Local Area Monitoring System (LAMS) for Microgrid
Funded by Korea Electrotechnology Research Institute

Synchrophasor Engineering Research and Training (SERT) Project at IIT
Funded by US Department of Energy DE-OE0000656

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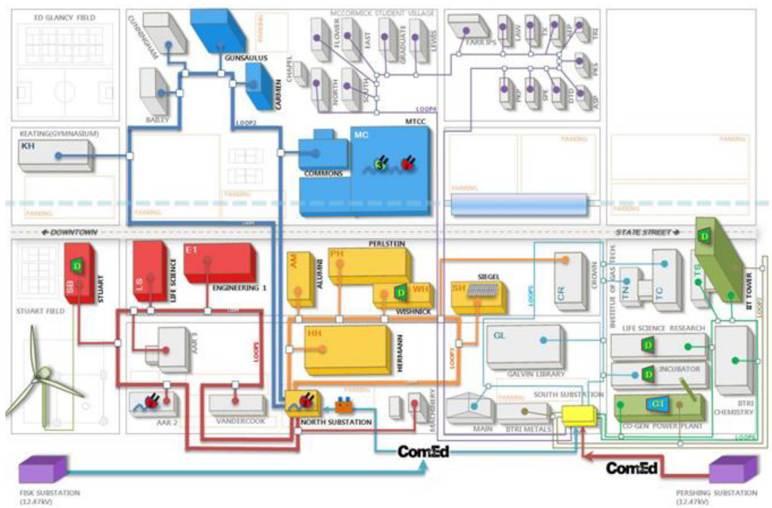
Joint work with Ms. Yinyin Ge, PhD candidate

Synchrophasor Applications in Distribution and Microgrids

Outline

- IIT Microgrid (DOE Perfect Power)
- Local Area Monitoring System (LAMS) for Microgrid
  - Korea Electrotechnology Research Institute
  - Event Detection
  - Data Archival
  - Model Validation
- DOE SERT
  - ComEd Transmission, Naperville Distribution, IIT Microgrid, SEL synchrophasor equipment

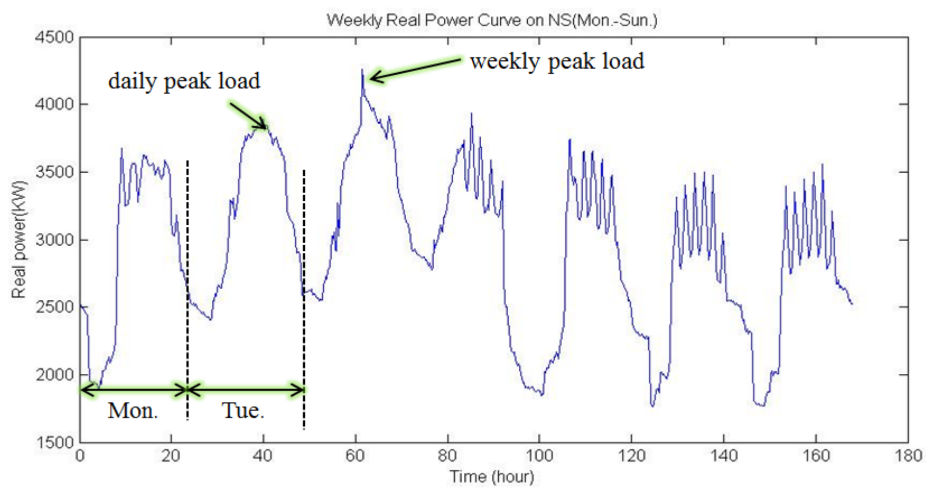
IIT Microgrid



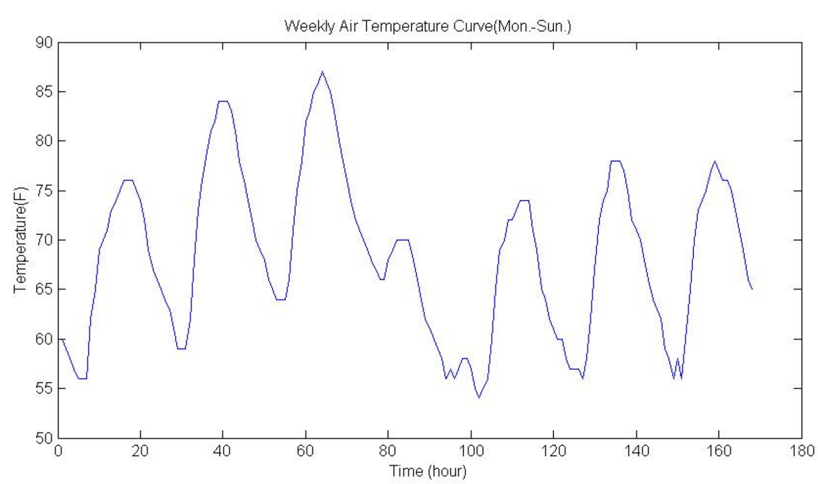
IIT PMU Installation

	IIT BUILDINGS	PMU		ANALOG			DIGITAL	MODULES						Remark
		Device	Type	PT	CT	SPARE		PT8	CT8	PTx/CTx		AI	DI	
1	ENGINEERING 1	1	24/16	12	12	0	16	1	1	1	PT4/CT4	3	1	set 1
2	LIFE SCIENCE	1	24/16	9	9	6	16	1	1	1	PT1/CT7	3	1	set 1
3	STUART	1	32/16	13	13	6	16	1	2	1	PT5/CT3	4	1	set 1
4	GUNSAULUS	1	8/16	3	3	2	16	0	0	1	PT3/CT5	1	1	set 2
5	MTCC & COMMONS	1	24/16	9	9	6	16	1	1	1	PT1/CT7	3	1	set 1
6	HERMANN	1	24/16	9	9	6	16	1	1	1	PT1/CT7	3	1	set 1
7	WISHNICK & PERLSTEIN & ALUMNI	1	32/16	9	18	5	16	1	2	1	PT1/CT7	4	1	set 1
8	SIEGEL	1	16/16	6	6	4	16	0	1	1	PT6/CT2	2	1	set 1
9	NORTH SUBSTATION	1	40/16	6	27	7	16	0	4	1	PT6/CT2	5	1	set 1
10	IIT TOWER	1	24/16	9	9	6	16	1	1	1	PT1/CT7	3	1	set 2
11	LIFE SCIENCE RESEARCH & INCUBATOR	1	24/16	12	12	0	16	1	1	1	PT4/CT4	3	1	set 2
12	CO-GEN POWER PLANT	1	16/16	9	6	1	16	1	0	1	PT1/CT7	2	1	set 2
	Total	12		106	133	49	192	9	15	12		36	12	

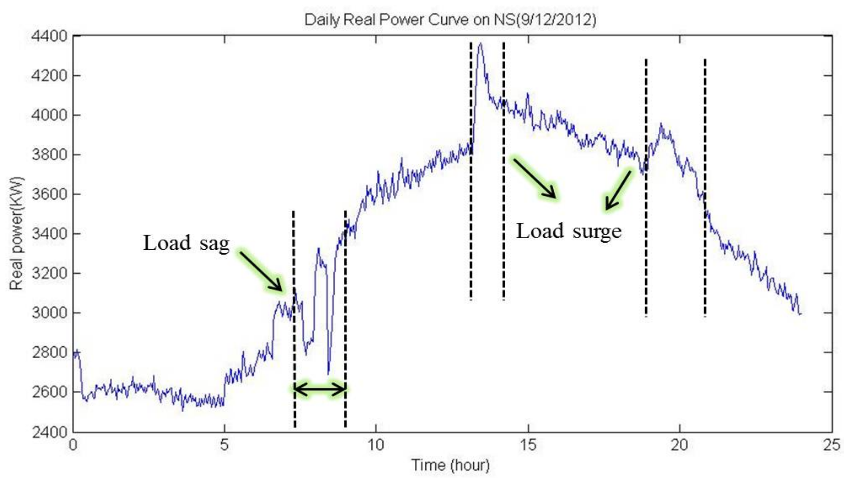
IIT North Sub Power (week in Sep)



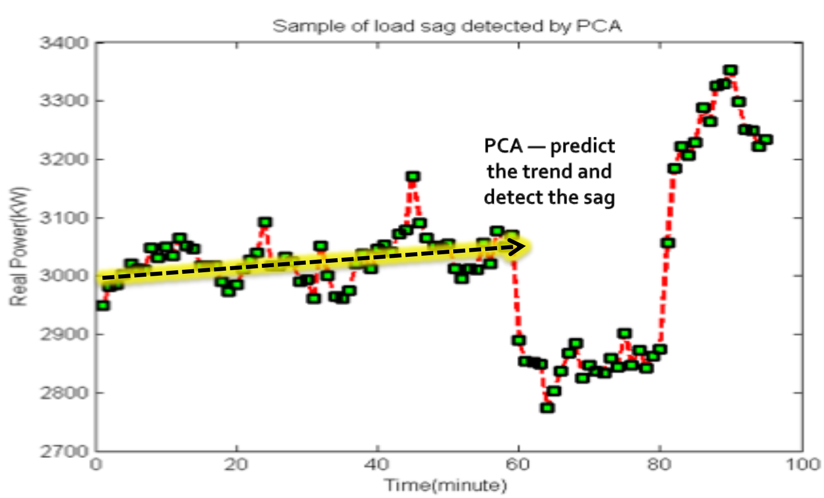
Temperature at MDW (week in Sep)



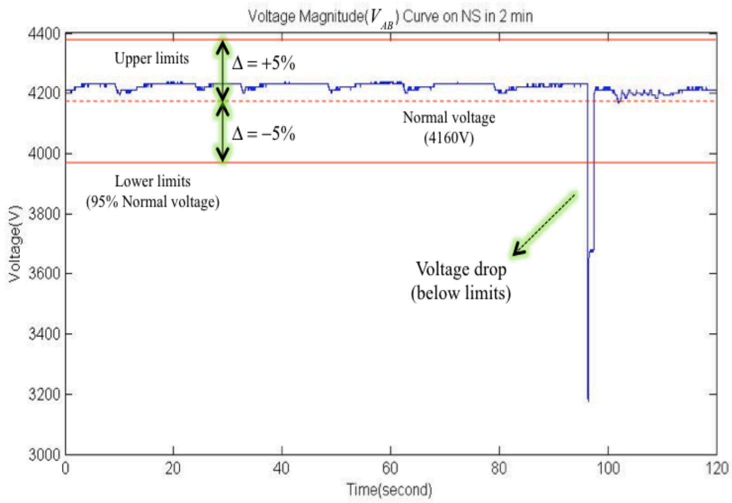
Daily N Sub Power (12 Sep 2012)



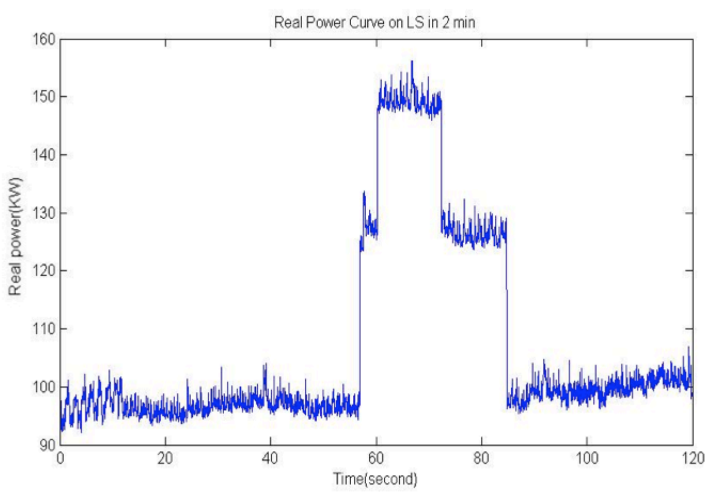
Principal Component Analysis



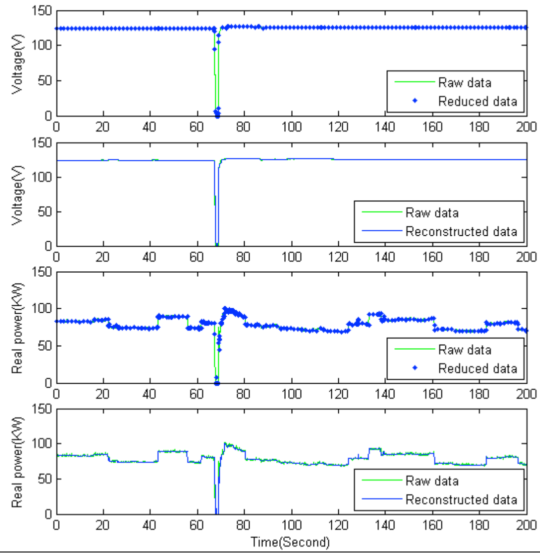
Voltage is Easier? (May want real-time relative limits…)



Power: 4160-208 V Transformer

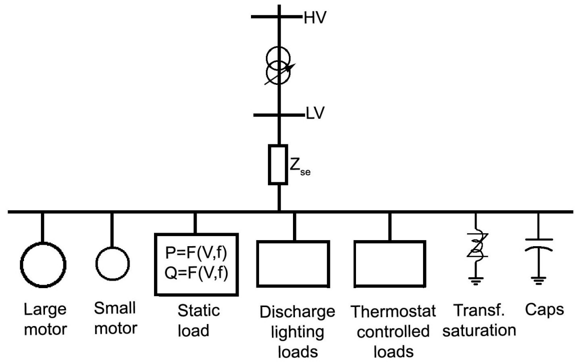


Data Archival – (100x smaller) Event Based Adjustable Sliding Window



Dynamic Load Models – Tough!

- How to know load parameters?



Induction Motor Model

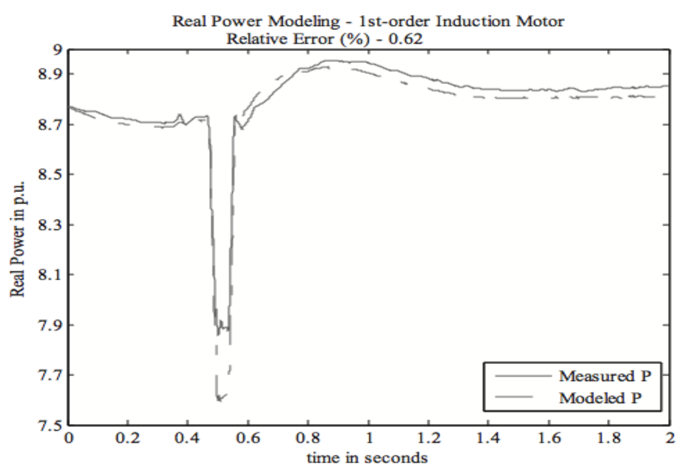
- Linear 1st-order induction motor model with five parameters

$$\Delta P_d + T_{pp}\frac{\mathrm{d}\Delta P_d}{\mathrm{d}t} = K_{pv}\left(\Delta V + T_{pv}\frac{\mathrm{d}\Delta V}{\mathrm{d}t}\right)$$

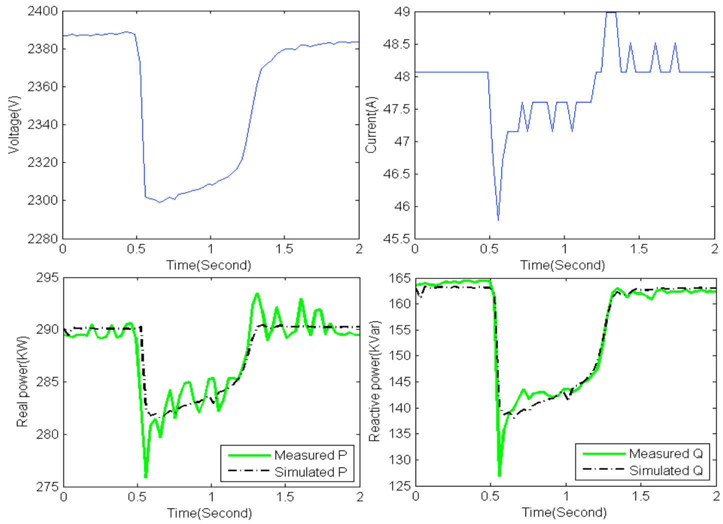
$$\Delta Q_d = K_{qv}\Delta V + K_{qp}\Delta P_d$$

$$\boldsymbol{p} = [T_{pp}, T_{pv}, K_{pv}, K_{qv}, K_{qp}]^{\mathrm{T}}.$$

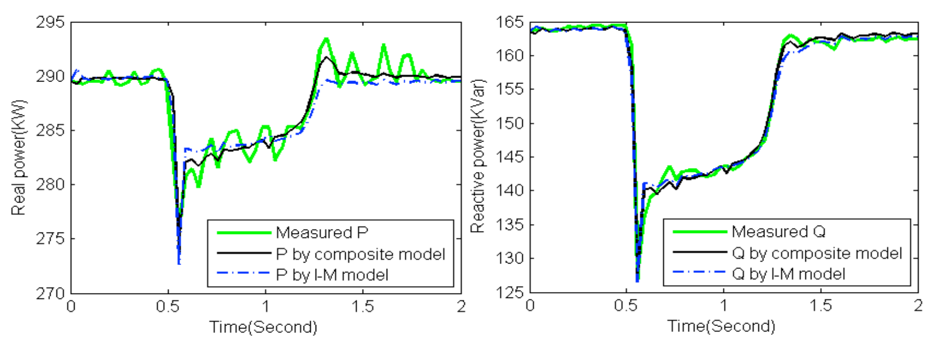
Dynamic Load Model Validation



Static ZIP Load Model (4% V drop)



Dynamic Load Model (4% V drop)



DOE SERT Project

- Analyzing synchrophasor data
  - IIT Microgrid: 4kV cable network, 60 samples/sec
  - Naperville: 34.5 kV distribution, 2 samples/sec
  - ComEd: 345 kV transmission, 30 samples/sec
- Event detection for voltage and power
- Oscillation detection
- Model validation

SEL Equipment

- 351 relays, AMS, clock, PDC, SynchroWAVe Central

Education

- Short course – Introduction to
  - Metrology
  - Instrument transformers
  - A/D conversion
  - Synchrophasor estimation
  - IEEE C37.118
  - PMU hardware
  - Synchrophasor applications

Future of Synchrophasors

- Wide Area Monitoring System (off-line)
  - Post mortem analysis of disturbances
  - Parameter estimation & model validation
- Wide Area Protection and Control (real-time)
  - State estimation
  - Adaptive protection
  - Dynamic stability analysis
  - Wide area voltage and frequency control
  - Higher penetration of renewables
  - Islanding and restoration

Questions?

I hope you found this interesting. Feel free to contact me: flueck@iit.edu