UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Kedua
Sidang Akademik 2003/2004

Februari/Mac 2004

JEE 366 – PENGHANTARAN DAN PENGAGIHAN SISTEM KUASA

Masa : 3 jam

ARAHAN KEPADA CALON:

Sila pastikan bahawa kertas peperiksaan ini mengandungi **LIMA BELAS (15)** muka surat, **DUA (2)** muka surat **FORMAT JAWAPAN AKHIR (FOJA)** berserta Lampiran (1 muka surat) bercetak dan **ENAM (6)** soalan sebelum anda memulakan peperiksaan ini.

Jawab **LIMA (5)** soalan. **Format Jawapan** peperiksaan ini adalah

[i] Anda hendaklah menunjukkan jalan kerja jawapan dalam **Buku Jawapan**.

[ii] Jawapan-jawapan akhir kepada setiap soalan hendaklah diisi dalam kertas format jawapan akhir (FOJA) yang disediakan dan **mesti dikepilkan bersama dengan Buku Jawapan anda.**

Agihan markah bagi soalan diberikan disut sebelah kanan soalan berkenaan.

Jawab semua soalan di dalam Bahasa Malaysia.

...2/-

1. Tiga transformer satu fasa disambung delta-delta untuk membekalkan kuasa kepada beban 200 kVA , tiga fasa sambungan-wye yang mempunyai faktor kuasa 0.8 menyusul dan suatu beban ringan 80 kVA satu fasa dengan faktor kuasa 0.90 menyusul seperti dalam Rajah 5.

Three single-phase transformers are connected delta-delta to provide power for a three-phase wye-connected 200 kVA load with a 0.80 lagging power factor and a 80 kVA single-phase light load with a 0.90 lagging power factor, as shown in Figure 5.

Dengan menganggap bahawa tiga transformer satu fasa mempunyai peratus impedans yang sama dan nisbah peratus reaktans ke peratus rintangan yang sama. Voltan sebelah-prima bank ialah 7620/13,200 V dan voltan sebelah sekunder ialah 240 V. Anggap bahawa transformer satu fasa yang disambung antara fasa b dan c dikadarkan pada 100 kVA dan dua yang lain dikadarkan pada 75 kVA. Tentukan yang berikut:

Assume that the three single-phase transformers have equal percent impedance and equal ratios of percent reactance to percent resistance. The primary-side voltage of the bank is 7620/13,200 V and the secondary-side voltage is 240 V. Assume that the single-phase transformer connected between phases b and c is rated at 100 kVA and the other two are rated at 75 kVA. Determine the following:

(a) Arus talian $\bar{I}_a$
The line current $\bar{I}_a$ (20%)

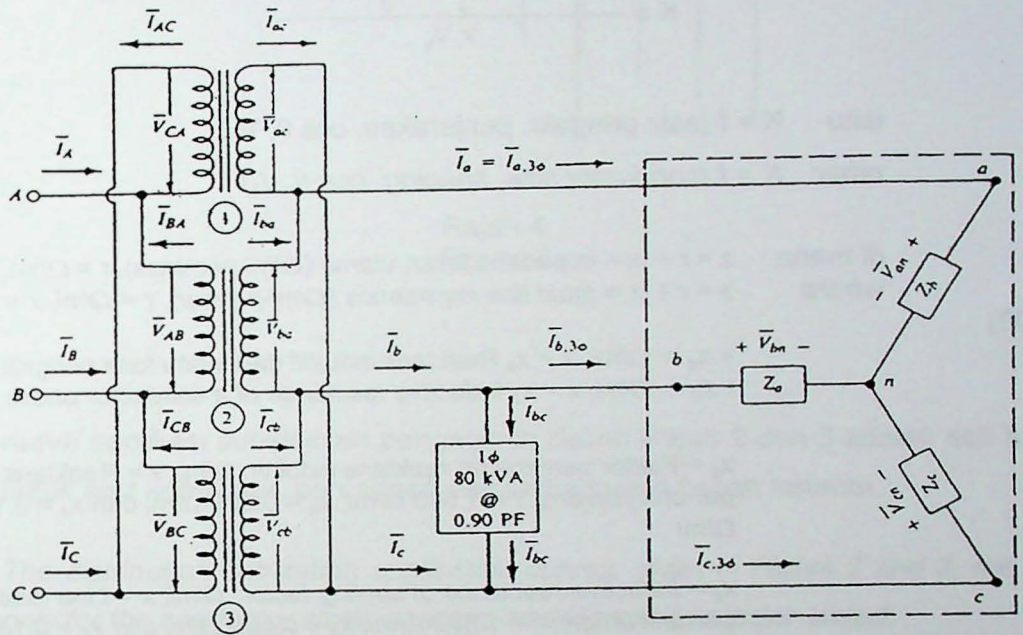
(b) Arus belitan sekunder I_{ba}
The current in the secondary winding I_{ba} (20%)

(c) Beban pada setiap transformer dalam Kva
The load on each transformer in kilovoltamperes (20%)

...3/-

(d) Arus belitan primer I_{CB}
The current primary winding I_{CB} (20%)

(e) Arus talian mengalir dalam wayar primer I_C
The line current flowing in primary-phase wire I_C (20%)



Rajah 5
Figure 5

2. Anggap bahawa suatu penyuap utama tiga fasa 4.16 kV terbumi-wye padu mempunyai pengalir tembaga dengan jarak setara 37 inci di antara fasa pengalir dan faktor kuasa beban menyusul 0.9.

Assume that a three-phase 4.16 kV wye-grounded feeder main has copper conductors until an equivalent spacing of 37 inch between phase conductors and a logging load power factor of 0.9.

...4/-

(a) Tentukan konstant K bagi penyuap utama dengan menggunakan persamaan berikut.

Determine the K constant of the main by employing the following formula.

$$K \cong \frac{(r \cos \theta + x \sin \theta)(\frac{1}{3} \times 1000)}{V_r V_b}$$

iaitu K = f (saiz pengalir, penjarakan, cos θ, V_b)

other $K = f$ *(conductor size, spacing, cos* θ*,* V_b*)*

di mana z = r + jx = impedans talian utama (Ω/mi-pemfasa), r = Ω/mi, x = x_a
where $z = r + jx$ *= main line impedance (Ω/mi-phasor), r = Ω/mi,* $x = x_a$

+ x_d = Ω/mi, x = x_a Reaktans induktif dari suatu fasa pengalir, Ω/mi,
+ x_d = *Ω/mi,* $x = x_a$ *Inductive reactance of a conductor phase, Ω/mi,*

x_d = Faktor penjarakan reaktans induktif, Ω/mi, x = Reaktans talian per unit panjang, r = 1.503 Ω/mi, x_a = 0.609 Ω/mi dan x_d = 0.1366 Ω/mi

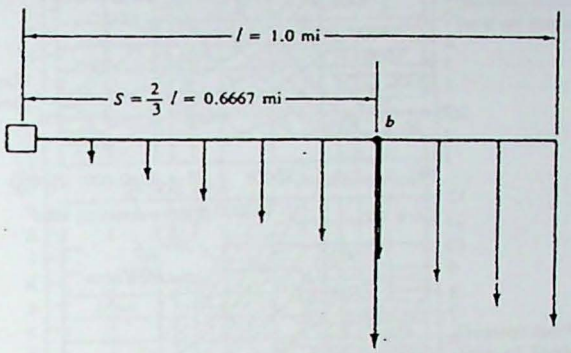
x_d *= Inductive reactance of spoling factor, Ω/mi, x = Line reactance per unit length, r = 1.503 Ω/mi,* x_a *= 0.609 Ω/mi and* x_d *= 0.1366 Ω/mi*

(50%)

(b) Anggap bahawa penyuap yang tertera dalam Rajah 4 mempunyai ciri yang sama seperti dalam bahagian (a) di atas tetapi beban 500 kVA diagihkan secara pertambahan ketumpatan beban disepanjang penyuap utama. Hitung kejatuhan voltan dalam penyuap utama,

By assuming that the feeder shown in Figure 4 has the same characteristic as in part (a) above but 500 kVA load density and has an increasing lood along the feeder main. Calculate the percentage voltage drop in the main.

...5/-



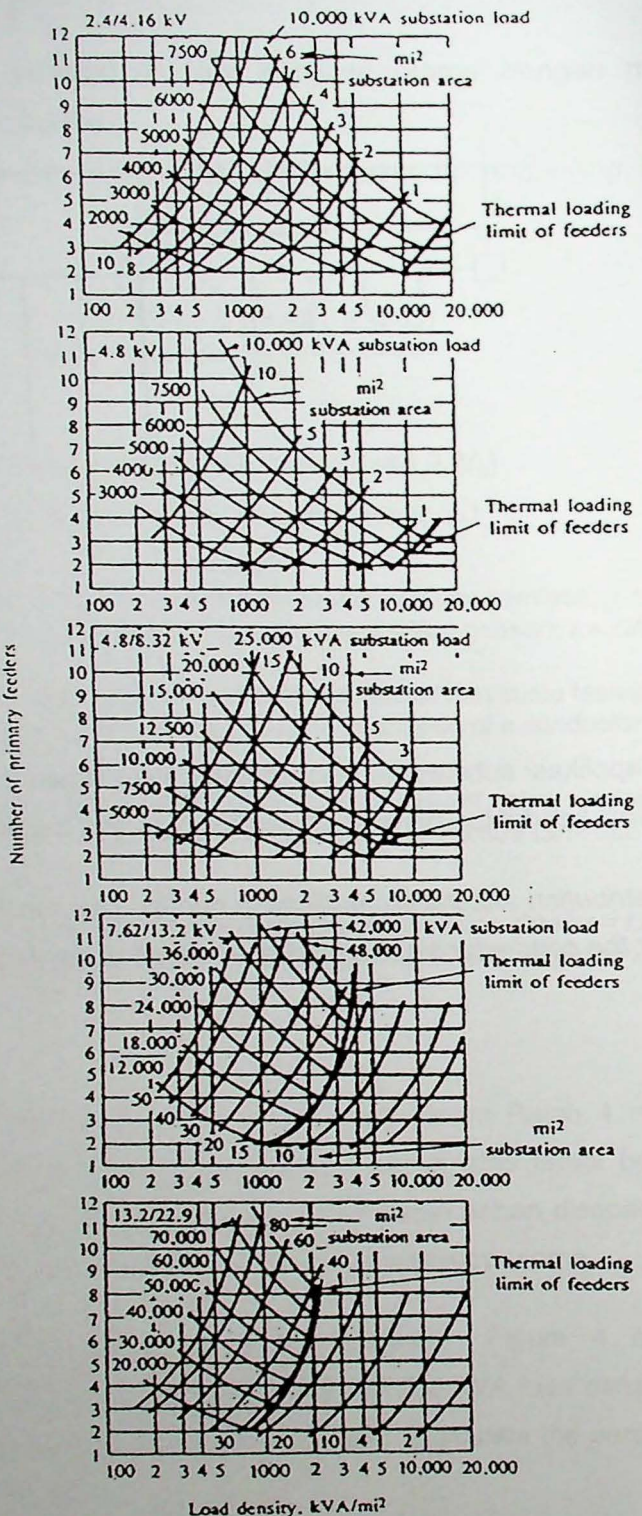
Rajah 4
Figure 4

(50%)

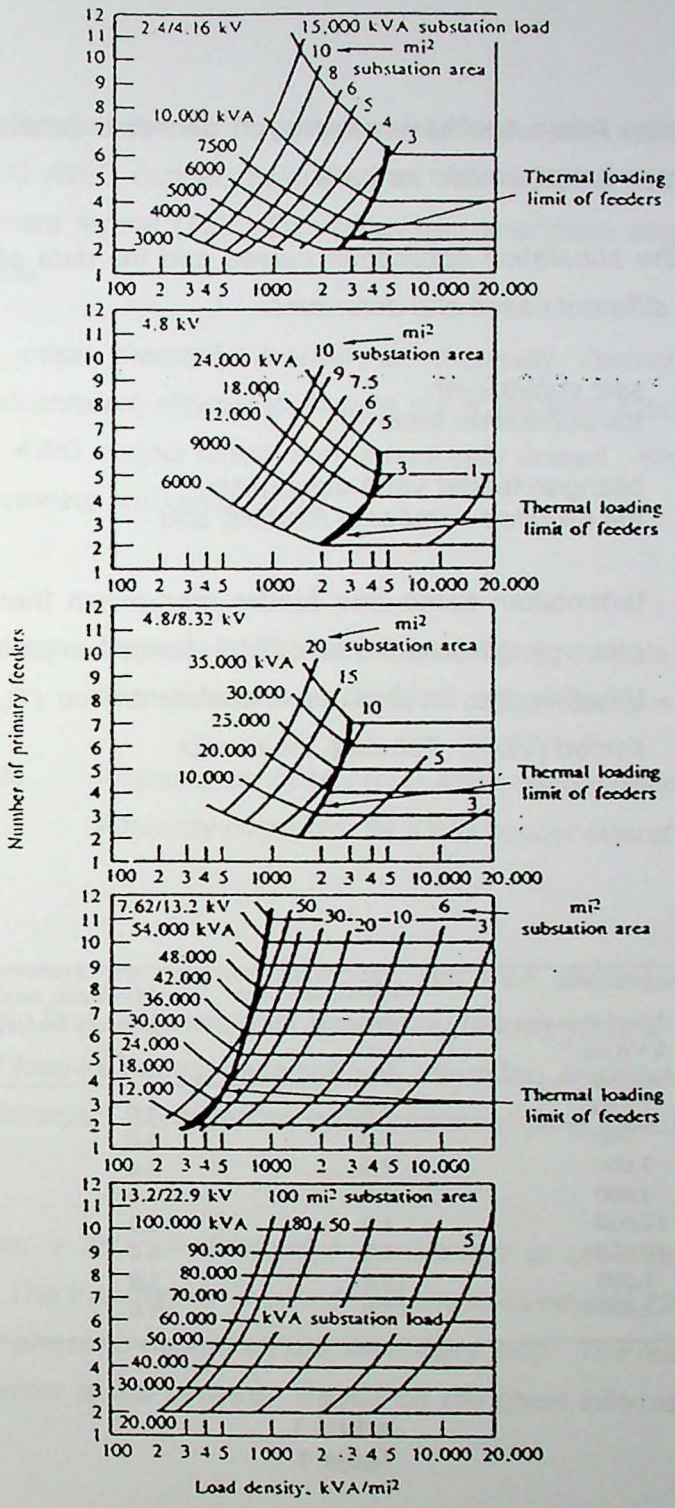
3. Kurva applikasi substesyen pengagihan dalam Rajah 2 dan 3 adalah sah hanya untuk saiz konduktor, peruangan dan faktor kuasa beban tertentu.

The distribution substation application curves, given in Figure 2 and 3, are valid only for the conductor sizes, spacing, and load power factor stated.

...6/-



Rajah 2
Figure 2



Rajah 3

Figure 3

...8/-

(a) Gunakan kurva applikasi substesyen dan data dalam Jadual 1 untuk lapan kes yang berlainan dan tentukan .

Use the substation application curves and the data given in Table 1 for eight different cases and determine.

(1) saiz substesyen
the substation sizes

(2) bilangan feeder yang diperlukan
the required number of feeders, and

(3) tertentukan sama ada feeder merupakan thermally limited (TL) atau voltage-drop-limited (VDL). Jadualkan jawapan anda.
Whether the feeders are thermally limited (TL) or voltage-drop-limited (VDL). Tabulate the results.

(50%)

Case no.	Load density D, kVA/mi^2	Substation area coverage TA_s, mi^2	Maximum total primary feeder, % VD	Base feeder voltage kV_{L-L}
1	500	6.0	3.0	4.16
2	500	6.0	6.0	4.16
3	2,000	3.0	3.0	4.16
4	2,000	3.0	6.0	4.16
5	10,000	1.0	3.0	4.16
6	10,000	1.0	6.0	4.16
7	2,000	15.0	3.0	13.2
8	2,000	15.0	6.0	13.2

Jadual 1
Table 1

...9/-

(b) Dalam hal feeder TL yang ditemui, cuba tafsir-kaitkan sama ada ianya #4/0 AWG copper main atau #4 AWG copper lateral yang dibataskan secara termal (TL). Tunjukkan dan terangkan alasan dan perhitungan anda.

In case thermally loaded or thermally limited (TL) feeders are encountered, attempt to deduce if it is the #4/0 AWG copper main or the #4 AWG copper lateral that is thermally limited. Show and explain your reasoning and calculations.

(50%)

Catatan: Ampasiti konduktor #4/0 AWG copper main = 480A
Ampsiti konduktor #4 AWG copper lateral = 180A

Note : Ampacity conductor #4/0 AWG copper main = 480A
Ampacity conductor #4 AWG copper lateral = 180A

4. Anggap bahawa transformer distribusi 250 kVA diletakkan atas tiang untuk bekalan satu fasa. Transformer disambung fasa-ke-neutral 7200V pada primer, dan 2520V fasa-ke-neutral pada sebelah sekunder. Impedans bocor transformer ialah 3.5 peratus. Berdasarkan pada informasi yang diberikan, tentukan yang berikut:

Assume that a 250kVA distribution transformer is used for single-phase pole mounting. The transformer is connected phase-to-neutral 7200V on the primary, and 2520V phase-to-neutral on the secondary side. The leakage impedance of the transformer is 3.5 percent. Based on the given information, determine the following:

...10/-

(a) Anggap bahawa transformer mempunyai 0.7 puA dalam belitan voltan tinggi. Cari nilai arus sebenar dalam belitan voltan tinggi dan voltan rendah. Apakah nilai arus dalam belitan voltan rendah dalam per unit?

Assume that the transformer has 0.7 puA in the high-voltage winding. Find the actual current values in the high-and low-voltage windings. What is the value of the current in the low-voltage winding in per units?

(25%)

(b) Cari impedans transformer bila dirujukkan ke belitan voltan tinggi dan voltan rendah per unit.

Find the impedance of the transformer as referred to the high-and low-voltage winding in per units?

(25%)

(c) Anggap bahawa terminal voltan rendah transformer dilitar-pintaskan dan 0.22 per unit voltan digunakan ke belitan voltan tinggi. Cari arus belitan voltan tinggi dan rendah yang wujud hasil daripada litar pintas dalam per unit dan amp.

Assume that the low-voltage terminals of the transformer are short-circuited and 0.22 per unit voltage is applied to the high-voltage winding. Find the high-and low-voltage winding currents that exist as a result of the short circuit in per units and amps.

(25%)

...11/-

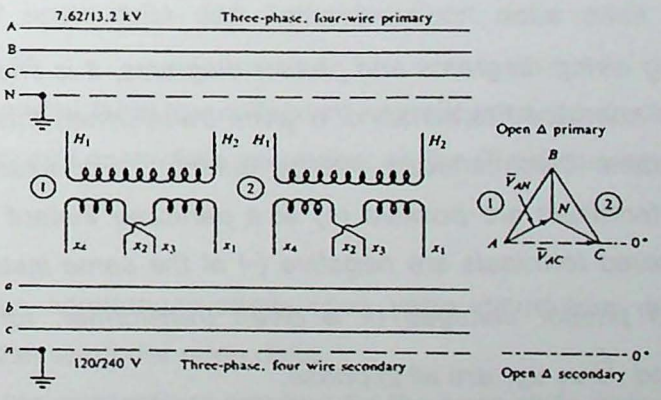
(d) Tentukan kejatuhan voltan dalaman transformer, akibat impedans bocornya, jika arus 1.2 per unit mengalir dalam belitan voltan tinggi. Berikan jawapan dalam per unit dan volt.

Determine the internal voltage drop of the transformer, due to its leakage impedance, if a 1.2 per unit current flows in the high-voltage winding. Give the result in per units and volts.

(25%)

5. Bank dua transformer terkadang-kadang digunakan dalam sistem distribusi, seperti tertera dalam Rajah 1, terutama untuk membekalkan beban-beban satu fasa yang besar dan beban-beban tiga-fasa (motor) yang kecil.

Two transformer banks are sometimes used in distribution systems, as shown in Figure 1, especially to supply customers having large single-phase lighting loads and small three-phase (motor) loads.



Rajah 1
Figure 1

...12/-

Sambungan voltan rendah ialah tiga-fasa empat wayar 120/240V delta terbuka. Sambungan voltan tinggi boleh sama ada delta terbuka atau wye terbuka. Jika ia delta terbuka, kadaran transformer voltan tinggi ialah voltan talian-ke-talian primer. Jika ianya wye terbuka, kadaran transformer voltan tinggi ialah voltan talian-ke-neutral primer.

The low-voltage connections are three-phase four-wire 120/240V open-delta. The high-voltage connections are either open-delta or open-wye. If it is open-delta, the transformer-rated high voltage is the primary line-to-line voltage. If it is open-wye, the transformer-rated high voltage is the primary line to-neutral voltage.

Dalam menyediakan rajah pengwayaran dan rajah pemfasa, adalah penting memahami bahawa semua terminal bernombor ganjil sesuatu transformer, iaitu H_1, x_1, x_3, ..., mempunyai kekutuban voltan seketika yang sama. Sebagai contoh, jika semua terminal bernombor ganjil ialah positif (+) pada ketika masa tertentu, maka semua terminal bernombor genap adalah negatif (-) pada ketika yang sama. Dalam perkataan lain voltan tanpa beban pemfasa transformer tersebut, sebagai contoh $\overline{V}\, H_1\, H_2$, $\overline{V}\, x_1\, x_2$, dan $\overline{V}\, x_3\, x_4$ adalah semua sefasa.

In preparing wiring diagrams and phasor diagrams, it is important to understand that all odd-numbered terminals of a given transformer, that is, H_1, x_1, x_3, etc., have the same instantaneous voltage polarity. For example, if all the odd-numbered terminals are positive (+) at a particular instant of time, then all the even-numbered terminals are negative (-) at the same instant. In other words, the no-load phasor voltages of a given transformer, for example, $\overline{V}\, H_1\, H_2$, $\overline{V}\, x_1\, x_2$, and $\overline{V}\, x_3\, x_4$, are all in phase.

...13/-

Anggap bahawa jujukan fasa ABC digunakan dalam sambungan untuk kedua-dua voltan tinggi dan voltan rendah dan rajah pemfasa diberi:

Assume that ABC phase sequence is used in the connections for both high voltage and low voltage and the phasor diagrams given:

$$\overline{V}_{AC} = 13{,}200\angle 0° \text{ V}$$

dan
and

$$\overline{V}_{AN} = 7620\angle 30° \text{ V}$$

Andaikan bahawa transformer sebelah kiri digunakan untuk lampu. Bagi menyediakan bank dua transformer dengan primer open delta dan sekunder open delta maka

Also assume that the left-hand transformer is used for lighting. To establish the two-transformer bank with open-delta primary and open-delta secondary

(a) Lukiskan dan/atau labelkan rajah pemfasa voltan yang diperlukan untuk primer open delta dan sekunder open delta pada rujukan 0° yang diberikan.
Draw and/or label the voltage phasor diagram required for the open-delta primary and open-delta secondary on the 0° references given.

(50%)

(b) Buatkan sambungan-sambungan yang diperlukan untuk primer open delta dan sekunder open delta.
Show the connections required for the open-delta primary and open-delta secondary.

(50%)

...14/-

6. Syarikat antarabangsa Transkrian, berlokasi di Nibong Tebal, menggunakan 16,000 kWh tenaga elektrik untuk produksi bulan ini. Penggunaan tenaga purata tahunan syarikat ialah juga 16,000 kWh. Ia mempunyai suatu permintaan maksimum bulanan 30-min sebanyak 200kW dan suatu permintaan tersambung 580kW. Gunakan jadual kadar elektrik yang diberi dalam Lampiran A.

The Transkrian International Company, located in Nibong Tebal, consumed 16,000 kWh of electric energy for Transkrian production this month. The company's annual average energy consumption is also 16,000 kWh due to some unknown reasons. It has a 30-min monthly maximum demand of 200kW and connected demand of 580kW. Use the electrical rate schedule given in Appendix A.

(a) Cari jumlah bulanan bil elektrik Transkrian International untuk bulan ini.
Find the Transkrian International's total monthly electrical bill for this month. (25%)

(b) Cari faktor beban bulanan 30-minnya.
Find its 30-min monthly load factor. (25%)

(c) Cari faktor permintaannya.
Find its demand factor. (25%)

...15/-

(d) Jurutera loji baru syarikat yang diambil bekerja, yang baru menamatkan kursus pengurusan beban di Kampus Kejuruteraan USM, mencadangkan bahawa, dengan menganjakkan jam-jam produksi tertentu daripada jam beban puncak ke jam luar puncak, permintaan bulanan maksimum dapat dikurangkan ke 140kW pada suatu kos $50/bulan. Adakah anda setuju dengannya?

The company 's newly hired plant engineer, who recently completed a load management course at Kampus Kejuruteraan USM, suggest that, by shifting the hours of certain production from the peak-load hours to off-peak hours, the maximum monthly demand can be reduced to 140kW at a cost $50/month. Do you agree with him?

(25%)

oooOooo

Residential:
Rate: (net) per month per meter

Energy charge

For first 25 kWh	6.0¢/kWh
For next 125 kWh	3.2¢/kWh
For next 850 kWh	2.0¢/kWh
All in excess of 1000	1.0¢ /kWh

Minimum: $1.50 per month

Commercial

A rate available for general, commercial, and miscellanceous power uses where consumption of energy does not exceed 10,000 kWh in any month during any calendar year.

Rate: (net) per month per meter
Energy charge

For the first 25 kWh	6.0¢/kWh
For the next 375 kWh	4.0¢/kWh
For the next 3600 kWh	3.0¢/kWh
All in excess of 4000 kWh	1.5¢/kWh

Minimum: $1.50 per month

General power

A rate available for service supplied to any commercial or industrial customer whose consumption in any month during the calendar year exceeds 10,000 kWh. A customer who exceeds 10,000 kWh per month in any 1 month may elect to receive power under this rate.
A customer who exceeds 10,000 kWh in any 3 months or who exceeds 12,000 kWh in any 1 month during a calendar year shall be required to receive power under this rate at the option of the supplier.

A customer who elects at his own option to receive power under this rate may not return to the commercial service rate except at the option of the supplier.
Rate: (net) per month per meter
kW is rate of flow. 1 kW for 1 h is 1kWh

Demand charge:

For the first 30kW of maximum demand per month	$2.50/kWh
For all maximum demand per month in excess of 30kW	$1.25/kW

Energy charge

For the first 100 kWh per kW of maximum demand per month	2.0¢/kWh
For the next 200 kWh per kW of maximum demand per month	1.2¢/kWh
All in excess of 300 kWh per kW of maximum demand per month	0.5¢/kWh

Minimum charge: The minimum monthly bill shall be the demand charge for the month.
Determination of maximum demand: The maximum demand shall be either the highest integrated kW load during any 30-minute period occurring the billing month for which the determination is made, or 75 percent of the highest maximum demand which has occurred in the preceding month, whichever is greater.
Water heating: 1.0¢/kWh with a minimum monthly charge of $1.00.

FORMAT JAWAPAN AKHIR (FOJA) [JEE 366]
(Mesti dikepilkan bersama Buku Jawapan)

ANGKA GILIRAN: .....

Jawapan Peperiksaan JEE 366 – Penghantaran Dan Pengagihan Sistem Kuasa
[Februari 2004]
Sesuaikan jawapan anda dengan unit-unit yang disediakan.

1. (a) I_a = _____ ∠ _____

(b) I_{ba} = _____ ∠ _____

(c) SL, ab = _____ kVA

SL, bc = _____ kVA

SL, ca = _____ kVA

(d) I_{CB} = _____ ∠ _____

(e) I_C = _____ ∠ _____

2. (a) K = _____ VD_{pu}/(kVA.mi)

Atau _____ % VD/(kVA.mi)

(b) % VD = _____ %

3. (a)

Case No.	Substation Size TS_n	Required no. of feeders n	Voltage-drop-limited (VDL) or thermally limited (TL) feeders
1			
2			
3			
4			
5			
6			
7			
8			

...2/-

4. (a) _____ actual current in HV winding.

_____ actual current in LV winding.

_____ current in LV in per unit.

(b) _____ impedance, HV winding.

_____ impedance, LV winding.

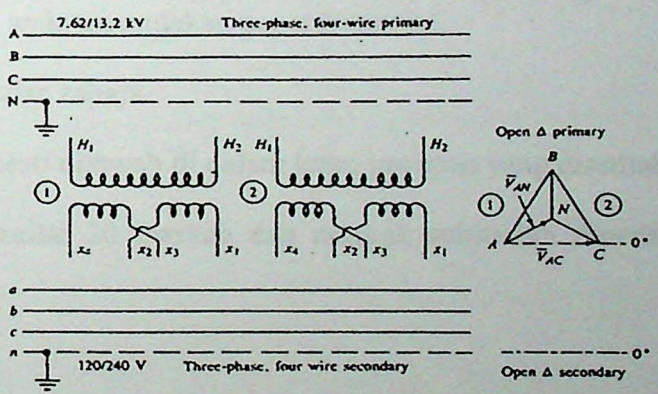
(c) _____ current, HV winding.

_____ current, LV winding.

(d) _____ voltage drop, p.u

_____ voltage drop, volt.

5.



Rajah 1

6. (a) _____ (b) _____

(c) _____ (d) setuju/tidak setuju

ooo0ooo