February 1996

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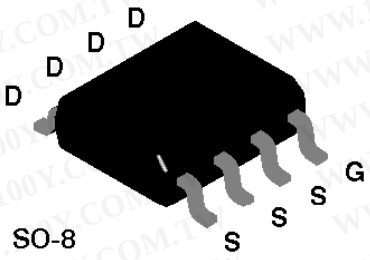
NDS9405
Single P-Channel Enhancement Mode Field Effect Transistor

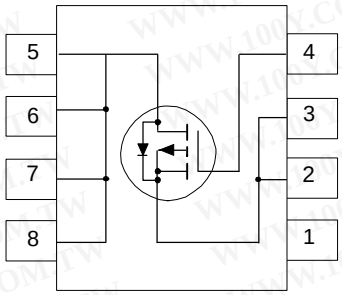
General Description

These P-Channel enhancement mode power field effect transistors are produced using National's proprietary, high cell density, DMOS technology. This very high density process is been 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 and other battery powered circuits where fast switching, low in-line power loss, and resistance to transients are needed.

Features

- -4.3A, -20V. $R_{DS(ON)}$ = 0.10Ω @ 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.





Absolute Maximum Ratings T_A = 25°C unless otherwise noted

Symbol	Parameter		NDS9405	Units
V_{DSS}	Drain-Source Voltage		-20	V
V_{GSS}	Gate-Source Voltage		± 20	V
I_D	Drain Current - Continuous T_A = 25°C	(Note 1a)	± 4.3	A
	- Continuous T_A = 70°C	(Note 1a)	± 3.3	
	- Pulsed T_A = 25°C		± 20	
P_D	Maximum Power Dissipation	(Note 1a)	2.5	W
		(Note 1b)	1.2	
		(Note 1c)	1	
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)	50	°C/W
$R_{\theta JC}$	Thermal Resistance, Junction-to-Case	(Note 1)	25	°C/W

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

Symbol	Parameter	Conditions		Min	Typ	Max	Units
OFF CHARACTERISTICS							
BV_{DSS}	Drain-Source Breakdown Voltage	V_{GS} = 0 V, I_D = -250 µA		-20			V
I_{DSS}	Zero Gate Voltage Drain Current	V_{DS} = -16 V, V_{GS} = 0 V				-2	µA
			T_J = 55°C			-25	µA
I_{GSSF}	Gate - Body Leakage, Forward	V_{GS} = 20 V, V_{DS} = 0 V				100	nA
I_{GSSR}	Gate - Body Leakage, Reverse	V_{GS} = -20 V, V_{DS} = 0 V				-100	nA
ON CHARACTERISTICS (Note 2)							
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS}, I_D = -250 µA		-0.5	-1.65	-3	V
			T_J = 125°C	-0.85		-2.6	
$R_{DS(ON)}$	Static Drain-Source On-Resistance	V_{GS} = -10 V, I_D = -2 A			0.053	0.1	Ω
			T_J = 125°C		0.075	0.15	
		V_{GS} = -4.5 V, I_D = -2 A			0.08	0.16	
			T_J = 125°C		0.12	0.24	
$I_{D(on)}$	On-State Drain Current	V_{GS} = -10 V, V_{DS} = -5 V		-20			A
		V_{GS} = -4.5, V_{DS} = -5V		-5			
g_{FS}	Forward Transconductance	V_{DS} = -15 V, I_D = -4.3 A			9		S
DYNAMIC CHARACTERISTICS							
C_{iss}	Input Capacitance	V_{DS} = -10 V, V_{GS} = 0 V, f = 1.0 MHz			1425		pF
C_{oss}	Output Capacitance				850		pF
C_{rss}	Reverse Transfer Capacitance				430		pF
SWITCHING CHARACTERISTICS (Note 2)							
$t_{D(on)}$	Turn - On Delay Time	V_{DD} = -10 V, I_D = -1 A, V_{GEN} = -10 V, R_{GEN} = 6 Ω			17	30	ns
t_r	Turn - On Rise Time				24	80	ns
$t_{D(off)}$	Turn - Off Delay Time				56	200	ns
t_f	Turn - Off Fall Time				30	200	ns
Q_g	Total Gate Charge	V_{DS} = -10 V, I_D = -4.3 A, V_{GS} = -10 V				40	nC
Q_{gs}	Gate-Source Charge					5	nC
Q_{gd}	Gate-Drain Charge					25	nC

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

Symbol	Parameter	Conditions	Min	Typ	Max	Units
DRAIN-SOURCE DIODE CHARACTERISTICS AND MAXIMUM RATINGS						
I_S	Maximum Continuous Drain-Source Diode Forward Current				-2.2	A
V_{SD}	Drain-Source Diode Forward Voltage	V_{GS} = 0 V, I_S = -1.25 A (Note 2)		-0.78	-1.6	V
t_{rr}	Reverse Recovery Time	V_{GS} = 0V, I_F = -1.25 A, dI_F/dt = 100 A/µs		80		ns

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.

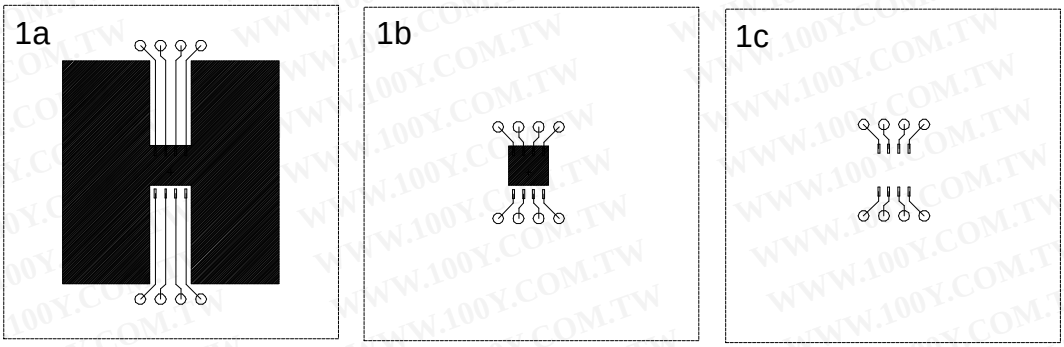
$$P_D(t) = \frac{T_J - T_A}{R_{\theta JA}(t)} = \frac{T_J - T_A}{R_{\theta JC} + R_{\theta CA}(t)} = I_D^2(t) \times R_{DS(ON)@T_J}$$

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

a. 50°C/W when mounted on a 1 in^2 pad of 2oz cpper.

b. 105°C/W when mounted on a 0.04 in^2 pad of 2oz cpper.

c. 125°C/W when mounted on a 0.006 in^2 pad of 2oz cpper.



Scale 1 : 1 on letter size paper

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

Typical Electrical Characteristics

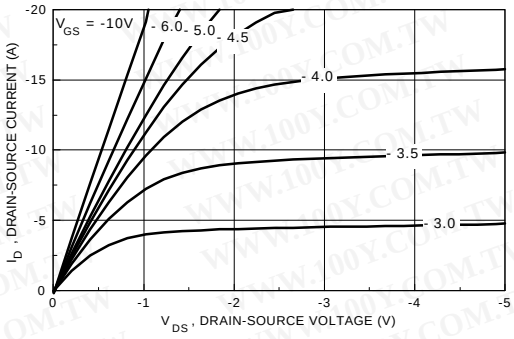


Figure 1. On-Region Characteristics.

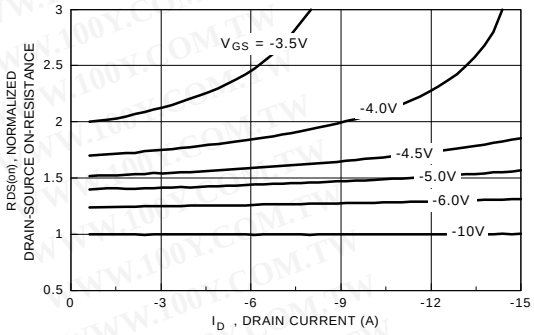


Figure 2. On-Resistance Variation with Drain Current and Gate Voltage.

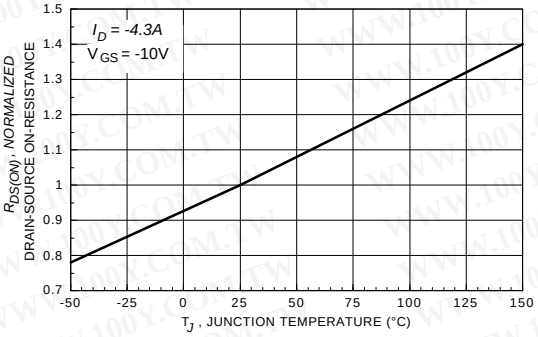


Figure 3. On-Resistance Variation with Temperature.

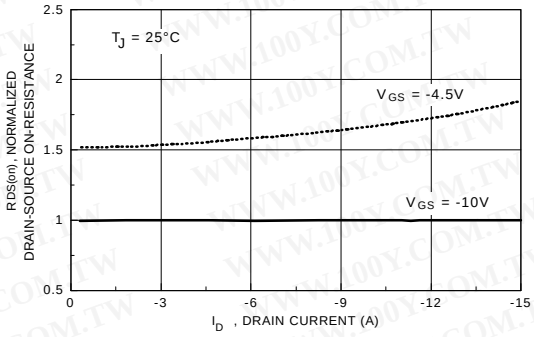


Figure 4. On-Resistance Variation with Drain Current.

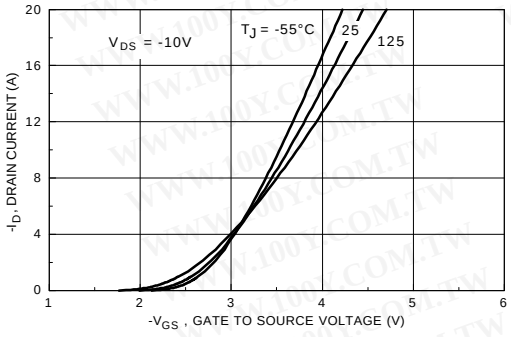


Figure 5. Transfer Characteristics.

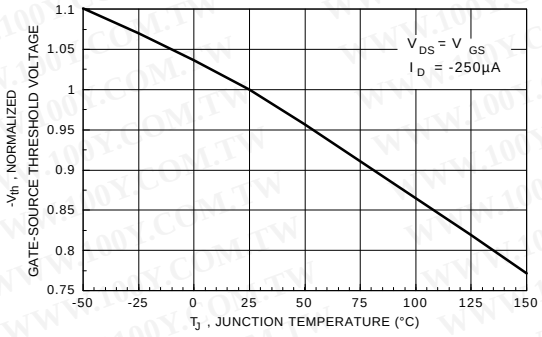


Figure 6. Gate Threshold Variation with Temperature.

Typical Electrical Characteristics (continued)

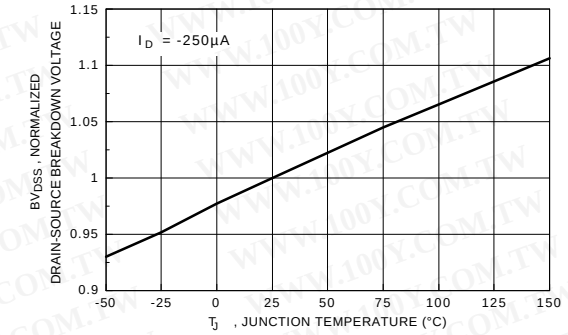


Figure 7. Breakdown Voltage Variation with Temperature.

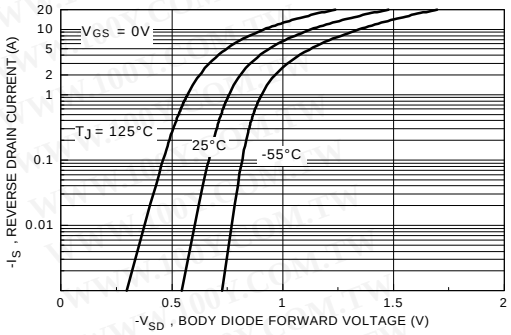


Figure 8. Body Diode Forward Voltage Variation with Source Current and Temperature.

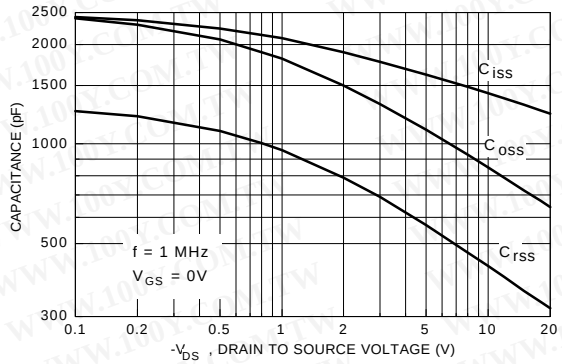


Figure 9. Capacitance Characteristics.

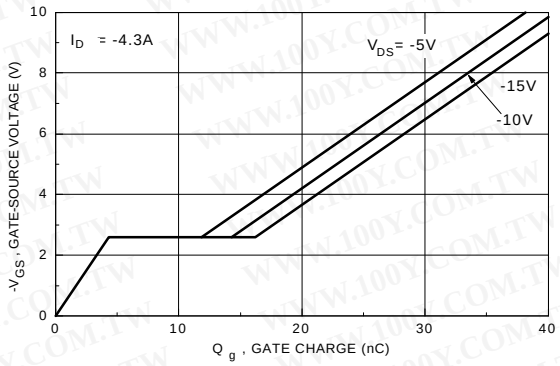


Figure 10. Gate Charge Characteristics.

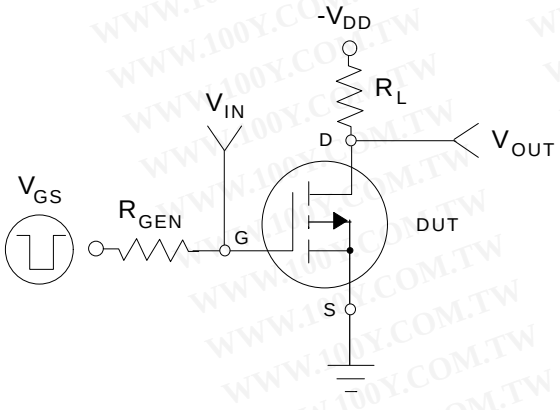


Figure 11. Switching Test Circuit.

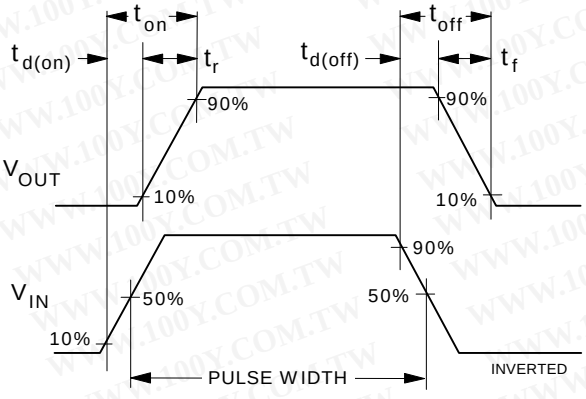


Figure 12. Switching Waveforms.

Typical Electrical Characteristics (continued)

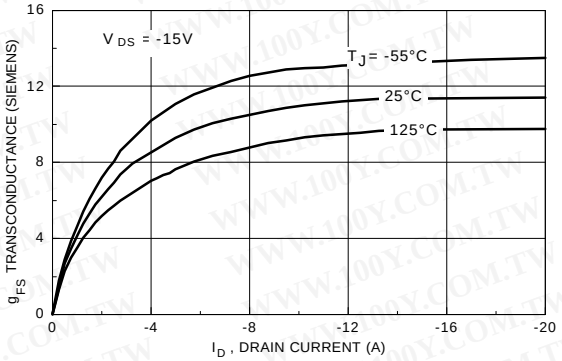


Figure 13. Transconductance Variation with Drain Current and Temperature.

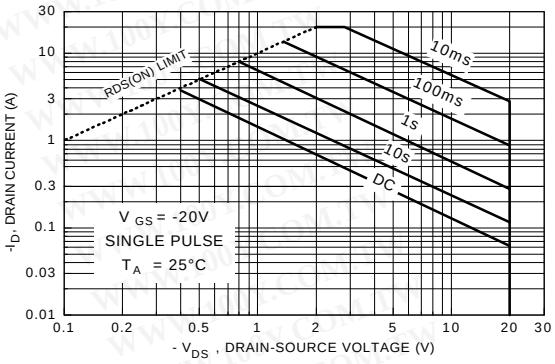


Figure 14. Maximum Safe Operating Area.

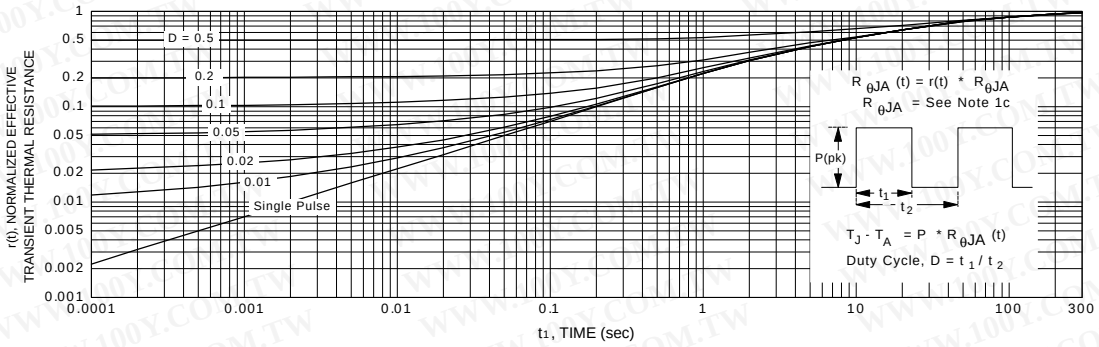


Figure 15. Transient Thermal Response Curve.

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