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विद्युत मंत्रालय / Ministry of Power
केन्द्रीय विद्युत प्राधिकरण / Central Electricity Authority
प्रणाली योजना एवं परियोजना मूल्यांकन प्रभाग
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No. 26/10/2012-SP&PA/ 1289–1302 Date: 5th December, 2012

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Sub: 35th meeting of the Standing Committee on Power System Planning in Western Region - Supplementary agenda

Sir,

In continuation to our earlier letter of even no. dated 22nd Nov., 2012, it is to intimate that the 35th meeting of the Standing Committee on Power System Planning in Western Region would be held on 19th Dec., 2012 (Wednesday) at PGCIL, Gurgaon. The main agenda (uploaded on 22-11-2012) and supplementary agenda notes for the meeting are available on CEA website (www.cea.nic.in at the following link: Home page-Wing Specific Document-Power Systems-Standing Committee on Power System Planning-Western Region). Kindly make it convenient to attend the meeting.

Yours faithfully,
रवीन्द्र गुप्ता
(Ravinder Gupta)
Director, SP&PA

1.0 Transmission system associated with New IPP projects in Chattishgarh- Shifting of converter terminal associated with ± 600 kV 4000 MW , Raigarh (Kotra) – Dhule HVDC line from Dhule in Western Region to a suitable location in Southern Region.

1.1 The transmission system associated with IPPs coming up in Raigarh and Champa generation complex was discussed and finalized in the 29th and 30th SCM of WR. The transmission system associated with new IPPs in Chattishgarh is as under:

A. Pooling Stations along with their interconnections for New IPP projects in Chattishgarh

(i) Raigarh Pooling Station (near Kotra)- Raipur Pooling station 765 kV D/C line
(ii) Raigarh Pooling Station (near Kotra) - Champa Pooling station 765 kV S/C line.
(iii) Champa Pooling station- Raipur Pooling station 765 kV D/C line.
(iv) Raigarh Pooling station (near Kotra) - Raigarh Pooling station (near Tamnar) 765 kV D/C line.
(v) Champa Pooling station – Dharamjaygarh / Korba 765 kV S/C line.
(vi) Establishment of 765/400 kV pooling stations at Raigarh (4X1500 MVA) near Kotra, at Raigarh (3X1500 MVA) near Tamnar, at Champa (6X1500 MVA), and at Raipur (1X1500 MVA).
(vii) Raigarh Pooling Station (near Kotra) - Raigarh (existing) 400 kV D/C (to be kept open at a later date).
(viii) Raipur Pooling Station – Raipur (existing) 400 kV D/C (to be kept open at a later date)

B. Transmission System within WR associated with New IPP projects in Chattishgarh

(i) Raipur Pooling station- Wardha 765 kV 2XD/C line.
(ii) Wardha- Aurangabad (PG) 765 kV 2XD/C line.
(iii) Aurangabad- Padge(PG) 765 kV 1XD/C line.
(iv) Establishment of 765/400 kV 2x1500 MVA substations at Aurangabad and Padghe (GIS Substation).
(v) Aurangabad(PG)-Boisar / Kharghar 400 kV D/C (quad) line.
(vi) Padghe(PG)- Padghe 400 kV D/C (quad) line.
(vii) Vadodra-Asoj (GETCO) 400 kV D/C (quad) line.
(viii) Establishment of 2X315 MVA, 400/220 kV substation at Dhule (PG).
(ix) Dhule (PG) – Dhule (IPTC) 400 kV 2X D/C with high capacity conductors.
(x) Dhule (PG) – Nasik (MSETCL) 400 kV D/C (quad) line.
(xi) Dhule (PG) – Malegaon (MSETCL) 400 kV D/C (quad) line.
(xii) ± 600 kV 4000 MW HVDC bipole between Raigarh pooling station (near Kotra) – Dhule (PG) along with metallic return conductor.
(xiii) Establishment of 4000 MW, ±600 kV HVDC bipole terminal each at Raigarh pooling station (near Kotra) and Dhule (PG).
(xiv) Aurangabad- Dhule (IPTC) 765 kV S/C *(Implementation by private sector through tariff based competitive bidding route)*

(xv) Dhule (IPTC) – Vadodara (PG) 765 kV S/C *(Implementation by private sector through tariff based competitive bidding route)*

(xvi) Establishment of 765/400 kV 2x1500 MVA substations at Dhule (IPTC) *(Implementation by private sector through tariff based competitive bidding route)*

(xvii) Dhule (IPTC) – Dhule (MSETCL) 400 kV D/C (quad) *(Implementation by private sector through tariff based competitive bidding route)*

C. Transmission System in NR associated with New IPP projects in Chattishgarh

(i) ± 800 kV 6000 MW HVDC bipole between Champa Pooling Station – near Kurushetra (NR) in Haryana with metallic return (initially to be operated at 3000 MW).

(ii) Establishment of 3000 MW, ±800 kV HVDC bipole terminal each at Champa pooling station and near Kurushetra in Haryana with provision to upgrade the terminals to 6000 MW.

(iii) Kurushetra- Jallandhar 400 kV D/C (Quad) line (one ckt via Nakodar S/S)

(iv) LILO of Abdullapur- Sonepat 400 kV D/C (triple) at Kurushetra

(v) Establishment of 400/220 kV , 2x500 MVA substation at Kurushetra

1.2 In the 15th Meeting of Western Regional Power Committee held on 12th Nov. 2010, MSETCL indicated that MSPGCL had planned about 3000MW generation near Dhule at Dondaicha and 1350 MW generation of M/s India Bulls at Sinnar in Nasik District was planned. In view of the same they had planned parallel additional corridors in Dhule – Nashik - Malegaon area and therefore had requested POWERGRID to review the decision of establishing HVDC converter station at Dhule with +/- 600kV Raigarh (Kotra) – Dhule (PG) HVDC bipolar link and 400kV interconnecting lines with Malegaon, Nashik, Dhule (MSETCL).

1.3 Presently, Southern Region is facing acute shortage of power of about 5000 MW. Following generation projects are planned in Southern Region during 12th Plan period :

XII Plan Projects in Southern Region (All figures in MW)

AP	Coal	Hydro	Gas
Pulichintala		120	
L. Jurala		240	
Rayalseema (U-6)	600		
Simhapuri	600		
Lanco Kondapally			740
GMR Rajamundry			768
GVK-Gautami			800
GVK-Jegrupadu			800
Meenakshi	900		
Hinduja	1040		
Kakatiya	600		
East Coast	1320		
Krishnapatnam(AP)	1600		
Thermal Powertech	1320		
Reliance -Vemagiri			2400
Total	**7980**	**360**	**5508**
Addition in AP		**13848**	

Karnataka	Coal	Hydro	Gas
Kudgi (NTPC)	2400		
Torangallu U-4	300		
Yeramaras	1600		
Uddupi (LANCO)	600		
Bellary	700		
Total	**5600**	**0**	**0**
Addition in Karnataka		**5600**	

Kerala	Coal	Hydro	Gas
Thottiar		40	
Pallivasal		60	
Total	**0**	**100**	**0**
Addition in Kerala		**100**	

TN	Coal	Hydro	Gas	Nuclear
Udangudi	800			
PEL- Naga	1050			
North Chennai	1200			
Mettur	1200			
ILFS- Naga.	1200			
Ind Barath-Tuti	1320			
Coastal Energen	1200			
Total	**7970**	**0**	**0**	**0**
Addition in TN		**7970**		
Central Sector	**Coal**	**Hydro**	**Gas**	**Nuclear**
Simhadri U- 4	500			
Kalpakkam				500
Neyveli St-III	500			
Tuticorin JV	1000			
Vallur (JV)	1500			
Kudankulam				2000
Total	**3500**	**0**	**0**	**2500**
Addition in Central Sector			**6000**	

Summary	Coal	Hydro	Gas	Nuclear
Andhra Pradesh	7980	360	5508	0
Tamilnadu	7970	0	0	0
Karnataka	5600	0	0	0
Kerala	0	100	0	0
Central Sector	3500	0	0	2500
Total	**25050**	**460**	**5508**	**2500**
Addition in Southern Region			**33518**	

1.4 Load in SR is expected to increase at least by another 20,000 MW during 12th Plan. The envisaged 33,500 MW of installed capacity can give a maximum generation availability of 25,000 MW. Most of the upcoming IPP generation projects in Southern Region are based on Gas / Imported Coal and hence, in view of the shortage of fuel, power availability from these projects is uncertain. Thus, out of the above list, some of the projects (shown in grey in above list) may get delayed / dropped / or may generate less due to issues related to coal, gas availability, environment etc. Further, in view of delay in Krishnapatnam UMPP, it is envisaged that southern region would be deficient in power in coming years also.

1.5 The above uncertainty in the addition of generation projects in 12th plan and present deficit shall leave Southern Region a total deficit of about 10000 – 13000 MW. This deficit is to be met from the surplus power available in neighboring regions which shall be imported to Southern region. However the present and planned inter-regional capacity of Southern Region grid with rest of the grid is not adequate for import of such a huge quantum of power. This necessitates augmentation of the inter-regional links to avoid any constraints in importing power in future which Southern Region is facing today to meet its demand.

1.6 Chhattisgarh IPPs have not indicated any firm beneficiaries for power generated from their plants and therefore the surplus power can be transferred to Southern Region for meeting its demand, subject to the availability of inter-regional transfer capacity. Hence, considering the requirement of transfer of power from Chhattisgarh to Southern region, POWERGRID has proposed to shift the converter station associated with the ± 600kV, 4000MW Raigarh (Kotra) – Dhule (PG) HVDC bipolar link proposed at Dhule in Western Region to Southern Region.

1.7 Thus, the termination of ± 600kV, 4000MW Raigarh (Kotra) – Dhule (PG) HVDC bipolar link agreed as a part of the Transmission system associated with new IPPs in Chhattisgarh is modified as under :-

- ± 600 kV, 4000 MW HVDC bipole between Raigarh pooling station (near Kotra) to a suitable location in Southern Region along with metallic return conductor.

- Establishment of 4000 MW, ±600 kV HVDC bipole terminal each at Raigarh (Kotra) and at a suitable location in Southern Region.

1.8 With the proposed modification at 16.7, the interconnection and system strengthening associated with Dhule HVDC terminal (**item no. viii to xi of 16.1 – B**) is deleted from the scope of the works agreed.

1.9 Members may discuss.

2.0 Proposal for Static VAR Compensators (SVC) in Western Region.

2.1 As per the recommendations of the Enquiry Committee constituted by Ministry of Power to analyze the causes of the grid disturbances experienced in the NEW grid on 30-07-2012 and 31-07-2012, system studies has been conducted by POWERGRID for assessing the requirement of dynamic reactive power compensation in Western Region. Based on the study results, installation of SVC of +600/-600 MVAR at following six locations are proposed:

S. No	400kV substation	SVC rating
1	Indore-PG	± 600 MVAR
2	Gwalior	± 600 MVAR
3	Satna	± 600 MVAR
4	Seoni	± 600 MVAR
5	Solapur	± 600 MVAR
6	Kolhapur	± 600 MVAR

2.2 A report on the proposal of installation of SVC in Western Region by POWERGRID is enclosed as Annexure- I.

2.3 The report was discussed in CEA and it was decided that POWERGRID would carry out additional studies as discussed and make a presentation in the meeting.

2.4 Members may discuss.

3.0 Termination of Vapi – Navi Mumbai 400kV D/c line at upcoming Kudus substation of MSETCL.

3.1 Vapi – Navi Mumbai 400 D/c line is being constructed by POWERGRID under WRSS-V. The line was awarded in the year 2007. However, the construction progress of the line has been very slow since beginning, due to severe ROW problems.

3.2 The total line length of this line is 185 kms, out of which the last 73 kms of the line from Navi Mumbai end involves 115 Ha of forest and Matheran Eco sensitive zone. Further, due to urbanization / industrialization, especially in the vicinity of Mumbai / Navi Mumbai area, severe RoW constraints are being encountered in completion of line. Gram Panchayat of 11 villages, in the vicinity of Mumbai / Navi Mumbai area / sub-urban area, have refused to give their NOC for FRA and are obstructing work. Also, proposal for Matheran Eco-sensitive zone is pending before National wildlife Board for last one year for approval. After this clearance, the proposal will have to be cleared from Supreme Court for Permission.

3.3 POWERGRID has been pursuing the matter for resolving the ROW with state administration at all levels regularly, however their response is not encouraging. Their main demand is to pay the land compensation for the entire line corridor at the market rate, which is beyond the provision of Indian Telegraphic Act 1885.

3.4 At present, a 400kV substation is being constructed by MSETCL at Kudus (near Padghe), which is located at a distance of around 2-3 kms, from the tower location no. 115/2 of the Vapi – Navi Mumbai 400kV D/c line (diagram attached at Annexure-II*)*. The large quantum of work is balance in the sections from tower location115/2 to Navi Mumbai S/s, which are highly urbanized areas and it is uncertain that ROW problem in these areas would be resolved. Already more than four years time is elapsed and due to the uncertainty in completing balance works, it is proposed that 400kV Vapi – Navi Mumbai D/c line may be terminated at upcoming Kudus substation of MSETCL, so as to facilitate interstate connectivity between Gujarat and Maharashtra.

3.5 With termination of the line at Kudus, the route length of the 400 kV Vapi – Kudus (MSETCL) D/c line will be tentatively 125 kms (approx.) against the route length of 185 kms of 400 kV D/c Vapi – Navi Mumbai line.

3.6 In the 32nd SCM of WR held on 13th May 2011, PGCIL has requested for reconsideration of Pune – Navi Mumbai 400kV D/c line, agreed as WR System strengthening scheme to be implemented in the time frame of Krishnapatnam UMPP, as severe RoW constraints were envisaged during its implementation. In the meeting MSETCL has agreed to suggest alternative suitable location for termination of line from Pune for onward dispersal of power.

3.7 The interconnection of Navi Mumbai 400 kV substation planned are Vapi - Navi Mumbai 400 kV D/C line, Pune – Navi Mumbai 400 kV D/C line and LILO of

Lonikhand/Pune - Kalwa 400 kV S/C line at Navi Mumbai. With the review of two nos. 400 kV D/C lines i.e., Vapi – Navi Mumbai and Pune – Navi Mumbai, the infeed to Navi Mumbai 400 kV substation would be severely affected. MSETCL may propose alternative feeding points for Navi Mumbai.

3.8 Members may discuss.

4.0 400 kV outlet from 765/400 kV Gwalior (PG) sub-station

4.1 At present Bina-Gwalior 765 kV 2xS/C lines and Gwalior-Agra 765 kV 2xS/C lines are existing, which are being operated at 400 kV. These lines are planned to be operated at 765 kV in near future. After operation of these lines at 765 kV, no 400 kV inter connection except 400/220 kV 2x315 MVA ICT would be there at Gwalior (PG).

4.2 MPPTCL may indicate suitable outlets / inter-connections from Gwalior (PG) at 400 kV level.

4.3 Member may discuss.

5.0 Review of Transmission System for transfer of power from IPPs of SR to WR / NR

5.1 The transmission system Associated with IPP projects in Southern Region, for transfer of power to other regions was finalized in the 30th meeting of standing committee on power system planning in Western Region held on 08-07-2010 and is given below:

i) Solapur-Pune 765 kV S/c (2nd) line
ii) Jabalpur Pooling station - Orai 765 KV S/c line
iii) Orai – Bulandshahar 765kV S/c line
iv) Buandshahar – Sonipat 765kV S/c line
v) Orai – Orai (UPPCL) 400kV D/c (Quad) line
vi) Sonipat - Kurushetra 400 KV D/c (Quad) line
vii) Sonipat (New) - Sonipat 400 KV D/c (Quad) line
viii) Bulandshahar-Hapur (UPPCL) 400 KV D/c (Quad) line
ix) 2x1000MVA, 765/400 KV substation at Orai by LILO of one circuit of Satna-Gwalior 765 KV D/c line
x) 2x1500MVA, 765/400KV S/s at Bulandshahar by LILO of Agra-Meerut 765 kV S/c line
xi) 2x1500MVA, 765/400KV S/s at Sonipat by LILO of Bhiwani-Meerut 765 kV S/c line

The above transmission system was also agreed in 14th WRPC meeting held on 19-08-2010

5.2 In the 32nd SCM of WR the change in quantum of LTA and beneficiaries from various IPPs in Southern Region associated with above transmission system was noted by the constituents. The Regulatory Approval for implementation of the above system by POWERGRID has also been granted by CERC.

5.3 Subsequently, with the grant of LTA to IPPs in Western Region like Today Energy Ltd. (1320MW), Dhariwal Infrastructure Ltd.(600MW) and DB Power Ltd.(1320MW) with target beneficiaries in Northern Region, the Jabalpur pooling station – Orai –

Bulandshahar 765 kV S/C corridor was strengthened as 765 kV D/C corridor along with addition of Sonipat (New) – Kaithal 400 kV D/C quad line. The Regulatory Approval for implementation of the upgradation by POWERGRID has been granted by CERC.

5.4 In view of the slow progress of generation projects in Southern Region, the above transmission scheme was not taken up for implementation. With grant of LTA to IPPs in WR with target beneficiaries in NR, WR-NR corridors needs to be further strengthened. Further in NR following changes have taken place:

- UP is establishing 765 kV substation at Greater Noida under PPP mode and already awarded the works. It has been gathered that the site identified for 765 kV Greater Noida and Bulandshahar S/s are in close proximity. Establishment of two 765 kV substations in close proximity is not desirable.

- Kanpur – Jhatikara 765 kV S/c line is under construction, which is about 450 km long and for smooth operation it is desirable to LILO this line at some substation to reduce its length.

- Earlier a 765/400 kV substation at Sonipat was planned, however with the coming up of CLP Jhajjar & Aravali Jhajjar generations as well as considering the injection of power from Adani at Mohindergarh, there is a need to review the requirement of establishment of 765/400 kV substation at Sonipat.

Considering the above, it is proposed that the establishment of 765/400 kV substation at Bulandshahar may be shifted to Aligarh and LILO of Kanpur – Jhatikara 765 kV S/c line is also carried out at Aligarh. Further it is also proposed that for power dispersal from Aligarh, a 765 kV D/c line may be taken towards Hapur substation.

5.5 In view of the above, POWERGRID has proposed to take up the Transmission System agreed for transfer of power from IPPs of SR to WR / NR as WR-NR System Strengthening Scheme. Accordingly, the following transmission works are proposed as WR-NR System Strengthening Scheme:

(i) Solapur – Pune 765kV S/c (2nd) line.
(ii) Jabalpur Pooling station - Orai 765 KV D/c line.
(iii) Orai – Aligargh 765kV D/c line.
(iv) Aligarh – Hapur 765kV D/c line.
(v) Orai – Orai (UPPTCL) 400kV D/c (Quad) line.
(vi) LILO of one circuit of Satna-Gwalior 765 KV line at Orai S/s.
(vii) 2x1000MVA, 765/400KV substation at Orai S/s.
(viii) LILO of Agra-Meerut 765 kV S/c line at Aligarh S/s.
(ix) 2x1500MVA, 765/400KV S/s at Aligarh.
xi) LILO of Kanpur – Jhatikara 765 kV S/c at Aligarh S/s.

5.6 Members may discuss.

6.0 Commissioning of line reactors as bus reactors at Bina 765kV substation.

6.1 POWERGRID has intimated that at Bina 765/400 kV substation, high voltage is persisting on 765kV Bus and on 400kV Bus also most of the time. The 1X240Mvar Line Reactor of Bina - Gwalior line along with the bay is available. 2X765kV Bina-

Gwalior line upgradation is pending completion of ICT Bays at Gwalior 765/400kV substation.

6.2 In view of the prevailing high voltage conditions in 765kV Bina Bus, POWERGRID has proposed to utilize the 240Mvar Gwalior line reactor as a Bus Reactor at Bina. Once the Bina-Gwalior line along with bays is ready at Gwalior end for upgradtation at 765 kV voltage level, this reactor shall be used as line reactors.

6.3 Members may discuss.

7.0 Review of Transmission Planning Criteria

7.1 The Enquiry Committee headed by Chairperson, CEA for grid events in July 2012 has recommended that transmission planning criteria needs to be reviewed in the context of market scenario within three months. In this regard, a note on the issues relating to "Review of Planning Criteria" has been prepared. . A copy of this note and the existing "Manual on Transmission Planning Criteria" are available on CEA website.

7.2 Members of the Standing Committee on Power System Planning of Southern Region are requested to furnish their comments/ suggestions regarding review of transmission planning criteria to the undersigned along with a soft-copy mailed to *cea.sppa@yahoo.in*.

7.3 Members may give their views/observations in regard to review of Transmission Planning Criteria.

8.0 Integrated planning for State transmission system:

8.1 As per section 39 of the Electricity Act, STUs need to carry out their planning function related to intra-state transmission in coordination with the CEA and CTU. There have been a few instances in the past where, the STU has planned important transmission system or allowed connectivity to large generation capacities without involving CEA and CTU and this may result in congestion/operational difficulties for the ISTS/national grid. To start with, it is proposed that STU should evolve following of their systems involving CEA and CTU, which would subsequently be firmed up through the Standing Committee forum:-

(a) 220 kV and above system
(b) Large scale harnessing of renewable generation
(c) System for evacuation of power from a complex having generation capacity of 250 MW and above in case of conventional and 50 MW and above in case of renewable.

9.0 State wise assessment of the Load Generation Scenario of Western Region.

9.1 For the assessment of load generation scenario, all STUs of Western Region are requested to provide the seasonal load and generation data in prescribed format given below.

State:

LOAD

	2014-15	2016-17	2019-20
Summer Peak			
Summer Off- Peak			
Winter Peak			
Winter off- Peak			
Monsoon Peak			
Monsoon Off-Peak			

18th EPS Load			

State:

GENERATION

		2014-15		2016-17		2019-20	
		Installed Capacity	**Dispatch**	**Installed Capacity**	**Dispatch**	**Installed Capacity**	**Dispatch**
	Thermal						
	Hydro						
	Wind						
Summer Peak	Solar						
	Thermal						
	Hydro						
	Wind						
Summer Off- Peak	Solar						
	Thermal						
	Hydro						
	Wind						
Winter Peak	Solar						
	Thermal						
	Hydro						
	Wind						
Winter off- Peak	Solar						
	Thermal						
	Hydro						
	Wind						
Monsoon Peak	Solar						
	Thermal						
	Hydro						
	Wind						
Monsoon Off-Peak	Solar						

Maximum Export/Import requirement of State considering various contingencies:

	2014-15	2016-17	2019-20
Summer Peak			
Summer Off- Peak			
Winter Peak			

Winter off- Peak			
Monsoon Peak			
Monsoon Off-Peak			

Annexure I

Proposal for Static VAR Compensators (SVC) in Western Region.

1.1 Back Ground

In the recent past, major grid disturbances had been experienced in NEW grid on 30-07-2012 and 31-07-2012. An Enquiry Committee was constituted by Ministry of Power to analyze the causes of these disturbances and to suggest measures to avoid recurrence of such disturbance in future. Based on the analysis of these grid disturbances, the committee recommended that "*In order to avoid frequent outages / opening of lines under over voltages and also providing voltage support under steady state and dynamic conditions, installation of adequate static and dynamic reactive power compensators should be planned*". The committee has recommended 6 months time frame for this reactive power planning in all the regions.

Looking into the observations & as per the recommendations of the Expert Committee on these grid disturbances and to avoid any such grid disturbance in future in Western Region, system studies were conducted for dynamic reactive power compensators in Western region and the details are given in the subsequent paras.

1.2 Role of Static Var Compensator (SVC)

The voltage stability of a power system is greatly dependent upon the amount, location and type of reactive power sources available. If the reactive power support is far away, insufficient in size, or too dependent on shunt capacitors, then a relatively low severity contingency, such as a line outage or the loss of a generator unit, can trigger a large system voltage drop.

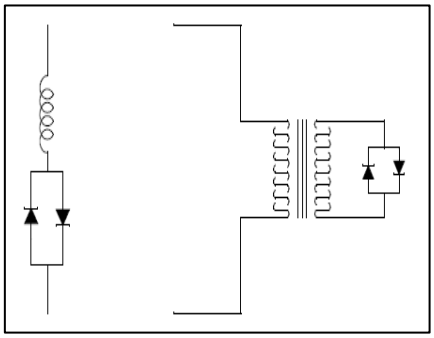
Conventional reactive power sources are suitable for steady-state control of the power system, or in instances where changes in system conditions occur relatively slowly. However, these are many instances where extremely rapid network changes take place and static VAr devices prove invaluable in these circumstances.

Static VAr Compensators (SVCs) are shunt connected sinks and/or sources of reactive power and their output ay be varied to maintain or control specific parameters of a power system. For example, by absorbing or generating reactive power an SVC can maintain virtually constant voltage at a particular network node. The term 'static' is used to indicate that an SVC, unlike a synchronous condenser, does not have inertia or any moving or rotating main components. This property of an SVC makes it very fast in responding to changing network conditions. And, because an SVC is composed of passive elements, it does not increase the short circuit level.

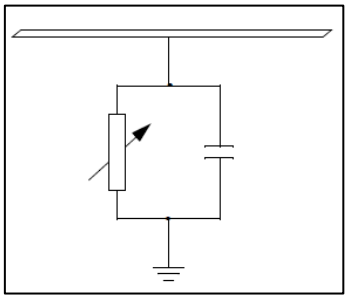
1.3 Characteristics of Static Var Compensator (SVC)

A static Car Compensator (SVC) is a parallel combination of controlled shunt reactor and capacitor to regulate the voltage at a bus where it is installed.

The arrangement shown in Figure–1, is that of a controlled shunt reactor in which the thyristors are in series with a reactor that directly control the current flow through the reactor. The effect of controlled firing of the thyristors is to control the effective fundamental frequency admittance of the thyristor-reactor unit as seen from its high-voltage terminals.

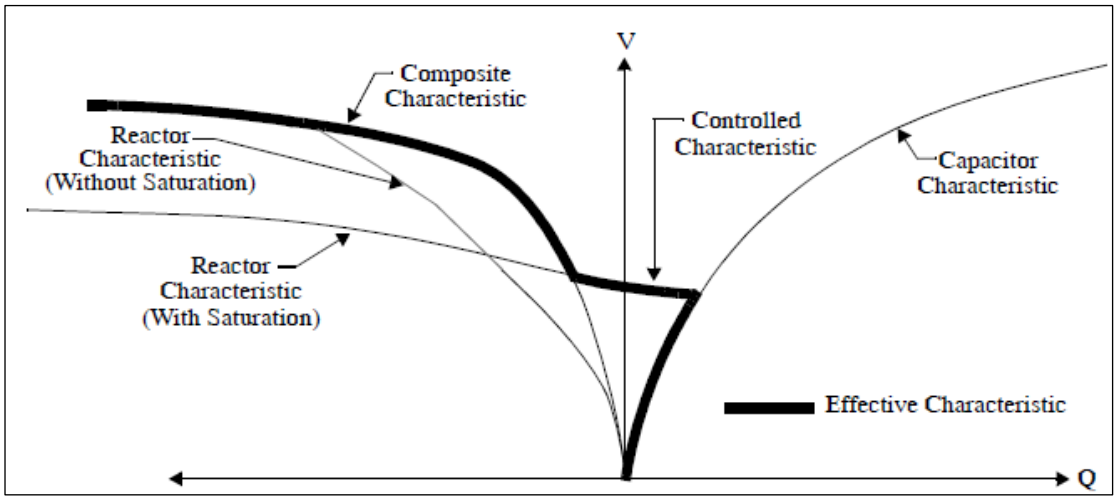


Figure–2 shows the arrangement of combination of controlled reactor in parallel to shunt capacitor.



- With the reactor turned “off” through thyristor switching, the installation is a shunt capacitor that will supply reactive power to the system.
- The reactor may be turned “on” in controlled fashion to absorb reactive power of varying quantum, thereby the effective value of reactive Vars absorbed from the system or supplied to the system can be controlled.

The characteristics of the combined controlled shunt reactor and capacitor is as shown below, wherein it may be seen that in the normal operating range of voltages the SVC provides a near flat characteristics for the reactive power generated/absorbed.



The Static VAR Compensator (SVC) facilitates enhanced voltage stability by providing reactive power support to the power system.

1.4 System Studies for Static Var Compensator (SVC) in Western Region.

The system studies were performed on the 2015-16 time frame peak condition to evaluate the relative impacts of varying system load, generation, and transfer levels on dynamic support requirements and load flow study results for the same are

placed at **Exhibit-I**. This was done to get an understanding of the severity of the contingencies and identify the most critical contingency from a dynamic standpoint. This worst case scenario was identified to be a three phase fault and tripping of critically loaded transmission line.

Location of SVC: Voltage Data for all the POWERGRID substations of Western Region for previous year were collected. Based on the analysis of the voltage data, it was observed that voltage deviations at the following locations were very high typically in the range of 30 – 70 kV and therefore they are the suitable locations for installation of SVC to improve reliability & security of the grid operation under dynamic conditions.

S. No	400kV Bus	Voltage (kV)	
		Min	Max
1	Indore-PG	391.6	429.1
2	Gwalior	388.0	430.7
3	Satna	396.4	424.1
4	Seoni	398.1	434.9
5	Solapur	371.0	440.0
6	Kolhapur-PG	386.1	432.0

Sizing of SVC: The sizing of the SVC shall depend upon the strength of Short Circuit MVA at a particular bus. Typically for a 3% voltage correction during the steady state, the size of the reactive compensation required is of the order of 500 MVAR. The Q-V analysis is also carried out on all above mentioned buses. The order of sensitivity is found to be varying from about 30MVAR/kV to about 75MVAR/kV. Based on the sensitivity range, it is proposed that the rating of SVC shall be +600/-600 MVAR at 400 kV level at all the above locations.

System Studies: The dynamic simulation studies have been carried out in PSS/E software at all above mentioned locations. The simulation results with SVC of +600/-600 MVAR at above locations in Western Region are placed at **Exhibit-II**.

Looking into the analysis of the voltage deviations and the dynamic study results, it is proposed for installation of SVC of +600/-600 MVAR at 1) Satna 2) Gwalior 3) Kolhapur 4) Solapur 5) Indore and 6) Seoni substations to improve reliability & security of the grid operation and to avoid any untoward grid incidences in Western Region.

SYSTEM STUDIES IN WESTERN REGION

EXHIBIT - I

POWER TECHNOLOGIES, INC.®

SVC STUDY
FAULT @ SEONI-KHANDWA, TRIP SEONI-KHANDWA

EXHIBIT-II (SEONI)

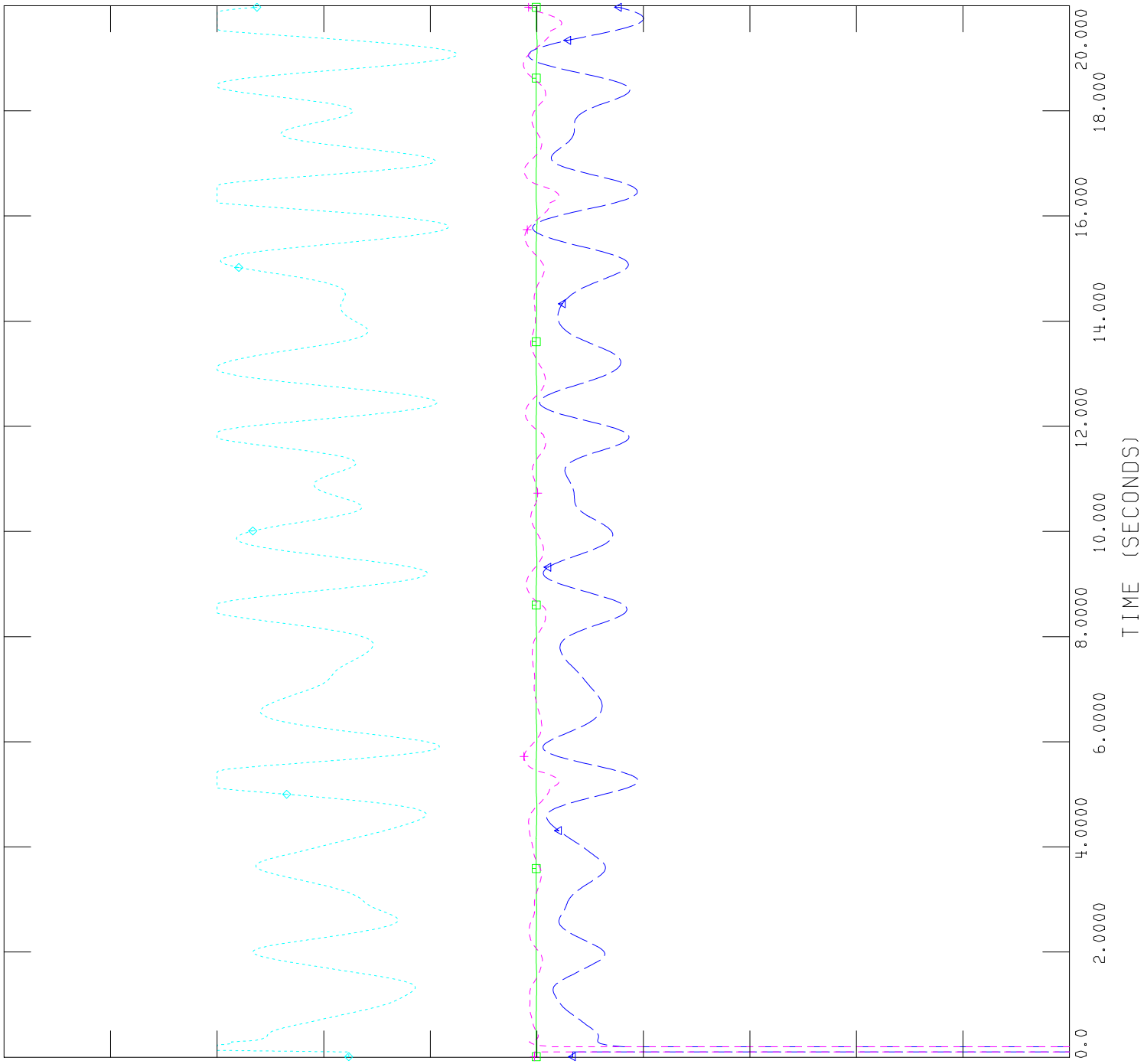
MON, OCT 15 2012 11:20 SEONI

CHNL# 626: [VLTG SEONI4 -WEST]
1.2000 FILE: C:\BHASKAR\study\statcom\16-17\2wsvc @Seoni-Khandwa.out 0.80000

CHNL# 2165: [SEONI_SVC]
10.000 FILE: C:\BHASKAR\study\statcom\16-17\2wsvc @Seoni-Khandwa.out -10.00

CHNL# 626: [VLTG SEONI4 -WEST]
1.2000 FILE: C:\BHASKAR\study\statcom\16-17\2wosvc @Seoni-Khandwa.out 0.80000

CHNL# 2165: [SEONI_SVC]
10.000 FILE: C:\BHASKAR\study\statcom\16-17\2wosvc @Seoni-Khandwa.out -10.00



POWER TECHNOLOGIES, INC.®

SVC STUDY
FAULT @ GWLR TRIP GWLR 765KV ICT

EXHIBIT - II (GWALIOR)

MON, OCT 15 2012 12:04

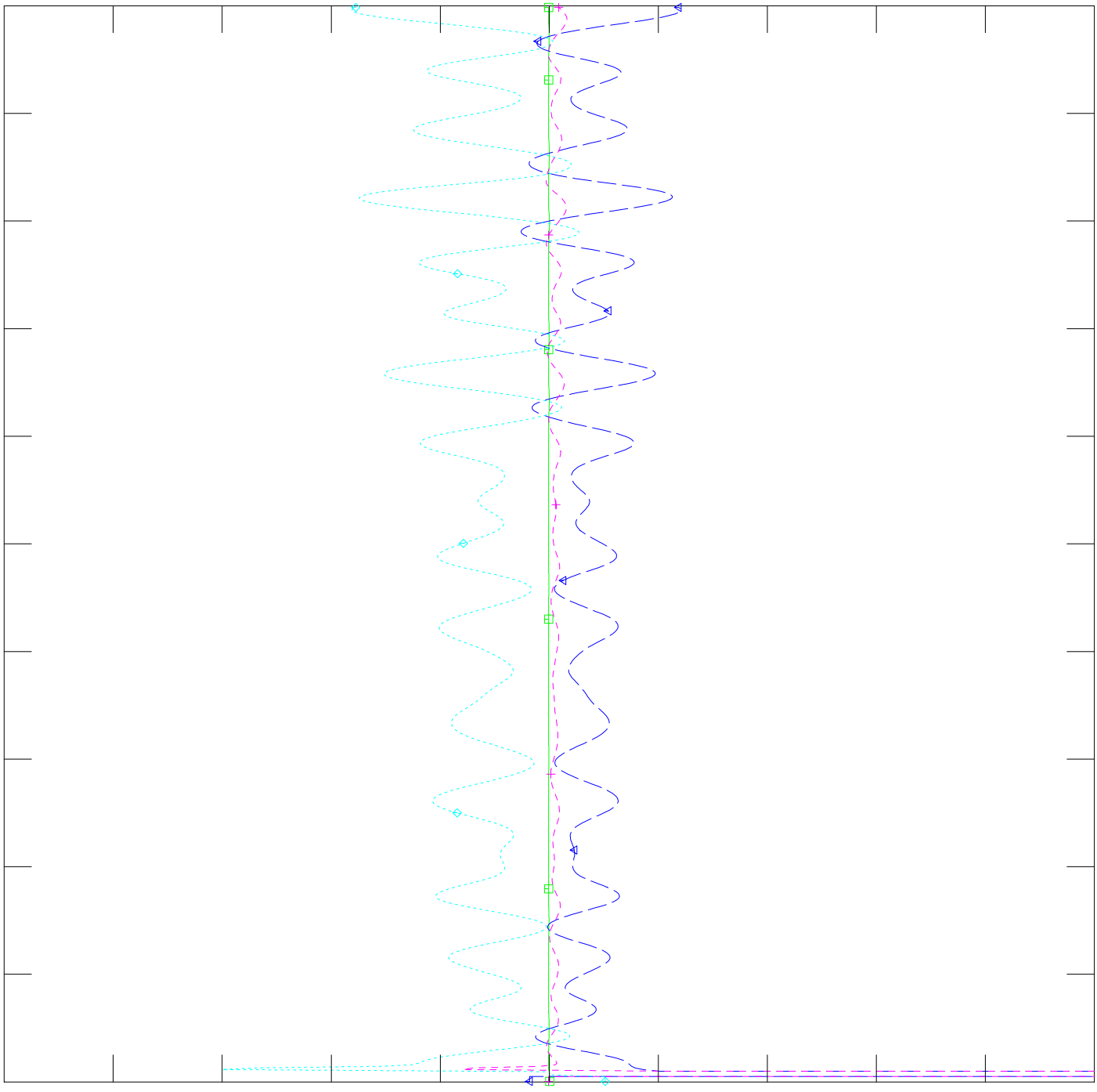
GWALIOR

CHNL# 640: [VLTG GWALOR4 -WEST]
1.2000 FILE: C:\BHASKAR\study\statcom\16-17\1wsvc @gwlr 765kV ICT.out 0.80000

CHNL# 2182: [GWALIOR-SVC]
10.000 FILE: C:\BHASKAR\study\statcom\16-17\1wsvc @gwlr 765kV ICT.out -10.00

CHNL# 640: [VLTG GWALOR4 -WEST]
1.2000 FILE: C:\BHASKAR\study\statcom\16-17\1wosvc @gwlr 765kV ICT.out 0.80000

CHNL# 2182: [GWALIOR-SVC]
10.000 FILE: C:\BHASKAR\study\statcom\16-17\1wosvc @gwlr 765kV ICT.out -10.00



POWER TECHNOLOGIES, INC.®

SVC STUDY
FAULT @ INPMP TRIP INDMP-NRMDSGR

EXHIBIT-II (INDORE)

MON, OCT 15 2012 12:01

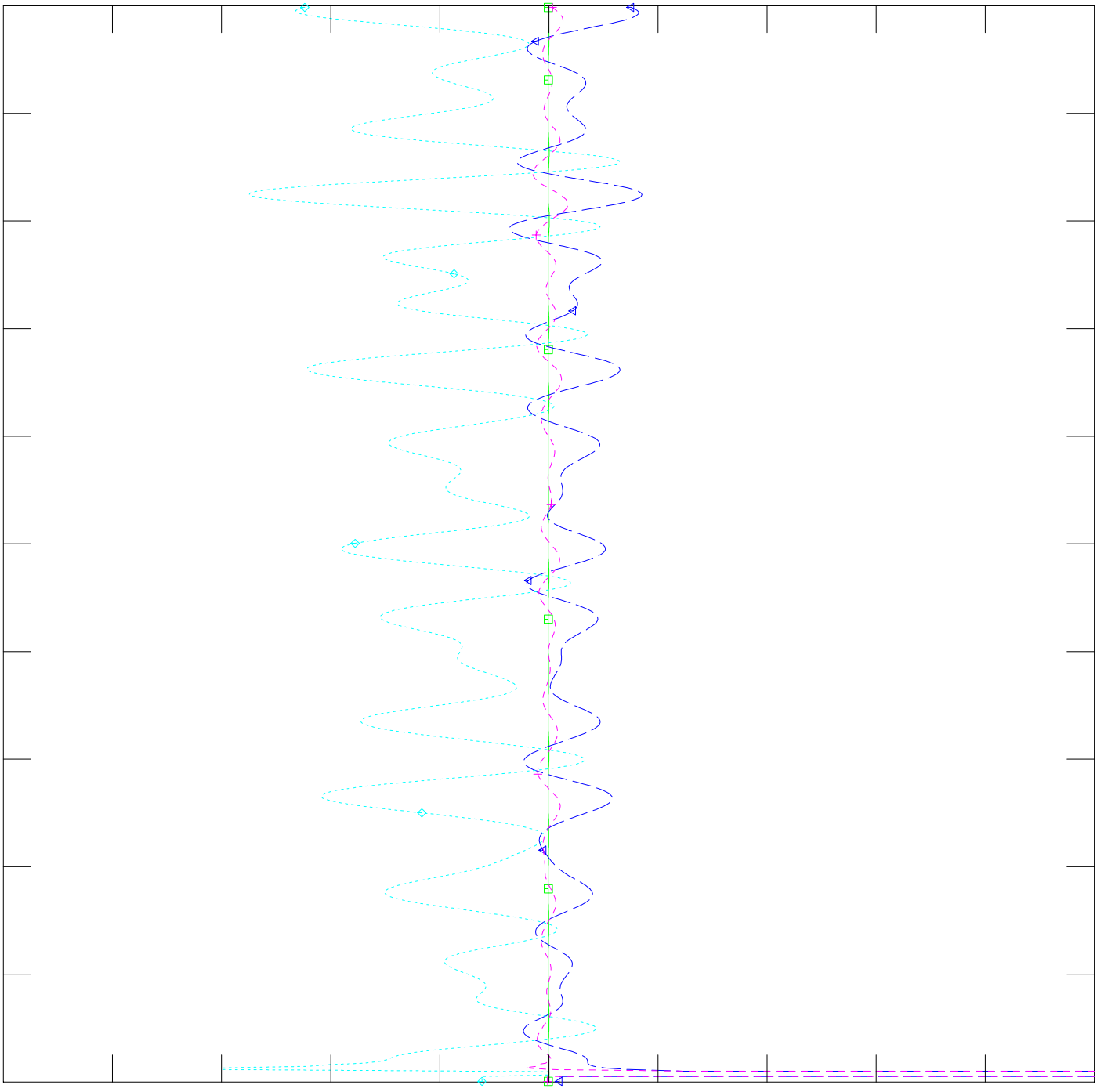
INDORE

CHNL# 642: [VLTG INDOR-PG -WEST]
1.2000 FILE: C:\BHASKAR\study\statcom\16-17\1wsvc @indmp_nrdsgr.out 0.80000

CHNL# 2166: [INDPG_SVC]
10.000 FILE: C:\BHASKAR\study\statcom\16-17\1wsvc @indmp_nrdsgr.out -10.00

CHNL# 642: [VLTG INDOR-PG -WEST]
1.2000 FILE: C:\BHASKAR\study\statcom\16-17\1wosvc @indmp_nrdsgr.out 0.80000

CHNL# 2166: [INDPG_SVC]
10.000 FILE: C:\BHASKAR\study\statcom\16-17\1wosvc @indmp_nrdsgr.out -10.00



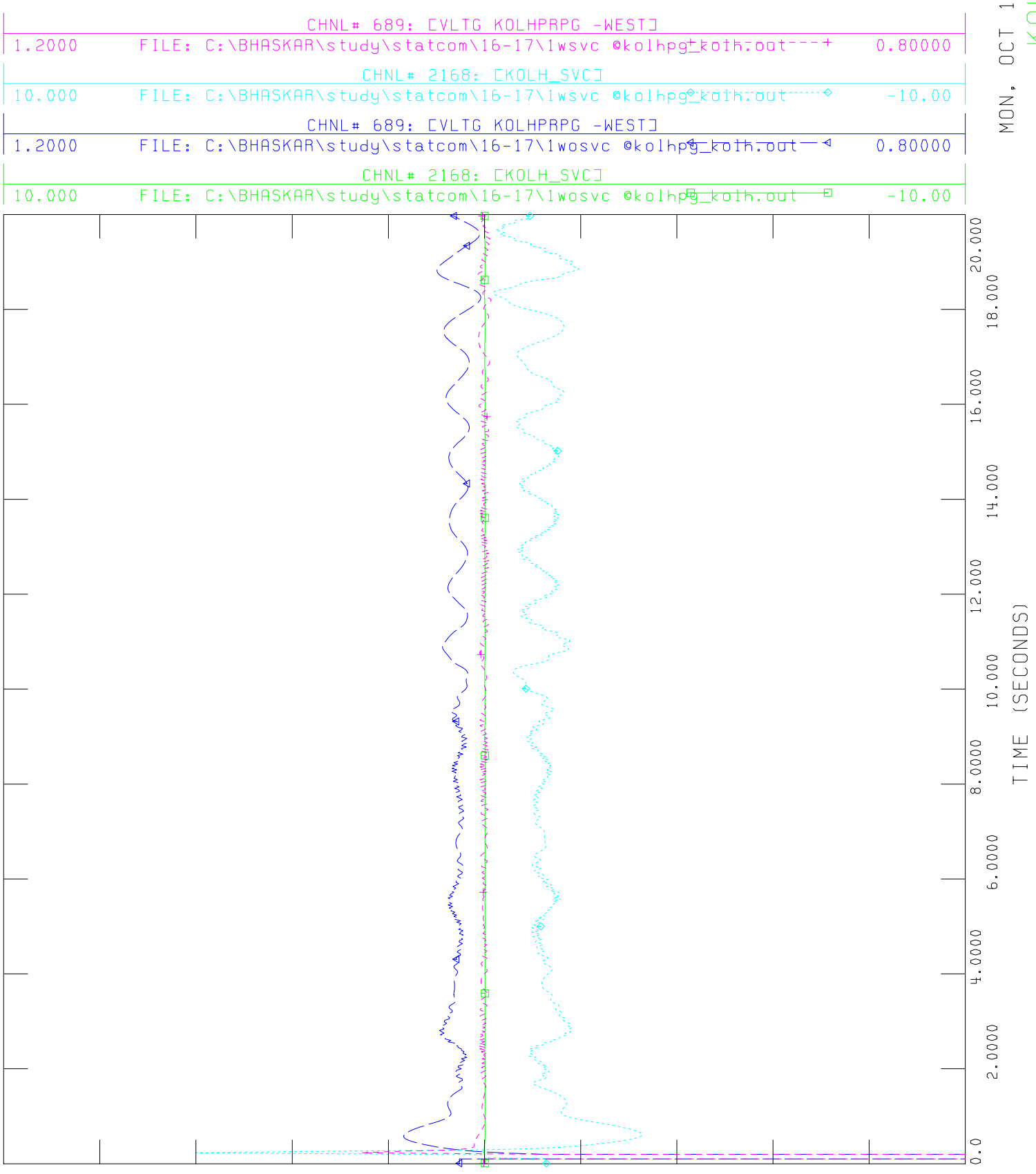
POWER TECHNOLOGIES, INC.®

SVC STUDY
FAULT @ KOLHPG TRIP KOLHPG-KOLH

EXHIBIT-II (KOLHAPUR-PG)

MON, OCT 15 2012 11:55

KOLHAPUR-PG



POWER TECHNOLOGIES, INC.®

SVC STUDY
FAULT @ SATNA TRIP SATNA-JPNGRI

EXHIBIT-II (SATNA)

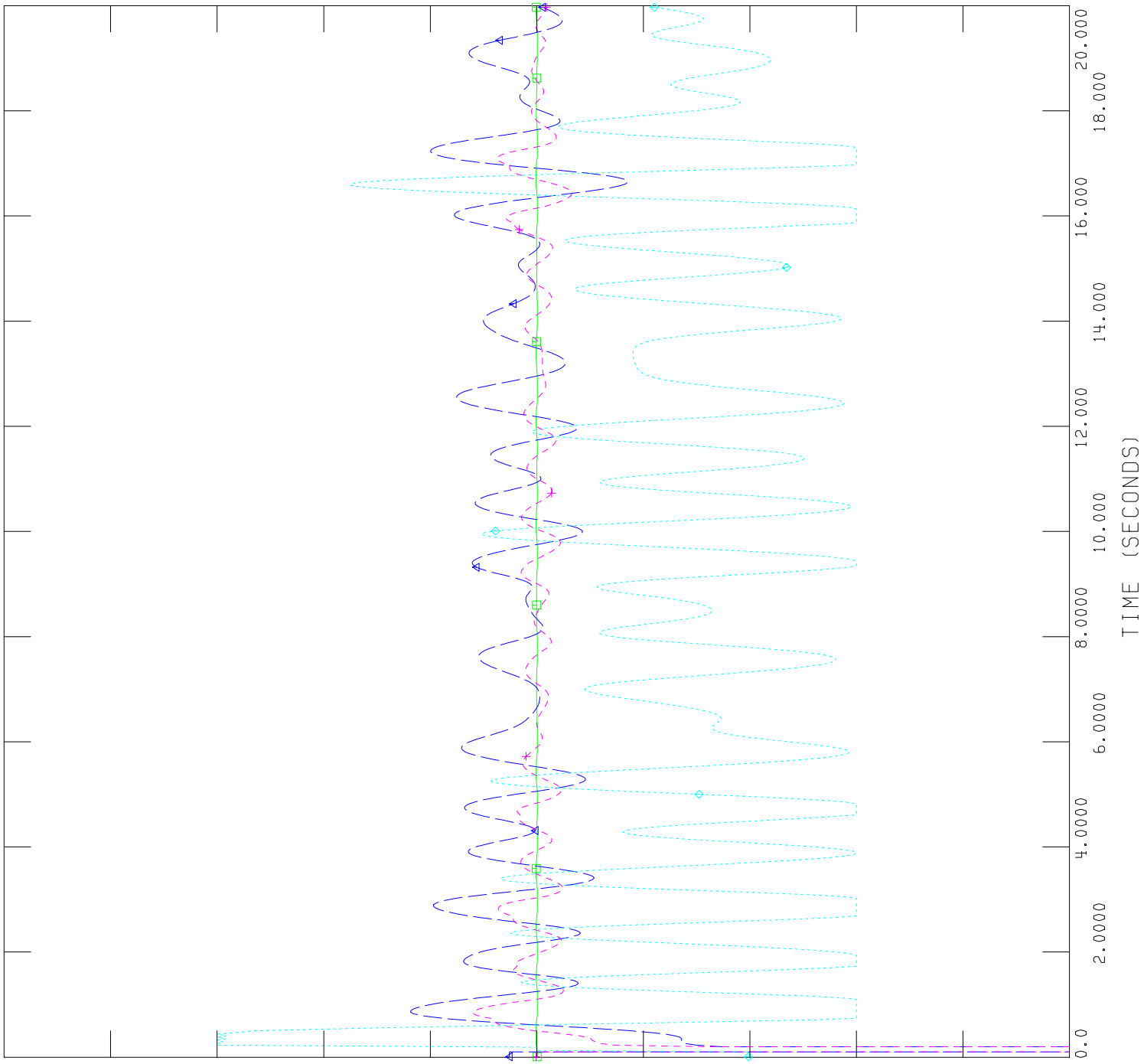
MON, OCT 15 2012 11:50 SATNA

CHNL# 620: [VLTG SATNA4 -WEST]
1.2000 FILE: C:\BHASKAR\study\statcom\16-17\1wsvc @Satna-JPngri.out 0.80000

CHNL# 2172: [SATNA_SVC]
10.000 FILE: C:\BHASKAR\study\statcom\16-17\1wsvc @Satna-JPngri.out -10.00

CHNL# 620: [VLTG SATNA4 -WEST]
1.2000 FILE: C:\BHASKAR\study\statcom\16-17\1wosvc @Satna-JPngri.out 0.80000

CHNL# 2172: [SATNA_SVC]
10.000 FILE: C:\BHASKAR\study\statcom\16-17\1wosvc @Satna-JPngri.out -10.00



POWER TECHNOLOGIES, INC.®

SVC STUDY
FAULT @ SOLPRPG TRIP SOLPRPG-SOLSTPP

EXHIBIT-II (SOLAPUR-PG)

MON, OCT 15 2012 11:45

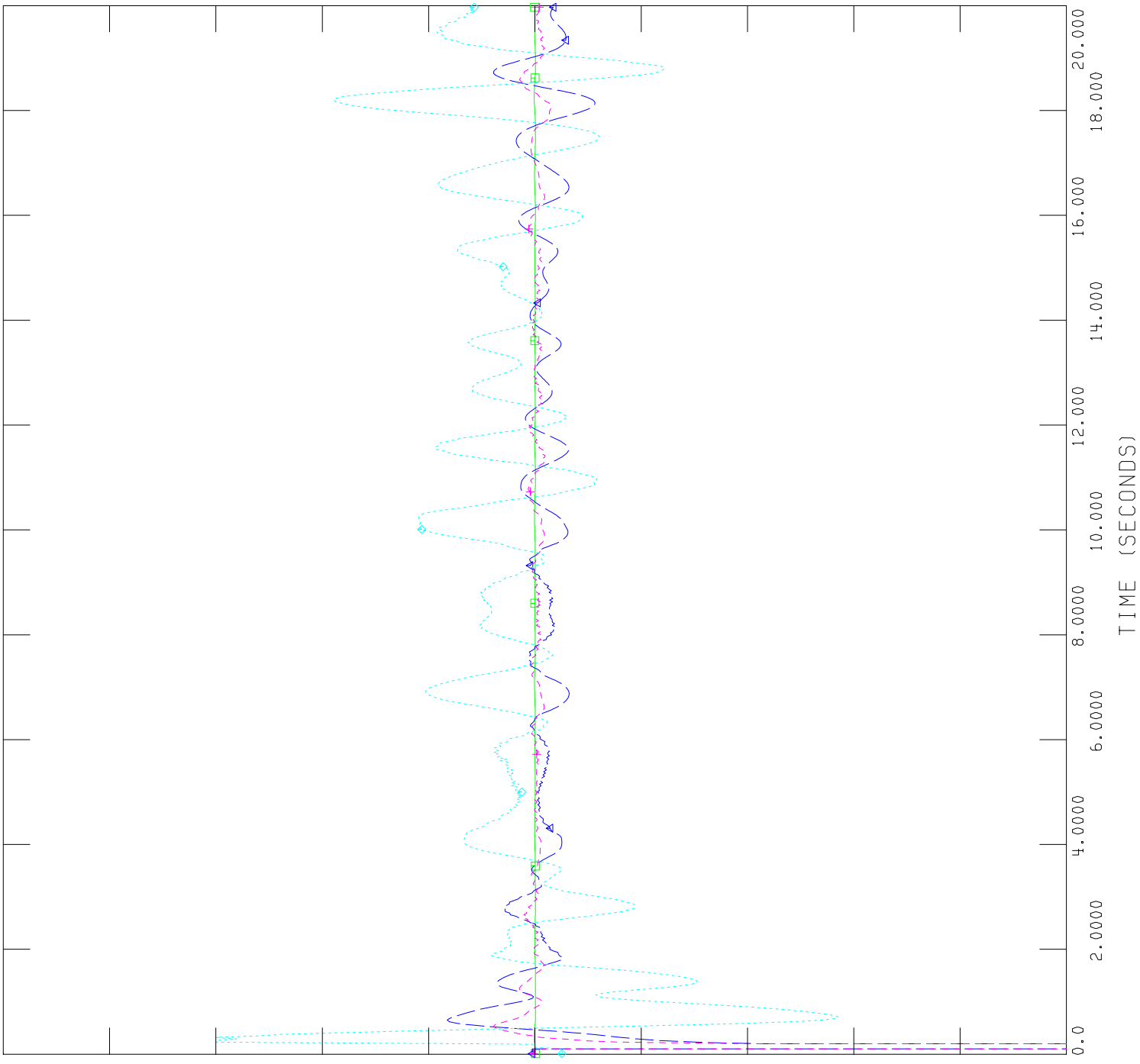
SOLAPUR-PG

CHNL# 692: [VLTG SOLPRPG -WEST]
1.2000 FILE: C:\BHASKAR\study\statcom\16-17\1wsvc @solprpg_solstpp.out 0.80000

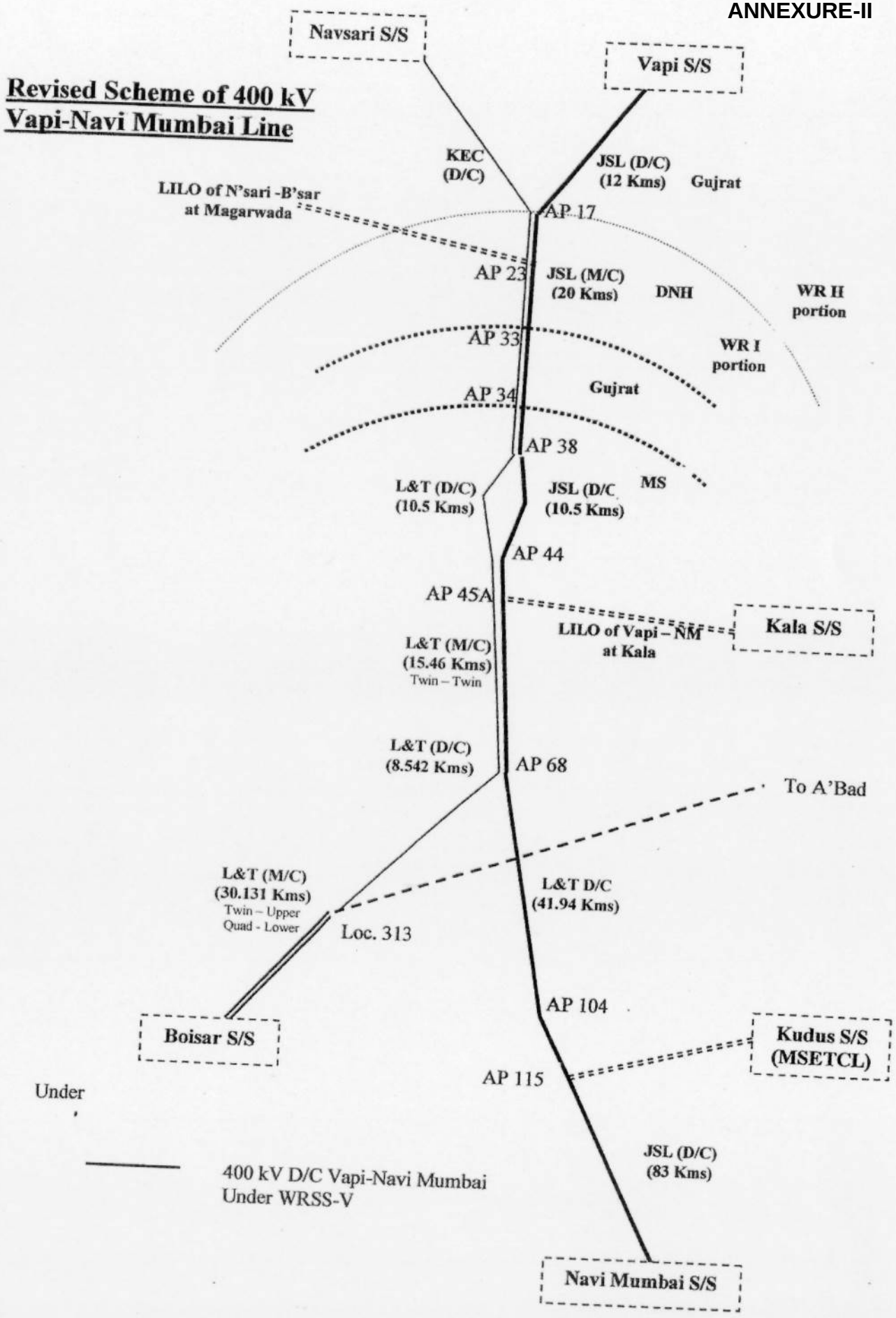
CHNL# 2164: [SOLPG_SVC]
10.000 FILE: C:\BHASKAR\study\statcom\16-17\1wsvc @solprpg_solstpp.out -10.00

CHNL# 692: [VLTG SOLPRPG -WEST]
1.2000 FILE: C:\BHASKAR\study\statcom\16-17\1wosvc @solprpg_solstpp.out 0.80000

CHNL# 2164: [SOLPG_SVC]
10.000 FILE: C:\BHASKAR\study\statcom\16-17\1wosvc @solprpg_solstpp.out -10.00



ANNEXURE-II


Revised Scheme of 400 kV
Vapi-Navi Mumbai Line
Navsari S/S
Vapi S/S
KEC
(D/C)
JSL (D/C)
(12 Kms)
Gujrat
LILO of N'sari -B'sar
at Magarwada
AP 17
AP 23
JSL (M/C)
(20 Kms)
DNH
WR II
portion
AP 33
WR I
portion
AP 34
Gujrat
AP 38
L&T (D/C)
(10.5 Kms)
JSL (D/C
(10.5 Kms)
MS
AP 44
AP 45A
LILO of Vapi – NM
at Kala
Kala S/S
L&T (M/C)
(15.46 Kms)
Twin – Twin
L&T (D/C)
(8.542 Kms)
AP 68
To A'Bad
L&T (M/C)
(30.131 Kms)
Twin – Upper
Quad - Lower
L&T D/C
(41.94 Kms)
Loc. 313
AP 104
Boisar S/S
Kudus S/S
(MSETCL)
AP 115
Under
JSL (D/C)
(83 Kms)
400 kV D/C Vapi-Navi Mumbai
Under WRSS-V
Navi Mumbai S/S