

# LM2742 N-Channel FET Synchronous Buck Regulator Controller for Low Output Voltages

Check for Samples: [LM2742](#)

## FEATURES

- Input Power from 1V to 16V
- Output Voltage Adjustable down to 0.6V
- Power Good Flag, Adjustable Soft-start and Output Enable for Easy Power Sequencing
- Reference Accuracy: 1.5% (0°C–125°C)
- Current Limit Without Sense Resistor
- Soft Start
- Switching Frequency from 50 kHz to 2 MHz
- 40ns Typical Minimum On-time
- TSSOP-14 Package

## APPLICATIONS

- POL Power Supply Modules
- Cable Modems
- Set-Top Boxes/ Home Gateways
- DDR Core Power
- High-Efficiency Distributed Power
- Local Regulation of Core Power

## DESCRIPTION

The LM2742 is a high-speed, synchronous, switching regulator controller. It is intended to control currents of 0.7A to 20A with up to 95% conversion efficiencies. Power up and down sequencing is achieved with the power-good flag, adjustable soft-start and output enable features. The LM2742 operates from a low-current 5V bias and can convert from a 1V to 16V power rail. The part utilizes a fixed-frequency, voltage-mode, PWM control architecture and the switching frequency is adjustable from 50kHz to 2MHz by setting the value of an external resistor. Current limit is achieved by monitoring the voltage drop across the on-resistance of the low-side MOSFET, which enables on-times on the order of 40ns, one of the best in the industry. The wide range of operating frequencies gives the power supply designer the flexibility to fine-tune component size, cost, noise and efficiency. The adaptive, non-overlapping MOSFET gate-drivers and high-side bootstrap structure helps to further maximize efficiency. The high-side power FET drain voltage can be from 1V to 16V and the output voltage is adjustable down to 0.6V.

## TYPICAL APPLICATION

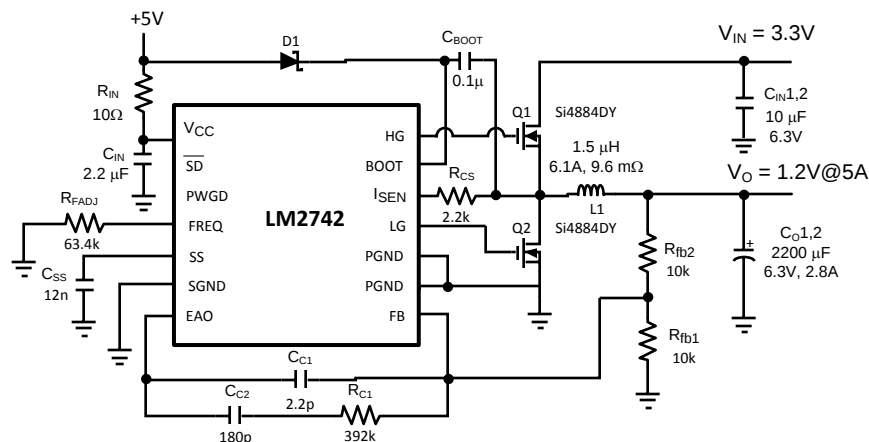


Figure 1. Typical Application Circuit



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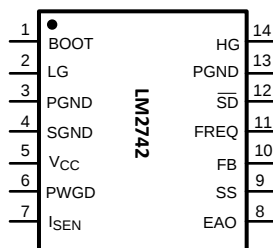
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These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

## CONNECTION DIAGRAM



**Figure 2. 14-Lead Plastic TSSOP**  
 $\theta_{JA} = 155^{\circ}\text{C/W}$

## PIN DESCRIPTIONS

**BOOT (Pin 1)** - Supply rail for the N-channel MOSFET gate drive. The voltage should be at least one gate threshold above the regulator input voltage to properly turn on the high-side N-FET.

**LG (Pin 2)** - Gate drive for the low-side N-channel MOSFET. This signal is interlocked with HG to avoid shoot-through problems

**PGND (Pins 3, 13)** - Ground for FET drive circuitry. It should be connected to system ground.

**SGND (Pin 4)** - Ground for signal level circuitry. It should be connected to system ground.

**V<sub>CC</sub> (Pin 5)** - Supply rail for the controller.

**PWGD (Pin 6)** - Power Good. This is an open drain output. The pin is pulled low when the chip is in UVP, OVP, or UVLO mode. During normal operation, this pin is connected to V<sub>CC</sub> or other voltage source through a pull-up resistor.

**ISEN (Pin 7)** - Current limit threshold setting. This sources a fixed 50μA current. A resistor of appropriate value should be connected between this pin and the drain of the low-side FET.

**EAO (Pin 8)** - Output of the error amplifier. The voltage level on this pin is compared with an internally generated ramp signal to determine the duty cycle. This pin is necessary for compensating the control loop.

**SS (Pin 9)** - Soft start pin. A capacitor connected between this pin and ground sets the speed at which the output voltage ramps up. Larger capacitor value results in slower output voltage ramp but also lower inrush current.

**FB (Pin 10)** - This is the inverting input of the error amplifier, which is used for sensing the output voltage and compensating the control loop.

**FREQ (Pin 11)** - The switching frequency is set by connecting a resistor between this pin and ground.

**$\overline{\text{SD}}$  (Pin 12)** - IC Logic Shutdown. When this pin is pulled low the chip turns off both the high side and low side switches. While this pin is low, the IC will not start up. An internal 20μA pull-up connects this pin to V<sub>CC</sub>. For a device which turns on the low side switch during shutdown, see the pin compatible LM2737.

**HG (Pin 14)** - Gate drive for the high-side N-channel MOSFET. This signal is interlocked with LG to avoid shoot-through problems.

## ABSOLUTE MAXIMUM RATINGS <sup>(1)</sup>

If Military/Aerospace specified devices are required, contact the Texas Instruments Semiconductor Sales Office/ Distributors for availability and specifications.

|                                 |                |
|---------------------------------|----------------|
| V <sub>CC</sub>                 | 7V             |
| BOOTV                           | 21V            |
| LG and HG to GND <sup>(2)</sup> | -2V to 21V     |
| Junction Temperature            | 150°C          |
| Storage Temperature             | -65°C to 150°C |
| Soldering Information Lead      |                |
| Temperature (soldering, 10sec)  | 260°C          |
| Infrared or Convection (20sec)  | 235°C          |
| ESD Rating                      | 2 kV           |

- (1) Absolute maximum ratings indicate limits beyond which damage to the device may occur. **Operating ratings** indicate conditions for which the device operates correctly. **Operating Ratings** do **not imply** ensured performance limits.
- (2) The LG and HG pin can have -2V to -0.5V applied for a maximum duty cycle of 10% with a maximum period of 1 second. There is no duty cycle or maximum period limitation for a LG and HG pin voltage range of -0.5V to 21V.

## RECOMMENDED OPERATING CONDITIONS

|                                      |                 |
|--------------------------------------|-----------------|
| Supply Voltage (V <sub>CC</sub> )    | 4.5V to 5.5V    |
| Junction Temperature Range           | -40°C to +125°C |
| Thermal Resistance ( $\theta_{JA}$ ) | 155°C/W         |

## ELECTRICAL CHARACTERISTICS

$V_{CC} = 5V$  unless otherwise indicated. Typical and limits appearing in plain type apply for  $T_A = T_J = +25^\circ C$ . Limits appearing in boldface type apply over full Operating Temperature Range. Datasheet min/max specification limits are specified by design, test, or statistical analysis.

| Symbol              | Parameter                                      | Conditions                                                               | Min      | Typ        | Max        | Units |
|---------------------|------------------------------------------------|--------------------------------------------------------------------------|----------|------------|------------|-------|
| V <sub>FB_ADJ</sub> | FB Pin Voltage                                 | V <sub>CC</sub> = 4.5V, 0°C to +125°C                                    | 0.591    | 0.6        | 0.609      | V     |
|                     |                                                | V <sub>CC</sub> = 5V, 0°C to +125°C                                      | 0.591    | 0.6        | 0.609      |       |
|                     |                                                | V <sub>CC</sub> = 5.5V, 0°C to +125°C                                    | 0.591    | 0.6        | 0.609      |       |
|                     |                                                | V <sub>CC</sub> = 4.5V, −40°C to +125°C                                  | 0.589    | 0.6        | 0.609      |       |
|                     |                                                | V <sub>CC</sub> = 5V, −40°C to +125°C                                    | 0.589    | 0.6        | 0.609      |       |
|                     |                                                | V <sub>CC</sub> = 5.5V, −40°C to +125°C                                  | 0.589    | 0.6        | 0.609      |       |
| V <sub>ON</sub>     | UVLO Thresholds                                | Rising<br>Falling                                                        |          | 4.2<br>3.6 |            | V     |
| I <sub>Q-V5</sub>   | Operating V <sub>CC</sub> Current              | SD = 5V, FB = 0.55V<br>Fsw = 600kHz                                      | 1        | 1.5        | 2          | mA    |
|                     |                                                | SD = 5V, FB = 0.65V<br>Fsw = 600kHz                                      | 0.8      | 1.7        | 2.2        |       |
|                     | Shutdown V <sub>CC</sub> Current               | SD = 0V                                                                  | 0.15     | 0.4        | 0.7        | mA    |
| t <sub>PWGD1</sub>  | PWGD Pin Response Time                         | FB Voltage Going Up                                                      |          | 6          |            | μs    |
| t <sub>PWGD2</sub>  | PWGD Pin Response Time                         | FB Voltage Going Down                                                    |          | 6          |            | μs    |
| I <sub>SD</sub>     | SD Pin Internal Pull-up Current                |                                                                          |          | 20         |            | μA    |
| I <sub>SS-ON</sub>  | SS Pin Source Current                          | SS Voltage = 2.5V<br>0°C to +125°C<br>-40°C to +125°C                    | 8<br>5   | 11<br>11   | 15<br>15   | μA    |
| I <sub>SS-OC</sub>  | SS Pin Sink Current During Over Current        | SS Voltage = 2.5V                                                        |          | 95         |            | μA    |
| I <sub>SEN-TH</sub> | I <sub>SEN</sub> Pin Source Current Trip Point | 0°C to +125°C<br>-40°C to +125°C                                         | 35<br>28 | 50<br>50   | 65<br>65   | μA    |
| ERROR AMPLIFIER     |                                                |                                                                          |          |            |            |       |
| GBW                 | Error Amplifier Unity Gain Bandwidth           |                                                                          |          | 5          |            | MHz   |
| G                   | Error Amplifier DC Gain                        |                                                                          |          | 60         |            | dB    |
| SR                  | Error Amplifier Slew Rate                      |                                                                          |          | 6          |            | V/μA  |
| I <sub>FB</sub>     | FB Pin Bias Current                            | FB = 0.55V<br>FB = 0.65V                                                 | 0<br>0   | 15<br>30   | 100<br>155 | nA    |
| I <sub>EAO</sub>    | EAO Pin Current Sourcing and Sinking           | V <sub>EAO</sub> = 2.5, FB = 0.55V<br>V <sub>EAO</sub> = 2.5, FB = 0.65V |          | 2.8<br>0.8 |            | mA    |
| V <sub>EA</sub>     | Error Amplifier Maximum Swing                  | Minimum<br>Maximum                                                       |          | 1.2<br>3.2 |            | V     |
| GATE DRIVE          |                                                |                                                                          |          |            |            |       |
| I <sub>Q-BOOT</sub> | BOOT Pin Quiescent Current                     | BOOT = 12V, EN = 0<br>0°C to +125°C<br>-40°C to +125°C                   |          | 95<br>95   | 160<br>215 | μA    |
| R <sub>DS1</sub>    | Top FET Driver Pull-Up ON resistance           | BOOT-SW = 5V at 350mA                                                    |          | 3          |            | Ω     |
| R <sub>DS2</sub>    | Top FET Driver Pull-Down ON resistance         | BOOT-SW = 5V at 350mA                                                    |          | 2          |            | Ω     |
| R <sub>DS3</sub>    | Bottom FET Driver Pull-Up ON resistance        | BOOT-SW = 5V at 350mA                                                    |          | 3          |            | Ω     |
| R <sub>DS4</sub>    | Bottom FET Driver Pull-Down ON resistance      | BOOT-SW = 5V at 350mA                                                    |          | 2          |            | Ω     |

## ELECTRICAL CHARACTERISTICS (continued)

$V_{CC} = 5V$  unless otherwise indicated. Typical and limits appearing in plain type apply for  $T_A = T_J = +25^\circ C$ . Limits appearing in boldface type apply over full Operating Temperature Range. Datasheet min/max specification limits are specified by design, test, or statistical analysis.

| Symbol                          | Parameter                    | Conditions                                                                                              | Min                          | Typ            | Max                          | Units |
|---------------------------------|------------------------------|---------------------------------------------------------------------------------------------------------|------------------------------|----------------|------------------------------|-------|
| <b>OSCILLATOR</b>               |                              |                                                                                                         |                              |                |                              |       |
| $f_{OSC}$                       | PWM Frequency                | $R_{FADJ} = 590k\Omega$                                                                                 |                              | 50             |                              | kHz   |
|                                 |                              | $R_{FADJ} = 88.7k\Omega$                                                                                |                              | 300            |                              |       |
|                                 |                              | $R_{FADJ} = 42.2k\Omega, 0^\circ C \text{ to } +125^\circ C$                                            | <b>500</b>                   | 600            | <b>700</b>                   |       |
|                                 |                              | $R_{FADJ} = 42.2k\Omega, -40^\circ C \text{ to } +125^\circ C$                                          | <b>490</b>                   | 600            | <b>700</b>                   |       |
|                                 |                              | $R_{FADJ} = 17.4k\Omega$                                                                                |                              | 1400           |                              |       |
|                                 |                              | $R_{FADJ} = 11.3k\Omega$                                                                                |                              | 2000           |                              |       |
| D                               | Max Duty Cycle               | $f_{PWM} = 300kHz$<br>$f_{PWM} = 600kHz$                                                                |                              | 90<br>88       |                              | %     |
| $t_{on-min}$                    | Minimum on-time              |                                                                                                         |                              | 40             |                              | ns    |
| <b>LOGIC INPUTS AND OUTPUTS</b> |                              |                                                                                                         |                              |                |                              |       |
| $V_{SD-IH}$                     | SD Pin Logic High Trip Point |                                                                                                         |                              | 2.6            | <b>3.5</b>                   | V     |
| $V_{SD-IL}$                     | SD Pin Logic Low Trip Point  | $0^\circ C \text{ to } +125^\circ C$<br>$-40^\circ C \text{ to } +125^\circ C$                          | <b>1.3</b><br><b>1.25</b>    | 1.6<br>1.6     |                              | V     |
| $V_{PWGD-TH-LO}$                | PWGD Pin Trip Points         | FB Voltage Going Down<br>$0^\circ C \text{ to } +125^\circ C$<br>$-40^\circ C \text{ to } +125^\circ C$ | <b>0.413</b><br><b>0.410</b> | 0.430<br>0.430 | <b>0.446</b><br><b>0.446</b> | V     |
| $V_{PWGD-TH-HI}$                | PWGD Pin Trip Points         | FB Voltage Going Up<br>$0^\circ C \text{ to } +125^\circ C$<br>$-40^\circ C \text{ to } +125^\circ C$   | <b>0.691</b><br><b>0.688</b> | 0.710<br>0.710 | <b>0.734</b><br><b>0.734</b> | V     |
| $V_{PWGD-HYS}$                  | PWGD Hysteresis              | FB Voltage Going Down FB Voltage Going Up                                                               |                              | 35<br>110      |                              | mV    |

## TYPICAL PERFORMANCE CHARACTERISTICS

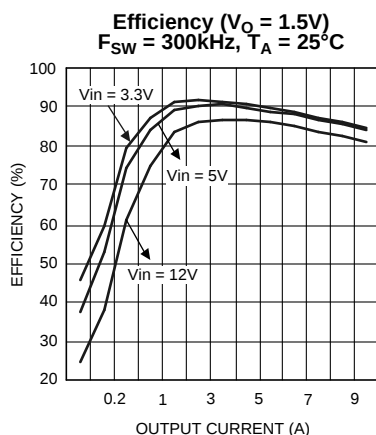


Figure 3.

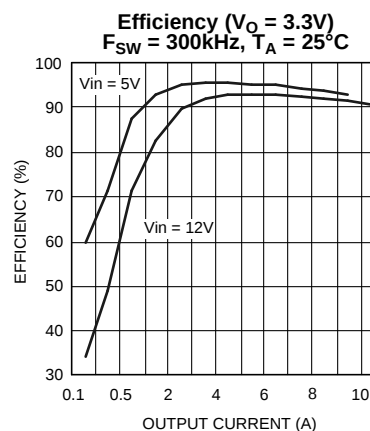


Figure 4.

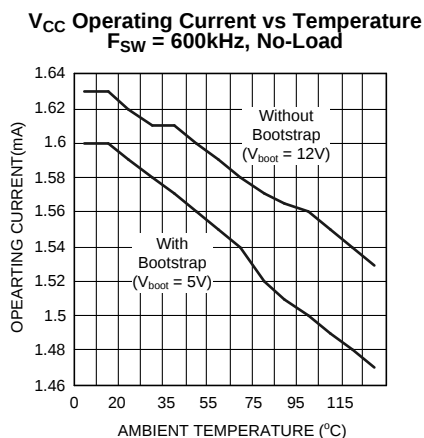


Figure 5.

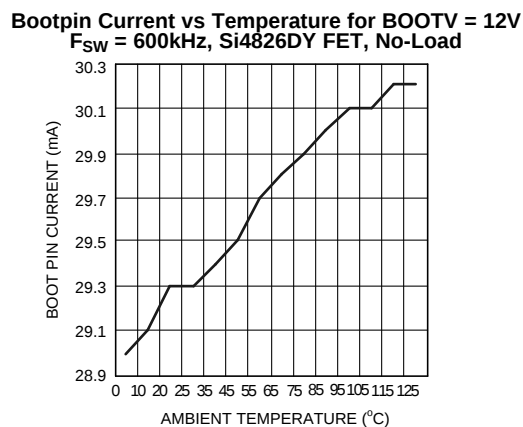


Figure 6.

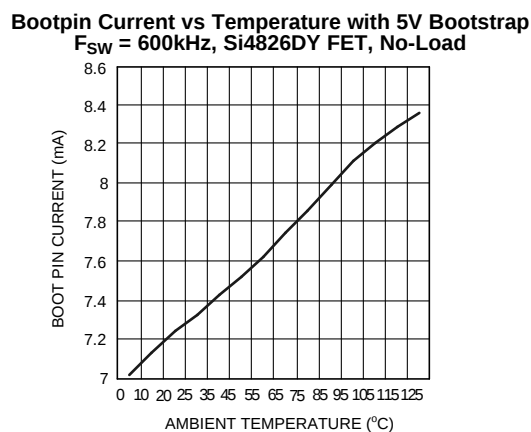


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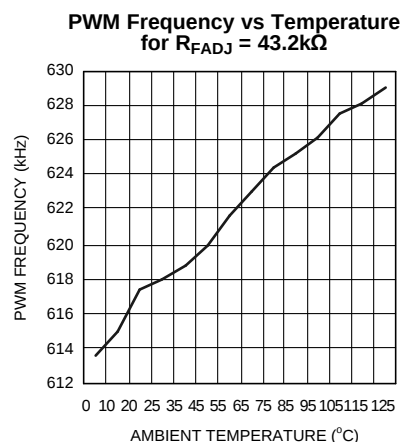


Figure 8.

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

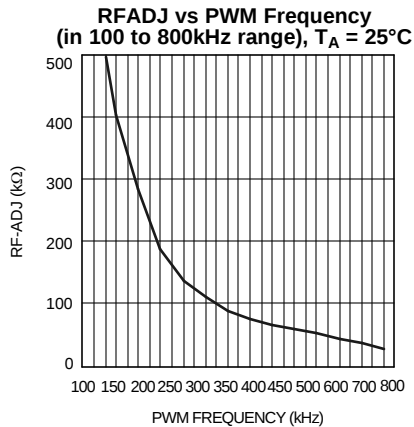


Figure 9.

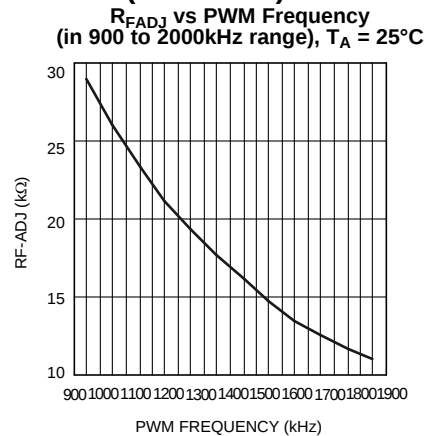


Figure 10.

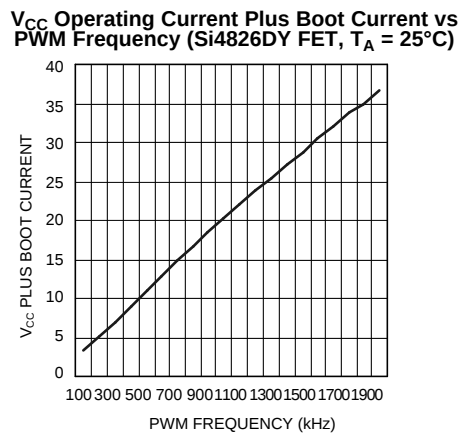


Figure 11.

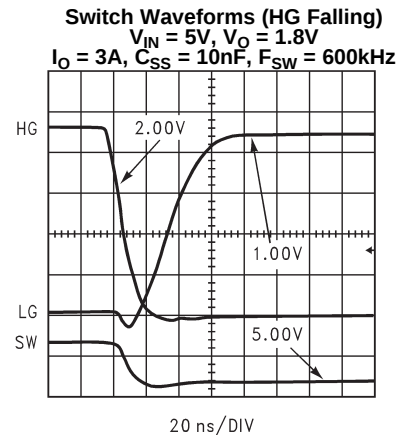


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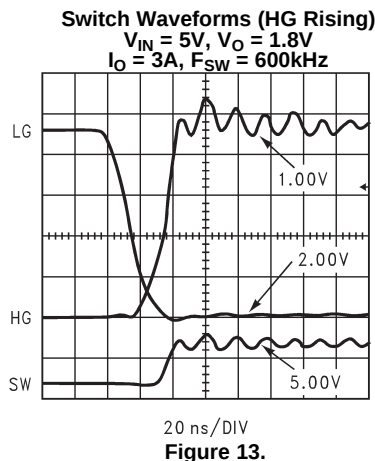


Figure 13.

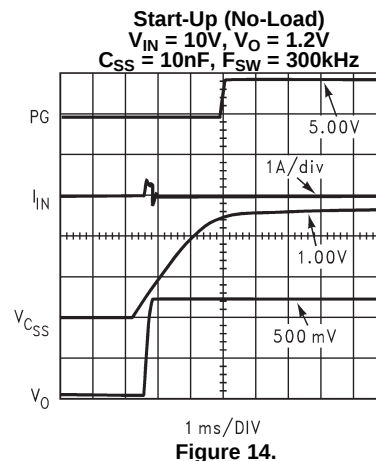


Figure 14.

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

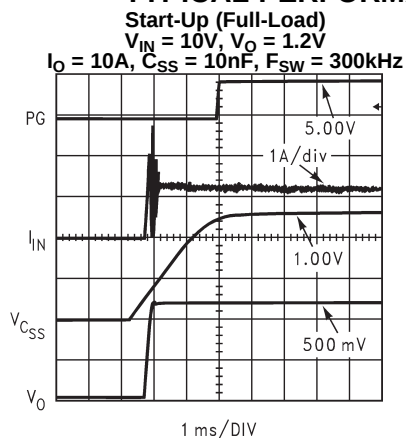


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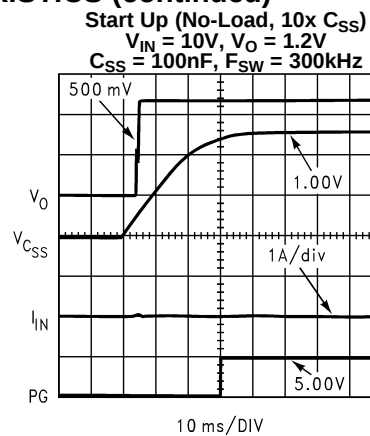


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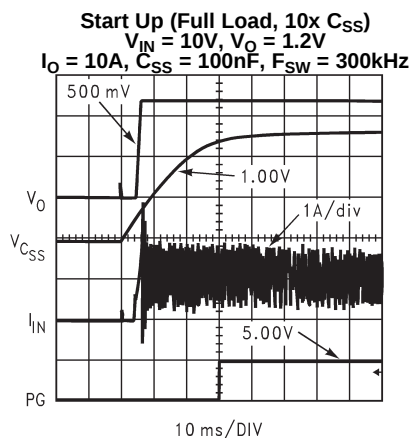


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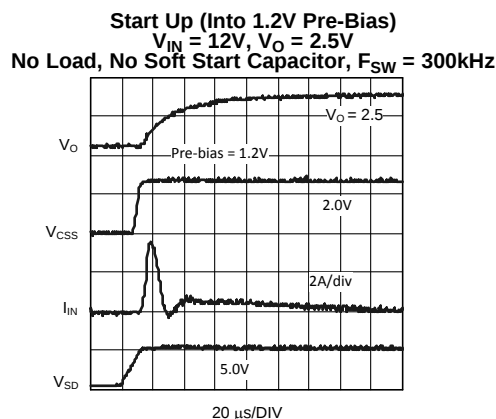


Figure 18.

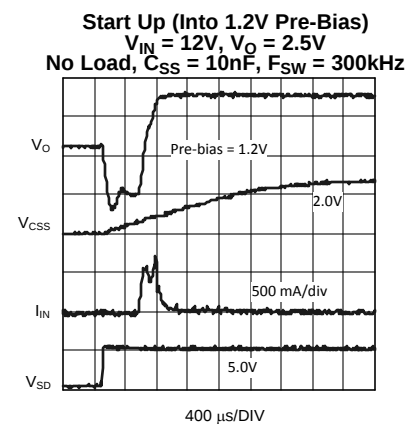


Figure 19.

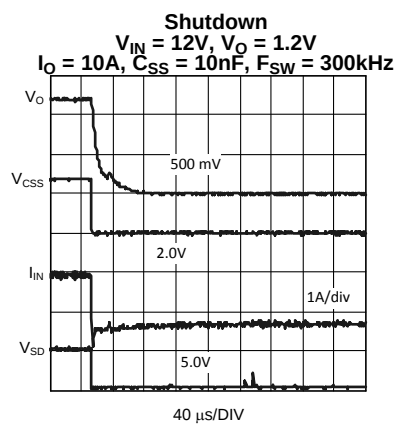


Figure 20.

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

### Shutdown (No Load)

$V_{IN} = 12V$ ,  $V_O = 1.2V$   
 $I_O = 10A$ ,  $C_{SS} = 10nF$   
 $F_{SW} = 300kHz$

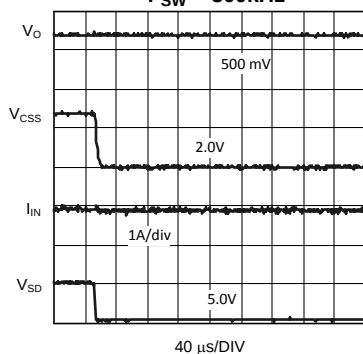


Figure 21.

### Load Transient Response ( $I_O = 0$ to 4A)

$V_{IN} = 12V$ ,  $V_O = 1.2V$   
 $F_{SW} = 300kHz$

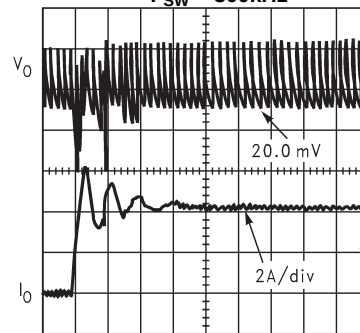


Figure 22.

### Load Transient Response ( $I_O = 4$ to 0A)

$V_{IN} = 12V$ ,  $V_O = 1.2V$   
 $F_{SW} = 300kHz$

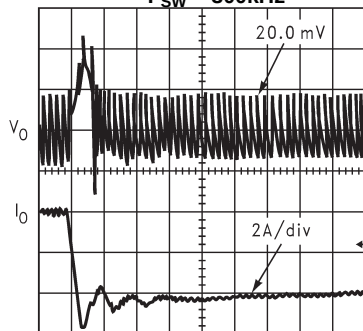


Figure 23.

### Line Transient Response ( $V_{IN} = 5V$ to 12V)

$V_O = 1.2V$ ,  $I_O = 5A$   
 $F_{SW} = 300kHz$

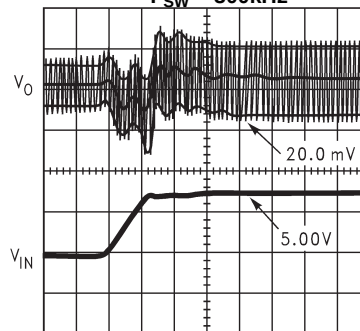


Figure 24.

### Line Transient Response ( $V_{IN} = 12V$ to 5V)

$V_O = 1.2V$ ,  $I_O = 5A$   
 $F_{SW} = 300kHz$

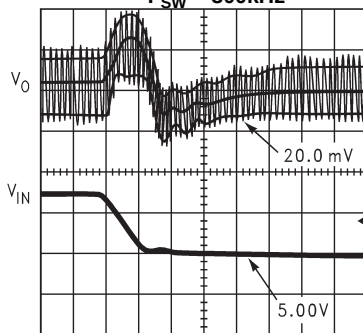


Figure 25.

### Line Transient Response

$V_O = 1.2V$ ,  $I_O = 5A$   
 $F_{SW} = 300kHz$

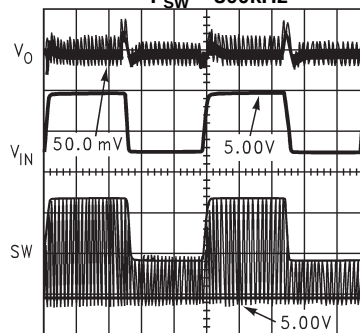


Figure 26.

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

**Peak Current During Current Limit**  
 $V_{IN} = 12V$ ,  $V_O = 3.3V$ ,  $I_{LIM} = 4A$ ,  $F_{SW} = 300kHz$ ,  $L = 15\mu H$

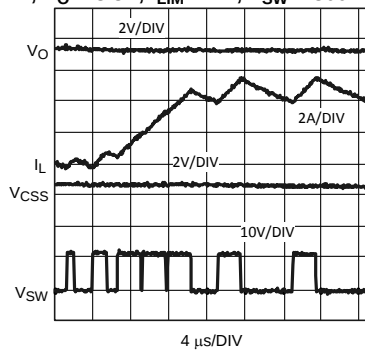


Figure 27.

**Peak Current During Current Limit**  
 $V_{IN} = 12V$ ,  $V_O = 3.3V$ ,  $I_{LIM} = 4A$ ,  $F_{SW} = 300kHz$ ,  $L = 15\mu H$

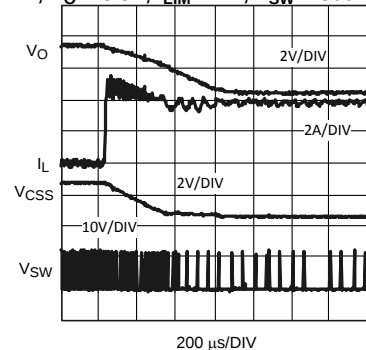
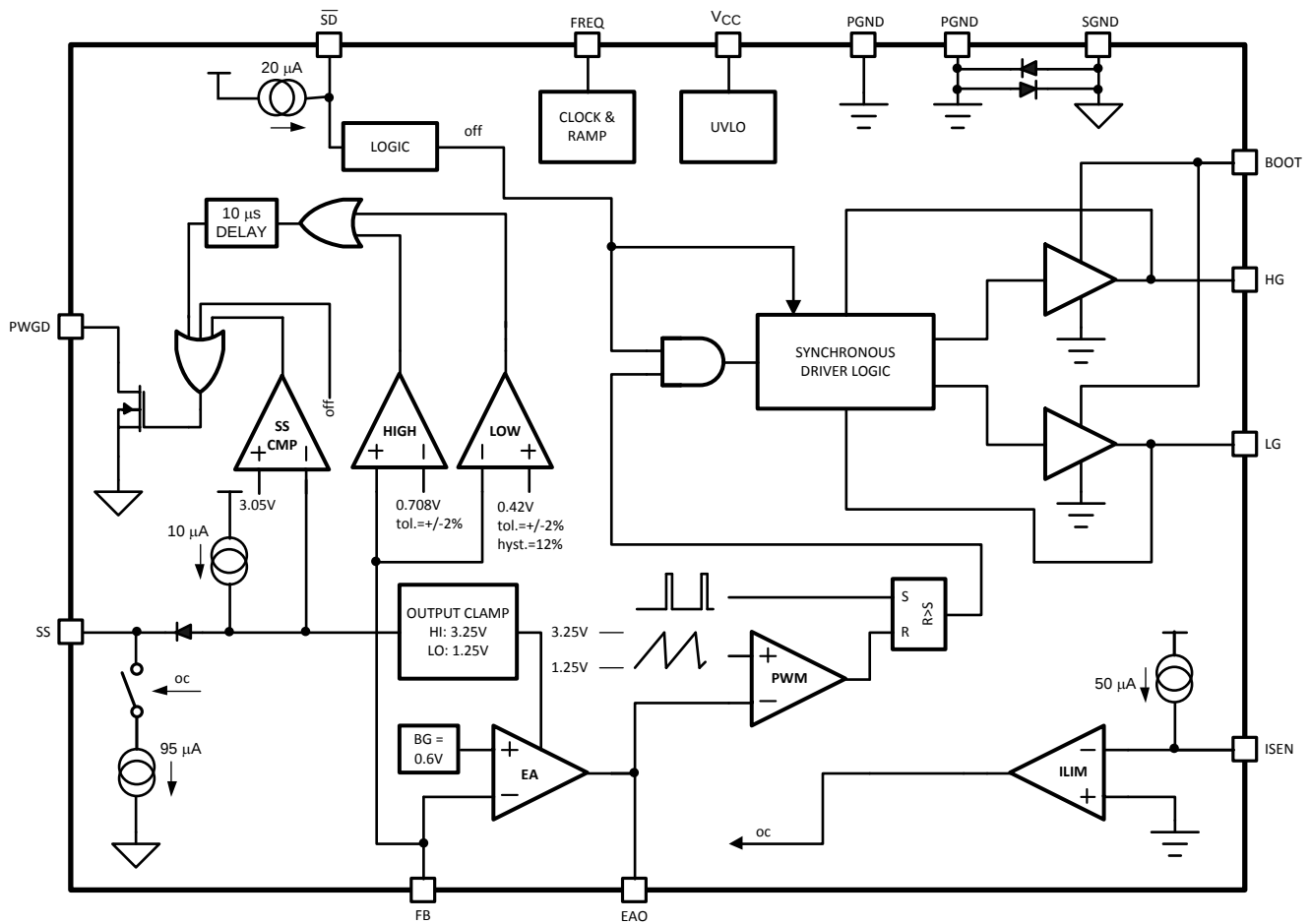


Figure 28.

## BLOCK DIAGRAM



## APPLICATION INFORMATION

### THEORY OF OPERATION

The LM2742 is a voltage-mode, high-speed synchronous buck regulator with a PWM control scheme. It is designed for use in set-top boxes, thin clients, DSL/Cable modems, and other applications that require high efficiency buck converters. It has power good (PWRGD), and output shutdown (SD). Current limit is achieved by sensing the voltage  $V_{DS}$  across the low side FET. During current limit the high side gate is turned off and the low side gate turned on. The soft start capacitor is discharged by a 95μA source (reducing the maximum duty cycle) until the current is under control.

### START UP

When  $V_{CC}$  exceeds 4.2V and the shutdown pin  $\overline{SD}$  sees a logic high the soft start capacitor begins charging through an internal fixed 10μA source. During this time the output of the error amplifier is allowed to rise with the voltage of the soft start capacitor. This capacitor,  $C_{SS}$ , determines soft start time, and can be determined approximately by:

$$C_{SS} = \frac{t_{ss}}{2.5 \times 10^5} \quad (1)$$

An application for a microprocessor might need a delay of 3ms, in which case  $C_{SS}$  would be 12nF. For a different device, a 100ms delay might be more appropriate, in which case  $C_{SS}$  would be 400nF. (390 10%) During soft start the PWRGD flag is forced low and is released when the voltage reaches a set value. At this point this chip enters normal operation mode and the Power Good flag is released.

Since the output is floating when the LM2742 is turned off, it is possible that the output capacitor may be precharged to some positive value. During start-up, the LM2742 operates fully synchronous and will discharge the output capacitor to some extent depending on the output voltage, soft start capacitance, and the size of the output capacitor.

### NORMAL OPERATION

While in normal operation mode, the LM2742 regulates the output voltage by controlling the duty cycle of the high side and low side FETs. The equation governing output voltage is:

$$V_O = 0.6 \times (R_{FB1} + R_{FB2}) / R_{FB1} \quad (2)$$

The PWM frequency is adjustable between 50kHz and 2MHz and is set by an external resistor,  $R_{FADJ}$ , between the FREQ pin and ground. The resistance needed for a desired frequency is approximately:

$$R_{FADJ} = \left( \frac{20500}{\text{freq}[\text{kHz}]} \right)^{1.0526} \text{ k}\Omega \quad (3)$$

### MOSFET GATE DRIVERS

The LM2742 has two gate drivers designed for driving N-channel MOSFETs in a synchronous mode. Power for the drivers is supplied through the BOOT pin. For the high side gate (HG) to fully turn on the top FET, the BOOT voltage must be at least one  $V_{GS(th)}$  greater than  $V_{in}$ . ( $\text{BOOT} \geq 2 \times V_{in}$ ) This voltage can be supplied by a separate, higher voltage source, or supplied from a local charge pump structure. In a system such as a desktop computer, both 5V and 12V are usually available. Hence if  $V_{in}$  was 5V, the 12V supply could be used for BOOT. 12V is more than  $2 \times V_{in}$ , so the HG would operate correctly. For a BOOT of 12V, the initial gate charging current is 2A, and the initial gate discharging current is typically 6A.

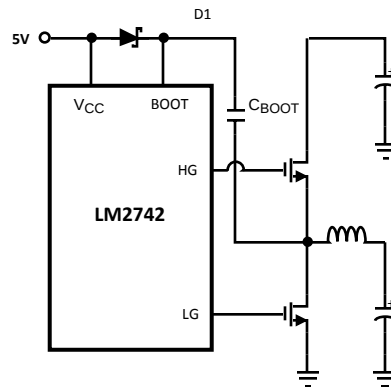


Figure 29. BOOT Supplied by Charge Pump

In a system without a separate, higher voltage, a charge pump (bootstrap) can be built using a diode and small capacitor, [Figure 29](#). The capacitor serves to maintain enough voltage between the top FET gate and source to control the device even when the top FET is on and its source has risen up to the input voltage level.

The LM2742 gate drivers use a BiCMOS design. Unlike some other bipolar control ICs, the gate drivers have rail-to-rail swing, ensuring no spurious turn-on due to capacitive coupling.

## POWER GOOD SIGNAL

The power good signal is the or-gated flag representing over-voltage and under-voltage protection. If the output voltage is 18% over its nominal value,  $V_{FB} = 0.7V$ , or falls 30% below that value,  $V_{FB} = 0.41V$ , the power good flag goes low. It will return to a logic high whenever the feedback pin voltage is between 70% and 118% of 0.6V. The power good pin is an open drain output that can be pulled up to logic voltages of 5V or less with a 10kΩ resistor.

## UVLO

The 4.2V turn-on threshold on  $V_{CC}$  has a built-in hysteresis of 0.6V. Therefore, if  $V_{CC}$  drops below 3.6V, the chip enters UVLO mode. UVLO consists of turning off the top FET, turning off the bottom FET, and remaining in that condition until  $V_{CC}$  rises above 4.2V. As with shutdown, the soft start capacitor is discharged through a FET, ensuring that the next start-up will be smooth.

## CURRENT LIMIT

Current limit is realized by sensing the voltage across the low side FET while it is on. The  $R_{DS(on)}$  of the FET is a known value, hence the current through the FET can be determined as:

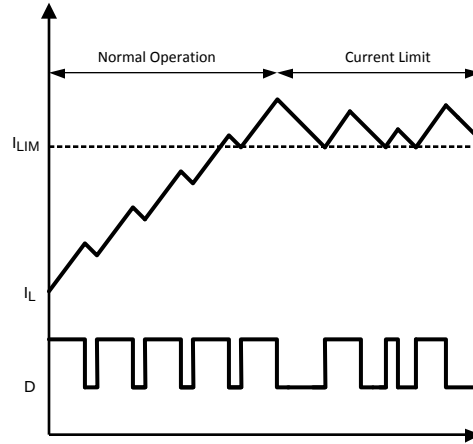
$$V_{DS} = I * R_{DS(on)} \quad (4)$$

The current through the low side FET while it is on is also the falling portion of the triangle wave inductor current. The current limit threshold is determined by an external resistor,  $R_{CS}$ , connected between the switch node and the  $I_{SEN}$  pin. A constant current of 50 μA is forced through  $R_{CS}$ , causing a fixed voltage drop. This fixed voltage is compared against  $V_{DS}$  and if the latter is higher, the current limit of the chip has been reached.  $R_{CS}$  can be found by using the following equation:

$$R_{CS} = R_{DS(on)(LOW)} * I_{LIM}/50\mu A \quad (5)$$

For example, a conservative 15A current limit in a 10A design with a minimum  $R_{DS(on)}$  of 10mΩ would require a 3.3kΩ resistor. Because current sensing is done across the low side FET, no minimum high side on-time is necessary. In the current limit mode the LM2727/37 will turn the high side off and keep low side on for as long as necessary. The LM2727/37 enters current limit mode if the inductor current exceeds the current limit threshold at the point where the high side FET turns off and the low side FET turns on. (The point of peak inductor current. See [Figure 30](#).) Note that in normal operation mode the high side FET always turns on at the

beginning of a clock cycle. In current limit mode, by contrast, the high side FET on pulse is skipped. This causes inductor current to fall. Unlike a normal operation switching cycle, however, in a current limit mode switching cycle the high side FET will turn on as soon as inductor current has fallen to the current limit threshold. The LM2727/37 will continue to skip high side FET pulses until the inductor current peak is below the current limit threshold, at which point the system resumes normal operation.



**Figure 30. Current Limit Threshold**

Unlike a high side FET current sensing scheme, which limits the peaks of inductor current, low side current sensing is only allowed to limit the current during the converter off-time, when inductor current is falling. Therefore in a typical current limit plot the valleys are normally well defined, but the peaks are variable, according to the duty cycle. The PWM error amplifier and comparator control the off pulse of the high side FET, even during current limit mode, meaning that peak inductor current can exceed the current limit threshold. Assuming that the output inductor does not saturate, the maximum peak inductor current during current limit mode can be calculated with the following equation:

$$I_{PK-CL} = I_{LIM} + (T_{OSC} - 200 \text{ ns}) \frac{V_{IN} - V_O}{L} \quad (6)$$

Where  $T_{OSC}$  is the inverse of switching frequency  $f_{OSC}$ . The 200ns term represents the minimum off-time of the duty cycle, which ensures enough time for correct operation of the current sensing circuitry. See the plots entitled Peak Current During Current Limit in the *Typical Performance Characteristics* section.

In order to minimize the time period in which peak inductor current exceeds the current limit threshold, the IC also discharges the soft start capacitor through a fixed 95  $\mu\text{A}$  source. The output of the LM2727/37 internal error amplifier is limited by the voltage on the soft start capacitor. Hence, discharging the soft start capacitor reduces the maximum duty cycle  $D$  of the controller. During severe current limit this reduction in duty cycle will reduce the output voltage if the current limit conditions last for an extended time. Output inductor current will be reduced in turn to a flat level equal to the current limit threshold. The third benefit of the soft start capacitor discharge is a smooth, controlled ramp of output voltage when the current limit condition is cleared. During the first few nanoseconds after the low side gate turns on, the low side FET body diode conducts. This causes an additional 0.7V drop in  $V_{DS}$ . The range of  $V_{DS}$  is normally much lower. For example, if  $R_{DS(on)}$  were 10m $\Omega$  and the current through the FET was 10A,  $V_{DS}$  would be 0.1V. The current limit would see 0.7V as a 70A current and enter current limit immediately. Hence current limit is masked during the time it takes for the high side switch to turn off and the low side switch to turn on.

## SHUT DOWN

If the shutdown pin  $\overline{SD}$  is pulled low, the LM2742 discharges the soft start capacitor through a MOSFET switch. The high side and low side switches are turned off. The LM2742 remains in this state until  $\overline{SD}$  is released.

## DESIGN CONSIDERATIONS

The following is a design procedure for all the components needed to create the circuit shown in [Figure 32](#) in the Example Circuits section, a 5V in to 1.2V out converter, capable of delivering 10A with an efficiency of 85%. The switching frequency is 300kHz. The same procedures can be followed to create many other designs with varying input voltages, output voltages, and output currents.

### Input Capacitor

The input capacitors in a Buck switching converter are subjected to high stress due to the input current waveform, which is a square wave. Hence input caps are selected for their ripple current capability and their ability to withstand the heat generated as that ripple current runs through their ESR. Input rms ripple current is approximately:

$$I_{rms\_rip} = I_o * \sqrt{D(1-D)}_{avg} \quad (7)$$

The power dissipated by each input capacitor is:

$$P_D = \frac{I_{rms\_rip}^2 * ESR}{n^2} \quad (8)$$

Here, n is the number of capacitors, and indicates that power loss in each cap decreases rapidly as the number of input caps increase. The worst-case ripple for a Buck converter occurs during full load, when the duty cycle D = 50%.

In the 5V to 1.2V case,  $D = 1.2/5 = 0.24$ . With a 10A maximum load the ripple current is 4.3A. The Sanyo 10MV5600AX aluminum electrolytic capacitor has a ripple current rating of 2.35A, up to 105°C. Two such capacitors make a conservative design that allows for unequal current sharing between individual caps. Each capacitor has a maximum ESR of 18mΩ at 100 kHz. Power loss in each device is then 0.05W, and total loss is 0.1W. Other possibilities for input and output capacitors include MLCC, tantalum, OSCON, SP, and POSCAPS.

### Input Inductor

The input inductor serves two basic purposes. First, in high power applications, the input inductor helps insulate the input power supply from switching noise. This is especially important if other switching converters draw current from the same supply. Noise at high frequency, such as that developed by the LM2742 at 1MHz operation, could pass through the input stage of a slower converter, contaminating and possibly interfering with its operation.

An input inductor also helps shield the LM2742 from high frequency noise generated by other switching converters. The second purpose of the input inductor is to limit the input current slew rate. During a change from no-load to full-load, the input inductor sees the highest voltage change across it, equal to the full load current times the input capacitor ESR. This value divided by the maximum allowable input current slew rate gives the minimum input inductance:

$$L_{in} = \frac{\Delta V}{\left(\frac{di}{dt}\right)_{max}} \quad (9)$$

In the case of a desktop computer system, the input current slew rate is the system power supply or "silver box" output current slew rate, which is typically about 0.1A/μs. Total input capacitor ESR is 9mΩ, hence  $\Delta V$  is  $10 * 0.009 = 90$  mV, and the minimum inductance required is 0.9μH. The input inductor should be rated to handle the DC input current, which is approximated by:

$$I_{IN-DC} = \frac{I_o * D}{\eta} \quad (10)$$

In this case  $I_{IN-DC}$  is about 2.8A. One possible choice is the TDK SLF12575T-1R2N8R2, a 1.2μH device that can handle 8.2Arms, and has a DCR of 7mΩ.

## Output Inductor

The output inductor forms the first half of the power stage in a Buck converter. It is responsible for smoothing the square wave created by the switching action and for controlling the output current ripple. ( $\Delta I_o$ ) The inductance is chosen by selecting between tradeoffs in output ripple, efficiency, and response time. The smaller the output inductor, the more quickly the converter can respond to transients in the load current. If the inductor value is increased, the ripple through the output capacitor is reduced and thus the output ripple is reduced. As shown in the efficiency calculations, a smaller inductor requires a higher switching frequency to maintain the same level of output current ripple. An increase in frequency can mean increasing loss in the FETs due to the charging and discharging of the gates. Generally the switching frequency is chosen so that conduction loss outweighs switching loss. The equation for output inductor selection is:

$$L = \frac{V_{in} - V_o}{\Delta I_o * F_{SW}} * D \quad (11)$$

A good range for  $\Delta I_o$  is 25 to 50% of the output current. In the past, 30% was considered a maximum value for output currents higher than about 2Amps, but as output capacitor technology improves the ripple current can be allowed to increase. Plugging in the values for output current ripple, input voltage, output voltage, switching frequency, and assuming a 40% peak-to-peak output current ripple yields an inductance of 1.5 $\mu$ H. The output inductor must be rated to handle the peak current (also equal to the peak switch current), which is  $(I_o + 0.5 * \Delta I_o)$ . This is 12A for a 10A design. The Coilcraft D05022-152HC is 1.5 $\mu$ H, is rated to 15Arms, and has a DCR of 4m $\Omega$ .

## Output Capacitor

The output capacitor forms the second half of the power stage of a Buck switching converter. It is used to control the output voltage ripple ( $\Delta V_o$ ) and to supply load current during fast load transients.

In this example the output current is 10A and the expected type of capacitor is an aluminum electrolytic, as with the input capacitors. (Other possibilities include ceramic, tantalum, and solid electrolyte capacitors, however the ceramic type often do not have the large capacitance needed to supply current for load transients, and tantalums tend to be more expensive than aluminum electrolytic.) Aluminum capacitors tend to have very high capacitance and fairly low ESR, meaning that the ESR zero, which affects system stability, will be much lower than the switching frequency. The large capacitance means that at switching frequency, the ESR is dominant, hence the type and number of output capacitors is selected on the basis of ESR. One simple formula to find the maximum ESR based on the desired output voltage ripple,  $\Delta V_o$  and the designed output current ripple,  $\Delta I_o$ , is:

$$ESR_{MAX} = \frac{\Delta V_o}{\Delta I_o} \quad (12)$$

In this example, in order to maintain a 2% peak-to-peak output voltage ripple and a 40% peak-to-peak inductor current ripple, the required maximum ESR is 6m $\Omega$ . Three Sanyo 10MV5600AX capacitors in parallel will give an equivalent ESR of 6m $\Omega$ . The total bulk capacitance of 16.8mF is enough to supply even severe load transients. Using the same capacitors for both input and output also keeps the bill of materials simple.

## MOSFETS

MOSFETS are a critical part of any switching controller and have a direct impact on the system efficiency. In this case the target efficiency is 85% and this is the variable that will determine which devices are acceptable. Loss from the capacitors, inductors, and the LM2742 is detailed in the Efficiency section, and come to about 0.54W. To meet the target efficiency, this leaves 1.45W for the FET conduction loss, gate charging loss, and switching loss. Switching loss is particularly difficult to estimate because it depends on many factors. When the load current is more than about 1 or 2 amps, conduction losses outweigh the switching and gate charging losses. This allows FET selection based on the  $R_{DS(on)}$  of the FET. Adding the FET switching and gate-charging losses to the equation leaves 1.2W for conduction losses. The equation for conduction loss is:

$$P_{CND} = D(I_o^2 * R_{DS(on)} * k) + (1-D)(I_o^2 * R_{DS(on)} * k) \quad (13)$$

The factor k is a constant which is added to account for the increasing  $R_{DS(on)}$  of a FET due to heating. Here, k = 1.3. The Si4442DY has a typical  $R_{DS(on)}$  of 4.1m $\Omega$ . When plugged into the equation for  $P_{CND}$  the result is a loss of 0.533W. If this design were for a 5V to 2.5V circuit, an equal number of FETs on the high and low sides would be the best solution. With the duty cycle D = 0.24, it becomes apparent that the low side FET carries the load current 76% of the time. Adding a second FET in parallel to the bottom FET could improve the efficiency by lowering the effective  $R_{DS(on)}$ . The lower the duty cycle, the more effective a second or even third FET can be. For a minimal increase in gate charging loss (0.054W) the decrease in conduction loss is 0.15W. What was an 85% design improves to 86% for the added cost of one SO-8 MOSFET.

## Control Loop Components

The circuit is this design example and the others shown in the Example Circuits section have been compensated to improve their DC gain and bandwidth. The result of this compensation is better line and load transient responses. For the LM2742, the top feedback divider resistor, Rfb2, is also a part of the compensation. For the 10A, 5V to 1.2V design, the values are:

Cc1 = 4.7pF 10%, Cc2 = 1nF 10%, Rc = 229kΩ 1%. These values give a phase margin of 63° and a bandwidth of 29.3kHz.

## Support Capacitors and Resistors

The Cinx capacitors are high frequency bypass devices, designed to filter harmonics of the switching frequency and input noise. Two 1μF ceramic capacitors with a sufficient voltage rating (10V for the Circuit of [Figure 32](#)) will work well in almost any case.

R<sub>IN</sub> and C<sub>IN</sub> are standard filter components designed to ensure smooth DC voltage for the chip supply. Depending on noise, R<sub>IN</sub> should be 10 to 100Ω, and C<sub>IN</sub> should be between 0.1 and 2.2 μF. C<sub>BOOT</sub> is the bootstrap capacitor, and should be 0.1μF. (In the case of a separate, higher supply to the BOOT pin, this 0.1μF cap can be used to bypass the supply.) Using a Schottky device for the bootstrap diode allows the minimum drop for both high and low side drivers. The On Semiconductor BAT54 or MBR0520 work well.

R<sub>p</sub> is a standard pull-up resistor for the open-drain power good signal, and should be 10kΩ. If this feature is not necessary, it can be omitted.

R<sub>CS</sub> is the resistor used to set the current limit. Since the design calls for a peak current magnitude (I<sub>o</sub> + 0.5 \* ΔI<sub>o</sub>) of 12A, a safe setting would be 15A. (This is well below the saturation current of the output inductor, which is 25A.) Following the equation from the Current Limit section, use a 3.3kΩ resistor.

R<sub>FADJ</sub> is used to set the switching frequency of the chip. Following the equation in the Theory of Operation section, the closest 1% tolerance resistor to obtain f<sub>sw</sub> = 300kHz is 88.7kΩ.

C<sub>SS</sub> depends on the users requirements. Based on the equation for C<sub>SS</sub> in the Theory of Operation section, for a 3ms delay, a 12nF capacitor will suffice.

## EFFICIENCY CALCULATIONS

A reasonable estimation of the efficiency of a switching controller can be obtained by adding together the loss is each current carrying element and using the equation:

$$\eta = \frac{P_o}{P_o + P_{\text{total-loss}}} \quad (14)$$

The following shows an efficiency calculation to complement the Circuit of [Figure 32](#). Output power for this circuit is 1.2V x 10A = 12W.

### Chip Operating Loss

$$P_{IQ} = I_{Q-VCC} * V_{CC} \quad (15)$$

$$2\text{mA} \times 5\text{V} = 0.01\text{W}$$

### FET Gate Charging Loss

$$P_{GC} = n * V_{CC} * Q_{GS} * f_{OSC} \quad (16)$$

The value n is the total number of FETs used. The Si4442DY has a typical total gate charge, Q<sub>GS</sub>, of 36nC and an r<sub>ds-on</sub> of 4.1mΩ. For a single FET on top and bottom: 2\*5\*36E-9\*300,000 = 0.108W

### FET Switching Loss

$$P_{SW} = 0.5 * V_{in} * I_o * (t_r + t_f) * f_{OSC} \quad (17)$$

The Si4442DY has a typical rise time t<sub>r</sub> and fall time t<sub>f</sub> of 11 and 47ns, respectively. 0.5\*5\*10\*58E-9\*300,000 = 0.435W

### FET Conduction Loss

$$P_{Cn} = 0.533\text{W} \quad (18)$$

### Input Capacitor Loss

$$P_{\text{Cin}} = \frac{I_{\text{rms-rip}}^2 * \text{ESR}}{n} \quad (19)$$

$$l_{\text{Nrms-rip}} = l_{\text{O}} * \sqrt{D(1-D)} \quad (20)$$

$$4.28^2 \cdot 0.018 / 2 = 0.164 \text{ W}$$

### Input Inductor Loss

$$P_{Lin} = I_{in}^2 * DCR_{input-L} \quad (21)$$

$$I_N = \frac{I_0 * D}{\eta_{est'd}} \quad (22)$$

$$2.82^2 \cdot 0.007 = 0.055 \text{ W}$$

### Output Inductor Loss

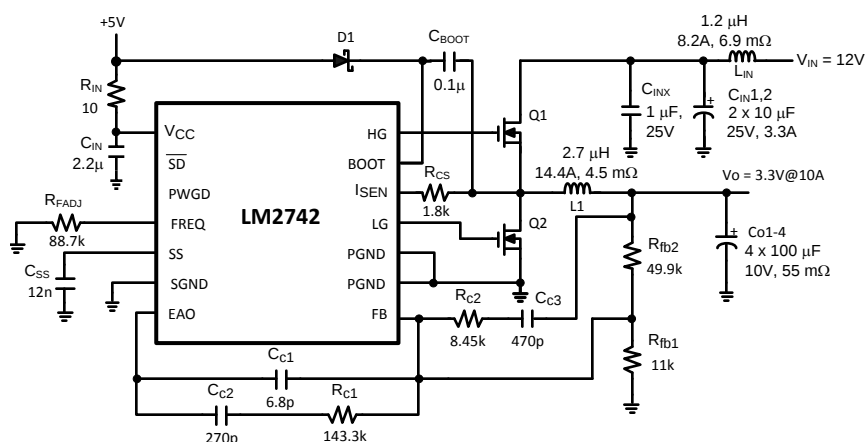
$$P_{l,out} = I_0^2 * DCR_{output-l} \quad (23)$$

$$10^2 * 0.004 = 0.4W$$

## System Efficiency

$$\frac{12}{22+1.7} = 87.5\% \quad (24)$$

## Example Circuits



**Figure 31. 5V-16V to 3.3V, 10A, 300kHz**

This circuit and the one featured on the front page have been designed to deliver high current and high efficiency in a small package, both in area and in height. The tallest component in this circuit is the inductor L1, which is 6mm tall. The compensation has been designed to tolerate input voltages from 5 to 16V.

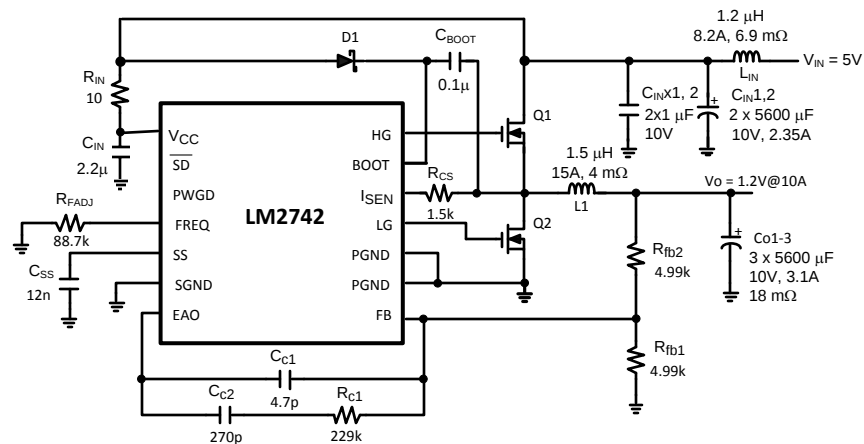


Figure 32. 5V to 1.2V, 10A, 300kHz

This circuit design, detailed in the Design Considerations section, uses inexpensive aluminum capacitors and off-the-shelf inductors. It can deliver 10A at better than 85% efficiency. Large bulk capacitance on input and output ensure stable operation.

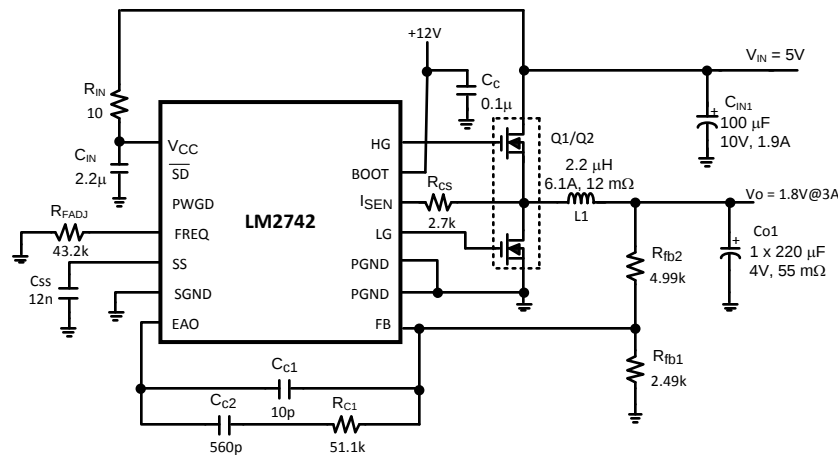


Figure 33. 5V to 1.8V, 3A, 600kHz

The example circuit of [Figure 33](#) has been designed for minimum component count and overall solution size. A switching frequency of 600kHz allows the use of small input/output capacitors and a small inductor. The availability of separate 5V and 12V supplies (such as those available from desk-top computer supplies) and the low current further reduce component count. Using the 12V supply to power the MOSFET drivers eliminates the bootstrap diode, D1. At low currents, smaller FETs or dual FETs are often the most efficient solutions. Here, the Si4826DY, an asymmetric dual FET in an SO-8 package, yields 92% efficiency at a load of 2A.

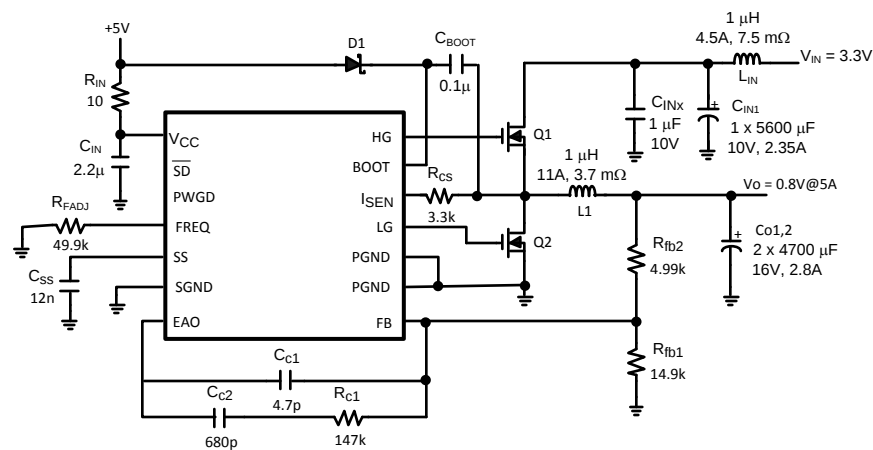


Figure 34. 3.3V to 0.8V, 5A, 500kHz

The circuit of [Figure 34](#) demonstrates the LM2742 delivering a low output voltage at high efficiency (87%). A separate 5V supply is required to run the chip, however the input voltage can be as low as 2.2

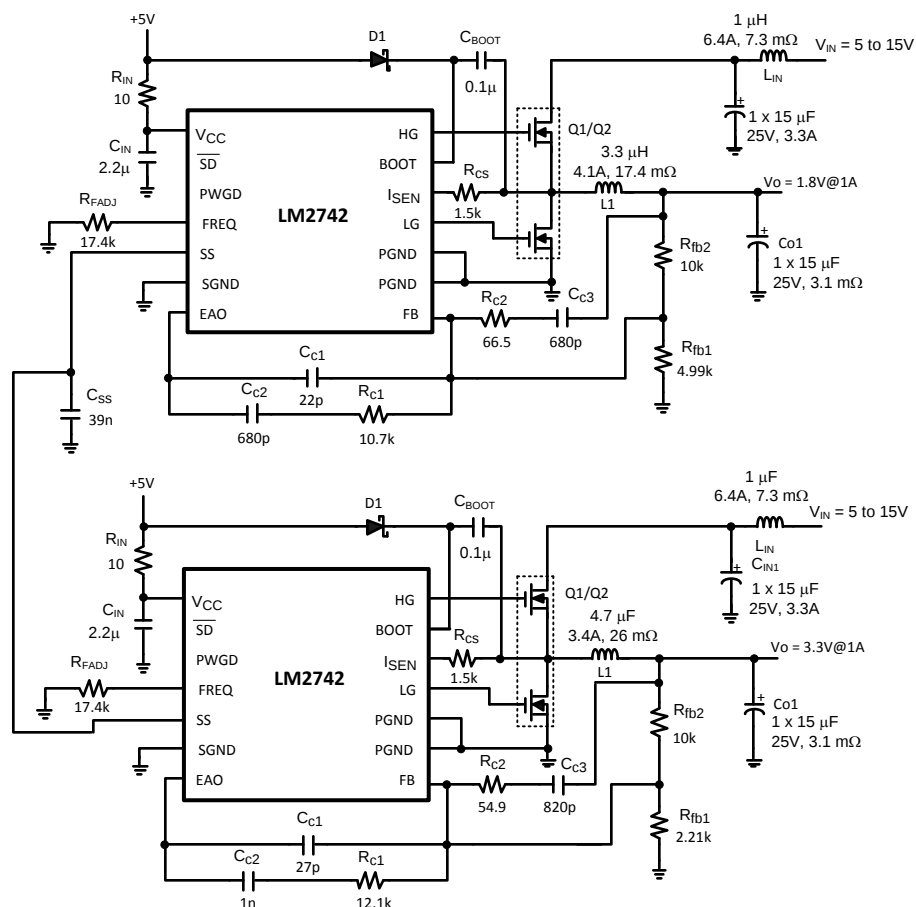


Figure 35. 1.8V and 3.3V, 1A, 1.4MHz, Simultaneous

The circuits in Figure 35 are intended for ADSL applications, where the high switching frequency keeps noise out of the data transmission range. In this design, the 1.8 and 3.3V outputs come up simultaneously by using the same softstart capacitor. Because two current sources now charge the same capacitor, the capacitance must be doubled to achieve the same softstart time. (Here, 40nF is used to achieve a 5ms softstart time.) A common softstart capacitor means that, should one circuit enter current limit, the other circuit will also enter current limit. The additional compensation components Rc2 and Cc3 are needed for the low ESR, all ceramic output capacitors, and the wide (3x) range of Vin.

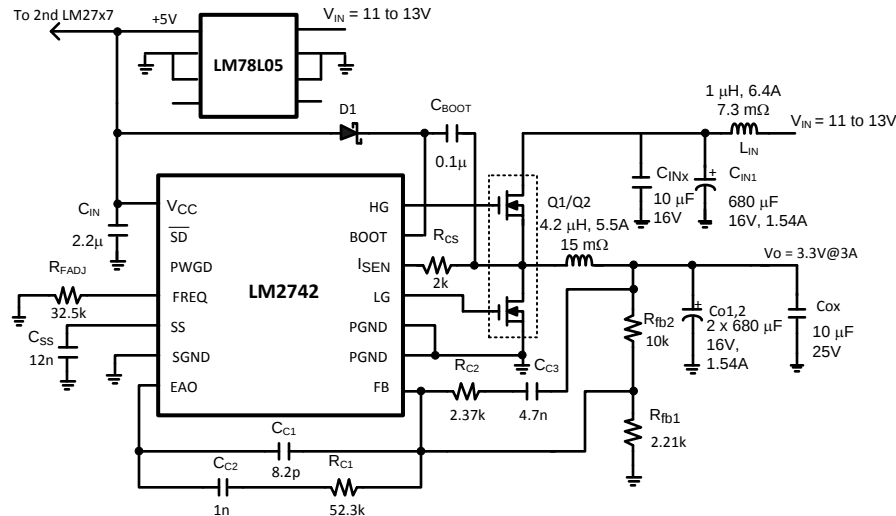


Figure 36. 12V Unregulated to 3.3V, 3A, 750kHz

This circuit shows the LM2742 paired with a cost effective solution to provide the 5V chip power supply, using no extra components other than the LM78L05 regulator itself. The input voltage comes from a 'brick' power supply which does not regulate the 12V line tightly. Additional, inexpensive 10uF ceramic capacitors (Cinx and Cox) help isolate devices with sensitive databands, such as DSL and cable modems, from switching noise and harmonics.

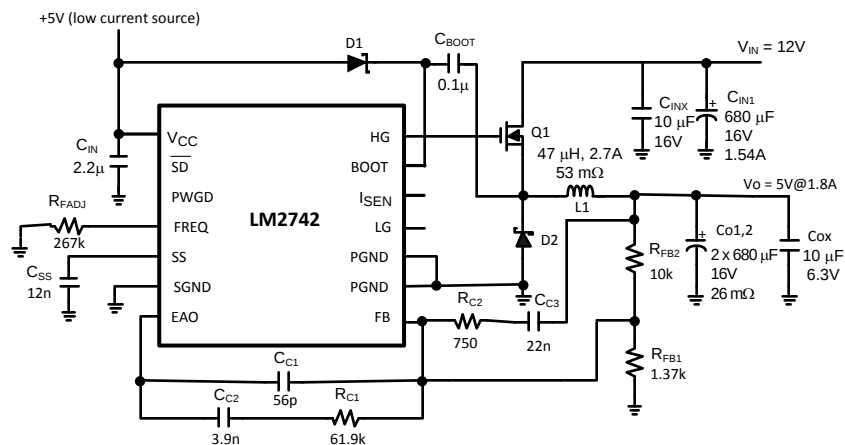


Figure 37. 12V to 5V, 1.8A, 100kHz

In situations where low cost is very important, the LM2742 can also be used as an asynchronous controller, as shown in the above circuit. Although a Schottky diode in place of the bottom FET will not be as efficient, it will cost much less than the FET. The 5V at low current needed to run the LM2742 could come from a Zener diode or inexpensive regulator, such as the one shown in Figure 36. Because the LM2742 senses current in the low side MOSFET, the current limit feature will not function in an asynchronous design. The ISEN pin should be left open in this case.

**Table 1. Bill of Materials for Typical Application Circuit (Figure 1)**

| ID         | Part Number      | Type                   | Size          | Parameters        | Qty. | Vendor |
|------------|------------------|------------------------|---------------|-------------------|------|--------|
| U1         | LM2742           | Synchronous Controller | TSSOP-14      | TSSOP-14          | 1    | NSC    |
| Q1, Q2     | Si4884DY         | N-MOSFET               | SO-8          | 30V, 13mΩ, 15nC   | 1    | Vishay |
| L1         | RLF7030T-1R5N6R1 | Inductor               | 7.1x7.1x3.2mm | 1.5μH, 6.1A 9.6mΩ | 1    | TDK    |
| Cin1, Cin2 | C2012X5R1J106M   | MLCC                   | 0805          | 10μF 6.3V         | 2    | TDK    |
| Cinx       | C3216X7R1E105K   | Capacitor              | 1206          | 1μF, 25V          | 1    | TDK    |
| Co1, Co2   | 6MV2200WG        | AL-E                   | 10mm D 20mm H | 2200μF 6.3V125mΩ  | 2    | Sanyo  |
| Cboot      | VJ1206X104XXA    | Capacitor              | 1206          | 0.1μF, 25V        | 1    | Vishay |
| Cin        | C3216X7R1E225K   | Capacitor              | 1206          | 2.2μF, 25V        | 1    | TDK    |
| Css        | VJ1206X123KXX    | Capacitor              | 1206          | 12nF, 25V         | 1    | Vishay |
| Cc1        | VJ1206A2R2KXX    | Capacitor              | 1206          | 2.2pF 10%         | 1    | Vishay |
| Cc2        | VJ1206A181KXX    | Capacitor              | 1206          | 180pF 10%         | 1    | Vishay |
| Rin        | CRCW1206100J     | Resistor               | 1206          | 10Ω 5%            | 1    | Vishay |
| Rfadj      | CRCW12066342F    | Resistor               | 1206          | 63.4kΩ 1%         | 1    | Vishay |
| Rc1        | CRCW12063923F    | Resistor               | 1206          | 392kΩ 1%          | 1    | Vishay |
| Rfb1       | CRCW12061002F    | Resistor               | 1206          | 10kΩ 1%           | 1    | Vishay |
| Rfb2       | CRCW12061002F    | Resistor               | 1206          | 10kΩ 1%           | 1    | Vishay |
| Rcs        | CRCW1206222J     | Resistor               | 1206          | 2.2kΩ 5%          | 1    | Vishay |

**Table 2. Bill of Materials for Circuit of Figure 31  
(Identical to BOM for 1.5V except as noted below)**

| ID                    | Part Number       | Type      | Size          | Parameters         | Qty. | Vendor |
|-----------------------|-------------------|-----------|---------------|--------------------|------|--------|
| L1                    | RLF12560T-2R7N110 | Inductor  | 12.5x12.8x6mm | 2.7μH, 14.4A 4.5mΩ | 1    | TDK    |
| Co1, Co2,<br>Co3, Co4 | 10TPB100M         | POSCAP    | 7.3x4.3x2.8mm | 100μF 10V 1.9Arms  | 4    | Sanyo  |
| Cc1                   | VJ1206A6R8KXX     | Capacitor | 1206          | 6.8pF 10%          | 1    | Vishay |
| Cc2                   | VJ1206A271KXX     | Capacitor | 1206          | 270pF 10%          | 1    | Vishay |
| Cc3                   | VJ1206A471KXX     | Capacitor | 1206          | 470pF 10%          | 1    | Vishay |
| Rc2                   | CRCW12068451F     | Resistor  | 1206          | 8.45kΩ 1%          | 1    | Vishay |
| Rfb1                  | CRCW12061102F     | Resistor  | 1206          | 11kΩ 1%            | 1    | Vishay |

**Table 3. Bill of Materials for Circuit of Figure 32**

| ID               | Part Number       | Type                   | Size            | Parameters               | Qty. | Vendor    |
|------------------|-------------------|------------------------|-----------------|--------------------------|------|-----------|
| U1               | LM2742            | Synchronous Controller | TSSOP-14        |                          | 1    | NSC       |
| Q1               | Si4442DY          | N-MOSFET               | SO-8            | 30V, 4.1mΩ, @ 4.5V, 36nC | 1    | Vishay    |
| Q2               | Si4442DY          | N-MOSFET               | SO-8            | 30V, 4.1mΩ, @ 4.5V, 36nC | 1    | Vishay    |
| D1               | BAT-54            | Schottky Diode         | SOT-23          | 30V                      | 1    | Vishay    |
| Lin              | SLF12575T-1R2N8R2 | Inductor               | 12.5x12.5x7.5mm | 12μH, 8.2A, 6.9mΩ        | 1    | Coilcraft |
| L1               | D05022-152HC      | Inductor               | 22.35x16.26x8mm | 1.5μH, 15A, 4mΩ          | 1    | Coilcraft |
| Cin1, Cin2       | 10MV5600AX        | Aluminum Electrolytic  | 16mm D 25mm H   | 5600μF10V 2.35Arms       | 2    | Sanyo     |
| Cinx             | C3216X7R1E105K    | Capacitor              | 1206            | 1μF, 25V                 | 1    | TDK       |
| Co1, Co2,<br>Co3 | 10MV5600AX        | Aluminum Electrolytic  | 16mm D 25mm H   | 5600μF10V 2.35Arms       | 2    | Sanyo     |
| Cboot            | VJ1206X104XXA     | Capacitor              | 1206            | 0.1μF, 25V               | 1    | Vishay    |
| Cin              | C3216X7R1E225K    | Capacitor              | 1206            | 2.2μF, 25V               | 1    | TDK       |
| Css              | VJ1206X123KXX     | Capacitor              | 1206            | 12nF, 25V                | 1    | Vishay    |
| Cc1              | VJ1206A4R7KXX     | Capacitor              | 1206            | 4.7pF 10%                | 1    | Vishay    |

**Table 3. Bill of Materials for Circuit of Figure 32 (continued)**

| ID    | Part Number   | Type      | Size | Parameters | Qty. | Vendor |
|-------|---------------|-----------|------|------------|------|--------|
| Cc2   | VJ1206A102KXX | Capacitor | 1206 | 1nF 10%    | 1    | Vishay |
| Rin   | CRCW1206100J  | Resistor  | 1206 | 10Ω 5%     | 1    | Vishay |
| Rfadj | CRCW12068872F | Resistor  | 1206 | 88.7kΩ 1%  | 1    | Vishay |
| Rc1   | CRCW12062293F | Resistor  | 1206 | 229kΩ 1%   | 1    | Vishay |
| Rfb1  | CRCW12064991F | Resistor  | 1206 | 4.99kΩ 1%  | 1    | Vishay |
| Rfb2  | CRCW12064991F | Resistor  | 1206 | 4.99kΩ 1%  | 1    | Vishay |
| Rcs   | CRCW1206152J  | Resistor  | 1206 | 1.5kΩ 5%   | 1    | Vishay |

**Table 4. Bill of Materials for Circuit of Figure 33**

| ID    | Part Number    | Type                    | Size              | Parameters                         | Qty. | Vendor    |
|-------|----------------|-------------------------|-------------------|------------------------------------|------|-----------|
| U1    | LM2742         | Synchronous Controller  | TSSOP-14          |                                    | 1    | NSC       |
| Q1/Q2 | Si4826DY       | Asymetric Dual N-MOSFET | SO-8              | 30V, 24mΩ/ 8nC<br>Top 16.5mΩ/ 15nC | 1    | Vishay    |
| L1    | DO3316P-222    | Inductor                | 12.95x9.4x 5.21mm | 2.2μH, 6.1A, 12mΩ                  | 1    | Coilcraft |
| Cin1  | 10TPB100ML     | POSCAP                  | 7.3x4.3x3.1mm     | 100μF 10V 1.9Arms                  | 1    | Sanyo     |
| Co1   | 4TPB220ML      | POSCAP                  | 7.3x4.3x3.1mm     | 220μF 4V 1.9Arms                   | 1    | Sanyo     |
| Cc    | C3216X7R1E105K | Capacitor               | 1206              | 1μF, 25V                           | 1    | TDK       |
| Cin   | C3216X7R1E225K | Capacitor               | 1206              | 2.2μF, 25V                         | 1    | TDK       |
| Css   | VJ1206X123KXX  | Capacitor               | 1206              | 12nF, 25V                          | 1    | Vishay    |
| Cc1   | VJ1206A100KXX  | Capacitor               | 1206              | 10pF 10%                           | 1    | Vishay    |
| Cc2   | VJ1206A561KXX  | Capacitor               | 1206              | 560pF 10%                          | 1    | Vishay    |
| Rin   | CRCW1206100J   | Resistor                | 1206              | 10Ω 5%                             | 1    | Vishay    |
| Rfadj | CRCW12064222F  | Resistor                | 1206              | 42.2kΩ 1%                          | 1    | Vishay    |
| Rc1   | CRCW12065112F  | Resistor                | 1206              | 51.1kΩ 1%                          | 1    | Vishay    |
| Rfb1  | CRCW12062491F  | Resistor                | 1206              | 2.49kΩ 1%                          | 1    | Vishay    |
| Rfb2  | CRCW12064991F  | Resistor                | 1206              | 4.99kΩ 1%                          | 1    | Vishay    |
| Rcs   | CRCW1206272J   | Resistor                | 1206              | 2.7kΩ 5%                           | 1    | Vishay    |

**Table 5. Bill of Materials for Circuit of Figure 34**

| ID            | Part Number    | Type                   | Size             | Parameters                    | Qty. | Vendor |
|---------------|----------------|------------------------|------------------|-------------------------------|------|--------|
| U1            | LM2742         | Synchronous Controller | TSSOP-14         |                               | 1    | NSC    |
| Q1            | Si4884DY       | N-MOSFET               | SO-8             | 30V, 13.5mΩ, @ 4.5V<br>15.3nC | 1    | Vishay |
| Q2            | Si4884DY       | N-MOSFET               | SO-8             | 30V, 13.5mΩ, @ 4.5V<br>15.3nC | 1    | Vishay |
| D1            | BAT-54         | Schottky Diode         | SOT-23           | 30V                           | 1    | Vishay |
| Lin           | P1166.102T     | Inductor               | 7.29x7.29 3.51mm | 1μH, 11A 3.7mΩ                | 1    | Pulse  |
| L1            | P1168.102T     | Inductor               | 12x12x4.5 mm     | 1μH, 11A, 3.7mΩ               | 1    | Pulse  |
| Cin1          | 10MV5600AX     | Aluminum Electrolytic  | 16mm D 25mm H    | 5600μF 10V 2.35Arms           | 1    | Sanyo  |
| Cinx          | C3216X7R1E105K | Capacitor              | 1206             | 1μF, 25V                      | 1    | TDK    |
| Co1, Co2, Co3 | 16MV4700WX     | Aluminum Electrolytic  | 12.5mm D 30mm H  | 4700μF 16V 2.8Arms            | 2    | Sanyo  |
| Cboot         | VJ1206X104XXA  | Capacitor              | 1206             | 0.1μF, 25V                    | 1    | Vishay |
| Cin           | C3216X7R1E225K | Capacitor              | 1206             | 2.2μF, 25V                    | 1    | TDK    |
| Css           | VJ1206X123KXX  | Capacitor              | 1206             | 12nF, 25V                     | 1    | Vishay |
| Cc1           | VJ1206A4R7KXX  | Capacitor              | 1206             | 4.7pF 10%                     | 1    | Vishay |

**Table 5. Bill of Materials for Circuit of Figure 34 (continued)**

| ID    | Part Number   | Type      | Size | Parameters | Qty. | Vendor |
|-------|---------------|-----------|------|------------|------|--------|
| Cc2   | VJ1206A681KXX | Capacitor | 1206 | 680pF 10%  | 1    | Vishay |
| Rin   | CRCW1206100J  | Resistor  | 1206 | 10Ω 5%     | 1    | Vishay |
| Rfadj | CRCW12064992F | Resistor  | 1206 | 49.9kΩ 1%  | 1    | Vishay |
| Rc1   | CRCW12061473F | Resistor  | 1206 | 147kΩ 1%   | 1    | Vishay |
| Rfb1  | CRCW12061492F | Resistor  | 1206 | 14.9kΩ 1%  | 1    | Vishay |
| Rfb2  | CRCW12064991F | Resistor  | 1206 | 4.99kΩ 1%  | 1    | Vishay |
| Rcs   | CRCW1206332J  | Resistor  | 1206 | 3.3kΩ 5%   | 1    | Vishay |

**Table 6. Bill of Materials for Circuit of Figure 35**

| ID    | Part Number      | Type                     | Size          | Parameters                         | Qty. | Vendor |
|-------|------------------|--------------------------|---------------|------------------------------------|------|--------|
| U1    | LM2742           | Synchronous Controller   | TSSOP-14      |                                    | 1    | NSC    |
| Q1/Q2 | Si4826DY         | Assymetric Dual N-MOSFET | SO-8          | 30V, 24mΩ/ 8nC<br>Top 16.5mΩ/ 15nC | 1    | Vishay |
| D1    | BAT-54           | Schottky Diode           | SOT-23        | 30V                                | 1    | Vishay |
| Lin   | RLF7030T-1R0N64  | Inductor                 | 6.8x7.1x3.2mm | 1μH, 6.4A, 7.3mΩ                   | 1    | TDK    |
| L1    | RLF7030T-3R3M4R1 | Inductor                 | 6.8x7.1x3.2mm | 3.3μH, 4.1A, 17.4mΩ                | 1    | TDK    |
| Cin1  | C4532X5R1E156M   | MLCC                     | 1812          | 15μF 25V 3.3Arms                   | 1    | Sanyo  |
| Co1   | C4532X5R1E156M   | MLCC                     | 1812          | 15μF 25V 3.3Arms                   | 1    | Sanyo  |
| Cboot | VJ1206X104XXA    | Capacitor                | 1206          | 0.1μF, 25V                         | 1    | TDK    |
| Cin   | C3216X7R1E225K   | Capacitor                | 1206          | 2.2μF, 25V                         | 1    | TDK    |
| Css   | VJ1206X393KXX    | Capacitor                | 1206          | 39nF, 25V                          | 1    | Vishay |
| Cc1   | VJ1206A220KXX    | Capacitor                | 1206          | 22pF 10%                           | 1    | Vishay |
| Cc2   | VJ1206A681KXX    | Capacitor                | 1206          | 680pF 10%                          | 1    | Vishay |
| Cc3   | VJ1206A681KXX    | Capacitor                | 1206          | 680pF 10%                          | 1    | Vishay |
| Rin   | CRCW1206100J     | Resistor                 | 1206          | 10Ω 5%                             | 1    | Vishay |
| Rfadj | CRCW12061742F    | Resistor                 | 1206          | 17.4kΩ 1%                          | 1    | Vishay |
| Rc1   | CRCW12061072F    | Resistor                 | 1206          | 10.7kΩ 1%                          | 1    | Vishay |
| Rc2   | CRCW120666R5F    | Resistor                 | 1206          | 66.5Ω 1%                           | 1    | Vishay |
| Rfb1  | CRCW12064991F    | Resistor                 | 1206          | 4.99kΩ 1%                          | 1    | Vishay |
| Rfb2  | CRCW12061002F    | Resistor                 | 1206          | 10kΩ 1%                            | 1    | Vishay |
| Rcs   | CRCW1206152J     | Resistor                 | 1206          | 1.5kΩ 5%                           | 1    | Vishay |

**Table 7. Bill of Materials for 3.3V Circuit of Figure 35  
(Identical to BOM for 1.8V except as noted below)**

| ID   | Part Number      | Type      | Size           | Parameters        | Qty. | Vendor |
|------|------------------|-----------|----------------|-------------------|------|--------|
| L1   | RLF7030T-4R7M3R4 | Inductor  | 6.8x7.1x 3.2mm | 4.7μH, 3.4A, 26mΩ | 1    | TDK    |
| Cc1  | VJ1206A270KXX    | Capacitor | 1206           | 27pF 10%          | 1    | Vishay |
| Cc2  | VJ1206X102KXX    | Capacitor | 1206           | 1nF 10%           | 1    | Vishay |
| Cc3  | VJ1206A821KXX    | Capacitor | 1206           | 820pF 10%         | 1    | Vishay |
| Rc1  | CRCW12061212F    | Resistor  | 1206           | 12.1kΩ 1%         | 1    | Vishay |
| Rc2  | CRCW12054R9F     | Resistor  | 1206           | 54.9Ω 1%          | 1    | Vishay |
| Rfb1 | CRCW12062211F    | Resistor  | 1206           | 2.21kΩ 1%         | 1    | Vishay |
| Rfb2 | CRCW12061002F    | Resistor  | 1206           | 10kΩ 1%           | 1    | Vishay |

**Table 8. Bill of Materials for Circuit of Figure 36**

| ID      | Part Number       | Type                     | Size              | Parameters                         | Qty. | Vendor |
|---------|-------------------|--------------------------|-------------------|------------------------------------|------|--------|
| U1      | LM2742            | Synchronous Controller   | TSSOP-14          |                                    | 1    | NSC    |
| U2      | LM78L05           | Voltage Regulator        | SO-8              |                                    | 1    | NSC    |
| Q1/Q2   | Si4826DY          | Assymetric Dual N-MOSFET | SO-8              | 30V, 24mΩ/ 8nC<br>Top 16.5mΩ/ 15nC | 1    | Vishay |
| D1      | BAT-54            | Schottky Diode           | SOT-23            | 30V                                | 1    | Vishay |
| Lin     | RLF7030T-1R0N64   | Inductor                 | 6.8x7.1x3.2mm     | 1μH, 6.4A, 7.3mΩ                   | 1    | TDK    |
| L1      | SLF12565T-4R2N5R5 | Inductor                 | 12.5x12.5x6.5mm   | 4.2μH, 5.5A, 15mΩ                  | 1    | TDK    |
| Cin1    | 16MV680WG         | Al-E                     | D: 10mm L: 12.5mm | 680μF 16V 3.4Arms                  | 1    | Sanyo  |
| Cinx    | C3216X5R1C106M    | MLCC                     | 1210              | 10μF 16V 3.4Arms                   | 1    | TDK    |
| Co1 Co2 | 16MV680WG         | MLCC                     | 1812              | 15μF 25V 3.3Arms                   | 1    | Sanyo  |
| Cox     | C3216X5R10J06M    | MLCC                     | 1206              | 10μF 6.3V 2.7A                     |      | TDK    |
| Cboot   | VJ1206X104XXA     | Capacitor                | 1206              | 0.1μF, 25V                         | 1    | Vishay |
| Cin     | C3216X7R1E225K    | Capacitor                | 1206              | 2.2μF, 25V                         | 1    | TDK    |
| Css     | VJ1206X123KXX     | Capacitor                | 1206              | 12nF, 25V                          | 1    | Vishay |
| Cc1     | VJ1206A8R2KXX     | Capacitor                | 1206              | 8.2pF 10%                          | 1    | Vishay |
| Cc2     | VJ1206X102KXX     | Capacitor                | 1206              | 1nF 10%                            | 1    | Vishay |
| Cc3     | VJ1206X472KXX     | Capacitor                | 1206              | 4.7nF 10%                          | 1    | Vishay |
| Rfadj   | CRCW12063252F     | Resistor                 | 1206              | 32.5kΩ 1%                          | 1    | Vishay |
| Rc1     | CRCW12065232F     | Resistor                 | 1206              | 52.3kΩ 1%                          | 1    | Vishay |
| Rc2     | CRCW120662371F    | Resistor                 | 1206              | 2.37Ω 1%                           | 1    | Vishay |
| Rfb1    | CRCW12062211F     | Resistor                 | 1206              | 2.21kΩ 1%                          | 1    | Vishay |
| Rfb2    | CRCW12061002F     | Resistor                 | 1206              | 10kΩ 1%                            | 1    | Vishay |
| Rcs     | CRCW1206202J      | Resistor                 | 1206              | 2kΩ 5%                             | 1    | Vishay |

**Table 9. Bill of Materials for Circuit of Figure 37**

| ID       | Part Number       | Type                   | Size              | Parameters           | Qty. | Vendor |
|----------|-------------------|------------------------|-------------------|----------------------|------|--------|
| U1       | LM2742            | Synchronous Controller | TSSOP-14          |                      | 1    | NSC    |
| Q1       | Si4894DY          | N-MOSFET               | SO-8              | 30V, 15mΩ, 11.5nC    | 1    | Vishay |
| D2       | MBRS330T3         | Schottky Diode         | SO-8              | 30V, 3A              | 1    | ON     |
| L1       | SLF12565T-470M2R4 | Inductor               | 12.5x12.8x 4.7mm  | 47μH, 2.7A 53mΩ      | 1    | TDK    |
| D1       | MBR0520           | Schottky Diode         | 1812              | 20V 0.5A             | 1    | ON     |
| Cin1     | 16MV680WG         | Al-E                   | 1206              | 680μF, 16V, 1.54Arms | 1    | Sanyo  |
| Cinx     | C3216X5R1C106M    | MLCC                   | 1206              | 10μF, 16V, 3.4Arms   | 1    | TDK    |
| Co1, Co2 | 16MV680WG         | Al-E                   | D: 10mm L: 12.5mm | 680μF 16V 26mΩ       | 2    | Sanyo  |
| Cox      | C3216X5R10J06M    | MLCC                   | 1206              | 10μF, 6.3V 2.7A      | 1    | TDK    |
| Cboot    | VJ1206X104XXA     | Capacitor              | 1206              | 0.1μF, 25V           | 1    | Vishay |
| Cin      | C3216X7R1E225K    | Capacitor              | 1206              | 2.2μF, 25V           | 1    | TDK    |
| Css      | VJ1206X123KXX     | Capacitor              | 1206              | 12nF, 25V            | 1    | Vishay |
| Cc1      | VJ1206A561KXX     | Capacitor              | 1206              | 56pF 10%             | 1    | Vishay |
| Cc2      | VJ1206X392KXX     | Capacitor              | 1206              | 3.9nF 10%            | 1    | Vishay |
| Cc3      | VJ1206X223KXX     | Capacitor              | 1206              | 22nF 10%             | 1    | Vishay |
| Rfadj    | CRCW12062673F     | Resistor               | 1206              | 267kΩ 1%             | 1    | Vishay |
| Rc1      | CRCW12066192F     | Resistor               | 1206              | 61.9kΩ 1%            | 1    | Vishay |
| Rc2      | CRCW12067503F     | Resistor               | 1206              | 750kΩ 1%             | 1    | Vishay |
| Rfb1     | CRCW12061371F     | Resistor               | 1206              | 1.37kΩ 1%            | 1    | Vishay |
| Rfb2     | CRCW12061002F     | Resistor               | 1206              | 10kΩ 1%              | 1    | Vishay |
| Rcs      | CRCW1206122F      | Resistor               | 1206              | 1.2kΩ 5%             | 1    | Vishay |

## REVISION HISTORY

### Changes from Revision B (March 2013) to Revision C

### Page

- Changed layout of National Data Sheet to TI format ..... [25](#)

## 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="#">LM2742MTC/NOPB</a>  | Active        | Production           | TSSOP (PW)   14 | 94   TUBE             | Yes         | NIPDAU   SN                          | Level-1-260C-UNLIM                | -40 to 125   | 2742<br>MTC         |
| LM2742MTC/NOPB.B                | Active        | Production           | TSSOP (PW)   14 | 94   TUBE             | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 125   | 2742<br>MTC         |
| <a href="#">LM2742MTCX/NOPB</a> | Active        | Production           | TSSOP (PW)   14 | 2500   LARGE T&R      | Yes         | NIPDAU   SN                          | Level-1-260C-UNLIM                | -40 to 125   | 2742<br>MTC         |
| LM2742MTCX/NOPB.A               | Active        | Production           | TSSOP (PW)   14 | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 125   | 2742<br>MTC         |
| LM2742MTCX/NOPB.B               | Active        | Production           | TSSOP (PW)   14 | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 125   | 2742<br>MTC         |

<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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## 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 |
|-----------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| LM2742MTCX/NOPB | TSSOP        | PW              | 14   | 2500 | 330.0              | 12.4               | 6.9     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |
| LM2742MTCX/NOPB | TSSOP        | PW              | 14   | 2500 | 330.0              | 12.4               | 6.95    | 5.6     | 1.6     | 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) |
|-----------------|--------------|-----------------|------|------|-------------|------------|-------------|
| LM2742MTCX/NOPB | TSSOP        | PW              | 14   | 2500 | 353.0       | 353.0      | 32.0        |
| LM2742MTCX/NOPB | TSSOP        | PW              | 14   | 2500 | 367.0       | 367.0      | 35.0        |

## TUBE



\*All dimensions are nominal

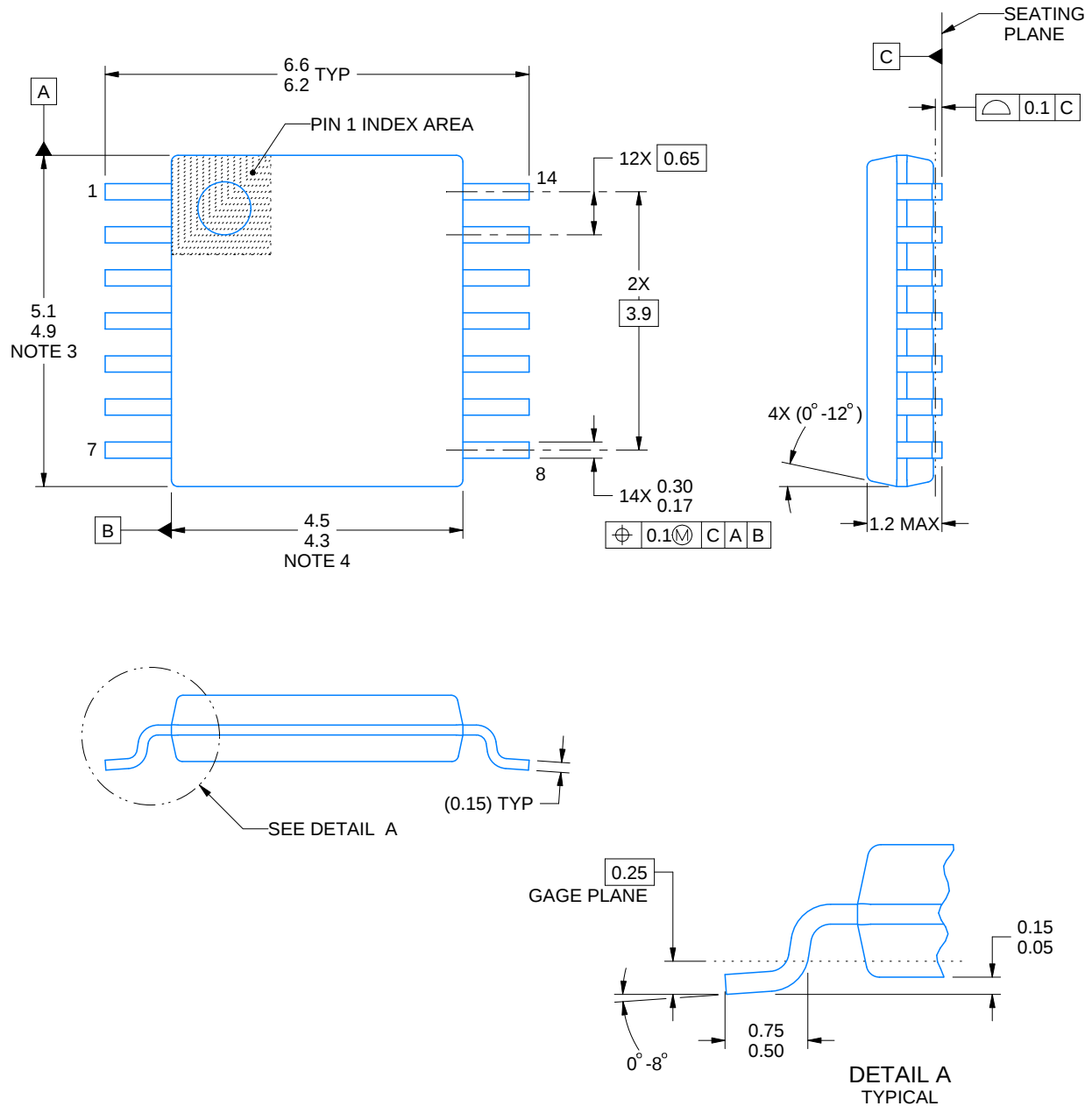
| Device           | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (μm) | B (mm) |
|------------------|--------------|--------------|------|-----|--------|--------|--------|--------|
| LM2742MTC/NOPB   | PW           | TSSOP        | 14   | 94  | 495    | 8      | 2514.6 | 4.06   |
| LM2742MTC/NOPB   | PW           | TSSOP        | 14   | 94  | 530    | 10.2   | 3600   | 3.5    |
| LM2742MTC/NOPB.B | PW           | TSSOP        | 14   | 94  | 495    | 8      | 2514.6 | 4.06   |
| LM2742MTC/NOPB.B | PW           | TSSOP        | 14   | 94  | 530    | 10.2   | 3600   | 3.5    |

**PW0014A**

## PACKAGE OUTLINE

**TSSOP - 1.2 mm max height**

SMALL OUTLINE PACKAGE



4220202/B 12/2023

NOTES:

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. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153.

# EXAMPLE BOARD LAYOUT

PW0014A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 10X



SOLDER MASK DETAILS

4220202/B 12/2023

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## EXAMPLE STENCIL DESIGN

PW0014A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE: 10X

4220202/B 12/2023

NOTES: (continued)

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

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