UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Pertama
Sidang Akademik 1995/96

Oktober-November 1995

EEE 467 - Penggunaan Komputer Dalam Kejuruteraan Kuasa

Masa [3 jam]

ARAHAN KEPADA CALON :

Sila pastikan bahawa kertas peperiksaan ini mengandungi 12 muka surat bercetak dan **ENAM (6)** soalan sebelum anda memulakan peperiksaan ini.

Jawab mana-mana **LIMA (5)** soalan.

Agihan markah bagi soalan diberikan di sut sebelah kanan soalan berkenaan.

Jawab semua soalan di dalam Bahasa Malaysia.

...2/-

1. (a) **Berikan takrifan betul dan lengkap komponen simetri dan kegunaan utamanya.**

Give a correct and complete definition of symmetrical components and its main applications.

(25%)

(b) **Jelaskan apa yang dimaksudkan dengan rangkaian jujukan berdasarkan impedan, voltan dan arus jujukan (Lakar gambarajah sekiranya perlu).**

Elaborate what it is meant by sequence network in terms of sequence impedance, voltage and current (Give illustration if necessary).

(25%)

(c) **Suatu talian tiga fasa yang membekalkan tenaga kepada beban seimbang Y mempunyai kegagalan siri pada satu fasa, iaitu, kegagalan satu talian terbuka (OLO) pada fasa b. Neutral beban dibumikan padu dan arus talian tak seimbang adalah**

A three-phase line feeding a balanced-Y load has a series fault on one of its phases , that is, one line open (OLO) fault on phase b. The load neutral is solidly grounded, and the unbalanced line currents are

$$\begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix} = \begin{bmatrix} 10\angle 0^0 \\ 0 \\ 10\angle 120^0 \end{bmatrix} A$$

Sistem ini diilustrasikan dalam Rajah S1. Kira

The system is illustrated in Fig. S1. Calculate

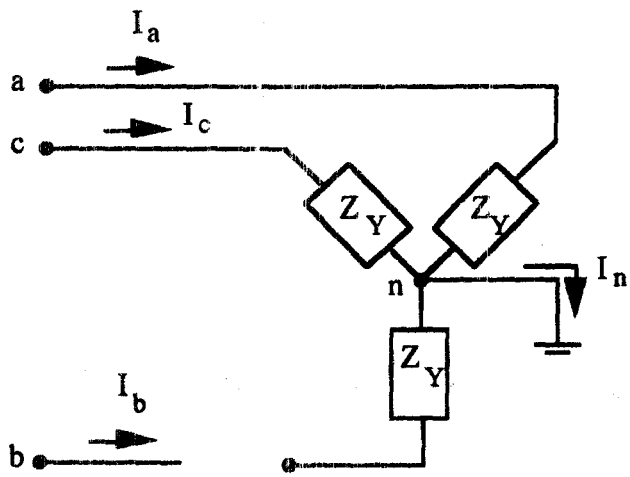
(i) **arus jujukan dan arus neutral**
The sequence currents and the neutral current

...3/-

(ii) Sahkan nilai arus fasa melalui arus jujukan yang diperolehi dalam (i).

Verify the results of phase currents by means of sequence currents obtained in (i).

(50%)

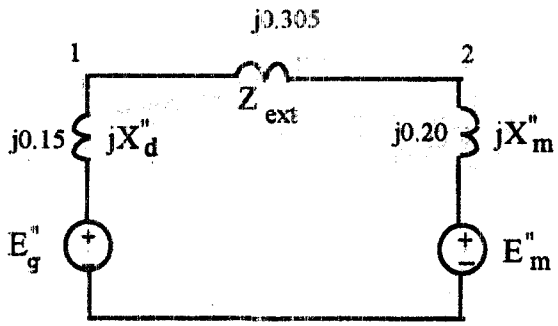


Rajah S1

Fig. S1

2. Gambarajah reaktan sistem kuasa mudah 2 bas ditunjukkan dalam Rajah S2 dengan nilai impedan dalam per unit. Impedan Z_{ext} termasuklah reaktan transformer dan talian. Voltan sebelum kegagalan ialah $1.05\angle 0^o$ per unit dan arus beban sebelum kegagalan diabaikan.

A reactance diagram of a simple 2-bus system is shown in Fig. S2 with all values are in per unit. Z_{ext} includes reactances of transformers and transmission line. The prefault voltage is $1.05\angle 0^o$ per unit and prefault load current is neglected.



Rajah S2
Fig. S2

(a) **Cari matriks admitan bas 2 x 2, Y_{bas}.**
Find the 2 x 2 bus admittance matrix, Y_{bus}. (10%)

(b) **Tentukan matriks impedan bas 2 x 2, Z_{bas}, yang bersepadanan melalui penyongsangan matriks.**

Determine the corresponding 2 x 2 bus impedance matrix Z_{bus}, by matrix inversion.

(10%)

(c) **Untuk litar pintas tiga fasa bolt pada bas 1, gunakan Z_{bas} untuk mengira arus kegagalan subtransien dan sumbangan kepada arus kegagalan dari cabang gabungan talian dan transformer.**

For a bolted three-phase short circuit at bus 1, use Z_{bus} to calculate the substransient fault current and the contribution to the fault current from a combined transformers and transmission line branch.

(40%)

(d) **Ulangi (c) jika litar pintas tiga fasa bolt terjadi pada bas 2.**

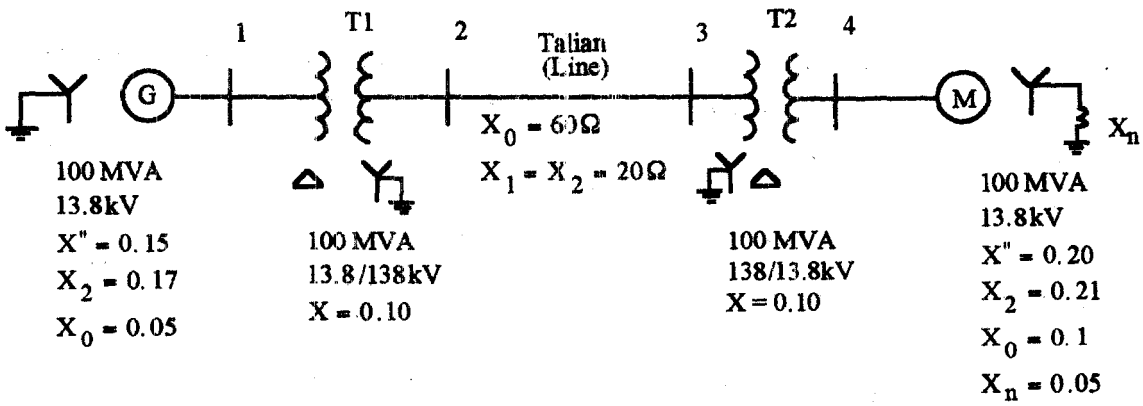
Repeat part (c) for a bolted three-phase short circuit at bus 2.

(40%)

...5/-

3. **Rajah S3 memaparkan gambarajah talian tunggal sistem kuasa yang terdiri dari penjana segerak membekalkan tenaga kepada motor segerak menerusi dua transformer dan talian penghantaran. Reaktan jujukan positif mesin segerak bersamaan dengan reaktan subtransien mesin dan reaktan bocoran transformer mewakili sama ada reaktan jujukan sifar, positif atau negatif. Reaktan jujukan alatan lain masing-masing ditandakan dengan subskrip 0, 1 dan 2. Neutral penjana dan transformer sambungan Y dibumi padu. Neutral motor dibumi menerusi reaktan X_n = 0.05 per unit berdasarkan asas motor. Pilih kadaran litar penjana sebagai asas rujukan.**

Figure S3 shows a single-line diagram of a power system consisting of a synchronous generator feeding a synchronous motor through two transformers and a transmission line. The positive sequence reactances of the synchronous machines are taken to be their subtransient reactances and leakage reactances of transformers represent either the zero, positive or negative-sequence reactances. Other equipment sequence reactances are respectively denoted by subscripts 0, 1 and 2. The neutrals of the generator and Y-connected transformers are solidly grounded. The motor neutral is grounded through a reactance X_n = 0.05 per unit on the motor base. Select the rating of the generator circuit as reference base.



Rajah 3
Fig. 3

...6/-

(a) Lakarkan rangkaian jujukan sifar-, positif- dan negatif- dalam per unit.

Draw the per unit zero-, positive- and negative-sequence networks.

(50%)

(b) Mudahkan rangkaian jujukan kepada litar setara Thevenin dan cari arus kegagalan subtransien apabila litar pintas tiga fasa simetri bolt berlaku pada bas 2. Anggapkan kedua-dua mesin segerak beroperasi pada 5% di bawah voltan terkadar.

Nota : Pertukaran Asas Impedan

$$\text{Per unit } Z_{\text{baru}} = \text{per unit } Z_{\text{lama}} \left(\frac{\text{asas kV}_{\text{lama}}}{\text{asas kV}_{\text{baru}}} \right)^2 \left(\frac{\text{asas kVA}_{\text{baru}}}{\text{asas kVA}_{\text{lama}}} \right)$$

Reduce the sequence networks to their Thevenin equivalents and find the subtransient fault current when a symmetrical, bolted three-phase short circuit occurs at bus 2 assuming both synchronous machines are operating at 5% below rated voltage.

(50%)

4. Untuk litar pintas satu talian-ke-bumi (SLG) menerusi impedan kegagalan 5 + j0Ω melibatkan fasa a ke bumi pada bas 2 bagi sistem kuasa Soalan 3, kirakan

For a single line-to-ground (SLG) short circuit through a fault impedance of 5 + j0Ω from phase 'a' to ground at bus 2 in the network of S3, calculate the following

(a) Arus kegagalan subtransien dalam per unit dan kA.
The subtransient fault current in per unit and in kA.

(40%)

...7/-

(b) **Voltan talian-ke-bumi (neutral) pada bas 2 dalam per unit.**
The per unit line-to-ground voltages at faulted bus 2.

(60%)

5. (a) **Setiap bas k dalam kajian aliran beban boleh dikelaskan kepada salah satu dari tiga jenis bas. Namakan ketiga-tiga jenis bas dan nyatakan kuantiti yang diketahui (data masukan) dan yang tidak diketahui (dihitungkan) berkaitan dengan setiap kategori bas.**

Each bus 'k' in load flow studies can be categorized into one of the three bus types. Name each of the bus type and state the known and unknown quantities associated with each bus.

(10%)

(b) **Sistem kuasa tiga fasa seimbang Rajah S5 menyenaraikan semua nilai dalam per unit berdasarkan asas sepunya. Beban rintangan tulen pada bas 2 boleh dianggapkan impedan tetap per unit. Voltan dalaman penjana disenaraikan seperti berikut:-**

A balanced three-phase power system shown in Fig. S5 has all values given in per unit on common base. The resistive load at bus 2 may be assumed to be a constant impedance in per unit. The internal generator voltages are given as follows.

$$E_A = 1.28 \angle 45^\circ \text{ pu}$$
$$E_B = 0.953 \angle 0^\circ \text{ pu}$$

Tentukan
Determine

(i) **Kuasa nyata dan reaktif yang dihantarkan ke mesin B dalam per unit.**

The real and reactive power delivered to machine B in per unit.

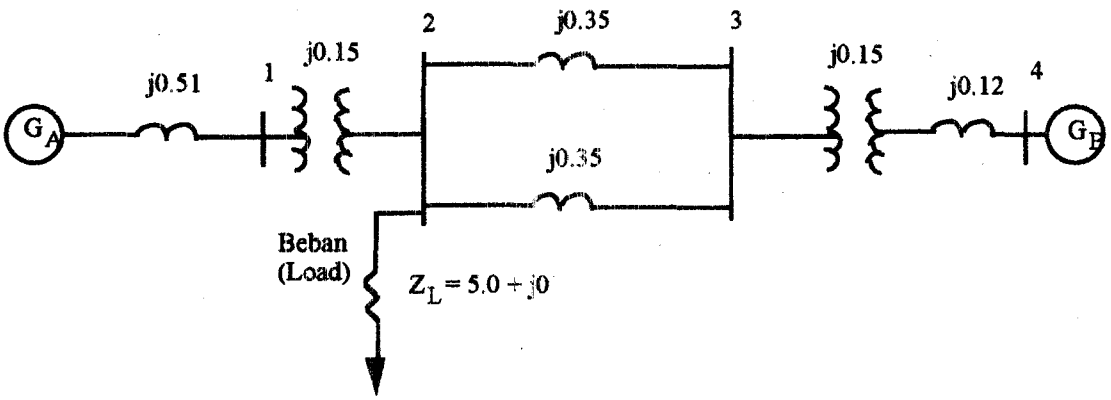
...8/-

(ii) Magnitud voltan pada bas beban (bas 2) dalam per unit.
The magnitude of the voltage at the load bus in per unit.

Pembayang: Anda mungkin perlu menggunakan transformasi Y-Δ untuk memudahkan rangkaian.

Hint : You may need to use Y-Δ transformation to reduce the network.

(90%)



Rajah S5
Fig. S5

6. (a) Bincangkan dengan ringkas konsep kriteria keluasan sama dalam kajian kestabilan transien yang disebabkan oleh kegagalan tiga fasa.

Discuss in brief the concept of the equal-area criterion in studying the transient stability due to a three-phase fault.

(20%)

...9/-

(b) Rajah S6 menggambarkan gambarajah talian tunggal penjana segerak tiga fasa, 50 Hz, disambungkan melalui transformer dan talian penghantaran litar berkembar kepada bas infinit. Semua reaktan diberikan dalam per unit atas asas sepunya sistem.

Fig. S6 shows a single-line diagram of a three-phase, 50 Hz synchronous generator, connected through a transformer and parallel transmission lines to an infinite bus. All reactances are given in per unit on a common system base.

(i) Jika bas infinit menerima kuasa nyata 1.0 per unit pada faktor kuasa 0.95 menyusul, cari voltan dalaman penjana, $E'\angle\delta$.

If the infinite bus receives 1.0 per unit real power at 0.95 power factor lagging, find the internal voltage of the generator, $E'\angle\delta$.

(ii) Penjana segerak sedang beroperasi pada keadaan mantap apabila litar pintas bolt tiga fasa-ke-bumi tetap terjadi atas talian 2-4 berhampiran dengan bas 4 (titik F). Kegagalan ini dilepaskan dengan pembukaan serentak pemutus litar pada hujung talian 2-4 dan talian 3-4. Pemutus litar ini kekal terbuka. Tentukan persamaan kuasa elektrik yang dihantarkan oleh penjana dalam sebutan sudut kuasa δ untuk sebelum, semasa, dan selepas kegagalan, masing-masing ditandakan oleh P_{e1}, P_{e2} dan P_{e3}.

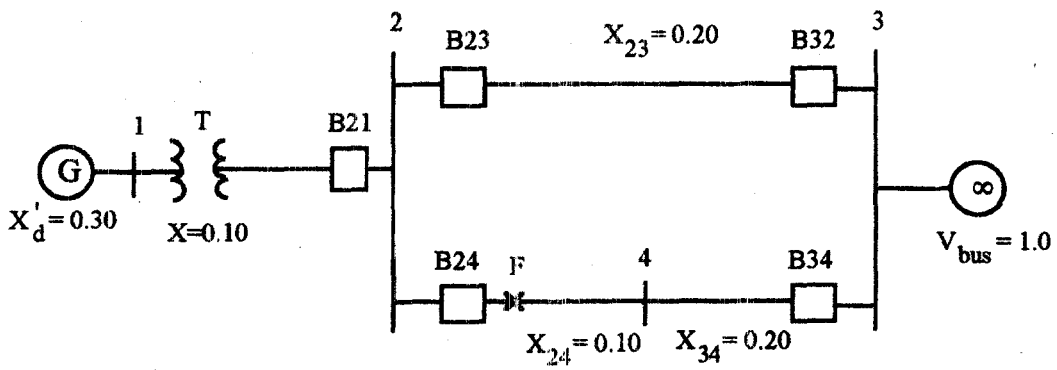
The synchronous generator is initially operating in the steady-state condition when a permanent three-phase-to-ground bolted short circuit occurs on line 2-4 at bus 4(point F). The fault is cleared by opening the circuit *breakers at ends of line 2-4 and line 3-4. These circuit breakers then remain open. Determine the equations for the electrical power delivered by the generator in terms of its power angle δ before, during, and after the fault, respectively denoted by P_{e1}, P_{e2} and P_{e3}.*

(80%)

...10/-

Pembayang : Anda mungkin perlu menggunakan transformasi Y-Δ dan Δ-Y.

Hint : You may need to use Y-Δ and Δ-Y tranformations



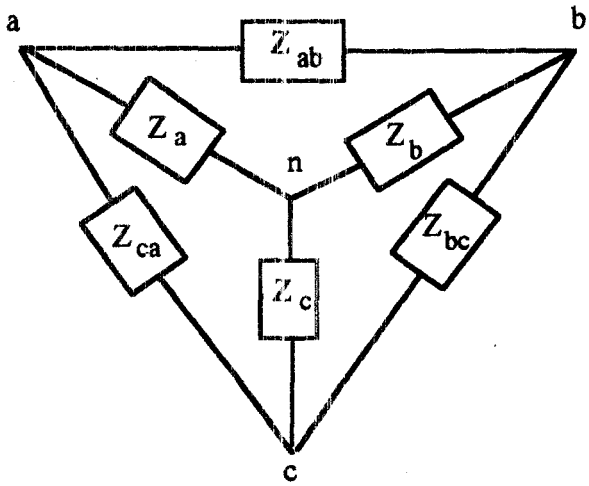
Rajah S6

Figure S6

- oooOooo -

Transformasi delta-wye dan wye-delta

Delta-wye or wye-delta transformations



Δ – Y

$$Z_a = \frac{Z_{ab} Z_{ca}}{Z_{ab} + Z_{bc} + Z_{ca}}$$

$$Z_b = \frac{Z_{ba} Z_{bc}}{Z_{ab} + Z_{bc} + Z_{ca}}$$

$$Z_c = \frac{Z_{ca} Z_{bc}}{Z_{ab} + Z_{bc} + Z_{ca}}$$

1

Y – Δ

$$Z_{ab} = Z_a + Z_b + \frac{Z_a Z_b}{Z_c}$$

$$Z_{bc} = Z_b + Z_c + \frac{Z_b Z_c}{Z_a}$$

$$Z_{ca} = Z_c + Z_a + \frac{Z_c Z_a}{Z_b}$$