Smart Grid & WAMS

Women in Engineering/ Young Professional opening talk
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Outline of Presentation

- Smart Grid
  - Why do we need Smart Grid?
  - What is Smart Grid?
  - Smart Grid conceptual model
- Wide Area Monitoring systems
  - What is WAMs
  - WAMS Architecture
- Applications of Phasor Measurement Unit (PMU)
- Concluding Remarks

Why Smart Grid?

As the world's electricity systems face a number of challenges such as

- New dynamics of future demand and supply
- Ageing infrastructure
- Complex interconnected grids
- Integration of large number of renewable generation sources
- Need to lower carbon emissions
- New type of loads such as Electric Vehicles

Definition

A Smart Grid is self-healing, enables active participation of consumers, operate resiliently against attack and natural disasters, accommodate all generation and storage options, enable introduction of new products, services and markets, optimize asset utilization and operate efficiently, provide power quality for the digital economy.

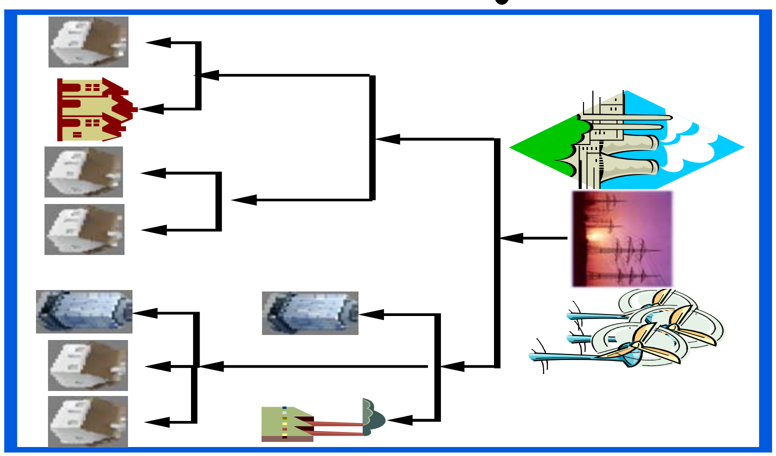
Source: US Department of Energy

A Smart Grid is an electricity network that can intelligently integrate the actions of all users connected to it – generators, consumers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies.

Source: European Technology Platform Smart Grids

Evolution of grid design : From traditional to future grids

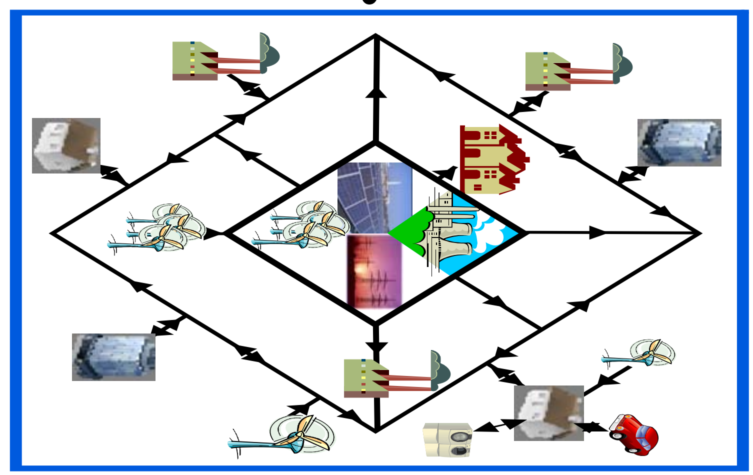
traditional grids



- Centralized power generation
- One-directional power flow
- Generation follows load
- Operation based on historical experience
- Limited grid accessibility for new producers

(Source: ABB Smart grid)

future grids



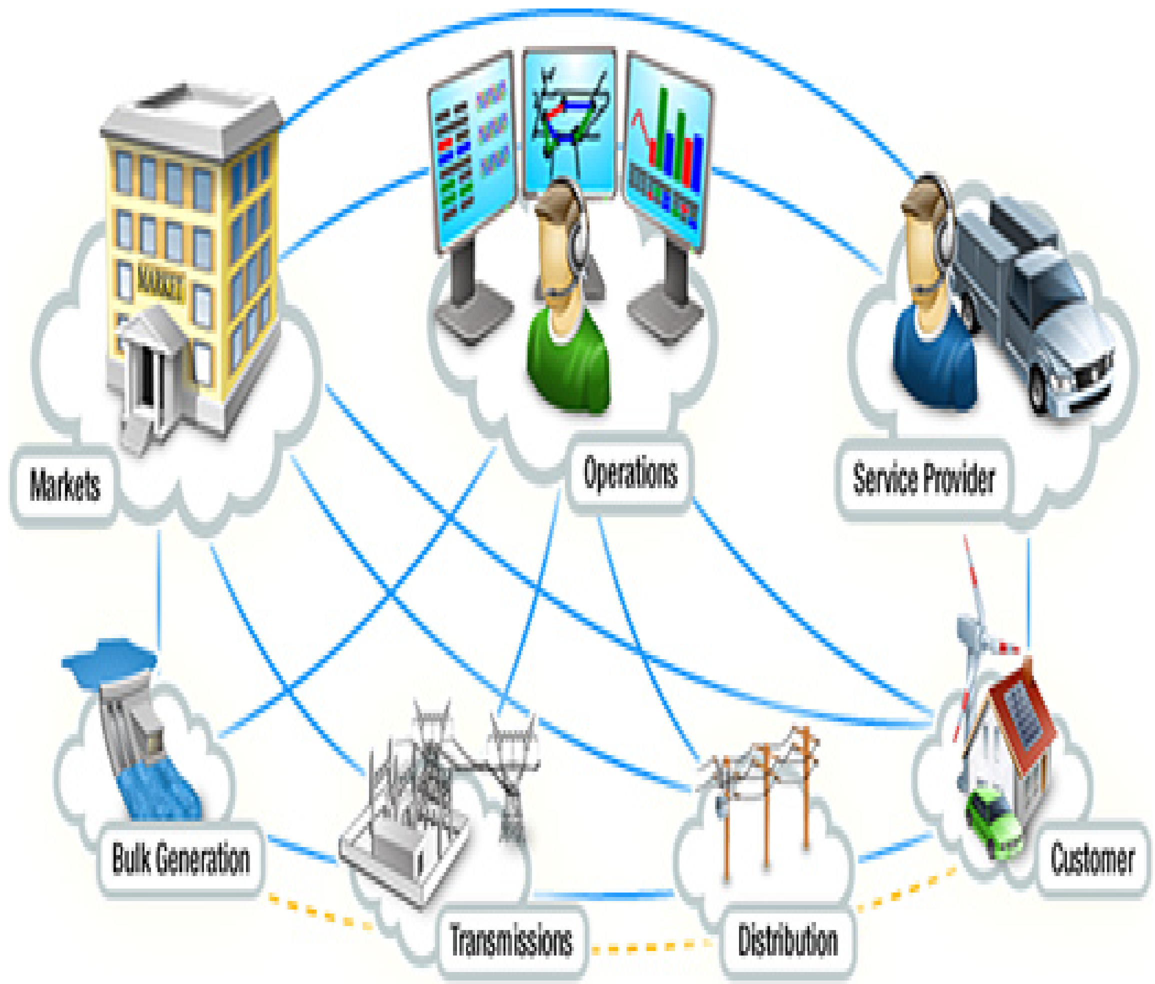
- Centralized and distributed power generation
- Intermittent renewable power generation
- Consumers become also producers
- Multi-directional power flow
- Load adapted to production
- Operation based more on real-time data

Smart Grid - A large "System of Systems”

Smart Grid Conceptual Model

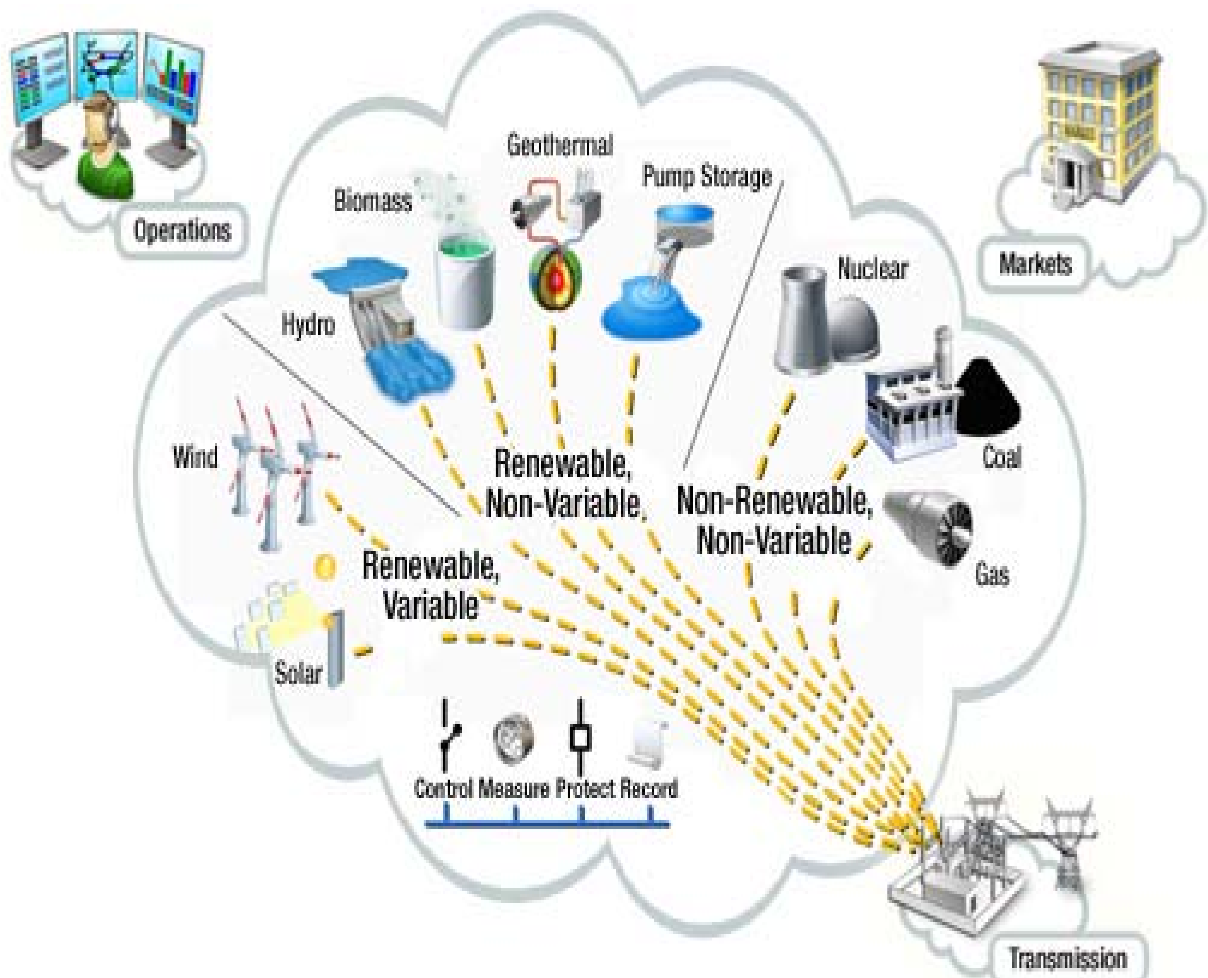
- Bulk Generation
- Transmission
- Distribution
- Customers
- Operations
- Markets
- Service Providers

(Source : IEEE Smart grid)



Bulk Generation

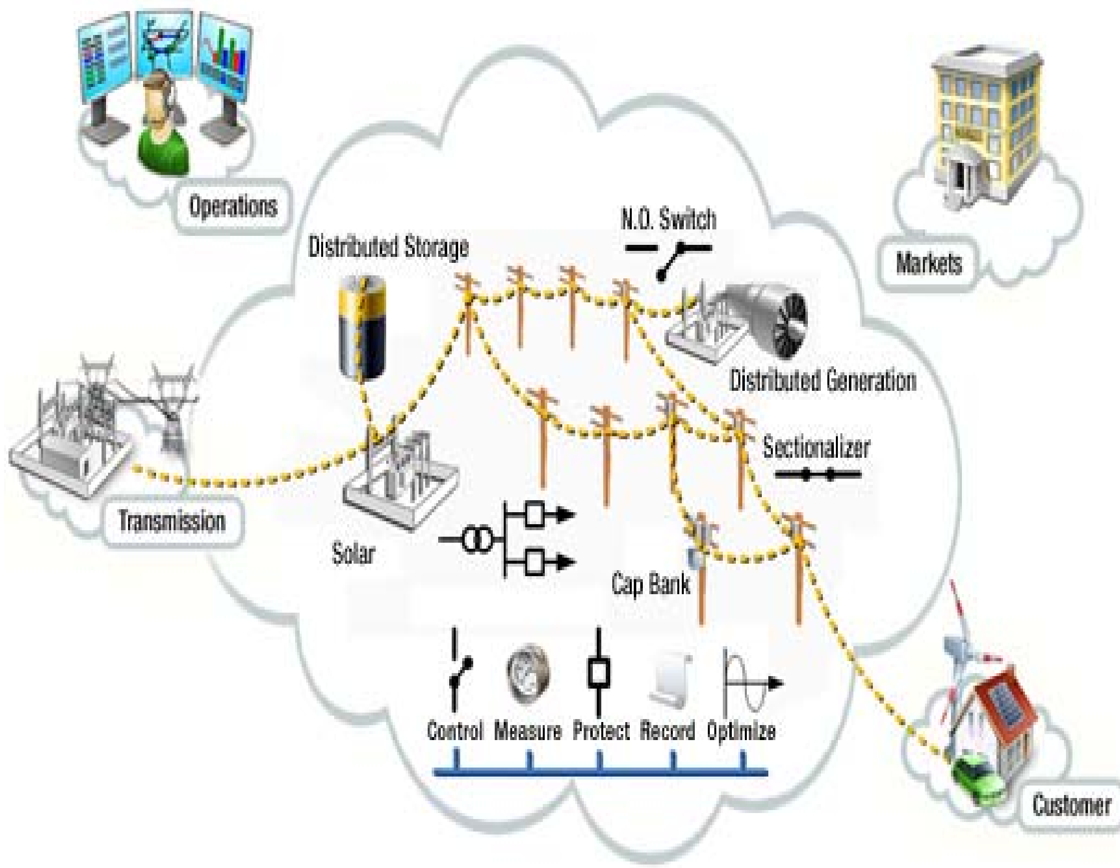
- ✓Renewable sources
  - ❖Variable
    - ❑Solar
    - ❑Wind
  - ❖Non-variable
    - ❑Hydro
    - ❑Biomass
    - ❑Geothermal
    - ❑Pump Storage
- ✓Non-renewable sources
  - ❖Non-variable
    - ❑Nuclear
    - ❑ coal
    - ❑ gas.



Distribution Domain

Distribution

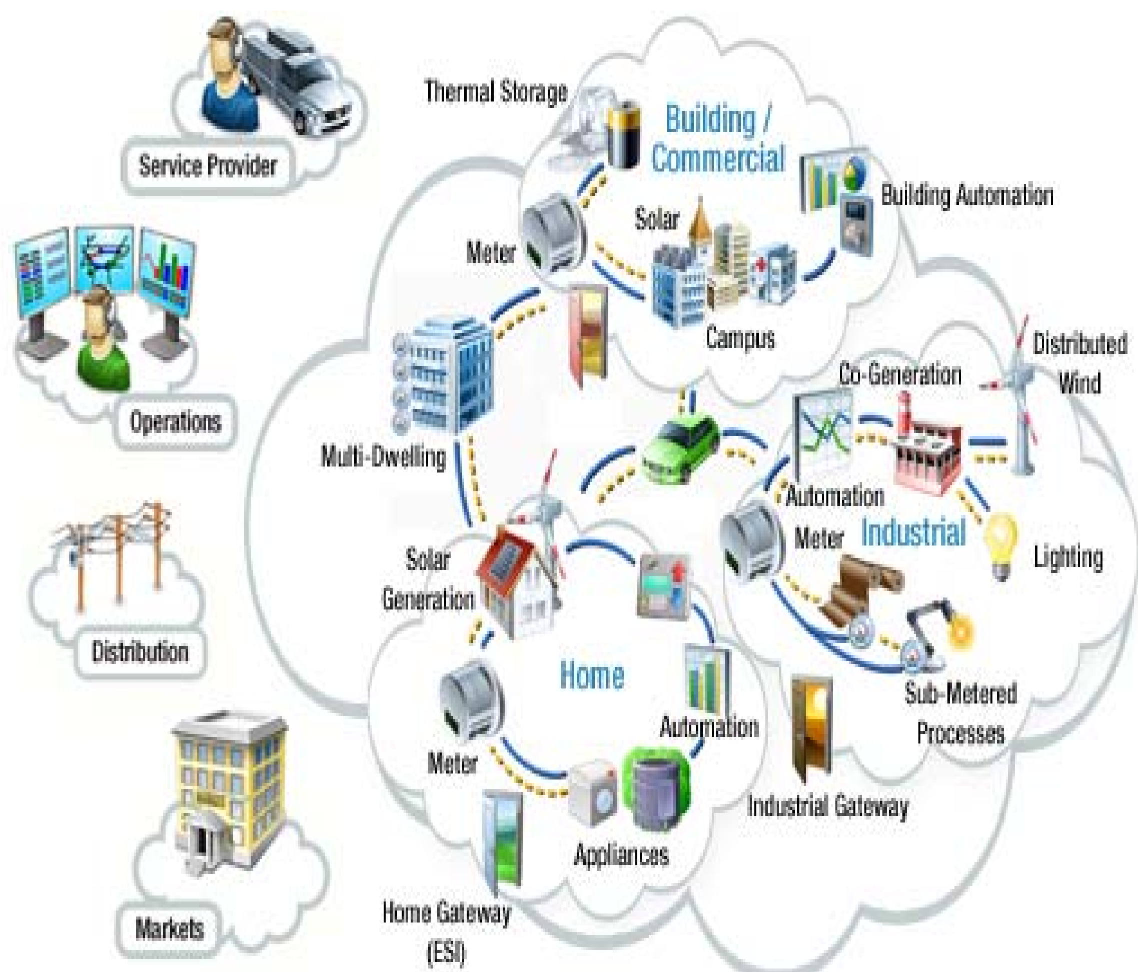
- Distributes the electricity to and from the end customers
- Connects the smart meters and all intelligent field devices, managing and controlling them through a two-way wireless or wire line communications network.
- It may also connect to energy storage facilities and alternative distributed energy resources at the distribution level.



Customer Domain

Customer

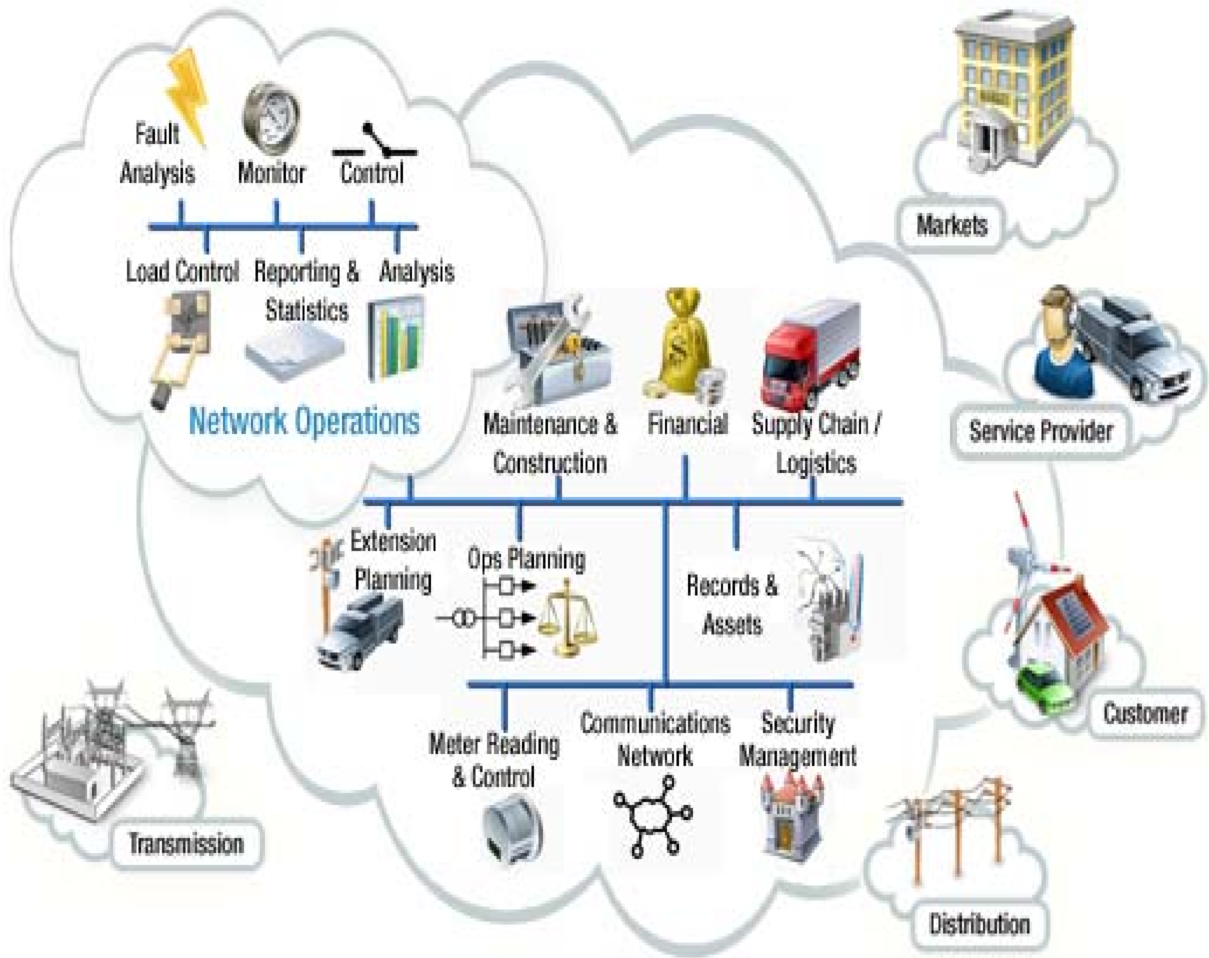
- The end-users of electricity
- Connected to the electric distribution network through the smart meters.
- The smart meters control and manage the flow of electricity to and from the customers and provide energy information about energy usage and patterns.
- Each customer has a discrete domain comprised of electricity premise and two-way communications networks.
- A customer domain may also generate, store and manage the use of energy, as well as the connectivity with plug-in vehicles.



Operations Domain

Operations

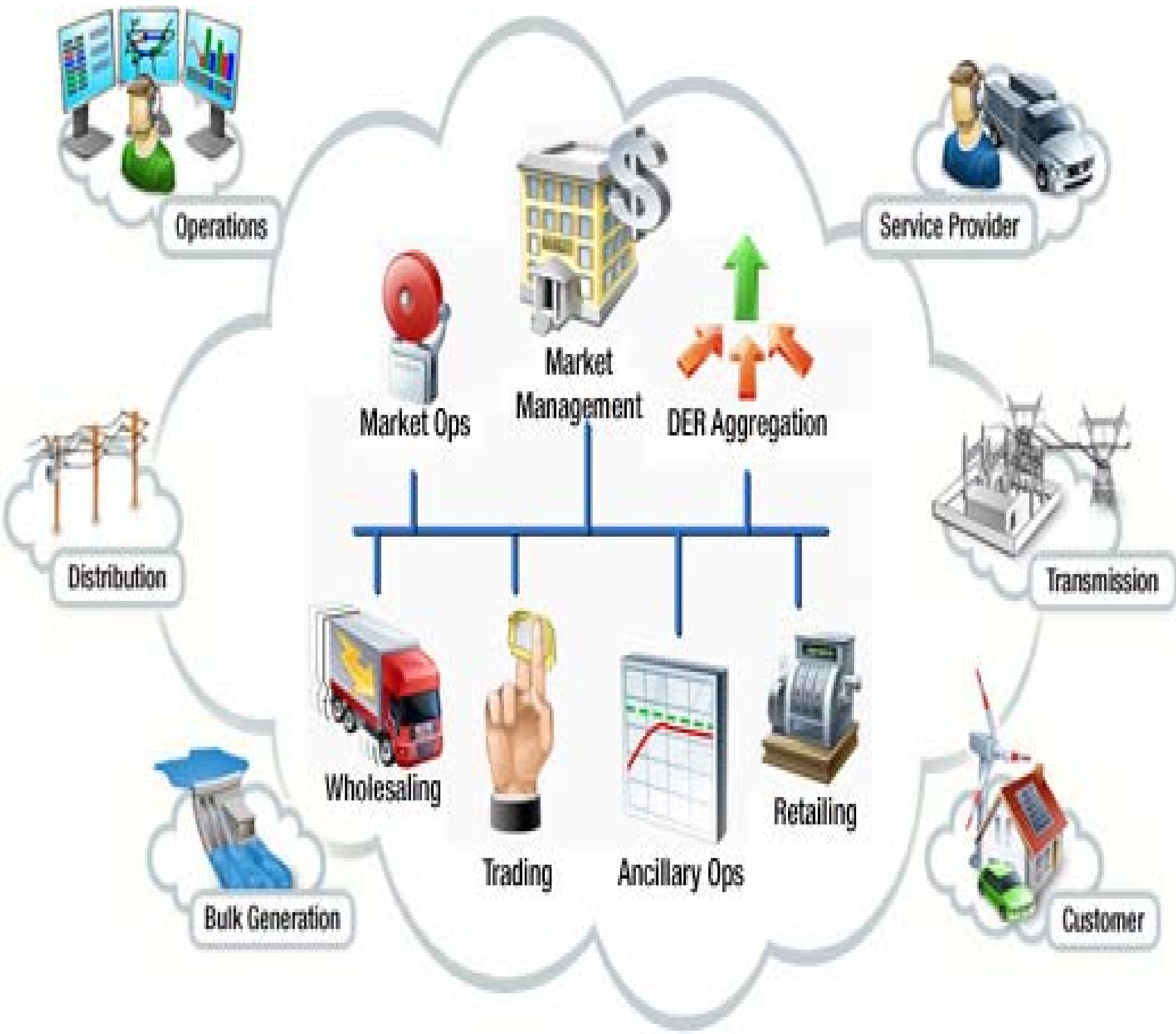
- Manages and controls the electricity flow of all other domains in the smart grid.
- It uses a two-way communications network to connect to substations, customer premises networks and other intelligent field devices.
- It provides monitoring, reporting, controlling and supervision status and important process information and decisions.
- Business intelligence processes gather data from the customer and network, and provide intelligence to support the decision-making.



Markets Domain

Markets

- The Markets domain operates and coordinates all the participants in electricity markets within the smart grid.
- It provides the market management, wholesaling, retailing and trading of energy services. The Markets domain interfaces with all other domains and makes sure they are coordinated in a competitive market environment.
- It also handles energy information clearinghouse operations and information exchange with third-party service providers.
- For example, roaming billing information for inter-utility plug-in-vehicles falls under this domain.



Service Provider Domain

Service Provider

- Smart grid handles all third-party operations among the domains.
- These might include web portals that provide energy efficiency management services to end-customers, data exchange between the customer and the utilities regarding energy management, and regarding the electricity supplied to homes and buildings.
- It may also manage other processes for the utilities, such as demand response programs, outage management and field services.

It means everyone has to play their part effectively to make our grid more efficient

Wide Area Monitoring System

Power & Energy Society®

WAMS-Definition

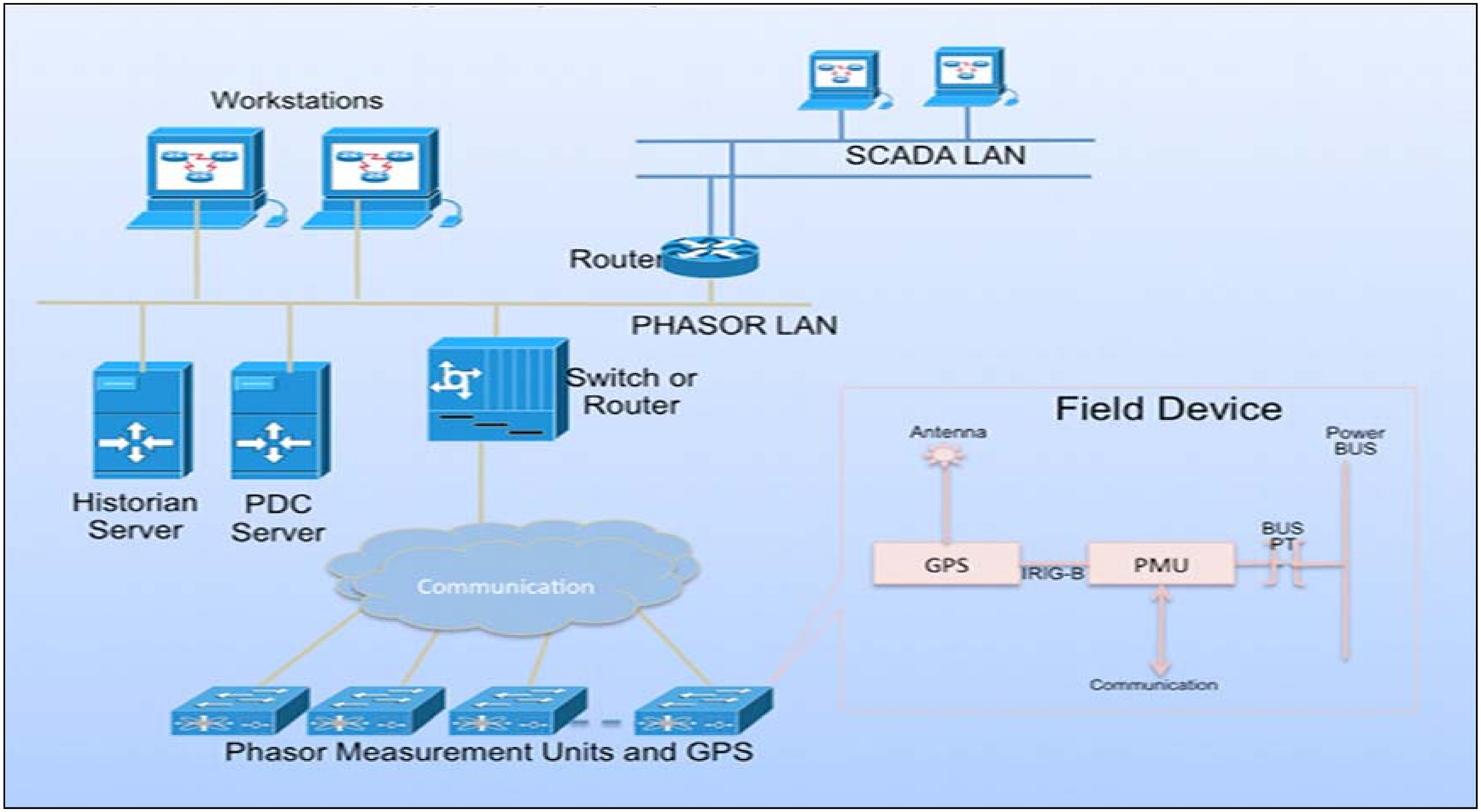
- It’s a collective technology to monitor power system dynamics in real time, identify system stability related weakness and helps to design and implement counter measures.(IEEE)

- It is based on Phasor measurement units(PMUs) which can deliver precisely time synchronized values of voltage and current phasors and other power system related quantities like frequency, ROCOF, breaker positions.

Components of WAMS

- Phasor Measurement Unit (PMU)
- Phasor Data Concentrator (PDC)
- Global Positioning System (GPS for Time Synchronization of the phasors)
- Communication channel (Preferably optical fiber cable)
- Visualization and analysis tools
- Wide area situational awareness system.
- Wide area protection and control

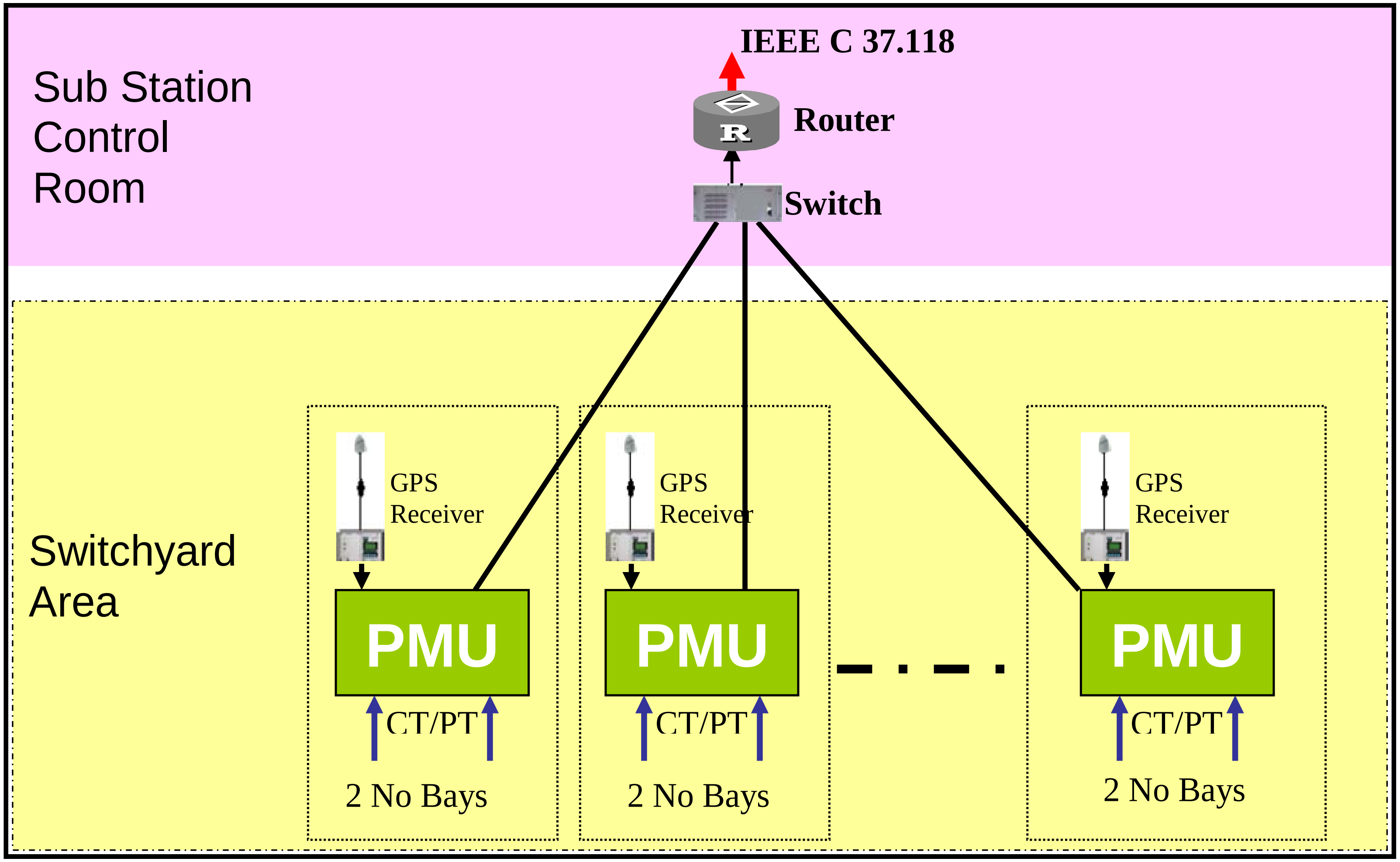
WAMS Architecture



Phasor Measurement Unit (PMU)

- The Phasor Measurement Unit (PMU) is a Power System device capable of measuring the synchronized voltage and current Phasor in a Power System.
- Synchronicity among Phasor Measurement Units (PMUs) is achieved by same-time sampling of voltage and current waveforms using a common synchronizing signal from the global positioning satellite (GPS).
- The ability to calculate synchronized phasors makes the PMU one of the most important measuring devices in the future of power system monitoring and control.

Communication Architecture



Key advantages for Phasor deployment ...

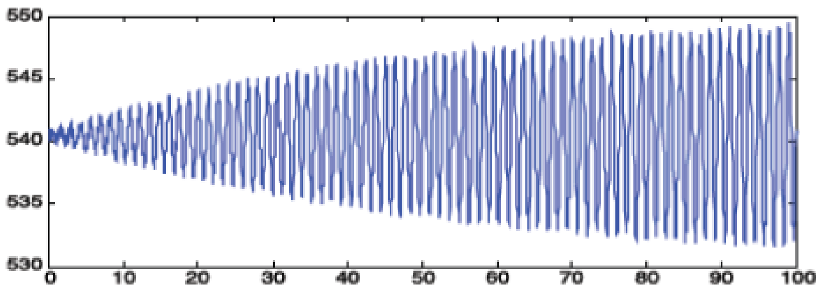
- Accurate phase angle measurements independent of frequency variations
- Real time synchronized differences
- Wide area protection
- Improve grid stability/reliability
- Minimize transmission congestion
- Optimize transmission capacity
- Forecasting grid instability and early warning to prevent blackouts and cascade collapse

PMU Applications

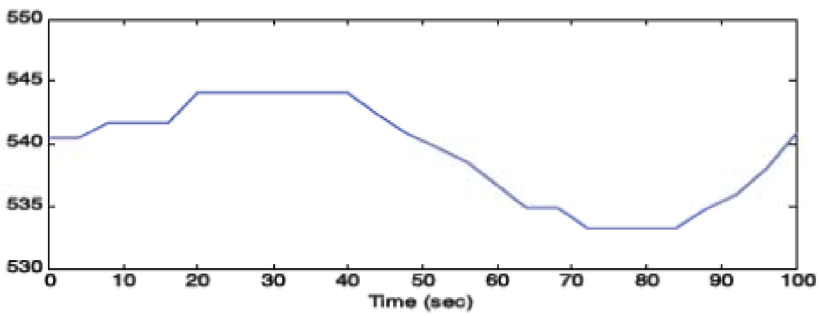
- Oscillation detection
- Fault location identification
- Fault classification
- Event analysis
- Model validation
- Situational awareness

Oscillations seen by PMU

- SCADA measurements cannot see most oscillation Worse – they can give misleading impression
- Synchro-phasors are needed to observe oscillations because of faster data sampling, greater data resolution, and wide-area



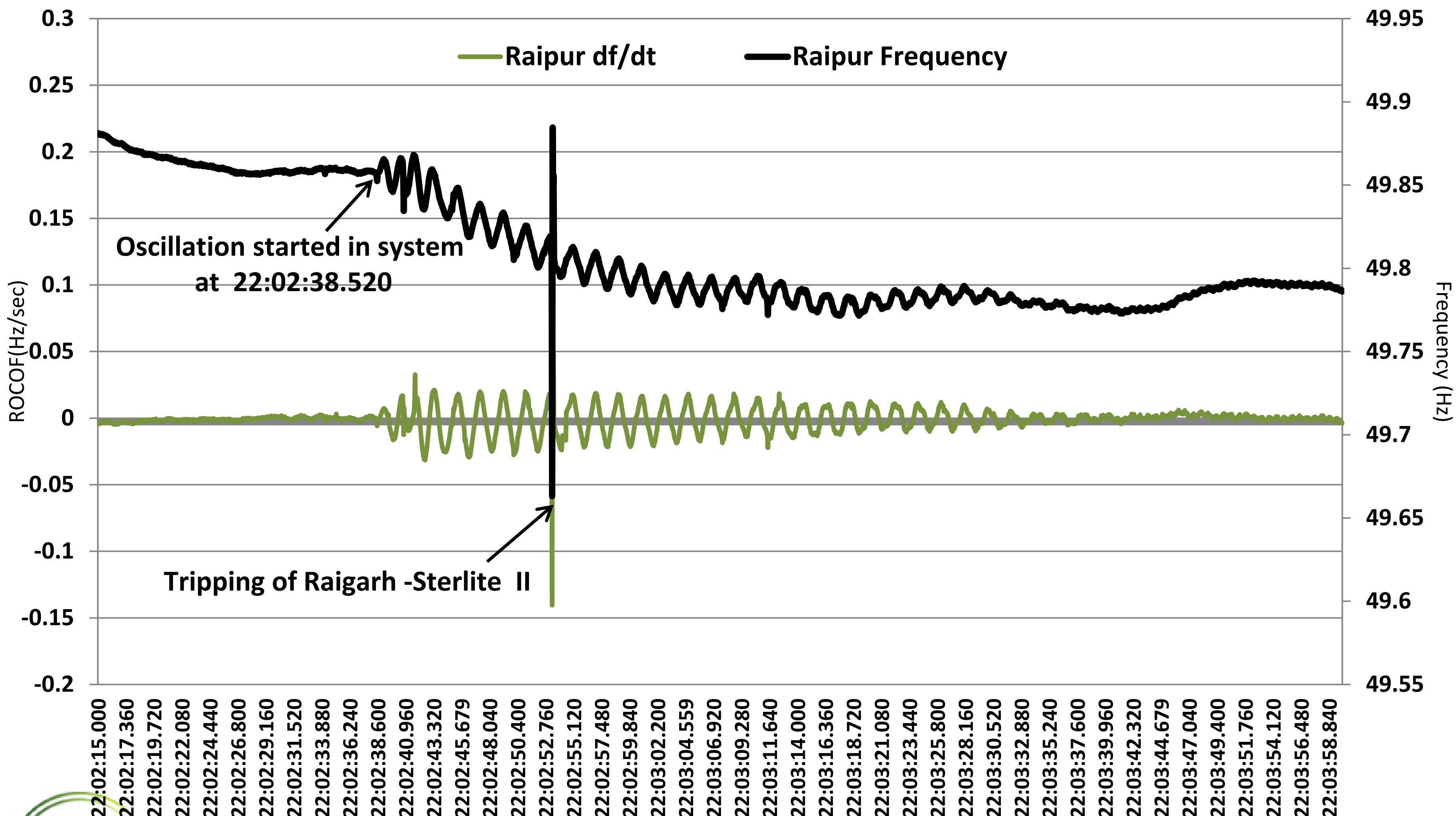
<< Synchrophasors



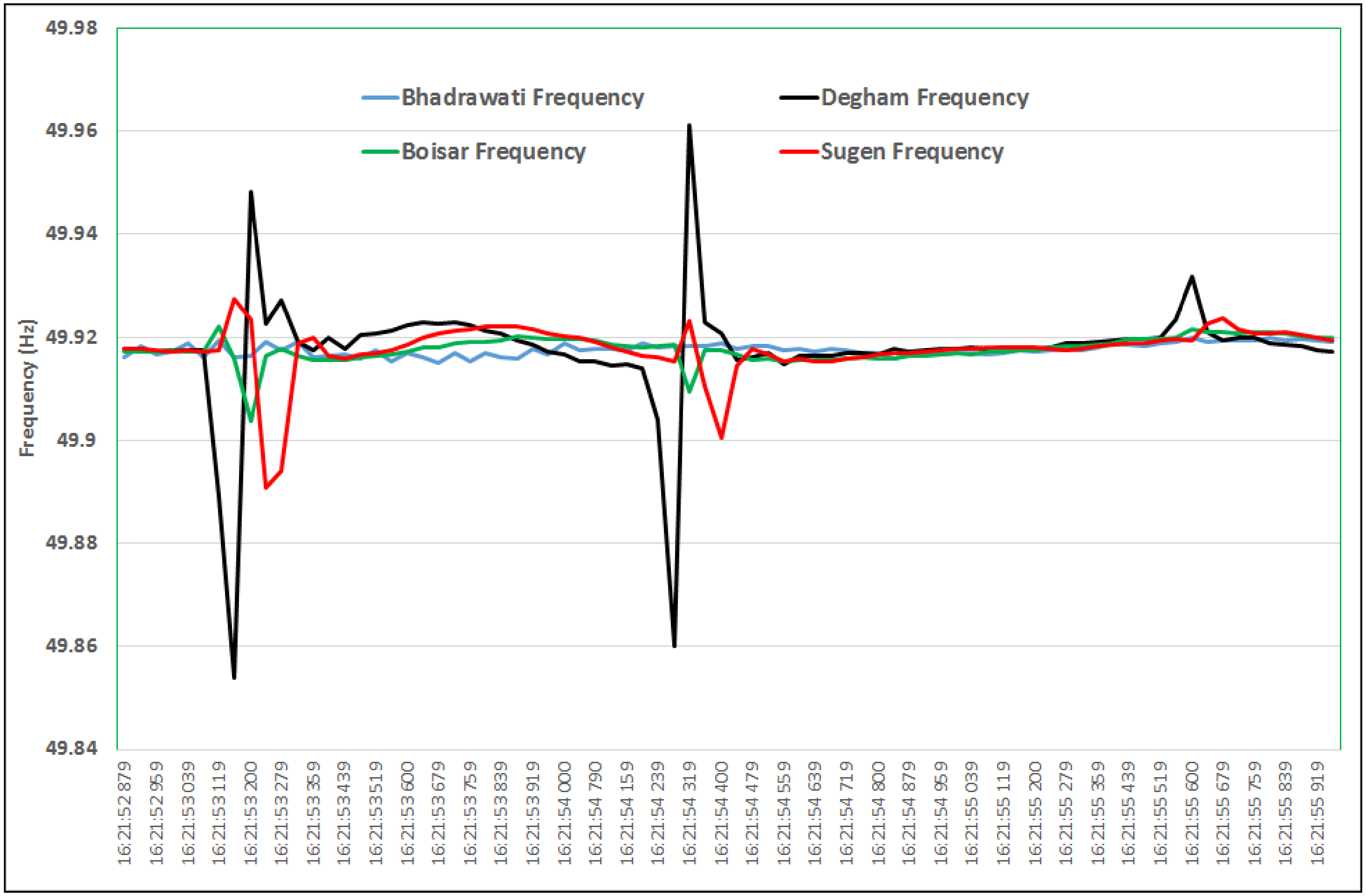
<< SCADA

PMU APPLICATIONS & ANALYTICS
INDIAN POWER SYSTEM

Oscillation monitoring and analysis

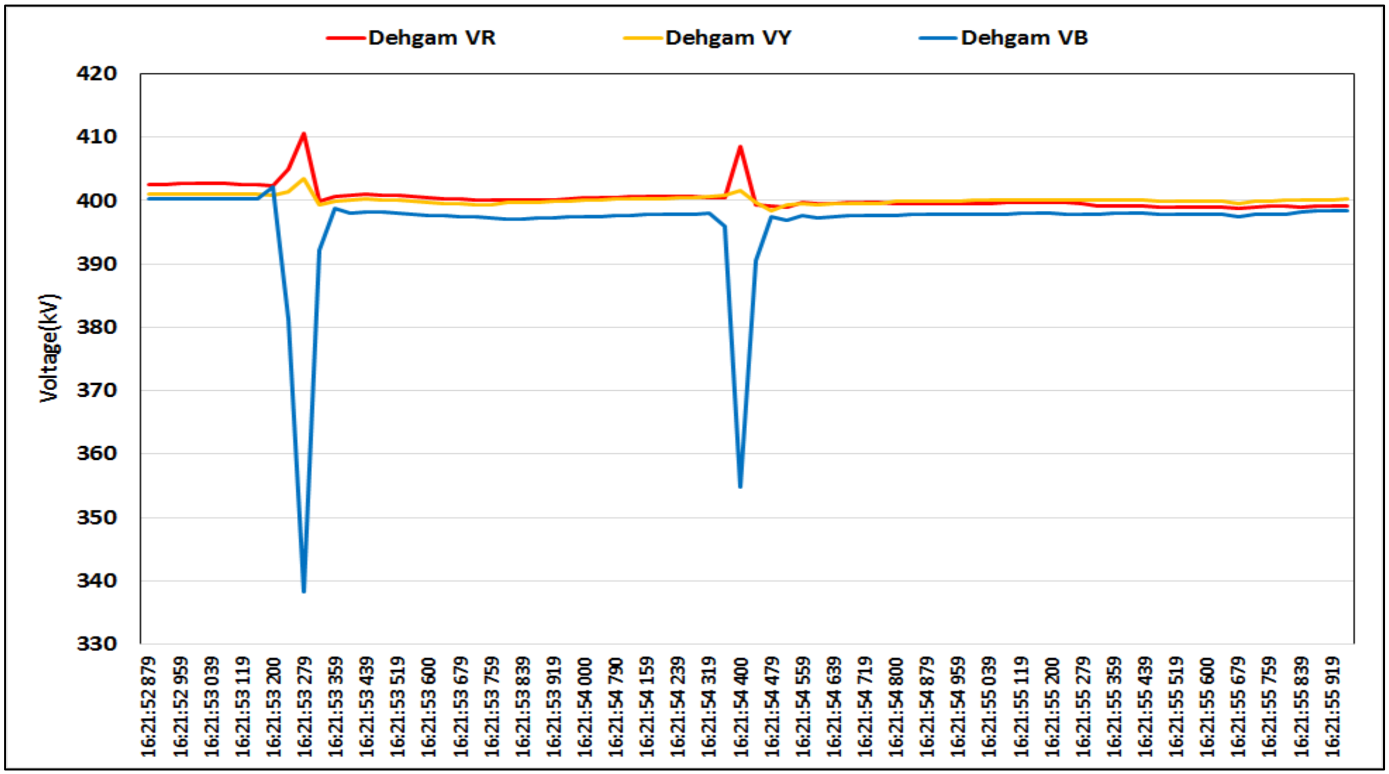


Fault Location Detection

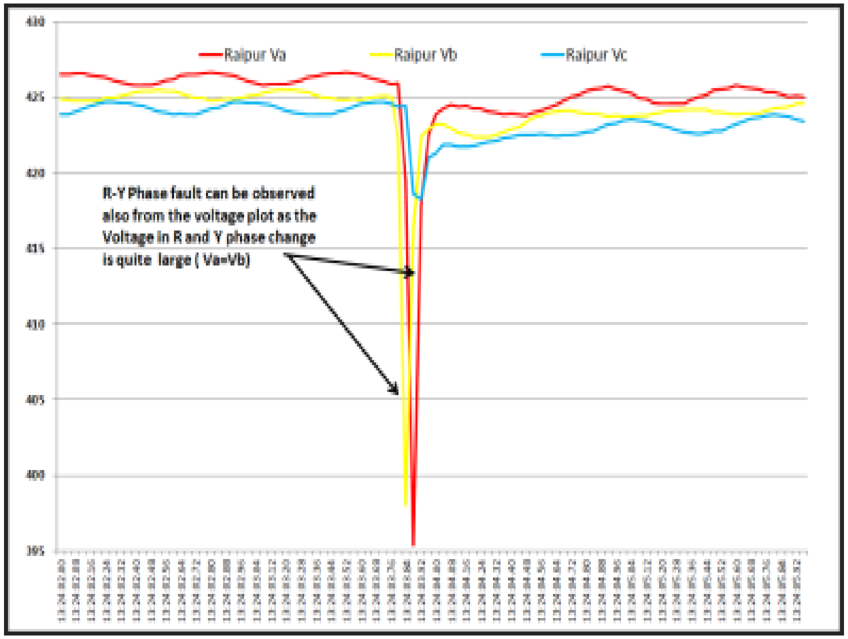


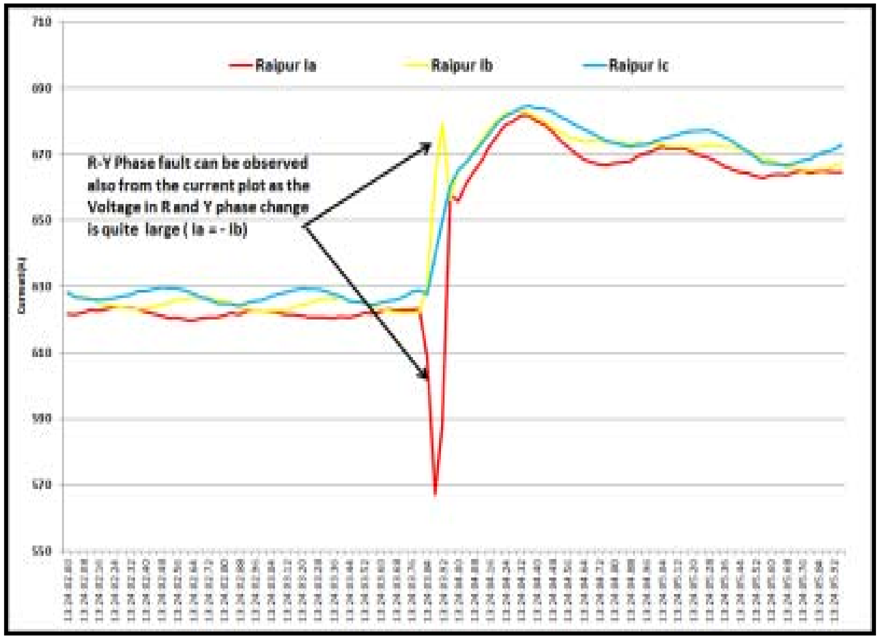
Fault Type Detection

- Single line to ground fault

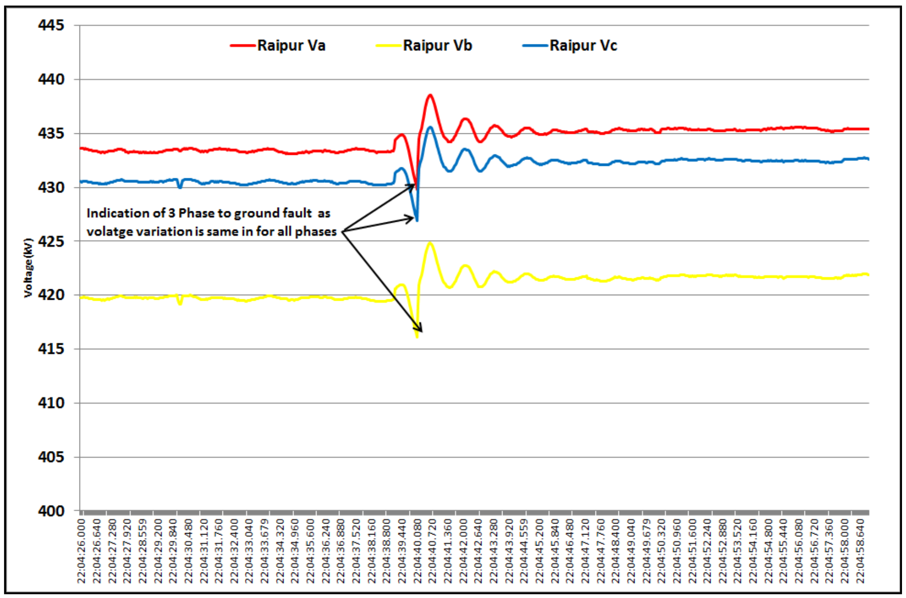


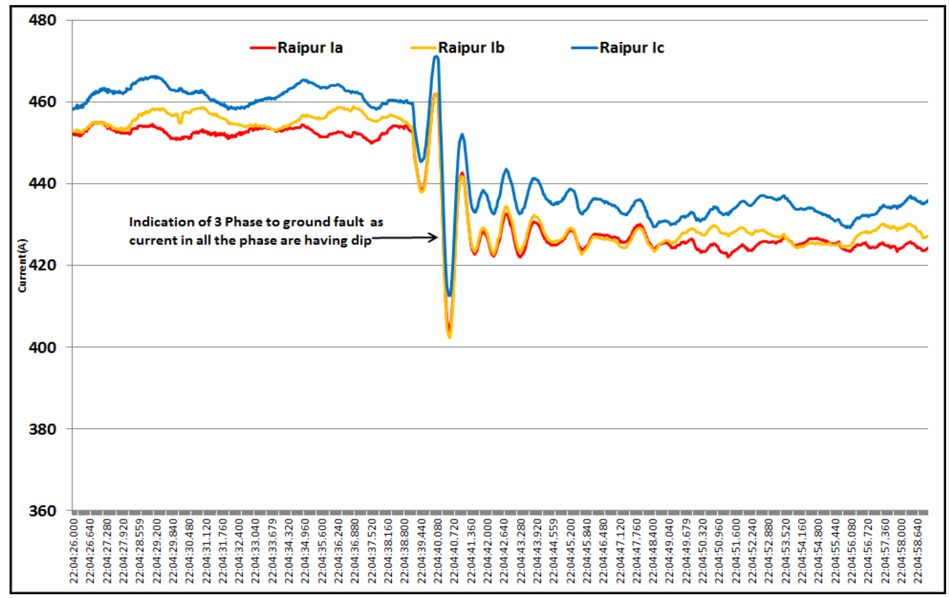
❖ Phase to Phase fault



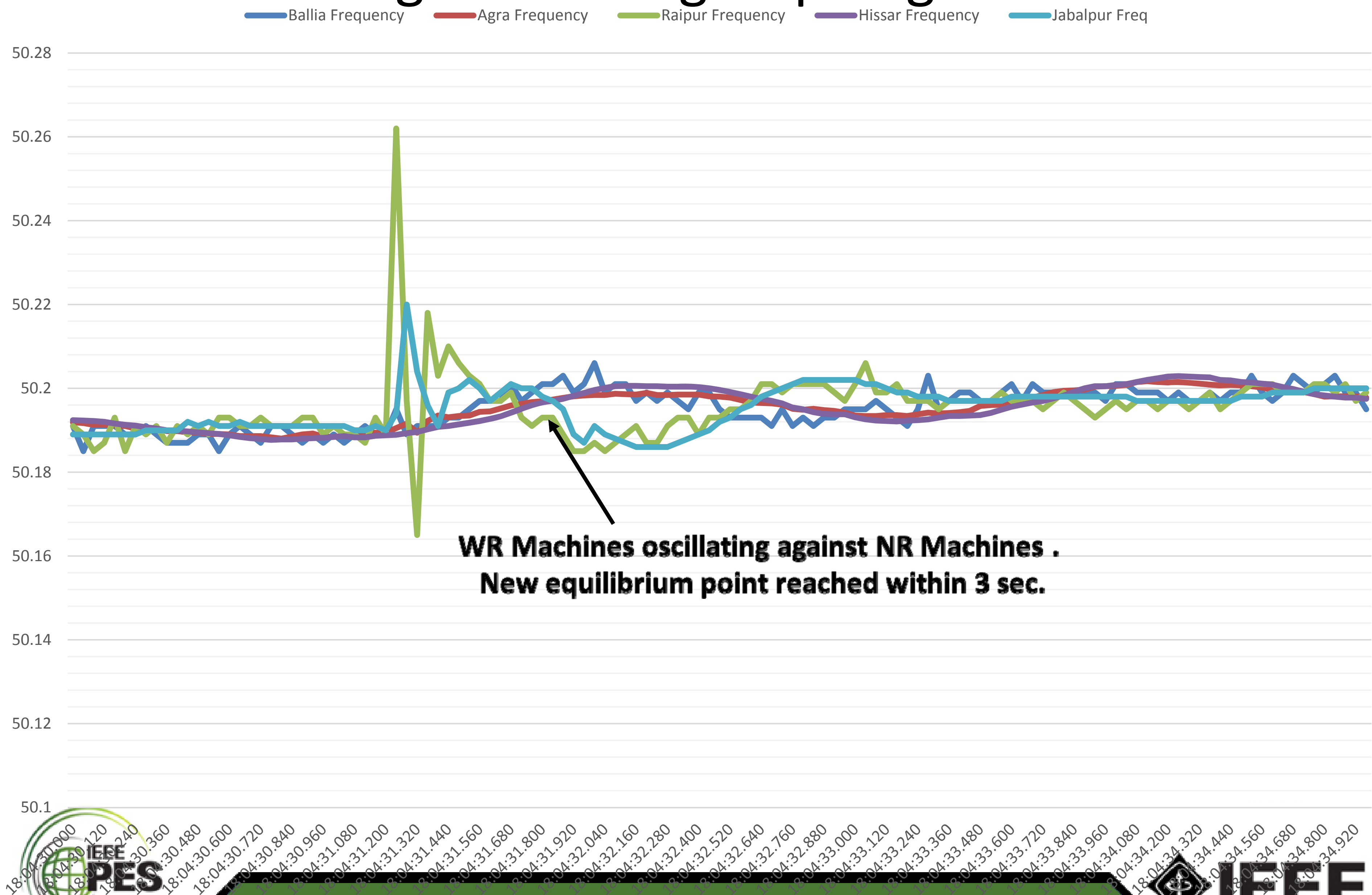


❖ Three Phase Fault





Detecting coherent group of generators



Mode Source Identification

Location 1			Location 2			Location 3		
Freq	Damp	Ampl	Freq	Damp	Ampl	Freq	Damp	Ampl
0.52	0.036	7.14	0.5	0.021	3.18	0.52	0.019	0.132
0.63	0.055	27.59	0.63	0.011	2.8	0.62	0.022	0.23
0.74	-0.012	1.2	0.70	0.006	1.16	0.7	0.017	0.09
1.43	0.00013	0.56	1.32	0.0019	0.429	1.45	-0.002	0.016

Symbol	Actual PMU position	Approx. Distance from Event location (km)
Location 1	Karcham	433
Location 2	Kanpur	603
Location 3	Vindyachal	919

Analysis of Indian grid blackout (PMU measurements)

- Inter- area oscillations identified for the grid disturbance case can be used as indicators in-order to avoid such catastrophe in the future.

Concluding remarks…

- Smart Grids are prerequisite to reach targets such as environmental, efficient energy and secure supply.
- Implementation of Smart Grids is an evolution of the existing grids.
- Many requirements, like increased efficiency and reliability can be addressed by the 'Smart Grid'
- Potential applications for synchrophasor technology evolving in parallel will be needed in order to maintain stable operation of the electric power grid of the future.

Thank you!!!