FAIRCHILD
SEMICONDUCTOR™

February 1996

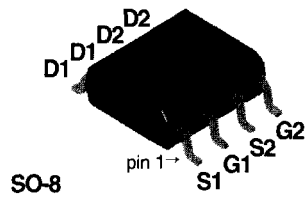
NDS9958
Dual N & P-Channel Enhancement Mode Field Effect Transistor

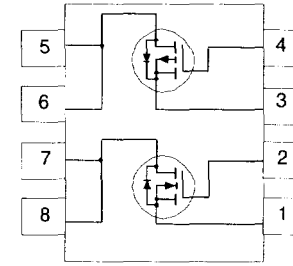
General Description

These dual N- and P-Channel enhancement mode power field effect transistors are produced using Fairchild's proprietary, high cell density, DMOS technology. This very high density process is especially tailored to minimize on-state resistance, provide superior switching performance, and withstand high energy pulses in the avalanche and commutation modes. These devices are particularly suited for low voltage applications such as notebook computer power management, Half bridge motor control, cellular phone, and other battery powered circuits where fast switching, low in-line power loss, and resistance to transients are needed.

Features

- N-Channel 3.5A, 20V, $R_{DS(ON)} = 0.1\Omega$ @ $V_{GS} = 10V$.
  P-Channel -3.5A , -20V, $R_{DS(ON)} = 0.1\Omega$ @ $V_{GS} = -10V$.
- High density cell design for extremely low $R_{DS(ON)}$.
- High power and current handling capability in a widely used surface mount package.
- Dual (N & P-Channel) MOSFET in surface mount package.





Absolute Maximum Ratings $T_A = 25$ C unless otherwise noted

Symbol	Parameter		N-Channel	P-Channel	Units
V_{DSS}	Drain-Source Voltage		20	-20	V
V_{GSS}	Gate-Source Voltage		±20	±20	V
I_D	Drain Current - Continuous $T_A = 25$ C	(Note 1a)	±3.5	±3.5	A
	- Continuous $T_A = 70$ C	(Note 1a)	±2.8	±2.8	
	- Pulsed $T_A = 25$ C		±14	±14	
P_D	Power Dissipation for Dual Operation		2		W
	Power Dissipation for Single Operation	(Note 1a)	1.6		
		(Note 1b)	1		
		(Note 1c)	0.9		
T_J, T_{STG}	Operating and Storage Temperature Range		-55 to 150		C
THERMAL CHARACTERISTICS					
$R_{\theta JA}$	Thermal Resistance, Junction-to-Ambient	(Note 1a)	78		C/W
$R_{\theta JC}$	Thermal Resistance, Junction-to-Case	(Note 1)	40		C/W

Electrical Characteristics (T_A= 25°C unless otherwise noted)

Symbol	Parameter	Conditions	Type	Min	Typ	Max	Units
OFF CHARACTERISTICS							
BV_{DSS}	Drain-Source Breakdown Voltage	V_{GS} = 0 V, I_D = 250 µA	N-Ch	20			V
		V_{GS} = 0 V, I_D = -250 µA	P-Ch	-20			
I_{DSS}	Zero Gate Voltage Drain Current	V_{DS} = 16 V, V_{GS} = 0 V	N-Ch			1	µA
		T_J = 70°C				5	µA
		V_{DS} = -16 V, V_{GS} = 0 V	P-Ch			-1	µA
		T_J = 70°C				-5	µA
I_{GSSF}	Gate - Body Leakage, Forward	V_{GS} = 20 V, V_{DS} = 0 V	All			100	nA
I_{GSSR}	Gate - Body Leakage, Reverse	V_{GS} = -20 V, V_{DS} = 0 V	All			-100	nA
ON CHARACTERISTICS (Note 2)							
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS}, I_D = 250 µA	N-Ch	1	1.5	3	V
		T_J = 125°C		0.7	1.1	2.2	
		V_{DS} = V_{GS}, I_D = -250 µA	P-Ch	-1	-2.2	-3	
		T_J = 125°C		-0.8	-1.9	-2.5	
$R_{DS(ON)}$	Static Drain-Source On-Resistance	V_{GS} = 10 V, I_D = 3.5 A	N-Ch		0.062	0.1	Ω
		T_J = 125°C			0.085	0.14	
		V_{GS} = -10 V, I_D = -3.5 A	P-Ch		0.08	0.1	
		T_J = 125°C			0.11	0.16	
		V_{GS} = 6V, I_D = 3.0 A	N-Ch		0.073	0.12	
		V_{GS} = -6 V, I_D = -3.0 A	P-Ch		0.112	0.12	
		V_{GS} = 4.5 V, I_D = 1.0 A	N-Ch		0.08	0.15	
		V_{GS} = -4.5 V, I_D = -1.0 A	P-Ch		0.165	0.19	
$I_{D(on)}$	On-State Drain Current	V_{GS} = 10 V, V_{DS} = 5 V	N-Ch	14			A
		V_{GS} = -10 V, V_{DS} = -5 V	P-Ch	-14			
		V_{GS} = 4.5 V, V_{DS} = 5 V	N-Ch	3.5			
		V_{GS} = -4.5 V, V_{DS} = -5 V	P-Ch	-2.5			
g_{FS}	Forward Transconductance	V_{DS} = 15 V, I_D = 3.5 A	N-Ch		7		S
		V_{DS} = -15 V, I_D = -3.5 A	P-Ch		5		
DYNAMIC CHARACTERISTICS							
C_{iss}	Input Capacitance	N-Channel V_{DS} = 10V, V_{GS} = 0 V, f = 1.0 MHz	N-Ch		525		pF
			P-Ch		785		
C_{oss}	Output Capacitance	P-Channel V_{DS} = -10 V, V_{GS} = 0 V, f = 1.0 MHz	N-Ch		315		pF
			P-Ch		500		
C_{rss}	Reverse Transfer Capacitance		N-Ch		185		pF
			P-Ch		245		

Electrical Characteristics (T_A = 25°C unless otherwise noted)

Symbol	Parameter	Conditions	Type	Min	Typ	Max	Units
SWITCHING CHARACTERISTICS (Note 2)							
$t_{D(on)}$	Turn - On Delay Time	N-Channel V_{DD} = 10 V, I_D = 1 A, V_{GEN} = 10 V, R_{GEN} = 6 Ω P-Channel V_{DD} = -10 V, I_D = -1 A, V_{GEN} = -10 V, R_{GEN} = 6 Ω	N-Ch		6	10	ns
			P-Ch		9	40	
t_r	Turn - On Rise Time		N-Ch		12	25	ns
			P-Ch		17	25	
$t_{D(off)}$	Turn - Off Delay Time		N-Ch		22	30	ns
			P-Ch		26	30	
t_f	Turn - Off Fall Time		N-Ch		8	20	ns
			P-Ch		13	20	
Q_g	Total Gate Charge	N-Channel V_{DS} = 10 V, I_D = 3.5 A, V_{GS} = 10 V P-Channel V_{DS} = -10 V, I_D = -3.5 A, V_{GS} = -10 V	N-Ch		17	30	nC
			P-Ch		19	30	
Q_{gs}	Gate-Source Charge		N-Ch		1.2	6	nC
			P-Ch		3	6	
Q_{gd}	Gate-Drain Charge		N-Ch		5	12	nC
			P-Ch		9	12	
DRAIN-SOURCE DIODE CHARACTERISTICS AND MAXIMUM RATINGS							
I_S	Maximum Continuous Drain-Source Diode Forward Current		N-Ch			1.7	A
			P-Ch			-1.7	
V_{SD}	Drain-Source Diode Forward Voltage	V_{GS} = 0 V, I_S = 1.7 A (Note 2)	N-Ch		0.86	1.2	V
		V_{GS} = 0 V, I_S = -1.7 A (Note 2)	P-Ch		-0.9	-1.2	
t_{rr}	Reverse Recovery Time	V_{GS} = 0V, I_F = 3.5 A, dI_F/dt = 100 A/µs	N-Ch			100	ns
			P-Ch			100	

Notes:

1. $R_{\theta JA}$ is the sum of the junction-to-case and case-to-ambient thermal resistance where the case thermal reference is defined as the solder mounting surface of the drain pins. $R_{\theta JC}$ is guaranteed by design while $R_{\theta CA}$ is determined by the user's board design.

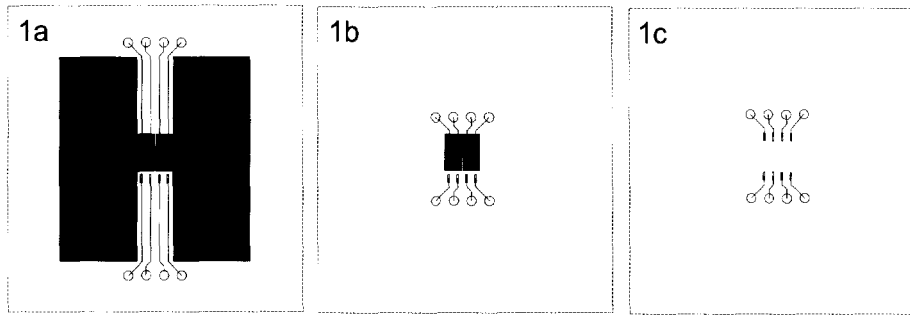
$$P_D(t) = \frac{T_J - T_A}{R_{\theta JA}(t)} = \frac{T_J - T_A}{R_{\theta JC} + R_{\theta CA}(t)} = I_D^2(t) \times R_{DS(ON)@T_J}$$

Typical $R_{\theta JA}$ for single device operation using the board layouts shown below on 4.5"x5" FR-4 PCB in a still air environment:

a. 78°C/W when mounted on a 0.5 in^2 pad of 2oz copper.

b. 125°C/W when mounted on a 0.02 in^2 pad of 2oz copper.

c. 135°C/W when mounted on a 0.003 in^2 pad of 2oz copper.



Scale 1 : 1 on letter size paper

2. Pulse Test: Pulse Width ≤ 300µs, Duty Cycle ≤ 2.0%.

Typical Electrical Characteristics: N-Channel

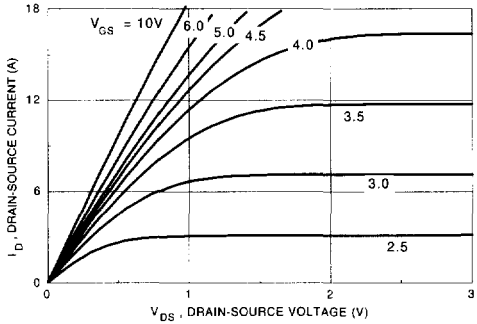


Figure 1. On-Region Characteristics.

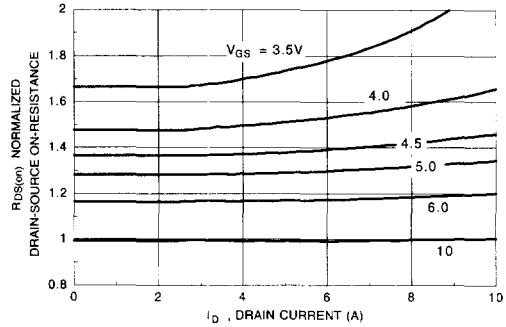


Figure 2. On-Resistance Variation with Gate Voltage and Drain Current.

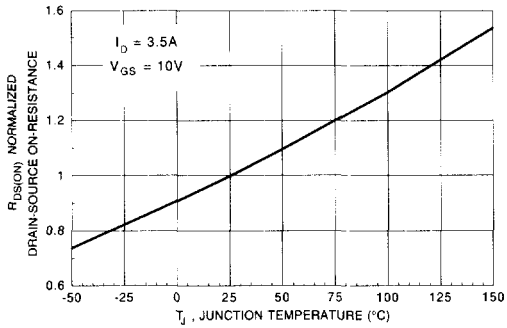


Figure 3. On-Resistance Variation with Temperature.

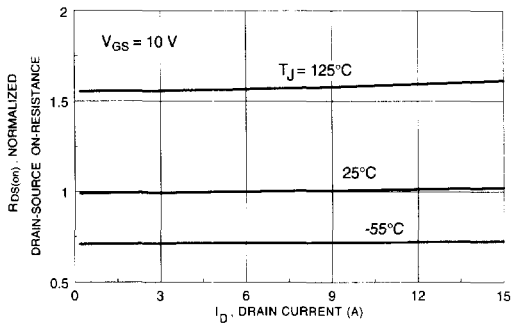


Figure 4. On-Resistance Variation with Drain Current and Temperature.

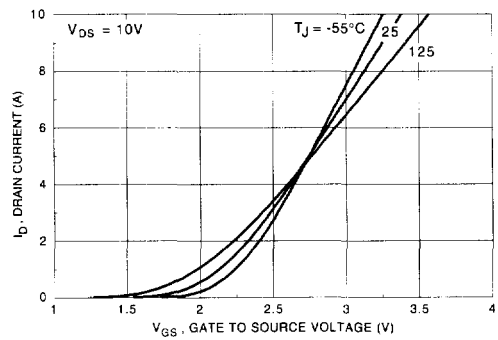


Figure 5. Transfer Characteristics.

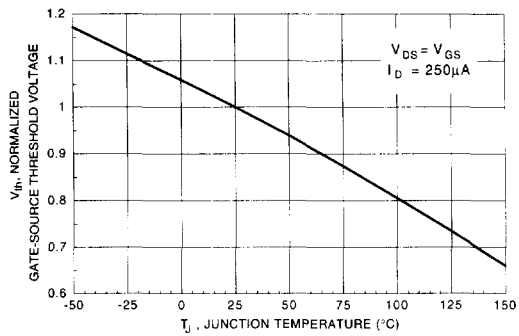


Figure 6. Gate Threshold Variation with Temperature.

Typical Electrical Characteristics: N-Channel (continued)

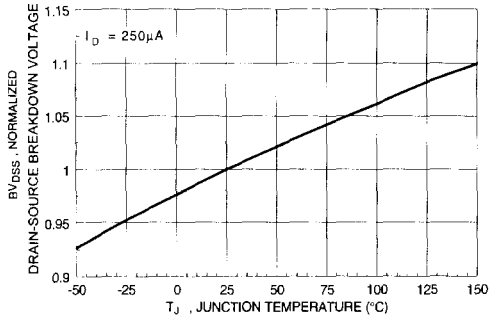


Figure 7. Breakdown Voltage Variation with Temperature.

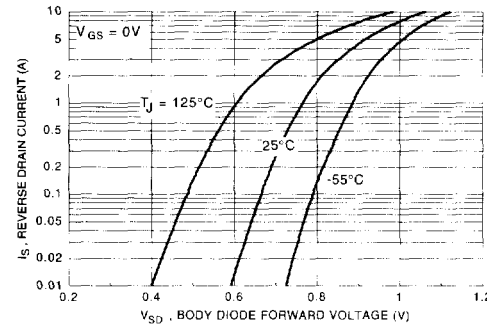


Figure 8. Body Diode Forward Voltage Variation with Current and Temperature

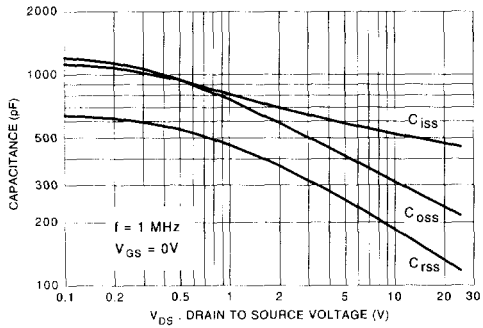


Figure 9. Capacitance Characteristics.

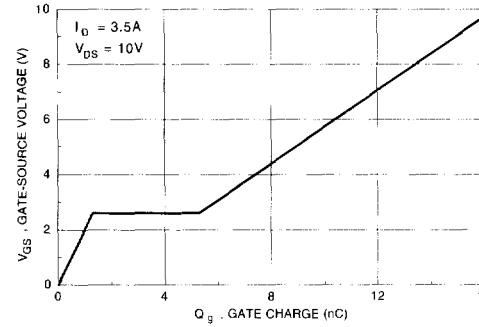


Figure 10. Gate Charge Characteristics.

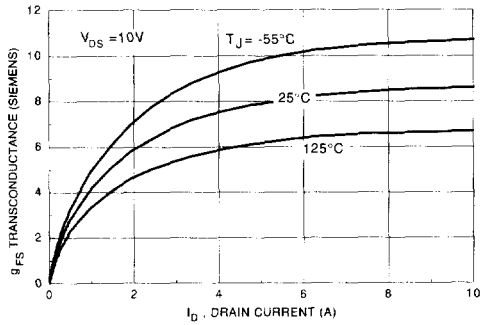


Figure 11. Transconductance Variation with Drain Current and Temperature.

Typical Electrical Characteristics: P-Channel

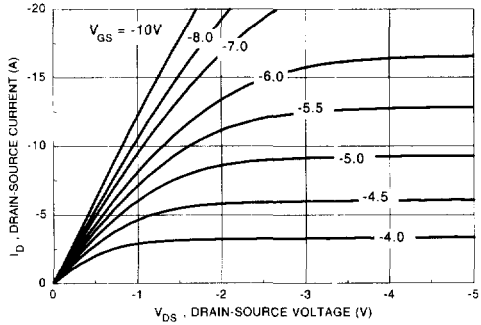


Figure 12. On-Region Characteristics.

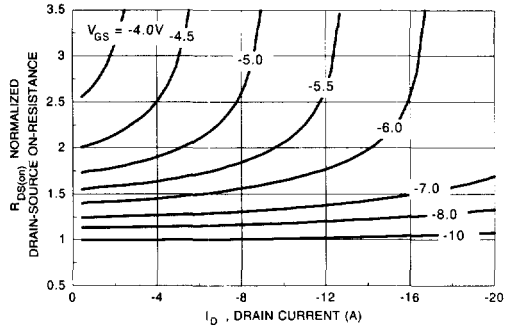


Figure 13. On-Resistance Variation with Gate Voltage and Drain Current.

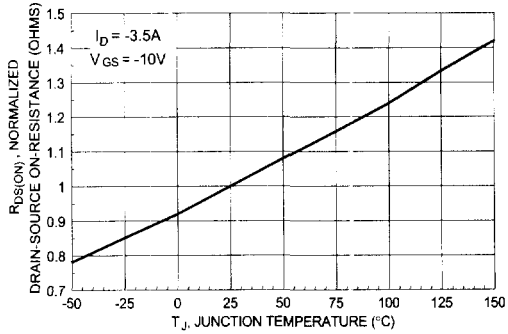


Figure 14. On-Resistance Variation with Temperature.

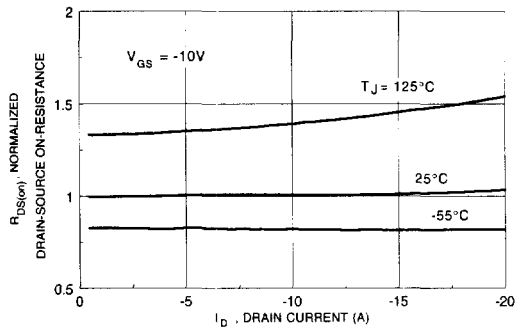


Figure 15. On-Resistance Variation with Drain Current and Temperature.

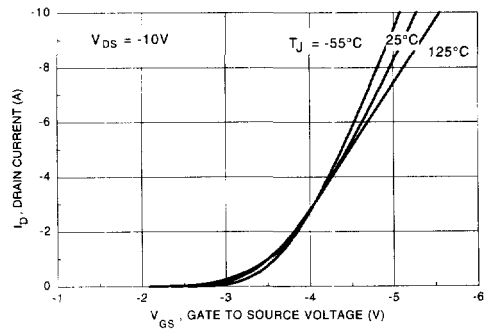


Figure 16. Drain Current Variation with Gate Voltage and Temperature.

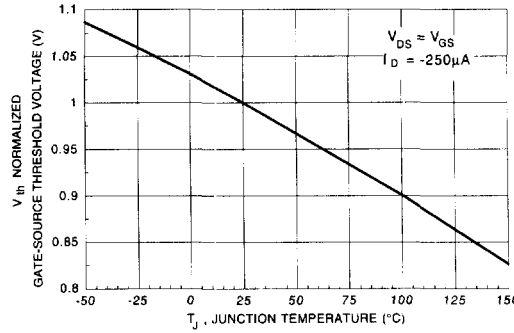


Figure 17. Gate Threshold Variation with Temperature.

Typical Electrical Characteristics: P-Channel (continued)

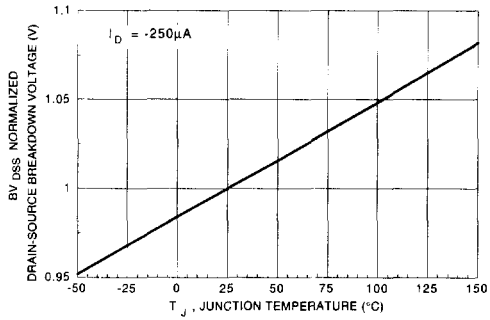


Figure 18. Breakdown Voltage Variation with Temperature.

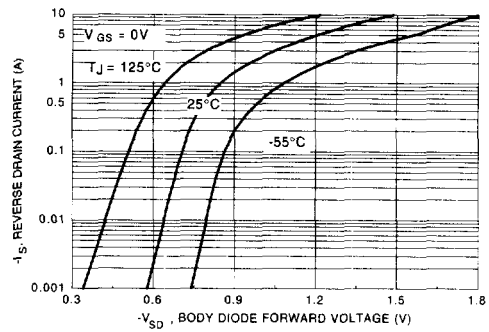


Figure 19. Body Diode Forward Voltage Variation with Current and Temperature

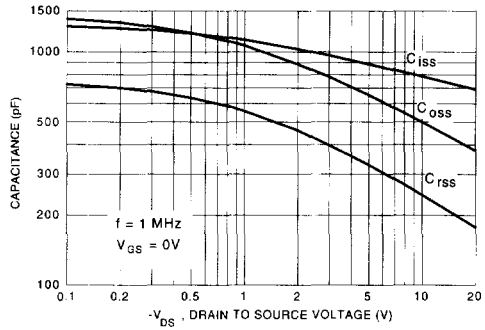


Figure 20. Capacitance Characteristics.

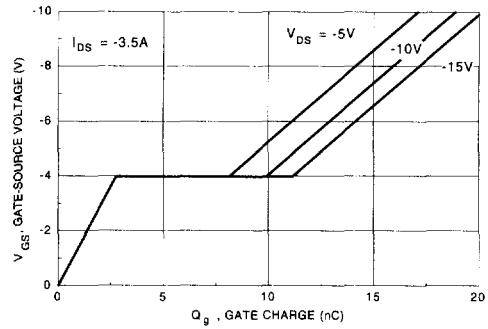


Figure 21. Gate Charge Characteristics

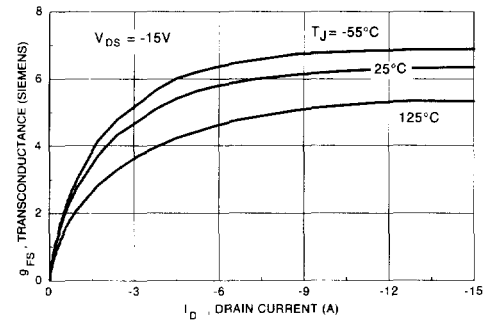


Figure 22. Transconductance Variation with Drain Current and Temperature.

Typical Electrical Characteristic: N & P-Channel (continued)

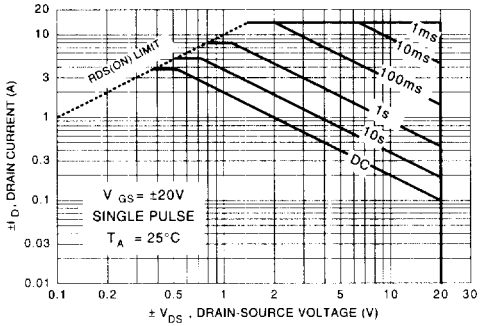


Figure 23. Maximum Safe Operating Area.

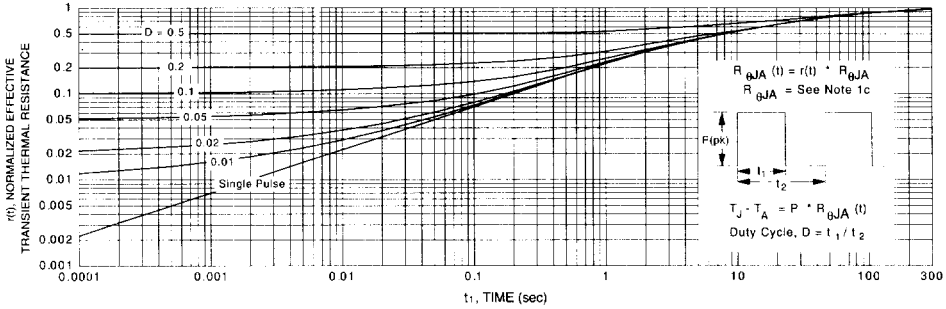


Figure 24. Transient Thermal Response Curve.

Note: Thermal characterization performed using the conditions described in note 1c. Transient thermal response will change depending on the circuit board design.

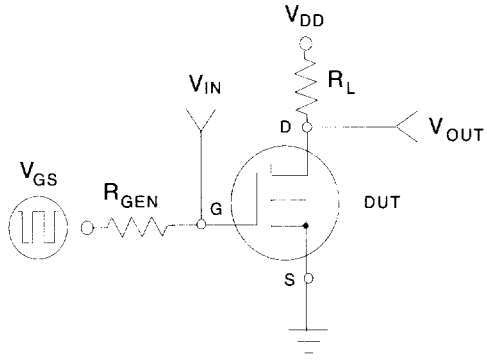


Figure 25. N or P-Channel Switching Test Circuit

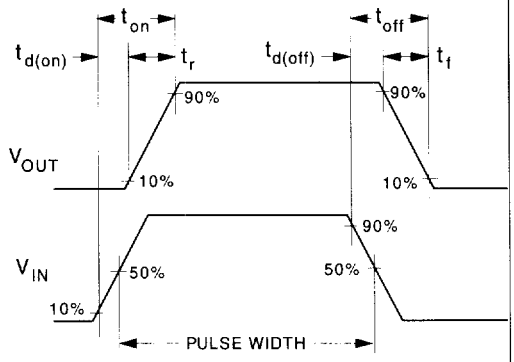


Figure 26. N or P-Channel Switching Waveforms