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Reactive Power Compensation in 132kv & 33kv Grid of Narsinghpur Area

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ABSTRACT

Power Sector is considered to be very important and priority sector as it leads to overall development of country. The cost of installation of new generating units is rising; hence generated electrical energy has to be utilized carefully and efficiently, which changes through each AC cycle. It is proposed to study the effect of group shunt compensation provided for the mix of rural and urban loads, catered from grid sub-stations in the district of Narsinghpur, to assess its adequacy and saving in transmission losses. An optimum combination of compensators which yields maximum benefits in the system shall be worked out. Load Flow Study for the effect of group shunt compensation provided on 132KV bus of 220KV sub-station Narsinghpur and on 33KV buses of 132KV sub stations Srinagar, Narsinghpur, Gadarwara and Burman sub-stations for the mix of rural and urban loads, catered from partial grid network in Narsinghpur district.

If reactive power is supplied near the load, the line current can be reduced or minimized, reducing power losses and improving voltage regulation at the load terminals. The leading current drawn by the shunt capacitors compensates the lagging current drawn by the load. The selection of shunt capacitors depends on many factors, the most important of which is the amount of lagging reactive power taken by the load.

Objective was to study the effect of group shunt compensation provided for the mix of rural and urban loads, catered from grid sub-stations in the district of Narsinghpur and to assess the adequacy and saving in transmission losses & to work out an optimum combination of compensators which yields maximum benefits in the system. Depending on the stages of 'ON' and 'OFF', operations to be carried out in various permutations and combinations of shunt compensators i.e. switchable capacitor banks provided on 132 KV bus of 220KV substation Narsinghpur and on 33KV buses of 132 KV substations

Keywords: *Reactive power, Reactive compensation, Load flow study, Group shunt compensation, Voltage Regulation, Shunt Capacitors, Transmission losses, WATTS, VARS, Apparent Power (S)*

I. INTRODUCTION

Reactive power has been recognized as a significant factor in the design and operation of alternating current electric power systems. It has been observed that, since the impedance of the network components are predominantly reactive, the transmission of active power requires a difference in angular phase between the voltages at the sending and receiving points, whereas the transmission of reactive power requires a difference in magnitude of these same voltages.

Reactive power is consumed not only by most of the network elements, but also by most of the consumer loads, so it must be supplied somewhere .If we cannot transmit it very easily, and then it ought to be generated where it is needed. With active power, the constraints on its transmission are much less severe and the penalties on, in-appropriate generator sizing are much more severe .Still the differences are only quantitative.

The reactive power has acquired importance due to reason that it increases the pressure to utilize transmission capacity as much as possible. The shunt capacitors are now installed in the transmission & distribution network to improve voltage profiles and reduce line loading and losses by power factor improvement. It was found that practically as much could be gained by switched capacitors at a much lower cost.

1.2 Reactive Power and its Importance: Reactive power is a concept used to describe the background energy movement in an Alternating Current (AC) system arising from the production of electric and magnetic fields.

Instantaneously, Power is the product of voltage and Current, when voltage and current are not in phase or not in synchronism, there are two components: Real power and Reactive power.

1.3 Effects of Reactive Power:

- Reactive Power is a circulating power in the grid that does no useful work
- Results from energy storage elements in the power grid (mainly inductors and capacitors)

- Has a strong effect on system voltages
- It must balance in the grid to prevent voltage problems
- Reactive power levels have an effect on voltage collapse.

1.4 Why Do We Need Reactive Power: Reactive power required to maintain the voltage to deliver active power: "Reactive power (VAR) is required to maintain the voltage to deliver active power (watts) through transmission lines. Motor loads and other loads require reactive power to convert the flow of electrons into useful work. When there is not enough reactive power, the voltage sags down and it is not possible to push the power demanded by loads through the lines".

II. REACTIVE POWER COMPENSATION

VAR compensation is defined as the management of reactive power to improve the performance of A.C. power systems. The concept of VAR compensation covers both system and customer problems, especially related with power quality issues since most of power quality problems can be solved with an adequate control of reactive power. In general, the problem of reactive power compensation is viewed from two aspects: Load compensation and Voltage support.

(a) **Load compensation:** The objectives are to increase the value of the system power factor, to balance the real power drawn from the ac supply source, compensate voltage regulation and to eliminate current harmonic components produced by large and fluctuating non-linear industrial loads ,like Thyristor or diode rectifier in process industry, metal industry and in variable speed drives etc.

(b) **Voltage support:** It is generally required to reduce voltage fluctuation at a given terminal of a transmission line. Reactive power compensation in transmission systems also improves the stability of the ac system by increasing the maximum active power that can be transmitted. It also helps to maintain a substantially flat voltage profile at all levels of power transmission.

2.1 Reactive Power Compensation Principles

In a linear circuit, the reactive power is defined as the A.C. component of the instantaneous power, with a frequency equal to 100Hz in a 50Hz system. The reactive power generated by the ac power source is stored in a capacitor or a reactor during a quarter of a cycle, and in the next quarter cycle is sent back to the power source.
For this reason, reactive power can be compensated using VAR generators, thereby avoiding its circulation between source and load (inductor or capacitor).This yields improvement in voltage stability.

2.2 Shunt Compensation: Figure .1: shows the principles and theoretical effects of shunt reactive power compensation in a basic A.C. system, which comprises a source V1, a power line and a typical inductive load. Figure (1-a) shows the system without compensation, and its associated phasor diagram. In the phasor diagram, the phase angle of the current has been related to the load side, which means that the active current IP is in phase with the load voltage V2. Since the load is assumed inductive, it requires reactive power for proper operation and hence, the source must supply it, increasing the current from the generator and through power lines. If reactive power is supplied near the load, the line current can be reduced or minimized, reducing power losses and improving voltage regulation at the load terminals. This can be done in three ways: a) with a capacitor, b) with a voltage source, or c) with a current source. In Fig. (1-b), a current source device is being used to compensate the reactive component of the load current (IQ). As a result, the system voltage regulation is improved and the reactive current component from the source is reduced or almost eliminated. If the load needs leading compensation, then an inductor would be required. Also a current source or a voltage source can be used for inductive shunt compensation. The main advantages of using voltage or current source VAR generators (instead of inductors or capacitors) is that the reactive power generated is independent of the voltage at the point of connection.

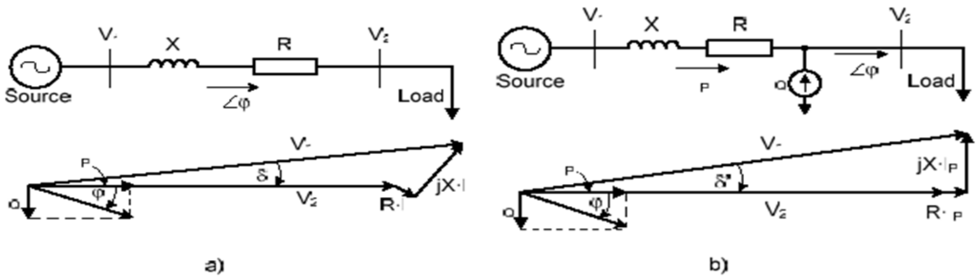

Figure no.1 Principal of shunt compensation in a radial ac system

(a) Without reactive compensation (b) Shunt compensation with a current source

In the case of widely fluctuating loads, the reactive power also varies over a wide range. Thus, a fixed capacitor bank may often lead to either over-compensation or under-compensation. To avoid such over-compensation or under-compensation due to fixed capacitor banks, capacitor bank are operated switched - ON during peak-load periods and switched- OFF during light load periods.

Figure-2: Shunt capacitor bank at grid substation

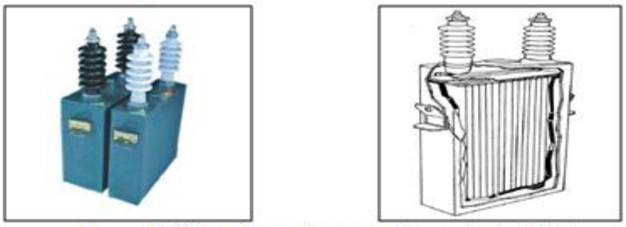

Figure-3: High voltage shunt capacitor units for 33KV

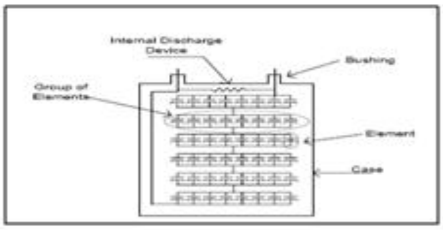

Figure-4: High voltage shunt capacitor unit For 33kv

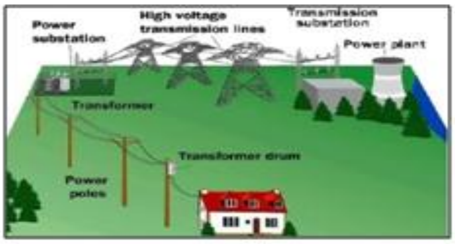

Figure-5: Power System interconnected

2.3 Reactive Power Compensation at Grid substations: As the maximum demand of any H.T. or L.T. installation can be reduced at the plant level by using capacitor banks and the optimum power factor could be maintained close to unity. similarly at 220KV and 132 KV grid sub stations in the partial network of Narsinghpur District , reactive compensation with shunt capacitor banks ,the reactive MVAR drawl due to load of power transformers could be reduced ,resulting in line loss reduction (i.e. energy saving).

III. OBJECTIVES OF THE STUDY

It is proposed to study the effect of group shunt compensation provided for the mix of rural and urban loads, catered from grid sub-stations in the district of Narsinghpur, to assess its adequacy and saving in transmission losses. An optimum combination of compensators which yields maximum benefits in the system shall be worked out.

1) Depending on the stages of 'ON' and 'OFF', operations to be carried out in various permutations and combinations of shunt compensators i.e. switchable capacitor banks provided on 132 KV bus of 220KV substation Narsinghpur and on 33KV buses of 132 KV substations Srinagar, Narsinghpur, Gadarwara and Barman.

2) **Table .2.** Capacity and Locations of initially installed Group compensating devices.(in partial Net-work of Narsinghpur)

Sr no	**Capacity of Group compensating devices in MVAR**	**Location in partial Net-work of Narsinghpur District**
1	2x33	132 KV bus of 220 KV S/S Narsingpur.
2	1x5	33 KV bus of 132 KV S/S Srinagar.
3	2x5	33 KV bus of 132 KV S/S Narsingpur.
4	1x12 + 2x5	33 KV bus of 132 KV S/S Gadarwara.
5	1x12 + 1x5	33 KV bus of 132 KV S/S Barman.

Total capacity of 33 KV capacitor banks=54 MVAR

3) **Table.3.** Capacity and Locations of Group compensating devices proposed to be installed, after carrying out load flow study, of partial Net-work of Narsinghpur District

Sr no	**Capacity of Group compensating devices at various grid s/s, in MVAR**	**Location in partial Net-work of Narsinghpur District**
1	(2x33) + 1x33	132 kv bus of 220 KV S/S Narsingpur.
2	1x5	33 kv bus of 132 KV S/S Srinagar.
3	(2x5)+2x5	33 kv bus of 132 KV S/S Narsingpur.
4.	(1x12 + 2x5)+ 2x5	33V bus of 132 KV S/S Gadarwara.

4) **Table.4.** Details of consumers in Narsinghpur district

a)	Total No of .consumers (general,unmetered, board employee, board pensioner, SC/ST, BPL case, unmetered, temporary, GOVT offices, X-ray plant, Public Water-Works, Street lights, Non-Seasonal, Seasonal industries, Metered and Unmetered Temporary) .	1, 41, 884
b)	Total No of H.T.Consumers (on11KV and 33KV)	21
c)	Grand Total No of (H.T. + L.T.) Consumers	1, 41, 905

IV. LOAD FLOW STUDY

Load Flow Study for the effect of group shunt compensation provided on 132KV bus at 220KV sub-station Narsinghpur & on 33KV buses of 132KV sub stations Srinagar, Narsinghpur , Gadarwara and Burman for the mix of rural and urban loads, catered from partial network /grid sub-stations in Narsinghpur district has been carried out. Load Flow Study is useful to assess the adequacy of shunt compensation provided for improvement of voltage profile, improvement of power factor, reduction in reactive VAR's, saving in system losses and energy.

4.1 About Load Flow Study: Load flow study is an important tool involving numerical analysis, a load flow study uses simplified notations such as one–line diagram and per-unit system, and focuses on various forms of AC power (i.e.; real, reactive and apparent) rather than voltage and current. The principal information obtained from the load flow study is the magnitude and phase angle of the voltage at each bus and the real and reactive power flowing in each line.

4.2 Data required for load flow study

a) Active power generation by various sources.
b) Reactive power generation limits from generating sources.
c) Voltage of generator terminals.
d) Transmission line data like R, XL and B.
e) Shunt and series compensation on line.
f) Transformer data like capacity in MVA, R, X and changer details.

4.3 Abnormal System Conditions:

a) Under or over voltages.
b) Under or over loading of lines.
c) Under or over loading of Transformers.
d) Increase in angular displacement.
e) Violation of Reactive Generation limits of Generators.

4.4 Selection of base MVA for load flow study:

a) For utility networks:100 MVA
b) For distribution networks:1 or 10 MVA
c) Industrial system: 20MVA,50 MVA based on incoming transformer rating
d) Depends on largest MVA equipment & smallest MVA equipment
e) Depends on largest load and smallest load.

4.5 Study Buses: The variables in the power flow solutions are P, Q, V and □

a) P & Q specified- PQ Bus- Load Bus
b) P & V specified- PV Bus- Generator Bus
c) V &δ specified- Slack Bus- Largest Gen. Bus

Table 5: Stages of switching Operations of various capacitor banks, in case –"A"

Sr No	Case No	Stages of switching Operations of various capacitor banks
1	I	Without any capacitor bank in circuit
2	II	With 132 KV capacitor bank "ON "and all other 33KV banks "OFF" the circuit
3	III	With 132KV capacitor bank "ON" and only 33KV bank at Srinagar "ON"
4	IV	With 132 KV capacitor bank "ON" and 33KV bank at Srinagar & Gadarwara "ON"
5	V	With 132 KV capacitor bank "ON" and 33KV bank at Narsinghpur & Barman "ON"
6	VI	With 132 KV capacitor bank "OFF" and all other 33KV banks "ON"
7	VII	With 132 KV capacitor bank "ON" and all other 33KV banks "ON"
8	VIII	With 132 KV Additional capacitor bank at 220 KV s/s NSP and all other 33KV banks "ON"

(Case No -I to Case no VIII)

Load flow study carried out for the stages Case No-I to Case no VIII, as per partial network Drawing, and the observations tabulated as per load flow study of each sub-Station, for stage-I to VII

Figure-6: Partial network of 220KV &132KV system of Narsinghpur District

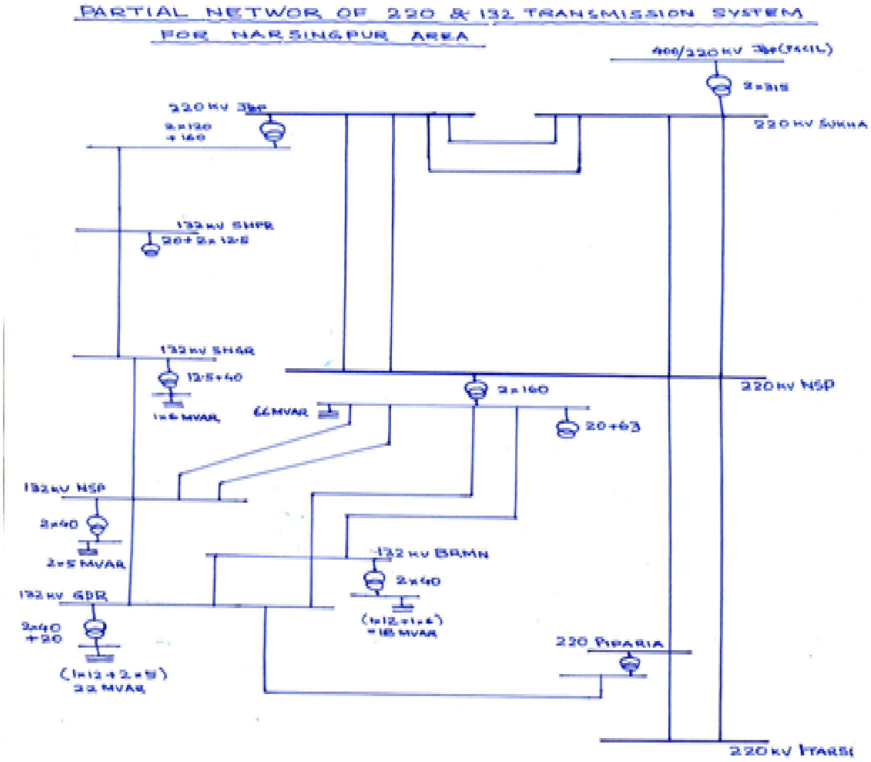

Table 6: Details Of Load Flow Data Analysis For Five Nos Grid Substations In Narsingpur District

Sr no	Stages of operation of capacitor banks	Loading of MVAR,Bus voltage	220kv s/s Narsinghpur	132kv s/s Srinagar	132kv s/s Gadarwara	132kv s/s Narsinghpur	132kv s/s Burman
1	Without any capacitor bank in circuit						
		MVAR	180.71				
		Bus Voltage	203.47	119.66	1117.7	119.52	117.85
2	With 132 kv capacitor bank "ON" and all other 33kv banks "OFF"						
		MVAR	124.58				
		Bus Voltage	205.24	121.29	119.29	121.72	119.81
3	With 132 kv capacitor bank "ON" and 33kv bank at Srinagar "ON"						
		MVAR	117.00				
		Bus Voltage	205.7	121.7	119.56	122.03	120.11
4	With 132 kv capacitor bank "ON" and 33kv bank at Srinagar &Gadarwara "ON"						
		MVAR	117.19				
		Bus Voltage	206.6	122.41	120.97	122.88	121.2
5	With 132 kv capacitor bank "ON" and 33kv bank at Narsinghpur&Barman "ON"						
		MVAR	104.78				
		Bus Voltage	206.7	122.17	120.65	123.12	121.59
6	With 132 kv capacitor bank "OFF" and all other 33kv banks "ON"						
		MVAR	124.00				
		Bus Voltage	206.94	122.59	121.64	122.68	121.74
7	With 132 kv capacitor bank "ON" and all other 33kv banks "ON"						
		MVAR	81.09				
		Bus Voltage	209.12	125.13	123.53	125.13	123.99
	Capacity of Additional passive shunt capacitors installed →	Existing 2×33+Additional 1×33 MVAR on 132 KV Bus of NSP 220 KV s/s		6 MVAR	22 MVAR	2×5 MVAR	24 MVAR
8	With 132 kv Additional capacitor bank "ON"at 220 KV s/s NSP and all other 33kv banks "ON"						
		MVAR	63.82				
		Bus Voltage	210.05	124.91	124.38	125.74	125.03

CASE-"A": Transmission & distribution system in partial network,

Study of Reactive power flow variations by effect of group compensation provided in various Narsinghpur and on 33 KV buses of 132 KV sub-stations in partial network, by way of reduction in MVAR, on power transformer.

Table: 7. Observations of MVAR, PF and bus voltages during Stages of operation of capacitor banks provided on 132 KV bus of 220KV sub-station Narsinghpur

Power Transformer Capacity: 2x160 MVA, 220/132/33 KV ,Capacity of passive shunt capacitors installed at 132 KV bus: (2x33) =66 MVAR

S.NO.	Stages of operation of capacitor banks	MVAR	Power Factor	Bus Voltage in KV
1	Without any capacitor bank in circuit	180.71	0.83	203.47
2	With 132 KV capacitor bank "ON" and all other 33KV banks "OFF"	124.58	0.91	205.24
3	With 132 KV capacitor bank "ON" and 33KV bank at Srinagar "ON"	117.00	0.92	205.70
4	With 132 KV capacitor bank "ON" and 33KV bank at Srinagar & Gadarwara "ON"	117.19	0.92	206.60
5	With 132 KV capacitor bank "ON" and 33KV bank at Narsinghpur & Barman "ON"	104.78	0.935	206.70
6	With 132 KV capacitor bank "OFF" and all other 33KV banks "ON"	124.00	0.91	206.94
7	With 132 KV capacitor bank "ON" and all other 33KV banks "ON"	81.09	0.96	209.12
8	With 132 KV Additional capacitor bank "ON "at 220 KV s/s NSP and all other 33KV banks "ON"	63.82	0.975	210.05

Table:8: Effects due to Stages of operation of capacitor banks installed on 132kv and 33kv buses of partial network , on 220 KV bus voltage at 220 KV s/s Narsinghpur

Stages of group compensation at 132 KV and 33KV buses of s/s in partial network of Narsinghpur. district	220KV S/S Narsinghpur bus voltages, in KV
STAGE-1	203.47
STAGE-2	205.24
STAGE-3	205.70
STAGE-4	206.60
STAGE-5	206.70
STAGE-6	206.94
STAGE-7	209.12
STAGE-8	210.05

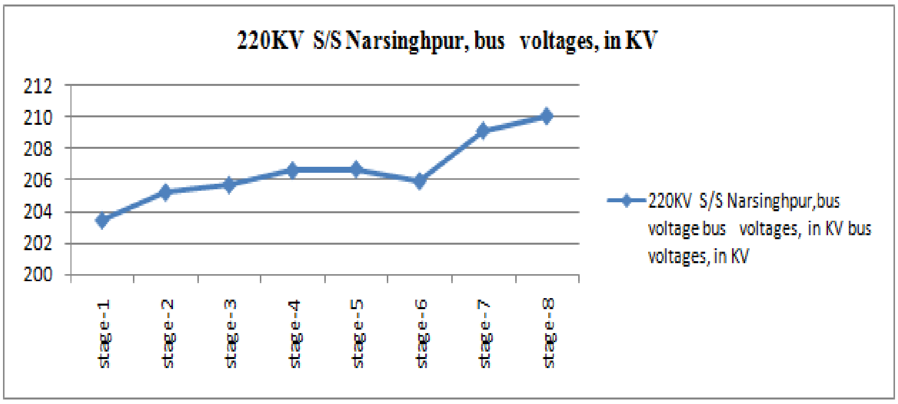

Figure: 8: Effect due to Stages of operation of capacitor banks in Partial network

Table: 9: Effect of variation in 132 kv bus voltages, due to operations of various stages of group compensation at artial network.

Bus voltage of 132 KV s/s of Partial Network of Narsinghpur District.	132kv s/s Srinagar	132kv s/s Gadarwara	132kv s/s Narsinghpur	132kv s/s Burman
STAGE-1	121.29	119.29	121.72	119.81
STAGE-2	121.29	119.29	121.72	119.81
STAGE-3	121.70	119.56	122.03	120.11
STAGE-4	122.41	120.97	122.88	121.2
STAGE-5	122.17	120.65	123.12	121.59
STAGE-6	122.59	121.64	122.68	121.74

STAGE-7	125.13	123.53	125.13	123.99
STAGE-8	124.91	124.38	125.74	125.03

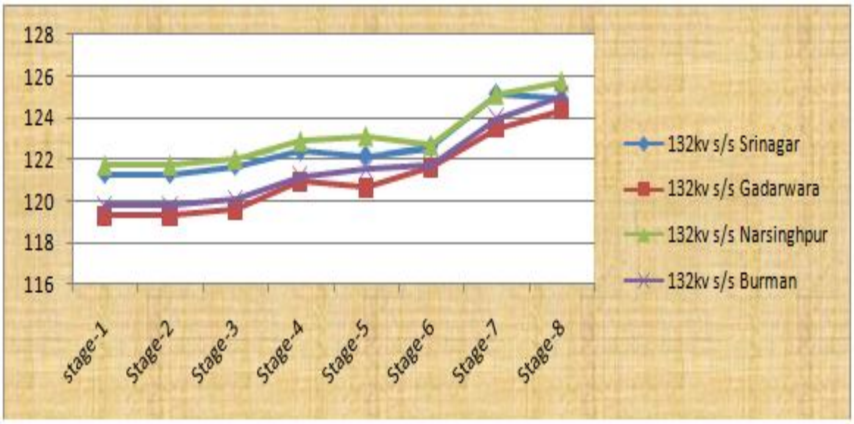

Figure 9: Effect of variation in 132 kv bus voltages, due to operations of various stages of group compensation

Table-10: Effect on MVAR due to Stages of operation of capacitor banks

Sr no	Stages of operation of capacitor banks	MVAR flow with 220 KV power transformer at NSPs/s
1	Without any capacitor bank in circuit	180.71
2	With 132 KV capacitor bank "ON" and all other 33KV banks "OFF"	124.58
3	With 132 KV capacitor bank "ON" and 33KV bank at Srinagar "ON"	117.00
4	With 132 KV capacitor bank "ON" and 33KV bank at Srinagar & Gadarwara "ON"	117.19
5	With 132 KV capacitor bank "ON" and 33KV bank at Narsinghpur & Barman "ON"	104.78
6	With 132 KV capacitor bank "OFF" and all other 33KV banks "ON"	124.00
7	With 132 KV capacitor bank "ON" and all other 33KV banks "ON"	81.09
8	With 132 KV Additional capacitor bank "ON"at 220 KV s/s NSP and all other 33KV banks "ON",,	63.82

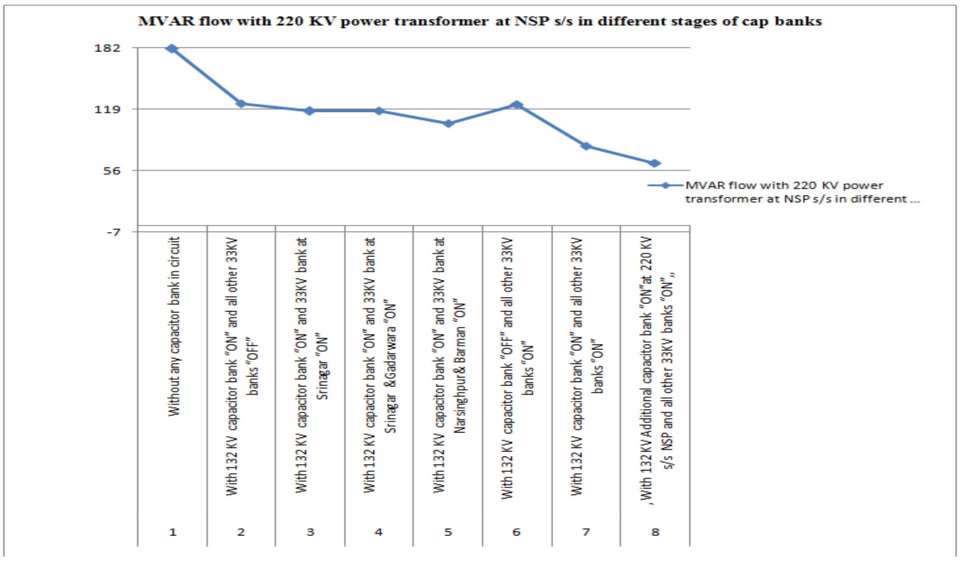

Figure 10: Effect on MVAR due to Stages of operation of capacitor banks.

Case-"B": Effect of variation in transformer loading and variation in operation of 33KV capacitor banks, on 33 KV bus voltages,of sub – stations ,have been studied in case 'B'

Table-11(B-1), Details of Transformer capacity and existing capacitor bank capacity

Name of sub-station	Transformer capacity	Existing capacitor banks
220 KV Narsinghpur	2x160 MVA,220/132/33 KV	2x33 MVAR
132 KV Narsinghpur	2x40 MVA,132/33 KV	2x5 MVAR
132 KV Barman	2x40 MVA,132/33 KV	(1x12 +1x5) MVAR
132 KV Srinagar	(1x40 +1x12.5)MVA,132/33 KV	1x5 MVAR
132 KV Gadarwara	(2x40 + 20)MVA,132/33 KV	(1x12 +2x5) MVAR

Table-12(B-*V*)-a:Effect of variation in percentage transformer loading and in operation of 2x5 MVAR ,33KV shunt capacitor banks, on 33 KV bus voltages of sub – stations

Name of 132 KV Grid sub-station in partial network	Status of Capacitor Bank on 33 KV bus	% Load x Transformer capacity =Load on Transformer (MVA)	Bus voltage in KV
132 KV Narsinghpur	ON	75%x80=60	32.3
	ON	80%x80=64	32
	ON +2x 5MVAR	80%x80=64	34.9
132 KV Barman	ON	70%x80=56	32.6
	ON	90%x80=72	31. 8
	ON +2x 5MVAR	90%x80=72	34.8
132 KV Srinagar	ON	73%x52.5=38.3	32.8
	ON	80%x52.5=42	32.6
	ON	80%x52.5=42	32.6
132 KV Gadarwara	ON	80%x100=80	32.5
	ON	90x100=90	31.8
	ON +2x 5MVAR	90x100=90	34.6

Table-13(B-*V*)-b: Effect of variation in percentage transformer loading and in operation of 33KV shunt capacitor banks, on 33 KV bus voltages of sub –stations

Name of Grid sub-station 132 KV sub-station in partial network	Stages of operations	Status of Capacitor Bank on 33 KV bus	Load in MVA	Bus voltage in KV
132 KV Narsinghpur	I	ON	60	32.3
	II	ON	64	32
	III	ON +2x 5MVAR	64	34.9
132 KV Barman	I	ON	56	32.6
	II	ON	72	31. 8
	III	ON +2x 5MVAR	72	34.8
132 KV Srinagar	I	ON	38.3	32.8
	II	ON	42	32.6
	III	ON	42	32.6
132 KV Gadarwara	I	ON	80	32.5
	II	ON	90	31.8
	III	ON +2x 5MVAR	90	34.6

- ✓ In stage-I: capacitor banks at 132kv s/s were initially kept “ON” with low load on Transformer.
- ✓ In stage-II: capacitor banks at all the grid substations were initially kept “ON” and study carried out with load on Transformer on higher side.
- ✓ In stage-III: additional capacitor banks at 132kv s/s NSP, Barman and Gadarwara were provided with loading as in stage II
- ✓ 33 KV bus voltages in stage-I , stage-II & stage - III (with additional capacitor banks) have been considered in the study).

Table 14: Rise in 33 KV bus voltages of 132 kv sub – stations, in stages-I, II and III

Stages, 33kv bus voltage rise in kv	132 KV Narsinghpur	132 KV Barman	132 KV Srinagar	132 KV Gadarwara
STAGE-I	32.3	32.6	32.8	32.5
STAGE-II	32	31.8	32.6	31.8
STAGE-III	34.9	34.8	32.6	34.6

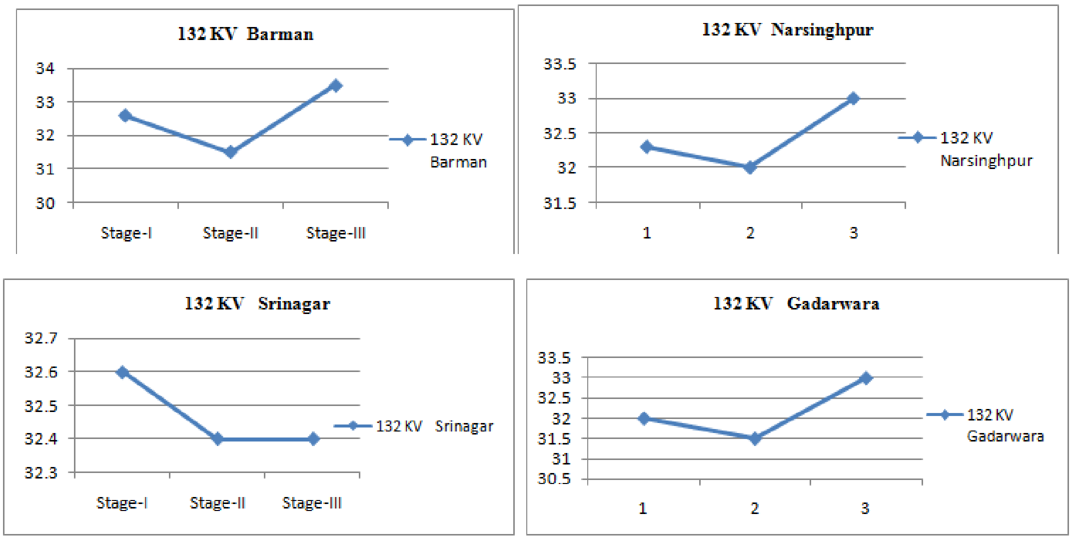

Figure: 11, (A, B, C. & D), Effect of variation on 33 KV bus voltages of 132 kv sub – stations, in stages-I, II and III of" case –B"

V. RESULTS

In Case-"A": Case of transmission & distribution system

Study carried out for Reactive power flow variations by effect of group compensation provided in various stages of the operation of capacitor banks provided on 132 KV bus of 220KV sub-station Narsinghpur and on 33 KV buses of 132 KV sub-stations in partial network .Reduction in MVAR, on power transformer has been observed along with improvement in power factor and rise in bus voltage profiles. Following table-22, explains the final results and conclusion of the work-done in case-'A'.

Sr no	**% Effect due to Stages of operation of capacitor banks in partial network of Narsinghpur District at 220 KV s/s NSP.**	
1	Reduction in MVAR (in stage - 1 to stage-8)	64.68%
2	Improvement in Power Factor(in stage 1 to 8)	17.46%
3	Rise in Bus Voltage of 220 KV bus(in stage 1 to 8)	3.23%
4	Maximum Rise in Bus Voltage of 132KV s/s bus (in stage 1 to 8)	4.36%

In Case-"B":Effect of stages of operation of 33KV switchable shunt capacitor banks on 33 KV bus voltages in the partial network of Narsinghpur Grid is explained by Table – 23(Effects of % variation in transformer loading and variation in operation of 33KV shunt capacitor banks on 33 KV bus voltages of sub –stations ,have been tabulated)

Name of Grid sub-station 132 KV sub-station in partial network	**Stages of operations**	**Status of Capacitor Bank on 33 KV bus**	**Load in MW on 33 KV bus**	**Bus voltage in KV in various stages**	**% variation in 33KV bus voltages due to Stages of operations**
132 KV Narsinghpur	I	ON	60	32.3	**8.04 %**
	II	ON	64	32	
	III	ON+2x5MVAR	64	**34.9**	
132 KV Barman	I	ON	56	32.6	6.75 %
	II	ON	72	31.8	
	III	ON+2x5MVAR	72	**34.8**	
132 KV Srinagar	I	ON	38.3	32.8	(-)0.61 %
	II	ON	42	32.6	
	III	ON	42	32.6	
132 KV Gadarwara	I	ON	80	32.5	**6.46 %**
	II	ON	90	31.8	
	III	ON+2x 5MVAR	90	34.6	

VI. CONCLUSION

To judge adequacy of compensation in case "A" and "B", In case "A" :It has been concluded that reduction in MVAR (in stage - 8 as compared to stage-1) to the extent of 64.68% have been observed using stages of capacitor banks in the partial grid network . Capacitor banks have generated reactive power and thus the requirement of reactive power drawl from the system reduces, it further reduces the corresponding amount of current in the line. Since line losses are a function of the current squared i.e. I^2R, Therefore applications of capacitor banks on various grid substations at 132KV and 33KV buses, reduces reactive power flow on power transformer & significantly reduces losses in square proportion.

Therefore out of this work one set of 132 KV Additional capacitor bank of capacity 1*33 MVAR has been proposed at 220KV substation Narsinghpur, for obtaining following results:-

i) Maximum control over requirement of reactive power drawls in MVAR reducing from 180.71 MVAR to 63.82 MVAR (in stage - 8)

ii) Improvement in power factor from 0.83 to 0.975(by 17.46%) in stage - 8.

iii) Rise in bus-voltages (from 203.47 to 210.05 KV) in 220KV side (by 3.23%)and corresponding rise in 132 KV bus voltages from 119.29 & 121.72 to the level of 125.93 & 125.74 KV(by 4.36%).

In case "B":% variation in 33KV bus voltage profile due to Stages of operations of capacitor banks have been observed between6.46 %,at Gadawara to 8.04 % ,at Narsinghpur 132 KV sub-station, In case where capacitor bank have not been added in the system ,at 132 KV Srinagar % variation in 33KV bus voltages due to Stages of operations of capacitor banks have been observed as(-)0.61 %,there was fall in bus voltage where capacitor banks have not been provided ,near load bus in the system.

Additional capacitor bank proposed

I) At 220kv sub- station Narsinghpur on 132 KV bus of capacity 1x33 MVAR ,for improvement in 132 KV voltage profile ,PF of 132 KV bus ,reduction in Transformer MVAR flow .

II) At 33 KV buses of 132 KV substations Narsinghpur, Barman and Gadarwara of capacity 2x5 MVAR ,for further improvement of 33KV voltage profile at s/s buses .

III) For better control over reduction in MVAR drawl(thereby reduce the losses), improvement in power factor and rise in bus voltages well within permissible limits, which will boost up better power quality in the system of Narsinghpur District.

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