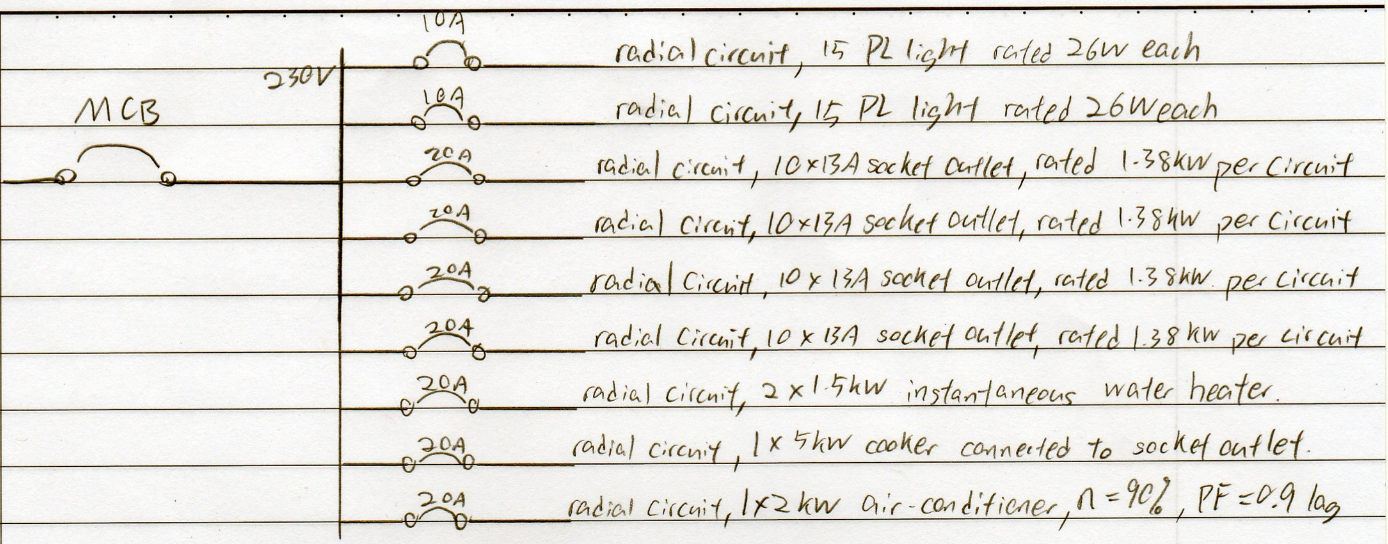
PYP EE4503 NOV/DEC 14 Megarine Tee

1)

a)



Residential apartment, 230V: CP5 Table 4B, pg117 1-ϕ

	Connected load	Diversity Factor	Current Demand
i)	$(30\times26\times1.8)/230 = 6.10A$ (item 1)	66%	4.03A
ii)	$(1\times1380)/230 = 6A$ (item 9)	100%	6A
	$(3\times1380)/230 = 18A$	40%	7.2A
iii)	$(1\times1500)/230 = 6.52A$ (item 5)	100%	6.52A
	$(1\times1500)/230 = 6.52A$	100%	6.52A
iv)	$(1\times5000)/230 = 21.74A$ (item 3)	1st 10A	10A
	$(21.74-10) = 11.74A$ (excess of 10A)	30%	3.52A
	SSO = 5A		5A
v)	$P_o = \eta\times V_{in}\times I_{in}\times PF$ (item 2)		
	$2000 = 0.9\times230\times I_{in}\times0.9$	100% of I_{in} up to 10A	10A
	$\Rightarrow I_{in} = 10.74A$		
	$(10.74-10) = 0.74A$	50%	0.37A

Total current demand = 59.16 A $\Rightarrow$ Rating = 63A #

b) 20A Type B MCB

$L = 20m$

$S_{ph} = S_{cpc} = 2.5mm^2$

1/c PVC insulated cables

$Z_E = 0.8\Omega$

CP5 Table 17A, pg 222

i) $Z_S = Z_E + 1.38[R_1 + R_2] \times 10^{-3} \times L$

$Z_S = 0.8 + 1.38[14.82] \times 10^{-3} \times 20$

$= 1.209\Omega$ #

ii) $I_f = 230 / 1.209 = 190A$ #

From CP5 20A Type B MCB graph, pg 196

$t = 0.012s$ #

Check CPC thermal constraint : $k^2 S_{cpc}^2 \geq I_f^2 t$

Given $k = 115$,

$115^2 \times 2.5^2 \geq 190^2 \times 0.012$

$82656 \geq 433$ (True)

∴ The CPC is able to withstand. #

2) Motor 120kW 3-ϕ, 400V

$\eta = 90\%$ @ full load

$PF_{start} = 0.5$ lag, $PF_{nom} = 0.85$ lag

$I_{start} = 3 \times I_{nom}$

a) $P_o = \eta \times \sqrt{3} \times PF_{nom} \times V \times I_{nom}$

$\Rightarrow I_{nom} = 226A$, $\therefore I_{start} = 678A$

Assume a motor starter is installed, hence limit starting current; ~~the~~ The motor is also assume to have an overload device.

$\therefore I_b = I_{nom}$, $I_z \geq I_b / [C_a \times C_g \times C_i]$, $I_b \leq I_n \leq I_z$

PVC, 1/C, trunking, 35°C

$C_i = 1$, $C_g = 1$, $C_a = 0.94$ — CP5 Table 4C1, pg216

$\therefore I_z \geq 240.4A$

I_n selected $= 300A$ for short circuit protection

From CP5 Table 4D1A, Col.5, pg217,

I_{tab} selected $= 346A \Rightarrow I_z = I_{tab} \times C_a \times C_g \times C_i = 325.24A$ $\therefore I_b \leq I_n \leq I_z$ holds.

$S_{ph} = 240mm^2$

Since CPC & Phase conductor are same material,

$S_{cpc} = S_{ph}/2 = 120mm^2$ # CP5 Table 54G, pg121

b) $V_{drop} = [r\cos\theta + x\sin\theta] \times 10^{-3} \times L \times I$, $L = 50m$,

$\theta_{start} = \cos^{-1}(0.5) = 60°$, $\theta_{nom} = \cos^{-1}(0.85) = 31.8°$

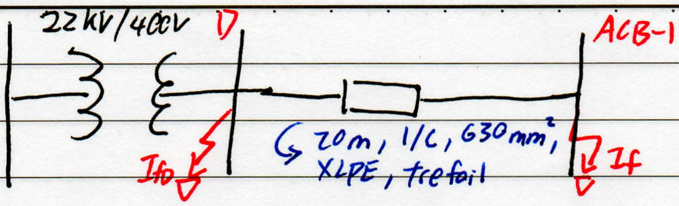
From CP5 Table 4D1B, Col.6, pg218

$r = 0.17$, $x = 0.23$

$V_{drop\ start} = [0.17\cos 60° + 0.23\sin 60°] \times 10^{-3} \times 50 \times 678 = 9.6V$ #

$V_{drop\ nom} = [0.17\cos 31.8° + 0.23\sin 31.8°] \times 10^{-3} \times 50 \times 226 = 3V$ #

c)



$V_b = 400V$, $S_b = 25MVA$, $I_b = 36.084\,kA$, $Z_b = 0.0064\,\Omega$

$\frac{X}{R} = 5$,

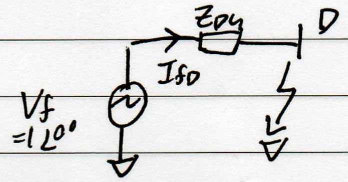
$|S_D| = 1pu$, $|V_f| = 1pu$, $Z_{pu} = R + jX = R + j5R$, $|Z_{pu}| = R\sqrt{26}$

$|I_{fD}| = |S_D| / |V_f| = 1pu$

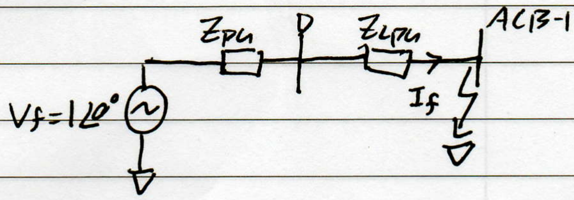
$|Z_{pu}| = |V_f| / |I_{fD}| = 1pu$

$R\sqrt{26} = 1pu \Rightarrow R = 0.196\,pu$

$\therefore Z_{pu} = 0.196 + j5(0.196) = 1\angle 78.7°$



$I_f = V_f / (Z_{pu} + Z_{Lpu})$



$Z_{L\,actual} = [(r + jx) \times 10^{-3} \times L] / \sqrt{3}$

Given $S = 630mm^2$, 1/c, 20m, XLPE, trefoil,
Using CP5 Table 4E1B, Col. 7, pg 226

$r = 0.074$, $x = 0.135$

$\Rightarrow Z_{L\,actual} = [(0.074 + j0.135) \times 10^{-3} \times 20] / \sqrt{3}$

$= 0.001778\angle 61.3°$

$\therefore Z_{Lpu} = 0.2778\angle 61.3°$

$I_f = 1\angle 0 / [1\angle 78.7° + 0.2778\angle 61.3°]$

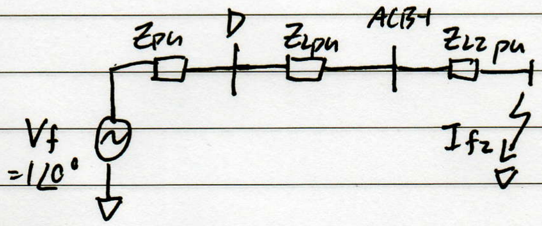
$= 0.7888\angle -74.9°$

$\therefore |I_{f\,actual}| = 28.46\,kA$ #

d) $I_{f2} = V_f / [Z_{pu} + Z_{Lpu} + Z_{L2pu}]$

Knowing $L = 50m$, 1/c PVC, truncking, $S = 240mm^2$

$\Rightarrow R = 0.17$, $X = 0.23$



$Z_{L2\,actual} = [(0.17 + j0.23) \times 10^{-3} \times 50] / \sqrt{3}$

$= 0.008256 \angle 53.5°$

$Z_{L2pu} = 1.29 \angle 53.5°$

$I_{f2} = 0.3979 \angle -64.1°$

$\therefore |I_{f2\,actual}| = 14.357\ kA$

Since MCCB rating choosen is 300A,

Multiple of rated current $= 14357/300$

$= 47.9$

$\Rightarrow$ MCCB operating time $= 0.1s$ #

3) $S = 3000\ kVA$ If $PF \geq 0.85$, no extra reactive cost

$PF = 0.8$ lag

30 days, 24 hrs

$P = 3000\ kVA \times 0.8 = 2400\ kW$

P is constant,

Total $kWh = 2400 \times 24 \times 30$

$= 1728000\ kWh$

$\theta = \cos^{-1} 0.8 = 36.87°$

Total $kVarh$ = Total $kWh \times \tan\theta$

$= 1296000\ kVarh$

Excess $kVarh$ = Total $kVarh - 62\% \times$ Total kWh

$= 224640\ kVarh$

$\therefore$ Cost save = Excess $kVarh \times \$0.59$

$= \$132537.60$ #

4) For lowest capacity of the generator, the starting sequence start from the highest transient to lowest transient.

$3\text{-}\phi \Rightarrow V$ assume 400V, $S = P/Pf$, $S \propto I$

Determine transient & steady-state of each equipment. S_T & S_{SS}

a) $S = 10kW/0.95 = 10.53kVA$

$\Rightarrow S_T = 10.53 kVA$, $S_{SS} = 10.53 kVA$

b) $S = 110kW/0.85 = 129.4 kVA$

$\Rightarrow S_T = 3 \times S = 388.2 kVA$, $S_{SS} = 129.4 kVA$

c) $S = 30kW/0.85 = 35.29 kVA$

$\Rightarrow S_T = 2.5 \times \cancel{35} S = 88.24 kVA$, $S_{SS} = 35.29 kVA$

d) $S = 15kW/0.85 = 17.65 kVA$

$\Rightarrow S_T = 6 \times S = 105.9 kVA$, $S_{SS} = 17.65 kVA$

From above cases, it can be seen that the starting sequence $(b) \rightarrow (d) \rightarrow (c) \rightarrow (a)$ will result in smallest generator capacity.

Combo:

a $S_G = S_{T(b)} = 388.2 kVA$

b $S_G = S_{SS(b)} + S_{T(d)} = 235.3 kVA$

c $S_G = S_{SS(b)} + S_{SS(d)} + S_{T(c)} = 235.29 kVA$

d $S_G = S_{SS(b)} + S_{SS(d)} + S_{SS(c)} + S_{T}(a) = 192.87 kVA$

e $S_G = S_{SS(b)} + S_{SS(d)} + S_{SS(c)} + S_{SS(a)} = 192.87 kVA$

Since combo a has the highest value,

$\therefore$ Generator rating $\geq 388.2 kVA$

$\Rightarrow$ Generator rating $= 400 kVA$ #