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# A NOVEL FAULT DETECTION TECHNIQUE FOR ELECTRICAL NETWORKS IN SMART GRID WITH NUMERIC METER AND IEC 61850 PROTOCOL

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**Abstract— Smart grid is an integration of three technologies namely electrical technology, information technology and communication technology. Substation automation system play an important role in monitoring, control and, protection of the system. Intelligent Electronic devices, Merging unit, Numeric meters, Numeric Relays of different manufacturers can communicate with each other through IEC61850, new standard developed for interoperability. Novel fault detection methodology using JAVA embedded chip on printed circuit board of Numeric meter is discussed in this paper. On the occurrence of the fault, Java embedded chip is enabled and the details such as magnitude of current and voltages, type of fault ,date and time of fault, zone of protection and distance at which the fault is occurred are sent to JAVA compilation unit . Thereafter the fault clearing process is initiated. The proposed methodology is found to be reliable, fast and accurate as compared to conventional methods of fault detection.**

**Index Terms—Smart Grid, fault detection, IEC61850, JAVA compilation unit.**

## I. INTRODUCTION

Smart grid ensures reliable and efficient supply of electricity. Substation is an important link between generation transmission and distribution of electrical energy. Substation Automation System (SAS) comprises of Intelligent Electronic Devices (IED), Merging Unit( MU), Numeric Meter, Numeric Relay, JAVA Compilation Unit(JCU) and communication networks as shown in Fig.1. For efficient working of SAS new standard IEC 61850[1] is developed for integration and interoperability of different manufactures IEDs. Interoperability is the capacity of to exchange information with several IEDs. Input signals from C.T. and P.T. are accumulated in the MU ( See Fig.2).Fault in power system is detected by the IEDs and MU installed near conventional instrument transformers by sensing the magnitudes of current and voltages. The logic for fault condition is based on voltage becoming zero and current having abnormal value. This information is sent to numeric meter which are provided with inbuilt Java Embedded chips(JEC). JEC further send this data to JCU through serial

port of the meter. The JCU compiles and analyzes the fault information and send it to the output devices through Ethernet switch. This communication is serial data transfer through a serial input or output port provided on the smart meter and relays. Java can be used as substation configuration language because of its significant features.

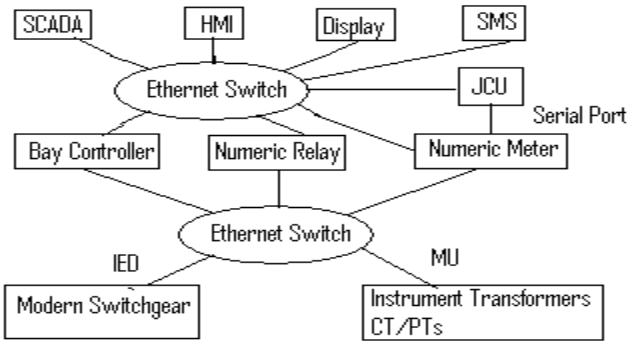


Fig. 1 Substation Automation System

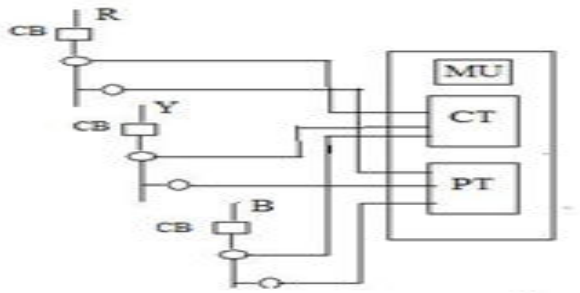


Fig. 2 Logical Diagram of Merging Unit

## II. NUMERIC METER

Numeric meter is a important component of Advanced Metering Infrastructure (AMI). Fig.3 shows the Functional block diagram of Numeric meter. Input signals from C.T. and P.T. are accumulated in the MU. Sampling of these signals is carried out by Sample and Hold circuit. Analogue to Digital Converter (ADC) will convert these signals to Digital Signal

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which are fed to CPU for calculations of Vrm, Irms and power factor. JEC is in wait or idle state in normal system conditions.

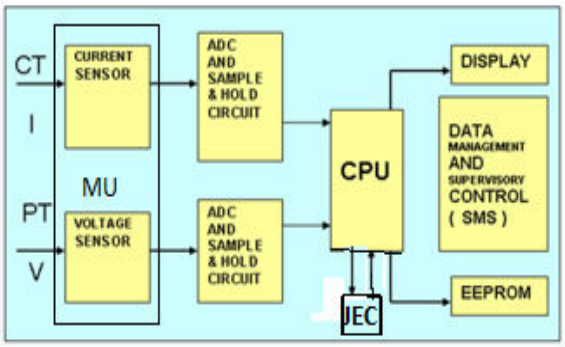


Fig. 3 Functional block diagram of Numeric meter

When fault takes place, JEC is enabled. It performs two functions. Firstly it gives indication of fault and secondly through serial port data is sent to JCU for further processing and analysis. The source code for serial data transfer is stored in JEC is given below.

```
//Write to output port
import java.io.*;
importjava.util.*;
importjavax.comm.*;
public class DataWrite {
staticEnumeration portList;
staticCommPortIdentifierportId;
static String messageString = Fault data\n";
staticSerialPortserialPort;
staticOutputStream outputStream;
public static void main(String[] args) {
portList = CommPortIdentifier.getPortIdentifiers();
while (portList.hasMoreElements()) {
portId = (CommPortIdentifier) portList.nextElement();
if (portId.getPortType() == CommPortIdentifier.PORT_SERIAL) {
if (portId.getName().equals("COM1")) {
            //if (portId.getName().equals("/dev/term/a")) {
try { serialPort = (SerialPort)
portId.open("faultdata", 2000);
            } catch (PortInUseException e) {}
try { outputStream = serialPort.getOutputStream();
            } catch (IOException e) {}
try { serialPort.setSerialPortParams(9600,
                SerialPort.DATABITS_8,
                SerialPort.STOPBITS_1,
SerialPort.PARITY_NONE);
            } catch (UnsupportedCommOperationException e) {}
try { outputStream.write(messageString.getBytes());
```

Fig. 4 Java source code to send indications to output port

## III. NUMERIC RELAY

Power systems problems and applications have been solved by means of purely analog circuits. However the scenario has changed and power system area was one of the most benefited areas from the booming in area of digital and signal processing. Numerical relays are the result of the application of microprocessor technology in relay industry, they convert the measured voltages and currents from analog to digital values and calculates from these samples the relay protection criterion i.e. impedance Protection relays, such as other monitoring and control equipments have taken the advantage from the increasing improvement of the semiconductor industry and the enormous number of digital signal processing and control algorithms. The latest generations of protective relays be provided with a large capacity of processing capabilities become more efficient and can perform a numerous number of functions such as fault locators, integrated monitoring and control functions.

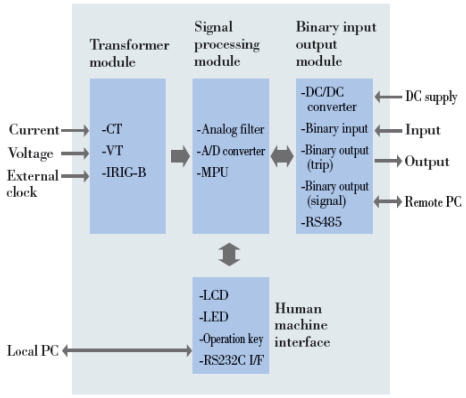


Fig.5 Functional block diagram of Numeric Relay

The relay has a multiple microprocessor design. The Microprocessors perform the software functions such as signal processing, protection algorithm, scheme logic, output relay control and handling of the human interface.

Analog inputs include phase current inputs, residual current inputs and phase voltage inputs. The number of analog inputs depends on the type of the relay. The internal auxiliary transformers are used to isolate, step down and condition the inputs from the VT and CTs. Their output signals are then converted into digital data for further processing. The front panel contains a liquid crystal display (LCD) and pushbutton keys to provide local access to the relay menu. There are also light emitting diodes (LED) for visual indication of the status of the relay. The relay provides three communication ports, RS232C for connection of a local PC, RS485 for a remote PC and IRIG-B for an external clock. These relays are compliant with IEC 61850 protocol.

## IV. PROPOSED METHOD OF FAULT DETECTION

### A. Probability of faults in Power Transmission system

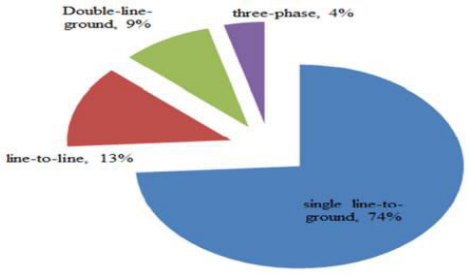

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Fig. 6 Probability of faults in Power Transmission system

The types of faults that may occur in order of frequency of occurrence are : single line to ground ( 74%), line to line fault (19%), double line to ground (9%) and three phase fault(4%) . This frequency may vary from power system to power system. For detection of faults distance protection scheme is used . These distance relay will compare impedance of line with the preset value. Measurements of the voltage and current for each phase (Van, Vbn, Vcn, Ia, Ib, Ic) at the relay location and computing of impedance according to fault type used enabled us to models of the distance relay. Comparing the measured impedance with impedance setting values for each zone allows for a fault or no faults to be declared and provided its zone information if any.

When fault occurs, current increases, voltage decreases and impedance of line changes which is sensed by distance relay indicating the location of fault. This conventional method gives inaccurate results especially when the series compensation is added to power line [2],[3].

B. MHO Distance Relay in Transmission Line

MHO Distance protection is so called because it is based on an electrical measure of distance along a transmission line to a fault. The distance along the transmission line is directly proportional to the series electrical impedance of the transmission line (ZL) between busbar A and B as shown in Fig. 7. The distance protection measures distance to a fault by Means of a measured voltage to measured current ratio computation [7]. The philosophy of setting relay is three forward zones (Z1, Z2 and Z3) for protection the line between busbar A and B with total impedance ZAB.

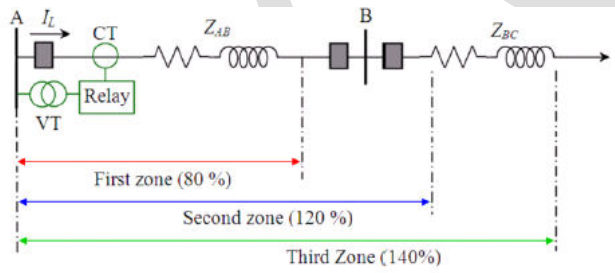


Fig. 7 Zone settings for distance relays

C. Proposed IEC61850 compatible method

In this proposed method the IEDs and MUs work on the polled approach. These units check magnitude of voltages and current continuously. The logic for fault condition is based on voltage becoming zero and currents having abnormal values. For each type of fault programming for preset values of the voltage and current magnitude is done. When fault occurs the actual values are compared with preset values and fault condition is sensed. The Java source code to send indications of fault to output port is shown in Fig. 4. The Java source code enables data transfer from meter to JCU. The meter is provided with serial port for serial data transfer. All details of faults such as type( L-G,LL-G, L-L, L-L-L) , magnitude of voltage and current, date and time of fault, zone of protection and location of fault are sent to JCU. The JCU processes the information and send it to the other components of the system. Then the fault clearing process is initiated.

## V. CONCLUSION

As compared to conventional fault detection the proposed method of detection using IEC61850 based IEDs and MUs near instrument transformers is reliable, fast and accurate and compliant to Smart Grid. Setting of distance protection requires special consideration when series compensation of transmission lines changes the line parameters. Proposed method is found to be reliable under such compensation schemes.

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