

TPS60400-Q1, TPS60401-Q1, TPS60402-Q1, TPS60403-Q1 UNREGULATED 60-mA CHARGE PUMP VOLTAGE INVERTER

查询"TPS60401-Q1"供应商

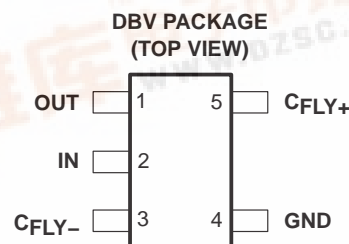
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features

- Qualified for Automotive Applications
- Inverts Input Supply Voltage
- Up to 60-mA Output Current
- Only Three Small 1- μ F Ceramic Capacitors Needed
- Input Voltage Range From 1.6 V to 5.5 V
- PowerSave-Mode for Improved Efficiency at Low Output Currents (TPS60400)
- Device Quiescent Current Typical 100 μ A
- Integrated Active Schottky-Diode for Start-Up Into Load
- Small 5-Pin SOT23 Package
- Evaluation Module Available
TPS60400EVM-178

applications

- LCD Bias
- GaAs Bias for RF Power Amps
- Sensor Supply in Portable Instruments
- Bipolar Amplifier Supply



description

The TPS6040x is a family of devices that generate an unregulated negative output voltage from an input voltage ranging from 1.6 V to 5.5 V. The devices are typically supplied by a preregulated supply rail of 5 V or 3.3 V. Due to its wide input voltage range, two or three NiCd, NiMH, or alkaline battery cells, as well as one Li-Ion cell can also power them.

Only three external 1- μ F capacitors are required to build a complete dc/dc charge pump inverter. Assembled in a 5-pin SOT23 package, the complete converter can be built on a 50-mm² board area. Additional board area and component count reduction is achieved by replacing the Schottky diode that is typically needed for start-up into load by integrated circuitry.

The TPS6040x can deliver a maximum output current of 60 mA with a typical conversion efficiency of greater than 90% over a wide output current range. Three device options with 20-kHz, 50-kHz, and 250-kHz fixed frequency operation are available. One device comes with a variable switching frequency to reduce operating current in applications with a wide load range and enables the design with low-value capacitors.

AVAILABLE OPTIONS†

PART NUMBER	MARKING DBV PACKAGE‡	TYPICAL FLYING CAPACITOR [μ F]	FEATURE
TPS60400QDBVRQ1	AWP	1	Variable switching frequency 50 kHz–250 kHz
TPS60401QDBVRQ1	AWQ	10	Fixed frequency 20 kHz
TPS60402QDBVRQ1	AWR	3.3	Fixed frequency 50 kHz
TPS60403QDBVRQ1	AWS	1	Fixed frequency 250 kHz

† For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at <http://www.ti.com>.

‡ Package drawings, thermal data, and symbolization are available at <http://www.ti.com/packaging>.



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INSTRUMENTS**

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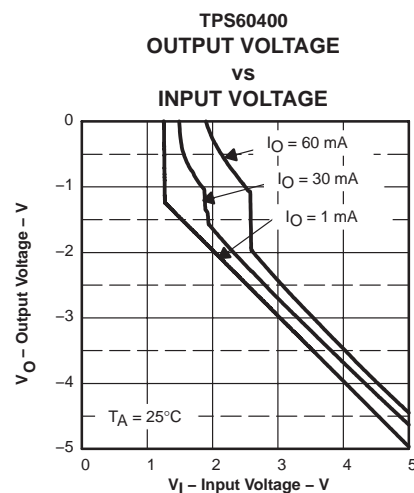
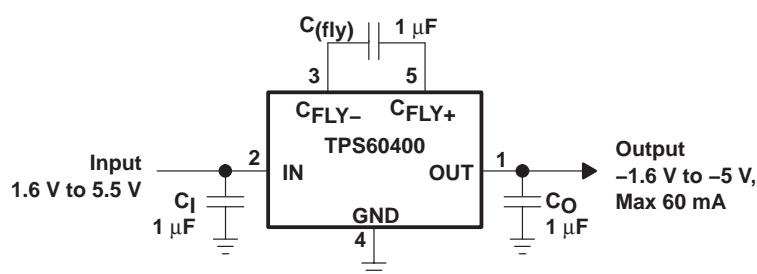
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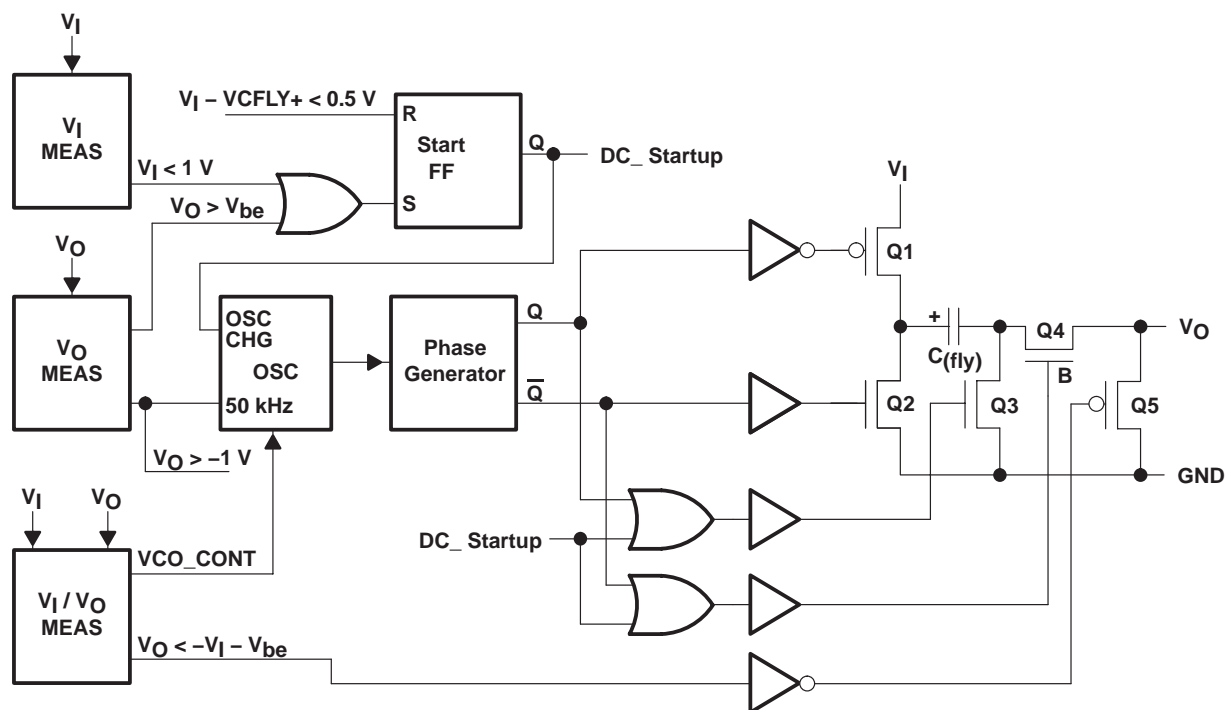


This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications. These devices have limited built-in ESD protection.

typical application circuit



TPS60400 functional block diagram



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Terminal Functions

TERMINAL NAME	NO.	I/O	DESCRIPTION
C _{FLY+}	5		Positive terminal of the flying capacitor C _(fly)
C _{FLY-}	3		Negative terminal of the flying capacitor C _(fly)
GND	4		Ground
IN	2	I	Supply input. Connect to an input supply in the 1.6-V to 5.5-V range. Bypass IN to GND with a capacitor that has the same value as the flying capacitor.
OUT	1	O	Power output with V _O = -V _I Bypass OUT to GND with the output filter capacitor C _O .

detailed description

operating principle

The TPS60400, TPS60401 charge pumps invert the voltage applied to their input. For the highest performance, use low equivalent series resistance (ESR) capacitors (e.g., ceramic). During the first half-cycle, switches S2 and S4 open, switches S1 and S3 close, and capacitor (C_(fly)) charges to the voltage at V_I. During the second half-cycle, S1 and S3 open, S2 and S4 close. This connects the positive terminal of C_(fly) to GND and the negative to V_O. By connecting C_(fly) in parallel, C_O is charged negative. The actual voltage at the output is more positive than -V_I, since switches S1–S4 have resistance and the load drains charge from C_O.

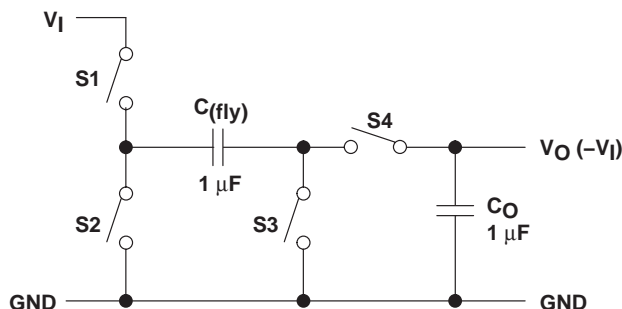


Figure 1. Operating Principle

charge-pump output resistance

The TPS6040x devices are not voltage regulators. The charge pumps output source resistance is approximately 15 Ω at room temperature (with V_I = 5 V), and V_O approaches -5 V when lightly loaded. V_O will droop toward GND as load current increases.

$$V_O = -(V_I - R_O \times I_O)$$

$$R_O \approx \frac{1}{f_{osc} \times C_{(fly)}} + 4(2R_{SWITCH} + ESR_{CFLY}) + ESR_{CO} \quad (1)$$

R_O = output resistance of the converter

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efficiency considerations

$$P_{\text{CAPACITOR LOSSES}} + P_{\text{CONVERSION LOSSES}} = I_o^2 \times R_o$$
$$P_{\text{CONV.LOSS}} = \left[\frac{1}{2} \times C_{(\text{fly})} (V_I^2 - V_O^2) + \frac{1}{2} C_O (V_{\text{RIPPLE}}^2 - 2V_O V_{\text{RIPPLE}}) \right] \times f_{\text{osc}} \quad (2)$$
$$\eta \cong \frac{I_O}{I_O + I_Q} \left(1 - \frac{I_O \times R_O}{V_I} \right)$$

capacitor selection

input capacitor (C_I)

flying capacitor (C_{fly})



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detailed description (continued)

output capacitor (C_O)

Increasing the output capacitor's size reduces the output ripple voltage. Decreasing its ESR reduces both output resistance and ripple. Smaller capacitance values can be used with light loads if higher output ripple can be tolerated. Use the following equation to calculate the peak-to-peak ripple.

$$V_{O(\text{ripple})} = \frac{I_O}{f_{\text{osc}} \times C_O} + 2 \times I_O \times \text{ESR}_{C_O}$$

Table 1. Recommended Capacitor Values

DEVICE	V _I [V]	I _O [mA]	C _I [μF]	C _(fly) [μF]	C _O [μF]
TPS60400	1.8...5.5	60	1	1	1
TPS60401	1.8...5.5	60	10	10	10
TPS60402	1.8...5.5	60	3.3	3.3	3.3
TPS60403	1.8...5.5	60	1	1	1

Table 2. Recommended Capacitors

MANUFACTURER	PART NUMBER	SIZE	CAPACITANCE	TYPE
Taiyo Yuden	EMK212BJ474MG	0805	0.47 μF	Ceramic
	LMK212BJ105KG	0805	1 μF	Ceramic
	LMK212BJ225MG	0805	2.2 μF	Ceramic
	EMK316BJ225KL	1206	2.2 μF	Ceramic
	LMK316BJ475KL	1206	4.7 μF	Ceramic
	JMK316BJ106KL	1206	10 μF	Ceramic
TDK	C2012X5R1C105M	0805	1 μF	Ceramic
	C2012X5R1A225M	0805	2.2 μF	Ceramic
	C2012X5R1A335M	0805	3.3 μF	Ceramic

Table 3 contains a list of manufacturers of the recommended capacitors. Ceramic capacitors will provide the lowest output voltage ripple because they typically have the lowest ESR-rating.

Table 3. Recommended Capacitor Manufacturers

MANUFACTURER	CAPACITOR TYPE	INTERNET
Taiyo Yuden	X7R/X5R ceramic	www.t-yuden.com
TDK	X7R/X5R ceramic	www.component.tdk.com
Vishay	X7R/X5R ceramic	www.vishay.com
Kemet	X7R/X5R ceramic	www.kemet.com



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

Voltage range:	IN to GND	.....	-0.3 V to 5.5 V
	OUT to GND	.....	-5 V to 0.3 V
	C _{FLY-} to GND	.....	0.3 V to (V _O - 0.3 V)
	C _{FLY+} to GND	.....	-0.3 V to (V _I + 0.3 V)
Continuous power dissipation	.....	See Dissipation Rating Table	
Continuous output current	.....	80 mA	
Electrostatic Discharge (Machine Model)	.....	passed 50 V	
	(Human Body Model)	.....	passed 2 kV
	(Charged Device Model)	.....	passed 1 kV
Storage temperature range, T _{stg}	.....	-55°C to 150°C	
Maximum junction temperature, T _J	.....	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.

DISSIPATION RATING TABLE

PACKAGE	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
DBV	437 mW	3.5 mW/°C	280 mW	227 mW

recommended operating conditions

	MIN	NOM	MAX	UNIT
Input voltage range, V _I	1.8		5.25	V
Output current range at OUT, I _O			60	mA
Input capacitor, C _I	0	C _(fly)		μF
Flying capacitor, C _(fly)		1		μF
Output capacitor, C _O		1	100	μF
Operating junction temperature, T _J	-40		125	°C

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electrical characteristics at $C_I = C_{(fly)} = C_O$ (according to Table 1), $T_J = -40^{\circ}\text{C}$ to 125°C , $V_I = 5\text{ V}$ over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
V_I	Supply voltage range	At $T_J = -40^{\circ}\text{C}$ to 125°C , $R_L = 5\text{ k}\Omega$		1.8		5.25	V
		At $T_C \geq 0^{\circ}\text{C}$, $R_L = 5\text{ k}\Omega$		1.6			
I_O	Maximum output current at V_O			60			mA
V_O	Output voltage				$-V_I$		V
V_{P-P}	Output voltage ripple	TPS60400	$I_O = 5\text{ mA}$	$C_{(fly)} = 1\text{ }\mu\text{F}$, $C_O = 2.2\text{ }\mu\text{F}$		35	mV _{P-P}
		TPS60401		$C_{(fly)} = C_O = 10\text{ }\mu\text{F}$		20	
		TPS60402		$C_{(fly)} = C_O = 3.3\text{ }\mu\text{F}$		20	
		TPS60403		$C_{(fly)} = C_O = 1\text{ }\mu\text{F}$		15	
I_Q	Quiescent current (no-load input current)	TPS60400	At $V_I = 5\text{ V}$			125	μA
		TPS60401				65	
		TPS60402				120	
		TPS60403				425	
		TPS60400	At $T_J \leq 60^{\circ}\text{C}$, $V_I = 5\text{ V}$			210	μA
		TPS60401				135	
		TPS60402				210	
		TPS60403				640	
f_{OSC}	Internal switching frequency	TPS60400	VCO version		25	50–250	kHz
		TPS60401			10	20	
		TPS60402			25	50	
		TPS60403			115	250	
	Impedance at 25°C , $V_I = 5\text{ V}$	TPS60400	$C_I = C_{(fly)} = C_O = 1\text{ }\mu\text{F}$		12	15	Ω
		TPS60401	$C_I = C_{(fly)} = C_O = 10\text{ }\mu\text{F}$		12	15	
		TPS60402	$C_I = C_{(fly)} = C_O = 3.3\text{ }\mu\text{F}$		12	15	
		TPS60403	$C_I = C_{(fly)} = C_O = 1\text{ }\mu\text{F}$		12	15	



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Table of Graphs

**TPS60400, TPS60401
EFFICIENCY
VS
OUTPUT CURRENT**



**TPS60402, TPS60403
EFFICIENCY
VS
OUTPUT CURRENT**



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TYPICAL CHARACTERISTICS

TPS60400, TPS60401
INPUT CURRENT
vs
OUTPUT CURRENT

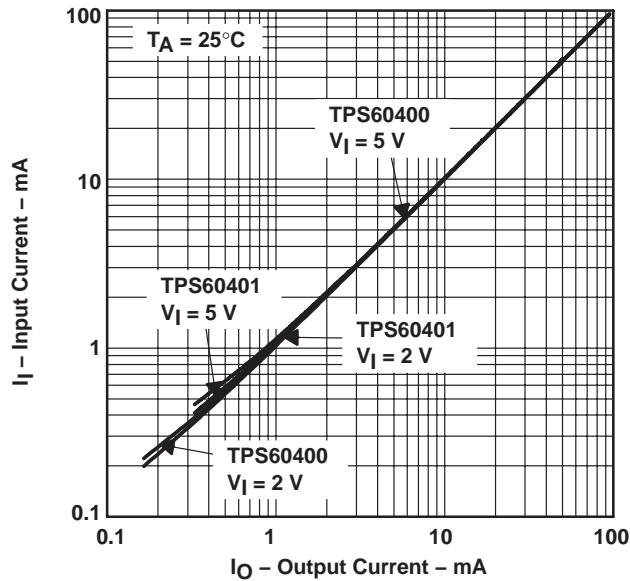


Figure 4

TPS60402, TPS60403
INPUT CURRENT
vs
OUTPUT CURRENT

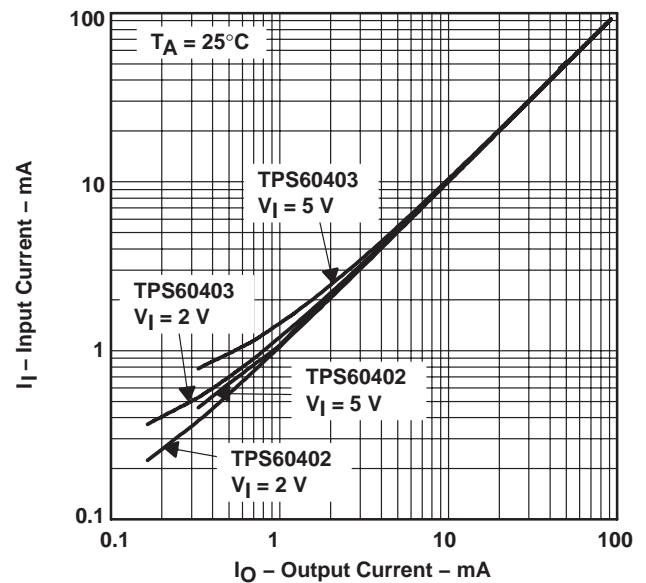


Figure 5

TPS60400, TPS60401
SUPPLY CURRENT
vs
INPUT VOLTAGE

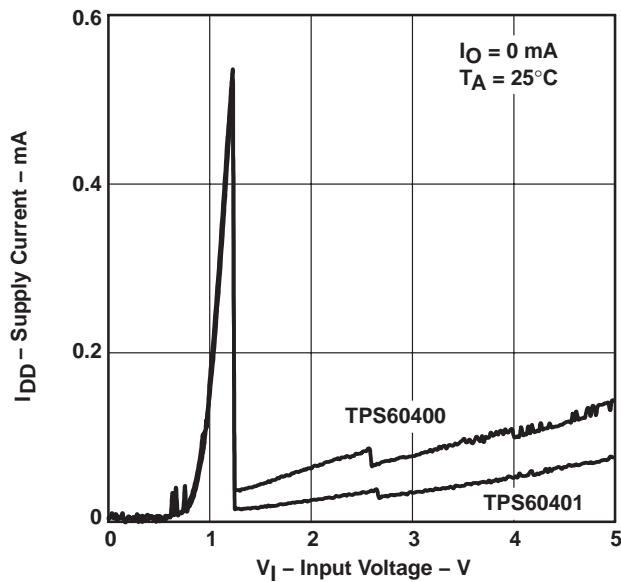


Figure 6

TPS60402, TPS60403
SUPPLY CURRENT
vs
INPUT VOLTAGE

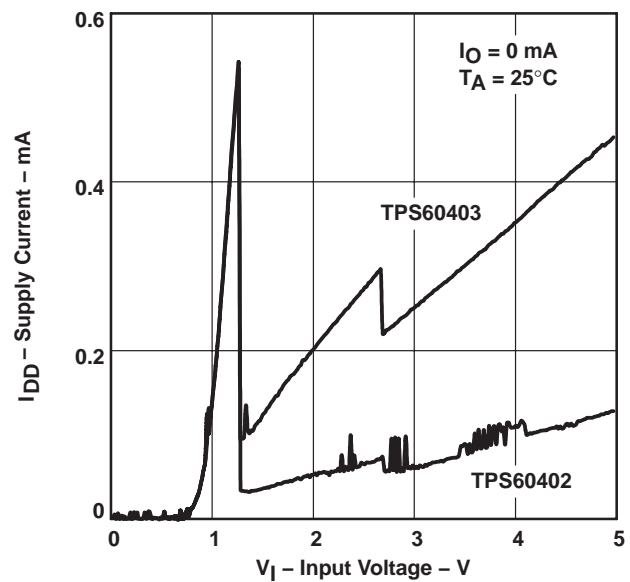
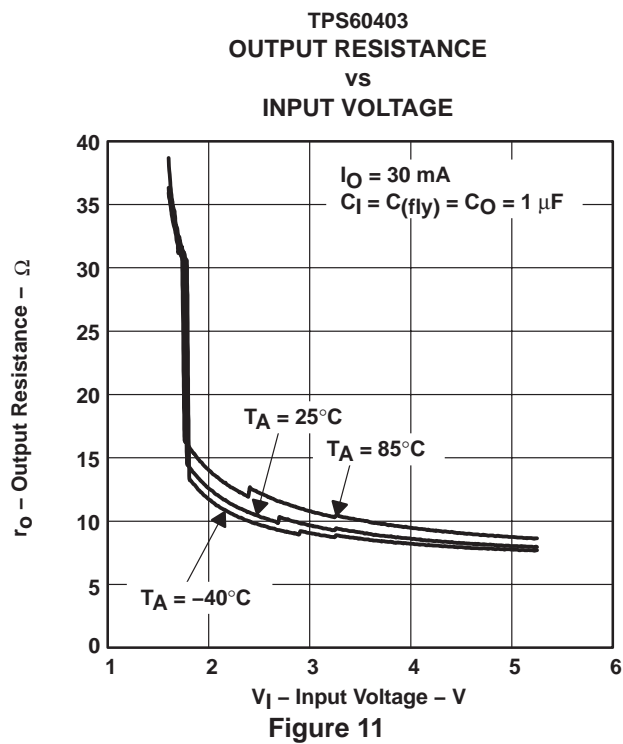
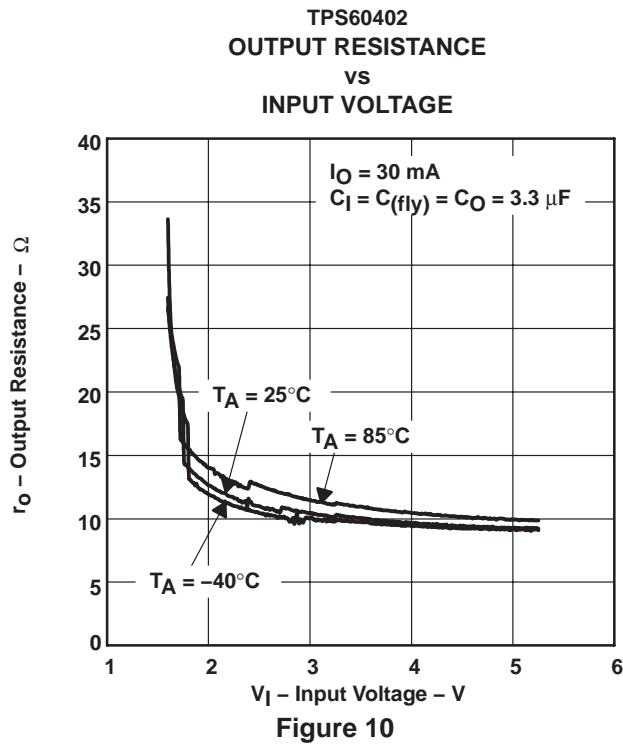
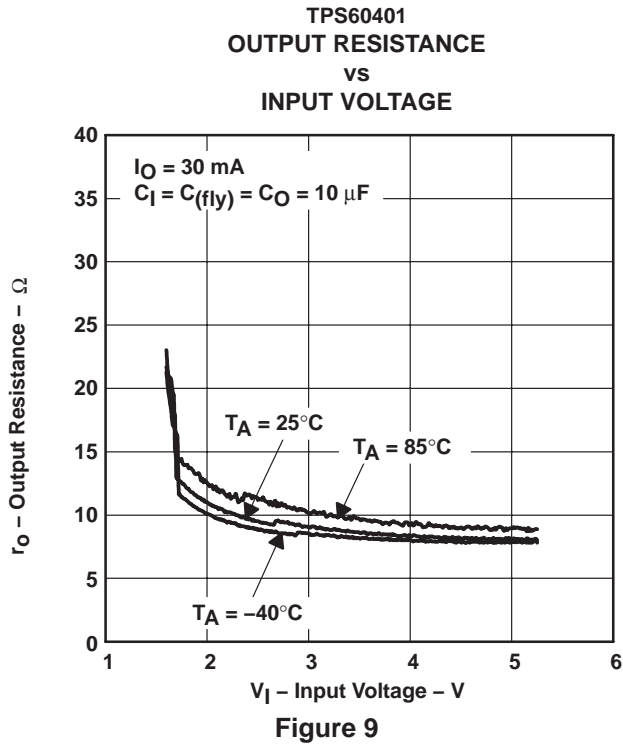
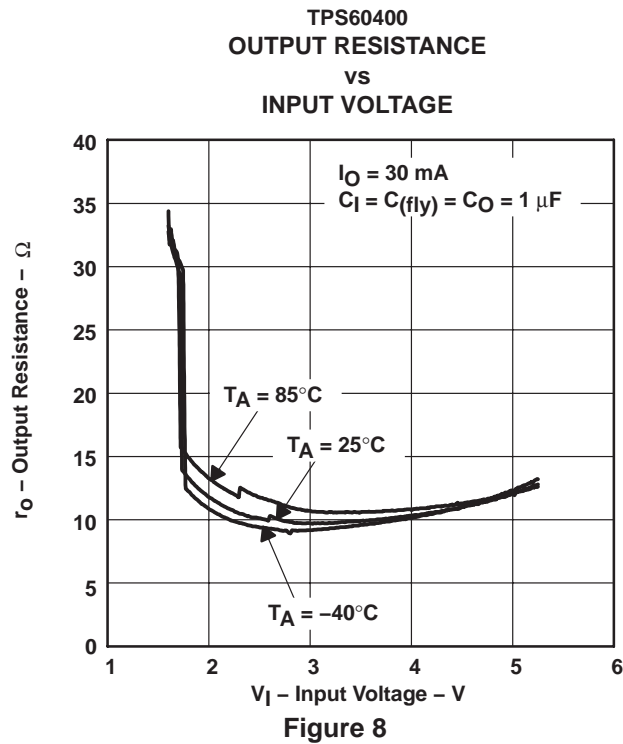


Figure 7

TPS60400-Q1, TPS60401-Q1, TPS60402-Q1, TPS60403-Q1
UNREGULATED 60-mA CHARGE PUMP VOLTAGE INVERTER

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TYPICAL CHARACTERISTICS



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TYPICAL CHARACTERISTICS

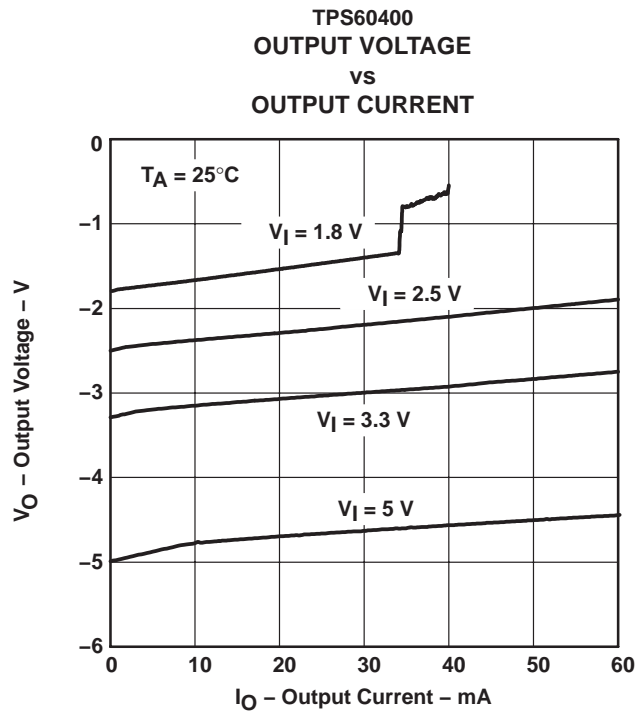


Figure 12

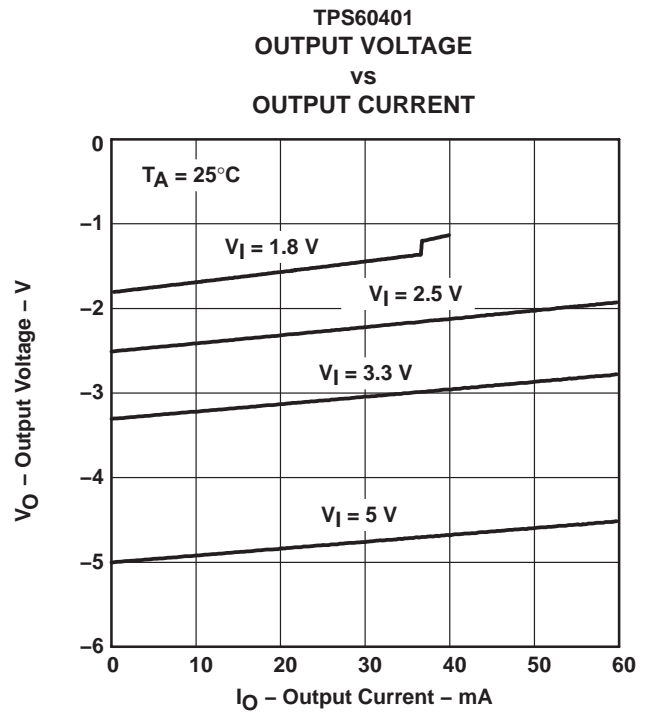


Figure 13

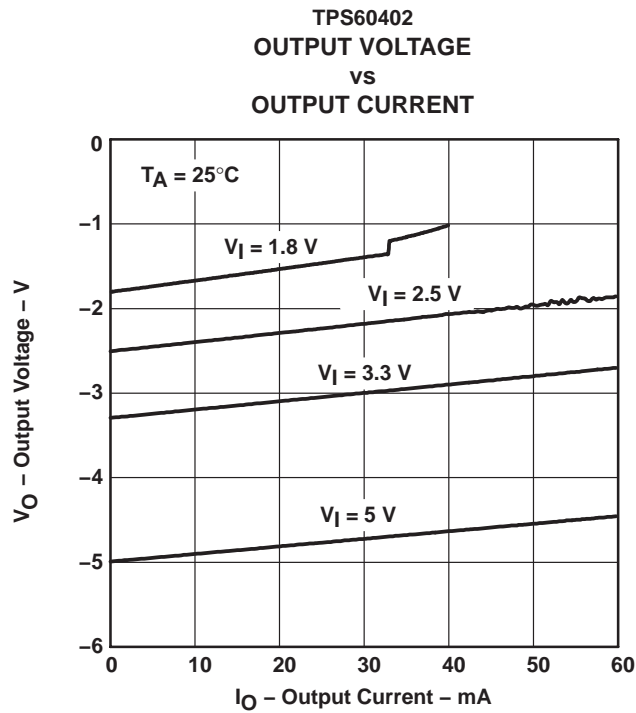


Figure 14

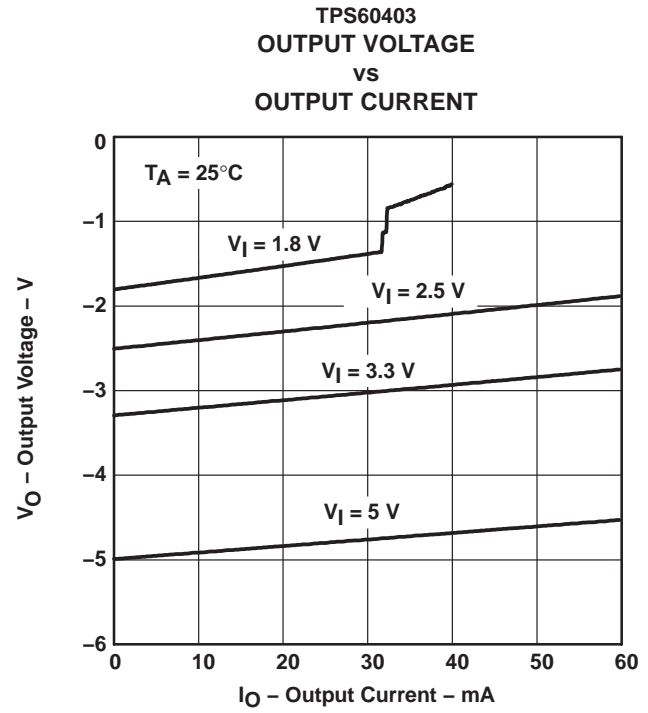


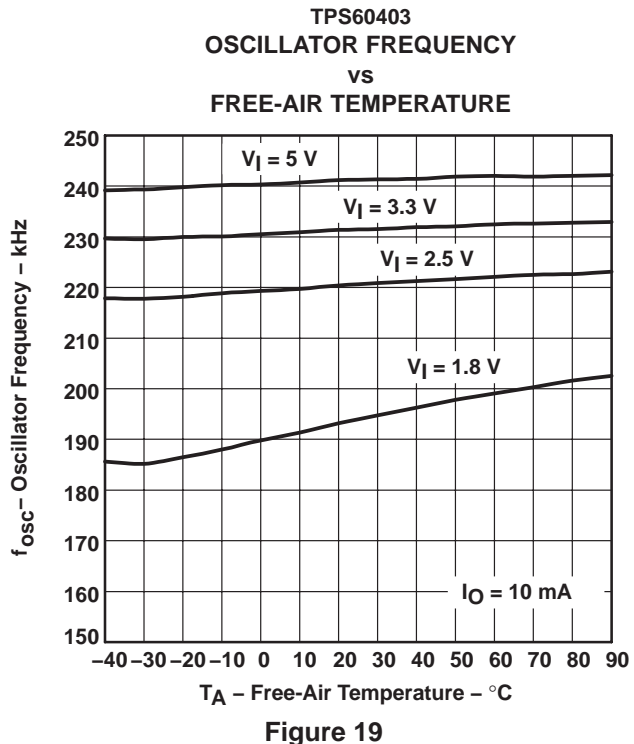
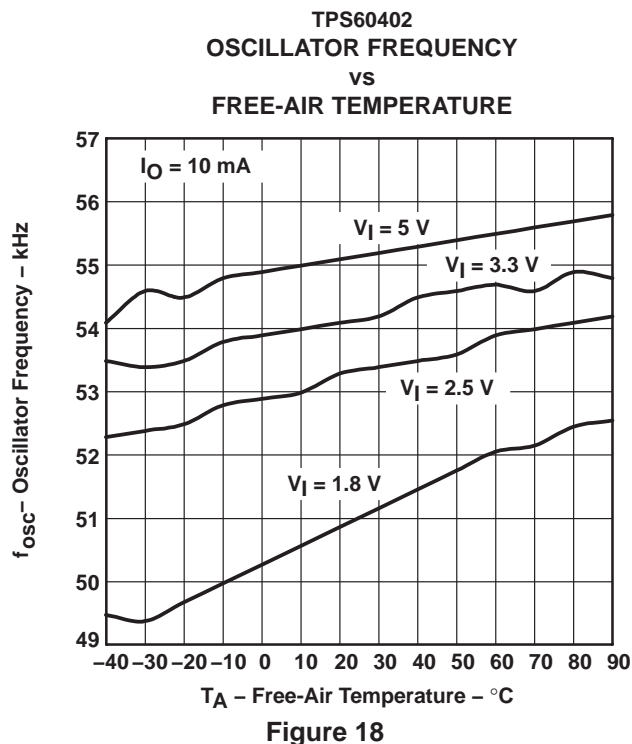
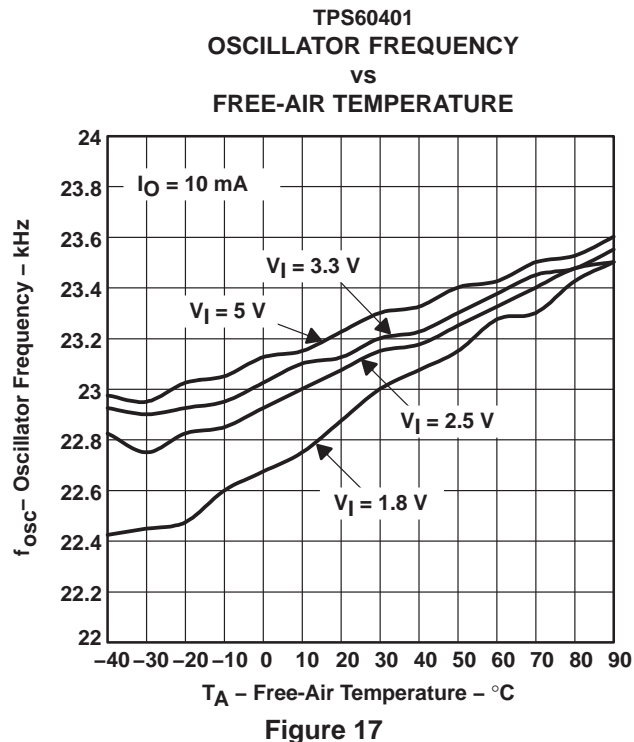
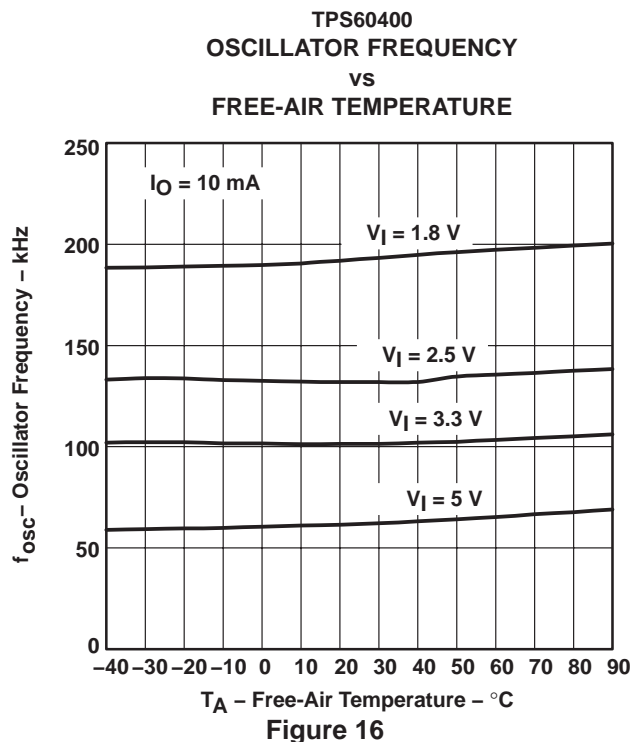
Figure 15

TPS60400-Q1, TPS60401-Q1, TPS60402-Q1, TPS60403-Q1 UNREGULATED 60-mA CHARGE PUMP VOLTAGE INVERTER

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TYPICAL CHARACTERISTICS

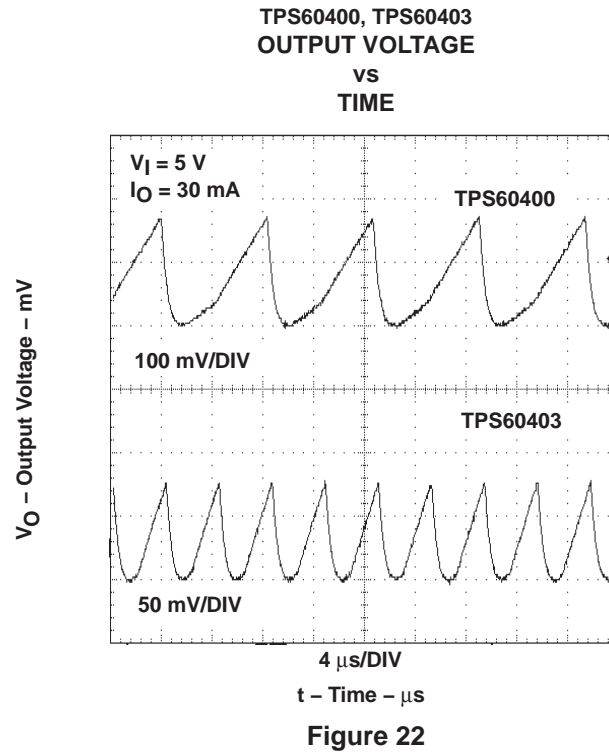
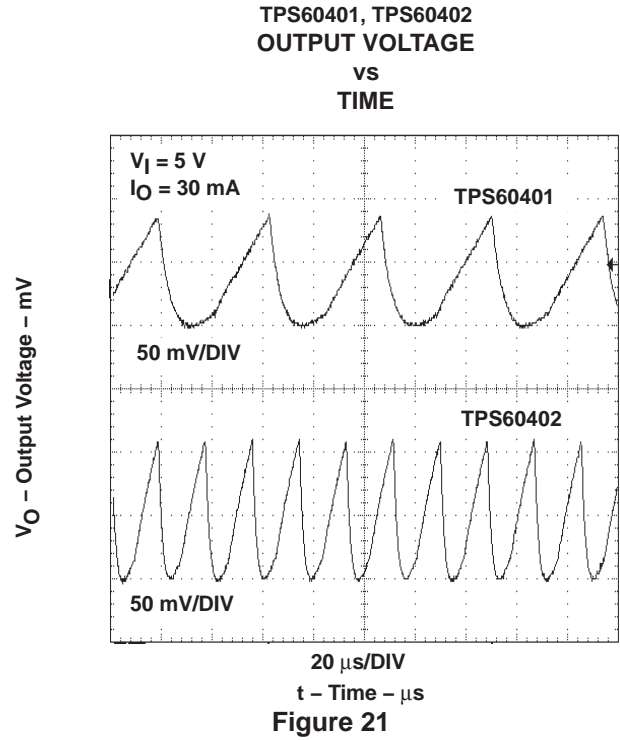
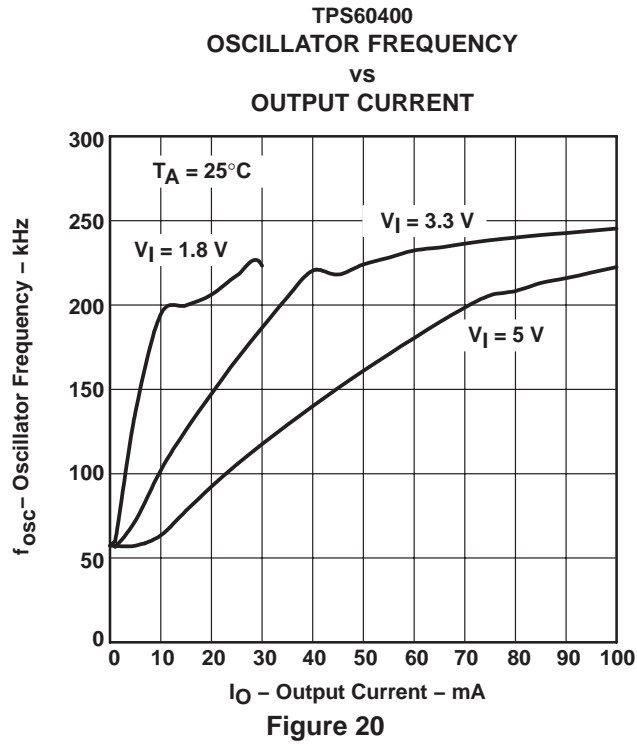


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TYPICAL CHARACTERISTICS



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APPLICATION INFORMATION

voltage inverter

The most common application for these devices is a charge-pump voltage inverter (see Figure 23). This application requires only two external components; capacitors $C_{(fly)}$ and C_O , plus a bypass capacitor, if necessary. See the *capacitor selection* section for suggested capacitor types.

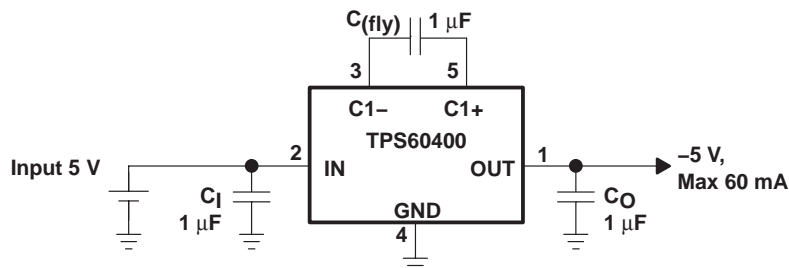


Figure 23. Typical Operating Circuit

For the maximum output current and best performance, three ceramic capacitors of 1 μF (TPS60400, TPS60403) are recommended. For lower currents or higher allowed output voltage ripple, other capacitors can also be used. It is recommended that the output capacitors has a minimum value of 1 μF . With flying capacitors lower than 1 μF , the maximum output power will decrease.

APPLICATION INFORMATION

RC-post filter

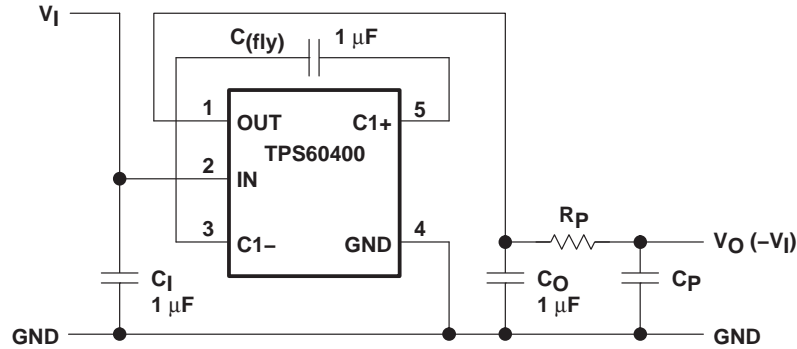


Figure 24. TPS60400 and TPS60401 With RC-Post Filter

An output filter can easily be formed with a resistor (R_P) and a capacitor (C_P). Cutoff frequency is given by:

$$f_c = \frac{1}{2\pi R_P C_P} \quad (1)$$

and ratio V_O/V_{OUT} is:

$$\left| \frac{V_O}{V_{OUT}} \right| = \frac{1}{\sqrt{1 + (2\pi f R_P C_P)^2}} \quad (2)$$

with $R_P = 50 \, \Omega$, $C_P = 0.1 \, \mu\text{F}$ and $f = 250 \, \text{kHz}$: $\left| \frac{V_O}{V_{OUT}} \right| = 0.125$

The formula refers only to the relation between output and input of the ac ripple voltages of the filter.

LC-post filter

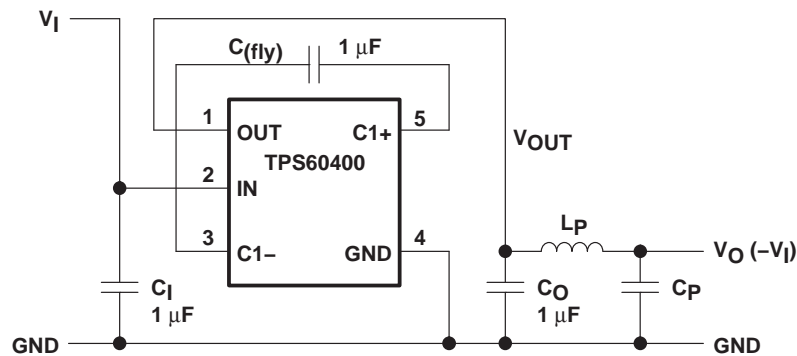


Figure 25. LC-Post Filter

Figure 25 shows a configuration with a LC-post filter to further reduce output ripple and noise.

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UNREGULATED 60-mA CHARGE PUMP VOLTAGE INVERTER

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APPLICATION INFORMATION

Table 4. Measurement Results on the TPS60400 (Typical)

V _I [V]	I _{O(2)} [mA]	C _I [μF]	C _(fly) [μF]	C _O [μF]	L _P [μH]	C _P [μF]	BW = 500 MHz V _{P_{OUT}} V _{P-P} [mV]	BW = 20 MHz V _{P_{OUT}} V _{P-P} [mV]	V _{P_{OUT}} V _{ACeff} [mV]
		CERAMIC	CERAMIC	CERAMIC		CERAMIC			
5	60	1	1	1			320	240	65
5	60	1	1	2.2			120	240	32
5	60	1	1	1		0.1 (X7R)	260	200	58
5	60	1	1	1	0.1	0.1 (X7R)	220	200	60
5	60	1	1	2.2	0.1	0.1 (X7R)	120	100	30
5	60	1	1	10	0.1	0.1 (X7R)	50	28	8

rail splitter

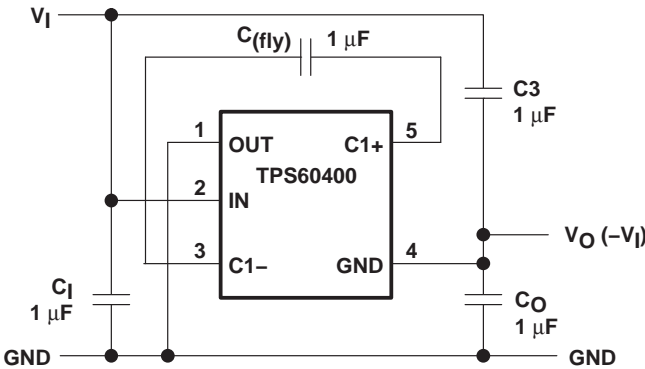


Figure 26. TPS60400 as a High-Efficiency Rail Splitter

A switched-capacitor voltage inverter can be configured as a high efficiency rail-splitter. This circuit provides a bipolar power supply that is useful in battery powered systems to supply dual-rail ICs, like operational amplifiers. Moreover, the SOT23-5 package and associated components require very little board space.

After power is applied, the flying capacitor ($C_{(fly)}$) connects alternately across the output capacitors C_3 and C_O . This equalizes the voltage on those capacitors and draws current from V_I to V_O as required to maintain the output at $1/2 V_I$.

The maximum input voltage between V_I and GND in the schematic (or between IN and OUT at the device itself) must not exceed 6.5 V.

APPLICATION INFORMATION

combined doubler/inverter

In the circuit of Figure 27, capacitors C_1 , $C_{(fly)}$, and C_O form the inverter, while C_1 and C_2 form the doubler. C_1 and $C_{(fly)}$ are the flying capacitors; C_O and C_2 are the output capacitors. Because both the inverter and doubler use part of the charge-pump circuit, loading either output causes both outputs to decline toward GND. Make sure the sum of the currents drawn from the two outputs does not exceed 60 mA. The maximum output current at $V_{(pos)}$ must not exceed 30 mA. If the negative output is loaded, this current must be further reduced.

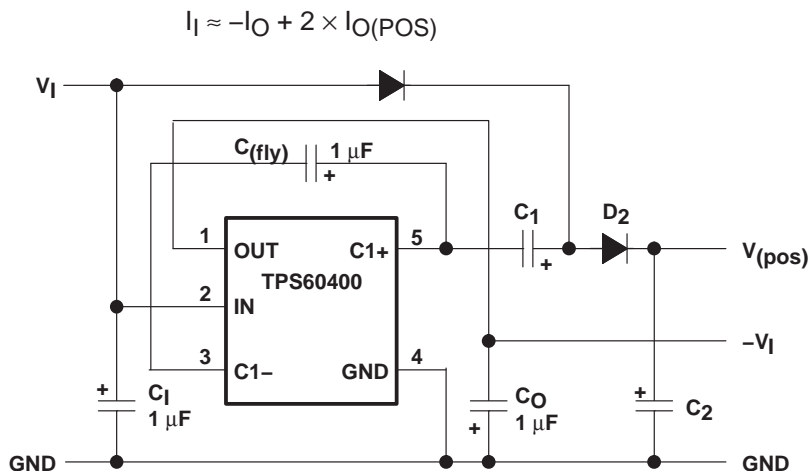


Figure 27. TPS60400 as Doubler/Inverter

cascading devices

Two devices can be cascaded to produce an even larger negative voltage (see Figure 28). The unloaded output voltage is normally $-2 \times V_I$, but this is reduced slightly by the output resistance of the first device multiplied by the quiescent current of the second. When cascading more than two devices, the output resistance rises dramatically.

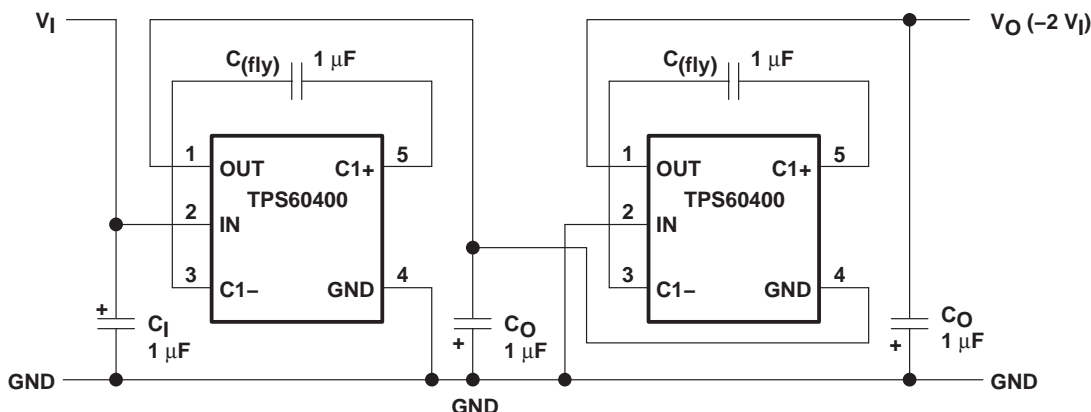


Figure 28. Doubling Inverter

TPS60400-Q1, TPS60401-Q1, TPS60402-Q1, TPS60403-Q1 UNREGULATED 60-mA CHARGE PUMP VOLTAGE INVERTER

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咨询"TPS60401-Q1"供应商

APPLICATION INFORMATION

paralleling devices

Paralleling multiple TPS6040xs reduces the output resistance. Each device requires its own flying capacitor (C_{fly}), but the output capacitor (C_O) serves all devices (see Figure 29). Increase C_O 's value by a factor of n , where n is the number of parallel devices. Equation 1 shows the equation for calculating output resistance.

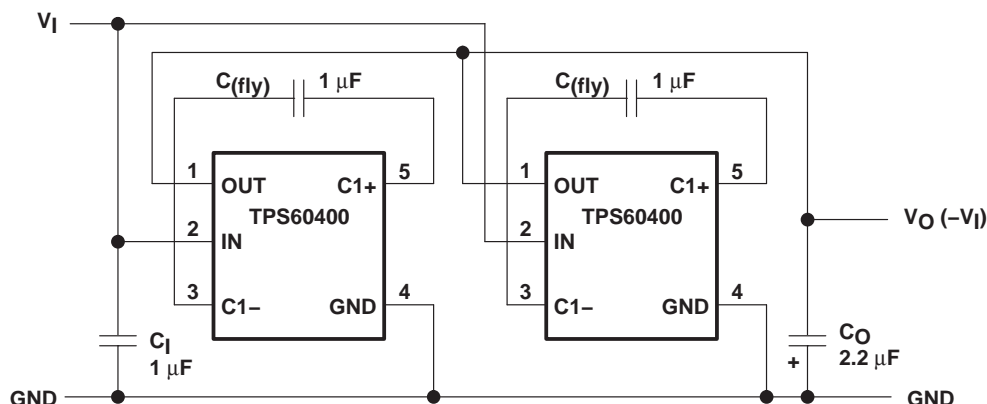


Figure 29. Paralleling Devices

active-Schottky diode

For a short period of time, when the input voltage is applied, but the inverter is not yet working, the output capacitor is charged positive by the load. To prevent the output being pulled above GND, a Schottky diode must be added in parallel to the output. The function of this diode is integrated into the TPS6040x devices, which gives a defined startup performance and saves board space.

A current sink and a diode in series can approximate the behavior of a typical, modern operational amplifier. Figure 30 shows the current into this typical load at a given voltage. The TPS6040x devices are optimized to start into these loads.

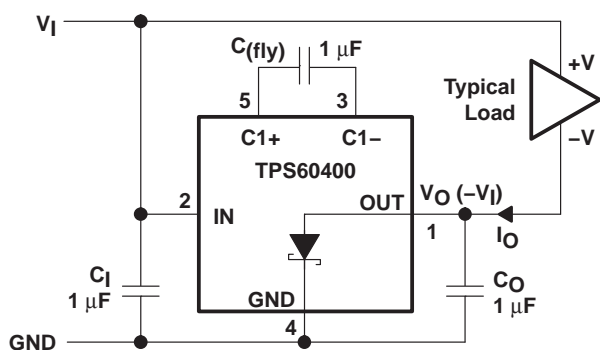


Figure 30. Typical Load

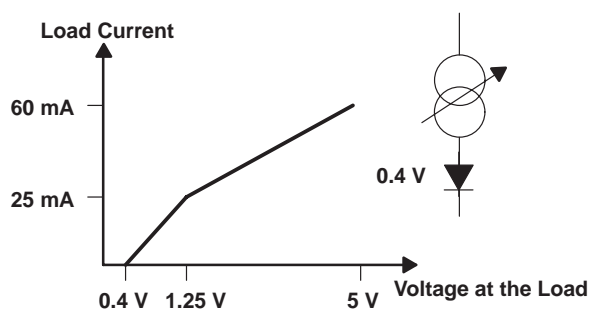


Figure 31. Maximum Start-Up Current

APPLICATION INFORMATION

shutting down the TPS6040x

If shutdown is necessary, use the circuit in Figure 32. The output resistance of the TPS6040x will typically be $15\ \Omega$ plus two times the output resistance of the buffer.

Connecting multiple buffers in parallel can reduce the output resistance of the buffer driving the IN pin.

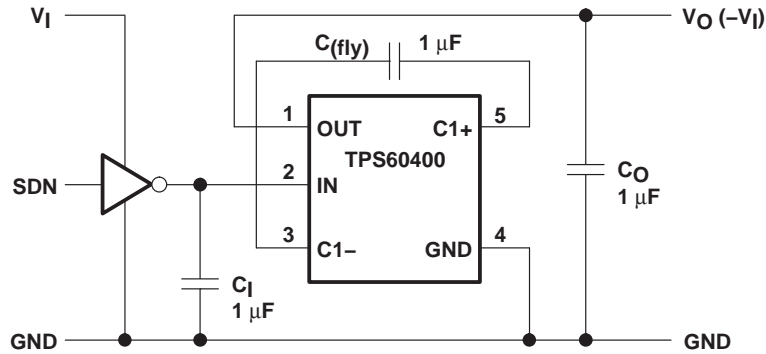


Figure 32. Shutdown Control

GaAs supply

A solution for a $-2.7\text{-V}/3\text{-mA}$ GaAs bias supply is proposed in Figure 33. The input voltage of 3.3 V is first inverted with a TPS60403 and stabilized using a TLV431 low-voltage shunt regulator. Resistor R_P with capacitor C_P is used for filtering the output voltage.

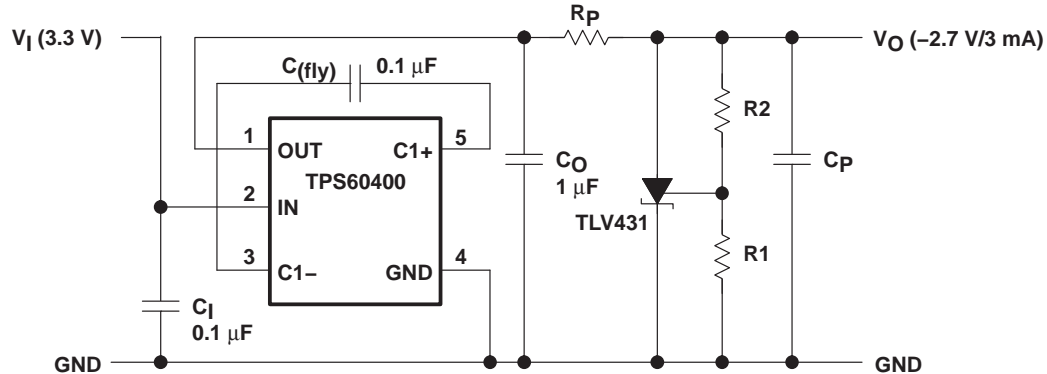


Figure 33. GaAs Supply

$$V_O = - \left(1 + \frac{R_1}{R_2} \right) \times V_{\text{ref}} - R_1 \times I_{\text{I(ref)}}$$

A $0.1\text{-}\mu\text{F}$ capacitor was selected for $C_{\text{(fly)}}$. By this, the output resistance of the inverter is about $52\ \Omega$.

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GaAs supply (continued)

$$R_{P\text{MAX}} = \left(\frac{V_{\text{CO}} - V_{\text{O}}}{I_{\text{O}}} - R_{\text{O}} \right)$$
$$R_{P\text{MAX}} = 200 \, \Omega - 52 \, \Omega = 148 \, \Omega$$

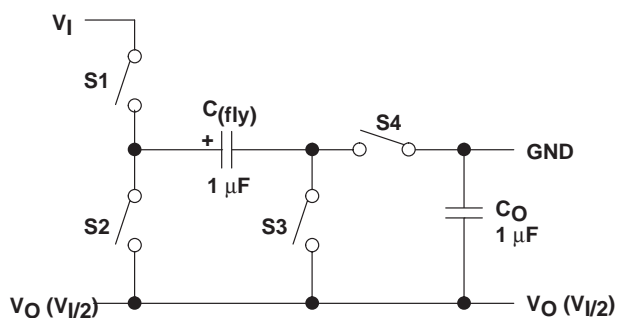
The reference voltage across R2 is 1.24 V typical. With 5- μ A current for the voltage divider, R2 gets:

$$R_2 = \frac{1.24 \text{ V}}{5 \mu\text{A}} \approx 250 \text{ k}\Omega$$

$$R1 = \frac{2.7 - 1.24 \text{ V}}{5 \mu\text{A}} \approx 300 \text{ k}\Omega$$

$$\left| \frac{V_O}{V_I} \right| = \frac{1}{\sqrt{1 + (2\pi \times 125000 \text{ Hz} \times 100 \Omega \times 1 \mu\text{F})^2}} \approx 0.01$$

By exchanging GND with OUT (connecting the GND pin with OUT and the OUT pin with GND), a step-down charge pump can easily be formed. In the first cycle S1 and S3 are closed, and $C_{(\text{fly})}$ with C_O in series are charged. Assuming the same capacitance, the voltage across $C_{(\text{fly})}$ and C_O is split equally between the capacitors. In the second cycle, S2 and S4 close and both capacitors with $V_I/2$ across are connected in parallel.



The maximum input voltage between V_I and GND in the schematic (or between IN and OUT at the device itself) must not exceed 6.5 V. For input voltages in the range of 6.5 V to 11 V, an additional Zener-diode is recommended (see Figure 36).

APPLICATION INFORMATION

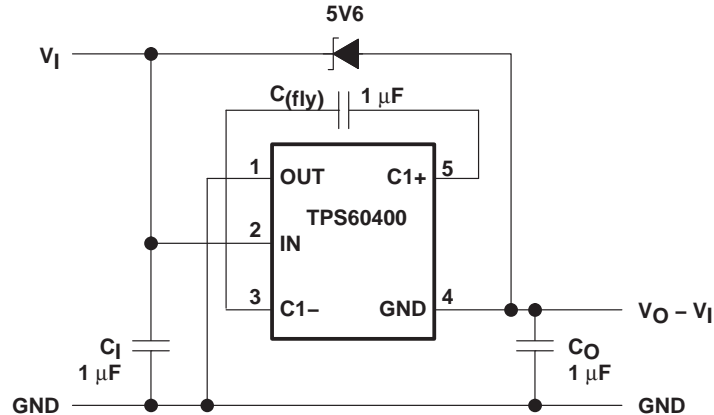


Figure 36. Step-Down Charge Pump Connection With Additional Zener Diode

power dissipation

As given in this data sheet, the thermal resistance of the unsoldered package is $R_{\theta JA} = 347^\circ\text{C/W}$. Soldered on the EVM, a typical thermal resistance of $R_{\theta JA(\text{EVM})} = 180^\circ\text{C/W}$ was measured.

The terminal resistance can be calculated using the following equation:

$$R_{\theta JA} = \frac{T_J - T_A}{P_D}$$

Where:

T_J is the junction temperature.

T_A is the ambient temperature.

P_D is the power that needs to be dissipated by the device.

$$R_{\theta JA} = \frac{T_J - T_A}{P_D}$$

The maximum power dissipation can be calculated using the following equation:

$$P_D = V_I \times I_I - V_O \times I_O = V_{I(\text{max})} \times (I_O + I_{(\text{SUPPLY})}) - V_O \times I_O$$

The maximum power dissipation happens with maximum input voltage and maximum output current.

At maximum load the supply current is 0.7 mA maximum.

$$P_D = 5 \text{ V} \times (60 \text{ mA} + 0.7 \text{ mA}) - 4.4 \text{ V} \times 60 \text{ mA} = 40 \text{ mW}$$

With this maximum rating and the thermal resistance of the device on the EVM, the maximum temperature rise above ambient temperature can be calculated using the following equation:

$$\Delta T_J = R_{\theta JA} \times P_D = 180^\circ\text{C/W} \times 40 \text{ mW} = 7.2^\circ\text{C}$$

This means that the internal dissipation increases T_J by $<10^\circ\text{C}$.

The junction temperature of the device shall not exceed 125°C .

This means the IC can easily be used at ambient temperatures up to:

$$T_A = T_{J(\text{max})} - \Delta T_J = 125^\circ\text{C/W} - 10^\circ\text{C} = 115^\circ\text{C}$$

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layout and board space



Other inverting dc-dc converters from Texas Instruments are listed in Table 5.

PART NUMBER	DESCRIPTION
TPS6735	Fixed negative 5-V, 200-mA inverting dc-dc converter
TPS6755	Adjustable 1-W inverting dc-dc converter

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
TPS60400QDBVRQ1	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TPS60401QDBVRQ1	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TPS60402QDBVRQ1	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TPS60403QDBVRQ1	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

⁽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.

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OTHER QUALIFIED VERSIONS OF TPS60400-Q1, TPS60401-Q1, TPS60402-Q1, TPS60403-Q1 :

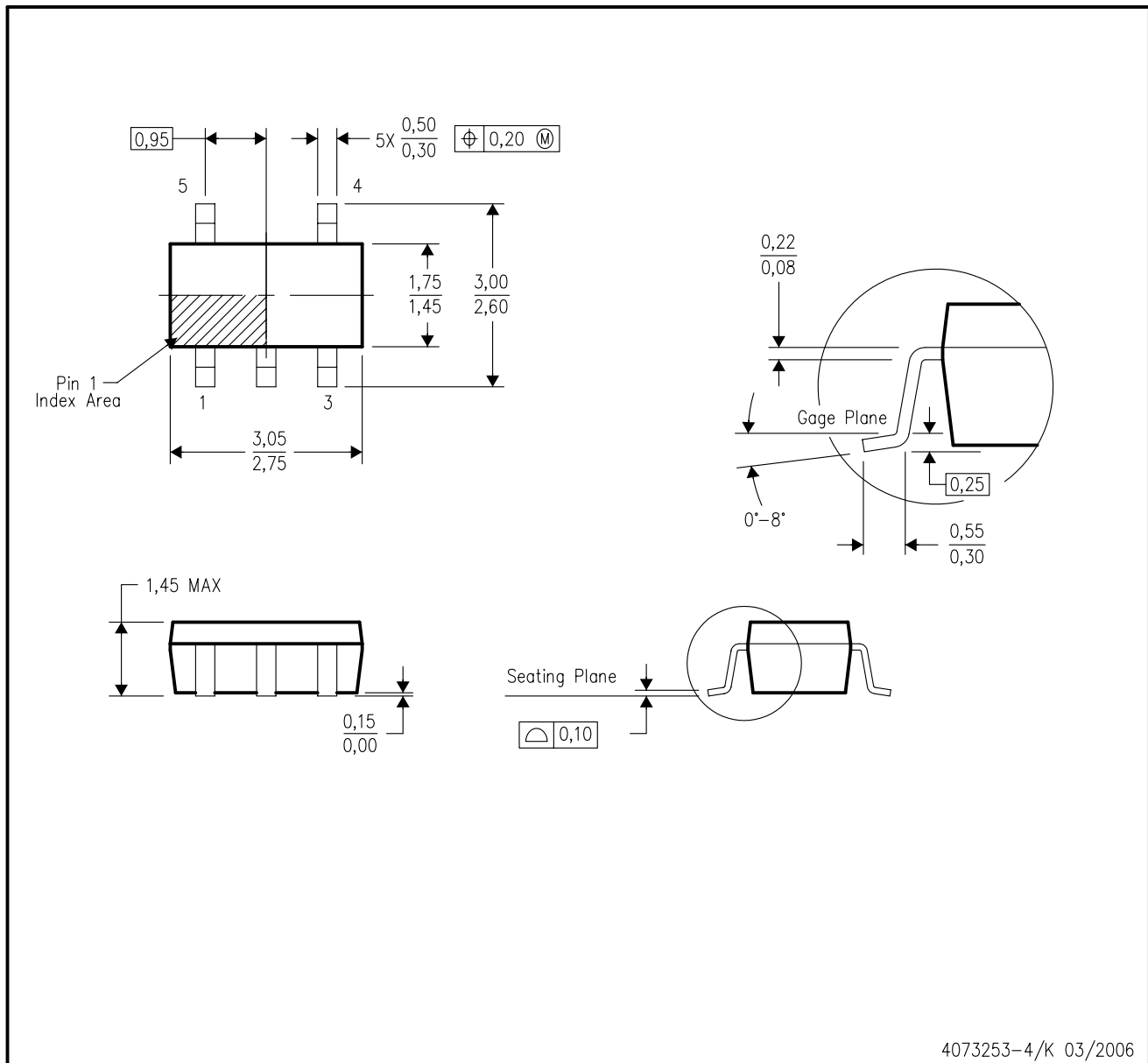
- Catalog: [TPS60400](#), [TPS60401](#), [TPS60402](#), [TPS60403](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

DBV (R-PDSO-G5)

PLASTIC SMALL-OUTLINE PACKAGE



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

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