

FQB60N03L

N-Channel Logic Level PWM Optimized Power MOSFET

General Description

This device employs a new advanced MOSFET technology and features low gate charge while maintaining low on-resistance.

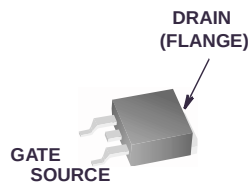
Optimized for switching applications, this device improves the overall efficiency of DC/DC converters and allows operation to higher switching frequencies.

Applications

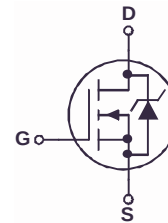
- DC/DC converters

Features

- Fast switching
- $r_{DS(ON)} = 0.010\Omega$ (Typ), $V_{GS} = 10V$
- $r_{DS(ON)} = 0.017\Omega$ (Typ), $V_{GS} = 5V$
- Q_g (Typ) = 13nC, $V_{GS} = 5V$
- Q_{gd} (Typ) = 4.5nC
- C_{ISS} (Typ) = 1650pF



TO-263AB



MOSFET Maximum Ratings $T_C = 25^\circ\text{C}$ unless otherwise noted

Symbol	Parameter	Ratings	Units
V_{DSS}	Drain to Source Voltage	30	V
V_{GS}	Gate to Source Voltage	± 16	V
I_D	Drain Current		
	Continuous ($T_C = 25^\circ\text{C}$, $V_{GS} = 10V$)	51	A
	Continuous ($T_C = 100^\circ\text{C}$, $V_{GS} = 4.5V$)	27	A
	Continuous ($T_C = 25^\circ\text{C}$, $V_{GS} = 10V$, $R_{\theta JA} = 43^\circ\text{C/W}$)	7	A
	Pulsed	Figure 4	A
P_D	Power dissipation	62	W
	Derate above 25°C	0.5	W/ $^\circ\text{C}$
T_J, T_{STG}	Operating and Storage Temperature	-55 to 150	$^\circ\text{C}$

Thermal Characteristics

$R_{\theta JC}$	Thermal Resistance Junction to Case TO-263	2	$^\circ\text{C/W}$
$R_{\theta JA}$	Thermal Resistance Junction to Ambient TO-263	62	$^\circ\text{C/W}$
$R_{\theta JA}$	Thermal Resistance Junction to Ambient TO-263, 1in ² copper pad area	43	$^\circ\text{C/W}$

Package Marking and Ordering Information

Device Marking	Device	Package	Reel Size	Tape Width	Quantity
FQB60N03L	FQB60N03L	TO-263AB	330mm	24mm	800 units

Electrical Characteristics $T_C = 25^\circ\text{C}$ unless otherwise noted

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
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Off Characteristics

$B_{V_{DS}}$	Drain to Source Breakdown Voltage	$I_D = 250\mu\text{A}$, $V_{GS} = 0\text{V}$	30	-	-	V
I_{DSS}	Zero Gate Voltage Drain Current	$V_{DS} = 25\text{V}$ $V_{GS} = 0\text{V}$ $T_C = 150^\circ\text{C}$	-	-	1	μA
I_{GSS}	Gate to Source Leakage Current	$V_{GS} = \pm 16\text{V}$	-	-	± 100	nA

On Characteristics

$V_{GS(TH)}$	Gate to Source Threshold Voltage	$V_{GS} = V_{DS}$, $I_D = 250\mu\text{A}$	1	-	3	V
$r_{DS(ON)}$	Drain to Source On Resistance	$I_D = 51\text{A}$, $V_{GS} = 10\text{V}$	-	0.010	0.0135	Ω
		$I_D = 27\text{A}$, $V_{GS} = 4.5\text{V}$	-	0.017	0.020	

Dynamic Characteristics

C_{ISS}	Input Capacitance	$V_{DS} = 15\text{V}$, $V_{GS} = 0\text{V}$, $f = 1\text{MHz}$	-	1650	-	pF
C_{OSS}	Output Capacitance		-	800	-	pF
C_{RSS}	Reverse Transfer Capacitance		-	200	-	pF
$Q_{g(TOT)}$	Total Gate Charge at 10V	$V_{GS} = 0\text{V}$ to 10V	$V_{DD} = 15\text{V}$ $I_D = 27\text{A}$ $I_g = 1.0\text{mA}$	25	52	nC
$Q_{g(5)}$	Total Gate Charge at 5V	$V_{GS} = 0\text{V}$ to 5V		13	30	nC
$Q_{g(TH)}$	Threshold Gate Charge	$V_{GS} = 0\text{V}$ to 1V		1.5	2.3	nC
Q_{gs}	Gate to Source Gate Charge			4.3	-	nC
Q_{gd}	Gate to Drain "Miller" Charge			4.5	-	nC

Switching Characteristics ($V_{GS} = 4.5\text{V}$)

t_{ON}	Turn-On Time	$V_{DD} = 15\text{V}$, $I_D = 12\text{A}$ $V_{GS} = 5\text{V}$, $R_{GS} = 11\Omega$	-	-	115	ns
$t_{d(ON)}$	Turn-On Delay Time		-	15	-	ns
t_r	Rise Time		-	60	-	ns
$t_{d(OFF)}$	Turn-Off Delay Time		-	25	-	ns
t_f	Fall Time		-	30	-	ns
t_{OFF}	Turn-Off Time		-	-	83	ns

Switching Characteristics ($V_{GS} = 10\text{V}$)

t_{ON}	Turn-On Time	$V_{DD} = 15\text{V}$, $I_D = 12\text{A}$ $V_{GS} = 10\text{V}$, $R_{GS} = 11\Omega$	-	-	57	ns
$t_{d(ON)}$	Turn-On Delay Time		-	8	-	ns
t_r	Rise Time		-	30	-	ns
$t_{d(OFF)}$	Turn-Off Delay Time		-	45	-	ns
t_f	Fall Time		-	30	-	ns
t_{OFF}	Turn-Off Time		-	-	115	ns

Unclamped Inductive Switching

t_{AV}	Avalanche Time	$I_D = 2.9\text{A}$, $L = 3.0\text{mH}$	195	-	-	μs
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Drain-Source Diode Characteristics

V_{SD}	Source to Drain Diode Voltage	$I_{SD} = 27\text{A}$	-	-	1.5	V
		$I_{SD} = 20\text{A}$	-	-	1.0	V
t_{rr}	Reverse Recovery Time	$I_{SD} = 27\text{A}$, $dI_{SD}/dt = 100\text{A}/\mu\text{s}$	-	-	71	ns
Q_{RR}	Reverse Recovered Charge	$I_{SD} = 27\text{A}$, $dI_{SD}/dt = 100\text{A}/\mu\text{s}$	-	-	104	nC

Typical Characteristic $T_C = 25^\circ\text{C}$ unless otherwise noted

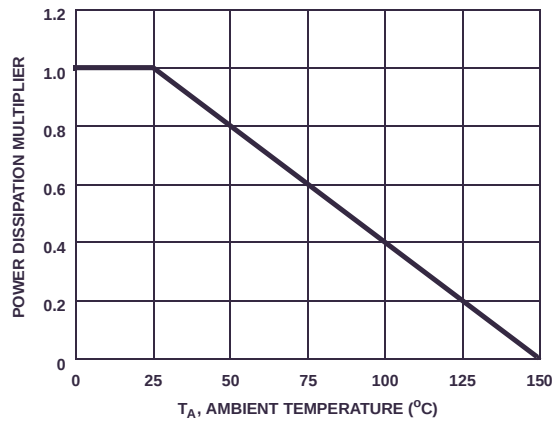


Figure 1. Normalized Power Dissipation vs Ambient Temperature

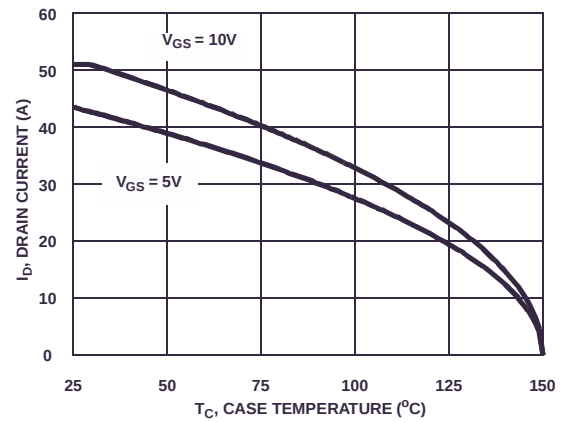


Figure 2. Maximum Continuous Drain Current vs Case Temperature

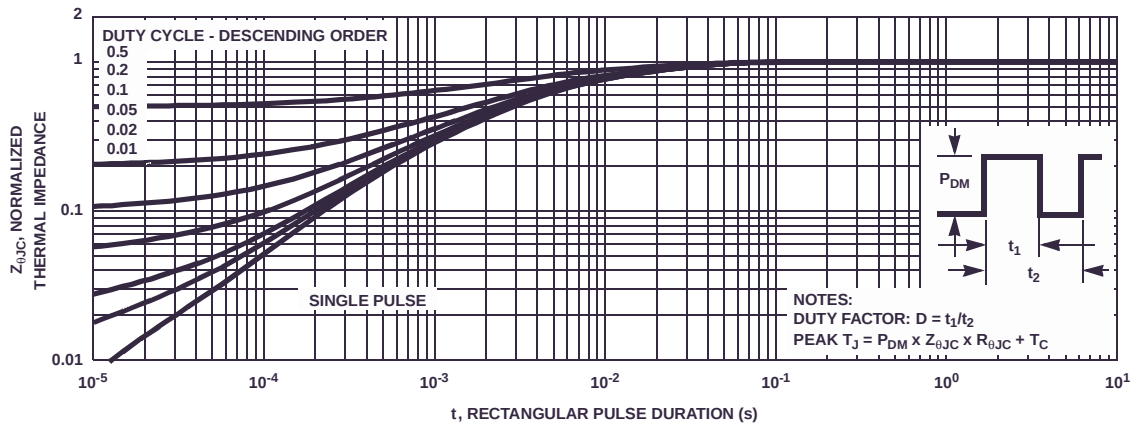


Figure 3. Normalized Maximum Transient Thermal Impedance

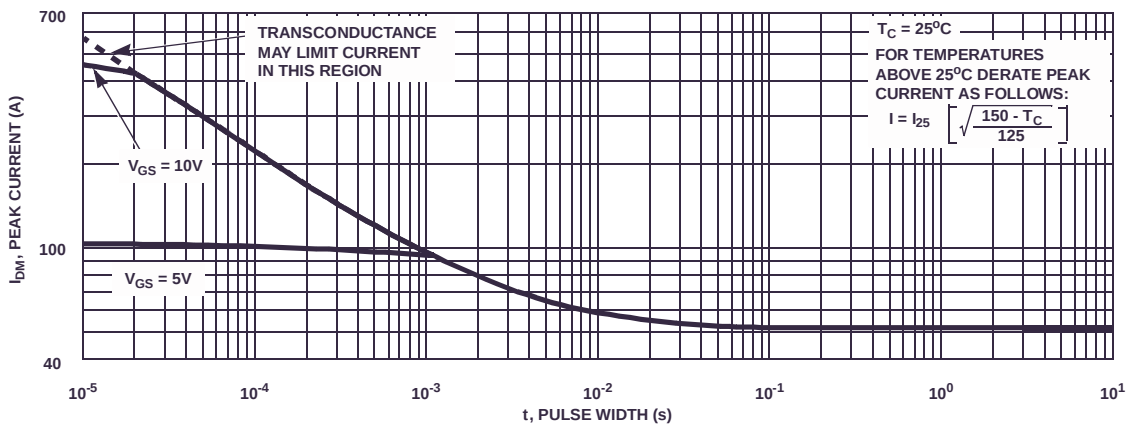


Figure 4. Peak Current Capability

Typical Characteristic (Continued) $T_C = 25^\circ\text{C}$ unless otherwise noted

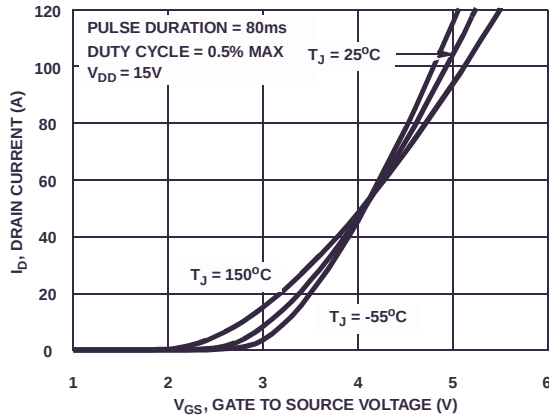


Figure 5. Transfer Characteristics

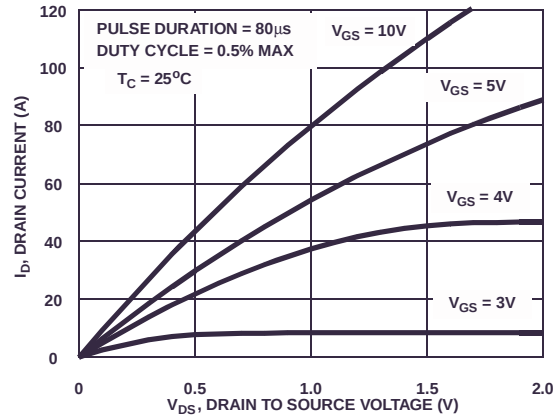


Figure 6. Saturation Characteristics

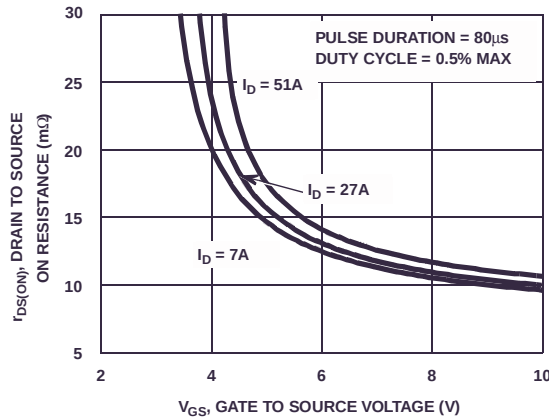


Figure 7. Drain to Source On Resistance vs. Gate Voltage and Drain Current

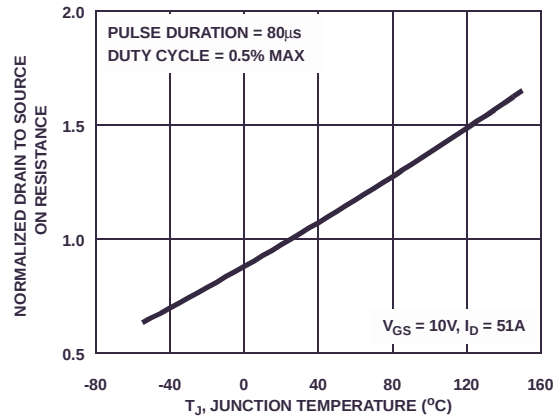


Figure 8. Normalized Drain to Source On Resistance vs. Junction Temperature

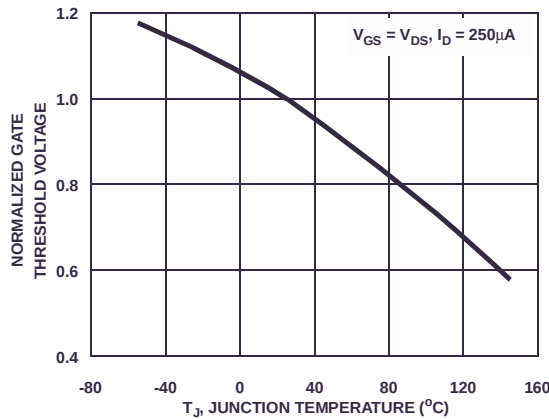


Figure 9. Normalized Gate Threshold Voltage vs. Junction Temperature

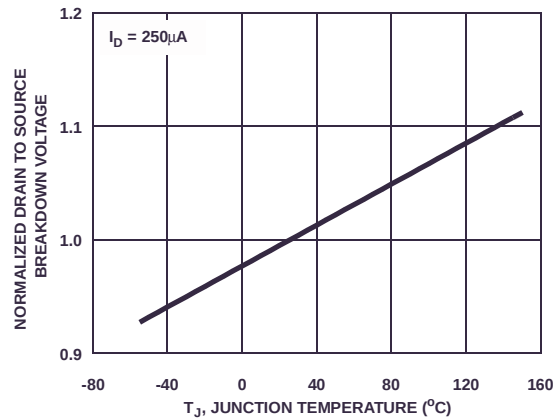


Figure 10. Normalized Drain to Source Breakdown Voltage vs. Junction Temperature

Typical Characteristic (Continued) $T_C = 25^\circ\text{C}$ unless otherwise noted

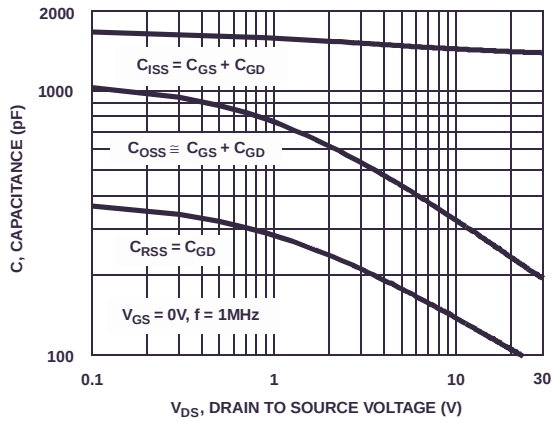


Figure 11. Capacitance vs Drain to Source Voltage

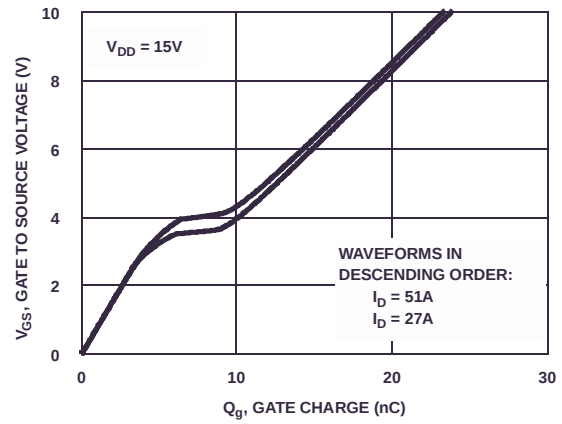


Figure 12. Gate Charge Waveforms for Constant Gate Currents

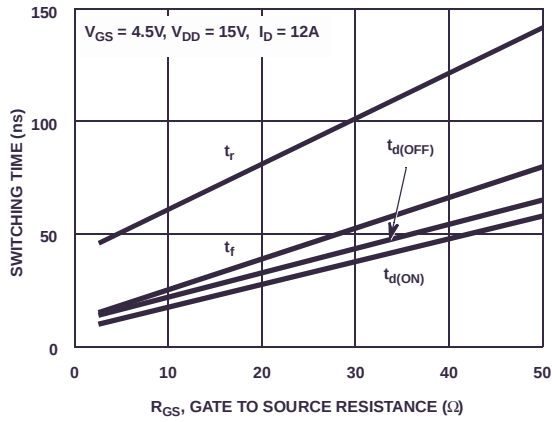


Figure 13. Switching Time vs Gate Resistance

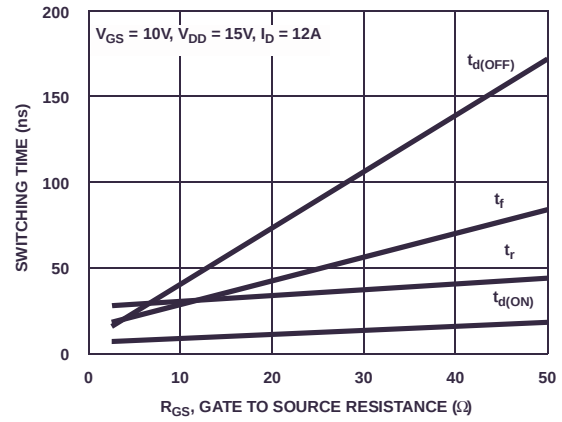


Figure 14. Switching Time vs Gate Resistance

Test Circuits and Waveforms

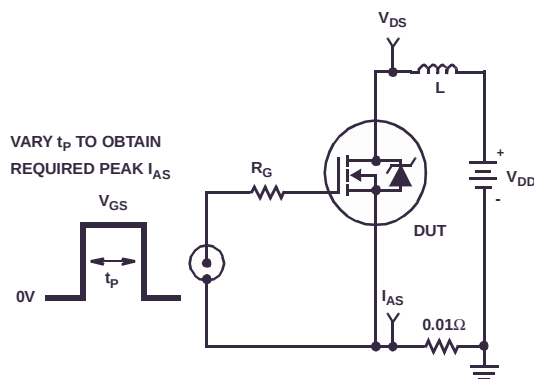


Figure 15. Unclamped Energy Test Circuit

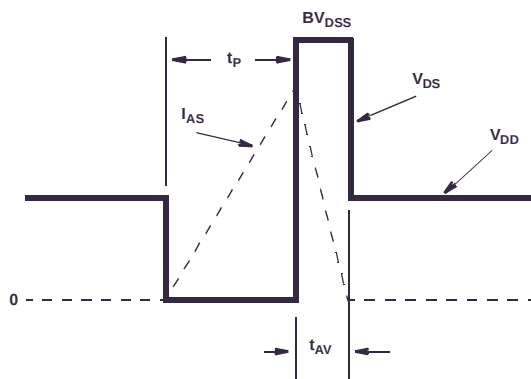


Figure 16. Unclamped Energy Waveforms

Test Circuits and Waveforms (Continued)

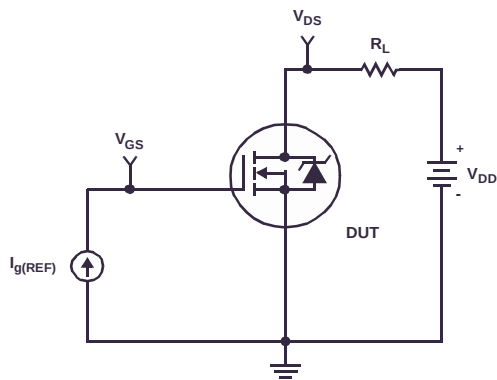


Figure 17. Gate Charge Test Circuit

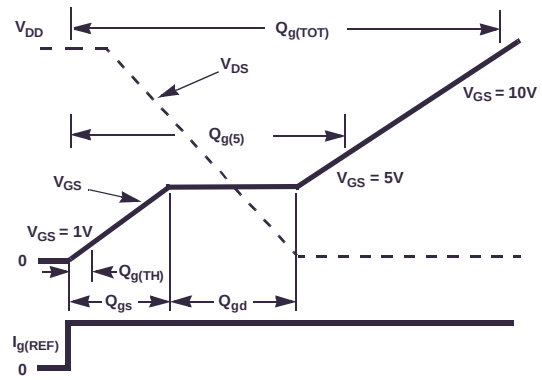


Figure 18. Gate Charge Waveforms

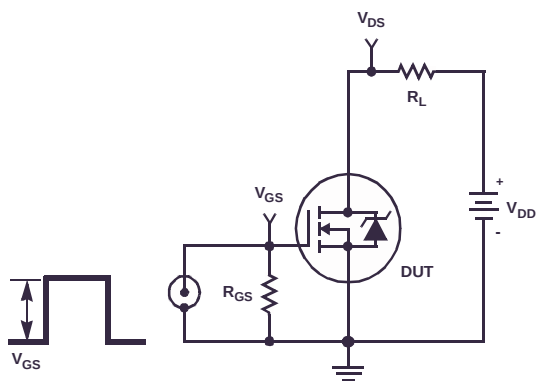


Figure 19. Switching Time Test Circuit

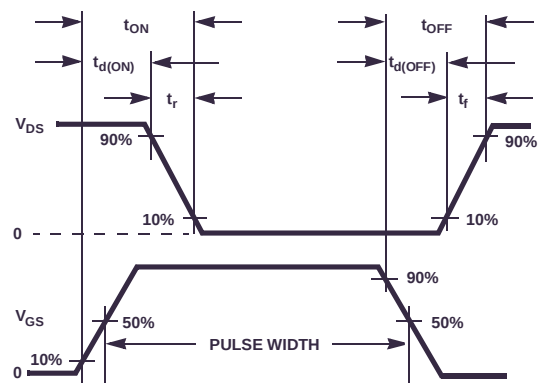


Figure 20. Switching Time Waveforms

Thermal Resistance vs. Mounting Pad Area

The maximum rated junction temperature, T_{JM} , and the thermal resistance of the heat dissipating path determines the maximum allowable device power dissipation, P_{DM} , in an application. Therefore the application's ambient temperature, T_A ($^{\circ}\text{C}$), and thermal resistance $R_{\theta JA}$ ($^{\circ}\text{C/W}$) must be reviewed to ensure that T_{JM} is never exceeded. Equation 1 mathematically represents the relationship and serves as the basis for establishing the rating of the part.

$$P_{DM} = \frac{(T_{JM} - T_A)}{Z_{\theta JA}} \quad (\text{EQ. 1})$$

In using surface mount devices such as the TO-263 package, the environment in which it is applied will have a significant influence on the part's current and maximum power dissipation ratings. Precise determination of P_{DM} is complex and influenced by many factors:

1. Mounting pad area onto which the device is attached and whether there is copper on one side or both sides of the board.
2. The number of copper layers and the thickness of the board.
3. The use of external heat sinks.
4. The use of thermal vias.
5. Air flow and board orientation.
6. For non steady state applications, the pulse width, the duty cycle and the transient thermal response of the part, the board and the environment they are in.

Fairchild provides thermal information to assist the designer's preliminary application evaluation. Figure 21 defines the $R_{\theta JA}$ for the device as a function of the top copper (component side) area. This is for a horizontally positioned FR-4 board with 1oz copper after 1000 seconds of steady state power with no air flow. This graph provides the necessary information for calculation of the steady state junction temperature or power dissipation. Pulse applications can be evaluated using the Fairchild device Spice thermal model or manually utilizing the normalized maximum transient thermal impedance curve.

Displayed on the curve are $R_{\theta JA}$ values listed in the Electrical Specifications table. The points were chosen to depict the compromise between the copper board area, the thermal resistance and ultimately the power dissipation, P_{DM} .

Thermal resistances corresponding to other copper areas can be obtained from Figure 21 or by calculation using Equation 2. $R_{\theta JA}$ is defined as the natural log of the area times a coefficient added to a constant. The area, in square inches is the top copper area including the gate and source pads.

$$R_{\theta JA} = 26.51 + \frac{19.84}{(0.262 + \text{Area})} \quad (\text{EQ. 2})$$

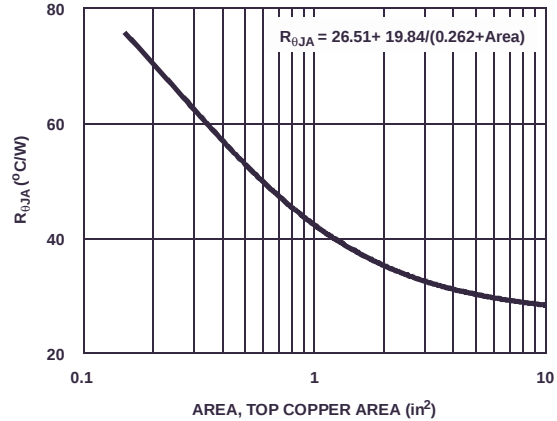
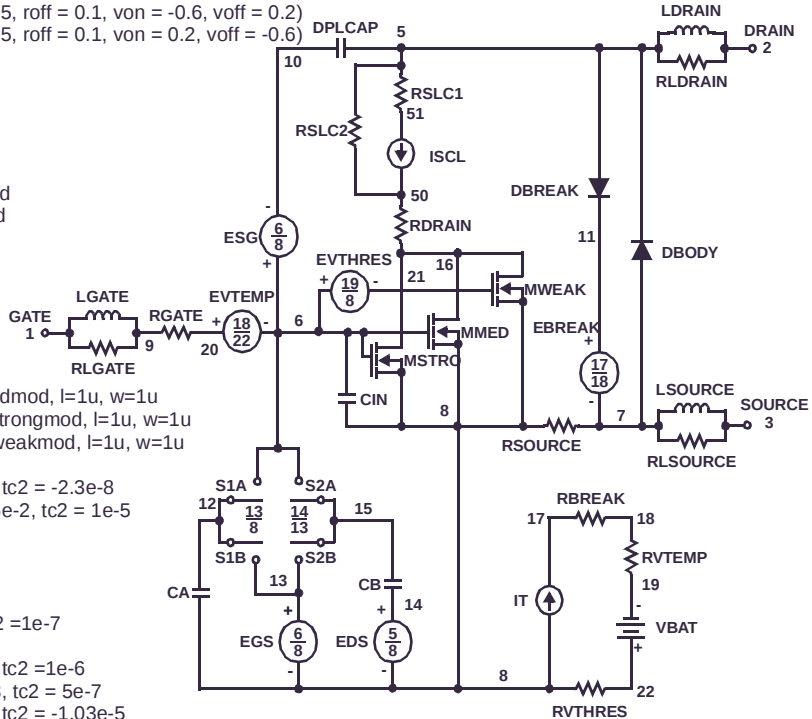


Figure 21. Thermal Resistance vs Mounting Pad Area



SPICE Thermal Model

REV 23 October 2002

FQB60N03L_Thermal

CTHERM1 th 6 1.0e-3
CTHERM2 6 5 3.5e-3
CTHERM3 5 4 4.8e-3
CTHERM4 4 3 5.2e-3
CTHERM5 3 2 8.0e-3
CTHERM6 2 tl 3.7e-2

RTHERM1 th 6 8.0e-3
RTHERM2 6 5 6.0e-2
RTHERM3 5 4 1.0e-1
RTHERM4 4 3 3.9e-1
RTHERM5 3 2 4.8e-1
RTHERM6 2 tl 5.1e-1

SABER Thermal Model

SABER thermal model FQB60N03L_Thermal

template thermal_model th tl
thermal_c th, tl

```
{  
  ctherm.ctherm1 th 6 = 1.0e-3  
  ctherm.ctherm2 6 5 = 3.5e-3  
  ctherm.ctherm3 5 4 = 4.8e-3  
  ctherm.ctherm4 4 3 = 5.2e-3  
  ctherm.ctherm5 3 2 = 8.0e-3  
  ctherm.ctherm6 2 tl = 3.7e-2
```

```
  rtherm.rtherm1 th 6 = 8.0e-3  
  rtherm.rtherm2 6 5 = 6.0e-2  
  rtherm.rtherm3 5 4 = 1.0e-1  
  rtherm.rtherm4 4 3 = 3.9e-1  
  rtherm.rtherm5 3 2 = 4.8e-1  
  rtherm.rtherm6 2 tl = 5.1e-1  
}
```

