Topics for Today:

- Announcements
  - Nov 6\textsuperscript{th} - Chance to perfect Detailed Term Project outline (3-level) in format of report **Table of Contents** + complete list of references.
  - Software: online students - apply for ATP/ATPDraw license, verify licensing when you receive it by e-mail, and we will mail you the install CD.
  - ASPEN software - arranging to run off of MTU server via internet.
  - Office: EERC 614. Phone: 906.487.2857
  - Recommended problems & all solutions: Ch.7, 8 solns now posted.

- Chapter 7, 10 - Network Equations, Basic Fault applications
  - Fault current - dc offset. Section 10.1
  - Importance of X/R ratio
  - Circuit breaker ratings
  - Three-Phase fault calcs using [Zbus]. Section 10.3
  - Fault current contributions using [Zbus]. Eqn. (10.21)
  - Admittance approach using [Ybus]
\[ \{Y\} = \{Z\} \quad \{Y_{bus}\} = \{Z_{bus}\} \]

Look at \{Z\} in regards to S.C. calcs.

If \{Z\} is symmetric about the main diagonal (bilateral) then use either row or col.
\[ Z_{nn} = Z_{TH} \text{ at bus } n. \]

* Off-diagonal \( Z \)'s represent the mutual impedances between bus \( n \) & all other buses.

\[ I_{sc} = \frac{V_F}{Z_{nn}} \]

\( V_F \) = Voltage at bus (Voc) pre-fault  

Reference
"Prefault" situation

\[
[Z] = [Y]^{-1}
\]

Lines, XFMRS, LOADS, SHUNT CAP, REACTORS 3
(for this case, also the Gen Impedances) *

Ex: Fig 7.5

Reference

IF there is a fault at bus n in system,

\[
V_{F,Bn} \sim \frac{V_F}{Z_{nn}}
\]

\[\bar{I}_F = \frac{\tilde{V}_F}{Z_{nn}}\]

Often assume that \(V_F = 1.05/\sqrt{3}\) p.u.
\[ V_i = V_F - I_F Z_m \]

\[ I_n = -I_F, \text{ injected into bus} \ n \]

\[ V_{\text{drops due to } I_F} \]

\[ I_Z_m = V_F \]

\[ \begin{bmatrix} \cdots & 2 \text{in} & \cdots \\ 2 \text{in} \\ 2 \text{in} \\ \vdots \\ 2 \text{in} \\ 0 & \vdots & 0 \end{bmatrix} = \begin{bmatrix} \text{In} \\ \text{In} \\ \text{In} \\ \vdots \\ \text{In} \\ \text{In} \end{bmatrix} \]
What happens at other buses during the fault? All bus voltages will dip. How much?

During Fault

\[ E_i = V_F - \frac{I_F}{Z_{mn}} \]

\[ = V_F - \frac{V_F}{Z_{mn}} \cdot 2_{in} \]

\[ = V_F - \frac{2_{in}}{Z_{mn}} V_F = \bar{V}_F \left( 1 - \frac{2_{in}}{Z_{mn}} \right) \]
Fault Contributions (i.e. current)

Must Know

I_{Fault cont}: Are CBS going to be able to interrupt?

- Relay engineers must know all current flows.
Referring to your Text, current contributions are

\[ [Z]^{-1} = \begin{bmatrix} \vdots \\ y_{m} \vdots \end{bmatrix} \]

\[ y_{ng} \quad \text{only non-zero values in row \( n \)} \]

\[ \bar{I}_{\text{From}} = \begin{cases} (V_g - V_n)(-y_{ng}) \\ (V_j - V_n)(-y_{nj}) \\ (V_k - V_n)(-y_{nk}) \end{cases} \]
P.6 method OK for Short-Line Connections.

- What about Pi-equiv Line
- Shunt Load
- Shunt Cap/React?

*Must include effect of Shunt Cap, unless $V_n = 0$.

More on this later, and in EE5240.

Not a contributor to 60-Hz Short-Circuit Current.
Begin with practical use of $[Z]$

Thevenin Impedance: Main diagonal element of $[Z_{bus}]$

Useful to know $Z_{TH}$ at bus

Prefault Voltage $\bar{V}_{TH}$

$\bar{I}_f = \frac{\bar{V}_{TH}}{Z_{kk}}$
Admittance Method to Calculate $I_{sc}$

\[
[Y] \begin{bmatrix} V_1 \\ V_m \\ V_N \end{bmatrix} = [I_{inj}]
\]

When building $[Y_{bus}]$

\[
\bar{Y}_{nn} = \frac{1}{R + jX} + jB_c + \frac{1}{R_T + jX_T} + \frac{1}{Z_L} + \frac{10^{15}}{Z_F} \equiv \infty
\]
Matlab
- Program a function of time.
- Plot.

Eqn: $I_{sc}$ of Synch Gen.

$X_d$ offset $\rightarrow t$

$X_s \approx X_d$

- $I_{true \, rms}$ (text).
- $I_{peak \, envelope}$
- $i(t)$