

Actual Size
(3,05 mm x 4,98 mm)

TPS60240, TPS60241
TPS60242, TPS60243

SLVS372B – JUNE 2001 – REVISED JANUARY 2002

170- μ Vrms ZERO-RIPPLE SWITCHED CAP BUCK-BOOST CONVERTER FOR VCO SUPPLY

FEATURES

- Wide Input Voltage Range:
 - 1.8 V To 5.5 V for 2.7-V, 3-V, 3.3-V Output (TPS60240/2/3)
 - 2.7 V To 5.5 V for 5-V Output (TPS60241)
- 170- μ Vrms Zero Ripple Output:
 - at 20 Hz to 10 MHz Bandwidth
- Minimum Number of External Components
 - No Inductors
 - Only Small Ceramic Chip Capacitors
- Up to 90% Efficiency
- Regulated 3.3-V (TPS60240), 5-V (TPS60241), 3-V (TPS60243), and 2.7-V (TPS60242) Output Voltage With $\pm 2.5\%$ Accuracy Over Load
- Up to 25-mA Output Current
- Shutdown Mode: 0.1 μ A Typical
- Thermal Protection and Current Limit
- Microsmall 8-Pin MSOP Package
- EVM Available TPS60241EVM-194

- Digital Cameras
- MP3 Players
- SIM Modules
- Electronic Games
- Memory Backup
- Handheld Meters
- Bias Supplies

DESCRIPTION

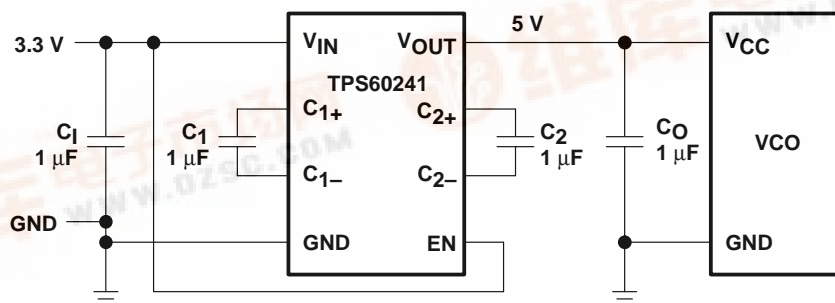
The TPS6024x is a switched capacitor voltage converter, ideally suited for VCO and PLL applications that require low noise and tight tolerances. Its dual-cap design uses four ceramic capacitors to provide ultralow output ripple yet high efficiency, while eliminating the need for inefficient linear regulators.

A wide input supply voltage range of 2.7 V to 5.5 V makes the TPS6024x ideal for lithium-based battery applications. The TPS60240/2/3 operates down to 1.8 V, supporting a 3.3-V, 2.7-V, 3-V output from two-cell, nickel- or alkaline-based chemistries. The devices work equally well for low EMI dc/dc step-up conversion without the need for an inductor. The high switching frequency (typical 160 kHz) promotes the use of small surface-mount capacitors, saving board space. The converter's shutdown mode conserves battery energy.

APPLICATIONS

- VCO and PLL Power for:
 - PDA Phones
 - Cellular Phones
 - PCMCIA Modems
- Smartcard Readers

typical application circuit



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.

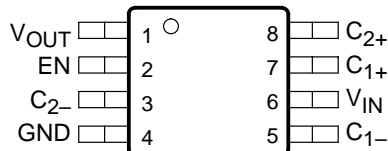
TPS60240, TPS60241 TPS60242, TPS60243

SLVS372B – JUNE 2001 – REVISED JANUARY 2002

description(continued)

The devices are thermally protected and current-limited for reliable operation even under persisting fault conditions. Normal quiescent current (ground pin current) is only 250 μ A, and typically 0.1 μ A in shutdown mode. The TPS6024x devices come in a thin, 8-pin MSOP (DGK) package with a component height of only 1,1 mm.

DGK PACKAGE
(TOP VIEW)

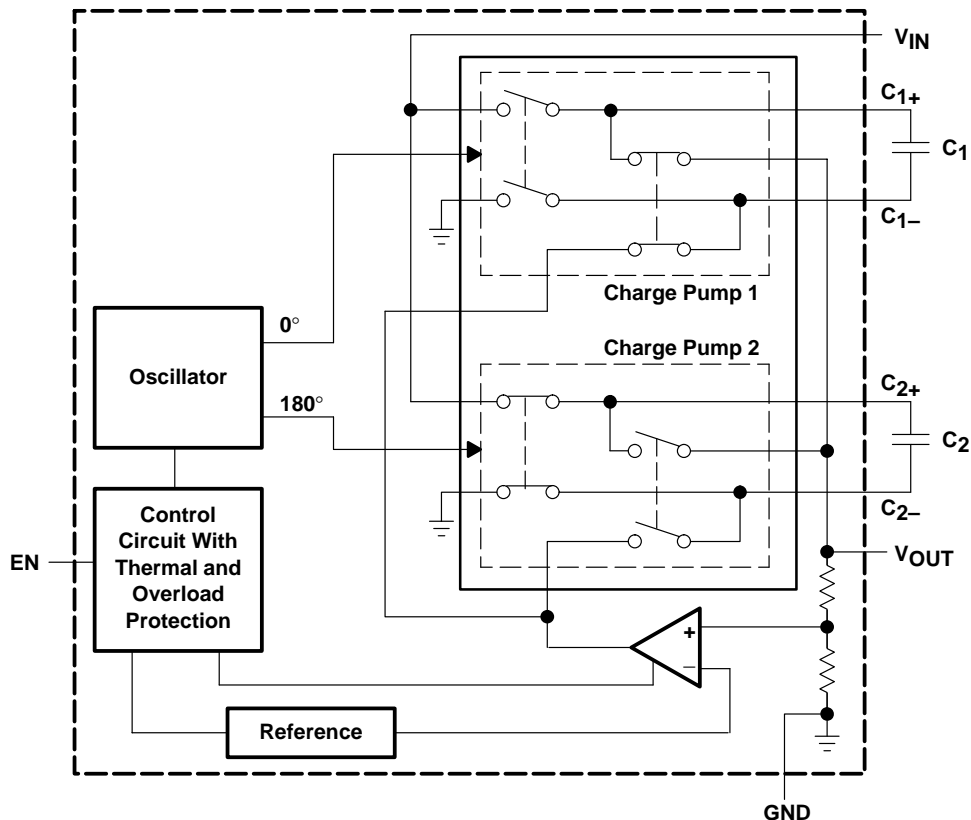


AVAILABLE OPTIONS

T _A	PART NUMBER†	PACKAGE MARKING	PACKAGE	OUTPUT VOLTAGE (V)
-40°C to 85°C	TPS60241DGKR	AUB	DGK (8-pin MSOP)	5 V
-40°C to 85°C	TPS60240DGKR	ATM	DGK (8-pin MSOP)	3.3 V
	TPS60242DGKR	AYF	DGK (8-pin MSOP)	2.7 V
	TPS60243DGKR	AYG	DGK (8-pin MSOP)	3 V

† This package type is available taped and reeled only. Quantity is 2500 units per reel (e.g., TPS60241DGKR). The devices are also available on mini reel with 250 units per reel. To order this packaging option, replace the R with a T in the part number (e.g., TPS60261DGKT).

functional block diagram



Terminal Functions

TERMINAL NAME	NO.	I/O	DESCRIPTION
C ₁₊	7		Positive terminal of the flying capacitor C ₁
C ₁₋	5		Negative terminal of the flying capacitor C ₁
C ₂₊	8		Positive terminal of the flying capacitor C ₂
C ₂₋	3		Negative terminal of the flying capacitor C ₂
EN	2	I	Enable terminal, active high
GND	4		Ground
V _{IN}	6	I	Supply voltage input TPS60241: 2.7 V to 5.5 V, TPS60240/2/3: 1.8 V to 5.5 V. Bypass V _{IN} to GND with a 1-μF external capacitor (C _I).
V _{OUT}	1	O	Regulated power output. Bypass V _{OUT} to GND with a 1-μF external filter capacitor (C _O). TPS60241: regulated 5-V output, TPS60240: regulated 3.3-V output, TPS60242: regulated 2.7-V output, TPS60243: regulated 3-V output

TPS60240, TPS60241 TPS60242, TPS60243

SLVS372B – JUNE 2001 – REVISED JANUARY 2002

detailed description

operating principle

The TPS6024x charge pump is a fixed-frequency, dual-phase charge pump that provides 25 mA of continuous supply current for low-noise applications such as VCOs used in cell phones and wireless appliances.

Low-noise operation results from using a proprietary dual-phase charge pump topology that relies on an operational amplifier in the feedback loop to reduce ripple. During the first phase, C_1 is charged to the supply voltage. Terminal C_{1+} is connected to V_{IN} , and C_{1-} is connected to GND. In the second phase, C_{1-} is connected to the output of the operational amplifier, and C_{1+} is connected to V_{OUT} . The operational amplifier then adjusts its output until the output V_{OUT} delivers the correct voltage to make the resistor divided feedback point equal to the reference voltage. During this second phase, C_2 is charged to supply voltage. Terminal C_{2-} is connected to GND, and C_{2+} is connected to V_{IN} . Phase one is then repeated with C_2 , now acting to provide charge to the output in place of C_1 , which is connected to the supply. The dual-phase operation lowers the output ripple voltage significantly compared to a standard single-phase charge pump. In addition, the linear feedback of the operational amplifier eliminates the ripple during discharge of the output capacitor (C_O).

shutdown

Driving EN low disables the converter. This disables the internal circuits and reduces input current to typically 0.1 μ A. In this mode, the load is disconnected from the supply voltage. The device exits shutdown once EN is set to a high level.

start-up procedure

The converter is enabled when EN is set from logic low to high. The start-up time to reach 90% of the nominal output voltage is typically 0.5 ms at load currents lower than 10 mA and with an output capacitor of 1 μ F. Increasing the values of C_O delays the start-up time.

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

Supply voltage, V_{DD}	-0.3 V to 6 V
Power dissipation, P_D	Internally limited
Voltage EN	-0.3 V to 6 V
Voltage C_{2-} , C_{1-}	-0.3 V to V_I or 5.5 V, whichever is lowest
Voltage C_{2+} , C_{1+}	-0.3 V to V_I , V_O , or 5.5 V, whichever is lowest
Junction temperature, T_J	125°C
Storage temperature, T_{stg}	-65°C to 150°C
Shortcircuit output current	80 mA maximum

[†] 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.

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
DGK	376 mW	3.76 mW/°C	207 mW	150 mW

NOTE: The thermal resistance junction to ambient of the DGK package is $R_{TH-JA} = 150^\circ\text{C/W}$.

TPS60240, TPS60241 TPS60242, TPS60243

SLVS372B – JUNE 2001 – REVISED JANUARY 2002

recommended operating conditions

		MIN	NOM	MAX	UNIT	
V _I	Input voltage range	TPS60240, TPS60242, TPS60243		1.8	5.5	V
		TPS60241		2.7	5.5	
I _O	Output current range	All devices		25	mA	
C _I	Input capacitor			1	μF	
C ₁ , C ₂	Flying capacitors			1	μF	
C _O	Output capacitor			1	μF	
T _A	Operating temperature range	-40		85	°C	

electrical characteristics for TPS6024X at T_A = 25°C, C_I = C_O = 1 μF, C₁ = C₂ = 1 μF (unless otherwise noted), limits apply over the specified temperature range, -40°C to 85°C

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT	
V _I	Input voltage	TPS60240 Assured start-up		I _O ≤ 5 mA, R _L = 600 Ω	1.8	5.5	V	
		TPS60241 Assured start-up		I _O ≤ 12 mA, R _L = 417 Ω	2.7	5.5		
		TPS60242 Assured start-up		I _O ≤ 12 mA, R _L = 225 Ω	1.8	5.5		
		TPS60243 Assured start-up		I _O ≤ 10 mA, R _L = 300 Ω	1.8	5.5		
V _O	Output voltage	TPS60240		1.8 V ≤ V _I ≤ 5.5 V, 0 mA ≤ I _O ≤ 5 mA	3.2175	3.3	3.3825	V
				2.4 V ≤ V _I ≤ 5.5 V, 0 mA ≤ I _O ≤ 25 mA				
		TPS60241		2.7 V ≤ V _I ≤ 5.5 V, 0 mA ≤ I _O ≤ 12 mA	4.875	5	5.125	
				3 V ≤ V _I ≤ 5.5 V, 0 mA ≤ I _O ≤ 25 mA				
		TPS60242		1.8 V ≤ V _I ≤ 5.5 V, 0 mA ≤ I _O ≤ 12 mA	2.6325	2.7	2.7675	
				2.3 V ≤ V _I ≤ 5.5 V, 0 mA ≤ I _O ≤ 25 mA				
		TPS60243		1.8 V ≤ V _I ≤ 5.5 V, 0 mA ≤ I _O ≤ 10 mA	2.925	3	3.075	
				2.3 V ≤ V _I ≤ 5.5 V, 0 mA ≤ I _O ≤ 25 mA				
I _O	Output current	TPS60240/2/3	Nominal	2 V ≤ V _I ≤ 5.5 V	12		mA	
			Short circuit	V _I = 2 V		80		
		TPS60241	Nominal	2.7 V ≤ V _I ≤ 5.5 V	12			
			Short circuit	V _I = 3.25 V		80		
f _{OSC}	Internal clock source			100	160	220	kHz	
V _n	Output noise voltage	TPS60240/2/3		V _I < 2.5 V, I _O = 5 mA, ESR < 0.1 Ω, measured over 20 Hz to 10 MHz, C _O = 4.7 μF		170	μV RMS	
		TPS60241		V _I = 2.7 V, I _O = 5 mA, ESR < 0.1 Ω, measured over 20 Hz to 10 MHz, C _O = 4.7 μF		170		
V _{I(H)}	EN	Logic high input voltage V _{OH}			1.3	5.5	V	
V _{I(L)}	EN	Logic low input voltage V _{OL}			-0.2	0.4	V	
I _{I(H)}	EN	Logic high input current				100	nA	
I _{I(L)}	EN	Logic low input current				100	nA	
t(EN)	EN	Start-up time		V _O > 90% of V(NOM) 0.1 mA ≤ I _O ≤ 10 mA, C _O = 1 μF		0.5	ms	
η	Efficiency	TPS60240		I _O = 5 mA, V _I = 1.8 V		89.6%		
		TPS60241		I _O = 10 mA, V _I = 2.7 V		90.8%		
		TPS60242		I _O = 10 mA, V _I = 1.8 V		73%		
		TPS60243		I _O = 10 mA, V _I = 1.8 V		81%		

**TPS60240, TPS60241
TPS60242, TPS60243**

SLVS372B – JUNE 2001 – REVISED JANUARY 2002

electrical characteristics for TPS6024X at $T_A = 25^\circ\text{C}$, $C_1 = C_O = 1\ \mu\text{F}$, $C_1 = C_2 = 1\ \mu\text{F}$ (unless otherwise noted), limits apply over the specified temperature range, -40°C to 85°C (continued)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_Q	Quiescent current	$I_O = 0\ \text{mA}$, $V_I = 3\ \text{V}$		250	325	μA
		In shutdown mode		0.1	1	
Thermal shutdown	Temperature activated			160		$^\circ\text{C}$
	Temperature deactivated			140		

TYPICAL CHARACTERISTICS

Table of Graphs

		FIGURE
Efficiency	vs Input voltage	1–4
	vs Output current	5–8
V_O Output voltage	vs Input voltage	9–12
	vs Output current	13–16
	vs Free-air temperature	17
Quiescent current	vs Input voltage	18
	vs Free-air temperature	19
$I_{L(sd)}$ Shutdown current	vs Free-air temperature	20
V_n Output noise voltage	vs Output current	21
Maximum output current	vs Input voltage	22–25
Load transient response		26
Start-up timing		27
Line transient response		28
Noise voltage spectrum		29
Output voltage ripple	vs Time	30

TYPICAL CHARACTERISTICS

TPS60240
EFFICIENCY
vs
INPUT VOLTAGE

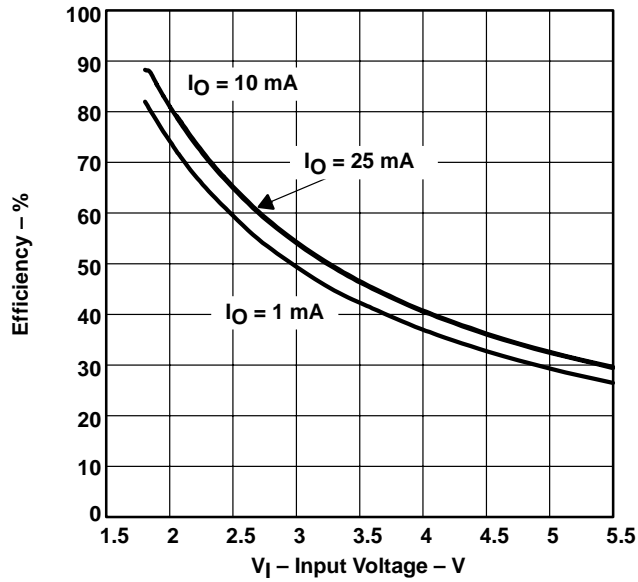


Figure 1

TPS60241
EFFICIENCY
vs
INPUT VOLTAGE

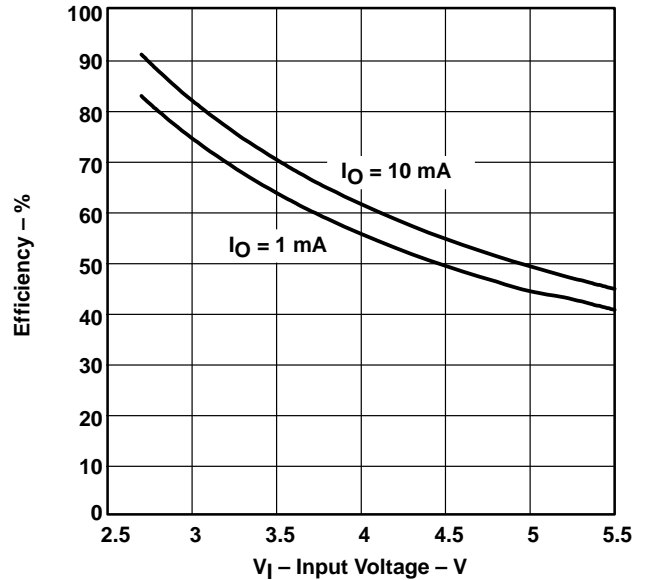


Figure 2

TPS60242
EFFICIENCY
vs
INPUT VOLTAGE

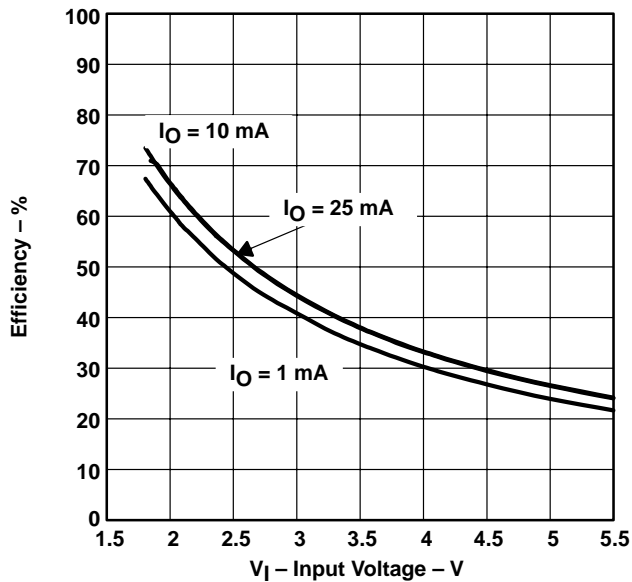


Figure 3

TPS60243
EFFICIENCY
vs
INPUT VOLTAGE

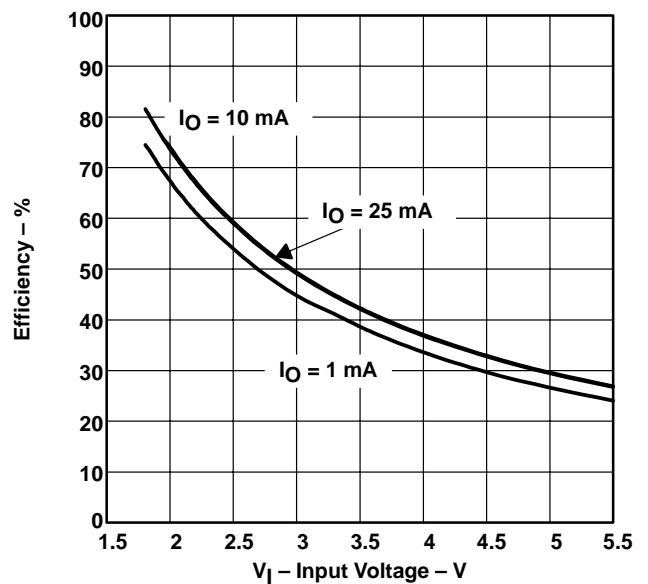


Figure 4

**TPS60240, TPS60241
TPS60242, TPS60243**

SLVS372B – JUNE 2001 – REVISED JANUARY 2002

TYPICAL CHARACTERISTICS

**TPS60240
EFFICIENCY
vs
OUTPUT CURRENT**

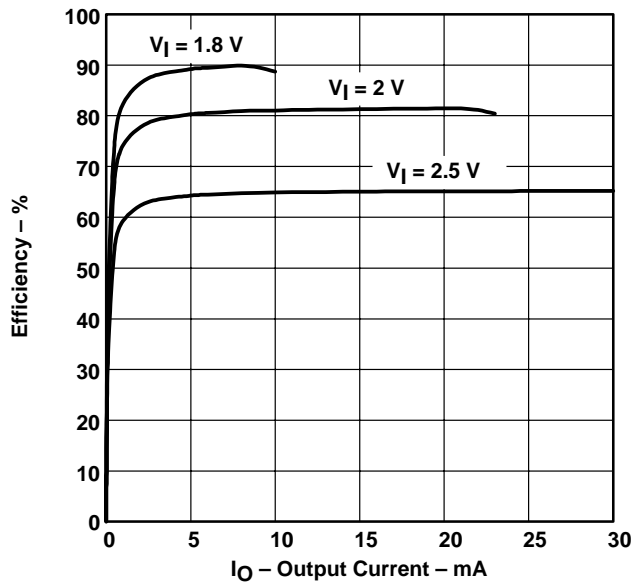


Figure 5

**TPS60241
EFFICIENCY
vs
OUTPUT CURRENT**

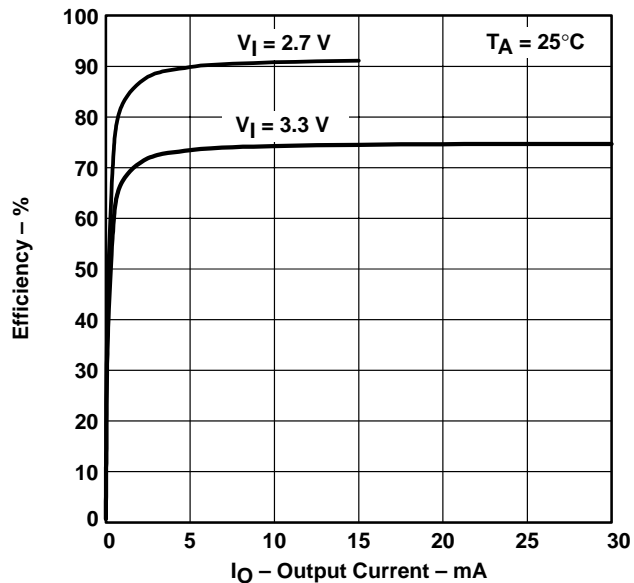


Figure 6

**TPS60242
EFFICIENCY
vs
OUTPUT CURRENT**

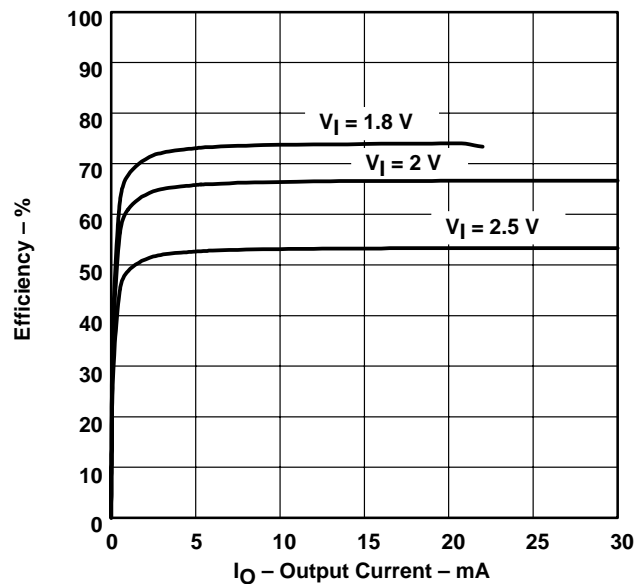


Figure 7

**TPS60243
EFFICIENCY
vs
OUTPUT CURRENT**

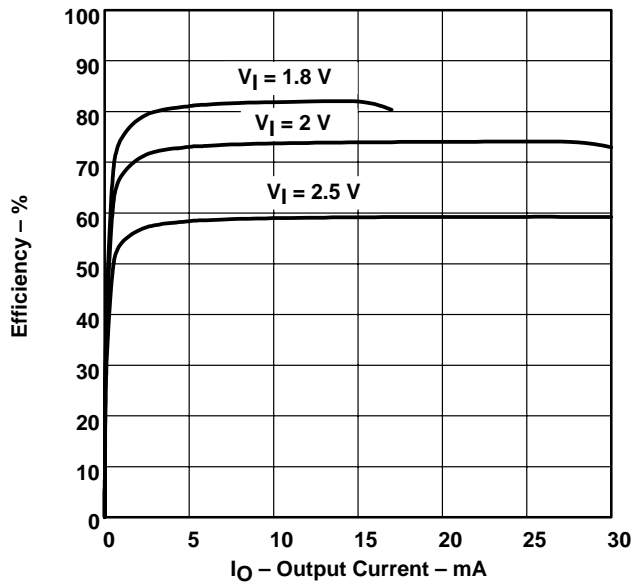


Figure 8

TYPICAL CHARACTERISTICS

TPS60240
OUTPUT VOLTAGE
vs
INPUT VOLTAGE

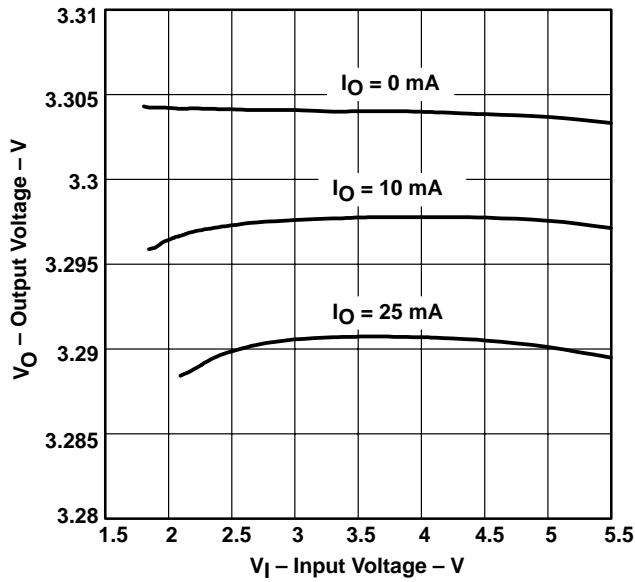


Figure 9

TPS60241
OUTPUT VOLTAGE
vs
INPUT VOLTAGE

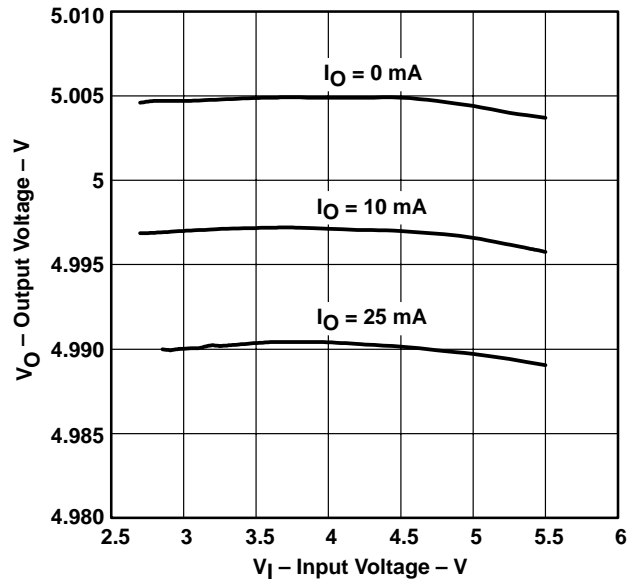


Figure 10

TPS60242
OUTPUT VOLTAGE
vs
INPUT VOLTAGE

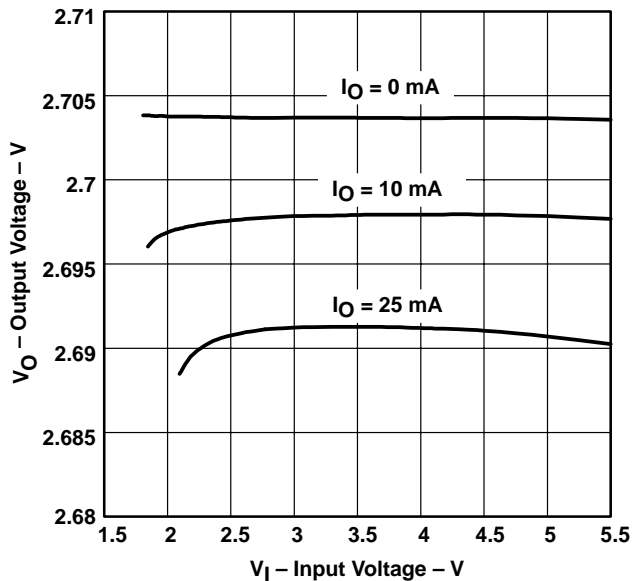


Figure 11

TPS60243
OUTPUT VOLTAGE
vs
INPUT VOLTAGE

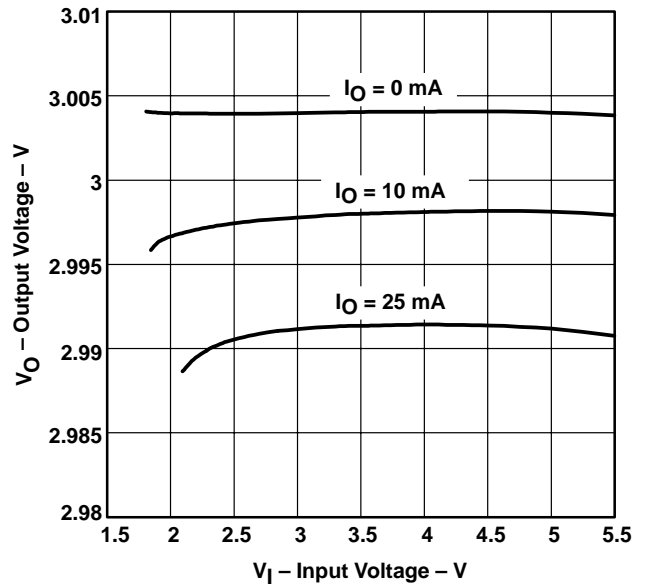


Figure 12

TPS60240, TPS60241
TPS60242, TPS60243

SLVS372B – JUNE 2001 – REVISED JANUARY 2002

TYPICAL CHARACTERISTICS

TPS60240
OUTPUT VOLTAGE
vs
OUTPUT CURRENT

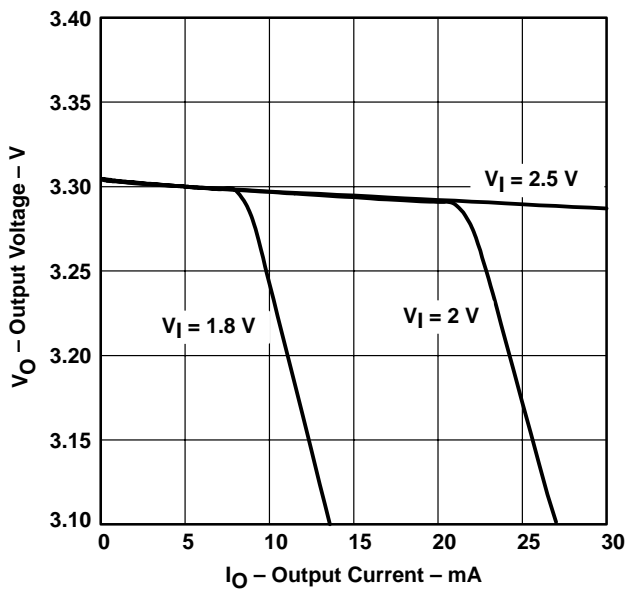


Figure 13

TPS60241
OUTPUT VOLTAGE
vs
OUTPUT CURRENT

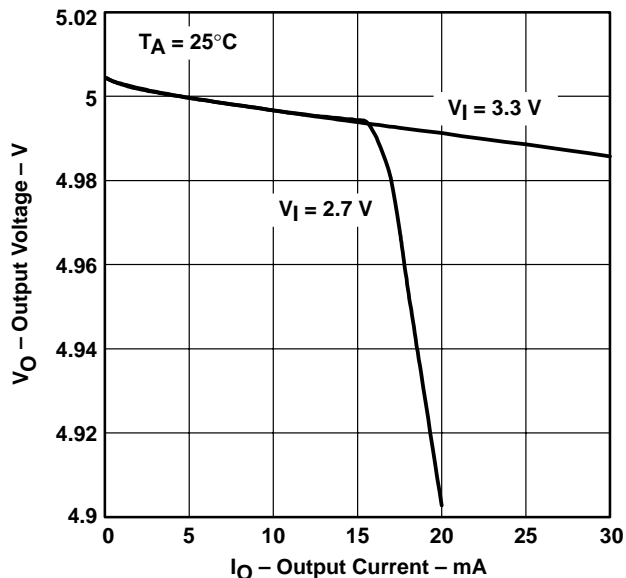


Figure 14

TPS60242
OUTPUT VOLTAGE
vs
OUTPUT CURRENT

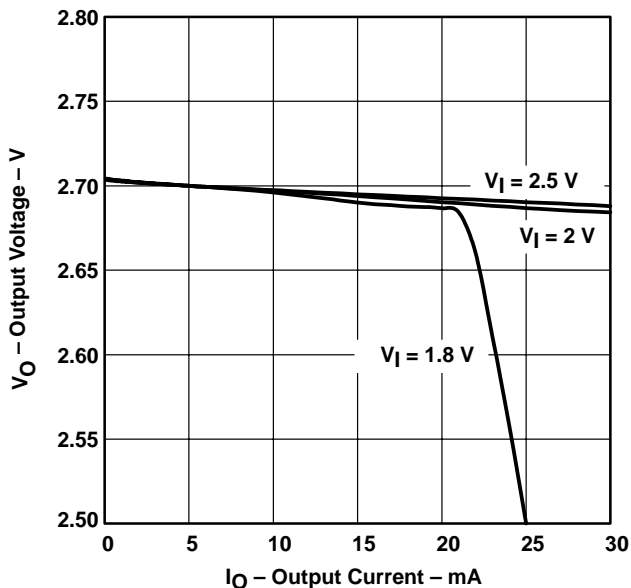


Figure 15

TPS60243
OUTPUT VOLTAGE
vs
OUTPUT CURRENT

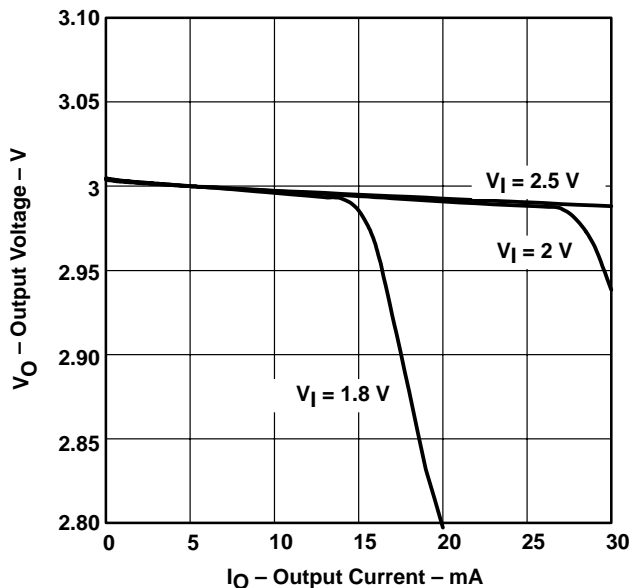


Figure 16

TYPICAL CHARACTERISTICS

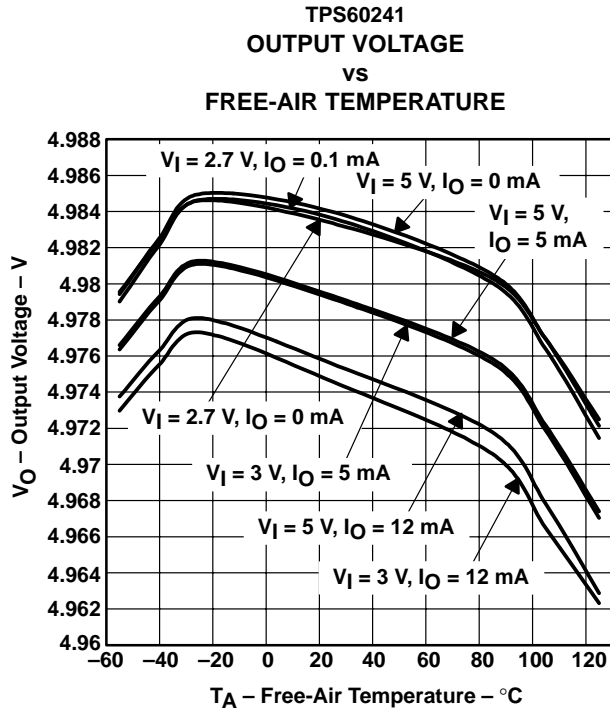


Figure 17

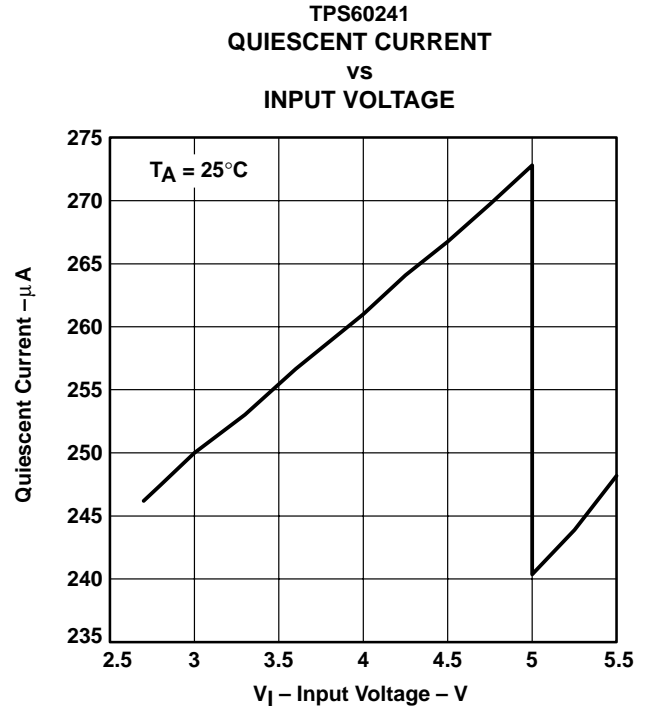


Figure 18

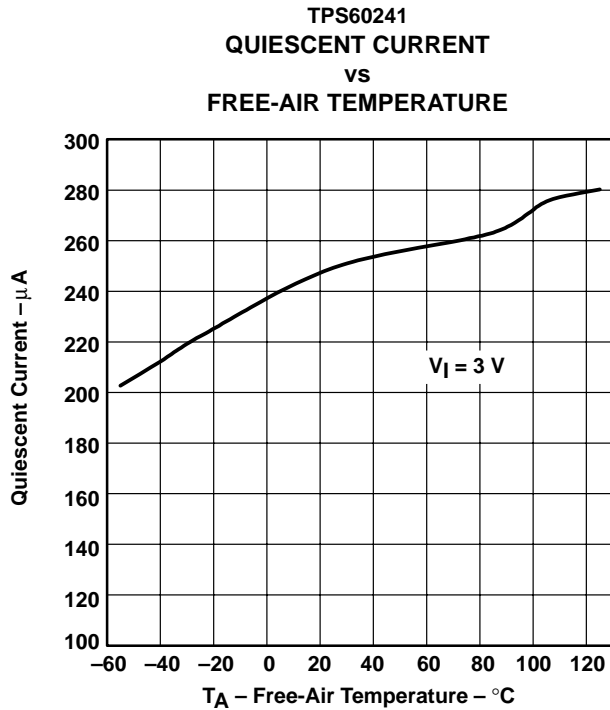


Figure 19

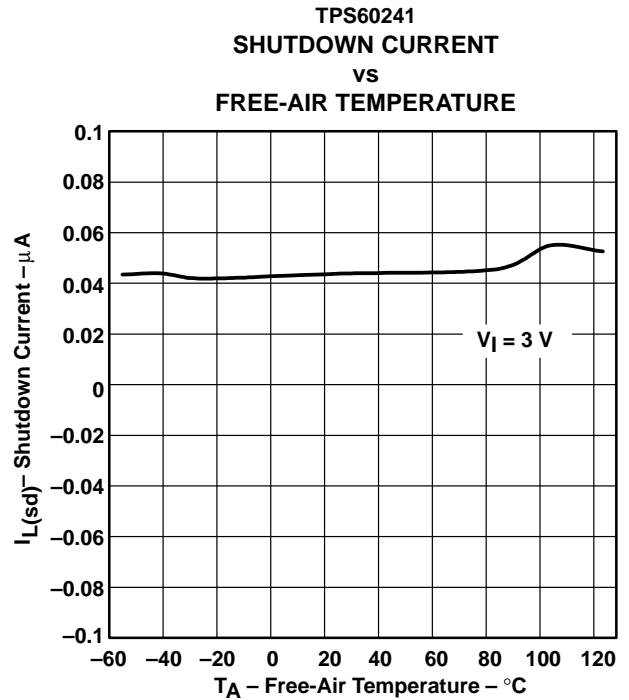
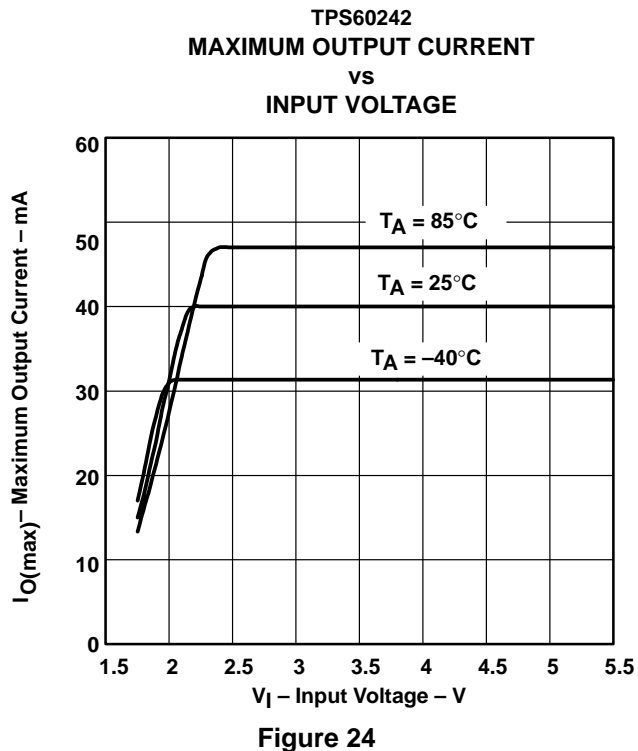
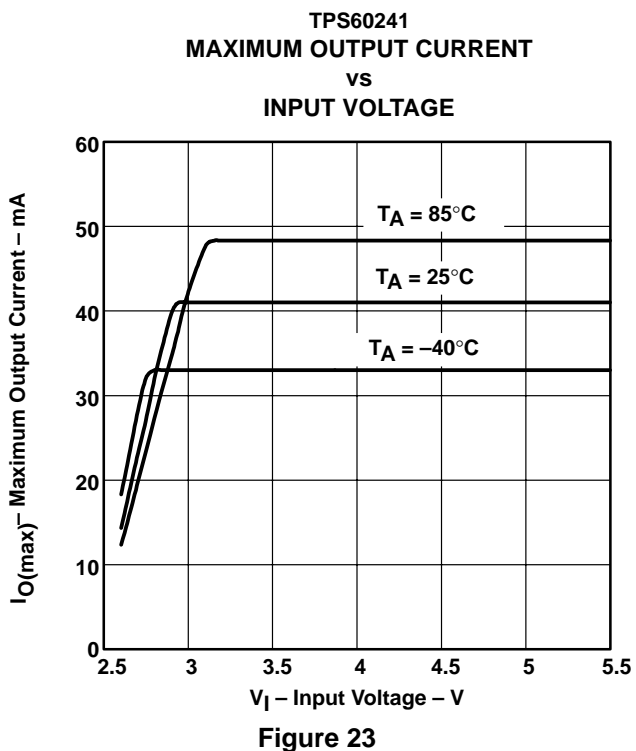
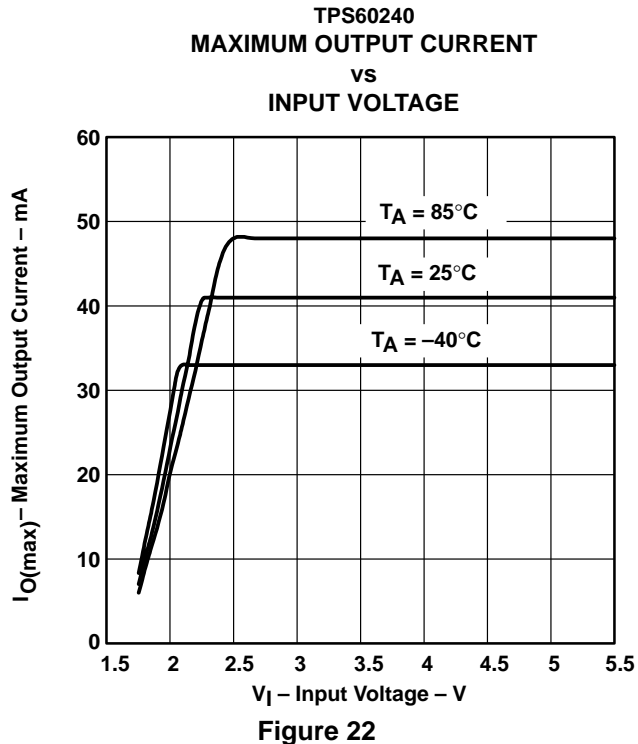
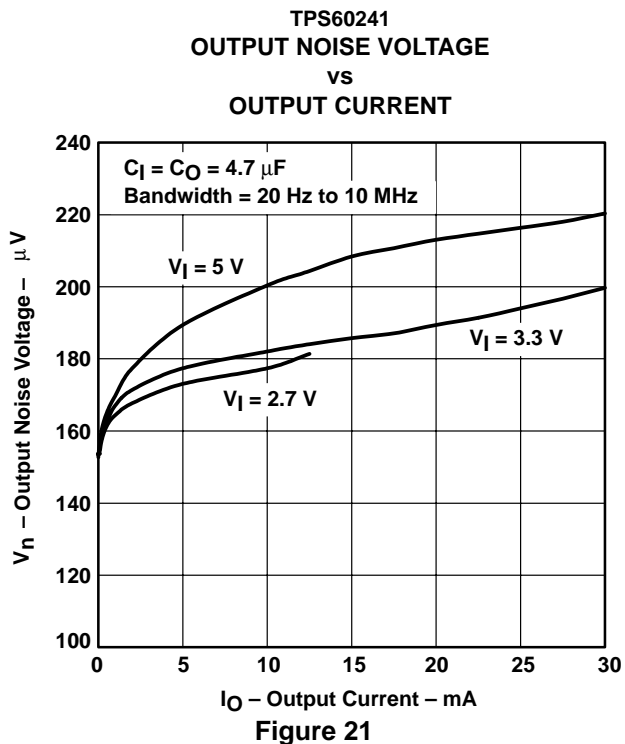


Figure 20

**TPS60240, TPS60241
TPS60242, TPS60243**

SLVS372B – JUNE 2001 – REVISED JANUARY 2002

TYPICAL CHARACTERISTICS



TYPICAL CHARACTERISTICS

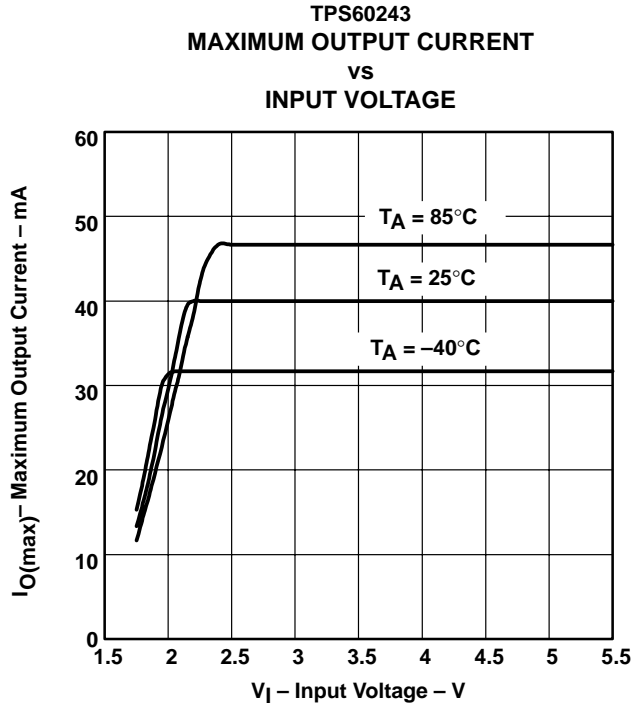


Figure 25

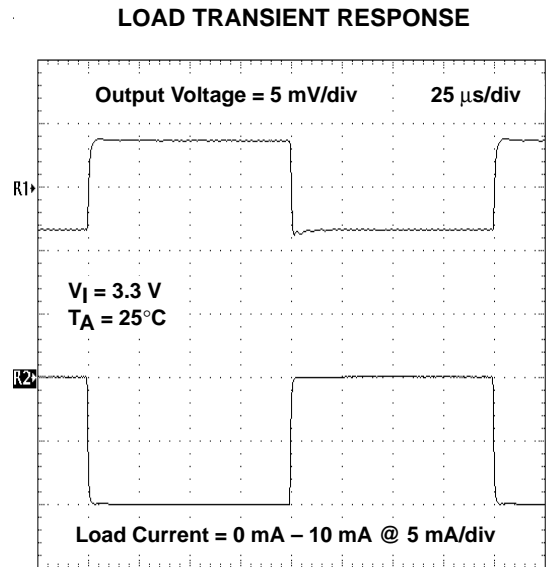


Figure 26

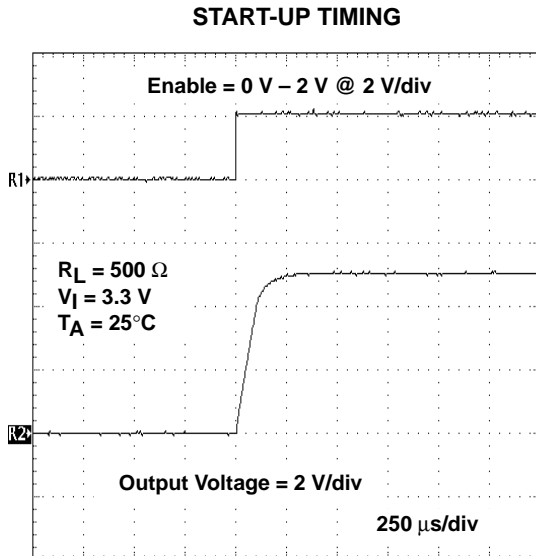


Figure 27

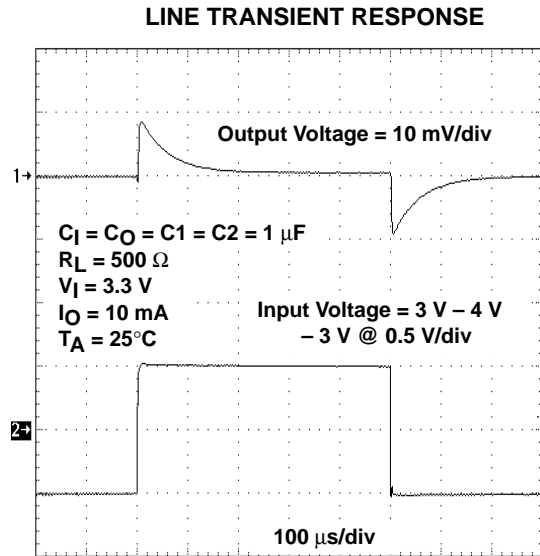


Figure 28

TYPICAL CHARACTERISTICS

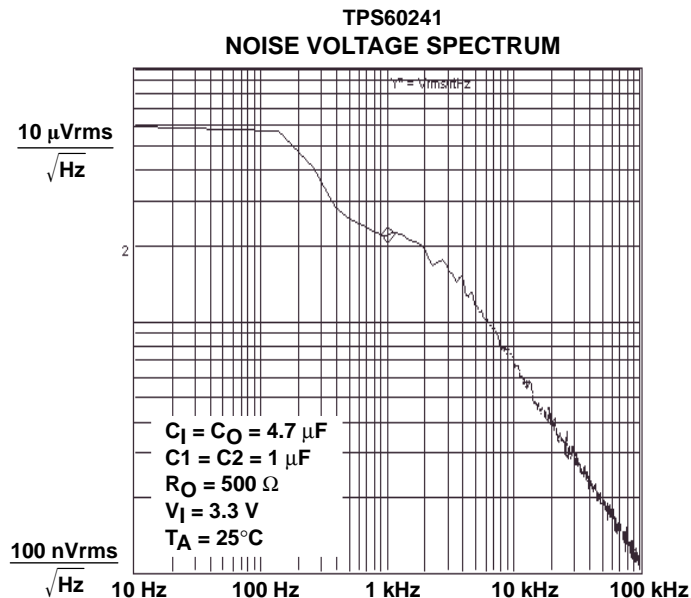
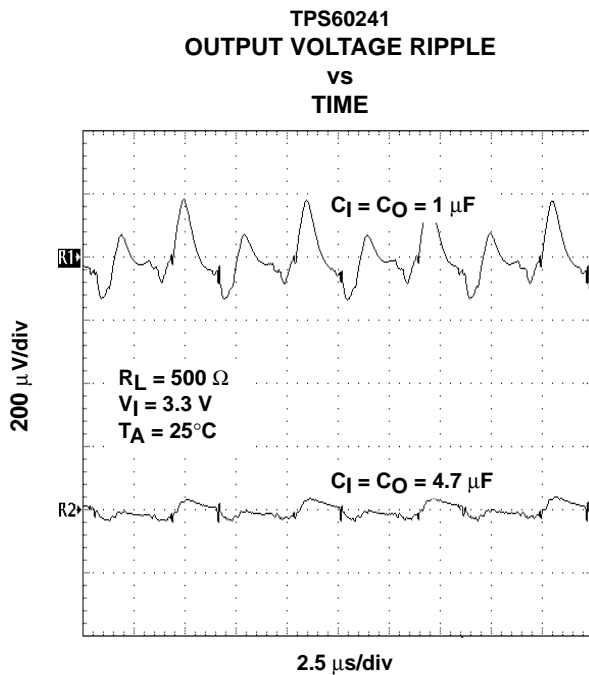


Figure 29



NOTE: Scope triggered by voltage at flying capacitors, noise removed by averaging function and bandwidth limit 20 MHz.

Figure 30

APPLICATION INFORMATION

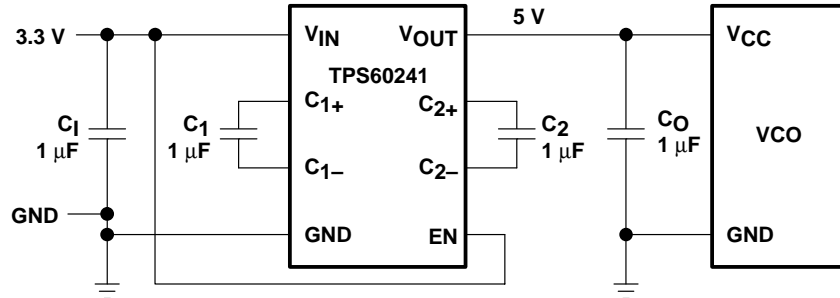


Figure 31. 5-V Low-Noise VCO Supply From 3.3-V Input

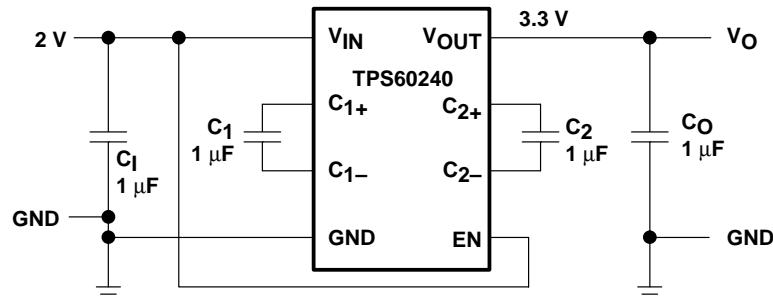


Figure 32. 2-V to 3.3-V Low-Noise Converter

output voltage ripple

The output voltage ripple depends on the capacitors used. Table 1 illustrates the dependence between output voltage ripple and capacitor selection.

Table 1. Output Voltage Ripple and Capacitor Selection

C _I	C _O	C ₁	C ₂	OUTPUT VOLTAGE RIPPLE [μ Vrms]
1 μ F	1 μ F	1 μ F	1 μ F	288
2.2 μ F	2.2 μ F	1 μ F	1 μ F	212
4.7 μ F	4.7 μ F	1 μ F	1 μ F	183
4.7 μ F	1 μ F	1 μ F	1 μ F	272
1 μ F	4.7 μ F	1 μ F	1 μ F	185

NOTE: V_I = 3.3 V, V_O = 5 V, R_L = 500 Ω , T_A = 25°C

TPS60240, TPS60241 TPS60242, TPS60243

SLVS372B – JUNE 2001 – REVISED JANUARY 2002

APPLICATION INFORMATION

components

For the best output ripple performance, low-ESR ceramic capacitors are recommended (see Table 2).

Table 2. Recommended Capacitors

PART	MANUFACTURER	PART NUMBER	VALUE	TOLERANCE	DIELECTRIC MATERIAL	PACKAGE	RATED VOLTAGE
C ₁	Taiyo Yuden	LMK212BJ105KG-T	1 μF	10%	X7R	0805	10
	TDK	C2012X5R0J475K	4.7 μF	10%	X5R	0805	6.3
C _O	Taiyo Yuden	LMK212BJ105KG-T	1 μF	10%	X7R	0805	10
	TDK	C2012X5R0J475K	4.7 μF	10%	X5R	0805	6.3
C ₁ , C ₂	Taiyo Yuden	LMK212BJ105KG-T	1 μF	10%	X7R	0805	10
C _F	Taiyo Yuden	LMK212BJ105KG-T	1 μF	10%	X7R	0805	10

layout consideration

In order to get optimal noise behavior, keep the power lines to the capacitors and load as short as possible. Use of power planes is recommended.

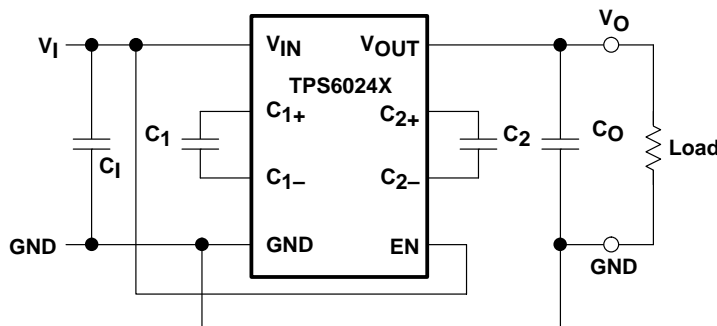


Figure 33. Layout Diagram

APPLICATION INFORMATION

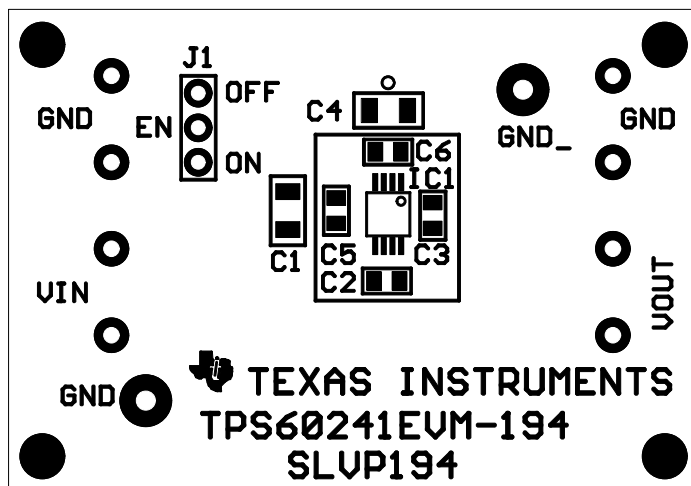


Figure 34. Top Silkscreen

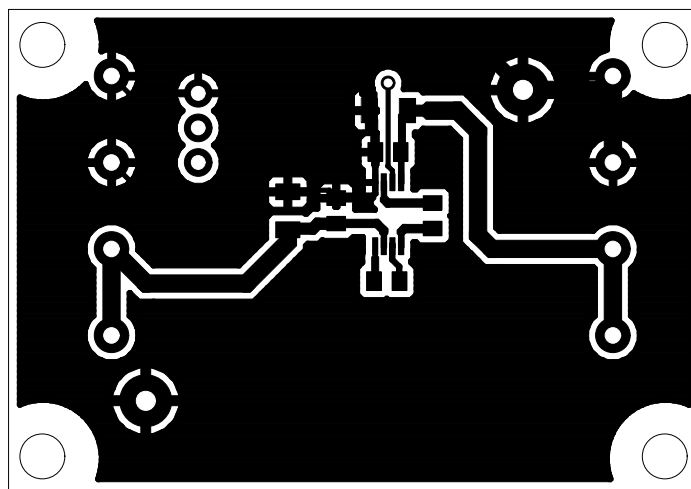


Figure 35. Top Layer

device family products

PART NUMBER	DESCRIPTION
REG710	30-mA switched cap dc/dc converter
REG711	50-mA switched cap dc/dc converter
TPS60110	Regulated 5-V, 300-mA low-noise charge pump dc/dc converter
TPS60111	Regulated 5-V, 150-mA low-noise charge pump dc/dc converter

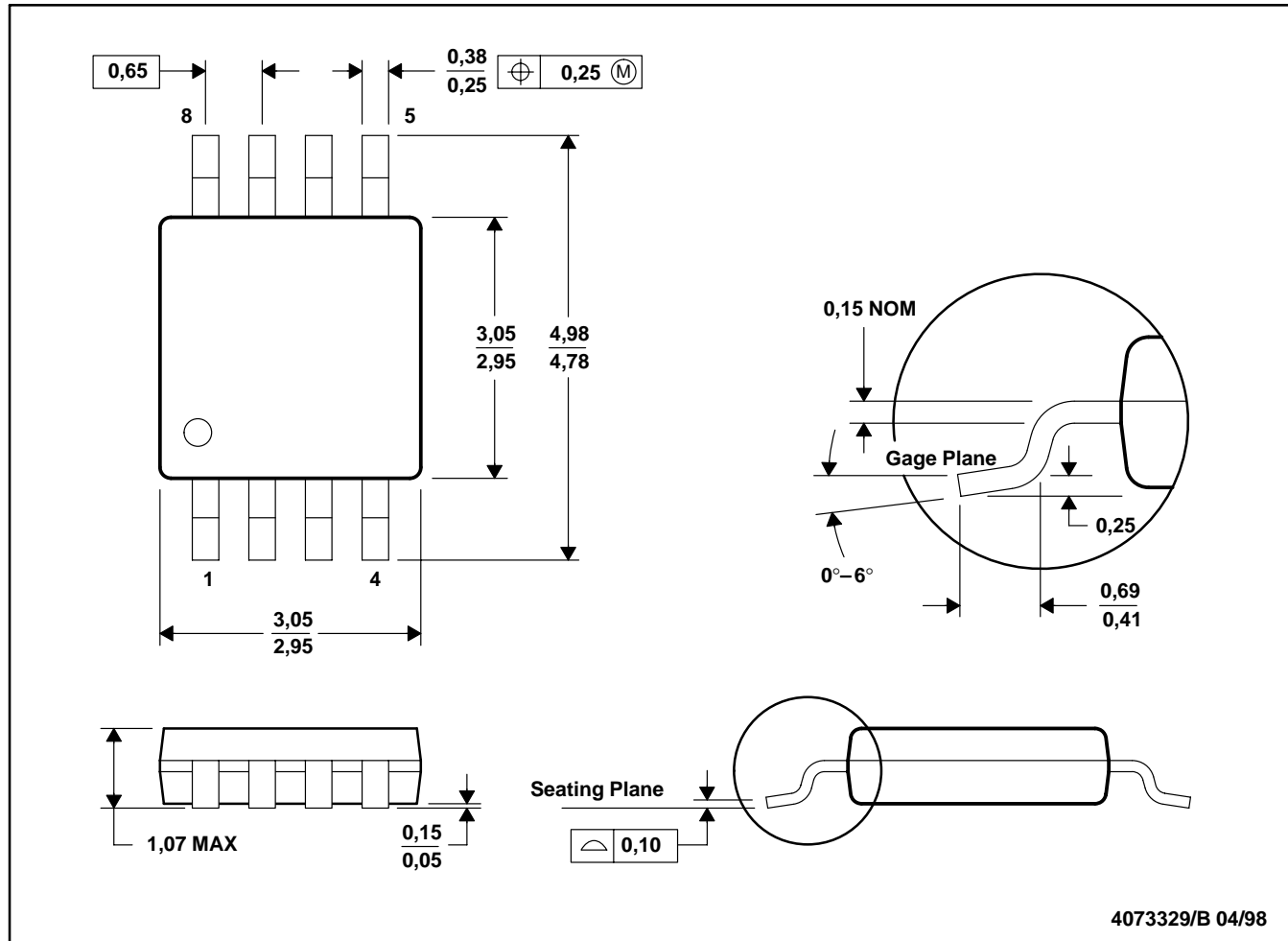
TPS60240, TPS60241
TPS60242, TPS60243

SLVS372B – JUNE 2001 – REVISED JANUARY 2002

MECHANICAL DATA

DGK (R-PDSO-G8)

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.
 D. Falls within JEDEC MO-187

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
TPS60240DGK	ACTIVE	MSOP	DGK	8		TBD	Call TI	Call TI
TPS60240DGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TPS60240DGKT	ACTIVE	MSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TPS60240DGKTG4	ACTIVE	MSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TPS60241DGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TPS60241DGKRG4	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TPS60241DGKT	ACTIVE	MSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TPS60241DGKTG4	ACTIVE	MSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TPS60242DGK	ACTIVE	MSOP	DGK	8		TBD	Call TI	Call TI
TPS60242DGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TPS60242DGKRG4	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TPS60242DGKT	ACTIVE	MSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TPS60242DGKTG4	ACTIVE	MSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TPS60243DGK	ACTIVE	MSOP	DGK	8		TBD	Call TI	Call TI
TPS60243DGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TPS60243DGKT	ACTIVE	MSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR

⁽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.

OBSOLETE: 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.

Important Information and Disclaimer:The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		Applications	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DSP	dsp.ti.com	Broadband	www.ti.com/broadband
Interface	interface.ti.com	Digital Control	www.ti.com/digitalcontrol
Logic	logic.ti.com	Military	www.ti.com/military
Power Mgmt	power.ti.com	Optical Networking	www.ti.com/opticalnetwork
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
		Telephony	www.ti.com/telephony
		Video & Imaging	www.ti.com/video
		Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments
Post Office Box 655303 Dallas, Texas 75265