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N−Channel DPAK

The MLD1N06CL is designed for applications that require a rugged power switching device with short circuit protection that can be directly interfaced to a microcontrol unit (MCU). Ideal applications include automotive fuel injector driver, incandescent lamp driver or other applications where a high in rush current or a shorted load condition could occur.

This Logic Level Power MOSFET features current limiting for short circuit protection, integrated Gate Source clamping for ESD protection and integral Gate Drain clamping for over voltage protection and technology for low on resistance. No additional gate series resistance is required when interfacing to the output of a MCU, but a 40 kΩ gate pulldown resistor is recommended to avoid a floating gate condition.

The internal Gate Source and Gate Drain clamps allow the device to be applied without use of external transient suppression components. The Gate Source clamp protects the MOSFET input from electrostatic voltage stress up to 2.0 kV. The Gate Drain clamp protects the MOSFET drain from the avalanche stress that occurs with inductive loads. Their unique design provides voltage clamping that is essentially independent of operating temperature.

Features

- Pb Free Package is Available

MAXIMUM RATINGS (T_J = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain−to−Source Voltage	V_{DSS}	Clamped	Vdc
Drain−to−Gate Voltage (R_{GS} = 1.0 MΩ)	V_{DGR}	Clamped	Vdc
Gate−to−Source Voltage − Continuous	V_{GS}	±10	Vdc
Drain Current − Continuous − Single Pulse	I_D I_{DM}	Self−limited 1.8	Adc Apk
Total Power Dissipation	P_D	40	W
Operating and Storage Temperature Range	T_J, T_{stg}	−50 to 150	°C
Electrostatic Discharge Voltage (Human Model)	ESD	2.0	kV

UNCLAMPED DRAIN−TO−SOURCE AVALANCHE CHARACTERISTICS

Rating	Symbol	Value	Unit
Single Pulse Drain−to−Source Avalanche Energy Starting T_J = 25°C	E_{AS}	80	mJ

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain−to−Source Breakdown Voltage (Internally Clamped) (I_D = 20 mAdc, V_{GS} = 0 Vdc) (I_D = 20 mAdc, V_{GS} = 0 Vdc, T_J = 150°C)	$V_{(BR)DSS}$	 59 59	 62 62	 65 65	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 45 Vdc, V_{GS} = 0 Vdc) (V_{DS} = 45 Vdc, V_{GS} = 0 Vdc, T_J = 150°C)	I_{DSS}	 – –	 0.6 6.0	 5.0 20	μAdc
Gate−Source Leakage Current (V_G = 5.0 Vdc, V_{DS} = 0 Vdc) (V_G = 5.0 Vdc, V_{DS} = 0 Vdc, T_J = 150°C)	I_{GSS}	 – –	 0.5 1.0	 5.0 20	μAdc
ON CHARACTERISTICS (Note 3)					
Gate Threshold Voltage (I_D = 250 μAdc, V_{DS} = V_{GS}) (I_D = 250 μAdc, V_{DS} = V_{GS}, T_J = 150°C)	$V_{GS(th)}$	 1.0 0.6	 1.5 –	 2.0 1.6	Vdc
Static Drain−to−Source On−Resistance (I_D = 1.0 Adc, V_{GS} = 4.0 Vdc) (I_D = 1.0 Adc, V_{GS} = 5.0 Vdc) (I_D = 1.0 Adc, V_{GS} = 4.0 Vdc, T_J = 150°C) (I_D = 1.0 Adc, V_{GS} = 5.0 Vdc, T_J = 150°C)	$R_{DS(on)}$	 – – – –	 0.63 0.59 1.1 1.0	 0.75 0.75 1.9 1.8	Ω
Static Source−to−Drain Diode Voltage (I_S = 1.0 Adc, V_{GS} = 0 Vdc)					

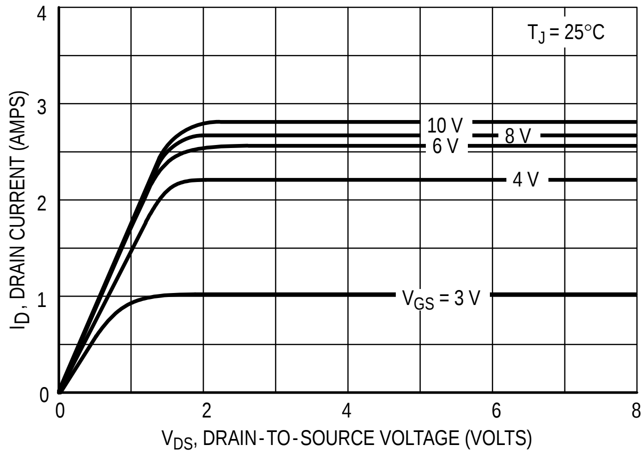


Figure 1. Output Characteristics

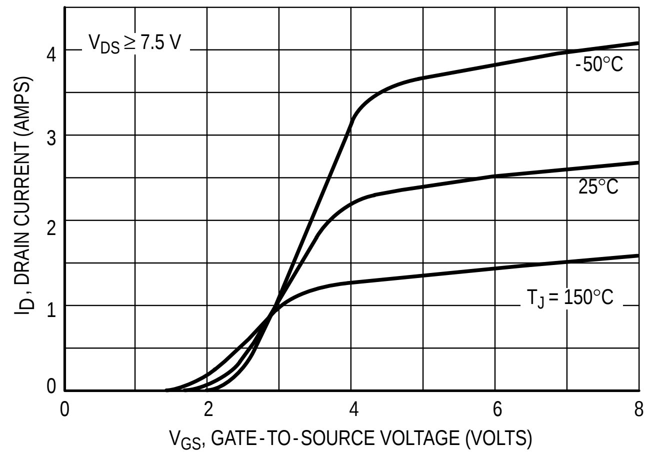


Figure 2. Transfer Function

THE CONCEPT

From a standard power MOSFET process, several active and passive elements can be obtained that provide on chip protection to the basic power device. Such elements require only a small increase in silicon area and/or the addition of one masking layer to the process. The resulting device exhibits significant improvements in ruggedness and reliability as well as system cost reduction. The device functions can now provide an economical alternative to smart power ICs for power applications requiring low on resistance, high voltage and high current.

These devices are designed for applications that require a rugged power switching device with short circuit protection that can be directly interfaced to a microcontroller unit (MCU). Ideal applications include automotive fuel injector driver, incandescent lamp driver or other applications where a high in rush current or a shorted load condition could occur.

OPERATION IN THE CURRENT LIMIT MODE

The amount of time that an unprotected device can withstand the current stress resulting from a shorted load before its maximum junction temperature is exceeded is dependent upon a number of factors that include the amount of heatsinking that is provided, the size or rating of the device, its initial junction temperature, and the supply voltage. Without some form of current limiting, a shorted load can raise a device's junction temperature beyond the maximum rated operating temperature in only a few milliseconds.

Even with no heatsink, the MLD1N06CL can withstand a shorted load powered by an automotive battery (10 to 14 V) for almost a second if its initial operating temperature is under 100°C. For longer periods of operation in the current limited mode, device heatsinking can extend operation from several seconds to indefinitely depending on the amount of heatsinking provided.

SHORT CIRCUIT PROTECTION AND THE EFFECT OF TEMPERATURE

The on chip circuitry of the MLD1N06CL offers an integrated means of protecting the MOSFET component from high in rush current or a shorted load. As shown in the schematic diagram, the current limiting feature is provided by an NPN transistor and integral resistors R1 and R2. R2 senses the current through the MOSFET and forward biases the NPN transistor's base as the current increases. As the NPN turns on, it begins to pull gate drive current through R1, dropping the gate drive voltage across it, and thus lowering the voltage across the gate to source of the power MOSFET and limiting the current. The current limit is temperature dependent as shown in Figure 3, and decreases from about 2.3 A at 25°C to about 1.3 A at 150°C.

Since the MLD1N06CL continues to conduct current and dissipate power during a shorted load condition, it is important

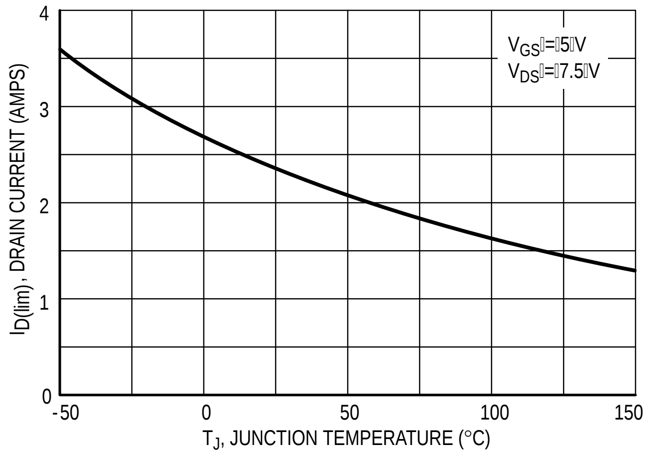


Figure 3. $I_{D(lim)}$ Variation With Temperature

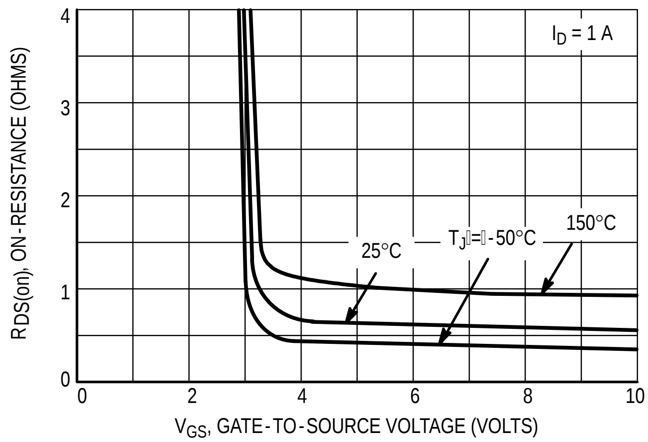


Figure 4. $R_{DS(on)}$ Variation With Gate−To−Source Voltage

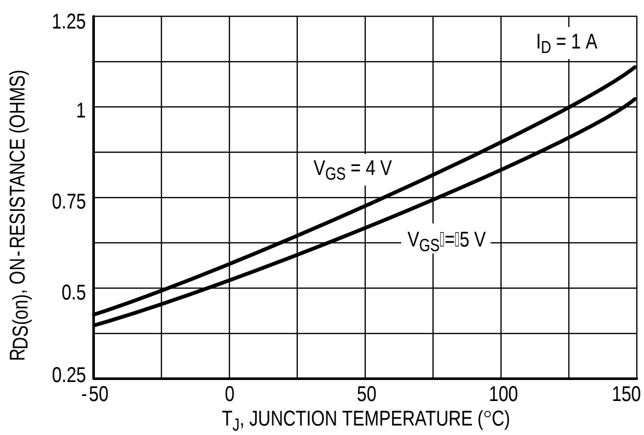


Figure 5. On−Resistance Variation With Temperature

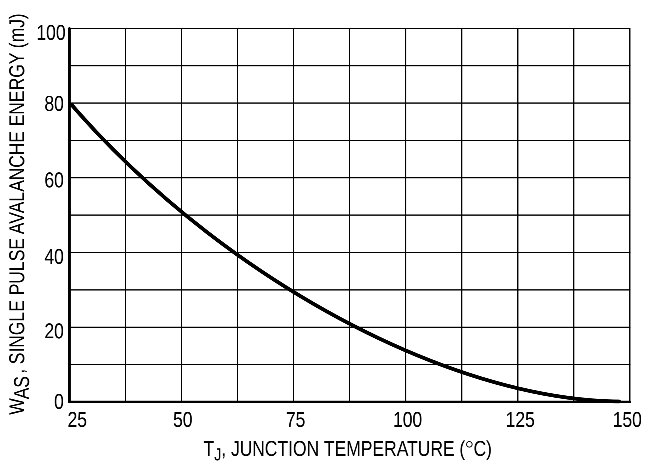


Figure 6. Single Pulse Avalanche Energy versus Junction Temperature

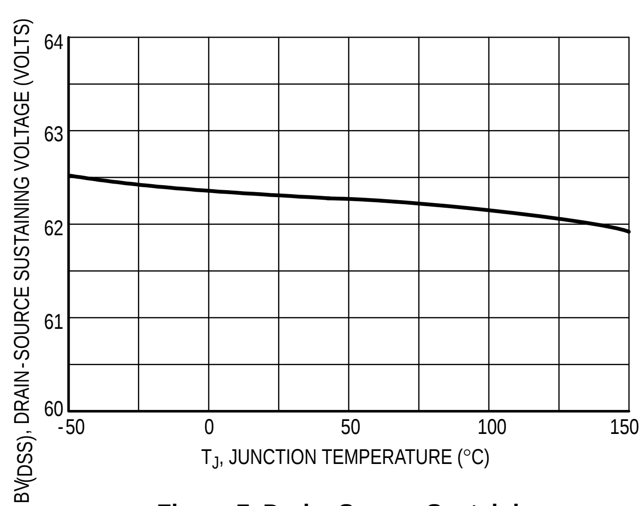
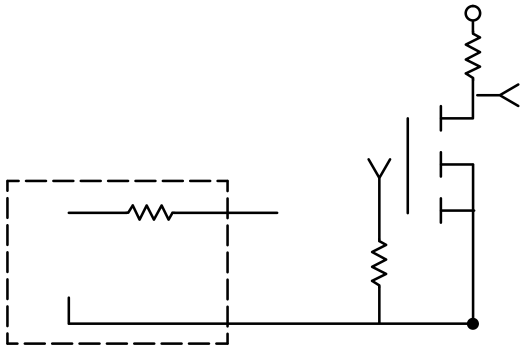
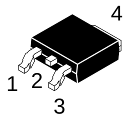


Figure 7. Drain−Source Sustaining Voltage Variation With Temperature

FORWARD BIASED SAFE OPERATING AREA





SCALE 1:1

DPAK (SINGLE GAUGE)
CASE 369C
ISSUE G

DATE 31 MAY 2023

STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER
4. COLLECTOR

STYLE 2:
PIN 1. GATE
2. DRAIN
3. SOURCE
4. DRAIN

STYLE 3:
PIN 1. ANODE
2. CATHODE
3. ANODE
4. CATHODE

STYLE 4:
PIN 1. CATHODE
2. ANODE
3. GATE
4. ANODE

STYLE 5:
PIN 1. GATE
2. ANODE
3. CATHODE
4. ANODE

STYLE 6:
PIN 1. MT1
2. MT2
3. GATE
4. MT2

STYLE 7:
PIN 1. GATE
2. COLLECTOR
3. EMITTER
4. COLLECTOR

STYLE 8:
PIN 1. N/C
2. CATHODE
3. ANODE
4. CATHODE

STYLE 9:
PIN 1. ANODE
2. CATHODE
3. RESISTOR ADJUST
4. CATHODE

STYLE 10:
PIN 1. CATHODE
2. ANODE
3. CATHODE
4. ANODE