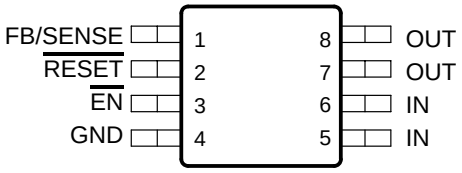
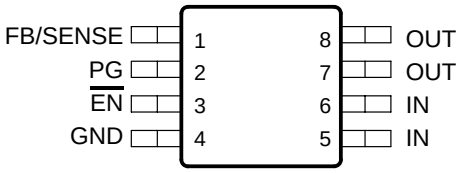
- **Open Drain Power-On Reset With 220-ms Delay (TPS773xx)**
- **Open Drain Power-Good (PG) Status Output (TPS774xx)**
- **250-mA Low-Dropout Voltage Regulator**
- **Available in 1.5-V, 1.6-V (TPS77316 Only), 1.8-V, 2.7-V, 2.8-V, 3.3-V, 5.0-V Fixed Output and Adjustable Versions**
- **Dropout Voltage Typically 200 mV at 250 mA (TPS77333, TPS77433)**
- **Ultralow 92-μA Quiescent Current (Typ)**
- **8-Pin MSOP (DGK) Package**
- **Low Noise (55 μV_{rms}) Without an External Filter (Bypass) Capacitor (TPS77318, TPS77418)**
- **2% Tolerance Over Specified Conditions For Fixed-Output Versions**
- **Fast Transient Response**
- **Thermal Shutdown Protection**
- **See the TPS779xx Family of Devices for Active High Enable**

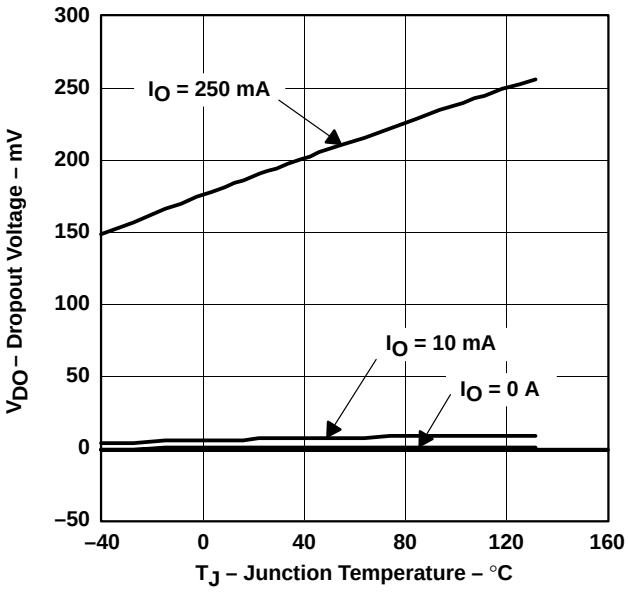
TPS773xx
DGK Package
(TOP VIEW)



TPS774xx
DGK Package
(TOP VIEW)



TPS77x33
DROPOUT VOLTAGE
vs
JUNCTION TEMPERATURE



description

The TPS773xx and TPS774xx are low-dropout regulators with integrated power-on reset and power good (PG) function respectively. These devices are capable of supplying 250 mA of output current with a dropout of 200 mV (TPS77333, TPS77433). Quiescent current is 92 μA at full load dropping down to 1 μA when device is disabled. These devices are optimized to be stable with a wide range of output capacitors including low ESR ceramic (10 μF) or low capacitance (1 μF) tantalum capacitors. These devices have extremely low noise output performance (55 μV_{rms}) without using any added filter capacitors. TPS773xx and TPS774xx are designed to have fast transient response for larger load current changes.

The TPS773xx or TPS774xx is offered in 1.5-V, 1.6 V (TPS77316 only), 1.8-V, 2.7-V, 2.8-V, 3.3-V, and 5.0-V fixed-voltage versions and in an adjustable version (programmable over the range of 1.5 V to 5.5 V). Output voltage tolerance is 2% over line, load, and temperature ranges. The TPS773xx and TPS774xx families are available in 8-pin MSOP (DGK) packages.

Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

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description (continued)

Because the PMOS device behaves as a low-value resistor, the dropout voltage is very low (typically 200 mV at an output current of 250 mA for 3.3-volt option) and is directly proportional to the output current. Additionally, since the PMOS pass element is a voltage-driven device, the quiescent current is very low and independent of output loading (typically 92 μA over the full range of output current, 0 mA to 250 mA). These two key specifications yield a significant improvement in operating life for battery-powered systems.

The device is enabled when the $\overline{EN}$ pin is connected to a low-level input voltage. This LDO family also features a sleep mode; applying a TTL high signal to $\overline{EN}$ (enable) shuts down the regulator, reducing the quiescent current to less than 1 μA at T_J = 25°C.

The TPS773xx features an integrated power-on reset, commonly used as a supply voltage supervisor (SVS), or reset output voltage. The $\overline{RESET}$ output of the TPS773xx initiates a reset in DSP, microcomputer or microprocessor systems at power up and in the event of an undervoltage condition. An internal comparator in the TPS773xx monitors the output voltage of the regulator to detect an undervoltage condition on the regulated output voltage. When OUT reaches 95% of its regulated voltage, $\overline{RESET}$ will go to a high-impedance state after a 220-ms delay. $\overline{RESET}$ will go to low-impedance state when OUT is pulled below 95% (i.e. over load condition) of its regulated voltage.

For the TPS774xx, the power good terminal (PG) is an active high output, which can be used to implement a power-on reset or a low-battery indicator. An internal comparator in the TPS774xx monitors the output voltage of the regulator to detect an undervoltage condition on the regulated output voltage. When OUT falls below 82% of its regulated voltage, PG will go to a low-impedance state. PG will go to a high-impedance state when OUT is above 82% of its regulated voltage.

AVAILABLE OPTIONS

T_J	OUTPUT VOLTAGE (V)	PACKAGED DEVICES MSOP (DGK)			
	TYP		TPS773xx SYMBOL		TPS774xx SYMBOL
–40°C to 125°C	5.0	TPS77350DGK	AGN	TPS77450DGK	AGW
	3.3	TPS77333DGK	AGM	TPS77433DGK	AGV
	2.8	TPS77328DGK	AGK	TPS77428DGK	AGT
	2.7	TPS77327DGK	AGJ	TPS77427DGK	AGS
	1.8	TPS77318DGK	AGH	TPS77418DGK	AGQ
	1.6	TPS77316DGK	AWF	—	—
	1.5	TPS77315DGK	AGG	TPS77415DGK	AGP
	Adjustable 1.5 V to 5.5 V	TPS77301DGK	AGF	TPS77401DGK	AGO

NOTE: The TPS77301 and TPS77401 are programmable using an external resistor divider (see application information). The DGK package is available taped and reeled. Add an R suffix to the device type (e.g., TPS77301DGKR).

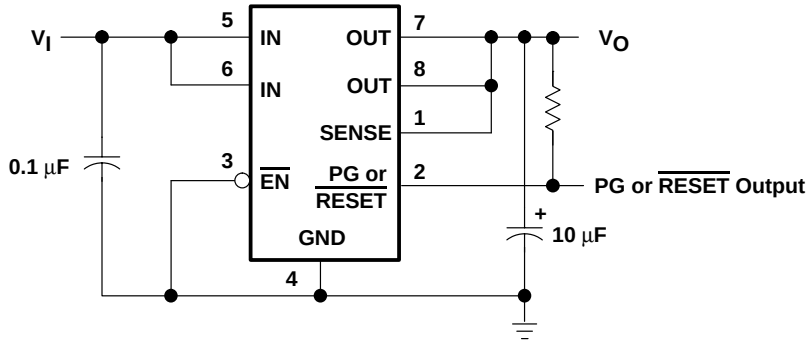
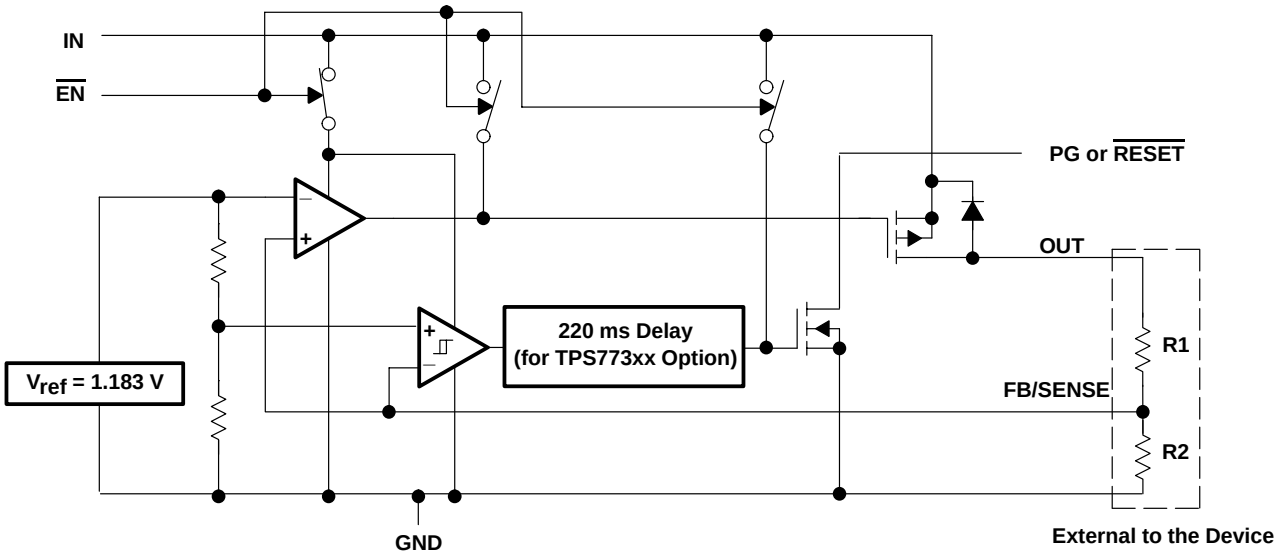


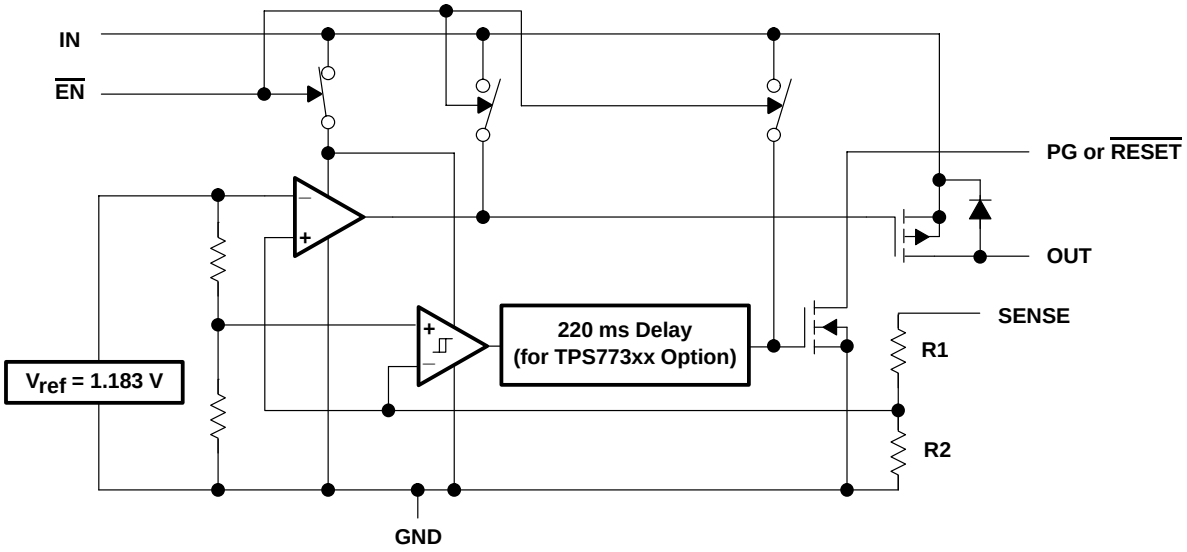
Figure 1. Typical Application Configuration (For Fixed Output Options)

functional block diagrams

adjustable version



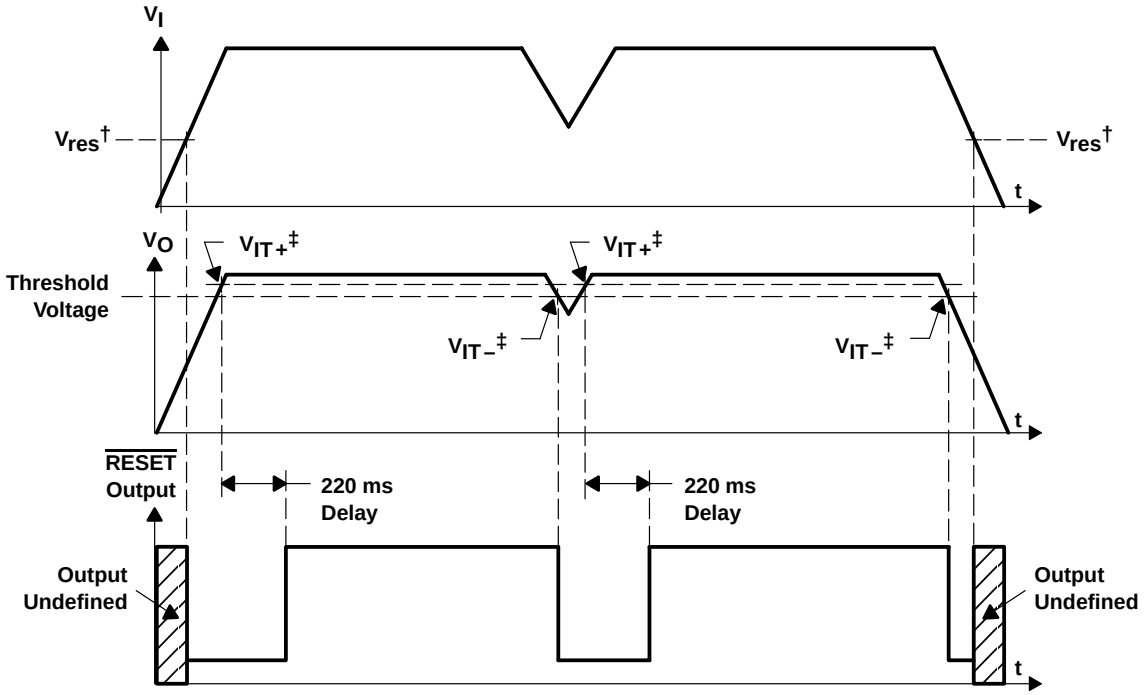
fixed-voltage version



Terminal Functions

TERMINAL NAME	TERMINAL NO.	I/O	DESCRIPTION
TPS773XX			
FB/SENSE	1	I	Feedback input voltage for adjustable device (sense input for fixed options)
$\overline{\text{RESET}}$	2	O	Reset output
$\overline{\text{EN}}$	3	I	Enable input
GND	4		Regulator ground
IN	5, 6	I	Input voltage
OUT	7, 8	O	Regulated output voltage
TPS774XX			
FB/SENSE	1	I	Feedback input voltage for adjustable device (sense input for fixed options)
PG	2	O	Power good
$\overline{\text{EN}}$	3	I	Enable input
GND	4		Regulator ground
IN	5, 6	I	Input voltage
OUT	7, 8	O	Regulated output voltage

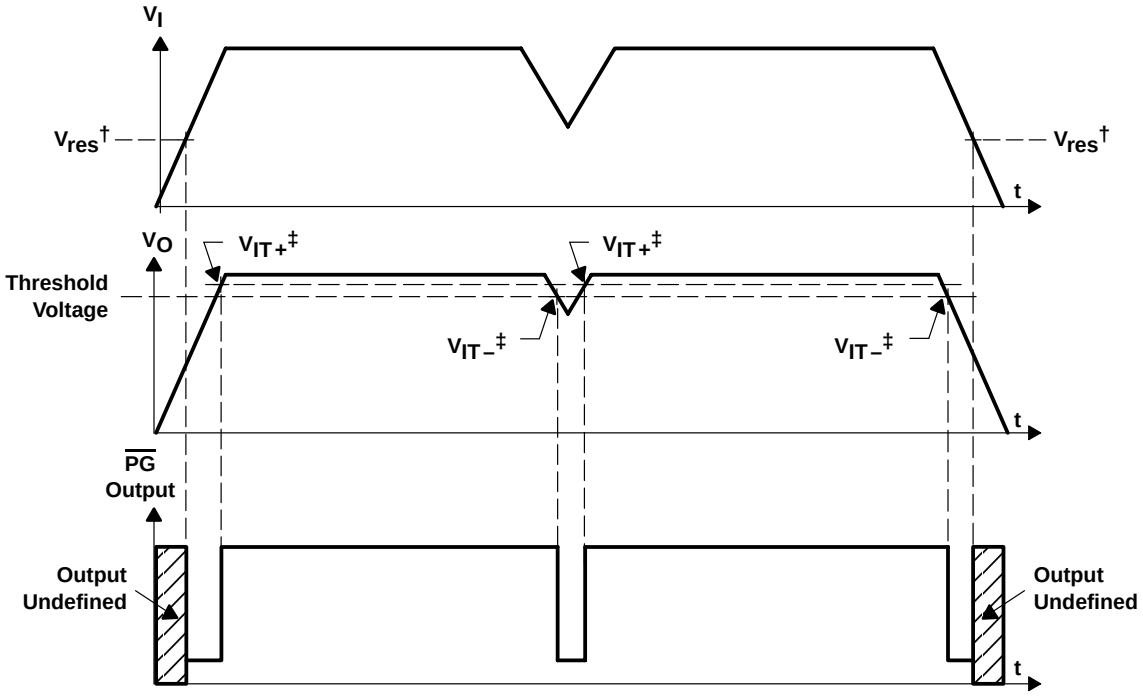
TPS773xx $\overline{\text{RESET}}$ timing diagram



† V_{res} is the minimum input voltage for a valid $\overline{\text{RESET}}$. The symbol V_{res} is not currently listed within EIA or JEDEC standards for semiconductor symbology.

‡ V_{IT} – Trip voltage is typically 5% lower than the output voltage (95%V_O) V_{IT-} to V_{IT+} is the hysteresis voltage.

TPS774xx PG timing diagram



† V_{res} is the minimum input voltage for a valid PG. The symbol V_{res} is not currently listed within EIA or JEDEC standards for semiconductor symbology.

‡ V_{IT} – Trip voltage is typically 18% lower than the output voltage (82%V_O) V_{IT-} to V_{IT+} is the hysteresis voltage.

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

Input voltage range‡, V_I . . . . . –0.3 V to 13.5 V
Voltage range at EN . . . . . –0.3 V to 16.5 V
Maximum RESET voltage (TPS773xx) . . . . . 16.5 V
Maximum PG voltage (TPS774xx) . . . . . 16.5 V
Peak output current . . . . . Internally limited
Continuous total power dissipation . . . . . See Dissipation Rating Table
Output voltage, V_O (OUT, FB) . . . . . 5.5 V
Operating virtual junction temperature range, T_J . . . . . –40°C to 125°C
Storage temperature range, T_{stg} . . . . . –65°C to 150°C
ESD rating, HBM . . . . . 2 kV

† 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.
‡ All voltage values are with respect to network terminal ground.

DISSIPATION RATING TABLE – FREE-AIR TEMPERATURES

PACKAGE	AIR FLOW (CFM)	θ_{JA} (°C/W)	θ_{JC} (°C/W)	T_A < 25°C POWER RATING	DERATING FACTOR ABOVE T_A = 25°C	T_A = 70°C POWER RATING	T_A = 85°C POWER RATING
DGK	0	266.2	3.84	376 mW	3.76 mW/°C	207 mW	150 mW
	150	255.2	3.92	392 mW	3.92 mW/°C	216 mW	157 mW
	250	242.8	4.21	412 mW	4.12 mW/°C	227 mW	165 mW

recommended operating conditions

	MIN	MAX	UNIT
Input voltage, V_I§	2.7	10	V
Output voltage range, V_O	1.5	5.5	V
Output current, I_O (see Note 1)	0	250	mA
Operating virtual junction temperature, T_J (see Note 1)	–40	125	°C

§ To calculate the minimum input voltage for your maximum output current, use the following equation: $V_{I(min)} = V_{O(max)} + V_{DO(max\ load)}$.
NOTE 1: Continuous 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 junction temperature range (T_J = –40°C to 125°C), $V_I = V_{O(typ)}$ + 1 V, I_O = 1 mA, $\overline{EN}$ = 0 V, C_O = 10 μF (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
Output voltage (see Notes 2 and 4)	Adjustable voltage	1.5 V ≤ V_O ≤ 5.5 V,	T_J = 25°C		V_O		V
		1.5 V ≤ V_O ≤ 5.5 V		0.98V_O		1.02V_O	
	1.5-V Output	T_J = 25°C,	2.7 V < V_{IN} < 10 V		1.5		V
		2.7 V < V_{IN} < 10 V		1.470		1.530	
	1.6-V Output	T_J = 25°C,	2.7 V < V_{IN} < 10 V		1.6		V
		2.7 V < V_{IN} < 10 V		1.568		1.632	
	1.8-V Output	T_J = 25°C,	2.8 V < V_{IN} < 10 V		1.8		V
		2.8 V < V_{IN} < 10 V		1.764		1.836	
	2.7-V Output	T_J = 25°C,	3.7 V < V_{IN} < 10 V		2.7		
		3.7 V < V_{IN} < 10 V		2.646		2.754	
	2.8-V Output	T_J = 25°C,	3.8 V < V_{IN} < 10 V		2.8		
		3.8 V < V_{IN} < 10 V		2.744		2.856	
	3.3-V Output	T_J = 25°C,	4.3 V < V_{IN} < 10 V		3.3		
		4.3 V < V_{IN} < 10 V		3.234		3.366	
	5.0-V Output	T_J = 25°C,	6.0 V < V_{IN} < 10 V		5.0		V
		6.0 V < V_{IN} < 10 V		4.900		5.100	
Quiescent current (GND current) (see Notes 2 and 4)		T_J = 25°C			92		μA
						125	
Output voltage line regulation ($\Delta V_O/V_O$) (see Note 3)		V_O + 1 V < V_I ≤ 10 V,	T_J = 25°C		0.005		%/V
		V_O + 1 V < V_I ≤ 10 V				0.05	%/V
Load regulation		T_J = 25°C			1		mV
Output noise voltage		BW = 300 Hz to 100 kHz, T_J = 25°C, TPS77318, TPS77418			55		μVrms
Output current limit		V_O = 0 V			0.9	1.3	A
Peak output current		2 ms pulse width,	50% duty cycle		400		mA
Thermal shutdown junction temperature					144		°C
Standby current		$\overline{EN}$ = V_I,	T_J = 25°C			1	μA
		$\overline{EN}$ = V_I				3	μA
FB input current	Adjustable voltage	FB = 1.5 V				1	μA
High level enable input voltage				2			V
Low level enable input voltage						0.7	V
Enable input current				–1		1	μA
Power supply ripple rejection (TPS77318, TPS77418)		f = 1 kHz,	T_J = 25°C		55		dB

NOTES: 2. Minimum input operating voltage is 2.7 V or $V_{O(typ)}$ + 1 V, whichever is greater. Maximum input voltage = 10 V, minimum output current 1 mA.

3. If V_O < 1.8 V then $V_{I(max)}$ = 10 V, $V_{I(min)}$ = 2.7 V:

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

If V_O > 2.5 V then $V_{I(max)}$ = 10 V, $V_{I(min)} = V_O$ + 1 V:

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

4. I_O = 1 mA to 250 mA

electrical characteristics over recommended operating junction temperature range (T_J = –40°C to 125°C), $V_I = V_{O(typ)}$ + 1 V, I_O = 1 mA, $\overline{EN}$ = 0 V, C_O = 10 μF (unless otherwise noted) (continued)

PARAMETER			TEST CONDITIONS	MIN	TYP	MAX	UNIT
PG (TPS774xx)	Minimum input voltage for valid PG		$I_{(PG)}$ = 300 μA, $V_{(PG)} \le$ 0.8 V		1.1		V
	Trip threshold voltage		V_O decreasing	79		85	%V_O
	Hysteresis voltage		Measured at V_O		0.5		%V_O
	Output low voltage		V_I = 2.7 V, $I_{(PG)}$ = 1 mA		0.15	0.4	V
	Leakage current		$V_{(PG)}$ = 5 V			1	μA
Reset (TPS773xx)	Minimum input voltage for valid $\overline{\text{RESET}}$		$I_{(RESET)}$ = 300 μA		1.1		V
	Trip threshold voltage		V_O decreasing	92		98	%V_O
	Hysteresis voltage		Measured at V_O		0.5		%V_O
	Output low voltage		V_I = 2.7 V, $I_{(RESET)}$ = 1 mA		0.15	0.4	V
	Leakage current		$V_{(RESET)}$ = 5 V			1	μA
	RESET time-out delay				220		ms
V_{DO}	Dropout voltage (see Note 5)	2.8-V Output	I_O = 250 mA, T_J = 25°C		270		mV
			I_O = 250 mA			475	
		3.3-V Output	I_O = 250 mA, T_J = 25°C		200		
			I_O = 250 mA			330	
V_{DO}	Dropout voltage (see Note 5)	5.0-V Output	I_O = 250 mA, T_J = 25°C		125		
			I_O = 250 mA			190	

NOTE 5: IN voltage equals V_O(typ) – 100 mV; 1.5 V, 1.6 V, 1.8-V, and 2.7-V dropout voltage limited by input voltage range limitations (i.e., 3.3 V input voltage needs to drop to 3.2 V for purpose of this test).

TYPICAL CHARACTERISTICS

Table of Graphs

			FIGURE
V_O	Output voltage	vs Output current	2, 3
		vs Junction temperature	4, 5
	Ground current	vs Junction temperature	6
	Power supply rejection ratio	vs Frequency	7
	Output spectral noise density	vs Frequency	8
Z_o	Output impedance	vs Frequency	9
V_{DO}	Dropout voltage	vs Input voltage	10
		vs Junction temperature	11
	Line transient response		12, 14
	Load transient response		13, 15
	Output voltage and enable pulse	vs Time	16
	Equivalent series resistance (ESR)	vs Output current	18 – 21

TYPICAL CHARACTERISTICS

TPS77x33
OUTPUT VOLTAGE
vs
OUTPUT CURRENT

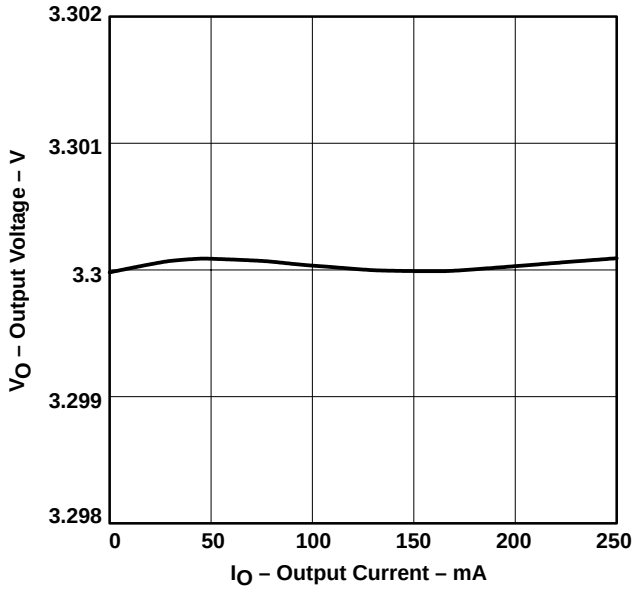


Figure 2

TPS77x18
OUTPUT VOLTAGE
vs
OUTPUT CURRENT

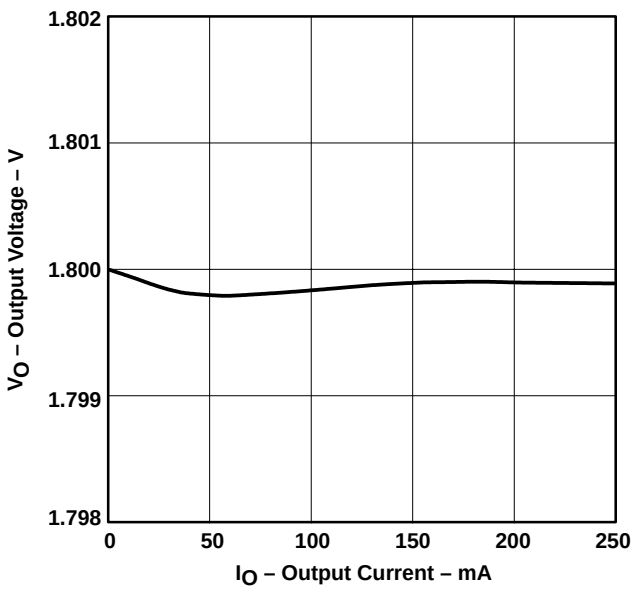


Figure 3

TPS77x33
OUTPUT VOLTAGE
vs
JUNCTION TEMPERATURE

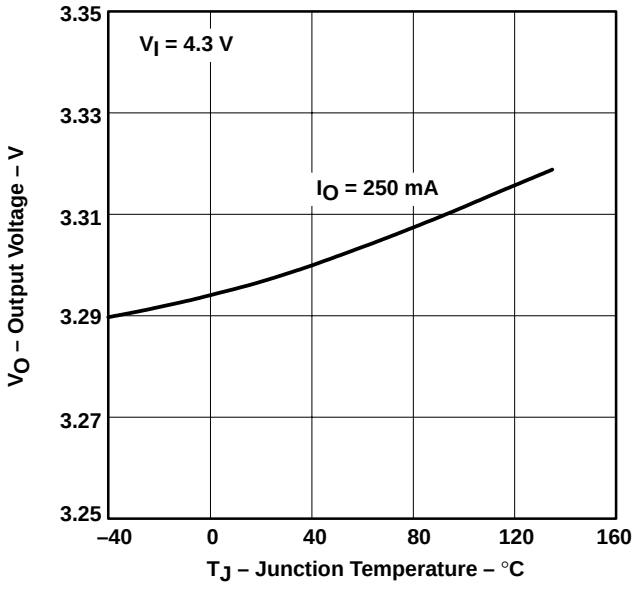


Figure 4

TPS77x18
OUTPUT VOLTAGE
vs
JUNCTION TEMPERATURE

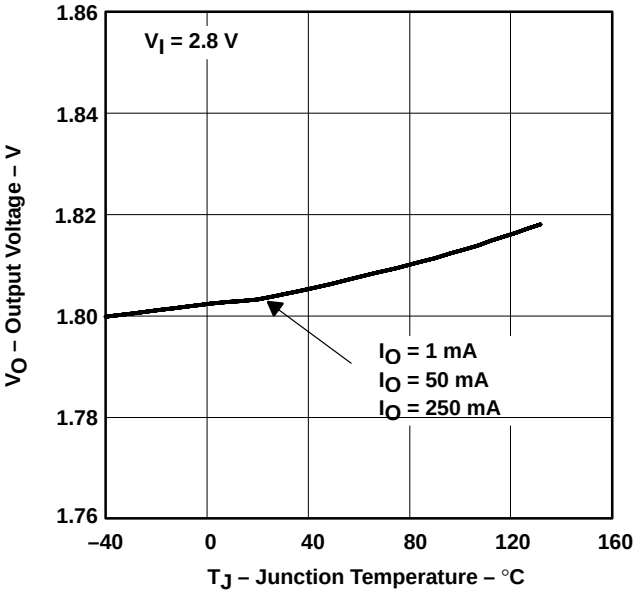


Figure 5

TYPICAL CHARACTERISTICS

TPS77xxx
GROUND CURRENT
vs
JUNCTION TEMPERATURE

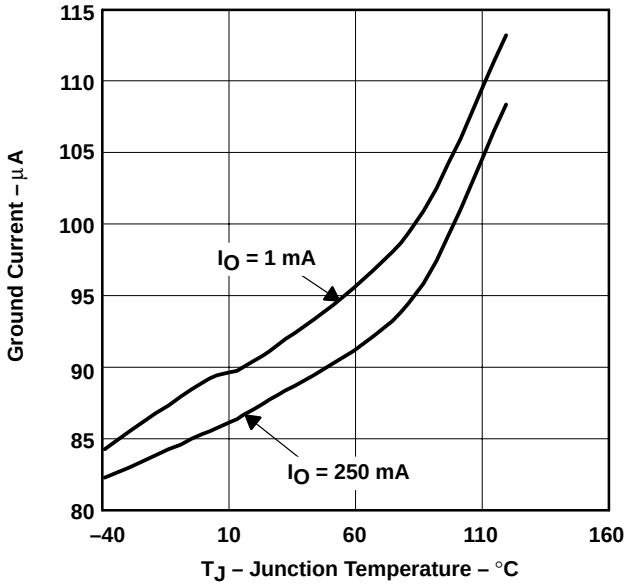


Figure 6

TPS77x33
POWER SUPPLY REJECTION RATIO
vs
FREQUENCY

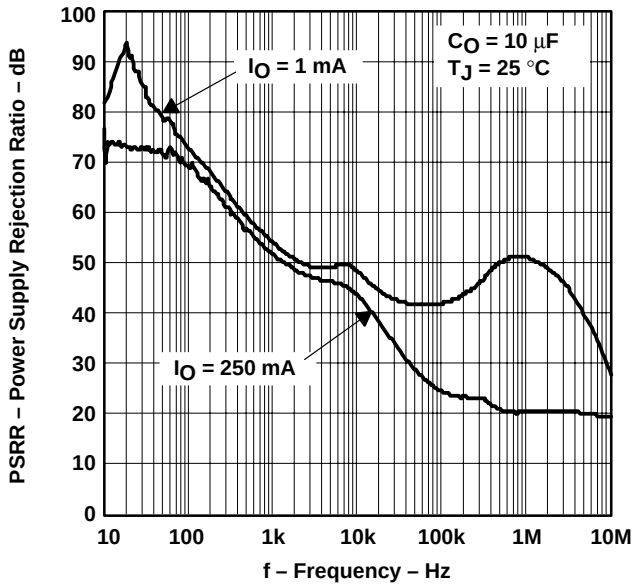


Figure 7

TPS77x33
OUTPUT SPECTRAL NOISE DENSITY
vs
FREQUENCY

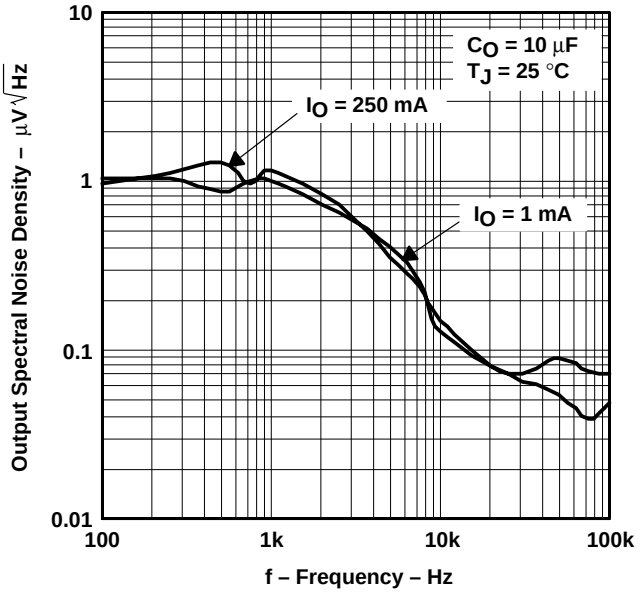


Figure 8

TYPICAL CHARACTERISTICS

TPS77x33
OUTPUT IMPEDANCE
vs
FREQUENCY

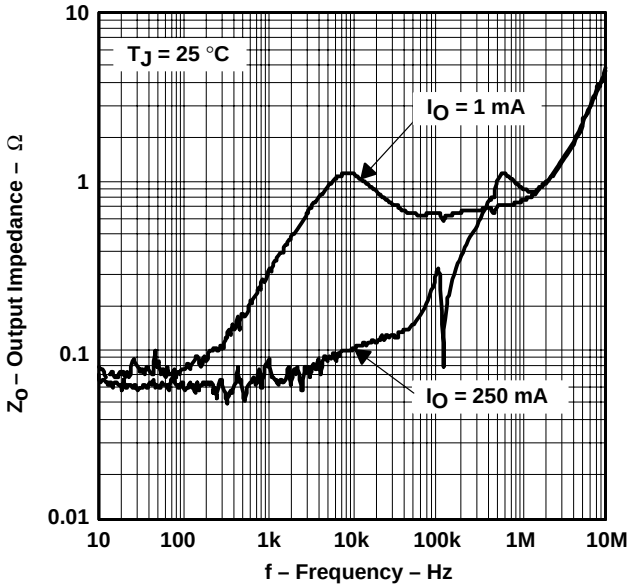


Figure 9

TPS77x01
DROPOUT VOLTAGE
vs
INPUT VOLTAGE

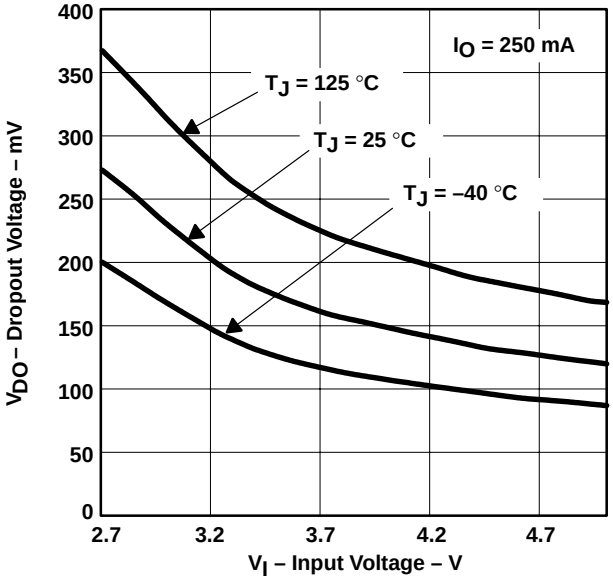


Figure 10

TPS77x33
DROPOUT VOLTAGE
vs
JUNCTION TEMPERATURE

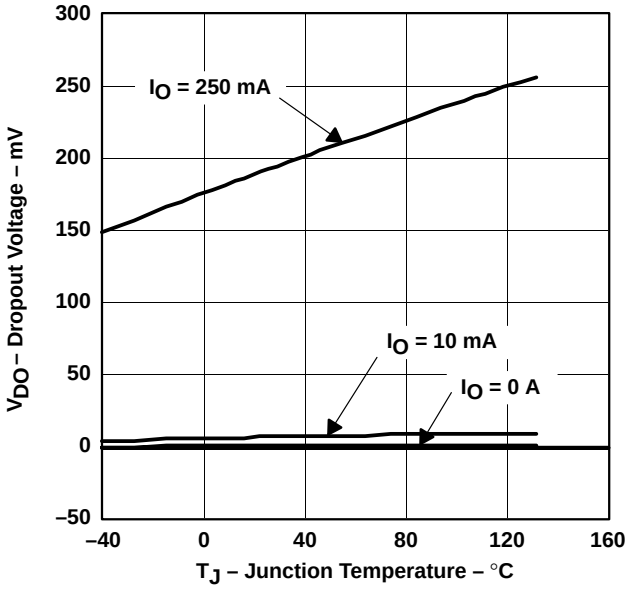


Figure 11

TYPICAL CHARACTERISTICS

TPS77x18
LINE TRANSIENT RESPONSE

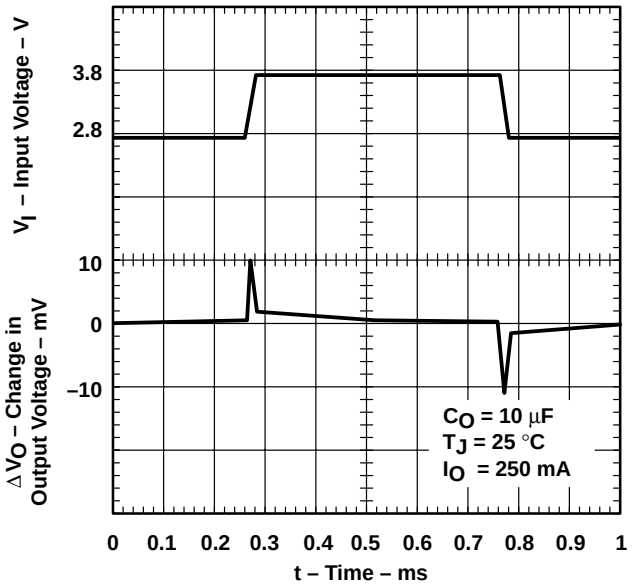


Figure 12

TPS77x18
LOAD TRANSIENT RESPONSE

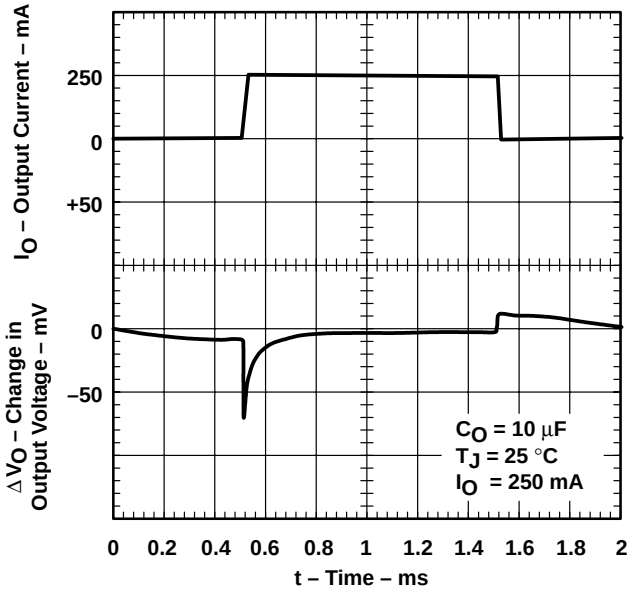


Figure 13

TPS77x33
LINE TRANSIENT RESPONSE

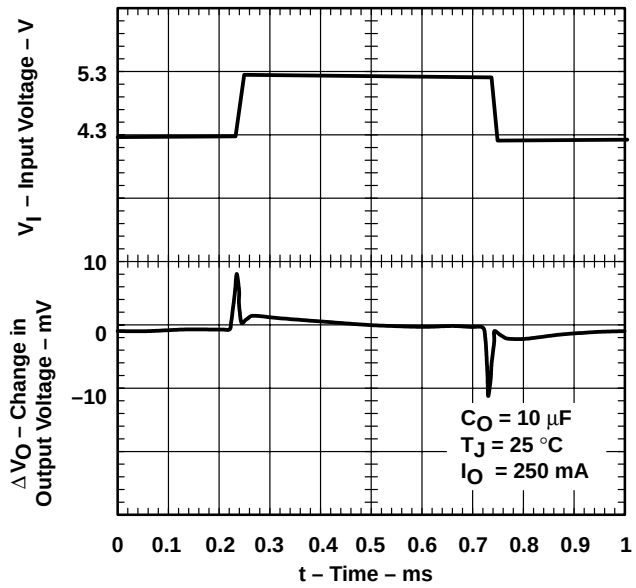


Figure 14

TPS77x33
LOAD TRANSIENT RESPONSE

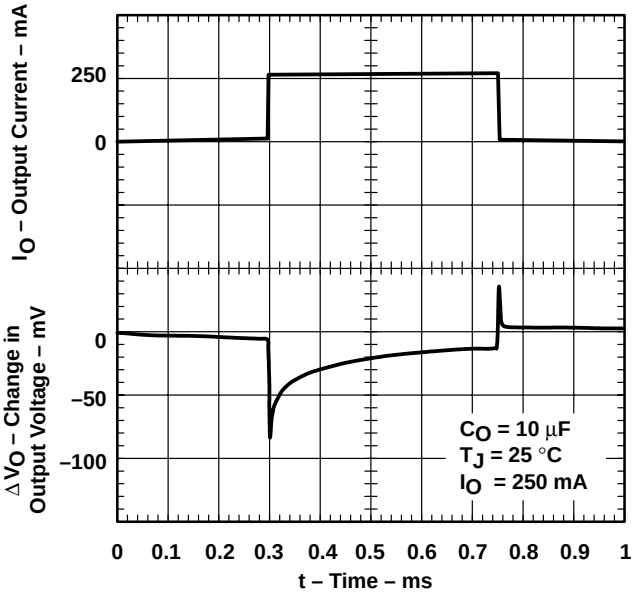


Figure 15

TYPICAL CHARACTERISTICS

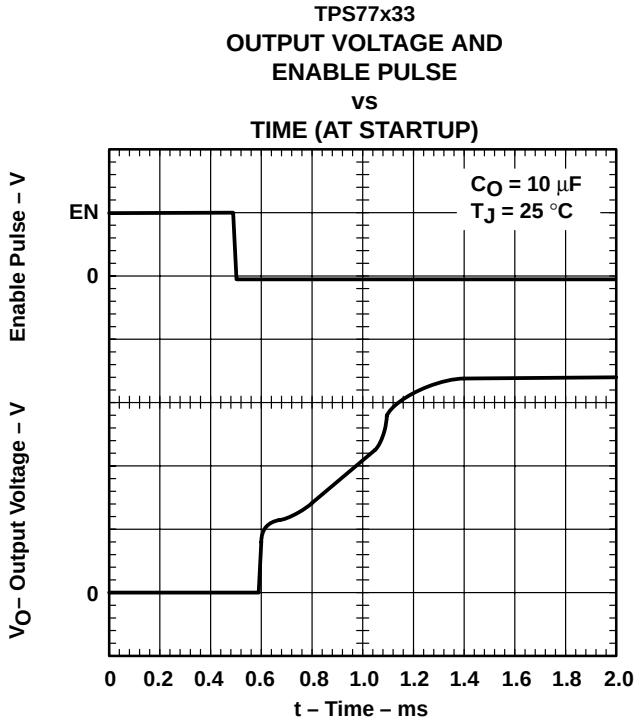


Figure 16

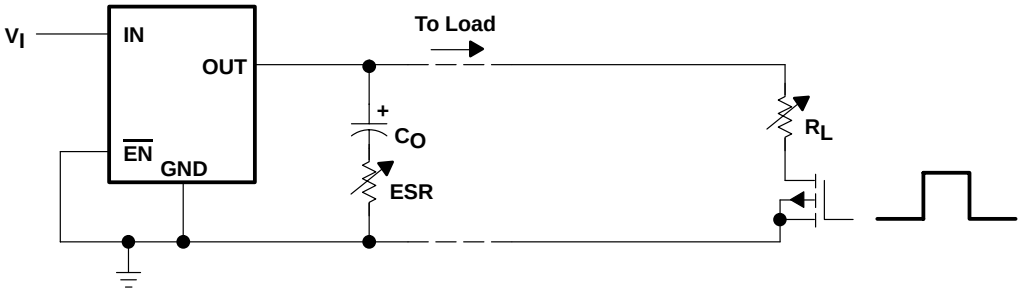


Figure 17. Test Circuit for Typical Regions of Stability (Figures 18 through 21) (Fixed Output Options)

TYPICAL CHARACTERISTICS

TYPICAL REGION OF STABILITY
EQUIVALENT SERIES RESISTANCE† vs OUTPUT CURRENT

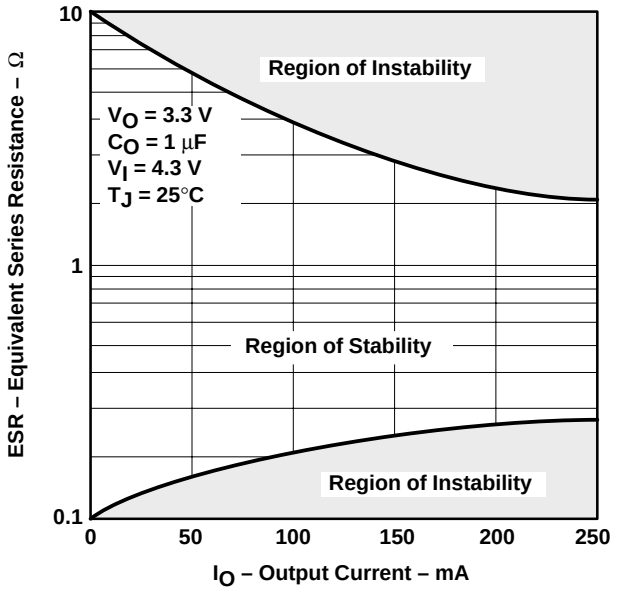


Figure 18

TYPICAL REGION OF STABILITY
EQUIVALENT SERIES RESISTANCE† vs OUTPUT CURRENT

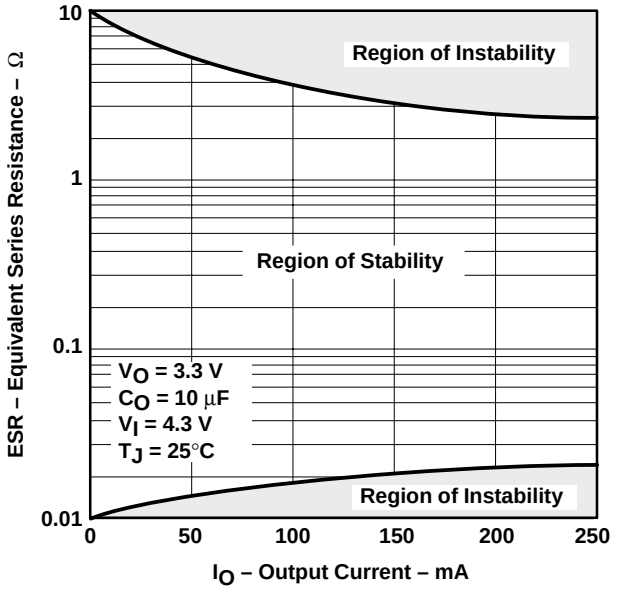


Figure 19

TYPICAL REGION OF STABILITY
EQUIVALENT SERIES RESISTANCE† vs OUTPUT CURRENT

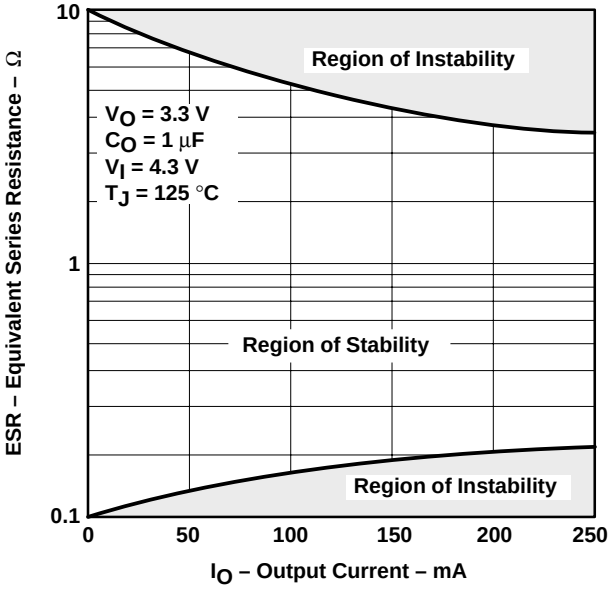


Figure 20

TYPICAL REGION OF STABILITY
EQUIVALENT SERIES RESISTANCE† vs OUTPUT CURRENT

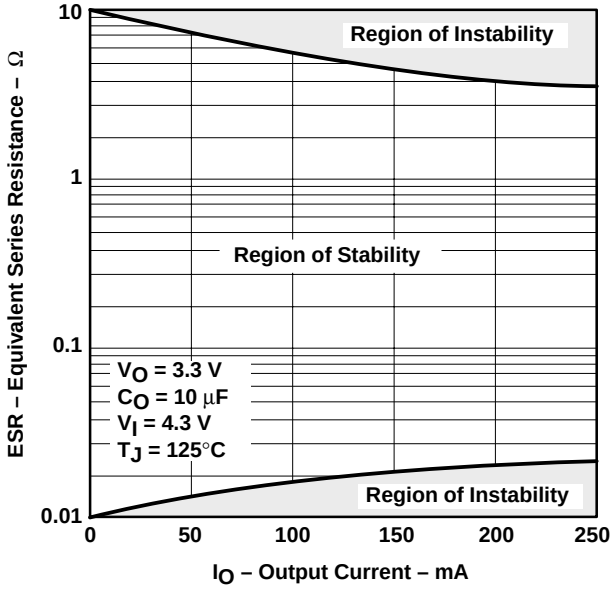


Figure 21

† Equivalent series resistance (ESR) refers to the total series resistance, including the ESR of the capacitor, any series resistance added externally, and PWB trace resistance to C_O.

APPLICATION INFORMATION

pin functions

enable ($\overline{\text{EN}}$)

The $\overline{\text{EN}}$ terminal is an input which enables or shuts down the device. If $\overline{\text{EN}}$ is a logic high, the device will be in shutdown mode. When $\overline{\text{EN}}$ goes to logic low, then the device will be enabled.

power good (PG) (TPS774xx)

The PG terminal is an open drain, active high output that indicates the status of V_{out} (output of the LDO). When V_{out} reaches 82% of the regulated voltage, PG will go to a high-impedance state. It will go to a low-impedance state when V_{out} falls below 82% (i.e. over load condition) of the regulated voltage. The open drain output of the PG terminal requires a pullup resistor.

sense (SENSE)

The SENSE terminal of the fixed-output options must be connected to the regulator output, and the connection should be as short as possible. Internally, SENSE connects to a high-impedance wide-bandwidth amplifier through a resistor-divider network and noise pickup feeds through to the regulator output. It is essential to route the SENSE connection in such a way to minimize/avoid noise pickup. Adding RC networks between the SENSE terminal and V_{out} to filter noise is not recommended because it may cause the regulator to oscillate.

feedback (FB)

FB is an input terminal used for the adjustable-output options and must be connected to an external feedback resistor divider. The FB connection should be as short as possible. It is essential to route it in such a way to minimize/avoid noise pickup. Adding RC networks between FB terminal and V_{out} to filter noise is not recommended because it may cause the regulator to oscillate.

reset ($\overline{\text{RESET}}$) (TPS773xx)

The $\overline{\text{RESET}}$ terminal is an open drain, active low output that indicates the status of V_{out}. When V_{out} reaches 95% of the regulated voltage, $\overline{\text{RESET}}$ will go to a high-impedance state after a 220-ms delay. $\overline{\text{RESET}}$ will go to a low-impedance state when V_{out} is below 95% of the regulated voltage. The open-drain output of the $\overline{\text{RESET}}$ terminal requires a pullup resistor.

external capacitor requirements

An input capacitor is not usually required; however, a bypass capacitor (0.047 μF or larger) improves load transient response and noise rejection if the TPS773xx or TPS774xx is located more than a few inches from the power supply. A higher-capacitance capacitor may be necessary if large (hundreds of milliamps) load transients with fast rise times are anticipated.

Most low noise LDOs require an external capacitor to further reduce noise. This will impact the cost and board space. The TPS773xx and TPS774xx have very low noise specification requirements without using any external components.

Like all low dropout regulators, the TPS773xx or TPS774xx requires an output capacitor connected between OUT (output of the LDO) and GND (signal ground) to stabilize the internal control loop. The minimum recommended capacitance value is 1 μF provided the ESR meets the requirement in Figures 19 and 21. In addition, a low-ESR capacitor can be used if the capacitance is at least 10 μF and the ESR meets the requirements in Figures 18 and 20. Solid tantalum electrolytic, aluminum electrolytic, and multilayer ceramic capacitors are all suitable, provided they meet the requirements described previously.

APPLICATION INFORMATION

external capacitor requirements (continued)

Ceramic capacitors have different types of dielectric material with each exhibiting different temperature and voltage variation. The most common types are X5R, X7R, Y5U, Z5U, and NPO. The NPO type ceramic type capacitors are generally the most stable over temperature. However, the X5R and X7R are also relatively stable over temperature (with the X7R being the more stable of the two) and are therefore acceptable to use. The Y5U and Z5U types provide high capacitance in a small geometry, but exhibit large variations over temperature; therefore, the Y5U and Z5U are not generally recommended for use on this LDO. Independent of which type of capacitor is used, one must make certain that at the worst case condition the capacitance/ESR meets the requirement specified in Figures 18 – 21.

Figure 22 shows the output capacitor and its parasitic impedances in a typical LDO output stage.

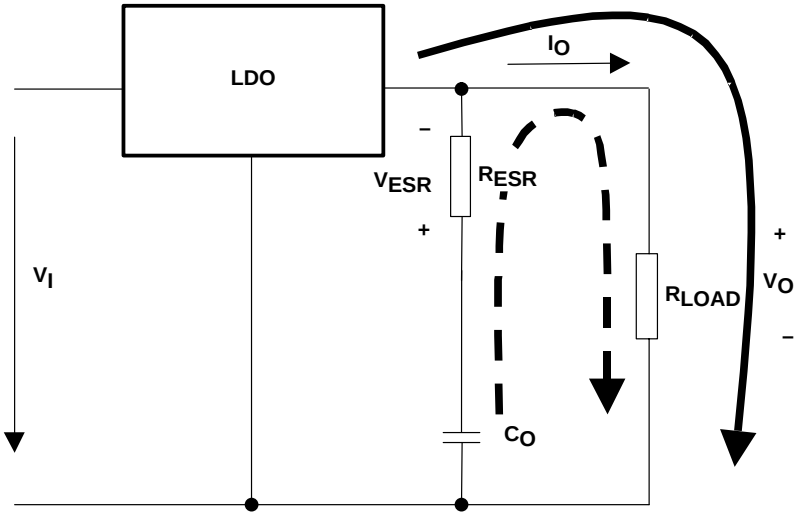


Figure 22. LDO Output Stage With Parasitic Resistances ESR

In steady state (dc state condition), the load current is supplied by the LDO (solid arrow) and the voltage across the capacitor is the same as the output voltage ($V_{Cout} = V_{out}$). This means no current is flowing into the C_{out} branch. If I_{out} suddenly increases (transient condition), the following occurs:

- The LDO is not able to supply the sudden current need due to its response time (t_1 in Figure 23). Therefore, capacitor C_{out} provides the current for the new load condition (dashed arrow). C_{out} now acts like a battery with an internal resistance, ESR. Depending on the current demand at the output, a voltage drop will occur at R_{ESR}. This voltage is shown as V_{ESR} in Figure 22.
- When C_{out} is conducting current to the load, initial voltage at the load will be $V_{out} = V_{Cout} – V_{ESR}$. Due to the discharge of C_{out}, the output voltage V_{out} will drop continuously until the response time t_1 of the LDO is reached and the LDO will resume supplying the load. From this point, the output voltage starts rising again until it reaches the regulated voltage. This period is shown as t_2 in Figure 23.

The figure also shows the impact of different ESRs on the output voltage. The left brackets show different levels of ESRs where number 1 displays the lowest and number 3 displays the highest ESR.

From above, the following conclusions can be drawn:

- The higher the ESR, the larger the droop at the beginning of load transient.
- The smaller the output capacitor, the faster the discharge time and the bigger the voltage droop during the LDO response period.

APPLICATION INFORMATION

conclusion

To minimize the transient output droop, capacitors must have a low ESR and be large enough to support the minimum output voltage requirement.

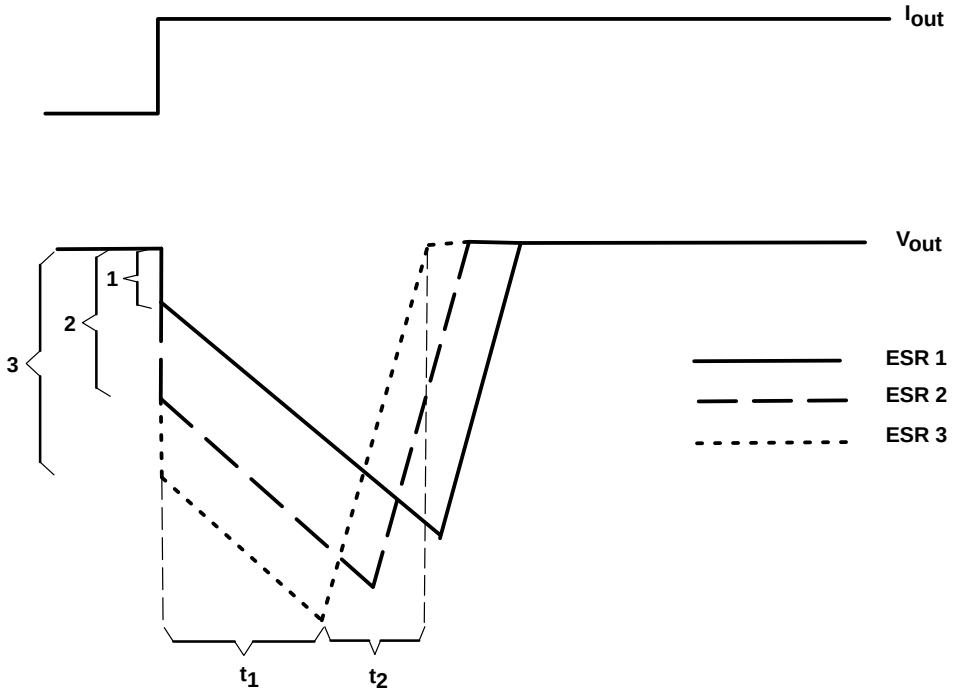


Figure 23. Correlation of Different ESRs and Their Influence to the Regulation of V_{out} at a Load Step From Low-to-High Output Current

APPLICATION INFORMATION

programming the TPS77x01 adjustable LDO regulator

The output voltage of the TPS77x01 adjustable regulator is programmed using an external resistor divider as shown in Figure 24. The output voltage is calculated using:

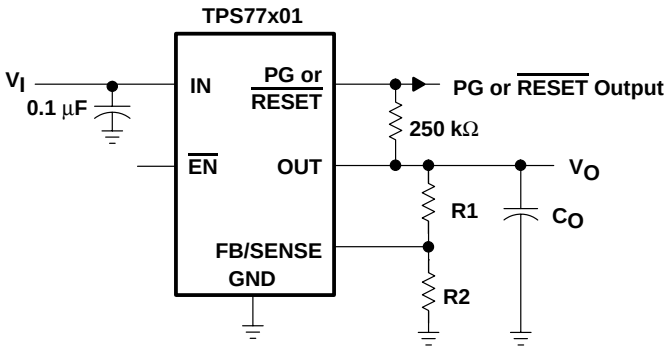
$$V_O = V_{ref} \times \left(1 + \frac{R1}{R2}\right) \quad (1)$$

Where:

V_{ref} = 1.1834 V typ (the internal reference voltage)

Resistors R1 and R2 should be chosen for approximately 50-μA divider current. Lower value resistors can be used but offer no inherent advantage and waste more power. Higher values should be avoided, as leakage currents at FB increase the output voltage error. The recommended design procedure is to choose R2 = 30.1 kΩ to set the divider current at 50 μA and then calculate R1 using:

$$R1 = \left(\frac{V_O}{V_{ref}} - 1\right) \times R2 \quad (2)$$



OUTPUT VOLTAGE PROGRAMMING GUIDE

OUTPUT VOLTAGE	R1	R2	UNIT
2.5 V	33.5	30.1	kΩ
3.3 V	53.8	30.1	kΩ
3.6 V	61.5	30.1	kΩ

NOTE: To reduce noise and prevent oscillation, R1 and R2 need to be as close as possible to the FB/SENSE terminal.

Figure 24. TPS77x01 Adjustable LDO Regulator Programming

APPLICATION INFORMATION

regulator protection

The TPS773xx or TPS774xx PMOS-pass transistor has a built-in back diode that conducts reverse currents 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. When extended reverse voltage is anticipated, external limiting may be appropriate.

The TPS773xx or TPS774xx also features internal current limiting and thermal protection. During normal operation, the TPS773xx or TPS774xx limits output current to approximately 0.9 A. 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 150°C(typ), thermal-protection circuitry shuts it down. Once the device has cooled below 130°C(typ), regulator operation resumes.

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, $P_{D(max)}$, and the actual dissipation, P_D, which must be less than or equal to $P_{D(max)}$.

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

$$P_{D(max)} = \frac{T_J max - T_A}{R_{\theta JA}}$$

Where:

$T_J max$ is the maximum allowable junction temperature.

$R_{\theta JA}$ is the thermal resistance junction-to-ambient for the package, i.e., 266.2°C/W for the 8-terminal MSOP with no airflow.

T_A is the ambient temperature.

The regulator dissipation is calculated using:

$$P_D = \left(V_I - V_O\right) \times I_O$$

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

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
TPS77301DGK	Active	Production	VSSOP (DGK) | 8	80 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGF
TPS77301DGK.A	Active	Production	VSSOP (DGK) | 8	80 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGF
TPS77301DGKR	Active	Production	VSSOP (DGK) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGF
TPS77301DGKR.A	Active	Production	VSSOP (DGK) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGF
TPS77315DGK	Active	Production	VSSOP (DGK) | 8	80 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGG
TPS77315DGK.A	Active	Production	VSSOP (DGK) | 8	80 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGG
TPS77315DGKR	Active	Production	VSSOP (DGK) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGG
TPS77315DGKR.A	Active	Production	VSSOP (DGK) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGG
TPS77316DGK	Active	Production	VSSOP (DGK) | 8	80 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AWF
TPS77316DGK.A	Active	Production	VSSOP (DGK) | 8	80 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AWF
TPS77316DGKR	Active	Production	VSSOP (DGK) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AWF
TPS77316DGKR.A	Active	Production	VSSOP (DGK) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AWF
TPS77318DGK	Active	Production	VSSOP (DGK) | 8	80 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGH
TPS77318DGK.A	Active	Production	VSSOP (DGK) | 8	80 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGH
TPS77318DGKG4	Active	Production	VSSOP (DGK) | 8	80 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGH
TPS77318DGKR	Active	Production	VSSOP (DGK) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGH
TPS77318DGKR.A	Active	Production	VSSOP (DGK) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGH
TPS77328DGK	Active	Production	VSSOP (DGK) | 8	80 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGK
TPS77328DGK.A	Active	Production	VSSOP (DGK) | 8	80 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGK
TPS77333DGK	Active	Production	VSSOP (DGK) | 8	80 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGM
TPS77333DGK.A	Active	Production	VSSOP (DGK) | 8	80 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGM
TPS77333DGKR	Active	Production	VSSOP (DGK) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGM
TPS77333DGKR.A	Active	Production	VSSOP (DGK) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGM
TPS77350DGK	Active	Production	VSSOP (DGK) | 8	80 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGN
TPS77350DGK.A	Active	Production	VSSOP (DGK) | 8	80 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGN
TPS77350DGKR	Active	Production	VSSOP (DGK) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGN
TPS77350DGKR.A	Active	Production	VSSOP (DGK) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGN
TPS77401DGK	Active	Production	VSSOP (DGK) | 8	80 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGO
TPS77401DGK.A	Active	Production	VSSOP (DGK) | 8	80 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGO

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
TPS77415DGK	Active	Production	VSSOP (DGK) | 8	80 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGP
TPS77415DGK.A	Active	Production	VSSOP (DGK) | 8	80 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGP
TPS77418DGK	Active	Production	VSSOP (DGK) | 8	80 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGQ
TPS77418DGK.A	Active	Production	VSSOP (DGK) | 8	80 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGQ
TPS77428DGK	Active	Production	VSSOP (DGK) | 8	80 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGT
TPS77428DGK.A	Active	Production	VSSOP (DGK) | 8	80 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGT
TPS77433DGK	Active	Production	VSSOP (DGK) | 8	80 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGV
TPS77433DGK.A	Active	Production	VSSOP (DGK) | 8	80 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGV
TPS77433DGKR	Active	Production	VSSOP (DGK) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGV
TPS77433DGKR.A	Active	Production	VSSOP (DGK) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGV
TPS77450DGK	Active	Production	VSSOP (DGK) | 8	80 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGW
TPS77450DGK.A	Active	Production	VSSOP (DGK) | 8	80 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AGW

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

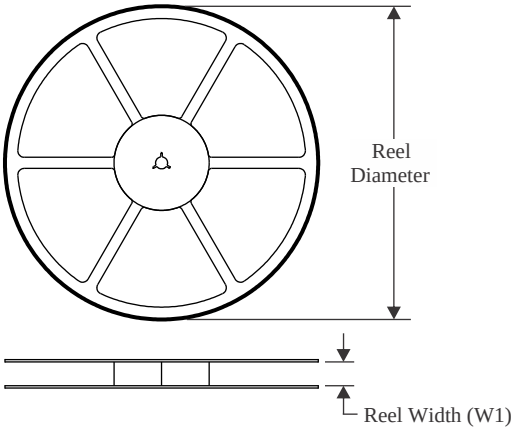
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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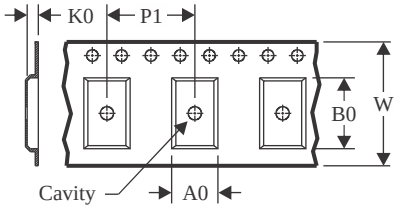
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TAPE AND REEL INFORMATION

REEL DIMENSIONS

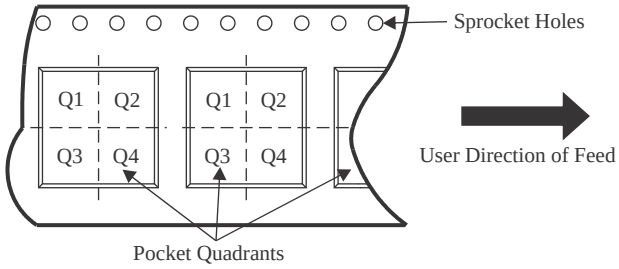


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

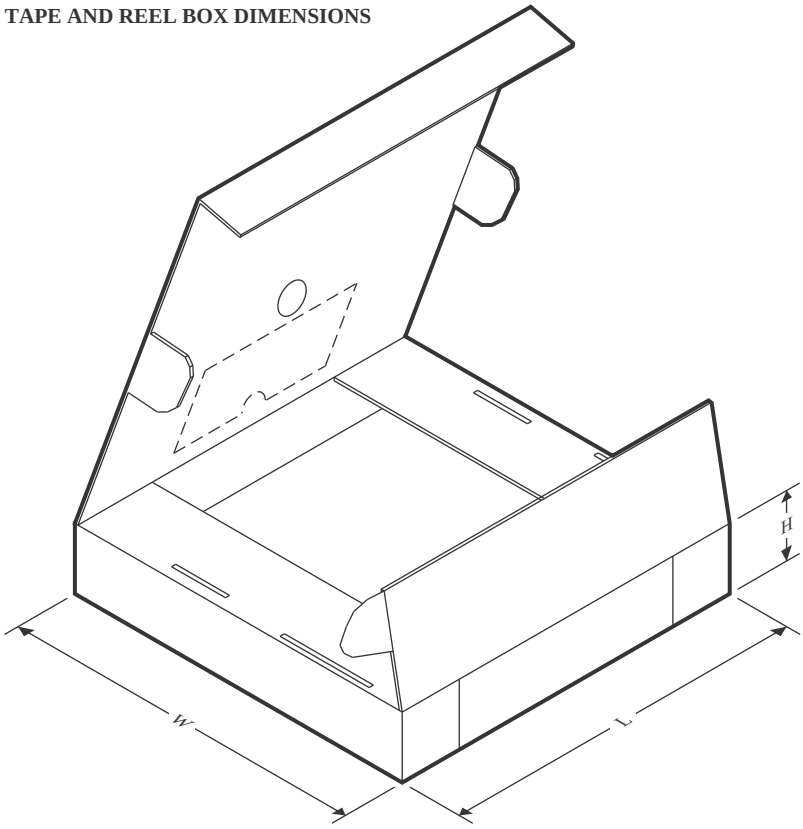
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TPS77301DGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
TPS77315DGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
TPS77316DGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
TPS77318DGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
TPS77333DGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
TPS77350DGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
TPS77433DGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1

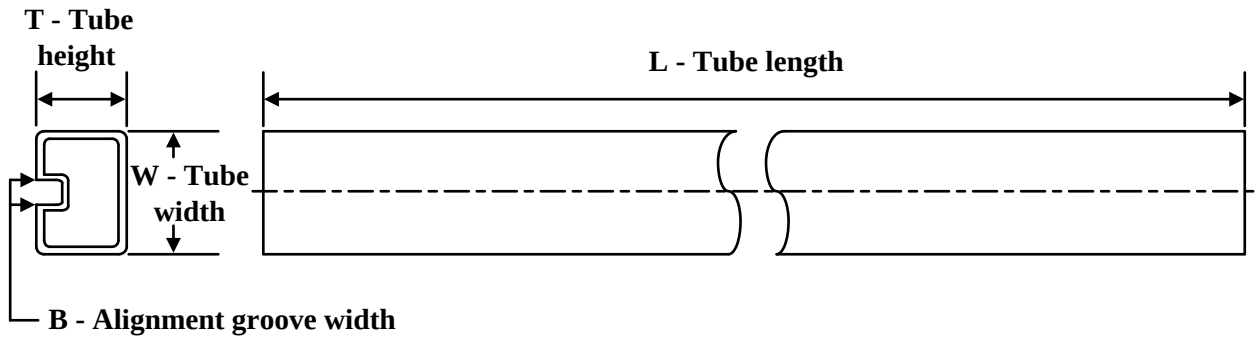
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS77301DGKR	VSSOP	DGK	8	2500	358.0	335.0	35.0
TPS77315DGKR	VSSOP	DGK	8	2500	358.0	335.0	35.0
TPS77316DGKR	VSSOP	DGK	8	2500	358.0	335.0	35.0
TPS77318DGKR	VSSOP	DGK	8	2500	358.0	335.0	35.0
TPS77333DGKR	VSSOP	DGK	8	2500	358.0	335.0	35.0
TPS77350DGKR	VSSOP	DGK	8	2500	358.0	335.0	35.0
TPS77433DGKR	VSSOP	DGK	8	2500	358.0	335.0	35.0

TUBE



*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
TPS77301DGK	DGK	VSSOP	8	80	274	6.2	2540	2.5
TPS77301DGK.A	DGK	VSSOP	8	80	274	6.2	2540	2.5
TPS77315DGK	DGK	VSSOP	8	80	274	6.2	2540	2.5
TPS77315DGK.A	DGK	VSSOP	8	80	274	6.2	2540	2.5
TPS77316DGK	DGK	VSSOP	8	80	274	6.2	2540	2.5
TPS77316DGK.A	DGK	VSSOP	8	80	274	6.2	2540	2.5
TPS77318DGK	DGK	VSSOP	8	80	274	6.2	2540	2.5
TPS77318DGK.A	DGK	VSSOP	8	80	274	6.2	2540	2.5
TPS77318DGKG4	DGK	VSSOP	8	80	274	6.2	2540	2.5
TPS77328DGK	DGK	VSSOP	8	80	274	6.2	2540	2.5
TPS77328DGK.A	DGK	VSSOP	8	80	274	6.2	2540	2.5
TPS77333DGK	DGK	VSSOP	8	80	274	6.2	2540	2.5
TPS77333DGK.A	DGK	VSSOP	8	80	274	6.2	2540	2.5
TPS77350DGK	DGK	VSSOP	8	80	274	6.2	2540	2.5
TPS77350DGK.A	DGK	VSSOP	8	80	274	6.2	2540	2.5
TPS77401DGK	DGK	VSSOP	8	80	274	6.2	2540	2.5
TPS77401DGK.A	DGK	VSSOP	8	80	274	6.2	2540	2.5
TPS77415DGK	DGK	VSSOP	8	80	274	6.2	2540	2.5
TPS77415DGK.A	DGK	VSSOP	8	80	274	6.2	2540	2.5
TPS77418DGK	DGK	VSSOP	8	80	274	6.2	2540	2.5
TPS77418DGK.A	DGK	VSSOP	8	80	274	6.2	2540	2.5
TPS77428DGK	DGK	VSSOP	8	80	274	6.2	2540	2.5
TPS77428DGK.A	DGK	VSSOP	8	80	274	6.2	2540	2.5
TPS77433DGK	DGK	VSSOP	8	80	274	6.2	2540	2.5
TPS77433DGK.A	DGK	VSSOP	8	80	274	6.2	2540	2.5
TPS77450DGK	DGK	VSSOP	8	80	274	6.2	2540	2.5
TPS77450DGK.A	DGK	VSSOP	8	80	274	6.2	2540	2.5

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Last updated 10/2025

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