Analyze the Effects of Remote Wind Generation Using Synchrophasors

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INTRODUCTION

This application note illustrates how synchrophasors can be used to analyze the effects of remote wind generation on major population centers by monitoring the phase angles reported by the synchronized phasor measurement units (PMUs) monitoring each location.

APPLICATION

The application highlighted here draws conclusions about the effects of distributed wind generation on the bulk power system from the observation of voltage phasor quantities and frequency content. The modal analysis (MA) functional block in the SEL-3378 Synchrophasor Vector Processor (SVP) is used to extract the frequency content of the signal along with the damping ratio. The outputs of the MA functional block are sent to an external IEEE C37.118 client for further analysis.

SEL SOLUTION

Consider Figure 1, in which remote wind generation is transmitting power over a simplified cross-country two-terminal line to a large population center. Each end is monitored by an SEL-421 Protection, Automation, and Control System sending time-synchronized measurement data to an SEL-3378.

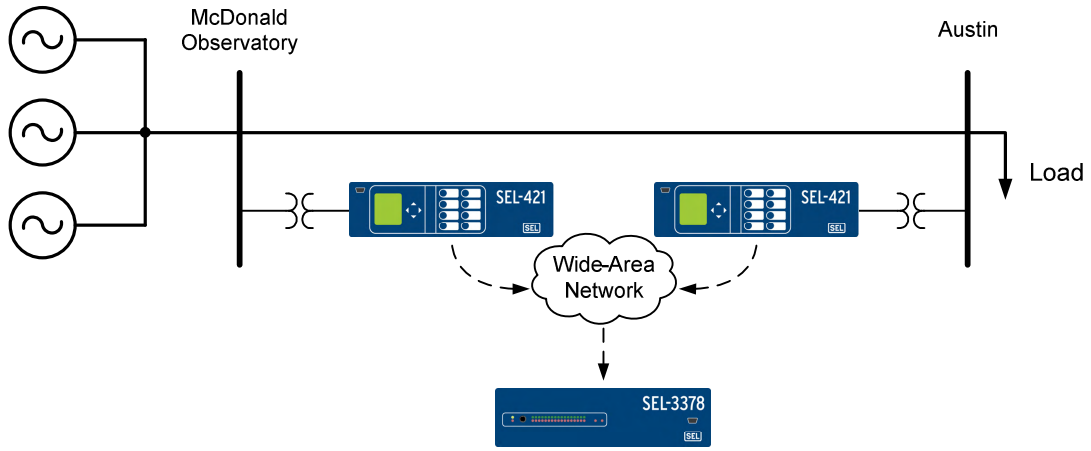

Figure 1 Simplified One-Line Diagram

The SEL-3378 outputs time-aligned phasor data to SEL-5078 SYNCHROWAVE® Console Software running on an external computer to visualize the relative phase angle and frequency variations between the source and load. Additionally, another output can send data to SEL-5076 SYNCHROWAVE Archiver Software for archiving and future system planning.

Figure 2 shows the relative phase angle between the two monitored stations. Post-event analysis of these data with information from the utility shows the high angle difference correlated with high wind generation.

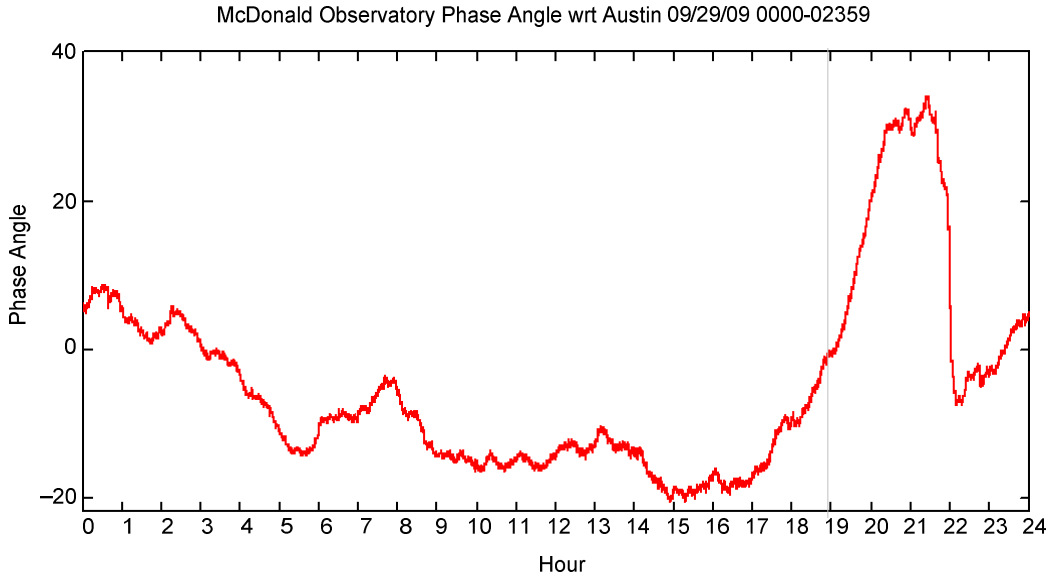

Figure 2 Relative Phase Angle Between Wind Generation and a Population Center

Using the MA functional block, we can identify the amplitude, frequency, and damping ratio of modes introduced into the power system by fluctuating wind generation. To do this, supply an input signal (e.g., angle difference between two PMUs), observation time in seconds, and sliding window in percent of observation time. Figure 3 displays results of an MA calculation plotting frequency versus damping ratio for cases in which wind penetration was very high (13 to 14 percent of total generation, on left) and very low (less than 1 percent of total generation, on right). The plot on the left shows a high concentration of samples around 2 Hz as a result of high wind penetration.

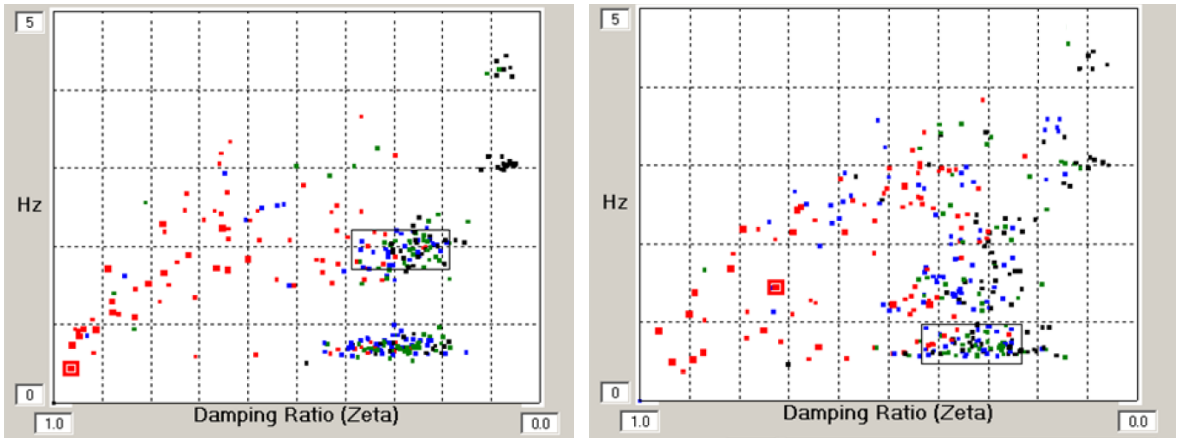

Figure 3 Phase Angle Difference Analysis Plot—Heavy Versus Low Wind Penetration

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