The Transmission Fault Detection Method Using Capacitive Properties on the Transmission Line: Case Study of South Sulawesi Power System

Arif Jaya
Electrical Engineering
Universitas Muslim Indonesia
Makassar, Indonesia
Email : arief.jaya@umi.ac.id

Syarifuddin Nojeng
Electrical Engineering
Universitas Muslim Indonesia
Makassar, Indonesia
Email : syarifuddin.nojeng@umi.ac.id

Hariani M Pakka
Electrical Engineering
Universitas Muslim Indonesia
Makassar, Indonesia
Email : hariani.m@umi.ac.id

Agung Pramono
PLN Sulselra Makassar
Makassar , Indonesia
Email : agung_pramono@pln.co.id

Abstract— Protection of the transmission line has a very important role in the electric power system. The line protection relay is a component system that used to detect a fault condition on the transmission line. Overhead Lines transmission line disturbances often occur due to the touch of a tree. To find out the type of disturbance that occurs, permanent or non-permanent, and to normalize the disturbance can only be done by inspection road on the transmission line from the substation to the location of the disturbance. To ascertain the type of disturbance condition it is permanent or not permanent on the transmission line is very difficult. For this reason, a fault detector using capacitive voltage is made using the PMT Auxiliary Contact, CB Status. The results of the design show that if there is interference, the capacitive voltage is zero so that the LED lamp will off, while in a healthy phase the LED lamp will on.

Keywords— Fault Detection, transmission lines, relay protection, capacitive properties.

I. INTRODUCTION

Recently, restructuring and deregulation of electrical systems in the light of increasing energy demand, environmental concerns, economic factors and road rights, led utilities to use transmission lines to their thermal limits. Several countries in the world that have excess power generation supply their load needs through distribution companies, causing an overload on the transmission line. On the other hand, the connection of renewable energy to the grid causes disturbances in the system voltage. Therefore, the protection of the transmission line has a very important role in the electric power system. Safety relay is a safety device used to detect a fault condition in electrical equipment. The transmission line is the link between the generating station system and the distribution system and connects other power systems through interconnections.

In general, High/Extra High Voltage Air Lines, both those using 70 kV, 150 kV, and 500 kV systems in Indonesia use Over Head Channels [1].The natural distribution of this electric power system. The problem that often occurs in this transmission line is that the source is a lot of trees. In January 2016 a permanent trip to the Transmission line in the section of Bulukumba - Sinjai. The disturbance record data downloaded from Relay Distance informs that the disturbance is around 36.61 km from Bulukumba Substation. However, it is not clear what disturbance has caused CB Lock-Out or permanent trip. The operator of the substation and the dispatcher has difficulty making the decision to normalize the Bulukumba - Sinjai Line. Therefore, to find out whether the transmission line is safe or not, a 36.61 km transmission line is inspected. Inspecting the transmission line from the substation to the location of the disturbance is not the right choice, because in addition to the distance is quite far the time of extinction also increases. This paper is divided into several sections, in the second part discusses the literature review. Then, propose method in the third part. Furthermore, discussed in the fourth section is result and discussion. Then in the last chapter is conclusion.

II. LITERATURE STUDY

Transmission line plays a critical role in the power system. Transmission lines regulate a principal amount of power. The requirements of power and its allegiance have grown up exponentially over the modern era and the major role of a transmission line is transmitting electric power from the source area to the distribution network. In this condition, fault detection plays an important role which can interrupt the system very quickly [1]. In the transmission line, there are fault types which are; single line to ground, line to line fault, double phase to ground and the last one is three phase faults. There are novel schemes for fault detection, classification and location which compensate for phase angle error due to line charging current using synchronized phasor measurements in SMART GRID [2]. Research on this case in Ungaran – South Section about detection of transmission lines using Wavelet and discriminant analysis. The results of this study obtained the effect of a short circuit with such a large resistance will result in a fault current equal to the nominal current. One method that can be used in the determination of disturbances is the Disturbance Classification Method by using a combination of Wavelet Transformation and Discriminant Analysis. Wavelet transforms are used to process transient signals that will produce input variables that are correlated with the type of noise. The pattern between the input variables and the type of disturbance will be classified by discriminant analysis using Linear Discriminant Analysis [3]. In this study, researchers conducted a study of the effectiveness of the use of the Ungaran Sub-Station using shunt reactor in compensating for the reactive power of Extra High Voltage (EHV) transmission 500 kV Ungaran - South Bandung. Including the operation of the EHV Java-Bali sub network on a long line without a generator, namely Ungaran - South Bandung in the condition of no load / low load will occur relatively high charging currents due to the influence of the line capacitance to the ground. The capacitance between two lines of a transmission-network is due to the potential difference between the conductor, the capacitance causes the conductor to be charged as happens with the capacitor plate if there is a potential difference between them. It is necessary to find the use of compensation by series compensating devices on voltages of a transmission system [4]. Series compensation can compensate the voltage variations that occur due to varying conditions of the load, and as well as by the voltage control methods. Voltage across capacitors should be properly regulated to avoid problems related to voltage. In the lines with light load conditions the voltages will take higher values and can be avoided by compensation using series devices, i.e. to decrease voltage from higher values.

The voltage breakdown or a low voltage drop that is too low can lead to decreased insulation life cycle and short circuit. Therefore, series compensation is compensated for simultaneously controlling the flow of voltage power. By taking asynchronous algorithm signals of voltage and current both sides get the value of error of the parameters in a distributed double-line circuit can be done [5-6]. Various mathematical equations can be derived by using of generalized fault-loop models. Fault distance does not depend on the parameters of the compensating network and is a function of the compensating modules, and current and voltage signals asynchronously measured.

A method to detect fault location by using the in a double circuit transmission line [7]. This method is used for protecting double circuit uncompensated lines and series-compensated lines. A model for transmission consisting static compensator banks and measurement devices has been presented. In the said algorithm, subroutines have been used, for balanced lines and unbalance current detection.

Approximately, the classification of fault done is 100%, approximately, and is for parallel lines in symmetrical in nature. And for unbalanced lines the percentage is 85-95%.

A method has been proposed to detect impedance and fault current location. Case studies in double circuit series compensated 400kV line which is of length is simulated in Matlab/Simulink. The simulation results demonstrate that the said method can be used for estimation of accurate fault distance [8]. The IEEE have been established a guidance for applications to transmission lines protection in [9]. Differential current relays, arranged at both the ends of line, are studied to determine the more precise solution for locating fault.

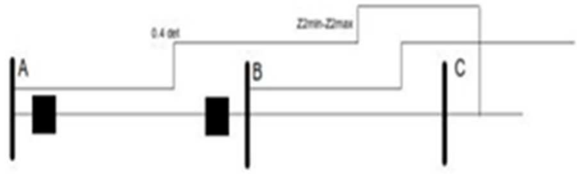

Figure 1. Line Protection using Distance Relay

Some of the proposed to fault location detection techniques can be used by combining differential shielding relays with fault locator. With a combination of communication infrastructure with differential relays it is obtained to make it easier to determine the location of the disturbance. So, no additional communication link is required. In addition, the utility of the differential relay is significantly improved in performance. To differentiate the fault zone precisely and show the right type of fault only one end data is used [10]. Another new scheme proposes a solution to the problem of protection of transmission network containing parallel lines by using currents of six phases and voltages between lines which are three in number. [11]. To analyze the error, wavelet transform has been used, where the internal-fault on the dual-circuit-line is identified by considering the magnitude of the current phasors with respective to the phase of every channel. In [6], current detection at the fault-point is proposed by taking voltage values at the relay point based on the current detection at the fault point with the voltage value at the relay distance.

Distance relay as main protection with remote backup protection for front and rear conductors (Zone-2, Zone-3, Zone-3 reverse). If in the next section there are several branches, to get good selectivity, the Z2 MAX setting is done with the smallest conductor value (Ohm). The working principle of the device based on the use of capacitive voltage for natural interference detection devices on a 150 kV transmission line is as shown in the transmission line the interference detection device gets a

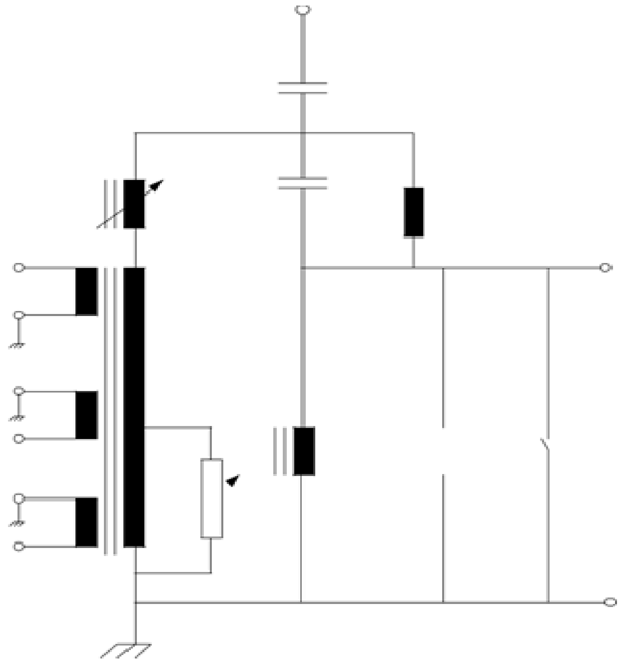

Figure 2. Topology of wiring diagram

capacitive voltage input from the secondary side of the CVT. In general, the transmission line interference detection device wiring includes the LED light cable control and the test light. Next up is the wiring control for the device which will be explained in the next section. In [12], a new proposal with a hybrid technique for detecting transmission line interference using Fasor Measurement Units (PMUs). The proposed fault detection and identification technique is based on Positive Sequence voltage and current measurements from the PMU. In fact, real-time fault location and type error for transmission line interference can be used for real-time detection based information technology [13].

A traveling wave application is proposed in [14-15] with the goal of determining the faulted line in a multi-terminal DC system. The approach of comparing the measured voltage to an already known signal is then used in 14. The reference signals are obtained by considering any possible fault scenarios in this proposal. Wavelet transform has been used to detect in the frequency domain. [16]–[20] have been proposed in the literature. The high frequency content in the shifting of DC fault current would be captured by this signal warning. Currently available transmission fault detection ideas can only provide theoretical analyses based on simulation results.

A novel fault detection methods based on the time and frequency domains is proposed in [21-22]. In [21], using the DC-link capacitor discharge to detection of transmission fault at the converter station. Along with DC fault, the capacitor will discharge immediately and appear large current to the fault point through the DC transmission lines. While, in [22], a method approaches using the DC short time Fourier transform to fault detection.

III. PROPOSE METHOD

In designing the natural disturbance detector for the transmission supply line, the DC voltage is 110 volts. This supply is obtained from the substation battery voltage, which is always available, which is 110 Vdc.

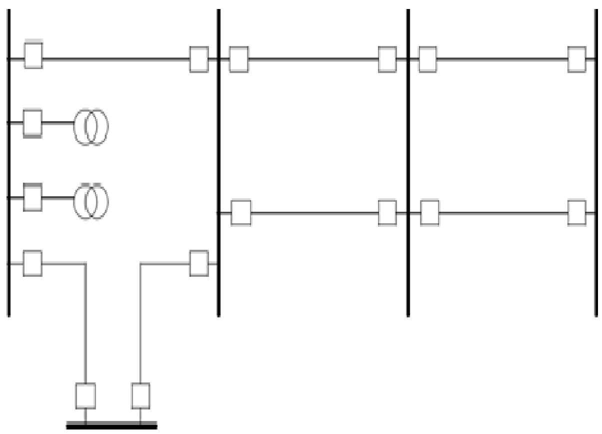

Figure 4.Single line diagram power system

Installation wiring in Fig. 1 and Fig.2, there are components status.

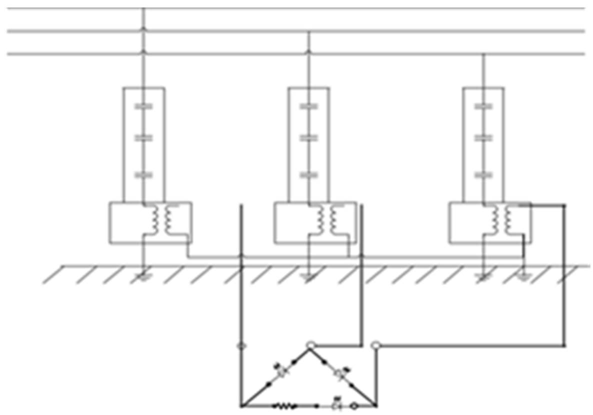

Figure 3. System topology for line detection

CB Status Series are NC (Normally Close) series obtained from the internal wiring of circuit breaker (CB). CB Status Series that are used are spare contacts that have not been used. The CB Status circuit is connected to the 110 Vdc on delay timer. When the timer is working, it will generate the Auxiliary Relay K1 coil so that the LED lights up. Contact Relay K1 used is contact NO (Normally Open) numbers 11, 8, and 5. Contacts numbers 12, 9 and 6 get the source of the CVT secondary side capacitive voltage. Test Lamp uses the principle of interlock with a series of LED lights. Therefore, the NC (Normally Close) Relay K1 contact is used. Contact number 1 is connected to the Switch Test Lamp while number 3 is connected to a positive 110 DC-DC source.

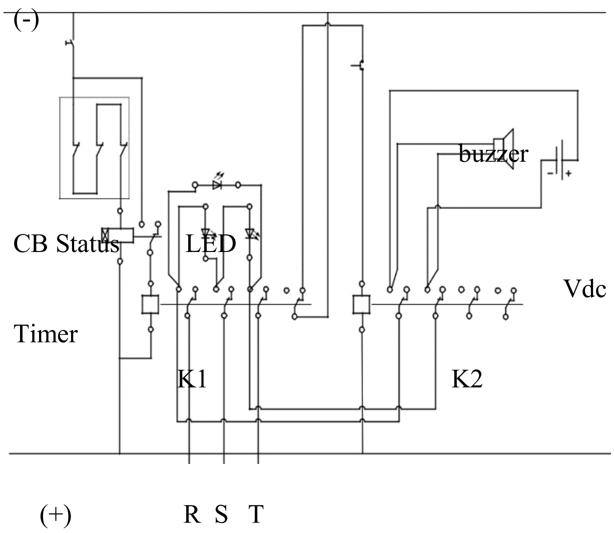

Figure 5. Detection scheme with LED Lamp and Buzzer.

When performing the Test Lamp function the detection circuit cannot work. When the Switch Test Lamp is pressed, the Auxiliary Relay K2 coil is energized, the K2 coil gets input voltage from the NC contact coil number 1 so that the system will not interfere with each other's work. At NO (Normally Open) contact numbers 11 and 8 are given a 6 Vdc battery voltage source. Contact number 11 is given a positive source for the battery while number 8 is a negative source for the battery. When the test lamp button is pressed Koil K2 will work so that the LED and buzzer lights will turn on.A-D below for more information on proofreading, spelling and grammar.

IV. Result and Discussion

The following data were obtained when testing the transmission line disturbance detection device at Jeneponto Control Panel Line # 1 at the Bulukumba Sub-Station (SS). On the opposite side is standby, the Bulukumba Sub-Station to simulate disturbances at the Jeneponto substation. The simulated disturbance is phase to ground and phase. CB between two lines that are facing off or not operating. To prove that there is a capacitive voltage when the transmission line is not in voltage condition, it is necessary to measure the secondary side terminal of the CVT. Measurements made at the secondary side terminal of the CVT are carried out when them CB (Circuit Breaker) between two opposite transmission lines is disconnected. When the CB is disconnected, the transmission line has loss voltage.

TABLE I. Measurement capacitive voltage each phase before fault.

No	Phase	Capacive voltage (Volt)
1	R - S	2.19
2	R - T	4.04
3	S - T	1.81
4	R - N	2.19
5	S - N	0.68
6	T - N	1.88

From both tables we can find out that:

1. The R-T phase is in normal condition then the LED3 R-T lamp is always on, when there is an R-T or three-phase interference, the 3-R-T LED lights goes out. The R-T phase when there is no interference always lights up because it is the sum of R-N and T-N

2. The S - N phase under normal conditions is always 0.04. When there is interference, the S-N Phase value is close to zero. Under normal circumstances the S-N Phase is 0.04 because in the transmission line configuration it is in the middle

3. The LED lights go out if the capacitive voltage value is between 0 - 1.5 volts.

TABLE II. Detection with LED Lamp

NO	Test phase	VOLTAGE (VAC)					
		R - S	S - T	T - R	R - N	S - N	T - N
1	R - S	0.4	2.64	2.96	0.35	0.01	2.6
2	R - T	0.04	0.04	0.04	0.04	0.04	0.04
3	S - T	1.76	1.20	2.95	1.76	0.01	1.20
4	R - N	0.96	2.18	2.51	0.45	0.04	2.14
5	S - N	2.08	1.97	4.05	2.08	0.01	1.98
6	T - N	2.17	0.15	2.17	2.17	0.04	0.15

Transmission line disturbance detector is an electrical circuit that works when there is a disturbance in the transmission line after a permanent disturbance. Disturbances that can be detected by this instrument are phase and phase ground disturbances. Transmission line disturbance detector utilizes capacitive voltage using CB auxiliary contact namely CB Status as a safety LED light. This tool can provide accurate information to the operator through which phase LED lights are disturbed.

TABLE III. Detection with LED Lamp

NO	PHASA TEST	LAMP CONDITTION		
		LED 1	LED 2	ED 3
1	R - S	OFF	ON	ON
2	R - T	OFF	OFF	OFF
3	S - T	ON	ON	OFF
4	R - N	OFF	ON	ON
5	S - N	ON	OFF	ON
6	T - N	ON	ON	OFF

Referring to table 2 and 3, this tool is equipped with a 110 V DC timer with a time setting of 3 seconds. This circuit will work after 3 seconds so it does not interfere with the protection of the transmission line and CB auto-recloser between two lines facing each other. The transmission line interference detection device circuit does not interfere with the existing protection system. This tool makes use of the status of unused or spare CB. This transmission line disturbance detector utilizes a CVT secondary voltage for measurement on the protection panel that serves to detect healthy and unhealthy phases on the transmission line.

V. Conclusion

As the results describe how the fault detection device operates in the timer circuit which is set for 3 seconds, they are able to secure this tool when normalizing the voltage from the opposite side of the transmission line. In addition, for phase to ground disturbance when the capacitive voltage is measured it is close to zero so that it is unable to turn on the LED light. Conversely, if the transmission line is in great condition then the capacitive voltage is able to turn the LED light on.

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