Negative Sequence Current Based Fault Detection in Shunt CompensatedLines

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Abstract- In transmission lines during line-charging or when there is a very low load at the receiving end, only a small current flows through the lines. To increase the power transfer capability, shunt reactors are employed in lines. They compensate for the ferranti effect in the lines. A distance relaying scheme is at certain times influenced by signal-noises. A signal noise is misinterpreted as a fault and the relay may trip. To avoid such conditions a blocking function must be used with the distance relays. However, if a fault occurs during noise conditions, the relay must detect the fault and trip. A negative sequence current based technique is used in this paper to detect all types of faults in shunt compensated lines during signal noise conditions. The technique is tested for faults occuring during no-noise and noise conditions in MATLAB/SIMULINK

Index Terms- **Negative Sequence Algorithm, Shunt Compensation, Fault, Noise, Matlab/Simulink**

I. INTRODUCTION

The increased growth of electric power systems over the last few years has resulted in a large increase of the number of transmission lines in operation and their total length. So inorder to increase the power transmission capability within the line, compensators are used. Shunt reactors are used either when charging the transmission line, or, when there is a very low load at the receiving end. Due to the very low, or no load only a very small current flows through the transmission line. Shunt capacitance in the transmission line causes voltage amplification (Ferranti effect). The receiving end voltage may become double the sending end voltage (generally in case of very long transmission lines). To compensate shunt inductors are connected across the transmission line. These lines are exposed to faults as a result of lightning, short circuits etc.

Noise can be defined as undesirable and unwanted electrical signal, which interfere with an original power signal. Noise could be temporary or constant. Transient noise is caused mainly by lightning. Constant noise can be due to the predictable 50 or 60 Hz AC signals from power circuits or harmonic multiples of power frequency close to the data communications cable.

On small electrical systems or over long transmission distances even a small disturbance can cause signal noises. It is very undesirable to disconnect the healthy lines or sustain a faulted line as this will affect stability of the system. In normal fault condition measured impedance value lie within set impedance value of relay but during signal noise, measured impedance value lie within set impedance value without having any fault. Inorder to solve this problem several techniques have been devoloped.

Recently, a discrete wavelet transform (DWT) and independent component analysis (ICA) based approach is proposed for fault detection in series compensated transmission lines[1].The negative sequence current signal is passed through DWT and ICA for detecting the faults under both no-noise and 20 dB noise scenarios. ANN and wavelet techniques are used to detect faults in transmission lines[2]. Techniques based on S-transform and wavelets were also proposed to detect faults but all these techniques failed in the presence of high dB noises. These techniques are able to distinguish faults only for noises upto a small amount. There are several techniques which are able to distinguish faults during other disturbances, but they have some limitations during signal-noise condition[4]-[12].Shunt reactors [13]-[14]with their compensating effect on the capacitive generation of the line offer an economical and technically sound means of controlling the undesirable over-voltage The distance relay misoperates for the transmission line with shunt compensator. The under-reaching and over-reaching is more severe with shunt compensator at mid-point of the transmission line.

This paper introduces a negative sequence current based technique for detecting all types of faults in shunt compensated lines during the noise condition. During unbalanced faults, the negative sequence components become significant and due to transients in current signals in the initial period, a negative sequence component is noticed even for three-phase faults. To discriminate the faults during noise conditions in shunt compensated line, change in the magnitude of negative sequence current method is used. The performance of the technique is tested using MATLAB/SIMULINK. The method proved to be accurate and fast.

II. PROPOSED SYSTEM

Recent regulatory developments, increased electricity demand, and restrictions on building new transmission lines result in enhanced transmission-line loading and necessitate optimized operation of transmission networks. To fulfill such requirements, the inclusion of compensators in long transmission lines is increasing day by day.

Shunt compensation is used either when charging the transmission line, or, when there is very low load at the receiving end. Due to very low, or no load very low current flows through the transmission line. Shunt capacitance in the transmission line causes voltage amplification (Ferranti effect).The receiving end voltage may become double the sending end voltage (generally in case of very long transmission lines). To compensate, shunt inductors are connected across the transmission line Shunt reactors with their compensating effect on the capacitive generation of the line offer a good nethod of controlling the undesirable over voltage. Regardless of where the point of maximum voltage is located, the reactor mounted at the middle of the line requires minimum reactor rating to bring the maximum voltage on the line within limit. The main reason why the shunt compensation is provided at the midpoint is that the voltage sag will be maximum at the midpont.

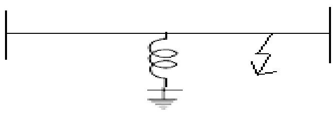
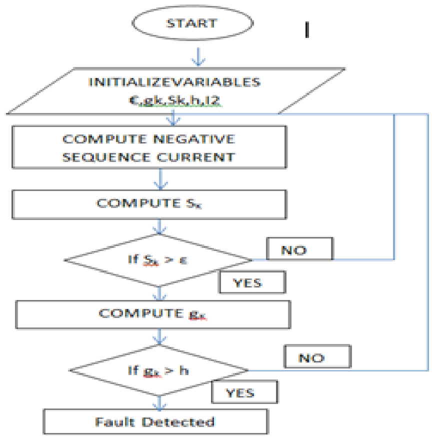


Fig:no:1 shunt compensated line

1)Sequence current based algorithm

A number of techniques are available to detect fault during the signal noise condition for transmission lines. They are able to detect signal noises upto only upto 20dB. Most of the techniques find limitations in the presence of compensation. A small amount of negative sequence current is present during both balanced and unbalanced faults. During the system disturbances a small amount of negative-sequence current is observed at the initial period of the fault due to transients in the current signals and in the subsequent period due to the presence of modulated frequency components due to the disturbances. To differentiate the faults and signal noises in a series and shunt compensated transmission line, change in the magnitude of the negative sequence current based approach is used. A high index value during fault was observed. The input signal used here is negative sequence current. Algorithm mainly depends on the change in magnitude of negative sequence current. The change in magnitude of negative sequence method is compared with the drift parameter €. If the value of change in magnitude of negative sequence current is greater than € then gk which is the test statistics is calculated using the equation $g_k=(g_{k-1}+s_k-€,0)$. g_k is compared with a constant h, which must be ideally zero.



Firstly the negative sequence current is obtained using the

sequence analyzer. The value of negative sequence current will be zero during normal conditions and it will have some value during fault. The value of s_k is set in such a way that it should be zero during all the conditions except the faulty situation. € is taken as 0.05 and g_k is known as the test statistics. The value of gk will be high during fault and will remain zero in normal conditions. In ideal conditions the value of h will be equal to zero. In this paper a small value for h is given.

III. RESULTS AND DISCUSSIONS

The technique is tested in MATLAB/Simulink R2013a.The technique is tested for all types of faults(both balanced and unbalanced faults).The method used in this paper is such that the output of the algorithm should be one during fault and must be zero for conditions without fault. The index value should begin to increase at the instant of fault, until then it should be zero.

2) Simulation result of shunt compensated transmission line

The shunt compensated transmission system is designed in MATLAB/Simulink R2013a. A reactor is connected in parallel with the line. The length of transmission line is taken as 400km. The faults are created at an instant of 0.6s and a signal noise of 30dB is created in between 0.1s and 0.9s. From the graphs it is clear that the technique prove to be accurate.

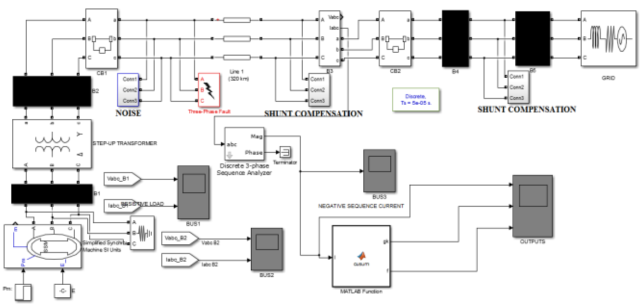


Fig:no:2 SIMULINK model of shunt compensated transmission line

3) Single line to ground fault

Single line to ground fault is created by applying a fault in between any phase and ground. The length of the line at which the fault occured is taken as 400km. The fault is created at an instant of 0.6s. The index value starts rising at the instant of fault and the output is one at that instant.

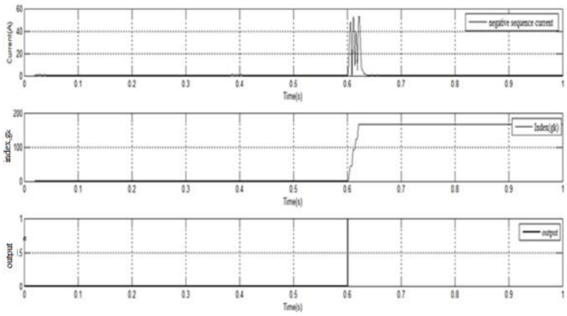


Fig:no:3 Single line to ground fault

4) Single line to ground fault with high fault resistance: As the value of fault resistance increases the value of negative sequence current decreases but even during that time the algorithm works satisfactorily and the output becomes one only during that instant.

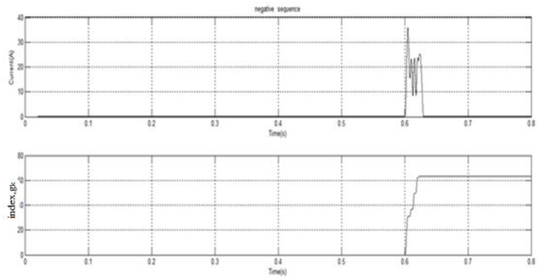


Fig:no:4 Single line to ground fault with high fault resistance

3) Double line to ground fault : Double line to ground fault is created in between any of the two lines and the ground at an instant of 0.6s.Signal noise is created for a duration of 0.1s to 0.9s. The index value starts to increase at the instant of fault.

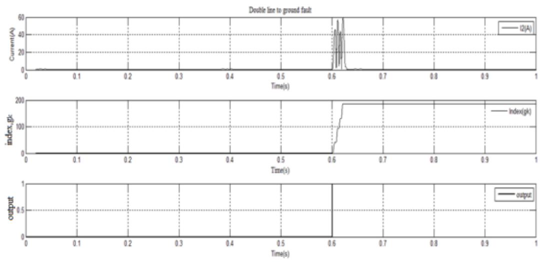


Fig:no:5 Double line to ground fault

4) Three phase to ground fault : Three phase to ground fault is created in between all of the three phases and ground at an instant of 0.6s.Signal noise is created for a duration of 0.1s to 0.9s.It is difficult to distinguish three-phase faults during the signal noise. But the method worked satisfactorily in that case also. The index value starts to increase at the instant of fault and the output was one at that instant.

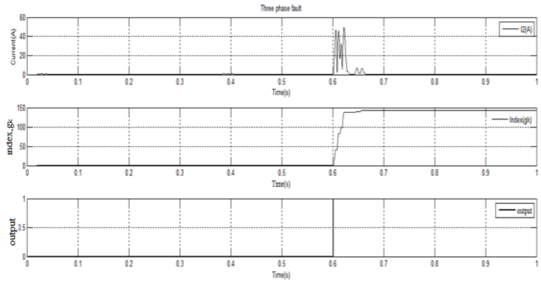


Fig:no:6 Single line to ground fault

The method can be said to be accurate only if it does not work in absence of a fault and in the presence of signal noise. From the figure given below it is clearly evident that the signal noise is not detected .The method is tested for long distances also and is satisfactory.

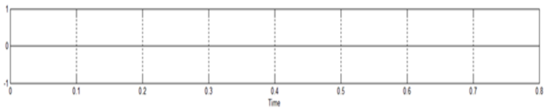


Fig:no:7 Graph during no-fault condition

IV. CONCLUSION

Fault detection shunt compensated transmission lines is studied using negative sequence techniques in absence as well as presence of fault. 30dB to 50dB noises were injected to the signals along with different types of faults. The simulated results show that the algorithm proved to be a better method of fault detection under noisy condition. The algorithm is effective in differentiating noise and faults.

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