

# TPS60300, TPS60301, TPS60302, TPS60303 SINGLE-CELL TO 3.0-V/3.3-V, 20-mA DUAL OUTPUT, HIGH-EFFICIENCY CHARGE PUMP

SLVS302A – DECEMBER 2000 – REVISED MARCH 2001

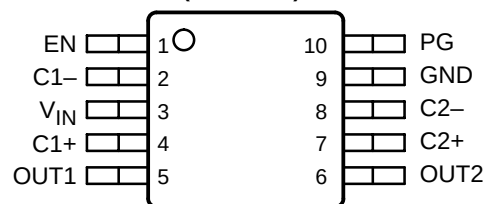
## features

- Regulated 3-V or 3.3-V Output Voltage With up to 20-mA Output Current From a 0.9-V to 1.8-V Input Voltage Range
- High Power Conversion Efficiency (up to 90%) Over a Wide Output Current Range, Optimized for 1.2-V Battery Voltage
- Additional Output With 2 Times  $V_{IN}$  (OUT1)
- Device Quiescent Current Less Than 35  $\mu$ A
- Supervisor Included; Open Drain or Push-Pull Power Good Output
- No Inductors Required/Low EMI
- Only Five Small, 1- $\mu$ F Ceramic Capacitors Required
- Load Isolated From Battery During Shutdown
- Microsmall 10-Pin MSOP Package

## applications

- Pagers
- Battery-Powered Toys
- Portable Measurement Instruments
- Home Automation Products
- Medical Instruments (Like Hearing Instruments)
- Metering Applications Using MSP430 Microcontroller
- Portable Smart Card Readers

DGS PACKAGES  
(TOP VIEW)



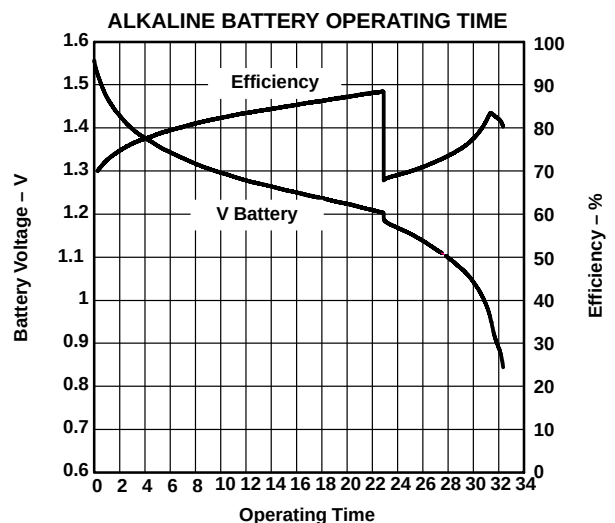
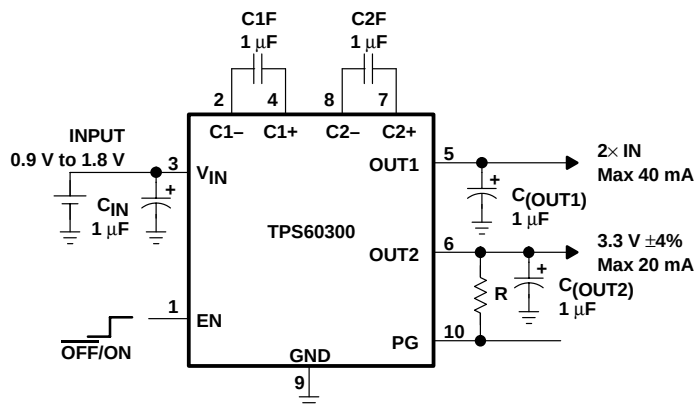
ACTUAL SIZE  
3,05 mm x 4,98 mm

## description

The TPS6030x step-up, regulated charge pumps generate a 3-V  $\pm 4\%$  or 3.3-V  $\pm 4\%$  output voltage from a 0.9-V to 1.8-V input voltage (one alkaline, NiCd, or NiMH battery).

Only five small 1- $\mu$ F ceramic capacitors are required to build a complete high efficiency dc/dc charge pump converter. To achieve the high efficiency over a wide input voltage range, the charge pump automatically selects between a 3x or 4x conversion mode.

## typical application circuit



Operating time (hours) with an alkaline battery  
(2000 mAh) until power good goes low @  $I_L = 20$  mA



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.

**TEXAS  
INSTRUMENTS**

POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

Copyright © 2001, Texas Instruments Incorporated

# TPS60300, TPS60301, TPS60302, TPS60303 SINGLE-CELL TO 3.0-V/3.3-V, 20-mA DUAL OUTPUT, HIGH-EFFICIENCY CHARGE PUMP

SLVS302A – DECEMBER 2000 – REVISED MARCH 2001

## description (continued)

Output 1 (OUT1) can deliver a maximum of 40 mA, from a 1-V input, with output 2 (OUT2) not loaded. OUT2 can deliver a maximum of 20 mA, from a 1-V input, with OUT1 not loaded. Both outputs can be loaded in the same time, but the total output current of the first voltage doubler must not exceed 40 mA. For example, the load at OUT1 is 20 mA and the load at output 2 is 10 mA.

The devices operate in the newly developed LinSkip mode. In this operating mode, the device switches seamlessly from the power saving, pulse-skip mode at light loads, to the low-noise, constant-frequency linear-regulation mode, once the output current exceeds the device-specific output current threshold.

A power-good function supervises the output voltage of OUT2 and can be used for power up and power down sequencing. Power good (PG) is offered as either open-drain or push-pull output.

### AVAILABLE OPTIONS

| PART NUMBER <sup>†</sup> | MARKING DGS PACKAGE | OUTPUT CURRENT 1 [mA] <sup>‡</sup> | OUTPUT CURRENT 2 [mA] <sup>§</sup> | OUTPUT VOLTAGE 1 [V] | OUTPUT VOLTAGE 2 [V] | FEATURE                      |
|--------------------------|---------------------|------------------------------------|------------------------------------|----------------------|----------------------|------------------------------|
| TPS60300DGS              | ALF                 | 40                                 | 20                                 | $2 \times V_{IN}$    | 3.3                  | Open-drain power-good output |
| TPS60301DGS              | ALG                 | 40                                 | 20                                 | $2 \times V_{IN}$    | 3.0                  | Open-drain power-good output |
| TPS60302DGS              | ALI                 | 40                                 | 20                                 | $2 \times V_{IN}$    | 3.3                  | Push-pull power-good output  |
| TPS60303DGS              | ALK                 | 40                                 | 20                                 | $2 \times V_{IN}$    | 3.0                  | Push-pull power-good output  |

<sup>†</sup> The DGS package is available taped and reeled. Add R suffix to device type (e.g. TPS60300DGSR) to order quantities of 2500 devices per reel.

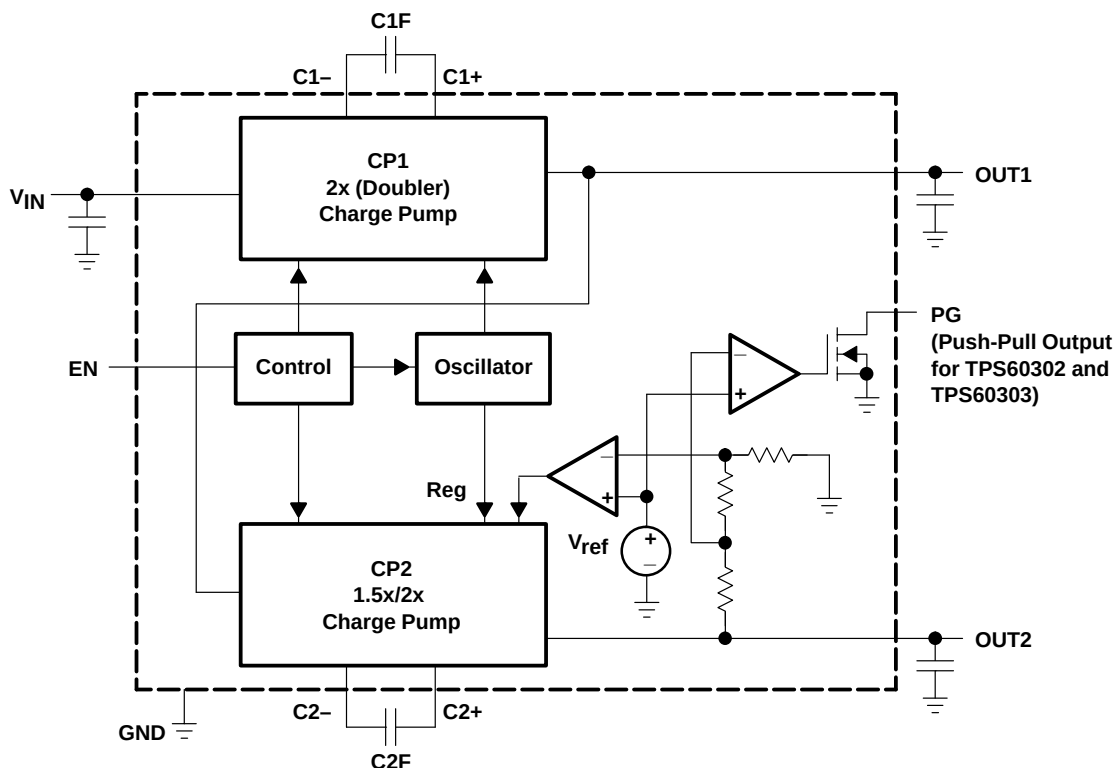
<sup>‡</sup> If OUT2 is not loaded

<sup>§</sup> If OUT1 is not loaded

**TPS60300, TPS60301, TPS60302, TPS60303**  
**SINGLE-CELL TO 3.0-V/3.3-V, 20-mA DUAL OUTPUT,**  
**HIGH-EFFICIENCY CHARGE PUMP**

SLVS302A – DECEMBER 2000 – REVISED MARCH 2001

**TPS60300 and TPS60301 functional block diagram**



**Terminal Functions**

| TERMINAL<br>NAME | NO. | I/O | DESCRIPTION                                                                                                                                                                                                                                                                                |
|------------------|-----|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| C1+              | 4   |     | Positive terminal of the flying capacitor C1F                                                                                                                                                                                                                                              |
| C1–              | 2   |     | Negative terminal of the flying capacitor C1F                                                                                                                                                                                                                                              |
| C2+              | 7   |     | Positive terminal of the flying capacitor C2F                                                                                                                                                                                                                                              |
| C2–              | 8   |     | Negative terminal of the flying capacitor C2F                                                                                                                                                                                                                                              |
| EN               | 1   | I   | Device-enable input<br>– EN = Low disables the device. Output and input are isolated in shutdown mode.<br>– EN = High enables the device.                                                                                                                                                  |
| GND              | 9   |     | GROUND                                                                                                                                                                                                                                                                                     |
| OUT1             | 5   | O   | $2 \times V_{IN}$ power output. Bypass OUT1 to GND with the output filter capacitor $C_{(OUT1)}$ .                                                                                                                                                                                         |
| OUT2             | 6   | O   | Regulated<br>3.3-V power output (TPS60300, TPS60302) or 3-V power output (TPS60301, TPS60303), respectively<br>Bypass OUT2 to GND with the output filter capacitor $C_{(OUT2)}$ .                                                                                                          |
| PG               | 10  | O   | Power good detector output. As soon as the voltage on OUT2 reaches about 98% of its nominal value this pin goes high.<br>Open drain output on TPS60300 and TPS60301. A pullup resistor should be connected between PG and OUT1 or OUT2.<br>Push-pull output stage on TPS60302 and TPS60303 |
| V <sub>IN</sub>  | 3   | I   | Supply input. Bypass V <sub>IN</sub> to GND with a $\geq 1\text{-}\mu\text{F}$ capacitor.                                                                                                                                                                                                  |

# TPS60300, TPS60301, TPS60302, TPS60303 SINGLE-CELL TO 3.0-V/3.3-V, 20-mA DUAL OUTPUT, HIGH-EFFICIENCY CHARGE PUMP

SLVS302A – DECEMBER 2000 – REVISED MARCH 2001

---

## detailed description

### operating principle

The TPS6030x charge pumps are voltage quadruplers that provide a regulated 3.3-V or 3.0-V output from a 0.9-V to 1.8-V input. They deliver a maximum load current of 20 mA. Designed specifically for space critical battery powered applications, the complete converter requires only five external capacitors and enables the design to use low-cost, small-sized, 1- $\mu$ F ceramic capacitors. The TPS6030x circuits consist of an oscillator, a voltage reference, an internal resistive feedback circuit, an error amplifier, two charge pump stages with MOSFET switches, a shutdown/start-up circuit, and a control circuit.

### shutdown

Driving EN low disables the converter. This disables all internal circuits, reducing input current to only 0.05  $\mu$ A. Leakage current drawn from the output pins OUT1 and OUT2 is a maximum of 1  $\mu$ A. The device exits shutdown once EN is set high (see start-up procedure described below). The typical no-load, start-up time is 400  $\mu$ s. When the device is disabled, the load is isolated from the input. This is an important feature in battery operated products because it extends the battery shelf life.

### start-up procedure

The device is enabled when EN is set from logic low to logic high. CP1 will first enter a dc start-up mode during which the capacitor on OUT1 is charged up to about  $V_{IN}$ . After that, it starts switching to boost the voltage further up to about two times  $V_{IN}$ . CP2 will then follow and charge up the capacitor on OUT2 to about the voltage on OUT1, after that, it will also start switching and boost up the voltage to its nominal value. EN must not exceed the highest voltage applied to the device.

#### NOTE:

During start-up with  $V_{OUT} = 0$  V, the highest voltage is the input voltage.

### power-good detector

The power-good output is an open-drain output on the TPS60300 and TPS60301 or a push-pull output on the TPS60302 and TPS60303. The PG-output pulls low when the output of OUT2 is out of regulation. When the output rises to within 98% of regulation, the power-good output goes active high. In shutdown, power-good is pulled low. In normal operation, an external pullup resistor with the TPS60300 and TPS60301 is typically used to connect the PG pin to VOUT. The resistor should be in the 100-k $\Omega$  to 1-M $\Omega$  range. If the PG output is not used, it should remain unconnected. Output current at PG (TPS60302, TPS60303) will reduce maximum output current at OUT2.



**TPS60300, TPS60301, TPS60302, TPS60303**  
**SINGLE-CELL TO 3.0-V/3.3-V, 20-mA DUAL OUTPUT,**  
**HIGH-EFFICIENCY CHARGE PUMP**

SLVS302A – DECEMBER 2000 – REVISED MARCH 2001

**absolute maximum ratings over operating free-air temperature (unless otherwise noted)<sup>†</sup>**

|                                                                |                                 |
|----------------------------------------------------------------|---------------------------------|
| Input voltage, $V_I$ (IN to GND) (see Note 1)                  | –0.3 V to 2 V                   |
| Output voltage, $V_O$ (OUT1, OUT2, EN, PG to GND) (see Note 1) | –0.3 V to 3.6 V                 |
| Voltage, (C1+ to GND)                                          | –0.3 V to $V_{O(OUT1)} + 0.3$ V |
| Voltage, (C1– to GND, C2– to GND)                              | –0.3 V to $V_{IN} + 0.3$ V      |
| Voltage, (C2+ to GND)                                          | –0.3 V to $V_{O(OUT2)} + 0.3$ V |
| Continuous power dissipation                                   | See Dissipation Rating Table    |
| Output current, $I_O$ (OUT1)                                   | 80 mA                           |
| Output current, $I_O$ (OUT2)                                   | 40 mA                           |
| Storage temperature range, $T_{stg}$                           | –55°C to 150°C                  |
| Maximum junction temperature, $T_J$                            | 150°C                           |

<sup>†</sup> Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTE 1: The voltage at EN and PG can exceed IN up to the maximum rated voltage without increasing the leakage current drawn by these pins.

**DISSIPATION RATING TABLE**

| PACKAGE | $T_A < 25^\circ\text{C}$<br>POWER RATING | DERATING FACTOR<br>ABOVE $T_A = 25^\circ\text{C}$ | $T_A = 70^\circ\text{C}$<br>POWER RATING | $T_A = 85^\circ\text{C}$<br>POWER RATING |
|---------|------------------------------------------|---------------------------------------------------|------------------------------------------|------------------------------------------|
| DGS     | 424 mW                                   | 3.4 mW/°C                                         | 271 mW                                   | 220 mW                                   |

NOTE: The thermal resistance junction to ambient of the DGS package is  $R_{TH-JA} = 294^\circ\text{C/W}$ .

**recommended operating conditions**

|                                            | MIN | NOM | MAX | UNIT |
|--------------------------------------------|-----|-----|-----|------|
| Input voltage, $V_I$                       | 0.9 |     | 1.8 | V    |
| Output current (OUT2), $I_{O(OUT2)}$       |     |     | 20  | mA   |
| Output current (OUT1), $I_{O(OUT1)}$       |     |     | 40  | mA   |
| Input capacitor, $C_I$                     | 1   |     |     | μF   |
| Flying capacitors, C1F, C2F                |     | 1   |     | μF   |
| Output capacitors, $C_{O(1)}$ , $C_{O(2)}$ | 1   |     |     | μF   |
| Operating junction temperature, $T_J$      | –40 |     | 125 | °C   |

**TPS60300, TPS60301, TPS60302, TPS60303**  
**SINGLE-CELL TO 3.0-V/3.3-V, 20-mA DUAL OUTPUT,**  
**HIGH-EFFICIENCY CHARGE PUMP**

SLVS302A – DECEMBER 2000 – REVISED MARCH 2001

**electrical characteristics at  $C_{IN} = C1F = C2F = C_{(OUT1)} = C_{(OUT2)} = 1\mu F$ ,  $T_C = -40^\circ C$  to  $85^\circ C$ ,  $V_{IN} = 1.0 V$ ,  $V_{(EN)} = V_{IN}$  (unless otherwise noted)**

| PARAMETER              |                                               | TEST CONDITIONS                                                                   | MIN                 | TYP  | MAX                 | UNIT              |
|------------------------|-----------------------------------------------|-----------------------------------------------------------------------------------|---------------------|------|---------------------|-------------------|
| $V_{IN}$               | Supply voltage range                          |                                                                                   | 0.9                 |      | 1.8                 | V                 |
| $I_{O(OUT1)}$          | Maximum output current for TPS60300, TPS60302 | $V_{IN} \geq 1.1 V$ , $I_{O(OUT2)} = 0 mA$ ,<br>$I_{(PG,1)} = 0 mA$               | 40                  |      |                     | mA                |
|                        |                                               | $V_{IN} = 0.9 V$ , $I_{O(OUT2)} = 0 mA$ ,<br>$I_{(PG,1)} = 0 mA$                  | 20                  |      |                     |                   |
| $I_{O(OUT2)}$          |                                               | $V_{IN} \geq 1.1 V$ , $I_{O(OUT1)} = 0 mA$ ,<br>$I_{(PG,1)} = 0 mA$               | 20                  |      |                     |                   |
|                        |                                               | $V_{IN} = 0.9 V$ , $I_{O(OUT1)} = 0 mA$ ,<br>$I_{(PG,1)} = 0 mA$                  | 10                  |      |                     |                   |
| $I_{O(OUT1)}$          | Maximum output current for TPS60301, TPS60303 | $V_{IN} \geq 1.1 V$ , $I_{O(OUT2)} = 0 mA$ ,<br>$I_{(PG,1)} = 0 mA$               | 40                  |      |                     | mA                |
|                        |                                               | $V_{IN} = 0.9 V$ , $I_{O(OUT2)} = 0 mA$ ,<br>$I_{(PG,1)} = 0 mA$                  | 20                  |      |                     |                   |
| $I_{O(OUT2)}$          |                                               | $V_{IN} \geq 1.0 V$ , $I_{O(OUT1)} = 0 mA$ ,<br>$I_{(PG,1)} = 0 mA$               | 20                  |      |                     |                   |
|                        |                                               | $V_{IN} = 0.9 V$ , $I_{O(OUT1)} = 0 mA$ ,<br>$I_{(PG,1)} = 0 mA$                  | 12                  |      |                     |                   |
| $V_{O(OUT2)}$          | Output voltage for TPS60300, TPS60302         | $1.1 V < V_{IN} < 1.8 V$ ,<br>$I_{O(OUT1)} = 0 mA$ ,<br>$0 < I_{O(OUT2)} < 20 mA$ | 3.17                | 3.30 | 3.43                | V                 |
|                        |                                               | $0.9 V < V_{IN} < 1.1 V$ ,<br>$I_{O(OUT1)} = 0 mA$ , $I_{O(OUT2)} < 10 mA$        | 3.17                | 3.30 | 3.43                |                   |
| $V_{O(OUT2)}$          | Output voltage for TPS60301, TPS60303         | $1.0 V < V_{IN} < 1.8 V$ ,<br>$I_{O(OUT1)} = 0 mA$ ,<br>$0 < I_{O(OUT2)} < 20 mA$ | 2.88                | 3    | 3.12                | V                 |
|                        |                                               | $V_{IN} > 1.65 V$ , $I_{O(OUT1)} = 0 mA$ ,<br>$25 \mu A < I_{O(OUT2)} < 20 mA$    | 2.88                | 3    | 3.15                |                   |
| $V_{P-P}$              | Output voltage ripple                         | OUT2<br>$I_{O(OUT2)} = 20 mA$ , $I_{O(OUT1)} = 0 mA$                              |                     | 20   |                     | mV <sub>P-P</sub> |
|                        |                                               | OUT1<br>$I_{O(OUT1)} = 40 mA$ , $I_{O(OUT2)} = 0 mA$                              |                     | 40   |                     |                   |
| $I_Q$                  | Quiescent current (no-load input current)     | $I_{O(OUT)} = 0 mA$ , $V_{IN} = 1.8 V$                                            |                     | 35   | 70                  | $\mu A$           |
| $I_{(SD)}$             | Shutdown supply current                       | $V_{IN} = 1.8 V$ ,<br>See Note 2<br>$V_{(EN)} = 0 V$                              |                     | 0.05 | 2.5                 | $\mu A$           |
|                        |                                               | $V_{IN} = 1.8 V$ ,<br>$T_C = 25^\circ C$ ,<br>$V_{(EN)} = 0 V$ ,<br>See Note 2    |                     |      | 0.5                 |                   |
| $f_{OSC}$              | Internal switching frequency                  |                                                                                   | 470                 | 700  | 900                 | kHz               |
| $V_{IL(EN)}$           | EN input low voltage                          | $V_{IN} = 0.9 V$ to $1.8 V$                                                       |                     |      | $0.3 \times V_{IN}$ | V                 |
| $V_{IH(EN)}$           | EN input high voltage                         | $V_{IN} = 0.9 V$ to $1.8 V$                                                       | $0.7 \times V_{IN}$ |      |                     | V                 |
| $I_{lkg}$              | EN input leakage current                      | $V_{(EN)} = 0 V$ or $V_{IN}$ or $V_{O(OUT2)}$ or<br>$V_{O(OUT1)}$                 |                     | 0.01 | 0.1                 | $\mu A$           |
|                        | LinSkip switching threshold                   | $V_{IN} = 1.25 V$                                                                 |                     | 7.5  |                     | mA                |
| Short circuit current  |                                               | $V_{IN} = 1.8 V$                                                                  |                     |      |                     | mA                |
|                        |                                               | $V_{O(OUT2)} = 0 V$                                                               | 5                   | 20   | 50                  |                   |
|                        |                                               | $V_{O(OUT1)} = 0 V$                                                               | 2                   | 80   | 150                 |                   |
| Output leakage current | OUT2                                          | $V_{O(OUT1)} = 3 V$ ,<br>$V_{O(OUT2)} = \text{nominal}$ , $EN = 0 V$              |                     |      | 1                   | $\mu A$           |

NOTE 2: OUT1 not loaded. If OUT1 is connected to GND via a resistor, leakage current will be increased.

**TPS60300, TPS60301, TPS60302, TPS60303**  
**SINGLE-CELL TO 3.0-V/3.3-V, 20-mA DUAL OUTPUT,**  
**HIGH-EFFICIENCY CHARGE PUMP**

SLVS302A – DECEMBER 2000 – REVISED MARCH 2001

**electrical characteristics at  $C_{IN} = C1F = C2F = C_{(OUT1)} = C_{(OUT2)} = 1\mu F$ ,  $T_C = -40^{\circ}C$  to  $85^{\circ}C$ ,  $V_{IN} = 1.0$  V,  $V_{(EN)} = V_{IN}$  (unless otherwise noted) (continued)**

| PARAMETER                                                       | TEST CONDITIONS                                                                                | MIN  | TYP  | MAX | UNIT     |
|-----------------------------------------------------------------|------------------------------------------------------------------------------------------------|------|------|-----|----------|
| Output load regulation                                          | $V_{IN} = 1.25$ V, $T_C = 25^{\circ}C$<br>$2\text{ mA} < I_{O(OUT2)} < 20\text{ mA}$           |      | 0.1  |     | %/mA     |
| Output line regulation                                          | $1.0\text{ V} < V_{IN} < 1.65\text{ V}$ ; $T_C = 25^{\circ}C$ ,<br>$I_{O(OUT)} = 10\text{ mA}$ |      | 0.75 |     | %/V      |
| No-load start-up time                                           |                                                                                                |      | 400  |     | $\mu s$  |
| Impedance of first charge pump stage                            |                                                                                                |      | 4    |     | $\Omega$ |
| Start-up performance at OUT2 (minimum start-up load resistance) | $V_{IN} \geq 1.1\text{ V}$                                                                     | 165  |      |     | $\Omega$ |
|                                                                 | $V_{IN} \geq 1.0\text{ V}$                                                                     | 330  |      |     |          |
|                                                                 | $V_{IN} = 0.9\text{ V}$                                                                        | 1000 |      |     |          |
| Start-up performance at OUT1 (minimum start-up load resistance) | $V_{IN} = 1.0\text{ V}$                                                                        | 500  |      |     | $\Omega$ |

**electrical characteristics for power good comparator of devices TPS6030x at  $T_C = -40^{\circ}C$  to  $85^{\circ}C$ ,  $V_{IN} = 1.0$  V and  $V_{(EN)} = V_{IN}$  (unless otherwise noted)**

| PARAMETER                                           | TEST CONDITIONS                                                 | MIN | TYP         | MAX   | UNIT     |
|-----------------------------------------------------|-----------------------------------------------------------------|-----|-------------|-------|----------|
| $V_{(PG)}$ Power good trip voltage                  | $V_O$ ramping positive                                          |     | $V_O - 2\%$ | $V_O$ | V        |
| $V_{hys}$ Power good trip voltage hysteresis        | $V_O$ ramping negative                                          |     | 10%         |       |          |
| $V_{OL}$ Power good output voltage low              | $V_O = 0$ V,<br>$I_{(PG)} = 1.6\text{ mA}$                      |     |             | 0.3   | V        |
| $I_{lkg}$ Power good leakage current                | TPS60300<br>$V_O = 3.3\text{ V}$ ,<br>$V_{(PG)} = 3.3\text{ V}$ |     | 0.01        | 0.1   | $\mu A$  |
|                                                     | TPS60301<br>$V_O = 3.0\text{ V}$ ,<br>$V_{(PG)} = 3.0\text{ V}$ |     | 0.01        | 0.1   |          |
| $V_{OH}$ Power good output voltage high             | TPS60302<br>$I_{(PG)} = -5\text{ mA}$                           | 3   |             |       | V        |
|                                                     | TPS60303                                                        | 2.7 |             |       |          |
| $I_{O(PG,1)}$ Output current at power good (source) | TPS60302,<br>TPS60303                                           | -5  |             |       | mA       |
| $I_{O(PG,0)}$ Output current at power good (sink)   | All devices<br>$V_{(PG)} = 0\text{ V}$                          | 1.6 |             |       | mA       |
| $R_{(PG,1)}$ Output resistance at power good        | TPS60302,<br>TPS60303<br>$V_{(PG)} = V_{O(OUT2)}$               |     | 15          |       | $\Omega$ |
| $R_{(PG,0)}$                                        | All devices<br>$V_{(PG)} = 0\text{ V}$                          |     | 100         |       | $\Omega$ |

**TPS60300, TPS60301, TPS60302, TPS60303**  
**SINGLE-CELL TO 3.0-V/3.3-V, 20-mA DUAL OUTPUT,**  
**HIGH-EFFICIENCY CHARGE PUMP**

SLVS302A – DECEMBER 2000 – REVISED MARCH 2001

**TYPICAL CHARACTERISTICS**

**Table of Graphs**

|             |                               |                                                                                                                           | <b>FIGURE</b> |
|-------------|-------------------------------|---------------------------------------------------------------------------------------------------------------------------|---------------|
| $\eta$      | Efficiency                    | vs Output current                                                                                                         | 1, 2          |
| $I_S$       | Supply current                | vs Output current                                                                                                         | 3             |
| $I_Q$       | Quiescent current             | vs Input voltage                                                                                                          | 4             |
| $V_O(OUT2)$ | Output voltage at OUT2        | vs Output current                                                                                                         | 5, 6          |
| $V_O(OUT1)$ | Output voltage at OUT1        | vs Output current at 25°C, $V_{IN} = 0.9\text{ V}, 1.1\text{ V}, 1.25\text{ V}, 1.4\text{ V}, 1.6\text{ V}, 1.8\text{ V}$ | 7             |
| $V_O(OUT2)$ | Output voltage at OUT2        | vs Input voltage                                                                                                          | 8, 9          |
| $V_O(OUT1)$ | Output voltage at OUT1        | vs Input voltage                                                                                                          | 10            |
| $V_O(OUT2)$ | Output voltage at OUT2        | vs Free-air temperature                                                                                                   | 11, 12        |
| $V_O(OUT2)$ | Output voltage ripple at OUT2 |                                                                                                                           | 13            |
|             | Minimum input voltage         | vs Output current for TPS60301, TPS60303                                                                                  | 14, 15        |
|             | Start-up timing               | Enable, OUT1 no load, OUT2 at full load                                                                                   | 16            |
|             | Switching frequency           | vs Input voltage                                                                                                          | 17            |
|             | Load transient response       | $V_{IN} = 1.25\text{ V}$ , $I_Q(OUT2) = 2\text{ mA}$ 18 mA 2 mA, OUT1: no load                                            | 18            |
|             | Line transient response       |                                                                                                                           | 19            |



# TPS60300, TPS60301, TPS60302, TPS60303 SINGLE-CELL TO 3.0-V/3.3-V, 20-mA DUAL OUTPUT, HIGH-EFFICIENCY CHARGE PUMP

SLVS302A – DECEMBER 2000 – REVISED MARCH 2001

## TYPICAL CHARACTERISTICS

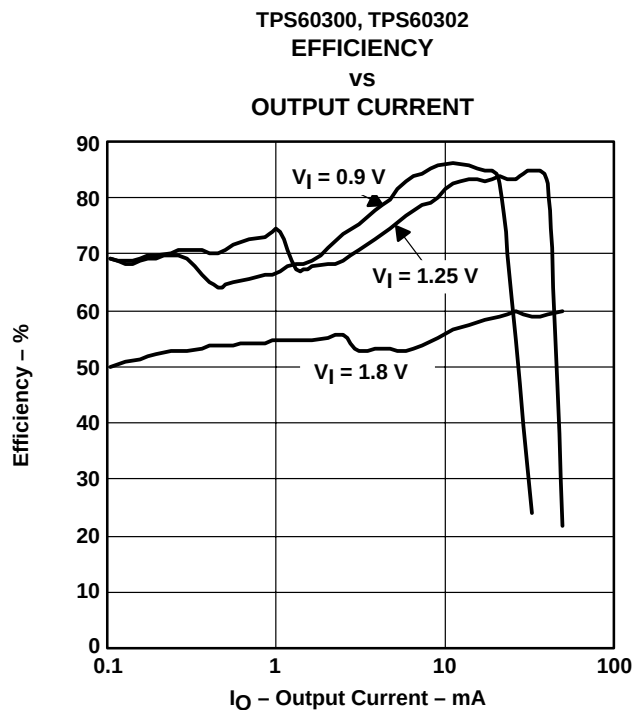


Figure 1

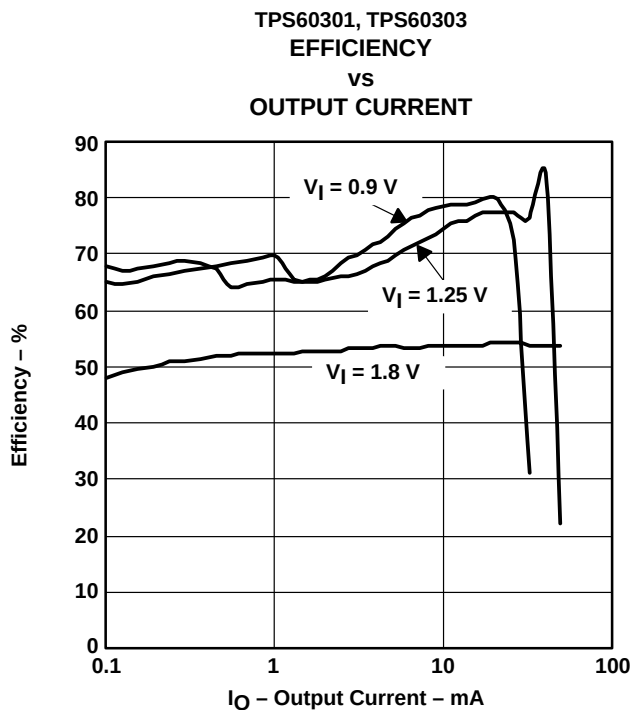


Figure 2

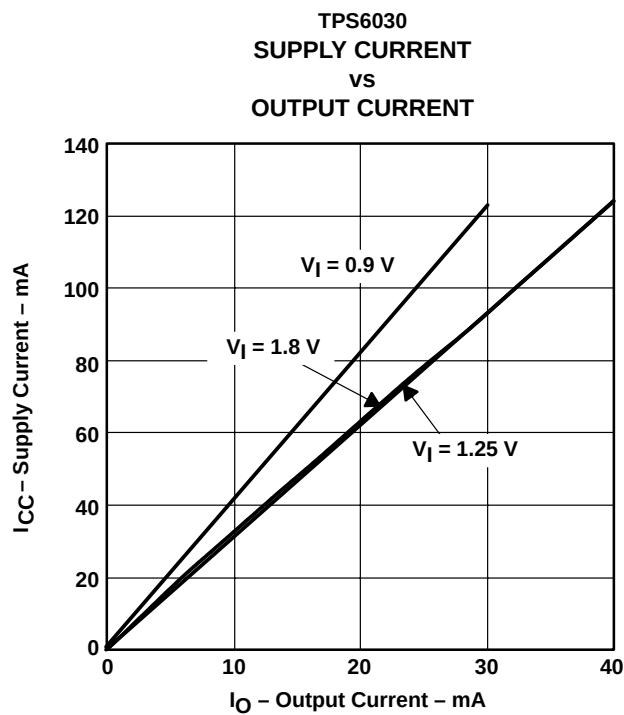


Figure 3

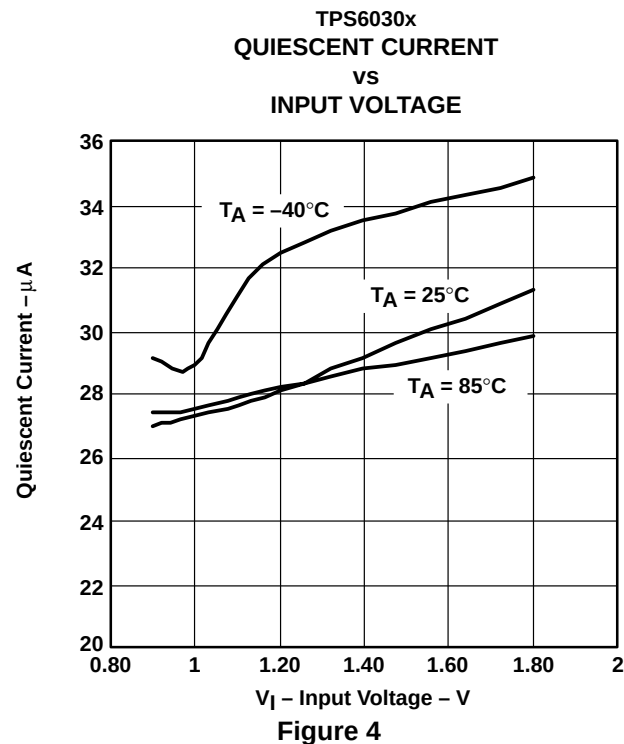
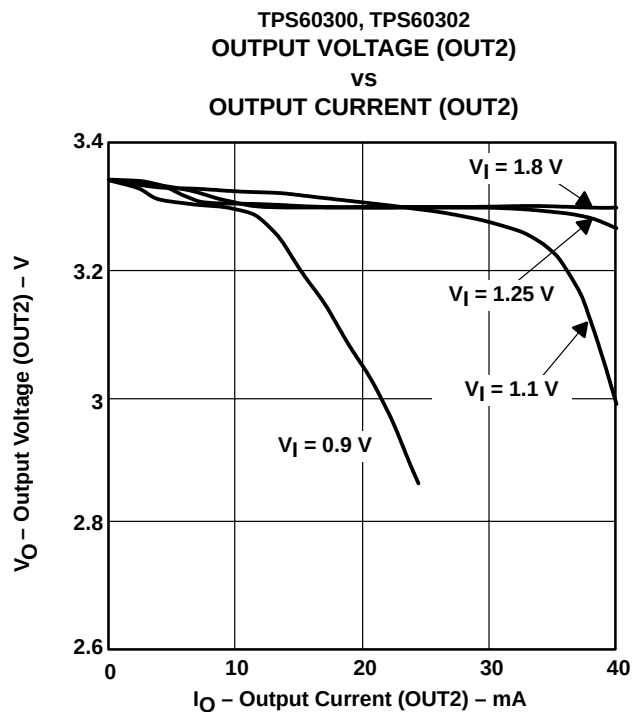


Figure 4

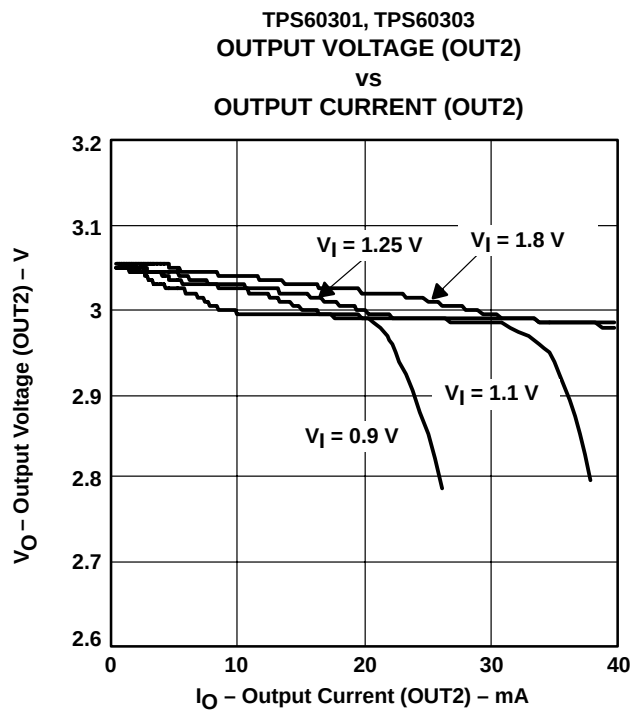
**TPS60300, TPS60301, TPS60302, TPS60303**  
**SINGLE-CELL TO 3.0-V/3.3-V, 20-mA DUAL OUTPUT,**  
**HIGH-EFFICIENCY CHARGE PUMP**

SLVS302A – DECEMBER 2000 – REVISED MARCH 2001

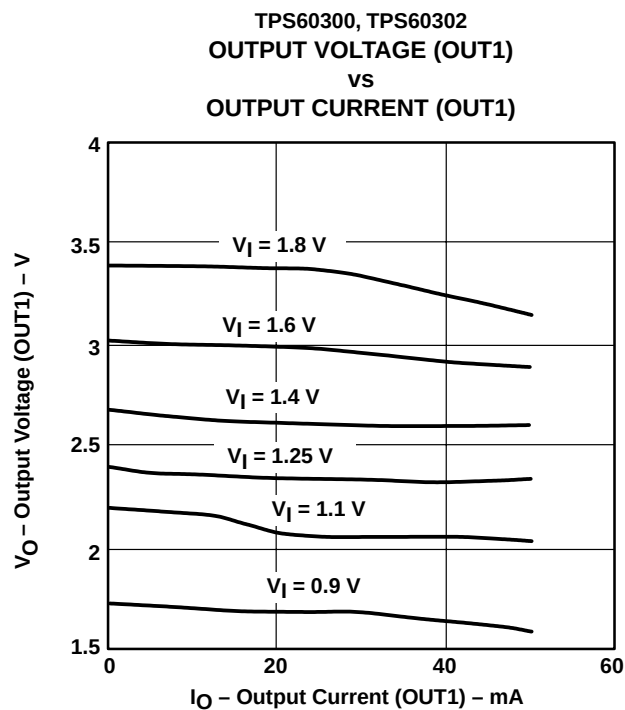
**TYPICAL CHARACTERISTICS**



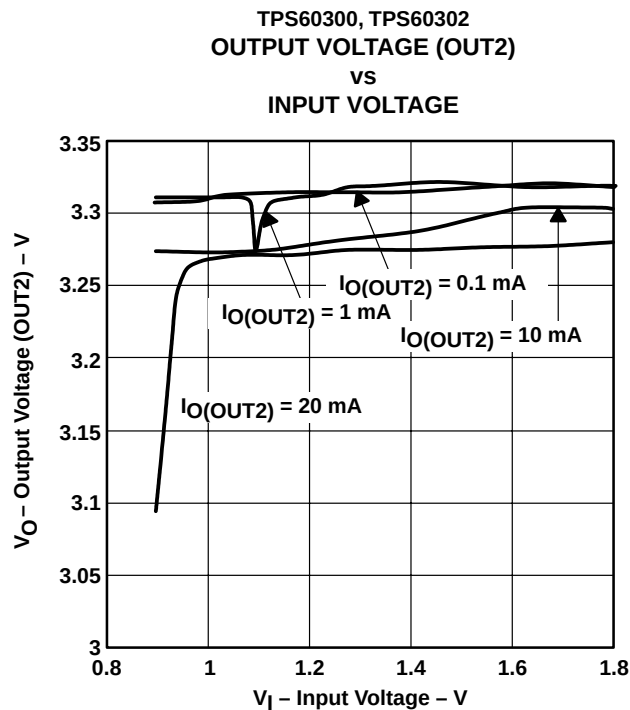
**Figure 5**



**Figure 6**



**Figure 7**



**Figure 8**

TPS60300, TPS60301, TPS60302, TPS60303  
SINGLE-CELL TO 3.0-V/3.3-V, 20-mA DUAL OUTPUT,  
HIGH-EFFICIENCY CHARGE PUMP

SLVS302A – DECEMBER 2000 – REVISED MARCH 2001

TYPICAL CHARACTERISTICS

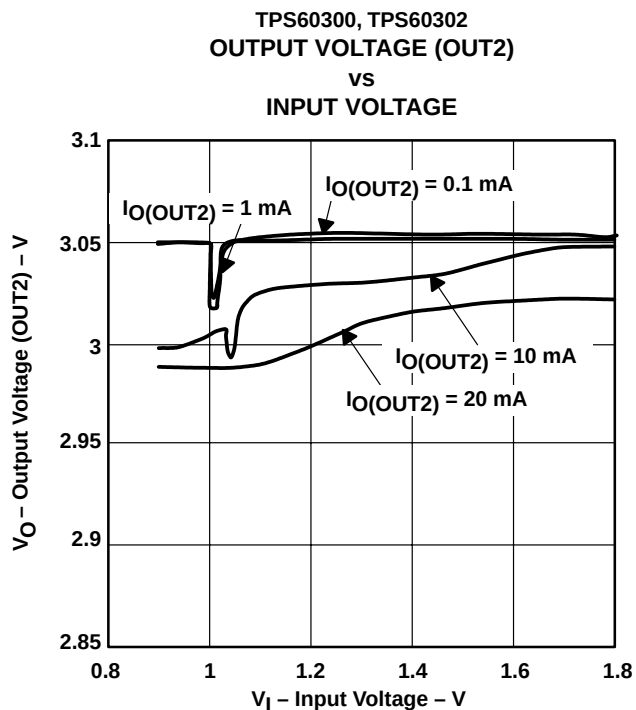


Figure 9

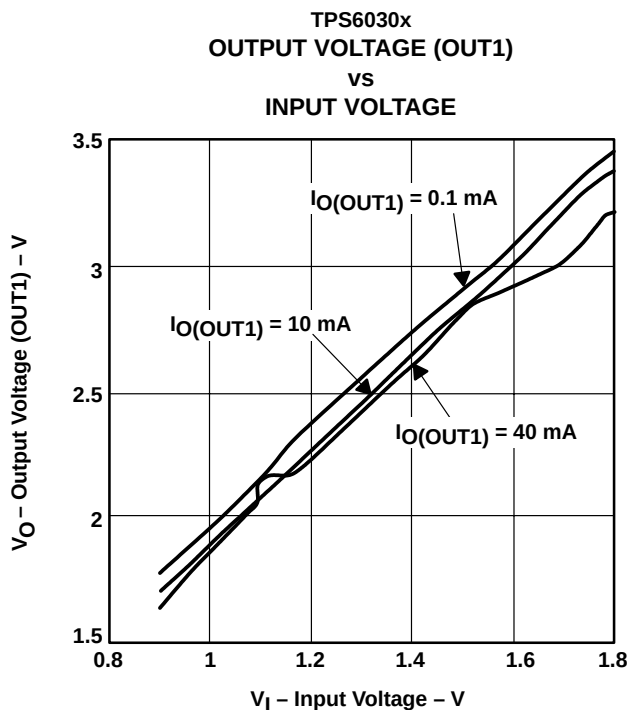


Figure 10

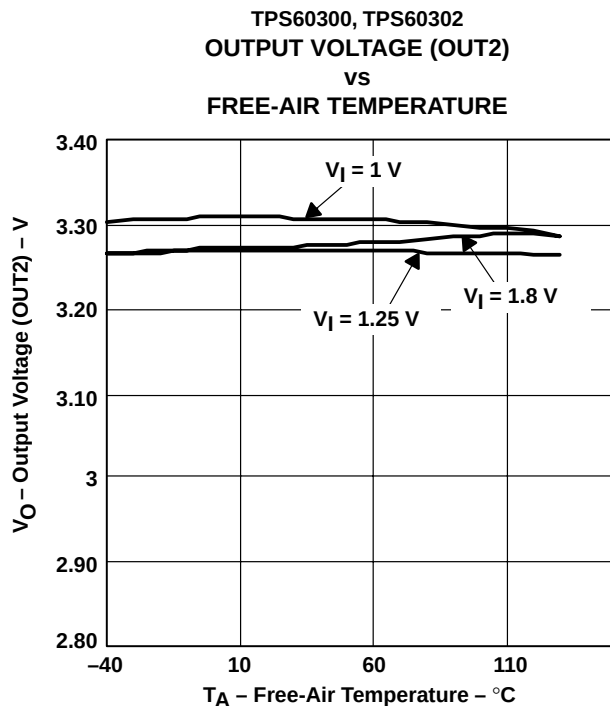


Figure 11

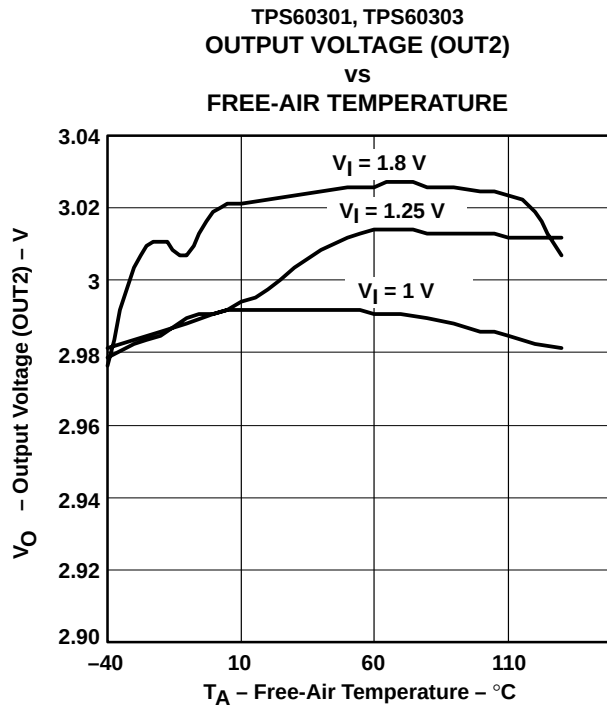
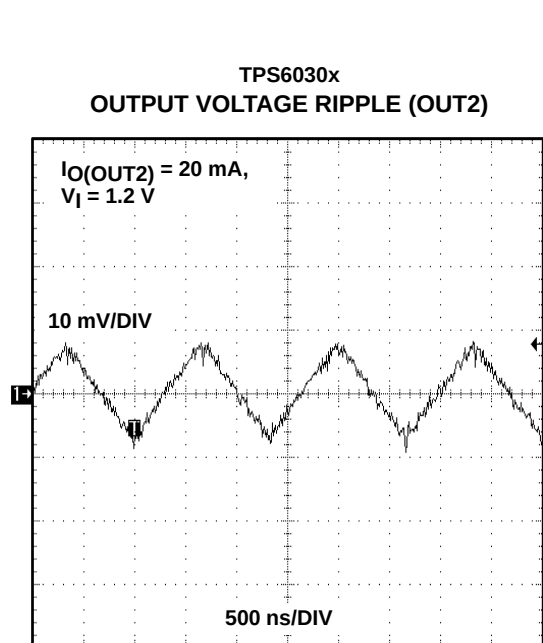


Figure 12

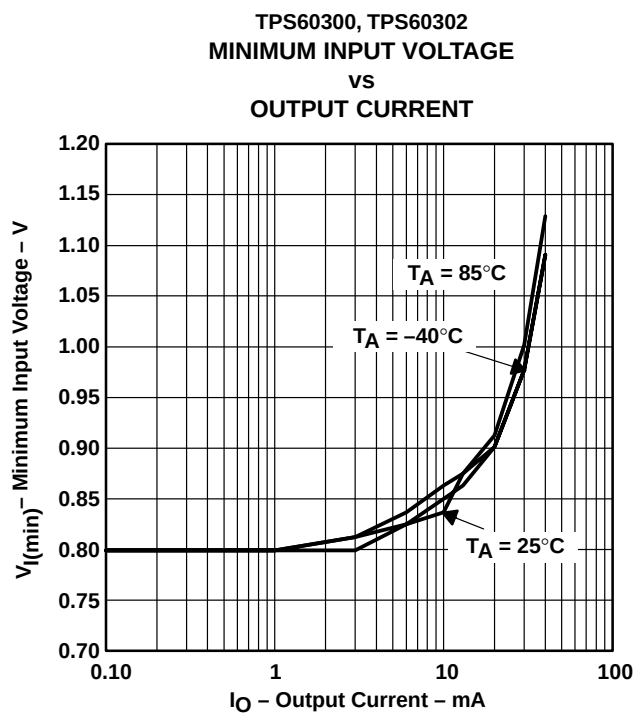
**TPS60300, TPS60301, TPS60302, TPS60303**  
**SINGLE-CELL TO 3.0-V/3.3-V, 20-mA DUAL OUTPUT,**  
**HIGH-EFFICIENCY CHARGE PUMP**

SLVS302A – DECEMBER 2000 – REVISED MARCH 2001

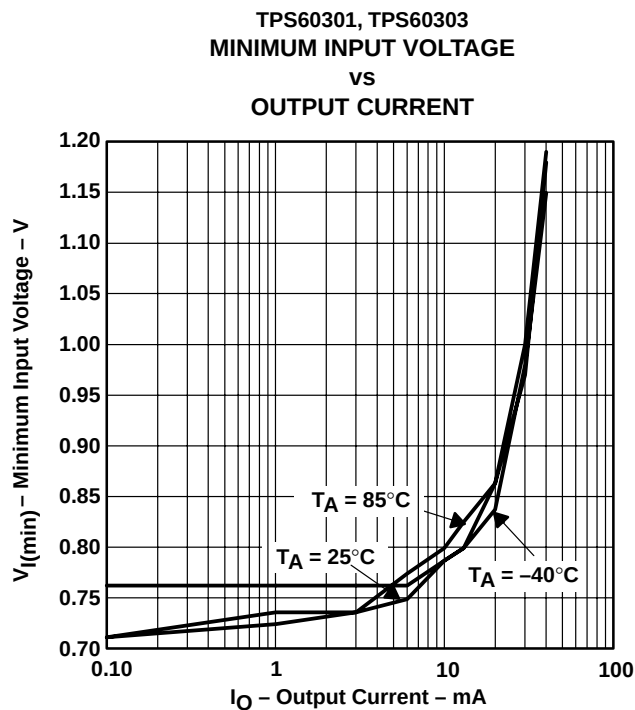
**TYPICAL CHARACTERISTICS**



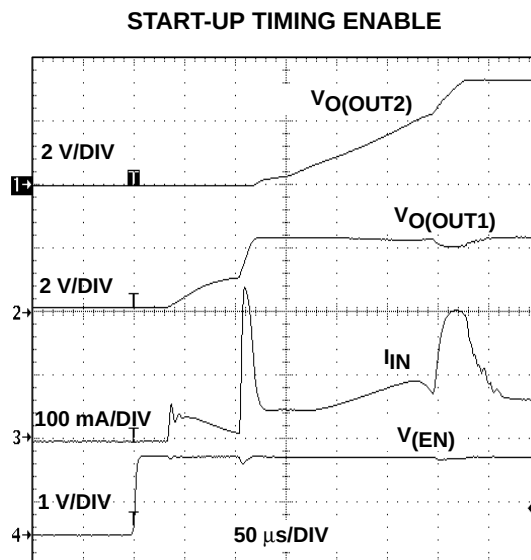
**Figure 13**



**Figure 14**



**Figure 15**



**Figure 16**

## TYPICAL CHARACTERISTICS

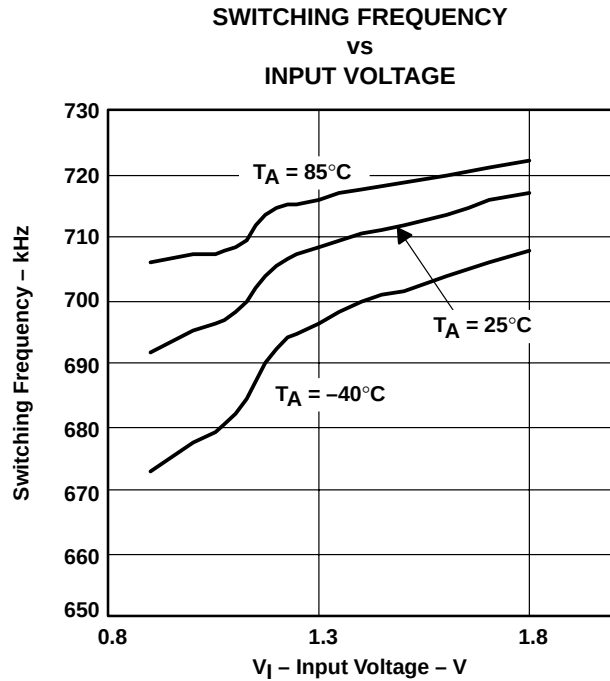


Figure 17

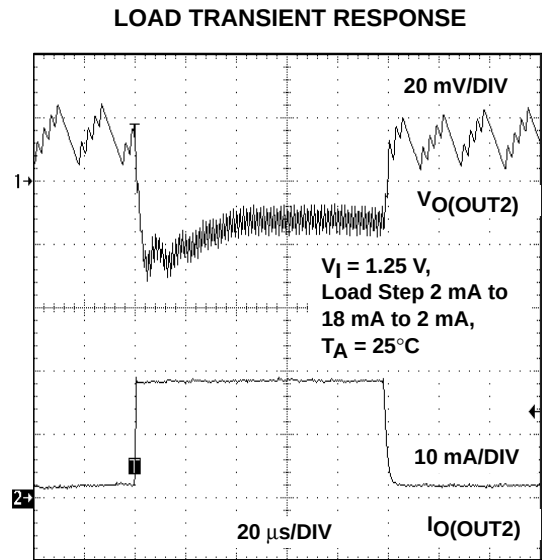


Figure 18

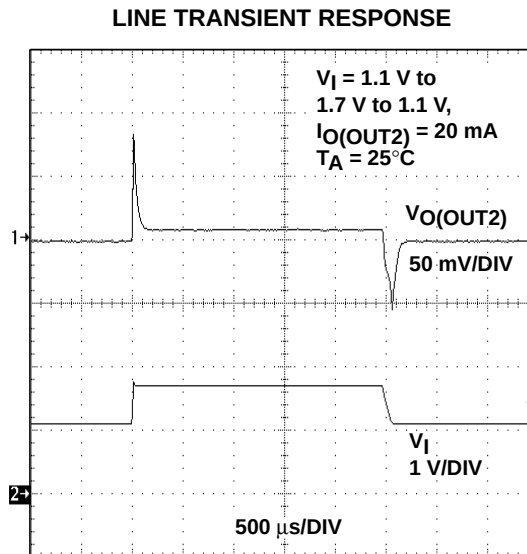


Figure 19

**TPS60300, TPS60301, TPS60302, TPS60303**  
**SINGLE-CELL TO 3.0-V/3.3-V, 20-mA DUAL OUTPUT,**  
**HIGH-EFFICIENCY CHARGE PUMP**

SLVS302A – DECEMBER 2000 – REVISED MARCH 2001

**APPLICATION INFORMATION**

**design procedure**

**capacitor selection**

The TPS6030x devices require only five external capacitors. Their values are closely linked to the required output current and the output noise and ripple requirements. It is possible to only use 1- $\mu$ F capacitors of the same type.

The input capacitor improves system efficiency by reducing the input impedance and stabilizing the input current.

The minimum required capacitance of the output capacitor ( $C_O$ ) that can be selected is 1  $\mu$ F. Depending on the maximum allowed output ripple voltage, larger values can be chosen. Table 1 shows capacitor values recommended for low output voltage ripple operation. A recommendation is given for the smallest size.

**Table 1. Recommended Capacitor Values for Low Output Voltage Ripple Operation**

| $V_{IN}$<br>[V] | $I_{O(OUT2)}$<br>[mA] | $C_{IN}$<br>[ $\mu$ F] | $C_{XF}$<br>[ $\mu$ F] | $C_{OUT}$<br>[ $\mu$ F] | $V_{P-P}$<br>[mV]<br>@ 20 mA/<br>$V_{IN} = 1.1$ V |
|-----------------|-----------------------|------------------------|------------------------|-------------------------|---------------------------------------------------|
|                 |                       | CERAMIC                | CERAMIC                | CERAMIC                 |                                                   |
| 0.9...1.8       | 0...20                | 1                      | 1                      | 1                       | 16                                                |
| 0.9...1.8       | 0...20                | 1                      | 1                      | 2.2                     | 10                                                |
| 0.9...1.8       | 0...20                | 1                      | 1                      | 10 // 0.1               | 6                                                 |

**Table 2. Recommended Capacitors**

| MANUFACTURER | PART NUMBER    | SIZE | CAPACITANCE | TYPE    |
|--------------|----------------|------|-------------|---------|
| Taiyo Yuden  | UMK212BJ104MG  | 0805 | 0.1 $\mu$ F | Ceramic |
|              | LMK212BJ105KG  | 0805 | 1 $\mu$ F   | Ceramic |
|              | LMK212BJ225MG  | 0805 | 2.2 $\mu$ F | Ceramic |
|              | JMK316BJ475KL  | 1206 | 4.7 $\mu$ F | Ceramic |
|              |                |      |             |         |
| AVX          | 0805ZC105KAT2A | 0805 | 1 $\mu$ F   | Ceramic |
|              | 1206ZC225KAT2A | 1206 | 2.2 $\mu$ F | Ceramic |

Table 3 lists the manufacturers of recommended capacitors. However, ceramic capacitors will provide the lowest output voltage ripple due to their typically lower ESR.

**Table 3. Recommended Capacitor Manufacturers**

| MANUFACTURER | CAPACITOR TYPE  | INTERNET                                                         |
|--------------|-----------------|------------------------------------------------------------------|
| Taiyo Yuden  | X7R/X5R ceramic | <a href="http://www.t-yuden.com">www.t-yuden.com</a>             |
| AVX          | X7R/X5R ceramic | <a href="http://www.avxcorp.com">www.avxcorp.com</a>             |
| Vishay       | X7R/X5R ceramic | <a href="http://www.vishay.com">www.vishay.com</a>               |
| Kemet        | X7R/X5R ceramic | <a href="http://www.kemet.com">www.kemet.com</a>                 |
| TDK          | X7R/X5R ceramic | <a href="http://www.component.tdk.com">www.component.tdk.com</a> |

## APPLICATION INFORMATION

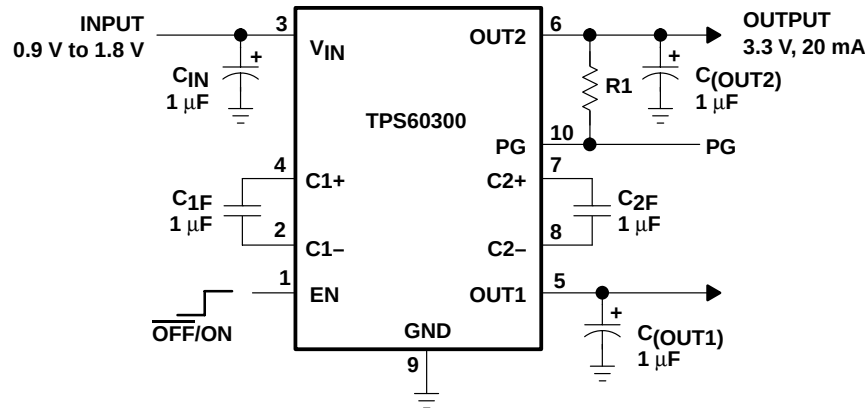


Figure 20. Typical Operating Circuit

For the maximum output current and best performance, five ceramic capacitors of 1 µF are recommended. For lower currents or higher allowed output voltage ripple, other capacitors can be used. It is recommended that the input and output capacitors have a minimum value of 1 µF. This value is necessary to assure a stable operation of the system due to the linear mode. With flying capacitors lower than 1 µF, the maximum output power will decrease. This means that the device will work in the linear mode with lower output currents.

### output filter design

The power-good output is capable of driving light loads up to 5 mA (see Figure 21). Therefore, the output resistance of the power-good pin, in addition with an output capacitor, can be used as an RC-filter.

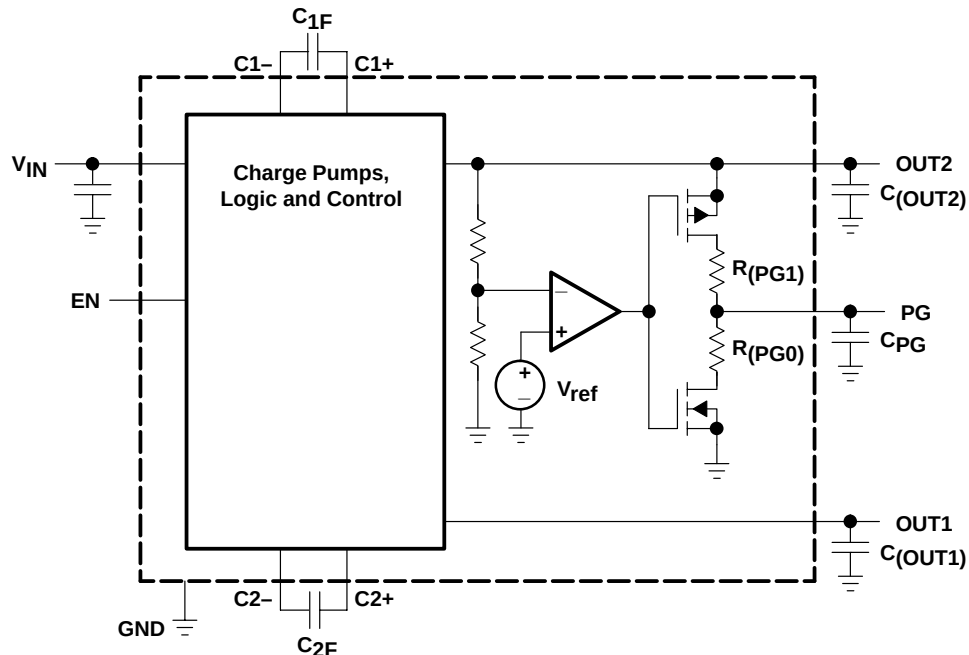


Figure 21. TPS60302, TPS60303 Push-Pull Power-Good Output-Stage as Filtered Supply

# TPS60300, TPS60301, TPS60302, TPS60303

## SINGLE-CELL TO 3.0-V/3.3-V, 20-mA DUAL OUTPUT, HIGH-EFFICIENCY CHARGE PUMP

SLVS302A – DECEMBER 2000 – REVISED MARCH 2001

### design procedure (continued)

Due to  $R_{(PG,1)}$ , an output filter can easily be formed with an output capacitor ( $C_{PG}$ ). Cut-off frequency is given by:

$$f_c = \frac{1}{2\pi R_{(PG,1)} C_{(PG)}} \quad (1)$$

and ratio  $V_{OUT}/V_{IN}$  is: 
$$\left| \frac{V_{(PG,1)}}{V_{O(OUT2)}} \right| = \frac{1}{\sqrt{1 + \left( 2\pi f R_{(PG,1)} C_{(PG)} \right)^2}} \quad (2)$$

with  $R_{(PG,1)} = 15 \, \Omega$ ,  $C_{(PG)} = 0.1 \, \mu\text{F}$  and  $f = 600 \, \text{kHz}$  (at nominal switching frequency)

$$\left| \frac{V_{(PG,1)}}{V_{O(OUT2)}} \right| = 0.175$$

Load current sourced by power-good output reduces maximum output current at OUT2. During start-up (power good going high) current charging  $C_{(PG)}$  will discharge  $C_{(OUT2)}$ . Therefore,  $C_{(PG)}$  must not be larger than 0.1  $C_{(OUT2)}$  or the device will not start. By charging  $C_{(PG)}$  through  $C_{(OUT2)}$ , the output voltage at OUT2 will decrease. If the capacitance of  $C_{(PG)}$  is too large, the circuit will detect power bad. The power-good output will go low and discharge  $C_{(PG)}$ . Then the cycle starts again. Figure 22 shows a configuration with an LC-post filter to further reduce output ripple and noise.

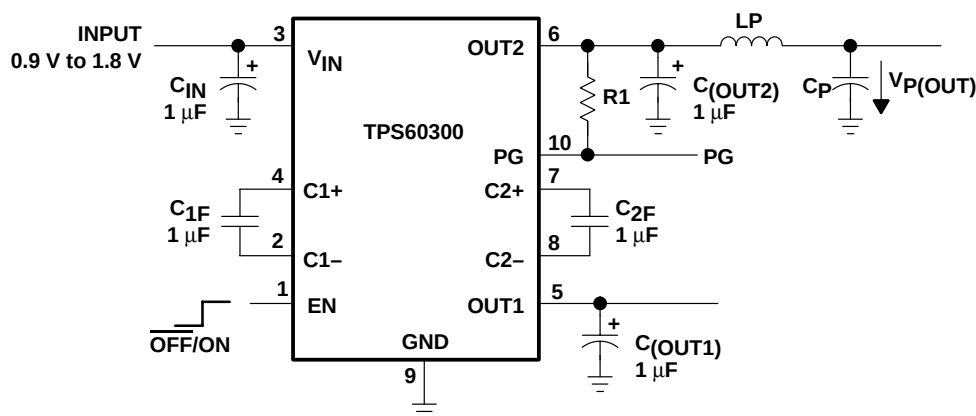


Figure 22. LC-Post Filter

Table 4. Recommended Values for Lowest Output Voltage Ripple

| $V_{IN}$<br>[V] | $I_{O(OUT2)}$<br>[mA] | $C_{IN}[\mu\text{F}]$ | $C_{XF}[\mu\text{F}]$ | $C_{OUT}[\mu\text{F}]$ | $L_P[\mu\text{H}]$ | $C_P[\mu\text{F}]$ | $V_{P(OUT)}$<br>$V_{P-P}[\text{mV}]$ |
|-----------------|-----------------------|-----------------------|-----------------------|------------------------|--------------------|--------------------|--------------------------------------|
|                 |                       | CERAMIC               | CERAMIC               | CERAMIC                |                    | CERAMIC            |                                      |
| 0.9...1.8       | 20                    | 1.0                   | 1.0                   | 1.0                    | 0.1                | 0.1 (X7R)          | 16                                   |
| 0.9...1.8       | 20                    | 1.0                   | 1.0                   | 1.0                    | 0.1                | 1 // 0.1 (X7R)     | 12                                   |
| 0.9...1.8       | 20                    | 1.0                   | 1.0                   | 1.0                    | 1.0                | 0.1 (X7R)          | 14                                   |
| 0.9...1.8       | 20                    | 1.0                   | 1.0                   | 10                     | 1.0                | 1 // 0.1 (X7R)     | 3                                    |



## design procedure (continued)

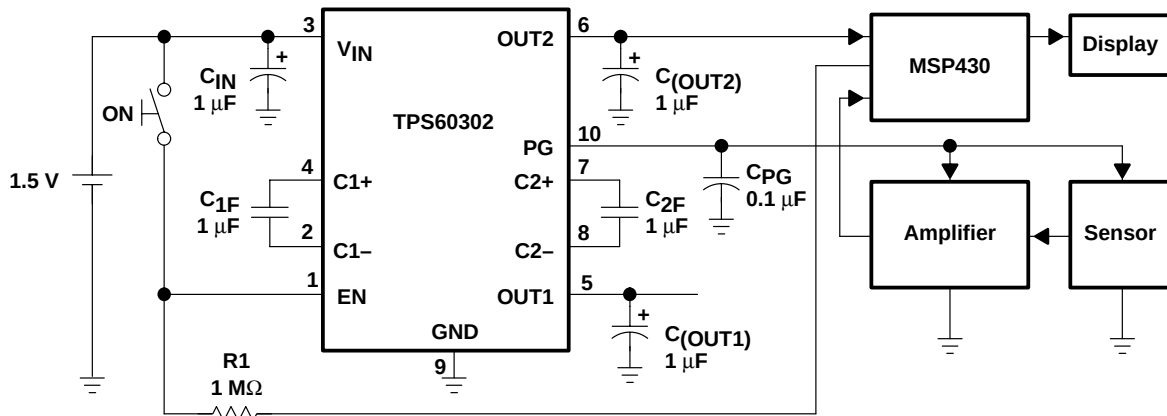


Figure 23. Application With MSP430; PG as Supply for Analog Circuits

## power dissipation

As given in the data sheet, the thermal resistance of the unsoldered package is  $R_{\theta JA} = 294^{\circ}\text{C/W}$ . Soldered on the EVM, a typical thermal resistance of  $R_{\theta JA(\text{EVM})} = 200^{\circ}\text{C/W}$  was measured.

The thermal resistance can be calculated as follows:

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

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.

The maximum power dissipation can be calculated with the following formula:

$$P_D = V_{IN} \times I_{IN} - V_O \times I_O = V_{IN(\text{max})} \times (3 \times I_O + I_{\text{SUPPLY}}) - V_O \times I_O$$

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

At maximum load the supply current is approximately 2 mA.

$$P_D = 1.8 \text{ V} \times (3 \times 20 \text{ mA} + 2 \text{ mA}) - 3.3 \text{ V} \times 20 \text{ mA} = 46 \text{ mW}$$

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

$$\Delta T_J = R_{\theta JA} \times P_D = 200^{\circ}\text{C/W} \times 46 \text{ mW} = 10^{\circ}\text{C}$$

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

The junction temperature of the device must not exceed  $125^{\circ}\text{C}$ .

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

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

## layout and board space

All capacitors should be soldered as close as possible to the IC. A PCB layout proposal for a two-layer board is shown in Figure 24. Care has been taken to connect all capacitors as close as possible to the circuit to achieve optimized output voltage ripple performance. The bottom layer is not shown in Figure 24. It only consists of a ground-plane with a single track between the two vias that can be seen in the left part of the top layer.

# TPS60300, TPS60301, TPS60302, TPS60303 SINGLE-CELL TO 3.0-V/3.3-V, 20-mA DUAL OUTPUT, HIGH-EFFICIENCY CHARGE PUMP

SLVS302A – DECEMBER 2000 – REVISED MARCH 2001

## layout and board space (continued)

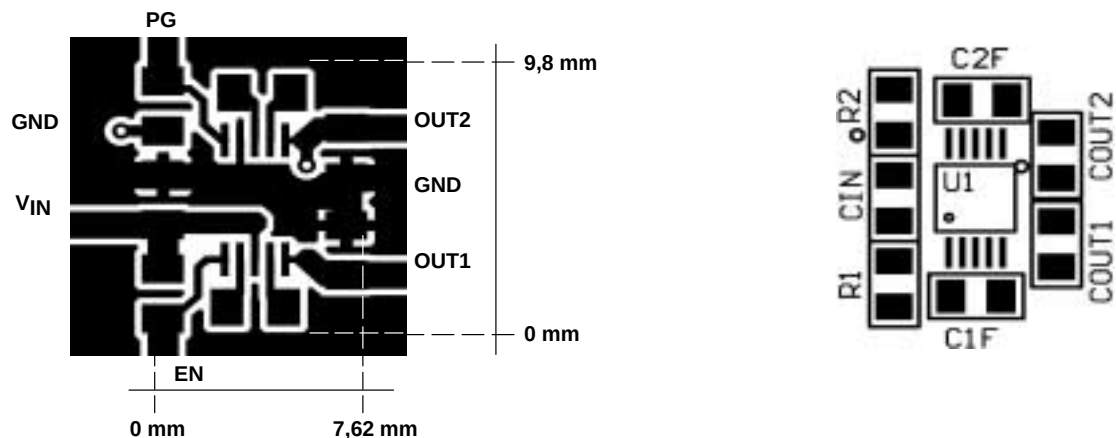


Figure 24. Recommended PCB Layout for TPS6030x (top layer)

## device family products

Other charge pump dc-dc converters in this family are:

Table 5. Product Identification

| PART NUMBER | DESCRIPTION                                                                                                                   |
|-------------|-------------------------------------------------------------------------------------------------------------------------------|
| TPS60100    | 2-cell to regulated 3.3-V, 200-mA low-noise charge pump                                                                       |
| TPS60101    | 2-cell to regulated 3.3-V, 100-mA low-noise charge pump                                                                       |
| TPS60110    | 3-cell to regulated 5-V, 300-mA low-noise charge pump                                                                         |
| TPS60111    | 3-cell to regulated 5-V, 150-mA low-noise charge pump                                                                         |
| TPS60120    | 2-cell to regulated 3.3-V, 200-mA high efficiency charge pump with low-battery comparator                                     |
| TPS60121    | 2-cell to regulated 3.3-V, 200-mA high efficiency charge pump with power-good comparator                                      |
| TPS60122    | 2-cell to regulated 3.3-V, 100-mA high efficiency charge pump with low-battery comparator                                     |
| TPS60123    | 2-cell to regulated 3.3-V, 100-mA high efficiency charge pump with power-good comparator                                      |
| TPS60124    | 2-cell to regulated 3-V, 200-mA high efficiency charge pump with low-battery comparator                                       |
| TPS60125    | 2-cell to regulated 3-V, 200-mA high efficiency charge pump with power-good comparator                                        |
| TPS60130    | 3-cell to regulated 5-V, 300-mA high efficiency charge pump with low-battery comparator                                       |
| TPS60131    | 3-cell to regulated 5-V, 300-mA high efficiency charge pump with power-good comparator                                        |
| TPS60132    | 3-cell to regulated 5-V, 150-mA high efficiency charge pump with low-battery comparator                                       |
| TPS60133    | 3-cell to regulated 5-V, 150-mA high efficiency charge pump with power-good comparator                                        |
| TPS60140    | 2-cell to regulated 5-V, 100-mA charge pump voltage tripler with low-battery comparator                                       |
| TPS60141    | 2-cell to regulated 5-V, 100-mA charge pump voltage tripler with power-good comparator                                        |
| TPS60200    | 2-cell to regulated 3.3-V, 100-mA low-ripple charge pump with low-battery comparator in MSOP10                                |
| TPS60201    | 2-cell to regulated 3.3-V, 100-mA low-ripple charge pump with power-good comparator in MSOP10                                 |
| TPS60202    | 2-cell to regulated 3.3-V, 50-mA low-ripple charge pump with low-battery comparator in MSOP10                                 |
| TPS60203    | 2-cell to regulated 3.3-V, 50-mA low-ripple charge pump with power-good comparator in MSOP10                                  |
| TPS60210    | 2-cell to regulated 3.3-V, 100-mA low-ripple charge pump with ultralow operating current and low-battery comparator in MSOP10 |
| TPS60211    | 2-cell to regulated 3.3-V, 100-mA low-ripple charge pump with ultralow operating current and power-good comparator in MSOP10  |
| TPS60212    | 2-cell to regulated 3.3-V, 100-mA low-ripple charge pump with ultralow operating current and low-battery comparator in MSOP10 |
| TPS60213    | 2-cell to regulated 3.3-V, 50-mA low-ripple charge pump with ultralow operating current and power-good comparator in MSOP10   |

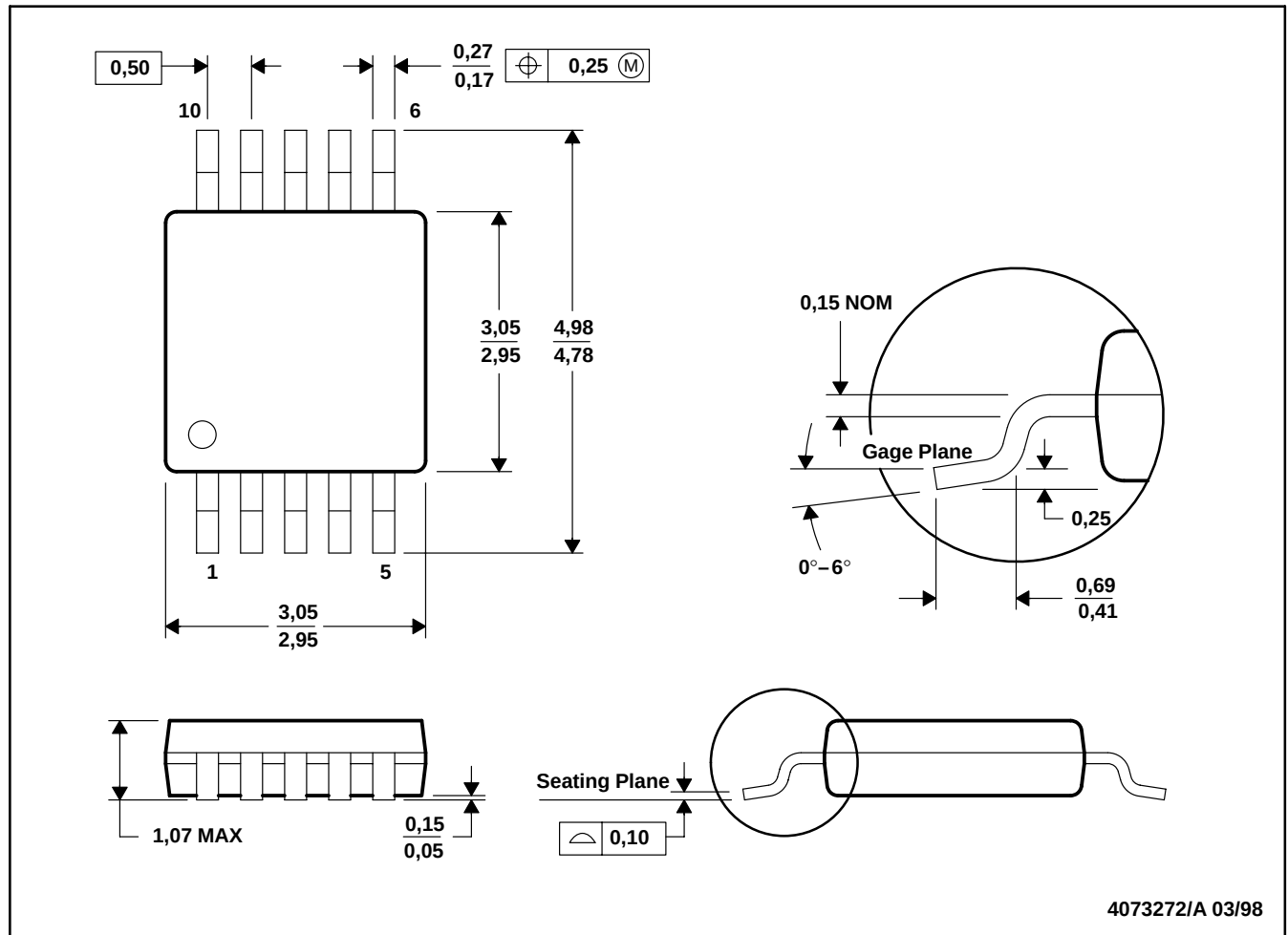
TPS60300, TPS60301, TPS60302, TPS60303  
SINGLE-CELL TO 3.0-V/3.3-V, 20-mA DUAL OUTPUT,  
HIGH-EFFICIENCY CHARGE PUMP

SLVS302A – DECEMBER 2000 – REVISED MARCH 2001

MECHANICAL DATA

DGS (S-PDSO-G10)

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.

**PACKAGING INFORMATION**

| Orderable Device | Status <sup>(1)</sup> | Package Type | Package Drawing | Pins | Package Qty | Eco Plan <sup>(2)</sup> | Lead/Ball Finish | MSL Peak Temp <sup>(3)</sup> |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| TPS60300DGS      | ACTIVE                | MSOP         | DGS             | 10   | 80          | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TPS60300DGSG4    | ACTIVE                | MSOP         | DGS             | 10   | 80          | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TPS60300DGSR     | ACTIVE                | MSOP         | DGS             | 10   | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TPS60300DGSRG4   | ACTIVE                | MSOP         | DGS             | 10   | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TPS60301DGS      | ACTIVE                | MSOP         | DGS             | 10   | 80          | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TPS60301DGSG4    | ACTIVE                | MSOP         | DGS             | 10   | 80          | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TPS60301DGSR     | ACTIVE                | MSOP         | DGS             | 10   | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TPS60301DGSRG4   | ACTIVE                | MSOP         | DGS             | 10   | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TPS60302DGS      | ACTIVE                | MSOP         | DGS             | 10   | 80          | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TPS60302DGSG4    | ACTIVE                | MSOP         | DGS             | 10   | 80          | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TPS60302DGSR     | ACTIVE                | MSOP         | DGS             | 10   | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TPS60302DGSRG4   | ACTIVE                | MSOP         | DGS             | 10   | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TPS60303DGS      | ACTIVE                | MSOP         | DGS             | 10   | 80          | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TPS60303DGSG4    | ACTIVE                | MSOP         | DGS             | 10   | 80          | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TPS60303DGSR     | ACTIVE                | MSOP         | DGS             | 10   | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TPS60303DGSRG4   | ACTIVE                | MSOP         | DGS             | 10   | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |

<sup>(1)</sup> 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.

<sup>(2)</sup> 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.

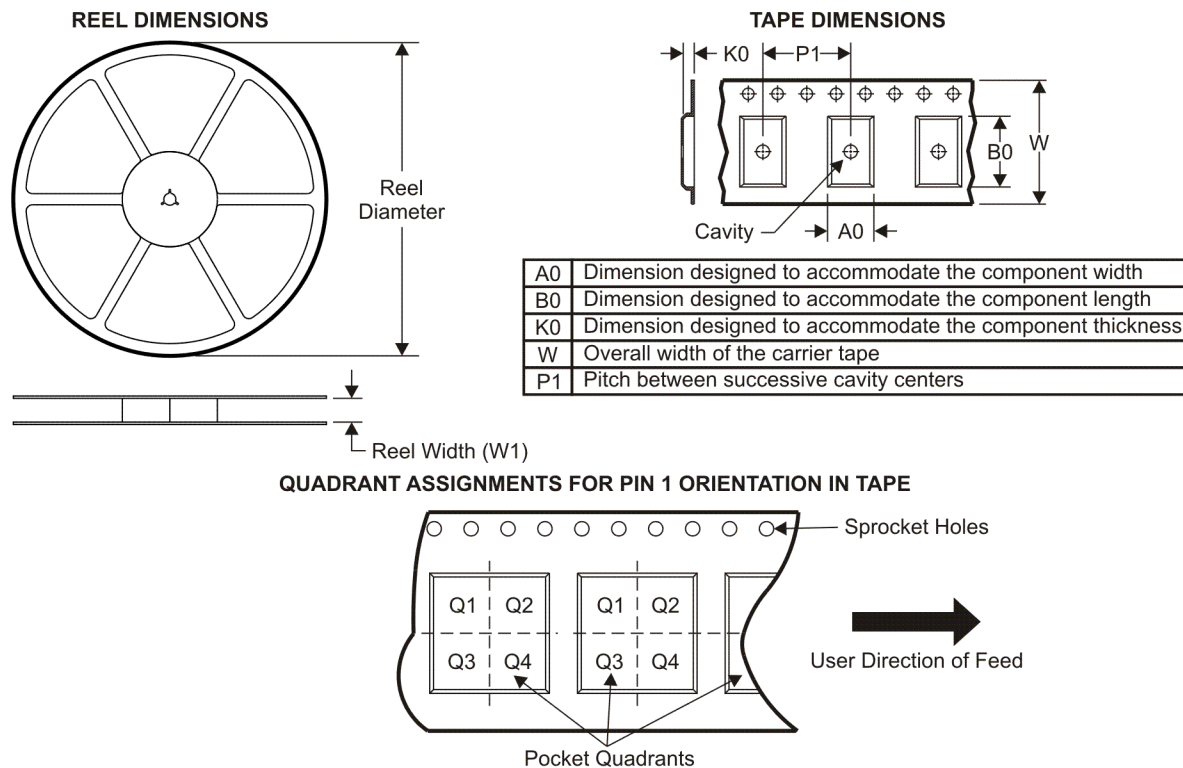
**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

<sup>(3)</sup> 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.

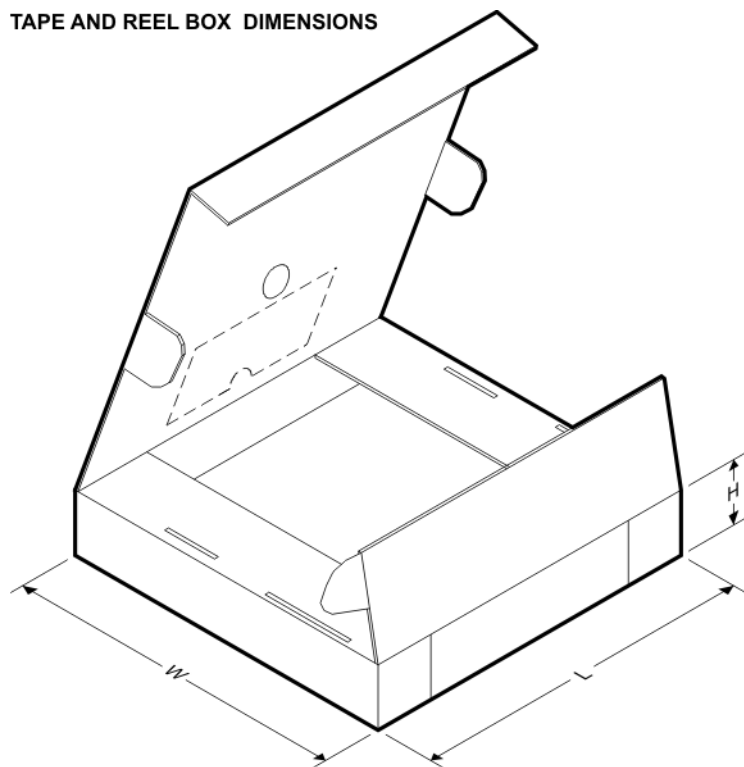
**TAPE AND REEL INFORMATION**



\*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 |
|--------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TPS60300DGSR | MSOP         | DGS             | 10   | 2500 | 330.0              | 12.4               | 5.3     | 3.4     | 1.4     | 8.0     | 12.0   | Q1            |
| TPS60301DGSR | MSOP         | DGS             | 10   | 2500 | 330.0              | 12.4               | 5.3     | 3.4     | 1.4     | 8.0     | 12.0   | Q1            |
| TPS60302DGSR | MSOP         | DGS             | 10   | 2500 | 330.0              | 12.4               | 5.3     | 3.4     | 1.4     | 8.0     | 12.0   | Q1            |
| TPS60303DGSR | MSOP         | DGS             | 10   | 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) |
|--------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TPS60300DGSR | MSOP         | DGS             | 10   | 2500 | 340.5       | 338.1      | 20.6        |
| TPS60301DGSR | MSOP         | DGS             | 10   | 2500 | 340.5       | 338.1      | 20.6        |
| TPS60302DGSR | MSOP         | DGS             | 10   | 2500 | 346.0       | 346.0      | 29.0        |
| TPS60303DGSR | MSOP         | DGS             | 10   | 2500 | 340.5       | 338.1      | 20.6        |

## 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 TI 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. Information of third parties may be subject to additional restrictions.

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.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

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

### Products

|                             |                                                                    |
|-----------------------------|--------------------------------------------------------------------|
| Amplifiers                  | <a href="http://amplifier.ti.com">amplifier.ti.com</a>             |
| Data Converters             | <a href="http://dataconverter.ti.com">dataconverter.ti.com</a>     |
| DSP                         | <a href="http://dsp.ti.com">dsp.ti.com</a>                         |
| Clocks and Timers           | <a href="http://www.ti.com/clocks">www.ti.com/clocks</a>           |
| Interface                   | <a href="http://interface.ti.com">interface.ti.com</a>             |
| Logic                       | <a href="http://logic.ti.com">logic.ti.com</a>                     |
| Power Mgmt                  | <a href="http://power.ti.com">power.ti.com</a>                     |
| Microcontrollers            | <a href="http://microcontroller.ti.com">microcontroller.ti.com</a> |
| RFID                        | <a href="http://www.ti-rfid.com">www.ti-rfid.com</a>               |
| RF/IF and ZigBee® Solutions | <a href="http://www.ti.com/lprf">www.ti.com/lprf</a>               |

### Applications

|                    |                                                                          |
|--------------------|--------------------------------------------------------------------------|
| Audio              | <a href="http://www.ti.com/audio">www.ti.com/audio</a>                   |
| Automotive         | <a href="http://www.ti.com/automotive">www.ti.com/automotive</a>         |
| Broadband          | <a href="http://www.ti.com/broadband">www.ti.com/broadband</a>           |
| Digital Control    | <a href="http://www.ti.com/digitalcontrol">www.ti.com/digitalcontrol</a> |
| Medical            | <a href="http://www.ti.com/medical">www.ti.com/medical</a>               |
| Military           | <a href="http://www.ti.com/military">www.ti.com/military</a>             |
| Optical Networking | <a href="http://www.ti.com/opticalnetwork">www.ti.com/opticalnetwork</a> |
| Security           | <a href="http://www.ti.com/security">www.ti.com/security</a>             |
| Telephony          | <a href="http://www.ti.com/telephony">www.ti.com/telephony</a>           |
| Video & Imaging    | <a href="http://www.ti.com/video">www.ti.com/video</a>                   |
| Wireless           | <a href="http://www.ti.com/wireless">www.ti.com/wireless</a>             |

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2008, Texas Instruments Incorporated