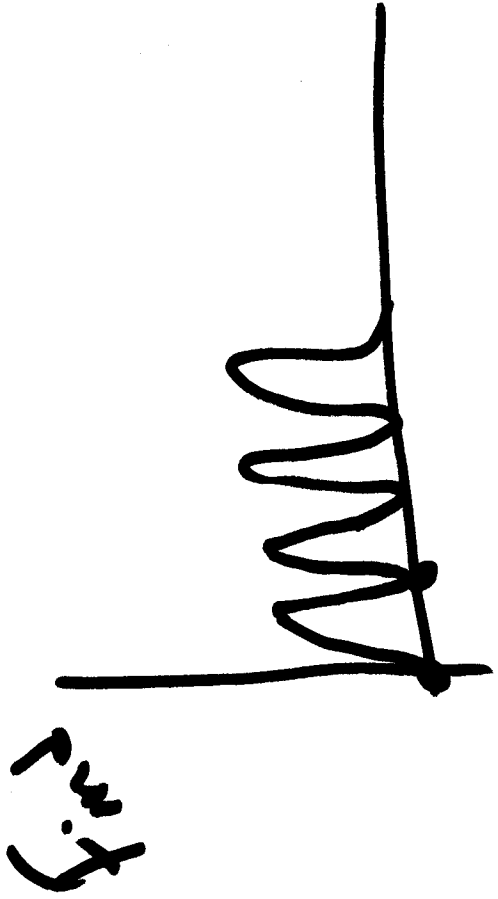
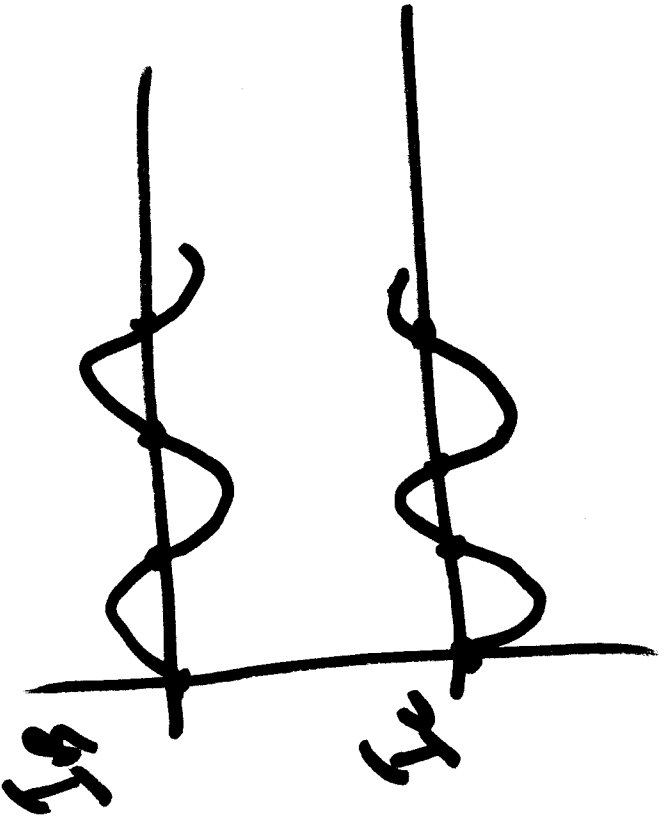


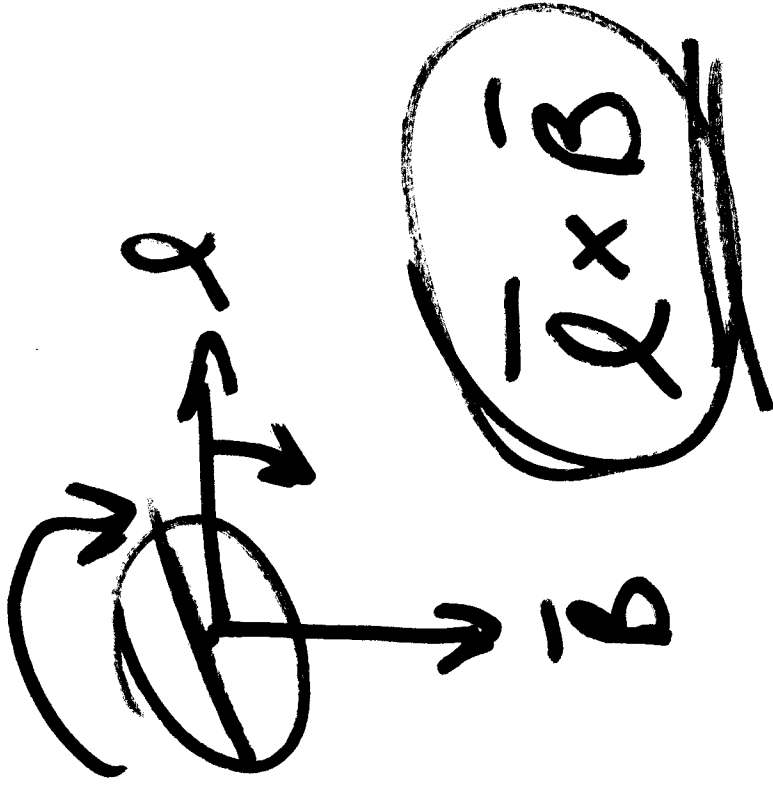
Topics for Today:

- Announcements
 - Help session hrs: TBA
 - Office: EERC 614. Phone: 906.487.2857
 - Recommended problems from Ch.3, solutions posted
- Transformers and circuits w/transformers
 - Paralleling of transformers
 - Proportioning of MVA flow for unequal MVA size, unlike impedances
 - Circuit calculations for above cases
 - Design and operations issues
 - Phase shifting transformers
 - Admittance matrix methods to simplify transformer calculations.
 - Remaining topics will be covered again in context of system operation & analysis, i.e. Chapters 7 and 8. We can introduce main concepts here:
 - Per phase Pi-equivalent for off-nominal turns ratio, phase shifts, etc.
 - Incorporation in system admittance matrix for short-circuit and load flow

Synchronous Machines - Chapter 3

- Recommended problems & solns for Ch.3 are posted.
- Phasor diagrams - unity, lag, lead
- Salient rotor machines - calculation with X_d and X_q .
- Calculation Example(s)
- P & Q flows thru transmission lines
- More on admittance matrix $[Y]$ construction





Screw moves
into page.

THREE PHASE
60 HERTZ
TYPE 8L
LTC AUTO
TRANSFORMER
CLASS 0A/FA
INSULDUR INSULATION

WINDING
 138000 GRD.Y VOLTS
 69000 GRD.Y VOLTS

55° C. AVG. RISE
 50000/66666 KVA
 50000/66666 KVA

65° C. AVG. RISE
 56000/74666 KVA
 56000/74666 KVA

ORIGINAL INSTRUCTION BOOK RNP-11061
L-SPEC XLL7952-08

SERIAL XLL7952

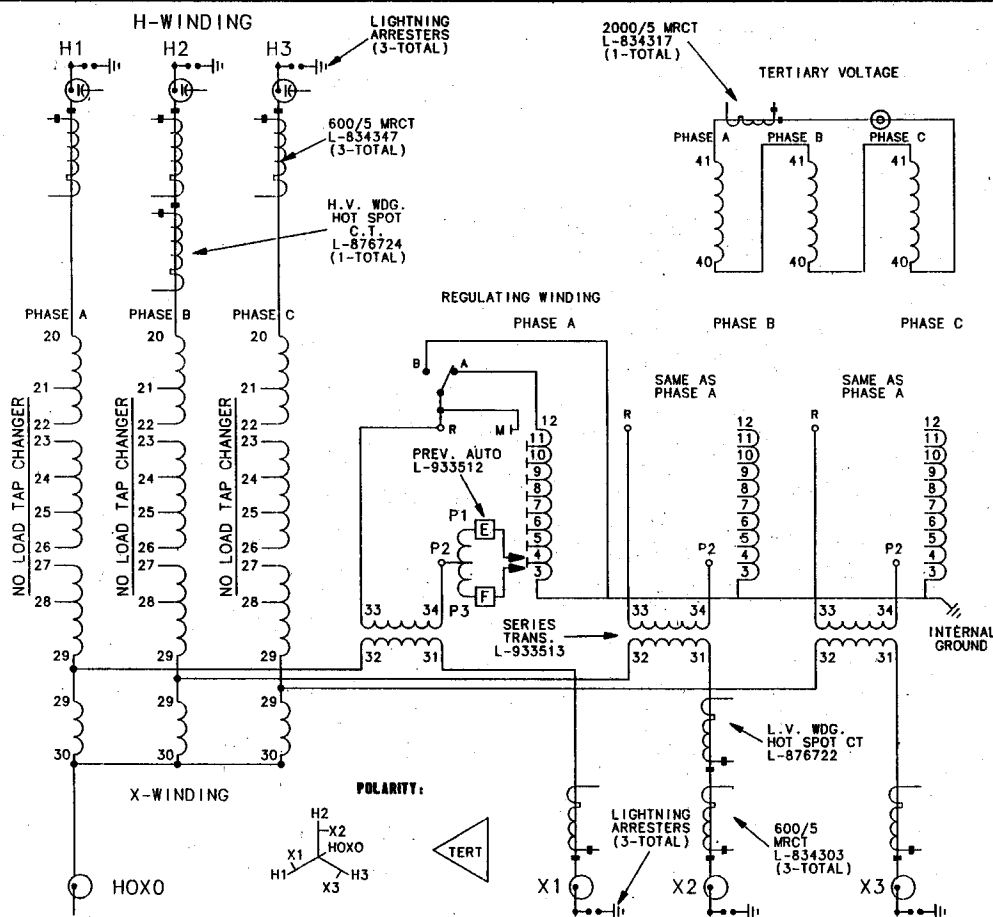
#GALLONS OIL: TRANS. TANK 15717 **LOAD TAP CHANGER COMPARTMENT** 360 **MFG. DATE** 7/95

POS SEQ. IMPEDANCE 4.69 % AT 50000 KVA, 138000 TO 69000 VOLTS
ZERO SEQ. IMPEDANCE 3.27 % AT 10131 KVA, 138000 TO 6900 VOLTS
ZERO SEQ. IMPEDANCE 2.83 % AT 10131 KVA, 69000 TO 6900 VOLTS

FULL WAVE IMPULSE TEST LEVEL: H-WDG 650 KV, X-WDG 350 KV,
 HOXO NEUT. 110 KV, TERTIARY 110 KV.

APPROX. WEIGHT IN LBS. CORE AND COILS 102200 **CASE** 88100 **OIL** 127200 **TOTAL** 317500

CAUTION: DO NOT ATTEMPT TO HANDLE, INSTALL, USE OR SERVICE THIS TRANSFORMER BEFORE READING INSTRUCTION BOOK XLL7952-12. TO DO SO MAY LEAD TO BODILY INJURY OR PROPERTY DAMAGE OR BOTH.



CONNECTIONS							
WINDING	VOLTS	MAX. 55° C. AMPERES	DE-ENERGIZED TAP CHANGER			LOAD TAP CHANGER	
			POS.	CONNECTS		POSITION	CONNECTS
HIGH VOLTAGE GRD. WYE	144900	265.6	1	22 - 23	27 - 26		
	141450	272.1	2	21 - 23	27 - 26		
	138000	278.9	3	21 - 24	27 - 26		
	134550	286.1	4	21 - 24	28 - 26		
	131100	293.6	5	21 - 24	28 - 25		
LOW VOLTAGE GRD. WYE	62100	588				LOWER	16 4 4 A
	62963	588				14 5 5 A	
	63825	588				12 6 6 A	
	64688	588				10 7 7 A	
	65550	588				8 8 8 A	
	66413	588				6 9 9 A	
	67275	588				4 10 10 A	
	68138	588				2 11 11 A	
	69000	588				N M M A	
	69863	551				2 4 4 B	
	70725	544				4 5 5 B	
	71588	538				6 6 6 B	
	72450	531				8 7 7 B	
	73313	525				10 8 8 B	
	74175	519				12 9 9 B	
	75038	513				14 10 10 B	
75900	507	16 11 11 B					

THIS IS A REPAIR OF ORIGINAL WESTINGHOUSE TRANSFORMER SERIAL #RNP-11061.
 * 0.3% OF D.B.P.C.

CONDUCTOR MATERIALS - H.V. CU., X.V. CU., TERT. CU.

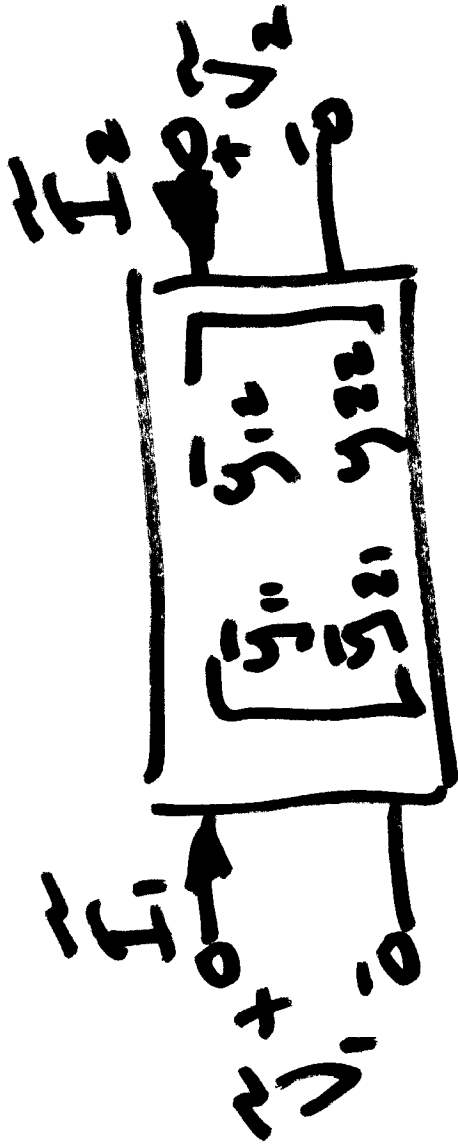
VOLTAGE AND CURRENT RATINGS FOR ODD NUMBERED POSITIONS OF LOAD TAP CHANGER ARE MIDWAY BETWEEN THOSE LISTED ABOVE.
 THE 25°C LIQUID LEVEL IS 15.88 INCHES BELOW TOP OF HIGHEST MANHOLE FLANGE. LIQUID LEVEL CHANGES 1.188 INCHES FOR EACH 10°C CHANGES IN AVERAGE LIQUID TEMPERATURE.

THE TRANSFORMER MUST NOT BE ENERGIZED FROM ANY VOLTAGE SOURCE WHEN DE-ENERGIZED TAP CHANGERS ARE OPERATED.
 THE TRANSFORMER IS DESIGNED FOR OPERATION BETWEEN PRESSURE LIMITS OF 6.5 POUNDS PER SQUARE INCH POSITIVE AND 6.5 POUNDS PER SQUARE INCH NEGATIVE.
 THE TRANSFORMER TANK AND THE LOAD TAP CHANGER TANK ARE DESIGNED TO WITHSTAND COMPLETE VACUUM EITHER INDIVIDUALLY OR TOGETHER. WHILE VACUUM IS APPLIED TO EITHER ONE ALONE, THE PRESSURE IN THE OTHER MUST NOT BE GREATER THAN ATMOSPHERIC PRESSURE.

THE MAXIMUM CONTINUOUS CURRENT RATING OF THE COMMON WINDING IS 318.7 AMPERES FOR 50000 KVA RATING.

THE TERTIARY WINDING SHORT CIRCUIT CURRENT MUST BE LIMITED TO A MAXIMUM OF 25 TIMES RATED CURRENT BASED ON 10131.4 KVA FOR 2 SECONDS.
 THE H AND X VOLTAGE WINDING NEUTRAL MUST BE PERMANENTLY GROUNDED EITHER DIRECTLY OR THROUGH A LOW IMPEDANCE. IF AN IMPEDANCE IS PLACED IN THE GROUND CIRCUIT, THE VOLTAGE FROM NEUTRAL TO GROUND DURING A FAULT MUST NOT EXCEED 15000 VOLTS.

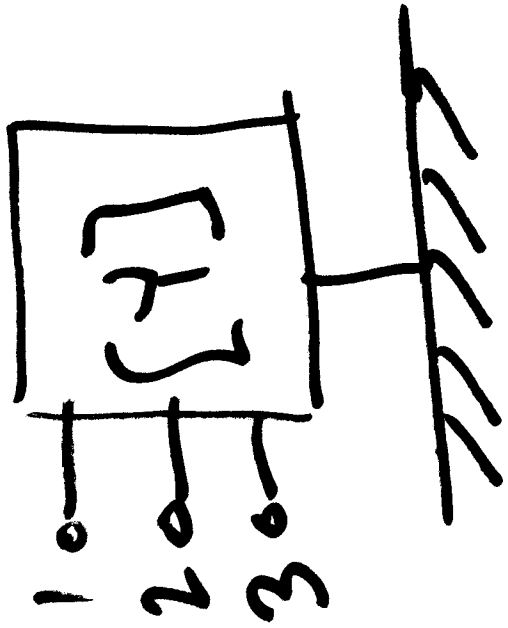
Admittance Approaches



$$\begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

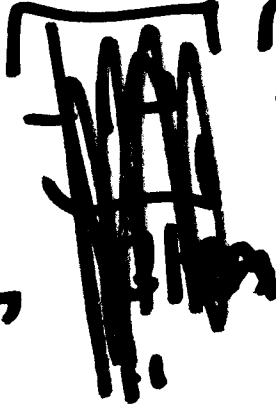
↑ injected!

$$[A] = [L^{-1}]$$



\rightarrow ~~closed~~

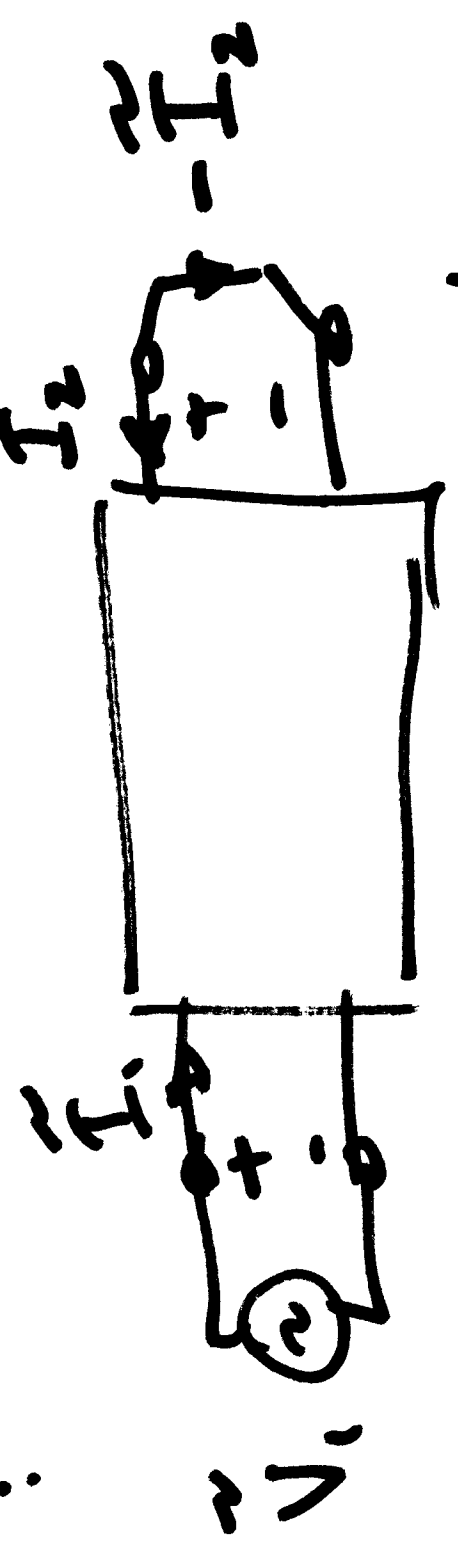
$$y = \frac{1}{3} \dots$$



$$= \frac{1}{3} [L^{-1}]$$

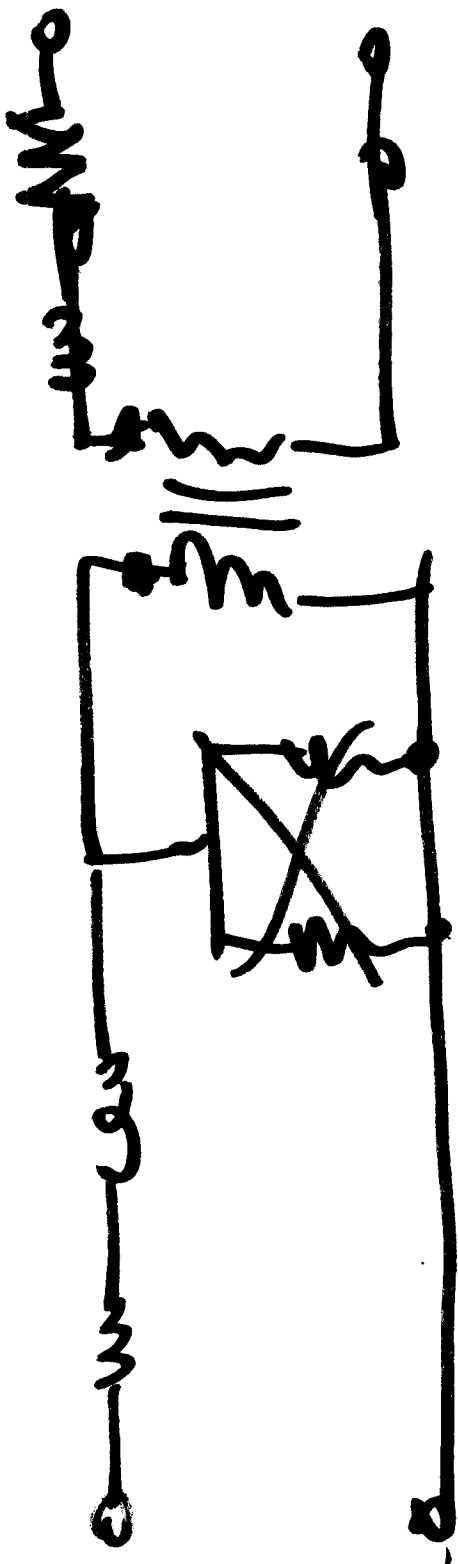
$$[Y] = \frac{1}{3} [L^{-1}]$$

$\vec{y}_1 =$



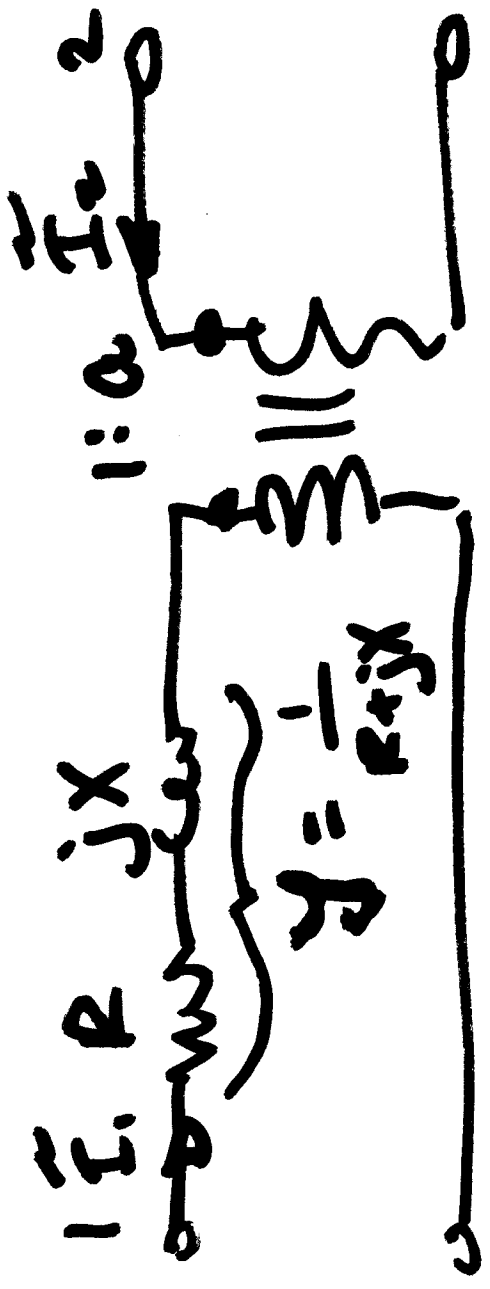
$$\vec{y}_1 = \begin{bmatrix} I_1 \\ V_2 = 0 \end{bmatrix}$$

$$\vec{y}_2 = \begin{bmatrix} I_2 \\ V_1 = 0 \end{bmatrix}$$

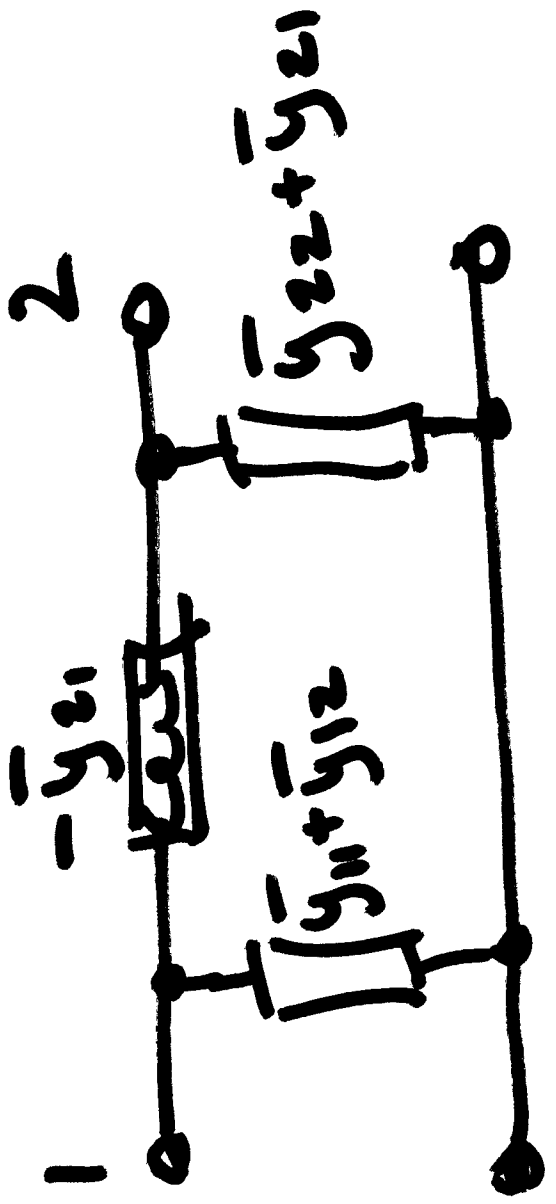


2-port theory

- H param (electronics)
- ABCD params
- Admittance Matrix



$$\begin{bmatrix} \bar{y}_{11} \\ \bar{y}_{21} \end{bmatrix} \begin{bmatrix} \bar{V}_1 \\ \bar{V}_2 \end{bmatrix} = \begin{bmatrix} \bar{H}_{11} \\ \bar{H}_{21} \end{bmatrix}$$



Tap Changing XFMRs - Variations (P.u. Representations)

"From" Bus "To" Bus

$$y_{sc} = \frac{1}{R+jX}$$

"C" is off-nominal turns ratio. In general C is complex.

C is real for LTC.
C is complex for PS.

If $|C| \neq 1$ then magnitude change.
If C is complex, Phase Shift.

