UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Pertama
Sidang Akademik 2005/2006

November 2005

EEK 361 – ELEKTRONIK KUASA

Masa : 3 Jam

ARAHAN KEPADA CALON:-

Sila pastikan kertas peperiksaan ini mengandungi **LAPAN** **(8)** muka surat beserta **Lampiran (2 muka surat)** bercetak dan **ENAM** **(6)** soalan sebelum anda memulakan peperiksaan ini.

Jawab **LIMA** **(5)** soalan.
Bagi soalan 4 jawab hanya **Bahagian (a) atau (b)**.

Agihan markah diberikan di sudut sebelah kanan soalan berkenaan.

Semua soalan hendaklah dijawab di dalam Bahasa Malaysia.

...2/-

1. (a) Terbitkan hubungan t_{rr} dan I_{RR} dalam sebutan Q_{RR} dan *di/dt* bagi ciri pulih balikan bagi diod untuk pulihan lambat.

Derive the relationship of t_{rr} and I_{RR} in term of Q_{RR} and di/dt of a reverse recovery characteristic of a diode for slow recovery.

(30%)

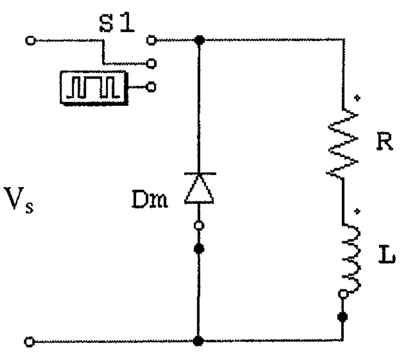
(b) Apakah kepentingan diod disambung secara siri. Huraikan dengan terperinci persamaan yang terbabit.

What is the need for series-connection of diode. Explain in detail the equations derivation.

(30%)

(c) Diod ditunjukkan oleh Rajah 1 beserta R=10Ω, L=5mH dan V_s=220V. Jika arus beban 10A mengalir menerusi diod meroda bebas D_m dan suis S1 ditutup pada t=0, terbitkan persamaan arus i yang mengalir menerusi suis.

A diode shown in Figure 1 with R=10Ω, L=5mH and V_s=220V. If a load current of 10A is flowing through freewheeling diode D_m and switch S1 is closed at t=0, determine the expression for the current i through the switch. (40%)



Rajah 1
Figure 1

...3/-

2. (a) Jelaskan ciri v-i bagi thiristor.

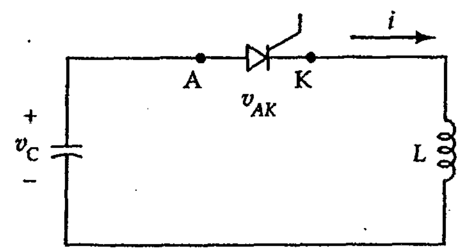
Explain the v-i characteristic of thyristor.

(20%)

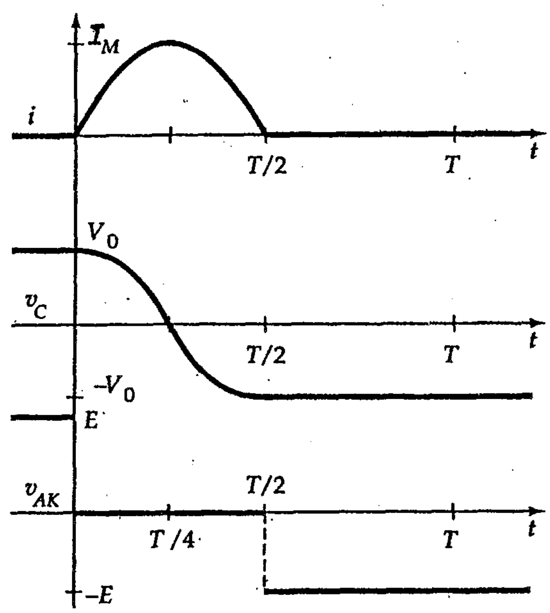
(b) Berdasarkan Rajah 2(a) dan 2(b), jika $v_c(0)$=200V, L=100μH dan C=5 μF, apakah arus puncak thiristor dan berapa lamakah thiristor mengkonduk?

In Figure 2(a) and 2(b), if $v_c(0)$=200V, L=100μH and C=5 μF, what is the peak thyristor current and how long does the thyristor conduct?

(30%)



Rajah 2(a)
Figure 2(a)



Rajah 2(b)
Figure 2(b)

(c) Jelaskan apakah maksud menghidupkan dan mematikan thiristor?
What are the means of turning-on and turning-off thyristors?

(20%)

(d) Thiristor dihidupkan dan dimatikan pada frekuensi 10kHz seperti ditunjukkan oleh Rajah 2(c). Masa naik arus anod I_A ialah 0.8μs dan masa jatuhnya ialah 1.2μs. Jika V_{AK}=350V dan load R=20Ω, kirakan:

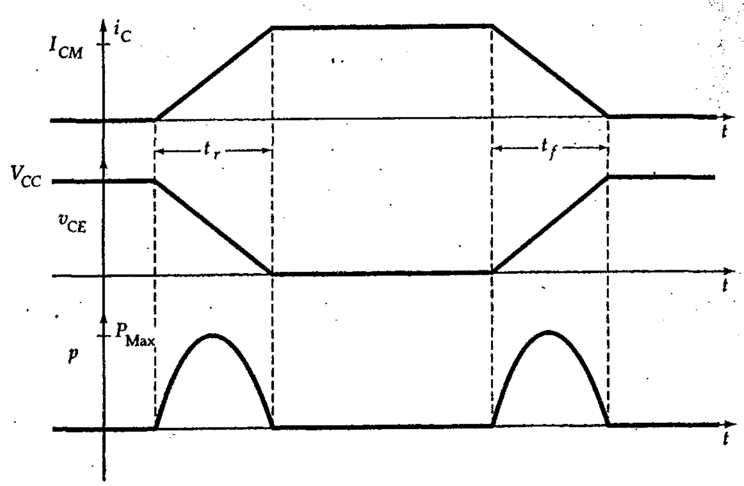
Thyristor is turned on and off at a frequency of 10kHz as shown in Figure 2(c). Anode current I_A rise time is 0.8μs and fall time is 1.2μs. If V_{AK}=350V and load R=20Ω, find:

(i) Kehilangan tenaga masa naik
Rise time energy loss

(ii) Kehilangan tenaga masa turun
Fall time energy loss

(iii) Kehilangan kuasa pensuisan
Switching loss power

(30%)



Rajah 2(c)
Figure 2(c)

...5/-

3. (a) Rekabentuk litar rektifier satu fasa tak terkawal penuh gelombang yang terdiri dari 4 diod berbeban R tulin. Huraikan operasi litar tersebut dan terbitkan persamaan untuk voltan keluaran purata dc dan rms.

Design a full wave single phase uncontrolled rectifier consisting of 4 diodes with R load. Explain the principle operation of the circuit and derive the equations for average dc and rms output voltage.

(40%)

(b) Jika rekabentuk dalam soalan 3(a) mempunyai beban R=20Ω dan punca voltan 240V rms, 60 Hz. Kirakan

If the design in question 3(a) has a resistive load R=20Ω and a source voltage of 240 V rms, 60 Hz, calculate:

(i) Voltan puncak V_m dan voltan purata V_{dc}.
Peak voltage V_m and average voltage V_{dc}.

(ii) Kuasa ke beban
Power to the load

(iii) Kecekapan litar
Circuit efficiency.

(60%)

...6/-

4. (a) Jelaskan apakah pengawal voltan ac satu fasa. Penjelasan mesti merangkumi prinsip operasi kawalan sudut fasa, bentuk gelombang yang terhasil, persamaan yang berkaitan dan bandingkan kesan beban R dan beban RL induktif.

Explain what is a single phase ac voltage controller. Explaination should cover the principle of phase control, waveforms, derivation of related equations and compare the results with R and RL inductive loads.

(100%)

Atau

Or

(b) Jelaskan apakah inverter satu fasa. Penjelasan mesti merangkumi prinsip operasi titi penuh, parameter prestasi, bentuk gelombang, persamaan yang berkaitan dan bandingkan kesan beban R dan beban RL induktif.

Explain what is a single phase inverter. Explaination should cover the principle of operation, performance parameters, waveforms, derivation of related equations and compare the results with R and RL inductive loads.

(100%)

5. (a) Apakah perwakilan analog secara elektrik untuk pemindahan haba peranti semikonduktor kuasa?

What is the electrical analog of heat transfer from a power semiconductor devices?

(30%)

(b) Pertimbangkan kes-kes berikut merujuk pada Appendiks A:

Consider the following cases refer to Appendix A:

...7/-

(i) MOSFET beroperasi dalam keadaan suhu malar dan menghilangkan 10W. Ianya dilekatkan pada penenggelam haba R_{SA}=2.5^0 C/W. Suhu persekitaran ambient ialah 70^{0}C. Kirakan suhu simpang peranti jika ianya dilekatkan terus pada penenggelam haba menggunakan suhu gris R_{CS}=0.15^0 C/W.

A MOSFET operates in a steady-state thermal condition and dissipates 10 W. It is mounted on heat sink with R_{SA}=2.5^0 C/W. The surrounding ambient air is at 70^{0}C. Find the device junction temperature if mounted directly on the heat sink using thermal grease R_{CS}=0.15^0 C/W.

(20%)

(ii) MOSFET digunakan dalam mod tunggal mengalirkan 10 A dan voltan sumber salir ialah 20 V untuk 10 ms. Suhu selonsong peranti ialah 75^0 C. Kira suhu simpang pada akhir denyut tersebut. Terangkan apa yang berlaku selepas t=10ms.

A MOSFET is used in a single pulse mode to conduct 10 A with a drain source voltage of 20 V for 10 ms. The device case temperature is 75^0 C. Find the junction temperature at the end of pulse duration. Explain what happens after t=10ms.

(20%)

(iii) MOSFET digunakan untuk operasi berkala 2 kHz. Untuk setiap tempoh 200μs, peranti tersebut mengalami kelesapan kuasa 100W dan untuk tempoh selain itu kelesapan adalah sifar. Jika T_A=65^{0}C, R_{CS}=0.4^{0}C/W, R_{CS}=0.4^{0}C/W, R_{JC}=1.2^{0}C/W dan T_J=130^0 C kira nilai T_C maksimum yang dibenarkan dan juga nilai R_{SA} yang diperlukan.

A MOSFET operate in a periodic manner at frequency of 2 kHz. For 100ms of each period, the device has a power dissipation of 100W with zero dissipation during the remainder of each period. If T_A=65^{0}C, R_{CS}=0.4^{0}C/W, R_{CS}=0.4^{0}C/W, R_{JC}=1.2^{0}C/W and T_J=130^0 C find the maximum permitted value of T_C and the required value of R_{SA}.

(30%)

...8/-

6. (a) Mengapa peranti kuasa perlu dilindungi? Terangkan.

Why power devices should be protected? Explain.

(20%)

(b) Apakah tujuan perlindungan di/dt dan dv/dt dalam rekabentuk litar thiristor? Apakah kaedah yang digunakan bagi setiap perlindungan tersebut.

What is the purpose of di/dt and dv/dt protections in thyristor circuit design? What are the common methods for each of the protections.

(30%)

(c) Apakah maksud perlindungan arus? Apakah langkah-langkah yang diambil dalam memilih fius untuk perlindungan peranti?

What is current protection? What are the considerations in selecting a fuse for a device protection?

(30%)

(d) Apakah punca EMI dan bagaimanakah penjanaannya dapat diminimumkan?

What are the sources of EMI and how can the EMI generation be minimized?

(20%)

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MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

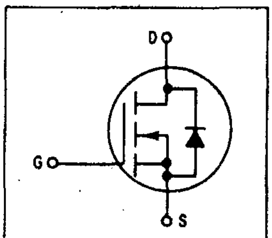
Designer's Data Sheet
Power Field Effect Transistor
N-Channel Enhancement-Mode Silicon Gate TMOS

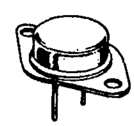
MTH8N55
MTH8N60
MTM8N60

These TMOS Power FETs are designed for high voltage, high speed power switching applications such as switching regulators, converters, solenoid and relay drivers.

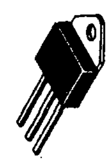
- Silicon Gate for Fast Switching Speeds — Switching Times Specified at 100°C
- Designer's Data — I_{DSS}, $V_{DS(on)}$, $V_{GS(th)}$ and SOA Specified at Elevated Temperature
- Rugged — SOA is Power Dissipation Limited
- Source-to-Drain Diode Characterized for Use With Inductive Loads

TMOS POWER FETs
8 AMPERES
$r_{DS(on)}$ = 0.5 OHM
550 and 600 VOLTS





MTM8N60
CASE 1-06
TO-204AA



MTH8N55
MTH8N60
CASE 340-02
TO-218AC

MAXIMUM RATINGS

Rating	Symbol	MTH8N55	MTH8N60 MTM8N60	Unit
Drain-Source Voltage	V_{DSS}	550	600	Vdc
Drain-Gate Voltage (R_{GS} = 1 MΩ)	V_{DGR}	550	600	Vdc
Gate-Source Voltage Continuous Non-repetitive ($t_p \le 50\ \mu s$)	V_{GS} V_{GSM}	±20 ±40		Vdc Vpk
Drain Current — Continuous — Pulsed	I_D I_{DM}	8 41		Adc
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	150 1.2		Watts W/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to 150		°C

THERMAL CHARACTERISTICS

Thermal Resistance — Junction to Case — Junction to Ambient	$R_{\theta JC}$ $R_{\theta JA}$	0.83 30	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/8" from case for 5 seconds	T_L	275	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 0.25 mA) MTH8N55 MTH8N60, MTM8N60	$V_{(BR)DSS}$	 550 600	 — —	Vdc
Zero Gate Voltage Drain Current (V_{DS} = Rated V_{DSS}, V_{GS} = 0) (V_{DS} = 0.8 Rated V_{DSS}, V_{GS} = 0, T_J = 125°C)	I_{DSS}	 — —	 0.2 1	mAdc

(continued)

Designer's Data for "Worst Case" Conditions — The Designer's Data Sheet permits the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

SAFE OPERATING AREA INFORMATION

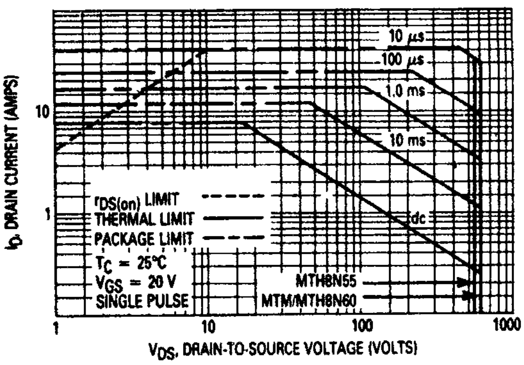


Figure 7. Maximum Rated Forward Biased Safe Operating Area

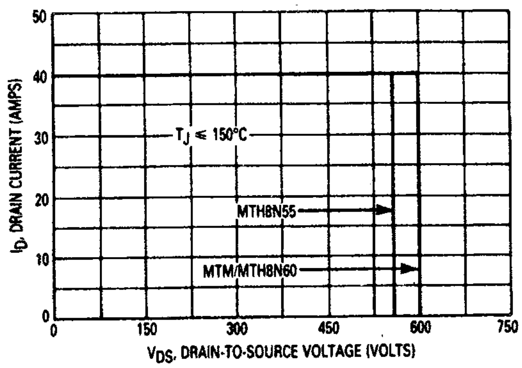


Figure 8. Maximum Rated Switching Safe Operating Area

FORWARD BIASED SAFE OPERATING AREA

The FBSOA curves define the maximum drain-to-source voltage and drain current that a device can safely handle when it is forward biased, or when it is on, or being turned on. Because these curves include the limitations of simultaneous high voltage and high current, up to the rating of the device, they are especially useful to designers of linear systems. The curves are based on a case temperature of 25°C and a maximum junction temperature of 150°C. Limitations for repetitive pulses at various case temperatures can be determined by using the thermal response curves. Motorola Application Note, AN569, "Transient Thermal Resistance-General Data and Its Use" provides detailed instructions.

SWITCHING SAFE OPERATING AREA

The switching safe operating area (SOA) of Figure 8 is the boundary that the load line may traverse without incurring damage to the MOSFET. The fundamental limits are the peak current, I_{DM} and the breakdown voltage, $V_{(BR)DSS}$. The switching SOA shown in Figure 8 is applicable for both turn-on and turn-off of the devices for switching times less than one microsecond.

The power averaged over a complete switching cycle must be less than:

$$\frac{T_{J(max)} - T_C}{R_{\theta JC}}$$

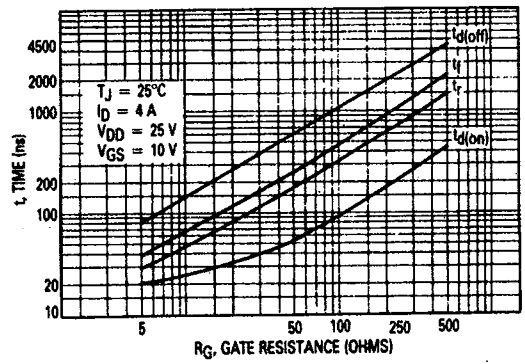


Figure 9. Resistive Switching Time Variation With Gate Resistance

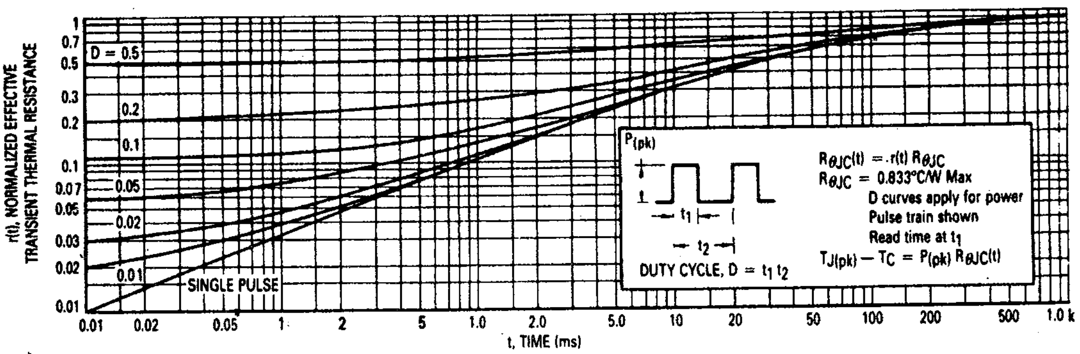


Figure 10. Thermal Response