

5.5 V, 15 A Low $R_{DS(ON)}$ Load Switch with Current Monitoring

■ Features

- Wide input voltage range (V_{IN}): 2.7 V to 5.5 V
- $R_{DS(ON)}$: 2 m Ω (typ.)
- Load current range: up to 15 A
- Shutdown current: 3.2 μ A (typ.)
- Output current monitor
- Power good pin with open-drain output
- Adjustable start-up slew rate
- Output discharge resistance: 200 Ω
- Short circuitry response protection
- Thermal protection
- Operating junction temperature range: -40°C to 125°C

■ Applications

- Notebooks
- Portable devices
- Optical module
- Industrial systems
- Solid state drivers
- Handheld devices

■ Package Information

Part Number	Package	Body Size
DIO76088	QFN-12	2.0 mm × 2.0 mm

■ Description

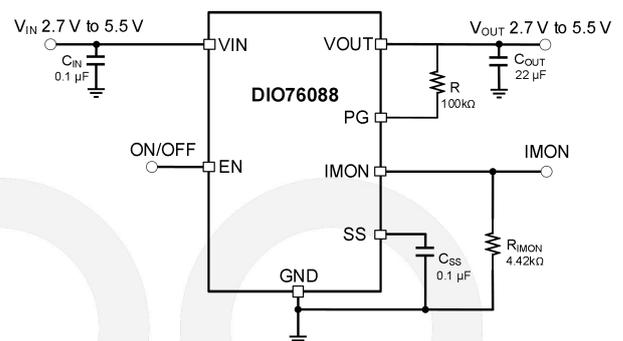
The DIO76088 is a load switch to provide up to 15 A load protection covering 2.7 V to 5.5 V voltage range, it could provide an integrated solution to monitor the output current to eliminate the need for an external current sense device.

The DIO76088 provides a constant current limit that can be programmed by an external resistor. Once the device reaches its current limit threshold, the internal circuit regulates the gate voltage to hold the current in the power FET constant. The response time and the output current may have a small overshoot during this period.

A capacitor connected to the SS pin determines the soft start time, with the soft start function, the DIO76088 can avoid inrush current during circuit start up.

The DIO76088 supports a small $R_{DS(ON)}$ in tiny package QFN-12 (2 mm × 2 mm), it could provide a highly efficient and space-saving solution for such as notebook, tablet, optical module or other applications.

■ Simplified Schematic



■ Ordering Information

Ordering Part No.	Top Marking	MSL	RoHS	T _A	Package	
DIO76088LT12	FV8H	3	Green	-40 to 125 °C	QFN2*2-12	Tape and Reel, 3000

If you encounter any issue in the process of using the device, please contact our customer service at marketing@dioo.com or phone us at (+86)-21-62116882. If you have any improvement suggestions regarding the datasheet, we encourage you to contact our technical writing team at docs@dioo.com. Your feedback is invaluable for us to provide a better user experience.

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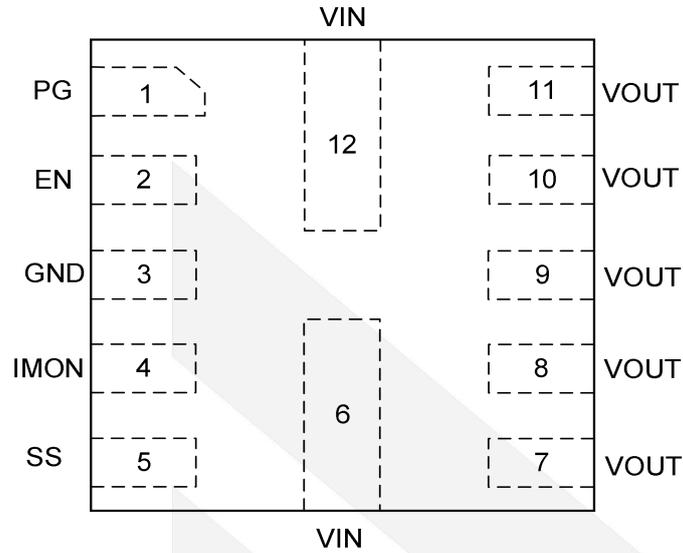
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1. Pin Assignment and Functions



*Figure 1. QFN2*2-12 (Top view)*

Pin No.	Pin Name	Description
1	PG	Power good. Active high. Open drain output. Pull PG up to an external power supply via a resistor.
2	EN	Enable input. Pulling this pin below the UVLO threshold shuts the chip down. Connect EN to VIN for automatic start-up. Connected to GND with 2 MΩ resistor internally.
3	GND	Ground.
4	IMON	Output current monitor. An external resistor used to set the current limit threshold. Provide a voltage proportional to the current flowing through the power device.
5	SS	Soft-start control. A capacitor from this pin to ground sets the rise slew rate of output voltage soft start period
6, 12	VIN	Input voltage.
7 to 11	VOUT	Output voltage.

2. Absolute Maximum Ratings

Exceeding the maximum ratings listed under Absolute Maximum Ratings when designing is likely to damage the device permanently. Do not design to the maximum limits because long-time exposure to them might impact the device's reliability. The ratings are obtained over an operating free-air temperature range unless otherwise specified.

Symbol	Parameter	Rating	Unit
V_{IN}		-0.3 to 6.5	V
V_{OUT}		-0.3 to 6.5	V
	EN, SS, IMON voltages	-0.3 to $V_{IN} + 0.3$	V
	PG sinking current	5	mA
T_J	Maximum junction temperature	150	°C
T_L	Maximum lead temperature	260	°C

3. Recommended Operating Conditions

Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. The ratings are obtained over an operating free-air temperature range unless otherwise specified.

Symbol	Parameter	Rating	Unit
V_{IN}	Supply voltage	2.7 to 5.5	V
V_{OUT}	Output voltage	2.7 to 5.5	V
$V_{EN}^{(1)}$	EN voltage	2.7 to 5.5	V
	PG sinking current	3	mA
T_J	Operating junction temperature	-40 to 125	°C

Note:

(1) V_{PG} must be lower than $V_{IN} + 0.3$.

4. ESD Ratings

When a statically-charged person or object touches an electrostatic discharge sensitive device, the electrostatic charge might be drained through sensitive circuitry in the device. If the electrostatic discharge possesses sufficient energy, damage might occur to the device due to localized overheating.

Model	Condition	Value	Unit
HBM	ANSI/ESDA/JEDEC JS-001	±6	kV
CDM	ANSI/ESDA/JEDEC JS-002	±2	kV

5. Electrical Characteristics

$V_{IN} = V_{EN} = 3.3\text{ V}$, $T_J = -40^\circ\text{C}$ to 125°C . Typical values are at $T_J = 25^\circ\text{C}$, unless otherwise noted.

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
Input and supply voltage						
V_{IN_R}	Input voltage undervoltage lockout threshold	UVLO rising threshold		2.4		V
V_{IN_HYS}	VIN UVLO hysteresis			100		mV
Enable						
V_{EN_R}	EN rising threshold	V_{EN} rises to SS charging	1.15 ⁽¹⁾	1.2	1.25 ⁽¹⁾	V
V_{EN_HYS}	EN hysteresis			200		mV
I_{EN}	EN input current	$V_{EN} = 1.2\text{ V}$		0.6		μA
Supply current						
I_{SD}	Shutdown current	$V_{IN} = 3.3\text{ V}$, EN = 0, no load. Test VIN current		3.2		μA
I_Q	Quiescent current	$V_{IN} = 3.3\text{ V}$, EN = High, no load. Test VIN current		250		μA
Startup delay						
V_{SS_RST}	SS reset threshold			250		mV
V_{O_RST}	Output reset threshold			300		mV
Soft start						
I_{SS}	SS current	SS = 0, $V_{OUT} = 0\text{ V}$		2.5		μA
Hot swap FET						
$R_{DS(ON)}$	ON resistance			2		m Ω
PG						
V_{PG_R}	Power good rising threshold	Voltage gap between VOUT and VIN	100 ⁽¹⁾	150	200 ⁽¹⁾	mV
V_{PG_F}	Power good falling threshold	Voltage gap between VOUT and VIN	150 ⁽¹⁾	200	250 ⁽¹⁾	mV
t_{PG_D}	Power good rising/falling delay			100		μs
V_{PG_L}	Power good low voltage	$I_{PG_SINK} = 1\text{ mA}$		0.11	0.2 ⁽¹⁾	V
I_{PG_LK}	PG leakage current	PG = High, connect PG to 5 V			1 ⁽¹⁾	μA

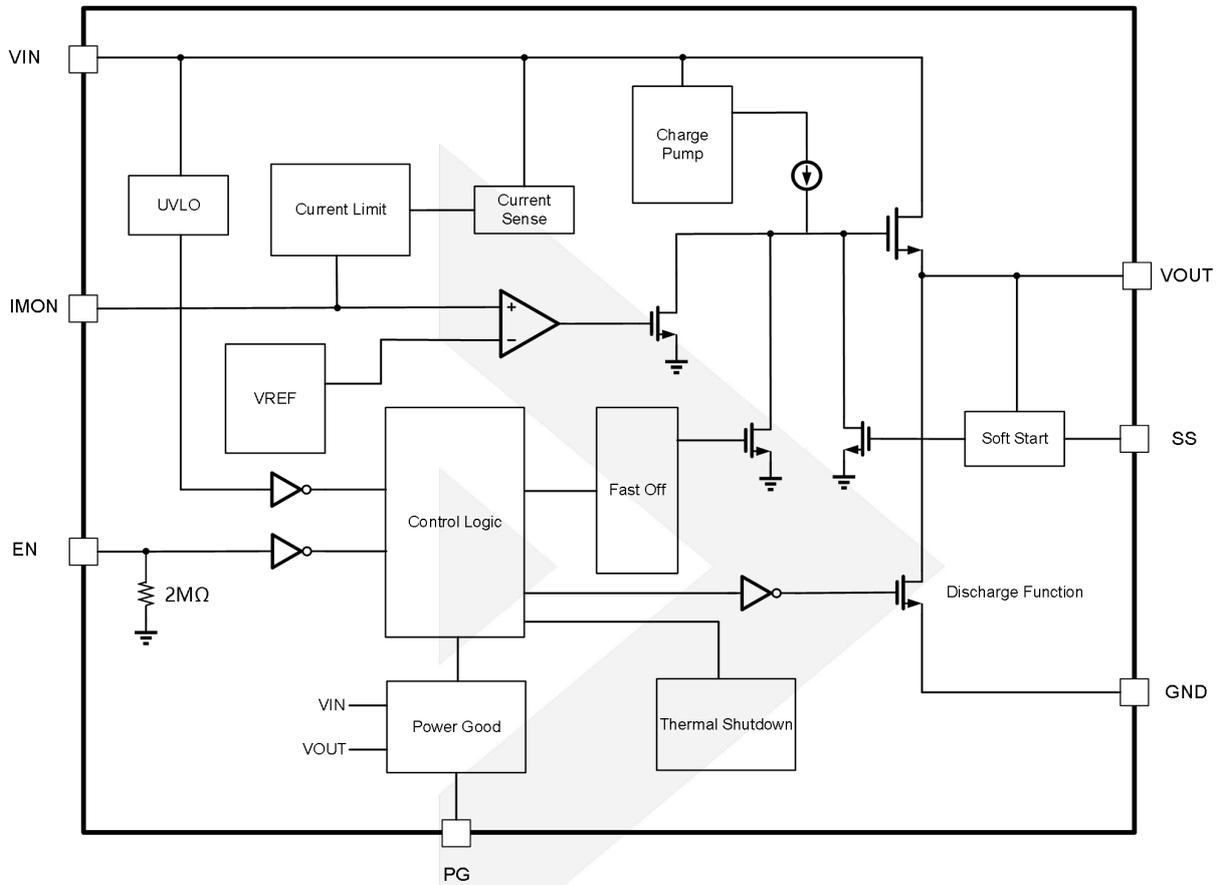
Output current monitor						
I_{MON_GAIN}	IMON sense gain	$I_{OUT} > 5\text{ A}, I_{IMON} / I_{OUT}$		20		$\mu\text{A/A}$
Current limit						
V_{LMT_REF}	Current limit reference voltage			1		V
I_{LMT}	Current limit during normal operation	$R_{IMON} = 3.32\text{ k}\Omega$		15		A
Discharge resistance						
R_{DIS}	Discharge resistance			200		Ω
Thermal protection						
$T_{SD}^{(1)}$	Shutdown temperature			150		$^{\circ}\text{C}$
$T_{HYS}^{(1)}$	Shutdown temperature hysteresis			20		$^{\circ}\text{C}$

Note:

- (1) Guaranteed by design.
- (2) Guaranteed by characteristics.
- (3) Specifications subject to change without notice.



6. Block Diagram



7. Function Description

The DIO76088 is a load switch to provide up to 15 A load protection covering 2.7 V to 5.5 V voltage range, it could provide an integrated solution to monitor the output current to eliminate the need for an external current sense device.

7.1. Power sequencing

Here below is the recommended power on / off sequencing for normal operation.

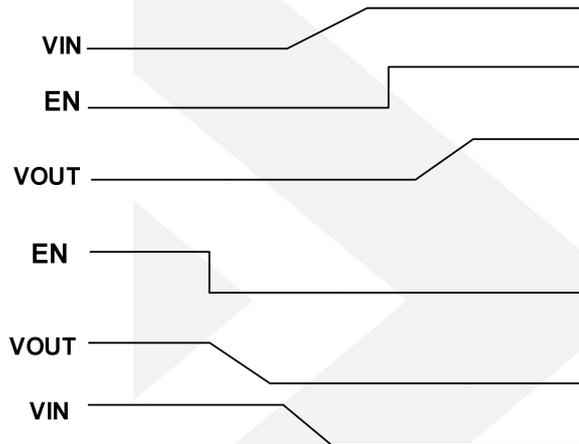


Figure 2. Power sequencing diagram

7.2. Enable

If the input voltage rises above the undervoltage lockout threshold V_{IN_R} while pulling EN pin to higher than V_{EN_R} threshold, the switch will be enabled. To disable the device, pull EN pin down to ground.

7.3. Current monitor output

The IMON pin can support an accurate monitor function for the output current. The current of IMON pin through the external resistor to GND is proportional to the current through internal hot swap FET. To calculate the voltage on IMON pin:

$$V_{IMON}(mV) = I_{OUT}(A) \times I_{MON_GAIN}(\mu A/A) \times R_{IMON}(k\Omega) \quad (1)$$

Where:

V_{IMON} is the IMON pin voltage.

I_{OUT} is the output current.

I_{MON_GAIN} is IMON sense gain.

R_{IMON} is the external resistance on IMON pin.

7.4. Current limit

A programmable current limit is provided by using the external resistor. When the device reaches its current limit threshold, the internal circuit regulates the gate voltage to hold the current in the power FET constant.

During response time, the output current may have a small overshoot. The pre-set current limit value can be calculated with equation:

$$I_{LMT}(A) = \frac{V_{REF}(V)}{R_{IMON}} \times \frac{1000}{I_{MON_GAIN}} \quad (2)$$

Where:

I_{LMT} is pre-set current limit.

V_{REF} is the internal reference voltage.

When the current limit block starts to regulate the output current, V_o will drop. If V_o continues dropping to the current limit foldback threshold, the DIO76088 will foldback the current limit and hold it.

When the current is regulated, the power FET will loss power, making the IC temperature higher. If the junction temperature rises too higher to trigger the thermal shutdown, then the output will be disabled until the temperature falls below the OTP threshold.

7.5. Overtemperature protection (OTP)

If the die temperature rises above the thermal shutdown threshold (T_{SD}), it will trigger thermal shutdown. After thermal shutdown event happened, it will disable the output until the temperature falls by T_{HYS} .

7.6. Short-circuit protection

When the load current increases fast as a short circuit occurs, the current can potentially exceed the current limit threshold significantly before the control loop makes a response. If the current reaches an internal short-circuit protection current, a fast turn-off circuit activates to turn off the power FET. After that, the power FET re-returns on with controlled current limit.

7.7. Output discharge

There is an output discharge feature included in the DIO76088. An internal resistor is connected between V_{OUT} and GND to discharge the output fast when the switch is disabled.

7.8. Power good

For DIO76088, the PG pin is the open-drain output that indicates whether V_{OUT} is within the normal range relative to V_{IN} . The PG pin can be pulled up to the external power supply by an external resistor. During start-up, the PG output is pulled low, which commands the system to remain off and minimize the load on V_{OUT} . Consequently, inrush current and power dissipation is reduced during start-up. If the voltage gap between V_{OUT} and V_{IN} is smaller than 150 mV and the SS voltage is charged to SS OK after soft start completes, the PG pin is pulled high. If any single one of these two conditions can't be met, the PG pin is pulled low.

7.9. Soft-start (SS)

A capacitor connected from the SS pin to the ground controls the soft-start duration time. There is an internal current source to charge SS cap and ramp up the voltage on the SS pin. The output voltage rises following the SS voltage ramps up. To calculate the soft-start time, refer to the equation below:

It is recommended that the value of C_{SS} should be higher than 10 nF. The V_{OUT} rising time will be limited by power MOS charge time when SS pin is floating or SS cap is too small.

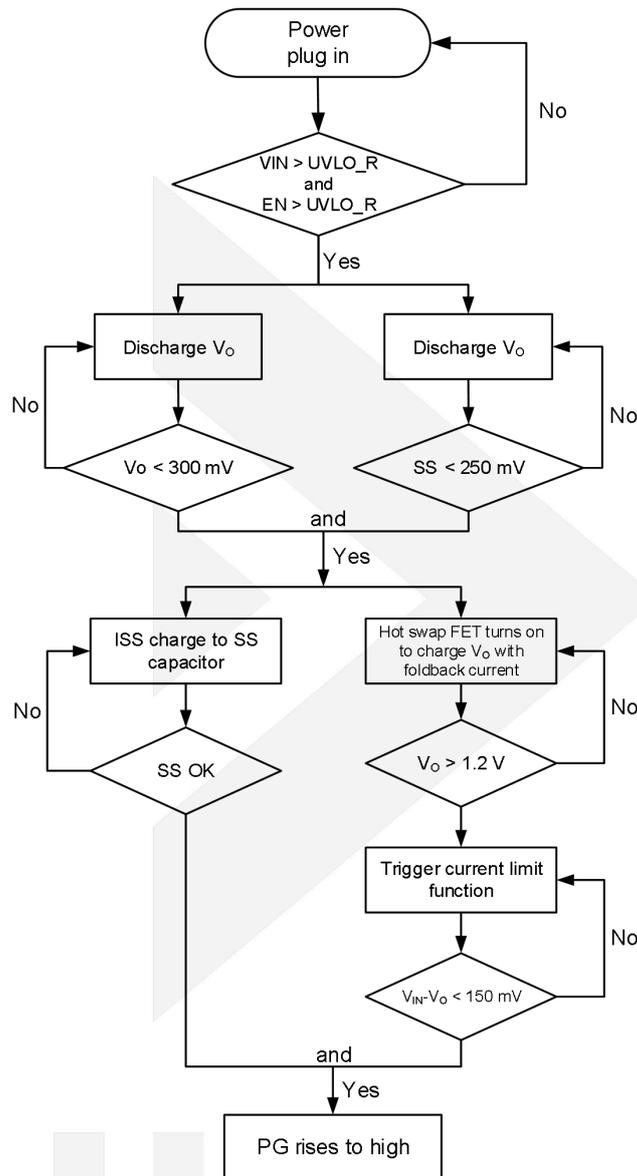


Figure 3. Start-up logic diagram

8. Application Information

Important notice: Validation and testing are the most reliable ways to confirm system functionality. The application information is not part of the specification and is for reference purposes only.

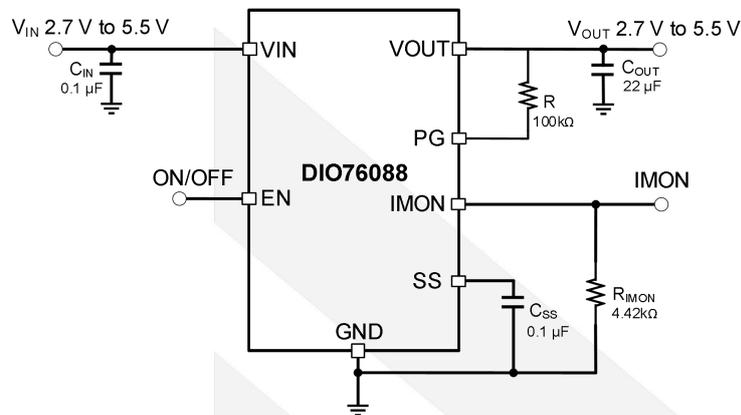


Figure 4. Typical application

8.1. IMON resistor

The ILIM resistor can adjust the current limit. The current limit can be calculated by equation (2) above. The recommended current limit threshold is to be higher than 110% to 120% of maximum load current. For example, if the full load is 10 A, the current limit can be 11.5 A.

It's recommended to use the resistor (R_{IMON}) with 1% accuracy.

8.2. SS capacitor

There is an internal current source charge SS cap and ramps up the voltage on the SS pin. The output voltage rises following the slew rate of SS voltage. During start up, the DIO76088 will limit the output current when the inrush on output current reaches the current limit (like with large output cap or very large load). At the same time, soft-start time will be increased.

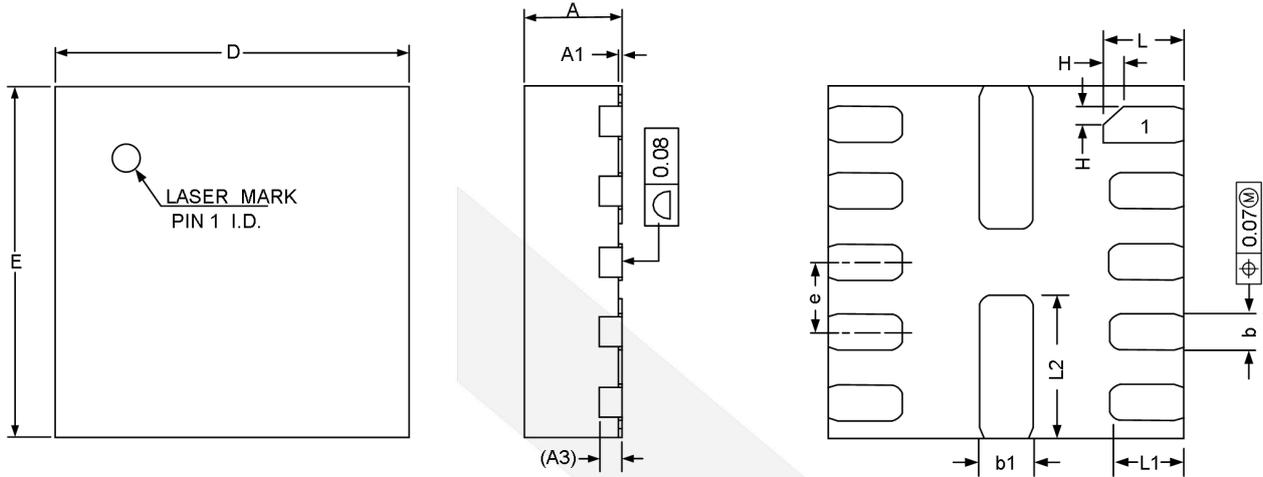
8.3. Input capacitor

For stable operation, it is recommended to use a decoupling capacitor (0.01 μ F to 1 μ F) between VIN and GND close to the device pins.

8.4. PG pin

The PG pin is an active high, open-drain output that requires an external pull-up resistor. The PG pin's maximum sink current should be lower than 3 mA. It is recommended to connect a pull-up resistor (20 k Ω to 100 k Ω) from PG to VOUT.

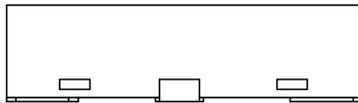
9. Physical Dimensions: QFN2*2-12



TOP VIEW

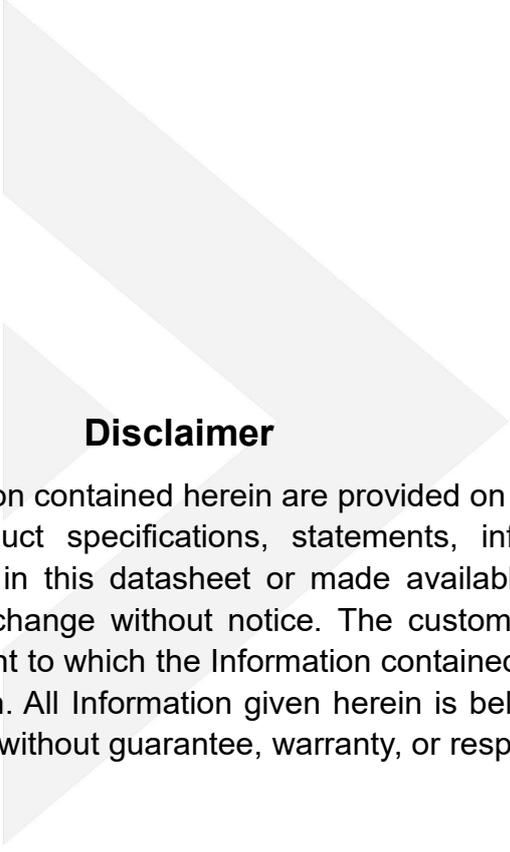
SIDE VIEW

BOTTOM VIEW



SIDE VIEW

Common Dimensions (Units of measure = Millimeter)			
Symbol	Min	Nom	Max
A	0.50	0.55	0.60
A1	0.00	0.02	0.05
A3	0.127 REF		
b	0.15	0.20	0.25
b1	0.250	0.30	0.35
D	1.95	2.00	2.05
E	1.95	2.00	2.05
e	0.35	0.40	0.45
L	0.40	0.45	0.50
L1	0.35	0.40	0.45
L2	0.75	0.80	0.85



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