

## TLV733P Capacitor-Free, 300-mA, Low-Dropout Regulator in a 1-mm x 1-mm SON Package

### 1 Features

- Stable Operation with or without Capacitors
- Foldback Overcurrent Protection
- Packages:
  - 1.0-mm x 1.0-mm X2SON (4)
  - SOT-23 (5)
- Very Low Dropout: 122 mV at 300 mA (3.3 V<sub>OUT</sub>)
- Accuracy: 1% typical, 1.4% maximum
- Low I<sub>Q</sub>: 34 μA
- Input Voltage Range: 1.4 V to 5.5 V
- Available in Fixed-Output Voltages: 1.0 V to 3.3 V
- High PSRR: 50 dB at 1 kHz
- Active Output Discharge

### 2 Applications

- Tablets
- Smartphones
- Notebook and Desktop Computers
- Portable Industrial and Consumer Products
- WLAN and Other PC Add-On Cards
- Camera Modules

### 3 Description

The TLV733 series of low-dropout linear regulators (LDOs) are ultra-small, low quiescent current LDOs that can source 300 mA with good line and load transient performance. These devices provide a typical accuracy of 1%.

The TLV733 series is designed with a modern capacitor-free architecture to ensure stability without an input or output capacitor. The removal of the output capacitor allows for a very small solution size, and can eliminate inrush current at startup. However, the TLV733 series is also stable with ceramic output capacitors if an output capacitor is necessary. The TLV733 also provides foldback current control during device power-up and enabling if an output capacitor is used. This functionality is especially important in battery-operated devices.

The TLV733 provides an active pull-down circuit to quickly discharge output loads when disabled.

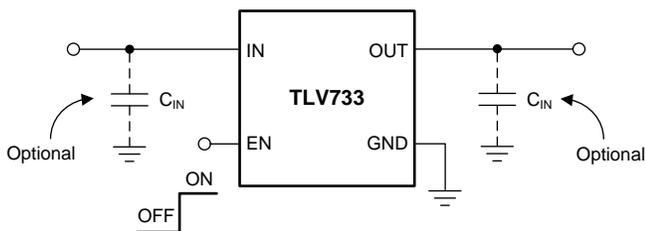
The TLV733 series is available in standard DBV (SOT-23) and DQN (X2SON) packages.

#### Device Information<sup>(1)</sup>

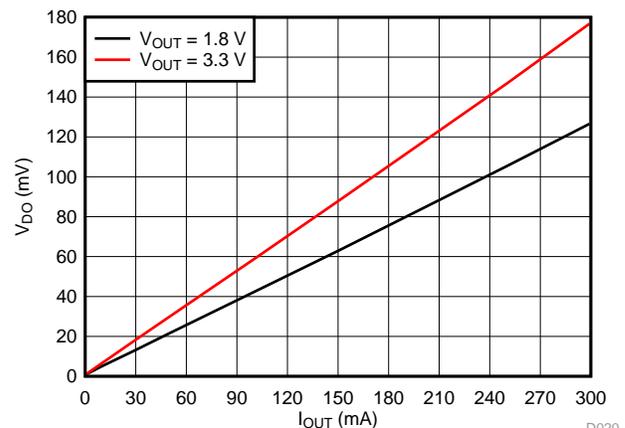
PART NUMBER	PACKAGE	BODY SIZE (NOM)
TLV733xxP	SOT-23 (5)	2.90 mm x 1.60 mm
	X2SON (4)	1.00 mm x 1.00 mm

(1) For all available packages, see the package option addendum at the end of the data sheet.

Typical Application Circuit



Dropout Voltage vs Output Current



D020



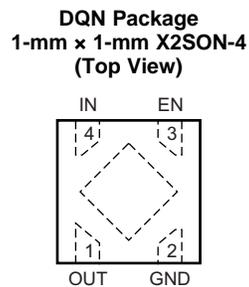
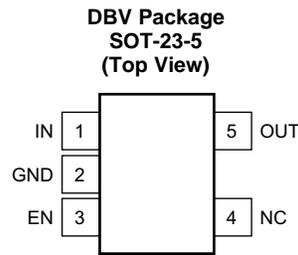
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## 4 Revision History

DATE	REVISION	NOTES
October 2014	*	Initial release.

## 5 Pin Configuration and Functions



### Pin Functions

NAME	PIN		I/O	DESCRIPTION
	DBV	DQN		
EN	3	3	Input	Enable pin. Drive EN greater than 0.9 V to turn on the regulator. Drive EN less than 0.35 V to put the LDO into shutdown mode.
GND	2	2	—	Ground pin
IN	1	4	Input	Input pin. A small capacitor is recommended from this pin to ground. See the <a href="#">Input and Output Capacitor Selection</a> section for more details.
NC	4	N/A	—	No internal connection
OUT	5	1	Output	Regulated output voltage pin. For best transient response, use a small 1- $\mu$ F ceramic capacitor from this pin to ground. See the <a href="#">Input and Output Capacitor Selection</a> section for more details.
Thermal pad	N/A	—	—	The thermal pad is electrically connected to the GND node. Connect to the GND plane for improved thermal performance.

## 6 Specifications

### 6.1 Absolute Maximum Ratings<sup>(1)</sup>

over operating junction temperature range, unless otherwise noted. All voltages are with respect to GND.

		VALUE		UNIT
		MIN	MAX	
Voltage	V <sub>IN</sub>	-0.3	6.0	V
	V <sub>EN</sub>	-0.3	V <sub>IN</sub> + 0.3 V	V
	V <sub>OUT</sub>	-0.3	3.6	V
Current	I <sub>OUT</sub>	Internally limited		A
Output short-circuit duration		Indefinite		
Temperature	Operating junction range, T <sub>J</sub>	-55	160	°C

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

### 6.2 Handling Ratings

			MIN	MAX	UNIT
T <sub>stg</sub>	Storage temperature range		-65	150	°C
V <sub>(ESD)</sub>	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins <sup>(1)</sup>	-2000	2000	V
		Charged device model (CDM), per JEDEC specification JESD22-C101, all pins <sup>(2)</sup>	-500	500	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

### 6.3 Recommended Operating Conditions

over operating junction temperature range (unless otherwise noted)

	MIN	NOM	MAX	UNIT
Input range, V <sub>IN</sub>	1.4		5.5	V
Output range, V <sub>OUT</sub>	1.0		3.3	V
Output current, I <sub>OUT</sub>	0		300	mA
Enable range, V <sub>EN</sub>	0		V <sub>IN</sub>	V
Junction temperature, T <sub>J</sub>	-40		125	°C

### 6.4 Thermal Information

THERMAL METRIC <sup>(1)</sup>		TLV733xxP		UNIT
		DQN (X2SON)	DBV (SOT-23)	
		4 PINS	5 PINS	
R <sub>θJA</sub>	Junction-to-ambient thermal resistance	218.6	228.4	°C/W
R <sub>θJC(top)</sub>	Junction-to-case (top) thermal resistance	164.8	151.5	
R <sub>θJB</sub>	Junction-to-board thermal resistance	164.9	55.8	
ψ <sub>JT</sub>	Junction-to-top characterization parameter	5.6	31.4	
ψ <sub>JB</sub>	Junction-to-board characterization parameter	163.9	54.8	
R <sub>θJC(bot)</sub>	Junction-to-case (bottom) thermal resistance	131.4	N/A	

(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, [SPRA953](#).

## 6.5 Electrical Characteristics

At operating temperature range ( $T_J = -40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ ),  $V_{IN} = V_{OUT(nom)} + 0.5\text{ V}$  or  $2.0\text{ V}$  (whichever is greater),  $I_{OUT} = 1\text{ mA}$ ,  $V_{EN} = V_{IN}$ , and  $C_{IN} = C_{OUT} = 1\text{ }\mu\text{F}$ , unless otherwise noted. All typical values at  $T_J = 25^{\circ}\text{C}$ .

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT	
$V_{IN}$	Input voltage		1.4		5.5	V	
	DC output accuracy	$T_J = 25^{\circ}\text{C}$	-1%		1%		
		$-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$	-1.4%		1.4%		
UVLO	Undervoltage lockout	$V_{IN}$ rising		1.3	1.4	V	
		$V_{IN}$ falling		1.25		V	
$\Delta V_{O(\Delta V)}$	Line regulation			1		mV/V	
$\Delta V_{O(\Delta I)}$	Load regulation	DQN package		16		mV	
		DBV package		25		mV	
$V_{DO}$	Dropout voltage <sup>(1)</sup>	$V_{OUT} = 0.98 \times V_{OUT(nom)}$ , $I_{OUT} = 300\text{ mA}$	$1.2\text{ V} \leq V_{OUT} < 1.5\text{ V}$ , $-40^{\circ}\text{C} \leq T_J \leq 85^{\circ}\text{C}$			420	mV
			$1.5\text{ V} \leq V_{OUT} < 1.8\text{ V}$ , $-40^{\circ}\text{C} \leq T_J \leq 85^{\circ}\text{C}$			370	mV
			$1.8\text{ V} \leq V_{OUT} < 2.5\text{ V}$ , $-40^{\circ}\text{C} \leq T_J \leq 85^{\circ}\text{C}$			270	mV
			$2.5\text{ V} \leq V_{OUT} < 3.3\text{ V}$ , $-40^{\circ}\text{C} \leq T_J \leq 85^{\circ}\text{C}$			260	mV
			$V_{OUT} = 3.3\text{ V}$ , $-40^{\circ}\text{C} \leq T_J \leq 85^{\circ}\text{C}$		125	220	mV
			$1.2\text{ V} \leq V_{OUT} < 1.5\text{ V}$ , $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$			450	mV
			$1.5\text{ V} \leq V_{OUT} < 1.8\text{ V}$ , $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$			400	mV
			$1.8\text{ V} \leq V_{OUT} < 2.5\text{ V}$ , $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$			300	mV
			$2.5\text{ V} \leq V_{OUT} < 3.3\text{ V}$ , $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$			290	mV
		$V_{OUT} = 3.3\text{ V}$ , $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$		125	270	mV	
$I_{GND}$	Ground pin current	$I_{OUT} = 0\text{ mA}$		34	60	$\mu\text{A}$	
$I_{SHDN}$	Shutdown current	$V_{EN} \leq 0.35\text{ V}$ , $2.0\text{ V} \leq V_{IN} \leq 5.5\text{ V}$ , $T_J = 25^{\circ}\text{C}$		0.1	1	$\mu\text{A}$	
PSRR	Power-supply rejection ratio	$V_{OUT} = 1.8\text{ V}$ , $I_{OUT} = 300\text{ mA}$	$f = 100\text{ Hz}$		68	dB	
			$f = 10\text{ kHz}$		35	dB	
			$f = 100\text{ kHz}$		28	dB	
$V_n$	Output noise voltage	$\text{BW} = 10\text{ Hz to } 100\text{ kHz}$ , $V_{OUT} = 1.8\text{ V}$ , $I_{OUT} = 10\text{ mA}$		120		$\mu\text{V}_{RMS}$	
$V_{EN(HI)}$	EN pin high voltage (enabled)		0.9	0.63		V	
$V_{EN(LO)}$	EN pin low voltage (disabled)			0.52	0.35	V	
$I_{EN}$	EN pin current	$V_{EN} = 5.5\text{ V}$		0.01		$\mu\text{A}$	
$t_{STR}$	Startup time	Time from EN assertion to $98\% \times V_{OUT(nom)}$ , $V_{OUT} = 1.0\text{ V}$ , $I_{OUT} = 0\text{ mA}$		250		$\mu\text{s}$	
		Time from EN assertion to $98\% \times V_{OUT(nom)}$ , $V_{OUT} = 3.3\text{ V}$ , $I_{OUT} = 0\text{ mA}$		800		$\mu\text{s}$	
	Pull-down resistor	$V_{IN} = 2.3\text{ V}$		120		$\Omega$	
$I_{LIM}$	Output current limit		360			mA	
$I_{OS}$	Short-circuit current limit	$V_{OUT}$ shorted to GND, $V_{OUT} = 1.0\text{ V}$		150		mA	
		$V_{OUT}$ shorted to GND, $V_{OUT} = 3.3\text{ V}$		170		mA	
$T_{sd}$	Thermal shutdown	Shutdown, temperature increasing		160		$^{\circ}\text{C}$	
		Reset, temperature decreasing		140		$^{\circ}\text{C}$	

(1) Dropout voltage for TLV73310P is not valid at room temperature. The device engages undervoltage lockout ( $V_{IN} < UVLO_{FALL}$ ) before the dropout condition is met.

## 6.6 Typical Characteristics

At operating temperature range ( $T_J = -40^\circ\text{C}$  to  $125^\circ\text{C}$ ),  $V_{IN} = V_{OUT,nom} + 0.5\text{ V}$  or  $2.0\text{ V}$  (whichever is greater),  $I_{OUT} = 1\text{ mA}$ ,  $V_{EN} = V_{IN}$ , and  $C_{IN} = C_{OUT} = 1\ \mu\text{F}$ , unless otherwise noted.

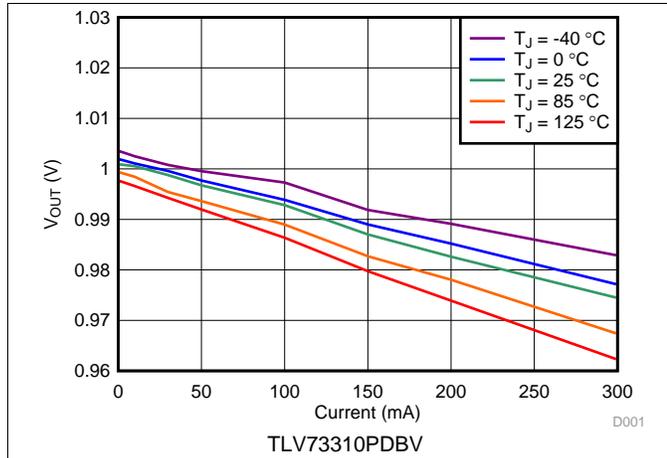


Figure 1. 1.0-V Load Regulation vs  $I_{OUT}$  and Temperature

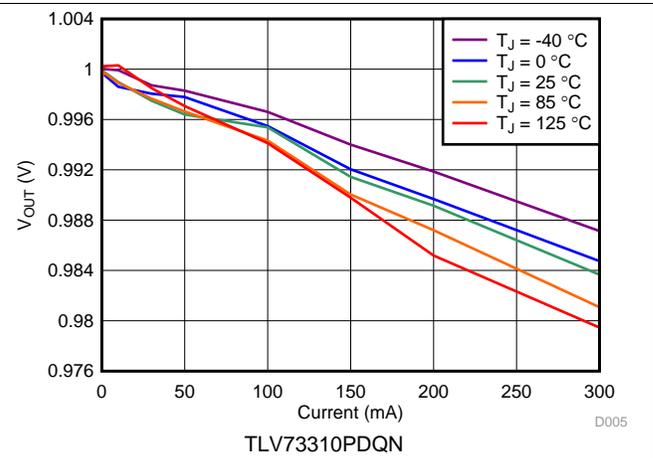


Figure 2. 1.0-V Load Regulation vs  $I_{OUT}$  and Temperature

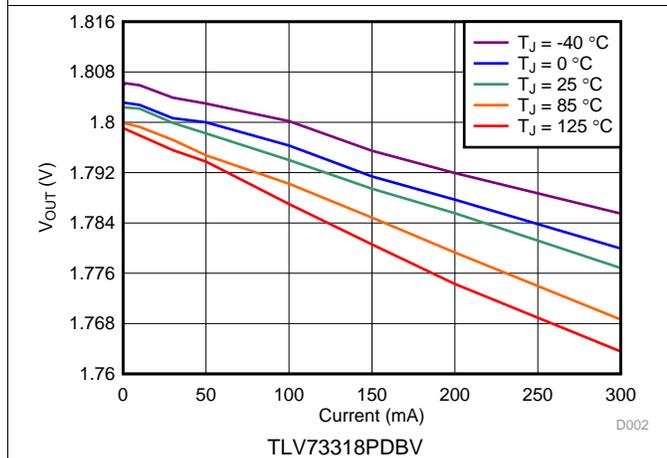


Figure 3. 1.8-V Load Regulation vs  $I_O$  and Temperature

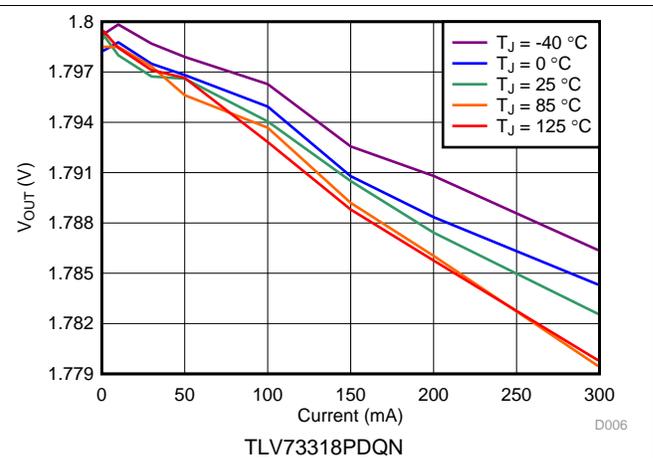


Figure 4. 1.8-V Load Regulation vs  $I_{OUT}$  and Temperature

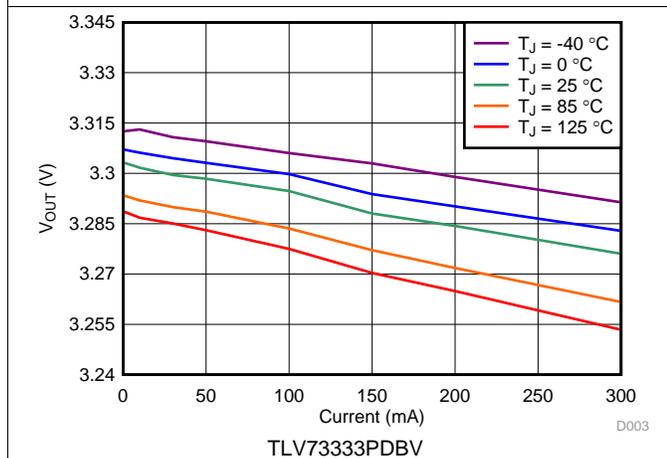


Figure 5. 3.3-V Load Regulation vs  $I_{OUT}$  and Temperature

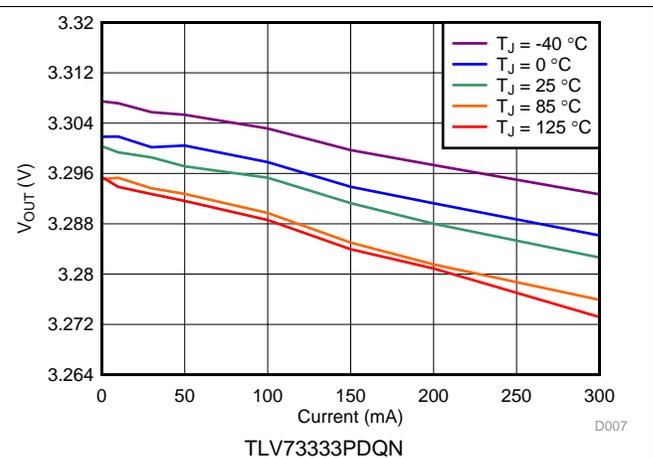


Figure 6. 3.3-V Load Regulation vs  $I_{OUT}$  and Temperature

### Typical Characteristics (continued)

At operating temperature range ( $T_J = -40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ ),  $V_{IN} = V_{OUTnom} + 0.5\text{ V}$  or  $2.0\text{ V}$  (whichever is greater),  $I_{OUT} = 1\text{ mA}$ ,  $V_{EN} = V_{IN}$ , and  $C_{IN} = C_{OUT} = 1\text{ }\mu\text{F}$ , unless otherwise noted.

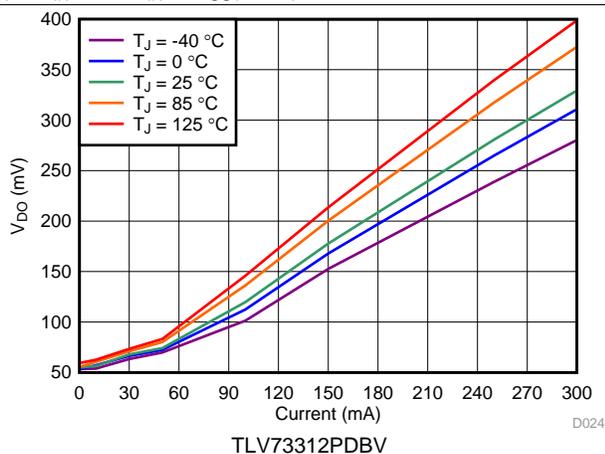


Figure 7. 1.2-V Dropout Voltage vs  $I_{OUT}$  and Temperature

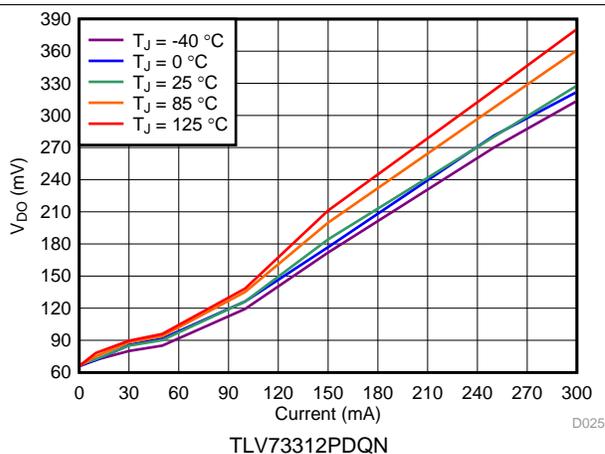


Figure 8. 1.2-V Dropout Voltage vs  $I_{OUT}$  and Temperature

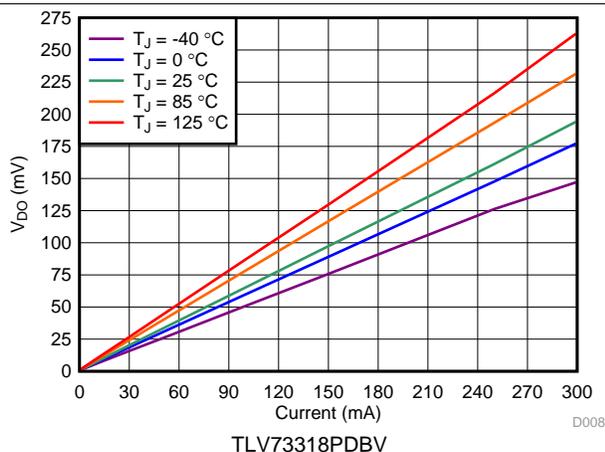


Figure 9. 1.8-V Dropout Voltage vs  $I_{OUT}$  and Temperature

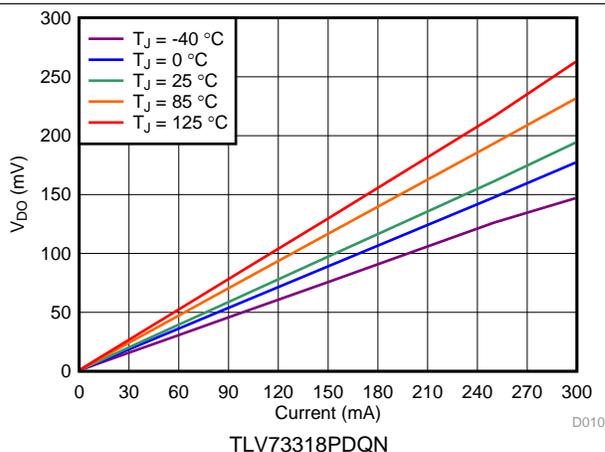


Figure 10. 1.8-V Dropout Voltage vs  $I_{OUT}$  and Temperature

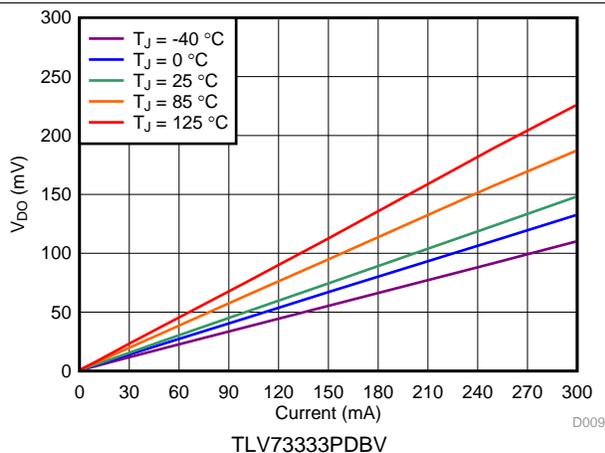


Figure 11. 3.3-V Dropout Voltage vs  $I_{OUT}$  and Temperature

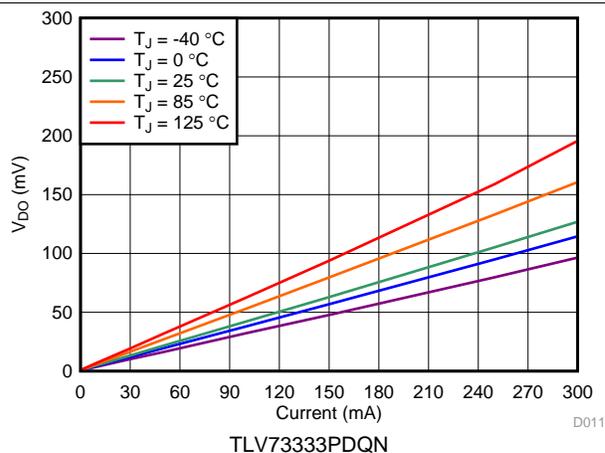


Figure 12. 3.3-V Dropout Voltage vs  $I_{OUT}$  and Temperature

### Typical Characteristics (continued)

At operating temperature range ( $T_J = -40^\circ\text{C}$  to  $125^\circ\text{C}$ ),  $V_{IN} = V_{OUTnom} + 0.5\text{ V}$  or  $2.0\text{ V}$  (whichever is greater),  $I_{OUT} = 1\text{ mA}$ ,  $V_{EN} = V_{IN}$ , and  $C_{IN} = C_{OUT} = 1\ \mu\text{F}$ , unless otherwise noted.

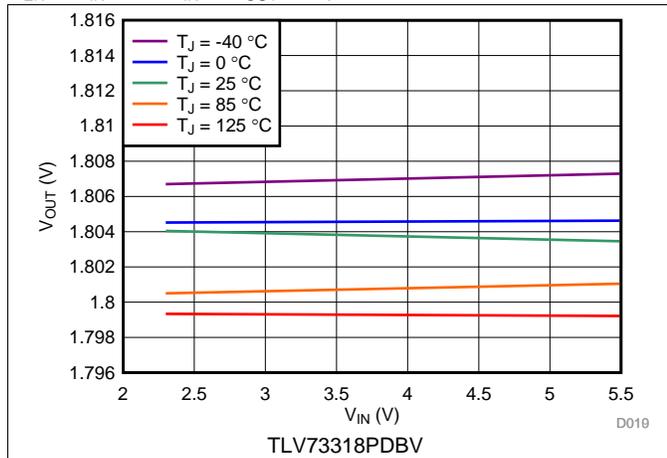


Figure 13. 1.8-V Regulation vs  $V_{IN}$  (Line Regulation) and Temperature

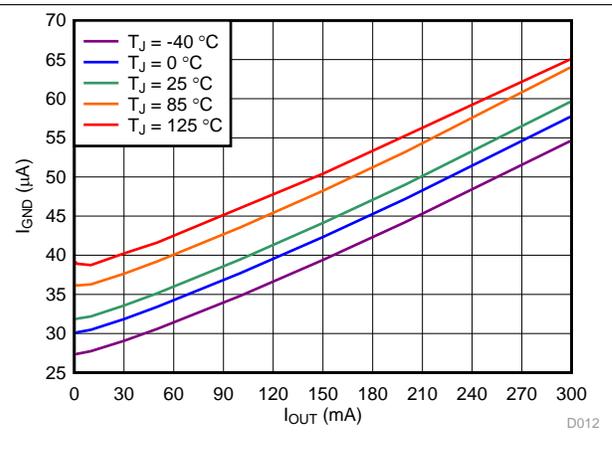


Figure 14. Ground Pin Current vs  $I_{OUT}$  and Temperature

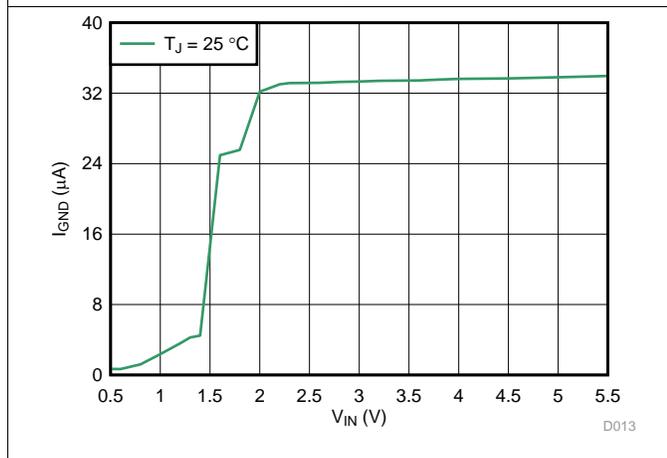


Figure 15. Ground Pin Current vs  $V_{IN}$

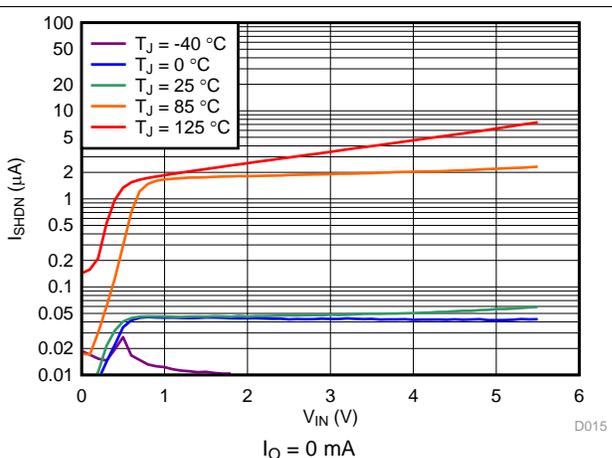


Figure 16. Shutdown Current vs  $V_{IN}$  and Temperature

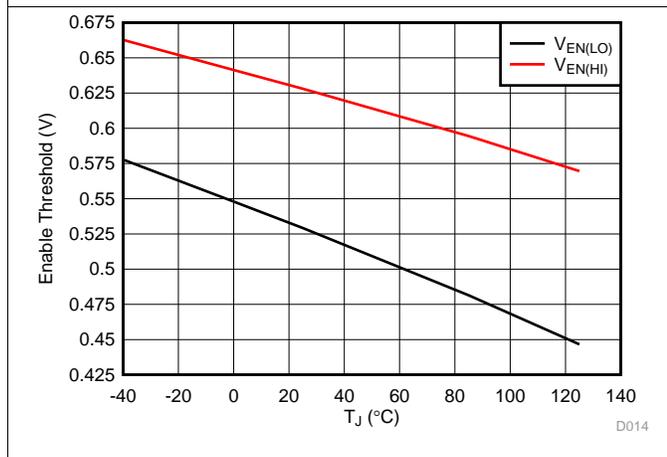


Figure 17. Enable Threshold vs Temperature

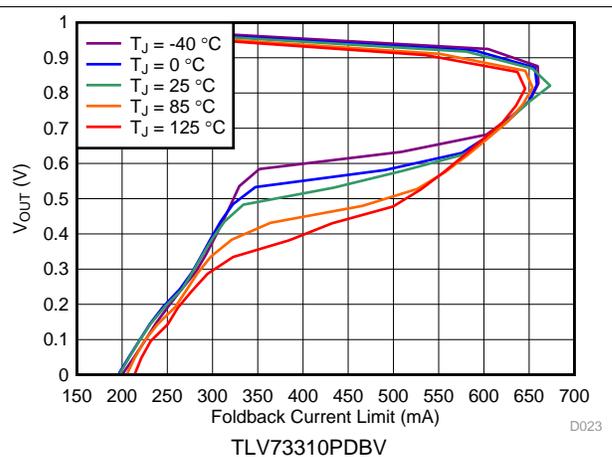


Figure 18. 1.0-V Foldback Current Limit vs  $I_{OUT}$  and Temperature

Typical Characteristics (continued)

At operating temperature range ( $T_J = -40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ ),  $V_{IN} = V_{OUTnom} + 0.5\text{ V}$  or  $2.0\text{ V}$  (whichever is greater),  $I_{OUT} = 1\text{ mA}$ ,  $V_{EN} = V_{IN}$ , and  $C_{IN} = C_{OUT} = 1\ \mu\text{F}$ , unless otherwise noted.

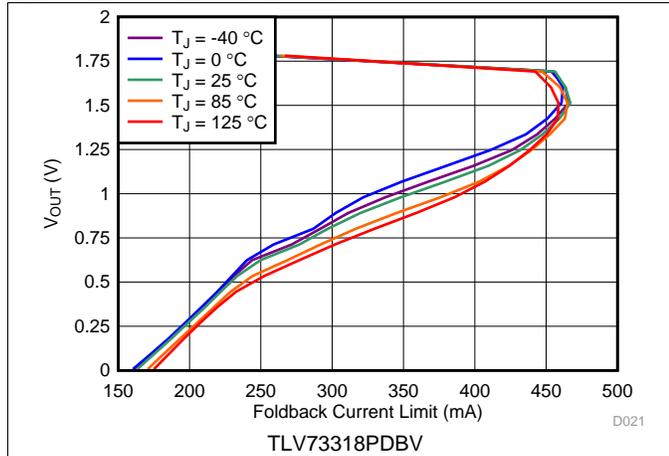


Figure 19. 1.8-V Foldback Current Limit vs  $I_{OUT}$  and Temperature

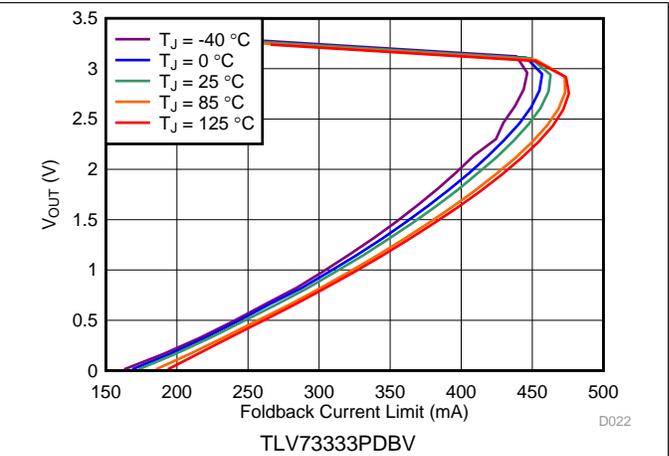


Figure 20. 3.3-V Foldback Current Limit vs  $I_{OUT}$  and Temperature

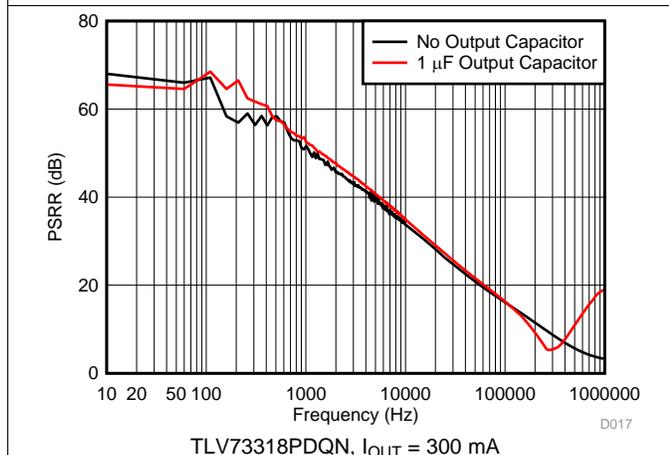


Figure 21. Power-Supply Rejection Ratio vs Frequency

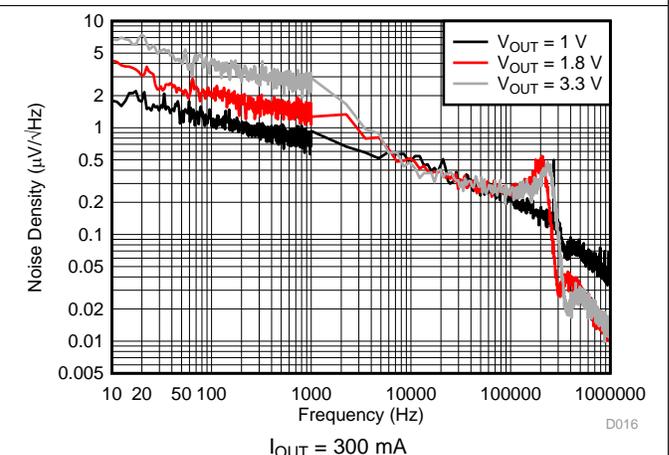


Figure 22. Output Spectral Noise Density

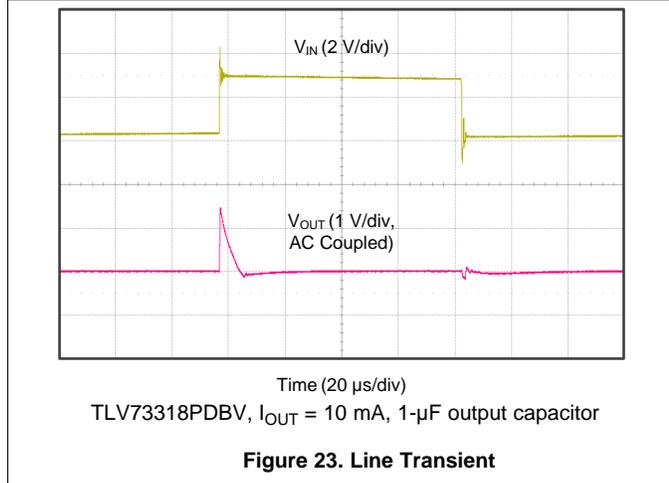


Figure 23. Line Transient

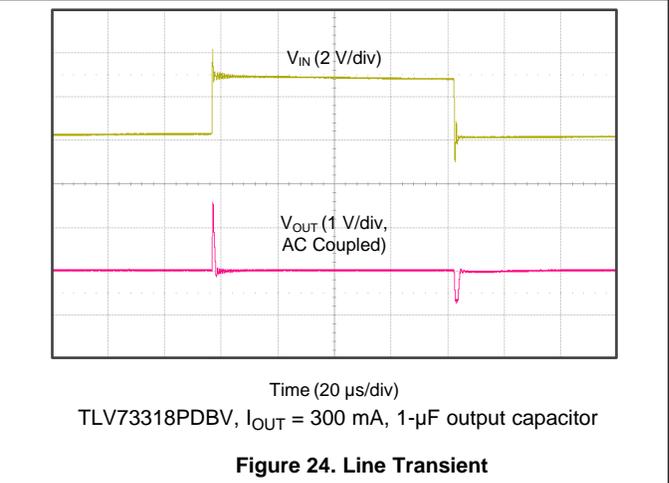
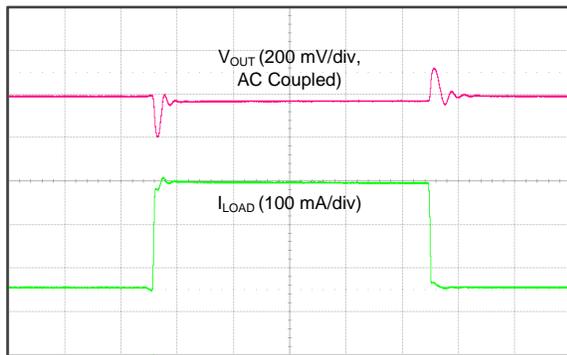


Figure 24. Line Transient

## Typical Characteristics (continued)

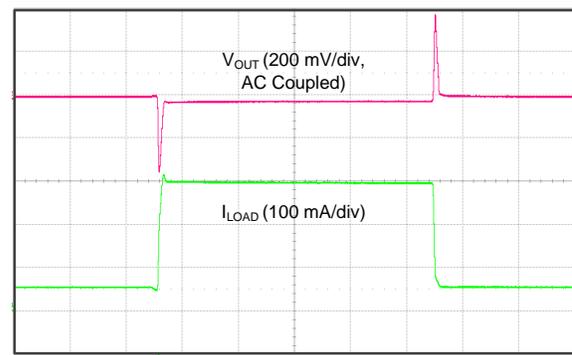
At operating temperature range ( $T_J = -40^\circ\text{C}$  to  $125^\circ\text{C}$ ),  $V_{IN} = V_{OUTnom} + 0.5\text{ V}$  or  $2.0\text{ V}$  (whichever is greater),  $I_{OUT} = 1\text{ mA}$ ,  $V_{EN} = V_{IN}$ , and  $C_{IN} = C_{OUT} = 1\ \mu\text{F}$ , unless otherwise noted.



Time (20  $\mu\text{s}/\text{div}$ )

TLV73310PDBV,  $V_{IN} = 2.0\text{ V}$ ,  $1\text{-}\mu\text{F}$  output capacitor, output current slew rate =  $0.25\text{ A}/\mu\text{s}$

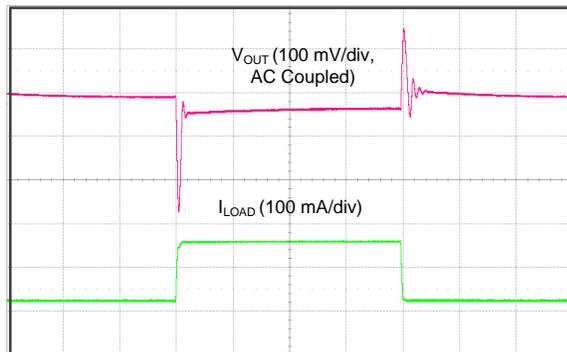
Figure 25. 1.0-V, 50-mA to 300-mA Load Transient



Time (20  $\mu\text{s}/\text{div}$ )

TLV73310PDBV,  $V_{IN} = 2.0\text{ V}$ , no output capacitor, output current slew rate =  $0.25\text{ A}/\mu\text{s}$

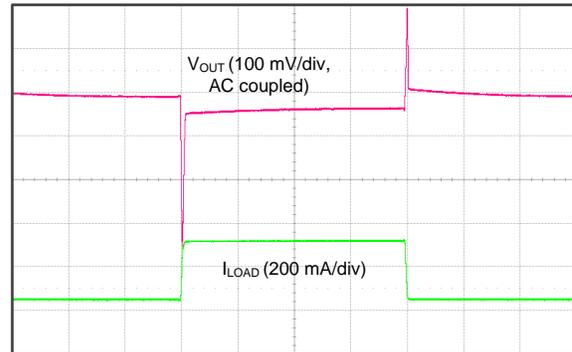
Figure 26. 1.0 V, 50-mA to 300-mA Load Transient



Time (20  $\mu\text{s}/\text{div}$ )

TLV73333PDBV,  $V_{IN} = 3.8\text{ V}$ ,  $1\text{-}\mu\text{F}$  output capacitor, output current slew rate =  $0.25\text{ A}/\mu\text{s}$

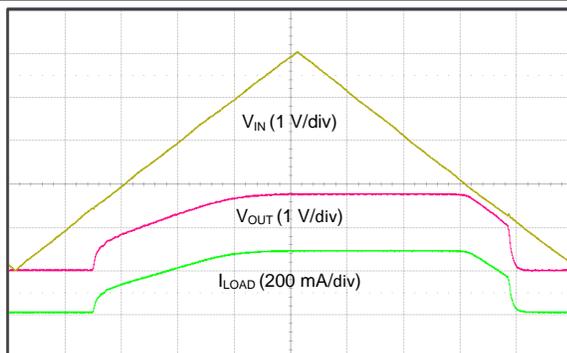
Figure 27. 3.3 V, 50-mA to 300-mA Load Transient



Time (50  $\mu\text{s}/\text{div}$ )

TLV73333PDBV,  $V_{IN} = 3.8\text{ V}$ , no output capacitor, output current slew rate =  $0.25\text{ A}/\mu\text{s}$

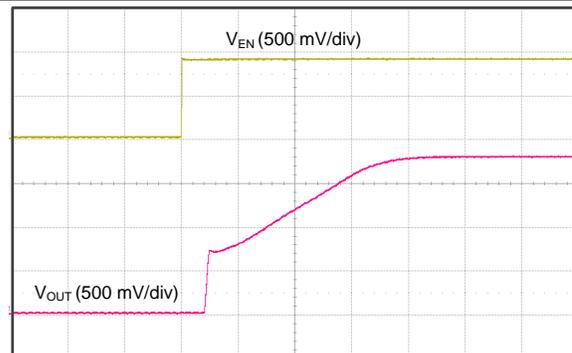
Figure 28. 3.3 V, 50-mA to 300-mA Load Transient



Time (100  $\mu\text{s}/\text{div}$ )

TLV73318PDBV,  $R_L = 6.2\ \Omega$ ,  $V_{EN} = V_{IN}$ ,  $1\text{-}\mu\text{F}$  output capacitor

Figure 29.  $V_{IN}$  Power-Up and Power-Down



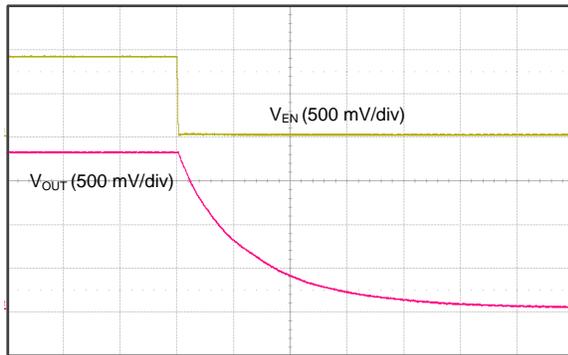
Time (100  $\mu\text{s}/\text{div}$ )

TLV73318PDBV,  $R_L = 6.2\ \Omega$ ,  $1\text{-}\mu\text{F}$  output capacitor

Figure 30. Startup with EN

**Typical Characteristics (continued)**

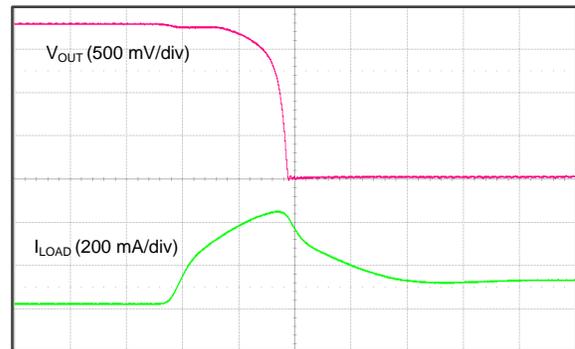
At operating temperature range ( $T_J = -40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ ),  $V_{IN} = V_{OUTnom} + 0.5\text{ V}$  or  $2.0\text{ V}$  (whichever is greater),  $I_{OUT} = 1\text{ mA}$ ,  $V_{EN} = V_{IN}$ , and  $C_{IN} = C_{OUT} = 1\text{ }\mu\text{F}$ , unless otherwise noted.



Time (100  $\mu\text{s/div}$ )

TLV73318PDBV,  $I_{OUT} = 300\text{ mA}$ ,  $1\text{-}\mu\text{F}$  output capacitor

**Figure 31. Shutdown Response with Enable**



Time (100  $\mu\text{s/div}$ )

TLV73318PDBV,  $1\text{-}\mu\text{F}$  output capacitor

**Figure 32. Foldback Current Limit Response**

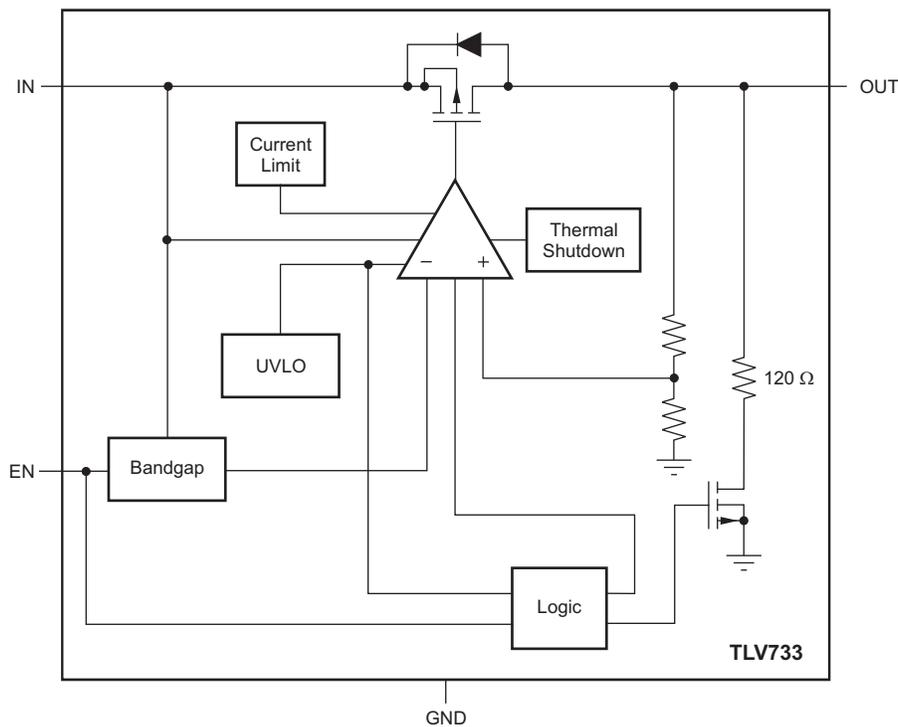
## 7 Detailed Description

### 7.1 Overview

The TLV733 belongs to a new family of next-generation, low-dropout regulators (LDOs). These devices consume low quiescent current and deliver excellent line and load transient performance. These characteristics, combined with low noise, good PSRR with low dropout voltage, make this family of devices ideal for portable consumer applications.

This family of regulators offers foldback current limit, shutdown, and thermal protection. The operating junction temperature for this family of devices is  $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ .

### 7.2 Functional Block Diagram



## 7.3 Feature Description

### 7.3.1 Undervoltage Lockout (UVLO)

The TLV733 uses an undervoltage lockout (UVLO) circuit that disables the output until the input voltage is greater than the rising UVLO voltage,  $UVLO_{RISE}$ . This circuit ensures that the device does not exhibit any unpredictable behavior when the supply voltage is lower than the operational range of the internal circuitry. During UVLO disable, the output is connected to ground with a 120- $\Omega$  pulldown resistor.

### 7.3.2 Shutdown

The enable pin (EN) is active high. Enable the device by forcing the EN pin to exceed  $V_{EN(HI)}$  (0.9 V, minimum). Turn off the device by forcing the EN pin to drop below 0.35 V. If shutdown capability is not required, connect EN to IN.

The TLV733 has an internal pulldown MOSFET that connects a 120- $\Omega$  resistor to ground when the device is disabled. The discharge time after disabling depends on the output capacitance ( $C_{OUT}$ ) and the load resistance ( $R_L$ ) in parallel with the 120- $\Omega$  pulldown resistor. The time constant is calculated in [Equation 1](#):

$$\tau = \frac{120 \cdot R_L}{120 + R_L} \cdot C_{OUT} \quad (1)$$

### 7.3.3 Internal Foldback Current Limit

The TLV733 has an internal foldback current limit that protects the regulator during fault conditions. The current allowed through the device is reduced as the output voltage falls. When the output is shorted, the LDO supplies a typical current of 150 mA. The output voltage is not regulated when the device is in current limit. In this condition, the output voltage is the product of the regulated current and the load resistance. When the device output is shorted, the PMOS pass transistor dissipates power  $[(V_{IN} - V_{OUT}) \times I_{OS}]$  until thermal shutdown is triggered and the device turns off. After the device cools down, the internal thermal shutdown circuit turns the device back on. If the fault condition continues, the device cycles between current limit and thermal shutdown. See the [Thermal Information](#) table for more details.

The foldback current-limit circuit limits the current allowed through the device to current levels lower than the minimum current limit at nominal  $V_{OUT}$  current limit ( $I_{LIM}$ ) during startup. See [Figure 18](#) to [Figure 20](#) for typical foldback current limit values. If the output is loaded by a constant-current load during startup, or if the output voltage is negative when the device is enabled, then the load current demanded by the load may exceed the foldback current limit and the device may not rise to the full output voltage. For constant-current loads, disable the output load until the TLV733 has fully risen to its nominal output voltage.

The TLV733 PMOS pass element has an intrinsic body diode that conducts current when the voltage at the OUT pin exceeds the voltage at the IN pin. Do not force the output voltage to exceed the input voltage because excessively high current may flow through the body diode.

### 7.3.4 Thermal Shutdown

Thermal shutdown protection disables the output when the junction temperature rises to approximately 160°C. Disabling the device eliminates the power dissipated by the device, allowing the device to cool. When the junction temperature cools to approximately 140°C, the output circuitry is again enabled. Depending on power dissipation, thermal resistance, and ambient temperature, the thermal protection circuit may cycle on and off. This cycling limits regulator dissipation, protecting it from damage as a result of overheating.

Activating the thermal shutdown feature usually indicates excessive power dissipation as a result of the product of the  $(V_{IN} - V_{OUT})$  voltage and the load current. For reliable operation, limit junction temperature to 125°C maximum. To estimate the margin of safety in a complete design, increase the ambient temperature until the thermal protection is triggered; use worst-case loads and signal conditions.

The TLV733 internal protection circuitry protects against overload conditions but is not intended to be activated in normal operation. Continuously running the TLV733 into thermal shutdown degrades device reliability.

## 7.4 Device Functional Modes

### 7.4.1 Normal Operation

The device regulates to the nominal output voltage under the following conditions:

- The input voltage has previously exceeded the UVLO rising voltage and has not decreased below the UVLO falling threshold.
- The input voltage is greater than the nominal output voltage added to the dropout voltage.
- The enable voltage has previously exceeded the enable rising threshold voltage and not decreased below the enable falling threshold.
- The output current is less than the current limit.
- The device junction temperature is less than the thermal shutdown temperature.

### 7.4.2 Dropout Operation

If the input voltage is lower than the nominal output voltage plus the specified dropout voltage, but all other conditions are met for normal operation, the device operates in dropout mode. In this condition, the output voltage is the same the input voltage minus the dropout voltage. The transient performance of the device is significantly degraded because the pass device is in a triode state and no longer controls the current through the LDO. Line or load transients in dropout may result in large output voltage deviations.

### 7.4.3 Disabled

The device is disabled under the following conditions:

- The input voltage is less than the UVLO falling voltage, or has not yet exceeded the UVLO rising threshold.
- The enable voltage is less than the enable falling threshold voltage or has not yet exceeded the enable rising threshold.
- The device junction temperature is greater than the thermal shutdown temperature.

When the device is disabled, the active pulldown resistor discharges the output.

Table 1 shows the conditions that lead to the different modes of operation.

**Table 1. Device Functional Mode Comparison**

OPERATING MODE	PARAMETER			
	$V_{IN}$	$V_{EN}$	$I_{OUT}$	$T_J$
Normal Mode	$V_{IN} > V_{OUT}^{nom} + V_{DO}$ and $V_{IN} > UVLO_{RISE}$	$V_{EN} > V_{EN(HI)}$	$I_{OUT} < I_{LIM}$	$T_J < 160^{\circ}C$
Dropout Mode	$UVLO_{RISE} < V_{IN} < V_{OUT}^{nom} + V_{DO}$	$V_{EN} > V_{EN(HI)}$	$I_{OUT} < I_{LIM}$	$T_J < 160^{\circ}C$
Disabled Mode (any true condition disables the device)	$V_{IN} < UVLO_{FALL}$	$V_{EN} < V_{EN(LO)}$	—	$T_J > 160^{\circ}C$

## 8 Application and Implementation

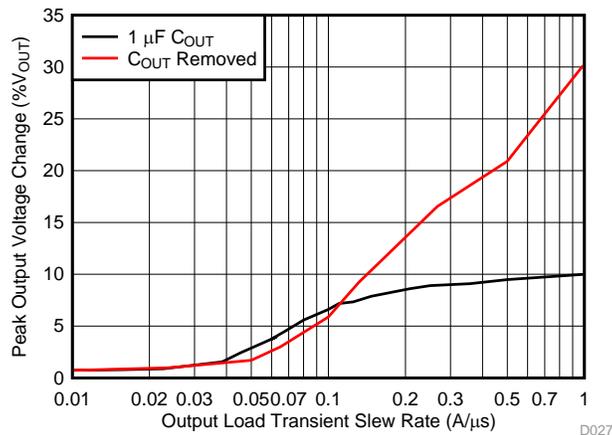
### 8.1 Application Information

#### 8.1.1 Input and Output Capacitor Selection

The TLV733 uses an advanced internal control loop to obtain stable operation both with and without the use of input or output capacitors. Dynamic performance is improved with the use of an output capacitor, and may be improved with an input capacitor. An output capacitance of 0.1  $\mu\text{F}$  or larger generally provides good dynamic response. Use X5R- and X7R-type ceramic capacitors because these capacitors have minimal variation in value and equivalent series resistance (ESR) over temperature.

Although an input capacitor is not required for stability, increased output impedance from the input supply may compromise the performance of the TLV733. It is a good analog design practice to connect a 0.1- $\mu\text{F}$  to 1- $\mu\text{F}$  capacitor from IN to GND. This capacitor counteracts reactive input sources and improves transient response, input ripple, and PSRR. Use an input capacitor if the source impedance is greater than 0.5  $\Omega$ . Use a higher-value capacitor if large, fast, rise-time load transients are anticipated, or if the device is located several inches from the input power source.

Figure 33 shows the transient performance improvements with an external 1- $\mu\text{F}$  capacitor on the output versus no output capacitor. The data in this figure are taken with an increasing load step from 50 mA to 300 mA, and the peak output voltage deviation (load transient response) is measured. For low output current slew rates, ( $< 0.1 \text{ A}/\mu\text{s}$ ), the transient performance of the device is similar with or without an output capacitor. As the current slew rate is increased, the peak voltage deviation is significantly increased. For loads that exhibit fast current slew rates above 0.1  $\text{A}/\mu\text{s}$ , use an output capacitor. For best performance, the maximum recommended output capacitance is 100  $\mu\text{F}$ .



TLV73333PDBV, output current stepped from 50 mA to 300 mA, output voltage change measured at positive  $dI/dt$

**Figure 33. Output Voltage Deviation vs Load Step Slew Rate**

Some applications benefit from the removal of the output capacitor. In addition to space and cost savings, the removal of the output capacitor lowers inrush current as a result of eliminating the required current flow into the output capacitor upon startup. In these cases, take care to ensure that the load is tolerant of the additional output voltage deviations.

## Application Information (continued)

### 8.1.2 Dropout Voltage

The TLV733 uses a PMOS pass transistor to achieve low dropout. When  $(V_{IN} - V_{OUT})$  is less than the dropout voltage ( $V_{DO}$ ), the PMOS pass device is in the linear region of operation and the input-to-output resistance is the  $R_{DS(ON)}$  of the PMOS pass element.  $V_{DO}$  scales approximately with output current because the PMOS device behaves like a resistor in dropout mode. As with any linear regulator, PSRR and transient response degrade as  $(V_{IN} - V_{OUT})$  approaches dropout operation. See [Figure 7](#) to [Figure 12](#) for typical dropout values.

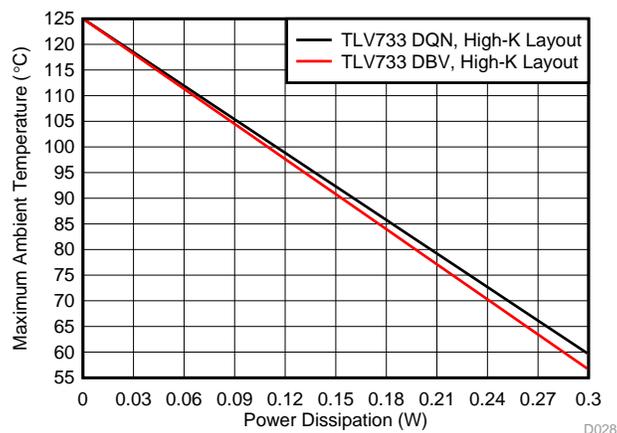
### 8.1.3 Power Dissipation

The ability to remove heat from the die is different for each package type, presenting different considerations in the printed circuit board (PCB) layout. The PCB area around the device that is free of other components moves the heat from the device to ambient air. Performance data for JEDEC high-K boards are given in the [Thermal Information](#) table. Using heavier copper increases the effectiveness in removing heat from the device. The addition of plated through-holes to heat-dissipating layers also improves heatsink effectiveness.

Power dissipation ( $P_D$ ) depends on input voltage and load conditions.  $P_D$  is equal to the product of the output current and voltage drop across the output pass element, as shown in [Equation 2](#).

$$P_D = (V_{IN} - V_{OUT}) \times I_{OUT} \quad (2)$$

[Figure 34](#) shows the maximum ambient temperature versus the power dissipation of the TLV733 in the DQN package. This figure assumes the device is soldered on JEDEC standard high-K layout with no airflow over the board. Actual board thermal impedances vary widely. If the application requires high power dissipation, it is helpful to have a thorough understanding of the board temperature and thermal impedances to make sure the TLV733 does not operate continuously above a junction temperature of 125°C.



TLV733 with DQN package, high-K layout

**Figure 34. Maximum Ambient Temperature vs Device Power Dissipation**

## 8.2 Typical Applications

### 8.2.1 DC-DC Converter Post Regulation

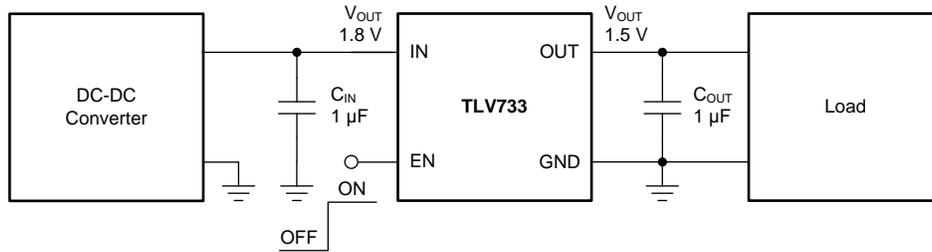


Figure 35. DC-DC Converter Post Regulation

#### 8.2.1.1 Design Requirements

Table 2. Design Parameters

PARAMETER	DESIGN REQUIREMENT
Input voltage	1.8 V, $\pm 5\%$
Output voltage	1.5 V, $\pm 1\%$
Output current	200 mA dc, 300 mA peak
Output voltage transient deviation	< 10%, 1 A/ $\mu$ s load step from 50 mA to 200 mA
Maximum ambient temperature	85°C

#### 8.2.1.2 Design Considerations

Input and output capacitors are required to achieve the output voltage transient requirements. Capacitance values of 1  $\mu$ F are selected to give the maximum output capacitance in a small, low-cost package.

Figure 7 shows the 1.2-V option dropout voltage. Given that dropout voltages are higher for lower output-voltage options, and given that the 1.2-V option dropout voltage is typically less than 300 mV at 125 °C, then the 1.5-V option dropout voltage is typically less than 300 mV at 125°C.

Verify that the maximum junction temperature is not exceeded by referring to Figure 34.

#### 8.2.1.3 Application Curves

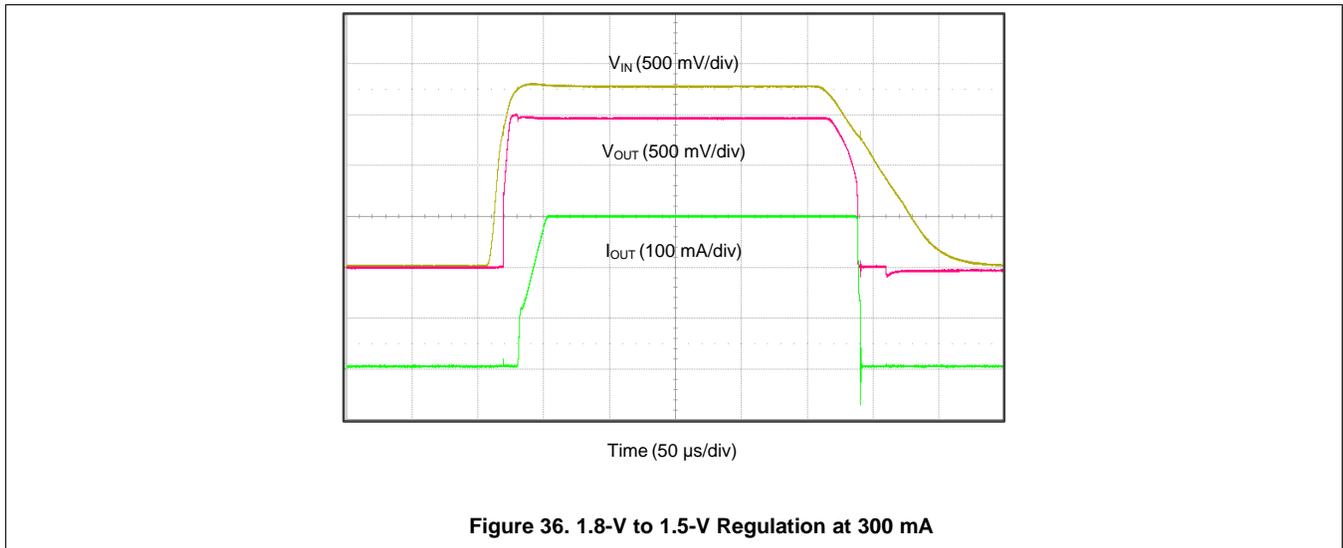


Figure 36. 1.8-V to 1.5-V Regulation at 300 mA

## 8.2.2 Capacitor-Free Operation from Battery Input Supply

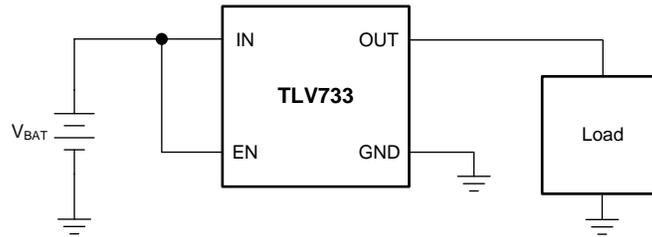


Figure 37. Capacitor-Free Operation from Battery Input Supply

### 8.2.2.1 Design Requirements

Table 3. Design Parameters

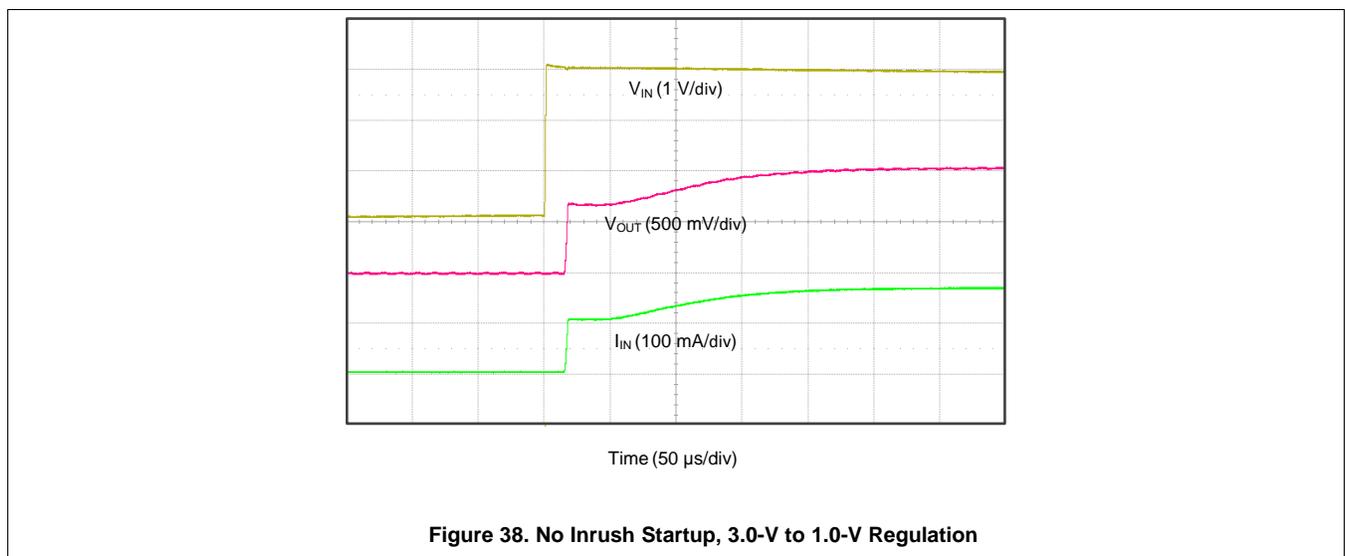
PARAMETER	DESIGN REQUIREMENT
Input voltage	3.0 V to 1.8 V (two 1.5-V batteries)
Output voltage	1.0 V, $\pm 1\%$
Input current	200 mA, maximum
Output load	100 mA dc
Maximum ambient temperature	70°C

### 8.2.2.2 Design Considerations

An input capacitor is not required for this design because of the low impedance connection directly to the battery. No output capacitor allows for the minimal possible inrush current during startup, ensuring the 200-mA maximum input current is not exceeded.

Verify that the maximum junction temperature is not exceeded by referring to [Figure 34](#).

### 8.2.2.3 Application Curves



## 9 Power-Supply Recommendations

Connect a low output impedance power supply directly to the IN pin of the TLV733. Inductive impedances between the input supply and the IN pin may create significant voltage excursions at the IN pin during startup or load transient events. If inductive impedances are unavoidable, use an input capacitor.

## 10 Layout

### 10.1 Layout Guidelines

- Place input and output capacitors as close to the device as possible.
- Use copper planes for device connections, in order to optimize thermal performance.
- Place thermal vias around the device to distribute the heat.
- Do not place a thermal via directly beneath the thermal pad of the DQN package. A via may wick solder or solder paste away from the thermal pad joint during the soldering process, leading to a compromised solder joint on the thermal pad.

### 10.2 Layout Example

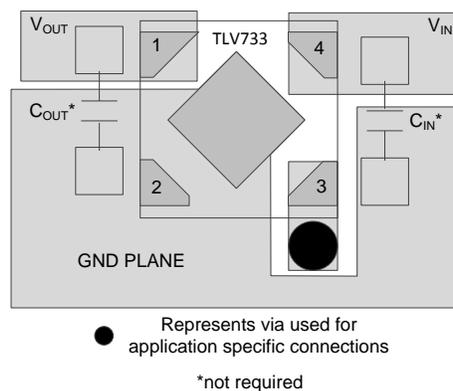


Figure 39. Layout Example for DQN package

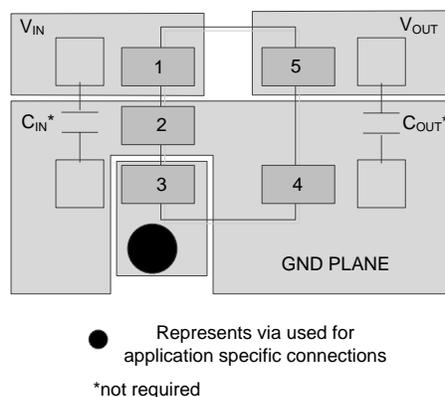


Figure 40. Layout Example for DBV Package

## 11 Device and Documentation Support

### 11.1 Device Support

#### 11.1.1 Device Nomenclature

Table 4. Device Nomenclature<sup>(1)(2)</sup>

PRODUCT	V <sub>OUT</sub>
TLV733xx(x)PyyyZ	<p><b>XX(X)</b> is the nominal output voltage. For output voltages with a resolution of 100 mV, two digits are used in the ordering number; otherwise, three digits are used (for example, 28 = 2.8 V; 125 = 1.25 V).</p> <p><b>P</b> indicates an active output discharge feature. All members of the TLV733 family will actively discharge the output when the device is disabled.</p> <p><b>YYY</b> is the package designator.</p> <p><b>Z</b> is the package quantity. R is for reel (3000 pieces), T is for tape (250 pieces).</p>

- (1) For the most current package and ordering information see the Package Option Addendum at the end of this document, or visit the device product folder on [www.ti.com](http://www.ti.com).
- (2) Output voltages from 1.0 V to 3.3 V in 50-mV increments are available. Contact the factory for details and availability.

### 11.2 Documentation Support

#### 11.2.1 Related Documentation

[SBVU024](#) — TLV73312PDQN-643 Evaluation Module

#### 11.3 Related Links

[Table 5](#) lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

Table 5. Related Links

PARTS	PRODUCT FOLDER	SAMPLE & BUY	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY
TLV73310P	<a href="#">Click here</a>				
TLV73312P	<a href="#">Click here</a>				
TLV73315P	<a href="#">Click here</a>				
TLV73318P	<a href="#">Click here</a>				
TLV73325P	<a href="#">Click here</a>				
TLV73333P	<a href="#">Click here</a>				

### 11.4 Trademarks

All trademarks are the property of their respective owners.

### 11.5 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

### 11.6 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

## 12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TLV73310PDBVR	PREVIEW	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	VCCQ	
TLV73310PDBVT	PREVIEW	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	VCCQ	
TLV73310PDQNR	PREVIEW	X2SON	DQN	4	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	FG	
TLV73310PDQNT	PREVIEW	X2SON	DQN	4	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	FG	
TLV73312PDBVR	PREVIEW	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	VCDQ	
TLV73312PDBVT	PREVIEW	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	VCDQ	
TLV73312PDQNR	PREVIEW	X2SON	DQN	4	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	FI	
TLV73312PDQNT	PREVIEW	X2SON	DQN	4	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	FI	
TLV73315PDBVR	PREVIEW	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	VCFQ	
TLV73315PDBVT	PREVIEW	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	VCFQ	
TLV73315PDQNR	PREVIEW	X2SON	DQN	4	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	FJ	
TLV73315PDQNT	PREVIEW	X2SON	DQN	4	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	FJ	
TLV73318PDBVR	PREVIEW	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	VCGQ	
TLV73318PDBVT	PREVIEW	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	VCGQ	
TLV73318PDQNR	PREVIEW	X2SON	DQN	4	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM		FK	
TLV73318PDQNT	PREVIEW	X2SON	DQN	4	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	FK	
TLV73325PDBVR	PREVIEW	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	VCHQ	

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TLV73325PDBVT	PREVIEW	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	VCHQ	
TLV73325PDQNR	PREVIEW	X2SON	DQN	4	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	FL	
TLV73325PDQNT	PREVIEW	X2SON	DQN	4	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	FL	
TLV73333PDBVR	PREVIEW	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	VCIQ	
TLV73333PDBVT	PREVIEW	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	VCIQ	
TLV73333PDQNR	PREVIEW	X2SON	DQN	4	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	FM	
TLV73333PDQNT	PREVIEW	X2SON	DQN	4	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	FM	

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSELETE:** TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "-" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

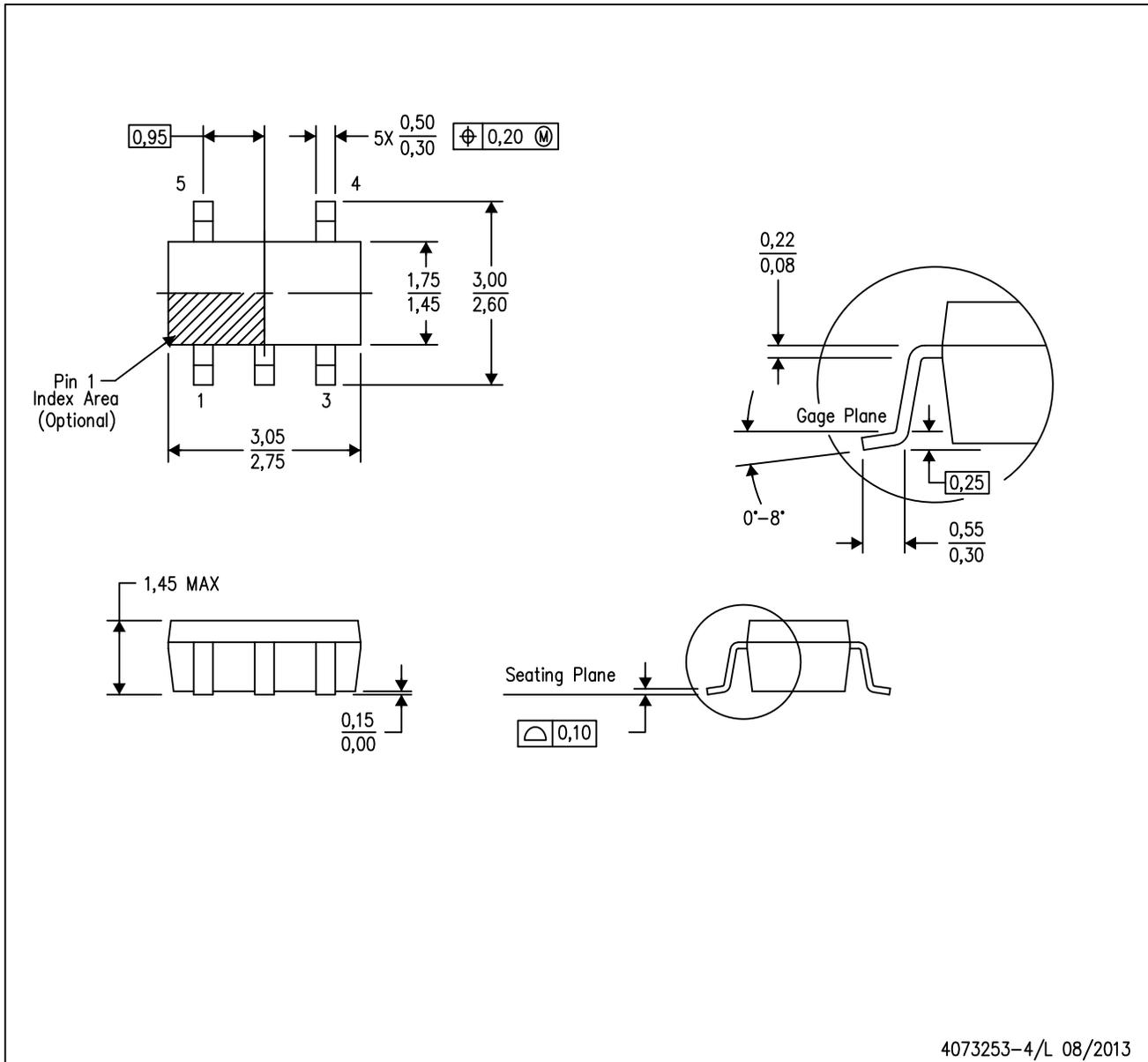
<sup>(6)</sup> Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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DBV (R-PDSO-G5)

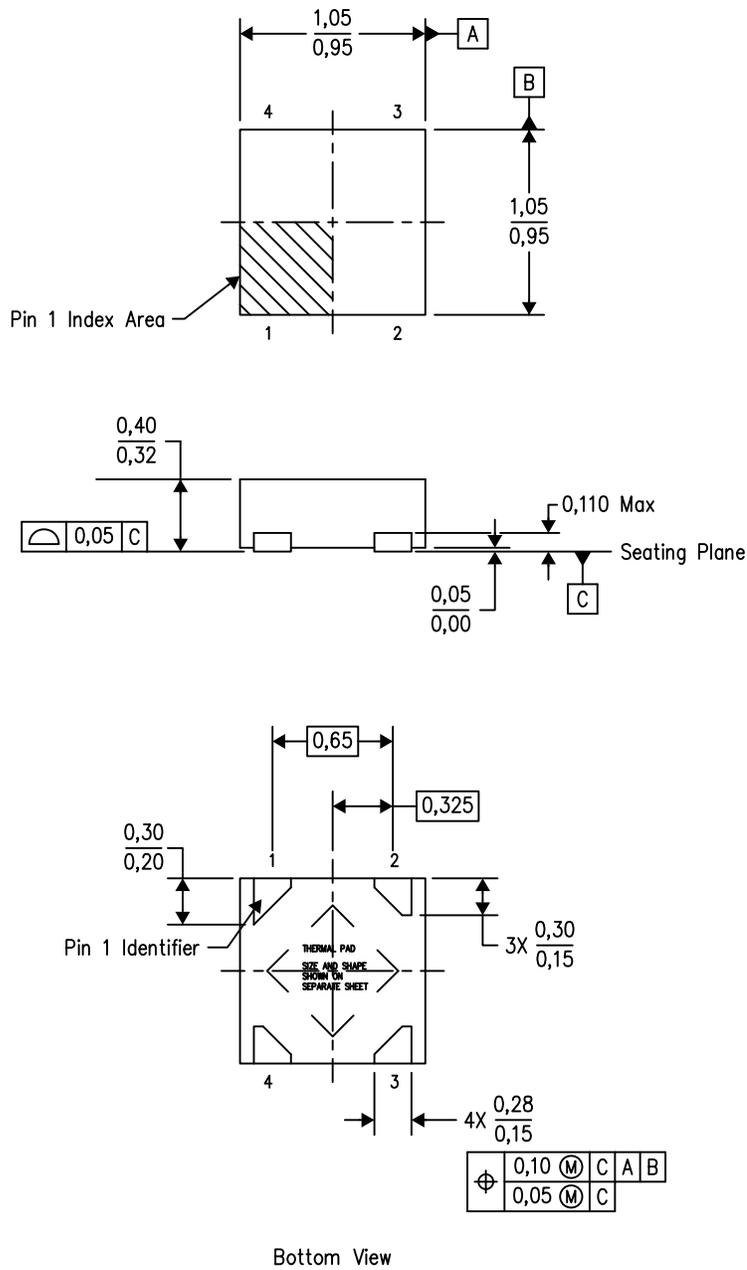
PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
  - D. Falls within JEDEC MO-178 Variation AA.

DQN (S-PX2SON-N4)

PLASTIC SMALL OUTLINE NO-LEAD



4210367/D 09/2012

- NOTES:
- All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - This drawing is subject to change without notice.
  - SON (Small Outline No-Lead) package configuration.
  - The package thermal pad must be soldered to the board for thermal and mechanical performance.
  - See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.

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