Improved Power Grid Resiliency through Interactive System Control

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Research objectives --

1.To identify synchronized wide area measurements that would enable decision making and provide corrective control actuation signals for system-wide overview and benefit.
2.To design controls that incorporate location based hierarchical signals to actuate controls and enhance reliability and robustness.

Importance for the future grid --

•Addresses a critical issue related to engineering resilient cyber-physical systems
•Effective means to use a hierarchical set of synchronized measurements for corrective control and increase grid resiliency
•Leverages large investment in installing PMUs across the nation
•Provide an approach to utilize a wide range of measurements in control and also add robustness to the control

Research deliverables --

•White paper detailing the use of hierarchical PMU measurements for decision making and control actuation
•A report along with an application guide detailing the use of hierarchical measurements as well as the procedure to design and utilize controls based on these measurements

Research approach –

Examine the observability and controllability characteristics of the system for various candidate signals and evaluate the effectiveness of the signals in identifying specific aspects of system dynamic behavior and in providing effective control. The IEEE-50-generator model is used.

A supplementary damping controller associated with a TCSC using a wide area signal is considered.

Several candidates for wide area signals are considered . The controllability and observability of each candidate signal is calculated.

Table 1 Controllability, observability and residue corresponding to mode -0.291+*j*10.274

Signal	Residues	Observability	Controllability
ΔI , line 2-6	-0.402 + *j*0.062	0.291	-1.378 - *j*0.224
ΔI , line 1-6	-0.418 + *j*0.058	0.302	-1.378 - *j*0.224
ΔI , line 40-44	-1.090- *j*0.159	0.789	-1.378 - *j*0.224
ΔI , line 61-63	-1.096- *j*0.158	0.793	-1.378 - *j*0.224
ΔI, line 44-45	-1.164- *j*0.183	0,844	-1.378 - *j*0.224
ΔI , line 43-46	-1.167 - *j*0.184	0.846	-1.378 - *j*0.224
ΔI , line 33-40	-1.186- *j*0.193	0.861	-1.378 - *j*0.224
ΔI , line 63-66	-1.358 + *j*0.258	0.990	-1.378 - *j*0.224

The line 63-66 current magnitude is then chosen as the input signal to the controller since it has the largest residue and observability factor from Table 1.

The signals with the next higher residue and observability is chosen next in the hierarchy as a back up signal if the signal which is highest in the hierarchy is lost.

Research approach continued --

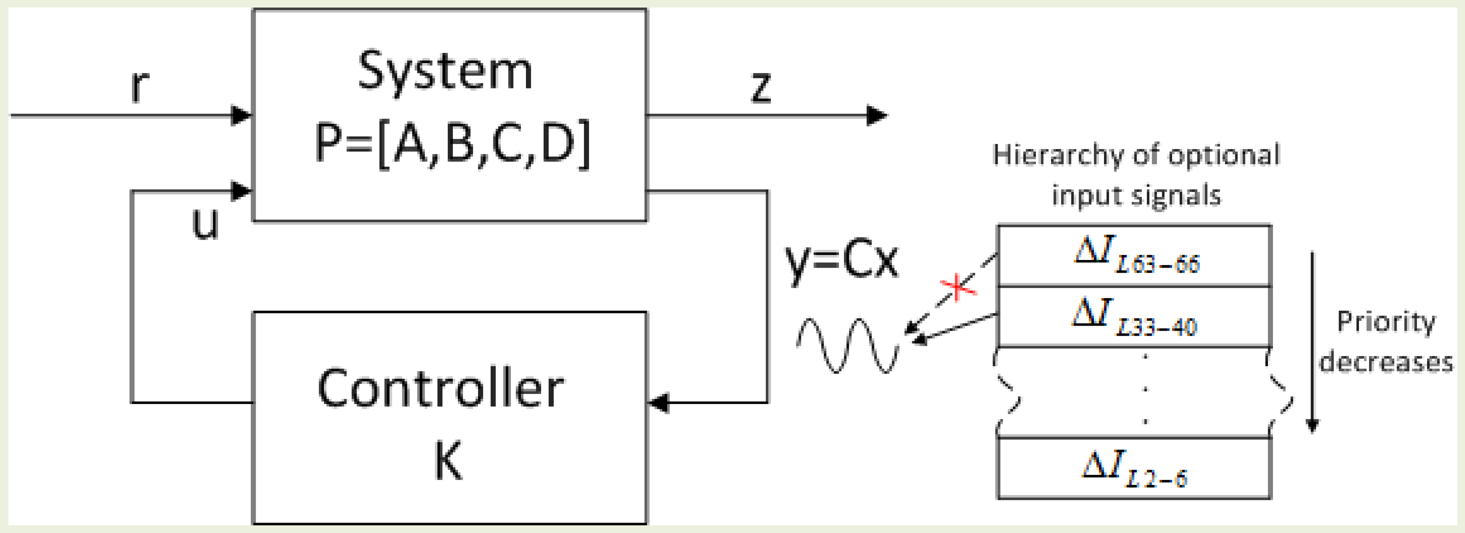

Figure 1 Design of controls that incorporate location based hierarchical signals

Controller K in Figure 1 could be obtained by a wide range of control design techniques such as Kalman Filter, H_∞ optimal control, μ synthesis.

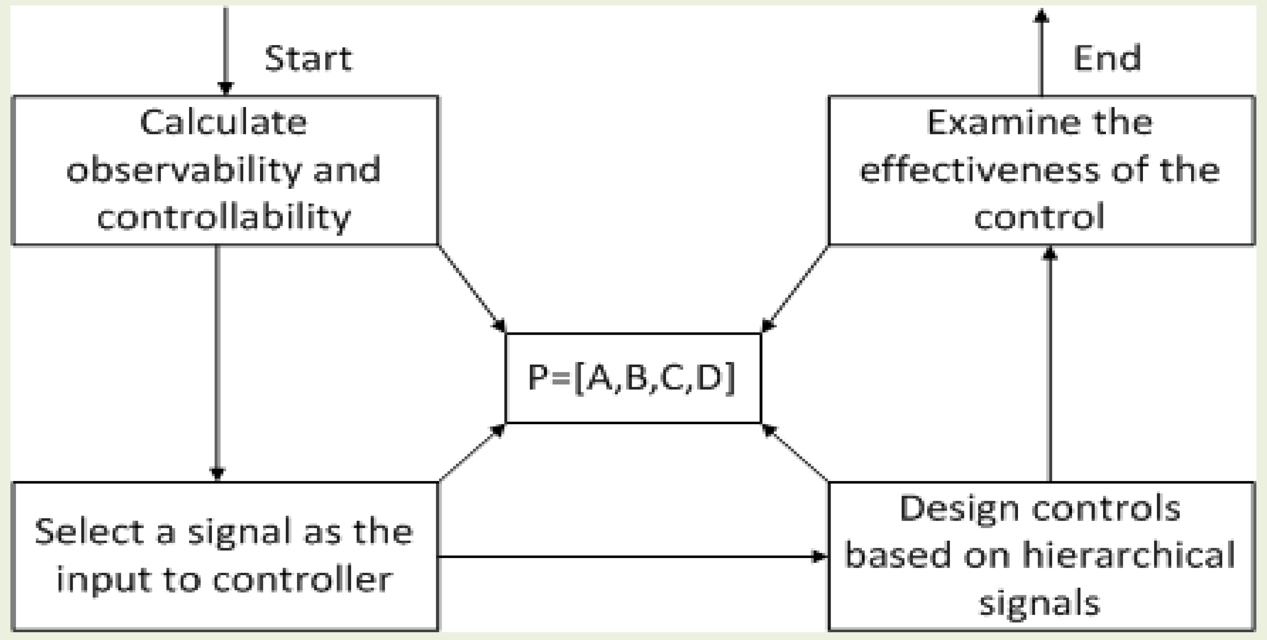

Figure 2 Flow chart of research procedure

•The design approaches would be tested on realistic system models by using commercial software including PSLF, DSA^{tools}, PSS/E

Potential uses of this research –

1.Provide an approach to utilize a wide range of synchronized measurements in control
2. Provide a method to add robustness to the control in the event of loss of communication of the measured signal based on utilizing different sets of measurements for determining control performance and for actuating control actions