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"ADOPTION OF SYNCHROPHASOR TECHNOLOGY IN INDIAN GRID TO AVOID GRID FAILURES & BLACKOUTS"

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ABSTRACT

India suffered a major grid disturbance in northern region at night at 02:33hrs on 30th July 2012 and further severe disturbance occurred at 13hrs on31st July resulting collapse of 48000MW of power in North, East& North-East Regions EXCEPT Western& South Regions. This grid disturbance affected normal life of 60crore population of the country for more than 8hrs.This has necessitated our grid system for modernization and development to the level of a smart grid by deploying synchrophasor technology which is world wide accepted as a solution towards future blackouts and grid failures. This is a ultra fast measurement system of grid parameters which would be 100 Times faster then present SCADA/EMS system. Adoption of this technology is been done in phased manner in coming 10years by 2022.This paper deals with present status of grid system and complicated structure to be dealt in future with coming IPPS and UMPPS and renewable energy generation to be added to the system for efficient grid operation.
Keywords: Synchrophasor technology, wide area measurement systems (WAMS).

INTRODUCTION

[1] DETAILS OF GRID FAILURE ON 30TH &31ST JULY 2012.

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On 30th july 2012 northern grid failed at 02.33hrs(AM) with load collapse of 36000 MW affecting the power failure in all nine states On 31st July 2012 all the three regional grids failed at 13hrs with collapse of 48000 MW power in N E & N E regions paralyzing the normal life of 60 crores population of the country for more than 8 hrs .This was spread in 20 states VIZ NR(9),East(5),NER(7) namely West Bengal,Bihar,Jharkhand,Orissa and Sikkim. NER [Assam, Arunachal Pradesh, Meghalaya ,Manipur, Nagaland, Mizoram, Tripura] [see fig1].

[2] SYNCHRO PHASOR TECHNOLOGY

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Synchrophasor technology is a powerful tool for diagnose, prevention and cure for grid system. Synchrophasor are high speed real time synchronized measurement device used for finding health of electrical grid. It is also considered as ULTRA FAST measurement system of grid parameters, and is 100 times faster than present SCADA system. With Synchrophasor data's electrical utilities can use existing power more efficiently and push more power through existing grid system. It reduces likely hood of power disturbances, false trips and cascade tripping leading towards BLACK OUT'S. Power grid proposed to go in big way for WAMS (wide area management systems) for whole country. Under pilot project 4 no's Synchrophasors
[ref. fig]

have been deployed in northern grid viz (1) Kanpur (2) Vindhyachal (3) Dadri (4) Moga, 400 KV substations and is being monitored at NRLDC, DELHI [refer fig 2]. The results are very much encouraging. This paper describes synchrophasor technology and its advantage over present SCADA system and how utilities can Integrate synchrophasor data's in existing SCADA/EMS. WAMS technology using PMU (Phasor measurement unit) data is found instrumented in improving early warning system. Wide Area Protection System and many other applications. [ref. fig.]

[3] DETAILS OF INDIAN GRID SYSTEM

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Indian grid is fourth biggest in world (USA, EUROPE, CHINA & INDIA) transferring pwer through five regional grids and one national grid with transmission voltage ranging from 132/220/400/765 KV Ac and + 500 KV HVDC transmission system. Interconnecting regional grids by HVDC Transmission inter link system . Our grid system has been using SCADA/EMS system for grid data processing and monitoring. Recently power grid has deployed four (4) Synchrophasors in northern grid in May 2010. Viz at 1) Kanpur (2) Vindhyachal (3) Dadri (4) Moga. NRLDC is monitoring & analysis PMU datas at Delhi. This technology has reduced possibility of future BLOCK OUT'S of systems. It is 100 times faster than present SCADA system. It is possible to monitor inside view of grid system of dynamic study of grid disturbance can be studied and analysis well.
Synchrophasors are the Phasor measurements taken synchronously at same instant of time. A phasor is a complex number that represents both magnitude and phase angle of the electricity waves.
Synchrophasors measurements can be taken precisely and time synchronously by the devices called phasor measurement unit (PMUs) which are synchronized with help of GPS. These measurements are taken at high speed typically 25 or 50 observations per second. Each measurement is time – stamped according to a common time reference provided.[ref. fig.]

[4] PRESENT POWER STATUS OF COUNTRY
:----------

Indian power system is expanding at high rate with present installed Power Generation capacity has reached to the level of 2,06,000 MW by end of 31-12-2012 . Power is generated through by 2000 Nos generating units feeding power to the grid. The size of generating set is 30 mw to 660mw in the thermal generation. In Hydel it is 10mw to 150mw each unit .Through Thermal Power stations of country generates 67% and from Hydel it is 20% of total Power and through Nuclear Power we Generate only 3% and Non conventional Renewable power generation is 10% only, mostly through wind power and biomass. Solar PV is opening their accounts now. Transmission system is having 132/220/400 KV and 765 KV AC system and + 500 kV through HVDC inter connected systems. In near future 1200 KV AC and 800 KV HVDC system is going to be introduced by year 2015. The complexity of operation of grid system will be further increased.

[5] INDIAN ELECTRICITY GRID CODE 2010
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As per Indian Electricity Grid code 2010-clause no 4.6.2
"The Reliable and efficient speech and Data Communication System shall be provided to facilitate necessary communication and data exchange, and supervision/control of the grid by the RLDC, under normal and abnormal conditions. All users, STUs and CTU shall provide systems to telemeter power system parameter such as flow, voltage and status of switches/transformer taps etc. in line with interface requirements and other guideline made available by RLDC. The associated communication system to facilitate data flow up to appropriate data collection point on CTUs system, shall also be established by the concern user or STU as specified by CTU in the Connection Agreement. All users/ STUs in coordination with CTU shall provide the required facilities at their respective ends as specified in the Connection Agreement" Synchrophasor definition measurement and applications have been coded in IEEE – 1344 and IEEE- C37.118 – 2005 standards in power systems the time accuracy of measurement reached up to 1 micro second, that is why the inside view of power system can be seen Dynamically and necessary preventive steps can be taken by system operators to avoid cascade tripping and black outs.
National ,Regional ,and State level load dispatch centers: The country is Geographically divided in five regions namely N,E,W, North-East and South Region from power system point of view 1st four out of five regional grid operating in synchronous mode with south region which is Inter connected with through asynchronous links Each of Five regions is carrying out grid management with support of system at regional load dispatch centers (RLDC) Data exchange with state load dispatch centers (SLDC) is taking place with ICCP connectivity between RLDC & SLDC for Integrated grid operation. Inter Regional connectivity through HVDC B2B and EHV Transmission network.
There are 33 control centers and 315 RTUs locations in Northern grid itself in integrated manner

[6] DEVELOPMENT OF NATIONAL GRID
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Realization of Nation's dream in formation of an Integrated National Grid with optimal and economic dispatch of Power between Regions/states is the driving force behind contemplating the load dispatch and communication Project for the country The capability, faster system restoration, post disturbance data Analysis. Government of India has entrusted Power Grid with the responsibility of implementing the load dispatch& Communication Project In association with the constituents The National Grid aims to integrate the Power Transmission Network across the country and consists of following grids.

National, Regional, State and Area Load Dispatch centers [refer fig 3]

1. All 5 grids separately working before October 1991
2. In October 1991 East and north east synchronized.
3. *In march 2003 west synchronized with north east we can central grid.*
4. *In august 2006 north synchronized with central grid.*
5. *In 2014 it is expected to synchronize south grid with other four grids.* This will make one nation one grid.

(6) COMPONENTS OF WAM TECHNOLOGY

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6.1.1 PMU's
6.1.2 Phasor Data concentrator (PDC).
6.1.3 Substation Phasor Data concentrator (SPDC)
6.1.4 Master Phasor Data concentrator (MPDC)
6.1.4 System architecture for WAMS in India.

6.1.1 PMU measurements are providing real time measurement of electrical quantity MW, MVAR, Voltage, Current , Phase angle of voltage , Power factor etc., its application includes validation, modeling , stability , magnitude and maximum power transfer. It is receiving

1. F
aults recording
2. D
ynamic system monitoring installation and continuous.
3. S
equence event recording
4. P
ower quality
5. F
ault location
6. S
yncrophasor data Sending through C.37.118, system

Installation of PMU

Input components

(
A)PM UNIT (SEL-451)

- 3
nos voltage Input
- 3
nos current inputs from selected CVTS,CTS of selected feeders.

(B) GPS UNIT (SEL-2404) Global Position

- A
ccurate Time
- T
ime synchronized.

CASE STUDY OF ANDHRA PRADESH

AP State Estimator to State Measurement State Estimator (SE) tools currently deployed in SCADA system uses measurements i.e., MW, MVAR, voltage magnitude except ,Phase angle measurement etc., which is done in case of Synchrophasors.

SALIENT FEATURES OF THE ULDC/SLDC SCHEME

EMS/SCADA

Energy Management System and Supervisory control and Data Acquisition System in five hierarchical control centers integrating RTUs located at 125 strategic substations and generating stations spread across the A.P.Grid for polling real time data for monitoring, control and analysis.

(6) MULTI LEVEL CONTROL CENTER SETUP OF LOAD DISPATCH CENTERS

NLDC (National load dispatch center) Delhi

RLDCS (REGIONAL LOAD DISPATCH CENTERS) [

(1) NRDC -- DELHI

(2) ERLDC -- KOLKATTA

(3) SRLDC -- BENGALURU

(4) WRLDC -- MUMBAI

(5) NERDC --GUWAHATI

SLDCS (STATE LOAD DISPATCH CENTER---ANDHRA PREDESH)

CPCC , PONDY , TNEB AP , KARNATAKA KERALA

ALDCS ------ (AREA LOAD DISPECH CENTERS OF AP)

WGL HYD VJA CDP

RTU 1TO 19 1TO 32 1TO 34 1TO 31

SYNCROPHASOR TECHNOLOGY THROUGH GPS SYSTEM

There are 24 Nos SATELLITES which are in 24 orbits at the distance of 16000 km from Earth and 6 orbits are being viewed all time giving time accuracy of 1 micro seconds.

The advent of SATELLITE based time keeping systems advances in computer technology have made possible protective relays sampling synchronization with 1 micro seconds. These relays can now provide synchronized Phasor measurements that eliminate the need to have different devices for protection, control and electrical power system analysis for system wide application and traditional protection applications. System wide applications have different sampling & signal processing requirement than do traditional protection applications.

POWER SYSTEM ANALYSIS

NLDC: NORTHERN LOAD DISPATCH CENTER

Substation	Instate estimate at NLDC (terminals)	Offline mode (terminals)
765 KV	2	2
400 KV	275	284
220 KV	34	1315
TRANSMISSION LINES		
765 KV	2	2
400 KV	611	622
220 KV	51	3034
Transformers	794	2031
Load	834	2672
Generator	263	557

Table no:1

A comparison of truncated state estimator network and All India Network, used offline studies is given above.

PMU's are installed at Dadri, Kanpur, Vindhyachal & Moga. Data's are compared with estimated angles in order to improve the results.

Table no:2

Comparison of PMU estimate Angles

Places of deployment of PMU	PMU estimated angle	Actual Angles
Dadri - Moga.	11.47	12.68
Kanpur - Dadri	11.62	13.44
Kanpur - Moga	23.09	22.10
Vindhyachal - Dadri	32.97	35.23
Vindhyachal - Kanpur	21.35	23.49
Vindhyachal - Moga	44.44	46.12

Four more additional places have been selected for PMU deployement.
(1).400 KV substation Kishnapur
(2) 400 KV substation Hissar
(3) 400 KV substation Bassi
(4) 400 KV substation Agra

Advantages Of adopting Synchrophasor Technology

(1) W

IDE AREA MEASURE-WHOLE COUNTRY

Power flow parameters can be visualize and monitored and control at National Load Dispatch Center –Delhi by end of 2012,Thirty seven thousand (37,000 MW) flow would be controlled by NLDC and 1,00,000 MW by end year 2017.

(2) POWER QUALITY MONITORING
(a) Unbalance
(b) Harmonics
(c) Sag & swell
(d) Monitoring Interruptions

(3)SYSTEM INTEGRATED PROTECTION SCHEMES

(4) Network Model Validation and Parameter Finalization for better GRID Management System.

Conclusion:

This technology provides wide area time synchronized and time stamped measurements commonly known as synchrophasor measurements. Present existing SCADA/EMS measurements has capability to provides only steady state view of grid / system , where as synchrophasor technology provides wide area dynamic real time visualization, monitoring safety , security of the grid in effective manner with advancement in communication in IT technology and ever increasing need of complex grid solutions visibility of power system of synchrophsor initiatives are been taken in Indian grid to face the future challenges. Grid is marching one step ahead towards smart grid .

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2)www.cea.nic.in

ABOUT AUTHOR

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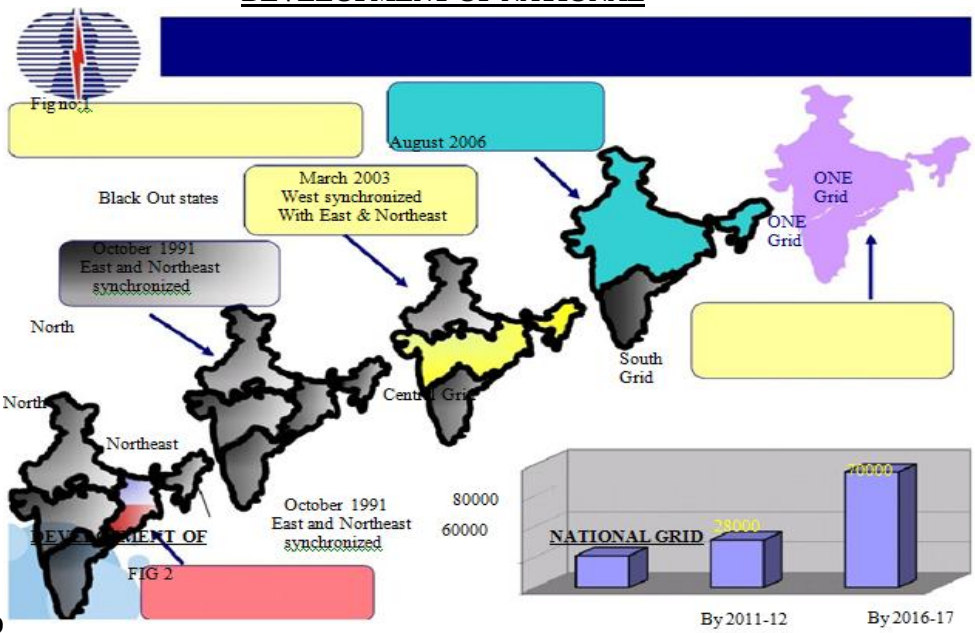
Kiran kumar jain born in khandwa mp on
15th march 1945 did BE(electrical) from MACT BHOPAL (MP) 1966 served MP state Electricity Boards for 36 years and did MTech (Energy Management)in June 2008 and since 14th July 2008 ONWARDS working as Professor&HOD EEE AND now working in BHASKER ENGINEERING COLLEGE Moinabad Hyderabad 500075.He got Regd for PhD in JNTU Hyderabad ,since 31 July 2009.-- and expected to be completed by July 2013..

DEVELOPMENT OF NATIONAL



West

GRID

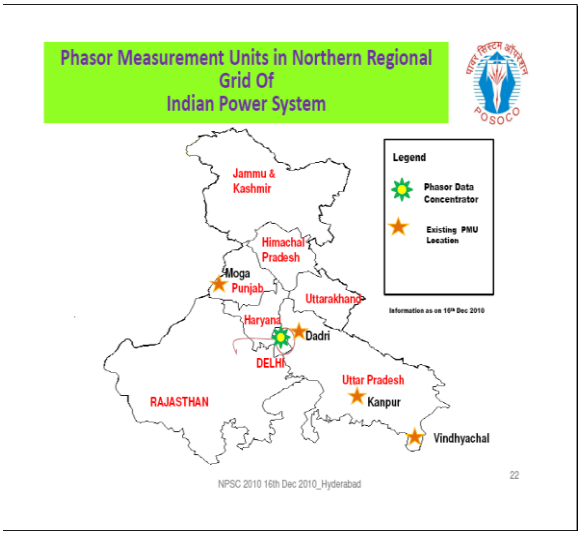
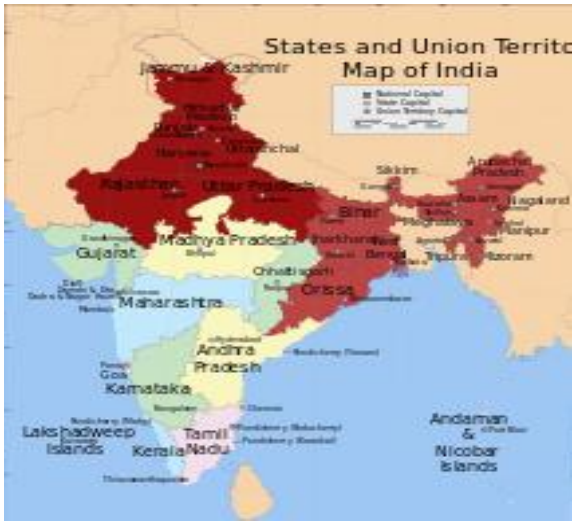
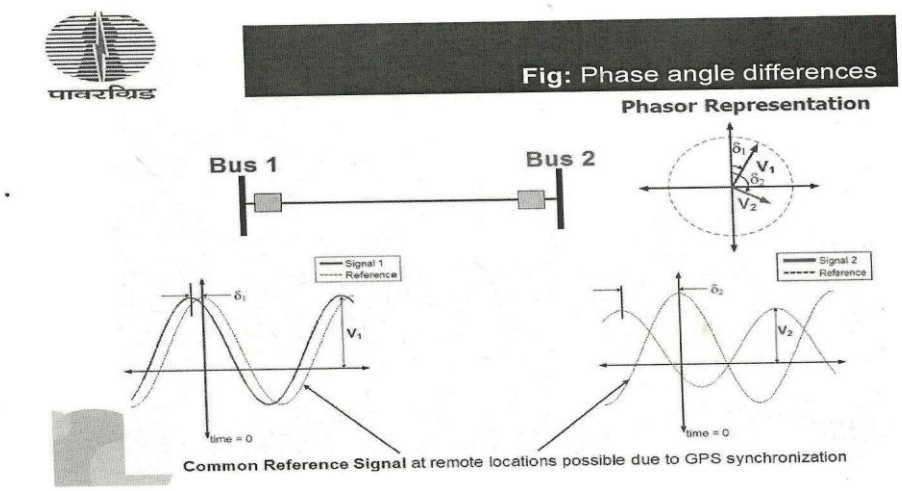
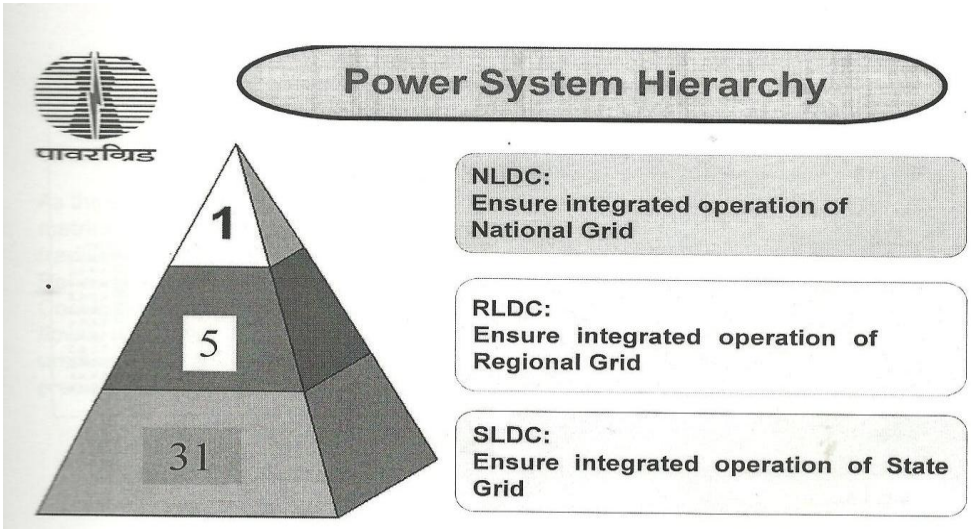
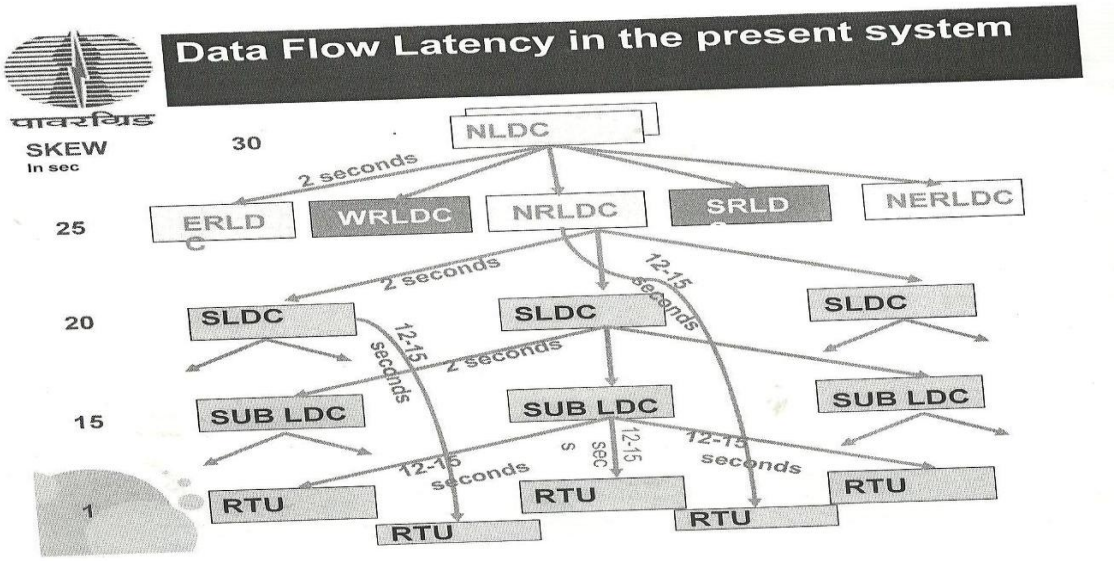


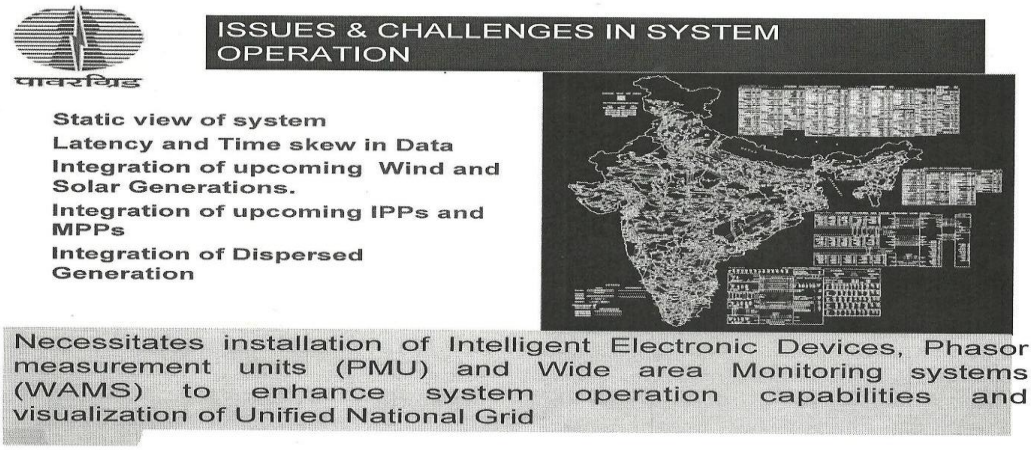
Fig no:2

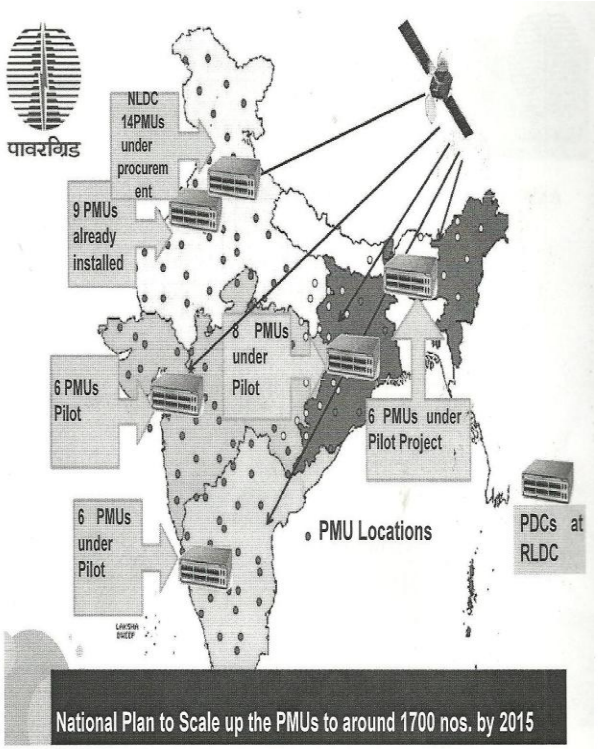

States and Union Territo
Map of India
Rajasthan
Gujarat
Madhya Pradesh
Maharashtra
Chhattisgarh
Orissa
Bihar
Andhra Pradesh
Goa
Karnataka
Lakshadweep Islands
Kerala
Tamil Nadu
Andaman & Nicobar Islands

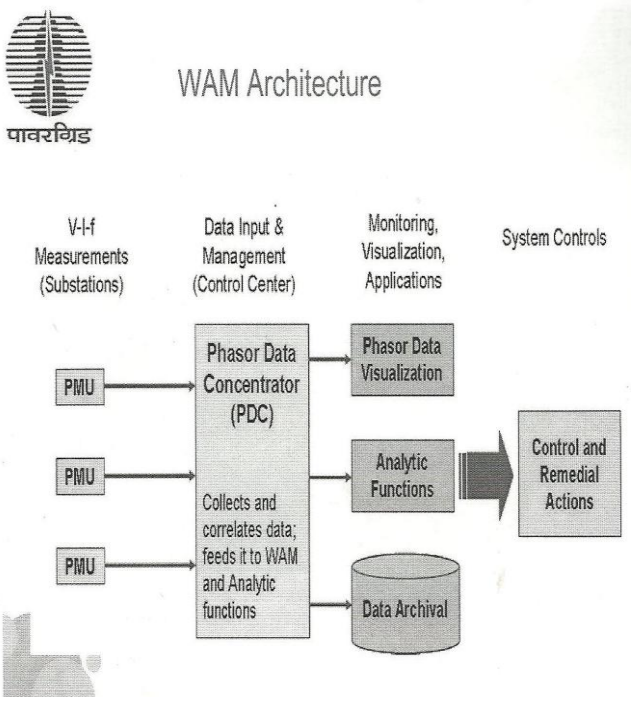

पावरग्रिड
Fig: Phase angle differences
Phasor Representation
Bus 1
Bus 2
Signal 1
Reference
Signal 2
Reference
time = 0
time = 0
Common Reference Signal at remote locations possible due to GPS synchronization


पावरग्रिड
Power System Hierarchy
1
5
31
NLDC:
Ensure integrated operation of National Grid
RLDC:
Ensure integrated operation of Regional Grid
SLDC:
Ensure integrated operation of State Grid


पावरग्रिड
Data Flow Latency in the present system
SKEW
In sec
30
25
20
15
1
NLDC
2 seconds
ERLDC
WRLDC
NRLDC
SRLD
NERLDC
SLDC
SLDC
SLDC
12-15 seconds
SUB LDC
SUB LDC
SUB LDC
RTU
RTU
RTU
RTU


पावरग्रिड
ISSUES & CHALLENGES IN SYSTEM OPERATION
Static view of system
Latency and Time skew in Data
Integration of upcoming Wind and Solar Generations.
Integration of upcoming IPPs and MPPs
Integration of Dispersed Generation
Necessitates installation of Intelligent Electronic Devices, Phasor measurement units (PMU) and Wide area Monitoring systems (WAMS) to enhance system operation capabilities and visualization of Unified National Grid





- Phasor data
  - Refresh rate 25 samples per second
  - All data points time tagged and easy to "line up" for input to state estimator, operator display or planning study
  - Compatible with modern communication technology
  - Enables action in response to system dynamics
  - Prelude to automatic switching schemes
- SCADA data
  - Refresh rate 2-5 seconds
  - Some data points are newer than others - no way to tell the difference. This leads to state estimator inaccuracy and uncertainty about what is "real".
  - Relies on legacy communication technology, i.e. does not take advantage of newer comm. networks
  - Enables action in response to system statics

WAMS : Milestones

POWERGRID has appointed a Panel of Experts to advise upon WAMS Implementation in Indian Power System.

Pilot projects for each region in the country underway

- Northern Region (8 PMUs) - Already installed
- Northern Region-
  Southern Region (6 PMUs)
- North Eastern Region (6 PMU)
- Western Region (6 PMUs)
- Eastern Region (8 PMUs)

Some Photographs of PMUs in NR

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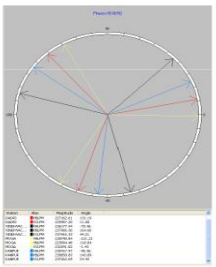
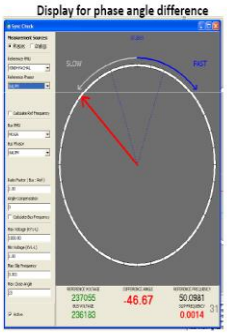
Displays available at the operator console for visualization

a) Dial Display

Voltage phasors from four locations



Display for phase angle difference



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Components at PMU Location

a) Phasor Measurement unit (SEL 451):-
- 3 voltage inputs
- 3 Current inputs

b) GPS (SEL 2404) :
- Accurate time
- Time synchronization

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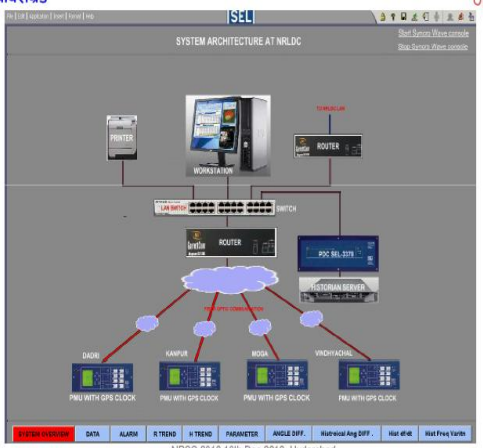
System Architecture under Pilot Project



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