cH 11: Balanced Three-phase Circuit. Three sources Three - phase $\equiv 3-\phi$ single - phase $\equiv 1-\phi$ Balanced 3- & Voltages: They are 3 voltage sources that have identical amplitudes and frequency, but are out of phase with each other by exactly 120° sequences of balanced . 3-0 systems 1) positive sequence "abe sequence " Valte Vn Cos (utor Or), Va = Vn 1 Gr Voltl= Vm Cas (we + 6v - 120 1, Vo = Vm 1 6v - 120 Volte Vm Cos (ut by 12"), V = Va 10x +120 Vo C.w 11.0 N A 12. 120 -VE P P 2) Nazative sequence "acb sequence" T

Va = Vm LGr Vp = Vm LGr+12. V - Vm 161-12. V6 C.CW 120 11. Va VVVVVVVVVVV 120 Balanced 3- & Voltages . Eu=0 Va (a) + Vo(I) ~ Vo(I) t- domin Vat Vat V phaser - domin = V_ Lo" + V_ L-120" + V_ Lizo = Vm + Vm (cosizo + jsin(+20)] + Vm (cosizo) + isin(20 = Vm + Vm Cost20 + Vm cost20 - j (Vm sighted - Vm sint = Vm + 2Vm Cos120 = 0 Instantaneous power in balanced 3-\$ systems ('-Va _(-+)___ P(+1= Pa(+1 + Pa(+1+ Pa(+1 -(--)-Total isstant mour C-> Cac

 $P_a = V_a(t) \dot{c}(\tau) \quad P_b = V_b(\tau) \dot{c}_b(\tau) \quad P_c = V_c(\tau) \dot{c}_c(\tau)$ Assume :. Val+1 = Vm Cos(ut+Gy) · C = Tm Cos(u++Gc) Volal: Van Coslut + 61 - 21 1 10 = Im Coslut + 62 - 21) Velt = Vm (us (u++Ov+LT) le= Jm Cos (u+Oc+ 2T) PCH = Valt 16alt + Volt 16 (+1 + Klt 16/1 $P(T) = \frac{3}{2} \quad V_m \quad T_m \quad \cos(b_V - G_c) = A \text{ verage Power}$ $\frac{1}{2} = \frac{3}{2} \quad V_m \quad T_m \quad \cos(b_V - G_c) = A \text{ verage Power}$ (No double frequency composed) i'n stantaneous Power p(+1 = 1 Vm Im Cas (0,-Gol + f(2w c) 1-0 Source and Load Connections Source on A J. V. and a wy Yang 6-5-6 line Voltage • 2

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Va Va Vie V. Load Source a a a a a a a a a a a a a a a line and phase Voltages in Y- connected load Sour VAN Zy VAR in the case $\overline{T}_{L} = \overline{T}_{\phi}$ VRN Brit Zy Ved -Ven Zy VBC Tag VAN I VBN I VEN Phase Voltages on L-N Voltage VAR, VBC, JCA line Voltage in L-L Voltages Docu

IGA, Jup Icc line Currents. Assume o, VAN = Vy Gra VBN = Volever 2 T VCN = VQ LOVO+25 A A A A A A VAB = VAN - VBN = Valeva - Valeva - 23 Var = (Va Cos (Gval) + j Vasin (Gval) $-\left(V_{\varphi}\cos\left(\Theta_{V_{\varphi}}-\frac{2\pi}{2}\right)+\int V_{\varphi}\sin\left(\Theta_{V}-\frac{2\pi}{2}\right)\right)$ 3 VAO = V3 VØ 164+30 $V_{AB} = \left(\sqrt{3} \frac{136}{3} \sqrt{4}\right)$ V_1 = (V3 130°) the VL-N $\frac{1}{1} = \left(\frac{1}{1} = \frac$

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A _ Connected Load on scarce a. TAR ZA Tax 2. IcA ZA I AR, IBC, ICA => Phase Current TaA, ITOB, Itc => line Current VAB, VRC , VCA Phase 16 trages $\overline{I}_{AB} = \overline{I}_{\phi} \left[\frac{\Theta(\phi)}{1} \right]_{BC} = \overline{I}_{\phi} \left[\frac{\Theta(\phi - 2\pi)}{2} \right]_{CA} = \overline{I}_{\phi} \left[\frac{\Theta(\phi - 2\pi)$ $I_{AA} = \overline{I_{AB}} - \overline{I_{CA}} = \sqrt{3} I_{Q} \left[\frac{C_{CQ} - 3}{3} \right]^{\circ}$ $T_{aA} = \left(\sqrt{3} \frac{1}{2^{\circ}} \right) \left(\frac{1}{q} \frac{1}{2^{\circ}} \frac{1}{2^{\circ}} \right) \left(\frac{1}{q} \frac{1}{2^{\circ}} \frac{1}{2^{\circ}} \right) \left(\frac{1}{q} \frac{1}{2^{\circ}} \frac{1}{2^{\circ}}$ $\overline{I}_{A} = \left(\sqrt{3} \left\lfloor \frac{-3c^{\circ}}{2} \right) \overline{I}_{AB}$

Y-Connected load or source V, = (J3 20 Vg IL-IO D - Connected lond or source VL = Va $\overline{T_L} = \left(\overline{J_3 L_3 \circ} \right) \overline{T_{\varphi}}$ Y-Y Analysii winding impedance Source local Vain a' Zu Iq Zine 24 B VN Von 6' 24 6 21mm 111 ZY Vin c' Zu C Zline ZV Transmission] source Generato ZNI Kelat Node N $\frac{\overline{V_N} - \overline{V_{a'N}}}{Z\phi} + \frac{\overline{V_N} - \overline{V_{b'n}}}{Z\phi} + \frac{\overline{V_N} - \overline{V_{c'n}}}{Z\phi} + \frac{\overline{V_N}}{Z\phi} = 0$ Zø Document created using Scan2PDF

 $\frac{3}{Z_q} \frac{V_N}{Z_q} - \frac{1}{Z_q} \left(\frac{V_{a'n} + V_{h}}{V_{n+1} + V_{n+1}} \right) + \frac{V_N}{Z_N} = 0$ $\left(\frac{3}{z_{\phi}} + \frac{1}{z_{N}}\right) \overline{V_{N}} = 0$ $\overline{V_N} = 0 \rightarrow \overline{T_N} = 0$ 1-0 equivalent Cincui C a trut 9 Rivine Vain Dame probance $T_{aA} = V_{a'n} = T_m L_{Ge}$ Zu+Zinc-+Zy $\overline{J}_{\mu} = I_m \left[\frac{G_{0T120}}{2} \right]$ $\overline{T} = T_m \left[\Theta_{C} \neq 120^{\circ} \right]$ A balanced 3-0 Y-Connected generator with positive sequence has an impedance of 0.2+jois2/0 EX and an internal voltage 120V/g. The generate P feels a balanced 3-9 Y- connected Load having an impedance of 34+ 128 2/0, The impedance 0 & TTLI 15 0.8+ 11.5 2/0 Docu

a) Draw the 1-d equivlent Circuit b) Calculare the line Current c) calculare the phase voltage at the load sel. d' = ime voltages " " " " a = ime voltages " " " " TA 39+ J26 12.60 1. Var = Up at more for top for the $\frac{1}{1} = \frac{120 100}{(0.2 + 50.5] + (0.6 + 51.5] + (39 + 520)} = 2.4 \pm 36.874$ $T_{1B} = 2.4 \left[-36.87 - 12^{\circ} - 2.4 \right] \frac{156.67^{\circ}}{156.67^{\circ}} \beta$ $\overline{T_{cc}} = 2.4 \left[-36.87 + 12^{\circ} - 2.4 \right] \frac{133.13}{9}$ C) VAN = (TA) (39+ 1221 = 115,72 - 119°V VPN - 115,22 1-1.19-120° VCN - 115,22 1-1.19-120°

&) VAB = V3 120° (VAN) VAR = (J30 20) (115,22 [-1.19° V - 199.5 28.610 VBc = 199.5 121.11-120 V - 199.5 128.81+120° E Calculate the phase Voltage at the generator side. Van=(02+1'05)(- Iat + 12010 Var = 112.9 1-0.320 V60 = 116.92-120 Ven > 118.91-0.32+1200

Y->A A-Connected Load 2 4 Vain A 9 Zu 120 Zhon Ziad Vb'n 6' 1 2. Zlune 24 -1207 generator TL Load A $Z_y = \frac{Z_A^2}{3Z_A} = \frac{Z_A}{3}$ 2. 2. R 1-0 equivalent circent al q Dine D TaA Vain Ct 2 2 * N n $T_{L} = (\overline{J_{3}} - 3^{\circ}) \overline{T_{g}}$ $\overline{V_{L}} = \overline{V_{g}}$ IaA = Vain ZurZine + 2+ 3 neoticreated using Scan2PDF

POSITIVE SEquence Source: Y- connected feed a D-Connected had - brough a distribution line having an impedance of 0.3 + j'o.9 A/q. The load impedance is 118.5 + j85.8 A/Q, the internal Voltage of phase (01) al the generator is 120 V ms/p a) Construct the 1-& equivelat Curca-CEP m m 24 0.31 Jo.91 12010 (+) 118.5 - 185.8 = 39.5 + 128.6 b) calculare the line current IaA = 12020 = 2.41-36.87 0.3+1.9+39.5+122.6 IBR 2.4 1-36.87-120 A I_ = 12.4 1-36.874120° A A A A A A A A A A (C) Galculare the phase voltages ar the load sides. HN= (Za) (Ian) = 1124.04 1-0.96° E A der r rest no phase VAR= (+ J3 13°] VAN = 202.72 129.04 V lingo que VB = 202, 72 29.04 =. 120 AB VCA = 202.71 [29.04+120

()) calculate the phase current. $\overline{L} = \sqrt{3L^{-36}} L_{\beta}$ IAR = IaA 121-30 IAR = 1.39 1-6.87 A I RC = 1.39 1-6.87-120° A T_A = 1.39 [-6.87+120° A power Calculation in 3-& Circuit P3-4 (+1- Parg 1 p(+) = Parg + . f(2we) In STANTARCOW Pointers / $P_{-}=3P_{\phi}$ B Iad Zy g average power power of early Source C Tib Zy t phace Pa = VA I& Cos(Og) Tic Pore face argle Pa= VAN Cos(EVAN-GIA) PL= VBN ILB Cos (GV - GIB) PC= VEN Tec Cos (GVEN - GIEC)



VAN = VAN = VAN = VA $\frac{T}{-GA} = \frac{T}{-BB} = T_{CC} = \int d$ GVAN - GIA = GVBN - GIB= GVON - GICE = G Pa=Po=Pc=Pø P-= 3 Vo Io Cos(Oo) VL=J3 VØ $T_{L-} I_{\phi}$ $P_T = 3(V_L)(T_L) \cos(\Theta_q)$ $\left(\begin{array}{c}P_{T}=\sqrt{3} \quad V_{L} \quad T_{L} \quad Cos\left(\Theta_{\beta}\right)\right)$ G-z JJ VL IL Sin (Gp) Ex P= 3 VJPF Praly- $P = \sqrt{3}$ VIPF , peal $(\frac{1}{2})$ -

B $\vec{S} = P_T + j \vec{Q} T \rightarrow \Theta_{Vq} - \Theta_{iq}$ J= J3 VL IL LG Source PT = 3VØ TØ Cas (6) VL = Vq = IL= JJ Jg $P_T = 3V_L \frac{T_L}{\sqrt{2}} \cos(6q) = \sqrt{2} V_L \frac{T_L}{\sqrt{2}} \cos(6q)$ EX Y-Y CIrcuit, Positive sequence generator, 22 Zu=0.2 + jo.5 1/6 . Van= 120 V/0 ZLord = 39+ j2b 1/\$ 1710= 6.8 + j1.5-1\$ a) calculace the total power delivered to the Lord. a 0.2 + 305 q 0.6 + 31.5 A · []3a+ jibi .!! 12010 () (] aA N

co e - c 2.4 IgA = 120 Loi - 129 1-6.87° A 40-130 x = 1.39 2.4 VAN = (39+j28/(1,39 [36,87°) VAN = 11512 1.19 V C=10 + 15.2 VL = (V 3 130°) VAN = 202,72 129,04° V $P_7 = \sqrt{3} (1.24) (202.72) \cos(-1.14^\circ - 6.87)$ PT= (72.9% W b) Calculte the total reactive and complex porce believed to the Load $Q_{-} = \sqrt{3} (1.39) (202.72) \sin(-1.19^{\circ} + 6.87^{\circ})$ a p p p p p c c c 5-=P-+1'0- - 2162. c) calculate The total any power lost ~ ~ ~ ~ ~ ~ P1 = 3 JaA (0.2) = (3)(2.4) (0.8) > 13.824 w Probles 11.9, N. 10 1.16, N.17, N. 19, N. 23, N.25, N.27 res.h. И. 40.

Transformer AC 10-01 220 V De induced Voltaginduced $\propto \frac{d\phi}{d\tau} = magnetic flux"$ Vs x dd , Ni dt Linear Transformer "Real Transforme" Jun Rr R. s. M: maruel coupling Low M = K. JL. L. "cho" juh E Ejuh V, ~ T, Coupling 6 tactor Transforme Kulin loop 7 MKulin loop 2: $\overline{T}_{s} = \left(R_{s} + j \omega L_{s} \right) \overline{L_{s}} - j \omega M \overline{L_{s}} \qquad (2 \omega + R_{s} + j \omega L_{s}) \overline{L_{s}}$ Document created using Scan

Reflected impedance Ĵ. 2:0 2 = Ri + jul, + Zref = V. T. Zin = Ri+ jul, + 2ref $\vec{J}_{i} = \frac{V_{s}}{Z_{in}}$ $Z_{reg} = \left(\frac{\omega_{M}}{|Z_{m}|}\right)^{2} \cdot Z_{22}^{*}$ 6 a 1 Z22 = | R2+ Jul + ZL | I deal Transformer $R_1 = R_2 = 0$ L L and L2 - + 00 K=1 NI : N2 $\vec{\nabla}_{i} = \left\{ \vec{I}_{i} \in \mathcal{I}_{i} \in \mathcal{I}_{i} \right\}$ $\frac{V_2}{V_1} = \frac{N_2}{N_1} + \frac{T_1}{T_1} = \frac{N_1}{N_2} + \frac{N_2}{N_1} = a$ Transforme Transition

N. : Nz Ex - V. Z + $\frac{V_1 - N_1}{V_1 - N_1} + \frac{J_2 - N_1}{T_1 - N_2}$ $a = \frac{V_2}{N_1}$ $2ref = \frac{1}{a}ZL$ Ex