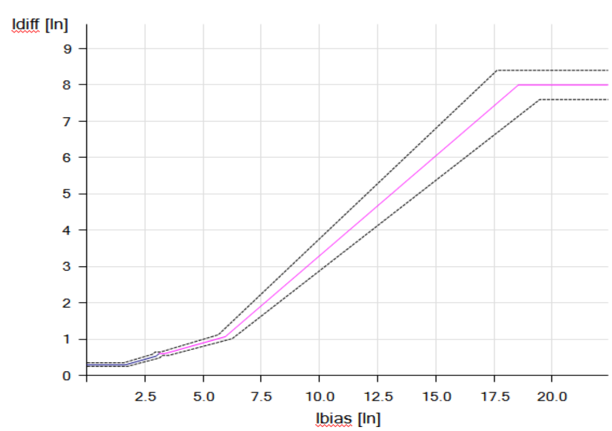


Fig 4.1: differential relay operating characteristics

3. DIFFERENTIAL CURVE TESTING:

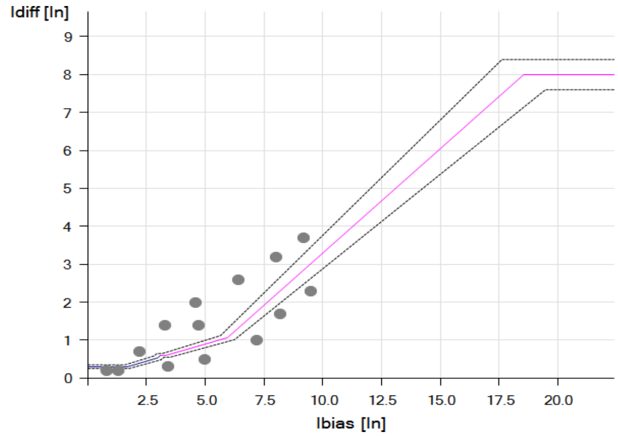


Fig 4.2: creating test points in operating characteristics

We need to create test point that is known as faults and check whether the relay is operating only for internal faults and not for any other type of faults

V. SIMULATION

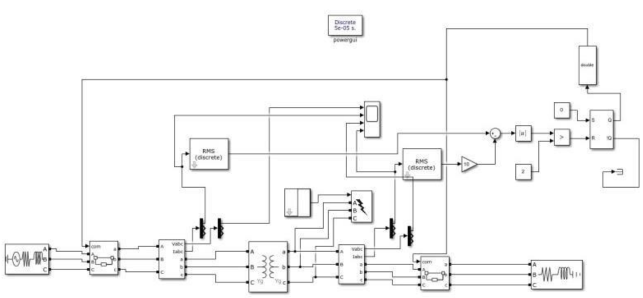


FIG 5.1: simulation of differential protection of a transformer

In the simulation of differential protection, we have made use of a 3-phase source, 3- phase load, 3-phase circuit breaker initially in a closed station either of the transformer which is monitored externally by making use of an SR flip flop. There is also a 3-phase V-I measurement on either side i.e., primary and secondary sides of the transformer which measures the phase voltage and current of the transformer. And the 3-pase fault block is used in order to create the fault in the transformer.

The analog value of current measured by V-I measurement is converted to digital form on either side of the transformer which is compared and finally, it is fed as input for SR flip flop which thereby monitors the state of the circuit breaker. When the fault occurs in the transformer the circuit breaker gets operated (opens) and the voltage and current of the transformer drop tozero.

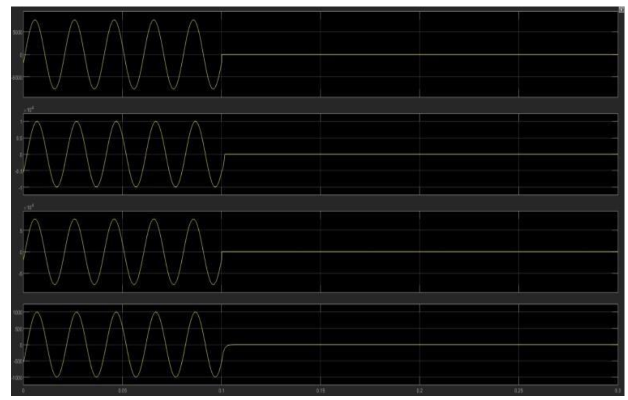


FIG 5.2: OUTPUT

On summary, in a practical implementation of differential protection of the transformer we have made use of Siemens Intelligent Electronic Device (IED)-7UT613 in order to protect the transformer from internal fault. Depending on the setting calculation that is fed to the IED which is actually a numerical relay it operates only for the internal fault i.e., the fault occurring within the protected zone. And with the help of human machine interface, we can conclude whether the fault has occurred and also the time of trip.

Whereas in the case of software simulation, we have made use of SR flip flop in order to monitor the position of the circuit breaker during normal and fault condition. When the fault occurs in the transformer the circuit breaker gets open finally, and the voltage and current of the transformer drop to zero which can be observed with the help of the scope.

Therefore in both cases, the differential protection of the transformer has been achieved.

VI. TEST REPORT GENERATEDIN OMICRON FOR 20 MVA TRANSFORMER

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 05 | May - 2023 SJIF 2023: 8.176 ISSN: 2582-3930

Diff Operating Characteristic:

Test Object - Differential Parameters

Protected Object:

Protected Object:	Transformer
Vector Group:	YY0

Winding/Leg Name:	Primary	Secondary
Voltage:	110.00 kV	11.00 kV
Power:	20.00 MVA	20.00 MVA
Starpoint Grounding:	Yes	Yes
Delta-connected CT:	No	No

CT:

Winding/Leg Name:	Primary	Secondary
CT Current Prim:	150.00 A	1600.00 A
CT Current Sec:	1.00 A	1.00 A
CT Grounding:	tow. Prot. Obj.	tow. Prot. Obj.
Gnd CT Prim Current:	200.00 A	800.00 A
Gnd CT Sec Current:	1.00 A	1.00 A
Gnd CT Grounding:	n/a	n/a

Protection device:

Reference Winding:	Primary
Ibias Calculation:	(|Ip| + |Is|) / K1 (K1 = 1.00)
Zero Seq. Elimination:	IL-I0
Reference Current:	PO nominal current
Ground CT Used:	No
Disable Comb. char.:	No

Idiff>:	0.30 In	tdiff>:	0.03 s
Idiff>>:	8.00 In	tdiff>>:	0.01 s
Itol rel:	5.00 %	ttol rel:	1.00 %
Itol abs:	0.05 In	ttol abs:	0.01 s

Test Module

Name:	OMICRON Diff Operating Characteristic	Version:	4.31
Test Start:		Test End:	
User Name:		Manager:	
Company:			

Test Settings

Testing:	Primary / Secondary		
Max. Test Time:	1.50 s	Delay Time:	0.25 s
Prefault:	No		
Prefault current:	0.00 In	Prefault time:	0.000 s
Vout enabled:	No	Vout winding:	Primary
Time-triggered:	No	Winding/leg output:	Primary

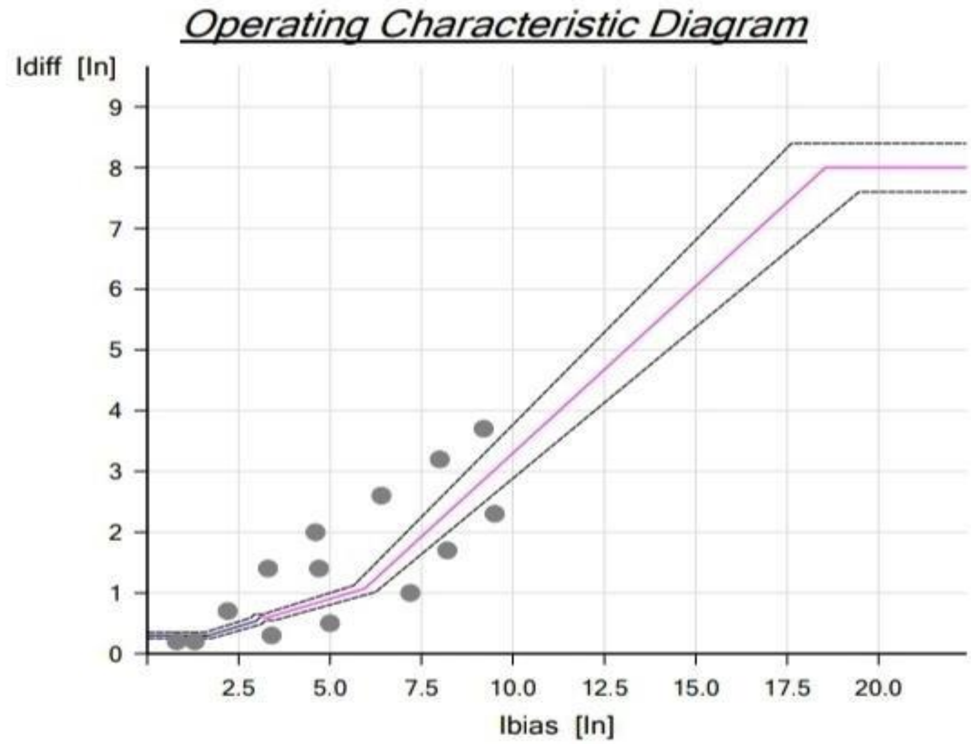
Binary Outputs

Bin. out 1:	0
Bin. out 2:	0
Bin. out 3:	0
Bin. out 4:	0

Test Results for Fault Type L1-E at Reference Side Primary

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 05 | May - 2023 SJIF 2023: 8.176 ISSN: 2582-3930

Idiff	Ibias	Nominal Trip Time	Actual Trip Time	State	Result
0.20 In	0.80 In	N/T	N/T	Not tested	n/a
0.30 In	3.40 In	N/T	N/T	Not tested	n/a
0.50 In	5.00 In	N/T	N/T	Not tested	n/a
1.00 In	7.20 In	N/T	N/T	Not tested	n/a
1.40 In	3.30 In	0.0300 s	N/T	Not tested	n/a
2.00 In	4.60 In	0.0300 s	N/T	Not tested	n/a
2.60 In	6.40 In	0.0300 s	N/T	Not tested	n/a
1.70 In	8.20 In	N/T	N/T	Not tested	n/a
3.20 In	8.00 In	0.0300 s	N/T	Not tested	n/a
0.20 In	1.30 In	N/T	N/T	Not tested	n/a
0.70 In	2.20 In	0.0300 s	N/T	Not tested	n/a
3.70 In	9.20 In	0.0300 s	N/T	Not tested	n/a
2.30 In	9.50 In	N/T	N/T	Not tested	n/a
1.40 In	4.70 In	0.0300 s	N/T	Not tested	n/a



Shot	1	2	3	4	5	6
Idiff: Ibias:	0.20 In 0.80 In	0.30 In 3.40 In	0.50 In 5.00 In	1.00 In 7.20 In	1.40 In 3.30 In	2.00 In 4.60 In
I Primary L1: Phase Primary L1:	0.525 A -180.000 °	1.942 A -180.000 °	2.887 A -180.000 °	4.304 A -180.000 °	2.467 A -180.000 °	3.464 A -180.000 °
I Primary L2: Phase Primary L2:	0.000 A 0.000 °	0.000 A 0.000 °	0.000 A 0.000 °	0.000 A 0.000 °	0.000 A 0.000 °	0.000 A 0.000 °
I Primary L3: Phase Primary L3:	0.000 A 0.000 °	0.000 A 0.000 °	0.000 A 0.000 °	0.000 A 0.000 °	0.000 A 0.000 °	0.000 A 0.000 °
I Secondary L1: Phase Secondary L1:	0.197 A 0.000 °	1.017 A 0.000 °	1.476 A 0.000 °	2.034 A 0.000 °	0.623 A 0.000 °	0.853 A 0.000 °
I Secondary L2: Phase Secondary L2:	0.098 A 180.000 °	0.508 A 180.000 °	0.738 A 180.000 °	1.017 A 180.000 °	0.312 A 180.000 °	0.426 A 180.000 °
I Secondary L3:	0.098 A	0.508 A	0.738 A	1.017 A	0.312 A	0.426 A

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 05 | May - 2023 SJIF 2023: 8.176 ISSN: 2582-3930

Phase Secondary L3:	180.000 °	180.000 °	180.000 °	180.000 °	180.000 °	180.000 °
I Tertiary L1: Phase Tertiary L1: I Tertiary L2: Phase Tertiary L2: I Tertiary L3: Phase Tertiary L3:						
V L1: Phase L1: V L2: Phase L2: V L3: Phase L3:						
Shot	**7**	**8**	**9**	**10**	**11**	**12**
Idiff: Ibias:	2.60 In 6.40 In	1.70 In 8.20 In	3.20 In 8.00 In	0.20 In 1.30 In	0.70 In 2.20 In	3.70 In 9.20 In
I Primary L1: Phase Primary L1: I Primary L2: Phase Primary L2: I Primary L3: Phase Primary L3:	4.724 A -180.000 ° 0.000 A 0.000 ° 0.000 A 0.000 °	5.196 A -180.000 ° 0.000 A 0.000 ° 0.000 A 0.000 °	5.878 A -180.000 ° 0.000 A 0.000 ° 0.000 A 0.000 °	0.787 A -180.000 ° 0.000 A 0.000 ° 0.000 A 0.000 °	1.522 A -180.000 ° 0.000 A 0.000 ° 0.000 A 0.000 °	6.771 A -180.000 ° 0.000 A 0.000 ° 0.000 A 0.000 °
I Secondary L1: Phase Secondary L1: I Secondary L2: Phase Secondary L2: I Secondary L3: Phase Secondary L3:	1.247 A 0.000 ° 0.623 A 180.000 ° 0.623 A 180.000 °	2.132 A 0.000 ° 1.066 A 180.000 ° 1.066 A 180.000 °	1.575 A 0.000 ° 0.787 A 180.000 ° 0.787 A 180.000 °	0.361 A 0.000 ° 0.180 A 180.000 ° 0.180 A 180.000 °	0.492 A 0.000 ° 0.246 A 180.000 ° 0.246 A 180.000 °	1.804 A 0.000 ° 0.902 A 180.000 ° 0.902 A 180.000 °
I Tertiary L1: Phase Tertiary L1: I Tertiary L2: Phase Tertiary L2: I Tertiary L3: Phase Tertiary L3:						
V L1: Phase L1: V L2: Phase L2: V L3: Phase L3:						
Shot	**13**	**14**				
Idiff: Ibias:	2.30 In 9.50 In	1.40 In 4.70 In				
I Primary L1: Phase Primary L1: I Primary L2: Phase Primary L2: I Primary L3: Phase Primary L3:	6.193 A -180.000 ° 0.000 A 0.000 ° 0.000 A 0.000 °	3.202 A -180.000 ° 0.000 A 0.000 ° 0.000 A 0.000 °				
I Secondary L1: Phase Secondary L1: I Secondary L2: Phase Secondary L2: I Secondary L3:	2.362 A 0.000 ° 1.181 A 180.000 ° 1.181 A	1.083 A 0.000 ° 0.541 A 180.000 ° 0.541 A				
Phase Secondary L3:	180.000 °	180.000 °				
I Tertiary L1: Phase Tertiary L1: I Tertiary L2: Phase Tertiary L2: I Tertiary L3: Phase Tertiary L3:						
V L1: Phase L1: V L2: Phase L2: V L3: Phase L3:						

Test State:
No results available!
0 out of 14 points tested.
0 points passed.
0 points failed.

VII. CONCLUSION

To safeguard a 20MVA industrial transformer from differential damage, the suggested relay setting can be employed. By introducing both internal and external defects, these settings can also be put to the test. The suggested relay configuration only works when there is an internal problem; it does not function in normal conditions or when there are any external faults. We can design a relay's functioning characteristics by employing these setup options. Since 87T successfully stops the flow of current; the second harmonic is also attained. Relays can be categorized based on the technology they employ. Another kind of differential relay used for transformers is the 87T. Test points are added to the graph after the curve has been derived using the digsi software setting. The relay runs by providing the travel time, frequency, etc. if the point is within the operational area. This test is run using an Omicron kit. A computer-controlled test set called the CMC 356 is used to evaluate protective relays. The omicron test universe includes CMC 356.Transformers of all voltage levels can be protected from short circuits quickly and selectively using the 7UT613 numerical differential protection system. The digsi software is configured for every parameter of the 7ut613. Only Siemens makes use of Digsi software. Thus, by doing this, we can safeguard the transformers from errors and harm. The circuit breaker will only trip for internal failures when the relay setting is used. Additionally, the testing feature of the Omicron software will produce a report of the test that was carried out.

VIII. REFERENCES

1. Shravya K M, Anusha B S, Deepashree K, Rashmi D, Govindappa R. “A review on design of differential protection system and its setting for industrial transformer”. IJRAR, 2023
2. Michael Bamber, Michael Bergstorm. “Network protection and automation guide”, text book. alstom grid,2011.
3. “Differential protection 7UT6 V4.0”, Siemens make, siprotec, 7Ut6 manual.
4. “Siprotec 4- devices”, protection,control, measurement and automation function, catalog SIP. Edition No 8/8.1,Siemens.
5. “Digsi 4 start up”, manual, 2015. Siemens.
6. “CMC 356”, user manual, omicron.
7. Lubomir Sevov, IIiaVoloh, Jorge Cardenas. “Differential protection for power transformer with non-standard Phase shifts”. IEEE, 2019.
8. K. Narendra, D. Fedirchuk, Zhang, R.Midence, N. Perera, V. Sood. “Phase angle comparison and differential rate of change methods used for differential protection of busbars and transformers”. 2011 IEEE Electrical Po9wer and Energy Conference. IEEE, 2011.
9. M. O. Oliveira, G. D. Ferreira, F. H. Garcia, A. S. Bretas, O. E. Perrone and J. H. Reversat. “Adaptive Differential Protection for Power Transformer Based on transient Signal Analysis”. IEEE, 2012.
10. B. Kasztenny, N. Fischer, Y. Xia. “A new inrush detection algorithm for transformer differential protection”. IEEE, 2014.
11. llija Jankovic. “High Impedance differential protection system versus low impedance differential protection system”. IEEE, 2015.
12. Muhammad farasat, Abbas, Liu Zhiyuan, Hao Zhiguo, Zhang, Guanjun. “Inrush current Discrimination in Power Transformer Differential Protection Using Wavelet Packet Transformer Based Technique”. 2016 IEEE PES Asia-Pacific Power and Energy Conference. IEEE, 2016.
13. R. P. Medeiros, F. B. Costa, K. M. Silva. “Power Transformer Differential Protection Using the Boundary Discrete Wavelet Transformer”. IEEE,2016
14. Ihedioha Ahmed C.“Differential Protection for Power Transformer Using Relay”. IJTRD, 2016.
15. Ashish Chauhan, Sunil Kumar. “Analysis of Modern Differential Relay Protection for Power Transformers”. IJESMR, 2016.
16. OkanOzgonenel. “Maximum Overlap Discrete Wavelet Based Transformer Differential protection”. IEEE, 2017.
17. Flavio Costa,Rodrigo Prado. “A Wavelength Based Transformer Differential Current Transformer Saturation and Cross-Country Fault Detection”. IEEE Power and Energy Society General Meeting (PESGM), 2018.
18. Ketan Shah, “Low Impedance Differential Protection Relay Settings for Transformer Differential Protection”. IJAREEIE, 2018.