



# LM284x-Q1 Automotive SIMPLE SWITCHER® 4.5-V to 42-V Input, 0.1-, 0.3-, or 0.6-A Output Step-Down DC/DC Regulator in Thin SOT

## 1 Features

- AEC-Q100-qualified for automotive applications:
  - Temperature grade 1:  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ ,  $T_A$
- Input voltage 4.5 V to 42 V
- Output current options of 100 mA, 300 mA, and 600 mA
- Feedback pin voltage of 0.765 V
- 550-kHz (X) or 1.25-MHz (Y) switching frequency
- Low shutdown  $I_Q$ : 16- $\mu\text{A}$  typical
- Short-circuit protected
- Internally compensated
- Soft-start circuitry
- Small overall solution size (SOT-6L package)
- Create a custom design using the LM2840-Q1 (or LM2841-Q1/42-Q1) with the [WEBENCH® Power Designer](#)

## 2 Applications

- Automotive ADAS camera
- Automotive wireless charging
- Automotive body control and lighting

## 3 Description

The LM284x-Q1 SIMPLE SWITCHER™ devices are PWM DC/DC buck (step-down) regulators. With an input range from 4.5 V to 42 V, they are suitable for a wide range of applications, such as power conditioning from unregulated sources. They feature a low  $R_{DS(on)}$  (0.9- $\Omega$  typical) internal switch for maximum efficiency (85% typical). Operating frequency is fixed at 550 kHz (X option) and 1.25 MHz (Y option), allowing the use of small external components while still being able to have low output voltage ripple. Soft start can be implemented using the shutdown ( $\overline{\text{SHDN}}$ ) pin with an external RC circuit allowing the user to tailor the soft-start time to a specific application.

The LM2840-Q1 is optimized for up to 100 mA, the LM2841-Q1 for up to 300 mA, and the LM2842-Q1 for up to 600-mA load currents. They all have a 0.765-V nominal feedback voltage.

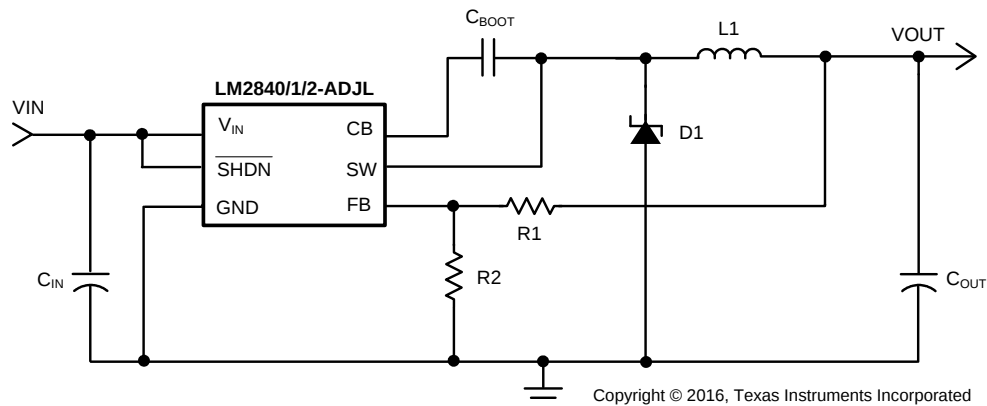
Additional features include: thermal shutdown,  $V_{IN}$  undervoltage lockout, and gate-drive undervoltage lockout. The LM284x-Q1 are available in a low-profile SOT-6L package.

### Device Information<sup>(1)</sup>

| PART NUMBER                     | PACKAGE | BODY SIZE (NOM)   |
|---------------------------------|---------|-------------------|
| LM2840-Q1, LM2841-Q1, LM2842-Q1 | SOT (6) | 1.60 mm × 2.90 mm |

(1) For all available packages, see the orderable addendum at the end of the data sheet.

### Typical Application Circuit



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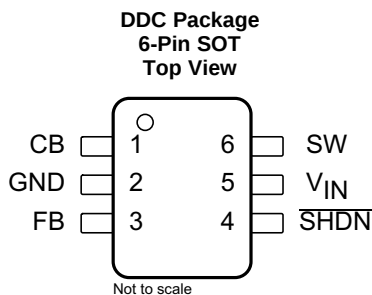
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## 4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| DATE       | REVISION | NOTES                                                                                                                                                                                                                |
|------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| April 2019 | *        | Split out LM284x-Q1 from the combined datasheet SNVS540 commercial and automotive document started March 2009. This document SNVSB E5 details the automotive LM284x-Q1. Made editorial changes; no technical changes |

## 5 Pin Configuration and Functions



### Pin Functions

| PIN |                          | I/O | DESCRIPTION                                                                                                                                                                    |
|-----|--------------------------|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NO. | NAME                     |     |                                                                                                                                                                                |
| 1   | CB                       | I   | SW FET gate bias voltage. Connect C <sub>BOOT</sub> capacitor between CB and SW.                                                                                               |
| 2   | GND                      | —   | Ground connection                                                                                                                                                              |
| 3   | FB                       | I   | Feedback pin: Set feedback voltage divider ratio with $V_{OUT} = V_{FB} (1 + (R1 / R2))$ . Resistors must be from 100 $\Omega$ to 10 k $\Omega$ to avoid input bias errors.    |
| 4   | $\overline{\text{SHDN}}$ | I   | Logic level shutdown input. Pull to GND to disable the device and pull high to enable the device. If this function is not used tie to V <sub>IN</sub> . DO NOT ALLOW TO FLOAT. |
| 5   | V <sub>IN</sub>          | I   | Power input voltage pin: 4.5-V to 42-V normal operating range.                                                                                                                 |
| 6   | SW                       | O   | Power FET output: Connect to inductor, diode, and C <sub>BOOT</sub> capacitor.                                                                                                 |

## 6 Specifications

### 6.1 Absolute Maximum Ratings

See <sup>(1)(2)</sup>

|                                  | MIN                | MAX                             | UNIT |
|----------------------------------|--------------------|---------------------------------|------|
| $V_{IN}$                         | –0.3               | 45                              | V    |
| $\overline{SHDN}$                | –0.3               | $(V_{IN} + 0.3 \text{ V}) < 45$ | V    |
| SW voltage                       | –0.3               | 45                              | V    |
| CB voltage above SW voltage      |                    | 7                               | V    |
| FB voltage                       | –0.3               | 5                               | V    |
| Power dissipation <sup>(3)</sup> | Internally Limited |                                 |      |
| Maximum junction temperature     |                    | 150                             | °C   |
| Storage temperature, $T_{stg}$   | –65                | 150                             | °C   |

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) If Military/Aerospace specified devices are required, contact the Texas Instruments Sales Office/Distributors for availability and specifications.
- (3) The maximum allowable power dissipation is a function of the maximum junction temperature,  $T_J(\text{MAX})$ , the junction-to-ambient thermal resistance,  $R_{\theta JA}$ , and the ambient temperature,  $T_A$ . The maximum allowable power dissipation at any ambient temperature is calculated using:  $P_D(\text{MAX}) = (T_J(\text{MAX}) - T_A) / R_{\theta JA}$ . Exceeding the maximum allowable power dissipation causes excessive die temperature, and the regulator goes into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage. Thermal shutdown engages at  $T_J=175^\circ\text{C}$  (typical) and disengages at  $T_J= 155^\circ\text{C}$  (typical).

### 6.2 ESD Ratings

|                                                                                                                               | VALUE | UNIT |
|-------------------------------------------------------------------------------------------------------------------------------|-------|------|
| $V_{(ESD)}$ Electrostatic discharge Human-body model (HBM), per AEC Q100-002 <sup>(1)</sup><br>HBM ESD Classification Level 2 | ±2000 | V    |

- (1) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

### 6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

|                                               | MIN | MAX | UNIT |
|-----------------------------------------------|-----|-----|------|
| Operating junction temperature <sup>(1)</sup> | –40 | 125 | °C   |
| Input voltage $V_{IN}$                        | 4.5 | 42  | V    |
| SW voltage                                    |     | 42  | V    |

- (1) All limits specified at room temperature ( $T_A = 25^\circ\text{C}$ ) unless otherwise specified. All room temperature limits are 100% production tested. All limits at temperature extremes are ensured through correlation using standard Statistical Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).

### 6.4 Thermal Information

| THERMAL METRIC <sup>(1)</sup> |                                                          | LM284x-Q1 | UNIT |
|-------------------------------|----------------------------------------------------------|-----------|------|
|                               |                                                          | DDC (SOT) |      |
|                               |                                                          | 6 PINS    |      |
| $R_{\theta JA}$               | Junction-to-ambient thermal resistance <sup>(2)(3)</sup> | 121       | °C/W |
| $R_{\theta JC(\text{top})}$   | Junction-to-case (top) thermal resistance                | 94        | °C/W |

- (1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report.
- (2) The package thermal impedance is calculated in accordance to JESD 51-7.
- (3) Thermal Resistances were simulated on a 4-layer, JEDEC board

## 6.5 Electrical Characteristics

Specifications are for  $T_J = 25^\circ\text{C}$  unless otherwise specified. Minimum and Maximum limits are specified through test, design, or statistical correlation. Typical values represent the most likely parametric norm at  $T_J = 25^\circ\text{C}$ , and are provided for reference purposes only. Unless otherwise stated the following conditions apply:  $V_{IN} = 12\text{ V}$ .<sup>(1)(2)(3)</sup>

| PARAMETER             | TEST CONDITIONS           |                                                  | MIN                                              | TYP   | MAX   | UNIT          |
|-----------------------|---------------------------|--------------------------------------------------|--------------------------------------------------|-------|-------|---------------|
| $I_Q$                 | Quiescent current         | $\overline{\text{SHDN}} = 0\text{ V}$            |                                                  | 16    |       | $\mu\text{A}$ |
|                       |                           | $T_J = -40^\circ\text{C}$ to $125^\circ\text{C}$ |                                                  |       | 40    |               |
|                       |                           | Device ON, not switching                         |                                                  | 1.3   |       | mA            |
|                       |                           | $T_J = -40^\circ\text{C}$ to $125^\circ\text{C}$ |                                                  |       | 1.75  |               |
| $R_{\text{DS(on)}}$   | Switch ON resistance      | See <sup>(4)</sup>                               |                                                  | 0.9   |       | $\Omega$      |
|                       |                           |                                                  | $T_J = -40^\circ\text{C}$ to $125^\circ\text{C}$ |       | 1.6   |               |
| $I_{\text{LSW}}$      | Switch leakage current    | $V_{\text{IN}} = 42\text{ V}$                    |                                                  | 0     |       | $\mu\text{A}$ |
|                       |                           |                                                  | $T_J = -40^\circ\text{C}$ to $125^\circ\text{C}$ |       | 0.5   |               |
| $I_{\text{CL}}$       | Switch current limit      | LM2840 <sup>(5)</sup>                            |                                                  | 525   |       | mA            |
|                       |                           |                                                  | $T_J = -40^\circ\text{C}$ to $125^\circ\text{C}$ |       | 900   |               |
|                       |                           | LM2841 <sup>(5)</sup>                            |                                                  | 525   |       | mA            |
|                       |                           |                                                  | $T_J = -40^\circ\text{C}$ to $125^\circ\text{C}$ |       | 900   |               |
| $I_{\text{FB}}$       | Feedback pin bias current | LM284[0,1,2] <sup>(6)</sup>                      |                                                  | 0.1   |       | $\mu\text{A}$ |
|                       |                           |                                                  | $T_J = -40^\circ\text{C}$ to $125^\circ\text{C}$ |       | 1     |               |
| $V_{\text{FB}}$       | FB Pin reference voltage  |                                                  |                                                  | 0.765 |       | V             |
|                       |                           |                                                  | $T_J = -40^\circ\text{C}$ to $125^\circ\text{C}$ | 0.747 | 0.782 |               |
| $t_{\text{ON(min)}}$  | Minimum ON-time           | See <sup>(7)</sup>                               |                                                  | 100   |       | ns            |
|                       |                           |                                                  | $T_J = -40^\circ\text{C}$ to $125^\circ\text{C}$ |       | 150   |               |
| $t_{\text{OFF(min)}}$ | Minimum OFF-time          | X option                                         |                                                  | 110   |       | ns            |
|                       |                           |                                                  | $T_J = -40^\circ\text{C}$ to $125^\circ\text{C}$ |       | 370   |               |
|                       |                           | Y option                                         |                                                  | 104   |       | ns            |
|                       |                           |                                                  | $T_J = -40^\circ\text{C}$ to $125^\circ\text{C}$ |       | 200   |               |
| $f_{\text{SW}}$       | Switching frequency       | X option, $V_{\text{FB}} = 0.5\text{ V}$         |                                                  | 550   |       | kHz           |
|                       |                           |                                                  | $T_J = -40^\circ\text{C}$ to $125^\circ\text{C}$ | 325   | 750   |               |
|                       |                           | X option, $V_{\text{FB}} = 0\text{ V}$           |                                                  | 140   |       | MHz           |
|                       |                           | Y option, $V_{\text{FB}} = 0.5\text{ V}$         |                                                  | 1.25  |       |               |
|                       |                           |                                                  | $T_J = -40^\circ\text{C}$ to $125^\circ\text{C}$ | 0.95  | 1.5   |               |
|                       |                           | Y option, $V_{\text{FB}} = 0\text{ V}$           |                                                  | 0.35  |       |               |
| $D_{\text{MAX}}$      | Maximum duty cycle        | X option                                         |                                                  | 94%   |       |               |
|                       |                           |                                                  | $T_J = -40^\circ\text{C}$ to $125^\circ\text{C}$ | 88%   |       |               |
|                       |                           | Y option                                         |                                                  | 87%   |       |               |
|                       |                           |                                                  | $T_J = -40^\circ\text{C}$ to $125^\circ\text{C}$ | 81%   |       |               |

(1) All limits specified at room temperature ( $T_A = 25^\circ\text{C}$ ) unless otherwise noted. Room temperature limits are production tested. Limits at temperature extremes are ensured through correlation using standard Statistical Quality Control (SQC) methods. Limits are used to calculate Average Outgoing Quality Level (AOQL).

(2) Typical numbers are at  $25^\circ\text{C}$  and represent the most likely norm.

(3) The part numbers in this table represent both the Q1 and non-Q1 versions of the respective parts.

(4) Includes the bond wires,  $R_{\text{DS(on)}}$  from  $V_{\text{IN}}$  pin to SW pin.

(5) Current limit at 0% duty cycle. May be lower at higher duty cycle or input voltages below 6 V.

(6) Bias currents flow into pin.

(7) Minimum ON-time specified by design and simulation.

## Electrical Characteristics (continued)

Specifications are for  $T_J = 25^\circ\text{C}$  unless otherwise specified. Minimum and Maximum limits are specified through test, design, or statistical correlation. Typical values represent the most likely parametric norm at  $T_J = 25^\circ\text{C}$ , and are provided for reference purposes only. Unless otherwise stated the following conditions apply:  $V_{IN} = 12\text{ V}$ .<sup>(1)(2)(3)</sup>

| PARAMETER                    |                                 | TEST CONDITIONS                                   |                                                 | MIN | TYP  | MAX  | UNIT          |
|------------------------------|---------------------------------|---------------------------------------------------|-------------------------------------------------|-----|------|------|---------------|
| $V_{UVP}$                    | Undervoltage lockout thresholds | On threshold                                      |                                                 |     | 3.7  |      | V             |
|                              |                                 |                                                   | $T_J = -40^\circ\text{C to } 125^\circ\text{C}$ | 4.4 |      |      |               |
|                              |                                 | Off threshold                                     |                                                 |     | 3.5  |      |               |
|                              |                                 |                                                   | $T_J = -40^\circ\text{C to } 125^\circ\text{C}$ |     |      | 3.25 |               |
| $V_{\overline{\text{SHDN}}}$ | Shutdown threshold              | Device ON                                         |                                                 |     | 1    |      | V             |
|                              |                                 |                                                   | $T_J = -40^\circ\text{C to } 125^\circ\text{C}$ | 2.3 |      |      |               |
|                              |                                 | Device OFF                                        |                                                 |     | 0.9  |      |               |
|                              |                                 |                                                   | $T_J = -40^\circ\text{C to } 125^\circ\text{C}$ |     |      | 0.3  |               |
| $I_{\overline{\text{SHDN}}}$ | Shutdown pin input bias current | $V_{\overline{\text{SHDN}}} = 2.3\text{ V}^{(6)}$ |                                                 |     | 0.05 |      | $\mu\text{A}$ |
|                              |                                 |                                                   | $T_J = -40^\circ\text{C to } 125^\circ\text{C}$ |     |      | 1.5  |               |
|                              |                                 | $V_{\overline{\text{SHDN}}} = 0\text{ V}$         |                                                 |     | 0.02 |      |               |
|                              |                                 |                                                   | $T_J = -40^\circ\text{C to } 125^\circ\text{C}$ |     |      | 1.5  |               |

## 6.6 Typical Characteristics

The part numbers in this section represent both the Q1 and non-Q1 versions of the respective parts.

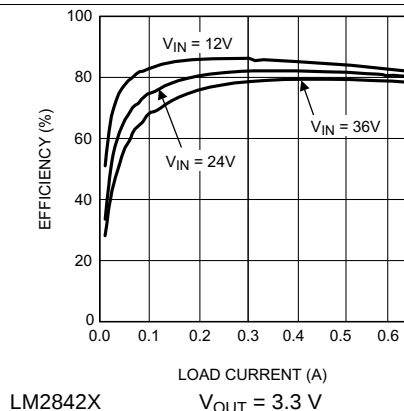


Figure 1. Efficiency vs Load Current

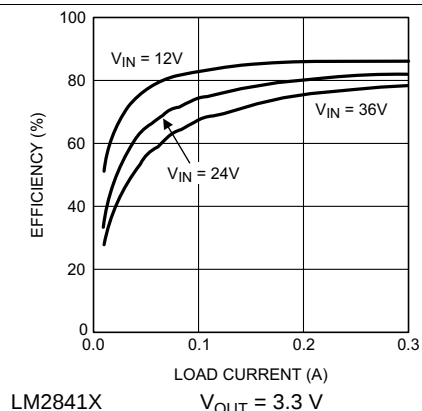


Figure 2. Efficiency vs Load Current

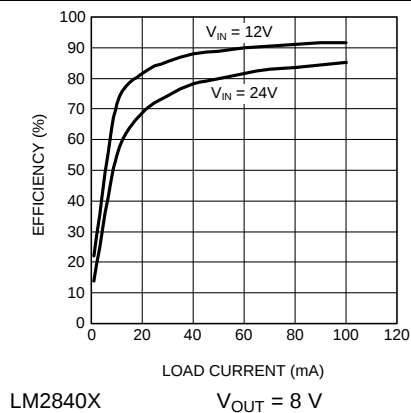


Figure 3. Efficiency vs Load Current

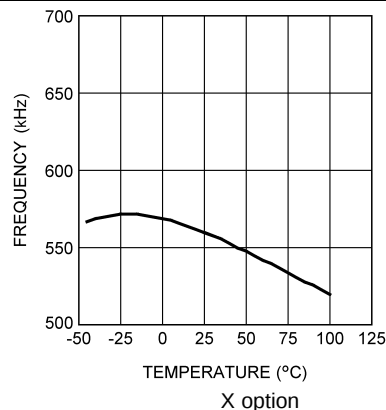


Figure 4. Switching Frequency vs Temperature

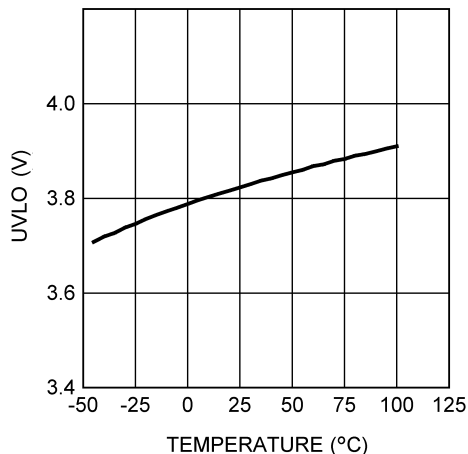


Figure 5. Input UVLO Voltage vs Temperature

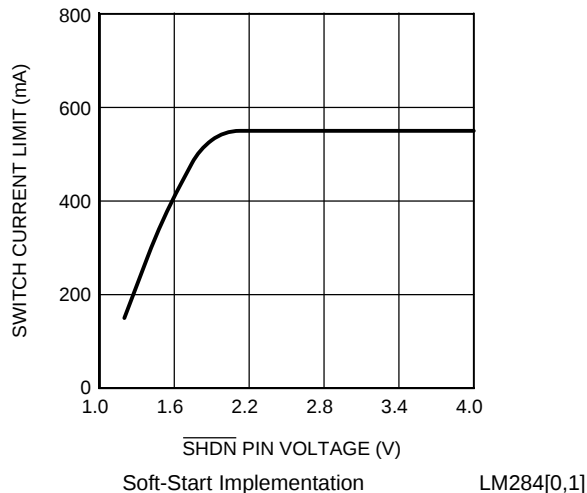


Figure 6. Switch Current Limit vs  $\overline{\text{SHDN}}$  Pin Voltage

## Typical Characteristics (continued)

The part numbers in this section represent both the Q1 and non-Q1 versions of the respective parts.

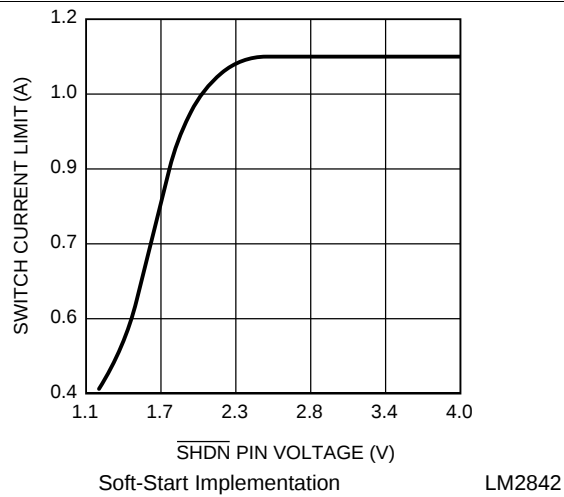


Figure 7. Switch Current Limit vs  $\overline{\text{SHDN}}$  Pin Voltage

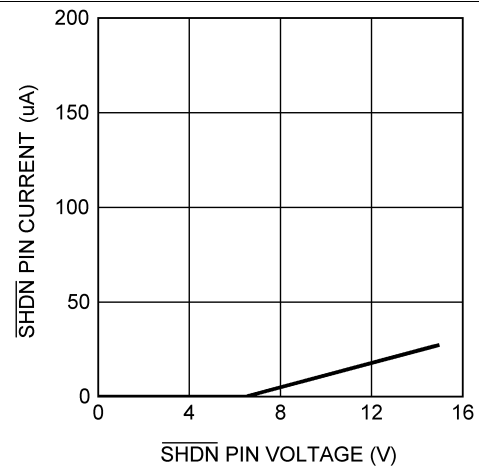


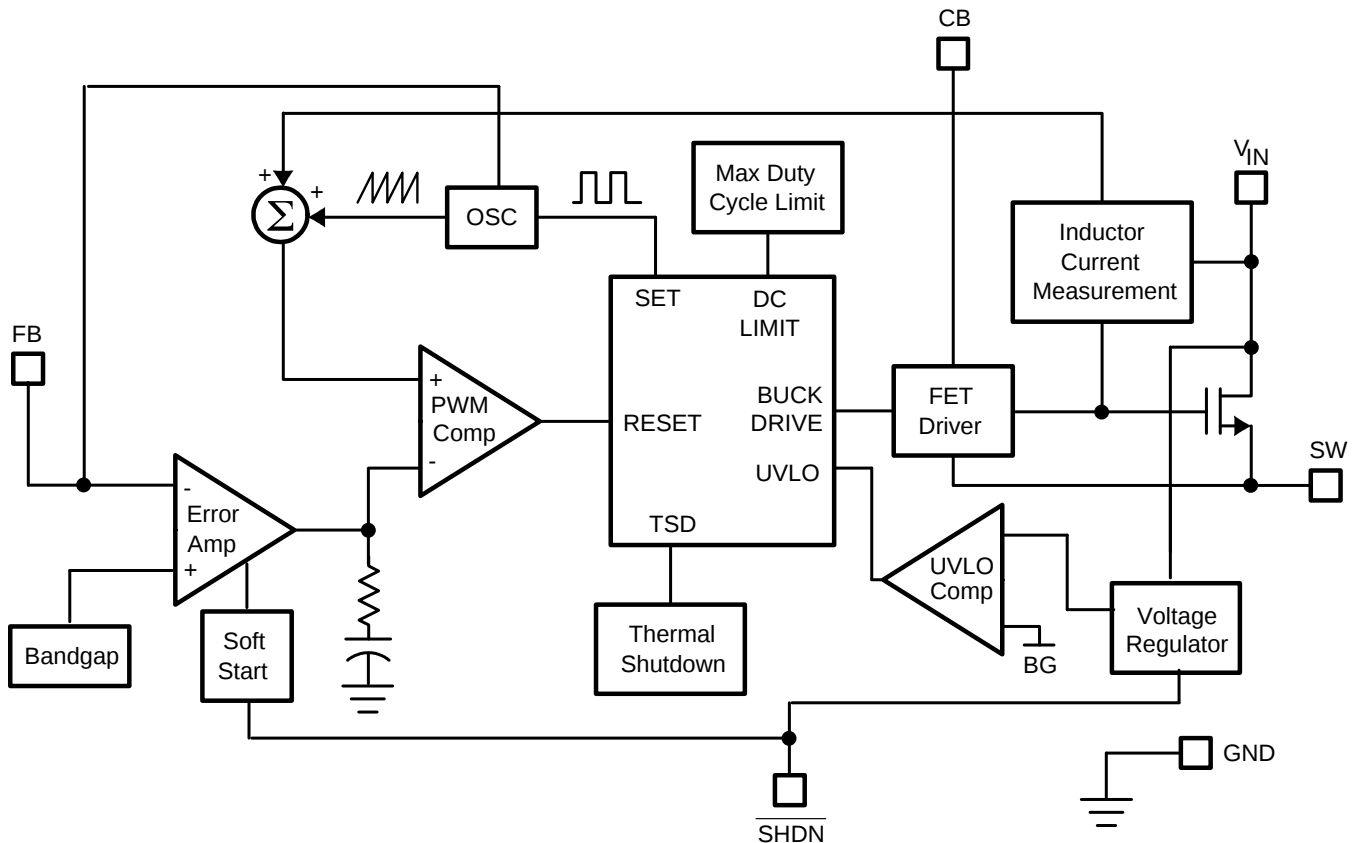
Figure 8.  $\overline{\text{SHDN}}$  Pin Current vs  $\overline{\text{SHDN}}$  Pin Voltage

## 7 Detailed Description

### 7.1 Overview

The LM284x-Q1 SIMPLE SWITCHER® regulators are easy-to-use, non-synchronous, step-down DC/DC converters with a wide input voltage range up to 42 V. The devices are capable of delivering up to 100-mA, 300-mA, or 600-mA DC load current with excellent line and load regulation. These devices are available in fixed frequency of 550 kHz and 1.25 MHz. The family requires few external components, and the pin arrangement was designed for simple, optimum PCB layout.

### 7.2 Functional Block Diagram



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### 7.3 Feature Description

#### 7.3.1 Protection

The LM284x-Q1 have dedicated protection circuitry running during normal operation to protect the IC. The thermal shutdown circuitry turns off the power device when the die temperature reaches excessive levels. The UVLO comparator protects the power device during supply power start-up and shutdown to prevent operation at voltages less than the minimum input voltage. A gate drive (CB) undervoltage lockout is included to ensure that there is enough gate drive voltage to drive the MOSFET before the device tries to start switching. The LM284x-Q1 also feature a shutdown mode decreasing the supply current to approximately 16  $\mu$ A.

## 7.4 Device Functional Modes

### 7.4.1 Continuous Conduction Mode

The LM284x-Q1 contain a current-mode, PWM buck regulator. A buck regulator steps the input voltage down to a lower output voltage. In continuous conduction mode (when the inductor current never reaches zero at steady-state operation), the buck regulator operates in two cycles. The power switch is connected between  $V_{IN}$  and SW. In the first cycle of operation the transistor is closed and the diode is reverse biased. Energy is collected in the inductor and the load current is supplied by  $C_{OUT}$  and the rising current through the inductor. During the second cycle the transistor is open and the diode is forward biased due to the fact that the inductor current cannot instantaneously change direction. The energy stored in the inductor is transferred to the load and output capacitor. The ratio of these two cycles determines the output voltage. The output voltage is defined approximately as shown in [Equation 1](#).

$$D = V_{OUT} / V_{IN} \quad (1)$$

$$D' = (1 - D)$$

where

- D is the duty cycle of the switch (2)

D and D' are required for design calculations.

## 8 Application and Implementation

### NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

### 8.1 Application Information

The LM284x-Q1 are step-down DC/DC regulators. They are typically used to convert a higher DC voltage to a lower DC voltage with a maximum output current of 100 mA, 300 mA, or 600 mA. The following design procedure can be used to select components for the LM284x-Q1. Alternately, the WEBENCH® software may be used to generate complete designs. When generating a design, the WEBENCH software uses iterative design procedure and accesses comprehensive databases of components. See [ti.com](http://ti.com) and [Detailed Design Procedure](#) for more details.

### 8.2 Typical Applications

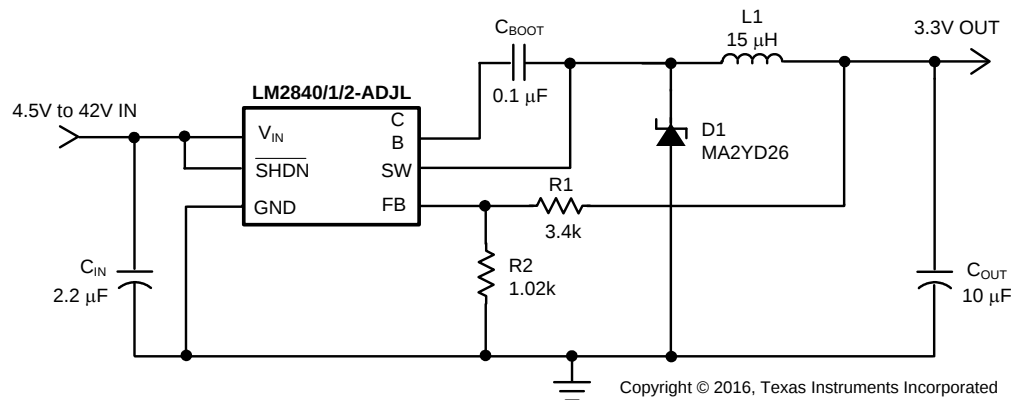


Figure 9. Application Circuit With 3.3-V Output Voltage at 100 mA

#### 8.2.1 Design Requirements

Table 1 lists the design parameters for this example.

Table 1. Design Parameters

| DESIGN PARAMETER | EXAMPLE VALUE |
|------------------|---------------|
| Input voltage    | 4.5 V to 42 V |
| Output voltage   | 3.3 V         |
| Output current   | 0.1 A         |

#### 8.2.2 Detailed Design Procedure

##### 8.2.2.1 Custom Design With WEBENCH® Tools

Click [here](#) to create a custom design using the LM2840 device with the WEBENCH® Power Designer.

1. Start by entering the input voltage ( $V_{IN}$ ), output voltage ( $V_{OUT}$ ), and output current ( $I_{OUT}$ ) requirements.
2. Optimize the design for key parameters such as efficiency, footprint, and cost using the optimizer dial.
3. Compare the generated design with other possible solutions from Texas Instruments.

The WEBENCH Power Designer provides a customized schematic along with a list of materials with real-time pricing and component availability.

In most cases, these actions are available:

- Run electrical simulations to see important waveforms and circuit performance
- Run thermal simulations to understand board thermal performance
- Export customized schematic and layout into popular CAD formats
- Print PDF reports for the design, and share the design with colleagues

Get more information about WEBENCH tools at [www.ti.com/WEBENCH](http://www.ti.com/WEBENCH).

This section presents guidelines for selecting external components.

### 8.2.2.2 Setting the Output Voltage

The output voltage is set using the feedback pin and a resistor divider connected to the output as shown in [Typical Application Circuit](#). The feedback pin voltage 0.765 V, so the ratio of the feedback resistors sets the output voltage according to [Equation 3](#):

$$V_{OUT} = 0.765 \text{ V} (1 + (R1 / R2)) \quad (3)$$

Typically R2 is given as 100  $\Omega$  to 10 k $\Omega$  for a starting value. To solve for R1 given R2 and  $V_{OUT}$ , use [Equation 4](#):

$$R1 = R2 ((V_{OUT} / 0.765 \text{ V}) - 1) \quad (4)$$

### 8.2.2.3 Inductor Selection

The most critical parameters for the inductor are the inductance, peak current, and the DC resistance. The inductance is related to the peak-to-peak inductor ripple current, the input and the output voltages.

$$L = \frac{(V_{IN} - V_{OUT})V_{OUT}}{V_{IN} \times I_{RIPPLE} \times f_{SW}} \quad (5)$$

A higher value of ripple current reduces inductance, but increases the conductance loss, core loss, and current stress for the inductor and switch devices. It also requires a bigger output capacitor for the same output voltage ripple requirement. A reasonable value is setting the ripple current to be 30% of the DC output current. Because the ripple current increases with the input voltage, the maximum input voltage is always used to determine the inductance. The DC resistance of the inductor is a key parameter for the efficiency. Lower DC resistance is available with a bigger winding area. A good tradeoff between the efficiency and the core size is letting the inductor copper loss equal 2% of the output power. See [Selecting Inductors for Buck Converters](#) for more information on selecting inductors. A good starting point for most applications is a 10  $\mu\text{H}$  to 22  $\mu\text{H}$  with 1.1 A or greater current rating for the LM2842-Q1 or a 0.7 A or greater current rating for the LM284x-Q1. Using such a rating enables the device to current limit without saturating the inductor. This is preferable to the device going into thermal shutdown mode and the possibility of damaging the inductor if the output is shorted to ground or other long-term overload.

**Table 2. Recommended Inductors**

| MANUFACTURER | INDUCTOR                                     | CONTACT INFORMATION                                                     |
|--------------|----------------------------------------------|-------------------------------------------------------------------------|
| Coilcraft    | LPS4018, DO1608C, DO3308, and LPO2506 series | <a href="http://www.coilcraft.com">www.coilcraft.com</a><br>800-3222645 |
| MuRata       | LQH55D and LQH66S series                     | <a href="http://www.murata.com">www.murata.com</a>                      |
| Coiltronics  | MP2 and MP2A series                          | <a href="http://www.cooperbussman.com">www.cooperbussman.com</a>        |

### 8.2.2.4 Input Capacitor

A low ESR ceramic capacitor ( $C_{IN}$ ) is needed between the  $V_{IN}$  pin and GND pin. This capacitor prevents large voltage transients from appearing at the input. Use a 2.2- $\mu\text{F}$  to 10- $\mu\text{F}$  value with X5R or X7R dielectric. Depending on construction, a ceramic capacitor's value can decrease up to 50% of its nominal value when rated voltage is applied. Consult with the capacitor manufacturer's data sheet for information on capacitor derating over voltage and temperature.

### 8.2.2.5 Output Capacitor

The selection of  $C_{OUT}$  is driven by the maximum allowable output voltage ripple. The output ripple in the constant frequency, PWM mode is approximated by Equation 6.

$$V_{RIPPLE} = I_{RIPPLE} (ESR + (1 / (8f_{SW}C_{OUT}))) \quad (6)$$

The ESR term usually plays the dominant role in determining the voltage ripple. Low-ESR ceramic capacitors are recommended. Capacitors in the range of 22  $\mu F$  to 100  $\mu F$  are a good starting point with an ESR of 0.1  $\Omega$  or less.

**Table 3. Recommended Input and Output Capacitors**

| MANUFACTURER     | CAPACITOR                                                                     | CONTACT INFORMATION                                                  |
|------------------|-------------------------------------------------------------------------------|----------------------------------------------------------------------|
| Vishay Sprague   | 293D, 592D, and 595D series tantalum                                          | <a href="http://www.vishay.com">www.vishay.com</a><br>407-324-4140   |
| Taiyo Yuden      | High capacitance MLCC ceramic                                                 | <a href="http://www.t-yuden.com">www.t-yuden.com</a><br>408-573-4150 |
| Cornell Dubilier | ESRD series Polymer Aluminum Electrolytic<br>SPV and AFK series V-chip series | <a href="http://www.cde.com">www.cde.com</a>                         |
| MuRata           | High capacitance MLCC ceramic                                                 | <a href="http://www.murata.com">www.murata.com</a>                   |

### 8.2.2.6 Bootstrap Capacitor

A 0.15- $\mu F$  ceramic capacitor or larger is recommended for the bootstrap capacitor ( $C_{BOOT}$ ). For applications where the input voltage is less than twice the output voltage a larger capacitor is recommended, generally 0.15  $\mu F$  to 1  $\mu F$  to ensure plenty of gate drive for the internal switches and a consistently low  $R_{DS(on)}$ .

### 8.2.2.7 Soft-Start Components

The devices have circuitry that is used in conjunction with the  $\overline{SHDN}$  pin to limit the inrush current on start-up of the DC/DC switching regulator. The  $\overline{SHDN}$  pin in conjunction with a RC filter is used to tailor the soft start for a specific application. When a voltage applied to the  $\overline{SHDN}$  pin is between 0 V and up to 2.3 V it causes the cycle-by-cycle current limit in the power stage to be modulated for minimum current limit at 0 V up to the rated current limit at 2.3 V. Thus controlling the output rise time and inrush current at start-up. The resistor value must be selected so the current injected into the  $\overline{SHDN}$  pin is greater than the leakage current of the  $\overline{SHDN}$  pin (1.5  $\mu A$ ) when the voltage at  $\overline{SHDN}$  is equal or greater than 2.3 V.

### 8.2.2.8 Shutdown Operation

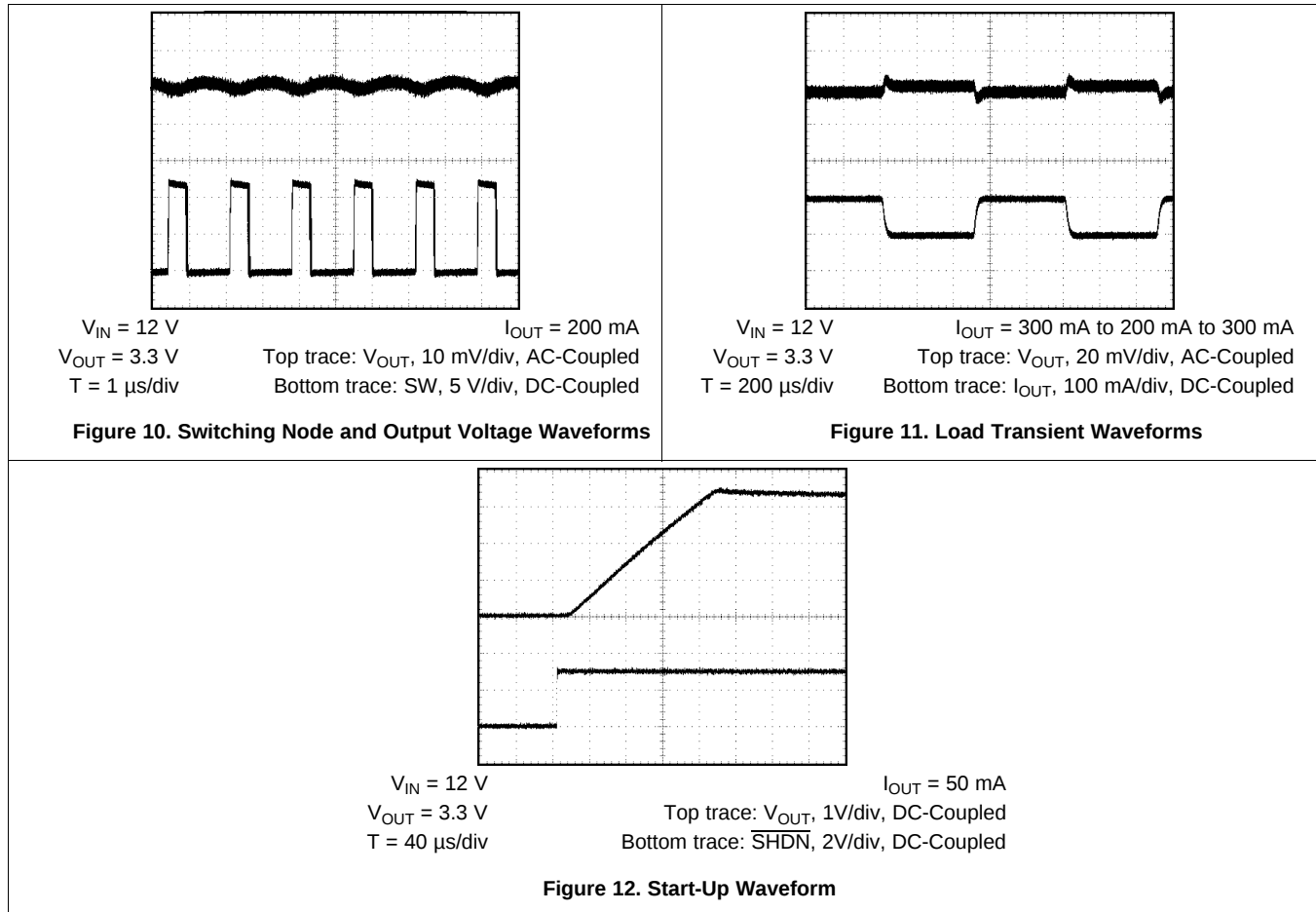
The  $\overline{SHDN}$  pin of the LM284x-Q1 is designed so that it may be controlled using 2.3 V or higher logic signals. If the shutdown function is not to be used the  $\overline{SHDN}$  pin may be tied to  $V_{IN}$ . This input must not be allowed to float.

The maximum voltage to the  $\overline{SHDN}$  pin should not exceed 42 V. If the use of a higher voltage is desired due to system or other constraints it may be used; however, a 100 k $\Omega$  or larger resistor is recommended between the applied voltage and the  $\overline{SHDN}$  pin to protect the device.

### 8.2.2.9 Schottky Diode

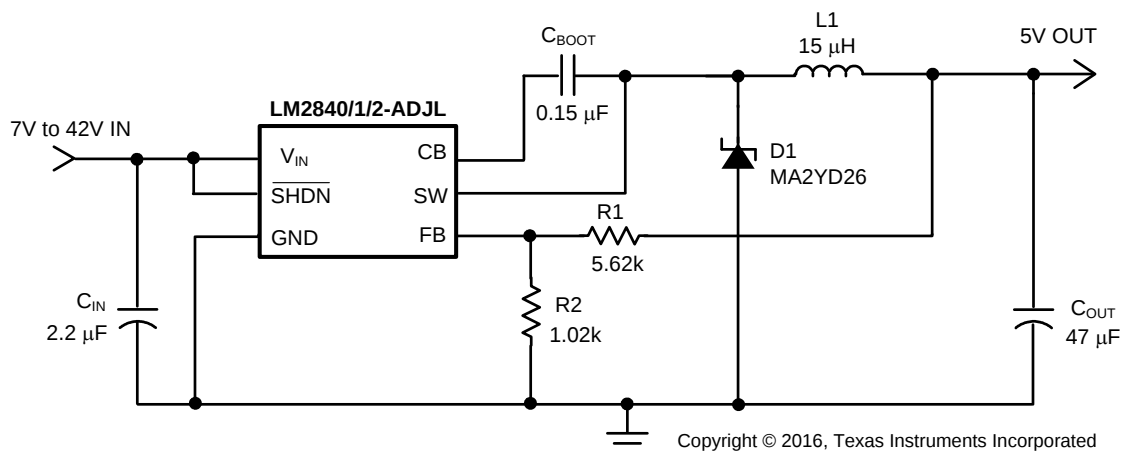
The breakdown voltage rating of the diode (D1) is preferred to be 25% higher than the maximum input voltage. The current rating for the diode must be equal to the maximum output current for best reliability in most applications. In cases where the duty cycle is greater than 50%, the average diode current is lower. In this case it is possible to use a diode with a lower average current rating, approximately  $(1 - D)I_{OUT}$ ; however, the peak current rating should be higher than the maximum load current. A 0.5-A to 1-A rated diode is a good starting point.

## 8.2.3 Application Curves



## 8.2.4 Other Application Circuits

Figure 13 to Figure 16 show application circuit examples using the LM284x-Q1 devices. Customers must fully validate and test these circuits before implementing a design based on these examples. Unless otherwise noted, the design procedures in are applicable to these designs.



**Figure 13. Step-Down Converter With 5-V Output Voltage**

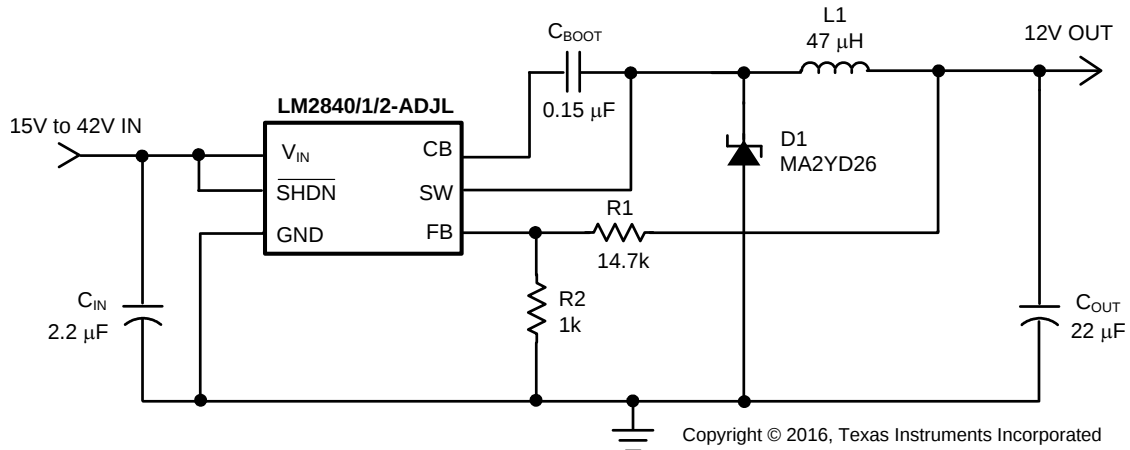


Figure 14. Step-Down Converter With 12-V Output Voltage

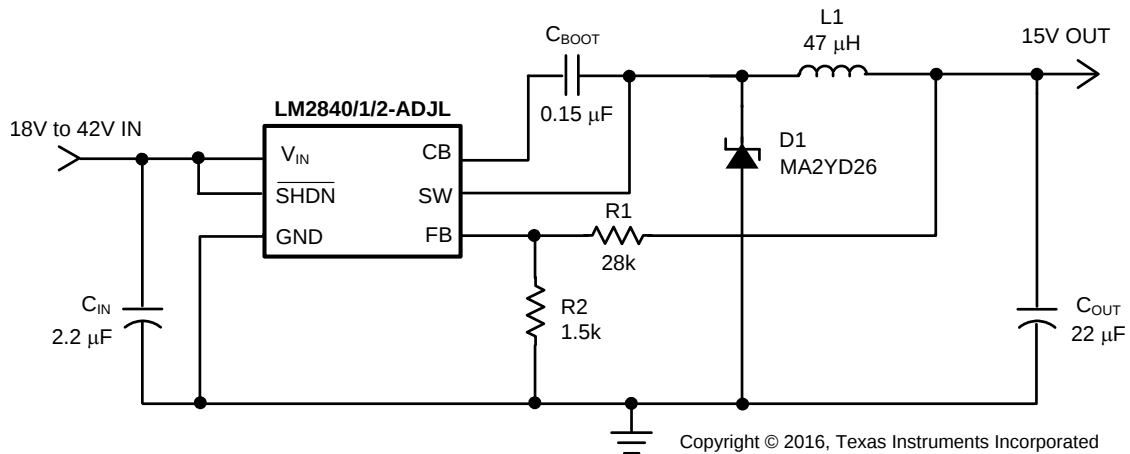


Figure 15. Step-Down Converter With 15-V Output Voltage

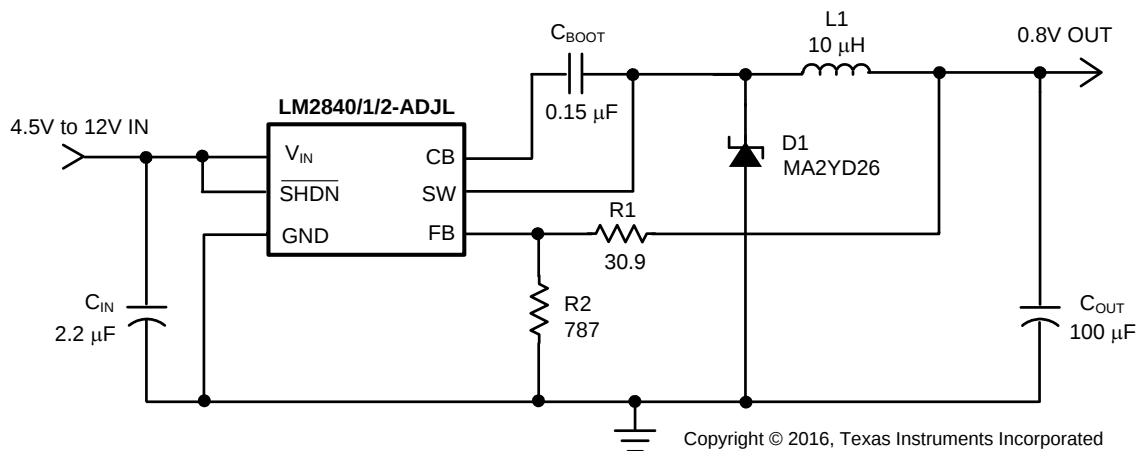


Figure 16. Step-Down Converter With 0.8-V Output Voltage

## 9 Power Supply Recommendations

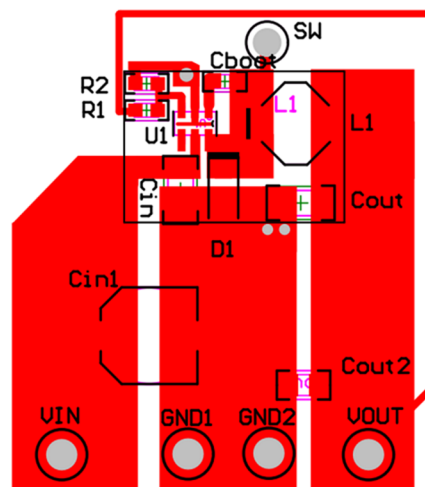
The LM284x-Q1 are designed to operate from an input voltage supply range between 4 V and 42 V. This input supply must be able to withstand the maximum input current and maintain a voltage above 4.5 V. The resistance of the input supply rail must be low enough that an input current transient does not cause a drop at the device supply voltage high enough to cause a false UVLO fault triggering and system reset. If the input supply is located more than a few inches from the device, additional bulk capacitance may be required in addition to the ceramic input capacitors.

## 10 Layout

### 10.1 Layout Guidelines

To reduce problems with conducted noise pickup, the ground side of the feedback network should be connected directly to the GND pin with its own connection. The feedback network, resistors R1 and R2, must be kept close to the FB pin, and away from the inductor to minimize coupling noise into the feedback pin. The input bypass capacitor  $C_{IN}$  must be placed close to the  $V_{IN}$  pin. This reduces copper trace resistance, which effects input voltage ripple of the IC. The inductor L1 must be placed close to the SW pin to reduce EMI and capacitive coupling. The output capacitor,  $C_{OUT}$  must be placed close to the junction of L1 and the diode D1. The L1, D1, and  $C_{OUT}$  trace must be as short as possible to reduce conducted and radiated noise and increase overall efficiency. The ground connection for the diode,  $C_{IN}$ , and  $C_{OUT}$  must be as small as possible and tied to the system ground plane in only one spot (preferably at the  $C_{OUT}$  ground point) to minimize conducted noise in the system ground plane. See [Layout Guidelines for Switching Power Supplies](#) for more detail on switching power supply layout considerations.

### 10.2 Layout Example



**Figure 17. Recommended Layout**

## 11 Device and Documentation Support

### 11.1 Device Support

#### 11.1.1 Third-Party Products Disclaimer

TI'S PUBLICATION OF INFORMATION REGARDING THIRD-PARTY PRODUCTS OR SERVICES DOES NOT CONSTITUTE AN ENDORSEMENT REGARDING THE SUITABILITY OF SUCH PRODUCTS OR SERVICES OR A WARRANTY, REPRESENTATION OR ENDORSEMENT OF SUCH PRODUCTS OR SERVICES, EITHER ALONE OR IN COMBINATION WITH ANY TI PRODUCT OR SERVICE.

#### 11.1.2 Development Support

##### 11.1.2.1 Custom Design With WEBENCH® Tools

[Click here](#) to create a custom design using the LM2840-Q1 device with the WEBENCH® Power Designer.

1. Start by entering the input voltage ( $V_{IN}$ ), output voltage ( $V_{OUT}$ ), and output current ( $I_{OUT}$ ) requirements.
2. Optimize the design for key parameters such as efficiency, footprint, and cost using the optimizer dial.
3. Compare the generated design with other possible solutions from Texas Instruments.

The WEBENCH Power Designer provides a customized schematic along with a list of materials with real-time pricing and component availability.

In most cases, these actions are available:

- Run electrical simulations to see important waveforms and circuit performance
- Run thermal simulations to understand board thermal performance
- Export customized schematic and layout into popular CAD formats
- Print PDF reports for the design, and share the design with colleagues

Get more information about WEBENCH tools at [www.ti.com/WEBENCH](http://www.ti.com/WEBENCH).

### 11.2 Documentation Support

#### 11.2.1 Related Documentation

For related documentation, see the following:

- [AN-1197 Selecting Inductors for Buck Converters](#) (SNVA038)
- [AN-1149 Layout Guidelines for Switching Power Supplies](#) (SNVA021)

### 11.3 Related Links

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to order now.

**Table 4. Related Links**

| PARTS     | PRODUCT FOLDER             | ORDER NOW                  | TECHNICAL DOCUMENTS        | TOOLS & SOFTWARE           | SUPPORT & COMMUNITY        |
|-----------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| LM2840-Q1 | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> |
| LM2841-Q1 | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> |
| LM2842-Q1 | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> |

### 11.4 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

## 11.5 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

**TI E2E™ Online Community** *TI's Engineer-to-Engineer (E2E) Community*. Created to foster collaboration among engineers. At [e2e.ti.com](http://e2e.ti.com), you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

**Design Support** *TI's Design Support* Quickly find helpful E2E forums along with design support tools and contact information for technical support.

## 11.6 Trademarks

SIMPLE SWITCHER, E2E are trademarks of Texas Instruments.

WEBENCH, SIMPLE SWITCHER are registered trademarks of Texas Instruments.

All other trademarks are the property of their respective owners.

## 11.7 Electrostatic Discharge Caution



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

## 11.8 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

## 12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

**PACKAGING INFORMATION**

| Orderable part number            | Status<br>(1) | Material type<br>(2) | Package   Pins            | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|----------------------------------|---------------|----------------------|---------------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| <a href="#">LM2840XQMK/NOPB</a>  | Active        | Production           | SOT-23-<br>THIN (DDC)   6 | 1000   SMALL T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | SE9B                |
| LM2840XQMK/NOPB.A                | Active        | Production           | SOT-23-<br>THIN (DDC)   6 | 1000   SMALL T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | SE9B                |
| <a href="#">LM2840YQMK/NOPB</a>  | Active        | Production           | SOT-23-<br>THIN (DDC)   6 | 1000   SMALL T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | SF2B                |
| LM2840YQMK/NOPB.A                | Active        | Production           | SOT-23-<br>THIN (DDC)   6 | 1000   SMALL T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | SF2B                |
| <a href="#">LM2840YQMKX/NOPB</a> | Active        | Production           | SOT-23-<br>THIN (DDC)   6 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | SF2B                |
| LM2840YQMKX/NOPB.A               | Active        | Production           | SOT-23-<br>THIN (DDC)   6 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | SF2B                |
| <a href="#">LM2841XQMK/NOPB</a>  | Active        | Production           | SOT-23-<br>THIN (DDC)   6 | 1000   SMALL T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | SB1B                |
| LM2841XQMK/NOPB.A                | Active        | Production           | SOT-23-<br>THIN (DDC)   6 | 1000   SMALL T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | SB1B                |
| <a href="#">LM2841YQMK/NOPB</a>  | Active        | Production           | SOT-23-<br>THIN (DDC)   6 | 1000   SMALL T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | SB2B                |
| LM2841YQMK/NOPB.A                | Active        | Production           | SOT-23-<br>THIN (DDC)   6 | 1000   SMALL T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | SB2B                |
| <a href="#">LM2841YQMKX/NOPB</a> | Active        | Production           | SOT-23-<br>THIN (DDC)   6 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | SB2B                |
| LM2841YQMKX/NOPB.A               | Active        | Production           | SOT-23-<br>THIN (DDC)   6 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | SB2B                |
| <a href="#">LM2842XQMK/NOPB</a>  | Active        | Production           | SOT-23-<br>THIN (DDC)   6 | 1000   SMALL T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | SB3B                |
| LM2842XQMK/NOPB.A                | Active        | Production           | SOT-23-<br>THIN (DDC)   6 | 1000   SMALL T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | SB3B                |
| <a href="#">LM2842XQMKX/NOPB</a> | Active        | Production           | SOT-23-<br>THIN (DDC)   6 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | SB3B                |
| LM2842XQMKX/NOPB.A               | Active        | Production           | SOT-23-<br>THIN (DDC)   6 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | SB3B                |

| Orderable part number            | Status<br>(1) | Material type<br>(2) | Package   Pins            | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|----------------------------------|---------------|----------------------|---------------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| LM2842XQMKX/NOPB.B               | Active        | Production           | SOT-23-<br>THIN (DDC)   6 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | SB3B                |
| <a href="#">LM2842YQMK/NOPB</a>  | Active        | Production           | SOT-23-<br>THIN (DDC)   6 | 1000   SMALL T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | SB4B                |
| LM2842YQMK/NOPB.A                | Active        | Production           | SOT-23-<br>THIN (DDC)   6 | 1000   SMALL T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | SB4B                |
| <a href="#">LM2842YQMKX/NOPB</a> | Active        | Production           | SOT-23-<br>THIN (DDC)   6 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | SB4B                |
| LM2842YQMKX/NOPB.A               | Active        | Production           | SOT-23-<br>THIN (DDC)   6 | 3000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | SB4B                |

<sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).

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

<sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

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

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

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

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

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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.

**OTHER QUALIFIED VERSIONS OF LM2840-Q1, LM2841-Q1, LM2842-Q1 :**

- Catalog : [LM2840](#), [LM2841](#), [LM2842](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

**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 |
|------------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| LM2840XQMK/NOPB  | SOT-23-THIN  | DDC             | 6    | 1000 | 178.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| LM2840YQMK/NOPB  | SOT-23-THIN  | DDC             | 6    | 1000 | 178.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| LM2840YQMKX/NOPB | SOT-23-THIN  | DDC             | 6    | 3000 | 178.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| LM2841XQMK/NOPB  | SOT-23-THIN  | DDC             | 6    | 1000 | 178.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| LM2841YQMK/NOPB  | SOT-23-THIN  | DDC             | 6    | 1000 | 178.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| LM2841YQMKX/NOPB | SOT-23-THIN  | DDC             | 6    | 3000 | 178.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| LM2842XQMK/NOPB  | SOT-23-THIN  | DDC             | 6    | 1000 | 178.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| LM2842XQMKX/NOPB | SOT-23-THIN  | DDC             | 6    | 3000 | 178.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| LM2842YQMK/NOPB  | SOT-23-THIN  | DDC             | 6    | 1000 | 178.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |

---

| 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 |
|------------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| LM2842YQMKX/NOPB | SOT-23-THIN  | DDC             | 6    | 3000 | 178.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |

## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

| Device           | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|------------------|--------------|-----------------|------|------|-------------|------------|-------------|
| LM2840XQMK/NOPB  | SOT-23-THIN  | DDC             | 6    | 1000 | 210.0       | 185.0      | 35.0        |
| LM2840YQMK/NOPB  | SOT-23-THIN  | DDC             | 6    | 1000 | 210.0       | 185.0      | 35.0        |
| LM2840YQMKX/NOPB | SOT-23-THIN  | DDC             | 6    | 3000 | 210.0       | 185.0      | 35.0        |
| LM2841XQMK/NOPB  | SOT-23-THIN  | DDC             | 6    | 1000 | 210.0       | 185.0      | 35.0        |
| LM2841YQMK/NOPB  | SOT-23-THIN  | DDC             | 6    | 1000 | 208.0       | 191.0      | 35.0        |
| LM2841YQMKX/NOPB | SOT-23-THIN  | DDC             | 6    | 3000 | 208.0       | 191.0      | 35.0        |
| LM2842XQMK/NOPB  | SOT-23-THIN  | DDC             | 6    | 1000 | 208.0       | 191.0      | 35.0        |
| LM2842XQMKX/NOPB | SOT-23-THIN  | DDC             | 6    | 3000 | 208.0       | 191.0      | 35.0        |
| LM2842YQMK/NOPB  | SOT-23-THIN  | DDC             | 6    | 1000 | 208.0       | 191.0      | 35.0        |
| LM2842YQMKX/NOPB | SOT-23-THIN  | DDC             | 6    | 3000 | 208.0       | 191.0      | 35.0        |



## SOT-23 - 1.1 max height

### SMALL OUTLINE TRANSISTOR



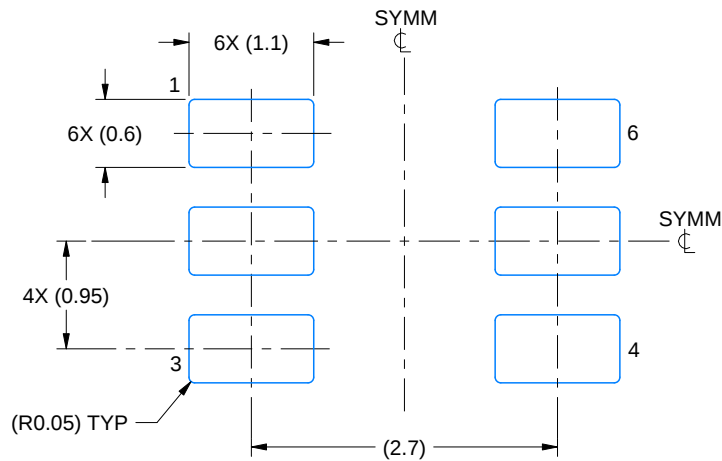
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Reference JEDEC MO-193.

# EXAMPLE BOARD LAYOUT

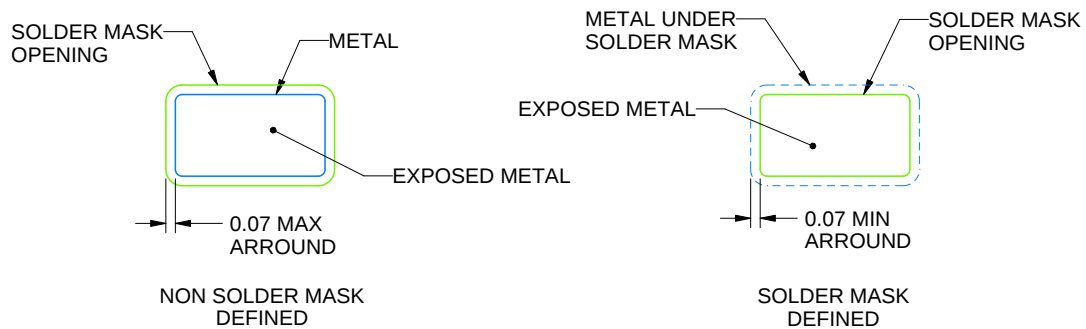
DDC0006A

SOT-23 - 1.1 max height

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE  
EXPLODED METAL SHOWN  
SCALE:15X



SOLDERMASK DETAILS

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NOTES: (continued)

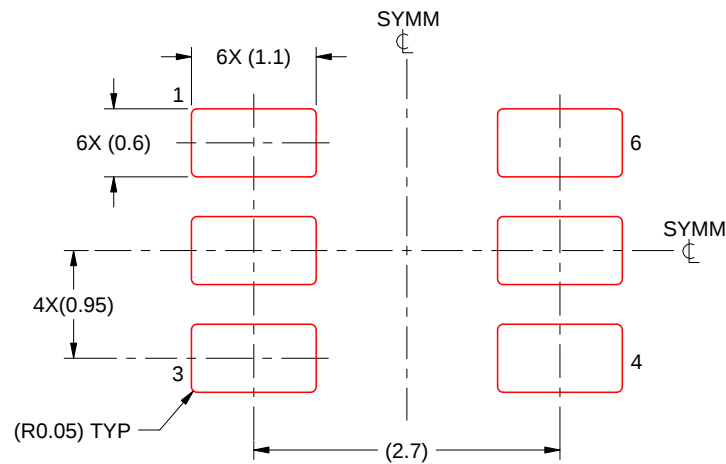
4. Publication IPC-7351 may have alternate designs.
5. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

DDC0006A

SOT-23 - 1.1 max height

SMALL OUTLINE TRANSISTOR



SOLDER PASTE EXAMPLE  
BASED ON 0.125 THICK STENCIL  
SCALE:15X

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NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
7. Board assembly site may have different recommendations for stencil design.

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