Using Synchrophasor-Based Modal Analysis to Detect Unstable Power System Oscillations

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INTRODUCTION

The SEL-3378 Synchrophasor Vector Processor (SVP) provides built-in modal analysis function blocks to detect unstable power system oscillations in real time. This application note illustrates how to use the modal analysis function blocks in the SVP to detect power system inter-area oscillations.

PROBLEM

Interconnected electrical power systems are constantly subjected to disturbances that may cause oscillations. Without early detection of oscillations and appropriate remedial actions, unstable power system oscillations may cause power system separation or major blackouts. The oscillations can be observed from various power system measurements, such as voltage magnitude, phasor angle difference between two areas, and power transfer through transmission lines. Power system oscillations normally last from tens to hundreds of seconds. When an oscillation occurs, power system operators may not be quick enough to identify unstable oscillation and take proper actions. Traditionally, engineers only conduct postmortem modal analysis on events that show system oscillations.

SEL SOLUTION

The modal analysis function block in the SVP takes real-time synchrophasor measurements as inputs. One SVP can have up to six modal analysis instances running simultaneously. Each modal analysis instance reports results of up to 15 estimated oscillation modes. The oscillation mode is characterized by the following five quantities: amplitude, frequency, phase, damping constant, and damping ratio. The negative damping ratio indicates that the corresponding oscillation is a growing oscillation. Use the programmability of the SVP to trigger alarms and remedial action schemes based on the modal analysis results and other supervision conditions.

A two-area power system model, shown in Figure 1, is used to illustrate the usage of the SVP modal analysis function block. This power system model is susceptible to inter-area oscillation when a disturbance occurs. An SEL-421 Protection, Automation, and Control System PMU (phasor measurement unit) monitors the intertie power transfer and sends the real-time active power measurement, *P*, to the SVP through synchrophasor messages at the rate of 30 messages per second. Table 1 lists the relevant settings to the modal analysis function block. Figure 2 shows the inter-area power transfer during a power oscillation condition. The modal analysis function issues an alarm signal when it detects the growing oscillation and a remedial action signal if the growing oscillation persists for a certain period of time. In this case, the system sheds load to maintain the system stability.

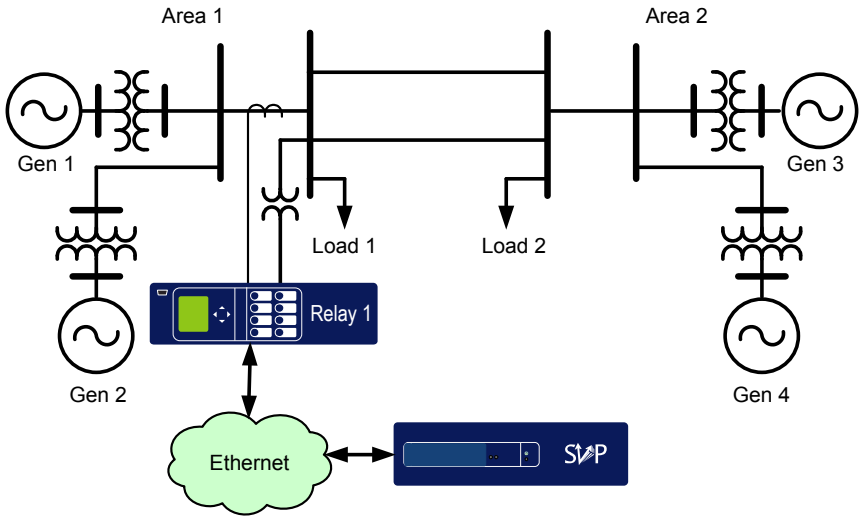

Figure 1 Power System Model Using Modal Analysis to Monitor Inter-Area Oscillation

Table 1 Modal Analysis Function Block Settings

NUM_MODES	DATA_RATE	OBS_TIME	SLIDING_WINDOW
15	30	20	10

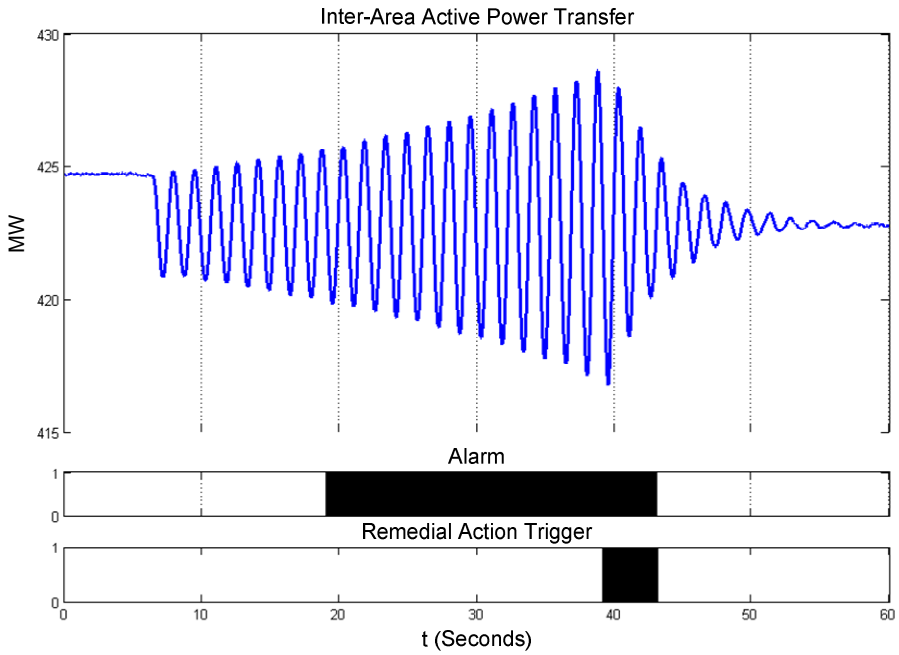

Figure 2 Inter-Area Power Oscillation and Modal Analysis System Outputs

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