Application Report
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AN-1572 Quick Start Guide for a 3 Amp Buck Regulator Using the LM5576 and LM25576

ABSTRACT

This application note provides an easy to use process to design a 3 Amp buck regulator using the LM5576 and LM25576 switching regulators.

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1 Introduction

The LM5576 and LM25576 switching regulators feature all of the functions necessary to implement an efficient high voltage buck regulator using a minimum of external components. These easy to use regulators include either a 42V (LM25576) or a 75V (LM5576) N-Channel buck switch with an output current capability of 3 Amps. The operating frequency is programmable from 50kHz up to 1MHz. Protection features include: current limit, thermal shutdown and remote shutdown capability. The device is available in a power enhanced TSSOP-20 package featuring an exposed die attach pad to aid thermal dissipation.

This step-by-step guide provides an easy to use process to quickly select the external components necessary to complete a design. More detailed information including theory of operation, design trade-offs and additional application guidance is available in the device datasheet. Shown below in Figure 1 is a complete schematic for a 3 Amp step-down DC-DC converter. Several external component values can be standardized for most applications. The input voltage range, output voltage and desired operating frequency dictate the remaining component values.

An Excel based spreadsheet derived from the guide is available on www.ti.com.

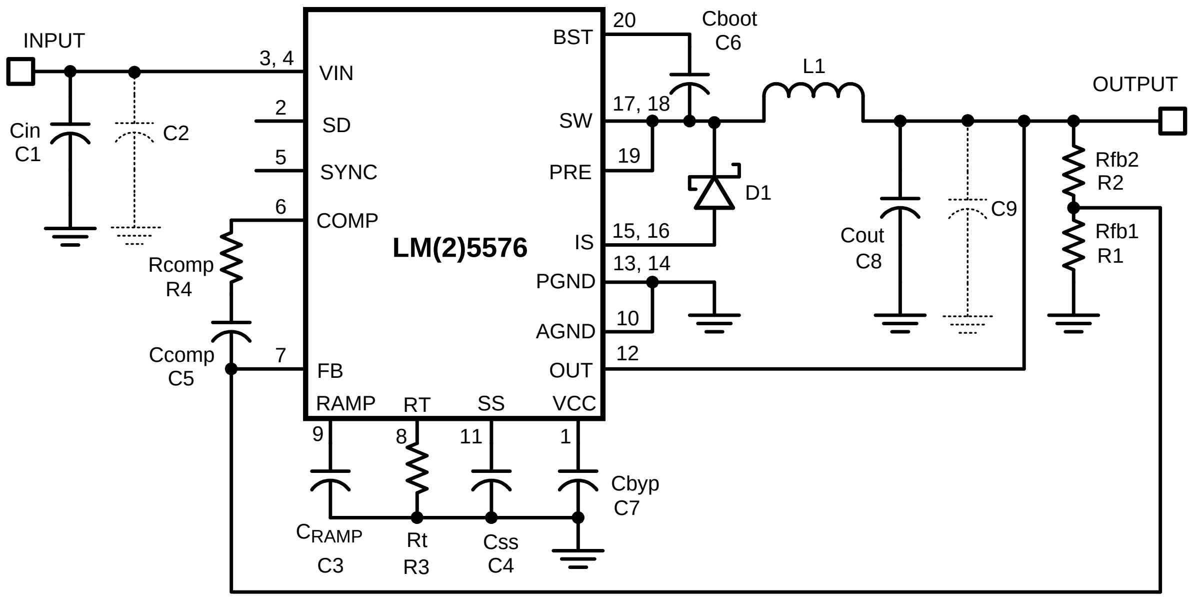

Figure 1. Application Schematic

2 Quick Guide Design Worksheet

Step 1. List the basic requirements:

Output Current: 0 to 3 Amp

Output Voltage:	________	V [1]
Input Voltage Min Spec:	________	V [2]
Input Voltage Max Spec:	________	V [3]

Step 2. If the Input Voltage Max Spec [3] is less than 42V use the LM25576. If the Input Voltage Max Spec [3] is greater than 42V but less than 75V use the LM5576. Both devices require the Input Voltage Min Spec [2] to be greater than 6V.

Selected Regulator:	________	[4]

Step 3. Selection of the operating frequency is a trade-off between the conversion efficiency and solution size. Operating at a high frequency, with a relatively high input voltage will severely impact the efficiency and consequently generate a lot of heat. In some applications, the selection of a high operating frequency will limit the input voltage range. The recommended maximum operating frequency for applications using LM5576 is 500 kHz. When using the LM25576 the operating frequency may be set as high as 1MHz. Select a target operating frequency from 50 kHz to 1MHz (500kHz for the LM5576). Check to see if the Vin(min) limits the selected operating frequency:

$$\text{Fsw(max)} = \frac{\text{Vin(min)[2]} - (\text{Vout[1]} + 0.6)}{\text{Vin(min)[2]} \times 5.5 \times 10^{-7}} \quad (1)$$

The selected operating frequency must be less than Fsw(max) calculated above, if not reduce the operating frequency. Check to see if the Vin(max) limits the selected operating frequency:

$$\text{Fsw(max)} = \frac{(\text{Vout[1]} + 0.6)}{\text{Vin(max)[3]} \times 8 \times 10^{-8}} \quad (2)$$

The selected operating frequency must be less than Fsw(max) calculated above, if not reduce the operating frequency.

Selected operating frequency Fsw:	________	Hz [5]

Step 4. Calculate the value of Rt for the selected operating frequency.

$$\text{Rt} = \frac{\frac{1}{\text{Fsw[5]}} - 580 \times 10^{-9}}{135 \times 10^{-12}} \quad (3)$$

Selected value for R1:	________	Ohms [6]

Step 5. Calculate the value of L1.

$$\text{L1} = \frac{\text{Vout[1]} \times (\text{Vin(max)[3]} - \text{Vout[1]})}{0.8 \times \text{Fsw[6]} \times \text{Vin(max)[3]}} \quad (4)$$

Select the nearest standard inductor value. During an overload condition the peak inductor current is limited to 4.5A nominal (5.1A maximum). The selected inductor must be rated for peak current of at least 5.1 Amps.

Selected value of L1:	________	Henrys [7]

Step 6. Calculate the value of C_{RAMP}:

$$C_{RAMP} = L1[7] \times 10^{-5} \quad (5)$$

Selected value of C_{RAMP}: ______________ Farads [8]

Step 7. Set Rfb2 to 5kOhms if Vout[1] is less than or equal to 5 Volts. If Vout[1] is greater than 5V set Rfb2 to 10K Ohms.

Selected value of Rfb2: ______________ Ohms [9]

Calculate the value of Rfb1:

$$Rfb1 = \frac{1.225 \times Rfb2[9]}{(Vout[1] - 1.225)} \quad (6)$$

Selected value of Rfb1: ______________ Ohms [10]

Step 8. Select the re-circulating diode, D1. A Schottky type diode is required for all applications. Ultra-fast diodes are not recommended and may result in damage to the IC due to reverse recovery current transients. The reverse breakdown rating should be greater than the Input Voltage Max Spec[3], plus some safety margin. For worst case design, assume a short circuit load condition. In this case the diode will carry the output current almost continuously. This current can be as high as 5.1A. Assuming a 0.6V drop across the diode, the maximum diode power dissipation can be as high as 3W. A DPAK or SMC case is recommended.

Selected diode part number: ______________ [11]

Step 9. A good quality input capacitor(s) is necessary to limit the ripple voltage at the VIN pin while supplying most of the switch current during the on-time. The minimum RMS ripple current rating for the input capacitor(s) is 1.5Amp. A quality ceramic capacitor(s) with a low ESR is recommended. The input capacitor voltage rating should be greater than the Input Voltage Max Spec [3], plus some safety margin. A guide to select the input capacitor(s) value in proportion to the operating frequency is:

$$Cin = \frac{1.5}{Fsw[5]} \quad (7)$$

Selected value for Cin: ______________ [12]
Farads:

Step 10. The output capacitor(s) smooth the inductor ripple current and provide a source of charge for transient loading conditions. A good starting point for the output capacitance is to parallel a ceramic capacitor (10 µF to 47 µF) and a low ESR organic or tantalum capacitor (22 µF to 220 µF). The ceramic capacitor provides ultra low ESR to reduce the output ripple voltage and noise spikes, while the larger bulk capacitor provides a source of charge for transient loading conditions. The output capacitor voltage rating should be greater than the Output Voltage Spec [1], plus some safety margin. An approximation for the output ripple voltage is:

$$\Delta Vout = 0.8 \times \left(ESR + \frac{1}{8 \times Fsw[5] \times Cout}\right) \quad (8)$$

Selected value for Cout: ______________ Farads [13]

Step 11. Ccomp and Rcomp configure the error amplifier gain characteristics to accomplish a stable overall loop gain. One advantage of current mode control is the ability to close the loop with only two feedback components. Calculate the value of Rcomp:

$$\text{Rcomp} = 6 \times 10^4 \times \text{Rfb1[9]} \times \text{Cout[13]} + \left(\frac{\text{Rfb1[9]}}{\text{Vout[1]}}\right) \quad (9)$$

Selected value of Rcomp: ____________ Ohms [14]

Calculate the value of Ccomp

$$\text{Ccomp} = \frac{1}{8 \times 10^3 \times \text{Rcomp[14]}} \quad (10)$$

Selected value of Ccomp: ____________ Farads [15]

Step 12. Shown in Table 1 is the Bill of Materials for your design. Transcribe each value [#] from worksheet above into the following table. Congratulations, you're done.

2.1 Bill of Materials

Table 1. Bill of Materials

SCH REF	PART NUMBER	DESCRIPTION	VALUE	WORK SHEET REF
C1 (Cin)		INPUT CAPACITOR		[12]
C2 (Cin)		OPTIONAL INPUT CAPACITOR		[12]
C3 (C_{RAMP})		RAMP CAPACITOR		[8]
C4 (Css)	C2012X7R2A103K	CAPACITOR, TDK	0.01µ, 100V	--
C5 (Ccomp)		COMPENSATION CAP		[15]
C6 (Cboot)	C2012X7R2A223K	CAPACITOR, TDK	0.047µ, 100V	--
C7 (Cbyp)	C2012X7R1C474M	CAPACITOR, TDK	0.47µ, 16V	--
C8 (Cout)		OUTPUT CAPACITOR		[13]
C9 (Cout)		OPTIONAL OUTPUT CAPACITOR		[13]
D1		SCHOTTKY DIODE		[11]
L1		INDUCTOR		[7]
R1 (Rfb1)		Feedback RESISTOR		[10]
R2 (Rfb2)		Feedback RESISTOR		[9]
R3 (Rt)		TIMING RESISTOR		[6]
R4 (Rcomp)		COMPENSATION RESISTOR		[14]
U1		REGULATOR, TI		[4]

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