Application Note

Substation Automation and Protection Division

Sequence Coordination Study

Introduction

In directional comparison pilot systems some users have applied ground directional overcurrent units with different polarizing types . . . negative and zero sequence, at the line terminals. This application generally occurs when applying newer microprocessor relays to coordinate with existing protection terminals, usually solid-state or electromechanical. This application has resulted in all terminals sensing a forward fault and tripping via the pilot logic for an external fault in a specific region of the power system. The following discussion explains the problem and makes the conclusion that all terminals must use the same polarization type to insure correct pilot operation.

Application

An external fault occurs very remote to a transmission line protected by a Directional Comparison Blocking Distance Scheme. This is illustrated in Figure 1. The scheme consist of an electromechanical relay system [K] at Bus F using zero sequence voltage and current for directional polarizing and a microprocessor based system [M] at Bus H using negative sequence voltage and current for directional polarizing. Both systems see the remote fault in the forward direction and undesirably trip the transmission line. The tripping results because of the different directional polarizing methods used at the line terminals and the fact that the negative and zero sequence current components are flowing in opposite directions in the protected line giving the appearance of an internal fault. This occurrence can easily be explained.

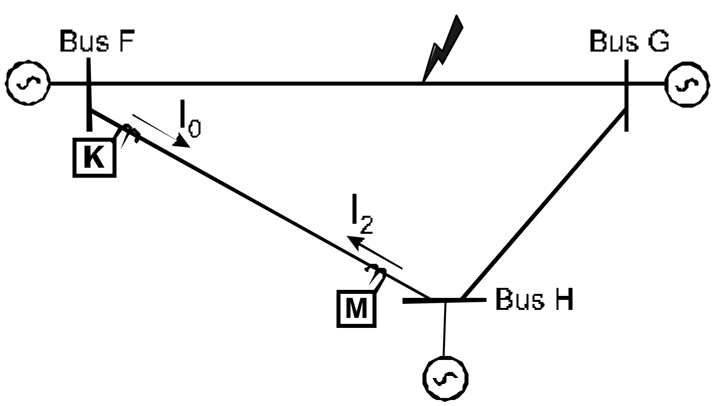

Figure 1 - Simplified System Showing Relay and Fault Locations

Analysis

Consider the sequence network with the impedance values as shown in Figure 2. The sequence networks are connected for a phase-to-ground fault on Line FG. The electromechanical and microprocessor relays are protecting Line FH. The positive and negative sequence impedances of Line FG are 2.0 ohms. The zero sequence impedance is 6.0 ohms. To study the problem a phase-to-ground fault is applied at different points distributed along Line FG from Bus F to Bus G, and the direction of the negative and zero sequence currents on Line FH is monitored.

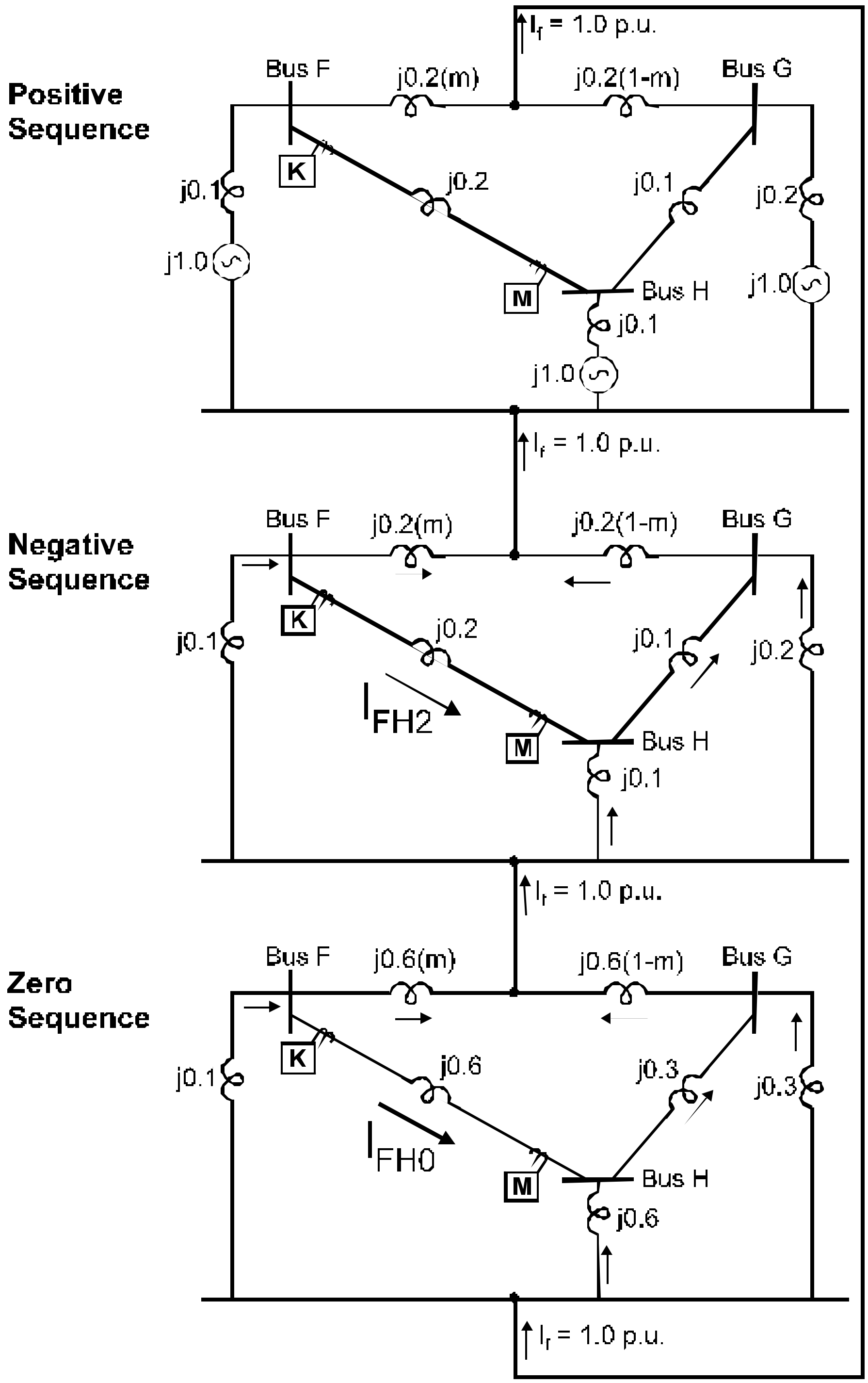

Figure 2 - Sequence Networks for Sequence Coordination Study

Results

The results are shown in Table 1 where **m** is the per unit length of the line and I_{FH2} and I_{FH0} are the negative and zero sequence currents (distribution factors) expressed in per unit of I_f.

Table 1 - Sequence Currents on Line FH for Different Fault Locations on Line FG

m	**0**	**.1**	**0.2**	**0.3**	**0.4**	**0.45**	**0.5**	**0.6**	**0.7**	**0.8**	**0.835**	**0.9**	**1.0**
$\mathbf{I_{FH2}}$	-.196	-.173	-.149	-.125	-.102	-	-.078	-.055	-.031	-.007	0	.016	.039
$\mathbf{I_{FH0}}$	-.078	-.061	-.043	-.026	-.009	0	.009	.026	.043	.061	-	.078	.096

These results show that for these networks and impedances that the negative and zero sequence currents will flow in opposite directions on Line FH for faults between 0.45 and 0.833 p.u. of Line FG length as measured from Bus F.

Conclusions

This simple analysis shows the real potential for incorrect pilot tripping for ground faults when using different polarizing quantities at the line terminal relays. Therefore, the use of the same polarizing quantities at all line terminals for pilot applications is required.

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