DESIGN NOTE

Selecting the Right Power Inductor for DC/DC Converters

INTRODUCTION

Buck and boost converters (Figure 1 and Figure 2) are common forms of DC/DC converters used in a wide variety of consumer automotive and industrial applications. Bourns® PQ Series power inductors are ideally suited for DC/DC converters operating at powers greater than 100 W. This Design Note provides a guide to selecting the right power inductor by providing design rules and key inductor values as well as the equations needed to determine peak and RMS currents.

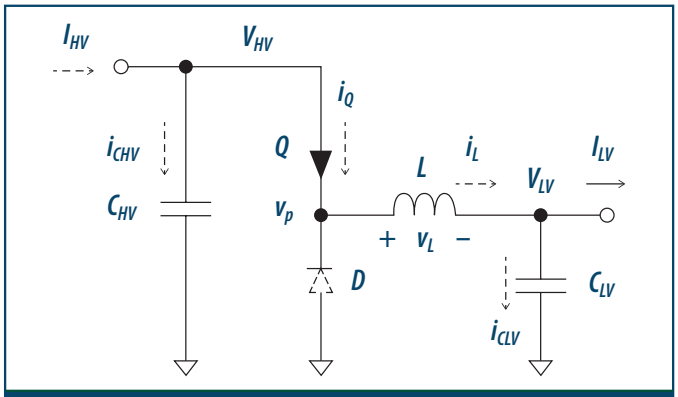

Figure 1 : Buck Converter

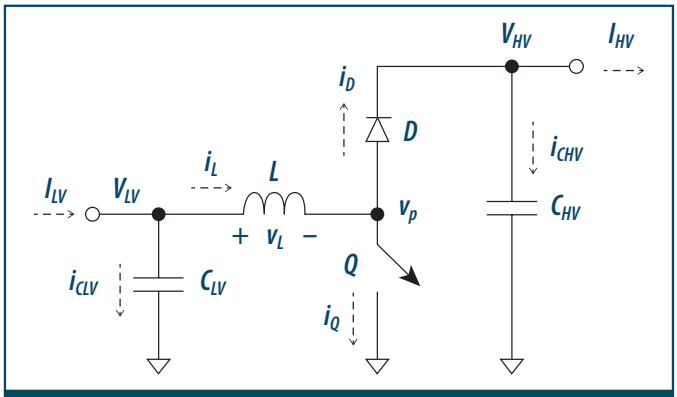

Figure 2 : Boost Converter

KEY PARAMETERS REQUIRED

The following questions need to be answered in order to calculate the correct inductor value:

1. Operating frequency F_{sw} (kHz)
2. Output Power (watts)
3. Input and Output Voltages (volts)
4. Ripple Current in Inductor ΔI_{pp} (amps)
5. Operating Mode (CCM, BCM, DCM)

DESIGN STEPS

The calculations and steps below are necessary to determine the inductor that best meets the application requirements.

1. Calculate Average Current I_{out} (amps)
2. Calculate Duty Cycle D (Equations 1, 2, 8, 10)
3. Calculate the Inductance Value (µH) (Equations 3, 9)
4. Calculate Inductor Max. Current (Amps) (Equations 4, 5)
5. Calculate Inductor RMS Current (Amps) (Equations 6,7)
6. Search for Suitable Inductor with Correct Inductance, I_{sat} and RMS Currents

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BUCK CONVERTER DESIGN EXAMPLE

The following inductor characteristics are typically required for a buck converter:

1. F_{sw} = 200 kHz
2. Power = 264 watts
3. V_{in} = 48 V_{dc} , V_{out} = 12 V_{dc}
4. Ripple Current Δ I_{pp} = 50 A
5. Operating Mode = DCM (DCM2 = 0.1)

CALCULATING A SOLUTION

Design Steps 1 through 6 are shown in Table 1 with the provided equations:

Calculate Average Current I_{out}	$I_{out} = \frac{264}{12} = 22$ A			
Calculate Duty Cycle D (Equations 1, 2, 8, 10)	$D = \frac{12}{48(1 - 0.1)} = 0.3125$			
	$Dcm1 = 1 - 0.3125 - 0.1 = 0.587$			
Calculate the Inductance Value (Equations 3, 9)	$L = \frac{(48 - 12) * 0.3125}{(50 * 200{,}000)} = 1.1\ \mu H$			
Calculate Inductor Max. Current (Equations 4, 5)	$I_{max} = 50$ A			
Calculate Inductor RMS current (Equations 6,7)	$I_{rms} = 50\sqrt{\frac{0.3125 + 0.587}{3}} = 27.37$ A			
The Optimum Power Inductor that Meets Inductance, I_{sat} and RMS Current Requirements	Part Number	Inductance	RMS Current	Peak Current (I_{sat})
	PQ2614BLA-1R5K	1.5 µH	30.0 A	100 A

Table 1

Selecting the Right Power Inductor for DC/DC Converters

BOURNS® PQ SERIES POWER INDUCTORS

Bourns designed the following features into the PQ Series power inductors to deliver considerable application benefits for high-power buck and boost converters.

Features	Benefits
Coil Made with Stamped Flat Wire	Low DC and AC Resistance
High Frequency Ferrite Core	• Low Core Losses at High Frequency • High Permeability Material Requiring Fewer Turns than Iron Powder which means lower DC resistance
Automated Production Line	High Quality
Available for Selection in LTpowerCAD®	Recognized by Leading Power Vendors

SUMMARY OF EQUATIONS AND WAVEFORMS

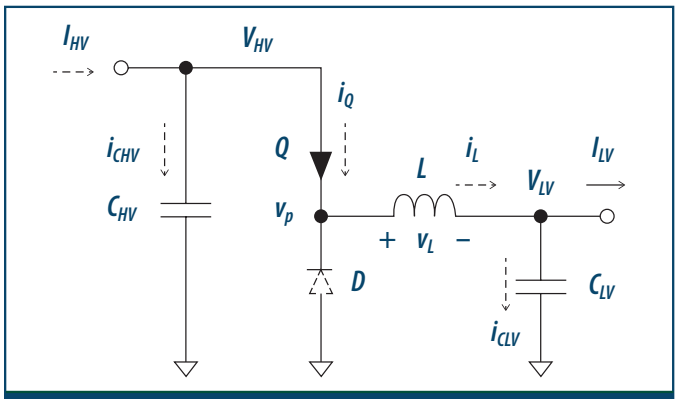

Figure 1 : Buck Converter

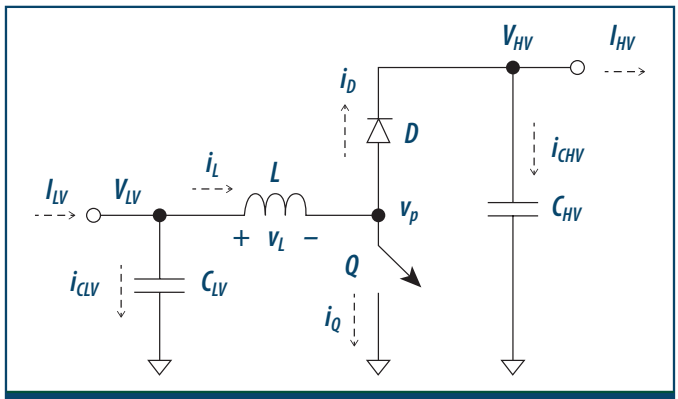

Figure 2 : Boost Converter

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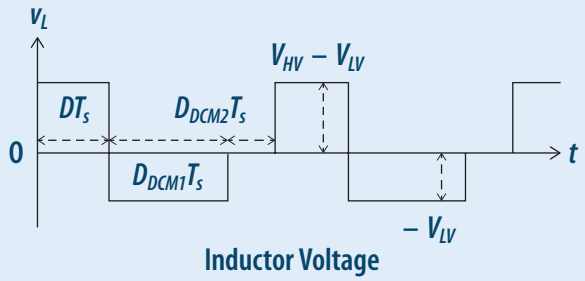
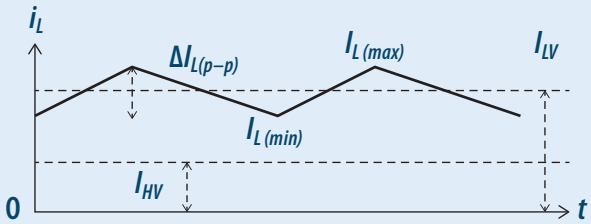
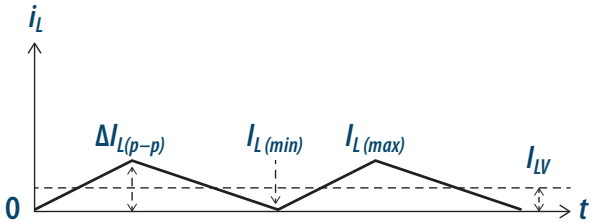
SUMMARY OF EQUATIONS AND WAVEFORMS (CONTINUED)

Reference	Equation	Description	Waveform (if applicable)
1	$D = \frac{V_{out}}{V_{in}}$	Duty Cycle Buck in CCM and BCM	
2	$D = \frac{V_{out}}{V_{in}(1 - Dcm2)}$	Duty Cycle Buck in DCM	 Inductor Voltage
3	$L = \frac{(V_{in} - V_{out}) * D}{F_{sw} * \Delta I}$	Inductance	
4	$I_{Lmax} = I_o + \frac{\Delta I}{2}$	Max. Current CCM	 Inductor Current
5	$I_{Lmax} = \Delta I$	Max. Current CCM and DCM	 Inductor Current

Selecting the Right Power Inductor for DC/DC Converters

SUMMARY OF EQUATIONS AND WAVEFORMS (CONTINUED)

Reference	Equation	Description	Waveform (if applicable)
6	$I_{Lrms} = \sqrt{I_{o^2} + \frac{\Delta I^2}{12}}$	RMS Current CCM and BCM	
7	$I_{Lrms} = \Delta I \sqrt{\frac{D + Dcm1}{3}}$	RMS Current Buck DCM and Boost DCM	
8	$D = 1 - \frac{V_{in}}{V_{out}}$	Duty Cycle Boost Converter	
9	$L = \frac{V_{in} D}{F_{sw} \Delta I}$	Inductance Boost Converter	
10	$Dcm2 = 1 - \frac{V_{out} D}{V_{out} - V_{in}}$	DCM Duty Cycle	

BOURNS®

Americas: *Tel* +1-951 781-5500
Email americus@bourns.com

EMEA: *Tel* +36 88 885 877
Email eurocus@bourns.com

Asia-Pacific: *Tel* +886-2 256 241 17
Email asiacus@bourns.com