## FEATURES

- Operational V_{IN} up to +40V
- +70V/−50V Voltage Transients
- Available with 3.3V or 5.0V Output Voltage
- Ultra Low Ground Pin Current, 25µA Typical for 100µA Load
- V_{OUT} Initial Accuracy of ±1.5%
- V_{OUT} Accurate to ±3% Over Load and Temperature Conditions
- Low Dropout Voltage, 200mV Typical with 150mA Load
- Low Off State Ground Pin Current for LM9076D in 8-pin SOP Package
- Delayed $\overline{\text{RESET}}$ Output Pin for Low V_{OUT} Detection

DESCRIPTION

The LM9076 is a ±3%, 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 output voltage falls below a minimum value. An external capacitor programs a delay times 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 a PNP pass transistor which allows low drop-out voltage operation.
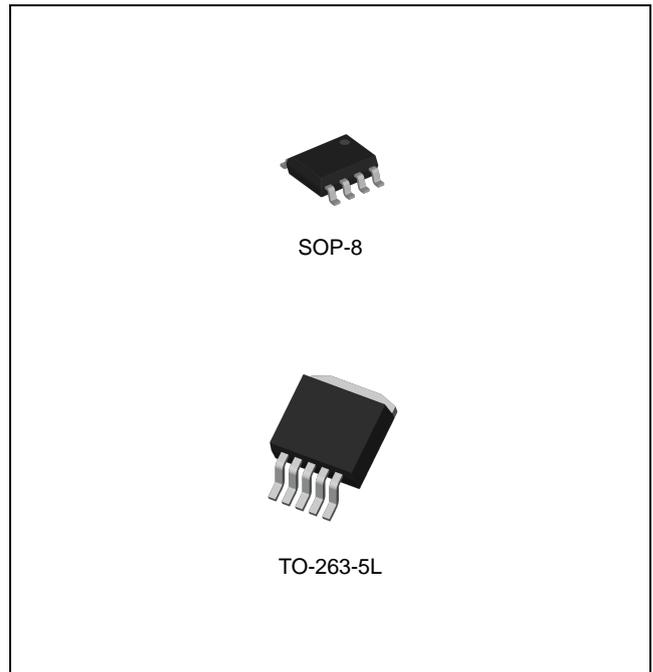
SOP-8

TO-263-5L

ORDERING INFORMATION

Device	Package
LM9076D-x.x	SOP-8
LM9076R-x.x	TO-263-5L

xx: Output Voltage

ABSOLUTE MAXIMUM RATINGS (Note 1)

CHARACTERISTIC	SYMBOL	MIN	MAX	UNIT
Input Voltage (DC)	V_{IN}	−15	50	V
Input Voltage (+Transient) t< 10ms, Duty Cycle <1%	V_{IN}	-	60	V
Input Voltage (−Transient) t< 1.0ms, Duty Cycle <1%	V_{IN}	−50	-	V
SHUTDOWN Pin	$V_{SHUTDOWN}$	−15	52	V
$\overline{RESET}$ Pin	$V_{\overline{RESET}}$	−0.3	20	V
DELAY Pin	V_{DELAY}	−0.3	V_{OUT} + 0.3	V
ESD Immunity (HBM)	V_{ESD}	-	±2	kV
Maximum Junction Temperature	T_J	-	175	°C
Storage Temperature	T_{STG}	−65	150	°C

Note 1. Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
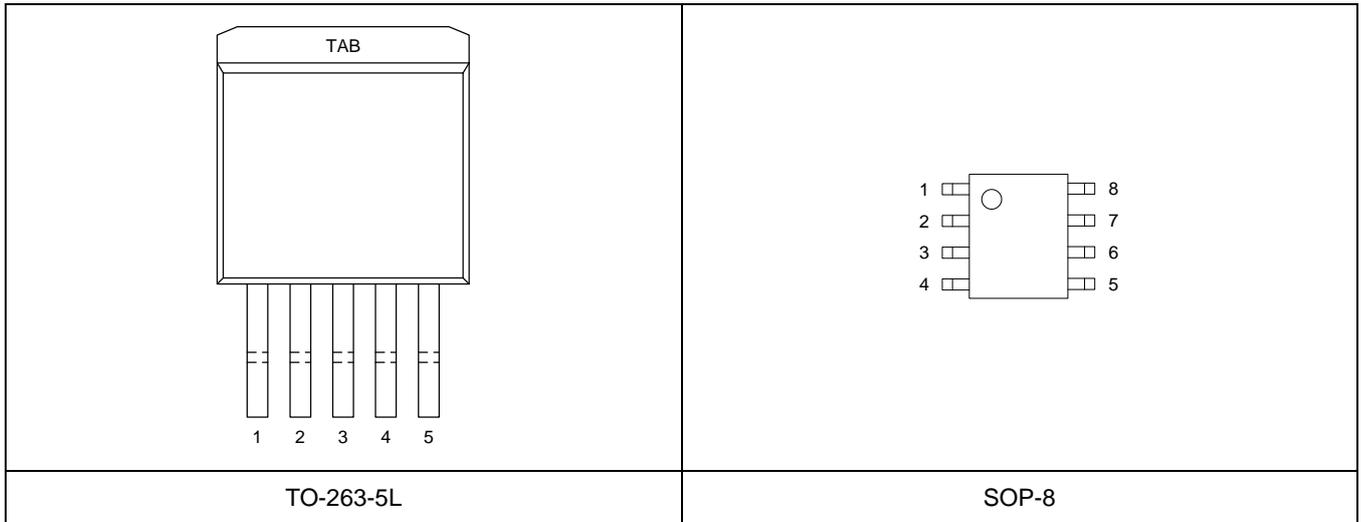
RECOMMENDED OPERATING RATINGS (Note 2)

CHARACTERISTIC	SYMBOL	MIN	MAX	UNIT
IN Pin	V_{IN}	5.35	40	V
SHUTDOWN Pin	$V_{SHUTDOWN}$	0	40	V
Operating Junction Temperature Range	T_J	−40	125	°C

Note 2. The device is not guaranteed to function outside its operating ratings.

ORDERING INFORMATION

VOUT	Package	Order No.	Description	Supplied As	Status
3.3V	TO-263-5L	LM9076R-3.3		Tape & Reel	Contact us
	SOP-8	LM9076D-3.3	With Shutdown Function	Tape & Reel	Active
5.0V	TO-263-5L	LM9076R-5.0		Tape & Reel	Active
	SOP-8	LM9076D-5.0	With Shutdown Function	Tape & Reel	Contact us

PIN CONFIGURATION

TAB ... 1 2 3 4 5	1 2 3 4 ... 8 7 6 5
TO-263-5L	SOP-8

PIN DESCRIPTION

Pin No.		Pin Name	Pin Function
TO-263-5L	SOP-8		
1	5	IN	Input Voltage.
2	8	OUT	Output Voltage.
3	4	GND	Ground.
4	1	$\overline{\text{RESET}}$	Delayed Reset Output Flag pin. An Open Collector Output which Requires an External Pull-Up Resistor to Develop the Reset Signal. The external pull-up resistor should be in the range of 10kΩ to 200kΩ.
5	2	DELAY	Connect Capacitor to Control Reset Delay Time.
-	3	SHUTDOWN	Shutdown Control Input. On/Off Control for the Regulator. By pulling the SHUTDOWN pin high the regulator output is switched off.
-	6	N.C.	Not Connected.
-	7	N.C.	Not Connected.
TAB	-	TAB	Connect to GND.

TYPICAL APPLICATION CIRCUITS
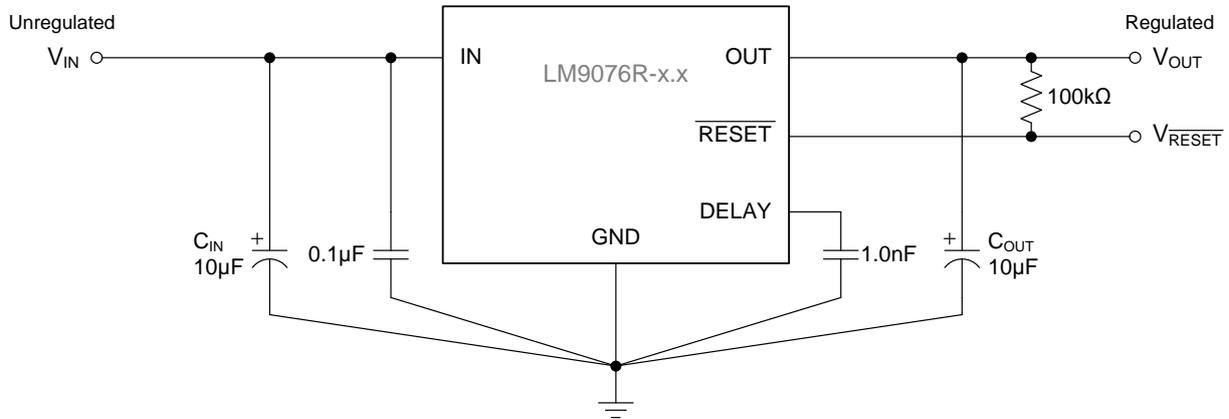
< LM9076R-x.x in TO-263-5L Package >
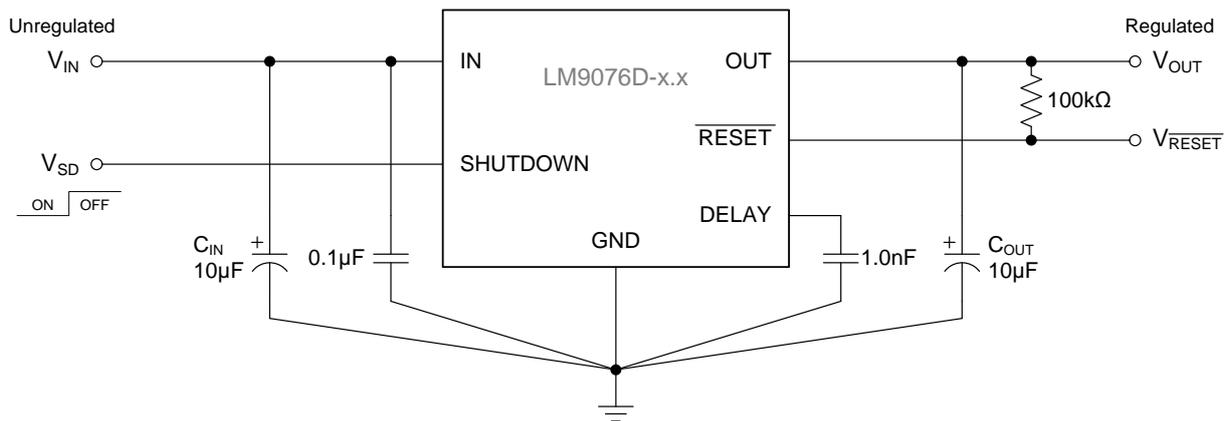
< LM9076D-x.x in SOP-8 Package >

* C_{IN} required for stability. Value given may be increased.

** C_{OUT} required for stability. Value given may be increased.

*** For the details, refer to the Application Information.

ELECTRICAL CHARACTERISTICS: LM9076-3.3

The following specifications apply for T_J = 25°C; V_{IN} = 14V; I_{LOAD} = 10mA; C_{OUT} = 10µF, 0.5Ω < ESR < 4.0Ω; unless otherwise specified. (Note 3, 4, 5) Minimum and maximum limits are specified through test, design or statistical correlation.

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{OUT}	Output Voltage		3.251	3.3	3.349	V
		1.0mA ≤ I_{LOAD} ≤ 150mA, −20°C ≤ T_J ≤ 85°C	3.234	3.3	3.366	V
		1.0mA ≤ I_{LOAD} ≤ 150mA, −40°C ≤ T_J ≤ 125°C	3.201	3.3	3.399	V
		V_{IN} = 50V, R_{LOAD} = 1.0kΩ, t ≤ 40ms	2.970	3.3	3.630	V
	Output Voltage Off (LM9076D)	$V_{SHUTDOWN}$ ≥ 2.0V, R_{LOAD} = 1kΩ	-	0	250	mV
	Reverse Battery	V_{IN} = −15V, R_{LOAD} = 1.0kΩ	−300	0	-	mV
ΔV_{LINE}	Line Regulation	9.0V ≤ V_{IN} ≤ 16V, I_{LOAD} = 10mA	-	4.0	25	mV
		16V ≤ V_{IN} ≤ 40V, I_{LOAD} = 10mA	-	17	35	mV
ΔV_{LOAD}	Load Regulation	1.0mA ≤ 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	9.0V ≤ V_{IN} ≤ 16V, I_{LOAD} = 100µA	-	25	50	µA
		9.0V ≤ V_{IN} ≤ 40V, I_{LOAD} = 10mA	-	125	160	µA
		9.0V ≤ V_{IN} ≤ 40V, I_{LOAD} = 50mA	-	0.6	-	mA
		9.0V ≤ V_{IN} ≤ 16V, I_{LOAD} = 150mA	-	3.6	4.5	mA
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 5)	-	1.3	2.0	V
V_{THR}	V_{OUT} Threshold for $\overline{RESET}$ Low	(Note 5)	0.83	0.89	0.94	× V_{OUT} (Nom)
V_{OH}	$\overline{RESET}$ Pin High Voltage	External pull-up resistor to V_{OUT} = 100kΩ	V_{OUT} × 0.90	V_{OUT} × 0.99	V_{OUT}	V
V_{OL}	$\overline{RESET}$ Pin Low Voltage	V_{DELAY} < 4.0V, I_{SINK} = 250µA	-	0.2	0.3	V
DELAY PIN CHARACTERISTICS						
I_{DELAY}	DELAY Pin Charging Current	V_{IN} = 14V, V_{DELAY} = 0V	−0.70	−0.42	−0.25	µA
V_{OL}	DELAY Pin Low Voltage	V_{OUT} < 4.0V, I_{SINK} = I_{DELAY}	-	0.1	-	V
t_{DELAY}	Reset Delay Time	V_{IN} = 14V, C_{DELAY} = 0.001µF, V_{OUT} rising from 0V, ∆t from V_{OUT} > V_{OR} to $\overline{RESET}$ pin HIGH	4.7	7.8	13.2	ms

Note 3. The regulated output voltage specification is not ensured for the entire range of V_{IN} and output 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 (I_{LOAD}). 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 4. Pulse testing used maintain constant junction temperature (T_J).

Note 5. Not Production tested, Specified by Design. Minimum, Typical, and/or Maximum values are provided for informational purposes only.

ELECTRICAL CHARACTERISTICS: LM9076-5.0

The following specifications apply for T_J = 25°C; V_{IN} = 14V; I_{LOAD} = 10mA; C_{OUT} = 10μF, 0.5Ω < ESR < 4.0Ω; unless otherwise specified. [Note 3, 4, 5] Minimum and maximum limits are specified through test, design or statistical correlation.

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{OUT}	Output Voltage		4.925	5.0	5.075	V
		1.0mA ≤ I_{LOAD} ≤ 150mA, −20°C ≤ T_J ≤ 85°C	4.900	5.0	5.100	V
		1.0mA ≤ I_{LOAD} ≤ 150mA, −40°C ≤ T_J ≤ 125°C	4.850	5.0	5.150	V
		V_{IN} = 50V, R_{LOAD} = 1.0kΩ, t ≤ 40ms	4.500	5.0	5.500	V
	Output Voltage Off (LM9076D)	$V_{SHUTDOWN}$ ≥ 2.0V, R_{LOAD} = 1kΩ	-	0	250	mV
	Reverse Battery	V_{IN} = −15V, R_{LOAD} = 1.0kΩ	−300	0	-	mV
ΔV_{LINE}	Line Regulation	9.0V ≤ V_{IN} ≤ 16V, I_{LOAD} = 10mA	-	4.0	25	mV
		16V ≤ V_{IN} ≤ 40V, I_{LOAD} = 10mA	-	17	35	mV
ΔV_{LOAD}	Load Regulation	1.0mA ≤ 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	9.0V ≤ V_{IN} ≤ 16V, I_{LOAD} = 100μA	-	25	50	μA
		9.0V ≤ V_{IN} ≤ 40V, I_{LOAD} = 10mA	-	125	160	μA
		9.0V ≤ V_{IN} ≤ 40V, I_{LOAD} = 50mA	-	0.6	-	mA
		9.0V ≤ V_{IN} ≤ 16V, I_{LOAD} = 150mA	-	3.6	4.5	mA
	Ground Pin Current in Shutdown Mode	9.0V ≤ 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
RESET PIN CHARACTERISTICS						
V_{OR}	Minimum V_{IN} for Valid RESET Status	(Note 5)	-	1.3	2.0	V
V_{THR}	V_{OUT} Threshold for RESET Low	(Note 5)	0.83	0.89	0.94	× V_{OUT} (Nom)
V_{OH}	RESET Pin High Voltage	External pull-up resistor to V_{OUT} = 100kΩ	V_{OUT} × 0.90	V_{OUT} × 0.99	V_{OUT}	V
V_{OL}	RESET Pin Low Voltage	V_{DELAY} < 4.0V, I_{SINK} = 250μA	-	0.2	0.3	V
DELAY PIN CHARACTERISTICS						
I_{DELAY}	DELAY Pin Charging Current	V_{IN} = 14V, V_{DELAY} = 0V	−0.70	−0.42	−0.25	μA
V_{OL}	DELAY Pin Low Voltage	V_{OUT} < 4.0V, I_{SINK} = I_{DELAY}	-	0.1	-	V

Note 3. The regulated output voltage specification is not ensured for the entire range of V_{IN} and output 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 (I_{LOAD}). 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 4. Pulse testing used maintain constant junction temperature (T_J).
Note 5. Not Production tested, Specified by Design. Minimum, Typical, and/or Maximum values are provided for informational purposes only.

ELECTRICAL CHARACTERISTICS: LM9076-5.0 (continued)

The following specifications apply for T_J = 25°C; V_{IN} = 14V; I_{LOAD} = 10mA; C_{OUT} = 10µF, 0.5Ω < ESR < 4.0Ω; unless otherwise specified. (Note 3, 4, 5)   Minimum and maximum limits are specified through test, design or statistical correlation.

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{DELAY}	Reset Delay Time	V_{IN} = 14V, C_{DELAY} = 0.001µF, V_{OUT} rising from 0V, Δt from V_{OUT} > V_{OR} to $\overline{RESET}$ pin HIGH	7.1	11.9	20.0	ms
SHUTDOWN CONTROL LOGIC (LM9076D Only)						
$V_{IL(SD)}$	SHUTDOWN Pin Low Threshold Voltage	$V_{SHUTDOWN}$ pin falling from 5.0V until V_{OUT} > 4.5V (V_{OUT} = On)	1.0	1.5	-	V
$V_{IH(SD)}$	SHUTDOWN Pin High Threshold Voltage	$V_{SHUTDOWN}$ pin rising from 0V until V_{OUT} < 0.5V (V_{OUT} = Off)	-	1.5	2.0	V
$I_{IH(SD)}$	SHUTDOWN Pin High Bias Current	$V_{SHUTDOWN}$ = 40V	-	35	-	µA
		$V_{SHUTDOWN}$ = 5.0V	-	15	45	µA
		$V_{SHUTDOWN}$ = 2.0V	-	6.0	12	µA
$I_{IL(SD)}$	SHUTDOWN Pin Low Bias Current	$V_{SHUTDOWN}$ = 0V	-	0	-	µA

Note 3. The regulated output voltage specification is not ensured for the entire range of V_{IN} and output 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 (I_{LOAD}). 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 4. Pulse testing used maintain constant junction temperature (T_J).

Note 5. Not Production tested, Specified by Design. Minimum, Typical, and/or Maximum values are provided for informational purposes only.

TYPICAL OPERATING CHARACTERISTICS

T.B.D.

APPLICATION INFORMATION

REGULATOR BASICS

The LM9076 regulator is suitable for Automotive and Industrial applications where continuous connection to a battery supply is required (refer to *Typical Application Circuits*).

The pass element of the regulator is a PNP device which requires an output bypass capacitor for stability. The minimum bypass capacitance for the output is 10µF (refer to ESR limitations). A 22µF or larger, output bypass capacitor is recommended for typical applications.

INPUT CAPACITOR

The LM9076 requires a low source impedance to maintain regulator stability because critical portions of the internal bias circuitry are connected to directly to IN pin. In general, a 10µF electrolytic capacitor, located within two inches of the LM9076, is adequate for a majority of applications. Additionally, and at a minimum, a 0.1µF ceramic capacitor should be located between the LM9076 IN pin and GND pin, and as close as is physically possible to the LM9076 itself.

OUTPUT CAPACITOR

An output bypass capacitor is required for stability. This capacitance must be placed between the LM9076 OUT pin and GND pin, as close as is physically possible, using traces that are not part of the load current path.

The output capacitor must meet the requirements for minimum capacitance and also maintain the appropriate ESR value across the entire operating ambient temperature range. There is no limit to the maximum output capacitance as long as ESR is maintained.

The minimum bypass capacitance for the output is 10µF (refer to ESR limitations). A 22µF, or larger, output bypass capacitor is recommended for typical applications.

Solid tantalums capacitors are recommended as they generally maintain capacitance and ESR ratings over a wide temperature range. Ceramic capacitor types XR7 and XR5 may be used if a series resistor is added to simulate the minimum ESR requirement.
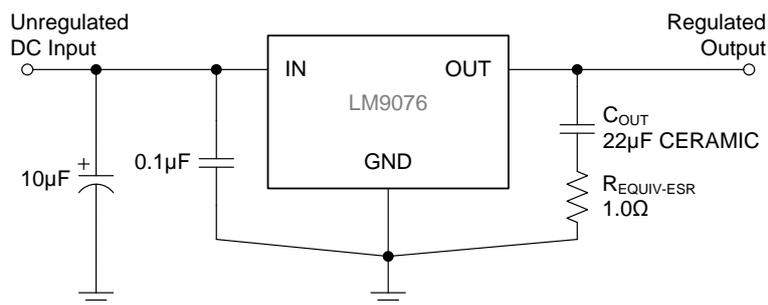
Aluminum electrolytic capacitors are not recommended as they are subject to wide changes in capacitance and ESR across temperature.

DELAY CAPACITOR

The capacitor on the DELAY pin must be a low leakage type since the charge current is minimal (420nA typical) and the pin must fully charge to V_{OUT}. 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.

Any leakage of the I_{DELAY} current, be it through the delay capacitor or any other path, will extend the delay time, possibly to the point that the $\overline{RESET}$ pin output does not go high.

SHUTDOWN PIN (LM9076D ONLY)

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 (0.001µF typical) from the SHUTDOWN pin to GND will add noise immunity to prevent accidental turn on due to noise on the supply line.

$\overline{RESET}$ FLAG

The $\overline{RESET}$ pin is and is an open collector output which requires an external pull-up resistor to develop the reset signal. The external pull-up resistor should be in the range of 10kΩ to 200kΩ.

At V_{IN} values of less than typically 2V the $\overline{RESET}$ pin voltage will be high. For V_{IN} values between typically 2V and approximately $V_{OUT} + V_{BE}$ the $\overline{RESET}$ pin voltage will be low. For V_{IN} values greater than approximately $V_{OUT} + V_{BE}$ the $\overline{RESET}$ pin voltage will be dependent on the status of the OUT pin voltage and the Delayed Reset circuitry. The value of V_{BE} is typically 600mV at 25°C and will decrease approximately 2mV for every 1°C increase in the junction temperature. During normal operation the $\overline{RESET}$ pin voltage will be high.

Any load condition that causes the OUT pin voltage to drop below typically 89% of normal will activate the Delayed Reset circuit and the $\overline{RESET}$ pin will go low for the duration of the delay time.

Any line condition that causes IN pin voltage to drop below typically $V_{OUT} + V_{BE}$ will cause the $\overline{RESET}$ pin to go low without activating the Delayed Reset circuitry.

Excessive thermal dissipation will raise the junction temperature and could activate the Thermal Shutdown circuitry which, in turn, will cause the $\overline{RESET}$ pin to go low.

For the LM9076D, pulling the SHUTDOWN pin high will turn off the output which, in turn, will cause the $\overline{RESET}$ pin to go low once the V_{OUT} voltage has decayed to a value that is less than typically 89% of normal.
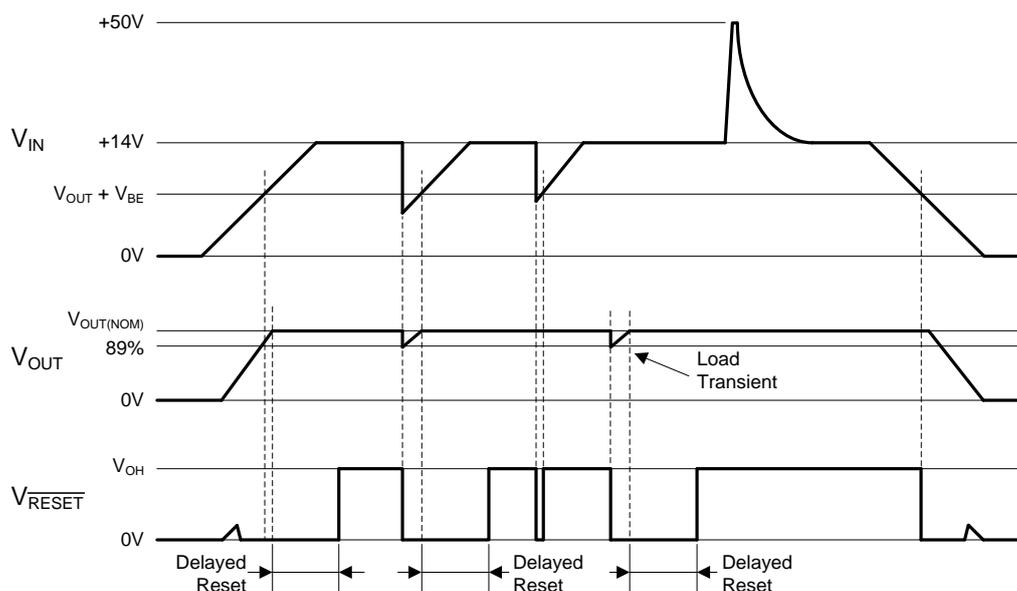
$\overline{\text{RESET}}$ DELAY TIME

When the regulator output is switched on, or after recovery from brief V_{OUT} fault condition, the $\overline{\text{RESET}}$ flag 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 DELAY pin. During normal operation the DELAY capacitor is charged to near V_{OUT}. When a V_{OUT} fault is removed, the V_{OUT} returns to the normal operating value, the DELAY capacitor begins charging at a typical constant 0.420μA rate. When the voltage on the DELAY capacitor reaches the same potential as the OUT pin the $\overline{\text{RESET}}$ pin will be allowed to return high.

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

$$t_{DELAY} = V_{OUT} \times (C_{DELAY} / I_{DELAY}) \tag{1}$$

For the LM9076-3.3 with a C_{DELAY} value of 0.001μF and a I_{DELAY} of 0.420μA the typical $\overline{\text{RESET}}$ delay time is:

$$t_{DELAY} = 3.3V \times (0.001μF / 0.420μA) = 7.8ms \tag{2}$$

For the LM9076-5.0 with a C_{DELAY} value of 0.001μF and a I_{DELAY} value of 0.420μA the typical $\overline{\text{RESET}}$ delay time is:

$$t_{DELAY} = 5.0V \times (0.001μF / 0.420μA) = 11.9ms \tag{3}$$

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.

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 circuitry monitors the temperature at the die level. When the die temperature exceeds typically 160°C the voltage regulator output will be switched off.

REVISION NOTICE

The description in this datasheet is subject to change without any notice to describe its electrical characteristics properly.