

TPS79015, TPS79018, TPS79025, TPS79028, TPS79030

ULTRALOW-POWER LOW-NOISE 50 mA

LOW-DROPOUT LINEAR REGULATORS

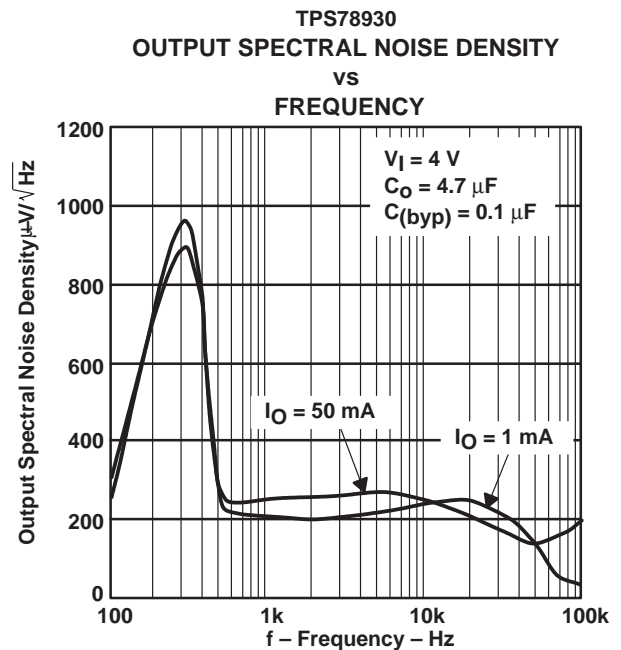
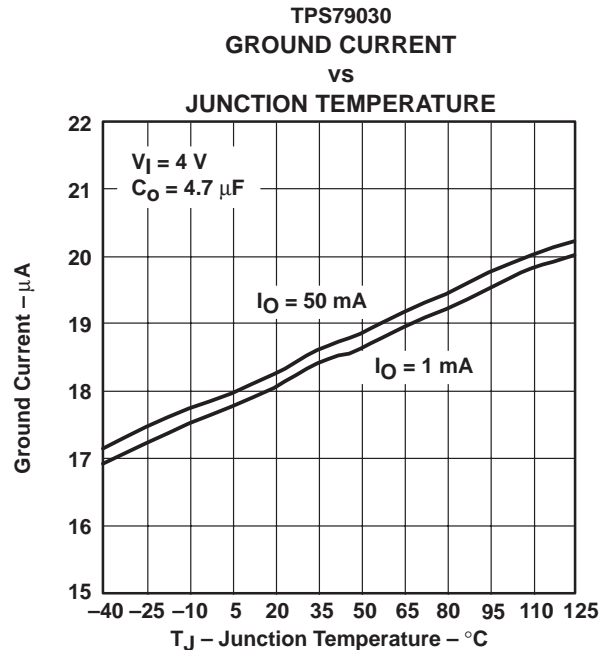
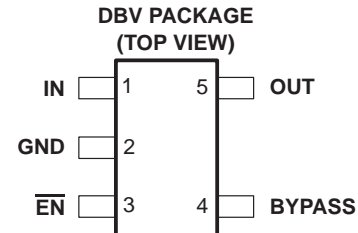
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- 50-mA Low-Dropout Regulator
- Available in 1.5-V, 1.8-V, 2.5-V, 2.8-V, 3.0-V
- Output Noise Typically 56 μV_{RMS} (TPS79030)
- Only 17 μA Quiescent Current at 50 mA
- 1 μA Quiescent Current in Standby Mode
- Dropout Voltage Typically 57 mV at 50 mA (TPS79030)
- Over Current Limitation
- -40°C to 125°C Operating Junction Temperature Range
- 5-Pin SOT-23 (DBV) Package

description

The TPS790xx family of low-dropout (LDO) voltage regulators offers the benefits of low-dropout voltage, ultralow-power operation, low-output noise, and miniaturized packaging. These regulators feature low-dropout voltages and ultralow quiescent current compared to conventional LDO regulators. An internal resistor, in conjunction with an external bypass capacitor, creates a low-pass filter to reduce the noise. The TPS79030 exhibits only 56 μV_{RMS} of output voltage noise using 0.01 μF bypass and 10 μF output capacitors. Offered in a 5-terminal small outline integrated-circuit SOT-23 package, the TPS790xx series devices are ideal for micropower operations, low output noise, and where board space is limited.

The usual PNP pass transistor has been replaced by a PMOS pass element. Because the PMOS pass element behaves as a low-value resistor, the dropout voltage is very low, typically 57 mV at 50 mA of load current (TPS79030), and is directly proportional to the load current. The quiescent current is ultralow (17 μA typically) and is stable over the entire range of output load current (0 mA to 50 mA). Intended for use in portable systems such as laptops and cellular phones, the ultralow-dropout voltage feature and ultralow-power operation result in a significant increase in system battery operating life.



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**TEXAS
INSTRUMENTS**

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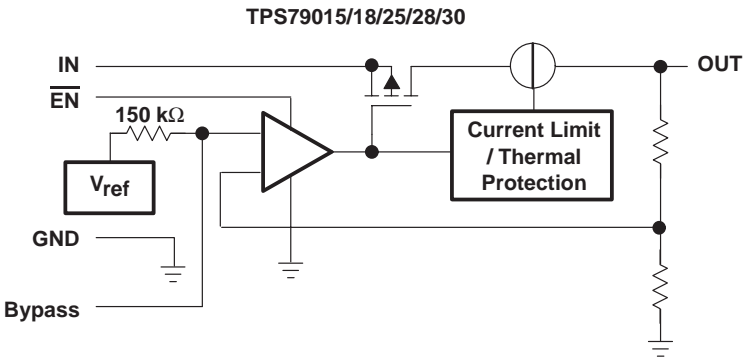
description (continued)

The TPS790xx also features a logic-enabled sleep mode to shut down the regulator, reducing quiescent current to 1 μ A typical at $T_J = 25^{\circ}\text{C}$. The TPS790xx is offered in 1.5-V, 1.8-V, 2.5-V, 2.8-V, 3.0-V.

| AVAILABLE OPTIONS | | | | | |
|--|---------|--------------|---------------|---------------|--------|
| T_J | VOLTAGE | PACKAGE | PART NUMBER | | SYMBOL |
| -40°C to 125°C | 1.5 V | SOT-23 (DBV) | TPS79015DBVT† | TPS79015DBVR‡ | PEBI |
| | 1.8 V | | TPS79018DBVT† | TPS79018DBVR‡ | PECI |
| | 2.5 V | | TPS79025DBVT† | TPS79025DBVR‡ | PEDI |
| | 2.8 V | | TPS79028DBVT† | TPS79028DBVR‡ | PEEI |
| | 3.0 V | | TPS79030DBVT† | TPS79030DBVR‡ | PEFI |

† The DBVT indicates tape and reel of 250 parts.
 ‡ The DBVR indicates tape and reel of 3000 parts.

functional block diagram



Terminal Functions

| TERMINAL NAME | NO. | I/O | DESCRIPTION |
|---------------|-----|-----|--------------------------|
| BYPASS | 4 | I | Bypass |
| EN | 3 | I | Enable input |
| GND | 2 | | Ground |
| IN | 1 | I | Input supply voltage |
| OUT | 5 | O | Regulated output voltage |

detail description

The TPS790xx uses a PMOS pass element to dramatically reduce both dropout voltage and supply current over more conventional PNP-pass-element LDO designs. The PMOS pass element is a voltage-controlled device and, unlike a PNP transistor, it does not require increased drive current as output current increases. Supply current in the TPS790xx is essentially constant from no load to maximum load.

The TPS790xx family of low-dropout (LDO) regulators have been optimized for use in battery-operated equipment. They feature extremely low dropout voltages, low output noise, low quiescent current (17 μ A typically), and enable inputs to reduce supply currents to 1 μ A when the regulators are turned off.

The internal voltage reference is a key source of noise in a LDO regulator. The TPS790xx has a BYPASS pin which is connected to the voltage reference through a 150-k Ω internal resistor. The 150-k Ω internal resistor, in conjunction with an external bypass capacitor connected to the BYPASS pin, creates a low pass filter to reduce the voltage reference noise and, therefore, the noise at the regulator output. Note that the output will start up slower as the bypass capacitance increases due to the RC time constant at the bypass pin that is created by the internal 150-k Ω resistor and external capacitor.

Current limiting and thermal protection prevent damage by excessive output current and/or power dissipation. The device switches into a constant-current mode at approximately 350 mA; further load reduces the output voltage instead of increasing the output current. The thermal protection shuts the regulator off if the junction temperature rises above approximately 165°C. Recovery is automatic when the junction temperature drops approximately 25°C below the high temperature trip point. The PMOS pass element includes a back gate diode that conducts reverse current when the input voltage level drops below the output voltage level.

A voltage of 1.7 V or greater on the EN input will disable the TPS790xx internal circuitry, reducing the supply current to 1 μ A. A voltage of less than 0.9 V on the $\overline{\text{EN}}$ input will enable the TPS790xx and will enable normal operation to resume. The $\overline{\text{EN}}$ input does not include any deliberate hysteresis, and it exhibits an actual switching threshold of approximately 1.5 V.

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)[†]

| | |
|---|------------------------------|
| Input voltage range (see Note 1) | –0.3 V to 13.5 V |
| Voltage range at $\overline{\text{EN}}$ | –0.3 V to $V_I + 0.3$ V |
| Voltage on OUT, FB | 7 V |
| Peak output current | Internally limited |
| ESD rating, HBM | 2 kV |
| Continuous total power dissipation | See Dissipation Rating Table |
| Operating virtual junction temperature range, T_J | –40°C to 150°C |
| Storage temperature range, T_{stg} | –65°C to 150°C |

[†] 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.

NOTE 1: All voltage values are with respect to network ground terminal.

DISSIPATION RATING TABLE

| | PACKAGE | $T_A \leq 25^\circ\text{C}$ POWER RATING | DERATING FACTOR ABOVE $T_A = 25^\circ\text{C}$ | $T_A = 70^\circ\text{C}$ POWER RATING | $T_A = 85^\circ\text{C}$ POWER RATING |
|------------------|---------|---|---|--|--|
| Recommended | DBV | 350 mW | 3.5 mW/°C | 192 mW | 140 mW |
| Absolute maximum | DBV | 437 mW | 3.5 mW/°C | 280 mW | 227 mW |

recommended operating conditions

| | MIN | NOM | MAX | UNIT |
|---|-----|-----|-----|------|
| Input voltage, V_I (see Note 2) | 2.7 | | 10 | V |
| Continuous output current, I_O (see Note 3) | 0 | | 50 | mA |
| Operating junction temperature, T_J | –40 | | 125 | °C |

NOTES: 2. To calculate the minimum input voltage for your maximum output current, use the following formula:

$$V_{I(\min)} = V_{O(\max)} + V_{DO}(\text{max load})$$

3. Continuous output current and operating junction temperature are limited by internal protection circuitry, but it is not recommended that the device operate under conditions beyond those specified in this table for extended periods of time.

electrical characteristics over recommended operating free-air temperature range,

$V_I = V_{O(\text{typ})} + 1 \text{ V}$, $I_O = 1 \text{ mA}$, $\overline{\text{EN}} = 0 \text{ V}$, $C_O = 4.7 \mu\text{F}$ (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|--|--|---|-------|------|-------|----------------------------|
| Output voltage (10 μA to 50 mA Load) (see Note 4) | TPS79015 | $T_J = 25^\circ\text{C}$, $2.7 \text{ V} < V_I < 10 \text{ V}$ | | 1.5 | | V |
| | | $T_J = -40^\circ\text{C}$ to 125°C , $2.7 \text{ V} < V_I < 10 \text{ V}$ | 1.455 | | 1.545 | |
| | TPS79018 | $T_J = 25^\circ\text{C}$, $2.8 \text{ V} < V_I < 10 \text{ V}$ | | 1.8 | | |
| | | $T_J = -40^\circ\text{C}$ to 125°C , $2.8 \text{ V} < V_I < 10 \text{ V}$ | 1.746 | | 1.854 | |
| | TPS79025 | $T_J = 25^\circ\text{C}$, $3.5 \text{ V} < V_I < 10 \text{ V}$ | | 2.5 | | |
| | | $T_J = -40^\circ\text{C}$ to 125°C , $3.5 \text{ V} < V_I < 10 \text{ V}$ | 2.425 | | 2.575 | |
| | TPS79028 | $T_J = 25^\circ\text{C}$, $3.8 \text{ V} < V_I < 10 \text{ V}$ | | 2.8 | | |
| | | $T_J = -40^\circ\text{C}$ to 125°C , $3.8 \text{ V} < V_I < 10 \text{ V}$ | 2.716 | | 2.884 | |
| | TPS79030 | $T_J = 25^\circ\text{C}$, $4.0 \text{ V} < V_I < 10 \text{ V}$ | | 3 | | |
| | | $T_J = -40^\circ\text{C}$ to 125°C , $4.0 \text{ V} < V_I < 10 \text{ V}$ | 2.910 | | 3.090 | |
| Quiescent current (GND current) (see Note 4) | $\overline{\text{EN}} = 0 \text{ V}$, $T_J = 25^\circ\text{C}$, $10 \mu\text{A} < I_O < 50 \text{ mA}$ | | | 17 | | μA |
| | $\overline{\text{EN}} = 0 \text{ V}$, $T_J = -40^\circ\text{C}$ to 125°C , $I_O = 50 \text{ mA}$ | | | | 28 | |
| Load regulation | $\overline{\text{EN}} = 0 \text{ V}$, $T_J = 25^\circ\text{C}$, $I_O = 10 \mu\text{A}$ to 50 mA | | | 8 | | mV |
| Output voltage line regulation ($\Delta V_O/V_O$) (see Notes 4 and 5) | $V_O + 1 \text{ V} < V_I \leq 10 \text{ V}$, $T_J = 25^\circ\text{C}$ | | | 0.04 | | %V |
| | $V_O + 1 \text{ V} < V_I \leq 10 \text{ V}$, $T_J = -40^\circ\text{C}$ to 125°C | | | | 0.1 | |
| Output noise voltage (TPS79030) | BW = 300 Hz to 50 kHz, $C_{(\text{byp})} = 0.01 \mu\text{F}$, $C_O = 10 \mu\text{F}$, $I_O = 50 \text{ mA}$, $T_J = 25^\circ\text{C}$ | | | 56 | | μV_{rms} |
| Output current limit | $V_O = 0 \text{ V}$, See Note 4 | | | 350 | 750 | mA |
| Standby current | $\overline{\text{EN}} = V_I$, $2.7 < V_I < 10 \text{ V}$ | | | 1 | | μA |
| | $T_J = -40^\circ\text{C}$ to 125°C | | | | 2 | μA |

NOTES: 4. The minimum IN operating voltage is 2.7 V or V_O (typ) + 1 V, whichever is greater. The maximum IN voltage is 10 V. The minimum output current is 10 μA and the maximum output current is 50 mA.

5. If $V_O \leq 1.8 \text{ V}$ then $V_{I\min} = 2.7 \text{ V}$, $V_{I\max} = 10 \text{ V}$:

$$\text{Line Reg. (mV)} = (\%/V) \times \frac{V_O(V_{I\max} - 2.7 \text{ V})}{100} \times 1000$$

If $V_O \geq 2.5 \text{ V}$ then $V_{I\min} = V_O + 1 \text{ V}$, $V_{I\max} = 10 \text{ V}$:

$$\text{Line Reg. (mV)} = (\%/V) \times \frac{V_O(V_{I\max} - (V_O + 1 \text{ V}))}{100} \times 1000$$

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**electrical characteristics over recommended operating free-air temperature range,
 $V_I = V_{O(typ)} + 1\text{ V}$, $I_O = 1\text{ mA}$, $\overline{EN} = 0\text{ V}$, $C_O = 4.7\text{ }\mu\text{F}$ (unless otherwise noted) (continued)**

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|--|----------|--|-----|-----|-----|---------------|
| High level enable input voltage | | $2.7\text{ V} < V_I < 10\text{ V}$ | 1.7 | | | V |
| Low level enable input voltage | | $2.7\text{ V} < V_I < 10\text{ V}$ | | | 0.9 | V |
| Power supply ripple rejection (TPS79030) | | $f = 1\text{ kHz}$, $T_J = 25^\circ\text{C}$, $C_O = 10\text{ }\mu\text{F}$, $C_{(byp)} = 0.01\text{ }\mu\text{F}$, | | 85 | | dB |
| Input current (\overline{EN}) | | $\overline{EN} = 0\text{ V}$ | -1 | 0 | 1 | μA |
| | | $\overline{EN} = V_I$ | -1 | | 1 | μA |
| Dropout voltage (see Note 6) | TPS79028 | $I_O = 50\text{ mA}$, $T_J = 25^\circ\text{C}$ | | 60 | | mV |
| | | $I_O = 50\text{ mA}$, $T_J = -40^\circ\text{C to } 125^\circ\text{C}$ | | | 125 | |
| Dropout voltage (see Note 6) | TPS79030 | $I_O = 50\text{ mA}$, $T_J = 25^\circ\text{C}$ | | 57 | | |
| | | $I_O = 50\text{ mA}$, $T_J = -40^\circ\text{C to } 125^\circ\text{C}$ | | | 115 | |

6. I_N voltage equals $V_{O(typ)} - 100\text{ mV}$; The TPS79030 output voltage is set to 2.9 V. The TPS79015, TPS79018, and TPS79025 dropout voltage is limited by input voltage range limitations.

TYPICAL CHARACTERISTICS

Table of Graphs

| | | | FIGURE |
|----------|------------------------------------|-------------------------|---------|
| V_O | Output voltage | vs Output current | 1, 2, 3 |
| | | vs Junction temperature | 4, 5, 6 |
| | Ground current | vs Junction temperature | 7 |
| | Output spectral noise density | vs Frequency | 8 – 10 |
| | Root mean squared output noise | vs Bypass capacitance | 11 |
| Z_O | Output impedance | vs Frequency | 12 |
| V_{DO} | Dropout voltage | vs Junction temperature | 13 |
| | Ripple rejection | vs Frequency | 14 – 16 |
| V_O | Output voltage, enable voltage | vs Time (start-up) | 17 – 19 |
| | Line transient response | | 20, 22 |
| | Load transient response | | 21, 23 |
| | Equivalent series resistance (ESR) | vs Output current | 24, 25 |



TYPICAL CHARACTERISTICS

TPS79025
OUTPUT VOLTAGE
vs
OUTPUT CURRENT

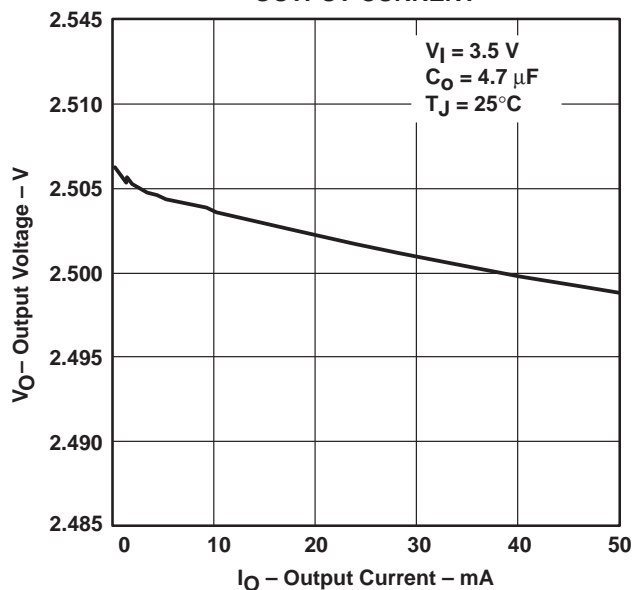


Figure 1

TPS79015
OUTPUT VOLTAGE
vs
OUTPUT CURRENT

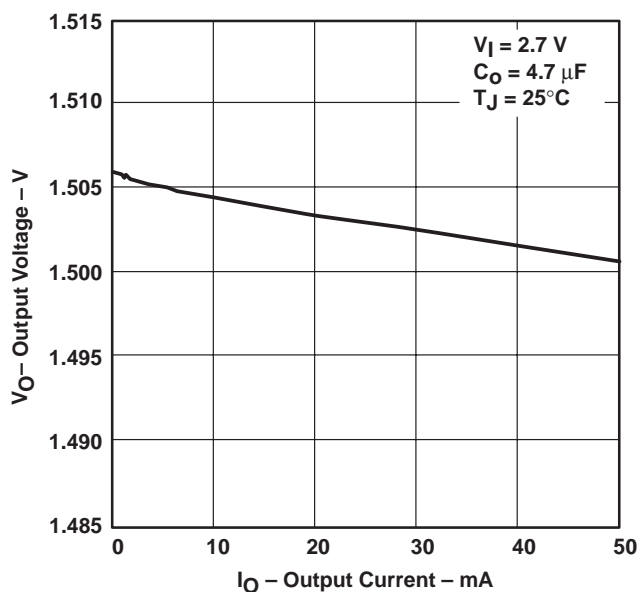


Figure 2

TPS79030
OUTPUT VOLTAGE
vs
OUTPUT CURRENT

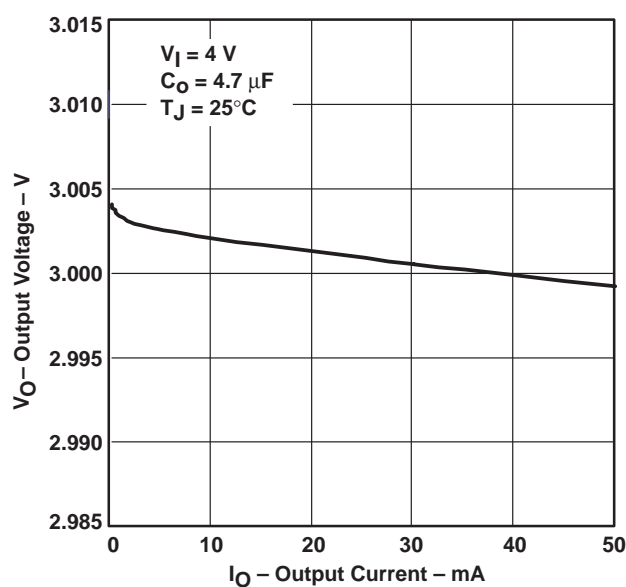


Figure 3

TPS79015
OUTPUT VOLTAGE
vs
JUNCTION TEMPERATURE

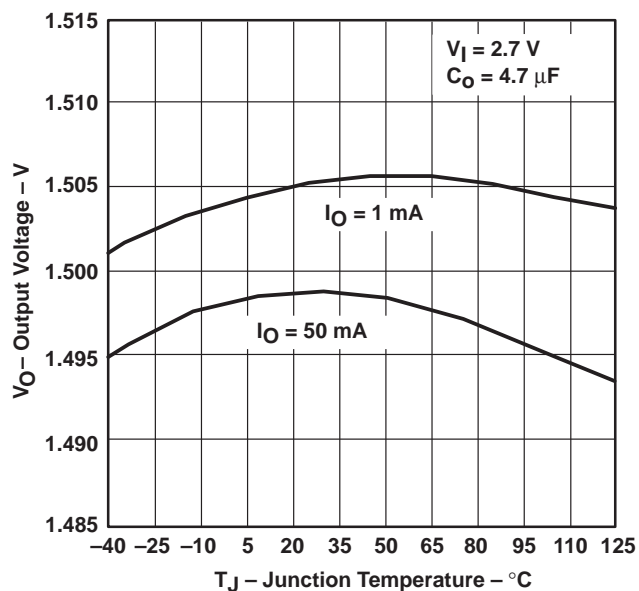


Figure 4

TYPICAL CHARACTERISTICS

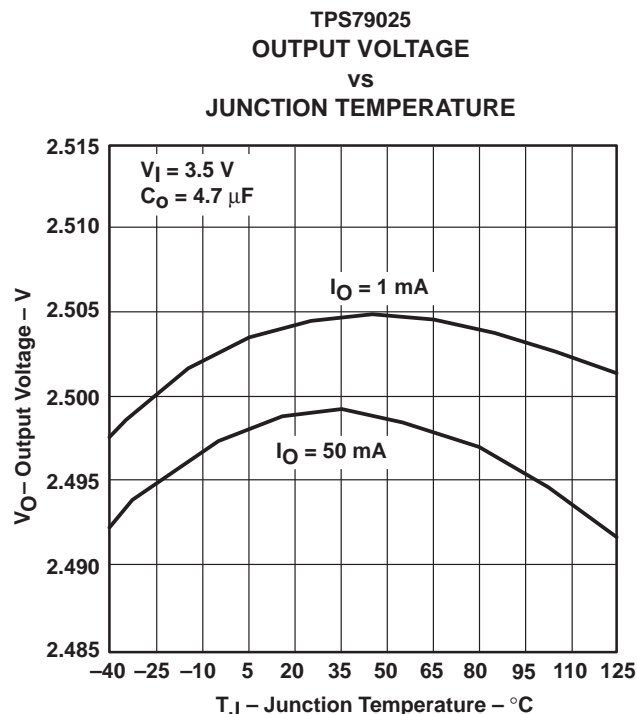


Figure 5

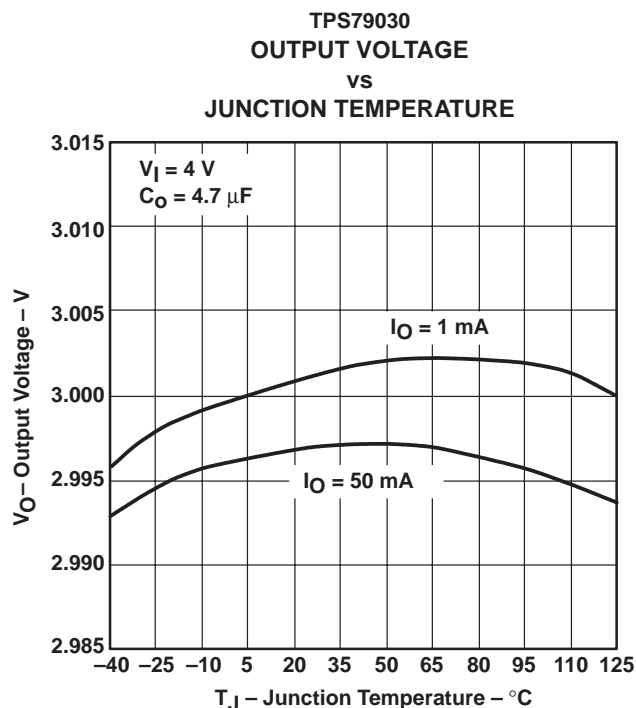


Figure 6

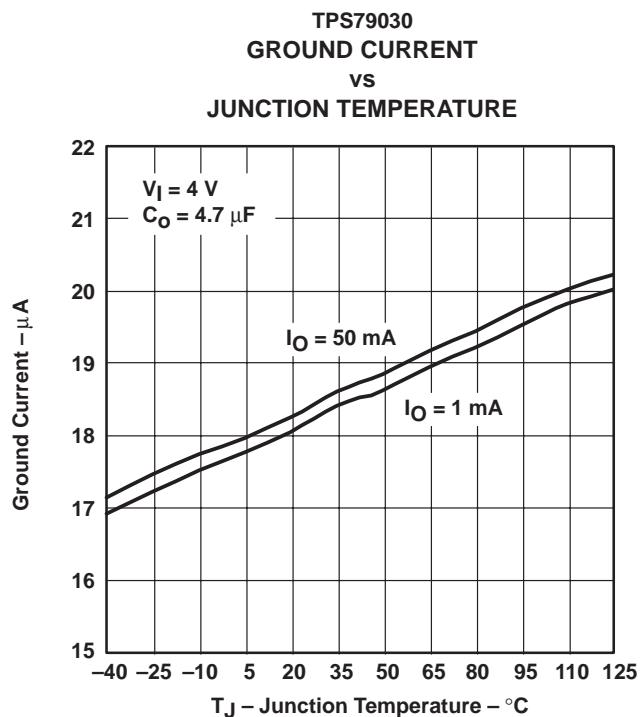


Figure 7

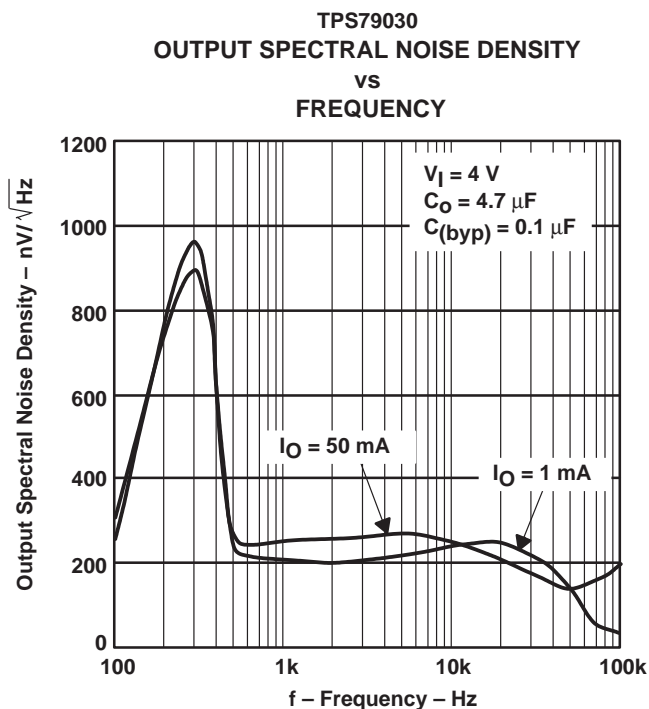


Figure 8

TYPICAL CHARACTERISTICS

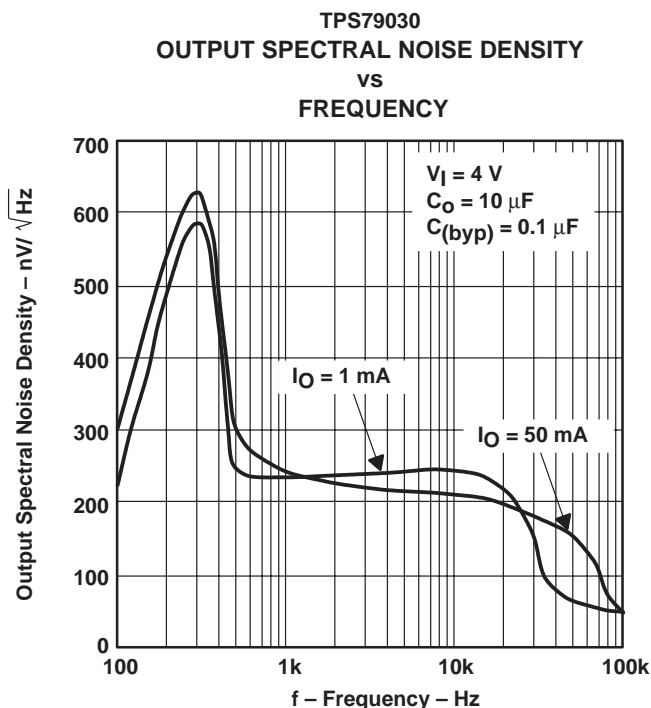


Figure 9

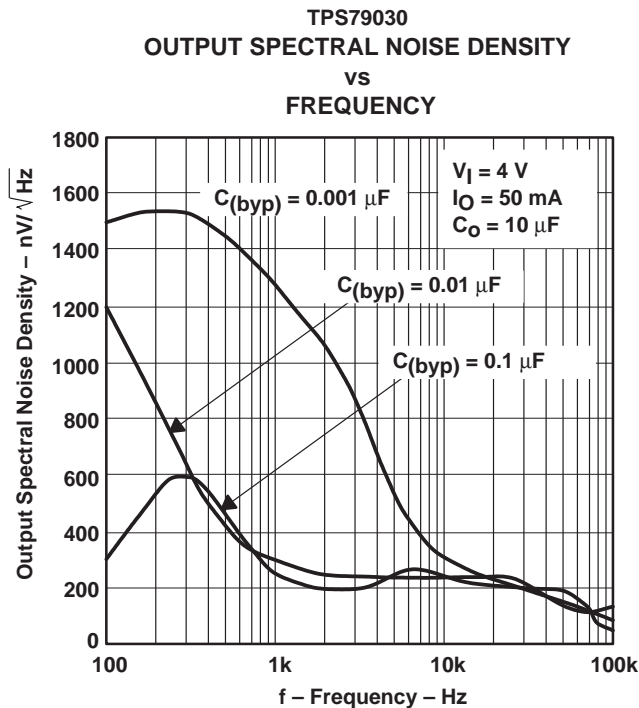


Figure 10

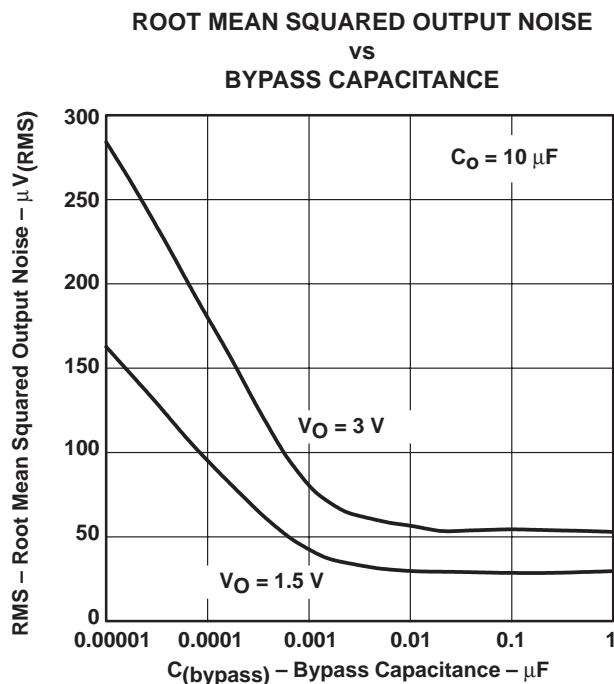


Figure 11

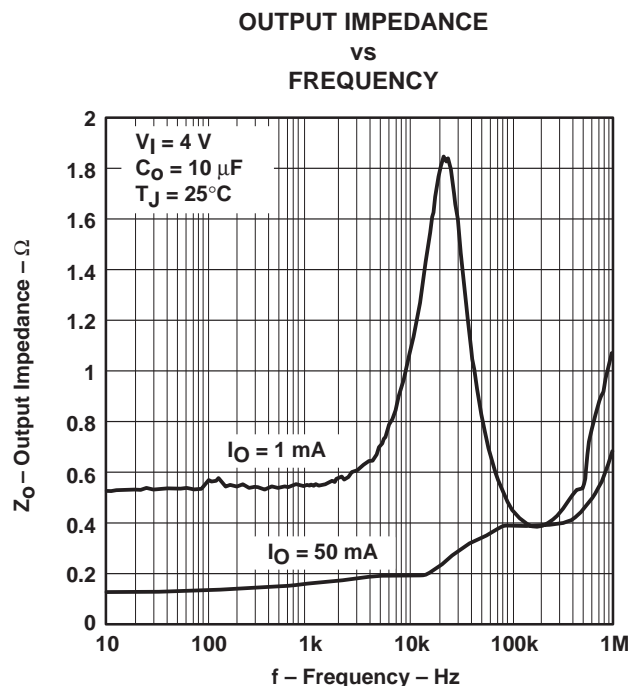
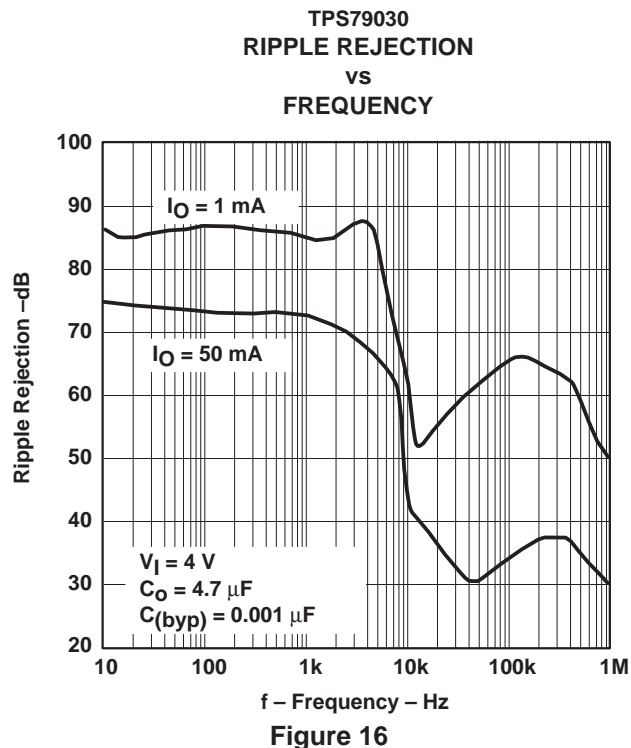
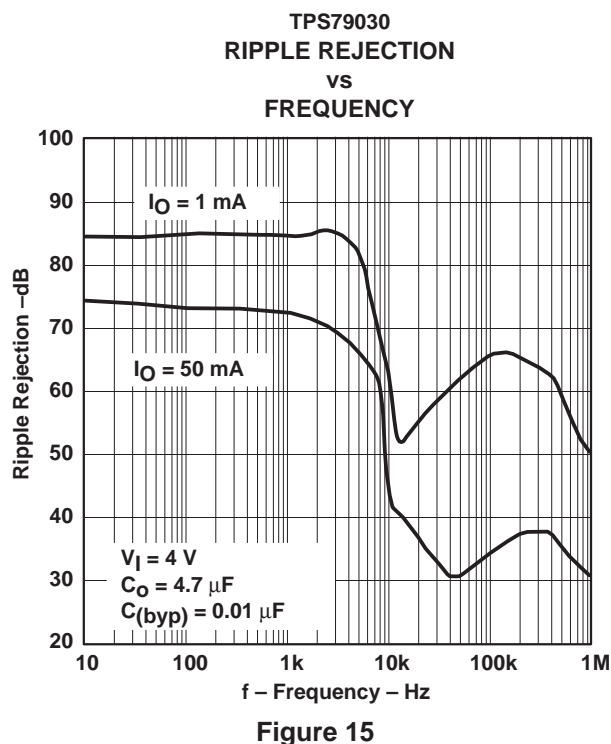
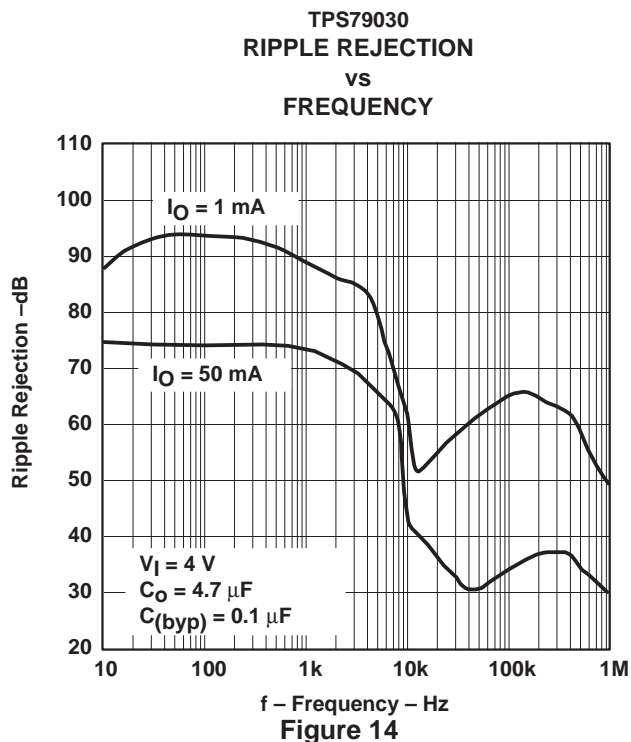
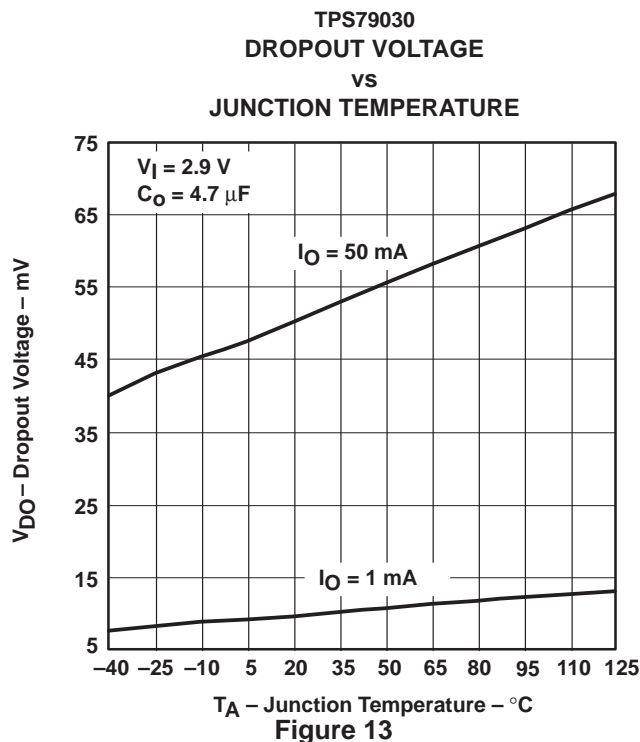


Figure 12

TYPICAL CHARACTERISTICS



TYPICAL CHARACTERISTICS

TPS79030
OUTPUT VOLTAGE, ENABLE VOLTAGE
vs
TIME (START-UP)

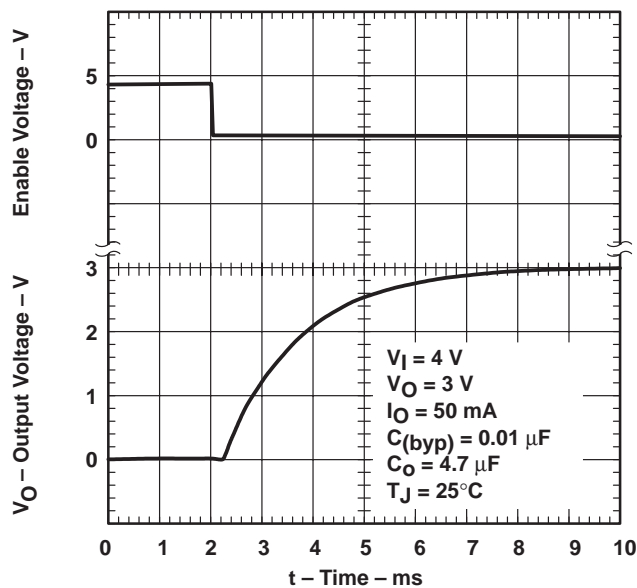


Figure 17

TPS79030
OUTPUT VOLTAGE, ENABLE VOLTAGE
vs
TIME (START-UP)

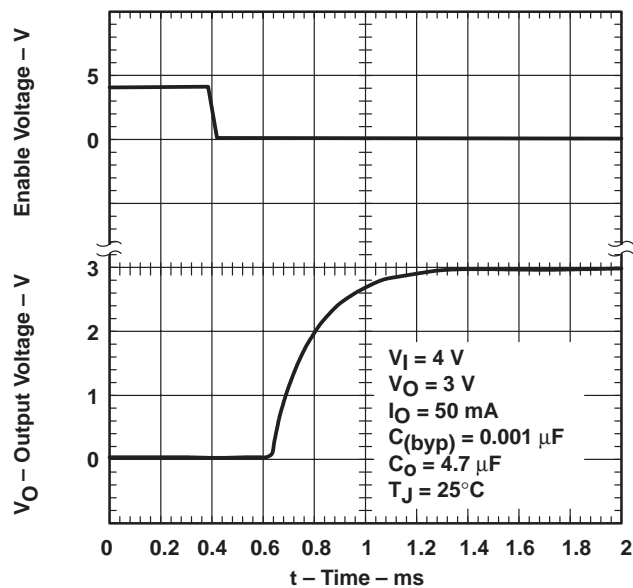


Figure 18

TPS79030
OUTPUT VOLTAGE, ENABLE VOLTAGE
vs
TIME (START-UP)

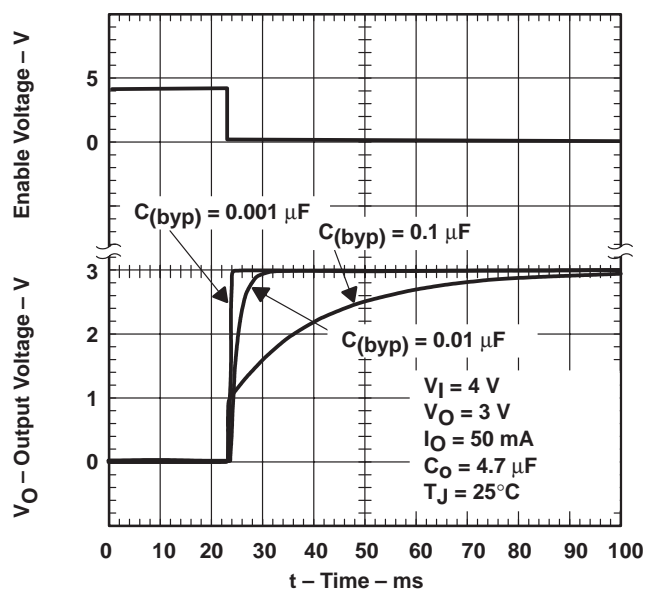


Figure 19

TYPICAL CHARACTERISTICS

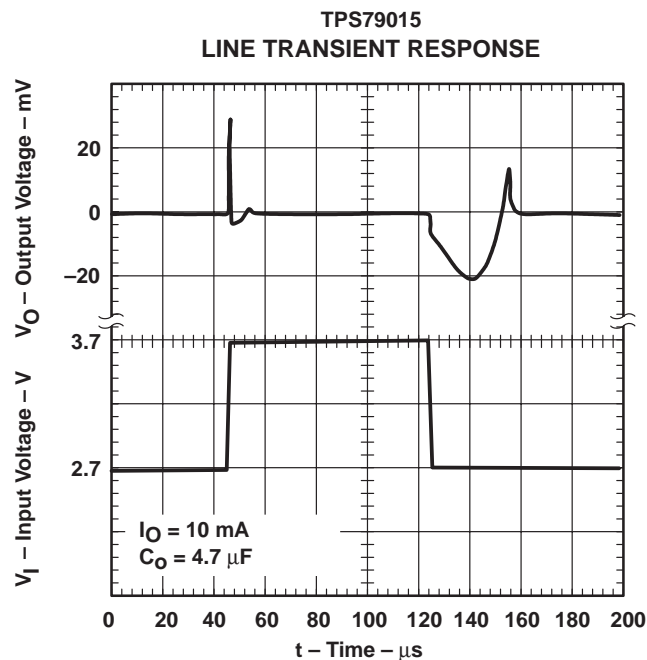


Figure 20

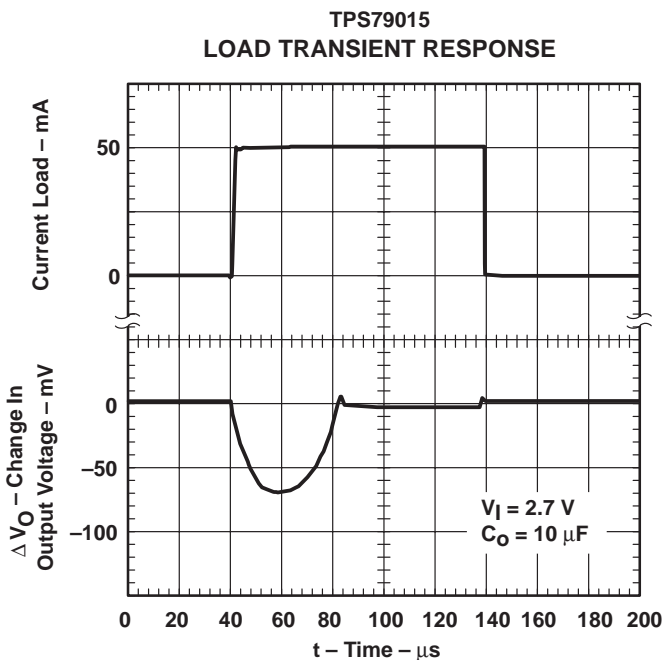


Figure 21

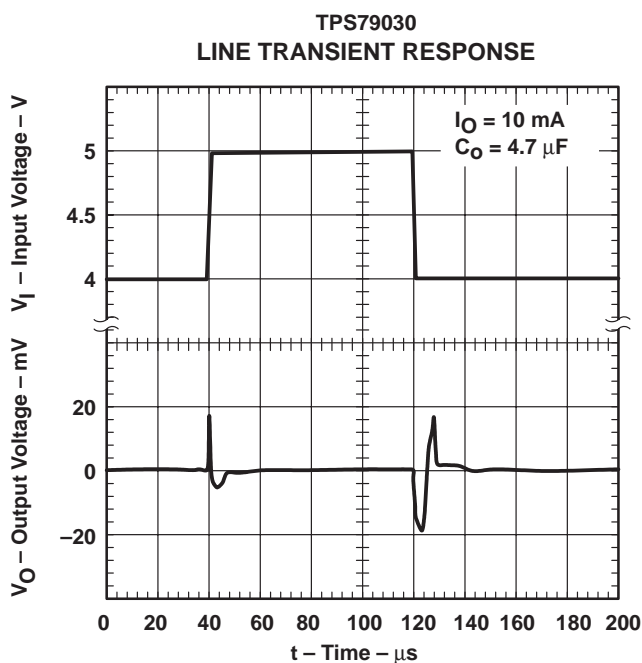


Figure 22

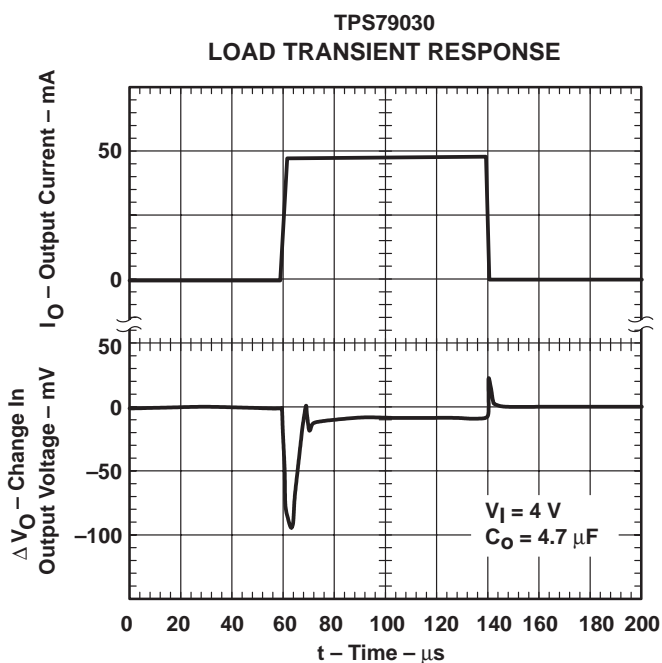


Figure 23

TYPICAL CHARACTERISTICS

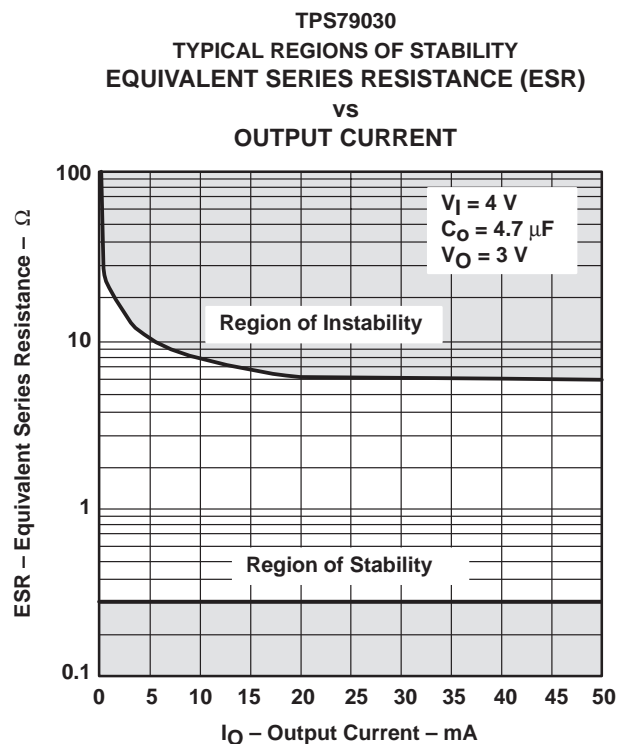


Figure 24

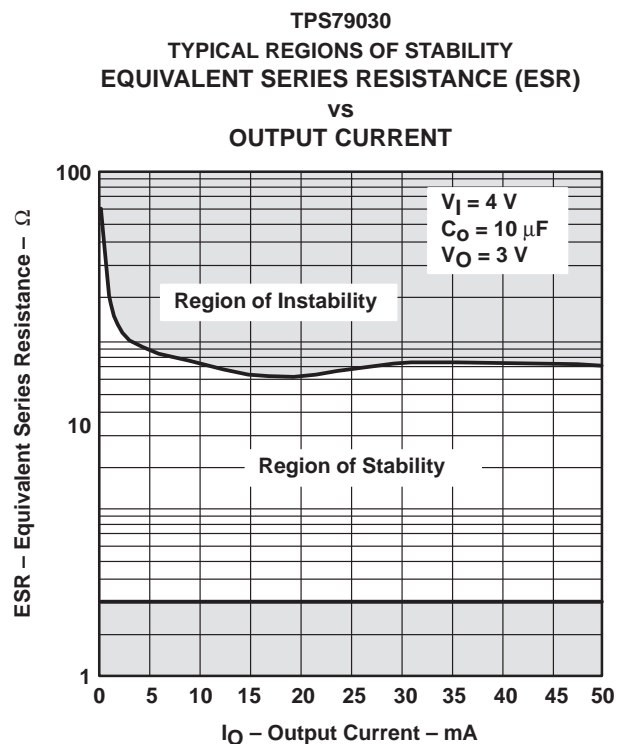


Figure 25

APPLICATION INFORMATION

The TPS790xx family of low-dropout (LDO) regulators have been optimized for use in battery-operated equipment. They feature extremely low dropout voltages, low quiescent current (17 μA typically), and enable inputs to reduce supply currents to less than 1 μA when the regulators are turned off.

A typical application circuit is shown in Figure 21.

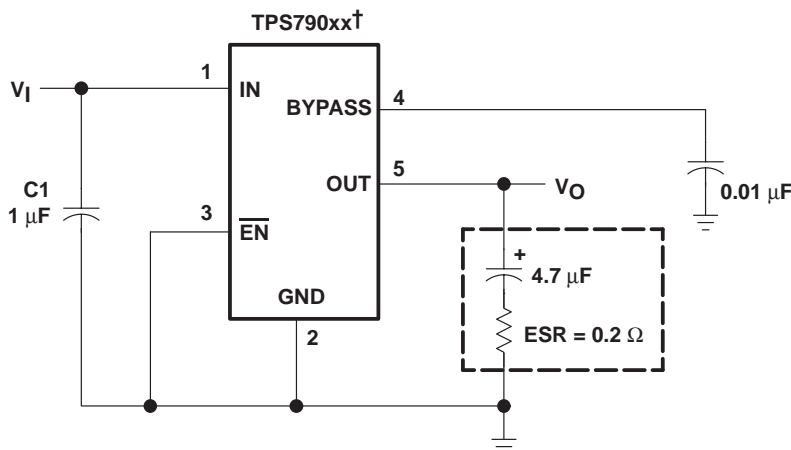


Figure 26. Typical Application Circuit

external capacitor requirements

Although not required, a 0.047- μF or larger ceramic input bypass capacitor, connected between IN and GND and located close to the TPS790xx, is recommended to improve transient response and noise rejection. A higher-value electrolytic input capacitor may be necessary if large, fast-rise-time load transients are anticipated and the device is located several inches from the power source.

Like all low dropout regulators, the TPS790xx requires an output capacitor connected between OUT and GND to stabilize the internal control loop. The minimum recommended capacitance is 4.7 μF . The ESR (equivalent series resistance) of the capacitor should be between 0.2 Ω and 10 Ω to ensure stability. Capacitor values larger than 4.7 μF are acceptable, and allow the use of smaller ESR values. Capacitances less than 4.7 μF are not recommended because they require careful selection of ESR to ensure stability. Solid tantalum electrolytic, aluminum electrolytic, and multilayer ceramic capacitors are all suitable, provided they meet the requirements described above. Most of the commercially available 4.7 μF surface-mount solid tantalum capacitors, including devices from Sprague, Kemet, and Nichico, meet the ESR requirements stated above. Multilayer ceramic capacitors may have very small equivalent series resistances and may thus require the addition of a low value series resistor to ensure stability.

CAPACITOR SELECTION

| PART NO. | MFR. | VALUE | MAX ESR† | SIZE (H × L × W)† |
|------------------|---------|-------------------|--------------|-------------------|
| T494B475K016AS | KEMET | 4.7 μF | 1.5 Ω | 1.9 × 3.5 × 2.8 |
| 195D106x0016x2T | SPRAGUE | 10 μF | 1.5 Ω | 1.3 × 7.0 × 2.7 |
| 695D106x003562T | SPRAGUE | 10 μF | 1.3 Ω | 2.5 × 7.6 × 2.5 |
| TPSC475K035R0600 | AVX | 4.7 μF | 0.6 Ω | 2.6 × 6.0 × 3.2 |

† Size is in mm. The ESR maximum resistance is in Ohms at 100 kHz and $T_A = 25^\circ\text{C}$. Contact the manufacturer for the minimum ESR values.

APPLICATION INFORMATION

external capacitor requirements (continued)

The external bypass capacitor, used in conjunction with an internal resistor to form a low-pass filter, should be a low ESR ceramic capacitor. For example, the TPS79030 exhibits only 56 μV_{RMS} of output voltage noise using a 0.01 μF ceramic bypass capacitor and a 10 μF ceramic output capacitors. Note that the output will start up slower as the bypass capacitance increases due to the RC time constant at the bypass pin that is created by the internal 150 k Ω resistor and external capacitor.

power dissipation and junction temperature

Specified regulator operation is assured to a junction temperature of 125°C; the maximum junction temperature should be restricted to 125°C under normal operating conditions. This restriction limits the power dissipation the regulator can handle in any given application. To ensure the junction temperature is within acceptable limits, calculate the maximum allowable dissipation, $P_{\text{D(max)}}$, and the actual dissipation, P_{D} , which must be less than or equal to $P_{\text{D(max)}}$.

The maximum-power-dissipation limit is determined using the following equation:

$$P_{\text{D(max)}} = \frac{T_{\text{Jmax}} - T_{\text{A}}}{R_{\theta\text{JA}}}$$

Where:

T_{Jmax} is the maximum allowable junction temperature.

$R_{\theta\text{JA}}$ is the thermal resistance junction-to-ambient for the package, i.e., 285°C/W for the 5-terminal SOT23.

T_{A} is the ambient temperature.

The regulator dissipation is calculated using:

$$P_{\text{D}} = (V_{\text{I}} - V_{\text{O}}) \times I_{\text{O}}$$

Power dissipation resulting from quiescent current is negligible. Excessive power dissipation will trigger the thermal protection circuit.

regulator protection

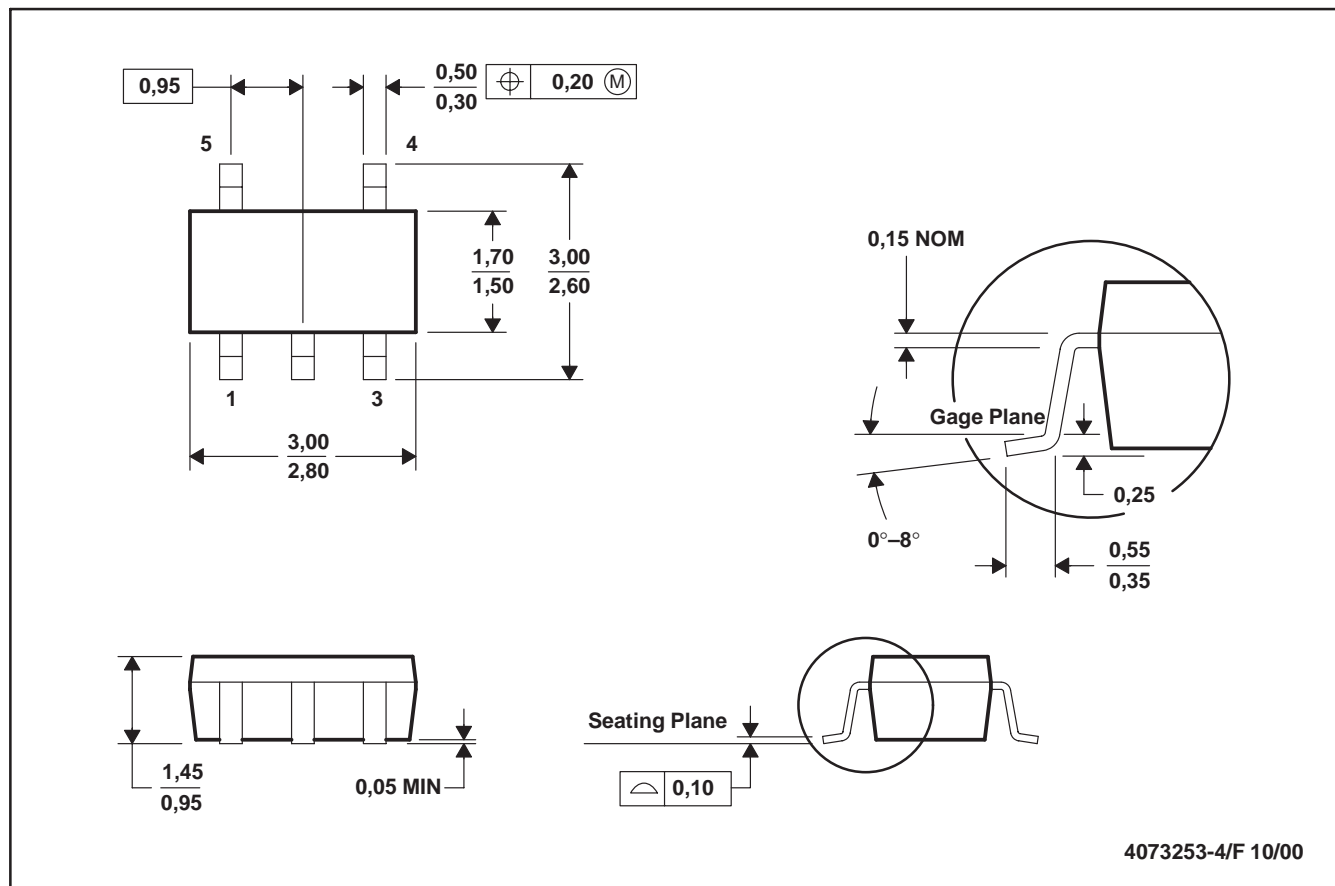
The TPS790xx PMOS-pass transistor has a built-in back diode that conducts reverse current when the input voltage drops below the output voltage (e.g., during power down). Current is conducted from the output to the input and is not internally limited. If extended reverse voltage operation is anticipated, external limiting might be appropriate.

The TPS790xx features internal current limiting and thermal protection. During normal operation, the TPS790xx limits output current to approximately 350 mA. When current limiting engages, the output voltage scales back linearly until the overcurrent condition ends. While current limiting is designed to prevent gross device failure, care should be taken not to exceed the power dissipation ratings of the package. If the temperature of the device exceeds approximately 165°C, thermal-protection circuitry shuts it down. Once the device has cooled down to below approximately 140°C, regulator operation resumes.

MECHANICAL DATA

DBV (R-PDSO-G5)

PLASTIC SMALL-OUTLINE



- 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.
 - D. Falls within JEDEC MO-178

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