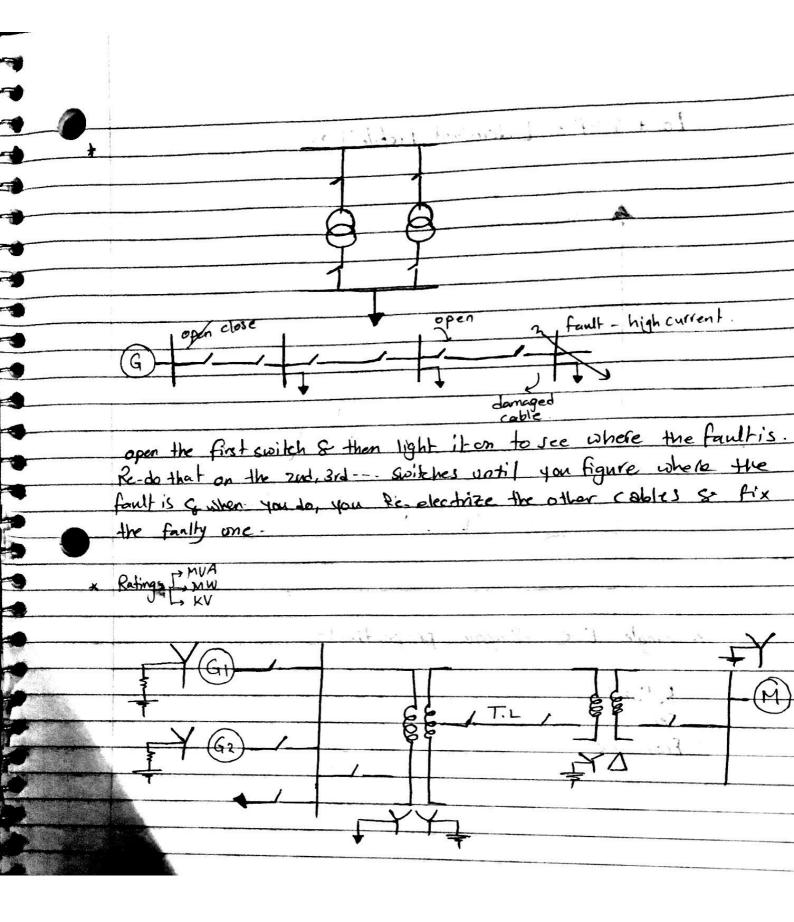
1 Thursday /13-9-2018 \* Power systems analysis: oper Re-tailer elect . energy NEPCO end-users. Distribution Transmission Fuel Generation (mech. energy) UKV (LV) Prosumers 132 KU consumers 6.6 KV 2 lost www I 1.100 9-[EDCO, JEPCO, TEDCO] 1 distribution license Peak-demand ~ 3.5 GW A Regulator 3 Renewable onergy A \* Transmission & distribution blocks are discriminated by their voltage [v]. A Ko/hr acents 132 KV 33KV 1 132 KV 13 KV 4 T.L 6 1 33 KV all. (transmitted over a long period of time). 100 IIKV 000 IIKV O.H KV 4 田田 1 4 HOME revery T.L has a certain capacity, 1 , Generator Models So you need a zota ¥ 1 I7 S.C -> Transmission lines (TL) that's able to hand le C Ly cables head lines (OHL) this carrent. -0 and want Loads Setato? 1) Transformers. stin & Nasid hun 15 , load - flow studies 19 Analysis r short-circuit studies. -0 1

Thesday/18-9-2018. ×. \* Single fine Diagram:-1 relative inter connections of generators, transformers, loads, a. Lines, switching elements. 1 \* symbols! lynnis. Heal Generators or Molors (M G C Secondary Primary V or Transformers > 2 winding transformer r In stands Primary Secondary mili r 3 winding transformer + Tertiary C. R (solidly grounded -= neutral on ground). connections ! C C 6 (Node) . 3\$- single line bus bar. Bus (nodes) --stal alet \* Loads 1. . . . 1 \* switching elements \_ - : circuit breaker CB Isolator . load-break switch . Re-closer 4 Section alizels fuse \_ ndelta fillers the third harmonly.



	1		
Ž	Load	profile [demand profile] 80	1
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دور محمد بر شریا بر روی بدین در بین ب		sour principal and	
		E	
	k single	Line diagram properties!-	
1			
- (	D Reliat	de	
2	Secure		
G	3) Econon	nic.	

12 \* to solve the previous system on the page before the graph: \* Models! R2 X2 9R1 X Transformer 000 com full-model. Re 2 Xm 1 1 \* Lines ; short T.L -000-1 Se her - medium long Tit L R R m\_\_\_\_\_cz 1. Stenes [1] 1 style Unperton's Amer LSI , long T.L Iq > Linknos [] + x synchronus generator: If soon XERY LUI Vł Ef \* Reactance Diagram: X > 30, 132 KV, 275 KV, 400 KV simplification! Balanced XA X3 yon m XIE Load \*in HV there's only X, Reference. So the R is gone at HV. Per phase. [Nentral-ground are the same because it's babaccod]

		11
and the state of the state	* load full specif: II Inductive - load =R	10
	ê L	10
nes		10
	2 Capacitive - load B	
t. 	3 unity PF-load R	MP.
t		
		23
<u>o</u> ¢	Second specification:	1
e	[] constant power  S =  V   I	210
	12) constant Impedance 7 = 1V/TJ (to keep the impedance constant]	
13.	11/71	
	31 constant current	
	[4] mix	
		ela

The per-unit system 82 Thursday - 20/9/ 2018 Actual value Base value A things we want to analyze: 2-1 St. Base selection: S30, VIL base base. \* Those = S 30 base Z base = (VIL base)<sup>2</sup> YLL S 30% loase J3 VL base struct selfs 6 N base 30 = 0.4 KV, T2 → 33 KV/ 6.4 KV (100 M) Ex: 21140 55 1 base 2 = 0.4 \* (33 KV) -= 33 KV Ex: S 30 base = 100 MVA é Pload = 8 MW Pload = 80 Pu 100 Is ar 1 Szø base = Pzø base = Øzg base Rhose = Moase = Zhase No set for the Rating of the transform Transformer 7=5% (Per-unit) 7=5% (100 KVA, 33/0.4 KV) Ex! Zpu (100 KVA, 33 KV.) ?? Fper-phase Actual (2) = pu x Base = 0.09 x 10.41<sup>2</sup> -8" 100 k 11 = actual value (LV)

 $= 0.05 \times (33)^2$ Zactual (I) 100 K H 11 33 Zactual 0.05 \* 11 Zpu (new)= 100 h Zbase(new) 33 KV / 100 K 5cmVA 10 %. 13 8/138KV ×No Resistances: 10%. 13.8 KV X= 10 % 13.8 13.5×1 13:0) Ex: TIL Homile 30MUA X=0.83 50 MVA 13.8KV 1210 4 13.8×13.8 - 13.8kV 138 KV ZO MUA 13.8 1-36% Vr \* Drow Reluctance Diagram given that you should represent them 5.00 per units (values) 21 in find all Regions' bases :-13.8 KV TI base 50 MVA Drawins 2 TIL coon com m 8 Trans former Ê Transfor motor load Generator 10 た 22 12,14 Vold Zpu (new) = Zpulold) \* (SNew Sold × Vnew 2=0.1 ×pn= 0.1 × (50) × (13.8 13.8 Xpy = U.35 x (50) 2\_0,35 G  $T.L = 3u \mathcal{R}$  $(1.38)^2/50$ Sup dans ... 1 C LEAL Vister St 1-125

 $T_{2}$  ,  $X_{pu} = 0.1 \times (S_{0})^{2} \times (\frac{13.8}{3.8})^{2} = 0.1$  $X_{Mobr pu} = 0.1 \times (\frac{50}{30}) \times (\frac{13.8}{13.8})^2 = 0.167$  pu unity  $\frac{13.8}{20} = \frac{13.8}{20} = \frac{50}{20} = \frac{2.5}{0}$ if it was logging: 2.5 X+(os'(PF) If it was leading: 2.5 X-(os'(PF) 5 - plates

$s \cdot (R_{LV} = 0.6$ $Lvside (6.6)^{2}/10$ $kv cide (6.2)^{2}/10$ $66^{2}/10$ $66^{2}/10$ $(e^{2}/10)$ $(e^{2$	
thus ratio $6/3$ $6/3$ $6/3$ $7$ remarking $1$ must be thus ratio $6/3$ $6/3$ $6/3$ $7$ remarking $1$ mp. 8 $8$ $66/3$ $8$ $66/3$ $1$ mp. 8 $66/3$ $8$ $66/3$ $1$ mp. 1 mp	
Hire - prase transformer: Hire - prase transformer: Hire - prase transformer: Hive - prase transfor	O Require

Load 101 fransformer . 1,0 6-6 x3 = 1.8 F.1 0.6x351.3 00 ORg. Seen from the \$1.8 21 HV side Cee 15 06×3=1.8 ree. 3602 260 2 60 2 6.6 66/53  $R HV = 0.6 \times 3 \times (\frac{66}{6.6})^2$ (must always be stri  $= 0.6 * (\frac{66}{6.6})^2$ LC MUA to convert from load to Requision from HU. side we moltiply by (transf. ratio) 2 regardless if the trans former the Reque must always be Yto was Yor A transformer is A I we didn't convert to D each is a single \$ 0.6 she cause 2.6 2 with 0.60 0.61 0.61 e but the 66 1=6ar answer will 60 be Y 200  $= 0.6 \times (66^2) \times 1$  $(\frac{6.6}{\sqrt{3}})^2$ ,  $\frac{3}{3}$ R(e) HI R Yequ. = 0.6 x (66) Very important (check configuration in the book = 60 0

21 Example: 3 single phase transforme 1.2 / 0.12 KV 14. y for pu (pu works on Y only) 3 of transformer 1 13. 62.001 7.2 KUA Find Yean pinpedance 3x7.2 KUA " 52 1.2× J3/0-12 KU From the HV: side ?? 5 55 X = 0.05 pu m = Requilet  $\frac{5 \times \left(\frac{1.2 \times \sqrt{3}}{0.12}\right)}{\left(\frac{0.12}{0.12}\right)}$ Solution : \*solution for explanation! 1.2 10.12 Storie! Require = 1500 2 + LIS. L. 244 34.5 2 convert ! (1.2 × J3) 102 X1005 / HV =0.05 % 3 × 7-2 KVA  $\binom{1.2}{0.12}$ 1500 0 R= Zegn. = 1500 + 10 X=0.05 × (1.2)2 = 10.1 Vin 10 Sin 1 1 Mostingen 7.2 als usit 7=1500 + 110. 3 > Direction of power flows '-2 \* .Pd8 leads - gives power · Q × [V] G - depending on agnitude Supplies. 12/ 282 188 Q< absorbs. G GI Loonly on HU when you neglect R. Real power decides whether its motor or generator. motor + Pipt generalor + P ver

	268+268	
<u></u>	supporter.	guest a
Example!	I m t will be	
P.7 100	×° (+) G P (+) 100 × 3° AUSI F	
		1
0	Determine which machine is generator or consuming P/Q?	1
	the state of the s	
	G1 - inject P, Q G2 - consume P, Q I - 100 K0° - 100 K3° = 10.35 K35° 15	
	J	
	SI = V I × 100 × 10.35 × -35 1 = -1000 + j 268	VAI
and the	injection with the injection of the inje	10 m
	S2 = VI = - 1000 - 1268 VA	(
1500	- FILL KIN -FICE	
	Pasing dia came line :	
*.01	N Le magnituar ( Guel Guel) av V	-
	oril, Consumes	()
-	- [ power]	()
	* Direction of some flows	()

Thesday 2/w/2018 transformer !-Three\_winding \* -3 home + 2 winding Arens former ..... Primary Secondary -5 WWW of it Kut to hig = "KUA" rating for secondary. different -5 Auge Visite Internet of printed LAVA rating Ter Hary ( 13 to ( 13 to Vd, 66 T ) -3 : 243 (1+ dd. ANACCO. N.P. - ja-.... LOM OIL N. 8 . 10 (14) -3 51 Equivalent circuit: impedances A Low Arts land ZP. - 3 Sinh primary Side ... Reflected to 1 753 4. ... 13 ZT -9 -5 Reference 1 2 2 \* 3- short circuit taks needed 151.1 EPS ; t:0. I secondary dance Zps seen from primary Short - circuited  $(\mathbf{A})$ ion mich (comber ) hain S Reflection Primary t Zps = Zp ZE Reflected Ni Zet= Zet Fst'= Zs' + Zt" ZE • . 9 Reflected to Zst secondary . .9 Reflected to Drimary : Scheck Memorize. Zpt (Zp++ Zs+ - Zps, 2.04 Zr= 6 69 1 - 1 40 m 1 no main . -

\* lated: load nest 3 winding transformer; Frample · N, 2 = N222 + N3 23 Primary Y- connected, 66 KV, 15 MVA Secondary Y-connected, 13.2KV, IDMVA 22 12 21 tertiary A-connected, 2.3 KV, 5 MUA SN2 ..... Zps= 7% (15MUA, 66 KV) they must NJ have common Zpt= 9% (15MUA, 66 KV) base use the le 7st= 8% (10 MUA, 13.2 KV) Find perunit impedances per phase: constatering abase of 15 MVA, 66 KV at primary side ?? P S Solution: 13.2 KV GKV - t 2.3 KV 12.3 KV 113.2 245 Zpu(new) = Zpuloid) x Seid (met 13.2 K 15 = 12 % using orrection 13.25 10, Now 1/2 equations!-21. 1 33 Zp=11 Zps+ Zpt-Zst ZS=1 (2ps+7st - Zpt) 701+ Zet-662 Zps(-2) = 0.07 x mother solution using (2) without conection: Zpt (r) = 0.09 \* Z+(1) = 0.08/ 13.22 Primary. Zst' (pu)= 0.08x (13.22 13.22 66 7510(2) = 0.08 × lefreet from 10 13.2 to s com daug Reflection brencard 15 Actual at primary Zst (pu) = 8 % × 15 = 12 % Secon dary which is the some

synchionus generator:-\* Sunday 7/10/2018 stator e(+)= N dø Ø(+) Grid L e(t)NS=120F P \* synchronus speed f= PXNS W 5120" (2) 8843 2 mi equi circuit per phase : シュートレック chronus impedance ..... JXS 115 0 D Ia Ra ~ Zero DIEF138 NT KO Ef. griet mits Taxs Ra = Zero 0 aremit-shally EFXY 1- ×0° Taxs Iq 1 Iq (deterstate) P= 3 VT Ia Cas O EF - VT P= 3 VT Ef Sin & Xs Ta XS COSO = Ef Sin & P 3VT EF2 Sin 8 P= 3 NT EF Sing Xs Ks EFZZEFI Q= 3 VTIA Sin O IAXS SIND = EFCOS & - VT In Sin O = Ef cos & -VT S 90 Xa

Q= 3VF (Efcos8-VT) 7/10/2018 Xs Small So , Q - 3 NH (EF - VT) XS +2 411 1 P= 3VTEF Sin & Xs (+) -1 27 (XS \* K 1 Ia 1 VT P= 3 VT EF Sin 8 Xs EF X8 (2 1 8 2X Q = 3VT (EF COS & - VT) 1 25-32 closed 1 3\$ fault -× G え 1 Nº 6 ialt) -X" (sub-transient) × -35 2Xm 10 x' (transient) x (steady - state) AT EF 5 4 2% X'I 43 18:5 C 1 X Ia 3 (t 0 Æ steedy state TV 8 20 13 0 42% 2

300 MVA . base , ~16 ?? (M) 200 MUA, X"= 20 %. 1/2 0.6273 Example: 0.5x/Km 100 MUA , X" = 20 %. 20KV - (M2) /ID/2015 54 KM 13.2 KV 300 MUA 3,1\$ transf. 350MVA 20 KV 100 MUA, 127/13.2 KV 20/230KV 300 MVA 201 Lor X "= 20% X= 10%. X = 10% syster) us ( undy 300 system) find: O Draw pu reachance. 350 OI. base 300MUA (2) Motor injouts are: M1 -> 120 MW at motor side. 13.8 KV end (13, 2 KU / Unity PF) M2 -> 60 MW act 7 J Lil V 2 5 11, 18x220, 0 SILFIP find voltage @ generator -13.2 S Las SOKV bys state ?? 12 ... 6130 Elect 4 Solution 12 0.1x/300 10/20 300 MUA 88-0 red a to ge 350 BUOMUA MUA 21 1 base values est. 230 x 1 300 230 350 eventhele (comun 18.2 12753 = 10. 857 220KU / 13.2 KVED 16 0-6275 300 220 0.5 × 64 uld me (20%) S 10.549 230 -10.2 (2502)/300 10.2745 E 300 10.09 3 た (13.8) (#) 4 300 3 Lipu diagram 3.2 = 0 196 py = Vmotor 300 113.212 stand 10 76 100 13.8 1 votors 5 1.G 530 = J3 VL II impedance 120 Mark 12 Inator - Vio.549 30 pm = J3 VL IL only if the 3 VLbase. IL base convent was no = VL pu. S3¢pul Tp.y 197 - 18 mm 115 1992-\*5 Sp.u = Vp.u. Ip.u 3 e unity 120/1 PF 1.2 0.96 300 leading theos pf o lagging - cost pof TI

is all him one the - I all TI= (120/11)/300 1 2 - T2= (60/1)/300 Tuesday 9/10/2018 18 9.96 0.96 hamos I = II + I2 = Ord2 FB Karument VASSAU Y 01 -1.01 1) NG = 0.96 do + 0.6273 to ( 10.0857 + jo.1815 + jo.0915) 134 B retain to 1/4 8.51 WHASIC , M DE CARGER SOLUTION (3) VG= 0.98 X13.3° pu. > V motor so that Q can flow MY LOOPEN which makes sense. NG gives the power & the angle should also be higher. 16 = 0.98 × 20K × 13.3 \* synchronus motors Lo to get the actual value give Q. you have to multiply by the base. m Example: I motor is given, load 100 MW, 0, 8 PF/ag - motor load ( Prnotor, P.F.) 13.2 KV base 300muA, 13.8 KV Moad given ( Pr) constant impedance 21 pu ?? JG ?? ZLpy=(13.2) / (100/0.8) JG?? Colution! (13.8)2 / (300) Vmotor m m ++cos (PF Itotal = I load + Imotor VG : た as leig lighter jeit (no velo reactance diagram.

\* Low Low Kallifre's You have volkage & power so find I motor pu -cos'(PF) Spu. J = Vpu. JIpu. Ton. Motor y lag. × V' = V Motor + Imotor \* 23 Tload = V' forfille bourde contrens NOFA 72+ 210ad Thursday 1/ 10/2018 3 Transmission lines:-\* 32 400 KV 2 % VR O.UK IKV 11 KV - 3 500 KV 3 HOO KV - 2 \* OHL - 2 \* cables (underground) towers . ? ? Modeling for Transmission Lines! Short length < 80 km 2 and? Approximate 1 80 Km < Longth < 240 Km medium 2 model long > 240 km " full model" Performance under steady state analysis. 2 voltage drop. . power losses. voltage regulation. 檲 \* voltage regulation, ve-load voltage rise full-load volkage drop

11+15- 00 YE C Line Inadability: + -> thermal limit -> voltage drop-limit. , Stability limit. reactive power compensation. La Line compensation techniques. 1 2 and a show the polo America 33 KV A . 33 KV -> conductor (ALU, CU) 500mm2 Lainsulatora 1 24 mm² support-structure AL CU FAI underar \* OHL (ACSR) Aluminium conductor steel veflected. -Transmission lines: -> electrical design on energy 201 ¥ pridebard -> mathematical design Shart Rac L m murkan. - Area is small compared to Do AC - solid m 13 . 2 Conduction ce d lotona effect

33 KV, U.G. cable	5			<u>)</u>	A JSL .	15:18	
crocs section	Rdc	L	c	(A) Continuou ratings		1 = 23	
150 mm <sup>2</sup>	2	1.5	. 1	300 A			
24 mm2	2014 1	1	1.12	<u>r</u> **			
			and a	and an an		1	
+ Short T.L (le	ngth s	so km	) and	1			
Z-stotal T.L	Line and the				<b>\$</b> \}'	1) = 1 s	Č.
J. Amon	1 1	R	to the	- 1		3	1
+	-	t	7	= Z. length .	12/2/1	(m) )	1
and the second	2	-	2		terine M		
2 port- network:					-	+ 8	the second
	IS T	TL		IR		the second second	
	A		B	+			
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0-	c						
VS = AVR + BI							
TS = CVR + DT	R						
TVS7. A	871	-VR-	1	·····			
	DH	IR_					
	P J[						7. 1.
	and together and				0.5		
A = VS						201 II.	A service of
NR IR=0 (	No-load)					and the second	
B=VS S	2	- 1 - 14 	1	n silan na sa			
IR   VR=0		-	- <u></u>	-	e de la tra	200 C 8	1
and the second second	Wingd			en ange and	Q		- And I wanted
c ~ s (sein	nrus)	e e		have a gran	100.0	orde i -	
			- 21	1		1	
D N Dimens							
D ~> Dimens		-151:					

*	AD-BC=1	- 14 - 1	the second	- the street of the sector
	JS=VR+IR(Z) large			29/das D to NA 28
	large		1	and an erais
	Is = IR	Sec. 20	AC 1 3	
	•	0	1	5 mm c)2
a de	and the second sec			Sam fis
	R + jwL			
	+	+	Find A, B, C, D?	2 13 13 1
len le	c/2 1/2 1/2 =	- c/2		Contract and the state
		Belege	· ·	1 1 10
	A AN INNE THE	Weber La		
			7	

	* medium T.L ( 80 Km < length <21	40 km) Sunday 14/10/2018
	IR +VRY Z(n)	
		IR Contents which go through
to the stand of the state and allow		11. Uz (cupio) -
tin an inclusion for the second test	JS = Y/2 =	VRS called charging
	-    -	currents
and the local system of the second	y = jw c Mf/amit longth	MIS - AVA - N
		TEECH DIF
an a	Y = jwc * length	the second s
11.0		
enoing.	VS = AVR + BIR	Lat I a 2 Per I
	IS = CVR + DIR	
	to find A, B we use VS!	2V = P
	VS = VR + (IR + VR Y) 7	A = VS p= x1 AV VR IR= Zero 2V = SI
10 10 10 10 10 10 10 10 10 10 10 10 10 1	2	VR IR= Zero 2V = SI
	$N_{S} = \left(1 + Y_{\frac{2}{2}}\right) NR + ZIR$	DE AT
*	A=1+YZ, B=Z	C ~ S (Seimtus)
		DAP Dimension/css.

6-6---to find C. D we use Is! (x) (x) - ( v = V + 5 IS = IR + VR Y + VS Y subs the US you found earlier in this equation: 6-2 57 12151 6-22  $\frac{T_{5}=Y\left(1+\frac{Y_{7}}{4}\right)V_{R}+\left(1+\frac{Y_{7}}{2}\right)I_{R}}{4}$ 6-3 (x)} 6-23 A, C + As C  $A = D = 1 + YZ \quad (unifless)$   $B = Z(A)^{2}$ 6.= in short J.L same conclusion (a/km) AD-6---c = Y (1+ Y Z) (sidnens) -6.--- $\Gamma(x+\Delta x)$ Fullin - WI 6-2 \* long Til 6.00 JAX V(X) 6.-V(X+Dx) 5.---X+DX. 0 sik: (v)v tim 1 home Anon (multiple medians) 314 · (x)1 Dx -> Zero long T.L is the full model. (Medium/shorts are approximations) V(x+Ax)=V(x)+7 AX I(x)  $V(x + 0x) - V(x) = \overline{z}I(x)$ AXdV(x) = ZI(x) Ast order DE. dx I(X+AX) = I(X) + YAX V(X+AX)  $I(x + \Delta x) - Ix = y V(x + \Delta x)$ 00 11 ( 97 + F, 18 ) /2 DX Ax -0 AIN (VP-BOLL)/2  $\frac{d}{dx} = y V(x)$ dx -

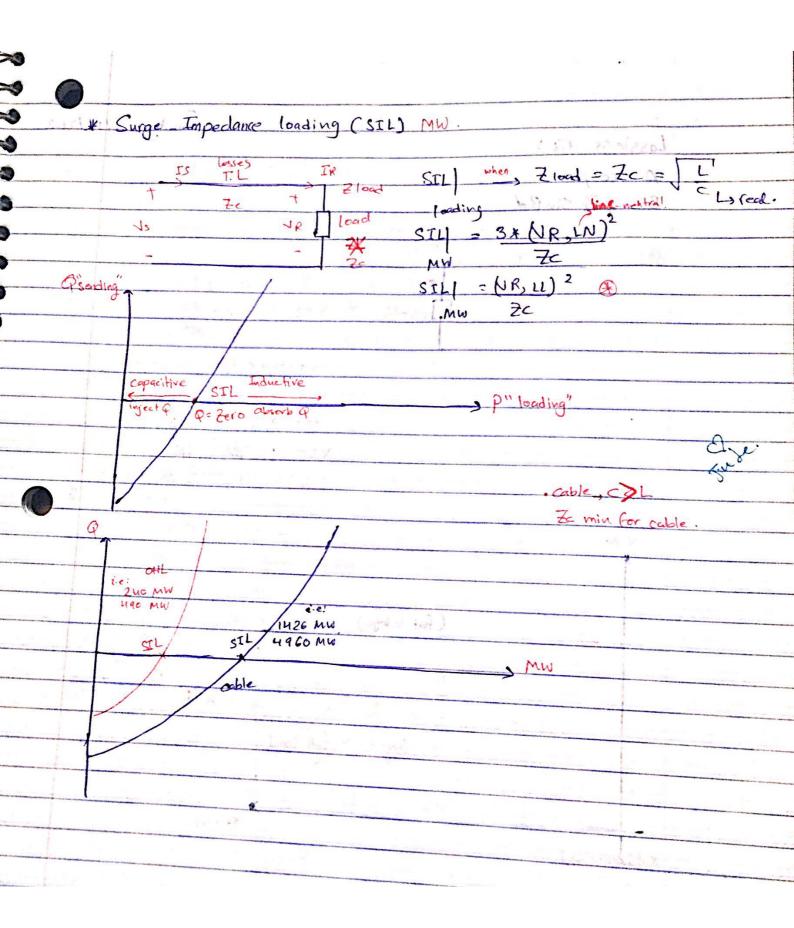
0000 6  $\frac{d^{2} V(x)}{dx^{2}} = \frac{7}{2} V(x)$   $\frac{d^{2} I(x)}{dx^{2}} = \frac{7}{2} \frac{\sqrt{2}}{\sqrt{2}}$   $\frac{d^{2} I(x)}{dx^{2}} = \frac{7}{2} \frac{\sqrt{2}}{\sqrt{2}} \frac{\sqrt{2}}$ 6 G 6 6  $\mathbf{N}(\mathbf{x}) = A_1 \stackrel{\mathbf{x}}{e} + A_2 \stackrel{-\mathbf{x}}{e}$ 61 6  $\frac{T(x) = 1 \ dv(x)}{2 \ dx} = \frac{A_1 \gamma}{2} \frac{\gamma x}{e} - \frac{A_2 \gamma e^{-\gamma x}}{2}$ G T(x)= A18 yex A28= 8x E 6  $\frac{x^2 - 2y}{2} = \sqrt{2y^2} = \sqrt{2y^2}$ 6 6 N(x) = A1 e + A2 e JZ → Zc A c/s im pedance 0 0 of a line. TLX)= AIe - Aze C. e han 2t + V(X+Ax)--V(x) Contrast of -, N(x=Zero) = NR X = Zero 0 I(x= 200) = IR 2-INTS - CANE X= Zero XL VR=A+A2  $IR = A_1 - A_2$ (va. 11, ale ale (var)] DALLING NI CLASSIT -A1= (VR+ZeIR)/2 Cà. A2= (VR-ZCIR)/2 -LOVY - (N: 1 Ale

 $\frac{N(\lambda) = VR + Z_c \Gamma R}{2} = \frac{\delta x}{VR - Z_c \Gamma R} = \frac{\delta x}{2}$  $V(x) = VR\left(\frac{\partial x}{\partial e} - \frac{\partial Y}{\partial e}\right) + \Gamma R\left(\frac{\partial x}{\partial e} - \frac{\partial x}{\partial e}\right)$ N(X) - VR cosh & x + Zc sinh & IR I(x) = VR Sinh &x + Cosh & x IR -Ze - $\chi = \sqrt{24} = d + j\beta$ Zc = 13 s -A = cosh & & relength of the line where did & come from ? N(X)= (osh XX VR + Ze sinh XX JR , VR length X= X > 11002 VS= cosh & LVR + Ze sinh& L IR 40 important conclusions. Is = sinh & KVR, cosh & K IR  $\delta = d + j \beta$   $\cosh \delta \lambda = 1 \left( e^{\delta \lambda} - \delta \lambda \right)$ = 1 (ext jpt - at - jpt) coshod = 1 ( e KPL + - d L K-BL) ] formulas to find cosh, sinh Sinhold = 1 ( dk KBL - dk K-BK) because you can't find easth (compter), sub(compter) directly on the calculator.

6 Thursday\_ 18/10/2018 \* Thequivalent of a long Th: (ABCD) 1.00 Amont 6 Mod-L D=A= cosh & 1 of long: 6 B=7 Sinh 71 S. C=Sinhox  $\Delta$ Ze (ABCD) 6 TI mode ( 16 of long.  $\frac{7'?}{2}$   $\frac{D=A=1+Y'?'}{B=2'}$ C=1+Y'?'C er 8 7' = Fesinhod C multiply by: 2 7'= Z sinh XX · [ZX] C 2 Sinh& L 22/24 = 21 C = 21. 1 71 sinhox Z'= Zd. sinh XR = Z. Sinh XR \* memorize. 81 YA 7 factor 1 6,5 Approximation: 240 K. Jim Up 2 y 2' = Z Medinm? Z=Zesinh & = Z. sinh & App. 11 sto der & ubb 21:60 charact. 82 -> 21

4 h 2V cosh 7x = 1+ 412 1 6  $\frac{Y' = \cosh \delta \lambda - 1}{2}$   $\frac{Y' = \cosh \delta \lambda - 1}{2}$ 1611115 Y = tanh 8x/2 . 4x/2 (ma 2) 2 Fe JZ yx/2  $\frac{Y'-y}{2} = \frac{y}{2} + \frac{tauh}{\sqrt{2y^2}} \frac{3x/2}{\sqrt{y^2}}$ . -Y' = yx tanh 8x/2 2 2 factor Y' = Y tanh 8x/2 \* memorize 2 2 8x/2 5 3 3 the the part way 7 production of performances 138 ... \* lossless Transmission Lines (T.L): R= 700 - N(A) = ANR + BIR hand calculations (initial design): gTSI-F grh=1 Z=r+jwL = jwL X = Jwc . Zero BT. Senie Site av La 200 - 1/ X = J-ZY = Jw JLC = R+jB LC rad /se NE ELER. \* ABCD constant. 1  $= \frac{1}{2} \left( \frac{d^{A} \times B^{A}}{4 + e^{-d^{A}}} \right)$  $d = \frac{1}{2} \left( \frac{d^{A} \times B^{A}}{1 + e^{-j}} \right)$  $A = \frac{1}{2} \left( \frac{1}{4} e^{jBA} + e^{-jBA} \right)$ A= cosh XX A = cos(BL) , ALL at no load VR>VS

US = AUR + BIR NR = NS = NS A (OS (BK) 6 6 B constant: B= Ze sinh 81 = Ze [ 1 get XB1 - et X-B1] 6 B=7c[1(1×PK-1×-BK)] = Te - isin BA 4 = Jul jsin Bd juc B=j L sin BL \* wave length (2) meter is the distance lequiled to change the phase of VSI by 360. at landt 2 1 2 ?? Copleste in this 2001 + alude V=AVR +BTR V= 105 BL VR + jZc sin BL + IR VR BX = 2TT 2 - 21 1 = 211  $\frac{\lambda = \lambda = 2\Pi}{\beta}$ 1- X-0 k + NS. 1 the set we while be



A Sunday 21/10/2018 6 (1 \* ) 0 6-Lossless T.L ! = []  $\frac{1}{2c} = \frac{2}{y} = \frac{jwL}{jwc}$ 6 A=cospt 6 B= jZc SinBd INT INRIKO 6 1. STL : TI TR R ZL=7c 6 VS = AVR+BIR 11.94 QSIL -> IR - VR te 6 G Vs=cosp2 VR+j7 sinp × VR 6 G Vs= (cospl+jsinpl) VR VS= 1×PL° VR G VS= 1 JP constant voltage [VS]= [VR] constant voltage but vanying phase. C 1 VOU No-load (fat vollage) STL XVR 1 -15 Load xt Short Chranit full-boad X=Zero Xalonghb (4) AF = 3 × 108 2 = 3 ×10 = 0.6+ 10 m LAinge #

in the land and the second C. INTING VS = A VR + BIR TS = CVR+DER anais Covilant. at no load = D IR = Zero = D'Is + Zero at short cht - D UR= Zere \* complex power flow through T.L ! objective = PR = F(A, B, C, D)3 GR XIGLIG 39 SR = VRIR\* (SR can be id or pu) -VS = AVR + BIR () - 1201 - (200) - 1201 3 JIR = VS - AVR B 5 2. 12 12V121- 54 A = IAI XOA B= |B| XOB Vs = 1451 ×8° VR = IVRI 20°  $\frac{TR = VS}{181} \times \frac{S - \Theta B}{181} = \frac{1 VR |A|}{181} \times \frac{1 VR |A|}{1$  $\frac{10}{10} \frac{10}{10} \frac{10$ NR, VS FLNG Line- Neutral. lay - stern 1 - 11 1911 - 20 SR,30 = 3 SR, 10 = 3 + [VR, LL] . 1VS, LL ] XOB-8 - 3 WI (VR, LL) 181 J3 J3 13 181 J3 SR. 30 = [VR] [VS] & OB-8 - [A] [VR] & XOB-0A 181 101 have lave have an

$$\begin{array}{c|c} P_{R} = |NR||VS| \cos(\theta B - S) - |A||VR|^{2} \cos(\theta B - \Theta A) & & \\ \hline IB| & & \\ \hline IS| & P A + TR_{1}X & |A = | \\ B = jX & & \\ \hline IB = jX & |A|| & \\ \hline IB = JX & & \\ \hline IB = JX & |A|| & \\ \hline IB = JX & & \\$$

. 84 ~ 0° \* Receiving end circle diagram: 1.301.10 Joil & in the origin 3 apr Lat jar. AILVRI 2 2. × A int 141 TVRIVS 1 601 - Colart-ov IB1 01141 -68-0A HOY INT 108-8 Splan! QR Y. STAUNIA tildy 191 SR V JOR PR 08-0A 125 11 V.R.1 131 . IAL VR12 IBI 15 Y 1 . 1

666 nit. Tuesday 23/10/2018 (a)m \* arcle diagram. Gr SR 30 = VSIIVRI 208-8 - LAIIVRI2 0B-0A IBI IBI 5 14 1B1 6 V5=145128 a 6 B = B JOB 6 A= IAL XOA G VR = IVRIKO° 2 conter SP 6 man GALUR12 IVSIIVA IBI [B] 108-8 P Cadius XSR1 Q30 SR2 Vs1, Vs2, US3 (different circles). WS2 VR SR, SR2 SR3 Flocus of SRL30 with 8/58/ constant [Us], IVR] IVSH VR1 -the same HUSSEVR 1B1 NSIL, VR TOLOAD P30 -4 03-0A Center 503-8

Example:	VSIX8? VRX0 AB.C.D or JX	Find SR ?? (Receiving power).	
8	SR ??		and another
Solution!	$\frac{SR = VR I^{*}}{SR = VR (VS   X = -VR)^{*}}$		
John tion.	SR = VR / VS X8-VR )		
	j×	الكوافعان):	خبر
		at no toad , PR = Zero SRI + SRZ no 20,	11
*	[NSI] SINSZI have the	ون نرانس ال 9 لعب من ب هو من برانس ال برا	tet
	Same [VR].	WRL, WSI VRIVSI SK2	
		ع من الم- المحلم لنظر والمحلم المعالية المحلم المحلم محلم المحلم ال محلم المحلم	- 5
and the second second	V N 35	the coloris ser rappingenes gener	chis C
		I'VSHVR!	
		1131	
	(TL) OB-DA	12 Aug - aug - aug	ik.
	had you built	1 IVS2 I, NRI	
and mail	IANURI2		
	161	hum and the AR. 1888	
27 N P	TOB-8	Last / Ist	
		Praybol	
		S SVADOD	
* 1	1 pT cost 1	66Cm	
15/8	VRXO		analis view
		* 58-1190 - 216 WW	
	SR, contuct		-
	SRI	0 + 5) + 6x + 12	1.
1	- 1		
can final	cheents so I lall		-
Fcont	vol SR, (by adding (C; Q))		-

-Ns X8 ?? Veto 1.4 1 0-0 [4.6) find SR, 8 ? Example: V JU SS DZ 6-1) reactor, ay by CJL Ser Spis 6 2 an W are me what ping 11 SR? Inductor tel teles in in in Sent. 6-0 \* if the PF was less than 6-0 inter (0.88 then it absorts more 9 5 the voltage will declease 8-51 Example: A=0.88 20° 0-2 B= no 277° 6-2 PR is 170 MW at 0.86 lag at 300 KV 6-9 find VS 8 ?? 0-9 ) V3 = A VR + BS R [SR = VR IR\* ] Colution . 0-9 you can use this way but C-P we'll use the circle 0-5 diagram 0-9 4) 1VR - 0.85 x (3007 = 660 MVA (if this was per-phase : # s if this was are 2-L J question 120 181 30 : #s 100 MUA - slcm GOUMVA -?? . × 6.6 cm \* SR=170 = 200 MVA 2cm 1320 08-04 = 75 - Cos' (0.85)= 0R = 32° IVSILVR1 -800m and then find VS (B) how money cms this is neasin ic scm 88-8 te 0) end of first exam material.

		at 1	Has same
	1 1100	sed to 265MW ay	A second s
e # find Vs	NR if power is mere.	sed to 265 MW at $\frac{1}{52^{\circ}}$ , $13 = 120 = 173^{\circ}$	
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a manuful lighter and the second s			
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An or a second			1cm- 100 pr/4
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			0.85 
			cas 0.86 = 32°
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3		Light	Load -	Valtage	Cise					
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		- travillar		A HAL		۲ حب	s	J	TR	
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			121. 21		1 m		JC)		STREET IN I	

30-1 6 6 VS= AVR + BIR 1 5 NR fixed, TR fixed 8-2 6-3 NSI=AVR + BIR without capacitor 8-3 NSZ = ANR + Begn IR with capacitor 97 200 USI - IVR Con the second IVS21 - IVRI - Duoitage drop & when you add earlies capacitor. -• maximum pour transfer when S=OB 8-0 XX Pmax ~ USI VRI sin & -BI 2 1Begu = Pmax 1 0 20 LAHVR12 WILVRI -B 1B1 -٠, AT WE SH 2 - circle diagram . 1 2 2 light load (shunt inductor): × singa .... Begn ersy 2 1 0 IR 2 B Cilla 1-1--2 15 VR C D 2 . Invieli 11 51 No load (TR= Zero) 1 VS = AVR + BTR . VS = AVR -3) VR = VS Notinge rive NL objective is to enlarge A [At]

Second exam material: Thursday 1/11/2018 Load flow / power flows × steady state operating point of an electric power system "Steady-state analysis tool" # voltage & flows must be 5 acceptable all the time Bus voltages complex power flows (P.Q). Vy XEN SM V3 483 12. 282 V1X81 (G) avi Grating 5 15 \$ \$ \$ \$ \$ + BIR ×2.55 Bus Vollages Single Une diagram Generatur. P. P. P. throughout Tils. -1 load Instite . ACI Power flow analysis needs [non-Linear analysis technique. \* \* loads are modeled as constant power VG R+JX SL= PL+ jQL + JX R S=VT# SL=PL+jQL AL+jQL = VL IX I iG? I= PL- jQL , Known VL\* NG=VL+ I(R+jX) VG=VL + PL-JOL (R+jx)

P	R+jX		
	TOT	(examples in CHI-2 & machines).	
VG (A)	+ VL? [] load	Y Machines J.	
		snstant npedance.	
		npedance.	
-6	R+ jX	2	
		(examples in power)	
Kinown	TE) VL	? SL=PL+JQL	
Inown	1	constant power load.	
		[S] = [V] [T]	· · · · · · · · · · · · · · · · · · ·
	×		
	= VL T*		
	QL = VL IX		
- I:	PL-JOL		
20-	VL*	state and	
, VL	=VG - T(R+jx)	and the second s	
VI.	VG-(R+JX)(F	2-jQL) [Numerical techniques].	
	VL.	*	
ysing	j iteration:		
Gitaation) k	(VL(K)	D & S Mar in Do a house	
	1 Ko° pu (initial case)	NL(t)	
0	VL(1)	VL(2)	
2	VL <sup>(2)</sup>	VLL3)	* '
3	VL(3)	VLLW)	
2	Conve	ugence	
losses (MW)	( Jues yes iteration is (	(المرى بير	· for power
Losses (MWAR)		the second se	for Q.
2	VI) V2		los
9 (6)	T.I.	• #8MW · P= 8MW	
9 · P= 9MW	MINUAR GMUA	PF 0.8 lag · Q = GMUAR	
Q = ZMUAR	K	$S = \frac{P}{PE} = 10$	
-	kri i		
A	KCL ( balo	anced equation).	

1							1
							1
	*	Power flow	problem			2	0
		* starting p	oint - Single Line	diagram.		Che an	1
		U	Dater.	a constant and a second			1
		•	Bus types.		1 1/10/201		- The
			reference.	Inown	unknown D D		-
				141, ×8°	injected mjected	•	
	1.	Bus types:	PQ bus bus	infected Q injected	111.280		6
	X	11	Py ons	P. IVI	Q. X8°	F) pt	25
	S F	8	pv bus	the constant		1	16
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	Q		•		i		6
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				T	- <b>N</b>	G 112	
					1 A State		6
			Pg <sup>(k)</sup> (	G. PL	(K).		6
		4200	$P_{g}^{(k)}$ ( $P_{k}$ (injected) =	PACKIE	- Pload		
			TR UNJECION)			Section 200	
					(d) a	i alin'	6
	Pa	$\Delta = P_2$ injected	= P2, G - P2, load		ų		
	1		NC	# of buses	initia hat ni	nject P.Q -> +Ve	<b>-</b>
		led (k)	- Pload =	PKi	out	-put Piq-s-VR	_
*	Pk inje	$cted = PG^{(k)}$	- Pload = ()	1 112	17		
4	P	2	2'=1	and the second sec	121.11		and the
			·	Mar	24 E C		-
	and strength of the second	and the second					

	105805 mat	Sunday 4/11/2018
	D Load Bus	2 N21 882
-	$P_2 = 0 - \Gamma P$	
3	Q2=0-[(	PL]=-QL PL,QL
3		2
	$P_2 = PG_2$	$2 \qquad PG + jQG$
•	Q2=QG2	
3		
	the second loss have	
•	Pa= PG- PL	G
	Q2=QG-QL	
	- John John John	
2	PV Bus	IVI Known, & unknown
-		PL+jQL
He		
	1	
	-	- G PG + jQG element element
	and the second s	element
		Q?? BY
	Pa=PG-PL	and the second s
	IVI apost	
	·@? <b>S</b> ?	
		U.S. COL
_	al 1 a	
3	Slack Bus	kct. t
		II = IG1 - ILI = (13 + 13
	1 2	3 PL+ iGL EIT FSIZ = IT
	(G)	- 1 = 20% . SV-1V = 513
		213 8.5
1	iPL2	jal2 1 1 1 1 1 1 1
4	the second secon	x I = Vil + V = I x

81051ns P Generation = Psystem Load + Psystem Losses and Bus System ensure balance for the system. PV bus . (G P2 - PG - PL G Je GG - QL L slack EN PV BAS G PG+jQG ZD \* Admittance Matrix 2 1-4 G ZB ZAS -11--11-P2 = P2 injected 3 Q2= Q2 injected (G I2 = I2 injected KCL: BI Slack Bus  $T_1 = TG_1 - T_{L1} = T_{12} + T_{13}$  $I_1 = I_{12} + I_{13}$  $T_{12} = V_1 - V_2$   $\overline{z}A$ II3 = V1-V3 Z13 12  $\overline{I_{j}} = V_{1} \left( \frac{1}{2A} + \frac{1}{2B} \right) - V_{2} \left( \frac{1}{2A} \right) - V_{3} \left( \frac{1}{2A} \right)$ ×

 $\frac{1}{2} = \frac{V_2}{2A} \left(\frac{1}{2A} + \frac{1}{2C}\right) + \frac{1}{2C} - \frac{V_1}{2A} \left(\frac{1}{2A}\right) - \frac{V_3}{2C} \left(\frac{1}{2C}\right) - \frac{V_4}{2D} \left(\frac{1}{2D}\right)$  $I3 = -V_1 \left(\frac{1}{2B}\right) - V_2 \left(\frac{1}{2c}\right) + V_3 \left(\frac{1}{2c} + \frac{1}{2B}\right)$ \*  $\frac{I_4 = -V_2}{2D} + \frac{V_4}{2D}$ Ti  $\begin{pmatrix} \frac{1}{2A} + \frac{1}{2B} \end{pmatrix} - \frac{1}{2A} - \frac{1}{2B} \\ \frac{1}{2A} + \frac{1}{2A} + \frac{1}{2C} + \frac{1}{2D} \\ \frac{1}{2A} + \frac{1}{2A} + \frac{1}{2C} + \frac{1}{2D} \\ \frac{1}{2C} + \frac{1}{2D} + \frac{1}{2D} + \frac{1}{2D} + \frac{1}{2D} \\ \frac{1}{2C} + \frac{1}{2D} + \frac{1}$ Γ2 V2 I3 -1 -1 + 1 6 7c 7c 7B In VS ZB -1 -2D 0 1 Vu 0 \* Diagonal are self-admittance terms equal the sum of admittances of all devices connected to the bus. 7= 0.03 + 10.04 -000 Example: Z=JWL Y=-jwL Find the Admittance matrix? yc = 0.1 YTL = 1 = 12-j16 0.03+j0.04 hon ye= jo.1 YT-L] = 16 4 TIL = - j16 - (12-j16) 12-j16+j0.1 -j(12-j16) 12-j16+j0.1

Classification : Type. -(2) ranknown known Bus 1 1.1 ×0° slact PI, QI Bus 2  $1^{2} = -1$ N2 ? Q2=0.4 S? batigia 52=-1-10.4 \* Vi= 1  $\frac{S_i^*}{V_i^*}$ JiVi yii T V2 = 52\* yzj V N'S \*:5 y22 V2× V2 (1) = (-1-jo.4)\* - (0.33+ j 3.33 × 1.1 80 0-33-j3-3 ( ) ( ) 1200 12(0)=1 20 V2(1) V2 = 0.9 & -15° = 0.99 8-16° it but substitute iteration JI 20 5+4  $V_1 - V_2$ 12(1) I12 in it. 0.03 + j0.3 pm 10 x N2 = 82 = I12 × V2 P+iQ' s given Example ! X 0.2 + 10.06 . 1 . 1 1 400 5 PL=1py T 25 MUAR af rated voltage Line charging 5 MUAR Find 1/2 using On each end. Gauss Sidel 20 8.21+

Model constant impedance. Qc = VI End Hable (1) Base = 100 MVA 1xc1 Constant impedance Xc constant e 1 . 03 .1 |V] = |pu. \_\_\_\_ 25 MVAR x 6) W 422 Note: if V=0.9 PM  $Qc = (0.9)^2 \times 25 \text{ MVAR}$ 28 (23V 483 Q=IVI2 yc QC p.u = 25 MUAR = 0.25 puil NZ Nº CD 1 (0J vi y y a cr  $|y_c| = 0.25 = 0.25$  $|P^4|$ yc = j0.25 (1) 25 21 charging end. × (a) = V 224 Q=V2 yc of WIEN 5 = 1 pu. lycl = 0.05 100 yc = jo.05 y=5-j15 Z=0-02+j0.6 PV PRS j0.05 G I ye= j 0.25 1+10.5  $(q_{rr})$ 5-j15+j0.05 Y= -S+j15 -5 + jis 5-j15+j0-05+j0:25 Sidel : W VIN Gauss = 20 A (0)2 N Vi= Sit yzj Vi 422 Nit 4 20 JII

N-Bus · 101 = 20 O slack bus 1 xl 2, 0, 0, 6) PQ buses  $V_2^{(1)} = 1 \int S_2^{*} - y_{21} V_1 - y_{23} V_3^{(0)}$  $y_{22} V_2^{(0)*} - y_{21} V_1 - y_{23} V_3^{(0)}$ 1411  $\frac{V_{(3)}}{y_{33}} = \frac{1}{V_{3}^{(0)}} = \frac{1}{y_{32}} \left[ \frac{S_3^*}{V_3^{(0)}} - \frac{y_{32}}{y_{32}} \frac{V_4^{(0)}}{V_4^{(0)}} \right]$ Su \* - yus V3(1) - yus V5(0) Vy(1) = 1 444 - 25 0 - LON  $V_{5} \stackrel{(1)}{=} \frac{1}{Y_{55}} \begin{bmatrix} S_{5} \times & -Y_{5y} \vee U_{4}^{(1)} \end{bmatrix}$ VI=IVI Ko° Slack P. IVI known 3 INC bus PV Bus × Dunknown Qis 5 IVI constant G PL, OL (4) 0 controller = static VAR compensator Ps = - PL 216+2- 2001-211-3 Qs=s??;+ 2001+211-2 -5 + 115  $y_{55} = 1 \left( \frac{55^{+}}{V_{500}} - \frac{y_{54}}{V_{500}} \right)$ V5 = 1 S5= P- jQs ?? = 's 1/ Si = Vi Ti\*

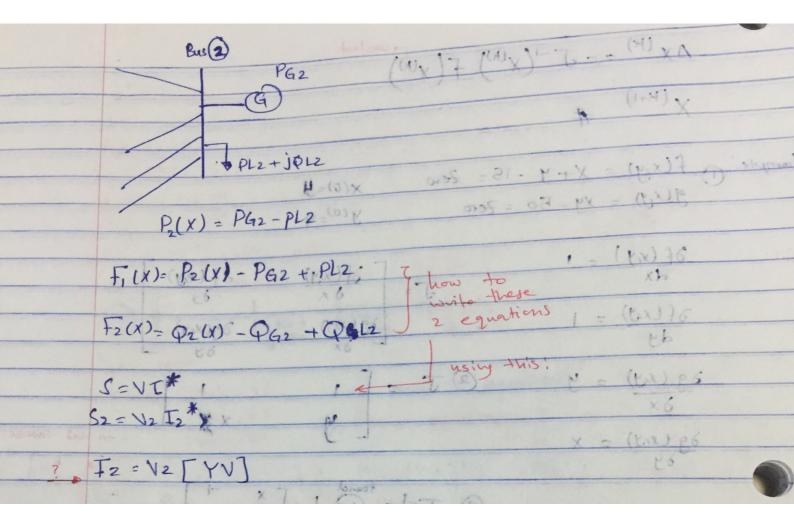
9  $\frac{P_{i+j} \phi_{i}}{\rho_{i}} = \frac{1}{2} \left[ \frac{2}{2} \frac{y_{i}}{y_{i}} V_{j} \right]^{\frac{1}{2}} \frac{y_{i}}{\rho_{i}} + \frac{1}{2} \frac{y_{i}}{\rho_{i}} \frac{y_{i}}{\rho_{i}} + \frac{1}{2} \frac{y_{i}}{\rho_{i}} \frac{y_{i}}{\rho_{i}} + \frac{1}{2} \frac{y_{i}}{\rho_{i}} \frac{y_{i}}{\rho_{i}} + \frac{1}{2} \frac{y_{i}}{\rho_{i}} \frac{y_{i}}{\rho_{i}} \frac{y_{i}}{\rho_{i}} + \frac{1}{2} \frac{y_{i}}{\rho_{i}} \frac{y_{i}}{\rho_{i}} + \frac{1}{2} \frac{y_{i}}{\rho_{i}} \frac{y_{i}}{\rho_{i}} \frac{y_{i}}{\rho_{i}} + \frac{1}{2} \frac{y_{i}}{\rho_{i}} \frac{y_{i$ 0  $P_{i} - j \Phi_{i} = V_{i} \times \begin{bmatrix} v_{i} \\ v_{j} \end{bmatrix}$ V2 (1) -3 · 1 1  $Q_i = -Im \left[ V_i^* \overset{\times}{\underset{j=1}{\overset{}}} J_j^2 \right] V_j$ Estimation for Q P: Pi-jQ2 -N d Vi= 1 [Si\* Let 1 (0) = V5 \$ 85 E, J 2j Vj -1 yer Livileza Ly correction [only IPVI chayed] 1 + 1 + 1 PV. Dus + 1 ( ) + 1 ( 07 201 6 Vi (1) corrected = V5 desired | \$85 Logiven in question. Controller: 5 Qmir &Q & Qmax Y PAN D C Qi >> Qmax :0 (we can't fix the voltage on this birs) PV \_\_\_ PQ bus , Q = Q max Known ] 88 W Example! ... 1 2 1 2 P Q (joi ) - 1.5 + jo.8 pm 2 01 -G \* Y- matrix 0 6 80.1 1 With perform 2 iterations jo.25 G of the [Granss/Side]] P=1, 1+=1-03pm 5.1% [load , frow] . 20201 folution: Bus known un known Type Slack (balance + Piq) EU-1= 21 1 500 P.Q P2=-1.5 2 PQ V. 52 Q2=-0.8 "et 1 : P=1.pu Q, S3 PV 3 V=1-02 pt S2 = -1.5 - jo.8 j10 2 -110 2 Y-matrix Y= -j14 2 j10jo.1 \_\_\_\_\_\_ - j10 jo.25 - - - ju

Q3 = 0.32 pm. (contratient Crain & Q & Quark Q3 > Qmax ?? Coi >> Quinax  $V_{3}^{(1)} = 1 \begin{bmatrix} S_{3}^{*} & -Y_{32} & V_{2}^{(1)} \end{bmatrix}$  $\overline{Y_{33}} \begin{bmatrix} V_{3}^{*} & V_{3}^{*} \end{bmatrix}$ J3<sup>(1)</sup>= 1 [1-j0.32 - j4 × 0.95744 X-6.4°] -j4 [1.03 X0° (5) V3 (1) = 1.0395 \$ 7.2° G convected  $V_{3}^{(1)} = 1.03 \quad \text{(1)} = 0.95 \quad \text{(-6.4)}$ 1 40° P. 9 2. 1.5 2. 1.5 1 = 1 40° PV PET PM C. SZ 17

Newton Raphson. \* Tuesday 13/11/2018 P(x) Ny tangential taking fangential you shart to find lines to find the derivative derivative reach the point R>>x, = Zaro x(0) [iteration initial 0 (guess O (guess) condition 6 equalic history Taylor Series: f(x(0)) 0×6) flx (x<sup>(0)</sup>) Ax<sup>(0)</sup> LF" v (0) 31 IF Approximation Zeve f(x\*)= 10) x () x (0) = Fero unknown × (0) X - X (0)) = Zero  $f(x^*)$ x (0) f(x(0)) f(x(0)) Ax(0) = f'(x(0) (H)V f'(x(0)) (1+2)  $= X^{2} + 5x + 4,$ × 100. = 6 FIX J:= Zero, x\* fu 14/4 iteration f(x) = x 2- 5x + 4 22 fol! f'(x) = 2x - 510 1 ax = 6) = x(1) 2 als 0.1 AX Los = (6) 13.10 = 4.57

	and a stand	*
Stass 2nd iteration:	Marchan Paplican	
X(1) = 4.57	1	
f(4.57) = 2.04		
F'(4.57)= 4.14		
$\Delta X^{(1)} = -2.04 = -0.49$	Slack: Controllabl	e
4.14	Slack. Unitage, I-	-
$\chi(2) = \chi(1) + \Delta \chi(1) = 4.08$		
Slack 12 282 12 283 44284		
N PL2 + PL3+ PL4+ JOL2 JOL3 JOLA		
4-bus system		
unknowns: [V2], 82 we need 6 equi	clions.	
1V31,83 balanced equations -	layber Series: 9.	4
1 \ 4)		
(()x) (()x) injected, (() x ()(()x) ) 1 (0) x ((0)x) 1 +	(0)x)+ - (*x)+	
$P_2 = -P_{L2} \longrightarrow f_1(V, S) = -P_{L2}$		
Appropriate postancionartica		
P2 (injected) (V, 8) = - PL2 = (0) × ((1×) ) -	f(x)- f(x))	
prinjected (V,S) + 9L2 = Zero		
$\frac{p_{2}}{p_{2}} = \frac{(v_{1}x) + p_{12}}{(v_{1}x) + p_{12}} = \frac{(v_{1}x) + p_{12}}{(v_{1}x) + p_{12}}$	100x12 - (ty)"	]
- Dijected	t Charles M.	
	x)7 f(x)	
		7
$X^{(k+1)} = X^{(k)} - \left[f'(X^{(k)})\right] f(X^{(k)})  (a)$	x)'7	A. 1.1
Tiell V Ten 197	* Jaccobian	
x + 4, FOr (x) Fix 1 1X 6	· र्राप) र्राप)	
$X = X_2$ , $F(x) = F_2(x)$ , $F'(x) =$	2×1 2×2	0 Xn
$Y_3$ F3(x)	$\partial F_2(x) \partial F_2(x)$	- 2F2(x)
	dx1 0x2	
(Xn _ Fritx)		
	dfn(x)	din (2)
load flow =>> Multi-vouriables.	dix,	den
F3.8 - 61 1.1	and the second	and the second sec

6.3 constant.  $\Delta x^{(k)} = - J^{-1}(x^{(k)}) + J^{-1}(x^{(k)}$ X(K) SD X (K+I) # 5121+6196 Example. f(x,y) = X+y -15= Zew x(0)=4 Æ y(0)=919-019-(x)9 g(x,y) = xy - 50 = Zero 10 of (xy) sing - Af (xy)  $\frac{\partial f(x,y)}{\partial x} = 1$ 1.1 fol: J= 93 (7x12) - 93(x12) 3f(x3) = 1 ) ( OT  $\frac{\partial g(x,y)}{\partial x} = y$ ١ = XX to find inverse! <u> x = (tix) 66</u> WV 19 3 T-1= () X -4 = X-Y F(x(0))  $\Delta x^{(0)} = - J^{-1} (x^{(0)})$ (4)  $\chi^{(0)} = 4, \gamma^{(0)} = 9$ × = -0.8 \*J Ĵ = 4, 4 (0) -9 F -2 = -M X (0) (x (a)) 2 Xui + Dx (0) (0) - 1.27 y(1) = 0.8 [y(1)] = [ 5.2] y(1)] = [ 9.8]



Thursday 15/11/2018 (x)+ Load flow: whenown Newton Raphson: Filx) = Fero X 2 X = F2(X) = Zero X'n-FN(X) = Zero 531.121  $X^{(k+1)} = X^{(k)} - J^{-1}(X^{k}) F(X^{k})$ SFICA USFICE 2Filx 81.13 dxn 24 8X2 ing . NOG & Fri(x)  $\delta Fn(x)$ dXn d XI 5034.2 C what's the Celation between this Settre load flow? NOP TPOD (x) 41 120 04 1V21×02 1V31×03 1Vu1×04  $(\sim)$ 1V2) 102 X = tval Slack 03 0 4 1Vul 1 = Gen + bus. V21 Ø1 . End . . 1231 02 P.10 - PE2 + PD2 Đ3 Vul 13(1)-163 + 202 θu : (x) + most Common Maga PHEN - PON JP- (x)SP 12 F(x)WV ] sdemand (load) Pi = Pi(x) = Pai - Poi -- () N2 XOi G) PGi + jQGi Fi(x) = Zero -> Pi(x) - PGi+ PDi = Zero : Xithand Y prothant 1=2 Pii + iQui +i(x)=Pi(x)-PGi+PDi =3 injected 1 Qi = Qi(x) = Qai - Qpi 1=4 F2(x) = Qi(x) - QGi + QDi = Zero 1 17 River? 1V ISP -

# of Fix) 163.7 Land flow 4 Buses Islack Fill) - Zaro 2 > 3 PQ Bus 6 F(x) ? F. (x) - 700 P2(x) - P62 + PD2 Fix) = (K+I) \_ X (K) T'(x") F/x P3 (x) - PG3 + PD3 abit add the Sleek because Pulx) - Pau + PDu we it's Known. Q2(x) - QG2 + QD2 Rid & mithat's why we wind the P first. Q3(x) -QG3 +QD3 Qu(x) - Qeu+ QDU QdV 4 Buses -> Islack PP 4 .. slack 1 PV Bus (v) 2 pg bus Juligzet Sill abs to an  $-P_2(x) - P_{62} + P_{D2}$ 83 X = P3(x) - P63 + PP3 F(x) = Qu (un known) PULY) - PEN + PDM (known) V3 Q3(X) - Q63 + QD3 VID. P,Q Vu Qu(X) - QGy +QDy finding Y-Matrix : File)-Poilx 1=1 G 62 Si= Vi Fi PDi 20 0x - (2) - j=3  $S_{2}^{i}=$ 11

F-Rample Vi= Vi XOi ter (P) Yij = gij + jbij  $S_{i} = \bigvee_{i} \begin{bmatrix} N \\ d_{i} & (g_{i}^{2}j + jb_{i}^{2}j) \end{bmatrix} \\ \bigvee_{i} & \forall \theta_{i}^{2} = \theta_{i}^{2} - \theta_{j}^{2} \\ \bigvee_{i} & \forall \theta_{i}^{2} = \theta_{i}^{2} - \theta_{j}^{2} \\ N \\ S_{i}^{2} = \sum_{i=1}^{N} |\bigvee_{i}| |\bigvee_{j}| (g_{i}^{2}j - jb_{i}^{2}j) (1 \neq \theta_{i}^{2} - \theta_{j}^{2}) \\ \cos \theta_{i}^{2}j + j \sin \theta_{i}^{2}j \end{bmatrix}$ PitjQi  $P_{i}(x) = \sum_{j=1}^{N} |V_{i}||V_{j}| \left( \frac{g_{i}}{g_{j}} \cos \theta_{ij} + b_{ij} \sin \theta_{ij} \right)$   $P_{i}(x) = \int_{-\infty}^{N} |V_{i}||V_{i}| \left( \cos \theta_{ij} + b_{ij} \sin \theta_{ij} \right)$  $P_2(x) = O_{j=1}^{N}$   $Q_{i(x)} = O_{i(x)} = V_{i(x)} (g_{i(x)} = O_{i(x)} - b_{i(x)} (\sigma O_{i(x)})$ steps: 1) Bus classifications 2) Y- matrix 3) find X = [] = 100 00 [0] [1] = (2) ] 4) find  $F(x) = \begin{bmatrix} p(x) - \cdots \\ \vdots \\ q(x) - \cdots \end{bmatrix}$ 5) find J(x) = F and F and J(x) = F and  $\frac{1}{6} \times \frac{(k+1)}{-J(x^{(k)})} = \frac{J(x^{(k)})}{-J(x^{(k)})} = \frac{J(x^{(k$ IVIX0 10MW anity of balanced equation -· Q

DY LVI = W N2, OZ Example! G 0.5+j0.5 1200 1 20°, Piq, (Slack) Solution : Bus (1) -0.5, Q2 = -0.5 (PQ Bus) 4 2 = 12 Bus @ P2 = y=-j10 Z= jo.1 -jiu jio Y = P. (1)= > 14/14/1 (9 -jio + 1302011 jio (x):  $\theta_2$ , F(x) =- P2(x) = X = V2 92jeos Ozj + b2j Bin Ozj  $P_2(x) = \frac{1}{2} |V_2| |V_j|$  
 P2(x) = |V2||V1| (921 cos θ21 + b21 sinθ21) +

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0m 7 (10' 10) 10 (01) 11 11 Sunday 18/11/2018 (G). IMUAR G=IMVAR P2 = 10 /12/ Sin 02 Q= 2MVAR E. O. ROMEISVIOL - INT. reactive power losses · 822 (05 D22 V-LISO 00 01- 1 1.VILV == 2) 5 1 sv 1 of + s0 202 [sv [01- 10] Solve for V2 by using Newton - Raphson? Z= jo. ? ? Ex: initial given conditions: 0.5+10.5  $\frac{* \sqrt{2^{(0)}} = 1 p m}{(0) + 6} \frac{* \sqrt{2^{(0)}} = 6}{506}$ bus 1, slack PQ [12=-0.5, Q2=-0.5] Y = - j10  $\frac{10}{10} = \frac{0}{10} = \frac{0}{10}$ Y= -10 10 j10 - 10 D P2(x) = - 0.5 - F(x) = P2(x) + 0.5  $Q_2(x) = -0.5 - f_2(x) = Q_2(x) + 0.5$ PK = ElVKINil Giki coso ki + Bki Sin Oki ] QK = & IVKI [ GKi Sin OKi - BKi Cos OKi]. G + iB- 10 10 10 -10

1  $\frac{P_2}{P_2} = |V_2||V_1|B_{21} \operatorname{Sin} \Theta_{21} + |V_2|^2 \operatorname{Sin} \Theta_{22} B_{22}$ and P2= 1V2/1V/1(10) Sin (02-01) Tero P2 = 10 [V2] Sin 02 Filx) = 10 V2 Sin 02 +0.5 ----Q2= |V2 ||V1 [-B21 (05 021 ]+ |V2|2 [-B22 (05 022 Power nismatches 0 Q2 = V21 V1 [-10 COS 021]+ 1 V212 (10) 20 Q2=-10 |V2| Cos O2 + 10 |V2|2  $F_2(x) = 10 |V_2|^2 - 10 |V_2| \cos \theta_2 + 0.5 - 2$ 20 20 20 20 J= dfi(x) SF(X) 202 2 dV2 2  $\frac{\partial F_2(x)}{\partial \theta_2} \qquad \frac{\partial F_2(x)}{\partial V_2}$ J 2 10 V2 CosiO2 , 10 Sin O2 T = 2 011 011. 10 V2 Sin 02 20 V2 - 10 Cos 02 L J (K+1)  $(1) = X^{(k)} - J^{-1}(X^{(k)}) \neq (X^{(k)})$ ショー Wellwil Gkish Ohi - Rhige Kil = T OK : 21' 5

 $J(\theta_2^{(0)} = \frac{1}{2}e_{10}, V_2^{(0)} = \frac{1}{2}e_{10}) = 10$ 0 10 0 J -1 ( 02(0), V2(0) J-1 = [ 0.1 0].  $-J^{-1}(F(x)^{(0)}) = \Delta x^{(0)}$  $\begin{bmatrix} 0.5 \\ -0.05 \\ -0.05 \\ -0.05 \end{bmatrix} = \Delta x (0)$ 0.1 0  $X^{(1)} = X^{(0)} = J^{-1} \mp (X^{(0)})$ svad 0 rad + [-0.05 1 + [-0.05 12:01 V2(1) = -0.05 rad VE V2(1) \_ 0.95 X - degree PI 37 after 3 iterations! -0.05288 \* DC - Load flow 0.94575 Admittance (capacitance) matrix for the capacitor. PV bus (V2) = 1 p.u. P2(x) = -0.5 - o Ficx) = P2(x) + 0.5 147 P3 (x) = 0.5 - F3(x) = P3 (x) - 10.5

2 (0) -1) -7 (0) Ficr) 13 01 F3(X) 01 F2(x) 101 11 ( (0) JF.W] JF. W) dFicx) J = 802 203 802 (0) < 1 2.01 (.)P 0 1.0 96 0.0. × = V 6 96 <u>90</u> 20 90 X C.R Transmission lossless line >> 30 601 Fast flow: de-coupled load >\* Approximation 2000 2P 10,01 30.0-(1) / d = of pproximation 02 68 ND 03 10,0 96 (1) 30 NB lossless system DC - Load flow! \* VK1=1 p.4 reconomics θĸ system reacts with power only. Power 1 Ko" 1×02 PTG1 11 p d (02-01) Linear relation. (2) cost / load flow 1 0) Lo 2 complicated G Cases. Do alsha E

* Fault analysis:		
Alunda ata	Wednesday 2:	2/11/2018
* Fault analysis:	<b>A</b>	
(short-circuit analysis):	LLLG	
symmetrical "Balanced"	ξ	
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Sunday Fault current 25/11/2018 + contributions from G.M. 30 Fault analysis. 21 internal voltage method. thevinin +1super position. JT. NTI " Havi Xa" (SALIX 4 7- bus : "pT. X Line 30 Fault West. G 1) I fault (balanced NUX IG" IM" 3\$ fault 3) bara 1.T -)v Im" a Ig JX Line Im" mxc TC Ę jXm" JXg (t) (t) En" 59 1 6 ground 1. - "7I (same in balanced) 6 ( soil X +" FX !! Xm If'' = Ig'' + Im''0 If" = (Eg") / j(Xg" + X line) Em" j (Xm internal vollage meth. 115 Eg" Em" I have to fault Plewhat system? Know these: fault analysis: \* Pie-Ngut JXLine shill VC Die fault voltage PX. 1 1 Carl Server \* Neglect impact of load current 11 Gioreiater Zero TI= Eq "= VF = En" of load current = " \* impact Eg" = Nf + JL ( j( Xg" + Xline) En" = Vf - I (ixm" mil

 $\frac{Vf + IL(j(Xg^{11} + X Une))}{j(Xg^{11} + X Une)}$ VF - IL (jXm If "= 30 Xmil vf JXm" If'' = Nf i(xg'' + Xune)D IL I Fault 12 Fault Tg'' = Vfj(Xg'' + Xline)TG" X Line ILoad Flow . 843 In" M 0 Im'' = Vfjxm'' - ILoad 6 UXLINE 65 Eg 1.500 Vf. 55 (F) Em 1.2.137) Pot Tio D T 5 If" = vf T 1 50 jxm" J(xg"+XLine 2+4 2 11 11 8 N = Zthl Jerridain Stand seen from fault location XLine 00 Ø Xg Xm Ø theulinin Xq" + JXLine 7th= 11 jXm" Method ! 11 t 0 Vf If. ÷ Zth. 6 Ig" = If"+ IL wrong 13 Fo If Im"= ·FI 

-	30 MUA	
Ex:	13.2 KV	
	(G) X=0-1PH 2 (M)	
Choose	30 MUA gon. 30 20 MW 12.8 to get P4.	
it to be base	0.8 PF lead	Solve it
	х"= 0.2 ри X"= 0.2 ри	using Orinternal
	30 fau 11:	() theoinin
	JC = 12.8 KV	
Find:	DIF" OIg" OIm"	

· Konst. Timpedance -> Ymatrix ( wont ) " ( blot ) ~ kto" X won" X . · I constant Q=? Srive · Xon Xoctall a) - 30, MUA 13.2 KV -Ex: operating pt: (G)--X=0.194 M 12-8 KY MARAOS - 12.8 to get pu. 30 MUA gon. 30 13.2 KU rating. foult 20 MMA choose if to be base 13.2 13.1 KV 13.2 KU 0.8 PF load : Jolve it Х" с 0.2ри Using Orinterna X "= 0.2 Pu (MG) 26 J Fre-12080 KV - 1 1 Story) Station and find tot fait Find: () If" () Ig" () Im" IL =0.86 X 36.9° 50.1 I Im" in the 0000 1. Eg"/Em" (internal EMF) E jo. 2 Jo.26 Opre - fault. 50 S= J3 VL IL, Spu= Vpu. Ipin. 20 = J3(12.8)(I) + 20/0.8 = 0.97 Tpu. 0.8 pt bix30 Ipu = 0.86 X+cos PF + 12-8 =0.97 13.2 2 II = 1128 × 36.9° Et/pu=ti (actual) i= 1128 \$ \$6:9 i (-0.86: \$36.9 i - 30.0 i ) . 1 9 9 9 2.01 - de 5"= 0.97+ 5 (joil+ joi2)=0.814+ joi2 15 Nits 2 En"= 0.97 - IL (jo.2) = 1.074 - jo.138 pm. 3 Ig "= Eg" = 0.814+ jo.207pu. jo.2+jo.1 Im" = Em" = 0.69 - j5.37 pu. If "= Ig"+ Im"= - - pu. TF" (KA) = IF"pm. ( 30MVA) P achual [ I B.2 ]

5 X"new = X"old x (Vold)<sup>2</sup>. (Snew)
Xpu = Xactual(-n) Zbase :3 10.9 10.2 Er: 10.083 -SF. AUMAS - A ... JO. 103 3\$fault 601 29 8.3 13.2 KV -Gz Nec. Spu x "= 0.2.PH 1 10.275 -J 0.143 PW. find T3\$ fault-using - Hevinin ?? (neglect load currents) VE = (pin) 0 · 11 " PT trat 6 8.00 ,1 1.01 Ti= jo.2 for: T2= 10-083 T25 jo.103 8 an sull and (M) iplie m Juil Y fault JOINS JO.5 0 10.167 ينجول 2-14 T 10 Zth N. Vpw I.S. t 51 -FP.O-20/05 400 (12) (2 えい 0. · . . . 05. --15 8.0 ZA=( jo.083+ jo.103 + jo.167)// (jo.143+ jol275)//-( -PARKESH- F -10.2+ 10.5 If"= NHL -Contraction of the second Zth 1

1 0 6 10 11 1 Thursday 29/11/2018 ..... \* fault analysis! nk [ x1" + X [ x ] 0 super position method: - V2 = VF - VF = Zerow 11 3 ٧. N2 (neglecting Ti)) ]. (G(m) 3 3\$ fault. + DVI VI= NF -1600 .-VI = Pie - fault vollage. -MIS -0 JXT.L D-VF off. - vor 0 others on JXg 8 vF E ixm" た 9 OD-NF on, ledace. the O others off た - YF 2 t voltage C . historily. (\*) bg:-; -01 2 -V. V. 71 Solution 1: - VF off, others ON: 2 л, JX T.L IL 1 1 1 VY jxm IGM= IL + IFg" jxg"Ę 1f (2 Tmt=-IL + Ifm" ing. 41.11 Eg t ~ 4 30 nalk. \* 77 Re-fault. -7 Solution 2: - - NF on Jothers off: =V 15 ildat m Current division 3 Bas i(e) & jxm - 1 (t) jig B Ifg"= IF" x jxm Fm# (IFm ) Jf" jxm"+ jxg"+jxt.L (Fg) Ig"" Ifm"= If" 1×9" + 1×T.4 fq" IG" H JXLine + jXg"+ jXm" IL + Ifm" In C the creates no itword into it . logical is not 100 200 200 1 :

for blutice D:  $\frac{Tf''=+Vf}{j(xg''+xline)} + \frac{Vf}{Jxm''}$ 48.001 inala 04  $Tf'' = vf\left(\frac{j(x_{q''+Xu_{de}})}{j(x_{q''+Xu_{de}})}\right)$ jXm" RC-C-If" = NF Hand in a Zth seen from the fault 15 and the second Timf" = ) carrent division. 67 1 10 X 4 CT-( Super position can be extended to large power system. IF NI, V2, ---, Vn per inter die le 6 Tinjected (Admithance matrix) YV = 22 1 10- 6 - 11 super position , D. Pie-Fault. 21000 Flow 7 23 , [-vfor, others off] Tf" 9 -2 -V= ZI Himpedance matrix ) 1 Jolution Y-1 2. 4 Bus fault as -JA9 10 -En DVI Z13 ZIY 212 -IP/ 723 -VF-7224 A 221 1232 AV3 233 231 234 0 Avy Zun izur 0 743 Zai theolinin impedance Seen from each bus. -NF ON, others off foult location N. TF ", DV, DV3, DV4 Column

101 Solution - of off, others on D: Neglar 3.6 54 Neglect load current V1 = V2 = V3 = Vn = Xf (1.)) Final step (Sol O + Sol @): NI=NE + DNI Fin V2=VF-VF= Zero , V2 = Zero V3 = VF - Z32 (VF) V3=VF + DV3 Vy=Vf-Zue (Vf 722) NU=NE + DNY If "= - Nf = Zth seen from the fault 722 016 AV1 = 712" (- FF") 14 + I . 9-1 ir 0.1. OIL  $\Delta V_1 = -Z_{12} \left( \frac{VF}{72} \right) + \frac{1}{12} \left( \frac{VF}{72} \right)$ 21  $\Delta V_3 = -\frac{7}{732} \left( \frac{Vf}{722} \right)$ 40 Ly . moituble In alt DVy = -Zu2 (VF) Zzz) 8-21-2-200 . . 7. 11. × 128 ....

Shout 2,3 -> 28,32,22,33 00 10.2 Jo. 2 -000-500 I · Ex: 10,26 ~ Thesday 4/12/2018 ~ were found in alle 3 ~ GZ Gi rigin tr. 74/ . N WAY IN W Ar Hint : and 1. Hint W 70 (XL) = 0.5 = 1xc1 =10.5 ; 45 11. ZL = jos 71= 10.5 ZY = 1 = j2 Y = -i26-1 6-1 5.4 - SIS \$10 YEJ 0 \* fired If at bus 1. assuming NF = 1.84. 6 Ex: -120 55 \$10 . . Sreglect, JL. Contraction of the second 15 -19 \* find N, V2, V3 0 6-6 Zbus = Y1 : 14 Solution: 6 -0.108 -0.063 -0.035 11/1 NA. = -1 -0.063 -0.094 -0.052 2.78 200 - -0.035 -0.052 -0.Mog Contra Contra 0.063 0.035 0.108 Zbus = j 0.052 0.063 0.094 0.1409-0.052 0.035 because fault at bus = 1.05 = -j 9.6 pu. It = NF ZII 10-0018 V2 = V2 (pre-Fault) + AV2 -superposition VE -1t 0 E DV2 Hous AN3 V2=1.05-0.6048= 014452 to find M2: - ZZIXJE = AVZ  $\Delta N_2 = -j0.063 \times \frac{1.05}{j0.0018} = -0.6048$ 

212 V3=11:05-2313 VF IF ----V3 = 0. 714 pu. VI = UF - VF = 0 before 4 after 111 Ex: (Rough 11KV/1000V 1000V 1000V 1.25 MUA 11XV / 1000 V » IF 300 ·25 MUA (base) Ð Charl Circuition 5.5% Switch is opened 3 30 fault at bus 1 15 2.5 ð 9 Xth=11K/J3 2.54 Ath(pu.) = (1K/J3) /2.5 K = 0.0262 pu. 1 / 11K) 2/ 1.25M (per-phase) steakage finx, if we had R-s copper losses. Xth + jample 145 5 5 fmall jo.0262+jo.055 = 12.315 pm. IF (KA) = 12.315 × ( 1.25 MVA え = 8.9 44 J3 × 1000 worst case: Xth = Zero TF = 1 = 18.2 pm. and when a pilotis) P. 0.055 Xancoal & ping al logit (3) IF (KA) = KS.2 \* (1.25 MUA) . ( WOUSI - SEMARIO (7) (V3 A 1000) plean inverse on colculator. \* solve Ybus, Zbus questions.

7777 Mursday 6/12/2018 Distributio 17 companies sV N; PIt Power system È 11/2 0 : 11 votie 13 R Fault Level (MUA) = 53 VL IF = Short circuit MUA 1 E Paral \* 5 Short Circuit(pin) = JE NL Jf J3 VL, base IL, base 1 1 1 2 2 2 2 1 2 V IF VL = VL, system base Sc. p.u. = If. p.u. 2 HILLENY 250.6 Xth HH C.S. if SC MUA = 500MUA Sm MOA base = loomua 1 2 ( (21 ( 11) ( 5 5 p. M. If p. .. = 5 p. .. M2 (1) Ipu= Wth to Xth p.n. = 1 = 0.2 pu. 6 A Power system 2 SCAVA 300 MUA 15.8 KV Dise SO MUA! 13.8 KV of 6 Example: HV 149 2 13-51 8 JARI BORDON to calculate IF, 30 LV 1 13.8 KV 1 00 (B) (P - 2 -6-: 5. TE, 30 HV TI SOMUA 2000 V Join 100151 6 Lentin 1001 2 6 Lansformer SCMUA = 300 MUA, 13:8 KV 12 000 6 Power m m : SCANA = V3 VL IF 6 Solution: 300 M = J3 (13.8.4) If 111 t icla igences · chi 38. C.C. TP = 0 300 M may VISBKir In the Cast TI ( Summer  $\frac{X_{\text{H}} = 13.8/J_{3}^{2} = (13.8\text{k})^{2} = \sqrt{2}}{\frac{300 \text{ MVA}}{300 \text{ M}} = \frac{300 \text{ MVA}}{300 \text{ M}} = \frac{3$ . V3. 13.8k STA. no it what

0 0.--3 Xth (p.n.) = (13.8K) 2/300 05 = 50 = 0.17 p. u. signer ; 6. (B.8K)2/50 base 0 at bus 2000 V.jo.17 10.08 m Ŧ 1 If. = 4p.u. Æ jo.17 + jo.08 CE = 4 × ( 50 MUA 6 = 148 KA. If actual 12122 2400 Simplifying the circuit: Actual 50 MUA = 4% = 8.4 KA -B-8 KV :11 USKA 1474 flower system · ( 40 (1 ) 10200 m 1.ax m Zth = jo. 17 4.4 Tf = 1 = 6 p. u. jo. 17 た fault 2000 V JO MUA S. WKA USK \* Pawer 3\$ that represents the Gige line diagram above T. System Xatural those shift between Q, currents = 30° 2400/3 In= 48K x 13.8K 124 ..... 17 1 1 - tallate

		1
Example!	Power system 1200 MUA	-
Une pie	a line C 's aren's	
	Isi tind 30 fruit at bus 1?	
	E jo.2 jo.5 bgie 100 m VA 13.8 KU	-
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	AN 26 10.2 Mars - E jo.25 -	-0
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	T P	6-9-
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febricon :	O Firstly find Uth of the power system:	0-0
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	$th = (13.6)^2 - 2$	
	1200MA	
	$X_{H_{4}} = \frac{(13.6K)^{2}}{1200} = 0.0809$	
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(grade )	(t_) (t_) (t_)	60
Carlos and		00
	24h (2) (2)	
	to find Zth (Kill all sources)	-6-2-
	Eth C.	
	If = 1 p.m. (must convert to actual) ?!	el
	IF (KA)	-p
		The-
*	if we had a delta system _ convert to Y	20

3 Ox Unbalanced Systems Fill Sunday 9/12/2018 1) ... (1) ... 3 5 \* Symmetrical components & Asymmetrical faults; (SINT FOR (UNLO + (O)NI JI. • ] Network we need to know what happens in each phase) LG fault. Hu. 0) ... symmetrical components: 15 TU2 Tan FR R 120 D Jal2) az Ign 1 120° Tbo) 15151 "is of the sequence the sequence unbalanced (Not some angle phase shift) 64. × 10 × 43 051 × 01 - 2 to (0) TL (0) Groy-D IG(0) Zao sequence opoil - UpT Ia = Ia(1) + Ia(2) + Ia(0) Ia(0) Ia(1) ( Ia(2))  $I_{L} = I_{L}^{(1)} + I_{b}^{(2)} + I_{b}^{(0)}$   $I_{c} = I_{c}^{(1)} + I_{c}^{(2)} + I_{c}^{(0)}$ Ib (0) Ib (1) X (I b(2)) ) Ic<sup>(0)</sup> Ic<sup>(1)</sup> Ic<sup>(2)</sup> Ia (0) = Ib(0) = Ic(0) Zero seq. 30  $Ib^{(1)} = a^2 Ia^{(1)} + ve seq$ Ia, Ib, Ic Te (1) = a Ia(1) ] j= 1 × 90° Tb(2) = a Ia(2) Z -ve seq a= 1 × 120° a2=1 × 240°  $I_{e}(2) = q^{2} I_{a}(2)$ a3 = 1 ×0° 1+ a + a2 = Zero

*	$T_{a} = I_{a}^{(0)} + I_{a}^{(1)} + I_{a}^{(2)}$
16	$The T_{\alpha}(b)$ $(a)$ $(b)$
×	$I_{c} = I_{A}(0) + AI_{A}(1) + Q^{2}I_{A}(2)$
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	10-
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	$\frac{1c}{1} = \frac{1}{a} = \frac{a^2}{a^2} = \frac{T_a(2)}{T_a(2)}$
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	= $T_0 + T_{b+} T_{c-3} \Gamma_0^{(0)}$
(x)	
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$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	
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	Tr(2) 7000
	11)
	$T_{1}(1) = 10 0 $ (0) $T_{1}(1) = 10 0 $
	$f_{0} = 10 q_{-120}$ (0) $f_{-120}$
	$f_{c}(1) = 10 \langle (20, 1) \rangle$

	Ţa
	$I_W = I_a + I_b + I_c$
	$T_N = 3 I_A(0)$ $T_N = 3 I_A(0)$
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	Ic (51, 0, 1) (- (0) 57
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	I. (0) = (0) :]
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	NN = 3 Ia (0). ZN
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and the	Tero sequence is only
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	(and anothe dard 1 = (u) at

6) a Iq Zero (Assumption) Ia = Zero Ib=-Ic Th Ь Ic , . LL fault C 1.  $\frac{Ia^{(0)} = 1(Ia + Ib + Ic)}{3}$ 1 Ia (0) = Zero Ig Sca C 17 The 1 Ia = 13 106 X-30° used in unbalanced the seq. Iq(1) a Iau)= Iabu) - Icau  $\frac{Ta^{(1)} = 1 \times 0^{\circ} - 1 \times 120^{\circ}}{Ta^{(1)}} = \sqrt{3} \times -30^{\circ}$ Iab(1) Tr(1) Ta (1) = J3 Tab (1) X-30 Ь  $V_{ab}(o) = \frac{1}{3} (V_{ab} + V_{bc} + V_{ca})$ Ica K 120 Iab 62/ 300 Nablo) = Zevo The 4 -

-3 Ne se 3 Ig(2) -3 , Teal2) Iq(2) Tab (2) Ica(2) . Eap(2) 5 Ia(2) = 13 Tab(2) ×30° 1 3 1 5 1 Toc (2) 1-4 Ibc(2) 130 121 day - (15 1 Iab(2) Ica(2) 2 01-5 (1) 11 Ind Y Ward's 05 Zero sog Tica(0) Inblo) - Icalo) Jublo) Ia(0)= Zero Strand! La V C b Line current of delta has Ibc (0) , Zero Seg. always a Zero = Iablo) Ibc(0) : Ia = J3 Iab (1) &-30 + J3 Iab (2) X 30° 100,100 p Tego \* × 30° \* (0), 100 pus Ia(1) X-120 + Ta(2) X 120° Tb = + Ia(2) 8-120° Iall Xizo Tc = \* (v) Sov & you 12.1 3766 1000 8

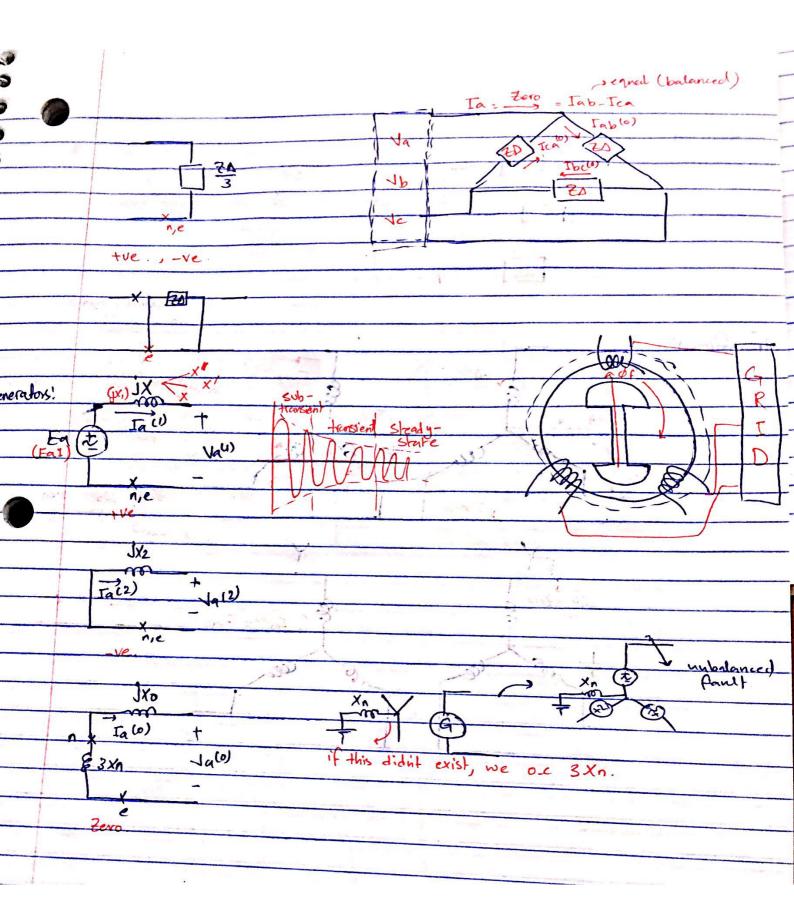
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and a second	.Ta co)	$\begin{bmatrix} 1 & 1 \end{bmatrix}$	[IA]	0	•
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3.	Iq(2) 3	1 a2 a	Te	10/2 (1) July	$(1)_{ij}$
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(E) dat	1/20 = 1/20 (0) + 1/0	$b^{(1)}$ + $Vab^{(2)}$	an la an	110	in
	· · · · · · · · · · · · · · · · · · ·	51	· · ·	1	
	Vab (1) = 13 Van (	1) X+30°		cr	
	Jab (2)= 5 Van (	2) X-30°		Ь	
COLUMN D	Vab (0) = 1 (Vab +	Vbc+lka) = Ze	10	Van	Vab = Van - Vbn
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and the second	Ss\$ = Vata*	+ VbIb* +1	Jc Ic*		
in terms of	S30 = 3Va(0) [.(0)	* L ENOUSTO	(1)*	3 Va(2) [a(2)*	
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la <u>D</u> vag <u>∆</u>	VCC balanca		- 1	,	Ean 1
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an a		(Yg)			. grand

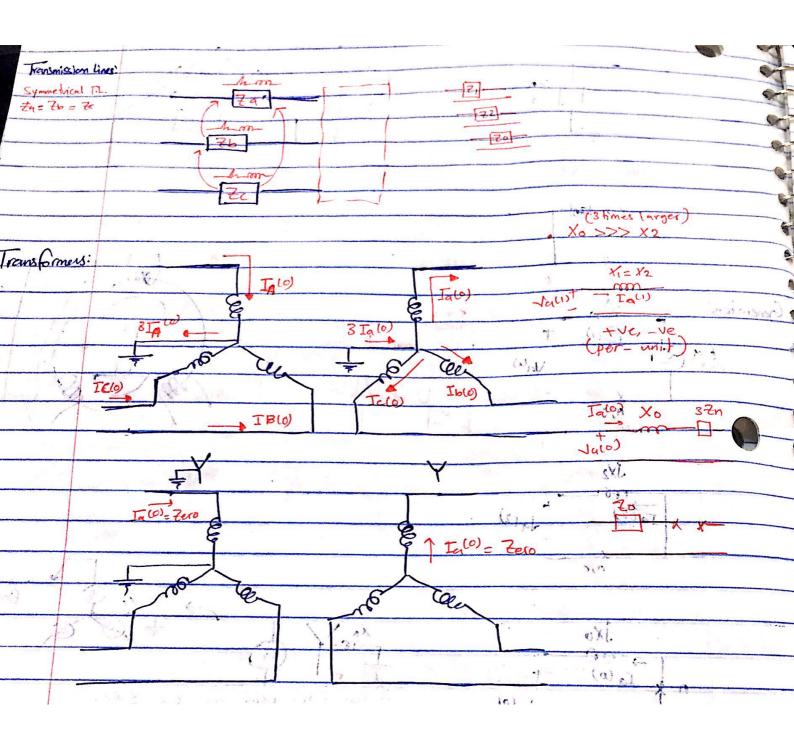
22772 -Vag - Ig Zy + Ean - IN ZN = Zero A ( ) - 1 + ~ . / Nago Ean - Ia Zy - IN ZN Tat Ib+ Ic \* balanced only have the seg Nag= Ean - Ia (Zy+ ZN) - Ib ZN - IEZN not Zevo or \$3 coupling. Nog= Ebn- IgZN - Ib (Zy+ZN) - ICZN (0) 11' Ncg = Een - IaZN\_ IbZN - Ic(ZY+ZN) (N ...  $(1)_{\beta}$ compling between phases ZN IZN Ia (2y+ZN) Ean Vag Th EN (23+2N) ZN Vb9 = Ebn Ic 2N -1 (2+2N Ecn Vcg (0), 765 instance (a), (1) b \$ : phase = (1). Vo = E0 = 76 Ip -(5) 1:15:15 yumetrical. (1) No = AVS, Id = AIS AVS = Eq - ZOA IS Vs = A-1 Ex - (A-1 Z#A) IS Zy+ ZN ZN ZN  $A^{-1} Z \phi A = 1$ ZY+ZN ZN ZN 92 a ZN ZN Zytza 92 a 1 2y + 3 2N = Zy. 0 ( + 8 + 15 ) (0 + 1 e) 0 6 . 24 0 15 (9) 27 balanced will A-1 Ed EI  $1 \int 1$ sonly the because balanced.

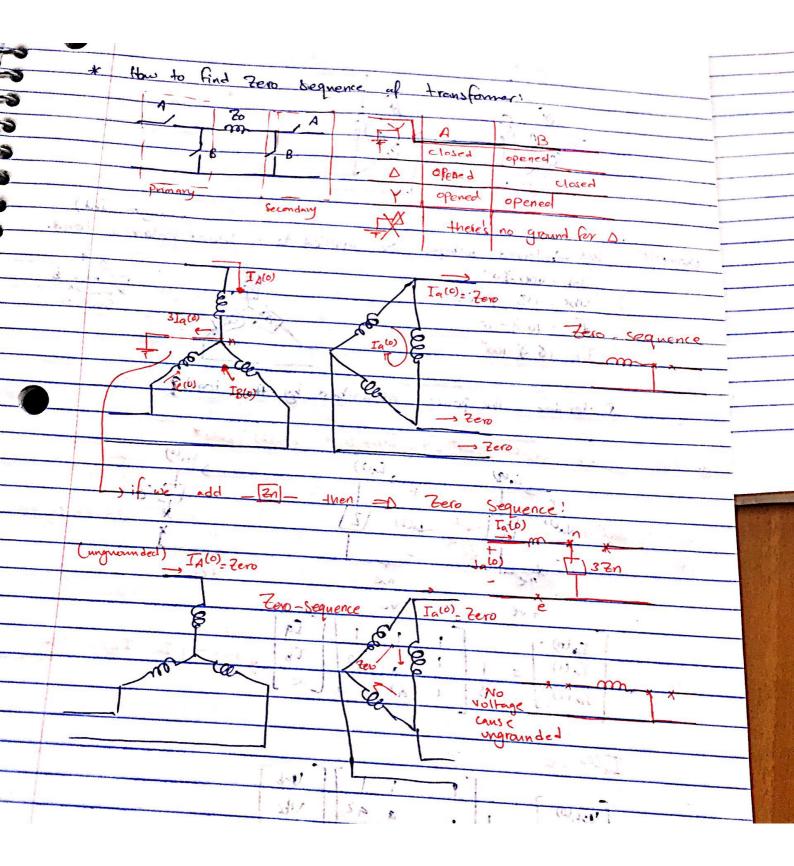
NS = A-1 E\$ - (A-1 76 A) IS [a(0)] ZY +3ZN O Va<sup>(0)</sup> 0 0 Ia (1) 0. Va(1) Ea(1) 0 · Zy ···· in T Ta (2) 24 Va(2) 0 O (minus) Va(0) = - (Zy+3ZN) Ta(0) Vau) = Fall) - Zy Talls - us it us Val2) = 0 - Zy Ta(2) unbalanced system coupling between phases. UNI 8.5V 1) symmetrical ut e.W nd } . 17 (uncoupled) st. ASTI 1.31  $\frac{\int a}{\int Ia^{(2)}}$ Ia (1) God Ig Valo) = 0- (37N + 7y) Ialo) 7 =D. Ib 1. Vall) = Ealling 75 Tall) Ic うん Ja(2) =10000 - Zy . Ia (2) Equip 1-41- 07-6 - 21/4  $\sqrt{aq^{(1)}} \stackrel{\wedge}{=} \sqrt{aq^{(1)}} \stackrel{\wedge}{=} \sqrt{aq^{(1)}} \stackrel{\wedge}{=} \sqrt{aq^{(1)}}$ ti Marto nogle 1 13 43-1 = A 55 -A - In(2)~ [29] 43 15-1-F we seq. (2) D Jore D Van A (2) 10 ngge usen es : - Iq(0) - Iq(0) - Iq(0) (Zy+ 37N) Zew. Seg. Jan(0) = - Ia(0) Zy 37N 1 -1 -1 + Vac (1) + Van (0) + Va(0) 6-1 Ed 13 (1 1 1)

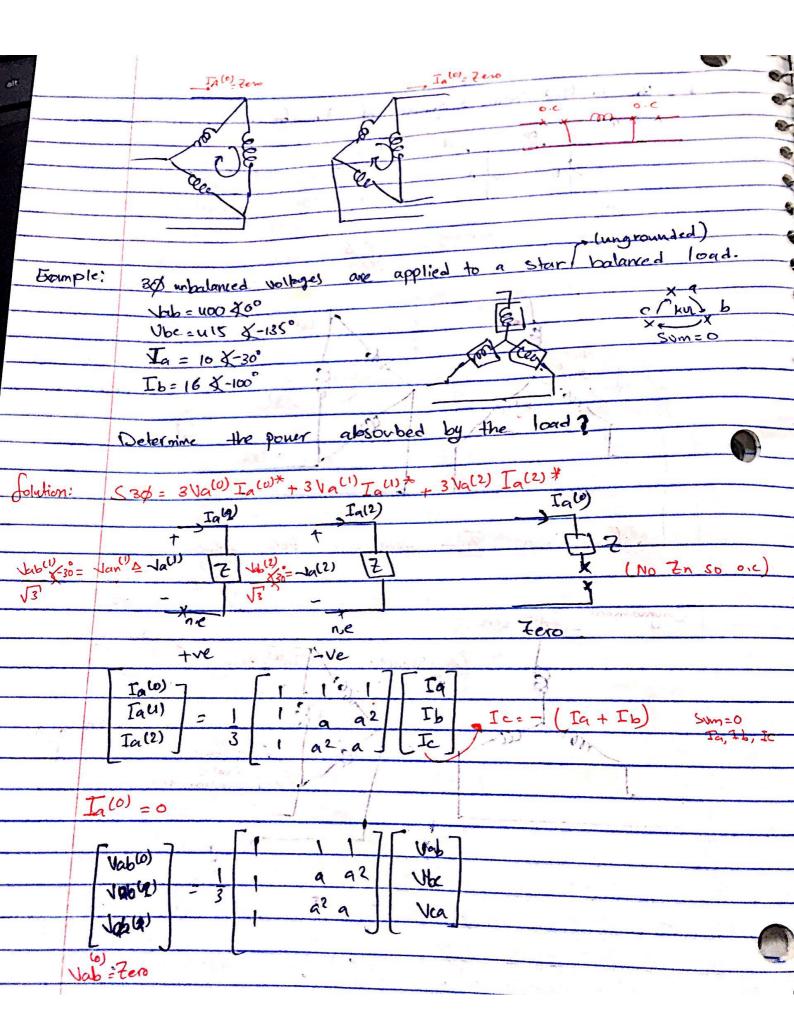
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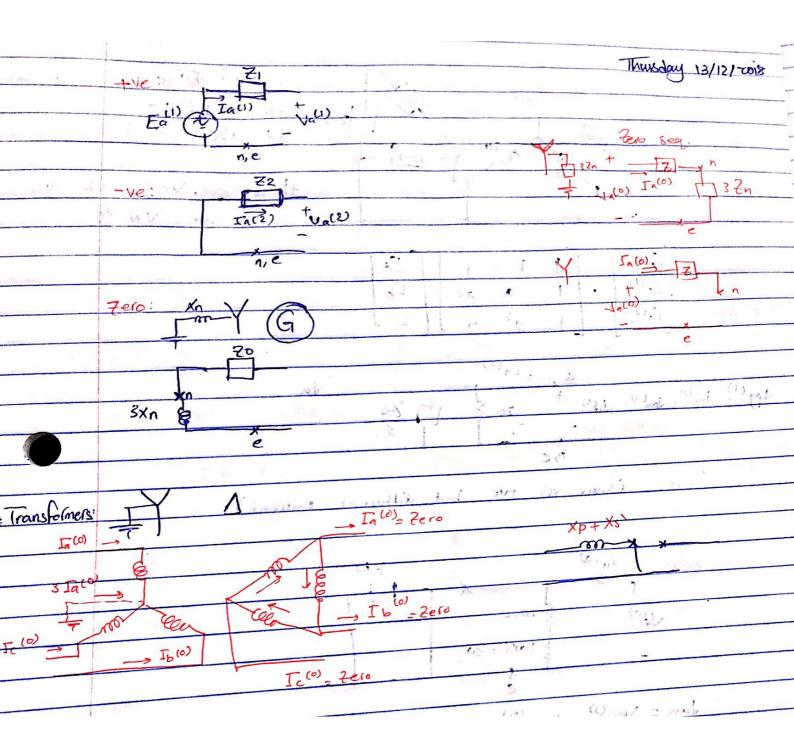
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 $\Gamma_{q} = 100 \chi^{\circ} A$   $\Gamma_{b} = 80 \chi^{2} u^{\circ} A$   $\Gamma_{c} = 120 \chi^{1} 30^{\circ} A$ Existen (20) 25 >70 Bud Var, Vag, Vab, Va Nac, VN ?? 10 20 20 20 Ia Schuliconi Ta (o) Tb a2 Jau) a To a2 Ig(2) 9 , Tall) Va Jag (1) Jack July = Jall + 12 20 20 ne (some as the but different entrent) -ve' Ia (0) 20 Fero: Valo) 3 1013 = 30 \*e Van = Van<sup>(2)</sup> + Van<sup>(2)</sup> + Van<sup>(0)</sup> van = Fa<sup>(1)</sup>(20/170) + Ta<sup>(2)</sup>(20/1720) + Ta<sup>(0)</sup>(70)  $be = Vau + V_N$   $\rightarrow Z_N$ .  $Vae = V + 3Ia^{(0)}(10)$ 

2 Van(0) Van Van(1) a2 Vbn 9 ١ = Van(2) 5 az Vcn R 3 1512 1 -1 11 Vab - Van - Ubn -20, 0 Nbc = Nbn - Vcn \* t.ur Ja = Var = Van + VN. ~9 21-0 :13 fault. Ja' G .... ZOMUA, 13.8 KV Example: JopuA find Vag? 71= 12.382 13.8 KV N bg = 8.071 × 102 KV. Z2= j3.33 2 Vcg = 8.071 \$ 102° ×V solidly grounded. 20 = jo. 95 r Solve in pu? Ib=0 Nab, Vbc, Vca ? (system unleaded (pre fault, UF = 1200 pu (pre fault, Voitage). IGEO Vag = Zero al: 111 Nalo) Val Lin 1.01 Va(1) 165 a a<sup>2</sup> ١ Vale VC ١ ar a Nab = Vag - Vibg. 21 t Val) Ia(1) = Va(1) Taci 1800 Lop. A Z1 Va (2) Zing Ja(2) 22 22/ Ig(2) = - Va(0) Iq (o) Va(2) . NIE 70  $Ta = Ia^{(0)} + Ia^{(1)} + Ia^{(2)}$ fourth e Ta(d) r (o) Zerd F 5.(0) 54 55 = Ic current. Ĩ 9 92 Ig(1) + (2)

Sunday 16/12/2018 , No Zaro seq. x(1)=0.2p. \* Unbalanced fault analysis à × (2) = 0. 21 py LG foult ZZOKV/IIIN LG LLG MKU/ZZOKU GZ Xo = 0.1pm IKV T.L Example. Gi XI=Y2 MS Fajoros = 0.105 X0=01315 base: FY 100 MUA 15  $X_1 = X_2 = X_0$ pre-faut V= 1.05Ko XI =X2 =10 Neglect Load current. x (1)= 0.15 pm = 0.1 pm = 0-1 p x (2) = 0.177n Xo = 0.05 74 Solution .. Zth = Z1 = jo-105 - ijou As days segnence m m (jo.15+ jo.1+ jo.1+ jo15) / joz E jo.2 jo.1 = NOTESTOCK . 810.15 53.6× 64 1.05 \$ 00 = јо. 1389 ри. -05 Ko reis Ballar U sequence Ne jat 5 10.1456 pm. m m 10:21 Th= Zz= jolos 10.1 (1) 10.17 (1). 36 S 1 Zero sequence jo.315 jo1 10.1 m m m T jail 1) joils jo.05 open close (1) (5) open close 5-1 131 ZH = Zo = 10.25 Theorinin: [ curls SP (1) . [ \$51.71

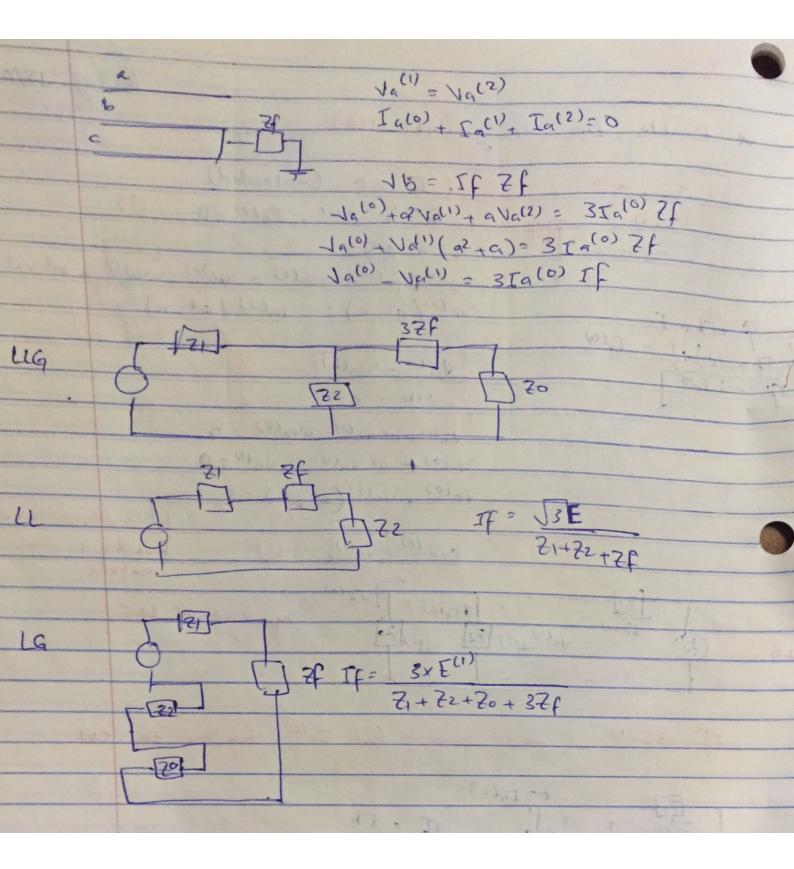
	E <sup>(1)</sup> = 1.05 × 0 pr. = NF.
	$7_{1} = 10.1389 p^{4}$
	Z2= jo. 1456 pm.
	20 = jo:25 pu.
¥	unloaded in the state of the state of the
	LG to many strain the strain the
	$a \rightarrow If \gamma Va=0$ $I_{a}(0)$ $1 1 I I I I I$
	I Ia(1) = 1 a a2 Ib) Ecro
- 19	Incol I a? a Tepzero
	No- OF IF ZF USISI
	$V_{a} = 0^{-9} \text{ If } \overline{zf} \stackrel{(1)}{=} 1^{-9} \frac{1}{2} I_{a} = \frac{1}{2} I_{a} I_{a}$
	$V_{a}^{(0)} + V_{a}^{(1)} + V_{a}^{(2)} = 0$ $I_{a}^{(0)} = \frac{1}{3}I_{a} = \frac{1}{3}I_{f}$ $I_{a}^{(0)} = I_{a}^{(1)} = I_{a}^{(2)}$
1	$Ia^{(1)} = \frac{1}{3} Ia = \frac{1}{3} If  [a^{(1)} = 1]a^{(1)}$
	$Ia = \frac{1}{3} Ia = \frac{1}{3} I$ $Ia (1) = \frac{1}{3} Ia$
	3
	the - Ne tero equ. ckts are coupled. Iqui
	G jo. 1389pn. + +Ve
1 46	$T_{a}^{(0)} = T_{a}^{(0)} = T_{a}^{(0)} = T_{a}^{(0)}$
[.05	
	$\overline{\overline{21+22+20}}$
	$Ta^{(2)}$ $Tf = Ia^{(1)} + Ia^{(2)} + Ia^{(0)}$
	$\frac{1}{56} = \frac{1}{\sqrt{12}} - \frac{1}{\sqrt{12}} = 3 I_{a}^{(0)}$
jo.10	$\frac{1}{F} = 3 \times 1.05 \times 0$
.	Jaco Autor al Lating Zitizz st Zoil al Lorgen
jo.	
	- (P850 FF.) =""ifj 5.8 (Prote ")" if
1	
1	( d'mal) ( ) ( dial - ( dial)

If if we TEL b had 2f 100 C  $V_{q(0)} + V_{q(1)} + V_{q(2)} = (I_{a}^{(0)} + I_{a}^{(1)} + I_{q}^{(2)}) \neq$ Va = If Zf shool 121 Ja(0) + Va(1) + Va(2) = 3 Ia(0) 7f In (c) = 1.05 \$ 00. 21+22+20+32F (0) 1 min steps! () the seq. - therining Lang Lai en Th 613 () -ve seq. is theoring convent D-s Y (1) .7 3 zero Seq. -> theolinin Wit Fro)  $TF = 3Ia^{(0)} = 3E^{(1)}$   $Z_{1+} Z_{2+} Z_{0+} 3Z_{f}$ · ) 05201 (0),1 SV. 020101 (c), I Va Nb Vc at fault location: going back 10.05 to previous (0) Juge Question Na (1) = 1.05 \$0° - Ia(1) (10.1389)  $\frac{Va^{(2)}}{Va^{(0)}} = -Ia^{(2)}(jo_{145}6)$   $Va^{(0)} = -Ia^{(0)}(jo_{25})$ ( 2F) • Va=0 Vb=1.166-j0.178pm. Va] F1 17[ Va<sup>(6)</sup> · VC = 1. 166 + jo. 178 pu. Va(1) a<sup>2</sup> a 16 Val2) a a<sup>2</sup> VC

LL fault : - Jaco 15 1 Currents, [Ia(0) Fa [all) a al C1' = [ - Ib Tall 1.92 a Ic  $I_{a}^{(0)} = \frac{1}{3} (I_{a} + I_{b} + I_{c})^{\circ} = 0$ 9 .... •  $T_a = 0$ •  $T_a^{(1)} = - T_a^{(2)}$  $\frac{T_a^{(1)} = 1}{3} \left( a \ Ib - a^2 \ Ib \right)$ 75+25+15 Ia (2) = 1 ( a' Ib - a Ib) (1) --17  $\frac{1}{4} \frac{1}{4} \frac{1}$  $Va^{(1)}(a^2-a) = Va^{(2)}(a^2-a)$ Val2) = Val2)  $- \begin{bmatrix} 21 \\ 3 \\ -1 \end{bmatrix} + \begin{bmatrix} 1a^{(1)} \\ 3 \\ -1a^{(1)} \end{bmatrix} + \begin{bmatrix} 1a^{(1)$ Ia(2) + 22 Va<sup>(2)</sup> La<sup>(2)</sup>  $I_{a}^{(1)} = 1.05 = 3.691 - 90^{\circ}$ Z1+ 22 1.05 \$0 TRACA Ig 7  $\frac{1}{16} = -6.39$ 3.691 X-90 -3.691 X-90 П a2 9 -1 Ic az a IC = 6.39 Ib = If.

1 June 1 Vb = + VC if we Nb-Vc=ZFIF had 2f E1 21 197 21 1) .-72 21 71 2 Ial": 1.05 [ Lal 21+22+2f  $Tf = Tb = Ta^{(0)} + a^2 Ta^{(1)} + a Ta^{(1)}$ = q2 Ia(1) - a Ia(1)  $= (a^{2} - a) I_{a}(1)$  $IF = \sqrt{3}$ IF LL Z1+Z2+Zf 1 X2no - 1×120 = JS ATA  $If = 3 \times E^{(i)}$ LG Z1+72+20+32f 32 = NU

Inesday 18/12, \* Double line to ground: (UG) · Ia = 0 (unloaded) b - Th In(0) = In(1) = In(2) = 0 -- () c - i Ie - NO = VC  $V_{0}(0) + qV_{0}(2) = V_{0}(0) + qV_{0}(1) + q^{2}V_{0}(1)$ o IF = Th+ F Vali (a2-a) = Val2) (a2-a)  $\frac{\overline{T_q} + \overline{T_b} + \overline{T_c} \times 1}{\overline{T_f} = 3 \overline{T_q}^{(0)}}$ Va() = Va(2) -- 0 319 . vb = 0 Va(0) + q2 Va(1) + qVa(2) = 0 Valo) + a2 Val) + aVal) = 0 Va(0) + Va(1) (a2 + a) = 0 Va= Va(0) + Va(1) + Va Na (0) = Va(1) - - (3) Find Vb, Vc from  $\frac{\overline{z_1}}{\overline{z_n(v)}} + \frac{1}{\overline{z_n(v)}} + \frac{1}{$ matrix. eqn. ckt LLG LLG. - 1 - F 1 - 1 0 If = 3Ia(0)you have to find Iq (0) from the equ. CKt  $\frac{21}{F_{a}(1)} + \frac{1}{T_{a}(2)} \frac{1}{22}$  $T_{f} = Tb$   $Tb = T_{g}(0) + G^{2}T_{g}(1) + G T_{g}(2)$ EE  $Ib = Ia^{(1)} (a^2 - a)$ IF = J3 E 21+22 Tu) 15(2) 1 22 In 10



T.LS . 1 3 2 x1 = x 2 = 0. 1pm. Transhmery 4 = 0.3 pm. Z-bus! X2=X, = X0 = 62 Thine 2.4 Example: Genero tors 13 G 12 X1 = X2 = 0.2 p.v 55 X = = 0.05 pm. T find 30 Fault at bus Yz C if we had wanted LG & S = find to solve using (unloaded system internal voltage. JE= ito pn. jost 10.05 10.05 -00 -tve. Si jo. 2 jo.E Ejon2 3 10.1 2th of bus 5 1.30 Zth2 = Zth, Cank X1 = X2 C 1 317 50.05 10.3 Find Zero: Jo.05 1. 100to jo.051 5 cloud cloud Bjo.s 10.2 en jo.05 Zast we had Xn add and  $\frac{TLG = 3 \times 140^{\circ}}{Z1 + Z2 + Z0}$ 6y 3 14 :51 Pi · 11 501 22) solve with load & motor: Gind 30 fault at bus (3) using 10 internal voitage method Ss = VSIS # 000 Gi - Vs IlineGi = Sline G2 -> Vs I Live G2 \* = Sline ( Er Toad Ę, 5. "  $(\mathbf{f})$ 

using Zbus! Lons 5 find "UL front (without ) len smoker) at bus s 13 10.1 = VF = 120° ZSS jo.175 jo. jo.125 Y-1 7= 5 - If = 5. 714 X-90° 10.123 IF. 6 = S. 714 X-210° jo.145 IF, c = 5.714 × 30° bus 5 10.05 7(0)= 10.1 7=4-1 j'0.2 : jo.3 1 5.0 V?  $V_1 = V_1 + \Delta V_1$ V1 = V5 - Z15 If V10=0. 42857, 50°, INS 1 VI, b = 0. 42857 X-120 VILC = 0. 4 2857 ×120° N3=Nf-Z35 If V3 - V4 Iline 3, 4 = manno Ju= NF - Zus If 10'

-\* Zous (Fault at bus 5 IfIG = 3 x EUN VE 255(1) + 255(0) + 255(2) if we asked for LL YOU Ifa (0) = 1 IIGIfall) = 1 ILG Ifa (1)=Ifa (0)= Ifa (2)  $\frac{\Gamma_{\text{Fa}}(2) = 1}{3} \frac{\Gamma_{\text{IG}}}{3}$ Zus (1) find. U. ?? Vijb Vije unbalanced System.  $V_{1} = V_{1}a^{(0)} + V_{1}a^{(1)}$ 375 + V1,4(2) 21(2) NI, a(1)  $= \sqrt{F - Eis IF, a(1)}$  $r_{,a}(2) = 0 - Z_{15}(2) If_{,a}(2)$ ,  $a(0) = 0 - Z_{15}(0) If_{,a}(0)$ 2550) Vi, alos Nig 1,6 V1, q(0) 92 9 Luc Vi, all) 92 1 N1,9(2)