National Semiconductor

October 24, 2008

LP38690/LP38692
1A Low Dropout CMOS Linear Regulators
Stable with Ceramic Output Capacitors

General Description

The LP38690/2 low dropout CMOS linear regulators provide tight output tolerance (2.5% typical), extremely low dropout voltage (450mV @ 1A load current, V_{OUT} = 5V), and excellent AC performance utilizing ultra low ESR ceramic output capacitors.

The low thermal resistance of the LLP, SOT-223 and T0-252 packages allow the full operating current to be used even in high ambient temperature environments.

The use of a PMOS power transistor means that no DC base drive current is required to bias it allowing ground pin current to remain below 100 µA regardless of load current, input voltage, or operating temperature.

Dropout Voltage: 450 mV (typ) @ 1A (typ. 5V out).

Ground Pin Current: 55 µA (typ) at full load.

Precision Output Voltage: 2.5% (25°C) accuracy.

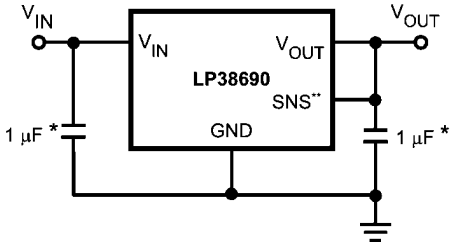
Features

- 2.5% output accuracy (25°C)
- Low dropout voltage: 450mV @ 1A (typ, 5V out)
- Wide input voltage range (2.7V to 10V)
- Precision (trimmed) bandgap reference
- Guaranteed specs for -40°C to +125°C
- 1µA off-state quiescent current
- Thermal overload protection
- Foldback current limiting
- T0-252, SOT-223 and 6-Lead LLP packages
- Enable pin (LP38692)

Applications

- Hard Disk Drives
- Notebook Computers
- Battery Powered Devices
- Portable Instrumentation

Typical Application Circuits



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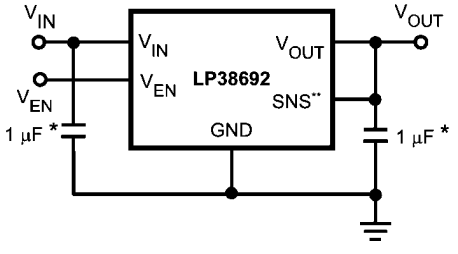

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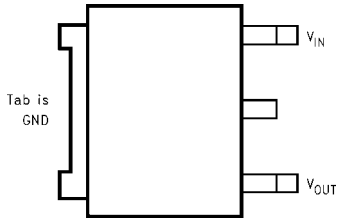
Note: * Minimum value required for stability.
**LLP package devices only.

Connection Diagrams



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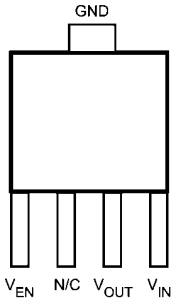
TO-252, Top View
LP38690DT-X.X



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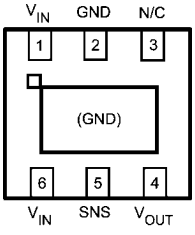
SOT-223, Top View
LP38692MP-X.X



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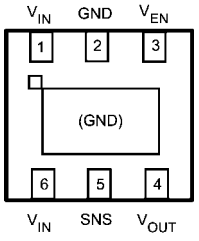
6-Lead LLP, Bottom View
LP38690SD-X.X



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6-Lead LLP, Bottom View
LP38692SD-X.X

Pin Description

PIN	DESCRIPTION
V_{IN}	This is the input supply voltage to the regulator. For LLP devices, both V_{IN} pins must be tied together for full current operation (500mA maximum per pin).
GND	Circuit ground for the regulator. This is connected to the die through the lead frame, and also functions as the heat sink when the large ground pad is soldered down to a copper plane.
SNS	Output sense pin allows remote sensing at the load which will eliminate the error in output voltage due to voltage drops caused by the resistance in the traces between the regulator and the load. This pin must be tied to V_{OUT}.
V_{EN}	The enable pin allows the part to be turned ON and OFF by pulling this pin high or low.
V_{OUT}	Regulated output voltage.

Ordering Information

Order Number	Package Marking	Package Type	Package Drawing	Supplied As
LP38690SD-1.8	L113B	6-Lead LLP	SDE06A	1000 Units Tape and Reel
LP38690SD-2.5	L114B	6-Lead LLP	SDE06A	1000 Units Tape and Reel
LP38690SD-3.3	L115B	6-Lead LLP	SDE06A	1000 Units Tape and Reel
LP38690SD-5.0	L116B	6-Lead LLP	SDE06A	1000 Units Tape and Reel
LP38690DT-1.8	LP38690DT-1.8	TO-252	TD03B	75 Units per Rail
LP38690DT-2.5	LP38690DT-2.5	TO-252	TD03B	75 Units per Rail
LP38690DT-3.3	LP38690DT-3.3	TO-252	TD03B	75 Units per Rail
LP38690DT-5.0	LP38690DT-5.0	TO-252	TD03B	75 Units per Rail
LP38692SD-1.8	L123B	6-Lead LLP	SDE06A	1000 Units Tape and Reel
LP38692SD-2.5	L124B	6-Lead LLP	SDE06A	1000 Units Tape and Reel
LP38692SD-3.3	L125B	6-Lead LLP	SDE06A	1000 Units Tape and Reel
LP38692SD-5.0	L126B	6-Lead LLP	SDE06A	1000 Units Tape and Reel
LP38692MP-1.8	LJPB	SOT-223	MP05A	1000 Units Tape and Reel
LP38692MP-2.5	LJRB	SOT-223	MP05A	1000 Units Tape and Reel
LP38692MP-3.3	LJSB	SOT-223	MP05A	1000 Units Tape and Reel
LP38692MP-5.0	LJTB	SOT-223	MP05A	1000 Units Tape and Reel
LP38690SDX-1.8	L113B	6-Lead LLP	SDE06A	4500 Units Tape and Reel
LP38690SDX-2.5	L114B	6-Lead LLP	SDE06A	4500 Units Tape and Reel
LP38690SDX-3.3	L115B	6-Lead LLP	SDE06A	4500 Units Tape and Reel
LP38690SDX-5.0	L116B	6-Lead LLP	SDE06A	4500 Units Tape and Reel
LP38690DTX-1.8	LP38690DT-1.8	TO-252	TD03B	2500 Units Tape and Reel
LP38690DTX-2.5	LP38690DT-2.5	TO-252	TD03B	2500 Units Tape and Reel
LP38690DTX-3.3	LP38690DT-3.3	TO-252	TD03B	2500 Units Tape and Reel
LP38690DTX-5.0	LP38690DT-5.0	TO-252	TD03B	2500 Units Tape and Reel
LP38692SDX-1.8	L123B	6-Lead LLP	SDE06A	4500 Units Tape and Reel
LP38692SDX-2.5	L124B	6-Lead LLP	SDE06A	4500 Units Tape and Reel
LP38692SDX-3.3	L125B	6-Lead LLP	SDE06A	4500 Units Tape and Reel
LP38692SDX-5.0	L126B	6-Lead LLP	SDE06A	4500 Units Tape and Reel
LP38692MPX-1.8	LJPB	SOT-223	MP05A	2000 Units Tape and Reel
LP38692MPX-2.5	LJRB	SOT-223	MP05A	2000 Units Tape and Reel
LP38692MPX-3.3	LJSB	SOT-223	MP05A	2000 Units Tape and Reel
LP38692MPX-5.0	LJTB	SOT-223	MP05A	2000 Units Tape and Reel

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Storage Temperature Range	−65°C to +150°C
Lead Temp. (Soldering, 5 seconds)	260°C
ESD Rating (Note 3)	2 kV
Power Dissipation (Note 2)	Internally Limited
V(max) All pins (with respect to GND)	-0.3V to 12V
I_{OUT}	Internally Limited
Junction Temperature	−40°C to +150°C

Operating Ratings

V_{IN} Supply Voltage	2.7V to 10V
Operating Junction Temperature Range	−40°C to +125°C

Electrical Characteristics

Limits in standard typeface are for T_J = 25°C, and limits in **boldface type** apply over the full operating temperature range. Unless otherwise specified: $V_{IN} = V_{OUT}$ + 1V, $C_{IN} = C_{OUT}$ = 10 µF, I_{LOAD} = 10mA. Min/Max limits are guaranteed through testing, statistical correlation, or design.

Symbol	Parameter	Conditions	MIN	TYP (Note 4)	MAX	Units
V_O	Output Voltage Tolerance		-2.5		2.5	$\%V_{OUT}$
		100 µA < I_L < 1A V_O + 1V ≤ V_{IN} ≤ 10V	**-5.0**		**5.0**	
$\Delta V_O/\Delta V_{IN}$	Output Voltage Line Regulation (Note 6)	V_O + 0.5V ≤ V_{IN} ≤ 10V I_L = 25mA		0.03	**0.1**	%/V
$\Delta V_O/\Delta I_L$	Output Voltage Load Regulation (Note 7)	1 mA < I_L < 1A $V_{IN} = V_O$ + 1V		1.8	**5**	%/A
$V_{IN} - V_{OUT}$	Dropout Voltage (Note 8)	(V_O = 1.8V) I_L = 1A		950	**1600**	mV
		(V_O = 2.5V) I_L = 0.1A I_L = 1A		80 800	**145** **1300**	
		(V_O = 3.3V) I_L = 0.1A I_L = 1A		65 650	**110** **1000**	
		(V_O = 5V) I_L = 0.1A I_L = 1A		45 450	**100** **800**	
I_Q	Quiescent Current	V_{IN} ≤ 10V, I_L =100 µA - 1A		55	**100**	µA
		V_{EN} ≤ 0.4V, (LP38692 Only)		0.001	1	
I_L(MIN)	Minimum Load Current	$V_{IN} - V_O$ ≤ 4V			**100**	
I_{FB}	Foldback Current Limit	$V_{IN} - V_O$ > 5V		450		mA
		$V_{IN} - V_O$ < 4V		1500		
PSRR	Ripple Rejection	$V_{IN} = V_O$ + 2V(DC), with 1V(p-p) / 120Hz Ripple		55		dB
T_{SD}	Thermal Shutdown Activation (Junction Temp)			160		°C
T_{SD} (HYST)	Thermal Shutdown Hysteresis (Junction Temp)			10		

Symbol	Parameter	Conditions	MIN	TYP (Note 4)	MAX	Units
e_n	Output Noise	BW = 10Hz to 10kHz V_O = 3.3V		0.7		$\mu V/\sqrt{Hz}$
V_O (LEAK)	Output Leakage Current	$V_O = V_O(NOM) + 1V$ @ $10V_{IN}$		0.5	12	µA
V_{EN}	Enable Voltage (LP38692 Only)	Output = OFF			**0.4**	V
		Output = ON, V_{IN} = 4V	**1.8**			
		Output = ON, V_{IN} = 6V	**3.0**			
		Output = ON, V_{IN} = 10V	**4.0**			
I_{EN}	Enable Pin Leakage	V_{EN} = 0V or 10V, V_{IN} = 10V	-1	0.001	1	µA

Note 1: Absolute maximum ratings indicate limits beyond which damage to the component may occur. Operating ratings indicate conditions for which the device is intended to be functional, but do not guarantee specific performance limits. For guaranteed specifications, see Electrical Characteristics. Specifications do not apply when operating the device outside of its rated operating conditions.

Note 2: At elevated temperatures, device power dissipation must be derated based on package thermal resistance and heatsink values (if a heatsink is used). The junction-to-ambient thermal resistance (θ_{J-A}) for the TO-252 is approximately 90°C/W for a PC board mounting with the device soldered down to minimum copper area (less than 0.1 square inch). If one square inch of copper is used as a heat dissipator for the TO-252, the θ_{J-A} drops to approximately 50°C/W. The SOT-223 package has a θ_{J-A} of approximately 125°C/W when soldered down to a minimum sized pattern (less than 0.1 square inch) and approximately 70°C/W when soldered to a copper area of one square inch. The θ_{J-A} values for the LLP package are also dependent on trace area, copper thickness, and the number of thermal vias used (refer to application note AN-1187). If power disspation causes the junction temperature to exceed specified limits, the device will go into thermal shutdown.

Note 3: ESD is tested using the human body model which is a 100pF capacitor discharged through a 1.5k resistor into each pin.

Note 4: Typical numbers represent the most likely parametric norm for 25°C operation.

Note 5: If used in a dual-supply system where the regulator load is returned to a negative supply, the output pin must be diode clamped to ground.

Note 6: Output voltage line regulation is defined as the change in output voltage from nominal value resulting from a change in input voltage.

Note 7: Output voltage load regulation is defined as the change in output voltage from nominal value as the load current increases from 1mA to full load.

Note 8: Dropout voltage is defined as the minimum input to output differential required to maintain the output within 100mV of nominal value.

Block Diagrams

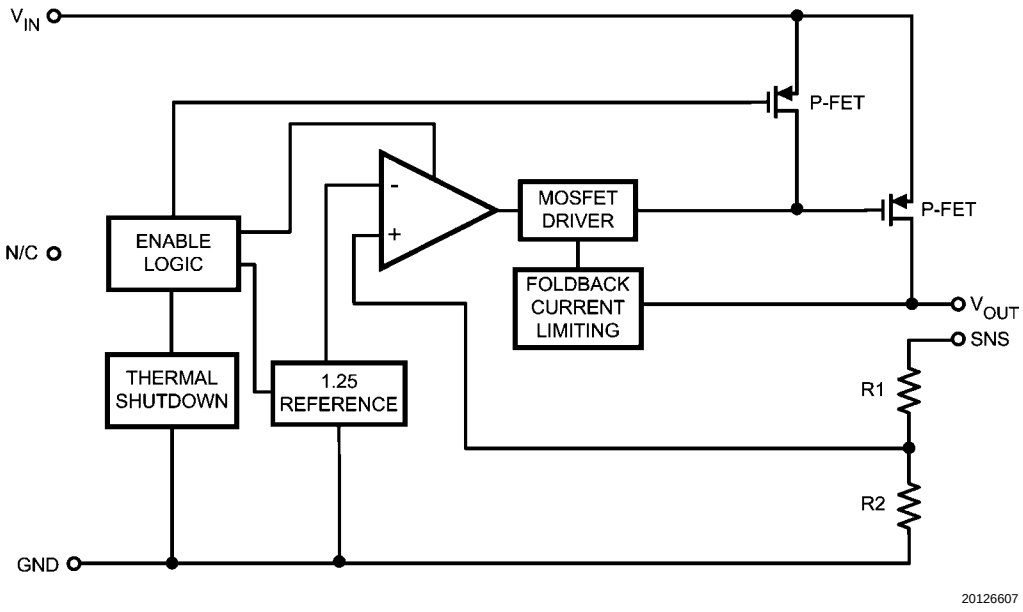


FIGURE 1. LP38690 Functional Diagram (LLP)

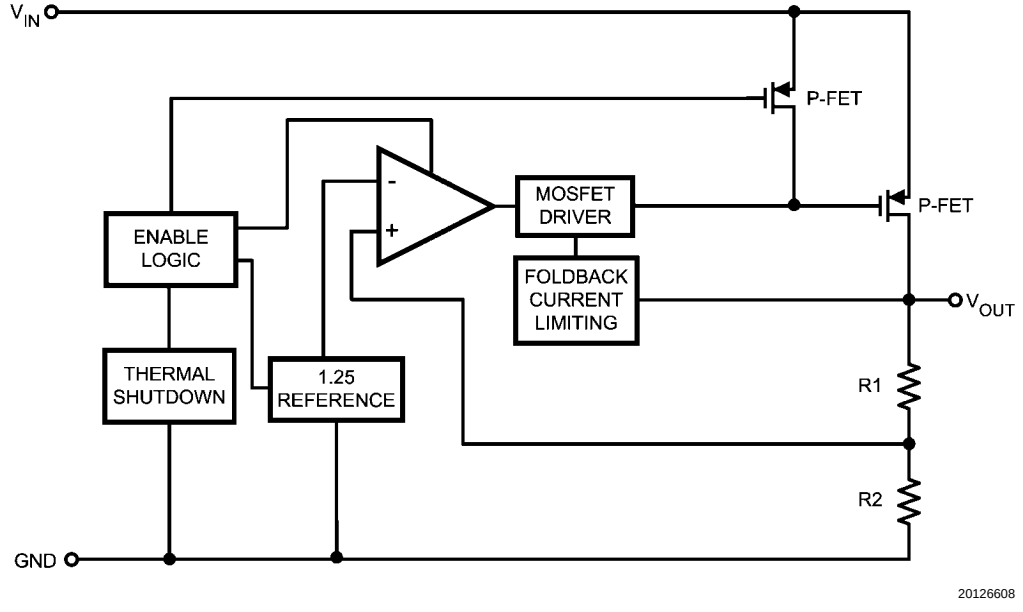


FIGURE 2. LP38690 Functional Diagram (TO-252)

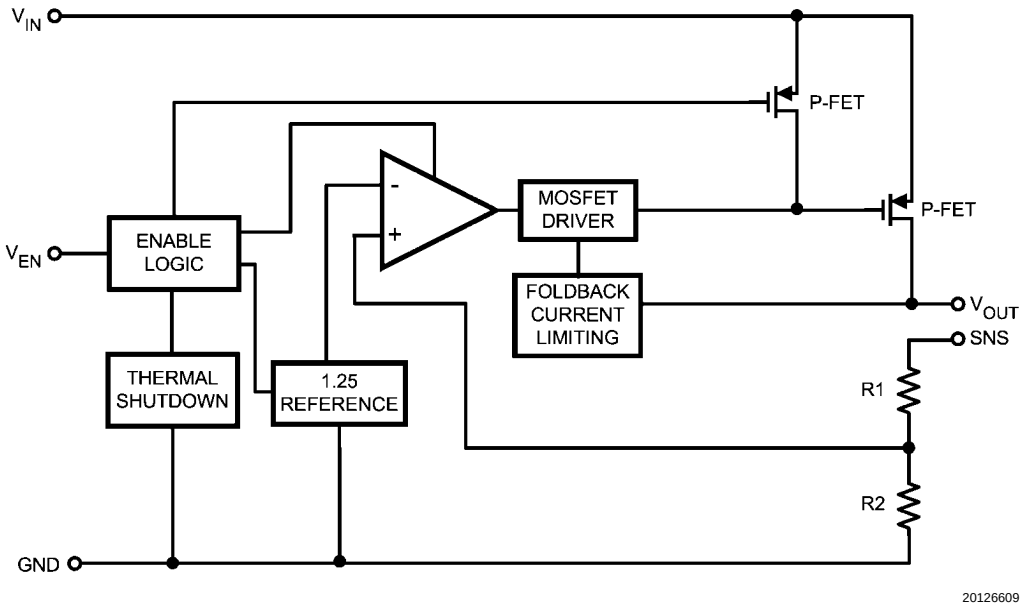


FIGURE 3. LP38692 Functional Diagram (LLP)

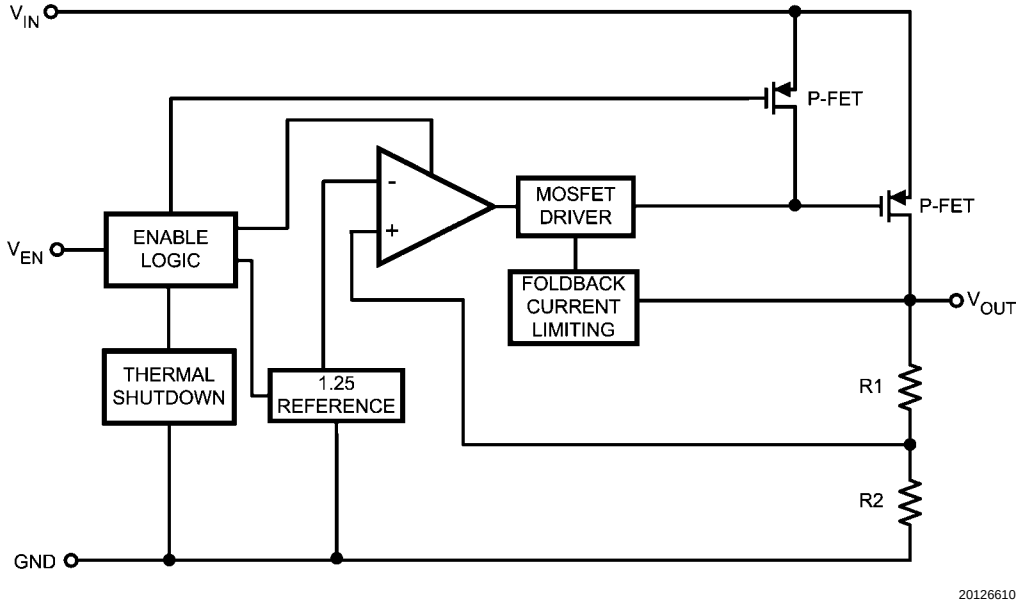
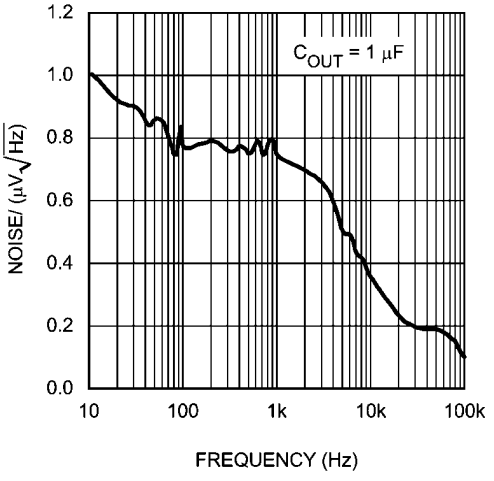


FIGURE 4. LP38692 Functional Diagram (SOT-223)

Typical Performance Characteristics

Unless otherwise specified: T_J = 25°C, C_{IN} = C_{OUT} = 10 µF, Enable pin is tied to V_{IN} (LP38692 only), V_{OUT} = 1.8V, V_{IN} = V_{OUT} +1V, I_L = 10mA.

Noise vs Frequency



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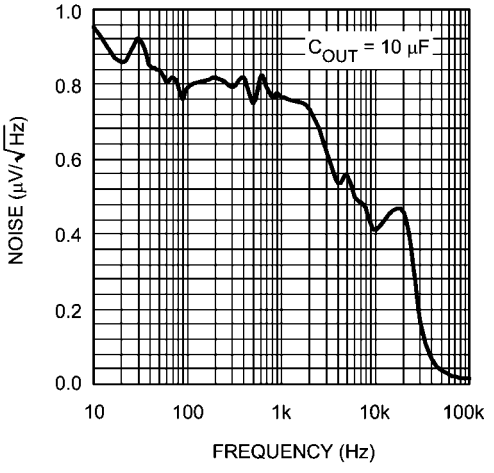
Noise vs Frequency



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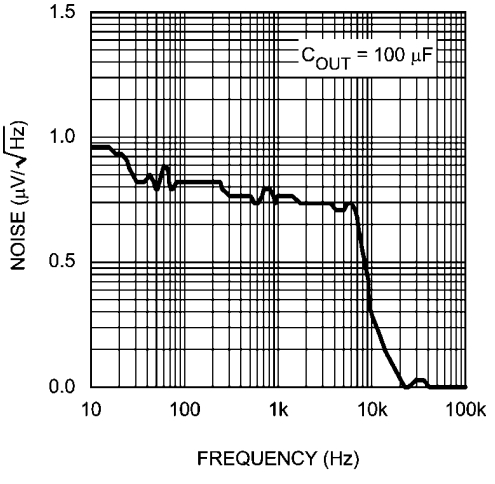
Noise vs Frequency



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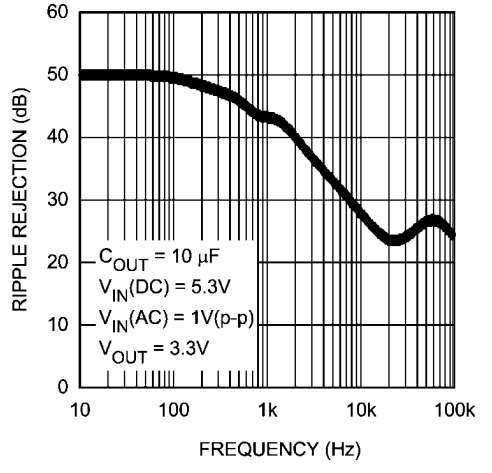
Ripple Rejection



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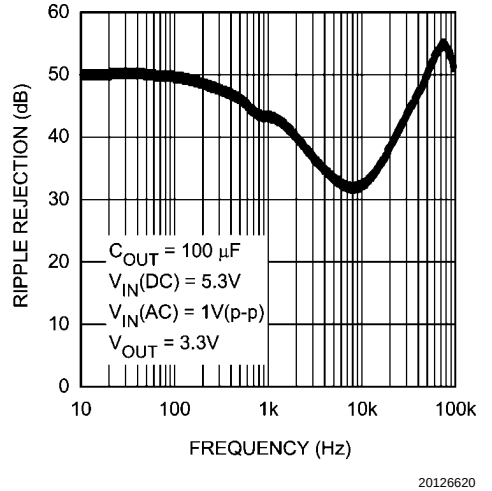
Ripple Rejection



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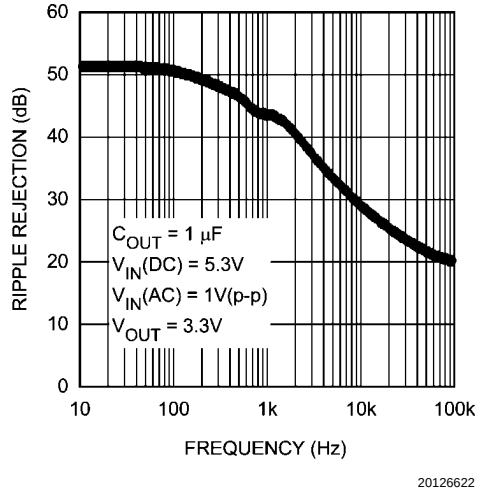
Ripple Rejection



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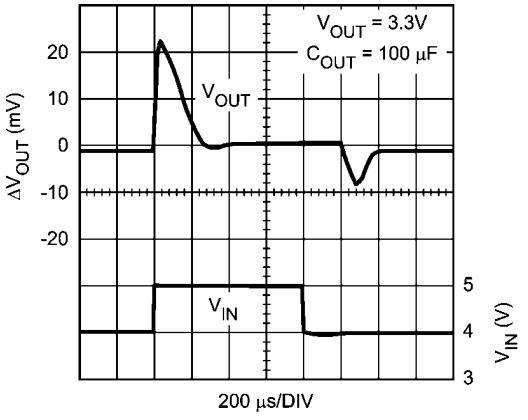
Line Transient Response



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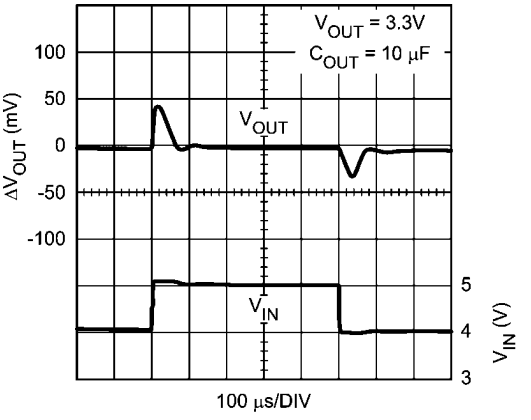
Line Transient Response



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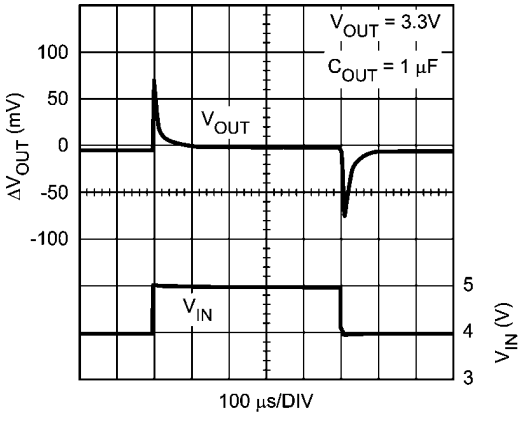
Line Transient Response



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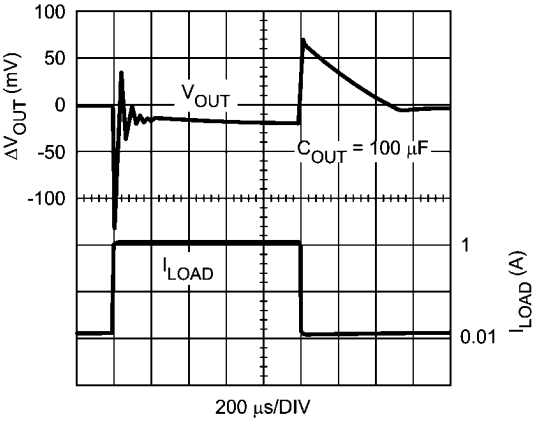
Load Transient Response



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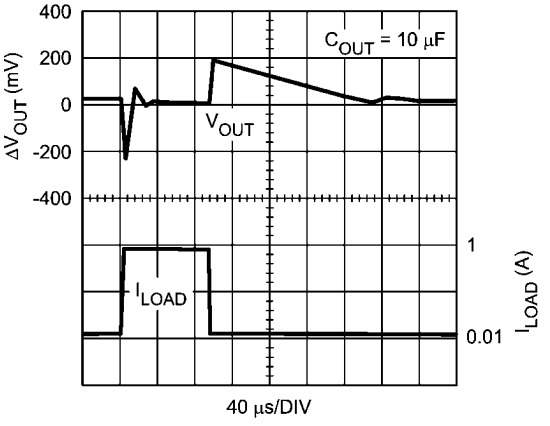
Load Transient Response



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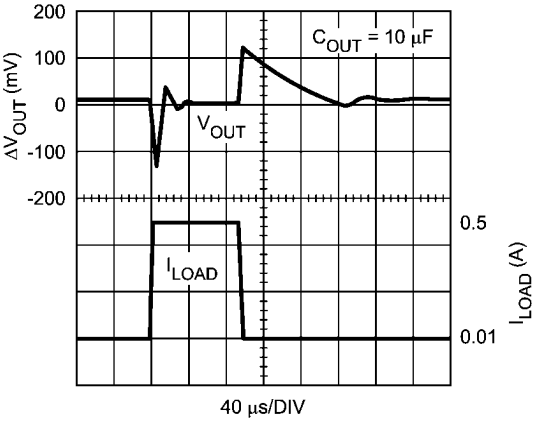
Load Transient Response



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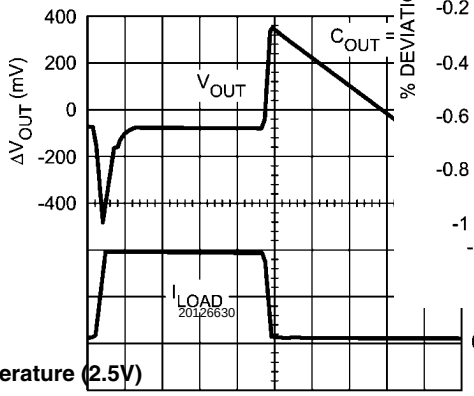
Load Transient Respons



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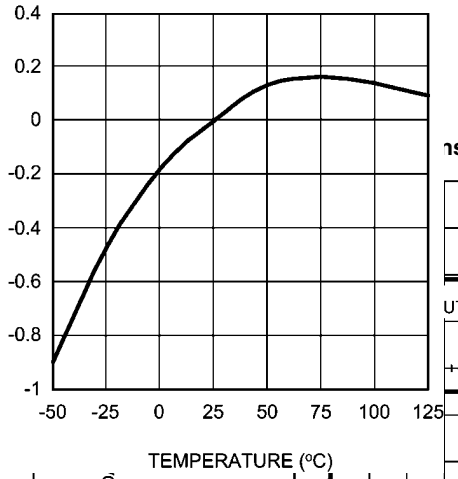
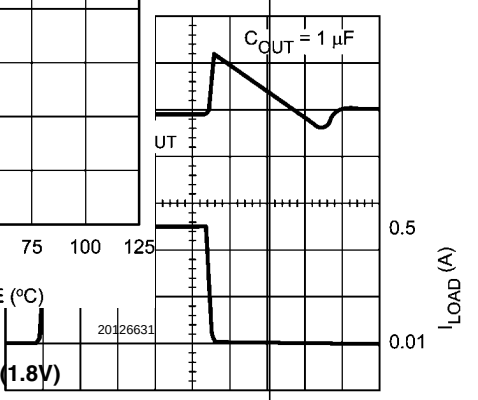


nsient Response



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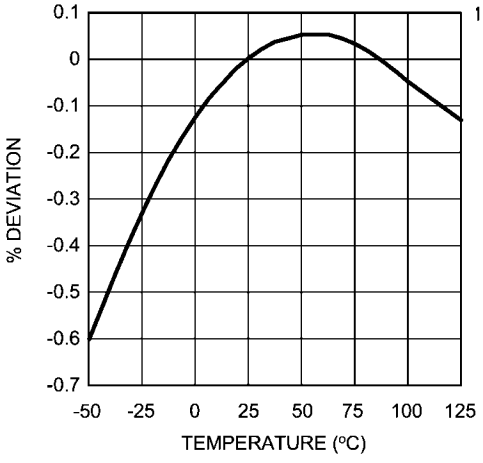
V_{OUT} vs Temperature (2.5V)



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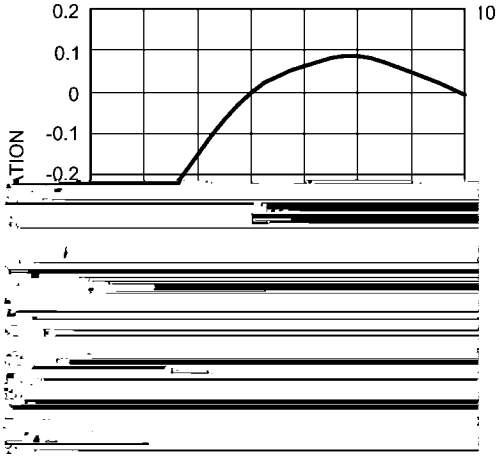
V_{OUT} vs Temperature (1.8V)



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10 µs/DIV

10 µs/DIV

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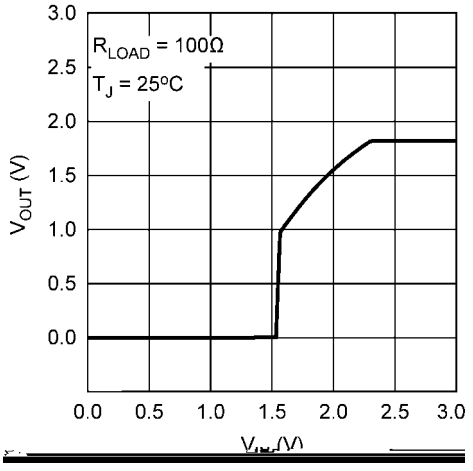
V_{OUT} vs V_{IN} (1.8V)



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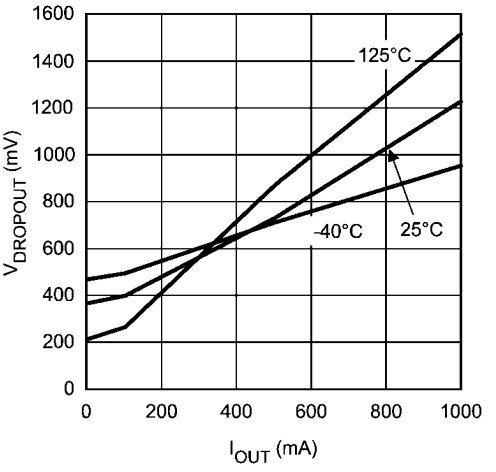
Dropout Voltage vs I_{OUT}



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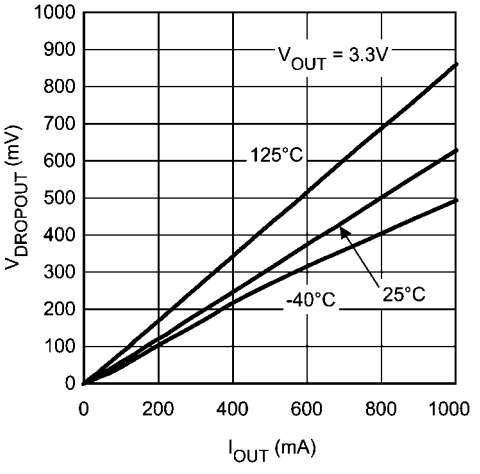
Dropout Voltage vs I_{OUT}



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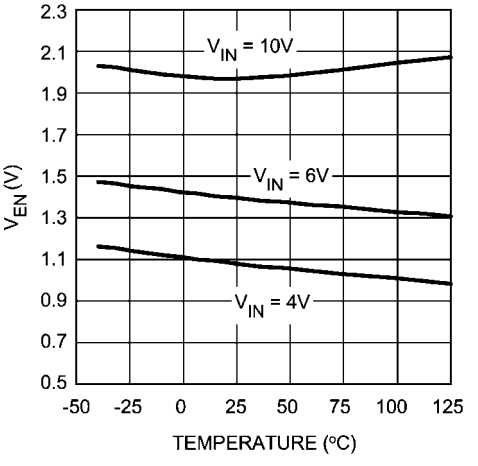
Enable Voltage vs Temperature



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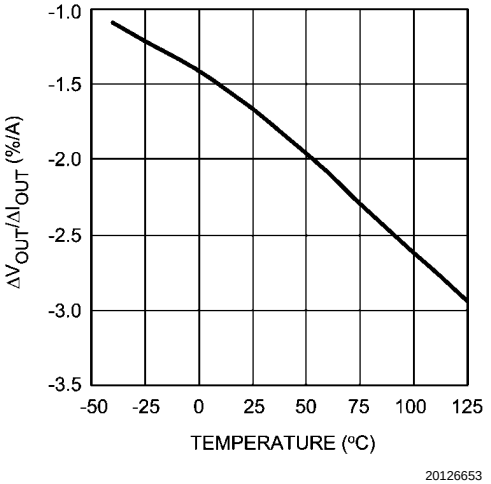
Load Regulation vs Temperature



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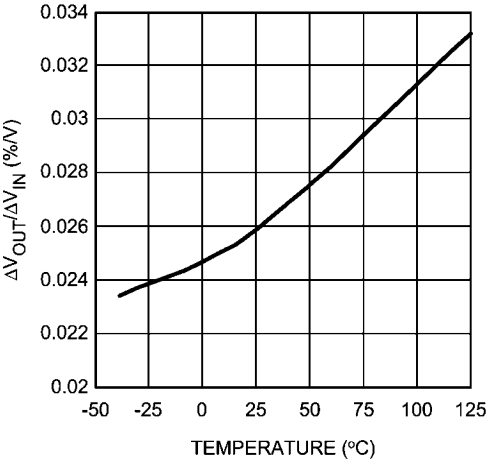
Line Regulation vs Temperature



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Application Hints

EXTERNAL CAPACITORS

Like any low-dropout regulator, external capacitors are required to assure stability. These capacitors must be correctly selected for proper performance.

INPUT CAPACITOR: An input capacitor of at least 1µF is required (ceramic recommended). The capacitor must be located not more than one centimeter from the input pin and returned to a clean analog ground.

OUTPUT CAPACITOR: An output capacitor is required for loop stability. It must be located less than 1 centimeter from the device and connected directly to the output and ground pins using traces which have no other currents flowing through them.

The minimum amount of output capacitance that can be used for stable operation is 1µF. Ceramic capacitors are recommended (the LP38690/2 was designed for use with ultra low ESR capacitors). The LP38690/2 is stable with any output capacitor ESR between zero and 100 Ohms.

ENABLE PIN (LP38692 only): The LP38692 has an enable pin which turns the regulator output on and off. Pulling the enable pin down to a logic low will turn the part off. The voltage the pin has to be pulled up to in order to assure the part is on depends on input voltage (refer to Electrical Characteristics section). This pin should be tied to V_{IN} if the enable function is not used.

Foldback Current Limiting: Foldback current limiting is built into the LP38690/2 which reduces the amount of output current the part can deliver as the output voltage is reduced. The amount of load current is dependent on the differential voltage between V_{IN} and V_{OUT}. Typically, when this differential voltage exceeds 5V, the load current will limit at about 450 mA. When the V_{IN} - V_{OUT} differential is reduced below 4V, load current is limited to about 1500 mA.

SELECTING A CAPACITOR

It is important to note that capacitance tolerance and variation with temperature must be taken into consideration when selecting a capacitor so that the minimum required amount of capacitance is provided over the full operating temperature range.

Capacitor Characteristics

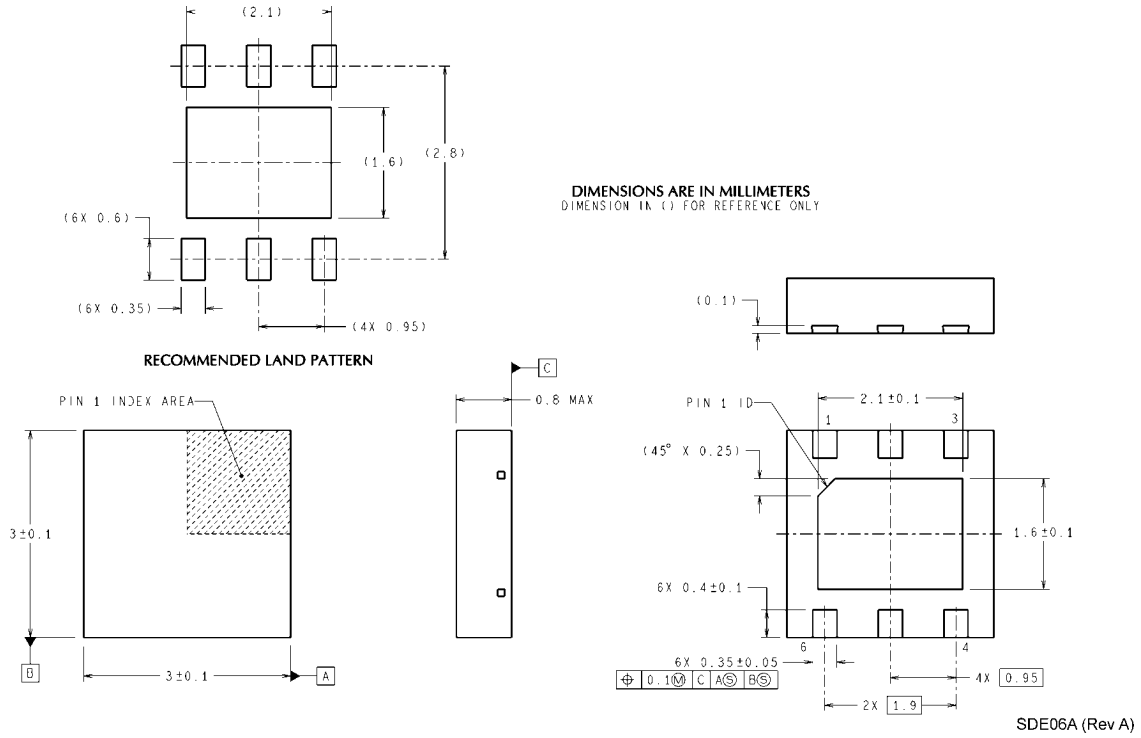
CERAMIC: For values of capacitance in the 10 to 100 µF range, ceramics are usually larger and more costly than tantalums but give superior AC performance for bypassing high frequency noise because of very low ESR (typically less than 10 m

a 1Hz bandwidth). This type of noise is usually plotted on a curve as a function of frequency. **Total Output Noise** or **Broad-Band Noise** is the RMS sum of spot noise over a specified bandwidth, usually several decades of frequencies.

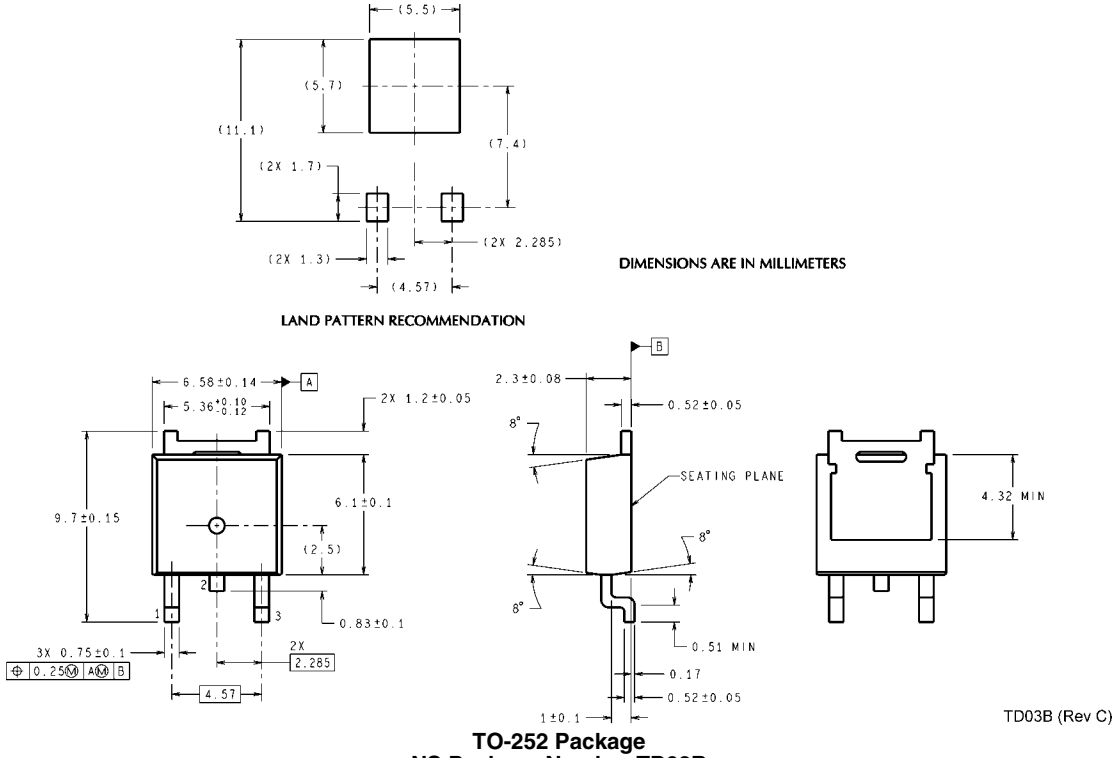
Attention should be paid to the units of measurement. Spot noise is measured in units µV/root-Hz or nV/root-Hz and total output noise is measured in µV(rms)

The primary source of noise in low-dropout regulators is the internal reference. Noise can be reduced in two ways: by increasing the transistor area or by increasing the current drawn by the internal reference. Increasing the area will decrease the chance of fitting the die into a smaller package. Increasing the current drawn by the internal reference increases the total supply current (ground pin current).

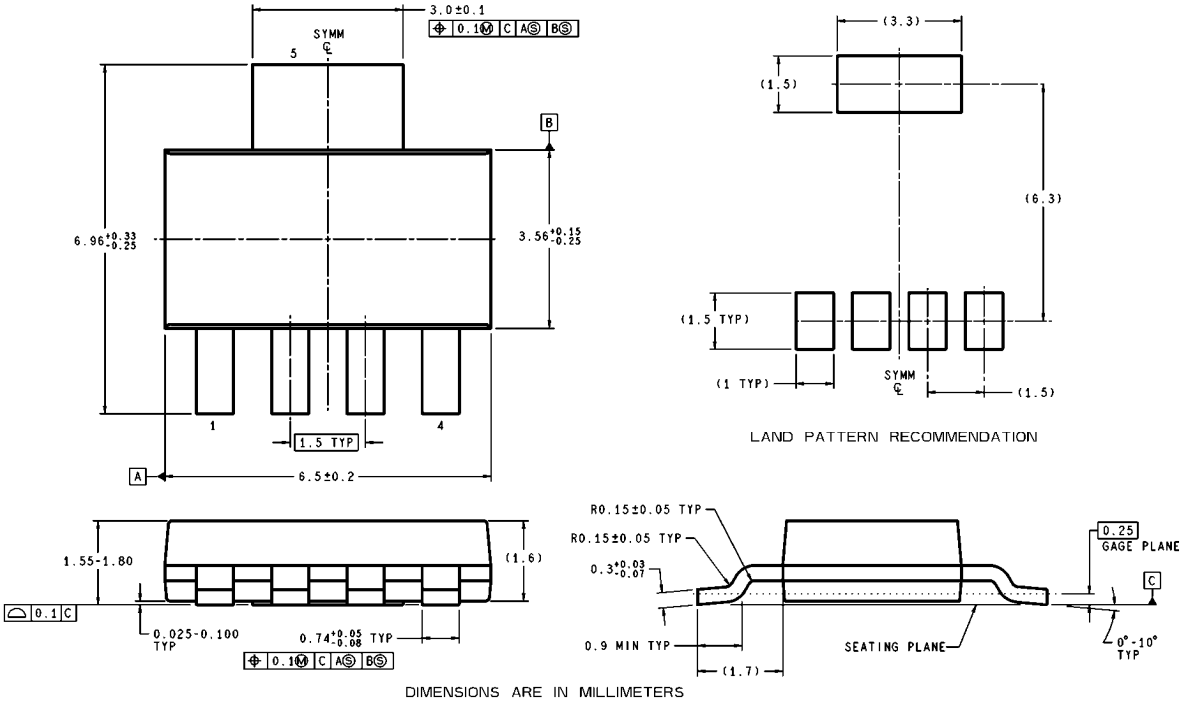
Physical Dimensions inches (millimeters) unless otherwise noted



6-lead, LLP Package
NS Package Number SDE06A



TO-252 Package
NS Package Number TD03B



SOT-223 Package
NS Package Number MP05A

Notes

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