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WAMS - MITIGATING ANGULAR INSTABILITY IN LARGE INTERCONNECTED POWER SYSTEMS

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Abstract- This paper explains the need of controller to detect the fast separation of phase angles among the critical areas automatically using synchrophasors and proceed to mitigate the instability by suitable switching action.

Power systems are large interconnected nonlinear systems where system wide instabilities or collapses do occur over time. In that case, the system breaks up into many islands resulting in large loss of loads and generations and a potential blackout scenario. Phasor Measurement Unit (PMU) technology provides phasor information (both magnitude and phase angle) in real time. The advantage of referring phase angle to a global reference time is helpful in capturing the wide area snap shot of the power system. Accordingly, operator actions together with automatic control actions are designed to prevent or minimize the damagecaused by such outages. Effective utilization of this technology is very useful in mitigating blackouts and learning the real time behavior of the power system.

Index Terms - Wide Area Measurement Security Phasor Measurement Unit (PMU), Power Systems, Phasor Data Concentrator (PDC), Global Time Reference, IRIG-B, Disturbance Fault Recorder (DFR), Smart Grid Security.

I. INTRODUCTION

With the increase interest in the Wide Area Monitoring systems, Control and Disturbance Analysis, and to minimize the future black outs caused due to the cascade tripping, there is a growing interest in the microprocessor based relays and disturbance recorders to provide an additional Phasor Measurement Unit (PMU) measurement and reporting[16]. Phasor Measurement Unit (PMU) is a device which measures both magnitude and angle of voltage and current. Moreover, these measurements are synchronized via the Global Positioning System (GPS). These measurements are highly accurate and sampled at a high rate sufficient to monitor the dynamic performance of the power grid in a much improved way. The recent IEEE C37.118[1] standard on the synchrophasors outlines certain stringent requirements in terms of how to precisely measure the phase angle with respect to the global time reference – the coordinated universal time (UTC), and how to report the phasor information. The standard also specifies the Total Vector Error (TVE) allowed in evaluating the phasor for different compliance level to allow interoperability between different vendor PMUs. As illustrated in Figure 1, when the voltages and currents in different substations are measured and converted to positive sequence phasors in this way, their phasors can be put in the same phasor diagram.

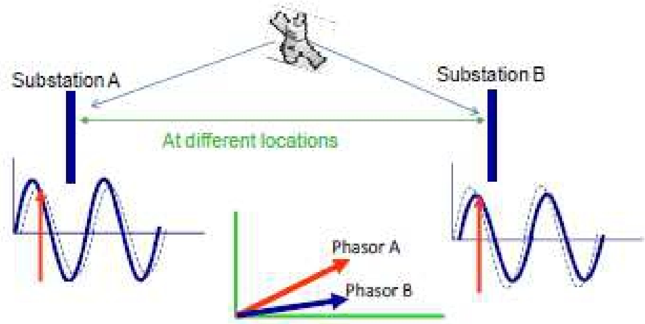

Figure 1: A typical Synchronized Phasor Measuerment between remote ends [8].

II. STATE ESTIMATION

The set of complex voltage phasors across its buses completely specifies the system; it is known as the sys- tem state. State estimator utilizes telemetered measurements from Remote Terminal Units (RTUs) to generate an optimal estimate of the system state. However these measurements do not contain the phase angles due to the difficulty associated with the synchronization of measurements. Consequently the phase angle has to be estimated with the slack bus as reference. However with the advent of Phasor Measurement Units (PMUs) this difficulty can be removed as the PMU measures voltage and current phasors synchronized through GPS. Due to technical and economical constraints it may not be feasible to install PMUs at every bus of the system. Therefore the existing SE can be improved by using data from a few PMUs installed at critical locations [7].

Figure 2 compares the voltage angle difference between two substations obtained using PMU measurements and traditional state estimation.

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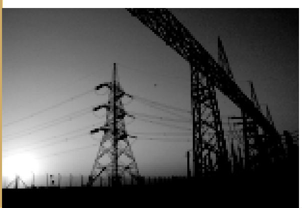

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