Application Note AN2009-36

Real-Time Synchrophasor-Based Control Using Direct Relay-to-Relay Communications

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INTRODUCTION

The use of traditional relay-to-relay communications is limited due to the nontime-correlated nature of the information sent between the relays. Using the real-time control capability in certain SEL relays to time-align data between two relays adds an entire new family of applications to protective relays. The information included in the received IEEE C37.118 protocol synchrophasor message is available to the logic of the local relay. The local relay also has a time-delayed local phasor data set that will correlate with the time stamp of the received data. In this way, phase angles from the two relays are compared from precisely the same time, so as to perform a valid comparison.

PROBLEM

Figure 1 shows a general system. If the system is only 0.1 Hz above nominal, and end-to-end communications take 75 milliseconds, there will be a change of 2.7 degrees between the ends during the transmission time. Consider a more severe case, such as a separation between the two ends, with one end at a transient 0.5 Hz above nominal and the other end at a transient 0.5 Hz below nominal frequency. Given a line trip during heavy load flow, this is a very reasonable oscillatory difference. In this case, the same 75-millisecond transmission time will lead to a 27-degree error. With generation shedding at angles as low as 5 degrees [1] or synchronism-check elements set at 15 degrees, these errors are huge.

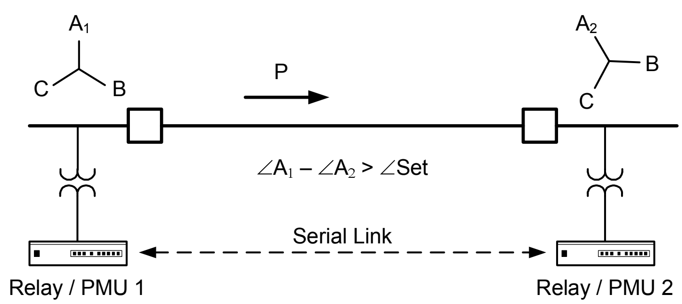

Figure 1 Relay-to-Relay Synchrophasor Communications and Logic

Information about phase angle across a line or transmission system is useful in a number of standard and special protection schemes. For example, a use in generator shedding at Comisión Federal de Electricidad (CFE) in Mexico is provided in [1]. The function described in the CFE paper is now available in standard protective relays, such as the SEL-421 Protection, Automation, and Control System and SEL-487E Transformer Protection Relay. Other potential applications include the following:

- **Trip and reclose conditioning based on line angle**. Enable single-pole trip with reclose only when the post-tripping line angle following a three-pole trip would be beyond safe breaker closing angles.
- **Adjusting of breaker failure assertion times to match system stability margins**. Because a breaker failure declaration almost always disables a large portion of the power system, margins should be as long as possible. Setting margin times for a worst-case condition at all times reduces security unnecessarily.
- **Local islanding detection**. Simple detection schemes based on angle or differences in the rate of change of frequency (df/dt) between two locations can be programmed into SELOGIC® control equations at a relay location determined to be susceptible to islanding.

SEL SOLUTION

Consider the system of Figure 1 with synchrophasor-equipped relays and serial communications between them. In addition to transmitting synchrophasor values, the relays at each end have “delayed synchrophasors” available in SELOGIC control equation analog quantities. These values can be compared with the received quantities from the remote relay, as shown in the SELOGIC control equation settings in Figure 2.

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Protection SELogic Row 009
PMV10 := (RTCAP02 - VALPMAD)

Protection SELogic Row 010
PSV10 := PMV10 > 10
```

Figure 2 SELOGIC Control Equation Settings

Conditioning timers, voltage level qualifiers, or additional logic can be added to these settings for more advanced schemes.

REFERENCE

[1] E. Martínez, A. Guzmán, G. Zweigle, N. Juárez, and J. León, “Using Synchronized Phasor Angle Difference for Wide-Area Protection and Control,” proceedings of the DistribuTECH Conference and Exhibition, San Diego, CA, February 2007.

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