UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Pertama
Sidang Akademik 2008/2009

November 2008

EEK 361 – ELEKTRONIK KUASA

Masa: 3 jam

Sila pastikan bahawa kertas peperiksaan ini mengandungi TUJUH muka surat dan [illegible] muka surat LAMPIRAN yang bercetak sebelum anda memulakan peperiksaan ini.

Kertas soalan ini mengandungi ENAM soalan.

Jawab LIMA soalan.

Mulakan jawapan anda untuk setiap soalan pada muka surat yang baru.

Agihan markah bagi setiap soalan diberikan di sudut sebelah kanan soalan berkenaan.

Jawab semua soalan dalam bahasa Malaysia atau bahasa Inggeris atau kombinasi kedua-duanya.

1. (a) Lakarkan simbol dan ciri bagi peranti semikonduktor yang berikut:

Sketch the symbol and characteristics of the following semiconductors:

(a) Diode

(b) MOSFET

(c) TRIAC

(d) IGBT

(20%)

(b) Terangkan 4 ciri penting bagi suis yang lelurus.

Explain 4 important characteristic of an ideal switch.

(20%)

(c) Apakah langkah-langkah yang perlu di ambil dalam rekabentuk peralatan elektronik kuasa?

What are the steps involved in designing power electronics equipment?

(20%)

(d) Apakah kepentingan analisis harmonik dalam rekabentuk litar elektronik kuasa. Jelaskan suatu contoh dengan merujuk kepada siri Fourier.

What is the important of harmonics analysis in design of power electronics circuit? Explain an example which refers to Fourier series.

(40%)

...3/-

2. (a) Terangkan ciri bagi suatu diod kuasa.

Explain the characteristic of a power diode.

(30%)

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

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

(30%)

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

What is the need for series-connected diode? Explain in detail the equations derivation.

(20%)

(d) Apakah diod meroda bebas dan apakah tujuannya? Huraikan dengan merujuk kepada litar dan bentuk gelombang.

What is a freewheeling diode and what is its purpose? Explain with reference to circuit and waveforms.

(20%)

3. (a) Takrifkan kuasa keluaran dc, kuasa keluaran ac dan kecekapan dalam litar rektifier.

Define the output dc power, output ac power and efficiency of a rectifier.

(20%)

(b) Anda dikehendaki merekabentuk rektifier mudah satu fasa yang terdiri dari satu diod kuasa, satu diod meroda bebas dan punca masukan ac. Jika beban terdiri dari gabungan R dan L:

Design a simple rectifier single-phase circuit which consists of a power diode, a free-wheeling diode and ac voltage supply. With R and L load:

(i) Lakarkan bentuk gelombang voltan keluaran pada diod dan beban.

Sketch the output voltage waveforms across the diode and load.

(ii) Terbitkan persamaan voltan keluaran dc.

Derive equation for the dc output voltage.

(40%)

(c) Rekabentuk litar rektifier tak terkawal satu fasa titi penuh berbeban R sahaja dan punca ac. Tentukan kecekapan litar tersebut.

Design a full-wave uncontrolled bridge rectifier with R load from an ac supply. Determine the efficiency of the circuit.

(40%)

...5/-

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

Explain the v-i characteristic of thyristor.

(2[illegible])

(b) Jelaskan apakah maksud menghidupkan dan mematikan thiristor?

What are the means of turning-on and turning-off thyristors?

(2[illegible])

(c) Empat thiristor digunakan dalam rekabentuk rektifier penuh satu f[illegible]. Litar tersebut disambung ke beban RL.

Four thyristors are being used in a single-phase full-rectifier design. The circuit is connected to RL load.

(i) Lakarkan rekabentuk lengkap tanpa diod meroda bebas.
Design the complete circuit without free wheeling diode.

(ii) Lakarkan bentuk gelombang voltan dan arus keluaran.
Sketch the output voltage and current waveforms.

(iii) Terbitkan nilai voltan purata dan rms dalam sebutan s[illegible]t pemicuan, α.
Derive the average value and rms value of the output voltage in term of firing angle, α.

(6[illegible])

...

5. (a) Apakah prinsip bagi penukaran dc ke ac? Huraikan dengan memberikan satu contoh merujuk kepada sistem satu fasa. Jelaskan dengan litar, operasi, gelombang voltan (arus) dan persamaan yang berkaitan.

What is the principle of dc to ac conversion? Describe using example refer to single phase system. Explanation should include the circuit, operation, voltage (current) waveform and the appropriate equations.

(50%)

(b) Apakah prinsip bagi penukaran dc ke dc? Huraikan dengan memberikan satu contoh rekabentuk. Jelaskan dengan litar, operasi, gelombang voltan (arus) dan persamaan yang berkaitan.

What is the principle of dc to dc conversion? Describe using example of the design involved. Explanation should include the circuit, operation, voltage (current) waveform and the appropriate equations.

(50%)

6. (a) Apakah perwakilan analog untuk pemindahan haba dari peranti semikonduktor kuasa?

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

(20%)

(b) Takrifkan:
Define:

(i) Masa lebur suatu fius.
Melting time of a fuse.

(ii) Masa arca fius.

Arcing time of a fuse.

(iii) Masa penjelasan bagi fius.

Clearing time of a fuse.

(20%)

(c) Satu MOSFET jenis MTM8N60 beroperasi dalam mod tunggal untuk tempoh 1ms. Pada permulaan denyut T_c=100^{0}C. Menggunakan data dari **Lampiran A**, kira suhu simpang pada akhir denyut untuk kehilangan kuasa maksimum.

A MOSFET of type MTM8N60 is used to conduct in a single pulse mode for duration of 1ms. At the beginning of the pulse T_c=100^{0}C. Using the data from ***Appendix A****, find the junction temperature at the end of the pulse for maximum power dissipation.*

(30%)

(d) Satu jenis MOSFET jenis MTM8N60 beroperasi dalam denyut berterusan iaitu 5ms ON dan 20 ms OFF. Kehilangan kuasa semasa pengaliran ialah 80W; R_{CS}=0.2 ^{0}C/W, R_{SA}=2 ^{0}C/W dan T_A=35 ^{0}C. Kira:

A MOSFET of type MTM8N60 operates in a period conduction mode of 5ms on and 20 ms off. The power dissipation during conduction is 80W; R_{CS}=0.2 ^{0}C/W, R_{SA}=2 ^{0}C/W and T_A=35 ^{0}C. Find:

(i) Suhu selonsong.

The case temperature.

(ii) Suhu puncak simpang.

The peak junction temperature.

(30%)

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MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

MTH8N55
MTH8N60
MTM8N60

Designer's Data Sheet

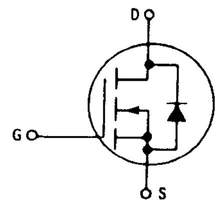
Power Field Effect Transistor

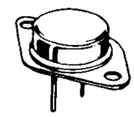
N-Channel Enhancement-Mode Silicon Gate TMOS

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

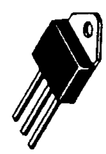
- Silicon Gate for Fast Switching Speeds — Switching Times Specified at 100°C
- Designer's Data — I_{DSS}, $V_{DS(on)}$, $V_{GS(th)}$ and SOA Specified at Elevated Temperature
- Rugged — SOA is Power Dissipation Limited
- Source-to-Drain Diode Characterized for Use With Inductive Loads

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 ($t_p \leq 50\ \mu s$)	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)

SAFE OPERATING AREA INFORMATION

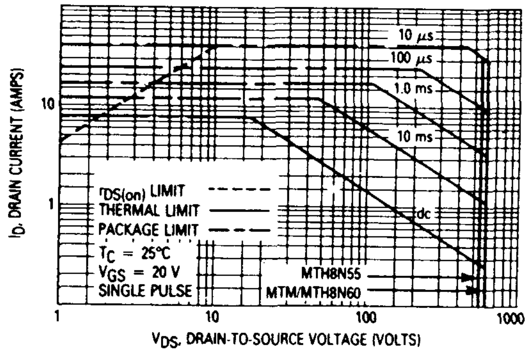


Figure 7. Maximum Rated Forward Biased Safe Operating Area

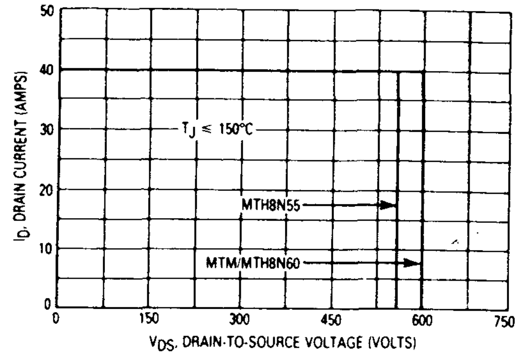


Figure 8. Maximum Rated Switching Safe Operating Area

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:

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

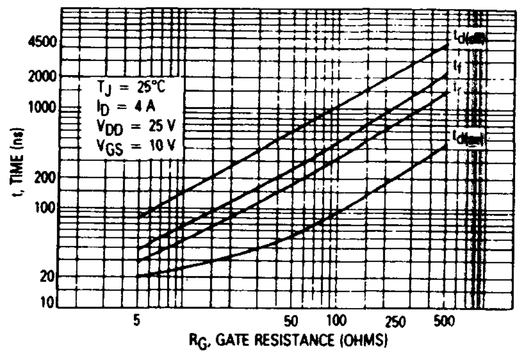


Figure 9. Resistive Switching Time Variation With Gate Resistance

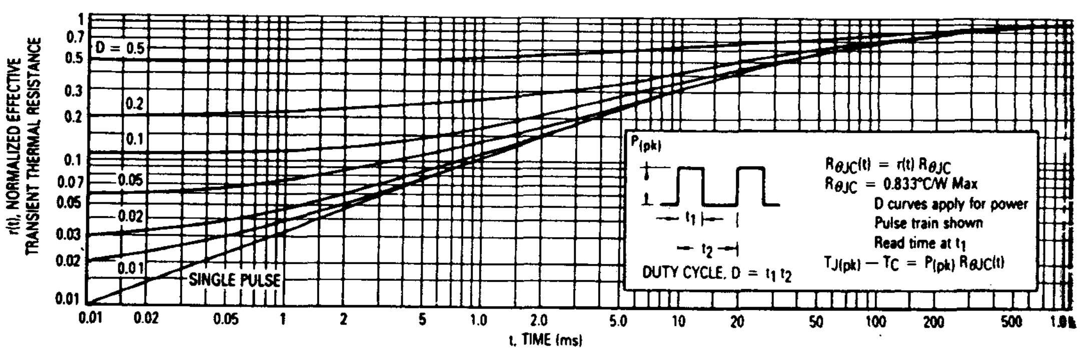


Figure 10. Thermal Response