Electrical Thumb Rules-(Part 1).

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- ## Cable Capacity:
- **For Cu Wire Current Capacity (Up to 30 Sq.mm) =** 6X Size of Wire in Sq.mm
- Ex. For 2.5 Sq.mm=6×2.5=15 Amp, For 1 Sq.mm=6×1=6 Amp, For 1.5 Sq.mm=6×1.5=9 Amp
- **For Cable Current Capacity =** 4X Size of Cable in Sq.mm ,Ex. For 2.5 Sq.mm=4×2.5=9 Amp.
- **Nomenclature for cable Rating =** Uo/U
- where Uo=Phase-Ground Voltage, U=Phase-Phase Voltage, Um=Highest Permissible Voltage
- ## Current Capacity of Equipments:
- **1 Phase Motor draws Current=**7Amp per HP.
- **3 Phase Motor draws Current=**1.25Amp per HP.
- **Full Load Current of 3 Phase Motor=**HPx1.5
- **Full Load Current of 1 Phase Motor=**HPx6
- **No Load Current of 3 Phase Motor =**30% of FLC
- **KW Rating of Motor=**HPx0.75
- **Full Load Current of equipment =**1.39xKVA (for 3 Phase 415Volt)
- **Full Load Current of equipment =**1.74xKw (for 3 Phase 415Volt)
- ## Earthing Resistance:
- **Earthing Resistance for Single Pit=**5Ω ,Earthing Grid=0.5Ω
- **As per NEC 1985 Earthing Resistance** should be <5Ω.
- **Voltage between Neutral and Earth** <=2 Volts
- **Resistance between Neutral and Earth** <=1Ω
- **Creepage Distance=**18 to 22mm/KV (Moderate Polluted Air) or
- **Creepage Distance=**25 to 33mm/KV (Highly Polluted Air)
- ## Minimum Bending Radius:
- **Minimum Bending Radius for LT Power Cable=**12xDia of Cable.
- **Minimum Bending Radius for HT Power Cable=**20xDia of Cable.
- **Minimum Bending Radius for Control Cable=**10xDia of Cable.
- ## Insulation Resistance:
- **Insulation Resistance Value for Rotating Machine=** (KV+1) MΩ.
- **Insulation Resistance Value for Motor (IS 732) =** ((20xVoltage (L-L)) / (1000+(2xKW)).
- **Insulation Resistance Value for Equipment (<1KV) =** Minimum 1 MΩ.
- **Insulation Resistance Value for Equipment (>1KV) =** KV 1 MΩ per 1KV.
- **Insulation Resistance Value for Panel =** 2 x KV rating of the panel.
- **Min Insulation Resistance Value (Domestic) =** 50 MΩ / No of Points. (All Electrical Points with Electrical fitting & Plugs). Should be less than 0.5 MΩ

- **Min Insulation Resistance Value (Commercial) =** 100 MΩ / No of Points. (All Electrical Points without fitting & Plugs).Should be less than 0.5 MΩ.
- **Test Voltage (A.C) for Meggering =** (2X Name Plate Voltage) +1000
- **Test Voltage (D.C) for Meggering = (**2X Name Plate Voltage).
- **Submersible Pump Take 0.4 KWH of extra Energy at 1 meter drop of Water.**
- ## Lighting Arrestor:
- **Arrestor have Two Rating=**
- (1) MCOV=Max. Continuous Line to Ground Operating Voltage.
- (2) Duty Cycle Voltage. (Duty Cycle Voltage>MCOV).
- ## Transformer:
- **Current Rating of Transformer**=KVAx1.4
- **Short Circuit Current of T.C /Generator=** Current Rating / % Impedance
- **No Load Current of Transformer=**<2% of Transformer Rated current
- **Capacitor Current (Ic)=**KVAR / 1.732xVolt (Phase-Phase)
- Typically the local utility provides transformers rated up to **500kVA** For maximum connected load of **99kW,**
- Typically the local utility provides transformers rated up to **1250kVA** For maximum connected load of **150kW.**
- The diversity they would apply to apartments is around **60%**
- Maximum HT (11kV) connected load will be around **4.5MVA per circuit**.
- 4No. earth pits per transformer (2No. for body and 2No. for neutral earthing),
- Clearances, approx.1000mm around TC allow for transformer movement for replacement.
- ## Diesel Generator:
- **Diesel Generator Set Produces=**3.87 Units (KWH) in 1 Litter of Diesel.
- **Requirement Area of Diesel Generator =** for 25KW to 48KW=56 Sq.meter, 100KW=65 Sq.meter.
- DG less than or equal to **1000kVA must be in a canopy.**
- DG greater **1000kVA** can either be in a canopy or skid mounted in an acoustically treated room
- DG noise levels to be less than **75dBA @ 1meter.**
- DG fuel storage tanks should be a maximum of **990 Litter per unit** Storage tanks above this level will trigger more stringent explosion protection provision.
- ## Current Transformer:
- **Nomenclature of CT:**
- **Ratio:** input / output current ratio
- **Burden (VA):** total burden including pilot wires. (2.5, 5, 10, 15 and 30VA.)
- **Class:** Accuracy required for operation (Metering: 0.2, 0.5, 1 or 3, Protection: 5, 10, 15, 20, 30)**.**
- **Accuracy Limit Factor:**
- Nomenclature of CT: Ratio, VA Burden, Accuracy Class, Accuracy Limit Factor.**Example: 1600/5, 15VA 5P10** (Ratio: 1600/5, Burden: 15VA, Accuracy Class: 5P, ALF: 10)

- **As per IEEE Metering CT:** 0.3B0.1 rated Metering CT is accurate to 0.3 percent if the connected secondary burden if impedance does not exceed 0.1 ohms.
- **As per IEEE Relaying (Protection) CT:** 2.5C100 Relaying CT is accurate within 2.5 percent if the secondary burden is less than 1.0 ohm (100 volts/100A).

Quick Electrical Calculation	
1HP=0.746KW	**Star Connection**
1KW=1.36HP	Line Voltage=√3 Phase Voltage
1Watt=0.846 Kla/Hr	Line Current=Phase Current
1Watt=3.41 BTU/H**r**	**Delta Connection**
1KWH=3.6 MJ	Line Voltage=Phase Voltage
1Cal=4.186 J	Line Current=√3 Phase Current
1Tone= 3530 BTU	
85 Sq.ft Floor Area=1200 BTU	
1Kcal=4186 Joule	
1KWH=860 Kcal	
1Cal=4.183 Joule	

Electrical Thumb Rules (Part-2)

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Useful Equations:

- For Sinusoidal Current : **Form Factor =** RMS Value/Average Value=1.11
- For Sinusoidal Current : **Peak Factor =** Max Value/RMS Value =1.414
- **Average Value of Sinusoidal Current(Iav**)=0.637xIm (Im= Max.Value)
- **RMS Value of Sinusoidal Current(Irms)=**0.707xIm (Im= Max.Value)
- **A.C Current=**D.C Current/0.636.
- **Phase Difference between Phase=** 360/ No of Phase (1 Phase=230/1=360°,2Phase=360/2=180°)
- **Short Circuit Level of Cable in KA (Isc)=(**0.094xCable Dia in Sq.mm)/√ Short Circuit Time (Sec)
- **Max.Cross Section Area of Earthing Strip(mm2)** =√(Fault Current x Fault Current x Operating Time of Disconnected Device) / K
- K=Material Factor, K for Cu=159, K for Alu=105, K for steel=58 , K for GI=80
- **Most Economical Voltage at given Distance=**5.5x√ ((km/1.6)+(kw/100))
- **Cable Voltage Drop(%)=(**1.732xcurrentx(RcosǾ+jsinǾ)x1.732xLength (km)x100)/(Volt(L-L)x Cable Run.
- **Spacing of Conductor in Transmission Line (mm) =** 500 + 18x (P-P Volt) + (2x (Span in Length)/50).

- **Protection radius of Lighting Arrestor** = √hx (2D-h) + (2D+L). Where h= height of L.A, D-distance of equipment (20, 40, 60 Meter), L=Vxt (V=1m/ms, t=Discharge Time).
- **Size of Lighting Arrestor=** 1.5x Phase to Earth Voltage or 1.5x (System Voltage/1.732).
- **Maximum Voltage of the System=** 1.1xRated Voltage (Ex. 66KV=1.1×66=72.6KV)
- **Load Factor=**Average Power/Peak Power
- If Load Factor is 1 or 100% = This is best situation for System and Consumer both.
- If Load Factor is Low (0 or 25%) =you are paying maximum amount of KWH consumption. Load Factor may be increased by switching or use of your Electrical Application.
- **Demand Factor=** Maximum Demand / Total Connected Load (Demand Factor <1)
- Demand factor should be applied for Group Load
- **Diversity Factor=** Sum of Maximum Power Demand / Maximum Demand (Demand Factor >1)
- Diversity factor should be consider for individual Load
- **Plant Factor(Plant Capacity)=** Average Load / Capacity of Plant
- **Fusing Factor=**Minimum Fusing Current / Current Rating (Fusing Factor>1).
- **Voltage Variation(1 to 1.5%)=** ((Average Voltage-Min Voltage)x100)/Average Voltage
- Ex: 462V, 463V, 455V, Voltage Variation= ((460-455) x100)/455=1.1%.
- **Current Variation(10%)=** ((Average Current-Min Current)x100)/Average Current
- Ex:30A,35A,30A, Current Variation=((35-31.7)x100)/31.7=10.4%
- **Fault Level at TC Secondary**=TC (VA) x100 / Transformer Secondary (V) x Impedance (%)
- **Motor Full Load Current=** Kw /1.732xKVxP.FxEfficiency

Electrical Thumb Rules-(Part-3)

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Size of Capacitor for P.F Correction:

For Motor	
Size of Capacitor = 1/3 Hp of Motor (0.12x KW of Motor)	
For Transformer	
< 315 KVA	5% of KVA Rating
315 KVA to 1000 KVA	6% of KVA Rating
>1000 KVA	8% of KVA Rating

Earthing Resistance value:

Earthing Resistance Value

Power Station	0.5 Ω
Sub Station Major	1.0 Ω
Sub Station Minor	2.0 Ω
Distribution Transformer	5.0 Ω
Transmission Line	10 Ω
Single Isolate Earth Pit	5.0 Ω
Earthing Grid	0.5 Ω
As per NEC Earthing Resistance should be <5.0 Ω	

Voltage Limit (As per CPWD & Kerala Elect.Board):

Voltage Limit (As Per CPWD)	
240V	< 5 KW
415V	<100 KVA
11KV	<3 MVA
22KV	<6 MVA
33KV	<12 MVA
66KV	<20 MVA
110KV	<40 MVA
220KV	>40 MVA

Voltage Variation

> 33 KV	(-) 12.5% to (+) 10%
< 33 KV	(-) 9% to (+) 6%
Low Voltage	(-) 6% to (+) 6%

Insulation Class:

Insulation	**Temperature**
Class A	105°C
Class E	120°C
Class B	130°C
Class F	155°C
Class H	180°C
Class N	200°C

Standard Voltage Limit:

Voltage	**IEC (60038)**	**IEC**	**Indian Elect.**

		(6100:3.6)	**Rule**
ELV	< 50 V		
LV	50 V to 1 KV	<=1 KV	< 250 V
MV		<= 35 KV	250 V to 650 V
HV	> 1KV	<= 230 KV	650 V to 33 KV
EHV		> 230 KV	> 33 KV

Standard Electrical Connection (As per GERC):

As per Type of Connection	
Connection	**Voltage**
LT Connection	<=440V
HT connection	440V to 66KV
EHT connection	>= 66KV
As per Electrical Load Demand	
Up 6W Load demand	1 Phase 230V Supply
6W to 100KVA(100KW)	3 Phase 440V Supply
100KVA to 2500KVA	11KV,22KV,33KV
Above 2500KVA	66KV
HT Connection Earthing	
H.T Connection's Earthing Strip	20mmX4mm Cu. Strip
CT & PT bodies	2Nos
PT Secondary	1Nos
CT Secondary	1Nos
I/C and O/G Cable+ Cubicle Body	2Nos

Standard Meter Room Size (As per GERC):

Meter Box Height	Upper level does not beyond 1.7 meter and Lower level should not below 1.2 meter from ground.
Facing of Meter Box	Meter Box should be at front area of Building at Ground Floor.
Meter Room / Closed Shade	4 meter square Size

Approximate Load as per Sq.ft Area (As per DHBVN):

Sq.ft Area	Required Load (Connected)
< 900 Sq.ft	8 KW
901 Sq.ft to 1600 Sq.ft	16 KW
1601 Sq.ft to 2500 Sq.ft	20 KW
> 2500 Sq.ft	24 KW
For Flats :100 Sq.ft / 1 KW	
For Flats USS /TC: 100 Sq.ft / 23 KVA	

Contracted Load in case of High-rise Building:

For Domestic Load	500 watt per 100 Sq. foot of the constructed area.
For Commercial	1500 watt per 100 Sq. foot of the constructed area
Other Common Load	For lift, water lifting pump, streetlight if any, corridor/campus lighting and other common facilities, actual load shall be calculated
Staircase Light	11KW/Flat Ex: 200Flat=200×11=2.2KW
Sanctioned Load for Building	
Up to 50 kW	The L.T. existing mains shall be strengthened.
50 kW to 450 kW (500 kVA)	11 kV existing feeders shall be extended if spare capacity is available otherwise, new 11 kV feeders shall be constructed.
450 kW to 2550 kW (3000 kVA)	11 kV feeder shall be constructed from the nearest 33 kV or 110 kV substation
2550 kW to 8500 kW (10,000 kVA)	33kV feeder from 33 kV or 110 kV sub station
8500 kW (10,000 kVA)	110 kV feeder from nearest 110 kV or 220 kV sub-station

Electrical Thumb Rules-(Part-4)

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Sub Station Capacity & Short Circuit Current Capacity:

As per GERC		
Voltage	**Sub Station Capacity**	**Short Circuit Current**
400 KV	Up to 1000 MVA	40 KA (1 to 3 Sec)
220 KV	Up to 320 MVA	40 KA (1 to 3 Sec)
132 KV	Up to 150 MVA	32 KA (1 to 3 Sec)

66 KV	Up to 80 MVA	25 KA (1 to 3 Sec)
33 KV	1.5 MVA to 5 MVA	35 KA (Urban) (1 to 3 Sec)
11 KV	150 KVA to 1.5 MVA	25 KA (Rural) (1 to 3 Sec)
415 V	6 KVA to 150 KVA	10 KA (1 to 3 Sec)
220 V	Up to 6 KVA	6 KA (1 to 3 Sec)

Sub Station Capacity & Short Circuit Current Capacity:

As per Central Electricity Authority		
Voltage	**Sub Station Capacity**	**Short Circuit Current**
765 KV	4500 MVA	31.5 KA for 1 Sec
400 KV	1500 MVA	31.5 KA for 1 Sec
220 KV	500 MVA	40 KA for 1 Sec
110/132 KV	150 MVA	40 KA or 50 KA for 1 Sec
66 KV	75 MVA	40 KA or 50 KA for 1 Sec

Minimum Ground Clearance and Fault Clearing Time:

Voltage	**Min. Ground Clearance**	**Fault Clear Time**
400 KV	8.8 Meter	100 mille second
220 KV	8.0 Meter	120 mille second
132 KV	6.1 Meter	160 mille second
66 KV	5.1 Meter	300 mille second
33 KV	3.7 Meter	
11 KV	2.7 Meter	

Bus bar Ampere Rating:

For Phase Bus bar	Aluminium 130 Amp / Sq.cm or 800Amp / Sq.inch.
For Phase Bus bar	Copper 160 Amp / Sq.cm or 1000Amp / Sq.inch
For Neutral Bus bar	Same as Phase Bus bar up to 200 Amp than Size of Neutral Bus bar is at least half of Phase Bus bar.

Bus bar Spacing:

Between Phase and Earth	26mm (Min)
Between Phase and Phase	32mm (Min)

Bus bar Support between Two Insulator	250mm.

Sound Level of Diesel Generator (ANSI 89.2&NEMA 51.20):

KVA	Max. Sound Level
<9 KVA	40 DB
10 KVA to 50 KVA	45 DB
51 KVA to 150 KVA	50 DB
151 KVA to 300 KVA	55 DB
301 KVA to 500 KVA	60 DB

IR Value of Transformer:

IR Value of Transformer			
Voltage	30°C	40°C	50°C
>66KV	600MΩ	300MΩ	150MΩ
22KV to 33KV	500MΩ	250MΩ	125MΩ
6.6KV to 11KV	400MΩ	200MΩ	100MΩ
<6.6KV	200MΩ	100MΩ	50MΩ
415V	100MΩ	50MΩ	20MΩ

Standard Size of MCB/MCCB/ELCB/RCCB/SFU/Fuse:

MCB	Up to 63 Amp (80Amp and 100 Amp a per Request)
MCCB	Up to 1600 Amp (2000 Amp as per Request)
ACB	Above 1000 Amp
MCB Rating	6A,10A,16A,20A,32A,40A,50A,63A
MCCB Rating	0.5A,1A,2A,4A,6A,10A,16A,20A,32A,40A,50A,63A,80A,100A (Domestic Max 6A)
RCCB/ELCB	6A,10A,16A,20A,32A,40A,50A,63A,80A,100A
Sen. of ELCB	30ma (Domestic),100ma (Industrial),300ma
DPIC (Double Pole Iron Clad) main switch	5A,15A,30 A for 250V
TPIC (Triple Pole Iron Clad) main switch	30A, 60A, 100A, 200 A For 500 V
DPMCB	5A, 10A, 16A, 32A and 63 A for 250V
TPMCCB	100A,200A, 300Aand 500 A For 660 V

TPN main switch	30A, 60A, 100A, 200A, 300 A For 500 V
TPNMCB	16A, 32A,63A For 500 V, beyond this TPNMCCB: 100A, 200A, 300A, 500 A For 660 V
TPN Fuse Unit (Rewirable)	16A,32A,63A,100A,200A
Change over switch (Off Load)	32A,63A,100A,200A,300A,400A,630A,800A
SFU (Switch Fuse Unit)	32A,63A,100A,125A,160A,200A,250A,315A,400A,630A
HRC Fuse TPN (Bakelite)	125A,160A,200A,250A,400A.630A
HRC Fuse DPN (Bakelite)	16A,32A,63A
MCB/MCCB/ELCB Termination Wire / Cable	
Up to 20A MCB	Max. 25 Sq.mm
20A to 63A MCB	Max. 35 Sq.mm
MCCB	Max. 25 Sq.mm
6A to 45A ELCB	16 Sq.mm
24A to 63A ELCB	35 Sq.mm
80A to 100A ELCB	50 Sq.mm

Electrical Thumb Rules-(Part-5)

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Standard Size of Transformer (IEEE/ANSI 57.120):

Single Phase Transformer	Three Phase Transformer
5KVA,10 KVA,15 KVA,25 KVA,37.5 KVA,50 KVA,75 KVA,100 KVA,167 KVA,250 KVA, 333 KVA,500 KVA,833 KVA,1.25 KVA,1.66 KVA,2.5 KVA,3.33 KVA,5.0 KVA,6.6 KVA,8.3 KVA,10.0 KVA,12.5 KVA,16.6 KVA,20.8 KVA,25.0 KVA,33.33 KVA	3 KVA,5 KVA,9 KVA,15 KVA,30 KVA,45 KVA,75 KVA,112.5 KVA,150 KVA,225 KVA,300 KVA,500 KVA,750 KVA,1MVA,1.5 MVA,2 MVA,2.5 MVA,3.7 MVA,5 MVA,7.5MVA, 10MVA ,12MVA,15MVA,20MVA ,25MVA, 30MVA,37.5MVA ,50MVA ,60MVA,75MVA,100MVA

Standard Size of Motor (HP):

Electrical Motor (HP)
1,1.5,2,3,5,7.5,10,15,20,30,40,50,60,75,100,125,150,200,250,300,400,450,500,600,700, 800,900,1000,1250,1250,1500,1750,2000,2250,3000,3500,4000

Approximate RPM of Motor

HP	RPM
< 10 HP	750 RPM
10 HP to 30 HP	600 RPM
30 HP to 125 HP	500 RPM
125 HP to 300 HP	375 RPM

Standard Size of Motor (HP):

Electrical Motor (HP)
1,1.5,2,3,5,7.5,10,15,20,30,40,50,60,75,100,125,150,200,250,300,400,450,500,600,700, 800,900,1000,1250,1250,1500,1750,2000,2250,3000,3500,4000

Motor Line Voltage:

Motor (KW)	Line Voltage
< 250 KW	440 V (LV)
150 KW to 3000KW	2.5 KV to 4.1 KV (HV)
200 KW to 3000KW	3.3 KV to 7.2 KV (HV)
1000 KW to 1500KW	6.6 KV to 13.8 KV (HV)

Motor Starting Current:

Supply	Size of Motor	Max. Starting Current
1 Phase	< 1 HP	6 X Motor Full Load Current
1 Phase	1 HP to 10 HP	3 X Motor Full Load Current
3 Phase	10 HP	2 X Motor Full Load Current
3 Phase	10 HP to 15	2 X Motor Full Load

	HP	Current
3 Phase	> 15 HP	1.5 X Motor Full Load Current

Motor Starter:

Starter	HP or KW	Starting Current	Torque
DOL	<13 HP(11KW)	7 X Full Load Current	Good
Star-Delta	13 HP to 48 HP	3 X Full Load Current	Poor
Auto TC	> 48 HP (37 KW)	4 X Full Load Current	Good/ Average
VSD		0.5 to 1.5 X Full Load Current	Excellent
Motor > 2.2KW Should not connect direct to supply voltage if it is in Delta winding			

Impedance of Transformer (As per IS 2026):

MVA	% Impedance
< 1 MVA	5%
1 MVA to 2.5 MVA	6%
2.5 MVA to 5 MVA	7%
5 MVA to 7 MVA	8%
7 MVA to 12 MVA	9%
12 MVA to 30 MVA	10%
> 30 MVA	12.5%

Standard Size of Transformer:

Standard Size of Transformer	KVA
Power Transformer (Urban)	3,6,8,10,16
Power Transformer (Rural)	1,1.6,3.15,5
Distribution Transformer	25,50,63,100,250,315,400,500,630

Electrical Thumb Rules-(Part-6)

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Transformer Earthing Wire / Strip Size:

Size of T.C or DG	Body Earthing	Neutral Earthing
<315 KVA	25×3 mm Cu / 40×6 mm GI Strip	25×3 mm Cu Strip
315 KVA to 500 KVA	25×3 mm Cu / 40×6 mm GI Strip	25×3 mm Cu Strip
500 KVA to 750 KVA	25×3 mm Cu / 40×6 mm GI Strip	40×3 mm Cu Strip
750 KVA to 1000 KVA	25×3 mm Cu / 40×6 mm GI Strip	50×3 mm Cu Strip

Motor Earthing Wire / Strip Size:

Size of Motor	Body Earthing
< 5.5 KW	85 SWG GI Wire
5.5 KW to 22 KW	25×6 mm GI Strip
22 KW to 55 KW	40×6 mm GI Strip
>55 KW	50×6 mm GI Strip

Panel Earthing Wire / Strip Size:

Type of Panel	Body Earthing
Lighting & Local Panel	25×6 mm GI Strip
Control & Relay Panel	25×6 mm GI Strip
D.G & Exciter Panel	50×6 mm GI Strip
D.G & T/C Neutral	50×6 mm Cu Strip

Electrical Equipment Earthing:

Equipment	Body Earthing
LA (5KA,9KA)	25×3 mm Cu Strip
HT Switchgear	50×6 mm GI Strip
Structure	50×6 mm GI Strip
Cable Tray	50×6 mm GI Strip
Fence / Rail Gate	50×6 mm GI Strip

Earthing Wire (As per BS 7671)

Cross Section Area of Phase, Neutral Conductor(S) mm2	Minimum Cross Section area of Earthing Conductor (mm2)
S<=16	S (Not less than 2.5 mm2)

16<S<=35	16
S>35	S/2

Area for Transformer Room: (As per NBC-2005):

Transformer Size	Min. Transformer Room Area (M2)	Min. Total Sub Station Area(Incoming HV,LV Panel, T.C Roof) (M2)	Min. Space Width (Meter)
1X160	14	90	9
2X160	28	118	13.5
1X250	15	91	9
2X250	30	121	13.5
1X400	16.5	93	9
2X400	33	125	13.5
3X400	49.5	167	18
2X500	36	130	14.5
3X500	54	172	19
2X630	36	132	14.5
3X630	54	176	19
2X800	39	135	14.5
3X800	58	181	14
2X1000	39	149	14.5
3X1000	58	197	19

- The Capacitor Bank should be automatic Switched type for Sub Station of 5MVA and Higher.
- Transformer up to 25KVA can be mounted direct on Pole.
- Transformer from 25KVA to 250KVA can be mounted either on "H" Frame of Plinth.
- Transformer above 250KVA can be mounted Plinth only.
- Transformer above 100MVA shall be protected by Drop out Fuse or Circuit Breaker.

Span of Transmission Line (Central Electricity Authority):

Voltage	Normal Span
765 KV	400 to 450 Meter
400 KV	400 Meter
220 KV	335,350,375 Meter
132 KV	315,325,335 Meter
66 KV	240,250,275 Meter

Max. Lock Rotor Amp for 1 Phase 230 V Motor (NEMA)

HP	Amp
1 HP	45 Amp
1.5 HP	50 Amp
2 HP	65 Amp
3 HP	90 Amp
5 HP	135 Amp
7.5 HP	200 Amp
10 HP	260 Amp

Three Phase Motor Code (NEMA)

HP	Code
<1 HP	L
1.5 to 2.0 HP	L,M
3 HP	K
5 HP	J
7 to 10 HPPHPHPHHHHH	H
>15 HP	G

Service Factor of Motor:

HP	Synchronous Speed (RPM)						
	3600 RPM	1800 RPM	1200 RPM	900 RPM	720 RPM	600 RPM	514 RPM
1 HP	1.25	1.15	1.15	1.15	1	1	1
1.5 to 1.25 HP	1.15	1.15	1.15	1.15	1.15	1.15	1.15
150 HP	1.15	1.15	1.15	1.15	1.15	1.15	1
200 HP	1.15	1.15	1.15	1.15	1.15	1	1
> 200 HP	1	1.15	1	1	1	1	1

Type of Contactor:

Type	Application
AC1	Non Inductive Load or Slightly Inductive Load
AC2	Slip Ring Motor, Starting, Switching OFF
AC3	Squirrel Cage Motor
AC4,AC5,AC5a, AC5b,AC6a	Rapid Start & Rapid Stop

AC 5a	Auxiliary Control circuit
AC 5b	Electrical discharge Lamp
AC 6a	Electrical Incandescent Lamp
AC 6b	Transformer Switching
AC 7a	Switching of Capacitor Bank
AC 7b	Slightly Inductive Load in Household
AC 5a	Motor Load in Household
AC 8a	Hermetic refrigerant compressor motor with Manual Reset O/L Relay
AC 8b	Hermetic refrigerant compressor motor with Automatic Reset O/L Relay
AC 12	Control of Resistive Load & Solid State Load
AC 13	Control of Resistive Load & Solid State Load with Transformer Isolation
AC 14	Control of small Electro Magnetic Load (<72 VA)
AC 15	Control of Electro Magnetic Load (>72 VA)

Contactor Coil:

Coil Voltage	Suffix
24 Volt	T
48 Volt	W
110 to 127 Volt	A
220 to 240 Volt	B
277 Volt	H
380 to 415 Volt	L

Electrical Thumb Rules-(Part-7)

September 16, 2013 10 Comments

Overhead Conductor /Cable Size:

Voltage	Overhead Conductor	Cable Size
33 KV	ACSR-Panther/Wolf/Dog , AAAC	150,185,300,400,240 mm2 Cable
11 KV	ACSR-Dog/Recon/Rabbit , AAAC	120, 150,185,300 mm2 Cable
LT	ACSR-Dog/Recon/Rabbit , AAC,AAAC	95,120, 150,185,300 mm2 Cable

Transmission / Distribution Line:

Span	Height of Tower
400KV=400 Meter	400KV=30Meter (Base 8.8 Meter)
220KV=350 Meter	220KV=23Meter (Base 5.2 Meter)
132KV=335 Meter	220KV Double Circuit=28 Meter
66KV=210 Meter	66KV=13Meter
Conductor Ampere	**Voltage wise Conductor**
Dog=300Amp	400KV=Moose ACSR=500MVA Load
Panther=514Amp	220KV=Zebra ACSR=200MVA Load
Zebra=720Amp	132KV=Panther ACSR=75MVA Load
Rabbit=208Amp	66KV=Dog ACSR=50MVA Load
Moose=218Amp	

Type of Tower:

Type	Used	Angle/Deviation
A	Suspension Tower	Up to 2°
B	Small Angle Tower	2° to 15°
C	Medium Angle Tower	15° to 30°
D	Large Angle / Dead End Tower	30° to 60° & Dead End

Tower Swing Angle Clearance (Metal Part to Live Part):

Swing Angle	Live Part to Metal Part Clearance (mm)			
	66KV	**132KV**	**220KV**	**400KV**
0°	915mm	1530mm	2130mm	3050mm
15°	915mm	1530mm	2130mm	-
22°	-	-	-	3050mm
30°	760mm	1370mm	1830mm	-
44°	-	-	-	1860mm
44°	610mm	1220mm	1675mm	-

Cable Coding (IS 1554) :(A2XFY / FRLS / FRPVC / FRLA / PILC)

A	Aluminium
2X	XLPE

F	Flat Armoured
W	Wire Armoured
Y	Outer PVC Insulation Sheath
W	Steel Round Wire
WW	Steel double round wire Armoured
YY	Steel double Strip Armoured
FR	Fire Retardation
LS	Low Smoke
LA	Low Acid Gas Emission
WA	Non Magnetic round wire Armoured
FA	Non Magnetic Flat wire Armoured
FF	Double Steel Round Wire Armoured

Corona Ring Size:

Voltage	Size
<170 KV	160mm Ring put at HV end
>170 KV	350mm Ring put at HV end
>275 KV	450mm Ring put at HV end & 350 mm Ring put at Earth end

Load as per Sq.Ft:

Type of Load	Load/Sq.Ft	Diversity Factor
Industrial	1000 Watt/Sq.Ft	0.5
Commercial	30 Watt/Sq.Ft	0.8
Domestic	15 Watt/Sq.Ft	0.4
Lighting	15 Watt/Sq.Ft	0.8

Size of Ventilation Shaft:

Height of Building in meter	Size of ventilation shaft in sq meter	Minimum size of shaft in meter
9.0	1.5	1.0
12.5	3.0	1.2
15 and above	4.0	1.5

Electrical Thumb Rules-(Part-8)

October 1, 2013 6 Comments

Accuracy Class of Metering CT:

Metering Class CT	
Class	**Applications**
0.1 To 0.2	Precision measurements
0.5	High grade kilowatt hour meters for commercial grade kilowatt hour meters
3	General industrial measurements
3 OR 5	Approximate measurements

Accuracy Class Letter of CT:

Metering Class CT	
Accuracy Class	**Applications**
B	Metering Purpose
Protection Class CT	
C	CT has low leakage flux.
T	CT can have significant leakage flux.
H	CT accuracy is applicable within the entire range of secondary currents from 5 to 20 times the nominal CT rating. (Typically wound CTs.)
L	CT accuracy applies at the maximum rated secondary burden at 20 time rated only. The ratio accuracy can be up to four times greater than the listed value, depending on connected burden and fault current. (Typically window, busing, or bar-type CTs.)

Accuracy Class of Protection CT:

Class	Applications
10P5	Instantaneous over current relays & trip coils: 2.5VA
10P10	Thermal inverse time relays: 7.5VA
10P10	Low consumption Relay: 2.5VA
10P10/5	Inverse definite min. time relays (IDMT) over current
10P10	IDMT Earth fault relays with approximate time grading:15VA
5P10	IDMT Earth fault relays with phase fault stability or accurate time grading: 15VA

Calculate IDMT over Current Relay Setting (50/51)

October 11, 2013 18 Comments

- Calculate setting of IDMT over Current Relay for following Feeder and CT Detail
- **Feeder Detail**: Feeder Load Current 384 Amp, Feeder Fault current Min11KA and Max 22KA.
- **CT Detail:** CT installed on feeder is 600/1 Amp. Relay Error 7.5%, CT Error 10.0%, CT over shoot 0.05 Sec, CT interrupting Time is 0.17 Sec and Safety is 0.33 Sec.
- **IDMT Relay Detail:**
- **IDMT Relay Low Current setting:** Over Load Current setting is 125%, Plug setting of Relay is 0.8 Amp and Time Delay (TMS) is 0.125 Sec, Relay Curve is selected as Normal Inverse Type.
- **IDMT Relay High Current setting :**Plug setting of Relay is 2.5 Amp and Time Delay (TMS) is 0.100 Sec, Relay Curve is selected as Normal Inverse Type

Calculation of Over Current Relay Setting:

(1) Low over Current Setting: (I>)

- **Over Load Current (In) = Feeder Load Current X Relay setting = 384 X 125% =480 Amp**
- **Required Over Load Relay Plug Setting= Over Load Current (In) / CT Primary Current**
- Required Over Load Relay Plug Setting = 480 / 600 = 0.8
- **Pick up Setting of Over Current Relay (PMS) (I>)= CT Secondary Current X Relay Plug Setting**
- Pick up Setting of Over Current Relay (PMS) (I>)= 1 X 0.8 = 0.8 Amp
- **Plug Setting Multiplier (PSM) = Min. Feeder Fault Current / (PMS X (CT Pri. Current / CT Sec. Current))**
- Plug Setting Multiplier (PSM) = 11000 / (0.8 X (600 / 1)) = 22.92
- Operation Time of Relay as per it's Curve
- Operating Time of Relay for Very Inverse Curve (t) =13.5 / ((PSM)-1).
- Operating Time of Relay for Extreme Inverse Curve (t) =80/ ((PSM)2 -1).
- Operating Time of Relay for Long Time Inverse Curve (t) =120 / ((PSM) -1).
- Operating Time of Relay for Normal Inverse Curve (t) =0.14 / ((PSM) 0.02 -1).
- Operating Time of Relay for Normal Inverse Curve (t)=0.14 / ((22.92)0.02-1) = 2.17 Amp
- Here Time Delay of Relay (TMS) is 0.125 Sec so
- **Actual operating Time of Relay (t>) = Operating Time of Relay X TMS =2.17 X 0.125 =0.271 Sec**
- **Grading Time of Relay = [((2XRelay Error)+CT Error)XTMS]+ Over shoot+ CB Interrupting Time+ Safety**

- Total Grading Time of Relay=[((2X7.5)+10)X0.125]+0.05+0.17+0.33 = 0.58 Sec
- **Operating Time of Previous upstream Relay = Actual operating Time of Relay+ Total Grading Time** Operating Time of Previous up Stream Relay = 0.271 + 0.58 = 0.85 Sec

(2) High over Current Setting: (I>>)

- **Pick up Setting of Over Current Relay (PMS) (I>>)= CT Secondary Current X Relay Plug Setting**
- Pick up Setting of Over Current Relay (PMS) (I>)= 1 X 2.5 = 2.5 Amp
- **Plug Setting Multiplier (PSM) = Min. Feeder Fault Current / (PMS X (CT Pri. Current / CT Sec. Current))**
- Plug Setting Multiplier (PSM) = 11000 / (2.5 X (600 / 1)) = 7.33
- Operation Time of Relay as per it's Curve
- Operating Time of Relay for Very Inverse Curve (t) =13.5 / ((PSM)-1).
- Operating Time of Relay for Extreme Inverse Curve (t) =80/ ((PSM)2 -1).
- Operating Time of Relay for Long Time Inverse Curve (t) =120 / ((PSM) -1).
- Operating Time of Relay for Normal Inverse Curve (t) =0.14 / ((PSM) 0.02 -1).
- **Operating Time of Relay for Normal Inverse Curve (t)=0.14 / ((7.33)0.02-1) = 3.44 Amp**
- Here Time Delay of Relay (TMS) is 0.100 Sec so
- **Actual operating Time of Relay (t>) = Operating Time of Relay X TMS =3.44 X 0.100 =0.34 Sec**
- **Grading Time of Relay = [((2XRelay Error)+CT Error)XTMS]+ Over shoot+ CB Interrupting Time+ Safety**
- Total Grading Time of Relay=[((2X7.5)+10)X0.100]+0.05+0.17+0.33 = 0.58 Sec
- **Operating Time of Previous upstream Relay = Actual operating Time of Relay+ Total Grading Time.**
- Operating Time of Previous up Stream Relay = 0.34 + 0.58 = 0.85 Sec

Conclusion of Calculation:

- Pickup Setting of over current Relay (PMS) (I>) should be satisfied following Two Condition.
- **(1)** Pickup Setting of over current Relay (PMS)(I>) >= Over Load Current (In) / CT Primary Current
- **(2)** TMS <= Minimum Fault Current / CT Primary Current
- For Condition (1) 0.8 > =(480/600) = 0.8 >= 0.8, Which found **OK**
- For Condition (2) 0.125 <= 11000/600 = 0.125 <= 18.33, Which found **OK**
- **Here Condition (1) and (2) are satisfied so**
- **Pickup Setting of Over Current Relay = OK**
- **Low Over Current Relay Setting: (I>) = 0.8A X In Amp**
- **Actual operating Time of Relay (t>) = 0.271 Sec**
- **High Over Current Relay Setting: (I>>) = 2.5A X In Amp**
- **Actual operating Time of Relay (t>>) = 0.34 Sec**

Selection of 3P-TPN-4P MCB & Distribution Board

November 1, 2013 28 Comments

Type of breakers based on number of pole:

- Based on the number of poles, the breakers are classified as

1. SP – Single Pole
2. SPN – Single Pole and Neutral
3. DP – Double pole
4. TP – Triple Pole
5. TPN – Triple Pole and Neutral
6. 4P – Four Pole

1. SP (Single Pole) MCB:

- In Single Pole MCCB, switching & protection is affected in only one phase.
- **Application:** Single Phase Supply to break the Phase only.

2. DP (Double Pole) MCB:

- In Two Pole MCCB, switching & protection is affected in phases and the neutral.
- **Application:** Single Phase Supply to break the Phase and Neutral.

3. TP (Triple Pole) MCB:

- In Three Pole MCB, switching & protection is affected in only three phases and the neutral is not part of the MCB.
- 3pole MCCB signifies for the connection of three wires for three phase system (R-Y-B Phase).
- **Application:** Three Phase Supply only (Without Neutral).

4. TPN (3P+N) MCB:

- In TPN MCB, Neutral is part of the MCB as a separate pole but without any protective given in the neutral pole (i.e.) neutral is only switched but has no protective element incorporated.
- TPN for Y (or star) the connection between ground and neutral is in many countries not allowed. Therefore the N is also switches.
- **Application:** Three Phase Supply with Neutral

5. 4 Pole MCB:

- 4pole MCCB for 4 wires connections, the one additional 4^{th} pole for neutral wire connection so that between neutral and any of the other three will supply.
- In 4-Pole MCCBs the neutral pole is also having protective release as in the phase poles.
- **Application:** Three Phase Supply with Neutral

Difference between TPN and 4P (or SPN and DP):

- TPN means a 4 Pole device with 4th Pole as Neutral. In TPN opening & closing will open & close the Neutral.
- For TPN, protection applies to the current flows through only 3 poles (Three Phase) only; there is no protection for the current flow through the neutral pole. Neutral is just an isolating pole.
- TP MCB is used in 3phase 4wire system. It is denoted as TP+N which will mean a three pole device with external neutral link which can be isolated if required.
- For the 4 pole breakers, protection applies to current flow through all poles. However when breaker trips or manually opened, all poles are disconnected.
- Same type of difference also applies for SPN and DP.

Where to Use TP, TPN and 4P in Distribution panel:

- For any Distribution board, the protection system (MCB) must be used in the incomer. For a three phase distribution panel either TP or TPN or 4P can be used as the incoming protection.
- **TP MCB:** It is most commonly used type in all ordinary three phase supply.
- **TPN MCB**: It is generally used where there are dual sources of incomer to the panel (utility source and emergency generator source).
- **4P MCB:** It is used where is the possibility of high neutral current (due to unbalance loads and /or 3^{rd} and multiple of 3^{rd} harmonics current etc) and Neutral / Earth Protection is provided on Neutral.

Where to use 4 Pole or TPN MCB instead of 3 Pole (TP) MCB.

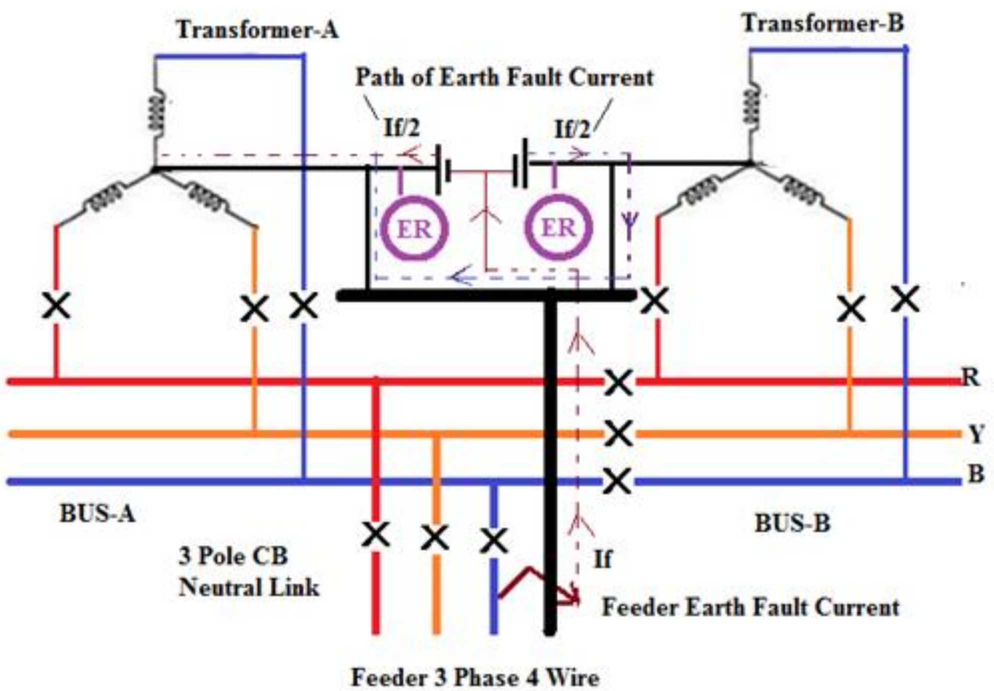
- **Multiple Incoming Power System:**
- When we have a transformer or a stand-by generator feeding to a bus, it is mandatory that at least either of the Incomers or the bus coupler must be TPN or 4-Pole Breaker please refers IS 3043.
- In multi incomer power feeding systems, we cannot mix up the neutrals of incoming powers to other Power Source so we can use TPN or 4P breakers or MCB instead of TP MCB to isolate the Neutral of other power sources from the Neutral of incomer power in use.
- We can use 4 Pole ACB instead of TP for safety reasons .If there is power failure and DG sets are in running condition to feed the loads, if there is some unbalance in loads(which is practically unavoidable in L.V. distribution system), depending of quantum of

unbalance, there will be flow of current through Neutral. During this time, if Power Supply Utility Technicians are working, and if they touch the neutral conductors(which is earthed at their point) they will likely to get electric shock depending on the potential rise in common neutral due flow of current through Neutral conductor as stated above. Even fatal accident may occur due the above reason. As such, it is a mandatory practice to isolate the two Neutrals.

- We can use 4-pole breakers or TPN Breakers when the system has two alternative sources and, in the event of power failure from the mains, change-over to the standby generator is done. In such a case, it is a good practice to isolate the neutral also.
- 4 pole circuit breakers have advantages in the case when one of the poles of the device will get damage, and it also provides isolation from neutral voltage.
- Normally, Neutral is not allowed to break in any conditions, (except special applications) for human & equipment safety. So for single incomer power fed systems, 3P breaker is used, where only phases are isolated during breaking operations.
- Where We have dual Power like in DG & other electricity supply sources ,it is required to isolate neutral, where neutral needs to be isolated in internal network TPN MCB or 4P MCB can be used.

Where to use 4 Pole MCB instead of TPN MCB

- **Any Protection Relay used on Neutral (Ground Fault Protection of Double ended System):**
- The use of four poles or three poles CB will depend on system protection and system configuration.
- Normally in 3phase with neutral we just use 3pole CB and Neutral is connected on common Neutral Link but if application of 3pole will affect the operation of protective relay then we must use 4pole CB.
- System evaluation has to be required to decide whether three-pole circuit breakers plus neutral link can be used or four-pole breakers are required.
- If unrestricted ground fault protection is fitted to the transformer neutral, then the bus section circuit breaker should have 4-poles and preferably incomer circuit breakers should also have 4-poles because un cleared ground fault located at the load side of a feeder have two return paths. As shown in fig a ground fault on a feeder at the bus section “A” will have a current return path in both the incomers, thus tripping both Bus. The sensitivity of the unrestricted ground fault relay is reduced due to the split current paths.



- **For System Stability :**
- In an unbalanced 3phase system or a system with non-linear loads, the neutral gives the safety to the unbalanced loads in the system and therefore It must not be neglected. In perfectly balanced conditions the neutral functions as a safety conductor in the unforeseen short-circuit and fault conditions. Therefore by using 4-pole MCB will enhance the system stability.
- 4 Poles will be decided after knowing the Earthing Systems (TT, TN-S, TN-C, IT).

(1) IT (with distributed neutral) System:

- The Neutral should be switched on & off with phases.
- Required MCB: TPN or 4P MCB.

(2) IT (without distributed neutral) System:

- There is no neutral.
- Required MCB: TP MCB.

(3) TN-S System:

- Required MCB: TP MCB because even when neutral is cut off system remains connected with Ground.

(4) TN-C System:

- Required MCB: TPN or 4P only, because we cannot afford to cut neutral doing so will result in system loosing contact with Ground.

(5) TN-C-S System:

- Neutral and Ground cable are separate
- Required MCB: TP MCB Because Neutral and Ground cable are separate.

(6) TT System:

- Ground is provided locally
- Required MCB: TP MCB because ground is provided locally.
- **Conclusion:** Its compulsory to use TPN in TN-C system rest everywhere you can use MCB.

Nomenclature of Distribution Board:

- Distribution Box can be decided by "way" means how many how many single phase (single pole) distribution. Circuit and Neutral are used.

1) SPN Distribution Board (Incoming+ Outgoing)

- 4way (Row) SPN = 4 X 1SP= 4Nos (Module) of single pole MCB as outgoing feeders.
- 6way (Row) SPN = 6 X 1SP= 6Nos (Module) of single pole MCB as outgoing feeders.
- 8way (Row) SPN = 8 X 1SP= 8Nos (Module) of single pole MCB as outgoing feeders.
- 10way (Row) SPN = 10 X 1SP= 10Nos (Module) of single pole MCB as outgoing feeders.
- 12way (Row) SPN = 12 X 1SP= 12Nos (Module) of single pole MCB as outgoing feeders.
- Normally single phase distribution is mainly used for small single phase loads at house wiring or industrial lighting wiring.

2) TPN Distribution Board (Incoming, Outgoing)

- 4way (Row) TPN = 4 X TP= 4nos of 3pole MCB as outgoing feeders =12 No of single pole MCB.
- 6way (Row) TPN = 6 X TP= 6nos of 3pole MCB as outgoing feeders =18 No of single pole MCB.
- 8way (Row) TPN = 8 X TP= 8nos of 3pole MCB as outgoing feeders =24 No of single pole MCB.
- 10way (Row) TPN = 10 X TP= 10nos of 3pole MCB as outgoing feeders =30 No of single pole MCB.
- 12way (Row) TPN =12 X TP= 12nos of 3pole MCB as outgoing feeders =36 No of single pole MCB

33)Transformer Losses-Regulation-Efficiency(TC Name Plate)

December 31, 2013 [9 Comments]

Calculate Transformer Losses- Regulation- Efficiency (From TC Name Plate Data)

- Calculate No Load Losses at various Loading of Transformer.
- Calculate Full Load Losses at various Loading of Transformer.
- Calculate Percentage Impedance
- Calculate Transformer regulation at various Power Factor.
- Calculate Transformer Efficiency at Unity P.F at various Loading condition.
- Calculate Transformer Efficiency at various P.F at various Loading condition

Calculate Size and Short Circuit Capacity of D.G Synchronous Panel

January 17, 2014 [7 Comments]

Size & Short Circuit Capacity of D.G Synchronous Panel

DG's	Voltage Rating (KV)	D.G Capacity (KVA)	Sub Transient Reactance (Xd") in PU	% Reactance (%Xd")	Impedence of the DG(Zg) (KVxKV/ KVA)x1000	Short Ciruit kVA at DG terminal (Psc) (KVA/%Xd")*100	Short Circuit Current(Isc) in KA (Psc/(1.732XEX1000)
1	0.415	1000	0.14	14	0.1722	7142.8571	9.937473417
2	0.415	1000	0.13	13	0.1722	7692.3077	10.70189445
3	0.415	2000	0.109	10.9	0.0861	18348.6239	25.52745465
4	0.415	2000	0.109	10.9	0.0861	18348.6239	25.52745465
5	0.415	2000	0.109	10.9	0.0861	18348.6239	25.52745465
6	0.415	1000	0.13	13	0.1722	7692.3077	10.70189445

Total Capacity of Synchronous Panel	9000	KVA
Total Fault level	77573.34	KVA
The equivalent Z at theDG Synch panel by parallel method	0.0066	Ohm
Short Circuit Current at DG sync panel is the cumulative of all individual DG short circuit	97.22	KA
OR		
Short Circuit Current at DG Synchronous Panel=(Total Fault level /1.732*E*1000)	107.92	KA

- Calculate Size of D.G Synchronous Panel.
- Calculate Total Fault Current of D.G Synchronous Panel.
- Total Equivalent Impedance of D.G Synchronous Panel.
- Calculate Short Circuit Current of D.G Synchronous Panel.

Electrical Thumbs Rules (Part-9)

March 15, 2014 7 Comments

Load in Multi-storied Building (Madhyanchal Vidyut Vitran Nigam)		
Type of Load	**Calculation**	**Diversity**
Domestic (Without Common Area)	50 watt / sq. meters	0.5
Commercial (Without Common Area)	150 watt / sq. meters	0.75
Lift, Water Pump, Streetlight ,Campus Lighting ,Common Facilities,	Actual load shall be calculated	0.75

Load in Multi-storied Building (Noida Power Company Limited)

Type of Load	Calculation	Diversity
Domestic (Constructed area)	15 watt / sq. Foot	0.4
Commercial(Constructed area)	30 watt / sq. Foot	0.8
Industrial (Constructed area)	100 watt/ 1 sq. Foot	0.5
Lift, Water Pump, Streetlight ,Campus Lighting ,Common Facilities,	0.5Kw / Flat	
Voltage Drop: 2% Voltage drop from Transformer to Consumer end.		
T&D Losses: 2% T&D Losses from Transformer to Consumer end.		

Approximate % Cost or Sq.Foot Cost		
Project Item	**% of Total Project Cost**	**Rs per Sq.Foot**
Articheture (Consultancy)	0.7%	13.1 Rs / Sq.Foot
Structural (Consultancy)	1.2%	21.8 Rs / Sq.Foot
Service Design (Consultancy)	0.4%	7.2 Rs / Sq.Foot
Fire Fighting Work	1.3%	23 Rs / Sq.Foot
Electrical Work (Internal)	4.1%	76 Rs / Sq.Foot
Lift Work	4.4%	82 Rs / Sq.Foot

Street Light Costing (CPWD-2012)	
Fluorescent Lamp	95 Rs/Sq.Meter
With HPMV Lamp	130 Rs/Sq.Meter
With HPSV Lamp	165 Rs/Sq.Meter
Electrical Sinage	85 Rs/Sq.Meter

Other Electrical Cost	
Area Required for Solar Light	10 Watt/Sq.Foot
Solar Power Installation	1.5 Lacs Rs/1Kw
HVAC Cost	18 Watt/Sq.Foot

Distribution Losses (Gujarat Electricity Board)

Voltage (Point of Injection)	At 11 KV	Point of Energy Delivered
11KV / 22KV / 33KV	10%	1082%
400 Volt	-	16.77%

Rate Analysis (CPWD-2012)	
Description	**Amount**
Sub Station Equipment	7000 Rs/ KVA
D.G Set with installation	1000 Rs / KVA
UPS with 30min Breakup	20000 Rs / KVA add 8000 Rs / KVA additional each 30 min
Solar Power Generation	1.25 Lacs / KW
Solar Water System (200Liter/Day)	46000 Rs
Solar Water System (300Liter/Day)	64000 Rs
Solar Water System (1000Liter/Day)	210000 Rs
Central AC Plant	75000 RS / Ton
VRF / VRV System	55000 Rs / HP
Air condition System	11000 Rs / Ton
CCTV System	300 Rs / Sq Meter
Access Control system	200 Rs / Sq Meter
Hydropenumatic Water system	2000 Rs / LPM
Building Management System	300 Rs / Sq Meter add 100 Rs / Sq Meter additional area beyond 10000 Sq Meter

Rate Analysis (Rs per Sq. Meter) (CPWD-2012)				
Work	**Office/College/Hospital**	**School**	**Hostel**	**Residence**
Fire Fighting (with Wet Riser)	500	500	500	500
Fire Fighting (with Sprinkler)	750	750	750	750
Fire Alarm (Manually)	-	-	-	300
Fire Alarm (Automatic)	500	500	500	500
Pressurized Mechanical Ventilation	650	650	650	650

Rate Analysis (% of Total Project Cost) (CPWD-2012)				
Work	**Office/College/Hospital**	**School**	**Hostel**	**Residence**
Internal Water Supply & Sanitary	4%	10%	5%	12%
Internal Electrical Installation	12.5%	12.5%	12.5%	12.5%

Lift Speed (Indian Army Manual)	
No of Floor	**Lift Speed**
4 to 5	0.5 to 0.7 meter/Sec
6 to 12	0.75 to 1.5 meter/Sec
3 to 20	1.5 to 2.5 meter/Sec
Above 20	Above 2.5 meter/Sec

Lift Details (CPWD-2012)						
Type of Lift	**Persons**	**Weight**	**Speed M/Sec**	**Travel**	**Price**	**Add Rs /Floor**
Passenger Lift	8 Person	544 Kg	1.0	G+4	18 Lacs	1.25 Lacs
Passenger Lift	13 Person	844 Kg	1.5	G+4	22 Lacs	1.25 Lacs
Passenger Lift	16 Person	1088 Kg	1.0	G+4	28 Lacs	1.50 Lacs
Passenger Lift	120 Person	1360 Kg	1.5	G+4	24 Lacs	1.50 Lacs

MCB Class according to Appliances			
Appliance	**Capacity / watt**	**MCB Rating**	**MCB Class**
Air Conditioner	1.0 Tone	10A	C Class
	1.5 Tone	16A	C Class
	2.0 Tone	20A	C Class
Freeze	165 Liter	3 A	C Class
	350 Liter	4 A	C Class
Oven /Grill	4500 Watt	32 A	B Class
	1750 Watt	10 A	B Class
Oven / Hotplate	750 Watt	6 A	B Class

	2000 Watt	10 A	B Class
Room Heater	1000 Watt	6 A	B Class
	2000 Watt	10 A	B Class
Washing Machine	300 Watt	2 A	C Class
	1300 Watt	8 A	C Class
Water Heater	1000 Watt	6 A	B Class
	2000 Watt	10 A	B Class
	3000 Watt	16 A	B Class
	6000 Watt	32 A	B Class
Iron	750 Watt	6 A	B Class
	1250 Watt	8 A	B Class
Toaster	1200 Watt	8 A	B Class
	1500 Watt	10 A	B Class

Electrical Thumbs Rules (Part-10)

March 18, 2014 9 Comments

Economical Voltage for Power Transmission:

- Economic generation voltage is generally limited to following values (CBIP Manual).

Economic generation voltage (CBIP Manual)	
Total Load	**Economical Voltage**
Up to 750 KVA	415 V
750 KVA to 2500 KVA	3.3 KV
2500 KVA to 5000 KVA	6.6 KV
Above 5000 KVA	11 KV or Higher

- Generally terminal voltage of large generators is 11 kV in India. Step up voltage depends upon Length of transmission line for interconnection with the power system and Power to be transmitted.
- High voltage increases cost of insulation and support structures for increased clearance for air insulation but decreases size and hence Cost of conductors and line losses.
- Many empirical relations have been evolved to approximately determine economic voltages for power evacuation. An important component in transmission lines is labor costs which are country specific.
- An empirical relation is given below.
- **Voltage in kV (line to line) = $5.5 x \sqrt{0.62L + kVA/150}$**
- where kVA is total power to be transmitted;

- L is length of transmission line in km.
- American practice for economic line to line voltage kV (based on empirical formulation) is
- **Voltage in kV line to line = 5.5x√0.62L + 3P/100**
- For the purpose of standardization in India transmission lines may be classified for operating at 66 kV and above. 33 kV is sub transmission, 11 kV and below may be classified as distribution.
- Higher voltage system is used for transmitting higher amounts of power and longer lengths and its protection is important for power system security and requires complex relay systems.

Required Power Transfer (MW)	Distance (KM)	Economical Voltage Level (KM)
3500	500	765
500	400	400
120	150	220
80	50	132

Factor affected on Voltage Level of system:

- Power carrying capability of transmission lines increases roughly as the square of the voltage. Accordingly disconnection of higher voltage class equipment from bus bars get increasingly less desirable with increase in voltage levels.
- High structures are not desirable in earthquake prone areas. Therefore in order to obtain lower structures and facilitate maintenance it is important to design such sub-stations preferably with not more than two levels of bus bars.

Size of Cable according to Short circuit (for 11kV,3.3kV only)

- Short circuit verification is performed by using following formula:
- **Cross Section area of Cable (mm2)S = I x√t / K**
- Where:
- t = fault duration (S)
- I = effective short circuit current (kA)
- K = 0.094 for aluminum conductor insulated with XLPE
- **Example:** Fault duration(t)= 0.25sec,Fault Current (I) = 26.24 kA
- Cross Section area of Cable = 26.24 x √ (0.25) / 0.094= 139.6 sq. mm
- The selected cross sectional area is **185 sq. mm.**

Ground Clearance:

- **Ground Clearance in Meter = 5.812 + 0.305 X K**
- **Where K= (Volt-33) / 33**

Voltage Level	Ground Clearance
<=33KV	5.2 Meter
66KV	5.49 Meter
132KV	6.10 Meter
220KV	7.0 Meter
400KV	8.84 Meter

Voltage Rise in Transformers due to Capacitor Bank:

- The voltage drop and rise on the power line and drop in the transformers. Every transformer will also experience a voltage rise from generating source to the capacitors. This rise is independent of load or power factor and may be determined as follows:
- **% Voltage Rise in Transformer=(Kvar / Kva)x Z**
- Kvar =Applied Kvar
- Kva = Kva of the transformer
- z = Transformer Reactance in %
- **Example:** 300 Kvar bank given to 1200 KVA transformer with 5.75% reactance.
- % Voltage Rise in Transformer=(300/1200)x 5.75 =**1.43%**

Calculate Size of Capacitor Bank / Annual Saving & Payback Period

April 1, 2014 5 Comments

- Calculate Size of Capacitor Bank Annual Saving in Bills and Payback Period for Capacitor Bank.
- Electrical Load of (1) 2 No's of 18.5KW,415V motor ,90% efficiency,0.82 Power Factor ,(2) 2 No's of 7.5KW,415V motor ,90% efficiency,0.82 Power Factor,(3) 10KW ,415V Lighting Load. The Targeted Power Factor for System is 0.98.
- Electrical Load is connected 24 Hours, Electricity Charge is 100Rs/KVA and 10Rs/KW.
- Calculate size of Discharge Resistor for discharging of capacitor Bank. Discharge rate of Capacitor is 50v in less than 1 minute.
- Also Calculate reduction in KVAR rating of Capacitor if Capacitor Bank is operated at frequency of 40Hz instead of 50Hz and If Operating Voltage 400V instead of 415V.
- Capacitor is connected in star Connection, Capacitor voltage 415V, Capacitor Cost is 60Rs/Kvar. Annual Deprecation Cost of Capacitor is 12%.

Calculation:

- For Connection (1):

- Total Load KW for Connection(1) =Kw / Efficiency=(18.5×2) / 90=41.1KW
- Total Load KVA (old) for Connection(1)= KW /Old Power Factor= 41.1 /0.82=50.1 KVA
- Total Load KVA (new) for Connection(1)= KW /New Power Factor= 41.1 /0.98= 41.9KVA
- Total Load KVAR= KWX([(√1-(old p.f)2) / old p.f]- [(√1-(New p.f)2) / New p.f])
- Total Load KVAR1=41.1x([(√1-(0.82)2) / 0.82]- [(√1-(0.98)2) / 0.98])
- **Total Load KVAR1=20.35 KVAR**
- OR
- tanǾ1=Arcos(0.82)=0.69
- tanǾ2=Arcos(0.98)=0.20
- Total Load KVAR1= KWX (tanǾ1- tanǾ2) =41.1(0.69-0.20)=20.35KVAR
- For Connection (2):
- Total Load KW for Connection(2) =Kw / Efficiency=(7.5×2) / 90=16.66KW
- Total Load KVA (old) for Connection(1)= KW /Old Power Factor= 16.66 /0.83=20.08 KVA
- Total Load KVA (new) for Connection(1)= KW /New Power Factor= 16.66 /0.98= 17.01KVA
- Total Load KVAR2= KWX([(√1-(old p.f)2) / old p.f]- [(√1-(New p.f)2) / New p.f])
- Total Load KVAR2=20.35x([(√1-(0.83)2) / 0.83]- [(√1-(0.98)2) / 0.98])
- **Total Load KVAR2=7.82 KVAR**
- For Connection (3):
- Total Load KW for Connection(2) =Kw =10KW
- Total Load KVA (old) for Connection(1)= KW /Old Power Factor= 10/0.85=11.76 KVA
- Total Load KVA (new) for Connection(1)= KW /New Power Factor= 10 /0.98= 10.20KVA
- Total Load KVAR3= KWX([(√1-(old p.f)2) / old p.f]- [(√1-(New p.f)2) / New p.f])
- Total Load KVAR3=20.35x([(√1-(0.85)2) / 0.85]- [(√1-(0.98)2) / 0.98])
- **Total Load KVAR1=4.17 KVAR**
- **Total KVAR=KVAR1+ KVAR2+KVAR3**
- Total KVAR=20.35+7.82+4.17
- **Total KVAR=32 Kvar**

Size of Capacitor Bank:

- **Site of Capacitor Bank=32 Kvar.**
- **Leading KVAR supplied by each Phase= Kvar/No of Phase**
- Leading KVAR supplied by each Phase =32/3=10.8Kvar/Phase
- **Capacitor Charging Current (Ic)= (Kvar/Phase x1000)/Volt**
- Capacitor Charging Current (Ic)= (10.8×1000)/(415/√3)
- Capacitor Charging Current (Ic)=44.9Amp
- **Capacitance of Capacitor = Capacitor Charging Current (Ic)/ Xc**
- Xc=2×3.14xfxv=2×3.14x50x(415/√3)=75362
- Capacitance of Capacitor=44.9/75362= 5.96µF
- **Required 3 No's of 10.8 Kvar Capacitors and**
- **Total Size of Capacitor Bank is 32Kvar**

Protection of Capacitor Bank

Size of HRC Fuse for Capacitor Bank Protection:

- **Size of the fuse =165% to 200% of Capacitor Charging current.**

- Size of the fuse=2×44.9Amp
- Size of the fuse=90Amp

Size of Circuit Breaker for Capacitor Protection:

- **Size of the Circuit Breaker =135% to 150% of Capacitor Charging current.**

- Size of the Circuit Breaker=1.5×44.9Amp
- Size of the Circuit Breaker=67Amp
- Thermal relay setting between 1.3 and 1.5of Capacitor Charging current.
- Thermal relay setting of C.B=1.5×44.9 Amp
- Thermal relay setting of C.B=67 Amp
- Magnetic relay setting between 5 and 10 of Capacitor Charging current.
- Magnetic relay setting of C.B=10×44.9Amp
- Magnetic relay setting of C.B=449Amp

Sizing of cables for capacitor Connection:

- Capacitors can withstand a permanent over current of 30% +tolerance of 10% on capacitor Current.
- Cables size for Capacitor Connection= 1.3 x1.1 x nominal capacitor Current
- **Cables size for Capacitor Connection = 1.43 x nominal capacitor Current**
- Cables size for Capacitor Connection=1.43×44.9Amp
- Cables size for Capacitor Connection=64 Amp

Maximum size of discharge Resistor for Capacitor:

- Capacitors will be discharge by discharging resistors.
- After the capacitor is disconnected from the source of supply, discharge resistors are required for discharging each unit within 3 min to 75 V or less from initial nominal peak voltage (according IEC-standard 60831).
- Discharge resistors have to be connected directly to the capacitors. There shall be no switch, fuse cut-out or any other isolating device between the capacitor unit and the discharge resistors.
- **Max. Discharge resistance Value (Star Connection) = Ct / Cn x Log (Un x√2/ Dv).**
- **Max. Discharge resistance Value (Delta Connection)= Ct / 1/3xCn x Log (Un x√2/ Dv)**

- Where Ct =Capacitor Discharge Time (sec)
- Cn=Capacitance Farad.
- Un = Line Voltage
- Dv=Capacitor Discharge voltage.
- Maximum Discharge resistance =60 / ((5.96/1000000)x log (415x√2 /50)
- **Maximum Discharge resistance=4087 KΩ**

Effect of Decreasing Voltage & Frequency on Rating of Capacitor:

- The kvar of capacitor will not be same if voltage applied to the capacitor and frequency changes
- Reduced in Kvar size of Capacitor when operating 50 Hz unit at 40 Hz
- Actual KVAR = Rated KVAR x(Operating Frequency / Rated Frequency)
- Actual KVAR = Rated KVAR x(40/50)
- Actual KVAR = 80% of Rated KVAR
- **Hence 32 Kvar Capacitor works as 80%x32Kvar= 26.6Kvar**
- Reduced in Kvar size of Capacitor when operating 415V unit at 400V
- Actual KVAR = Rated KVAR x(Operating voltage / Rated voltage)^2
- Actual KVAR = Rated KVAR x(400/415)^2
- Actual KVAR=93% of Rated KVAR
- **Hence 32 Kvar Capacitor works as 93%x32Kvar= 23.0Kvar**

Annual Saving and Pay Back Period

Before Power Factor Correction:

- **Total electrical load KVA (old)= KVA1+KVA2+KVA3**
- Total electrical load= 50.1+20.08+11.76
- Total electrical load=82 KVA
- Total electrical Load KW=kW1+KW2+KW3
- Total electrical Load KW=37+15+10
- Total electrical Load KW =62kw
- Load Current=KVA/V=80×1000/(415/1.732)
- Load Current=114.1 Amp
- KVA Demand Charge=KVA X Charge
- KVA Demand Charge=82x60Rs
- KVA Demand Charge=8198 Rs
- Annual Unit Consumption=KWx Daily usesx365
- Annual Unit Consumption=62x24x365 =543120 Kwh
- Annual charges =543120×10=5431200 Rs
- Total Annual Cost= 8198+5431200
- **Total Annual Cost before Power Factor Correction= 5439398 Rs**

After Power Factor Correction:

- **Total electrical load KVA (new)= KVA1+KVA2+KVA3**
- Total electrical load= 41.95+17.01+10.20
- Total electrical load=69 KVA
- Total electrical Load KW=kW1+KW2+KW3
- Total electrical Load KW=37+15+10
- Total electrical Load KW =62kw
- Load Current=KVA/V=69×1000/(415/1.732)
- Load Current=96.2 Amp
- KVA Demand Charge=KVA X Charge
- KVA Demand Charge=69x60Rs =6916 Rs————-(1)
- Annual Unit Consumption=KWx Daily usesx365
- Annual Unit Consumption=62x24x365 =543120 Kwh
- Annual charges =543120×10=5431200 Rs——————(2)
- Capital Cost of capacitor= Kvar x Capacitor cost/Kvar = 82 x 60= 4919 Rs—(3)
- Annual Interest and Deprecation Cost =4919 x 12%=590 Rs—–(4)
- Total Annual Cost= 6916+5431200+4919+590
- **Total Annual Cost After Power Factor Correction =5438706 Rs**

Pay Back Period:

- Total Annual Cost before Power Factor Correction= 5439398 Rs
- Total Annual Cost After Power Factor Correction =5438706 Rs
- Annual Saving= 5439398-5438706 Rs
- **Annual Saving= 692 Rs**
- Payback Period= Capital Cost of Capacitor / Annual Saving
- Payback Period= 4912 / 692
- **Payback Period = 7.1 Years**

Calculate No of Lighting Fixtures / Lumen for Indoor Lighting

April 8, 2014 6 Comments

- An office area is 20meter (Length) x 10meter (width) x 3 Meter (height). The ceiling to desk height is 2 meters. The area is to be illuminated to a general level of 250 lux using twin lamp 32 watt CFL luminaires with a SHR of 1.25. Each lamp has an initial output (Efficiency) of 85 lumen per watt. The lamps Maintenance Factor (MF) is 0.63 ,Utilization Factor is 0.69 and space height ratio (SHR) is 1.25

Calculation:

Calculate Total Wattage of Fixtures:

- **Total Wattage of Fixtures= No of Lamps X each Lamp's Watt.**
- Total Wattage of Fixtures=2×32=64Watt.

Calculate Lumen per Fixtures:

- **Lumen per Fixtures = Lumen Efficiency(Lumen per Watt) x each Fixture's Watt**
- Lumen per Fixtures= 85 x 64 = 5440Lumen

Calculate No's of Fixtures:

- **Required No of Fixtures = Required Lux x Room Area / MFxUFx Lumen per Fixture**
- Required No of Fixtures =(250x20x10) / (0.63×0.69×5440)
- **Required No of Fixtures =21 No's**

Calculate Minimum Spacing Between each Fixture:

- The ceiling to desk height is 2 meters and Space height Ratio is 1.25 so
- Maximum spacing between Fixtures =2×1.25=2.25meter.

Calculate No of Row Fixture's Row Required along with width of Room:

- Number of Row required = width of Room / Max. Spacing= 10/2.25
- Number of Row required=4.

Calculate No of Fixture's required in each Row:

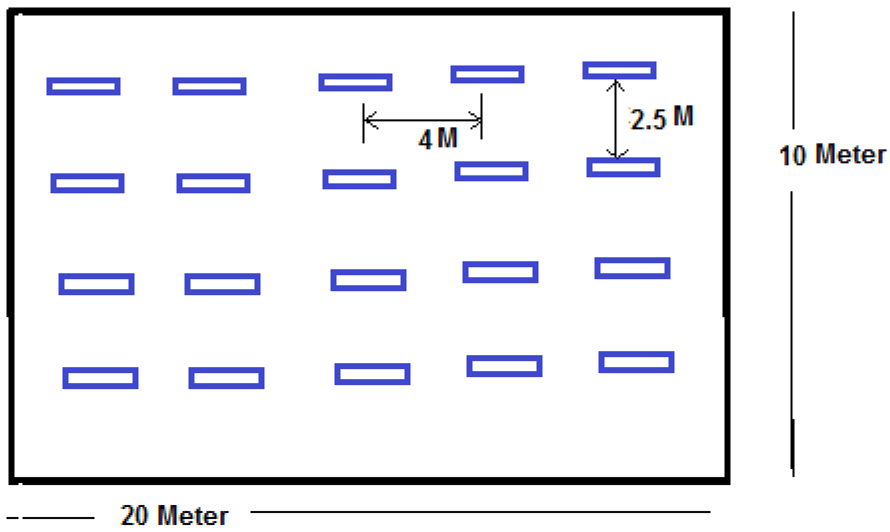
- Number of Fixture Required in each Row = Total Fixtures / No of Row = 21/4
- Number of Fixture Required in each Row = 5 No's:

Calculate Axial Spacing between each Fixture:

- Axial Spacing between Fixtures = Length of Room / Number of Fixture in each Row
- Axial Spacing between Fixtures =20 / 5 = 4 Meter

Calculate Transverse Spacing between each Fixture:

- Transverse Spacing between Fixtures = width of Room / Number of Fixture's row
- Transverse Spacing between Fixtures = 10 / 4 = 2.5 Meter.



Conclusion:

- **No of Row for Lighting Fixture's= 4 No**
- **No of Lighting Fixtures in each Row= 5 No**
- **Axial Spacing between Fixtures= 4.0 Meter**
- **Transverse Spacing between Fixtures= 2.5 Meter**
- **Required No of Fixtures =21 No's**