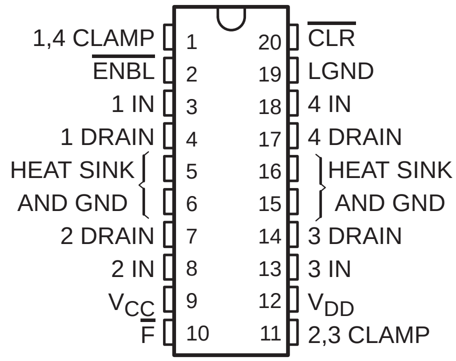
SLIS012 – D3378, FEBRUARY 1990

- Output Voltage up to 60 V
- Four Output Channels of 700-mA Nominal Current Per Channel
- Pulsed Current . . . 3 A Per Channel
- Low $r_{DS(on)}$ . . . 0.5 Ω Typ
- Avalanche Energy . . . 50 mJ
- Thermal Shutdown Protection With Fault (Overtemperature) Output
- NE Package Designed for Heat Sinking
- Integral Output Clamp Diodes
- Input Transparent Latches for Data Storage
- Asynchronous Clear to Turn off All Outputs
- Output Parallel Capability for Increased Current Drive up to 12-A Total Pulsed Load Current

NE PACKAGE
(TOP VIEW)



FUNCTION TABLE
(each channel)

FUNCTION	INPUTS			OUTPUT	FAULT
	$\overline{ENBL}$	$\overline{CLR}$	IN	Y	$\overline{F}$
Normal Operation	X	L	X	H	H
	L	H	L	H	H
	L	H	H	L	H
	H	H	X	Q_0	H
Thermal Shutdown	X	X	X	H	L

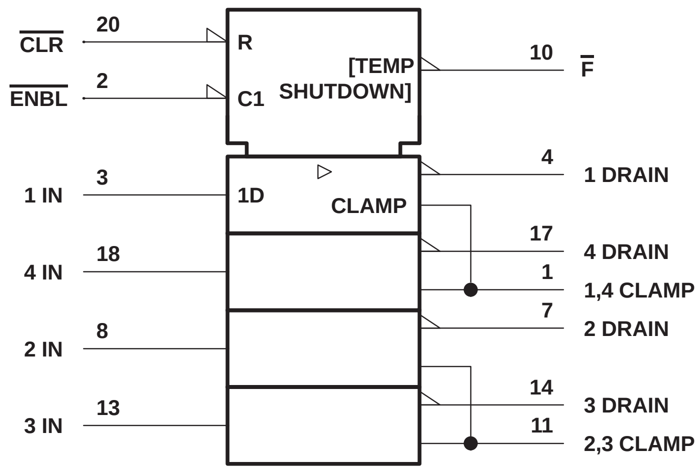
H = high-level, L = low-level, X = irrelevant

description

The TPIC2406 is a monolithic, high-voltage, high-current, quadruple power driver designed for use in systems that require high load power. The device contains built-in high-speed output clamp diodes for inductive transient protection. Power driver applications include lamps, relays, solenoids, and dc stepping motors.

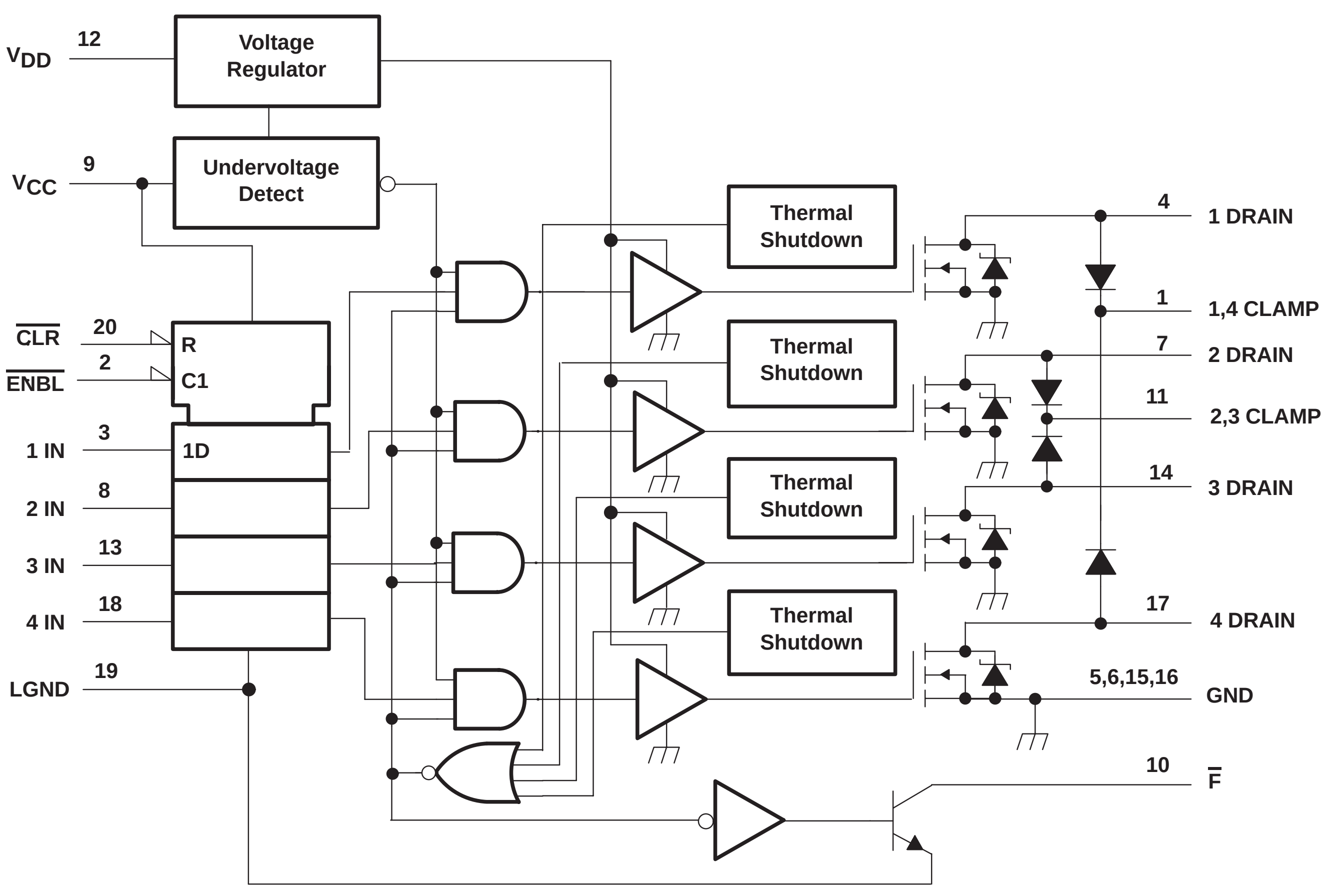
The device features four inverting open-drain outputs, each controlled by an input storage latch with common clear and enable controls. All inputs accept standard TTL- and CMOS-logic levels. The $\overline{CLR}$ function is asynchronous and turns all four outputs off regardless of data inputs. Taking $\overline{ENBL}$ low puts the input latch into a transparent mode, allowing the data inputs to affect the output. In this state, all four outputs are held off while $\overline{CLR}$ is low, but return to the stages on the data inputs when $\overline{CLR}$ goes high. When $\overline{ENBL}$ is taken high, the latch is put into a storage mode and the last state of the data inputs is held in the latches. If $\overline{CLR}$ is taken low, the data in the latches is cleared and all outputs are turned off. If $\overline{CLR}$ is taken high again, $\overline{ENBL}$ must be cycled low to read new data into the latch.

logic symbol†

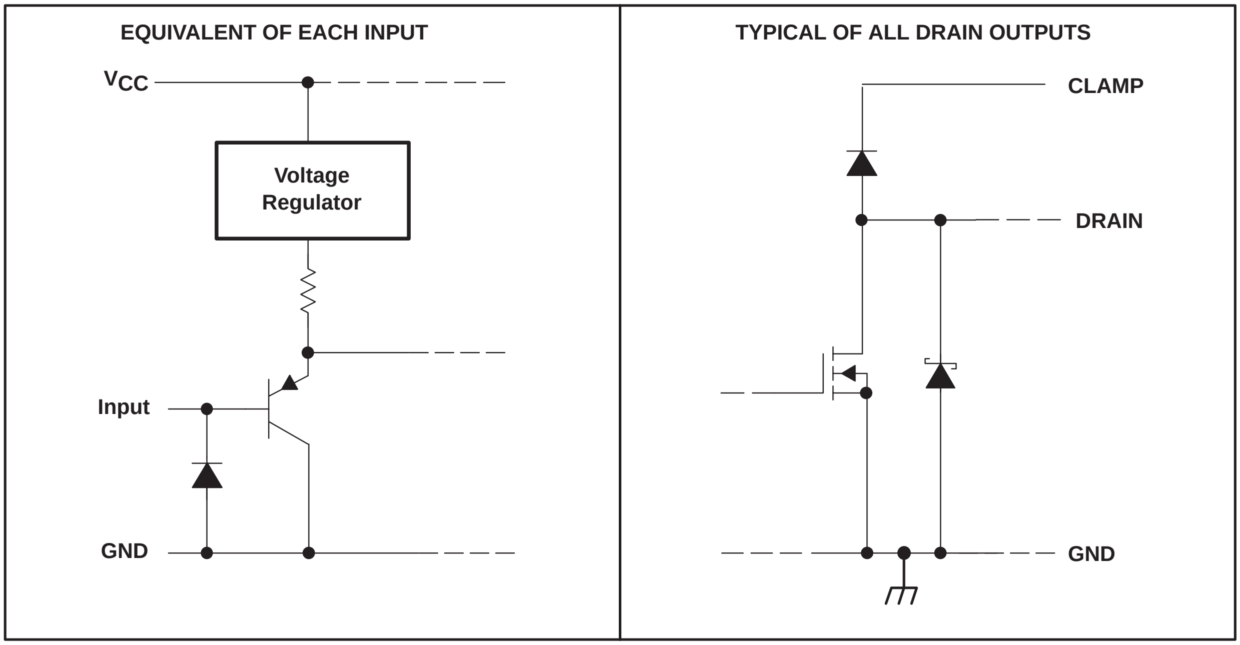


† This symbol is in accordance with ANSI/IEEE Std 91-1984 and IEC Publication 617-12.

logic diagram (positive logic)



schematics of inputs and outputs



absolute maximum ratings over –40°C to 125°C case temperature range (unless otherwise noted)

Logic supply voltage, V_{CC} (see Note 1)	7 V
Power MOSFET driver supply voltage, V_{DD}	60 V
Logic input voltage, V_I	7 V
Power MOSFET drain-source voltage, V_{DS}	60 V
Output voltage at $\overline{F}$, V_O	7 V
Clamp-diode voltage	60 V
Continuous source-drain diode anode current	1.25 A
Pulsed source-drain diode anode current	6 A
Pulsed drain current, each output, all outputs on, $I_{D1} = I_{D2} = I_{D3} = I_{D4}$, $T_A = 25°C$ (see Note 2 and Figures 5 through 8)	3 A
Continuous drain current, each output, all outputs on, $I_{D1} = I_{D2} = I_{D3} = I_{D4}$, $T_A = 25°C$	770 mA
Peak drain current, single output, I_{DM}, $T_A = 25°C$ (see Note 3)	12.5 A
Single-pulse avalanche energy, E_{AS}	50 mJ
Continuous total dissipation at or below 25°C free-air temperature (see Note 4)	2.5 W
Continuous total dissipation at or below 100°C case temperature (see Note 4)	6 W
Operating junction temperature range, T_J	–40°C to 150°C
Storage temperature range	–40°C to 150°C
Lead temperature 1.6 mm (1/16 inch) from case for 10 seconds	260°C

NOTES: 1. All voltage values are with respect to the five ground (GND and LGND) terminals connected together.
2. Pulse duration = 10 ms, duty cycle = 6%.
3. Pulse duration ≤ 100 µs, duty cycle ≤ 2%.
4. For operation above 25°C free-air temperature, derate linearly at the rate of 20 mW/°C. For operation above 100°C case temperature, derate linearly at the rate of 120 mW/°C. To avoid exceeding the design maximum junction temperature, these ratings should not be exceeded. Due to variations in individual devices, electrical characteristics, and thermal resistance, the built-in thermal overload protection can be activated at power levels slightly above or below the rated dissipation.

recommended operating conditions

		MIN	NOM	MAX	UNIT
Logic supply voltage, V_{CC}		4.5		5.5	V
Output supply voltage, V_{DD}		10		35	V
High-level input voltage, V_{IH}		2			V
Low-level input voltage, V_{IL}				0.6	V
Setup time, data before $\overline{ENBL}$ ↑, t_{su} (see Figure 1)		100			ns
Hold time, data after $\overline{ENBL}$ ↑, t_h (see Figure 1)		100			ns
Pulse duration, t_w (see Figure 1)	$\overline{ENBL}$ low	300			ns
	$\overline{CLR}$ low				
Operating case temperature, T_C		–40		125	°C

electrical characteristics, V_{CC} = 5 V, V_{DD} = 14 V, T_C = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS†			MIN	TYP	MAX	UNIT
$V_{(BR)DSX}$	Drain-source breakdown voltage	I_D = 1 mA			60			V
$V_{F(K)}$	Clamp-diode forward voltage	I_F = 1.25 A,	See Notes 5 and 6				1.6	V
V_{SD}	Source-drain diode forward voltage	I_S = 1.25 A,	See Notes 5 and 6				1.5	V
V_{IK}	Input clamp voltage	V_{CC} = MIN,	I_I = ~ 12 mA				–1.5	V
V_{OL}	Low-level output voltage at $\overline{F}$	I_{OL} = 4 mA				0.4		V
I_{IH}	High-level input current	V_{CC} = 5.5 V,	V_I = 2.7 V				20	µA
I_{IL}	Low-level input current	V_{CC} = 5.5 V,	V_I = 0.4 V				0.1	mA
I_{CC}	Logic supply current	I_O = 0,	All outputs off				10	mA
I_N	Nominal current	$V_{DS(on)}$ = 0.5 V, See Notes 5, 6, and 7	I_N = I_D,	T_C = 85°C,		700		mA
I_{DD}	Output supply current	I_O = 0,	All outputs off				6	mA
$I_{R(K)}$	Clamp-diode reverse current	V_{DS} = 55 V,	V_O = 0				1	µA
		V_{DS} = 55 V,	V_O = 0,	T_C = 125°C			10	
I_{DSX}	Off-state drain current	V_R = 55 V					1	µA
		V_R = 55 V,	T_C = 125°C				10	
$I_{O(F)}$	High-level fault leakage current	V_{OH} = 5.5 V					1	µA
$r_{DS(on)}$	Static drain-source on-state resistance	I_D = 1.25 A	See Notes 5 and 6			0.5	0.6	Ω
		I_D = 1.25 A, T_C = 125°C				0.8	1	
		I_D = 3 A				0.55	0.65	

† For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.

NOTES: 5. Technique should limit T_J – T_C to 10°C maximum.
6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.
7. Nominal current is defined for a consistent comparison between devices from different sources. It is the current that produces a voltage drop of 0.5 V at 85°C case temperature.

switching characteristics, V_{CC} = 5 V, V_{DD} = 24 V, T_C = 25°C

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
t_{PLH}	Propagation delay time, low-to-high-level drain output from clock	C_L = 30 pF,	See Figure 1		450		ns
t_{PHL}	Propagation delay time, high-to-low-level drain output from clock				550		ns
t_{TLH}	Transition time, low-to-high-level of source-drain output				35		ns
t_{THL}	Transition time, high-to-low-level of source-drain output				30		ns
t_{PLH}	Propagation delay time, low-to-high-level drain output from input	C_L = 30 pF, $I_D = I_N$ = 700 mA	See Figure 2,		380		ns
t_{PHL}	Propagation delay time, high-to-low-level drain output from input				380		ns
t_r	Rise time, low-to-high-level of source-drain output				35		ns
t_f	Fall time, high-to-low-level of source-drain output				70		ns
t_a	Reverse-recovery-current rise time	I_F = 3 A, See Notes 5 and 6,	di/dt = 100 A/µs, See Figure 3		45		ns

NOTES: 5. Technique should limit $T_J - T_C$ to 10°C maximum.
6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

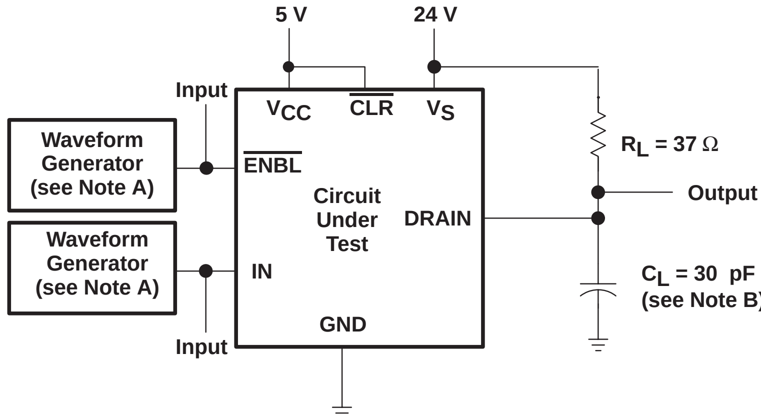
thermal resistance

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$R_{\theta JC}$	Junction-to-case thermal resistance	All four outputs with equal power			8.33	°C/W
$R_{\theta JA}$	Junction-to-ambient thermal resistance				50	

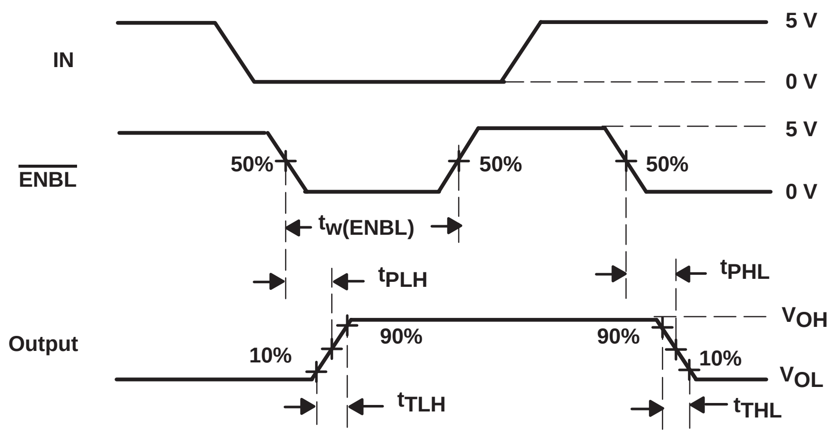
operating characteristics over –40°C to 125°C case temperature range

PARAMETER	MIN	TYP	MAX	UNIT
Undervoltage shutdown	3		4.5	V
Thermal shutdown temperature		155		°C
Thermal shutdown hysteresis		15		°C

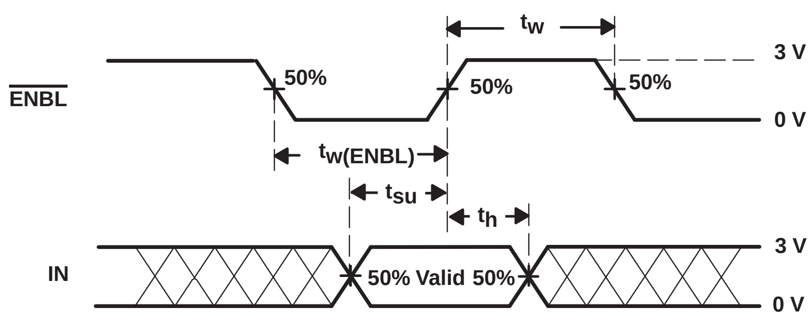
PARAMETER MEASUREMENT INFORMATION



(a) TEST CIRCUIT



(b) SWITCHING TIMES FROM ENABLE INPUT

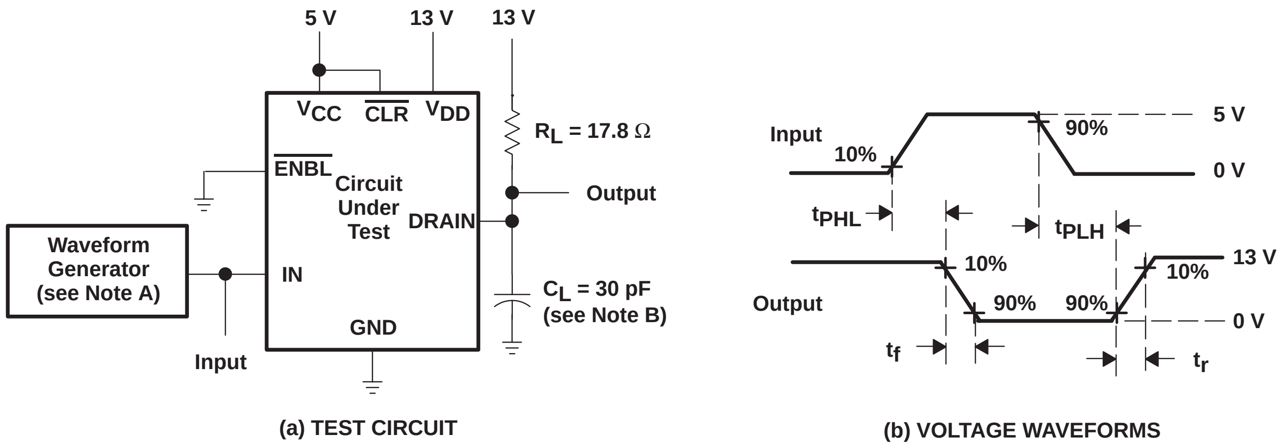


(c) INPUT SETUP AND HOLD WAVEFORMS

NOTES: A. The pulse generator has the following characteristics: $t_r \leq 10$ ns, $t_f \leq 10$ ns, $t_w = 300$ ns, PRR = 5 kHz, $Z_O = 50\ \Omega$.
B. C_L includes probe and jig capacitance.

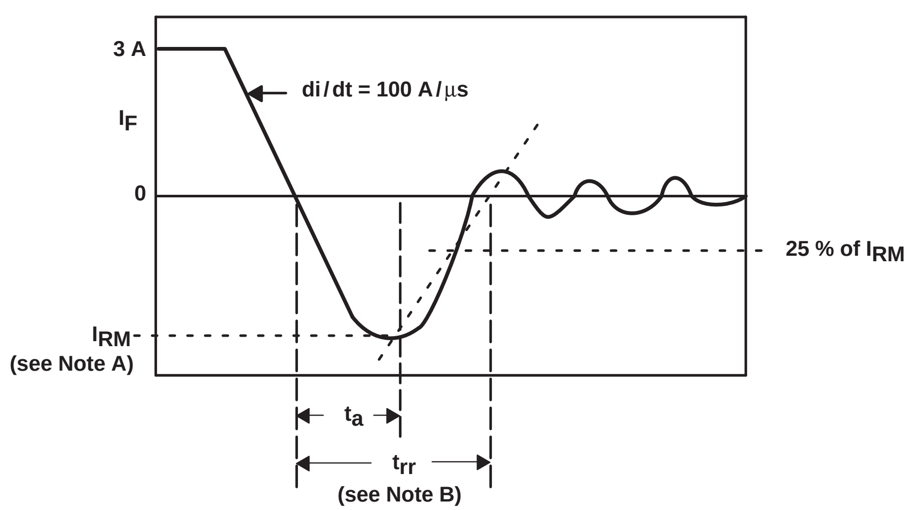
Figure 1. Test Circuit and Voltage Waveforms

PARAMETER MEASUREMENT INFORMATION



NOTES: A. The pulse generator has the following characteristics: $t_r \leq 10$ ns, $t_f \leq 10$ ns, $t_W = 5$ ms, PRR = 5 kHz, $Z_O = 50\ \Omega$.
B. C_L includes probe and jig capacitance.

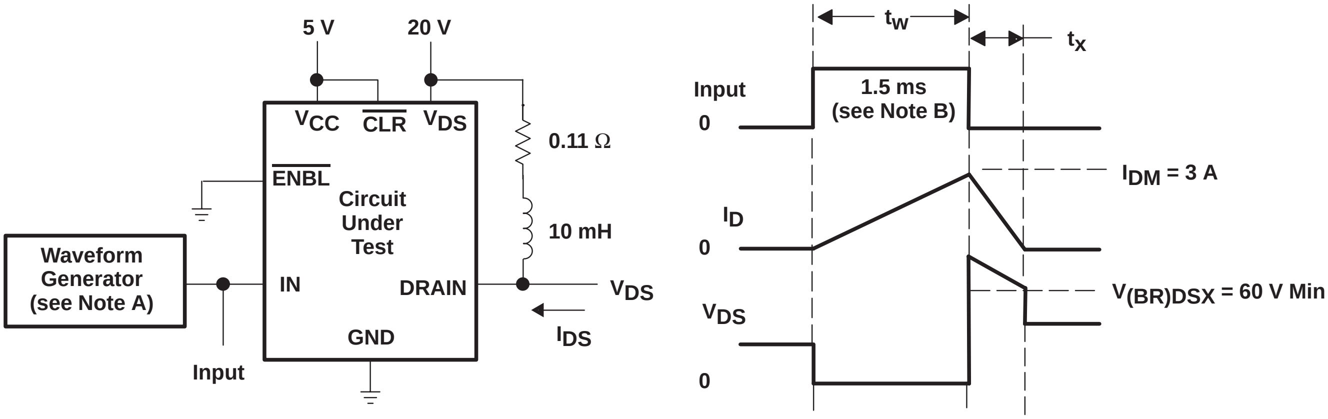
Figure 2. Test Circuit and Voltage Waveforms



NOTES: A. I_{RM} = maximum recovery current.
B. t_{rr} = reverse recovery time.

Figure 3. Reverse-Recovery-Current Waveforms of Source-Drain Diode

PARAMETER MEASUREMENT INFORMATION



(a) TEST CIRCUIT (b) VOLTAGE WAVEFORMS

NOTES: A. The pulse generator has the following characteristics: $t_r \le 10$ ns, $t_f \le 10$ ns, $t_w = 1$ ms, PRR = 5 kHz, $Z_O = 50\ \Omega$.
B. Input pulse duration (t_w) is increased until peak current $I_{DM} = 3$ A.

Energy test level is defined as $E_{AS} = \frac{I_{DM} \times V_{(BR)DSX} \times t_X}{2} = 50\ \text{mJ min.}$

Figure 4. Single-Pulse Avalanche Energy Test Circuit and Waveforms

MAXIMUM RATINGS

MAXIMUM DRAIN CURRENT vs DUTY CYCLE

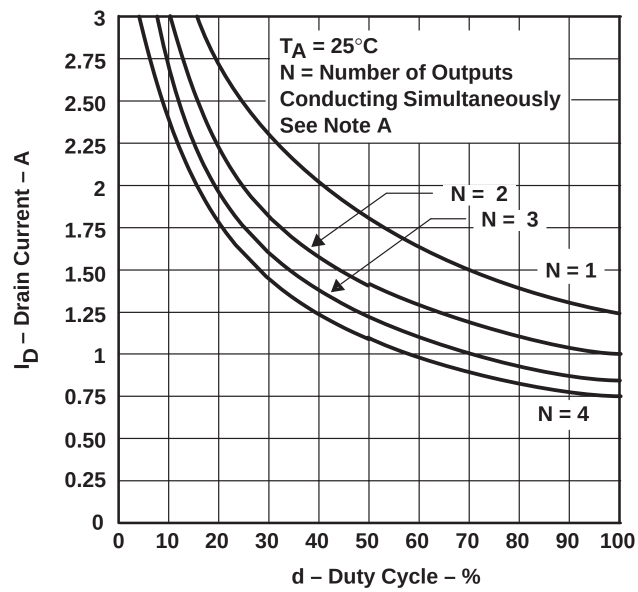


Figure 5

MAXIMUM DRAIN CURRENT vs DUTY CYCLE

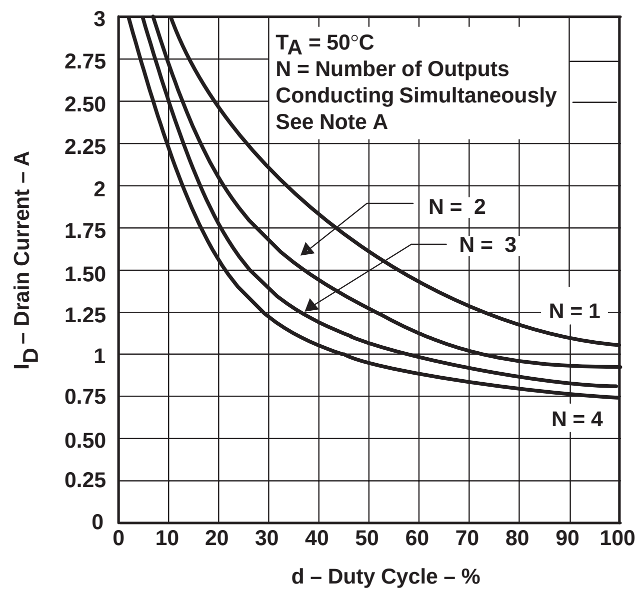


Figure 6

MAXIMUM DRAIN CURRENT vs DUTY CYCLE

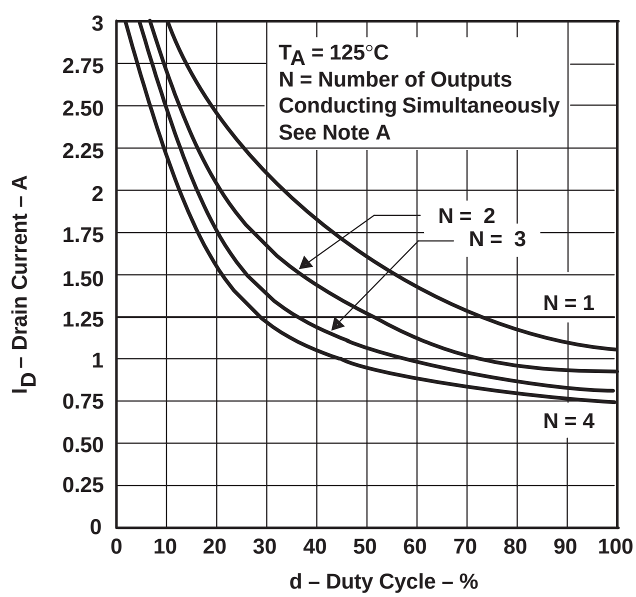


Figure 7

MAXIMUM DRAIN CURRENT vs PULSE DURATION

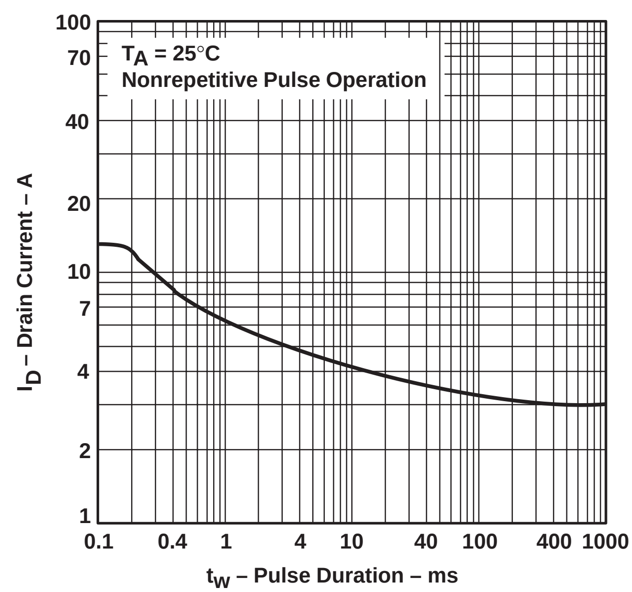
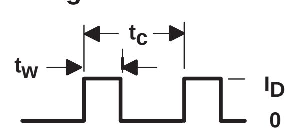


Figure 8

NOTE A: For Figures 5, 6, and 7, $d = \frac{t_W}{t_C} = \frac{10\ ms}{t_C}$, where t_W and t_C are defined by the following:



MAXIMUM RATINGS

MAXIMUM CONTINUOUS DRAIN CURRENT
vs
FREE-AIR TEMPERATURE

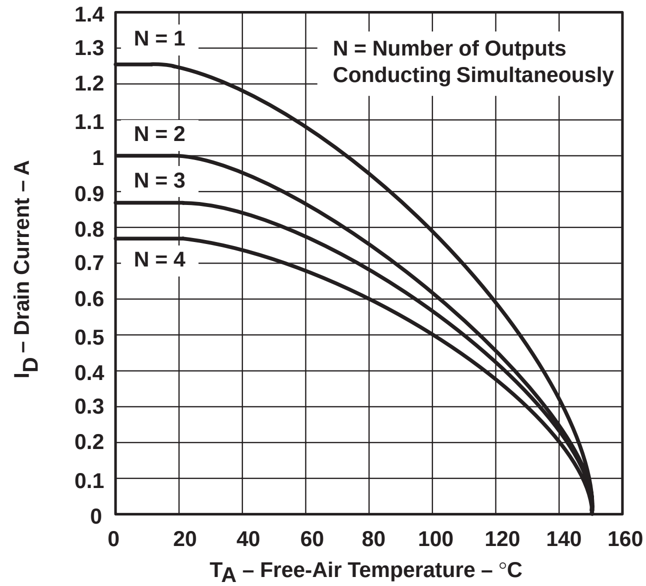
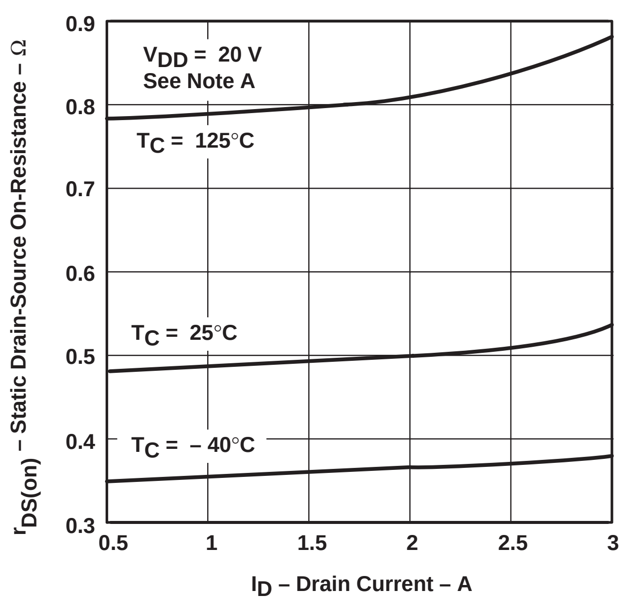


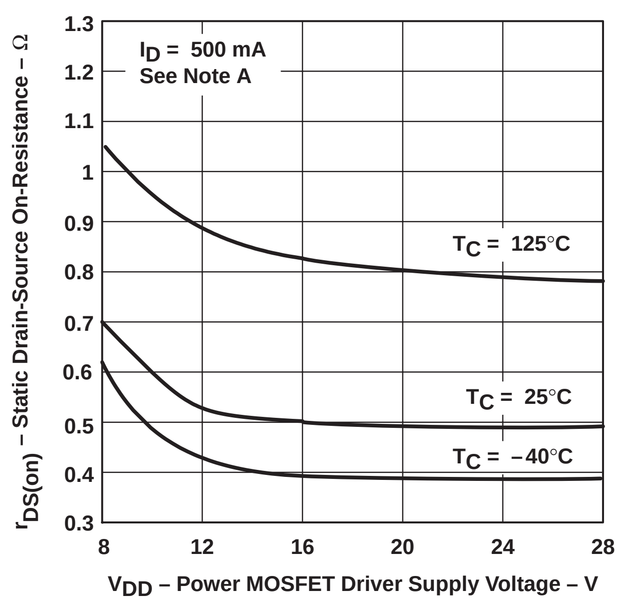
Figure 9

TYPICAL CHARACTERISTICS

STATIC DRAIN-SOURCE ON-RESISTANCE
vs
DRAIN CURRENT



STATIC DRAIN-SOURCE ON-RESISTANCE
vs
POWER MOSFET DRIVER SUPPLY VOLTAGE



NOTE A: Technique should limit T_J – T_C to 10°C maximum.

Figure 10

Figure 11

THERMAL INFORMATION

FREE-AIR TEMPERATURE DISSIPATION DERATING CURVE

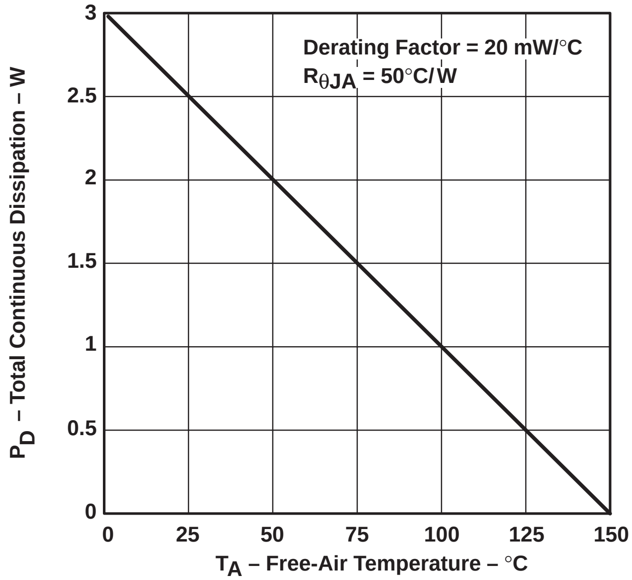


Figure 12

TRANSIENT THERMAL IMPEDANCE vs ON TIME

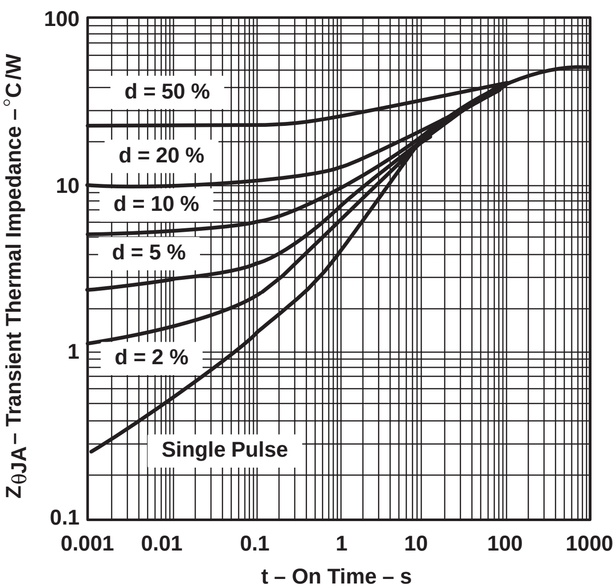


Figure 13

The single-pulse curve in Figure 11 represents measured data. The curves for various pulse durations are based on the following equation:

$$Z_{\theta JA} = \left|\frac{t_w}{t_c}\right| R_{\theta JA} + \left|1 - \frac{t_w}{t_c}\right| Z_{\theta(t_w + t_c)} + Z_{\theta(t_w)} - Z_{\theta(t_c)}$$

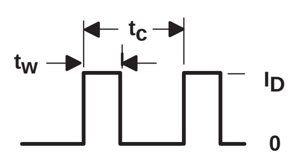
Where:

$Z_{\theta(t_w)}$ = the single-pulse thermal impedance for t = t_w seconds

$Z_{\theta(t_c)}$ = the single-pulse thermal impedance for t = t_c seconds

$Z_{\theta(t_w + t_c)}$ = the single-pulse thermal impedance for t = $t_w + t_c$ seconds

$$d = t_w/t_c$$



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