Selection and location of site for substation(s)

- It should be located nearer or at the center of the gravity of load.
- It should provide safe and reliable arrangement
- Maintenance of regulation clearances (deals with political issues)
- Facilities for carrying out repairs and maintenance.
- Immediate facilities against abnormalities such as possibility of explosion or fire etc.
- Good design and construction
- Provision of suitable switchgear and protective gear etc.
- Land cost
- Number of incoming and out

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Selection and location of site for substation(s)

- Transfer of power
- Short-circuit levels
- Types of substation (objective/function)
- It should be away from airport and terrorist zones
- Physical amenities should be available for engineers such as transportation, schools, houses, hospitals, communication services, availability of drinking water etc.
- Drainage facility for rainwater
- Should be easily operated and maintained
- Should involve minimum capital cost
- Provision for future expansion

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Selection and rating of S/s equipment

- Surge arrester
- CT
- PT
- Isolator
- Circuit breaker
- Transformer
- Busbar
- Shunt capacitor
- Earth switch
- Relays
- Auxiliaries

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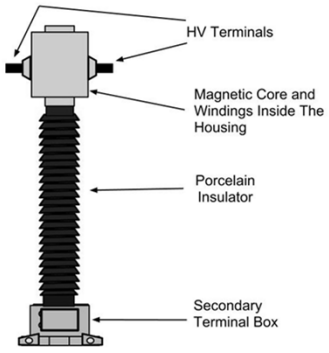
Current transformer: Functions

- Measurement
- Protection

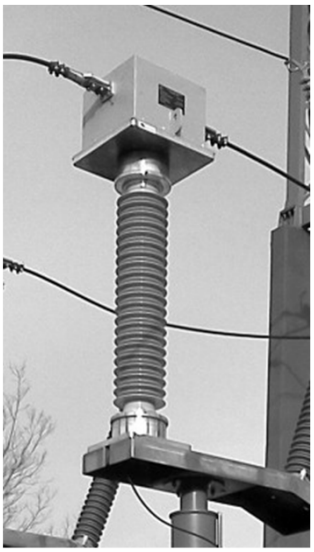
- Types:

Bar type

Wound type



Sketch of Top Core Type Current Transformer



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Current transformer: Ratings

Rated current (Primary)		
10	100	1000
12.5	125	125
15	150	1500
20	200	2000
25	250	2500
30	300	3000
40	400	4000
50	500	5000
60	600	6000
75	750	7500

Rated current (secondary)
1A or 5A

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Current transformer: VA calculations

- Pe=Pr(Is/Ir)*(Is/Ir)

where Pe=effective VA burden off relay on CT

Pr=VA burden of relay at given current setting Ir

Is=rated secondary current of CT

Ir= current setting of relay

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Voltage Transformer: Functions

- Indication of voltage conditions
- Metering of supply
- Relaying
- Synchronizing

- Types:

Magnetic

CVT

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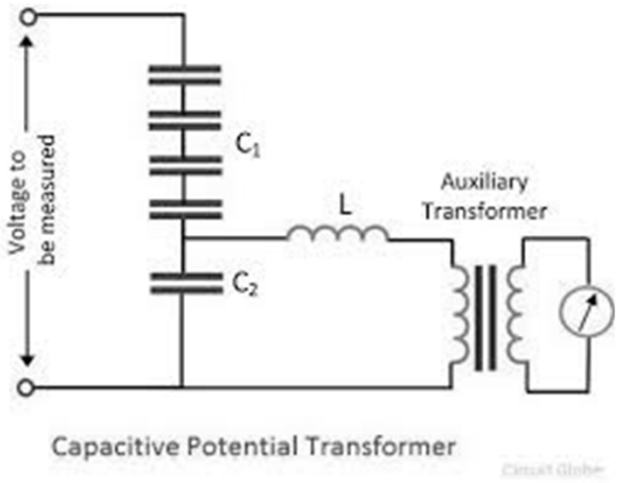
CVT: capacitor voltage transformer



Capacitive Potential Transformer

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Voltage Transformer: Ratings and specifications

- Earthing: effectively earthed & non-effectively earthed
- Rated secondary voltage (as per IS)- 110 V
- Rated output (as per IS)- 5,10, 25, 50, 100, 200, 500 VA/ph

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Phase displacement and Accuracy class

- Difference in phase between the primary and secondary current vectors, the direction of the vectors so chosen that the angle is zero for a perfect transformer usually expressed in minutes.
- The accuracy class is guaranteed if the voltage is **between 80 and 120%** of the rated primary voltage and for any load **between 25 and 100%** of the rated accuracy power with an inductive power factor of 0.8.
- The **class** designation is an approximate measure of the **CT's accuracy**. The ratio (primary to secondary current) error of a **Class** 1 **CT** is 1% at rated current; the ratio error of a **Class** 0.5 **CT** is 0.5% or less. Errors in phase are also important, especially in power measuring circuits.

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Voltage transformer/current transformer: Class of accuracy

- Measuring Potential transformer

Class	Voltage Error (%)	Phase displacement in minutes
0.1	+- 0.1	+-5
0.2	+-0.2	+-10
0.5	+-0.5	+-20
1.0	+-1.0	+-40
3.0	+-3.0	----

Frequency: 50 Hz

Protective Potential transformer

Class	Voltage Error (%)	Phase displacement in minutes
3P	+-3.0	+-120
6P	+-6.0	+-240

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Current transformer: Class of accuracy

- Measuring transformer

Class	Voltage Error (%)	Phase displacement
0.1	+- 0.1	+-5
0.2	+-0.2	+-10
0.5	+-0.5	+-20
1.0	+-1.0	+-40
3.0	+-3.0	----

Frequency: 50 Hz

Protective transformer

Class	Current at primary (%)
5P	+-1
10P	+-3
15P	+-5

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Current error at primary

- Current error:

$$\%\ error = \frac{k_n\ I_s - I_p}{I_p} * 100$$

Kn- rated transformation ratio

IS-actual secondary current when Ip flows

IP-actual primary current

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Current transformer/Voltage transformer: Insulation level

Rated voltage (kVrms)	BIL (kVpeak) rated lightning impulse voltage
3.6	40
7.2	60
12	75
24	125
36	170
52	250
72.5	325
123	450/550
145	550/650
245	850/950/1050
420	1300/1425

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Surge Arrester: Types

- Rod gap type
- Expulsion type
- Valve type
- Metal oxide

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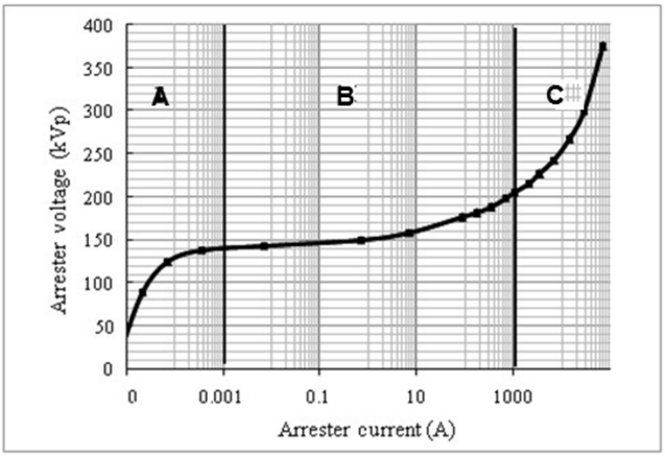
Surge Arrester: Rating and characteristics

- Rated voltage
- Rated frequency
- Nominal discharge current



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Surge Arrester: Voltage (kV) & discharge current ratings (kA)

0.280	18
0.5	21
0.66	24
3	27
4.5	30
6	33
7.5	36
9	60
12	75
15	96
18	102

108
120
138
186
198
318
336

1.5, 2.5, 5.5, 10 kA, 8/20µA

Frequency: 50 Hz

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Circuit breaker: Types

- Oil CB — Up to 11 kV
- AB CB — Up to 110 kV
- VCB — 22 kV to 66 kV
- SF6 CB — 765 kV

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Circuit breaker: specifications

- Rated voltage
- Rated insulation level
- Rated frequency
- Rated current
- Rated SC breaking current
- Rated transient recovery voltage for terminal faults
- Rated SC making current
- Rated operating sequence
- Rated short time constant

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Circuit breaker: Rated voltage (corresponds to highest system voltage) and BIL

- Rated voltages: 24, 36,48.3,72.5, 123, 145, 245, 420 kV

BIL		
Rated voltage	Rated lightning impulse voltage	Rated switching impulse voltage
300	1050	850
362	1175	950
420	1425	1050
525	1550	1175
765	2100	1425

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Circuit breaker: Current ratings

- Rated Current (RMS): 400, 630, 800, 1250, 1600, 2000, 2500, 3150, 4000 A
- Rated SC breaking current: 6.3, 8, 10, 12.5, 16, 20, 25, 31.5, 40, 50, 63, 80, 100 kA

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