Application Report
SNVA255A – June 2007 – Revised April 2013

# AN-1658 LM2735 BOOST and SEPIC DC-DC Regulator

## ABSTRACT

This report discusses the features and use of the LM2735 Boost and SEPIC DC-DC Regulator.

## Contents

1 Introduction ..... 3
2 Typical Boost Application Circuit ..... 3
3 Connection Diagrams ..... 4
4 Design Guide ..... 4
  4.1 Enable Pin / Shutdown Mode ..... 4
  4.2 Thermal Shutdown ..... 4
  4.3 Soft-Start ..... 5
  4.4 Inductor Selection ..... 5
  4.5 Input Capacitor ..... 6
  4.6 Output Capacitor ..... 6
  4.7 Setting the Output Voltage ..... 7
  4.8 Compensation ..... 7
5 PCB Layout Considerations ..... 7
6 Thermal Design ..... 8
7 SEPIC Converter ..... 8
8 SEPIC Converter PCB Layout ..... 9
9 LM2735X SOT23-5 Design Example 1: ..... 10
10 LM2735Y SOT23-5 Design Example 2: ..... 10
11 LM2735X LLP-6 Design Example 3: ..... 11
12 LM2735Y LLP-6 Design Example 4: ..... 12
13 LM2735Y eMSOP-8 Design Example 5: ..... 12
14 LM2735X SOT23-5 Design Example 6: ..... 13
15 LM2735Y SOT23-5 Design Example 7: ..... 14
16 LM2735X SOT23-5 Design Example 8: ..... 14
17 LM2735Y SOT23-5 Design Example 9: ..... 15
18 LM2735X LLP-6 Design Example 10: ..... 16
19 LM2735Y LLP-6 Design Example 11: ..... 16
20 LM2735X LLP-6 SEPIC Design Example 12: ..... 17
21 LM2735Y eMSOP-8 SEPIC Design Example 13: ..... 18
22 LM2735X SOT23-5 LED Design Example 14: ..... 19
23 LM2735Y LLP-6 FlyBack Design Example 15: ..... 19

## List of Figures

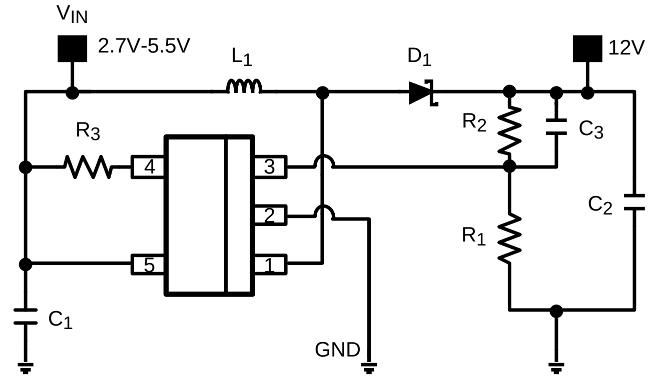
1 Efficiency vs Load Current $V_O$ = 12V ..... 3
2 5-Pin SOT23 (Top View) ..... 4
3 6-Pin LLP (Top View) ..... 4
4 8-Pin eMSOP (Top View) ..... 4
5 Inductor Current ..... 5
6 Example of Proper PCB Layout - Boost PCB Layout Guidelines ..... 8

7 SEPIC PCB Layout ........ 9
8 LM2735X (1.6MHz): Vin = 5V, Vout = 12V @ 350mA ........ 10
9 LM2735Y (520kHz): Vin = 5V, Vout = 12V @ 350mA ........ 10
10 LM2735X (1.6MHz): Vin = 3.3V, Vout = 12V @ 350mA ........ 11
11 LM2735Y (520kHz): Vin = 3.3V, Vout = 12V @ 350mA ........ 12
12 LM2735Y (520kHz): Vin = 3.3V, Vout = 12V @ 350mA ........ 12
13 LM2735X (1.6MHz): Vin = 3V, Vout = 5V @ 500mA ........ 13
14 LM2735Y (520kHz): Vin = 3V, Vout = 5V @ 750mA ........ 14
15 LM2735X (1.6MHz): Vin = 3.3V, Vout = 20V @ 100mA ........ 14
16 LM2735Y (520kHz): Vin = 3.3V, Vout = 20V @ 100mA ........ 15
17 LM2735X (1.6MHz): Vin = 3.3V, Vout = 20V @ 150mA ........ 16
18 LM2735Y (520kHz): Vin = 3.3V, Vout = 20V @ 150mA ........ 16
19 LM2735X (1.6MHz): Vin = 2.7V - 5V, Vout = 3.3V @ 500mA ........ 17
20 LM2735Y (520kHz): Vin = 2.7V - 5V, Vout = 3.3V @ 500mA ........ 18
21 LM2735X (1.6MHz): Vin = 2.7V - 5V, Vout = 20V @ 80mA ........ 19
22 LM2735Y (520kHz): Vin = 5V, Vout = ±12V 150mA ........ 19

## 1 Introduction

The LM2735 is an easy-to-use, space-efficient 2.1A low-side switch regulator ideal for Boost and SEPIC DC-DC regulation. It provides all the active functions to provide local DC/DC conversion with fast-transient response and accurate regulation in the smallest PCB area. Switching frequency is internally set to either 520kHz or 1.6MHz, allowing the use of extremely small surface mount inductor and chip capacitors while providing efficiencies up to 90%. Current-mode control and internal compensation provide ease-of-use, minimal component count, and high-performance regulation over a wide range of operating conditions. External shutdown features an ultra-low standby current of 80 nA ideal for portable applications. Tiny SOT23-5, LLP-6, and eMSOP-8 packages provide space-savings. Additional features include internal soft-start, circuitry to reduce inrush current, pulse-by-pulse current limit, and thermal shutdown.

## 2 Typical Boost Application Circuit



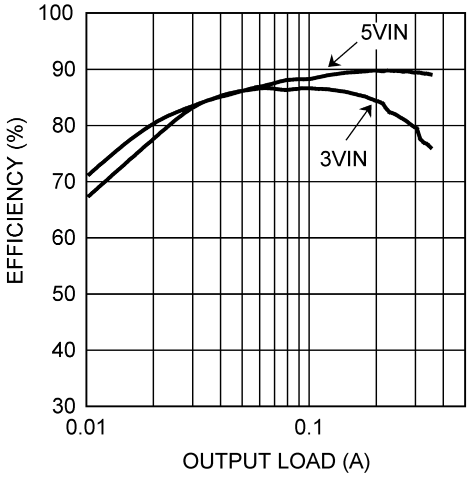


Figure 1. Efficiency vs Load Current $V_O$ = 12V

# 3 Connection Diagrams

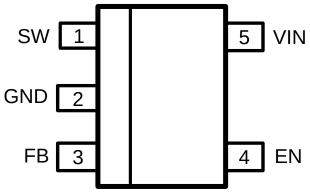


**Figure 2. 5-Pin SOT23 (Top View)**

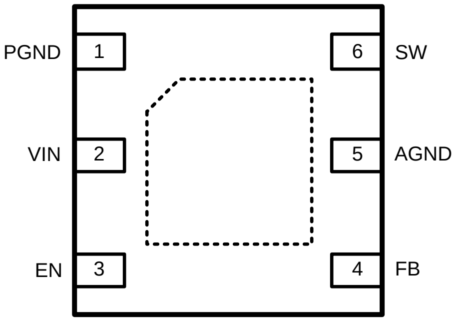


**Figure 3. 6-Pin LLP (Top View)**

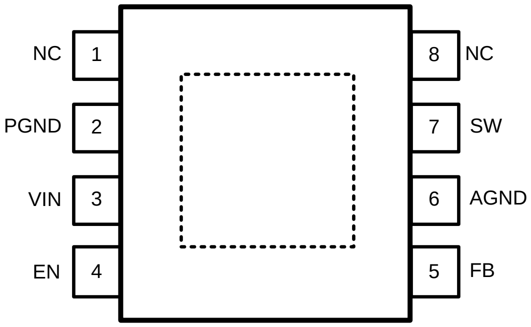


**Figure 4. 8-Pin eMSOP (Top View)**

# 4 Design Guide

## 4.1 Enable Pin / Shutdown Mode

The LM2735 has a shutdown mode that is controlled by the Enable pin (EN). When a logic low voltage is applied to EN, the part is in shutdown mode and its quiescent current drops to typically 80 nA. Switch leakage adds up to another 1 µA from the input supply. The voltage at this pin should never exceed $V_{IN}$ + 0.3V.

## 4.2 Thermal Shutdown

Thermal shutdown limits total power dissipation by turning off the output switch when the IC junction temperature exceeds 160°C. After thermal shutdown occurs, the output switch doesn’t turn on until the junction temperature drops to approximately 150°C.

## 4.3 Soft-Start

This function forces $V_{OUT}$ to increase at a controlled rate during start up. During soft-start, the error amplifier's reference voltage ramps to its nominal value of 1.255V in approximately 4.0ms. This forces the regulator output to ramp up in a more linear and controlled fashion, which helps reduce inrush current.

## 4.4 Inductor Selection

The Duty Cycle (D) can be approximated quickly using the ratio of output voltage ($V_O$) to input voltage ($V_{IN}$):

$$\frac{V_{OUT}}{V_{IN}} = \left(\frac{1}{1-D}\right) = \frac{1}{D'} \tag{1}$$

Therefore:

$$D = \frac{V_{OUT} - V_{IN}}{V_{OUT}} \tag{2}$$

Power losses due to the diode (D1) forward voltage drop, the voltage drop across the internal NMOS switch, the voltage drop across the inductor resistance ($R_{DCR}$) and switching losses must be included to calculate a more accurate duty cycle (See Calculating Efficiency and Junction Temperature for a detailed explanation). A more accurate formula for calculating the conversion ratio is:

$$\frac{V_{OUT}}{V_{IN}} = \frac{\eta}{D'} \tag{3}$$

Where η equals the efficiency of the LM2735 application.

The inductor value determines the input ripple current. Lower inductor values decrease the size of the inductor, but increase the input ripple current. An increase in the inductor value will decrease the input ripple current.

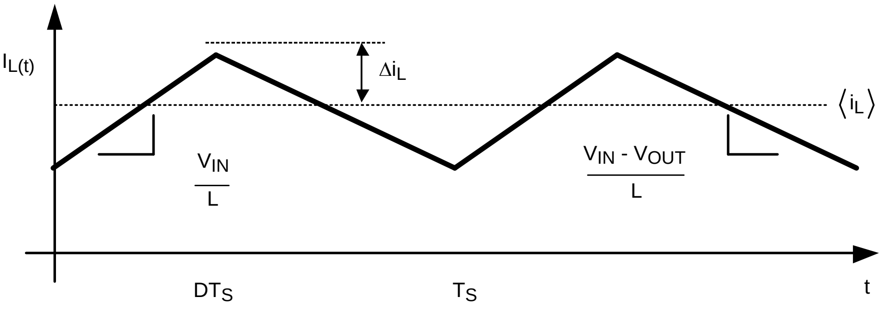


**Figure 5. Inductor Current**

$$\frac{2\Delta i_L}{DT_S} = \left(\frac{V_{IN}}{L}\right)$$

$$\Delta i_L = \left(\frac{V_{IN}}{2L}\right) x\ DT_S \tag{4}$$

A good design practice is to design the inductor to produce 10% to 30% ripple of maximum load. From the previous equations, the inductor value is then obtained.

$$L = \left(\frac{V_{IN}}{2\ x\ \Delta i_L}\right) x\ DT_S \tag{5}$$

Where: $1/T_S = F_{SW}$ = switching frequency

One must also ensure that the minimum current limit (2.1A) is not exceeded, so the peak current in the inductor must be calculated. The peak current ($I_{LPK}$) in the inductor is calculated by:

$$IL_{pk} = I_{IN} + \Delta I_L \tag{6}$$

or

$$IL_{pk} = I_{OUT} / D' + \Delta I_L \tag{7}$$

When selecting an inductor, make sure that it is capable of supporting the peak input current without saturating. Inductor saturation will result in a sudden reduction in inductance and prevent the regulator from operating correctly. Because of the speed of the internal current limit, the peak current of the inductor need only be specified for the required maximum input current. For example, if the designed maximum input current is 1.5A and the peak current is 1.75A, then the inductor should be specified with a saturation current limit of >1.75A. There is no need to specify the saturation or peak current of the inductor at the 3A typical switch current limit.

Because of the operating frequency of the LM2735, ferrite based inductors are preferred to minimize core losses. This presents little restriction since the variety of ferrite-based inductors is huge. Lastly, inductors with lower series resistance (DCR) will provide better operating efficiency. For recommended inductors see Example Circuits.

## 4.5 Input Capacitor

An input capacitor is necessary to ensure that $V_{IN}$ does not drop excessively during switching transients. The primary specifications of the input capacitor are capacitance, voltage, RMS current rating, and ESL (Equivalent Series Inductance).The recommended input capacitance is 10 µF to 44 µF depending on the application. The capacitor manufacturer specifically states the input voltage rating. Make sure to check any recommended deratings and also verify if there is any significant change in capacitance at the operating input voltage and the operating temperature. The ESL of an input capacitor is usually determined by the effective cross sectional area of the current path. At the operating frequencies of the LM2735, certain capacitors may have an ESL so large that the resulting impedance (2πfL) will be higher than that required to provide stable operation. As a result, surface mount capacitors are strongly recommended. Multilayer ceramic capacitors (MLCC) are good choices for both input and output capacitors and have very low ESL. For MLCCs it is recommended to use X7R or X5R dielectrics. Consult capacitor manufacturer datasheet to see how rated capacitance varies over operating conditions.

## 4.6 Output Capacitor

The LM2735 operates at frequencies allowing the use of ceramic output capacitors without compromising transient response. Ceramic capacitors allow higher inductor ripple without significantly increasing output ripple. The output capacitor is selected based upon the desired output ripple and transient response. The initial current of a load transient is provided mainly by the output capacitor. The output impedance will therefore determine the maximum voltage perturbation. The output ripple of the converter is a function of the capacitor’s reactance and its equivalent series resistance (ESR):

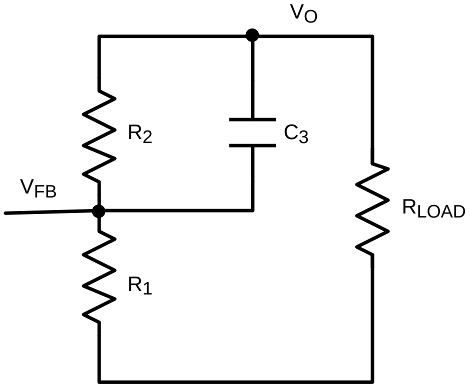
$$\Delta V_{OUT} = \Delta i_L \text{ x } R_{ESR} + \left( \frac{V_{OUT} \text{ x } D}{2 \text{ x } F_{SW} \text{ x } R_{Load} \text{ x } C_{OUT}} \right) \tag{8}$$

When using MLCCs, the ESR is typically so low that the capacitive ripple may dominate. When this occurs, the outputripple will be approximately sinusoidal and 90° phase shifted from the switching action.

Given the availability and quality of MLCCs and the expected output voltage of designs using the LM2735, there is really no need to review any other capacitor technologies. Another benefit of ceramic capacitors is their ability to bypass high frequency noise. A certain amount of switching edge noise will couple through parasitic capacitances in the inductor to the output. A ceramic capacitor will bypass this noise while a tantalum will not. Since the output capacitor is one of the two external components that control the stability of the regulator control loop, most applications will require a minimum at 4.7 µF of output capacitance. Like the input capacitor, recommended multilayer ceramic capacitors are X7R or X5R. Again, verify actual capacitance at the desired operating voltage and temperature.

### 4.7 Setting the Output Voltage

The output voltage is set using the following equation where R1 is connected between the FB pin and GND, and R2 is connected between $V_{OUT}$ and the FB pin.

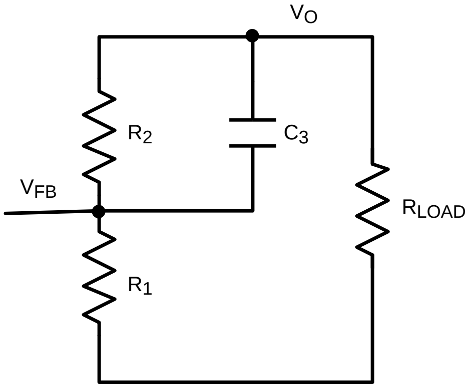


A good value for R1 is 10kΩ.

$$R_2 = \left(\frac{V_{OUT}}{V_{REF}} - 1\right) x\ R_1 \tag{9}$$

### 4.8 Compensation

The LM2735 uses constant frequency peak current mode control. This mode of control allows for a simple external compensation scheme that can be optimized for each application. Lower output voltages should have a zero set close to 10 kHz, and higher output voltages will usually have the zero set closer to 5 kHz.



$$F_{ZERO\text{-}CF} = \frac{1}{2\pi\left(R_2\ x\ C_3\right)} \tag{10}$$

## 5 PCB Layout Considerations

When planning layout there are a few things to consider when trying to achieve a clean, regulated output. The most important consideration when completing a Boost Converter layout is the close coupling of the GND connections of the $C_{OUT}$ capacitor and the LM2735 PGND pin. The GND ends should be close to one another and be connected to the GND plane with at least two through-holes. There should be a continuous ground plane on the bottom layer of a two-layer board except under the switching node island. The FB pin is a high impedance node and care should be taken to make the FB trace short to avoid noise pickup and inaccurate regulation. The feedback resistors should be placed as close as possible to the IC, with the AGND of R1 placed as close as possible to the GND (pin 5 for the LLP) of the IC. The $V_{OUT}$ trace to R2 should be routed away from the inductor and any other traces that are switching. High AC currents flow through the $V_{IN}$, SW and $V_{OUT}$ traces, so they should be as short and wide as possible. However, making the traces wide increases radiated noise, so the designer must make this trade-off. Radiated noise can be decreased by choosing a shielded inductor. The remaining components should also be placed as close as possible to the IC. Please see *AN-1229 SIMPLE SWITCHER PCB Layout Guidelines* (SNVA054) for further considerations and the LM2735 demo board as an example of a four-layer layout.

Below is an example of a good thermal and electrical PCB design. This is very similar to our LM2735 demonstration boards that are obtainable via the www.ti.com website. The demonstration board consists of a two layer PCB with a common input and output voltage application. Most of the routing is on the top layer, with the bottom layer consisting of a large ground plane. The placement of the external components satisfies the electrical considerations, and the thermal performance has been improved by adding thermal vias and a top layer “Dog-Bone”.

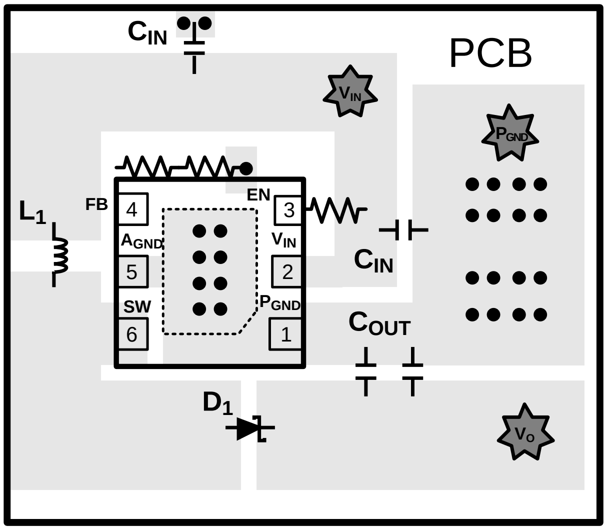


**Figure 6. Example of Proper PCB Layout - Boost PCB Layout Guidelines**

## 6 Thermal Design

### PCB design with thermal performance in mind:

The PCB design is a very important step in the thermal design procedure. The LM2735 is available in three package options (5 pin SOT23, 8 pin eMSOP and 6 pin LLP). The options are electrically the same, but difference between the packages is size and thermal performance. The LLP and eMSOP have thermal Die Attach Pads (DAP) attached to the bottom of the packages, and are therefore capable of dissipating more heat than the SOT23 package. It is important that the customer choose the correct package for the application. A detailed thermal design procedure has been included in this data sheet. This procedure will help determine which package is correct, and common applications will be analyzed.

## 7 SEPIC Converter

The LM2735 can easily be converted into a SEPIC converter. A SEPIC converter has the ability to regulate an output voltage that is either larger or smaller in magnitude than the input voltage. Other converters have this ability as well (CUK and Buck-Boost), but usually create an output voltage that is opposite in polarity to the input voltage. This topology is a perfect fit for Lithium Ion battery applications where the input voltage for a single cell Li-Ion battery will vary between 3V & 4.5V and the output voltage is somewhere in between. Most of the analysis of the LM2735 Boost Converter is applicable to the LM2735 SEPIC Converter.

**SEPIC Design Guide:**

SEPIC Conversion ratio without loss elements:

$$\frac{V_O}{V_{IN}} = \frac{D}{D'} \tag{11}$$

Therefore:

$$D = \frac{V_O}{V_O + V_{IN}} \tag{12}$$

$$\frac{V_O}{V_{IN}} = \left(\frac{D}{1 - D}\right) \text{ x } \eta \tag{13}$$

$$D = \left(\frac{V_O}{(V_{IN} \text{ x } \eta) + V_O}\right) \tag{14}$$

It is important to remember that the internal switch current is equal to $I_{L1}$ and $I_{L2}$. During the D interval design the converter so that the minimum ensured peak switch current limit (2.25A) is not exceeded.

$$I_{L2} = \left(\frac{D}{D'}\right) \text{ x } I_{L1}$$

and

$$I_{L1} = \left(\frac{D}{D'}\right) \text{ x } \left(\frac{V_O}{R}\right) \tag{15}$$

Substituting $I_{L1}$ into $I_{L2}$

$$I_{L2} = \frac{V_O}{R} \tag{16}$$

## 8 SEPIC Converter PCB Layout

The layout guidelines described for the LM2735 Boost-Converter are applicable to the SEPIC Converter. Below is a proper PCB layout for a SEPIC Converter.

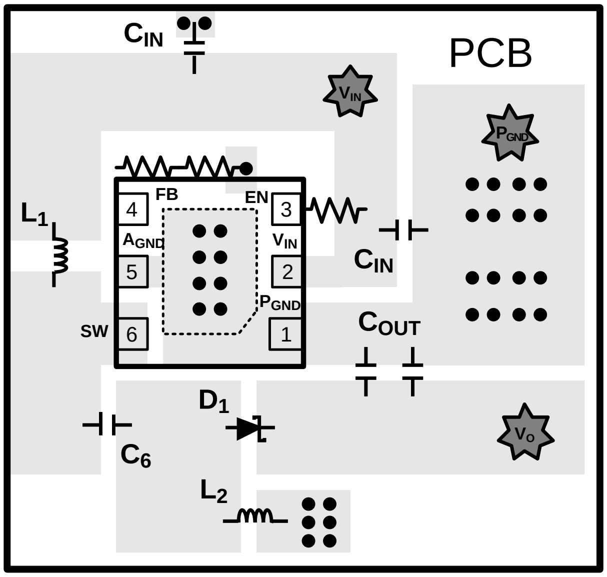


Figure 7. SEPIC PCB Layout

## 9 LM2735X SOT23-5 Design Example 1:

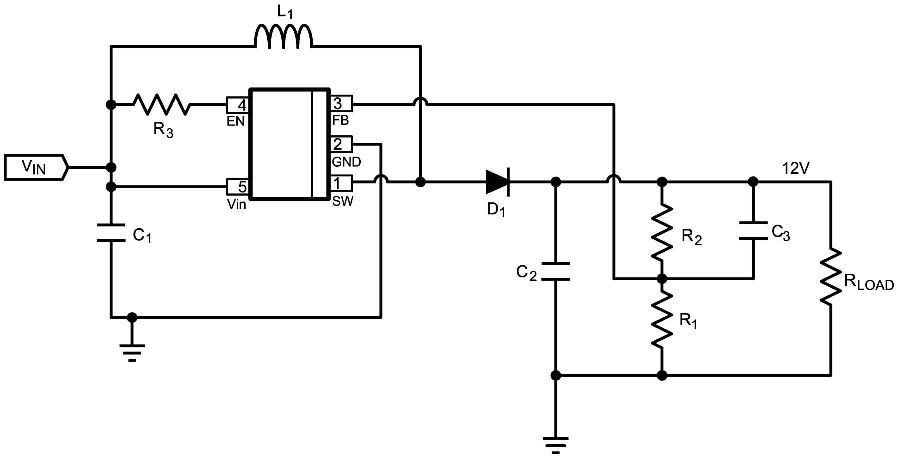


**Figure 8. LM2735X (1.6MHz): Vin = 5V, Vout = 12V @ 350mA**

| Part ID | Part Value | Manufacturer | Part Number |
|---|---|---|---|
| U1 | 2.1A Boost Regulator | TI | LM2735XMF |
| C1, Input Cap | 22µF, 6.3V, X5R | TDK | C2012X5R0J226M |
| C2 Output Cap | 10µF, 25V, X5R | TDK | C3216X5R1E106M |
| C3 Comp Cap | 330pF | TDK | C1608X5R1H331K |
| D1, Catch Diode | 0.4$V_f$ Schottky 1A, 20$V_R$ | ST | STPS120M |
| L1 | 15µH 1.5A | Coilcraft | MSS5131-153ML |
| R1 | 10.2kΩ, 1% | Vishay | CRCW06031022F |
| R2 | 86.6kΩ, 1% | Vishay | CRCW06038662F |
| R3 | 100kΩ, 1% | Vishay | CRCW06031003F |

## 10 LM2735Y SOT23-5 Design Example 2:

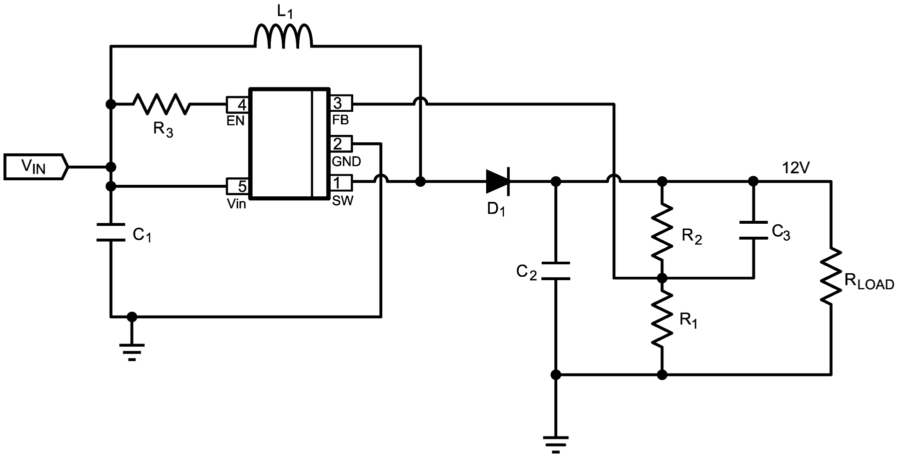


**Figure 9. LM2735Y (520kHz): Vin = 5V, Vout = 12V @ 350mA**

| Part ID | Part Value | Manufacturer | Part Number |
|---|---|---|---|
| U1 | 2.1A Boost Regulator | TI | LM2735YMF |
| C1, Input Cap | 22µF, 6.3V, X5R | TDK | C2012X5R0J226M |
| C2 Output Cap | 10µF, 25V, X5R | TDK | C3216X5R1E106M |
| C3 Comp Cap | 330pF | TDK | C1608X5R1H331K |
| D1, Catch Diode | 0.4$V_f$ Schottky 1A, 20$V_R$ | ST | STPS120M |
| L1 | 33µH 1.5A | Coilcraft | DS3316P-333ML |
| R1 | 10.2kΩ, 1% | Vishay | CRCW06031022F |
| R2 | 86.6kΩ, 1% | Vishay | CRCW06038662F |
| R3 | 100kΩ, 1% | Vishay | CRCW06031003F |

## 11 LM2735X LLP-6 Design Example 3:

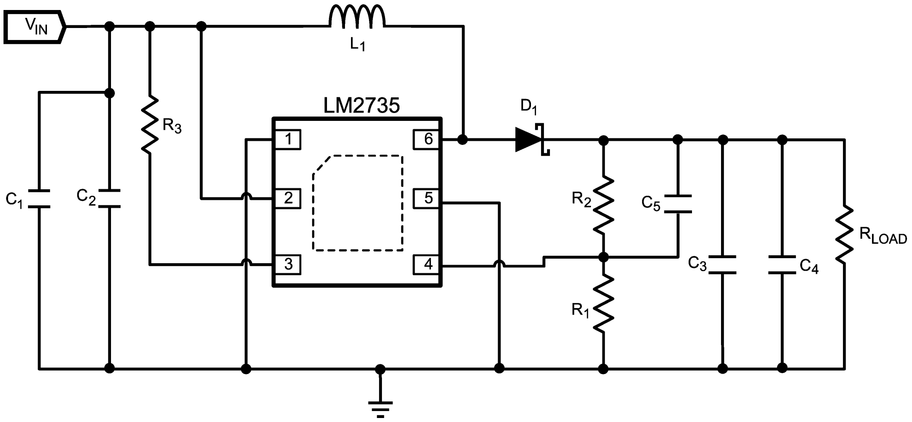


**Figure 10. LM2735X (1.6MHz): Vin = 3.3V, Vout = 12V @ 350mA**

| Part ID | Part Value | Manufacturer | Part Number |
|---|---|---|---|
| U1 | 2.1A Boost Regulator | TI | LM2735XSD |
| C1 Input Cap | 22µF, 6.3V, X5R | TDK | C2012X5R0J226M |
| C2 Input Cap | No Load | | |
| C3 Output Cap | 10µF, 25V, X5R | TDK | C3216X5R1E106M |
| C4 Output Cap | No Load | | |
| C5 Comp Cap | 330pF | TDK | C1608X5R1H331K |
| D1, Catch Diode | 0.4$V_f$ Schottky 1A, 20$V_R$ | ST | STPS120M |
| L1 | 6.8µH 2A | Coilcraft | DO1813H-682ML |
| R1 | 10.2kΩ, 1% | Vishay | CRCW06031022F |
| R2 | 86.6kΩ, 1% | Vishay | CRCW06038662F |
| R3 | 100kΩ, 1% | Vishay | CRCW06031003F |

## 12 LM2735Y LLP-6 Design Example 4:

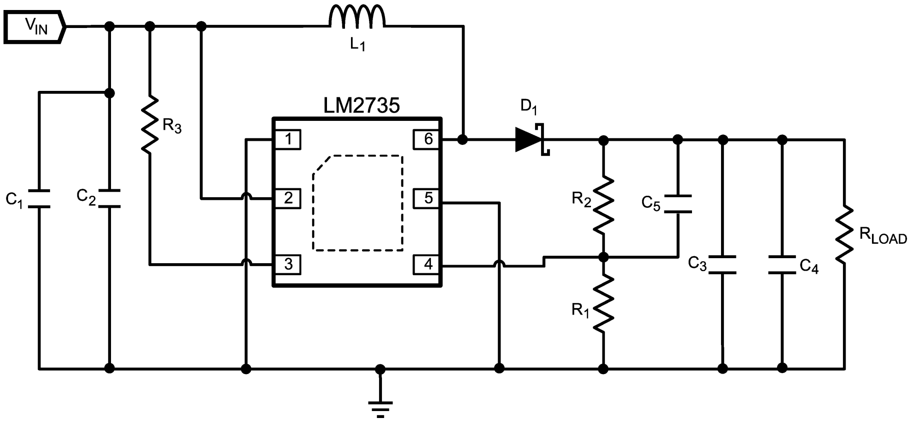


**Figure 11. LM2735Y (520kHz): Vin = 3.3V, Vout = 12V @ 350mA**

| Part ID | Part Value | Manufacturer | Part Number |
|---|---|---|---|
| U1 | 2.1A Boost Regulator | TI | LM2735YSD |
| C1 Input Cap | 22µF, 6.3V, X5R | TDK | C2012X5R0J226M |
| C2 Input Cap | No Load | | |
| C3 Output Cap | 10µF, 25V, X5R | TDK | C3216X5R1E106M |
| C4 Output Cap | No Load | | |
| C5 Comp Cap | 330pF | TDK | C1608X5R1H331K |
| D1, Catch Diode | 0.4V$_f$ Schottky 1A, 20V$_R$ | ST | STPS120M |
| L1 | 15µH 2A | Coilcraft | MSS5131-153ML |
| R1 | 10.2kΩ, 1% | Vishay | CRCW06031022F |
| R2 | 86.6kΩ, 1% | Vishay | CRCW06038662F |
| R3 | 100kΩ, 1% | Vishay | CRCW06031003F |

## 13 LM2735Y eMSOP-8 Design Example 5:

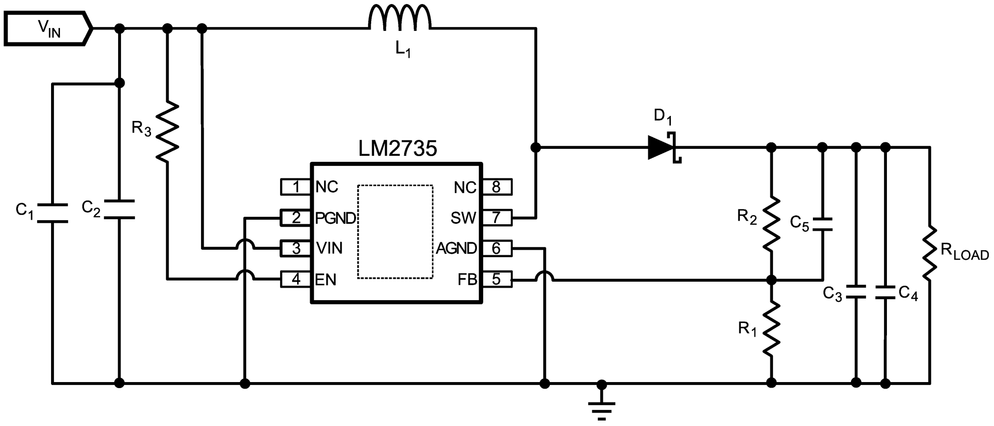


**Figure 12. LM2735Y (520kHz): Vin = 3.3V, Vout = 12V @ 350mA**

| Part ID | Part Value | Manufacturer | Part Number |
|---|---|---|---|
| U1 | 2.1A Boost Regulator | TI | LM2735YMY |
| C1 Input Cap | 22µF, 6.3V, X5R | TDK | C2012X5R0J226M |
| C2 Input Cap | No Load | | |
| C3 Output Cap | 10µF, 25V, X5R | TDK | C3216X5R1E106M |
| C4 Output Cap | No Load | | |
| C5 Comp Cap | 330pF | TDK | C1608X5R1H331K |
| D1, Catch Diode | $0.4V_f$ Schottky 1A, $20V_R$ | ST | STPS120M |
| L1 | 15µH 1.5A | Coilcraft | MSS5131-153ML |
| R1 | 10.2kΩ, 1% | Vishay | CRCW06031022F |
| R2 | 86.6kΩ, 1% | Vishay | CRCW06038662F |
| R3 | 100kΩ, 1% | Vishay | CRCW06031003F |

## 14 LM2735X SOT23-5 Design Example 6:

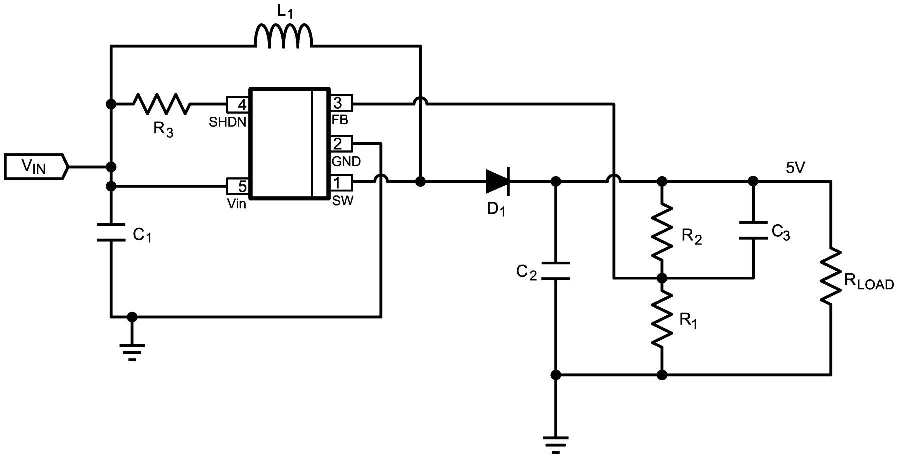


Figure 13. LM2735X (1.6MHz): Vin = 3V, Vout = 5V @ 500mA

| Part ID | Part Value | Manufacturer | Part Number |
|---|---|---|---|
| U1 | 2.1A Boost Regulator | TI | LM2735XMF |
| C1, Input Cap | 10µF, 6.3V, X5R | TDK | C2012X5R0J106K |
| C2, Output Cap | 10µF, 6.3V, X5R | TDK | C2012X5R0J106K |
| C3 Comp Cap | 1000pF | TDK | C1608X5R1H102K |
| D1, Catch Diode | $0.4V_f$ Schottky 1A, $20V_R$ | ST | STPS120M |
| L1 | 10µH 1.2A | Coilcraft | DO1608C-103ML |
| R1 | 10.0kΩ, 1% | Vishay | CRCW08051002F |
| R2 | 30.1kΩ, 1% | Vishay | CRCW08053012F |
| R3 | 100kΩ, 1% | Vishay | CRCW06031003F |

## 15 LM2735Y SOT23-5 Design Example 7:

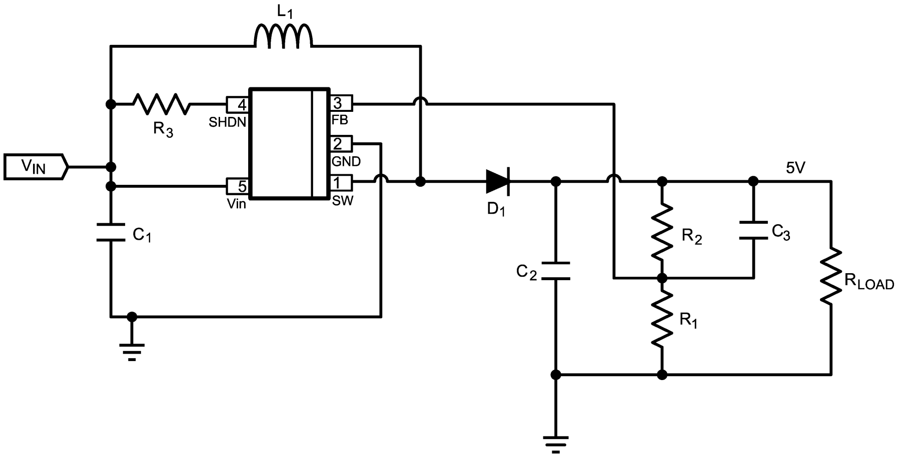


Figure 14. LM2735Y (520kHz): Vin = 3V, Vout = 5V @ 750mA

| Part ID | Part Value | Manufacturer | Part Number |
|---|---|---|---|
| U1 | 2.1A Boost Regulator | TI | LM2735YMF |
| C1 Input Cap | 22µF, 6.3V, X5R | TDK | C2012X5R0J226M |
| C2 Output Cap | 22µF, 6.3V, X5R | TDK | C2012X5R0J226M |
| C3 Comp Cap | 1000pF | TDK | C1608X5R1H102K |
| D1, Catch Diode | 0.4$V_f$ Schottky 1A, 20$V_R$ | ST | STPS120M |
| L1 | 22µH 1.2A | Coilcraft | MSS5131-223ML |
| R1 | 10.0kΩ, 1% | Vishay | CRCW08051002F |
| R2 | 30.1kΩ, 1% | Vishay | CRCW08053012F |
| R3 | 100kΩ, 1% | Vishay | CRCW06031003F |

## 16 LM2735X SOT23-5 Design Example 8:

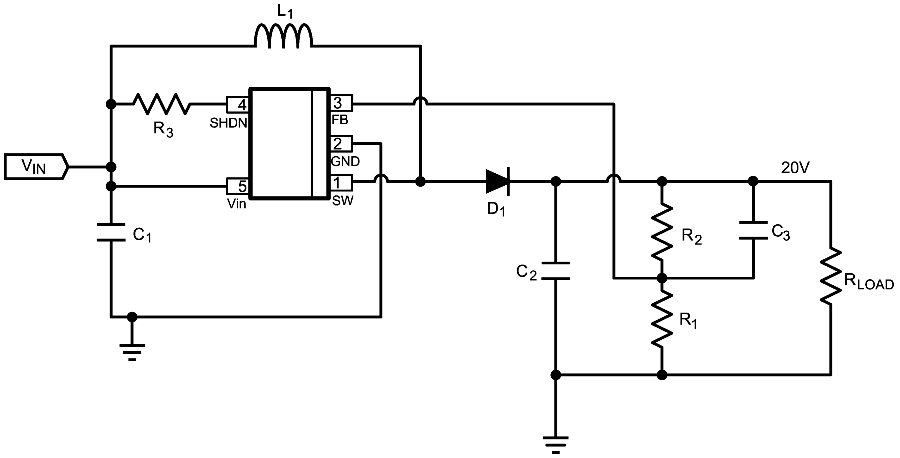


Figure 15. LM2735X (1.6MHz): Vin = 3.3V, Vout = 20V @ 100mA

| Part ID | Part Value | Manufacturer | Part Number |
|---|---|---|---|
| U1 | 2.1A Boost Regulator | TI | LM2735XMF |
| C1, Input Cap | 22µF, 6.3V, X5R | TDK | C2012X5R0J226M |
| C2, Output Cap | 4.7µF, 25V, X5R | TDK | C3216X5R1E475K |
| C3 Comp Cap | 470pF | TDK | C1608X5R1H471K |
| D1, Catch Diode | 0.4$V_f$ Schottky 500mA, 30$V_R$ | Vishay | MBR0530 |
| L1 | 10µH 1.2A | Coilcraft | DO1608C-103ML |
| R1 | 10.0kΩ, 1% | Vishay | CRCW06031002F |
| R2 | 150kΩ, 1% | Vishay | CRCW06031503F |
| R3 | 100kΩ, 1% | Vishay | CRCW06031003F |

## 17 LM2735Y SOT23-5 Design Example 9:

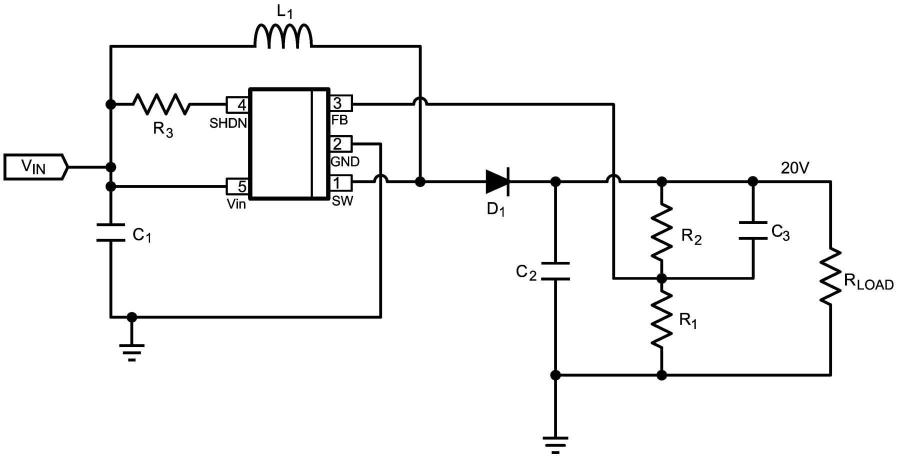


Figure 16. LM2735Y (520kHz): Vin = 3.3V, Vout = 20V @ 100mA

| Part ID | Part Value | Manufacturer | Part Number |
|---|---|---|---|
| U1 | 2.1A Boost Regulator | TI | LM2735YMF |
| C1 Input Cap | 22µF, 6.3V, X5R | TDK | C2012X5R0J226M |
| C2 Output Cap | 10µF, 25V, X5R | TDK | C3216X5R1E106M |
| C3 Comp Cap | 470pF | TDK | C1608X5R1H471K |
| D1, Catch Diode | 0.4$V_f$ Schottky 500mA, 30$V_R$ | Vishay | MBR0530 |
| L1 | 33µH 1.5A | Coilcraft | DS3316P-333ML |
| R1 | 10.0kΩ, 1% | Vishay | CRCW06031002F |
| R2 | 150.0kΩ, 1% | Vishay | CRCW06031503F |
| R3 | 100kΩ, 1% | Vishay | CRCW06031003F |

## 18 LM2735X LLP-6 Design Example 10:

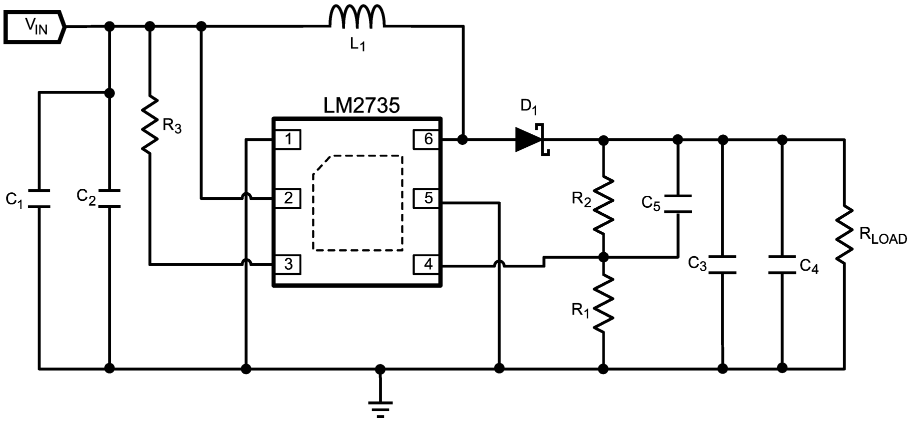


**Figure 17. LM2735X (1.6MHz): Vin = 3.3V, Vout = 20V @ 150mA**

| Part ID | Part Value | Manufacturer | Part Number |
|---|---|---|---|
| U1 | 2.1A Boost Regulator | TI | LM2735XSD |
| C1 Input Cap | 22µF, 6.3V, X5R | TDK | C2012X5R0J226M |
| C2 Input Cap | 22µF, 6.3V, X5R | TDK | C2012X5R0J226M |
| C3 Output Cap | 10µF, 25V, X5R | TDK | C3216X5R1E106M |
| C4 Output Cap | No Load | | |
| C5 Comp Cap | 470pF | TDK | C1608X5R1H471K |
| D1, Catch Diode | 0.4$V_f$ Schottky 500mA, 30$V_R$ | Vishay | MBR0530 |
| L1 | 8.2µH 2A | Coilcraft | DO1813H-822ML |
| R1 | 10.0kΩ, 1% | Vishay | CRCW06031002F |
| R2 | 150kΩ, 1% | Vishay | CRCW06031503F |
| R3 | 100kΩ, 1% | Vishay | CRCW06031003F |

## 19 LM2735Y LLP-6 Design Example 11:

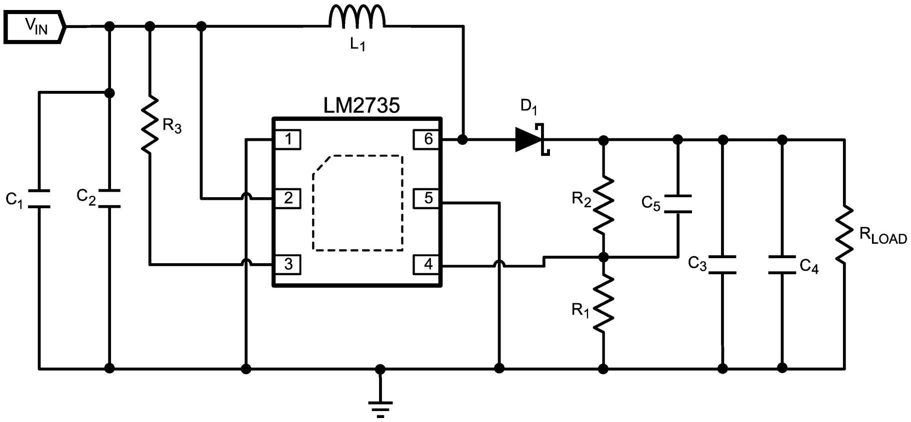


**Figure 18. LM2735Y (520kHz): Vin = 3.3V, Vout = 20V @ 150mA**

| Part ID | Part Value | Manufacturer | Part Number |
|---|---|---|---|
| U1 | 2.1A Boost Regulator | TI | LM2735YSD |
| C1 Input Cap | 10µF, 6.3V, X5R | TDK | C2012X5R0J106K |
| C2 Input Cap | 10µF, 6.3V, X5R | TDK | C2012X5R0J106K |
| C3 Output Cap | 10µF, 25V, X5R | TDK | C3216X5R1E106M |
| C4 Output Cap | No Load | | |
| C5 Comp Cap | 470pF | TDK | C1608X5R1H471K |
| D1, Catch Diode | 0.4$V_f$ Schottky 500mA, 30$V_R$ | Vishay | MBR0530 |
| L1 | 22µH 1.5A | Coilcraft | DS3316P-223ML |
| R1 | 10.0kΩ, 1% | Vishay | CRCW06031002F |
| R2 | 150kΩ, 1% | Vishay | CRCW06031503F |
| R3 | 100kΩ, 1% | Vishay | CRCW06031003F |

## 20 LM2735X LLP-6 SEPIC Design Example 12:

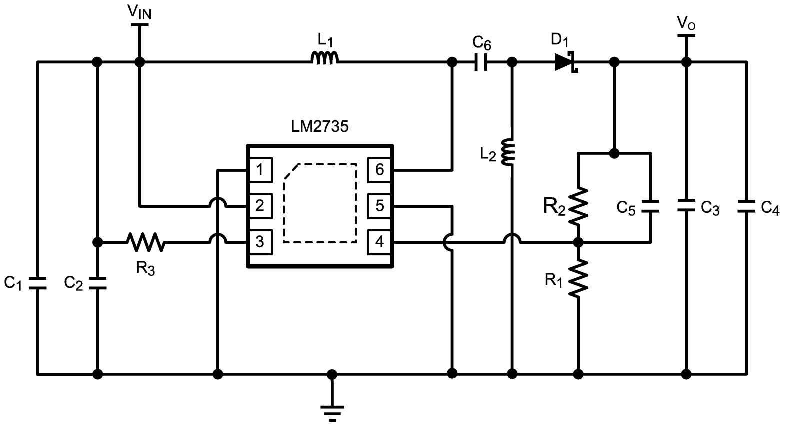


**Figure 19. LM2735X (1.6MHz): Vin = 2.7V - 5V, Vout = 3.3V @ 500mA**

| Part ID | Part Value | Manufacturer | Part Number |
|---|---|---|---|
| U1 | 2.1A Boost Regulator | TI | LM2735XSD |
| C1 Input Cap | 22µF, 6.3V, X5R | TDK | C2012X5R0J226M |
| C2 Input Cap | No Load | | |
| C3 Output Cap | 10µF, 25V, X5R | TDK | C3216X5R1E106M |
| C4 Output Cap | No Load | | |
| C5 Comp Cap | 2200pF | TDK | C1608X5R1H222K |
| C6 | 2.2µF 16V | TDK | C2012X5R1C225K |
| D1, Catch Diode | 0.4$V_f$ Schottky 1A, 20$V_R$ | ST | STPS120M |
| L1 | 6.8µH | Coilcraft | DO1608C-682ML |
| L2 | 6.8µH | Coilcraft | DO1608C-682ML |
| R1 | 10.2kΩ, 1% | Vishay | CRCW06031002F |
| R2 | 16.5kΩ, 1% | Vishay | CRCW06031652F |
| R3 | 100kΩ, 1% | Vishay | CRCW06031003F |

## 21 LM2735Y eMSOP-8 SEPIC Design Example 13:

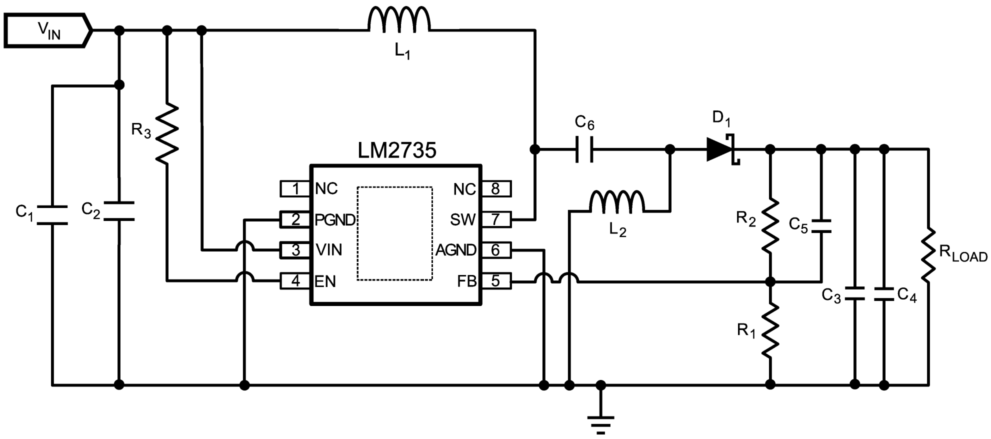


**Figure 20. LM2735Y (520kHz): Vin = 2.7V - 5V, Vout = 3.3V @ 500mA**

| Part ID | Part Value | Manufacturer | Part Number |
|---|---|---|---|
| U1 | 2.1A Boost Regulator | TI | LM2735YMY |
| C1 Input Cap | 22µF, 6.3V, X5R | TDK | C2012X5R0J226M |
| C2 Input Cap | No Load | | |
| C3 Output Cap | 10µF, 25V, X5R | TDK | C3216X5R1E106M |
| C4 Output Cap | No Load | | |
| C5 Comp Cap | 2200pF | TDK | C1608X5R1H222K |
| C6 | 2.2µF 16V | TDK | C2012X5R1C225K |
| D1, Catch Diode | 0.4$V_f$ Schottky 1A, 20$V_R$ | ST | STPS120M |
| L1 | 15µH 1.5A | Coilcraft | MSS5131-153ML |
| L2 | 15µH 1.5A | Coilcraft | MSS5131-153ML |
| R1 | 10.2kΩ, 1% | Vishay | CRCW06031002F |
| R2 | 16.5kΩ, 1% | Vishay | CRCW06031652F |
| R3 | 100kΩ, 1% | Vishay | CRCW06031003F |

## 22 LM2735X SOT23-5 LED Design Example 14:

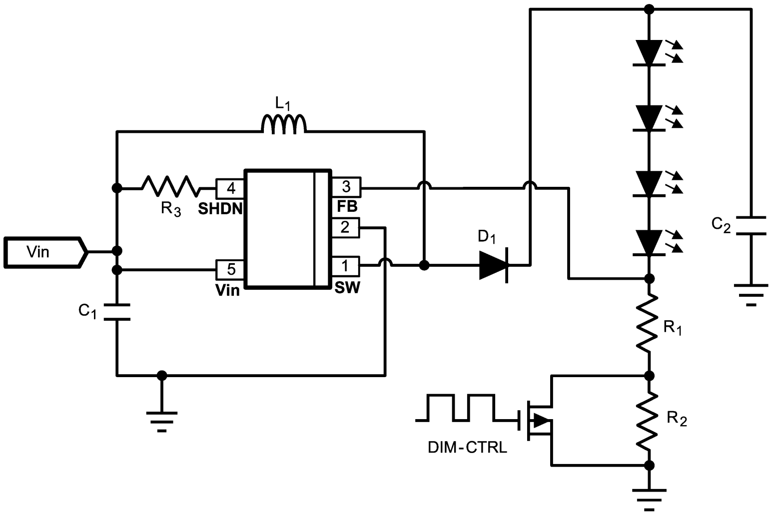


Figure 21. LM2735X (1.6MHz): Vin = 2.7V - 5V, Vout = 20V @ 80mA

| Part ID | Part Value | Manufacturer | Part Number |
|---|---|---|---|
| U1 | 2.1A Boost Regulator | TI | LM2735XMF |
| C1 Input Cap | 22µF, 6.3V, X5R | TDK | C2012X5R0J226M |
| C2 Output Cap | 4.7µF, 25V, X5R | TDK | C3216JB1E475K |
| D1, Catch Diode | 0.4$V_f$ Schottky 500mA, 30$V_R$ | Vishay | MBR0530 |
| L1 | 15µH 1.5A | Coilcraft | MSS5131-153ML |
| R1 | 80.6Ω, 1% | Vishay | CRCW080580R6F |
| R2 | 402Ω, 1% | Vishay | CRCW08054020F |
| R3 | 100kΩ, 1% | Vishay | CRCW06031003F |

## 23 LM2735Y LLP-6 FlyBack Design Example 15:

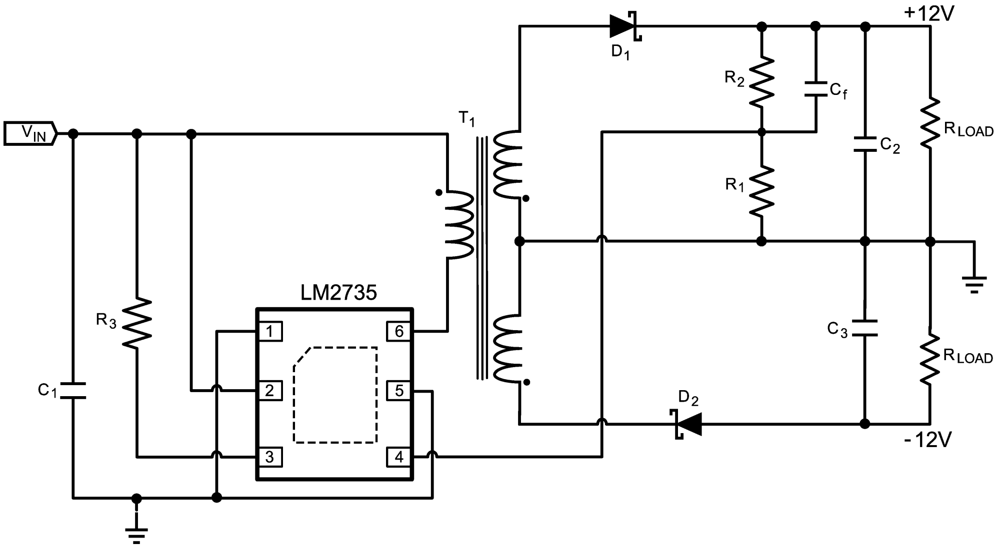


Figure 22. LM2735Y (520kHz): Vin = 5V, Vout = ±12V 150mA

| Part ID | Part Value | Manufacturer | Part Number |
|---|---|---|---|
| U1 | 2.1A Boost Regulator | TI | LM2735YSD |
| C1 Input Cap | 22µF, 6.3V, X5R | TDK | C2012X5R0J226M |
| C2 Output Cap | 10µF, 25V, X5R | TDK | C3216X5R1E106M |
| C3 Output Cap | 10µF, 25V, X5R | TDK | C3216X5R1E106M |
| Cf Comp Cap | 330pF | TDK | C1608X5R1H331K |
| D1, D2 Catch Diode | 0.4$V_f$ Schottky 500mA, 30$V_R$ | Vishay | MBR0530 |
| T1 | | | |
| R1 | 10.0kΩ, 1% | Vishay | CRCW06031002F |
| R2 | 86.6kΩ, 1% | Vishay | CRCW06038662F |
| R3 | 100kΩ, 1% | Vishay | CRCW06031003F |

# IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as “components”) are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

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

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

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

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

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have ***not*** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

| **Products** | | **Applications** | |
|---|---|---|---|
| Audio | www.ti.com/audio | Automotive and Transportation | www.ti.com/automotive |
| Amplifiers | amplifier.ti.com | Communications and Telecom | www.ti.com/communications |
| Data Converters | dataconverter.ti.com | Computers and Peripherals | www.ti.com/computers |
| DLP® Products | www.dlp.com | Consumer Electronics | www.ti.com/consumer-apps |
| DSP | dsp.ti.com | Energy and Lighting | www.ti.com/energy |
| Clocks and Timers | www.ti.com/clocks | Industrial | www.ti.com/industrial |
| Interface | interface.ti.com | Medical | www.ti.com/medical |
| Logic | logic.ti.com | Security | www.ti.com/security |
| Power Mgmt | power.ti.com | Space, Avionics and Defense | www.ti.com/space-avionics-defense |
| Microcontrollers | microcontroller.ti.com | Video and Imaging | www.ti.com/video |
| RFID | www.ti-rfid.com | | |
| OMAP Applications Processors | www.ti.com/omap | **TI E2E Community** | e2e.ti.com |
| Wireless Connectivity | www.ti.com/wirelessconnectivity | | |

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2013, Texas Instruments Incorporated