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Designing and Development of Impedance Relay Characteristics using Microcontroller with Interface to TLS

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ABSTRACT: Distance relay protection scheme is widely used scheme for protection of EHV and UHV transmission lines. Major drawbacks of overcurrent relay for the protection of transmission lines are overcome by distance protection. Impedance characteristics proved to be the building block for development of distance relaying. This paper presents the hardware implementation of distance relay interfaced with Transmission line simulator (TLS) for real time fault detection. This designed relay is an independent unit that continuously monitors TLS for faults. After incidence of fault, this system isolates the faulty section with accuracy. Performance of hardware of relay is analysed on TLS after simulating EHV transmission line of 220 KV and 100km.

KEYWORDS: Transmission line protection, Distance protection, Impedance relay characteristics, Microcontroller based hardware, transmission line simulator.

I.INTRODUCTION

Transmission lines that transfer bulk amount of power from generating station to load centre, are the most crucial element of power system. As transmission lines are spread over thousands of kilometres, they are continuously exposed to extreme climatic conditions like dirt, dust, ice, storms, lightening, fog, salt spray etc. that are out of human control. Transmission lines have fault incidence rate of about 50% out of total faults that occur in power system [1]. Transmission line protection being the most vital part in power system protection scheme much advancement in transmission line protection scheme took place over the period of time. Distance protection scheme employing number of distance relays for measuring impedance or some component of impedance at the relay location is the most widely used protection scheme for high voltage and extra high voltage transmission lines[2].

This paper presents implementation of basic distance protection scheme for TLS. The present setup of TLS is provided with merely different overcurrent protection schemes [3]. Micro controller based hardware interface is developed and that is interfaced with TLS to get actual fault conditions and distance protection scheme is implemented on TLS.

II. TRANSMISSION LINE SIMULATOR

Transmission line simulator (TLS) is the module developed for understanding the basic concepts of power transmission lines and actual fault conditions. The basic block diagram of TLS is as shown in figure 1.

TLS has 8 pi circuits having series inductors, resistors and shunt capacitors, sending and receiving end control panels and series compensation box. TLS works on 415 V 50Hz AC and can simulate various transmission lines upto 400 KV and 200 kilometres, each pi section representing maximum of 25 km. TLS works in connection with the software called Power TLS for simulation and calculation of various parameters of transmission lines. PowerTLS is the software that calculates the values of R, L and C as the replica of actual practical transmission line with respect to 110V rms line voltages.

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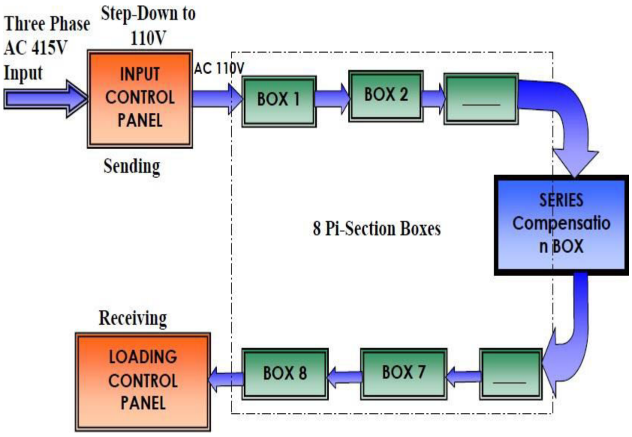

Fig. 1 Block diagram of TLS

III. IMPEDANCE RELAY

Impedance relay being voltage restrained overcurrent relay, it measures the impedance of line as seen from the relay location to the point where the fault actually occurs [5]. The impedance measured by the relay is proportional to the line length. Whenever the impedance seen by the relay is lesser than the set value of impedance, relay sends trip signal to the circuit breaker to isolate the faulty section. Distance relays being the most important and the most versatile

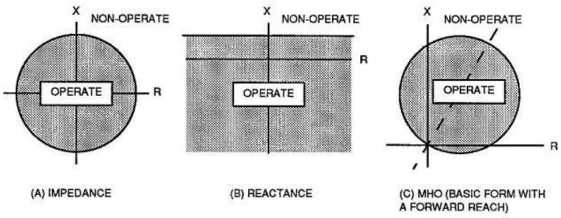

Figure 2 Basic impedance relay characteristics

family of relays, these are widely used for protection of high voltage and extra high voltage transmission lines. Basic characteristics of distance relays are: impedance characteristics, reactance characteristics and mho characteristics as shown in figure 2.

As reactance characteristics, representing straight line parallel to R axis, occupies the largest area on R-X plane as compared to the other two, it gets affected easily by the power swings but experiences the least effect of arc resistance on relay performance, making it suitable for the protection of short transmission lines where the power surges remain for the shorter duration. Circular R-X planer, mho characteristics occupying the least area on R-X plane and least prone to power surges, makes itself suitable for the protection of long transmission lines. Impedance characteristics representing circle with centre at origin gets moderately affected by both arc resistance and power surges, makes it suitable for the protection of medium length transmission line.

Problem of variable reach of overcurrent protection scheme implemented for transmission line protection depending upon type of fault occurring and resistance of fault is overcome in impedance relay to some extent. Though not perfect, impedance, reactance and mho characteristics proved to be the basic building blocks of modern high speed, miscellaneous, composite characteristics of distance relay schemes implemented for EHV and UHV transmission lines

IV.HARDWARE IMPLEMENTATION

Hardware implementation of impedance relay consists of microcontroller, signal conditioning of inputs from TLS, man machine interfaces, tripping circuit and independent power supply circuit as shown in below figure 3.

The controller used is high speed dsPIC30F3011 which has 1KB of memory and conversion rate of 1msps. Measurement of 50 Hz voltages, currents and phase angles with accuracy requires crystal of 6MHz giving execution time of 60nSec [4]. Display includes type of fault and values of fault currents.

The signal conditioning circuit consists of filter, zero crossing detector and current to voltage converter. Being compact and cost saving unit, five-key keyboard is designed on only one pin of the controller. Simple series diode 1N4007 acts

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as AC to DC converter and LM358N op-amp chip is used in zero crossing detector circuit to measure phase difference between respective phase voltage and current. Replica of single circuit is used for all three phases which made the designing of the unit simple to understand.

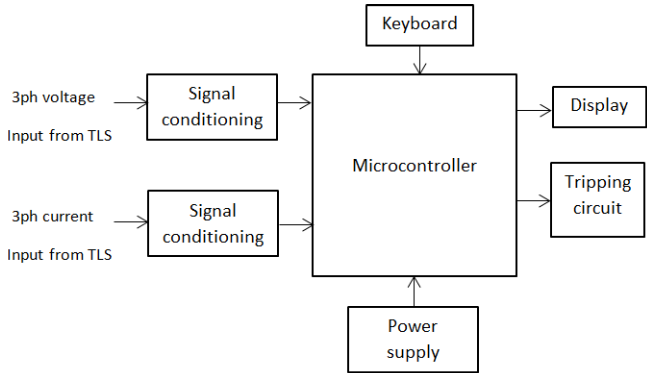

Fig. 3 Block diagram of hardware setup

A. SIMULATION OF LINE PARAMETERS:

For hardware testing, following line parameters are selected and simulated on TLS. Line parameters are given in figure 4 below.
Conductor type: Zebra Voltage: 220 kV
Line length: 100 km Load= 100 MVA
Number of pi sections: 8
Line length per pi section= 12.5km
Resistance per km=0.08017ohm/km
Reactance per km=0.41273 ohm/km

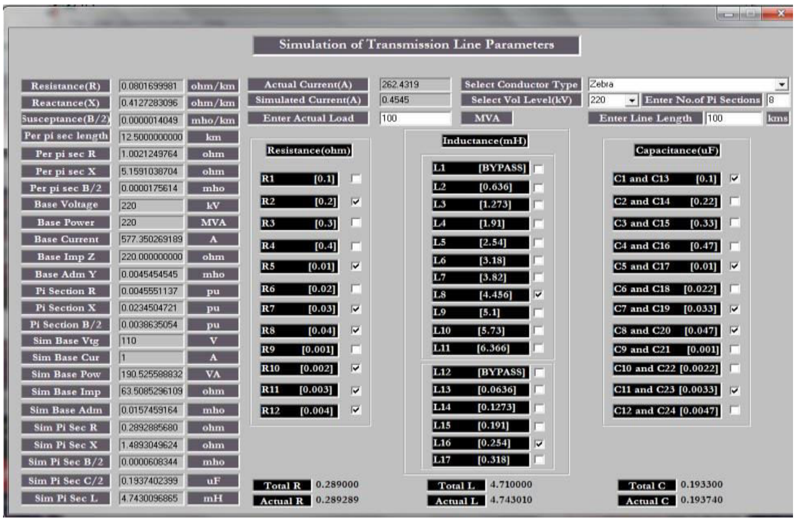

Fig. 3 Simulation of line parameters

B. PROGRAMMING OF MICROCONTROLLER:

While calculating impedance of line as seen from the relay location, rms values of voltage and current are considered. Calculations of impedance and components of impedance are done and the decisions are made.

Z=V/I, if Zmeasured<Zset, thentripotherwiserestrain

X= Z sin Ø , if Z sin Ø <Kset, then trip otherwise restrain

M= Z/ cos (Ø - α), if (Z/ cos (Ø - α))<Kset then trip otherwise restrain

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Firstly, values of impedances and tripping time are set by the user. All three phase currents and voltages are continuously read along with phase angle between them. The tripping decision is made after comparing all calculated values of impedances with set values given by user. The process continues until any kind of fault is detected and if detected, tripping signal is sent to isolate faulty part of the transmission line [6].

Here zonal protection is also considered. Zone 1 is set for 80% of total line length and the further part of line is covered in zone 2. Relay being the backup protection for zone 2, time setting is accordingly adjusted and is given to choice of user. Selection of type of relay characteristics to be used for decision making is also given to the choice of user.

Flowchart of this algorithm can be summarized as shown in below figure 4.

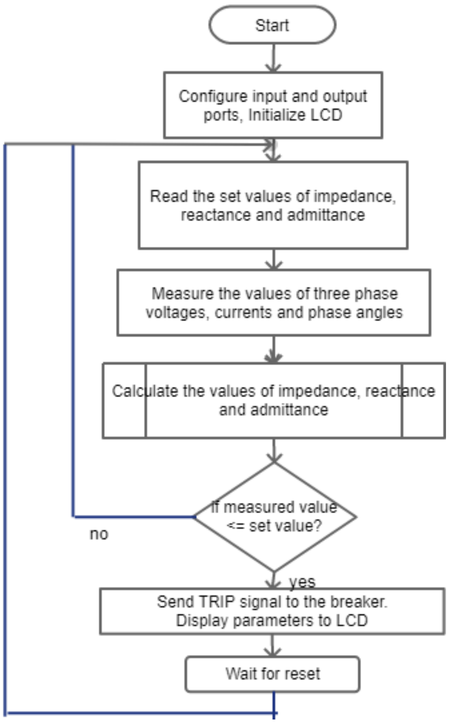

Fig. 3 Flowchart of algorithm

V. RESULTS

Impedance relay algorithm is developed on controller and hardware is tested in interconnection with TLS. Zones of transmission line protection, i.e. 80% in zone 1 and further in zone 2, are also considered while setting the values. The results obtained on TLS multifunction meter and microcontroller based hardware display after incidence of various faults in zone 1 are given below:

1. LG fault in zone 1: (fault on R phase)

Phases	TLS Readings			Relay Display readings		
	Voltage	Current	PF	Voltage	Current	Impedance
R	57.72	2.55	-0.999	58.02	2.53	22.9
Y	62.16	0.065	0.048	62.31	0.06	1038
B	62.37	0.064	0.042	62.32	0.06	1039

2. LLG fault in zone 1: (fault including R and B phases with ground)

Phases	TLS Readings			Relay Display readings		
	Voltage	Current	PF	Voltage	Current	Impedance
R	58.32	2.60	0.884	58.12	2.6	22.3
Y	62.35	0.065	0.024	62.02	0.06	1034
B	57.21	2.50	-0.896	56.87	2.54	22.3

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3. LLLG fault in zone 1: (fault including R, Y and B phases with ground)

Phases	TLS Readings			Relay Display readings		
	Voltage	Current	PF	Voltage	Current	Impedance
R	57.23	2.59	-0.998	57.01	2.6	22.3
Y	50.19	2.33	-0.998	50.42	2.3	22.3
B	57.65	2.52	-0.998	56.24	2.5	23.1

4. LL fault in zone 2: (fault including R and Y phases)

Phases	TLS Readings			Relay Display readings		
	Voltage	Current	PF	Voltage	Current	Impedance
R	60.23	1.54	0.952	60.00	1.5	40
Y	62.17	1.48	-0.901	61.89	1.5	41
B	63.57	0.06	0.024	63.12	0.06	1052

5. LLL fault in zone 2: (fault including R Y and B phases without ground)

Phases	TLS Readings			Relay Display readings		
	Voltage	Current	PF	Voltage	Current	Impedance
R	59.12	1.67	-0.952	60.00	1.6	40
Y	51.92	1.62	-0.901	61.89	1.6	41
B	57.24	1.77	-0.9221	63.12	1.7	40

VI.CONCLUSION

This paper presents the hardware developed to interface with TLS for identification of fault through impedance relay algorithm with zone setting. Transmission line of 220 KV and 100 km with Zebra conductor is simulated on TLS using linked Power TLS software. Working of relay is tested successfully with actual fault conditions created with different types of faults occurring on transmission lines at various lengths using TLS and fault simulator. The developed relay algorithm works successfully on all simulated fault conditionsand displays type of fault and impedance with accuracy

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