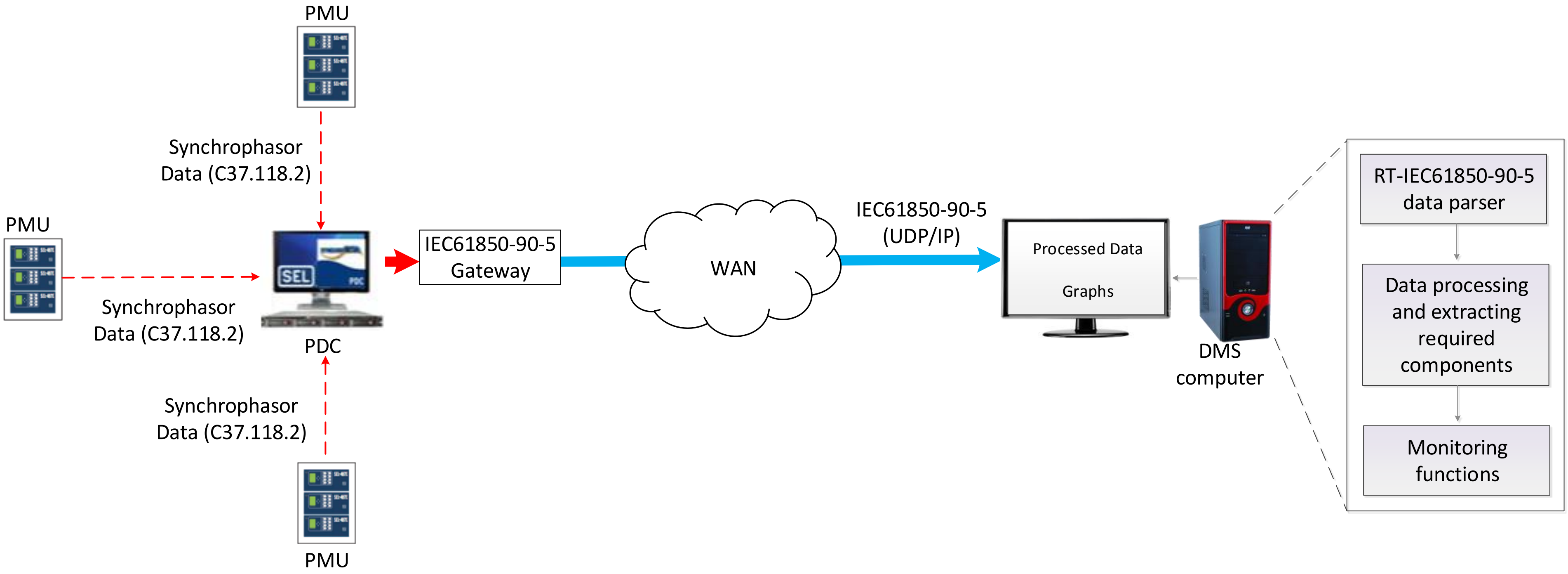
Interfacing TSOs and DSOs via PMU-based information exchange

Data Flow


PMU
Synchrophasor Data (C37.118.2)
PMU
Synchrophasor Data (C37.118.2)
PDC
Synchrophasor Data (C37.118.2)
PMU
IEC61850-90-5 Gateway
WAN
IEC61850-90-5 (UDP/IP)
Processed Data
Graphs
DMS computer
RT-IEC61850-90-5 data parser
Data processing and extracting required components
Monitoring functions

IEC 61850-90-5 Gateway

for

IEEE C37.118.2 Synchrophasor Data Transfer

- ***Theory:***
  - **IEEE C37.118** → Synchrophasor data transfer by exchange of 4 types of messages:
    1. Data, 2. Configuration, 3. Header and 4. Command Frames
  - **IEC 61850-90-5** → PMU data (Based on C37.118) mapped to *IEC 61850 Data Model*

  → Communication mechanism: *Routed-Sampled Value* and *Routed-GOOSE* → Multicast *UDP/IP*

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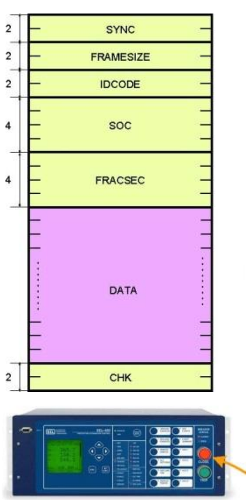
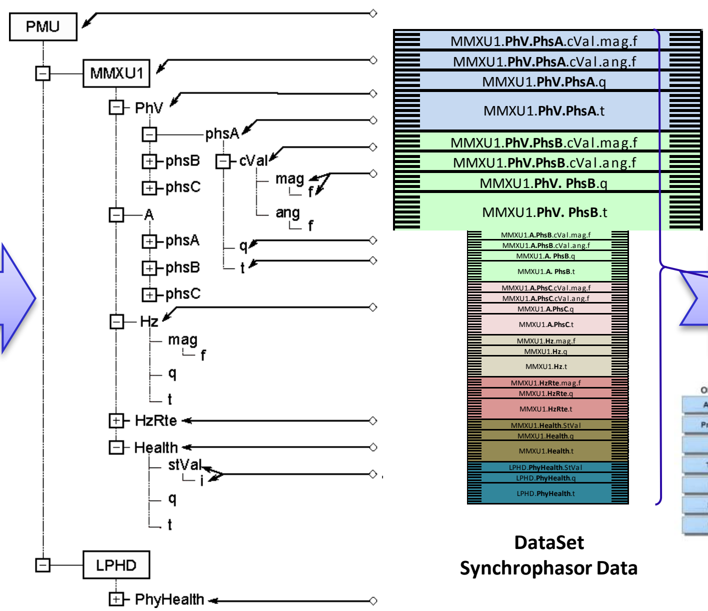
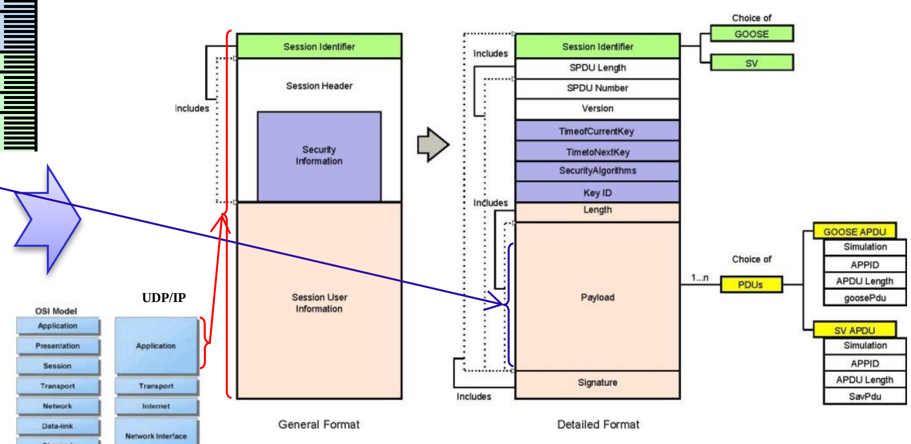
(1) IEEE C37.118 PMU Data → (2) IEC 61850 Data Model & Dataset → (3) IEC 61850 Routed-Sampled Value / GOOSE Publisher and (4) Subscriber



Connection with PMU Based on IEEE Std C37.118



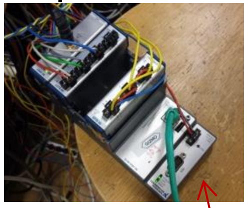
DataSet Synchrophasor Data

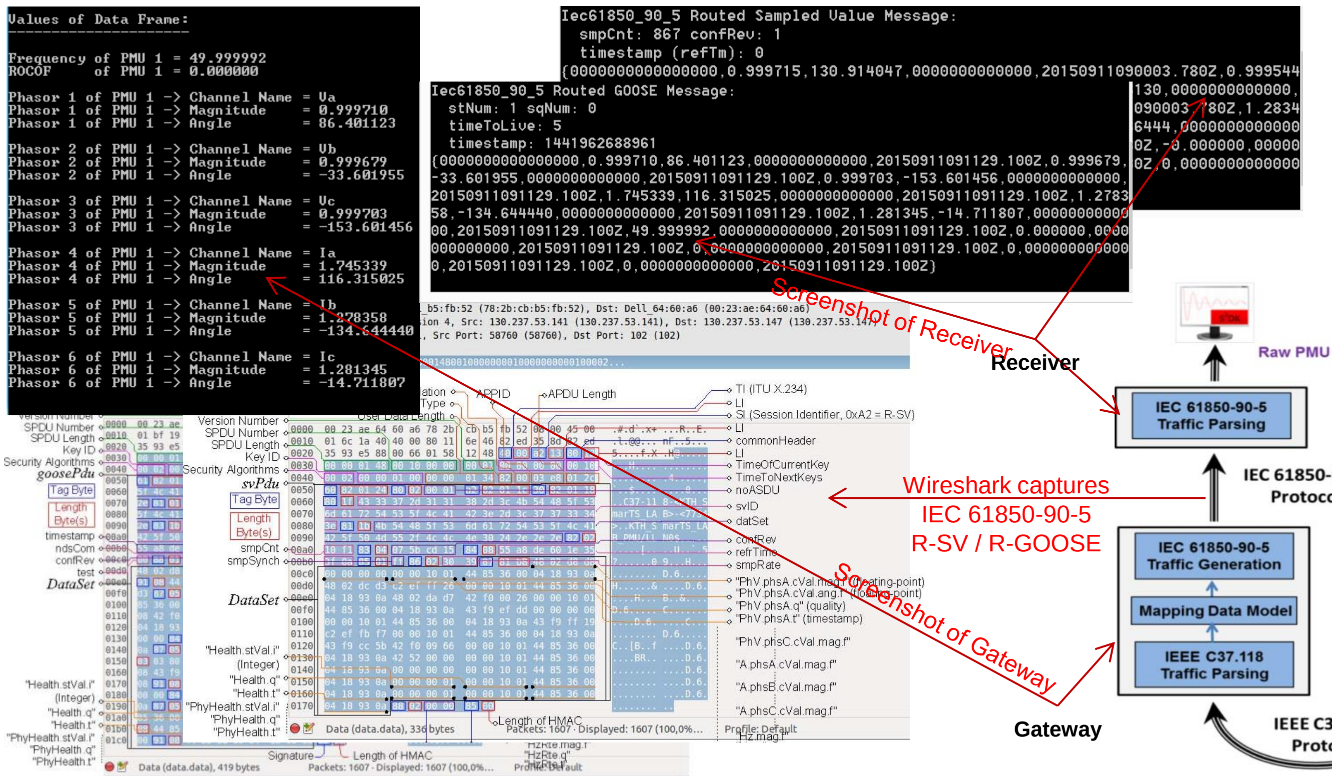


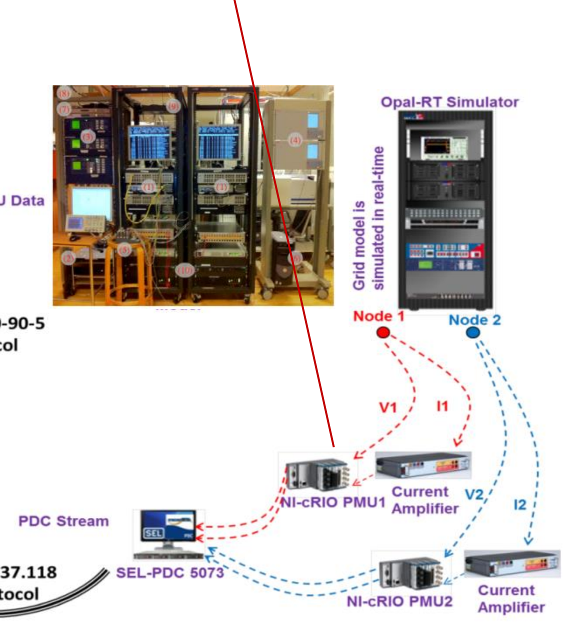
IEC 61850-90-5 frame specification

- ***Implementation and Results***
  - ***HIL Real-time simulation → SmarTS Lab***
    - Conformance of the functionality of the library with the requirements of IEEE C37.118.2 and IEC 61850-90-5 is validated.

National Instrument CompactRIO → PMU



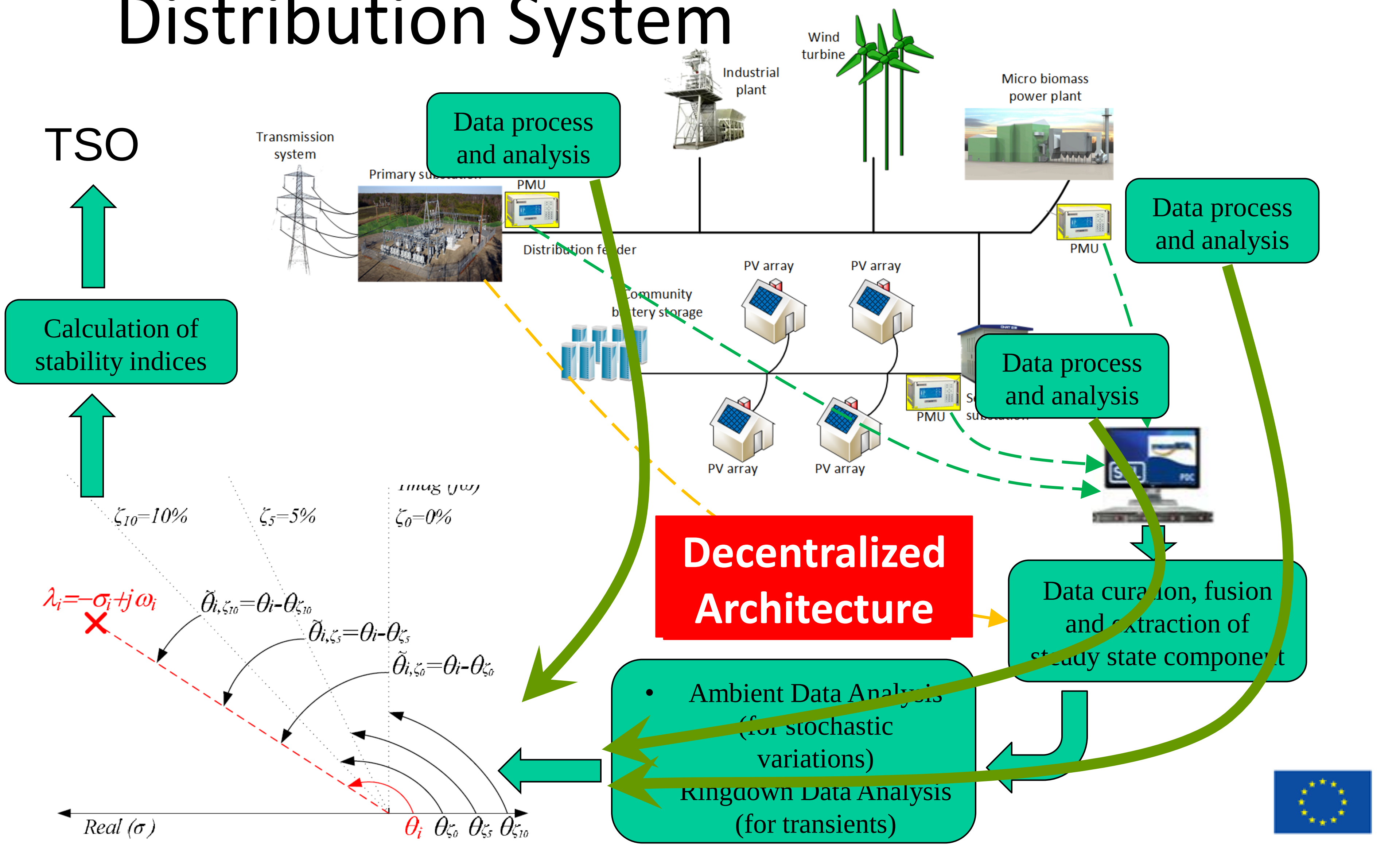




Applications

Providing Dynamic Information

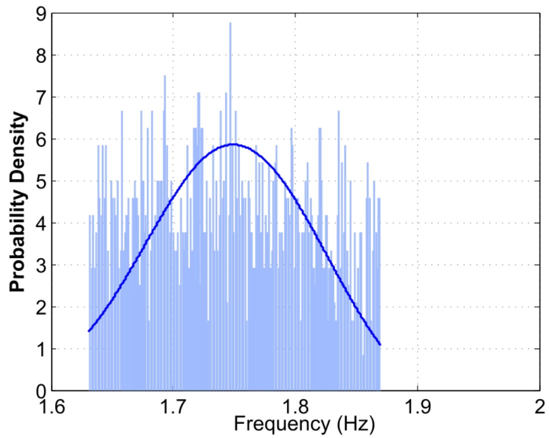
Dynamic Model Synthesis of Distribution System



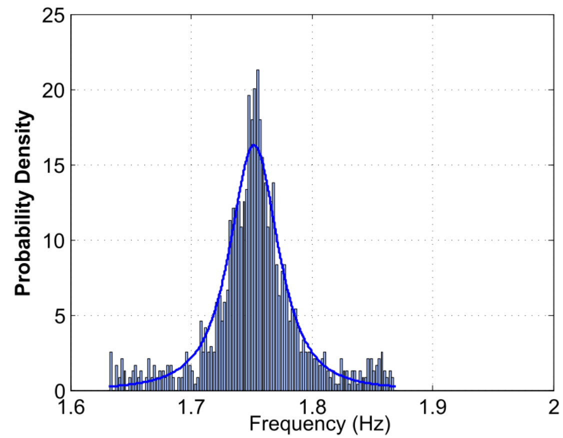
Centralized vs decentralized architecture (better observability)

Decentralized Mode Estimation

Better observability of local modes by using Decentralized Mode Estimation Architecture!

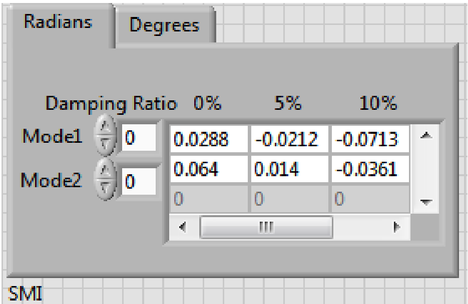


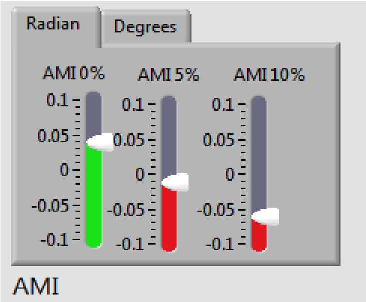
Centralized Mode Estimation (4 PMUs)

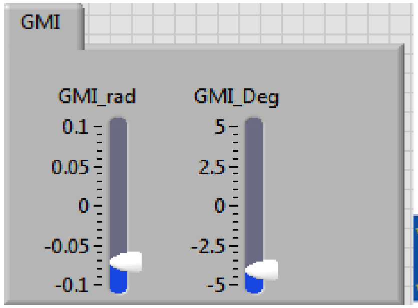


Decentralized Mode Estimation (PMU ID: 4)

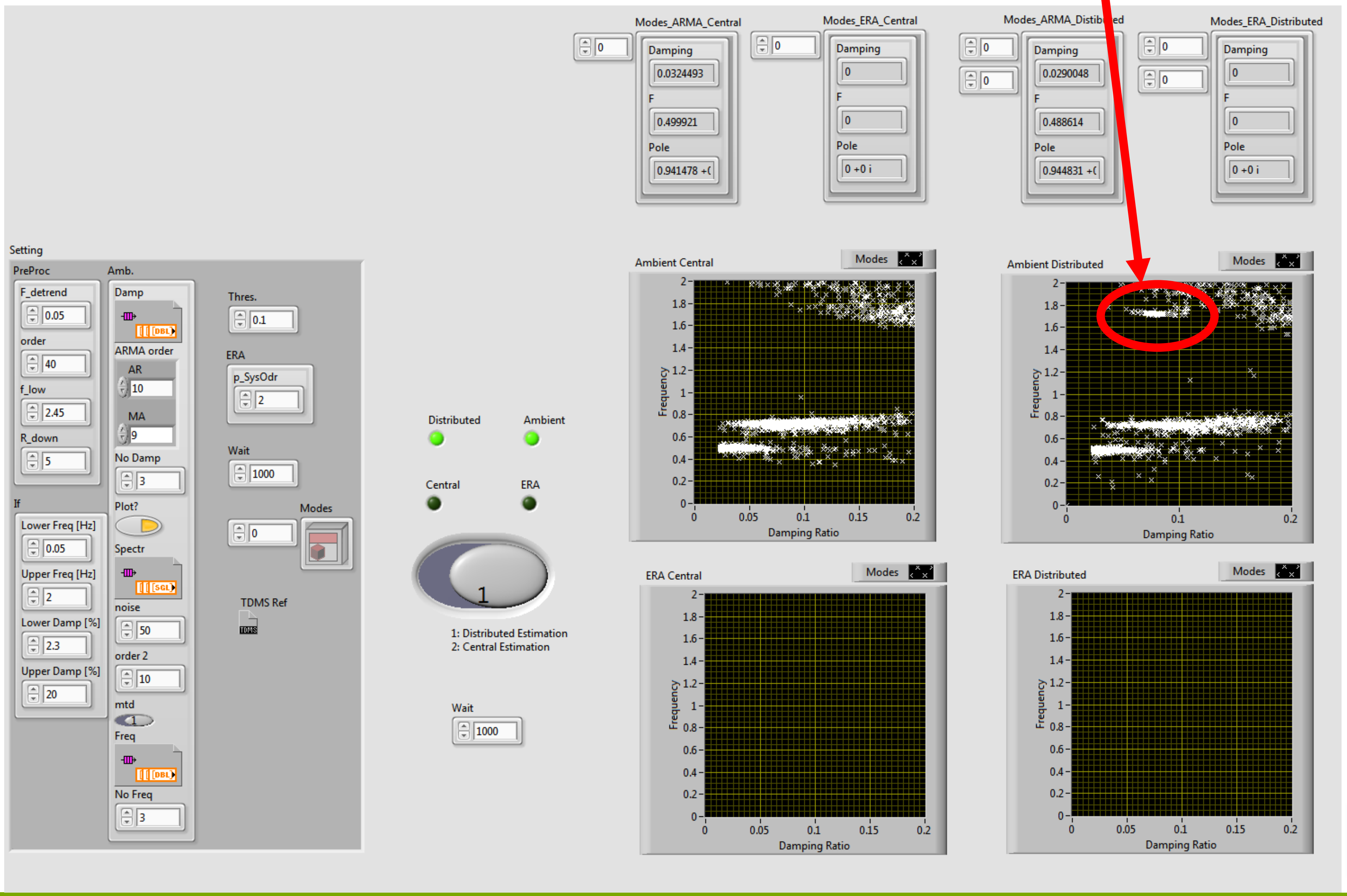
Dynamic Stability Indices





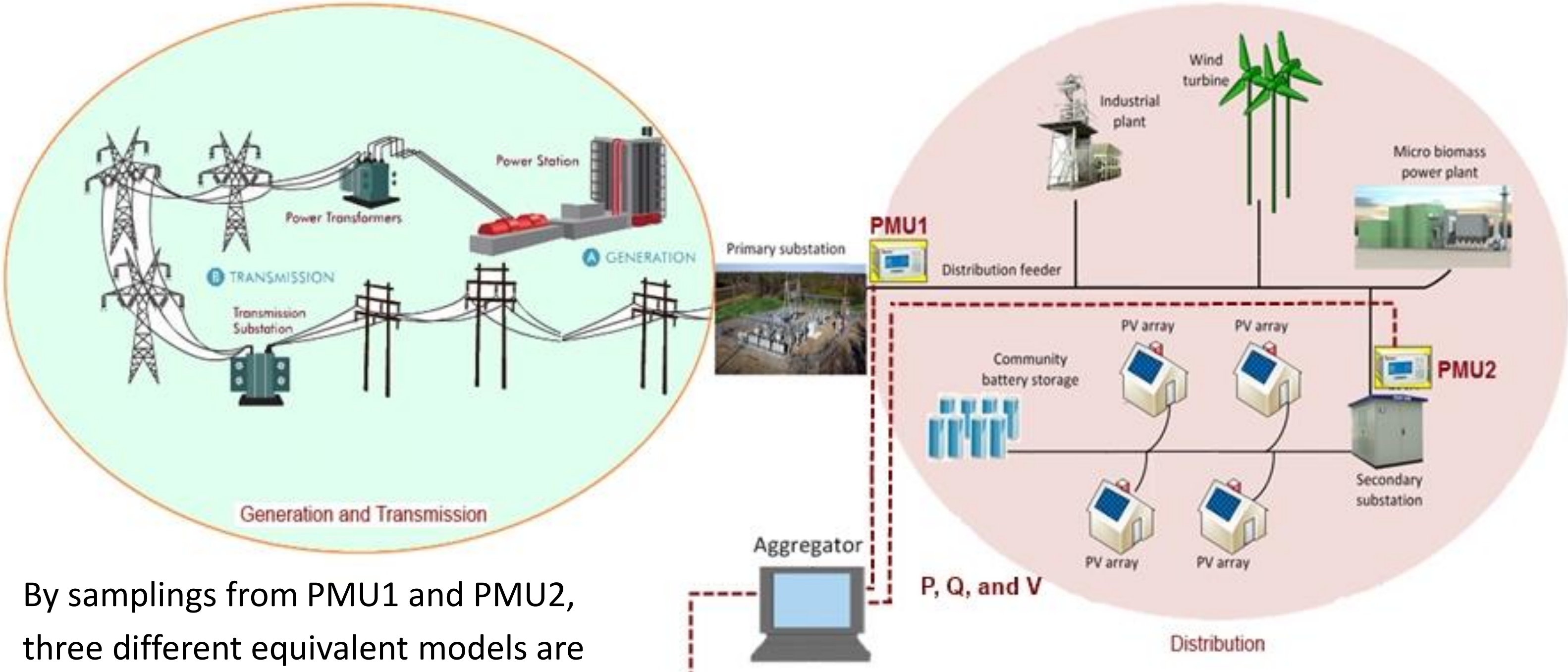


Centralized vs decentralized architecture (local mode visibility)

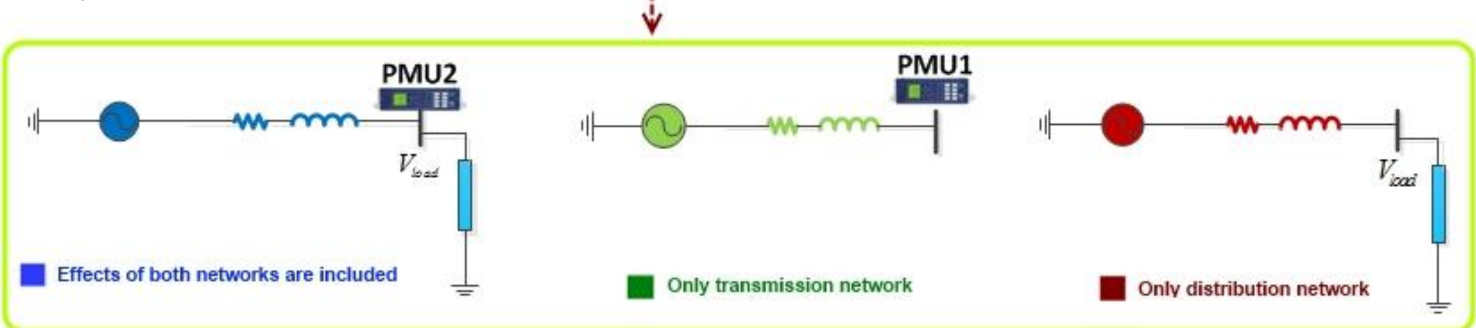


Voltage Stability Analysis in Distribution Networks

Computation of stability indicators based on real-time measurements and equivalent models.

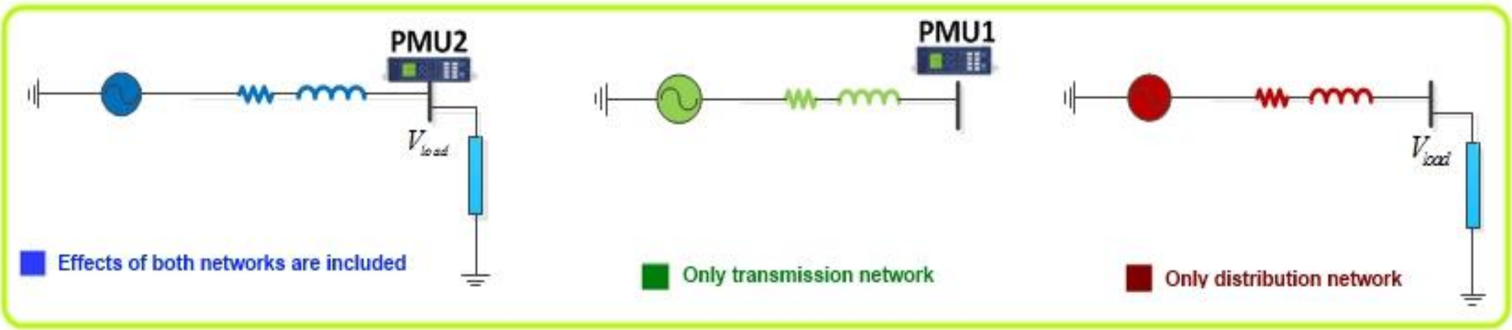


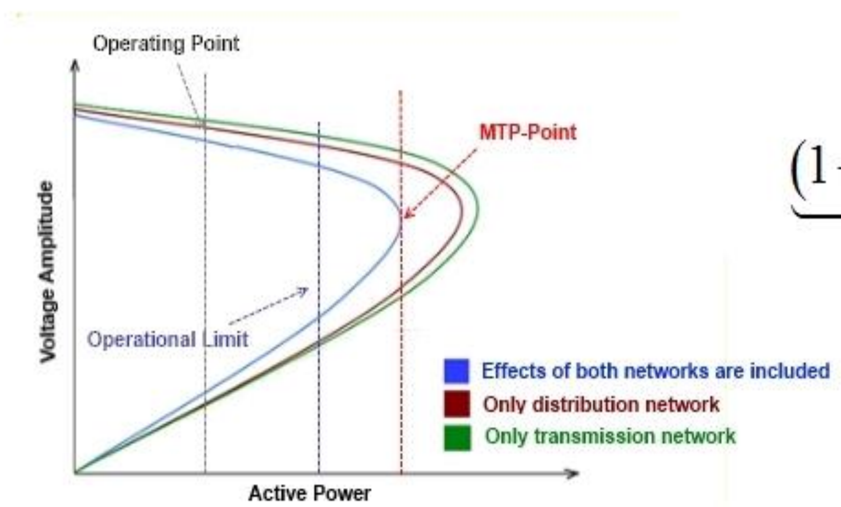
By samplings from PMU1 and PMU2, three different equivalent models are developed



Three different PV curves are calculated from the three models.

The voltage stability and instability indices are calculated from these models to indicate the contributions of two networks on the voltage stability.

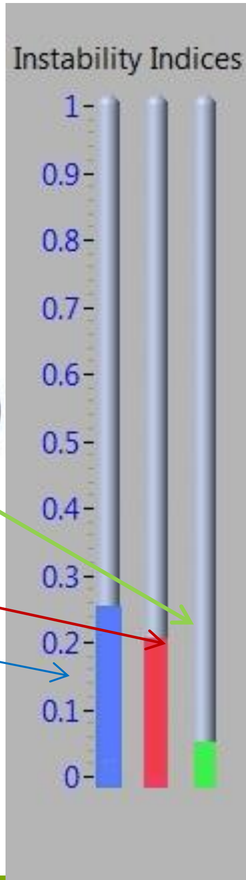




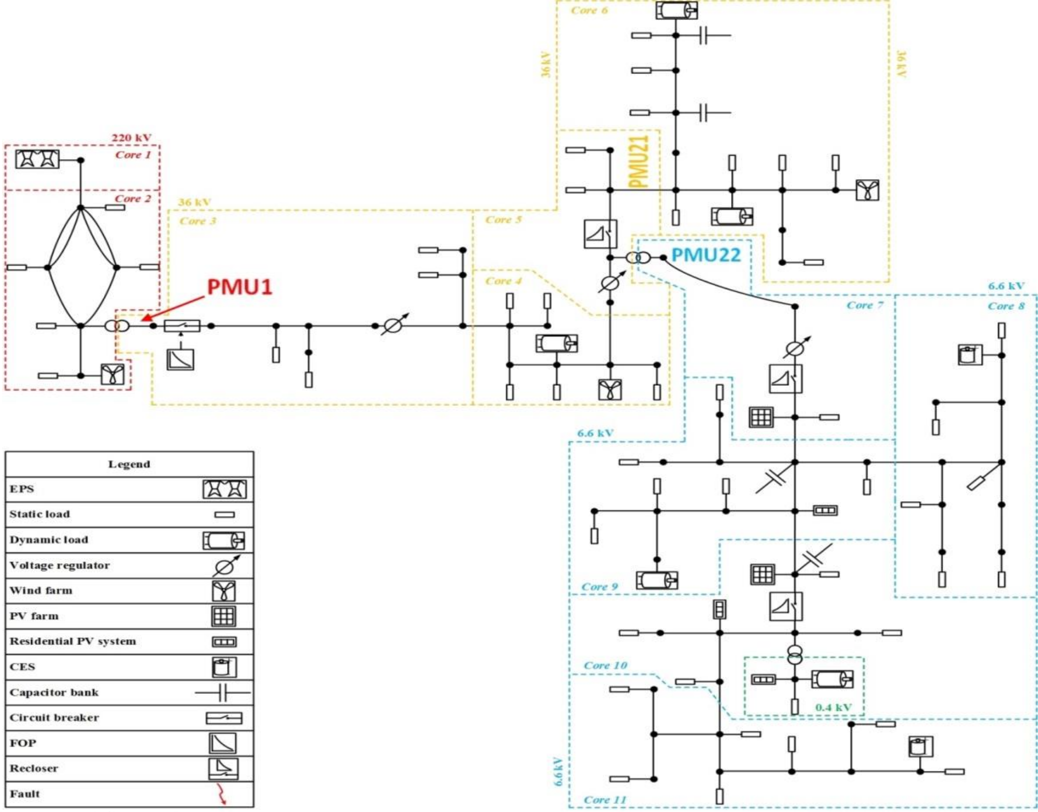
$$\underbrace{(1 - VSI_{total})}_{VISI_{total}} = \underbrace{(1 - VSI_{dist.})}_{VISI_{dist.}} + \underbrace{(1 - VSI_{trans.})}_{VISI_{trans.}}$$

$VSI =$ Voltage Stability Index

$VISI =$ Voltage Instability Index



LABVIEW Application



Real-time simulations results for aggregated load (LV network) seen from PMU22:

A. all distributed generations inside MV network are disconnected

B. all distributed generations inside MV network are connected