Keywords: high current, buck converter, DCR current sense

REFERENCE DESIGN 4375 INCLUDES: √Tested Circuit √Schematic √BOM √Board Available √Description √Test Data

Reference Design for a High-Current Power Supply with Lossless Current Sensing Using the MAX5060

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Abstract: This reference design shows how to use a MAX5060 current-mode, step-down power-supply controller to implement lossless current sensing for high-current applications. In this design, the series resistance (DCR) of the inductor is used for current sensing to avoid power loss in the current-sense resistor.

Introduction

Today's data processing elements demand higher currents from power supplies to achieve higher speed. Lossless current sensing and ground bouncing are key challenges for accurate control of output voltage and current in these applications.

The MAX5060 PWM buck power-supply controller uses an average-current-mode control technique to track the load current, and it employs differential sensing to accurately control the output voltage. In this reference design, the series resistance (DCR) of the inductor is used for current sensing to avoid power loss in the current-sense resistor.

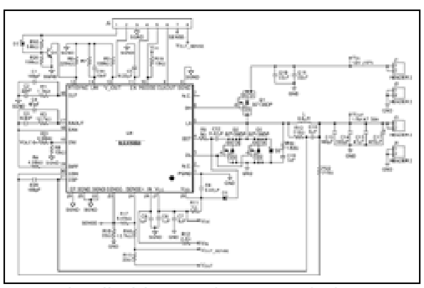
This design shows a solution for implementing a high-current (30A) power supply with high system efficiency and good load regulation. The complete schematic, bill of materials (BOM), efficiency measurements, and test results are included below.

Specifications and Design Setup

This reference design achieves the following specifications.

- Input voltage: 12V ±10%
- Output voltage: 1.5V
- Output current: 30A
- Output ripple: ±15mV
- Input ripple: ±250mV
- Efficiency: > 88% with half of full load (15A)
- Switching frequency: 275kHz
- Footprint size: 5cm × 3.3cm

The schematic for this reference design is shown in **Figure 1**, and the BOM is given in **Table 1**. In this design, the MAX5060 is used in a buck configuration.



More detailed image (PDF, 100kB)
Figure 1. Schematic of the MAX5060 buck converter for F_{SW} = 275kHz.

Table 1. Bill of Materials

Designator	Description	Comment	Footprint	Manufacturer	Quantity	Value
C1, C20	Capacitor	GRM1555C1H101JZ01D	402	Murata	2	100pF
C2	Capacitor	GRM155R71E223KA61D	402	Murata	1	22nF
C3	Capacitor	GRM155R71H682KA88D	402	Murata	1	6.8nF
C4	Capacitor	GRM1555C1H470JZ01D	402	Murata	1	47pF
C5	Capacitor	GRM155R61A224KE19D	402	Murata	1	0.22µF
C6, C12	Capacitor	GRM155R61A474KE15D	402	Murata	2	0.47µF
C7, C8, C9, C18	Capacitor	GRM188R71A105KA61D	402	Murata	4	1µF
C10, C11	Capacitor	GRM32ER71C226KE18L	1210	Murata	2	22µF/16V
C13, C14	Capacitor	GRM32ER60J107ME20L	1210	Murata	1	100µF/6.3V
C15	Capacitor	GRM31CR60J476KE19L	1206	Murata	1	47µF
C16	Capacitor	GRM155R71H103KA88D	402	Murata	1	10nF
C17	SP Capacitor	EEFSX0D471E4	7.3mm x 4.3mm SP CAP	Panasonic	1	470µF/2V
C19	Capacitor	GRM155R71H102KA01D	402	Murata	1	1nF
D1	Schottky Diode	CMHSH5-2L	SOD-123	Central Semiconductor	1	20V, 500mA Schottky
D2	Schottky Diode	UPS835LE3	POWERMITE3	Microsemi	1	35V, 8A Schottky Rectifier
L	Inductor	T5060 (0.6µH)	T5060_Falco_Inductor	Falco	1	0.6µH
Q1	N-Channel MOSFET	Si7136DP	PowerPAK SO8	Vishay	1	20V, 30A nMOSFET
Q2, Q3	N-Channel MOSFET	Si7866DP	PowerPAK SO8	Vishay	2	20V, 40A nMOSFET
Q4	NPN Transistor	CMUT2222A	SOT-523	Central Semiconductor	1	75V, 600mA NPN
R1	Resistor	Res1	402	Multisource	1	1.7kΩ
R3, R16	Resistor	Res1	402	Multisource	2	12.7kΩ
R4, R21	Resistor	Res1	402	Multisource	2	4.99kΩ
R5, R20	Resistor	Res1	402	Multisource	2	100kΩ
R6	Resistor	Res1	402	Multisource	1	226kΩ
R7	Resistor	Res1	402	Multisource	1	Open
R8, R19	Resistor	Res1	402	Multisource	2	10kΩ
R9	Resistor	Res1	402	Multisource	1	0
R10	Resistor	Res1	402	Multisource	1	5.6kΩ
R11	Resistor	Res1	402	Multisource	1	1Ω
R12	Resistor	Res1	402	Multisource	1	2.2Ω
R13, R22	Resistor	Res1	402	Multisource	2	715Ω
R14	Resistor	Res1	402	Multisource	1	1.82Ω
R15, R18	Resistor	Res1	402	Multisource	2	22Ω
R17	Resistor	Res1	402	Multisource	1	8.45kΩ
U1	**PWM Controller**	**MAX5060**	**28-TQFN-EP**	**Maxim**	**1**	**—**

Efficiency Plots

Figure 2 provides a plot of efficiency versus load current plots for this design, and **Figure 3** presents load-regulation data.

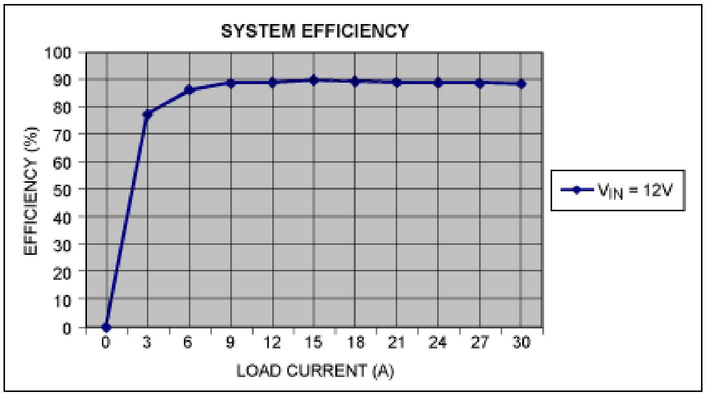


Figure 2. Load current versus converter efficiency for V_{IN} = 12V.

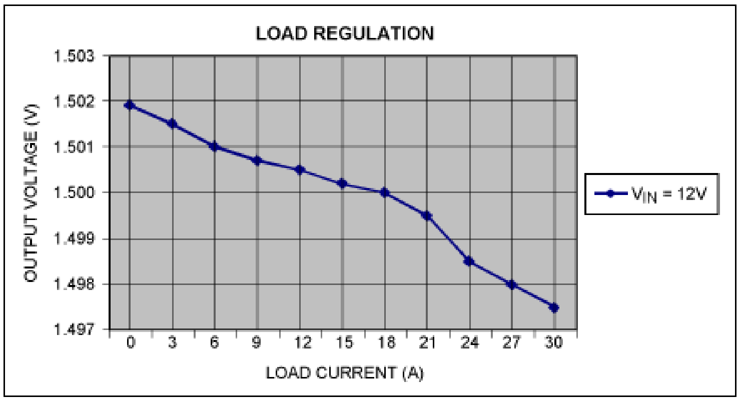


Figure 3. Load current versus converter output voltage for V_{IN} = 12V.

Experimental Results

Converter output voltage and load current are shown in **Figures 4**–**7** for different input excitations.

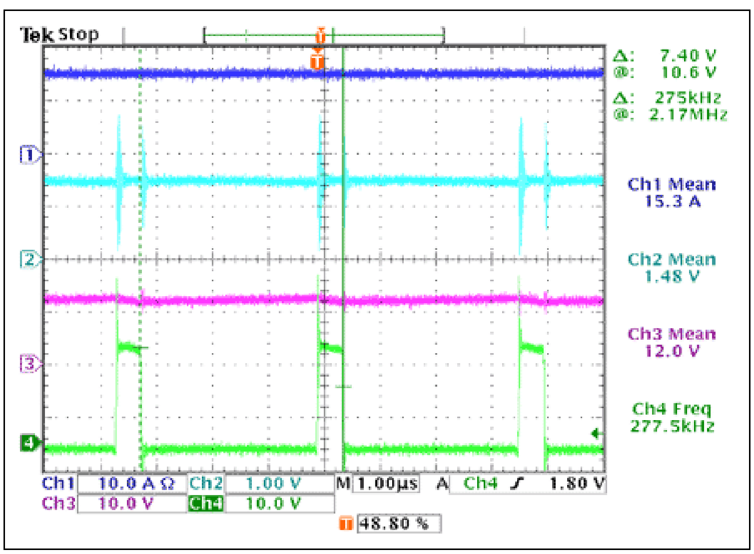


Figure 4. Converter waveforms with V_{IN} = 12V and I_{OUT} = 30A.
V_{IN} = 12V and I_{OUT} = 2 × 15A
Ch1: Output current (2x)
Ch2: Output voltage
Ch3: Input voltage

Ch4: High-side MOSFET gate drive

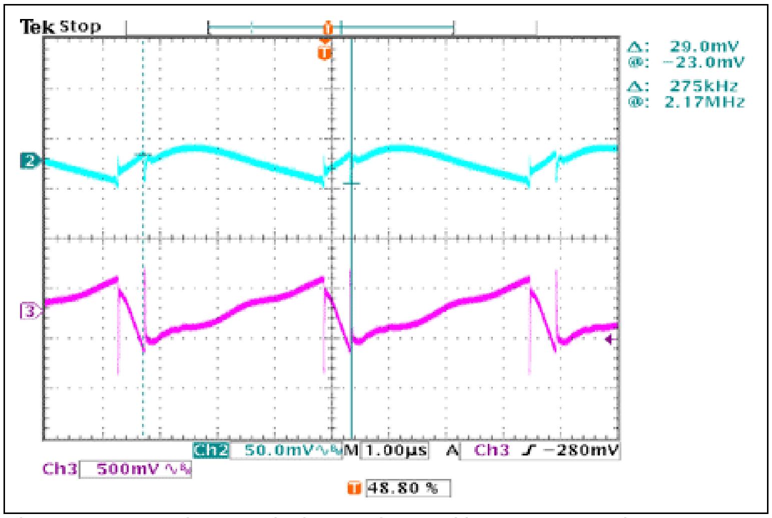


Figure 5. Input and output ripple waveforms with V_{IN} = 12V and I_{OUT} = 30A.
V_{IN} = 12V and I_{OUT} = 2 × 15A
Ch2: Output voltage ripple
Ch3: Input voltage ripple

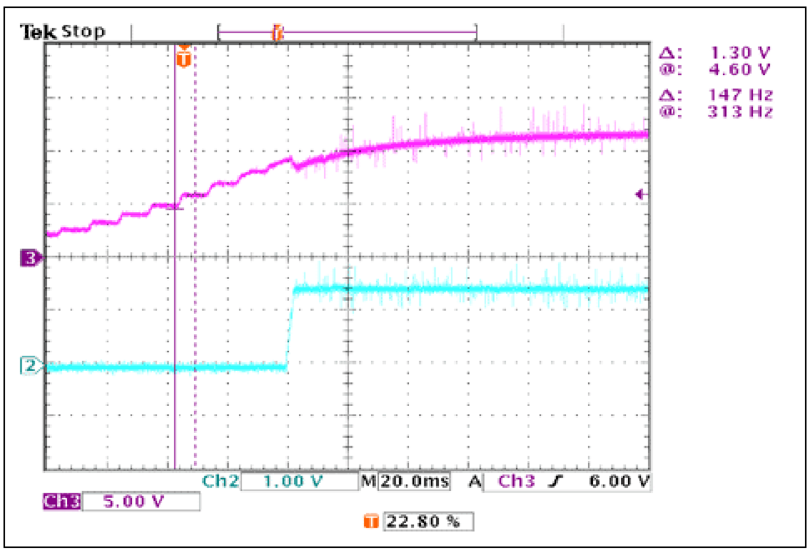


Figure 6. Line transient response.
V_{IN} = 0 to 12V and I_{OUT} = 2 × 15A
Ch2: Output voltage
Ch3: Input voltage

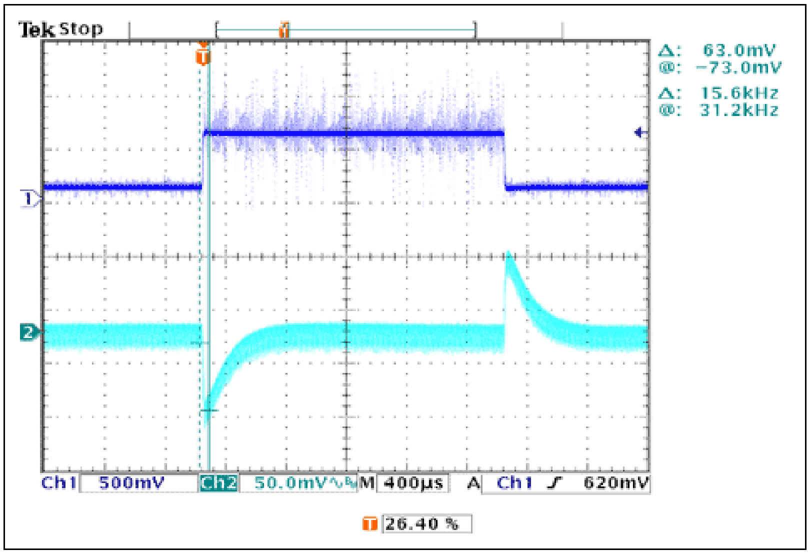
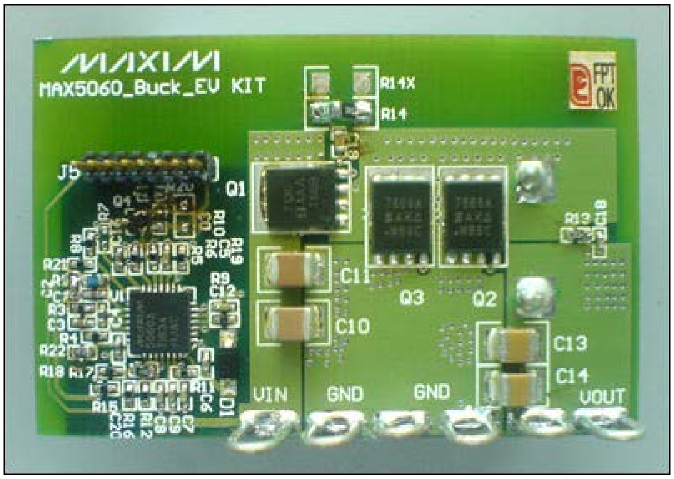


Figure 7. Load transient response.
V_{IN} = 12V and I_{OUT} = 1A to 7A
Ch1: Output current transient (1A to 7A)
Ch2: Output voltage ripple

The board developed for this application is shown in **Figure 8**.



More detailed image (PDF, 16kB)
Figure 8. Four-layer MAX5060 buck board.

Related Parts		
MAX5060	0.6V to 5.5V Output, Parallelable, Average-Current-Mode DC-DC Controllers	Free Samples

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Application Note 4375: http://www.maximintegrated.com/an4375
REFERENCE DESIGN 4375, AN4375, AN 4375, APP4375, Appnote4375, Appnote 4375