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Analysis and Testing of Multifunctional relay using IEC-61850 Protocol

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Abstract

The IEC-61850 with Intelligent Electronics Device is used as protection, control, monitoring in real time operation of power system. In this paper discussed functional capability of relay including different types of protection function. These relays have optimized cost because of its multifunctional capability in single unit. Such relays eliminate need of various individual field equipment such as measurement transducer, fault recorder and sensors. Also in this paper we are focusing on different types of transformers protection alarm such as Buchholz relay (BZ), Oil temperature Indicator (OTI), Pressure Relief Valve (PRV), Magnetic Oil level Gauge (MOG). This is implemented through over current relay (7SJ64) and Differential relay (7UT61) which is integrated with IEC-61850. This paper helps to understand IEC-61850, transformer operation in digital substation.

Keywords: *IEC-61850, functional testing, Substation automation systems, Transformer Protection, multifunctional relay, DIGSI.*

NOMENCLATURE

GOOSE Generic Object Oriented Substation Event

IEC International Electrotechnical Commission

IED Intelligent Electronic Device

BZ Buchholz relay

MOG Magnetic Oil level Gauge

OTI Oil Temperature Indicator

PRV Pressure Relief Valve

UCA Utility Communication Architecture

IEEE Institute of Electrical and Electronics Engineers

EPRI Electric Power Research Institute

TC-57 Technical Committee 57

1. Introduction

Power transformer is essential equipment in power system which require highly reliable protecting device. Transformer protection depends on their size. For small transformer, fuses are used as a

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protecting device. For medium size transformer, over current relay is used as a protecting devices and the large size transformer differential protection scheme is used.

There are two types of faults that are associated in transformer named as internal fault & external fault [1, 2, 3].

i. External fault:

In this type of occurrence of fault transformer must be disconnected if any protecting device fails to operate within a predetermined time. In case of occurrence of external fault we need back up protection, for facing this trouble we use time graded over current relay. Also for detecting overload condition thermal relay is employed.

ii. Internal fault:-

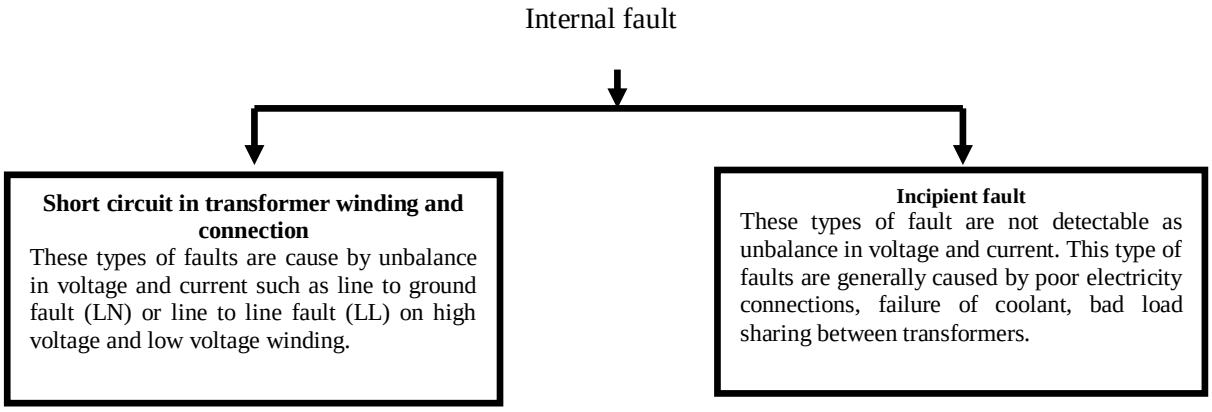

Fig.1:- Internal fault in transformer

iii. Different Protection Scheme used in power transformer:-

a) Percentage differential protection

This type of protection is employed on large size of transformer having rating of >5MVA. These types of protection schemes are capable to detect short circuit fault, but are not capable of detecting incipient fault.

b) Overheating protection

The maximum allowed temperature for safe overloading of transformer is 95°C, for protection of above this temperature thermal image processing technique is used.

c) Protecting against Magnetizing inrush current

Basically magnetizing inrush current is initial magnetizing current which is several time the rated current of transformer. This current is flow in primary winding so differential protection see this as an internal fault. When the transformer is in danger condition in the substation, there are six types of alarms. These alarms protect different parts of the transformer under danger condition [4, 5].

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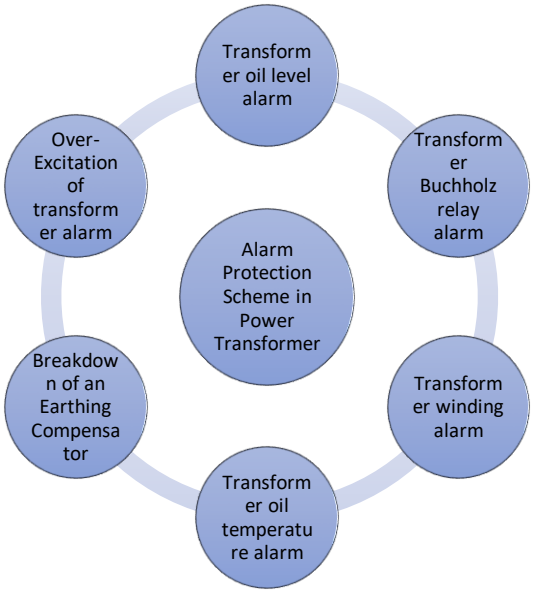

Figure 2: Different types of alarm protection in Power Transformer

2. IEC-61850 Overview

International Electrotechnical Commission (IEC) issued a communication standard named as IEC-61850. IEC-61850 is basically International Standard which is applicable for automation of Existing substation. It is not a protocol genuinely rather it is standardization of communication between components incorporated with existing substation.

It is partly based on UCA 2.0 which is a substation automation concept developed by EPRI (USA) in 1990's. In 1997 IEEE/EPRI and IEC TC-57 merged both standards to provide a global, unique, process oriented substation automation solution. IEC-61850 in substation automation offer interchange ability is in limit of communication standard. Basically this interchange ability or inter-operability function done by replacing conventional component like as different types electromagnetic relay with smart multifunctional device named as Intelligent Electronics Device (IED). It is an International Standard for fulfilling requirement of protection, control and monitoring function enabling self-correction functionality [6, 7].

IEC 61850 Benefits

- Installation cost minimized
- High speed communication make device interoperable
- Easy to design high voltage substation
- Easy future integration of device
- Circuit complexity reduce which minimize wiring cost
- Adaptability level increase
- Less prone to fault which is cause due to Environment

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3. Laboratory Setup:-

Hardware model is having following relays, devices and software:

- SIPROTEC 4 Over current Protection relay 7SJ64
- SIPROTEC 4 Differential Protection relay 7UT61
- Ethernet- ABB AFS677
- PC for testing, monitoring and configure the relays
- DIGSI 4 software

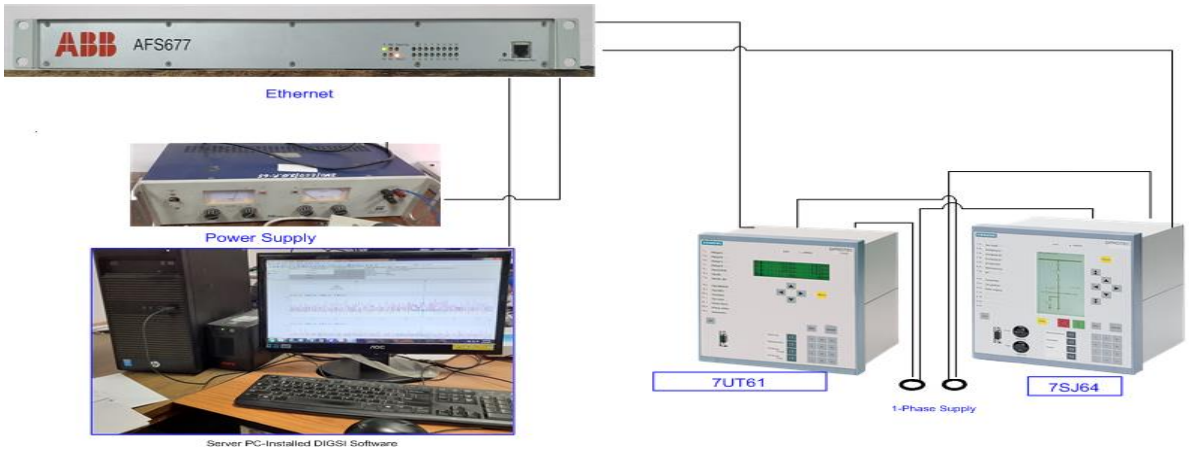

Fig.3:- Circuit Diagram

a) Intelligent Electronic Devices (IEDs):-An Intelligent Electronic Device (IED) is utilized to the company to help the microchip based controllers of intensity framework types of gear, similar to circuit breakers, transformers and capacitor banks.

b) 7UT61:-

The 7ut61 relay has used for differential protection in the power system network. With the help of this relay, short circuit testing in transformer and rotating machine of different voltage level may be cleared. 7UT61 relay is also used as a backup protection [8].

The four parts are defined for the following Applications

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Table:-1 Breaker Part of 7UT61

S.No.	Breaker Parts
1	Single-Breaker (double or single bus) with 3-Phase tripping
2	Single-Breaker (double or single bus) with 1-Phase tripping
3	Single-Breaker (one and half/ring) with 3-Phase tripping
4	Single-Breaker (one and half/ring) with 1-Phase tripping

Communication interfacing devices

Table:-2 Communication Interface Devices of 7UT61

S.No.	**System Port**	**Service Port**	**Front port**
1	IEC(International Electrotechnical Commission)-61850	DIGSI 4	DIGSI 4
2	IEC(International Electrotechnical Commission)-61850-5-103	Modem	
3	Profibus (Process Field Bus)-DP	Thermo box	
4	DNP 3.0		
5	MODBUS RTU (Remote Terminal Unit)		

c) 7SJ64:-

Siprotec 7SJ64 is including the “flexible protection function”. Up to 20 protection capacities can be added by individual necessities. Along these lines, for instance, rate-of-frequency change protection or turn around power protection can be implemented. It is also gives simple to-utilize nearby control and computerization capacities [9, 10].

Communication interfaces

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Table:-3 Communication Interface Devices of 7SJ64

S.No.	System Port	Service Port	Front port
1	IEC(International Electrotechnical Commission)-61850	DIGSI 4	Thermo box
2	Profenet	Modern	
3	DNP3 TCP (Transmission Control Protocol)	Thermo box	
4	IEC(International Electrotechnical Commission)-61850-5-103		
5	Profibus (Process Field Bus)-DP		
6	DNP (Distributed Network Protocol 3) 3.0		
7	MODBUS RTU (Remote Terminal Unit)		

d) Ethernet:-

IEC-61850 uses an Ethernet association as the physical mode of correspondence between IEDs. Logical Input/output via Ethernet communication is used in place of traditional hardwired systems to data transfer between IEDs [11].

Figure 4: Ethernet switch AFS677 for communication LAN networking

e) DIGSI 4:-

The PC working system DIGSI 4 is the UI (user interface) to the SIPROTEC relays. It is design with an advanced, instinctive UI. With DIGSI 4, SIPROTEC relay are designed and assessed – it is the customized program for modern [12].

DIGSI 4 software utilized for arrangement of SIPROTEC 4 device as per the protection scheme.

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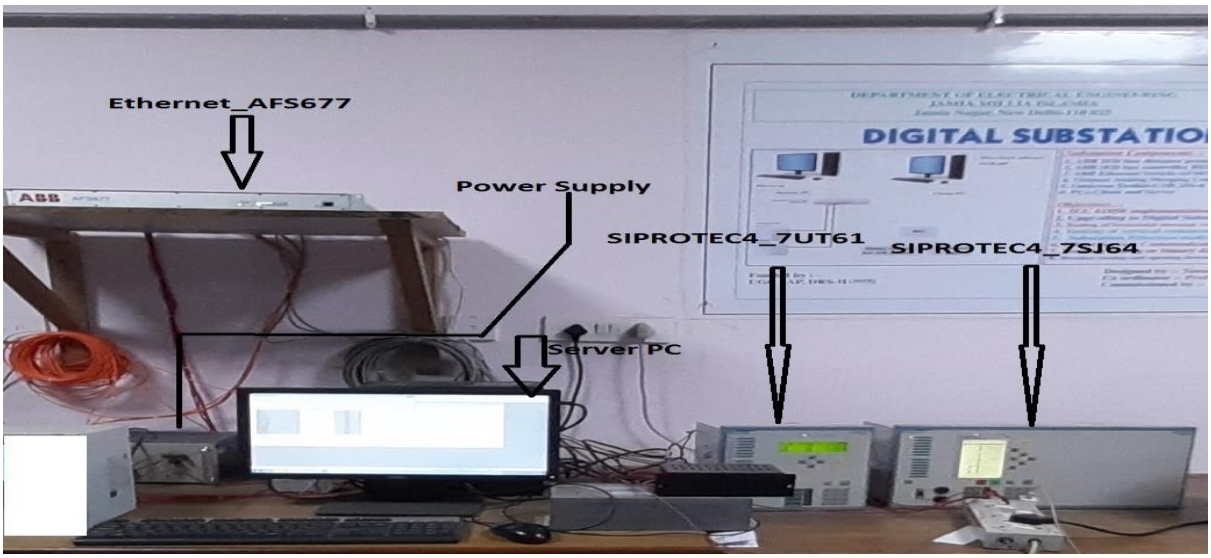

Figure 5: Laboratory Set up

4. Results Analysis:-

In the laboratory used differential protection of transformer with the help of SIPROTEC 4 Siemens Multi Protection relay. Two types of relays (7UT61, 7SJ64), we have used in this setup and these relays configured with IEC-61850 protocol.

Due to alarm protection, we can already know the problems encountered in the transformer. Six types of alarms are used in substations to protect power transformers. With digital multifunctional relay, we have used four types of alarms protection in this paper. Digital substations have multifunctional relays installed that periodically monitor the health of the transformer. If the build-up of gas, increase of oil and its temperature, too much gas pressure within the transformer oil conservator and indicate the oil level in the transformer.

iL1-M1, iL2-M1, iL3-M1 is the phase voltage. Similar iL1-M2, iL2-M2, iL3-M2 and iL1-M3, iL2-M3, iL3-M3 represents the secondary side and tertiary side of the transformer. It has L1, L2 and L3 represent the phase voltage. These L1, l2, l3 also represent the R, Y and B winding phase voltage. 3i0-M1 is the natural side phase voltage.

When some problems occur in the transformer, BZ (Buchholz relay), MOG (Magnetic Oil level Gauge), OTI (Oil Temperature Indicator), PRV (Pressure Relief Valve) trip the relay.

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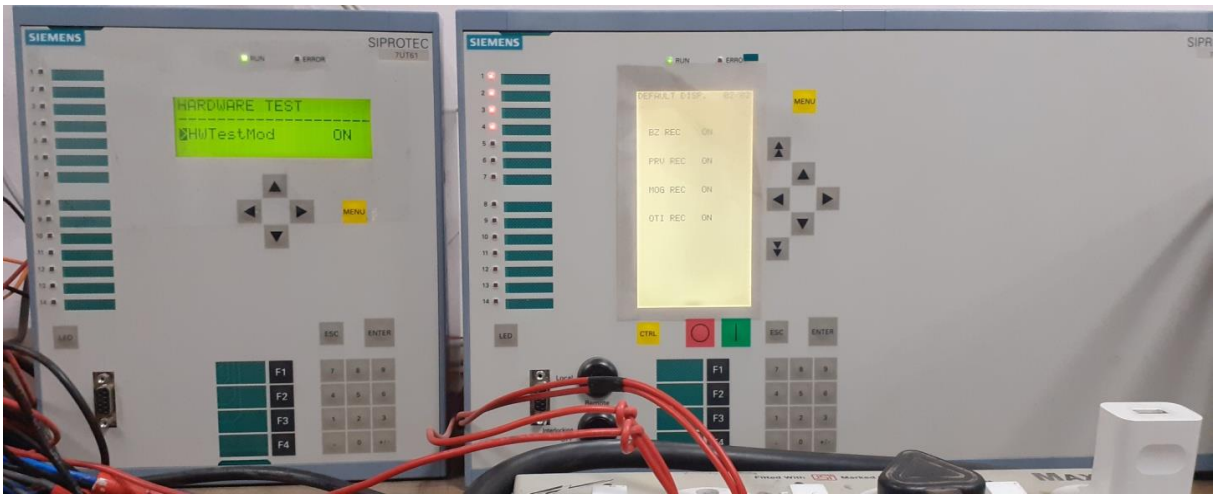

Figure 6: 7SJ64 and 7UT61 during test Mode

During the test mode found the harmonic content in the form of graph, value of current of analogue inputs along with DC and harmonics and time signal view of the transformer.

Fig.7: Time signal view where we can observe the RMS and instantaneous values for analogue input

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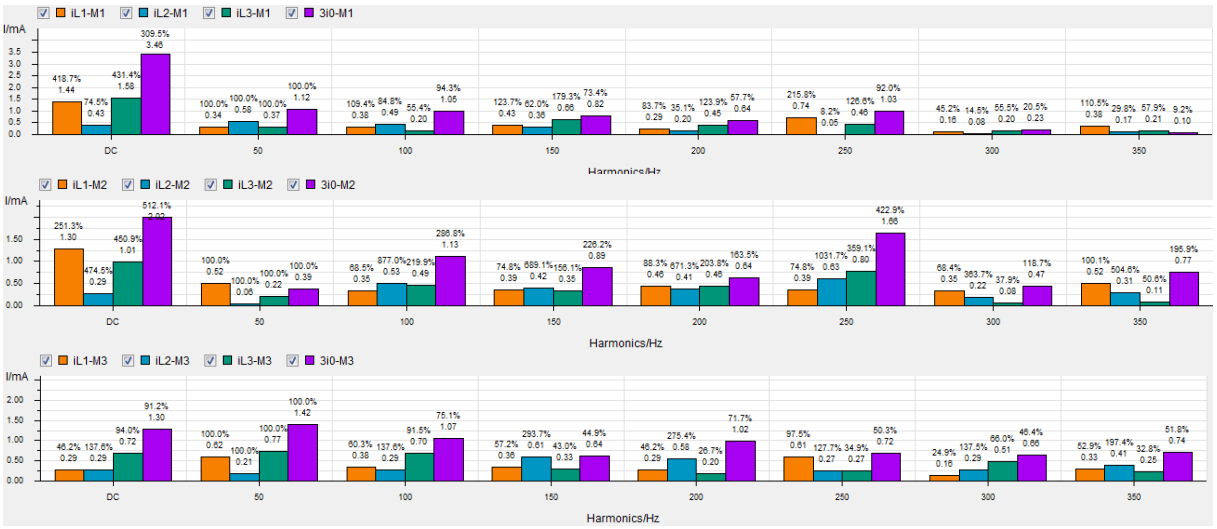

Figure 8: harmonic content as R.M.S. values

Table:- 4 value of current and analogue inputs along with DC and harmonics

Measuring Signal	Value	Phase	Extremum	DC	2nd Harmon.	3rd Harmon.	5th Harmon.
iL1-M1	0.3440 mA	-91.0°	-2.3040 mA	418.7 %	109.4 %	123.7 %	215.8 %
iL2-M1	0.5799 mA	-112.4°	0.00000 mA	74.5 %	84.8 %	62.0 %	8.2 %
iL3-M1	0.3672 mA	-39.8°	-2.3040 mA	431.4 %	55.4 %	179.3 %	126.6 %
3i0-M1	1.1167 mA	92.8°	4.6080 mA	309.5 %	94.3 %	73.4 %	92.0 %
iL1-M2	0.5156 mA	-130.0°	0.00000 mA	251.3 %	68.5 %	74.8 %	74.8 %
iL2-M2	0.06066 mA	-56.1°	0.00000 mA	474.5 %	877.0 %	689.1 %	1031.7 %
iL3-M2	0.2236 mA	15.6°	0.00000mA	450.9 %	219.9 %	156.1 %	359.1 %
3L0-M2	0.3937 mA	77.9°	0.00000 mA	512.1 %	286.8 %	226.2 %	422.9 %
iL1-M3	0.6237 mA	61.5°	2.3040 mA	46.2 %	60.3 %	57.2 %	97.5 %
iL2-M3	0.2092 mA	-13.1°	0.00000 mA	137.6 %	137.6 %	293.7 %	127.7 %
iL2-M3	0.7657 mA	14.4°	0.00000 mA	94.0 %	91.5 %	43.0 %	34.9 %
3L0-M3	1.4220 mA	-150.9°	-2.3040 mA	91.2 %	75.1 %	44.9 %	50.3 %

5. Conclusion:-

In this paper we have discussed the different types of transformer trouble trip alarm BZ (Buchholz relay), MOG (Magnetic Oil level Gauge), OTI (Oil Temperature Indicator) and PRV (Pressure Relief Valve) of power transformer this procedure through the IEC-61850 communication protocol. We have created a digital substation in the power system laboratory and installed different types of

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multifunction protective relay differential protection (7UT61) and over current relay (7SJ64). These relay communicate between through GOOSE communication.

Installed setup, for practical implementation, commissioning and testing of GOOSE (Generic object oriented substation event) based protection schemes, presented in this paper intends to provide a very useful stage for industry and researcher.

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