Application Note AN2006-07

Detecting Power System Islanding With Time Error Measurement

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INTRODUCTION

This application note demonstrates synchrophasor measurement in the SEL-421/-451 Relay and how it can enhance the protection and control of power systems. IEEE communications protocol Standard C37.118 defines the transmission of data related to synchronized measurement as well as supplemental data in either analog or digital form.

APPLICATIONS

Growth in electrical loads without a corresponding growth in service infrastructure results in systems that operate closer to their limits. Unexpected events, hidden failures in protection systems, and human errors may cause the system to lose stability and may even lead to catastrophic failure. It is increasingly important to properly configure relays and other devices for events like power swing blocking, power swing tripping, and islanding detection.

SEL SOLUTIONS

Consider the simple, two-source power system shown in Figure 1.

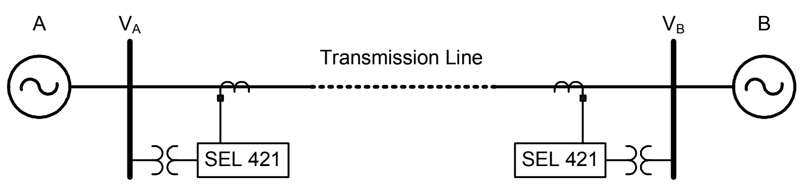

Figure 1 Two-Source Power System

The transmission line is protected by high-speed, distance-protection SEL-421 Relays. Both relays are time-synchronized with a high-accuracy GPS clock, such as the SEL-2401 or SEL-2407. In addition to protecting the transmission line, these relays also provide synchronized phasor measurements.

Time Error

Time error (TE) is an analog value automatically calculated by the SEL-421 Relay. TE can be defined and measured as the difference between a clock synchronized to the electrical system and a clock running at the nominal system frequency. Because TE calculation is the integral of frequency variations, the stored results accumulate over time. It is desirable to occasionally reset these TEs, every night at midnight, for example. The TEs calculated by the two relays in Figure 1 are equal as long as the two-source power system is stable.

TE can be included as an analog value in the synchrophasor messages sent by the SEL-421 Relay. Using the SYNCHROWAVE™ Console SEL-5078 Software, synchronized values of measured frequencies, magnitudes, angles of the voltages, currents, and TEs can be observed. Figure 2 shows the frequencies and TE values from both stations displayed by the SYNCHROWAVE Console software.

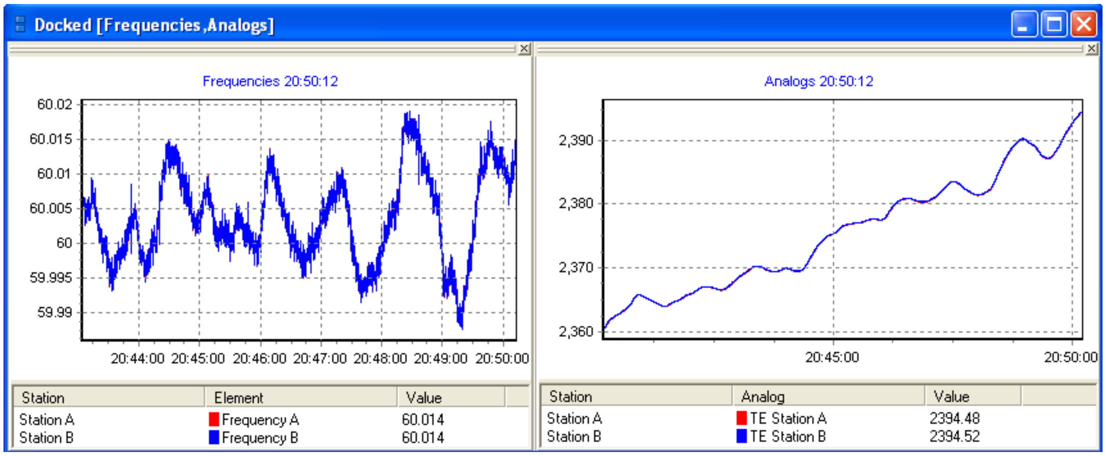

Figure 2 Frequencies and Time Errors From Stations A and B Displayed by SYNCHROWAVE Console Software

In Figure 2, the frequencies and TEs from Stations A and B are practically the same, and the system is stable and connected. If the two-system network becomes electrically separated, it is immediately recognized by the difference in measured TE values at the stations. When the discrepancy in the calculated TE value exceeds one cycle (16.7 ms), an islanding condition between Systems A and B is declared. Depending on other criteria for this specific network, islanding is declared for stability control. For example, a load-shedding sequence is triggered to disconnect large loads in order to restore stability of the islanded system.

Figure 3 shows the differences in calculated TEs in Station A and B after the systems are electrically separated.

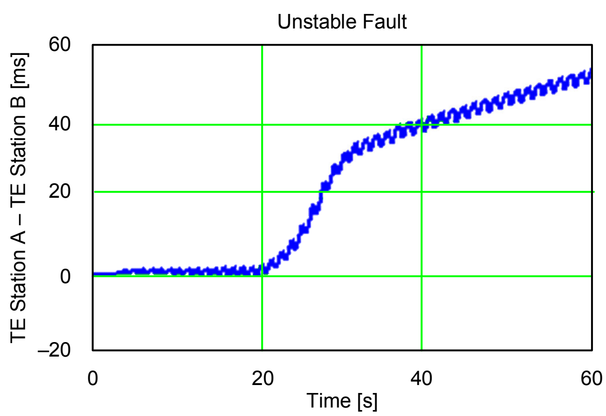

Figure 3 TE Difference Between Stations A and B

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