PYPEE4503 NOV/DEC 15 Megarine Tee

1) 1-ϕ 230V

25A Type B MCB

PVC 1/c copper

$S_{ph} = 4mm^2$, $S_{cpc} = 2.5mm^2$

$L = 30m$

$Z_E = 5\Omega$

$R_A = 2\Omega$

a) Shock protection => $Z_s \leq Z_{smax}$

$Z_{smax} = 230/125 = 1.84\Omega$ CP5 Type B MCB graph, pg 196

$Z_s = Z_E + 1.38[\underbrace{R_1 + R_2}_{\text{CP 5 Table 17A pg 222}}] \times 10^{-3} \times L$

$= 5 + 1.38[12.02] \times 10^{-3} \times 30$

$= 5.497628\Omega$

Since $Z_s > Z_{smax}$ ∴ does not complies with shock protection requirement #

b) $I_f = V/Z_s$

$= 230/5.497628$

$= 41.84A$ #

c) $k = 115$ # copper PVC @70°c

thermal constraints of CPC => $S_{cpc}^2 k^2 \geq I_f^2 t$

$t = 700s$ CP5 Type B MCB graph, pg 196

Check:

$S_{cpc}^2 k^2 \geq I_f^2 t$

$(2.5)^2 \times (115)^2 \geq (41.84)^2 \times (700)$

$82656 \geq 1225410$ (false)

∴ The size of CPC is unable to meet the thermal constraints requirement. #

d) V_t without bonding $\Rightarrow I_f \times (R_Z + R_A)$

$R_Z = 1.38 \times [R_Z'] \times 10^{-3} \times L$

$R_Z' = [r] / 2$ Assume the cable is in the wall.

$r = 18$ CP5 Table 4D1B, col. 3, pg 218

$\Rightarrow R_Z = 1.38 \times [\frac{18}{2}] \times 10^{-3} \times 30$

$= 0.3726\,\Omega$

$V_t = 41.84 \times [2 + 0.3726]$

$= 99.27V$ #

Assume human body impedance under dry condition $= 100\,k\Omega$,

$I_b = V_t / 100k = 0.9927\,mA$

Under "Consequences on the individual" graph, I_b is located in AC-2.
Under AC-2 region, there is usually no harmful physiological effects. #

e) V_t with bonding $\Rightarrow I_f \times (R_Z)$

$V_t = (41.84) \times (0.3726)$

$= 15.58V$ #

Comparing both V_t result, we can conclude that bonded equipment have lower touch voltage which can reduce the risk of a person when touching the faulted equipment. #

2a) 3-ϕ 400V

2 set 1/C PVC copper cable

flat & touching on a horizontal cable tray

Max demand 1400A

temperature 35°C

Since 2 sets, assume identical set with each carrying 700A

$I_Z \geq I_n / (C_a \times C_i \times C_g)$, $I_n = 700A$

$C_i = 1$, $C_a = 0.94$, $C_g = 0.9$

CP5 Table 4C1 CP5 Table 4B1

$I_Z = 700 / (1 \times 0.94 \times 0.9)$

$= 827A$

$I_{tab} = 892A \Rightarrow S = 630mm^2$ # CP5 Table 4D1A, Col 9, pg 217

b) $V_{d\,max} = 1.5\%$ of 400V

$= 6V$

$V_d = [r\cos\theta + X\sin\theta] \times 10^{-3} \times L \times I_{fL}$

$\theta = \cos^{-1}(0.85) = 31.8°$, $L = 30m$, $I_{fL} = 150A$

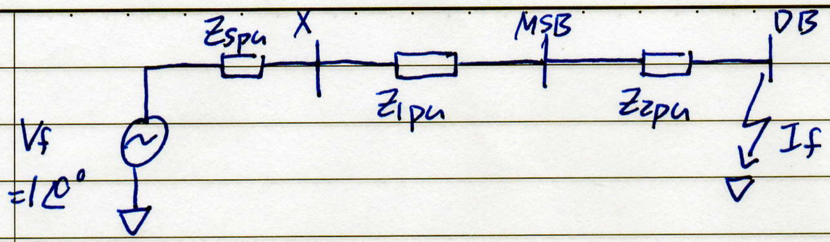
$r = 0.56$, $X = 0.25$ CP5 Table 4D1B, Col.6, pg 218

$V_d = [0.56\cos(31.8°) + 0.25\sin(31.8°)] \times 10^{-3} \times 30 \times 150$

$= 2.735V$

Since $V_d < V_{d\,max}$ ∴ the cable comply with the voltage drop requirement. #

c)



$S_b = 1000 MVA$

$V_{b1} = 22 kV$, $V_{b2} = 400 V$

$Z_{b2} = 0.00016 \Omega$

$I_{b2} = 1.443 MA$

$Z_{spu} = j0.05$

CP5 Table 4D1B, Col 8, Pg 218

$Z_{1pu} = [(r + jx) \times 10^{-3} \times L_1] / [2 \times \sqrt{3} \times Z_{b2}]$

$= [(0.072 + j0.21) \times 10^{-3} \times 20] / [2 \times \sqrt{3} \times 0.00016]$

$= 8.011 \angle 71^\circ$

CP5 Table 4D1B, Col 6, Pg 218

$Z_{2pu} = [(r + jx) \times 10^{-3} \times L_2] / [\sqrt{3} \times Z_{b2}]$

$= [(0.56 + j0.25) \times 10^{-3} \times 30] / [\sqrt{3} \times 0.00016]$

$= 66.39 \angle 24.1^\circ$

$I_f = V_f / [Z_{spu} + Z_{1pu} + Z_{2pu}]$

$= 0.01386 \angle -28.8^\circ$

$|I_{f\,actual}| = 0.01386 \times I_{b2}$

$= 20 kA$ #

3a) Risk due to lightning to the building structure resulting physical damage.
(S1) (D2)

$\Rightarrow R_B = N_D \times P_B \times r_p \times h_z \times r_f \times L_f$
$\Rightarrow N_D = N_g \times A_d \times C_d \times 10^{-6}$
$\Rightarrow A_d = [L \times W] + [6H(L+W)] + [9\pi H^2]$

$A_d = [40 \times 20] + [6 \times 25 \times (40+20)] + [9\pi \times (25)^2]$
$= 27471$
$N_g = 25$ (NTU)
$C_d = 1$ (point (iv))

$\Rightarrow N_D = 0.686775$

$P_B = 1$ (point (iii))
$r_p = 1$ (point (ii))
$h_z = 2$ (70 staff)
$r_f = 10^{-3}$ (point (ii))
$L_f = 10^{-1}$ (office building)

$\Rightarrow R_B = 1.37355 \times 10^{-4}$ #

b) $R_B > R_{Tol.}$ $\Rightarrow 1.37355 \times 10^{-4} > 1 \times 10^{-5}$.
We assume certain factor to remain the same due to constraint such as location and building size. (A_d, C_d, N_g, h_z, r_f & L_f remain the same)

Method 1: Install LPS of Class 2 or higher. #

Method 2: Install LPS of Class 3 or higher in additional to provision of fire extinguishers. #

Method 3: Install LPS of Class 4 or higher in additional to provision of fixed automatically operated extinguishing installations. #

The method is choosen such that $R_{B\,new} < 10^{-5}$.