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Asymmetrical Fault Detection Using Thyristor-Bridge

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***Abstract*: -- A distribution line is de-energized for repairing or maintenance purpose. Fault detection is required in order to re-energize the line safely. It is more difficult to detect the fault in de-energized lines as it requires system level voltage production and execution to downstream. Implementation of asymmetrical fault detection technique by controlling a thyristor-based device is proposed in this paper. The proposed method involves injecting a thyristor-based controllable signal to the de-energized feeder. The responses of feeder voltage and current are observed to identify if a fault still exists. A thyristor gating control strategy and fault detection algorithm are also developed to detect all types of asymmetrical faults that can occur in the system. The effectiveness of the proposed method has been verified through MATLAB simulation.**

***Keywords*: - Fault Detection, Thyristor bridge device, Fault Classification, De-energized Distribution Feeder.**

I. INTRODUCTION

Re-energizing or reclosing to a de-energizing overhead distribution feeder safely is a major consideration for a utilities safe work practice. It is de-energized due to the abnormal weather conditions such as rainy atmosphere and storms. In this condition, animal or human being may come in contact with the conductor of distribution feeder. If reclosing action is done in such a case, then it lead to harmful effects on them. The extreme case is human death. Therefore to avoid this and to detect the different asymmetrical faults on distribution system we are proposing a new scheme which will helpful for analyzing the faults before reclosing the feeder by feeding the controllable signals to the downstream line which are generated by the thyristor bridge device. The fault detection in de-energized systems is challenging as it requires the generation and injection of a voltage signal to the de-energized feeder. Available techniques for this signal generation are either self-powered which is based on battery/capacitor or by using energy from the upstream. A pulse-recloser technique it can reduce a fault from a stalled motor or a shunt capacitor bank, which behaves like a short- circuit. Moreover, all available methods cannot detect all types of faults in a single device. The above techniques are having some limitation, so we are proposing the thyristor based device for detecting the faults in de-energized distribution feeder. The parallel connection of the device is made with the firing angle of thyristor when the system is de-energized. A low impedance fault is generally a low resistance short circuit fault. It allow to flow of a large amount of fault current. An arc fault is high impedance fault. It is hard to Detect a high impedance fault by conventional over current protection devices because of low fault current. About 85-98% faults are low impedance faults and remaining are the high impedance faults which are having a very low percentage in power distribution system. The major fault detection methods for high impedance fault identification uses signal generated by an electric arc (harmonic and non-harmonic components). But, before gathering much information by the detection system to confirm the fault, the arc may vanish. The high impedance fault may happen when a conductor breaks and falls to ground or touches high impedance surfaces like sand or cement. In some case, conductor breaks and touches the branches of the tree. In this case feeder current rises but not much todetectby conventional relays. So these types of faults are very harmful for human life so it is necessary to detect the faults without fail. In this paper, we concentrated on the study of various types of asymmetrical faults in the distribution line. The faults are classified as symmetrical and asymmetrical faults. The symmetrical faults includes open conductor faults, L-LG Fault, L-G Fault, L-L Fault.as compared to three phase faults the LG fault having greater fault current. Also the asymmetrical fault examination is useful for single-phase switching, relay setting and system stability studies. The possibility of two or more side by side faults i.e. cross-country faults on a power system is very few therefore it is ignored.

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II.BASICS

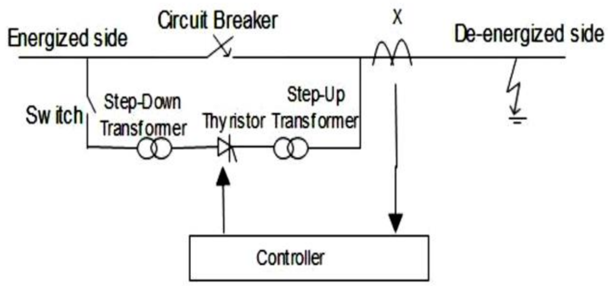


Fig.1. Single line representation of a thyristor bridge device.

A fault current is any abnormal electric current in power system. For instance, a short circuit fault is a fault in which current passes through the normal load. An open-circuit fault occurs if a circuit is disturbed by some failure. In three-phase systems, a fault may involve more than one phases and ground, or may occur only between phases. In a poly-phase system, afault may affect all phases equally which is a “symmetrical fault”. If only some phases are affected, the resulting “asymmetrical fault” became more complicated to analyse. There are many faults like transient fault, persistent fault, symmetrical fault, asymmetrical fault and bolted, realistic, arcing faults. Here we determined the asymmetrical fault.
The proposed plan has been shown in figure. These consist of thyristor bridge in parallel with recloser or circuit breakerconnected by using switch. The step-down transformer is connected after the switch to step-down the system voltage to the thyristor operating voltage so that it will reduce cost and the size of the thyristors to be used. The thyristor bridge is connected between step-down and step-up transformer. The step-up transformer transforms the thyristor operating voltage to the voltage level of the distribution system. After connecting the thyristor circuit to the upstream energized line, the thyristor are triggered according to the control modes.

III. CONTROL LOGIC

Steps	Type of fault	Control strategy used
Step1	Single phase to ground fault Double phase to ground fault Three phase to ground fault	T1,T3,T5 ON Others are off
Step2	Phase A to phase B fault Phase A to phase C fault	T1,T2,T4 ON Others are off
Step3	Phase B to phase C fault	T3, T6 ON Others are off

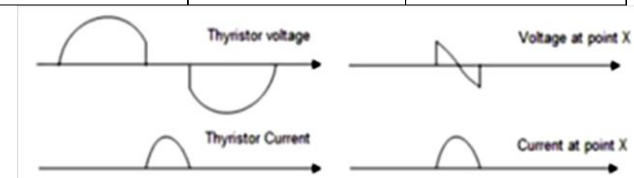


Fig.2. Waveforms of voltages and currents of thyristors and at point X.

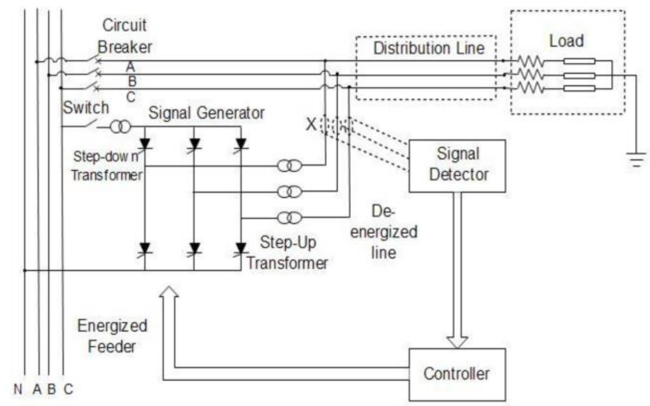


Fig.3. Thyristor-bridge based fault detection method.

The detection and classification of faults in aone device are possible by this scheme by just observing the magnitudes of current and voltage signals at point X.

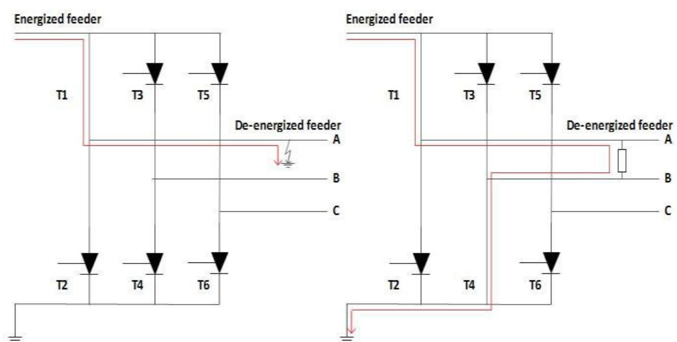


Fig.4. Control logic for phase-to-ground and phase-to-phase fault detection.

In the first mode, when an upper thyristor (T1) is turned on and all bottom thyristors are off, a detection pulse is injected to the corresponding phase of the de-energized line through the upper thyristor, creating a fault current if there is a phase-to-ground fault in that phase. In the other mode, T1 andT4 are fired simultaneously. If a fault between phase A and B exists, it provides a path for the fault current to flow from T1 and T4 to the neutral. The all fault detection logic is listed in table.

IV. FAULT ANALYSIS

Overhead power lines are easiest to damage since the problem is usually obvious, e.g., a tree has fallen across the line, or utility pole is broken and the conductors are lying on the ground. Locating faults in a cables system can be done either with the circuit de-energized, or in some cases, with the circuit under power. Fault location techniques can be broadly divided into terminal methods, which require inspection along the length of the cables.

a. Phase-to-ground fault Detection

Statistics have shown that a single phase-to-ground fault is the most common fault in a distribution system, which accounts for 70%-80% of distribution line faults. On the contrary, a three- phase- to-ground fault with balanced three- phase currents only account for 5% of faults.

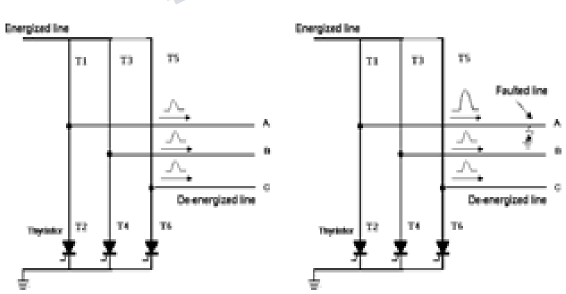
In step1 of the fault detection algorithm, when T1, T3, and T5 (upper switches in a thyristor bridge) are turned on simultaneously and T2, T4and T6 (lower switches in a thyristor bridge) are off, a pulse is injected into all three phases at the de-energized side.

The criterion for detecting an unbalanced phase-to-ground fault is designed as follows.

1. Among the three phase currents in step1
2. Calculate the magnitude of the injected current in each phase (Ia, Ib, Ic). Are they identical? If yes, there is no asymmetrical fault. If no, an asymmetrical fault exists.

i. The three current magnitudes, if one of them is larger and others are the same (Ia>Ib=Ic) it indicates a L-G fault and the faulted phase is identified.

ii. If two of them are the same and larger than the third one (Ia=Ib>Ic) it indicates L-L-G fault and then two phase fault detected.



(a) (b)

Fig.5. Current waveforms under

(a) No fault with balanced three-phase current and

(b) A single line-to-ground fault with unbalanced three-phase currents.

b. Phase-to-phase fault Detection

A short circuit, between lines caused by ionization of air, or when lines come into physical contact, for instance due to a broken insulator. In transmission line faults, roughly 5%-10% are asymmetrical line-to-line faults. In this case, one phase connects to the energized side and others connected to the neutral line. If a phase-to-phase fault exists, a current pulse will show up on both phases in reverse direction. Otherwise, there is no path for current flowing in the de-energized phases. The criterion is therefore designed as follows:

In step2, the magnitude of phase B and phase C currents are measured.

If (-Ib>0), a fault exists between phase A and phase B.

If (-Ic>0), a fault exists between phase A and phase B.

Otherwise, there is no fault between phase B and any other phases.

i. In step3, the magnitude of phase C current is measured.

ii. If (Ic>0), a fault exists between phase B and phase C.

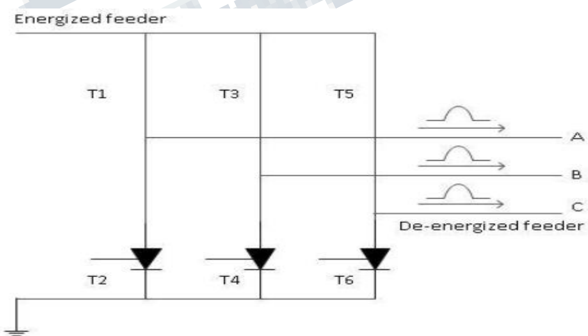


Fig.6. Current waveform with gating control during no fault condition.

V. CONCLUSION

For detection of fault in de-energized distribution feeder the thyristor based device is proposed. This device can detect various asymmetrical forms of faults by using only one device. The device connected in parallel to the re-closer can generate a controllable signal and applied it to detect the fault by analyzing the voltage and current waveforms.

The signal strength can be adjusted from low to high to detect high impedance faults and to avoid hazards to the downstream devices or personnel. Also it ensures safety reclosing of the feeder.

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