Reactive power compensation & capacitor banks

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DB स्टार

दैनिक भास्कर

INDORE, TUESDAY, 05/07/2016

पेज-4
पेज-5
पेज-9

फिल्म फिटनेस के लिए राजी हुई करीना?
पेज-6

सावधानी • लाइन लॉस घटाने के लिए नई कॉलोनियों में बिजली कंपनी का नया फॉर्मूला

ट्रांसफार्मर के साथ ही अब केपेसीटर बैंक भी अनिवार्य

- **सब स्टेशनों के बाद डिस्ट्रीब्यूशन ट्रांसफार्मरों में भी केपेसीटर बैंक**
- **चुनिंदा फीडरों से शुरुआत, धीरे-धीरे हर फीडर होगा सीबी से लैस**

इंदौर • डीबी स्टार

नई कॉलोनियों में बिजली कंपनी अब बगैर केपेसीटर बैंक के ट्रांसफार्मर लगाने की अनुमति नहीं देगी। बढ़ते लाइन लॉस को कम करने के लिए अधिकारियों ने यह फॉर्मूला तैयार किया है। कंपनी जल्द ही कुछ फीडरों से अपने डिस्ट्रीब्यूशन ट्रांसफार्मरों को भी केपेसीटर बैंक से लैस करने जा रही है।

DB STAR EXCLUSIVE

पोलोग्राउंड स्थित पश्चिम क्षेत्र बिजली कंपनी का दफ्तर

बिजली कंपनी अपनी तमाम कोशिशों के बाद भी शहर में बढ़ते लाइन लॉस पर काबू नहीं कर पा रही है। घरेलू बिजली कनेक्शनों में तेजी से बढ़ते एसी और कूलरों के इस्तेमाल के कारण बिजली कंपनी का इंडक्टिव लोड तो बढ़ रहा है, लेकिन उसकी भरपाई के लिए अधिकारियों के पास कोई तयशुदा तकनीक या उपाय नहीं है। यही वजह है कि एक तरफ जहां पावर फैक्टर का लॉस हो रहा है, वहीं बड़ी मात्रा में बिजली बर्बाद भी हो रही है।

कंपनी ने अब लाइन लॉस के स्लाइलाज मर्ज को खत्म करने के लिए नया नुस्खा ईजाद किया है। इसके तहत अब नई विकसित होने वाली टाउनशिप और कॉलोनियों में ट्रांसफार्मर के साथ केपेसीटर बैंक फिट करना अनिवार्य होगा। अगर कोई इससे इन्कार करता है तो संबंधित कॉलोनी में ट्रांसफार्मर लगाने की अनुमति नहीं दी जाएगी। सिटी सर्कल ने पूरी योजना पर काम शुरू कर दिया है। आने वाले दिनों में व्यवस्था प्रभावी होगी।
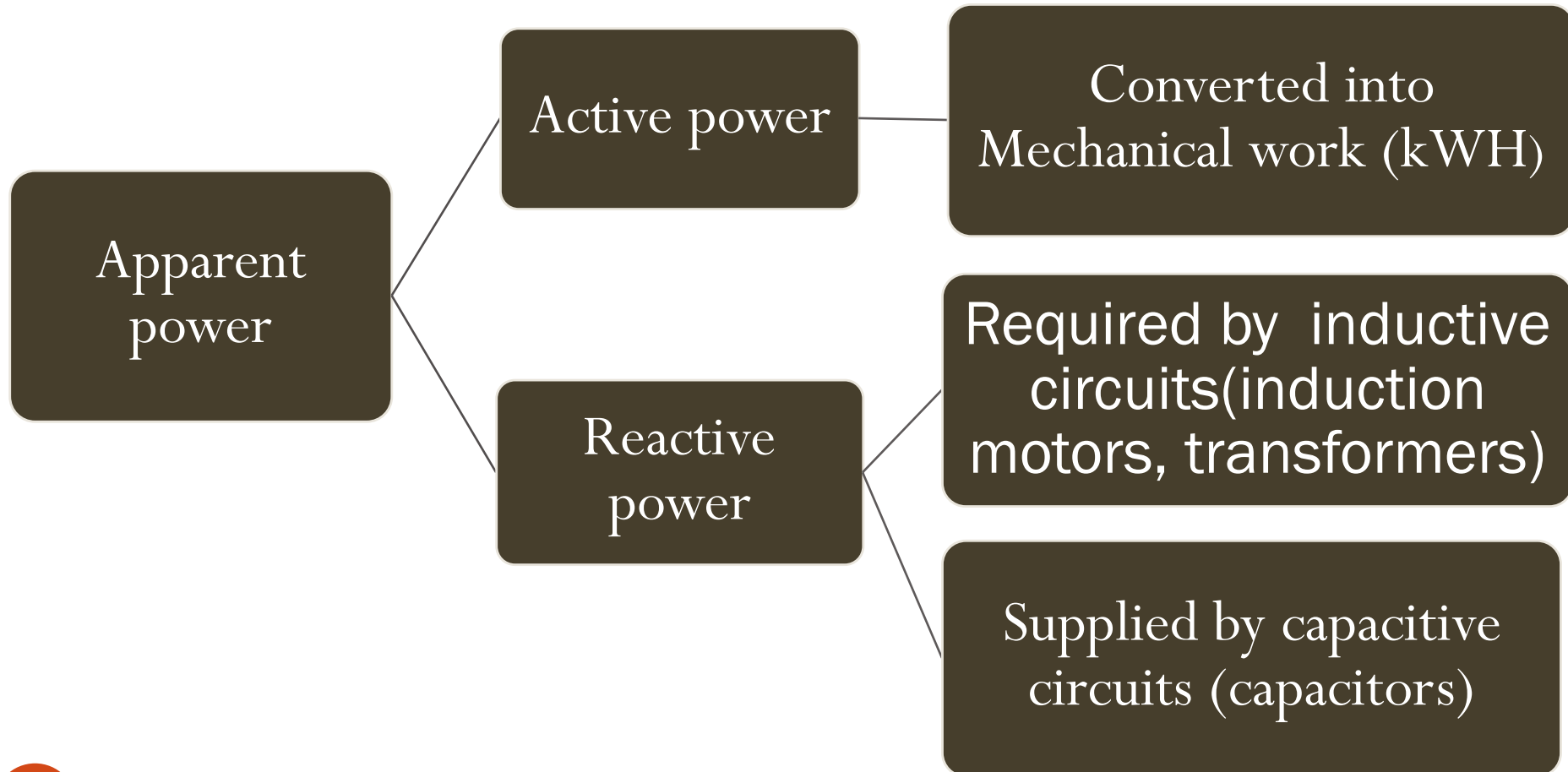
Concept of Reactive Power

Power Diagram

Apparent power

Active power — Converted into Mechanical work (kWH)

Reactive power — Required by inductive circuits(induction motors, transformers)

Supplied by capacitive circuits (capacitors)

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Power triangle

Apparant Power, S = VI

Active Power, P = VI cosϕ

Reactive Power, Q = VI sinϕ

$$S = \sqrt{P^2 + Q^2}$$

ϕ
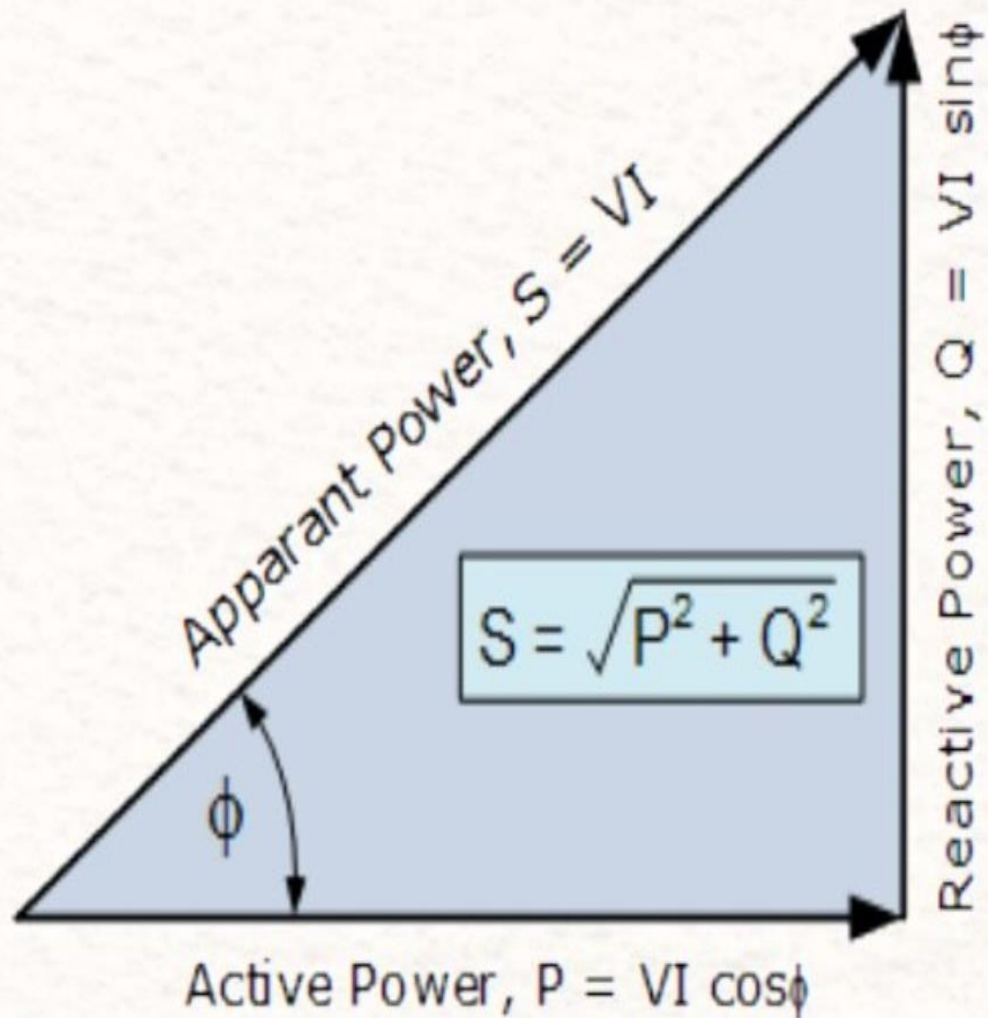
$$Cos(\Phi) = \frac{ACTIVE\ POWER}{APPARENT\ POWER}$$

# WHAT IS REACTIVE POWER ?

Power is referred as the product of voltage and current

i.e. power = V x I

The portion of electricity that establishes and sustains the electric and magnetic fields of alternating-current equipment. Reactive power must be supplied to most types of magnetic equipment, such as motors and transformers.

In an ac transmission, when the voltage and current go up and down at the same time, only real power is transmitted and when there is a time shift between voltage and current both active and reactive power are transmitted.

ANALOGY OF REACTIVE POWER

➢Why an analogy? Reactive Power is an essential aspect of the electricity system, but one that is difficult to comprehend by a lay man. The horse and the boat analogy best describe the Reactive Power aspect. Visualize a boat on a canal, pulled by a horse on the bank of the canal.
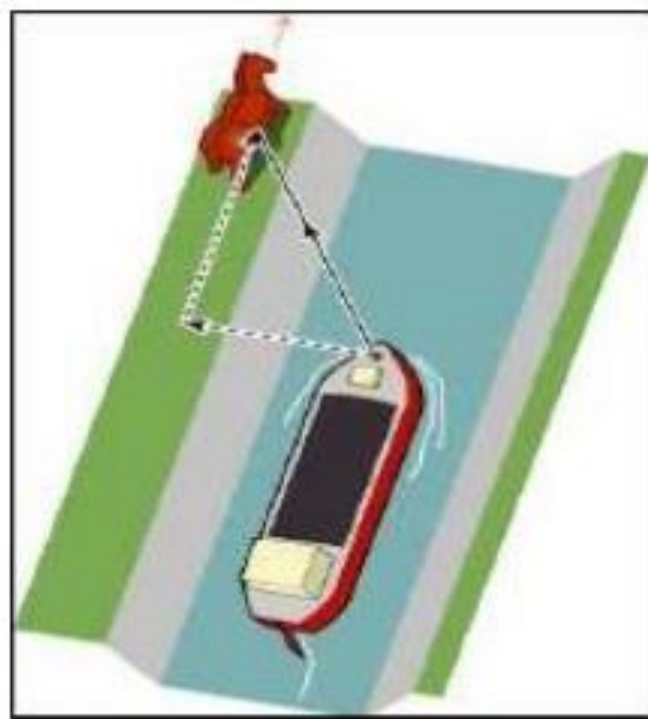
➢In the horse and boat analogy, the horse's objective (real power) is to move the boat straightly.

➢ The fact that the rope is being pulled from the flank of the horse and not straight behind it, limits the horse's capacity to deliver real work of moving straightly.

➢Therefore, the power required to keep the boat steady in navigating straightly is delivered by the rudder movement (reactive power).

➢Without reactive power there can be no transfer of real power, likewise without the support of rudder, the boat cannot move in a straight line.

ANALOGY OF POWER

kVAR Reactive Power

kVA Apparent Power

kW Real or True Power
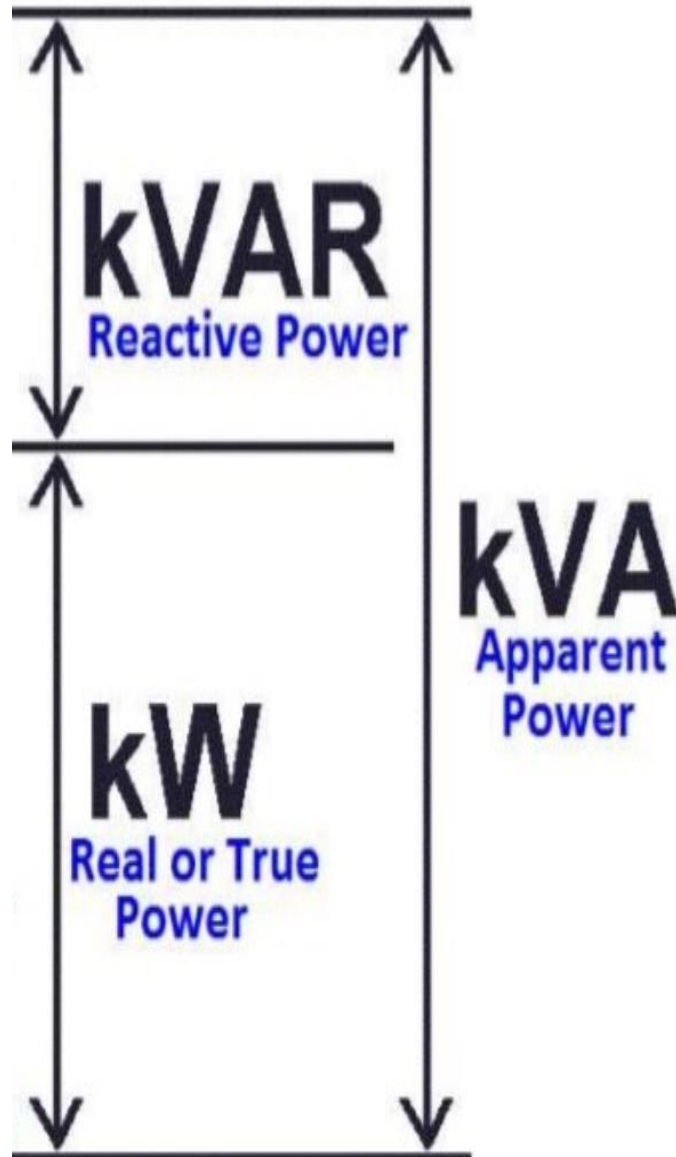
- ACTIVE POWER= CHIPS
- REACTIVE POWER=AIR
- APPARENT POWER=WHOLE PACKET

WHY DO WE NEED REACTIVE POWER?

- In resistive loads the current produces the heat energy which produces the desired output but incase of inductive loads the current creates the magnetic field which further produces the desired work. Therefore reactive power is the non working power caused by the magnetic current to operate and sustain magnetism in the device .

- Reactive power (vars) is required to maintain the voltage to deliver active power (watts)through transmission lines. When there is not enough reactive power the voltage sags down and it is not possible to deliver the required power to load through the lines.

Reactive power sources and sinks in power system

Dynamic Reactive Power Sources:

- Synchronous generators
- Synchronous condensers
- Solid state devices such as FACT devices (STATCOM, SVC)

Static Reactive Power Sources:

- Shunt capacitors
- Underground cables
- Transmission lines when lightly loaded
- PV systems

Reactive Power Sinks

- Induction motors(pumps, fans)
- induction loads (Arc furnace, heaters)
- Induction generators
- Synchronous machines (under excited)
- Transmission lines heavily loaded
- Transformers
- Shunt reactors

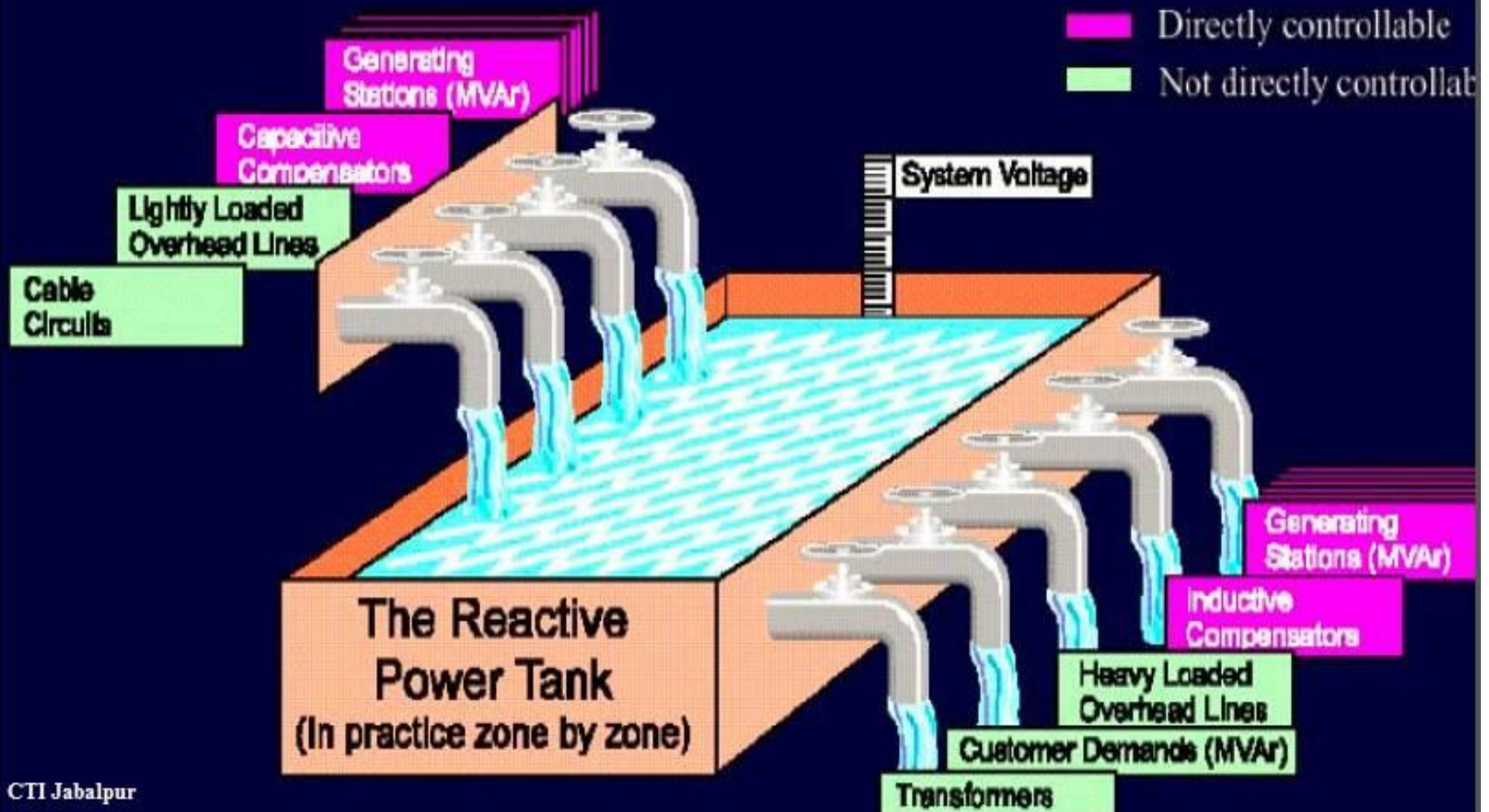# Two Prominent Challenges faced by Distribution Companies due to low power factor

1. Low Voltage Problems.

This has a direct relation to demand of reactive power by loads.

2. Power/Energy Losses.

This concerns unbilled/Unaccounted energy also called Commercial Losses.

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Low Voltage Problem and its Remedy

Distribution Systems are worst affected by low voltage problems and DISCOMS are unable to provide power supply of good quality.

Reason

1.   Gross mismatch of availability and demand of reactive power by loads.

2.   99% loads in a Grid are R –L mix loads and need Q

3.   Majority of loads comprise of 3 & 1 phase induction motors which are poor power factor   loads.

        3 phase motors – Pf is between 0.7 – 0.8
        1 phase motors – Pf is between 0.5 – 0.6

Low Voltage problem

- **Induction motors as well as all small and large transformers work on principle of electro-magnetic induction and need reactive power for their functioning.**

- **Poor power factor loads draw large current from source because $Cos\phi = P / V.I$**
  i. e, it is inversely proportional to current.

- **Now, more the current flow on lines, more is voltage drop and poorer is receiving end or consumer voltage.**

- **So, it becomes obligatory for DISCOMS to make arrangements for supply of reactive power and the source is Capacitor**
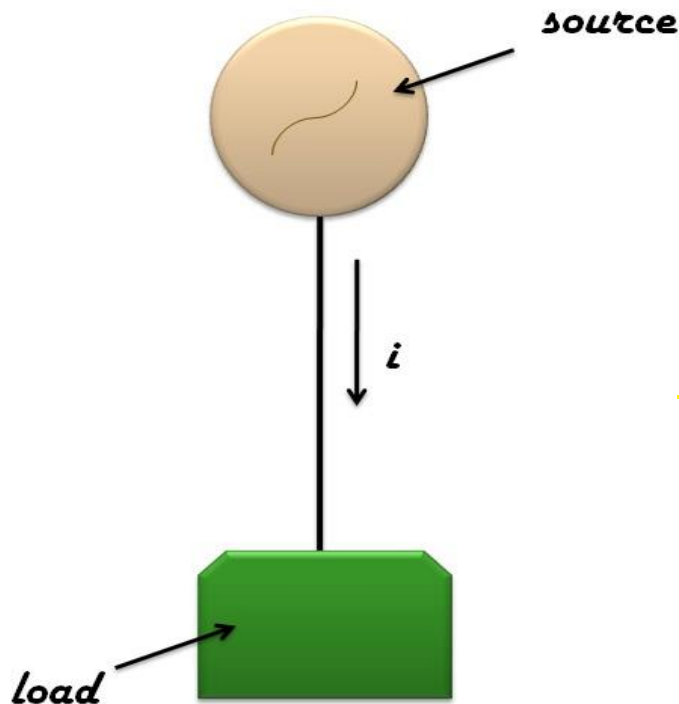
Role of shunt capacitor in improving system voltage

- **A Capacitor basically improves the power factor**
- **Improved Pf means less current drawl.**
- **Reduced current drawl means less voltage drop on line/feeder.**
- **Reduced voltage drop means better consumer end voltage.**

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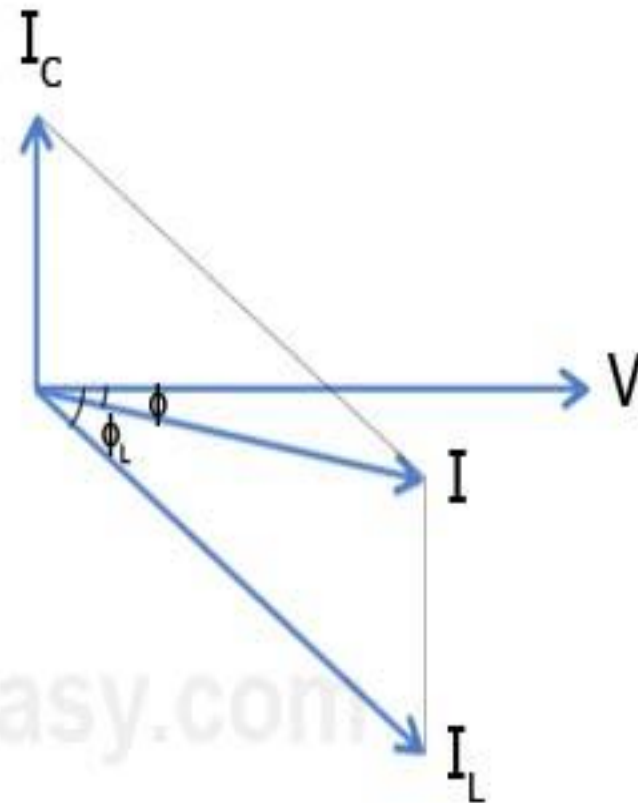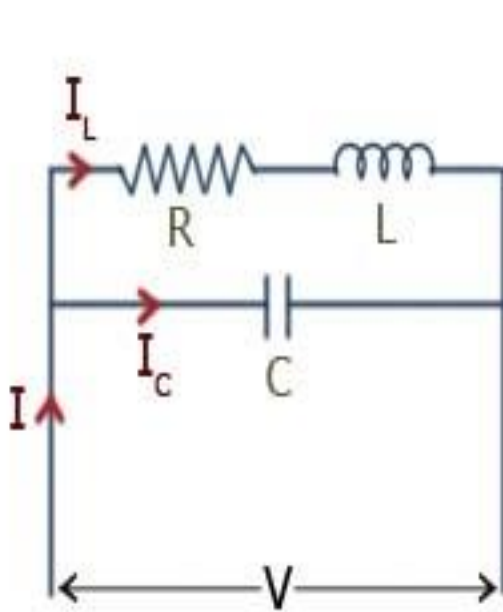
Problems Due To Uncompensated Reactive Power

line losses (I²Z losses)

$$I = \frac{P}{V \cos\phi}$$

Increased current

Reduced Voltage

Increased Losses

$V_{\text{Receiving end}} = V_{\text{Source}} - V_{\text{Drop in transmission lines}}$

Var Compensation

□ Reactive power (VAR) compensation is defined as the management of reactive power to improve the performance of ac systems. There are two aspects:-

a) Load Compensation – The main objectives are to :-

    i) increase the power factor of the system

    ii) to balance the real power drawn from the system

    iii) compensate voltage regulation

    iv) to eliminate current harmonics.

b) Voltage Support – The main purpose is to decrease the voltage fluctuation at a given terminal of transmission line.

    Therefore the VAR compensation improves the stability of ac system by increasing the maximum active power that can be transmitted.

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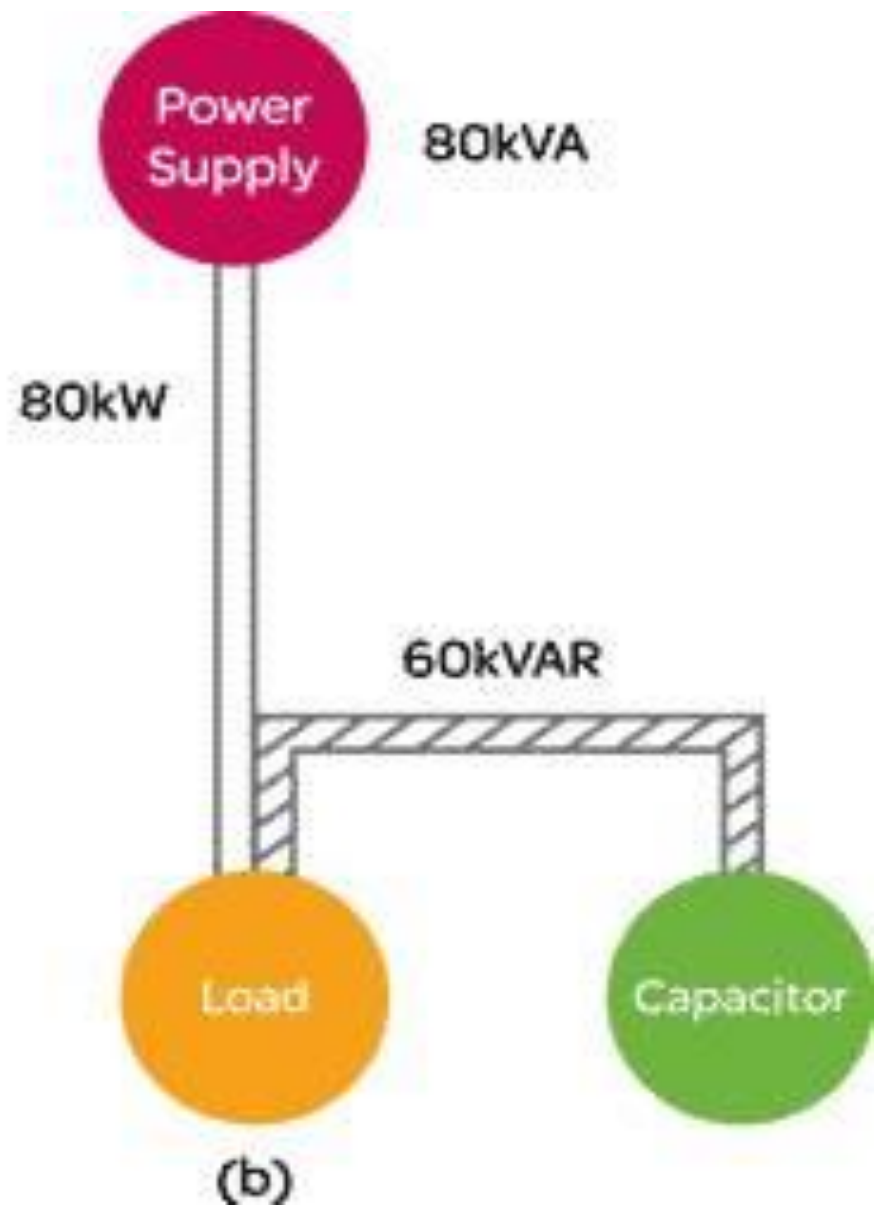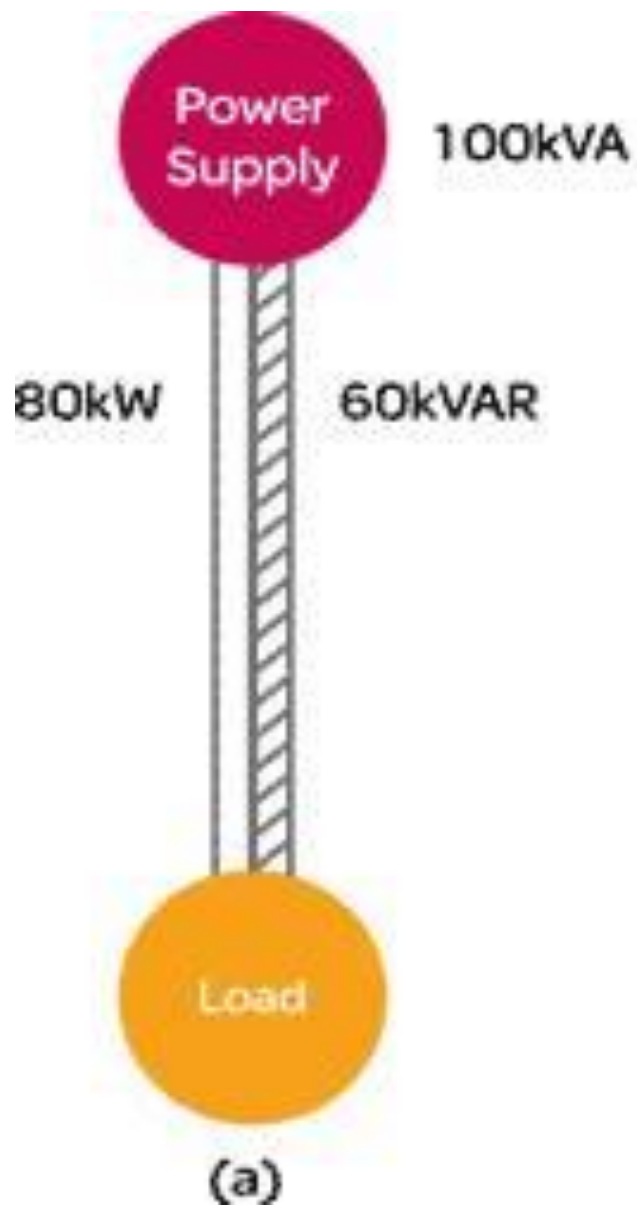
Shunt Compensation

- ✓ Capacitors act as reactive power producers .

- ✓ Capacitor across a motor nullifies the reactive power. demand there itself relieving the burden on power lines
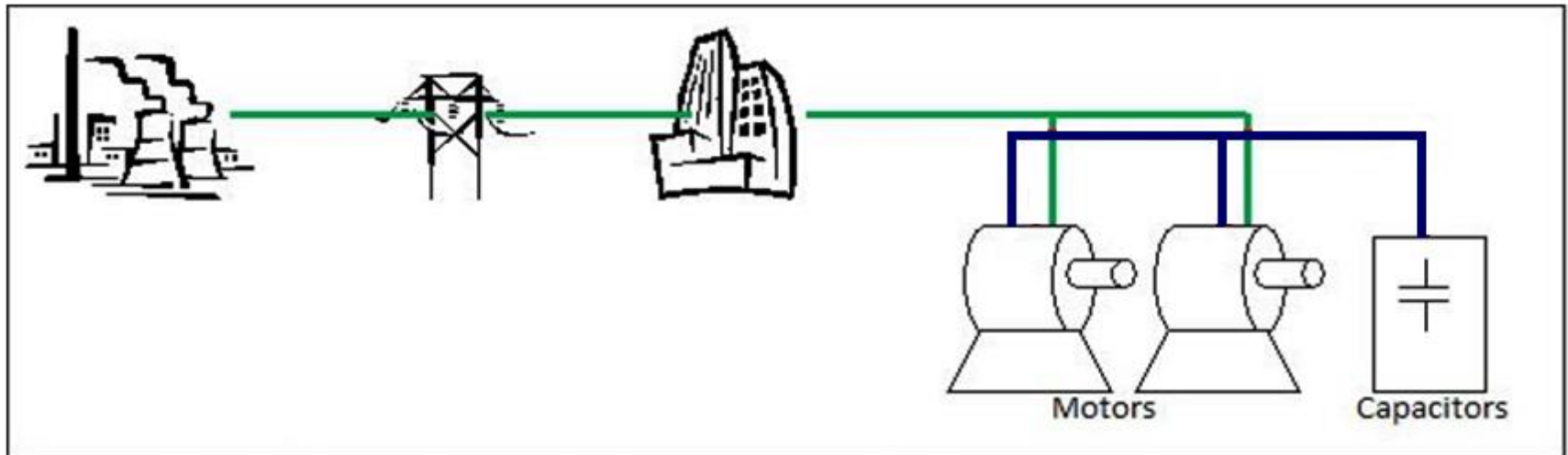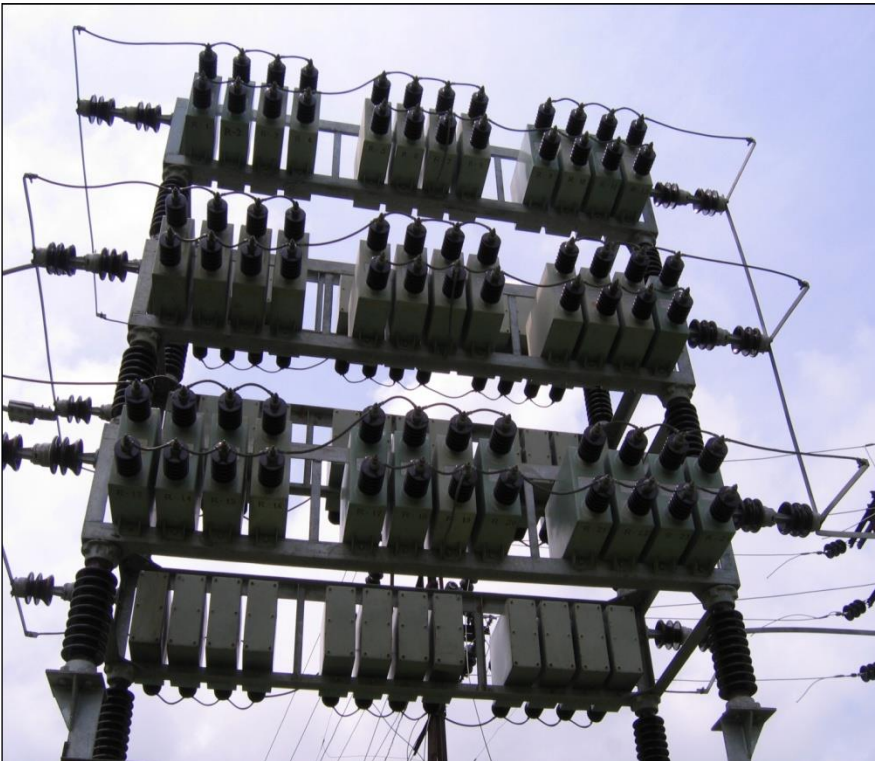

Simplified electrical generation, transmission, distribution, and load diagram with capacitors installed to improve power factor

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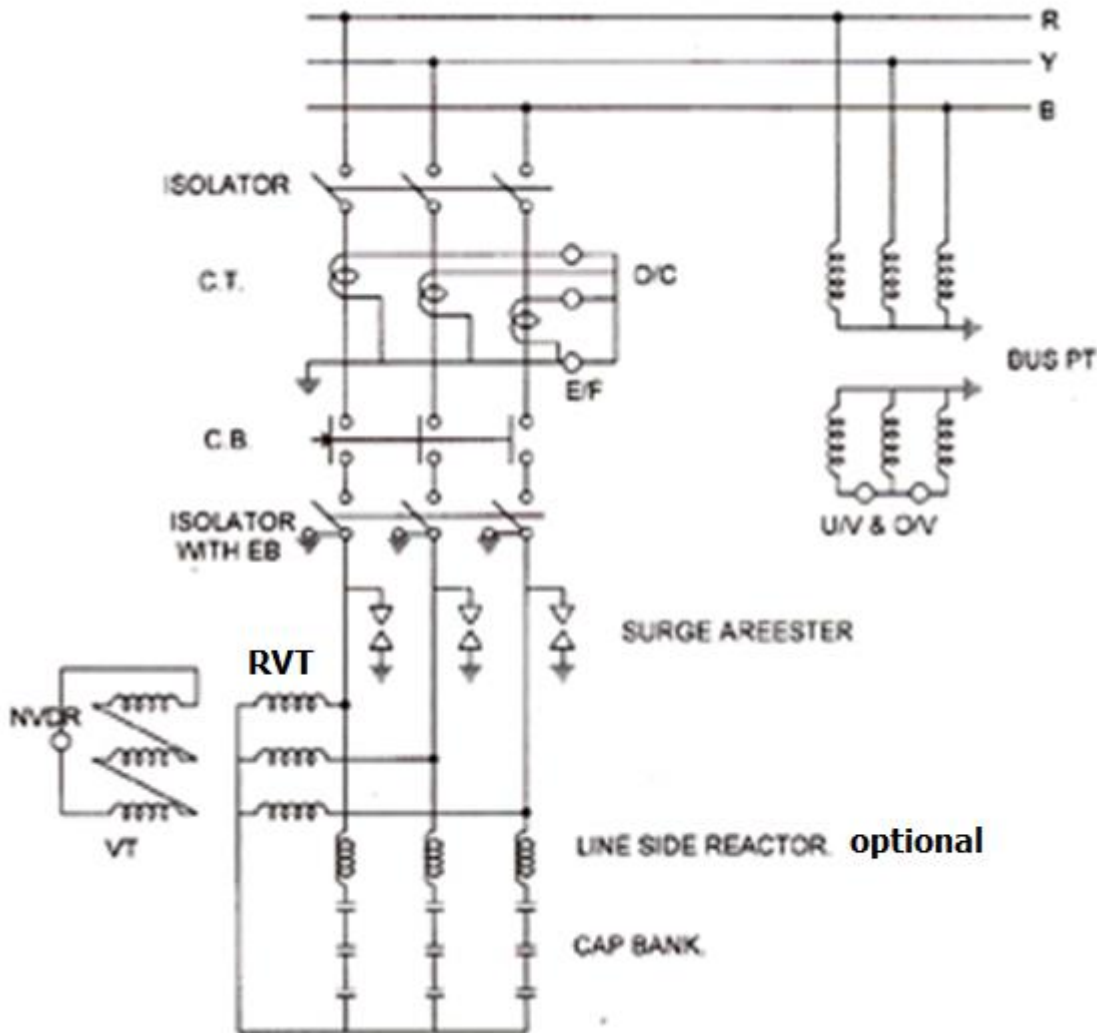## Techniques of Shunt Compensation

- Global compensation

✓ This involves implementation of capacitor bank Primary and Secondary distribution network.

✓ Remains in service during period of peak load.

Capacitor bank in EZ

Following different capacitor banks are available in EZ

- 33KV - 5 MVAr & 10 MVAr

- 11 KV - 600 KVAr ,
  - o 1200 KVAr &
  - o 1500 kVAr

Problems--

1. Capacitive current chopping

2. Discharging of Capacitor bank

Calculation of kVAr required

Example

A 33/11 kV substaion has an 8 MVA installed PTR which is having 5 outgoing 11 kV feeders.One of 11 KV feeders has pf of 0.70 lagging and additional load of 100 Amp. What is the rating of required capacitor bank to be connected to this feeder in kVAr to improve pf to 0.9 lagging.

Solution:-

Additional real power P =√3*V*I* cos α1=1333.64 kW
Previous power factor   =0.70 = cos α1
Required power factor   =0.90 = cos α2
Formula   Required kVAr   = P(tan α1-tan α2)
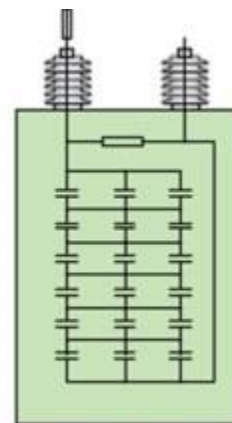
=1333.64 (1.02-0.48) kVAr

=720.17 kVAr

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Capacitance calculation

$$Kvar = \frac{2\pi f C}{1000} \times kV^2$$
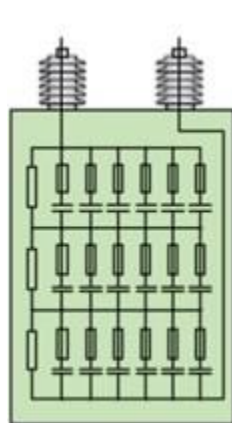
Internally fused

Externally fused

Fuseless

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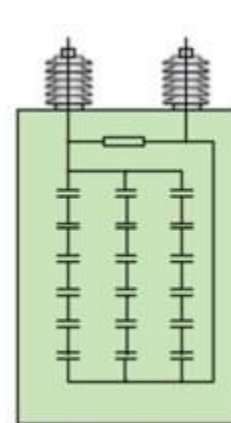
Valid for pf 0.95 to 0.97,for 33.3 to 125% load,220/400 volt

- Power capacitor capacity for direct connection in induction motor

Motor h.p	3000rpm(kvar)	1500rpm(kvar)	1000rpm(kvar)
3	1	1	1
5	2	2	2
7.5	2	2	3
10	3	3	4
15	3	4	5
20	5	6	7
25	6	7	8

30	7	8	9
40	9	10	12
50	10	12	15
60	12	14	15
75	15	16	20
100	20	22	25
125	25	26	30
150	30	32	35
200	40	45	45
250	45	50	55

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Operation and Maintenance of 11 kV 600 KVAR Capacitor Bank

- Before putting the Capacitor Bank in service, the earth switch must be opened to isolate same from earth and then only the main isolator contacts should be closed. Further it should be ensured that all male/female contacts of all phases of isolator should get arrested in each other properly.

- During the operation of isolator or electrical equipment, the hand gloves must be used by the operator.

- 600 KVAR bank equipped with an automatic vacuum switch which operates automatically producing a prominent sound when the load current become more than 52 Amp.

- After every tripping, the automatic switch of Capacitor Bank takes 10 minutes time interval. Thereafter it brings the capacitor bank back to normal service only when the current valued more than 52 Amps. The automatic switch keeps the capacitor bank in service for a system voltage ranging only between 9 KV to 12 KV. Beyond this values the automatic switch will remain Off.

- For maintenance or replacement of fuse of Capacitor unit, supply should be tripped from Xmer main VCB. Then the bank isolator should be opened, and earth switch closed and after discharging of all three phases, the maintenance work should be carried out.

Thank you !

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