

Selecting a Boost Regulator and Its Inductor

Application Note

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ABSTRACT

This application note will assist with the proper selection of a boost regulator with integrated switches and its inductor for a given application. The first section of this application note starts with a rule of thumb calculation to help select a boost regulator quickly. The second section addresses the inductor selection process. Finally, the selection results are compared to a simulation based on the same design criteria.

Figure 1 shows the boost converter topology. The red arrows indicate the current flow in the system during the different stages of operation.

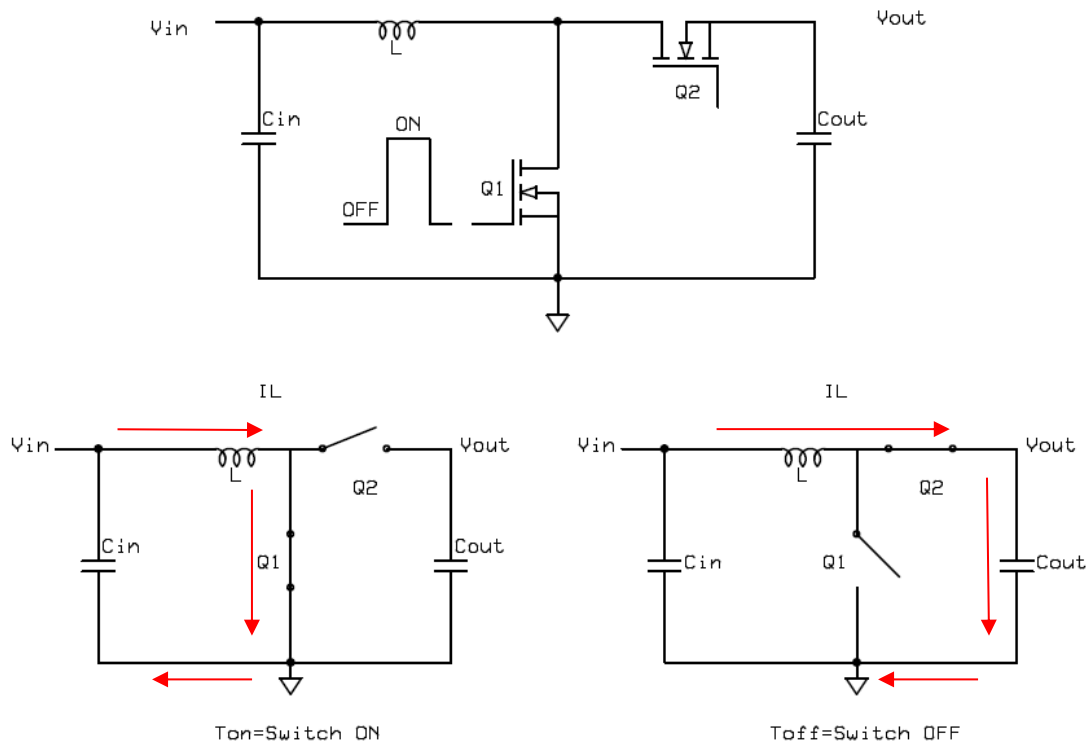


Figure 1: Synchronous Boost Regulator and Its Current Flow

BOOST REGULATOR SELECTION

The biggest problem that occurs when selecting a boost regulator is in the definition of the output current capability. Typically, a current is stated in the title and/or bullet points of the boost regulator datasheets, such as in the datasheet of the [MP3422](#) (see Figure 2).

MP3422

6.5A, 600kHz High Efficiency, Synchronous Step-Up Converter with Output Disconnect in 2x2mm QFN Package

Figure 2: [MP3422](#) Datasheet Title

Based on this information, one might think that this device can deliver up to 6.5A of output current, but this is incorrect. The reason for this incorrect determination is that in a buck regulator, the specified output current is equal to the switch current of the device. In a boost regulator, this is not the case. For boost regulators, the listed switch current is on the input rather than the output of the regulator (see Figure 1). Therefore, when selecting a boost regulator, one must consider the conversion ratio before making a decision. Note that the listed current is typically stated as the peak inductor current and not the average current. The peak current can be approximately calculated with Equation (1):

$$I_{peak} = \left(\frac{V_{out} \cdot I_{out}}{V_{inmin}} \right) \cdot 1.4 \quad (1)$$

Where I_{peak} is the peak inductor current, V_{out} is the output voltage, I_{out} is the maximum output current, and V_{inmin} is the minimum input voltage.

A multiplier of 1.4 is used to compensate for the peak inductor current based on a 30% ripple current and any efficiency loss. This first calculation is a way to narrow down the options of boost regulators based on the switch current limit of the part. Remember that the input and output voltages also must be considered in the selection process.

If more data is available, the accuracy of Equation (1) can be improved by approximating the efficiency of the regulator based on data that already exists in the datasheet. Even if the data is not exact, the approximation of the inductor current can still be improved. In this approach, it is better to err on the lower side of efficiency. The constant of 1.15 assumes a ripple current of 30% in the inductor.

When using efficiency, calculate the peak inductor current with Equation (2):

$$I_{peak} = \left(\frac{V_{out} \cdot I_{out}}{V_{inmin} \cdot n} \right) \cdot 1.15 \quad (2)$$

Where I_{peak} is the peak inductor current, V_{out} is the output voltage, I_{out} is the maximum output current, V_{inmin} is the minimum input voltage, and n is the efficiency approximated based on previous data.

At this point, the selection can be narrowed down based on the required switch current limit of the boost regulator.

INDUCTOR SELECTION

Once the proper boost regulator is selected, the next step is to calculate the inductor value, which can be done with Equation (3):

$$L = \frac{V_{in} \times (V_{out} - V_{in})}{\Delta I_L \times f_s \times V_{out}} \quad (3)$$

Where L is the inductor inductance, V_{in} is the input voltage, V_{out} is the output voltage, ΔI_L is the inductor ripple current, and f_s is switching frequency.

There are two unknowns in Equation (3): the inductor value (L) and the inductor ripple current (ΔI_L). To begin the inductor calculation, we can use another rule of thumb for ΔI_L . This value is chosen between 20% and 40% of the average inductor current (I_{ave}), typically. A larger inductor ripple current allows for a smaller inductor value and a smaller physical inductor size. A lower inductor ripple current can increase the output power capability of the boost but also increases the inductor size. Note that the switching frequency has a direct impact on the inductor value. Typically, the higher the switching frequency, the smaller the inductor value, which in turn decreases the overall inductor size. The drawback of a higher switching frequency is that the efficiency of the regulator suffers due to higher switching losses.

To find the value of ΔI_L , calculate the average inductor current with Equation (4):

$$I_{ave} = \left(\frac{V_{out} \cdot I_{out}}{V_{inmin} \cdot n} \right) \quad (4)$$

Where I_{ave} is the average inductor current, V_{out} is the output voltage, I_{out} is the maximum output current, V_{inmin} is the minimum input voltage, and n is the efficiency approximated based previous data

Once the average inductor current is known, calculate ΔI_L using Equation (5):

$$\Delta I_L = I_{ave} \cdot \%ripple \quad (5)$$

Now ΔI_L can be substituted into Equation (3) to calculate the inductor's inductance. As a rule, the inductor current rating is set by the maximum switch current limit of the boost regulator. This prevents the inductor from saturating under fault conditions and possibly damaging the boost regulator.

In cases where the inductor value chosen is significantly lower than the calculated value of the inductor, recalculate the peak current in the design. To do this, insert the chosen inductor value into Equation (3) to calculate ΔI_L and back-calculate the value of I_{peak} to ensure that the current limit of the device will not be tripped.

It is always advised to perform a more thorough investigation by either simulation or bench testing. MPS offers design tools, such as DC/DC Designer and MPSmart, which can be downloaded from the MPS website (see Appendix A).

EXAMPLE CALCULATIONS

Assume an application requires an input voltage range of 2.5V to 4.2V with a maximum output current of 2A at 5V_{OUT}.

The [MP3422](#) can be used for this application. Its V_{IN} operating range is 1.8 - 5.5V and has an output voltage range of 2.5 - 5.5V. The switch current limit listed in the datasheet is 6.5A.

If no efficiency curve is used, the peak current limit can be calculated by plugging the above values into Equation (1):

$$I_{peak} = \left(\frac{5V \cdot 2A}{2.5V} \right) \cdot 1.4 = 5.6A \quad (1)$$

For Equation (2), approximate the efficiency of the converter based on existing efficiency curves in the datasheet. There is no exact efficiency curve for 2.5 to 5V_{IN}, but based on the graph shown in Figure 3, an efficiency of about 92% can be assumed.

The peak current limit can be calculated by plugging these values into Equation (2):

$$I_{peak} = \left(\frac{5V \cdot 2A}{2.5V \cdot 0.92} \right) \cdot 1.15 = 5A \quad (2)$$

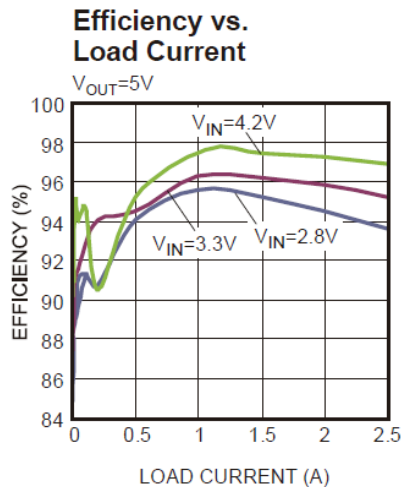


Figure 3: Efficiency Curve of the [MP3422](#)

Based on the above calculations, the approximate value of I_{peak} is 5.6A and 5A, respectively. The listed switch current limit for the [MP3422](#) is 6.5A, so the [MP3422](#) should be able to deliver the desired output power level.

Inductor Calculations

Calculate the average inductor current with Equation (4):

$$I_{ave} = \frac{5V \cdot 2V}{2.5V \cdot 0.92} = 4.34A \quad (4)$$

Then take the value from Equation (4) and insert it into Equation (5):

$$\Delta I_L = 4.34A \cdot .3 = 1.3A \quad (5)$$

Now calculate the inductance by substituting ΔI_L into Equation (3):

$$L = \frac{2.5 \times (5V - 2.5V)}{1.3A \times 600Khz \times 5V} = 1.64\mu H \tag{3}$$

For the [MP3422](#), the switching frequency is fixed at 600kHz. As noted earlier, if the boost has a frequency set pin, try different values for the frequency to optimize the inductor size based on earlier assumptions. A good inductor choice for this application is a 1.6μH inductor with a minimum current rating of 6.5A.

For a comparisons of results, the MPS DC/DC Designer was used for the simulations of this example (see Figure 4 and Figure 5).

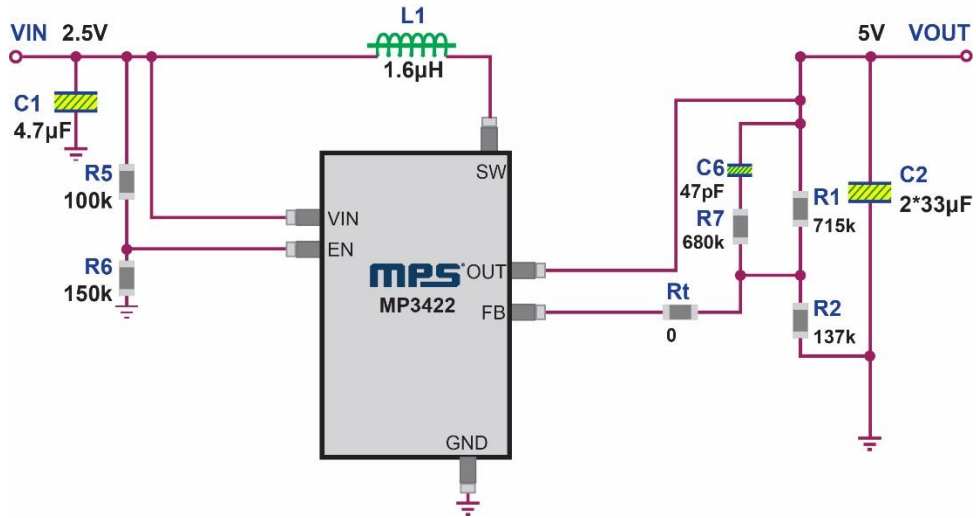


Figure 4: Simulation Schematic

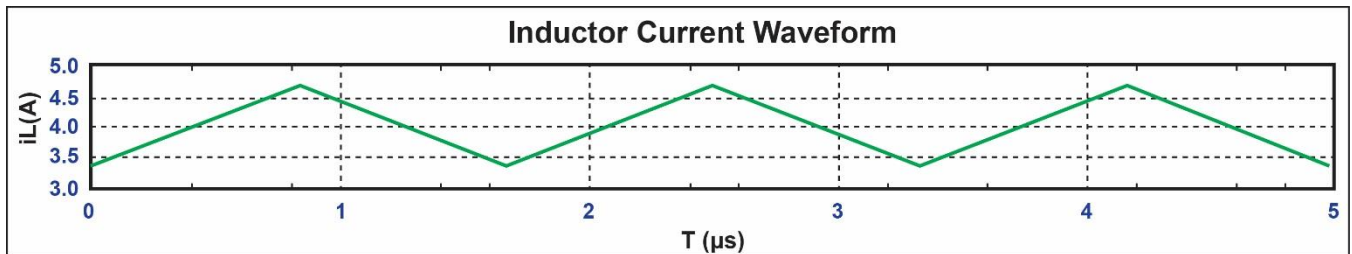


Figure 5: Inductor Current Waveform

In conclusion, when choosing a boost regulator, the options must be considered carefully. Based on the results in Figure 5, a peak current of 4.75A at 2.5V_{IN} is required for 10W of output power. In the datasheet, the part’s description is for a 6.5A boost regulator, but now it can be seen that the output current delivered is much less than what is stated.

MPS offers a great selection of highly integrated, synchronous, boost regulators. Depending on the desired needs, MPS can offer a micro power boost that operates from an input of 0.6V to power devices from a single-cell alkaline battery to a high-power, fully synchronous boost that can deliver tens of watts of output power to the load. To find out more about MPS’s boost offerings, please visit our website at www.monolithicpower.com.

APPENDIX A

Please visit the following links to download or learn more about MPS's design and support tools.

Support Tools

<http://www.monolithicpower.com/Design-Support/Design-Tools-Overview>

MPS DC/DC Designer

<http://www.monolithicpower.com/Design-Support/DC-DC-Designer>

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