



SYNCHRO PHASOR TECHNOLOGY ADOPTION IN INDIAN GRID SYSTEM

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Abstract :

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 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. 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.

Key words: Synchrophasor technology, SCADA /EMS (Electrical measurement systems), NRLDC (north regional load dispatch centre). WAMS

[1] INTRODUCTION:

Indian grid is fourth biggest in world (USA, EUROPE, CHINA & INDIA) transferring power through five regional grids and one national grid with transmission voltage ranging from 132/220/400/765 KV Ac and \pm 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



[2] 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 2,53,000 MW by end of 31-3-2015 . 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.

[3] INDIAN ELECTRICITY GRID CODE 2010

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 centres: 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

NATIONAL GRID

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 follow control-- National, Regional, State and Area Load Dispatch centers

1. Wide Area Protection scheme (WAP's) detecting and analyzing transfer IV COMPONENTS OF WAMS TECHNOLOGY

4.1 PMU's

4.2 Phasor Data concentrator (PDC).

4.2.1 Substation Phasor Data concentrator (SPDC)

4.2.2 Master Phasor Data concentrator (MPDC)

4.2.3 System architecture for WAMS in India.

4.1 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. Faults recording
2. Dynamic system monitoring installation and continuous.
3. Sequence event recording
4. Power quality
5. Fault location
6. Synchrophasor data Sending through C.37.118, system

5. 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

- Accurate Time
- Time synchronized.

Case study of AP state

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) HIERARCHICAL CONTROL CENTER SETUP OF LOAD DISPATCH CENTERS

NLDC (NATIONAL LOAD DISPATCH CENTER) DELHI

RLDCs (REGIONAL LOAD DISPATCH CENTERS)

(1) NRDC

(2) ERLDC

(3) SRLDC



(4) WRLDC

(5) NERDC

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

CPCC , PONDY , TNEB AP ,
KARNATAKA KERALA

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

WGL HYD VJA
CDP

RTUs - 1TO 19 1TO 32 1TO 34
1TO 31

SYNCRPHASOR 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 application have different sampling & signal processing requirement than do traditional protection applications.

POWER SYSTEM ANALYSIS

NLDC: NORTHERN LOAD DISPATCH CENTER

Substation	Instate	Offline
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	estimate at NLDC (terminals)	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 PMU deployment	of PMU of	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



Synchrophasors Technology

Synchrophasors are the phasor measurements taken synchronously at the same instant of time. Phasor is a complex number that represent both magnitude and phase angle of electricity waves as shown in figure.

Further to above four more places have been selected

- (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) Wide 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.

Stage 2 Advantages:

- (2) POWER QUALITY MONITORING

- (a) Unbalance
- (b) Harmonics
- (c) Sag & swell
- (d) Monitoring Interruptions
- (3) System Integrated Protection Schemes
- (4) Network Model Validation & Parameters Finalization for better Grid Management System.

Stage 3:

- (1) Increase the size of observation & control
- (2) State Estimator

Conclusion:

This technology provides wide area time synchronized and time stamped measurements commonly known's 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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- 5 POWER GRID CORPORATION OF INDIA LIMITED.

Phasor Measurement Units in Northern Regional Grid Of Indian Power System

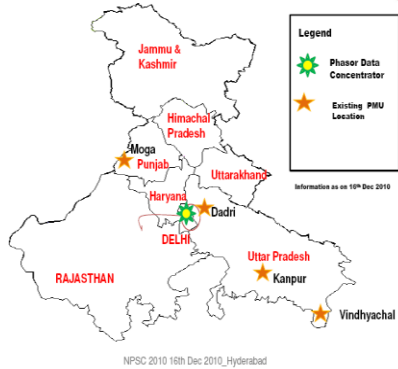


Fig 1



Some Photographs of PMUs in NR



Fig 4

ANDHRA PRADESH STATE LOAD DESPATCH CENTRE

RTU STATIONS

HYDERABAD SUB_LDC	VIZAGWADA SUB_LDC	WARANGAL SUB_LDC	CHENNAI SUB_LDC
1. BANGLAUDA	1. BIRNACOLE	1. BODILAMPAD	1. AMALAPUR
2. CHANDRAYANOPETA	2. BONGHURU	2. BONGHURU	2. AP CHANDRER
3. CHILLAKURTY SSP	3. BURE	3. BIRNACOLE	3. CHITREMPALLY
4. BRAGARDA	4. CHILLAKURTY	4. DURBESD	4. CHITTOOR
5. GANDHARU	5. DAREY FARM	5. DUTCHPALLY	5. CUDAPUR
6. GANDHARVU	6. GARTYD	6. JAGTIPAL	6. GOOBY SSP
7. GUNDOOR	7. GARTYD	7. KATP A, B, C	7. GOOBY SS
8. JUMBLE HILLS	8. GARTYD	8. KATP V STAGE	8. HINDUPUR
9. KANT	9. GUNADALA	8. KATP TOTAL	9. KANT
10. KOTUR	10. JHANSAPUR	9. KALYANPALLY	10. KALYANP
11. MALEKUR	11. KALYANP	10. KANUKURU	11. KOTUR
12. MANAKURU	12. KALYAN GOVY SS	11. KATYALOGUDA	12. KOTUR
13. MANDIPALLY GOVYSS	13. KUMARAPALLI	12. KOTUR	13. KOTUR
14. MEDICAL 220 KV SS	14. LAMP	13. KATP	14. KOTUR
15. KOTUR	15. LOWER SILEBU	14. KANUKURU	15. KOTUR
16. KOTUR	16. MIDANAPALLY GOVY SS	15. KATYALOGUDA	16. KOTUR
17. KATYALOGUDA	17. MIDANAPALLY GOVY SS	16. KANUKURU	17. KOTUR
18. N. SINGH 110 KV SS	18. MIDANAPALLY GOVY SS	17. KANUKURU	18. KOTUR
19. N. SINGH 110 KV	19. MIDANAPALLY GOVY SS	18. KANUKURU	19. KOTUR
20. N. SINGH 110 KV	20. MIDANAPALLY GOVY SS	19. KANUKURU	20. KOTUR
21. KALYANPALLY SSP	21. MIDANAPALLY GOVY SS	20. KANUKURU	21. KOTUR
22. KANUKURU SSP	22. MIDANAPALLY GOVY SS	21. KANUKURU	22. KOTUR
23. KANUKURU SSP	23. MIDANAPALLY GOVY SS	22. KANUKURU	23. KOTUR
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33. KANUKURU SSP	33. MIDANAPALLY GOVY SS	32. KANUKURU	33. KOTUR

Fig 2



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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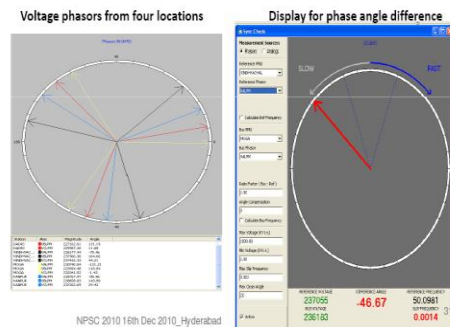
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Fig 5



Displays available at the operator console for visualization

- a) Dial Display



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System Architecture under Pilot Project



Fig 3

Fig 6



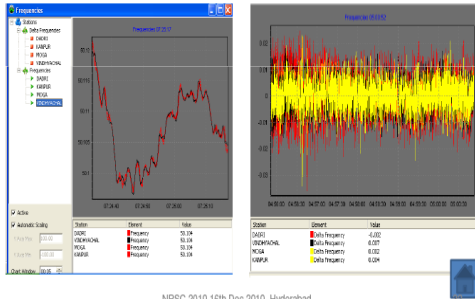
Displays available at the operator console for visualization



b) Trend Display

Display for absolute frequency

Display for frequency difference

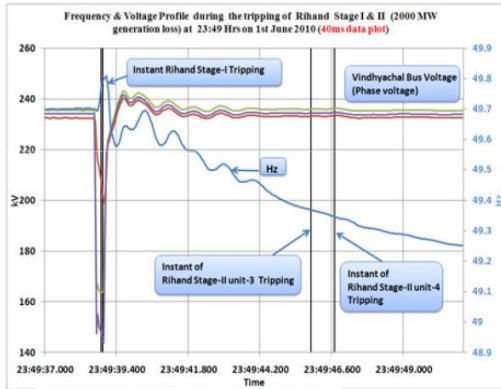


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Fig 7



Note: Plots are Based on 40 mili sec PMU data.



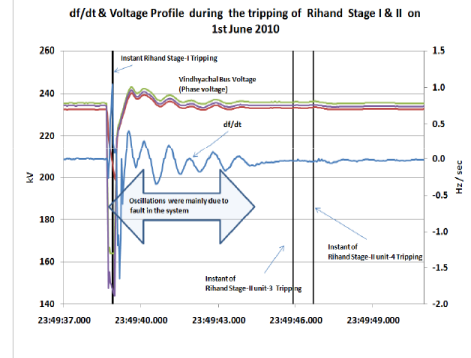
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Fig 8



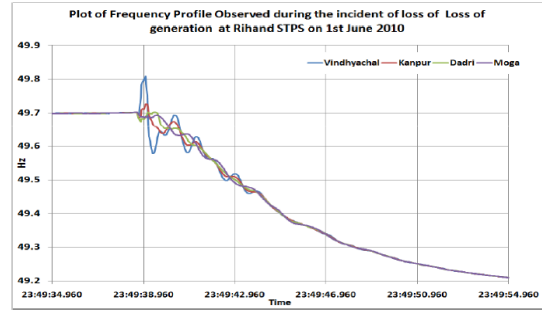
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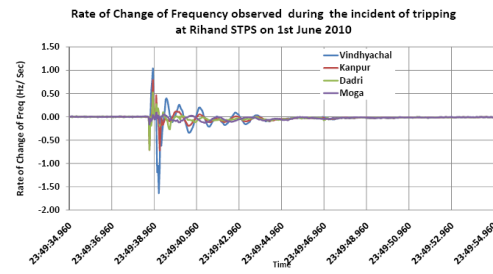
Fig 9



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Fig 9



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Fig 10

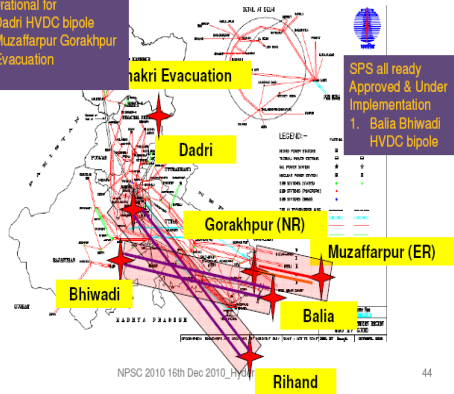


SPS in Northern Region System



SPS are operational for

1. Rihand Dabri HVDC bipole
2. 400 KV Muzaffarpur Gorakhpur
3. Jharkri /Evacuation



SPS all ready Approved & Under Implementation

1. Balia Bhiwadi HVDC bipole

Fig 11

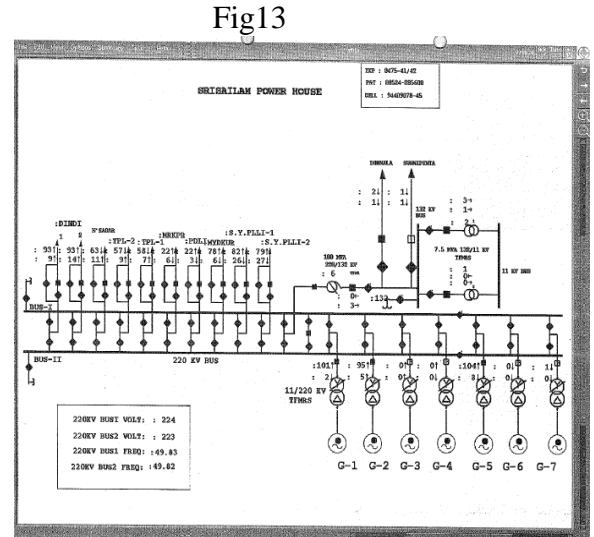


Fig 14

DAY: Thursday	TIME: 13:52 HRS	TIME BLOCK: :56	CLICK HERE FOR MANUAL DATA ENTRY
SYSTEM DEMAND PARTICULARS			
TOTAL U1 U2 U3 U4 U5 U6 U7 U8			
KTS-AMC : 506	52 : 54 : 52 : 51 : 104 : 102 : 105 : 0	NRPC : 1583	WR_CH : 1867
KTS-V : 456	239 : 232	CTR-MAD : 1219	NLR-ALM1 : 1342
VTPS : 1632	193 : 197 : 198 : 192 : 203 : 196 : 486	CDP-KLR : 1323	NLR-ALM2 : 1340
RZPP : 734	198 : 186 : 207 : 170 : 0	RZS-B : 56	GTY-HDY : 1432
KZPP : 381	387	GTY-NLMG : 1620	VLTR-RCH : 1311
JRL (-0-0 220KVdrs Data)		LS_BR : 10	GTY-RCH1 : 1323
NSR-BC : 49	17 : 15 : 17	EL-62 FLOWGATE : 11936	GTY-RCH2 : 1318
NSR-LC : 37	25 : 12	HYDEL : 1876	TERMAL : 3788
NSR : 518	110 : -0 : 1 : 100 : 102 : 103 : 101 : 0	GAS : 149	
SSL-RB : 302	101 : 95 : 0 : 0 : 104 : 0 : 0	AP GEN : 5816	
SSL-LB : 485	0 : 120 : 121 : 0 : 121 : 122	IPPR+Oth : 2905	
USL : 165	53 : 54 : 0 : 58	CGS SHARE : 1063	
LJSL : 230	54 : 0 : 87 : 89	CGS UTIL : 1109	
MKD : 77	[42]	GRID DEMAND : 9851	
SNHDR : 983	486 : 497	PUMP LOAD : 70	
MTL [32 : 36]	USP : 16	TOTAL DEMAND : 9866	
VOC-S21 : 0	0 : 0 : 0	FRQ (Mndply) : 49.83	
VOC-S22 : 149	96 : 52	FRQ (Chgta) : 49.87	
GVK-I : 140	30 : 30 : 22 : 58		
DEL : 125	72 : 54		
LANCO : 119	1114 : 0 : 0		
GVK-II : 170	67 : 103		
YKNSA : 204	101 : 88 : 116		
CMR : 165	167		

Fig 12

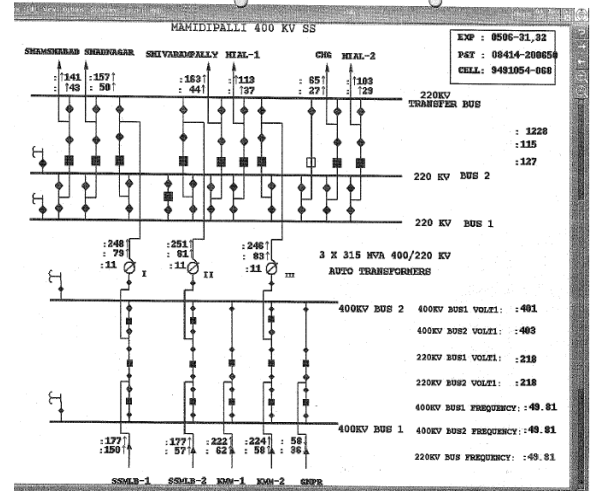
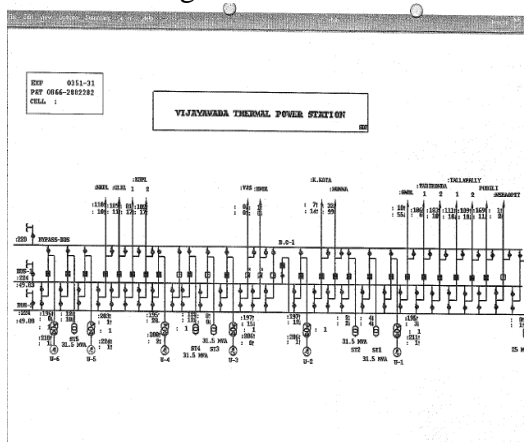


Fig 15



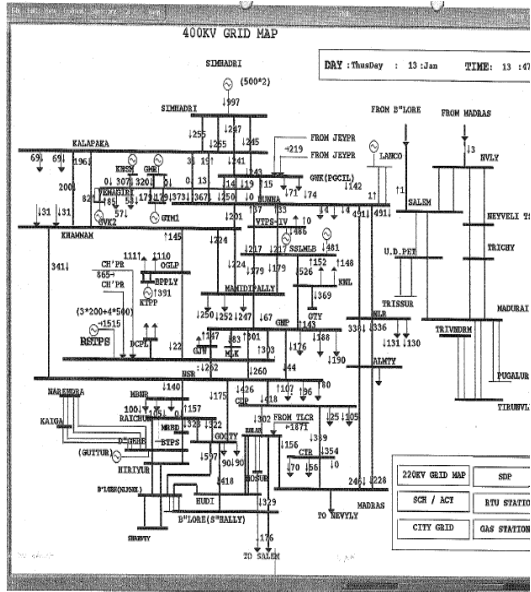


Fig 16

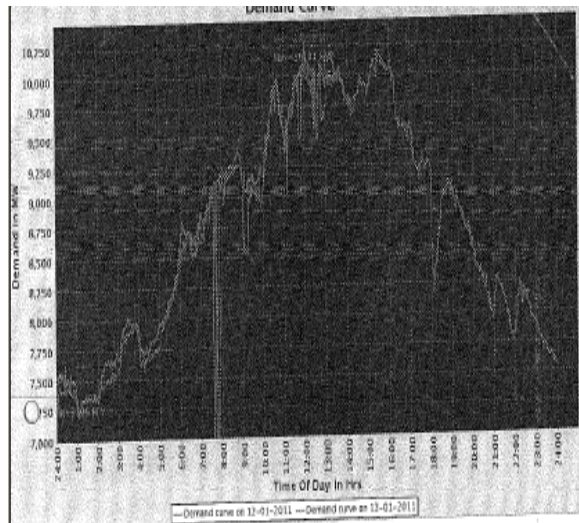


Fig 17