EE 5240 - Lecture 1 Mon Jan 14, 2018

Topics for Today:

- Introductions: course syllabus (being updated)
- Startup
  - Book
  - Software: Matlab, (Cyme, Aspen may be used for benchmarking)
  - Access to EERC 134 (SGOC - Smart Grid Operations Center)
  - May be useful to buy 3-ring binder
  - Use grid paper or white paper for homework submissions.
- Quick Review of Mesh and NODE equations
- Matrix formulations
- Possible Solution Methods
- Buy book, scan through Chapters 1 and 2 for Wed
- Matlab tutorials for beginners, posted on EE5200 web page.
- Pre-Req review notes and video, posted on EE5200 web page

"BIG DATA"

1/2

Traditional

- Data Structures

[Y]

- Algorithms
- Applications

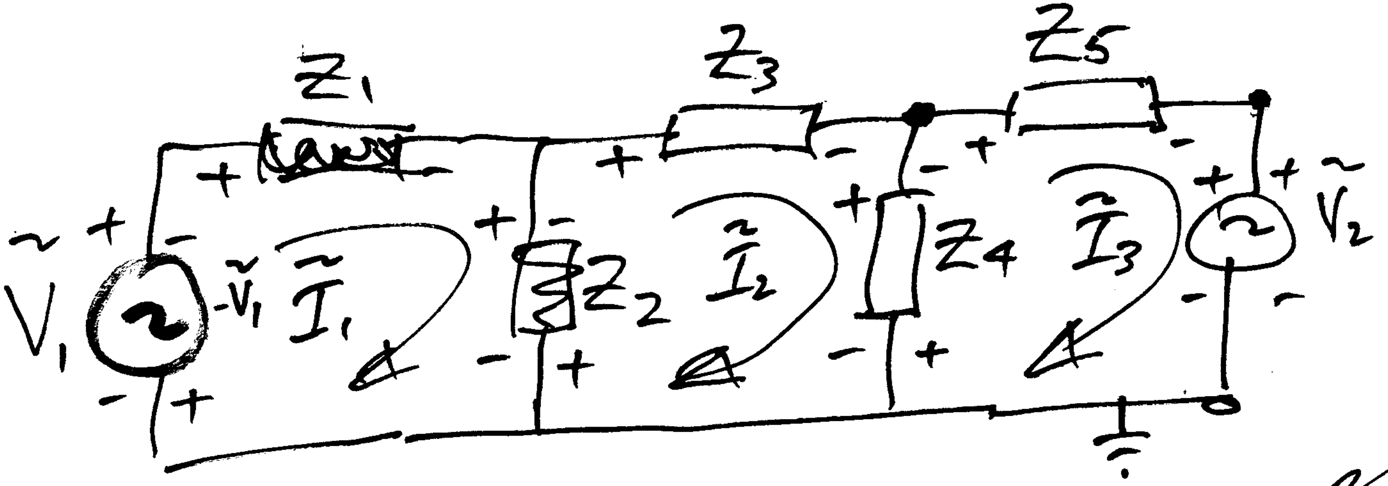
Matlab

- Cyme
- Aspen

New

1/2

- Servers
- Dynamic Flow of data
- Dist Process Algorithms



KVL
$\sum V's = 0$

Mesh 1: $\tilde{V}_1 = Z_1\tilde{I}_1 + Z_2(\tilde{I}_1 - \tilde{I}_2)$

Mesh 2: $0 = Z_2(\tilde{I}_2 - \tilde{I}_1) + Z_3(\tilde{I}_2\cancel{)} + Z_4(I_2 - I_3)$

Mesh 3: $-\tilde{V}_2 = Z_4(\tilde{I}_3 - \tilde{I}_2) + Z_5(\tilde{I}_3)$

In Matrix Form:

$$\underbrace{\begin{bmatrix} \underline{Z_1+Z_2} & -Z_2 & 0 \\ -Z_2 & \underline{Z_2+Z_3+Z_4} & -Z_4 \\ 0 & -Z_4 & \underline{Z_4+Z_5} \end{bmatrix}}_{Z_{LOOP} \text{ or } \underline{\underline{\underline{Z_{MESH}}}}} \underset{\substack{\text{Mesh}\\ \text{Currents}}}{\begin{bmatrix} \tilde{I}_1 \\ \tilde{I}_2 \\ \tilde{I}_3 \end{bmatrix}} = \underset{\substack{\text{Mesh}\\ \text{Voltage}\\ \text{Sources}\\ \text{(usually L-G)}}}{\begin{bmatrix} \tilde{V}_1 \\ 0 \\ -\tilde{V}_2 \end{bmatrix}}$$

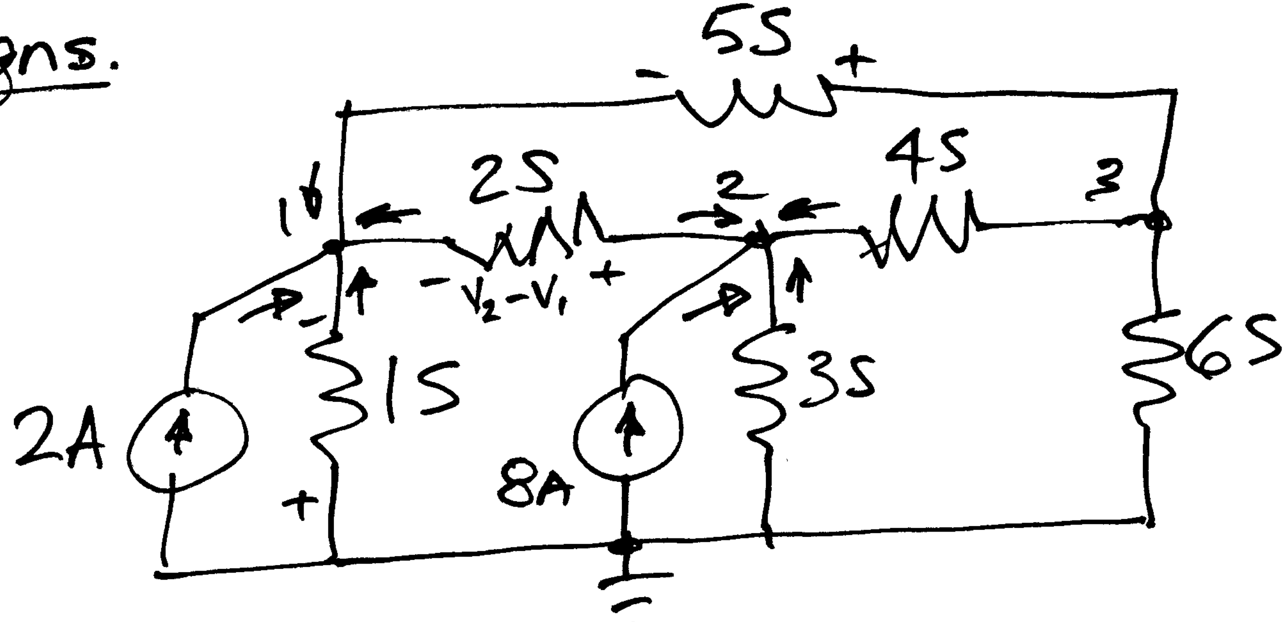
$Z_{NN} = \Sigma Z$s around mesh N (Self-impedance of mesh)

$Z_{NK} = -\Sigma Z$s that are mutual to meshes N & K.

$\tilde{I}$s are mesh currents - not much use in power system analysis.

$\tilde{V}$s usually node voltages, but at inner node of Gen.

Node Eqns.



KCL: $\sum I_{s(IN)} = 0$

Node 1: $2 + (V_2 - \underline{V_1})2 + (V_3 - \underline{V_1})5 + (-\underline{V_1})1$

Node 2: $8 + (V_1 - V_2)2 + (V_3 - V_2)4 + (-V_2)3$

Node 3: $0 + (V_2 - V_3)4 + (V_1 - V_3)5 + (-V_3)6$

In Matrix Form:

$$\underbrace{\begin{bmatrix} 8 & -2 & -5 \\ -2 & 9 & -4 \\ -5 & -4 & 15 \end{bmatrix}}_{\text{Nodal Admit. Matrix}} \underset{\text{Node V's}}{\begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix}} = \underset{\text{Injected Currents}}{\begin{bmatrix} 2 \\ 8 \\ 0 \end{bmatrix}}$$

$[Y_N]$ or $[Y_{BUS}]$

$y_{NN} = +\Sigma$ Admittances "landing" on node N

$y_{NK} = -\Sigma$ Admittances "spanning" between nodes N & K.

Typical System: *Lots of zeroes* in off-diagonal elements

Exploit this by *not* store zero values.

Use *SPARSE Matrix* methods

Key Points:

$$[Z_{MESH}]^{-1} = [Y_{MESH}]$$

$$\underbrace{[Y_{BUS}]^{-1}}_{\text{SPARSE}} = \underbrace{[Z_{BUS}]}_{\text{FULL}}$$

From previous example:

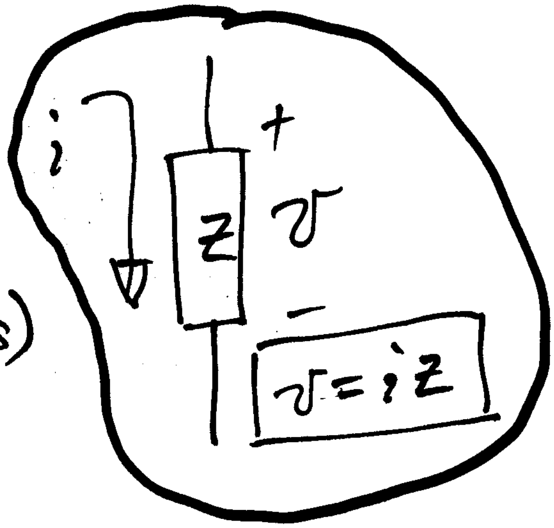
$$\underset{\boxed{\text{KNOWN}}}{[Y_{BUS}]}\underset{\underset{\text{UNKNOWN}}{\uparrow}}{[V_{BUS}]} = \underbrace{[I_{INJ}]}_{\text{Knowns (Generators)}}$$

How to solve?

- Brute force → $[Y_{BUS}]^{-1}[Y_{BUS}][V_{BUS}] = [Y_{BUS}]^{-1}[I_{INJ}]$
- en situ methods
  - Gauss Elimination
  - Gauss-Jordan
  - LU Factorization ← Preferred for large systems

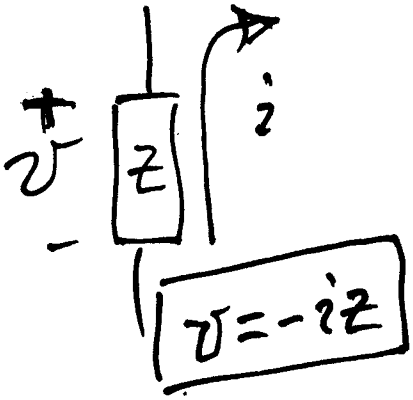
Review -

Passive ~~Voltage Drop~~ Sign convention
- Motors
- Loads (Impedances)



$\boxed{v = iZ}$

Active Sign Convention
- Generators
  (Sources)



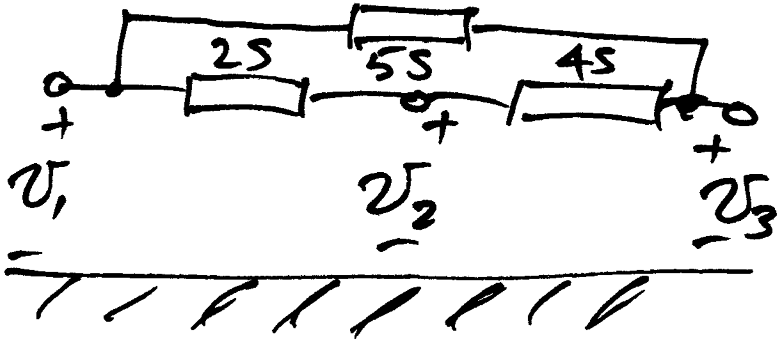
$\boxed{v = -iZ}$

Observations on topology of $[Y_{Bus}]$

- Main diagonal is non-zero
- Most off-diagonal terms are zero (sparse systems) most $y_{nk} = 0$
- Can $[Y_{Bus}]$ always be inverted? (i.e. nonsingular). Singular matrices will produce "divide by zero overflow" and crash program.

  Answer: Make sure you have at least one branch to ground/reference!

Ex:

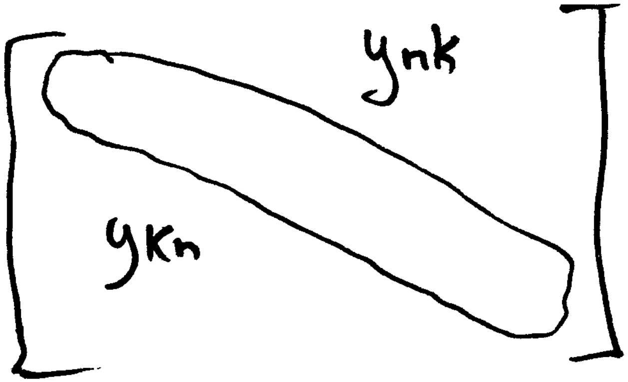


$$[Y_{Bus}] = \begin{bmatrix} +7 & -2 & -5 \\ -2 & +6 & -4 \\ -5 & -4 & +9 \end{bmatrix}$$

Problem to look for:
If Σ of terms in a row is zero, then you're probably dealing with a singular matrix!

TRY TO INVERT with MATLAB!

- Symmetry about main diagonal



If no dependent sources, or phase-shifting xfmrs, then it will be Symmetric.