HOMEWORK # 4 - deadline : December 13, 2019

Consider the system used in the lecture "Dynamic simulation of a 5-bus system".

Change the model of the load at bus 2 into a constant admittance (see next slide).

Consider the following initial operating point and generator inertia :

variant No	1	2	3	4
operating point No	1	2	1	2
inertia constant H (s)	3.	4.	3.	4.

Part 1.

Using RAMSES, determine with an accuracy of 0.01 s the Critical Clearing Time (CCT) of a short-circuit without impedance on line "1-3", next to bus 3, cleared by opening that line (which remains open).

Devise a procedure to compute the CCT that tends to minimize the number of time simulations. *Describe it in the report.*

Changes in the `dyn.dat` file

change to 3 if requested

```
# synchronous machine

#              name bus FP    FQ    P     Q     NOM   Pnom   H    D    IBRATIO
SYNC_MACH      G5   5   1.    1.    0.    0.    500.  460.   4.   0.   2.05
#  mod_type Xl    Xd    X'd   X"d   Xq    X'q   X"q    m    n        Ra   T'do  T"do  T'qo  T"qo
    XT      0.15  2.2   0.3   0.2   2.    0.4   0.2    0.   6.0257   0.   7.00  0.05  1.5   0.05
# EXC  model_name      G    Ta   Tb    Te    vfmin  vfmax
  EXC  exc_GENERIC3    70.  1.   1.    0.40  0.     5.
# Kpss   Tw    T1     T2      T3     T4      C
   50.   5.    0.323  0.0138  0.323  0.0138  0.06
# if1lim  if2lim  Toel    Koel   L1     L2    L3
   2.90    1.00    8.0     2.0   -1.10  0.10  0.20
# TOR  model_name        sigma  Tmes  Tsm   zdotmin zdotmax  zmin  zmax  Thp  fhp  Tr   fmp  Tlp
  TOR  THERMAL_GENERIC1  0.04   0.10  0.40  -0.05    0.05    0.0   1.0   0.3  0.4  5.0  0.3  0.3  ;

# induction machines
```

comment with a #

```
#                name         bus   FP   FQ   P   Q   SNOM   RS    LLS   LSR   RR    LLR   H   A   B   LF
INJEC INDMACH1   Small_Motor  2     0.2  0.2  0.  0.  0.    0.031 0.100 3.200 0.018 0.180 0.7 0.5 0.0 0.6 ;
INJEC INDMACH1   Large_Motor  2     0.2  0.2  0.  0.  0.    0.013 0.067 3.800 0.009 0.170 1.5 0.5 0.0 0.8 ;

# voltage dependent load
```

change FP and FQ to 1.0

```
#                name            bus   FP   FQ   P   Q   Dp  a1   alpha1  a2  alpha2  alpha3  Dq  b1   beta1  b2  beta2  beta3
INJEC vfd_load   Impedance_Load  2     0.6  0.6  0.  0.  0.  1.0  2.0     0.  0.      0.      0.  1.0  2.0    0.  0.     0.
#                Vinit  Vlow  foption  Tmes
                 0.     0.7   0        0.1  ;
```

Part 2.

Compute the same CCT using the equal-area criterion.

- Take $X' = X'_d$ and assume a constant mechanical power P_m for the generator
- for simplicity it can be assumed that the generator does not produce active power during the fault.

Hint. The Thévenin equivalent seen by generator G5 may be obtained from :

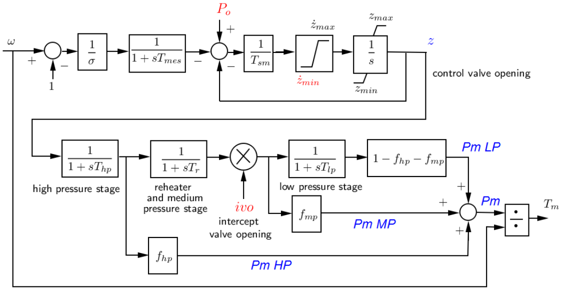
$$\boldsymbol{I} = \boldsymbol{Y}\boldsymbol{V}$$

where $\boldsymbol{Y}$ is 5×5 the nodal admittance matrix (ignoring generator G5, of course)
$\boldsymbol{I}$ is the vector of complex currents injected at the buses
$\boldsymbol{V}$ is the vector of complex voltages at the buses.

The Matlab script `ini.m` provides the $\boldsymbol{Y}_o$ matrix corresponding to the 4 lines and the 2 transformers, in the initial system configuration. $\boldsymbol{Y}$ is obtained from $\boldsymbol{Y}_o$ by adding the contributions of the load at bus 2 and the external system at bus 1. Replace the latter by its Norton equivalent.

Explain your computations in detail. Please append your MATLAB code

Part 3. Simulation of a *temporary* fast valving in the 5-bus system



- The intercept valve *starts* closing 0.06 s after the fault appears; this is the delay to take the decision of closing, based on measurements
- the maximum rate of decrease of `ivo` is 1 pu / 0.3 s
- once it is fully closed, there is dead time before the intercept valve can re-open (required by servomotors) : 3 s
- the maximum rate of re-opening is 1 pu / 10 s
- RAMSES syntax: to change `ivo` at time `t` by `delta` pu in `tvar` seconds :

```
t CHGPRM TOR G5 ivo delta tvar
```

Consider operating point #1.

Set the inertia constant of generator g5 to $H = 3$ s.

Consider the same fault as in Parts 1 and 2, cleared after the following times :

variant No	1	2	3	4
clearing time (s)	0.11	0.12	0.13	0.14

- Observe that without fast valving, the system is unstable.
- Simulate the system evolution with fast valving, until the generator has fully recovered its pre-fault active power. Check that the system is stabilized..
- Comment on the evolution of the active power produced by the generator. Which uncomfortable transient is observed ? Explain it qualitatively using the equal area criterion.