National Semiconductor

December 2003

LM9076
150mA Ultra-Low Quiescent Current LDO Regulator with Delayed Reset Output

General Description

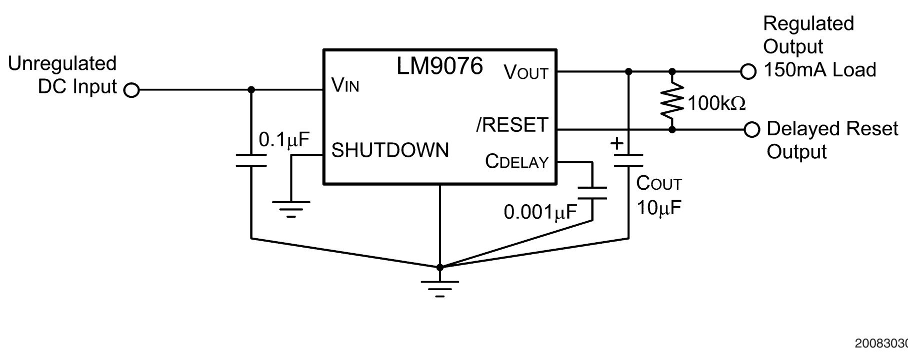
The LM9076 is a 5 Volt, +/-2%, 150mA logic controlled voltage regulator. The regulator features an active low delayed reset output flag which can be used to reset a microprocessor system at turn-ON and in the event that the regulator input voltage falls below a minimum value. An external capacitor programs a delay time interval before the reset output pin can return high.

Designed for automotive and industrial applications, the LM9076 contains a variety of protection features such as thermal shutdown, input transient protection and a wide operating temperature range. The LM9076 uses an PNP pass transistor which allows low drop-out voltage operation.

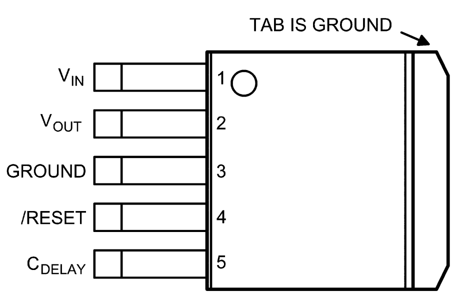
Features

- Ultra Low Ground Pin Current, 25µA typical for 100µA load
- V_{OUT} initial accuracy of +/-1%
- V_{OUT} accurate to +/2% over Load and Temperature Conditions
- Low Dropout Voltage, 200mV typical with 150mA load
- Low Off State Ground Pin current
- Delayed $\overline{\text{RESET}}$ output pin for low V_{OUT} detection
- +70V/-50V Voltage Transients
- Operational V_{IN} up to +40V

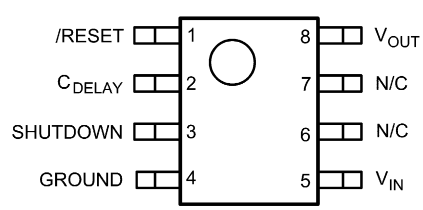
Typical Application



Package Outline



Top View
Part Number LM9076S–5.0
See NS TO-263 Package Number TS5



Top View
Part Number LM9076BMA–5.0
See NS SOIC Package Number M08A

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Absolute Maximum Ratings (Note 1)

V_{IN}(DC)	-15V to +55V
V_{IN}(+Transient) t< 10ms, Duty Cycle <1%	+70V
V_{IN}(-Transient) t< 1ms, Duty Cycle <1%	-50V
SHUTDOWN Pin	-15V to +52V
$\overline{RESET}$ Pin	-0.3V to 20V
C_{DELAY} Pin	-0.3V to V_{OUT} +0.3V
Storage Temperature	-65˚C to +150˚C
Junction Temperature (T_J)	+175C
ESD, HBM, per AEC - Q100 - 002	+/-2kV
ESD, MM, per AEC - Q100 - 003	+/-250V

Operating Ratings (Note 1)

V_{IN} Pin	5.35V to 40V
$V_{SHUTDOWN}$ Pin	0V to 40V
Ambient Temperature	–40˚C < T_A < +125˚C
Thermal Resistance TS5B (Note 6)	
θja	75˚C/W
θjc	2.9˚C/W
Thermal Resistance M08A (Note 6)	
θja	156˚C/W
θjc	59˚C/W

Electrical Characteristics for LM9076–5.0

The following specifications apply for V_{IN}= 14V; $V_{SHUTDOWN}$ = Open; I_{LOAD} = 10mA; T_A = +25˚C; C_{OUT} = 10µF, 0.5Ω < ESR < 4.0Ω; unless otherwise specified. **Bold Values indicate –40˚C ≤ T_A≤ 125˚C. (Note 4, Note 5)**

Symbol	Parameter	Conditions	Min	Typ	Max	Units
LM9076–5.0 REGULATOR CHARACTERISTICS						
V_{OUT}	Output Voltage		4.95	5.00	5.05	V
		1mA ≤ I_{LOAD} ≤ 150mA	**4.90**	**5.00**	**5.10**	V
		V_{IN} = 60V, R_{LOAD} = 1KΩ, t ≤ 40ms	4.50	5.00	5.50	V
	Output Voltage Off	$V_{SHUTDOWN}$ ≥ 2V, R_{LOAD} = 1KΩ	–	40	250	mV
	Reverse Battery	V_{IN} = -15V, R_{LOAD} = 1KΩ	–	0	–300	mV
ΔV_{OUT}	Line Regulation	9.0V ≤ V_{IN} ≤ 16V, I_{LOAD} = 10mA	–	4	25	mV
		16V ≤ V_{IN} ≤ 40V, I_{LOAD} = 10mA	–	17	25	mV
	Load Regulation	1mA ≤ I_{LOAD} ≤ 150mA	–	42	60	mV
V_{DO}	Dropout Voltage	I_{LOAD} = 10mA	–	30	50	mV
		I_{LOAD} = 50mA	–	80	–	mV
		I_{LOAD} = 150mA	–	150	250	mV
I_{GND}	Ground Pin Current	9V ≤ V_{IN} ≤ 16V, I_{LOAD} = 100uA	–	25	35	µA
		9V ≤ V_{IN} ≤ 40V, I_{LOAD} = 10mA	–	125	160	µA
		9V ≤ V_{IN} ≤ 40V, I_{LOAD} = 50mA	–	0.6	–	mA
		9V ≤ V_{IN} ≤ 16V, I_{LOAD} = 150mA	–	3.6	4.5	mA
	Ground Pin Current in Shut- down Mode	9V ≤ V_{IN} ≤ 40V, $V_{SHUTDOWN}$ = 2V	–	15	25	µA
I_{SC}	V_{OUT} Short Circuit Current	V_{IN} = 14V, R_{LOAD} = 1Ω	200	400	750	mA
PSRR	Ripple Rejection	V_{IN} = (14V_{DC}) + (1V_{RMS} @ 120Hz) I_{LOAD} = 50mA	50	60	–	dB
$\overline{RESET}$ PIN CHARACTERISTICS						
V_{OR}	Minimum V_{IN} for valid $\overline{RESET}$ Status	(Note 3)	–	1.3	2.0	V

Electrical Characteristics for LM9076–5.0 (Continued)

The following specifications apply for V_{IN}= 14V; $V_{SHUTDOWN}$ = Open; I_{LOAD} = 10mA; T_A = +25˚C; C_{OUT} = 10µF, 0.5Ω < ESR < 4.0Ω; unless otherwise specified. **Bold Values indicate –40˚C ≤ T_A≤ 125˚C. (Note 4, Note 5)**

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$\overline{RESET}$ PIN CHARACTERISTICS						
V_{THR}	V_{OUT} Threshold for $\overline{RESET}$ Low	(Note 3)	0.83	0.89	0.94	X V_{OUT} (Nom)
V_{OH}	$\overline{RESET}$ pin high voltage	External pull-up resistor to V_{OUT} = 100kΩ	V_{OUT} X 0.90	V_{OUT} X 0.99	V_{OUT}	V
V_{OL}	$\overline{RESET}$ pin low voltage	C_{DELAY} < 4.0V, I_{SINK} = 250µA	–	0.2	0.3	V
C_{DELAY} PIN CHARACTERISTICS						
I_{DELAY}	C_{DELAY} Charging Current	V_{IN} = 14V, V_{DELAY} = 0V	-0.35	-0.42	-0.50	uA
V_{OL}	C_{DELAY} pin low voltage	V_{OUT} < 4.0V, I_{SINK} = I_{DELAY}	—	0.100	—	V
t_{DELAY}	Reset Delay Time	V_{IN} = 14V, C_{DELAY} = 0.001uF V_{OUT} rising from 0V, Δt from V_{OUT} > V_{OR} to $\overline{RESET}$ pin HIGH	9.5	11.9	14.3	ms
SHUTDOWN CONTROL LOGIC — LM9076BMA Only						
$V_{IL(SD)}$	SHUTDOWN Input Low Threshold Voltage	$V_{SHUTDOWN}$ pin falling from 5.0V until Vout >4.5V (Vout = On)	1	1.5	—	V
$V_{IH(SD)}$	SHUTDOWN Input High Threshold Voltage	$V_{SHUTDOWN}$ pin rising from 0V until Vout < 0.5V (Vout = Off)	—	1.5	2	V
$I_{IH(SD)}$	SHUTDOWN Pin High Bias Current	$V_{SHUTDOWN}$ = 40V	—	35		µA
		$V_{SHUTDOWN}$ = 5V	—	15	35	µA
		$V_{SHUTDOWN}$ = 2V	—	6	10	µA
$I_{IL(SD)}$	SHUTDOWN Input Low Bias Current	$V_{SHUTDOWN}$ = 0V	—	0	—	µA

Note 1: Absolute Maximum Ratings indicate the limits beyond which the device may cease to function, and/or damage to the device may occur.

Note 2: Operating Ratings indicate conditions for which the device is intended to be functional, but does not guarantee specific performance limits. For guaranteed specifications and conditions refer to the Electrical Characteristics

Note 3: Not Production tested, Guaranteed by Design. Minimum, Typical, and/or Maximum values are provided for informational purposes only.

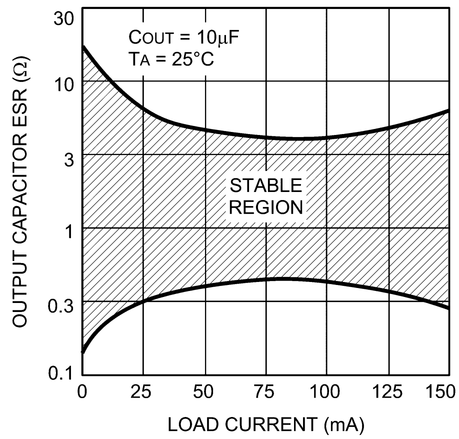
Note 4: Pulse testing used maintain constant junction temperature (T_J).

Note 5: The regulated output voltage specification is not guaranteed for the entire range of V_{IN} and ouput loads. Device operational range is limited by the maximum junction temperature (T J). The junction temperature is influenced by the ambient temperature (T A), package selection, input voltage (V_{IN}), and the output load current. When operating with maximum load currents the input voltage and/or ambient temperature will be limited. When operating with maximum input voltage the load current and/or the ambient temperature will be limited.

Note 6: Worst case (FREE AIR) per EIA/JESD51–3.

Typical Performance Characteristics

Output Capacitor ESR



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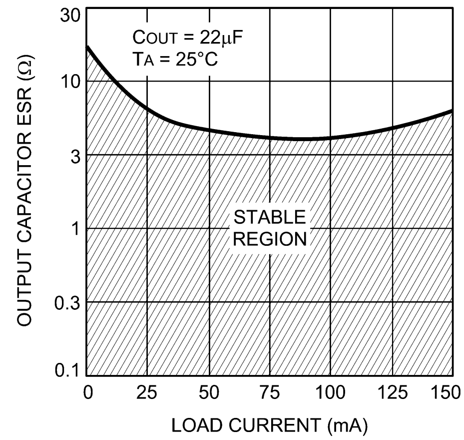
Output Capacitor ESR



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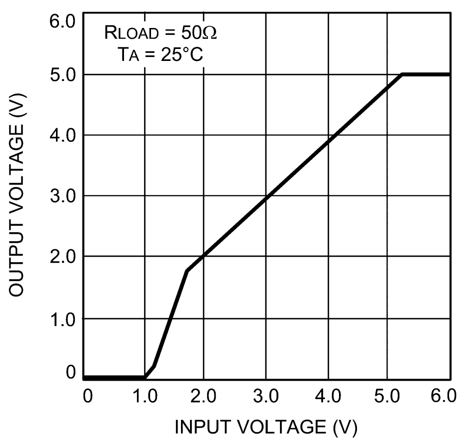
Low Voltage Behavior



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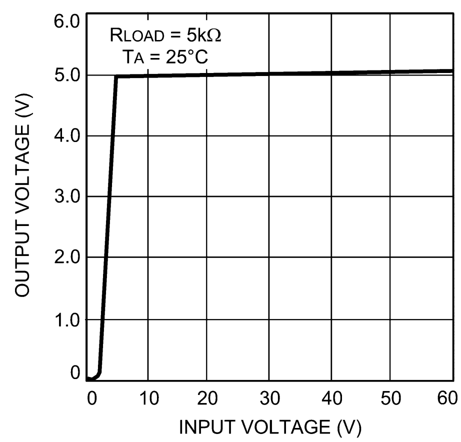
High Voltage Behavior



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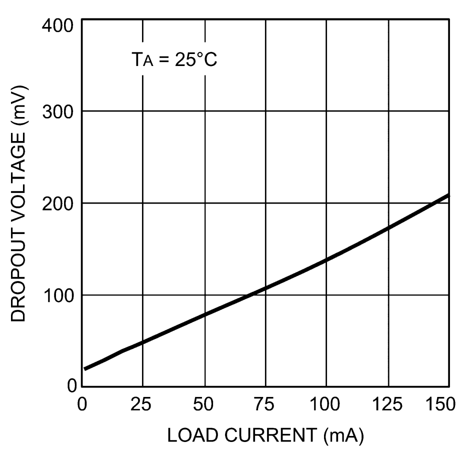
Dropout Voltage



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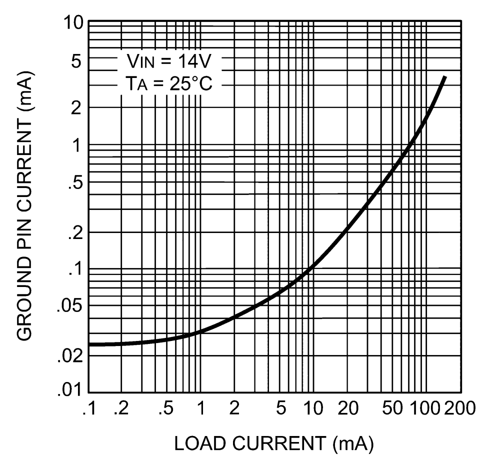
Ground Pin Current vs Load Current



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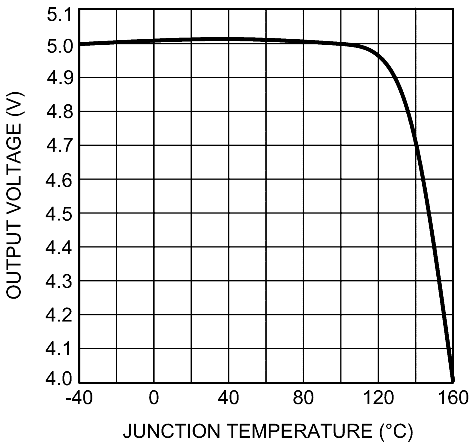
Typical Performance Characteristics (Continued)

Output Voltage vs Junction Temperature



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Application Information

REGULATOR BASICS

This regulator is suitable for Automotive applications where continuous connection to the battery is required (refer to the Typical Application circuit).

The pass transistor of the regulator is an PNP device. A 10uF capacitor on the V_{OUT} pin will provide adequate performance in most circumstances. There is no maximum value for the regulator output bypass capacitance.

INPUT CAPACITOR

The LM9076 requires a low source impedance to maintain regulator stability because portions of the internal bias circuitry are connected directly to V_{IN}. At a minimum, at 0.1µF ceramic capacitor should be placed between the LM9076 V_{IN} and Ground pins, as close as is physically possible.

OUTPUT CAPACITOR

An output capacitor is also required for stability. This capacitor must be placed between the LM9076 V_{OUT} and Ground pins, as close as is physically possible, using traces that are not part of the main load current path.

The output capacitor must meet the requirements for minimum capacitance and also maintain the appropriate ESR value of the full operating ambient temperature range to assure stability. There is no maximum limit for the output capacitance value, as long as ESR is maintained. See the Typical Performance Characteristics curves for details.

Solid tantalum capacitors are recommended as they generally maintain capacitance and ESR ratings over a wide temperature range.

Ceramic capacitor types XR7 and X5R may be used if a series resistor is added to simulate the ESR requirement.

Aluminum electrolytic capacitors are not recommend, as they are subject to wide changes in capacitance and ESR values across temperature.

DELAY CAPACITOR

The capacitor on the Delay pin must be a low leakage type since the charge current is minimal (500nA typical) and the pin must fully charge to 5V. Ceramic, Mylar, and polystyrene capacitor types are generally recommended, although changes in capacitance values across temperature changes will have some effect on the delay timing.

SHUTDOWN PIN

The basic On/Off control of the regulator is accomplished with the SHUTDOWN pin. By pulling the SHUTDOWN pin high the regulator output is switched Off. When the regulator is switched Off the load on the battery will be primarily due to the SHUTDOWN pin current.

When the SHUTDOWN pin is low, or left open, the regulator is switched On. When an unregulated supply, such as V BATTERY , is used to pull the SHUTDOWN pin high a series resistor in the range of 10KΩ to 50KΩ is recommended to provide reverse voltage transient protection of the SHUTDOWN pin. Adding a small capacitor (0.001uF typical) from the SHUTDOWN pin to Ground will add noise immunity to prevent accidental turn on due to noise on the supply line.

$\overline{\text{RESET}}$ FLAG

Proper operation of the $\overline{\text{RESET}}$ circuity is not guaranteed for V_{IN} voltages of less than 2.0V. The $\overline{\text{RESET}}$ pin will provide information on the status of the regulator V_{OUT} voltage level. Any condition that causes the V_{OUT} voltage to drop to typically 89% normal would cause the $\overline{\text{RESET}}$ pin to go low. This will warn of a system Vcc supply that may cause abnormal operation.

Of course, when the regulator is switched Off in normal operation the $\overline{\text{RESET}}$ pin will be low.

If the regulator is On, and then switched off, the $\overline{\text{RESET}}$ flag will go low when the V_{OUT} voltage stored on the output capacitor has decayed adequately.

Excessive thermal dissipation of the device such that the Thermal Shutdown circuit is activated which then switches the regulator output Off, would cause the $\overline{\text{RESET}}$ pin to go low.

The $\overline{\text{RESET}}$ pin is an open collector output and requires an external pull-up resistor to V_{OUT} . The external pull-up resistor should be in the range of 10KΩ to 200KΩ.

Application Information (Continued)

$\overline{RESET}$ DELAY TIME

When the regulator output is switched On, or after recovery from brief V_{OUT} fault condition, the $\overline{RESET}$ flag can be can be programmed to remain low for an additional delay time. This will give time for any system reference voltages, clock signals, etc., to stabilize before the micro-controller resumes normal operation.

This delay time is controlled by the capacitor value on the C_{DELAY} pin. During normal operation the C_{DELAY} capacitor is charged to near V_{OUT} . When a V_{OUT} fault causes the $\overline{RESET}$ pin to go low, the C_{DELAY} capacitor is quickly discharged to ground. When the V_{OUT} fault is removed, and V_{OUT} returns to the normal operating value, the C_{DELAY} capacitor begins charging at a typical constant 0.420uA rate. When the voltage on the C_{DELAY} capacitor reaches the same potential as the V_{OUT} pin the $\overline{RESET}$ pin will be allowed to return high.

The typical $\overline{RESET}$ delay time can be calculated with the following formula:

$$t_{DELAY} = V_{OUT} \text{ X } (C_{DELAY} / I_{DELAY})$$

For a C_{DELAY} value of 0.001uF and a I_{DELAY} value of 0.475uA the typical $\overline{RESET}$ delay time is:

$$t_{DELAY} = V_{OUT} \text{ X } (0.001\text{uF} / 0.475\text{uA})$$

$$t_{DELAY} = 5.0\text{V X } (0.001\text{uF} / 0.420\text{uA}) = 11.9\text{ms}$$

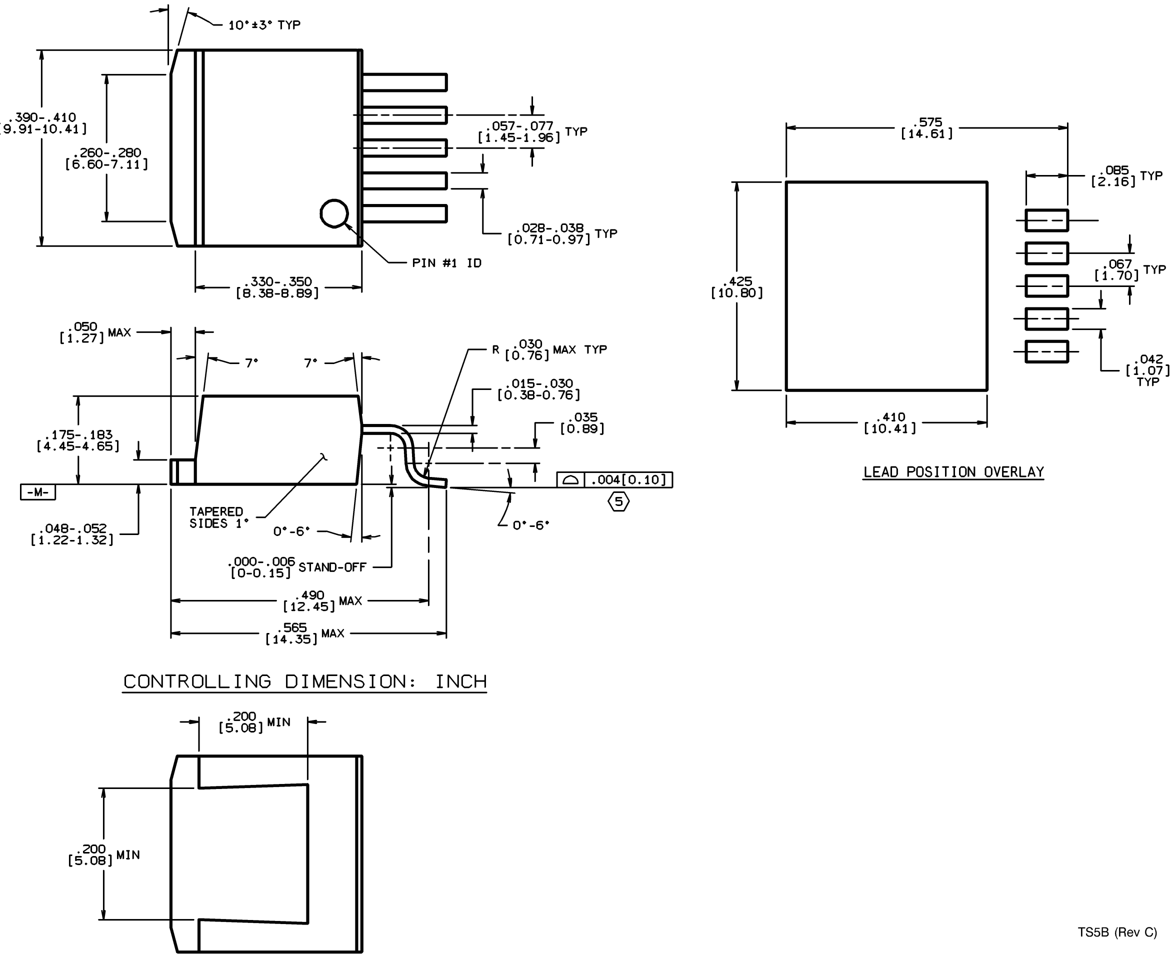
THERMAL PROTECTION

Device operational range is limited by the maximum junction temperature (T_J). The junction temperature is influenced by the ambient temperature (T_A), package selection, input voltage (V_{IN}), and the output load current. When operating with maximum load currents the input voltage and/or ambient temperature will be limited. When operating with maximum input voltage the load current and/or the ambient temperature will be limited.

Even though the LM9076 is equipped with circuitry to protect itself from excessive thermal dissipation, it is not recommended that the LM9076 be operated at, or near, the maximum recommended die junction temperature (T_J) as this may impair long term device reliability.

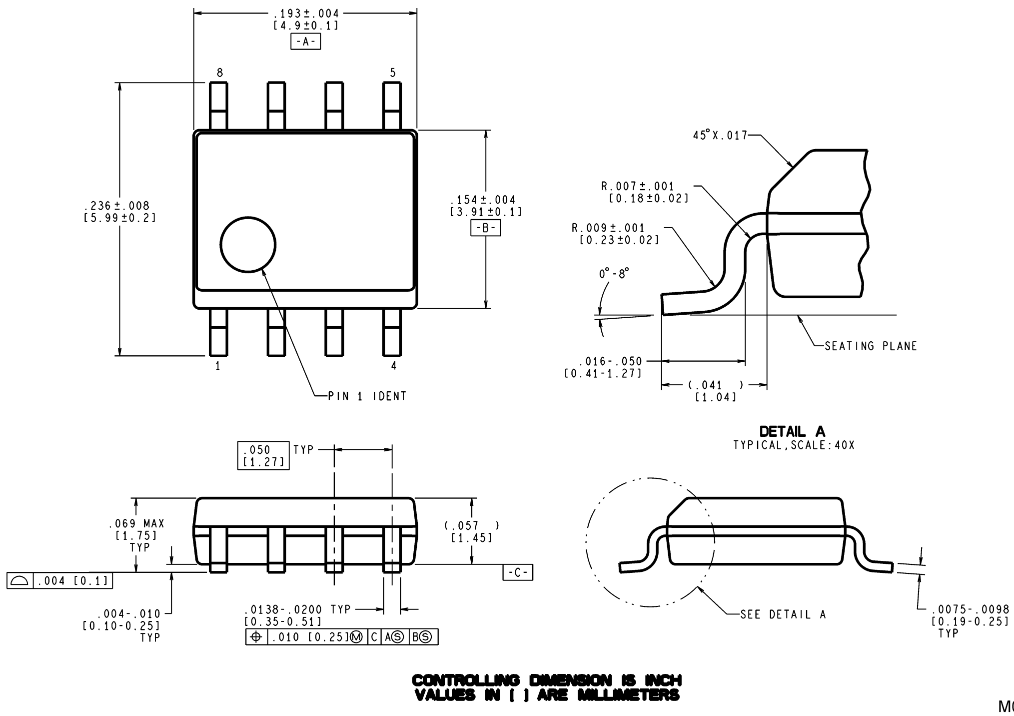
The thermal protection circuity monitors the temperature at the die level. When the die temperature exceeds typically 160C the voltage regulator output will be switched off.

Physical Dimensions inches (millimeters) unless otherwise noted



5-Lead
Order Number LM9076S
NS Package Number TS5B

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



M08A (Rev J)

8-Lead (0.150" Wide) Molded SO Package
Order Number LM9076M
NS Package Number M08A

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