



# FQD4N60/FQI4N60/FQU4N60

## 600V,4A N-Channel MOSFET

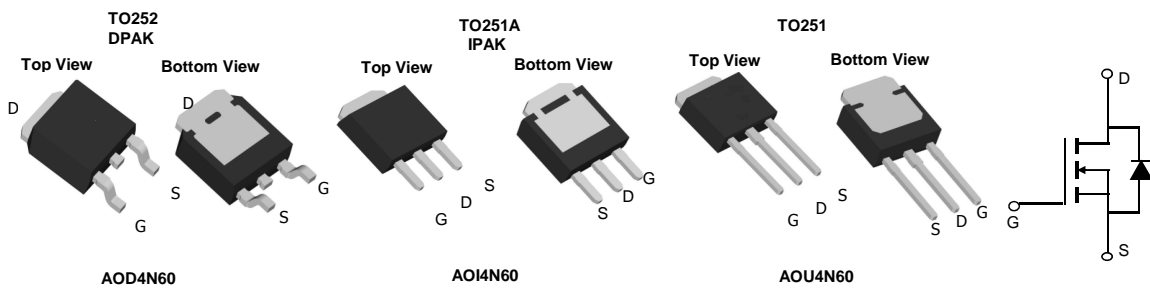
### General Description

The FQD4N60 & FQI4N60 & FQU4N60 have been fabricated using an advanced high voltage MOSFET process that is designed to deliver high levels of performance and robustness in popular AC-DC applications. By providing low  $R_{DS(on)}$ ,  $C_{iss}$  and  $C_{rss}$  along with guaranteed avalanche capability these parts can be adopted quickly into new and existing offline power supply designs.

### Product Summary

$V_{DS}$	700V@150°C
$I_D$ (at $V_{GS}=10V$ )	4A
$R_{DS(ON)}$ (at $V_{GS}=10V$ )	< 2.3Ω

100% UIS Tested!  
100%  $R_g$  Tested!



### Absolute Maximum Ratings $T_A=25^\circ C$ unless otherwise noted

Parameter	Symbol	Maximum	Units
Drain-Source Voltage	$V_{DS}$	600	V
Gate-Source Voltage	$V_{GS}$	±30	V
Continuous Drain Current <sup>B</sup>	$I_D$	$T_C=25^\circ C$	4
		$T_C=100^\circ C$	2.6
Pulsed Drain Current <sup>C</sup>	$I_{DM}$	14	A
Avalanche Current <sup>C</sup>	$I_{AR}$	2.8	A
Repetitive avalanche energy <sup>C</sup>	$E_{AR}$	118	mJ
Single pulsed avalanche energy <sup>H</sup>	$E_{AS}$	235	mJ
MOSFET dv/dt ruggedness	dv/dt	50	V/ns
Peak diode recovery dv/dt		5	
Power Dissipation <sup>B</sup>	$P_D$	$T_C=25^\circ C$	104
		Derate above 25°C	0.83
Junction and Storage Temperature Range	$T_J, T_{STG}$	-50 to 150	°C
Maximum lead temperature for soldering purpose, 1/8" from case for 5 seconds	$T_L$	300	°C

### Thermal Characteristics

Parameter	Symbol	Typical	Maximum	Units
Maximum Junction-to-Ambient <sup>A,G</sup>	$R_{\theta JA}$	43	55	°C/W
Maximum Case-to-sink <sup>A</sup>	$R_{\theta CS}$	-	0.5	°C/W
Maximum Junction-to-Case <sup>D,F</sup>	$R_{\theta JC}$	1	1.2	°C/W

Electrical Characteristics (T<sub>J</sub>=25°C unless otherwise noted)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
<b>STATIC PARAMETERS</b>						
BV <sub>DSS</sub>	Drain-Source Breakdown Voltage	I <sub>D</sub> =250μA, V <sub>GS</sub> =0V, T <sub>J</sub> =25°C	600			V
		I <sub>D</sub> =250μA, V <sub>GS</sub> =0V, T <sub>J</sub> =150°C		700		
BV <sub>DSS</sub> /ΔT <sub>J</sub>	Zero Gate Voltage Drain Current	I <sub>D</sub> =250μA, V <sub>GS</sub> =0V		0.67		V/°C
I <sub>DSS</sub>	Zero Gate Voltage Drain Current	V <sub>DS</sub> =600V, V <sub>GS</sub> =0V			1	μA
		V <sub>DS</sub> =480V, T <sub>J</sub> =125°C			10	
I <sub>GSS</sub>	Gate-Body leakage current	V <sub>DS</sub> =0V, V <sub>GS</sub> =±30V			±100	nA
V <sub>GS(th)</sub>	Gate Threshold Voltage	V <sub>DS</sub> =5V, I <sub>D</sub> =250μA	3.4	4.1	4.5	V
R <sub>DS(ON)</sub>	Static Drain-Source On-Resistance	V <sub>GS</sub> =10V, I <sub>D</sub> =2A		1.8	2.3	Ω
g <sub>FS</sub>	Forward Transconductance	V <sub>DS</sub> =40V, I <sub>D</sub> =2A		6		S
V <sub>SD</sub>	Diode Forward Voltage	I <sub>S</sub> =1A, V <sub>GS</sub> =0V		0.76	1	V
I <sub>S</sub>	Maximum Body-Diode Continuous Current			4		A
I <sub>SM</sub>	Maximum Body-Diode Pulsed Current			14		A
<b>DYNAMIC PARAMETERS</b>						
C <sub>iss</sub>	Input Capacitance	V <sub>GS</sub> =0V, V <sub>DS</sub> =25V, f=1MHz	420	528	640	pF
C <sub>oss</sub>	Output Capacitance		35	53	70	pF
C <sub>rss</sub>	Reverse Transfer Capacitance		2.5	4.8	7	pF
R <sub>g</sub>	Gate resistance	V <sub>GS</sub> =0V, V <sub>DS</sub> =0V, f=1MHz	1.2	2.5	3.8	Ω
<b>SWITCHING PARAMETERS</b>						
Q <sub>g</sub>	Total Gate Charge	V <sub>GS</sub> =10V, V <sub>DS</sub> =480V, I <sub>D</sub> =4A	9.5	12	14.5	nC
Q <sub>gs</sub>	Gate Source Charge		2.8	3.6	4.5	nC
Q <sub>gd</sub>	Gate Drain Charge		2.2	4.4	6.6	nC
t <sub>D(on)</sub>	Turn-On DelayTime	V <sub>GS</sub> =10V, V <sub>DS</sub> =300V, I <sub>D</sub> =4A, R <sub>G</sub> =25Ω		17		ns
t <sub>r</sub>	Turn-On Rise Time			26		ns
t <sub>D(off)</sub>	Turn-Off DelayTime			34		ns
t <sub>f</sub>	Turn-Off Fall Time			21		ns
t <sub>rr</sub>	Body Diode Reverse Recovery Time	I <sub>F</sub> =4A, di/dt=100A/μs, V <sub>DS</sub> =100V	150	190	230	ns
Q <sub>rr</sub>	Body Diode Reverse Recovery Charge	I <sub>F</sub> =4A, di/dt=100A/μs, V <sub>DS</sub> =100V	1.9	2.4	3	μC

- A. The value of R<sub>θJA</sub> is measured with the device in a still air environment with T<sub>A</sub>=25° C.
- B. The power dissipation P<sub>D</sub> is based on T<sub>J(MAX)</sub>=150° C in a TO252 package, using junction-to-case thermal resistance, and is more useful in setting the upper dissipation limit for cases where additional heatsinking is used.
- C. Repetitive rating, pulse width limited by junction temperature T<sub>J(MAX)</sub>=150° C.
- D. The R<sub>θJA</sub> is the sum of the thermal impedance from junction to case R<sub>θJC</sub> and case to ambient.
- E. The static characteristics in Figures 1 to 6 are obtained using <300 μs pulses, duty cycle 0.5% max.
- F. These curves are based on the junction-to-case thermal impedance which is measured with the device mounted to a large heatsink, assuming a maximum junction temperature of T<sub>J(MAX)</sub>=150° C.
- G. These tests are performed with the device mounted on 1 in<sup>2</sup> FR-4 board with 2oz. Copper, in a still air environment with T<sub>A</sub>=25° C.
- H. L=60mH, I<sub>AS</sub>=2.8A, V<sub>DD</sub>=150V, R<sub>G</sub>=10Ω, Starting T<sub>J</sub>=25° C

TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS

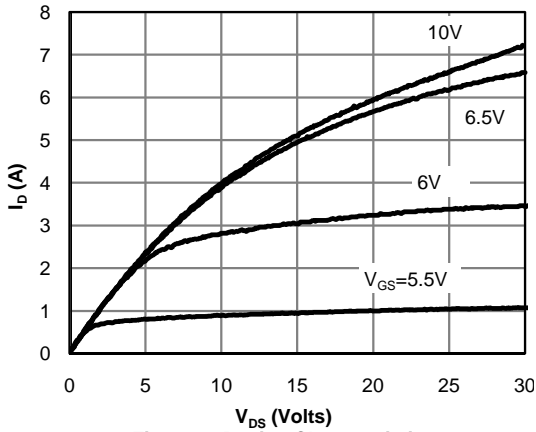


Fig 1: On-Region Characteristics

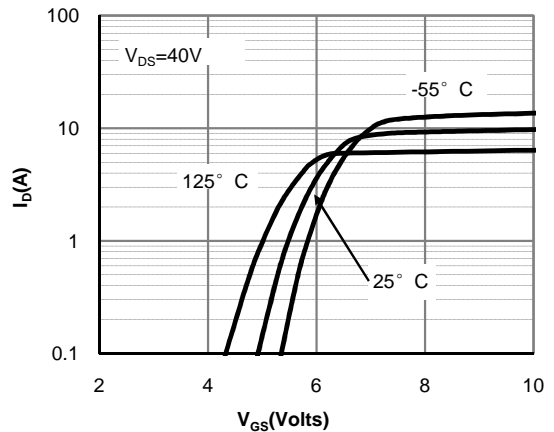


Figure 2: Transfer Characteristics

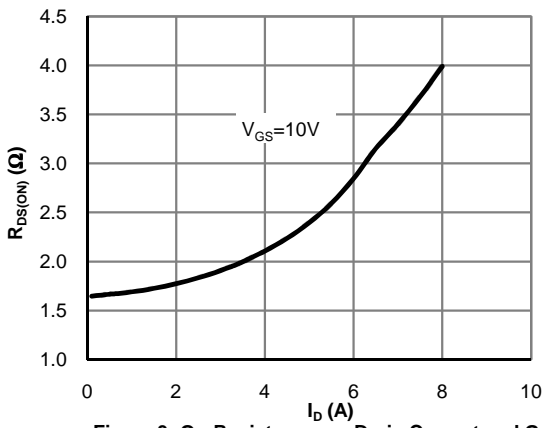


Figure 3: On-Resistance vs. Drain Current and Gate Voltage

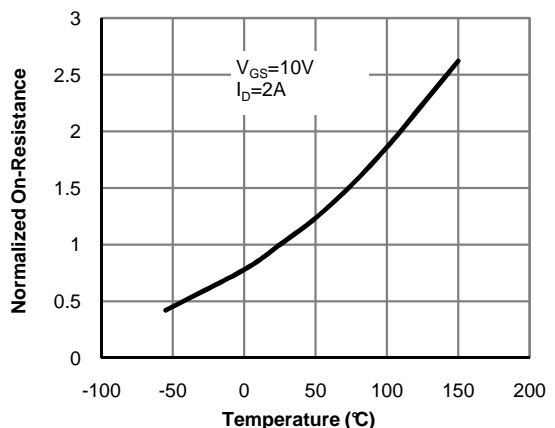


Figure 4: On-Resistance vs. Junction Temperature

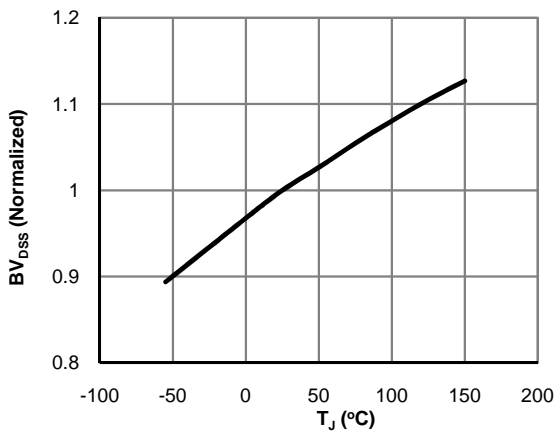


Figure 5: Break Down vs. Junction Temperature

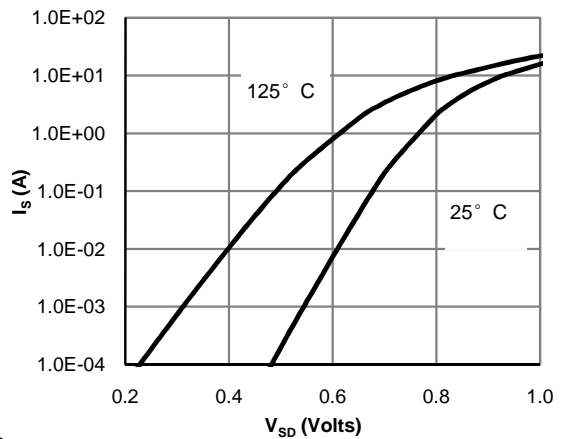


Figure 6: Body-Diode Characteristics

TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS

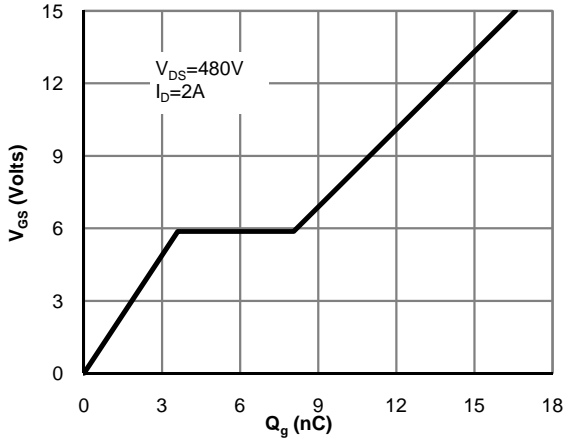


Figure 7: Gate-Charge Characteristics

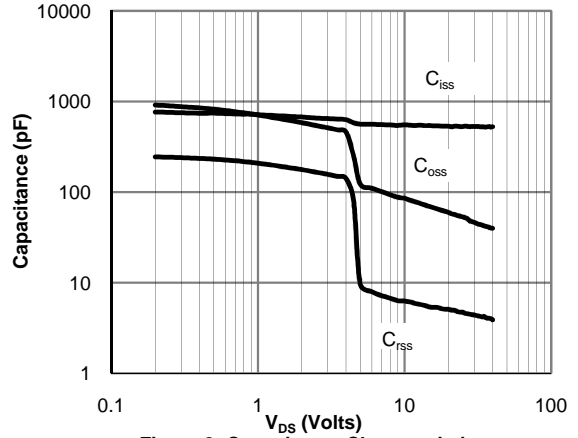


Figure 8: Capacitance Characteristics

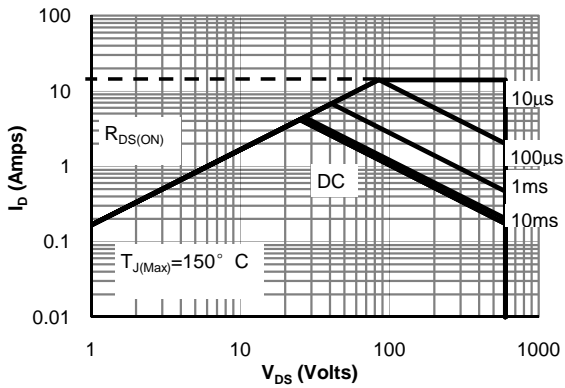


Figure 9: Maximum Forward Biased Safe Operating Area (Note F)

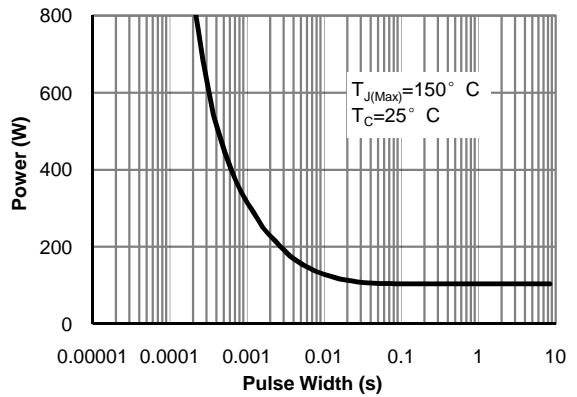


Figure 10: Single Pulse Power Rating Junction-to-Case (Note F)

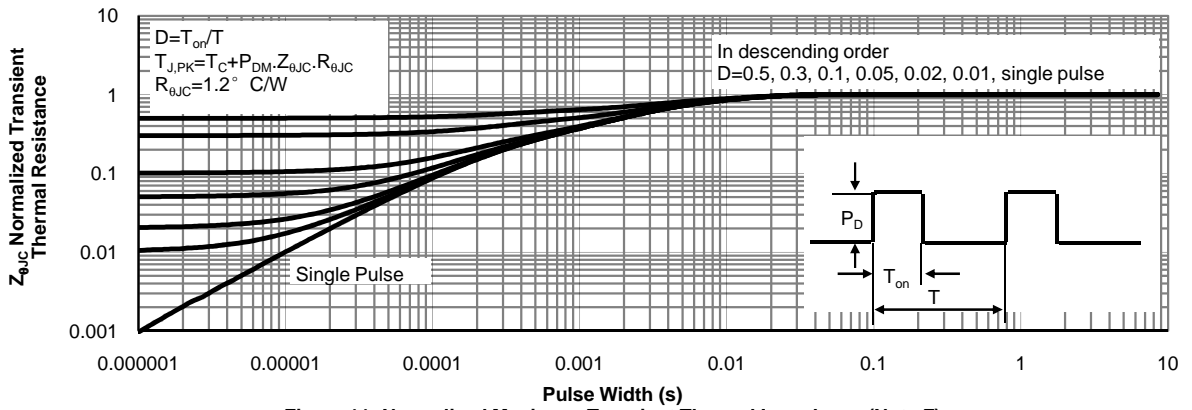


Figure 11: Normalized Maximum Transient Thermal Impedance (Note F)

TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS

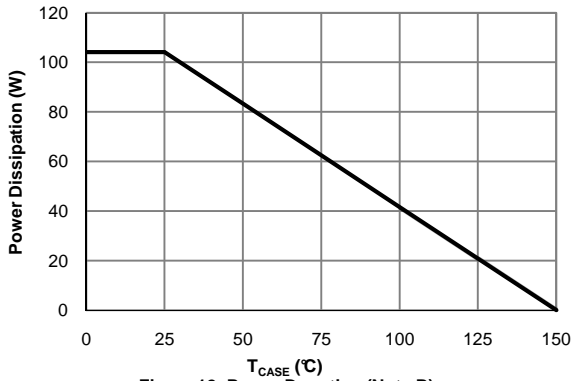


Figure 12: Power De-rating (Note B)

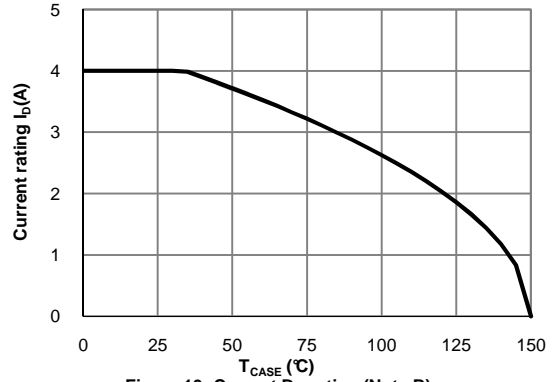


Figure 13: Current De-rating (Note B)

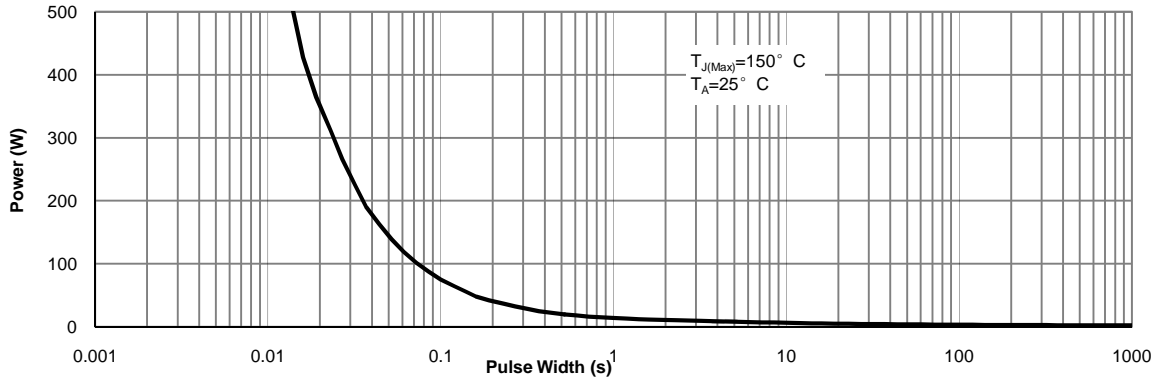


Figure 14: Single Pulse Power Rating Junction-to-Ambient (Note G)

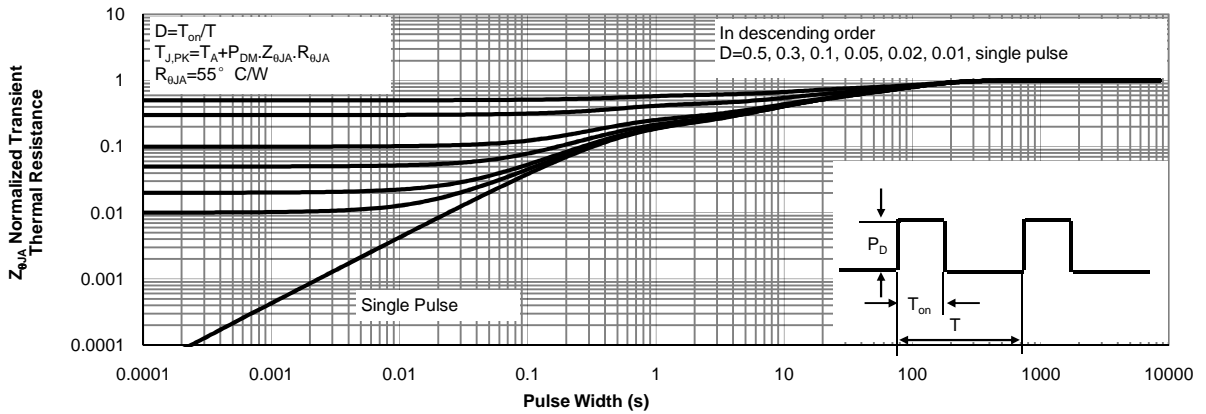
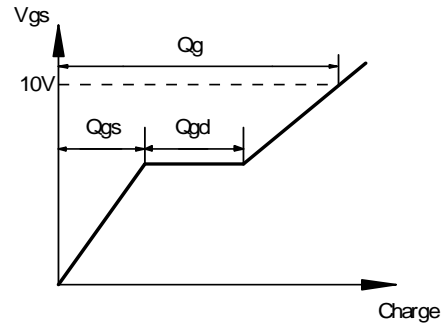
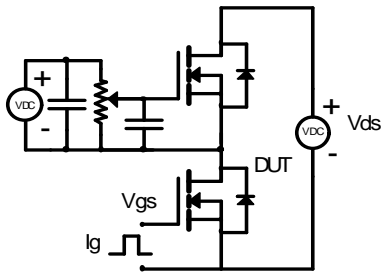
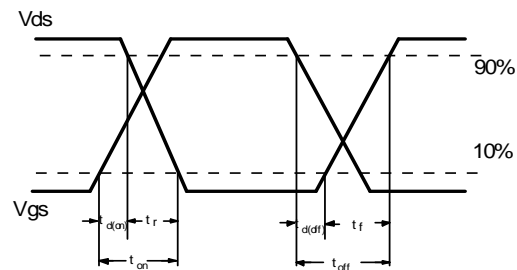
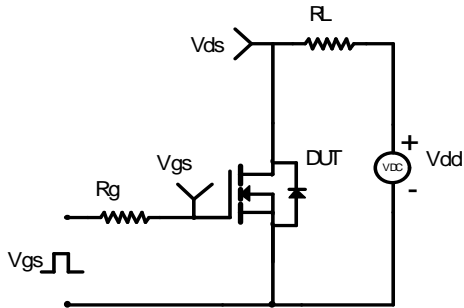


Figure 15: Normalized Maximum Transient Thermal Impedance (Note G)

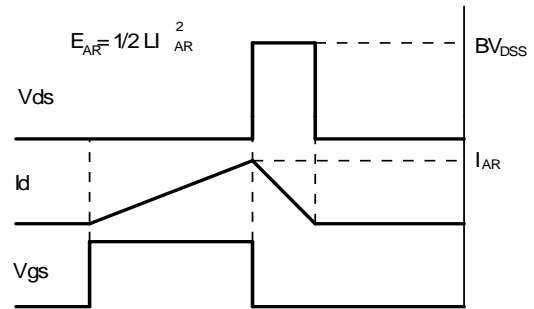
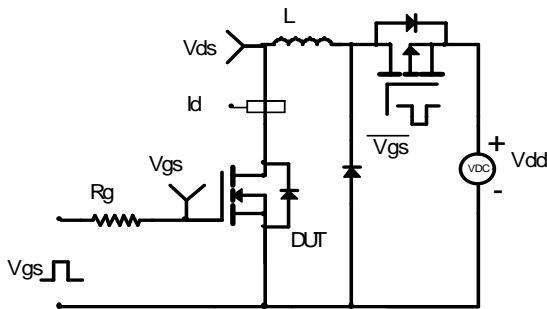
Gate Charge Test Circuit & Waveform



Resistive Switching Test Circuit & Waveforms



Unclamped Inductive Switching (UIS) Test Circuit & Waveforms



Diode Recovery Test Circuit & Waveforms

