Smart Energy Systems Lab

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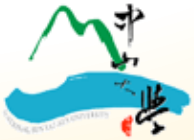
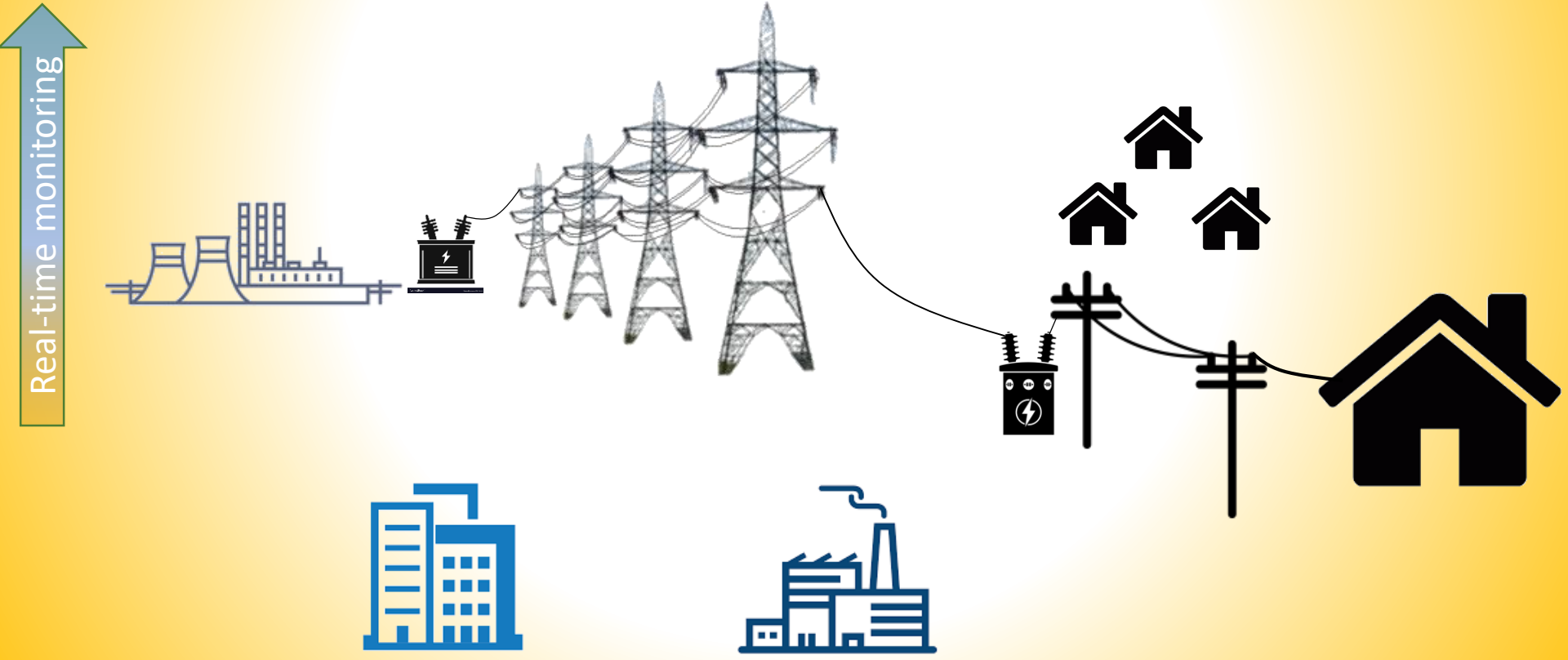
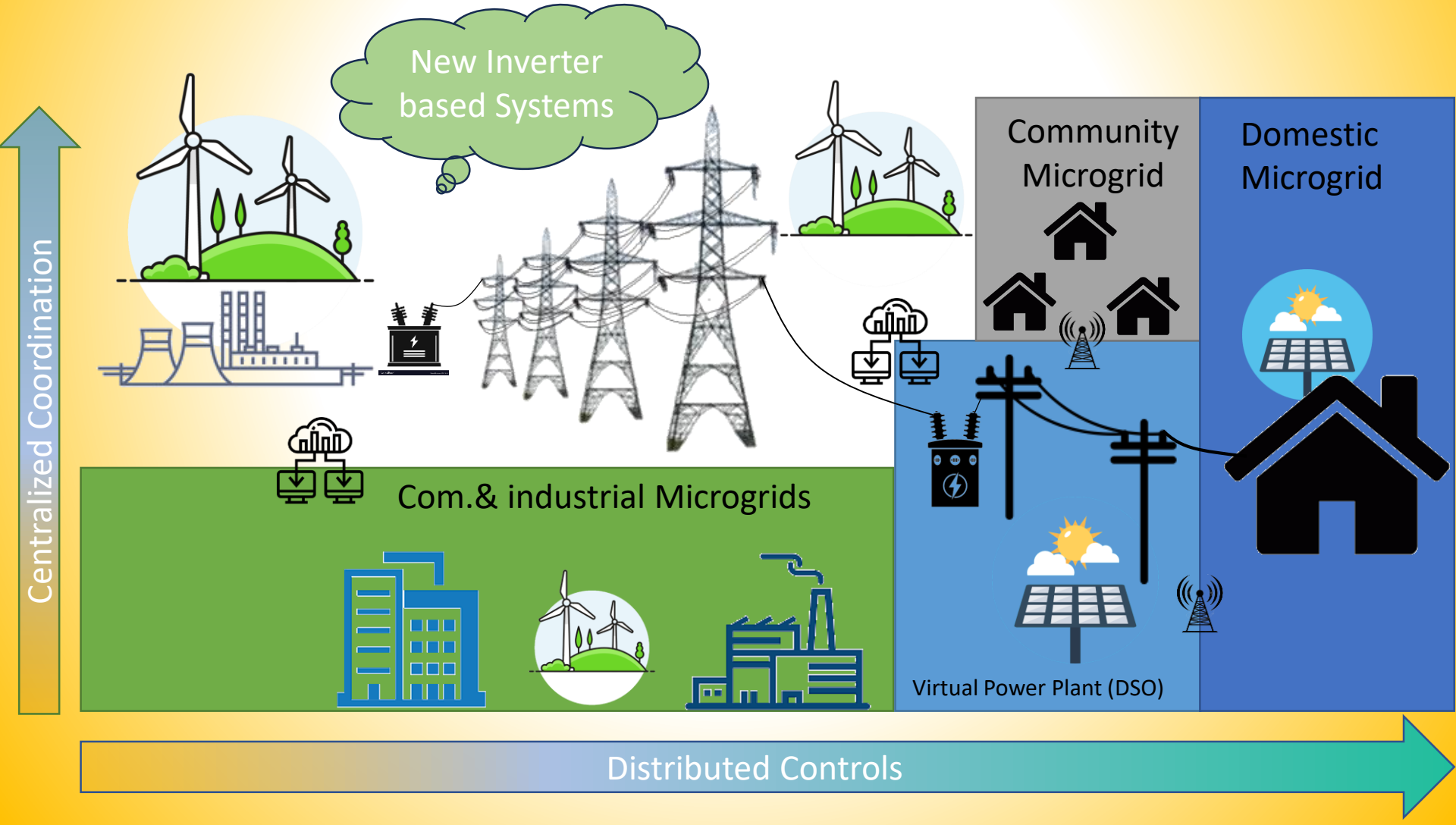


國立中山大學
National Sun Yat-sen University

Conventional power systems

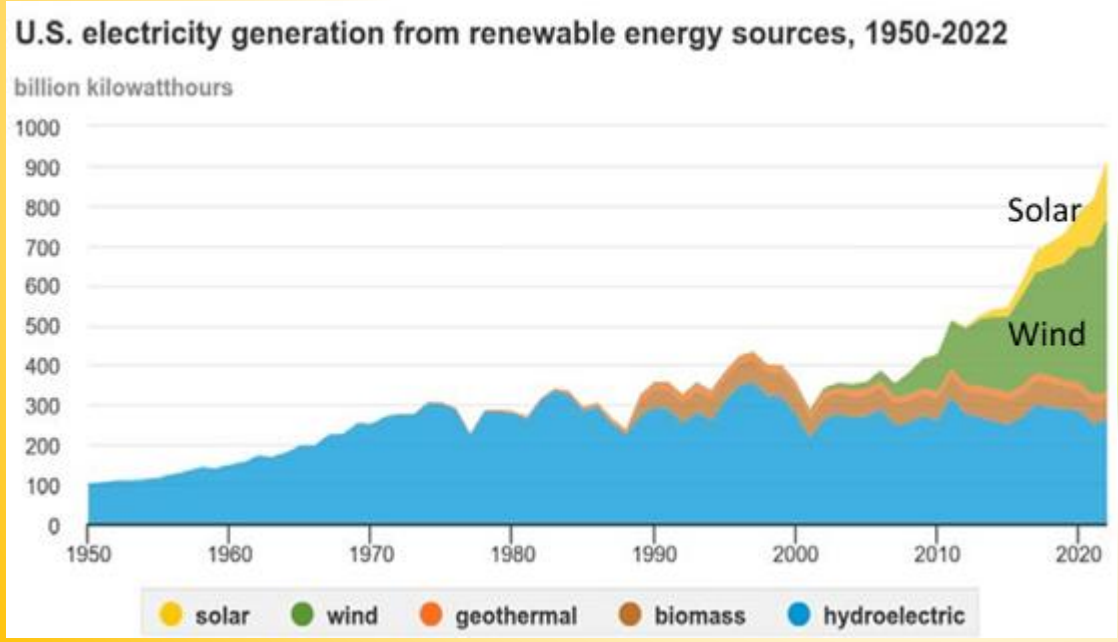


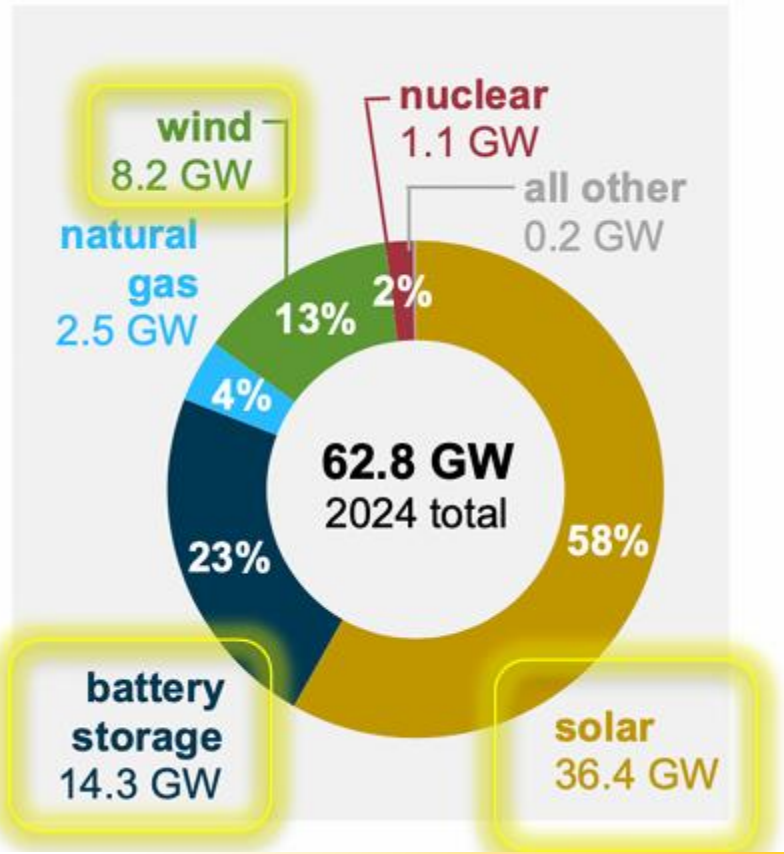
Modern power systems



Inverter Control & Synchronization

- Inverter-based renewable energy will soon become dominant.





Major Research Areas

- Grid interaction and control of inverter-based systems
  - **Synchronization**
  - Grid-forming (GFM) inverter control
- Renewable energy integration issues
  - Transients and dynamic stability
  - Distribution system state estimation
  - Planning

to learn more…
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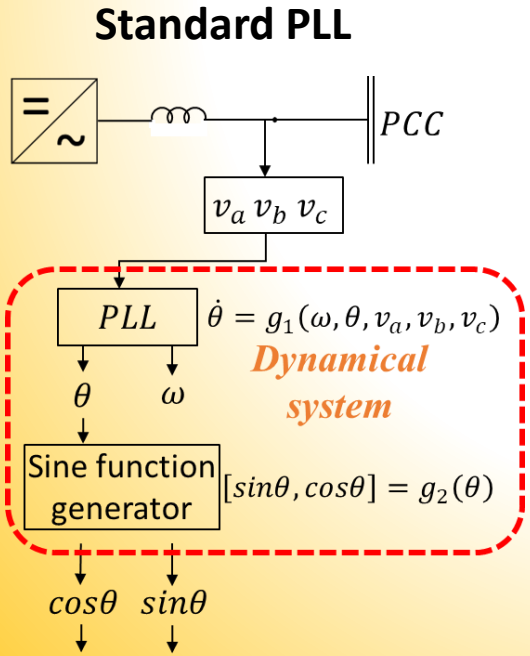
Inverter Control & Synchronization

- Phase locked loop (PLL): Synchronize, track AC voltage phase.
- Park transformation: Converts AC voltage & current to equivalent DC quantities.

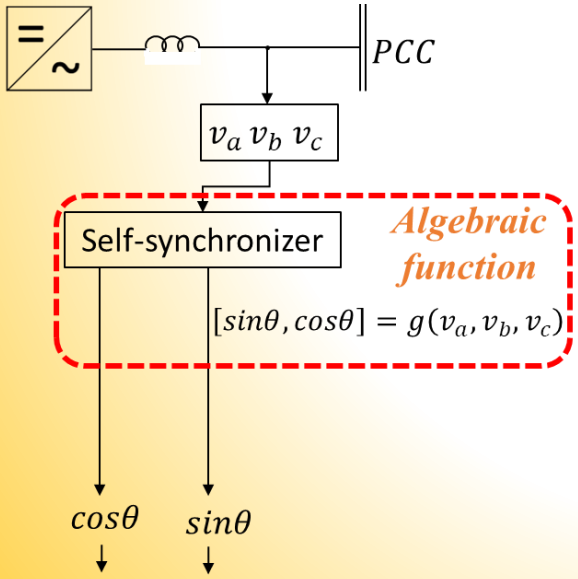


$$v_{abc} \Rightarrow \omega \Rightarrow \theta \Rightarrow \sin\theta\,, \cos\theta \Rightarrow \underbrace{\mathbf{P}(\sin\theta\,, \cos\theta)}_{Park\ trans.matrix}$$

Inverter Control & Synchronization

- Self-sychronizer: Synchronize, track AC voltage phase. More stable compared to PLL.

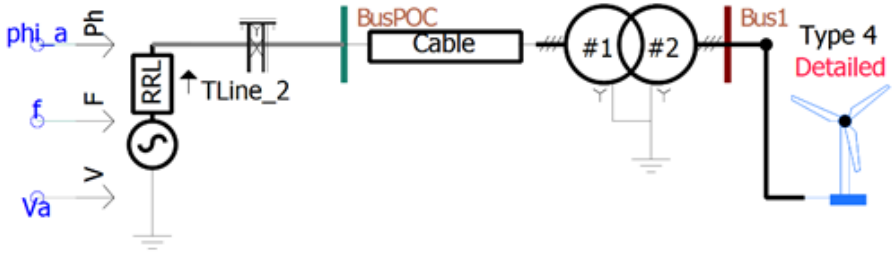
Proposed Self-sync method



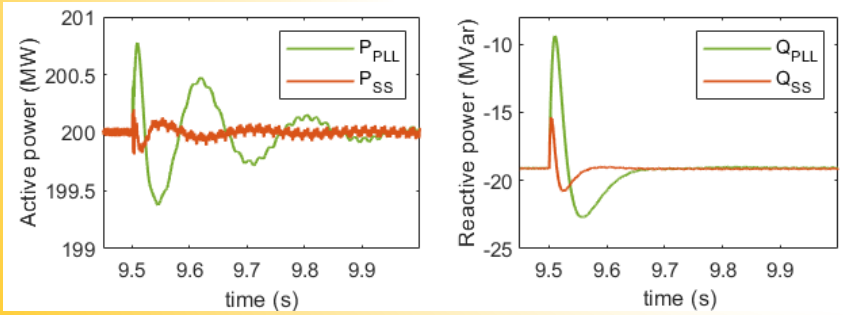
$$v_{abc} \Rightarrow \sin\theta\,, \cos\theta \Rightarrow \underbrace{\mathbf{P}(\sin\theta\,, \cos\theta)}_{Park\ trans.matrix}$$
$$\Rightarrow \theta$$
$$\Rightarrow \omega$$

Inverter Control & Synchronization

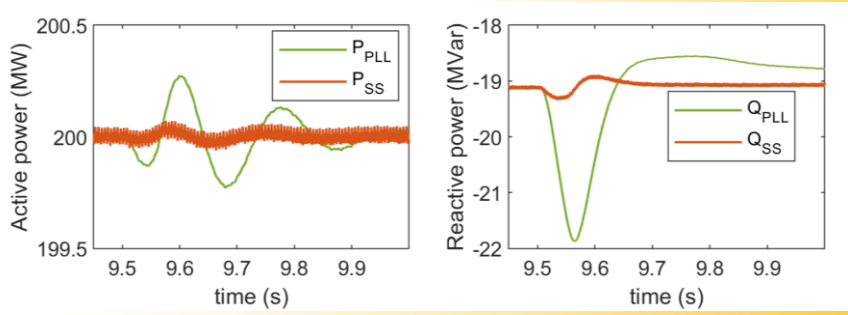
- Self-sychronizer: Synchronize, track AC voltage phase. More stable compared to PLL.



Type-4 wind turbine system control.



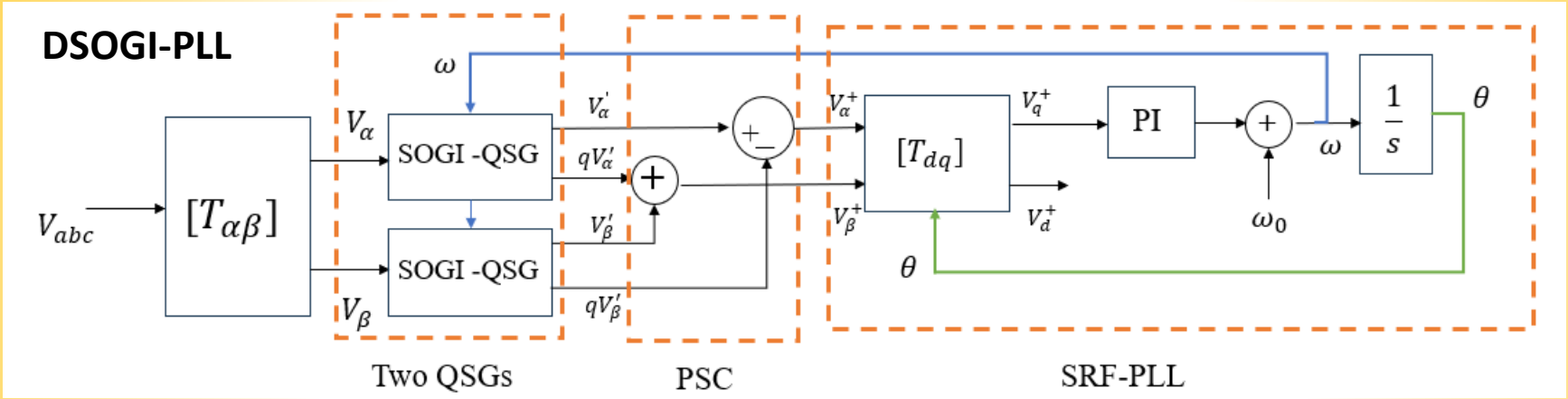
Active and reactive power output deviations observed following a 10° phase jump event when using the PLL-method and SS-method.



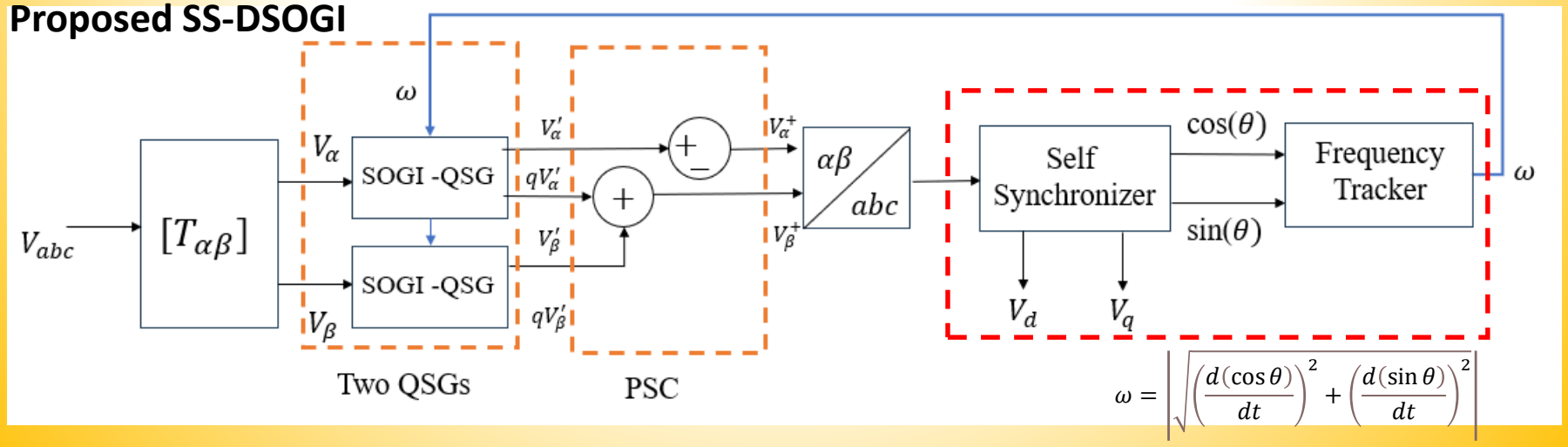
Active and reactive power output deviations observed following a 0.5Hz frequency drop event when using the PLL-method and SS-method.

Inverter Control & Synchronization

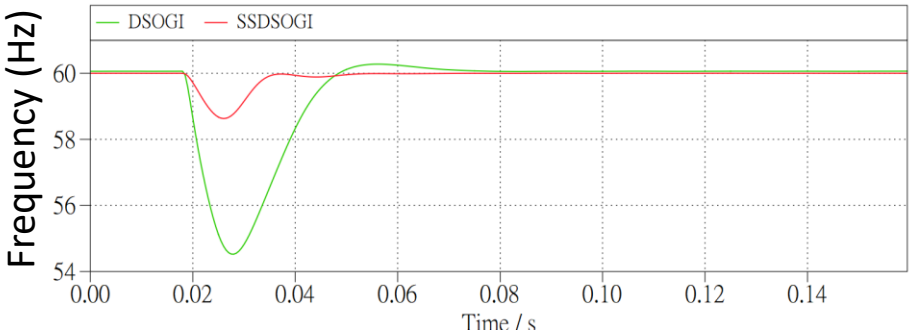
DSOGI-PLL



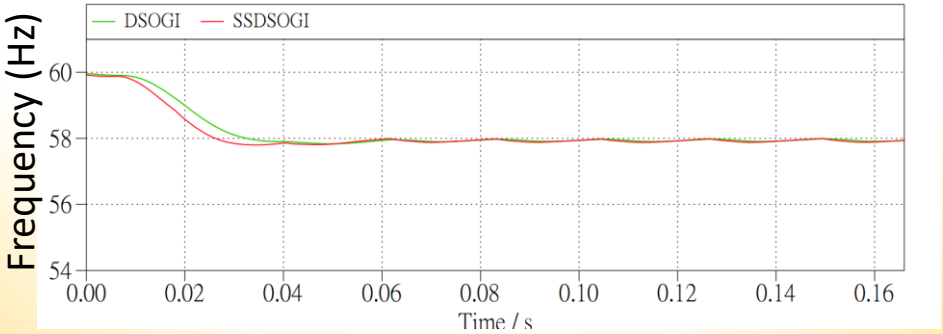
Proposed SS-DSOGI



Inverter Control & Synchronization



Estimated frequency after **30° phase jump** event at 0.02s when using the DSOGI-method and SS-DSOGI method.



Estimated frequency after following a **2Hz frequency drop** event when using the DSOGI-method and SS-DSOGI method.

Major Research Areas

- Grid interaction and control of inverter-based systems
  - Synchronization
  - Grid-forming (GFM) inverter control
- Renewable energy integration issues
  - Transients and dynamic stability
  - **Distribution system state estimation**
  - Planning

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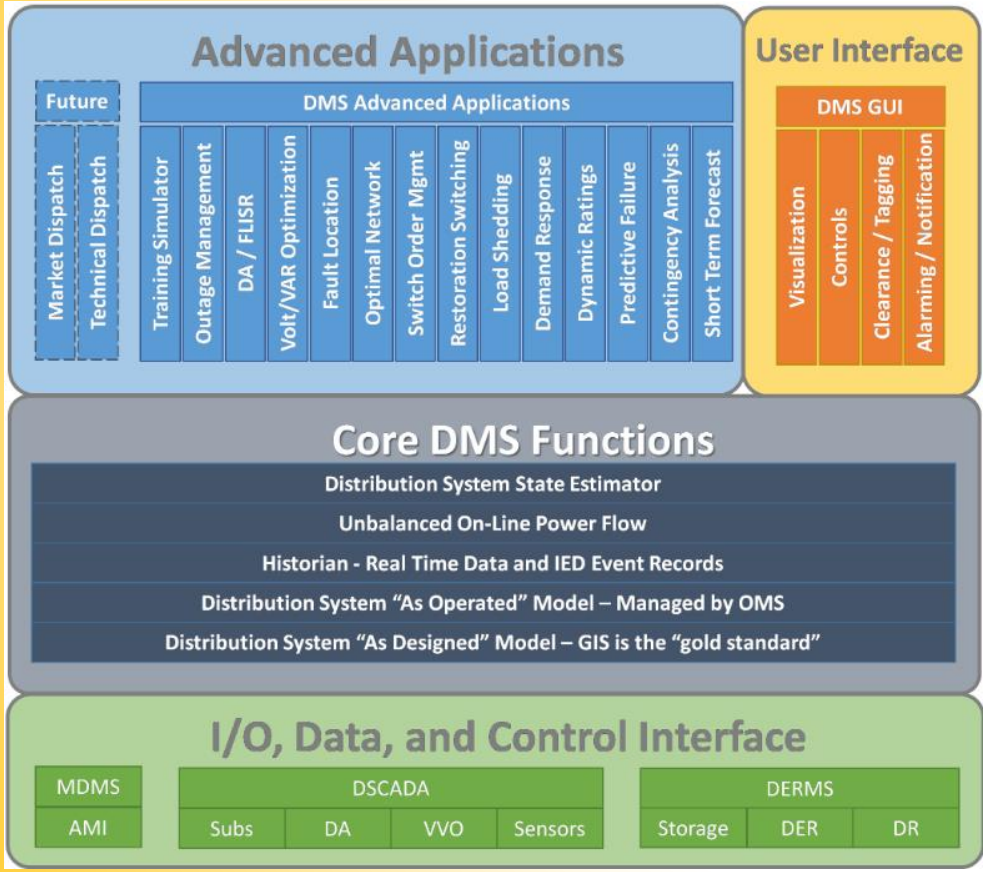
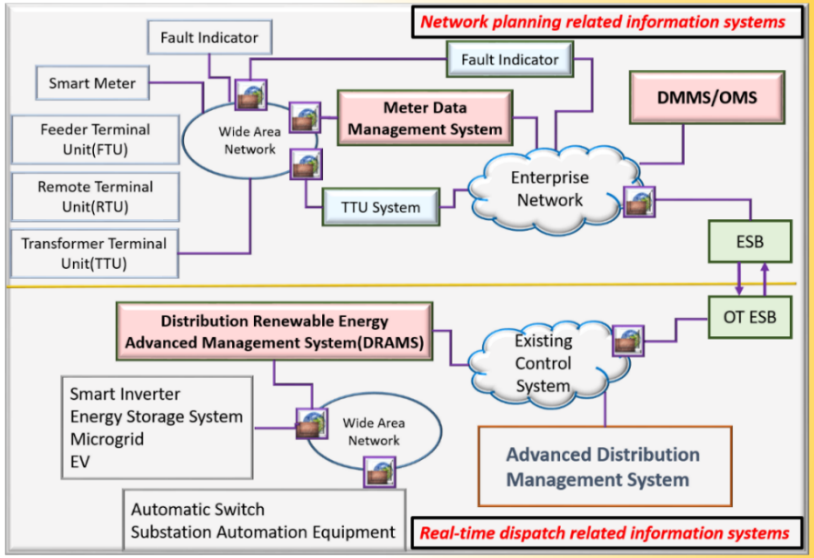
Distribution System State Estimation



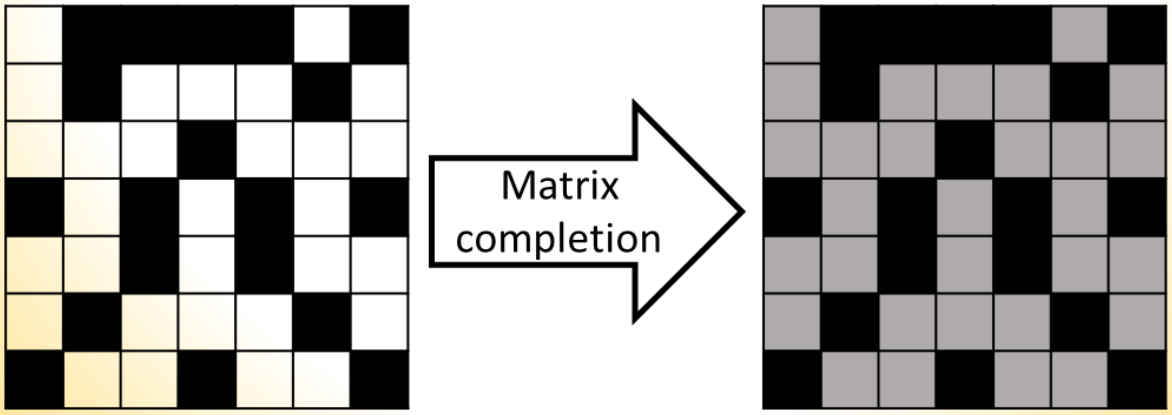
Distribution management system architecture and core functions.



Measurement data sources in TPC's active distribution network..

Distribution System State Estimation

- How to find the actual states using the available noisy measurements?
- Matrix completion: A low-rank optimization-based method to guess the missing pixels of in an image.



Distribution System State Estimation

- How to find the actual states using the available noisy measurements?
- Matrix completion: A low-rank optimization-based method to guess the missing pixels of in an image.

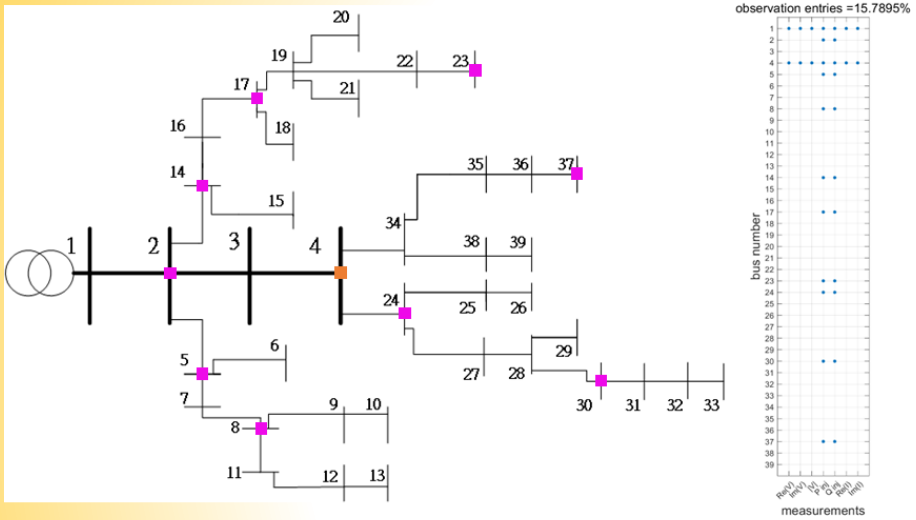
A snapshot of the distribution system

	$\Re(v_f)$	$\Im(v_f)$	$\lvert v_f \rvert$	$\Re(s_f)$	$\Im(s_f)$	$\Re(v_t)$	$\Im(v_t)$	$\lvert v_t \rvert$	$\Re(s_t)$	$\Im(s_t)$	$\Re(I_{ft})$	$\Im(I_{ft})$
1_a												
1_b												
1_c												
2_a												
2_b												
2_c												
3_a												
3_b												
3_c												
⋮												
m_a												
m_b												
m_c												

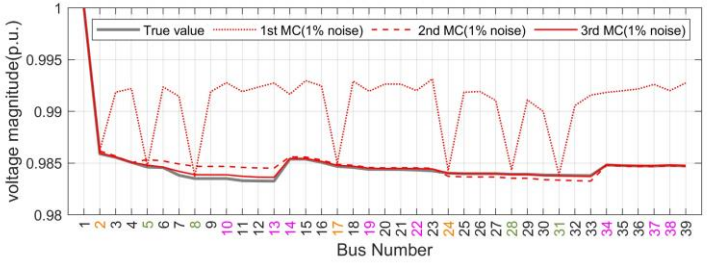
Each cell represents a pixel

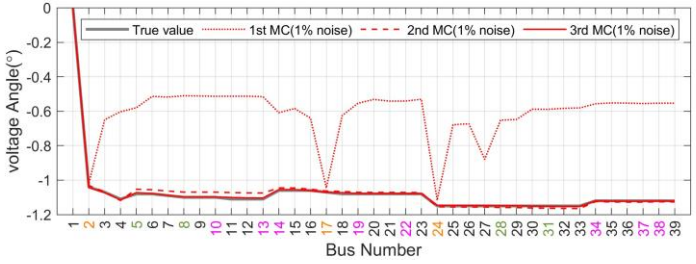
Value of each pixel represents the color

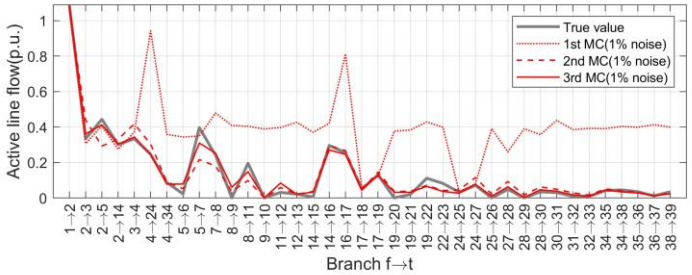
Distribution System State Estimation

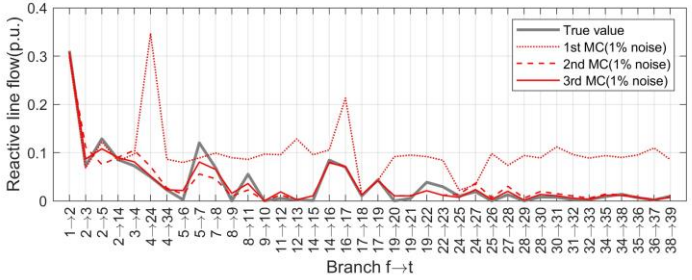


- Solving matrix completion with Iterative model fitting give good estimation performance even with very low measurements (~15%)









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- Visit the Smart Energy Systems Lab located in EC8016-1

- Send an email to mohdmanaz@mail.ee.nsysu.edu.tw

Thank You!