Reference Design Cookbook II

Power Management Products

2Q 2006

→ *Welcome to TI Power Management's Second in a Series of Reference Design Cookbooks*

Welcome to TI's latest Power Management Cookbook! Based on popular demand and distribution of over 20,000 copies of the first *Reference Design Cookbook*, we are happy to bring you Issue 2. This is a collection of complete power solutions and design documentation from TI's extensive library of reference designs and evaluation modules (EVMs) available to our customers. It includes input from Robert Kollman, his Design Services team and TI Applications Engineers.

TI has hundreds of other reference designs that may be found at: **www.ti.com/powerreferencedesigns.** If you want to view more of these, please check this website. It is frequently updated with new circuits. If you would like to access the first issue of the Cookbook from 2005, please download at the URL referenced above, or request a copy by calling; **972-644-5580 and mention Lit #: SLUB009**.

TI hopes you enjoy these "recipes", and that this Cookbook will help simplify and streamline your power supply designs.

→ *Device Quick Search Tool*

Device Quick Search

Either Nominal OR both Min and Max is Required

device quick search

Input	Output 1
*Nominal Vin (V)	Vout (V) Iout (A)

OR

*Min Vin (V) *Max Vin (V)	Output 2
	Vout (V) Iout (A)

☐ Search for devices with more than two outputs

☐ Search for isolated solutions

Search

Check out TI's Power Quick Search Tool for recommended power solutions across DC/DC Conversion and PWM Controller products based on user input criteria.

power.ti.com

Inside   ←

TI has many other reference designs that may be found at:

www.ti.com/powerreferencedesigns

Synchronous Boost Converter for Battery-Powered Applications

Description

The TPS6102x family of synchronous boost converters provides a solution for products powered by either a one-cell, two-cell, or three-cell alkaline, NiCd or NiMH, or one-cell Li-Ion or Li-Polymer battery. Output currents can go as high as 200 mA while using a single-cell alkaline discharged down to 0.9 V. It can also be used for generating 5 V at 500 mA from a 3.3-V rail or Li-Ion battery. The boost converter is based on a fixed frequency, pulse-width-modulation (PWM) controller using a synchronous rectifier to obtain maximum efficiency. At low load currents the converter enters the Power Save Mode to maintain high efficiency over a wide load current range.

The TPS6102x devices keep the output voltage regulated even when the input voltage exceeds the nominal output voltage. The output voltage can be programmed by an external resistor divider, or is fixed internally on the chip. The converter can be disabled to minimize battery drain. During shutdown, the load is completely disconnected from the battery.

Web Links:
Reference Designs:
www.ti.com/powerreferencedesigns

Datasheets, User's Guides, Samples, Software:
www.ti.com
Part Number Search: **TPS61020**

| Specifications					
Parameter	Test Conditions	Min	Typ	Max	Unit
Input Voltage		0.9		6.5	V
Output Voltage		1.8		5.5	V
Output Current			500		mA
Output Ripple Voltage	V_{IN} = 1.2 V; I_O = 100 mA; PWM Mode		16		mV_{PP}
	V_{IN} = 1.2 V; I_O = 10 mA; PFM Mode		18		mV_{PP}
Efficiency	V_{IN} = 3.0 V; I_O = 250 mA		96		%
	V_{IN} = 1.4 V; I_O = 300 mA		85		%

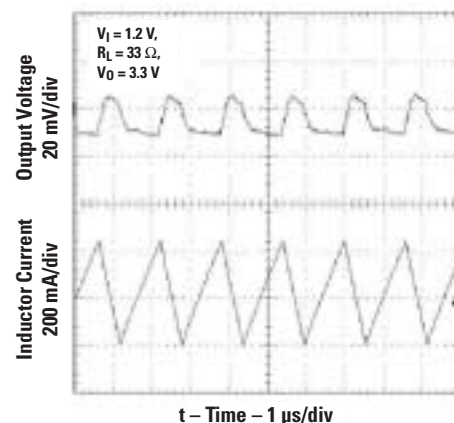### Evaluation Module TPS61020EVM
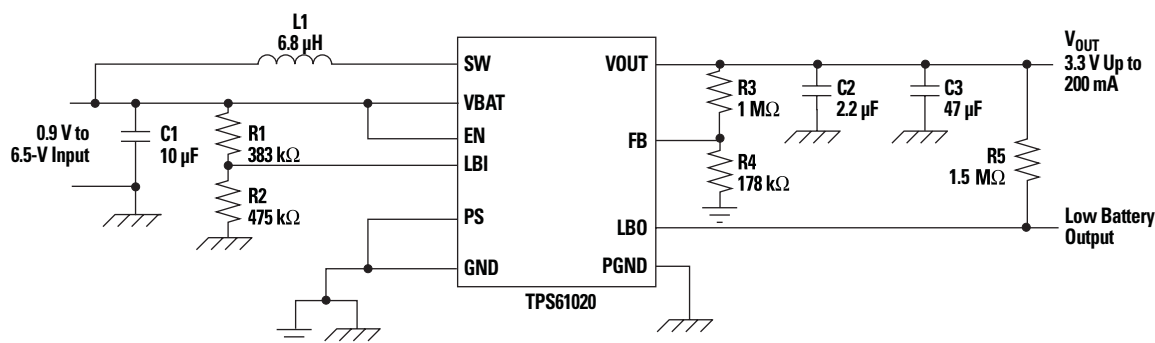
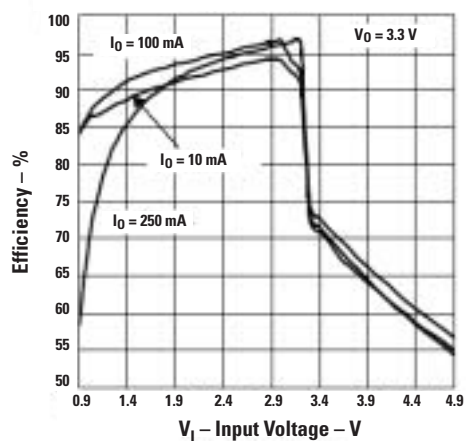## *Synchronous Boost Converter for Battery-Powered Applications*
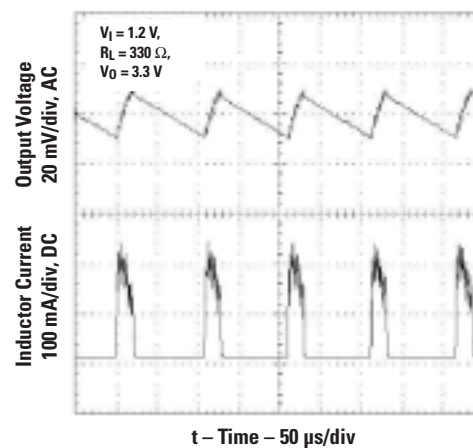
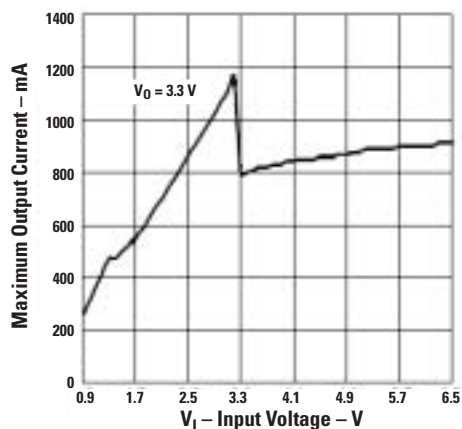Efficiency vs. Output Current
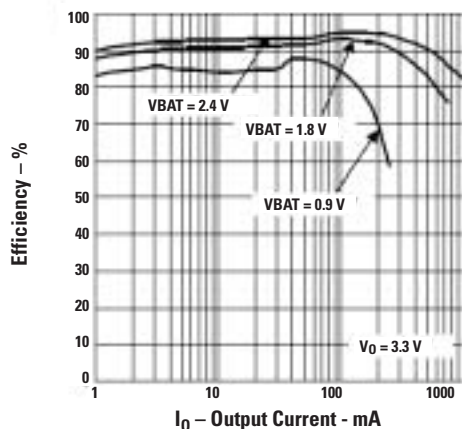
Output Voltage in Continuous Mode

Efficiency vs. Input Voltage

Output Voltage in Power Save Mode

Maximum Output Current vs. Input Voltage

Load Transient Response

Reference Design Cookbook II for Power Management Products

1.5-A Synchronous Buck Converter with Light Load Efficiency

Description
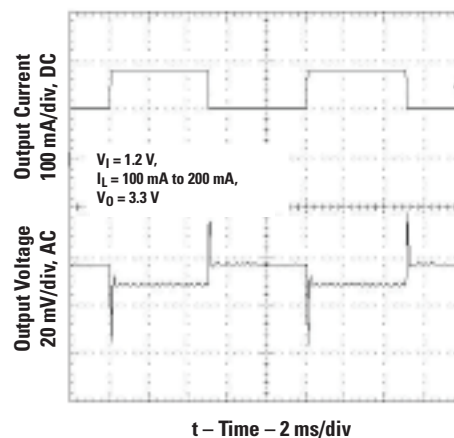
The TPS6211x family of synchronous buck converters with integrated FETs can provide up to 1.5 A of output current from inputs as low as 6 V. The circuit below uses the TPS62111 fixed output voltage option configured to provide 3.3 V and up to 1500 mA with a 6.8-µH inductor and 22-µF output capacitor. The TPS6211x achieves high efficiency over the entire load current range by switching from traditional pulse width modulation (PWM) at high load to pulsed frequency modulation (PFM) or Power Save Mode at light load.
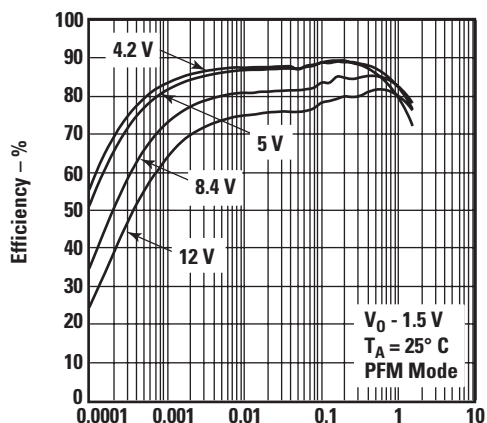
Web Links:

Reference Designs:
www.ti.com/powerreferencedesigns

Datasheets, User's Guides, Samples, Software:
www.ti.com
Part Number Search: **TPS62111**

Specifications					
Parameter	Test Conditions	Min	Typ	Max	Unit
Input Voltage		3.8		17	V
Output Voltage		3.201	3.3	3.399	V
Load Current	$3.8\ V < V_{IN} < 4.3\ V$	0		500	mA
	$4.3\ V < V_{IN} < 6.0\ V$	0		1200	mA
	$6.0\ V < V_{IN} < 17\ V$	0		1500	mA
Output Ripple Voltage	$V_{IN} = 8.4\ V;\ I_O = 100\ mA$		25	40	mV_{PP}
	$V_{IN} = 8.4\ V;\ I_O = 1500\ mA$		5	10	mV_{PP}
Efficiency	$V_{IN} = 8.4\ V;\ I_O = 1\ mA$		83		%
	$V_{IN} = 8.4\ V;\ I_O = 750\ mA$		90		%

Evaluation Module TPS62110EVM-001

1.5-A Synchronous Buck Converter with Light Load Efficiency

Efficiency vs. Output Current

Efficiency – %

V_O - 1.5 V
T_A = 25° C
PFM Mode

4.2 V
5 V
8.4 V
12 V

Load Transient

V_I = 8.4 V
V_O = 3.3 V
I_{LOAD} = 150 mA to 1350 mA
T_A = 25° C

V_O = 50 mV/div

I_O = 500 mA/div

t – Time = 20 µs/div

Line Transient

C1 = 5 V/div

C2 = 50 mV/div

V_I = 7.2 V to 12 V
V_O = 3.3 V
I_{LOAD} - 800 mA
T_A - 25° C

t –Time = 2 ms/div

Output Ripple

V_1 = 8.4 V, V_O = 3.3 V I_{LOAD} = 100 mA, T_A = 25° C

CH1 = 20 mV/div

CH2 = 5 V/div

CH4 = 200 mA/div

t – Time= 5 µs/div
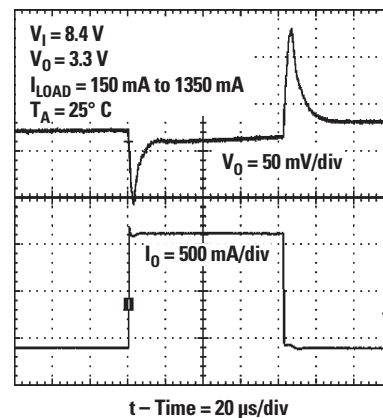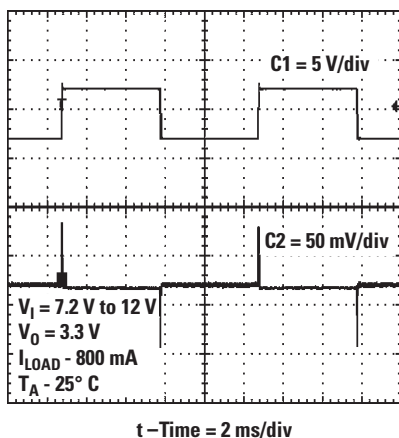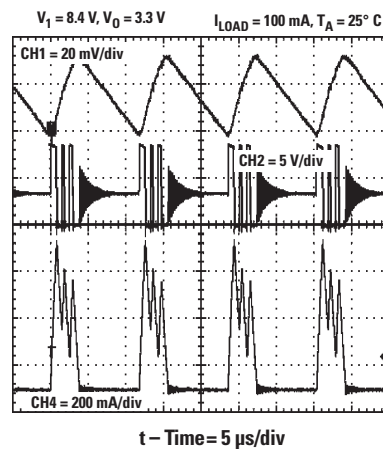
1.1-MHz, Highly Efficient 3-A Buck Converter

Description

The TPS54317 DC/DC converter is designed to provide up to 3 A output from an input voltage source of 3 V to 6 V. This device features extended operating frequency range. This evaluation module is designed to demonstrate the small PCB areas that may be achieved when designing with the TPS54317 regulator, and does not reflect the high efficiencies that may be achieved when designing with this part. The switching frequency is set at a nominal 1.1 MHz, allowing the use of a small-footprint 1.5-mH output inductor. The high- and low-side MOSFETs are incorporated inside the TPS54317 package along with the gate-drive circuitry. The low drain-to-source on resistance of the MOSFETs allows the TPS54317 to achieve high efficiencies and helps to keep the junction temperature low at high output currents. The compensation components are provided external to the IC, and allow for an adjustable output voltage and a customizable loop response. Additionally, the TPS54317 provides a full feature set including programmable undervoltage lockout, synchronization, adjustable switching frequency, enable, and power-good functions.

Web Links:

Reference Designs:
www.ti.com/powerreferencedesigns
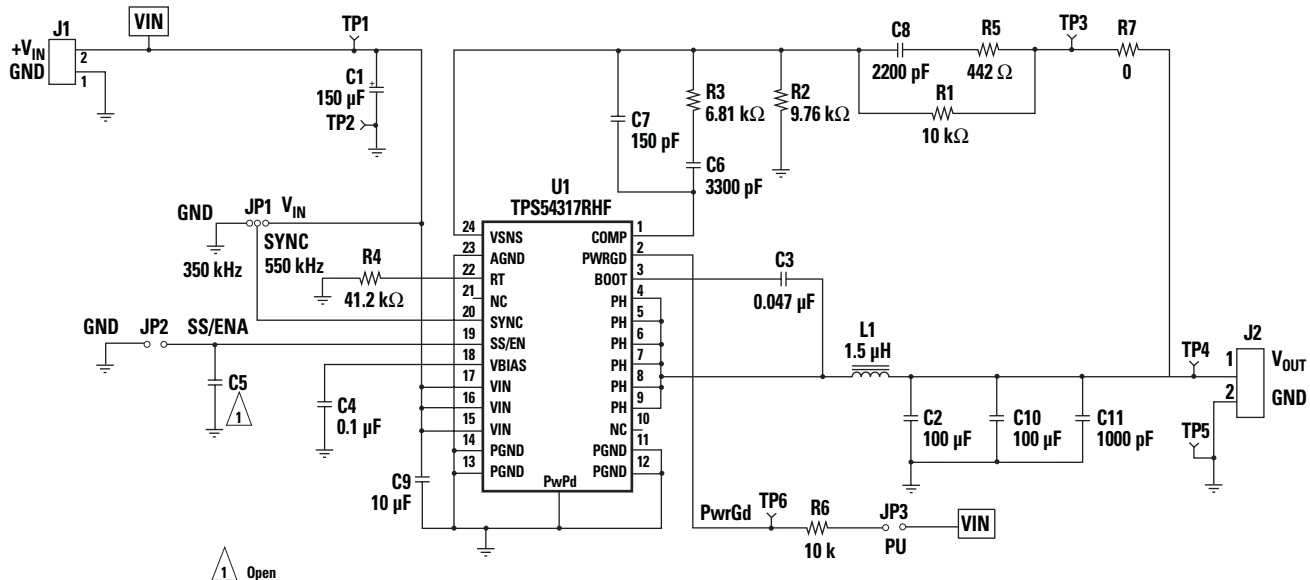
Datasheets, User's Guides, Samples, Software:
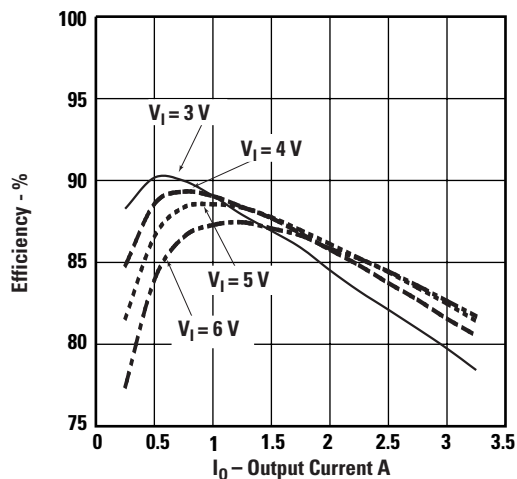**www.ti.com**
Part Number Search: **TPS54317**

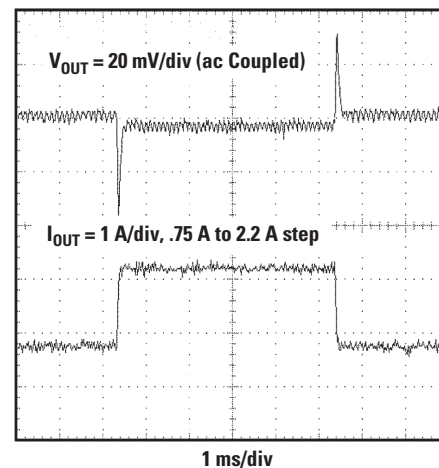| Specifications					
Parameter	Test Conditions	Min	Typ	Max	Unit
Input Voltage		3.1	3.3	3.5	V
V_{OUT} Set Point			1.8		V
I_{OUT} Range	V_{IN} = 3.3V	0		3	A
Operating Frequency			1.1		MHz
Output Ripple			4		mV_{PP}
Efficiency	V_{IN} = 3.3 V, = V_O = 1.8 V, I_O = 0.6 A		90.5		%

Evaluation Module TPS54317EVM-159

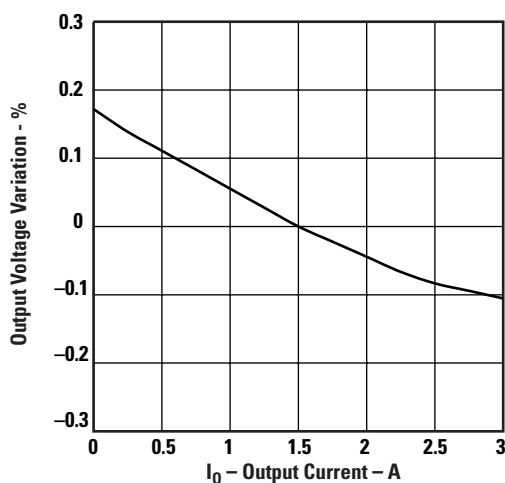## *1.1-MHz, Highly Efficient 3-A Buck Converter*

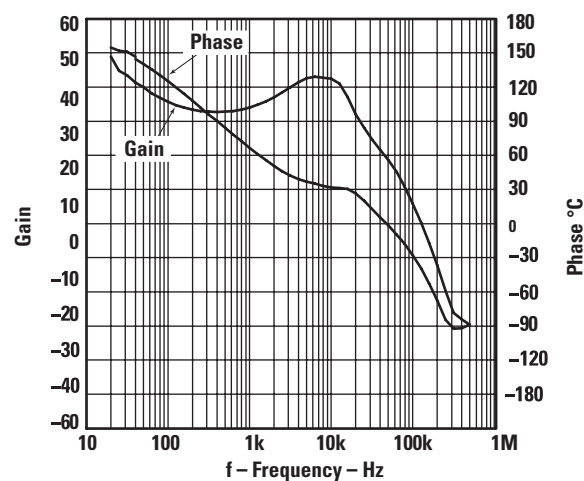Efficiency vs. Output Current

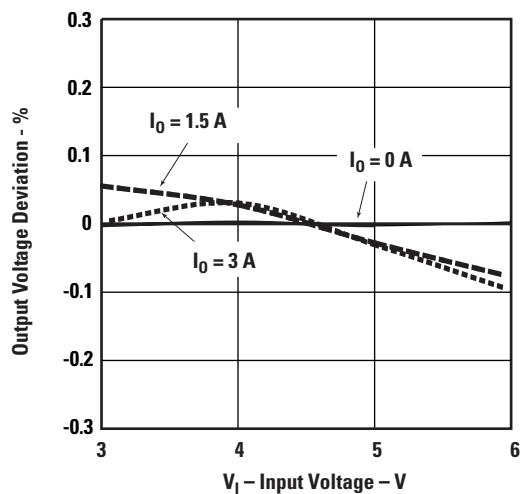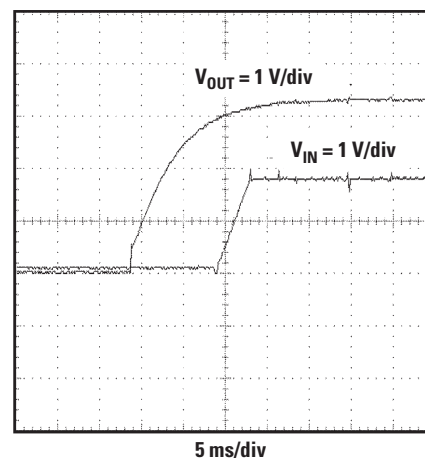Load Transient Response

Load Regulation

Measure Loop Response

Line Regulation

Power Up, V_{OUT} Relative to V_{IN}

12-V to 3.3-V, 3-A Buck Converter Input with Bi-Directional Synchronization

Description

The TPS54356 DC/DC converter is designed to provide up to 3-A output from an input voltage source of 6 to 10 V. This evaluation module is designed to demonstrate the small PCB areas that may be achieved when designing with the TPS54356 regulator, and does not reflect the high efficiencies that may be achieved when designing with this part. The switching frequency is set at a nominal 500 kHz, allowing the use of a relatively small footprint 22-µH output inductor. The high-side MOSFET is incorporated inside the TPS54356 package along with gate drive circuitry for an external synchronous FET. The low drain-to-source on resistance of the MOSFET allows the TPS54356 to achieve high efficiencies and helps to keep the junction temperature low at high output currents. The compensation components are provided internal to the IC. The TPS54356 is a full featured device including programmable under-voltage lockout, bidirectional synchronization, adjustable switching frequency, enable and power good functions.

Web Links:
Reference Designs:
**www.ti.com/powerreferencedesigns**

Datasheets, User's Guides, Samples, Software:
www.ti.com
Part Number Search: **TPS54356**

| Specifications					
Parameter	Test Conditions	Min	Typ	Max	Unit
Input Voltage		6.0	12.0	18.0	V
Output Voltage Set Point			3.3		V
Output Current Range	V_{IN} = 6 V to 18 V	0		3	A
Switching Frequency			500		kHz
Output Ripple	Full Load		5	10	mV_{PP}
Max Efficiency	V_{IN} = 6.0 V, V_{OUT} = 3.3 V, I_{OUT} = 0.5 A			92	%

Evaluation Module TPS54356EVM-058
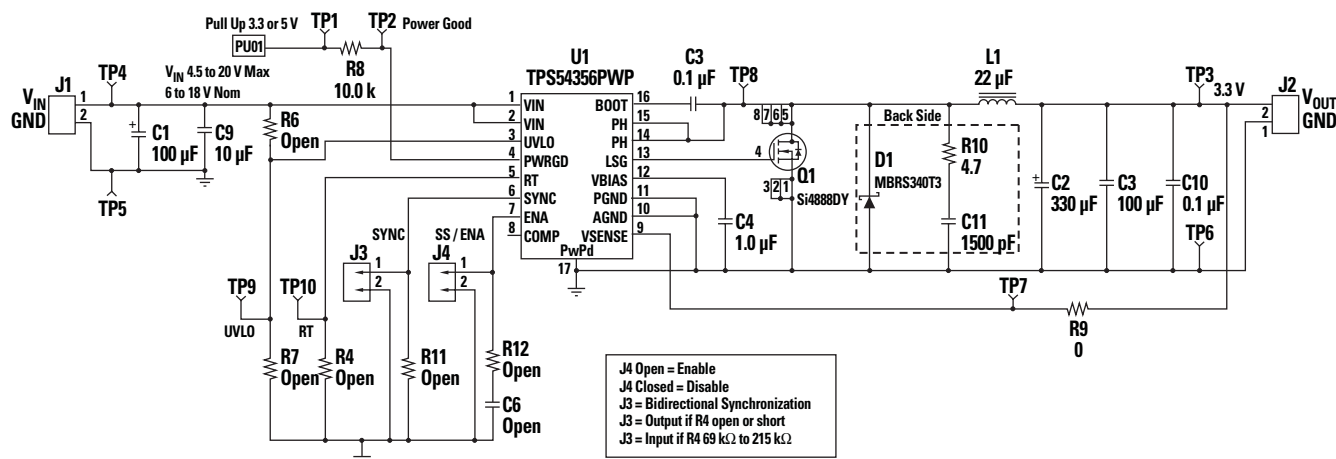
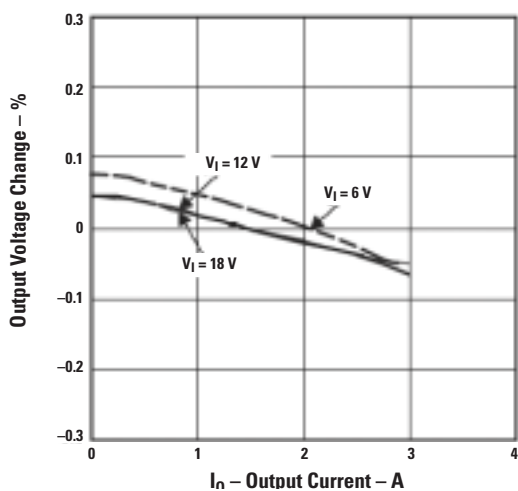## *12-V to 3.3-V, 3-A Buck Converter Input with Bi-Directional Synchronization*
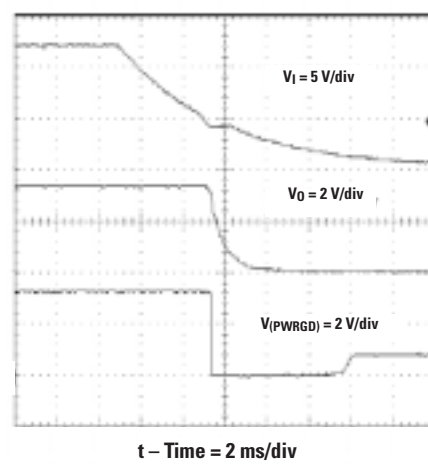
Efficiency vs. Output Current

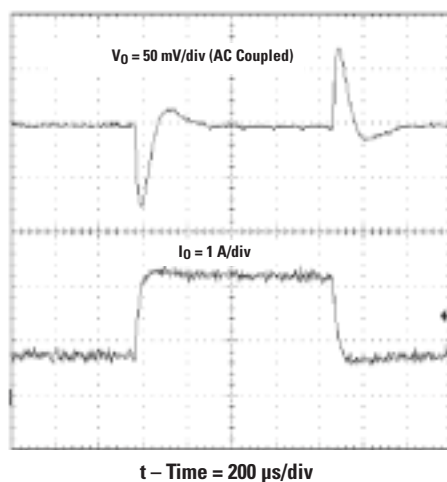
Load Regulation
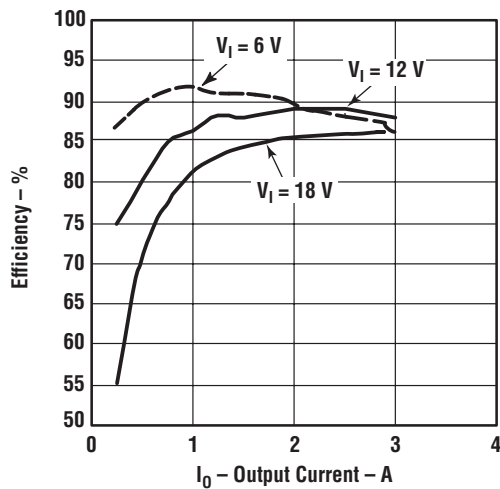
Load Transient

Power Up with Tracking
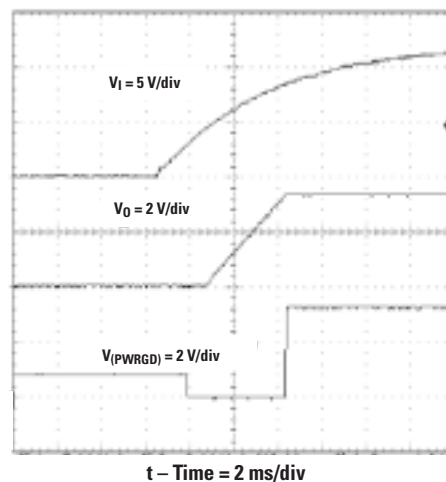
Power Down with Tracking

TPS40021

Synchronous Buck Converter Delivers 20 A from Standard 5-V Input

Description

This is a synchronous buck design that uses the TPS40021 to generate a 3.3-V output at up to 20 A from a 5-V input. The TPS40021 is a low-input voltage synchronous buck controller with integrated N-channel MOSFET drivers and Predictive Gate Drive™ technology for high efficiency in a small footprint. A user-programmable operating frequency and synchronization input make the TPS40021 a versatile device that can be used in a wide variety of applications. The focus for this design was to generate a low-voltage/high-current output from a standard 5-V input.

Web Links:

Reference Designs:
www.ti.com/powerreferencedesigns

Datasheets, User's Guides, Samples, Software:
www.ti.com
Part Number Search: **TPS40021**

Specifications

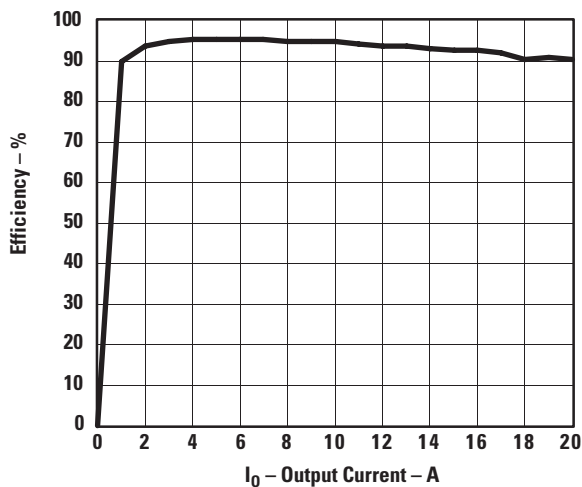| Parameter	Test Conditions	Min	Typ	Max	Unit
Input Voltage		4.25	5	5.75	V
Output Voltage		3.25	3.3	3.35	V
Load Current		0		20	A
Switching Frequency		255	300	345	kHz
Output Ripple Voltage	V_{IN} = 5 V; I_O = 20 A		20	30	mV_{PP}
Efficiency	V_{IN} = 5 V; I_O = 20 A		91		%
	V_{IN} = 5 V; I_O = 10 A		95		%
	V_{IN} = 5 V; I_O = 1 A		90		%

Reference Design PMP1050
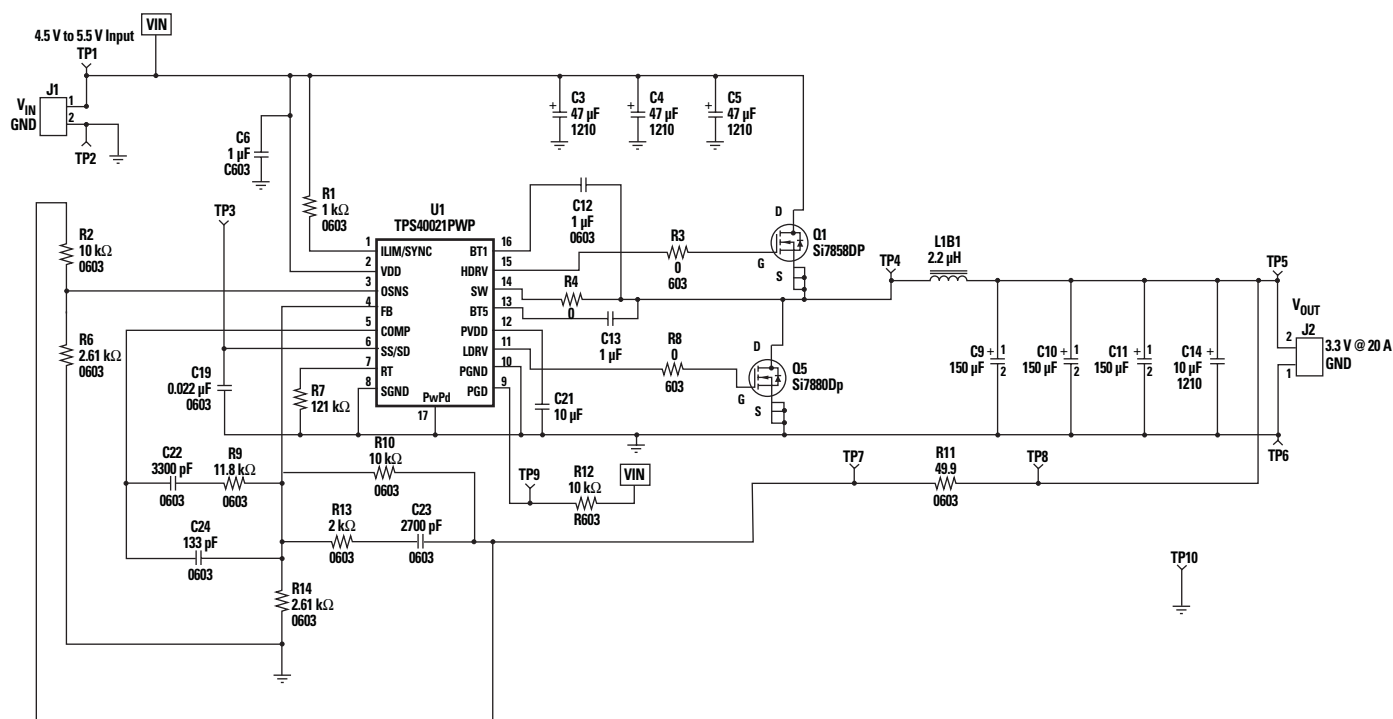
Synchronous Buck Converter Delivers 20 A from Standard 5-V Input
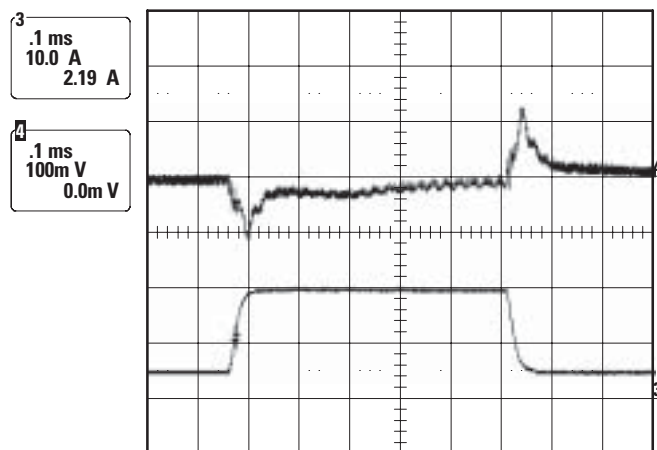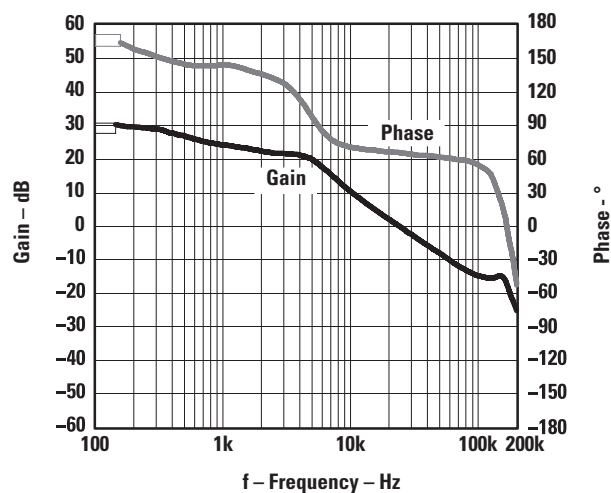
Efficiency (V_{IN} = 5 V)

Transient Response (V_{IN} = 5 V, I_{OUT} = 0 A to 15 A)
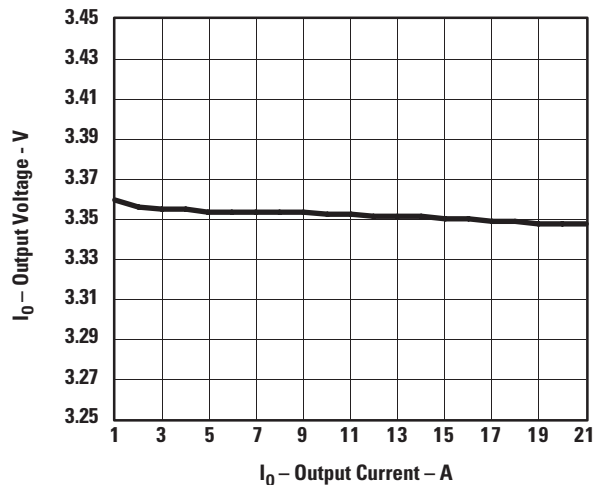Channel 3 = Output Current, Channel 4 = Output Voltage

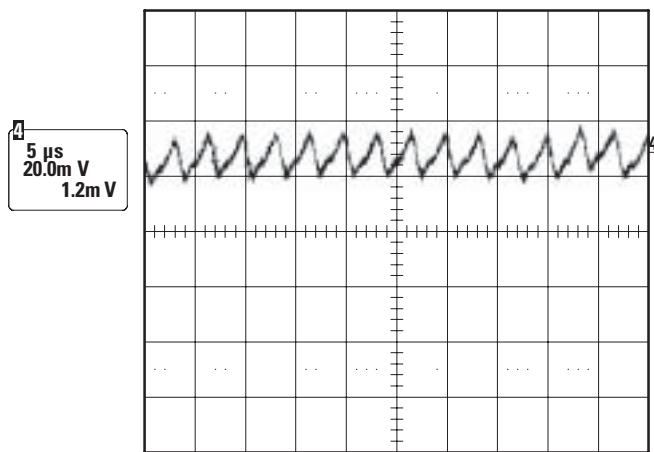Loop Response (V_{IN} = 5 V, I_{OUT} = 20 A)

Output Voltage Precision

Output Voltage Ripple (V_{IN} = 5 V, I_{OUT} = 20 A)

Reference Design Cookbook II for Power Management Products

Cost-Optimized Synchronous Buck Converter Provides 4 A from 5.5 V

Description

This reference design uses the TPS40040 controller to provide an output voltage of 1 V at a current up to 4 A from a regulated 5.5-V input voltage. The TPS40040 is a low-cost synchronous buck controller that operates over the input voltage range of 2.25 V to 5.5 V. The TPS40040 integrates several circuit functions, such as over-current, soft start, and fixed switching frequency to minimize the number of external components required. The controller also provides a short circuit threshold that is user selectable between one of three values. The protection level is set by a single external resistor from COMP to GND. The controller ensures a monotonic startup of the output voltage whether the output voltage starts from zero volts or from a pre-biased output level. The controller utilizes voltage mode operation at a fixed 300 kHz switching frequency (or 600 kHz for the TPS40041) to maximize circuit efficiency. This reference design achieves a peak efficiency of greater than 88%. The actual design PWB area is less than 0.8 in^2.

Web Links:
Reference Designs:
www.ti.com/powerreferencedesigns

Datasheets, User's Guides, Samples:
www.ti.com
Part Number Search: **TPS40040**

Specifications

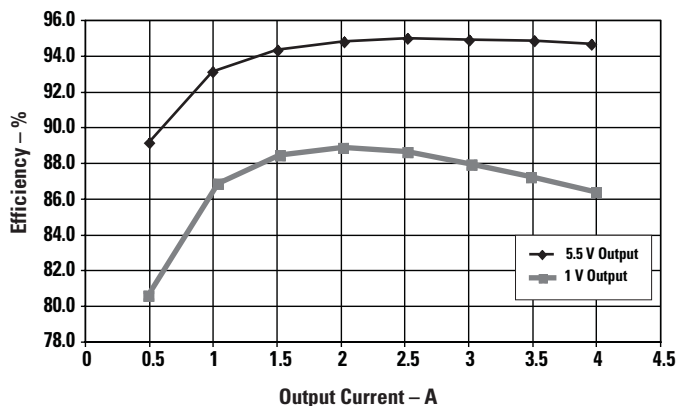| Parameter	Test Conditions	Min	Typ	Max	Unit
Input Voltage			5.5		V
V_{OUT}	All		1		V
I_{OUT}		0		4	A
Switching Frequency			300		kHz
Efficiency	5.5 V at 4 A		88		%

Reference Design PMP1632A
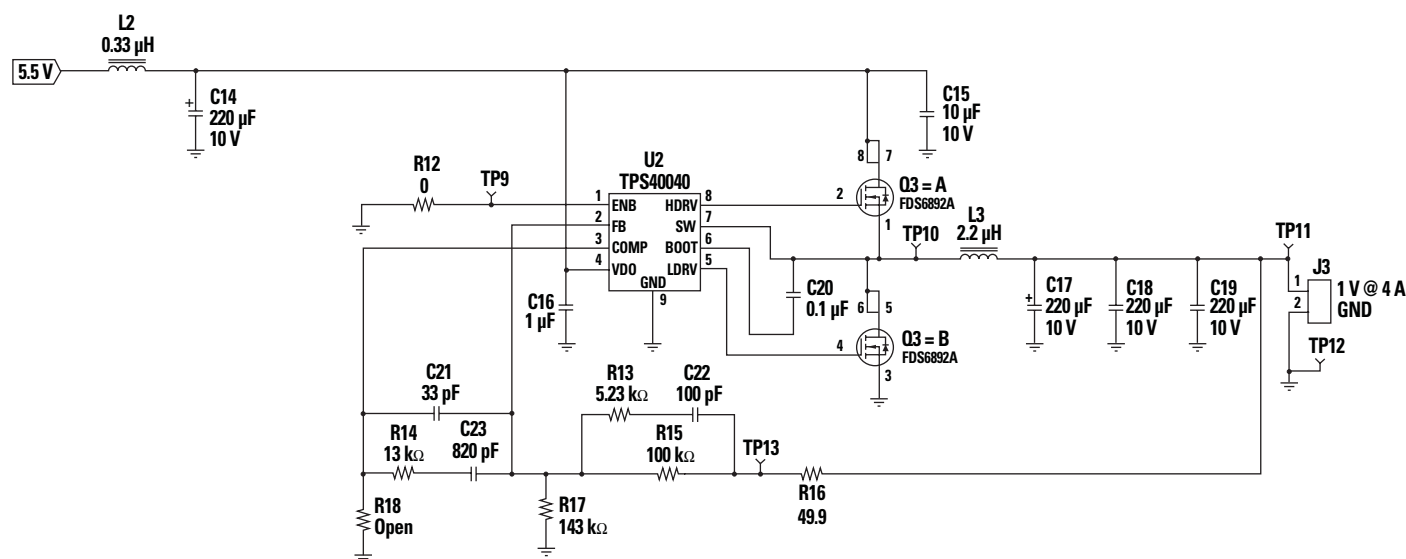
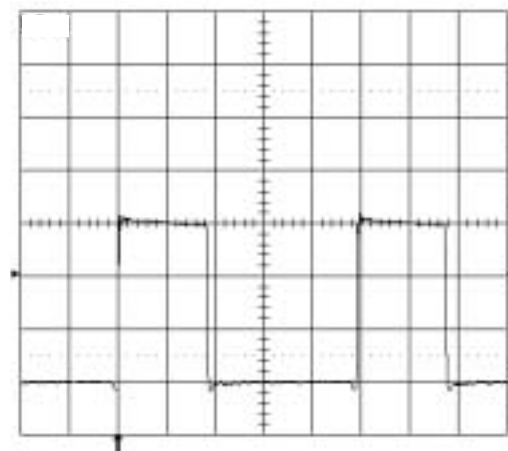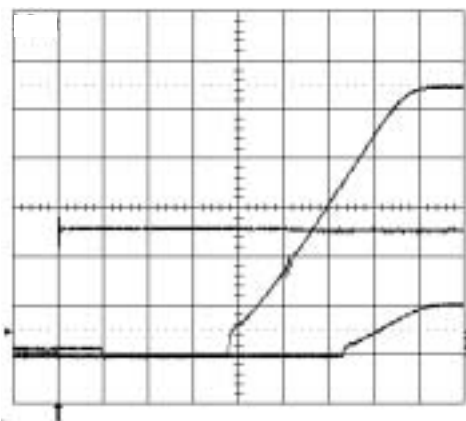## *Cost-Optimized Synchronous Buck Converter Provides 4 A from 5.5 V*

Efficiency

Switch Node Waveforms (V_{IN} = 12 V, V_{OUT} 5.5 V)
(Loaded Current Stepped Between 0.5 A and 1 A)

Startup
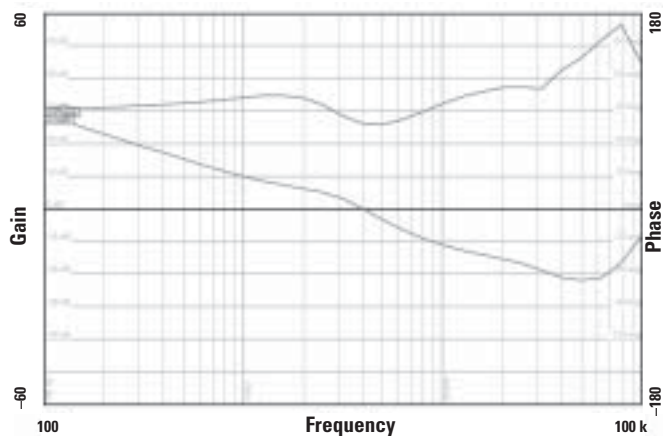(V_{IN} = 12 V, V_{OUT} = 5.5 V @ 1 A, 1 V @ 4 A, 1.8 V @ 1.8 A)
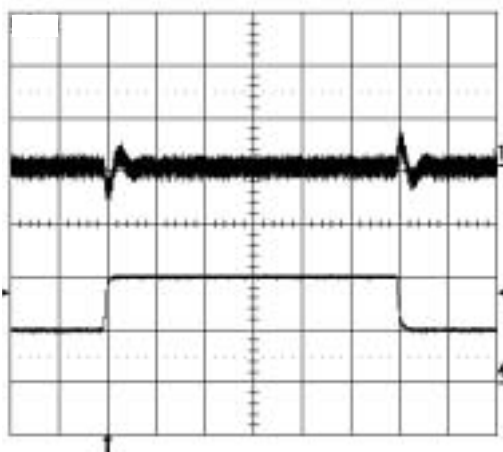

Control Loop Gain/Stability
(V_{IN} = 15 V, V_{OUT} 5.5 V, Loaded to 4 A)

Load Transients (V_{IN} = 12 V, V_{OUT} 5.5 V)

→ ## 12-V$_{IN}$, 5-A Synchronous Buck Converter with Voltage Margining and Tracking

Description

This design utilizes the TPS40100 in a synchronous buck configuration to generate a 1.8-V/5-A output from a 12-V input. In addition to providing this power conversion, voltage margining, tracking, and device enable are supported through the use of user-configurable jumpers. The TPS40100's voltage margining feature allows the output to be adjusted 3% or 5% above or below the nominal 1.8 V through the use of a digital input. The TPS40100 also has an integrated tracking control loop that can limit the output voltage according to the input voltage on the Tracking Input line. This feature is useful in designs where power-up sequencing is needed. Other features of the TPS40100 include a wide input voltage range (4.5 V to 18 V), integrated gate drivers for N-channel MOSFETs, adaptive gate-drive circuitry for improved efficiency, programmable Under Voltage Lockout (UVLO) protection, and programmable overcurrent protection.

Web Links:
Reference Designs:
www.ti.com/powerreferencedesigns

Datasheets, User's Guides, Samples:
www.ti.com
Part Number Search: **TPS40100**

Specifications					
Parameter	Test Conditions	Min	Typ	Max	Unit
Input Voltage		10.8	12	13.2	V
Output Voltage		1.76	1.8	1.84	V
Load Current		0	5	6.5	A
Switching Frequency		255	300	345	kHz
Output Ripple Voltage	V_{IN} = 12 V; I_O = 5 A		20	30	mV$_{PP}$
Efficiency	V_{IN} = 12 V; I_O = 5 A		89		%
	V_{IN} = 12 V; I_O = 0.5 A		72		%

Reference Design PMP1048

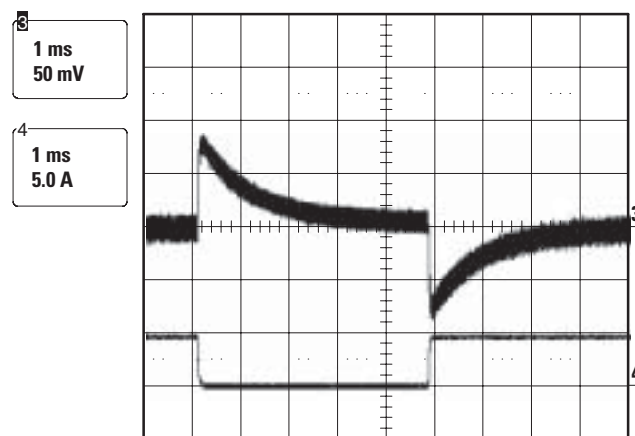## 12-V$_{IN}$, 5-A Synchronous Buck Converter with Voltage Margining and Tracking
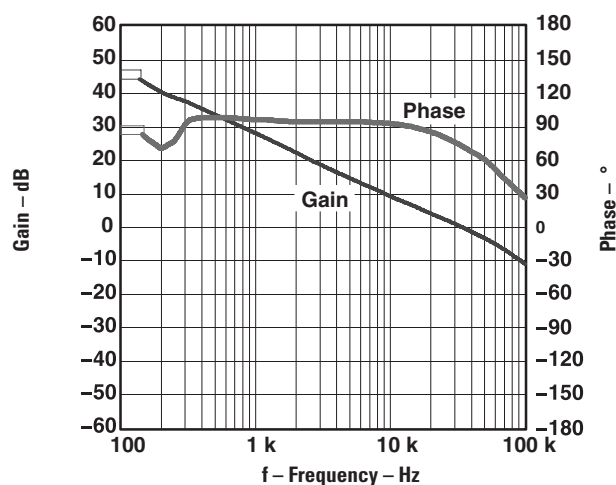
Efficiency (V$_{IN}$ = 12 V)
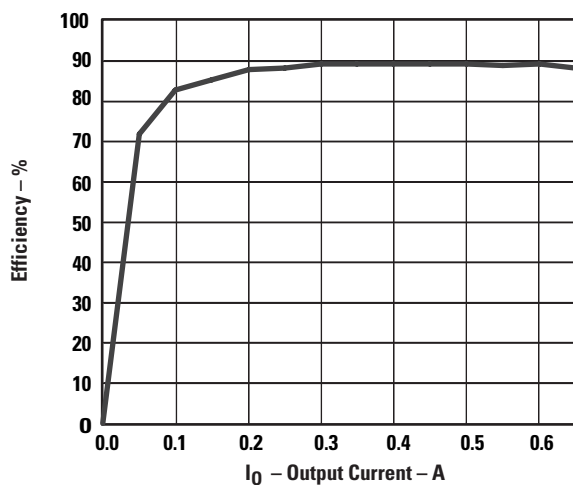
Transient Response (V$_{IN}$ = 12 V, I$_{OUT}$ = 0 A to 5 A)
Channel 3 = Output Voltage
Channel 4 = Output Current

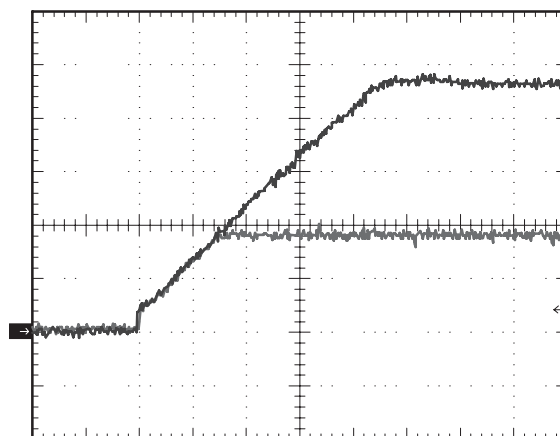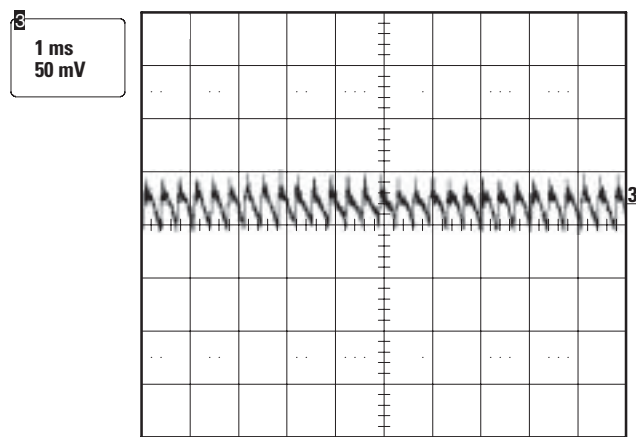Loop Response (V$_{IN}$ = 12 V, I$_{OUT}$ = 5 A)

Tracking Input Response
Channel 3 = 5-V Tracking Input
Channel 4 = 1.8-V Output

Output Voltage Ripple (V$_{IN}$ = 12 V, I$_{OUT}$ = 5 A)

➡️ *12-V Input, 1.5-V Output, 10-A Synchronous Buck Converter*

Description

The TPS40190EVM-001 evaluation module (EVM) is a synchronous buck converter providing a fixed 1.5-V output at up to 10 A from a 12-V input bus. The EVM is designed to startup from a single supply, so no additional bias voltage is required for startup. The module uses the TPS40190 reduced pin count synchronous buck controller. TPS40190EVM-001 is designed to use a regulated 12-V (10 V to 14 V) bus to produce a high current, regulated 1.5-V output at up to 10 A of load current. The TPS40190EVM-001 is designed to demonstrate the TPS40190 in a typical regulated bus to low-voltage application while providing a number of test points to evaluate the performance of the TPS40190 in a given application. The EVM can be modified to support output voltages from 0.9 V to 3.3 V by changing a single set resistor.

Web Links:

Reference Designs:
www.ti.com/powerreferencedesigns
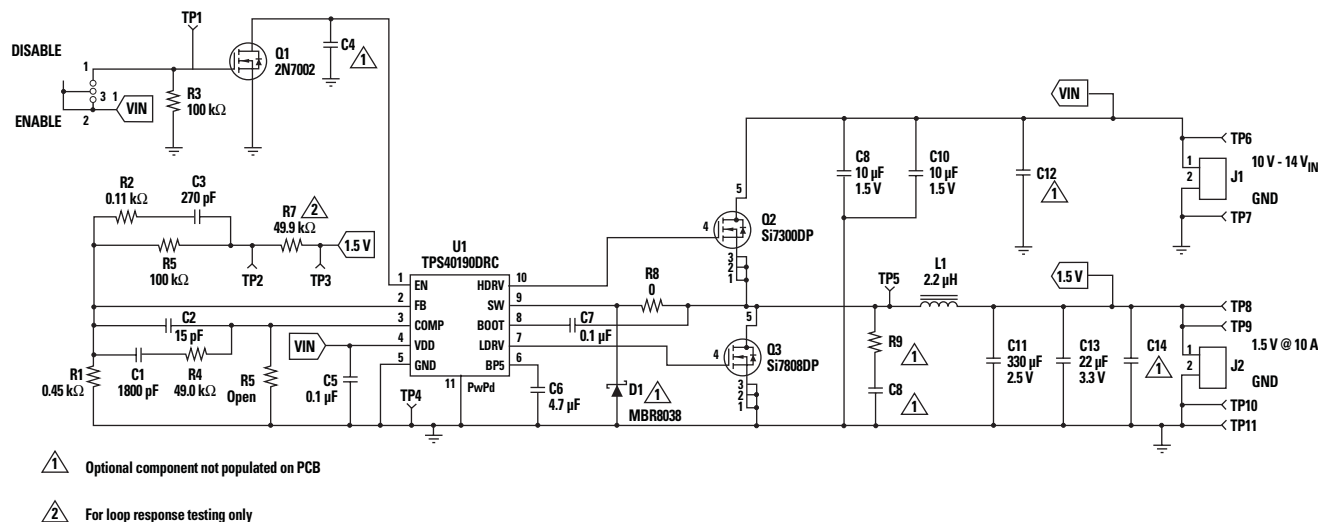
Datasheets, User's Guides, Samples, Software:
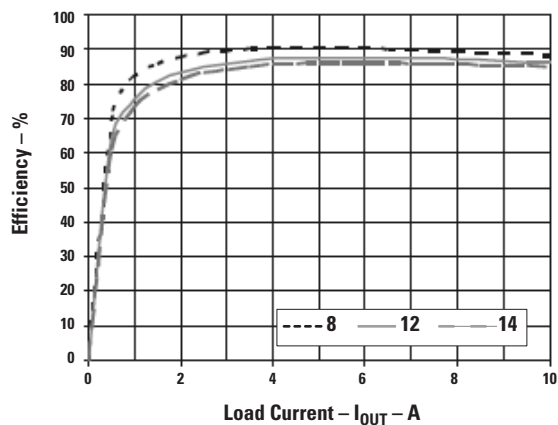**www.ti.com**
Part Number Search: **TPS40190**

Specifications					
Parameter	Test Conditions	Min	Typ	Max	Unit
V_{IN}		10	12	14	V
V_{OUT}	R6 = 9.53 k, R5 = 105 k	1.45	1.50	1.55	V
I_{OUT}		0		10	A
Switching Frequency		240	300	360	kHz
Output Ripple	V_{IN} = 14 V, I_{OUT} = 10 A		25	50	mV_{PP}
Peak Efficiency	V_{OUT} = 1.5 V, 8 A < 1_{OUT} < 12 A V_{IN} =10 V		87		%
	V_{IN} = 12 V		85		
	V_{IN} = 14 V		83		
Full Load Efficiency	V_{OUT} = 1.5 V, I_{OUT} = 15 A V_{IN}=10 V		84		%
	V_{IN} = 12 V		83		
	V_{IN} = 14 V		81		

Evaluation Module TPS40190EVM-001

⚠️1   Optional component not populated on PCB

⚠️2   For loop response testing only

Efficiency vs. Load Current

Line and Load Regulation
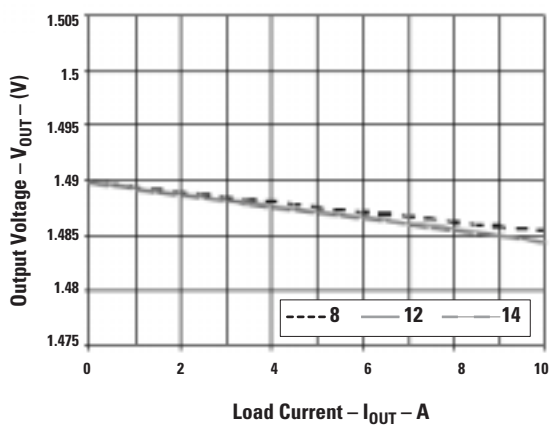
TPS5124

Dual Synchronous Converter Provides 3.3 V at 15 A and 1.5 V at 10 A from a 12-V Bus

Description

The TPS5124 is a dual independent synchronous buck controller. Both controllers internal to the TPS5124 operate at 180° phase shift and the input ripple is partially cancelled and therefore the required input capacitance is reduced. Other features include separate soft start circuit and standby control. See the TPS5124 data sheet (SLUS571) for detail. This EVM is designed to operate from 12-V bus voltage. It generates two outputs, 3.3 V at 15 A and 1.5 V at 10 A.

Web Links:

Reference Designs:
www.ti.com/powerreferencedesigns

Datasheets, User's Guides, Samples:
www.ti.com
Part Number Search: **TPS5124**

Specifications					
Parameter	Test Conditions	Min	Typ	Max	Unit
Input Voltage		6.5	12	15	V
Switching Frequency			300		kHz
Channel 1					
Output Current Range	6.5 V V_{IN} 15 V	0	15	16	
Output Ripple	I_{OUT} = 15 A		33	66	mV$_{PP}$
Full Load Efficiency	V_{IN} = 12 V, V_{OUT} = 3.3 V, I_{OUT} = 15 A		90.6		%
Channel 2					
Output Current Range	6.5 V V_{IN} 15 V	0	10	12	
Output Ripple	I_{OUT} = 10 A		15	30	mV$_{PP}$
Efficiency	V_{IN} = 12 V, V_{OUT} = 1.53 V, I_{OUT} = 10 A		85.5		%

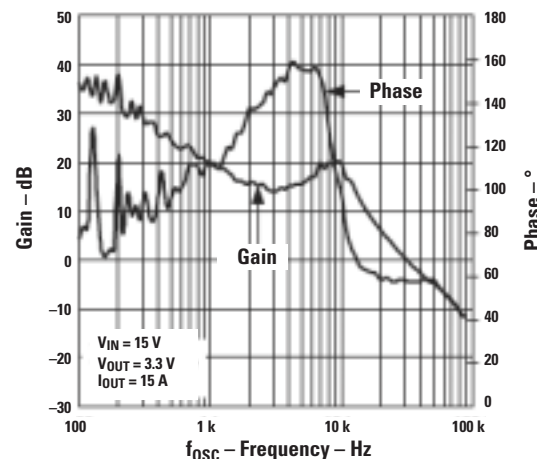### Evaluation Module TPS5124EVM-001
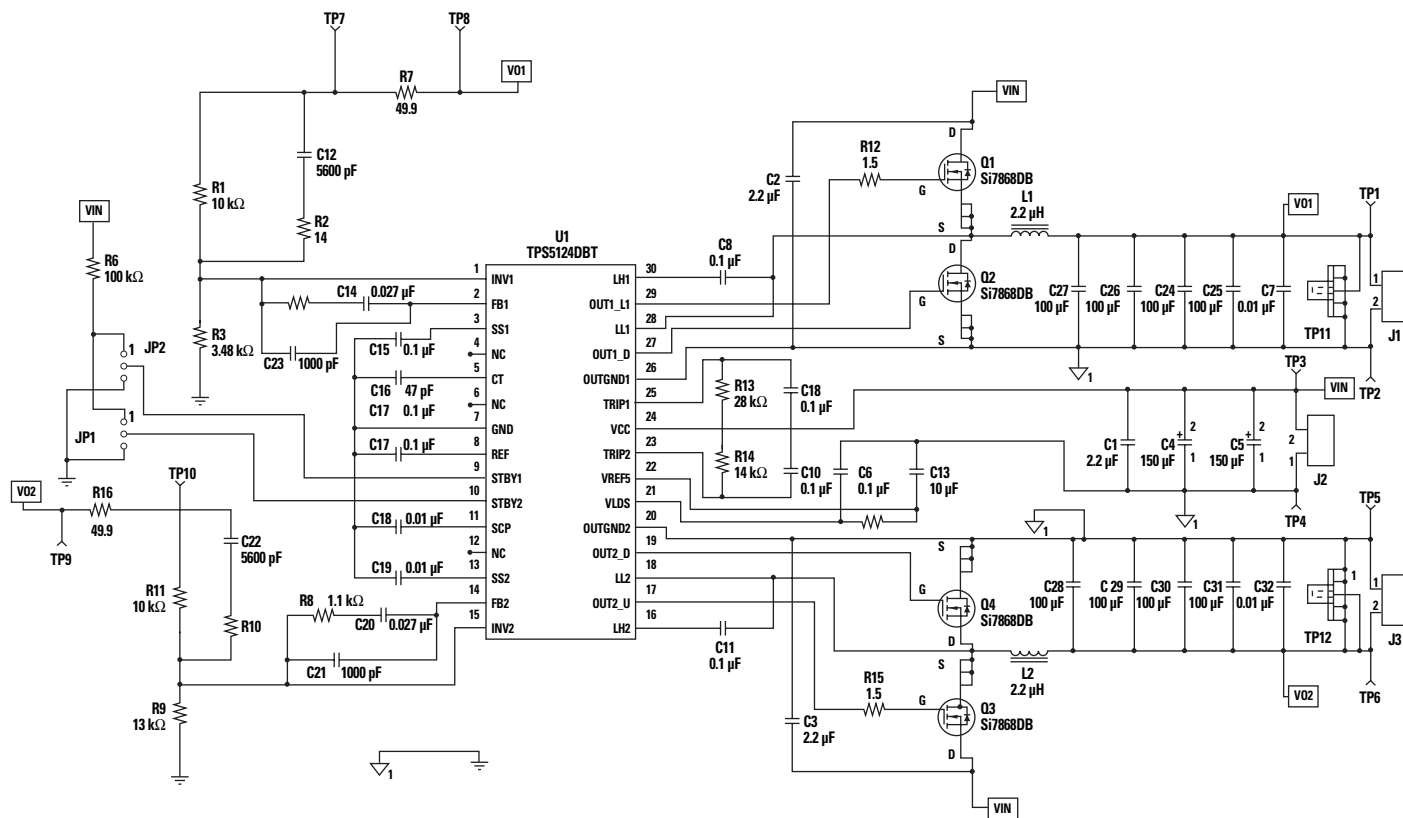
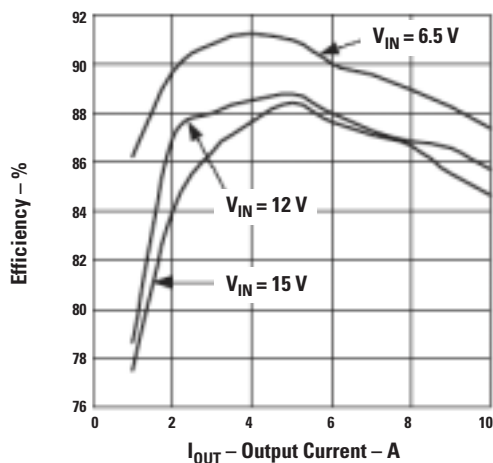# *Dual Synchronous Converter Provides 3.3 V at 15 A and 1.5 V at 10 A from a 12-V Bus*

Overall Efficiency vs. Output Current
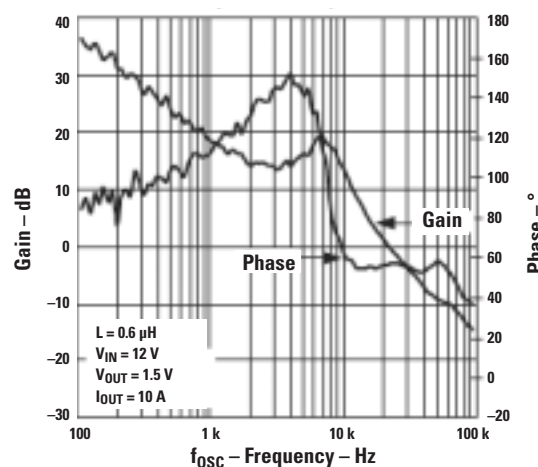V$_{OUT1}$ (3.3 V) Enabled Only
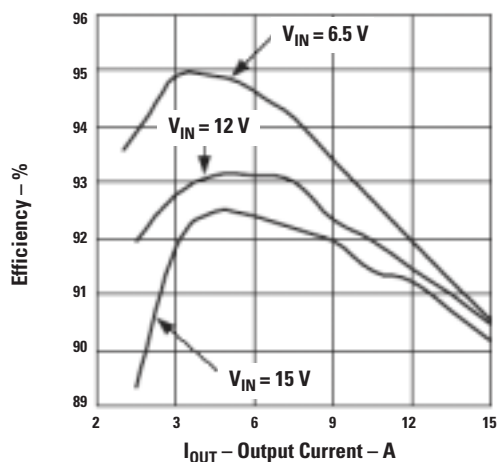
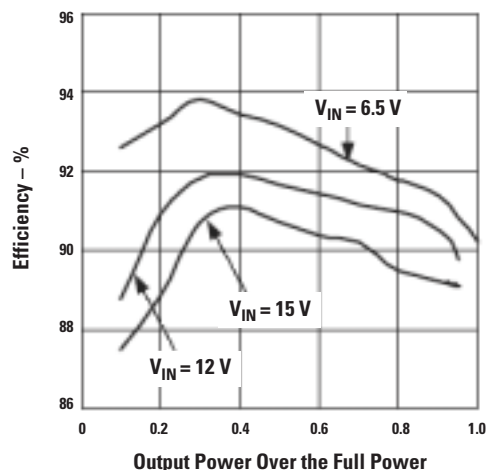Gain and Phase vs. Oscillator Frequency
(Channel 1)

Overall Efficiency vs. Output Current
V$_{OUT2}$ (1.5 V) Enabled Only

Gain and Phase vs. Oscillator Frequency
(Channel 2)

Overall Efficiency vs. Output Power
Both Channels Enabled

Converter Provides Dual 2-A Buck Outputs and 300-mA Regulator

Description

The TPS75003 is a multi-channel power management IC. The device consists of two step-down controllers, each capable of providing up to 3 A of output current and a 300-mA linear regulator. The input voltage input range is 2.2 V to 6.5 V. The buck controllers can be configured for output voltages between 1.2 V and 6.5 V and the linear regulator can be configured for output voltages between 1.0 V and 6.5 V. Individual enable pins and soft start capacitors for each output allow minimization of inrush currents at startup.

Web Links:
Reference Designs:
**www.ti.com/powerreferencedesigns**

Datasheets, User's Guides, Samples:
www.ti.com
Part Number Search: **TPS75003**

Specifications

| Parameter	Test Conditions	Min	Typ	Max	Unit
V_{IN}		4.75	5	5.25	V
V_{OUT1}	$-40°$ C to $85°$ C, I_{OUT1} = 0 to 2 A	1.16	1.22	1.28	V
V_{OUT2}	$-40°$ C to $85°$ C, I_{OUT1} = 0 to 2 A	3.14	3.3	3.47	
V_{OUT3}	$-40°$ C to $85°$ C, I_{OUT1} = 0 to 0.30 A	2.38	2.5	2.63	
I_{OUT1}		0		2	A
I_{OUT2}		0		2	A
I_{OUT3}		0		300	mA
V_{OUT1} Ripple Voltage	V_{IN} = 5.0 V; I_O = 2 A		20		mV_{PP}
V_{OUT2} Ripple Voltage	V_{IN} = 5.0 V; I_O = 2 A		40		mV_{PP}
V_{OUT1} Efficiency	V_{IN} = 5 V; I_O = 10 mA		69		%
V_{OUT1} Efficiency	V_{IN} = 5 V; I_O =1 A		79		%
V_{OUT2} Efficiency	V_{IN} = 5 V; I_O = 10 mA		84		%
V_{OUT2} Efficiency	V_{IN} = 5 V; I_O =1 A		91		%

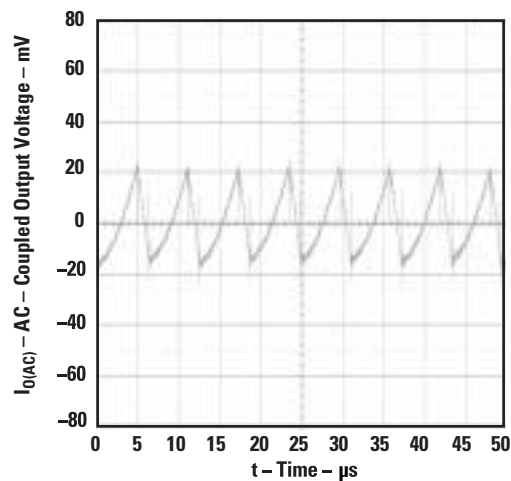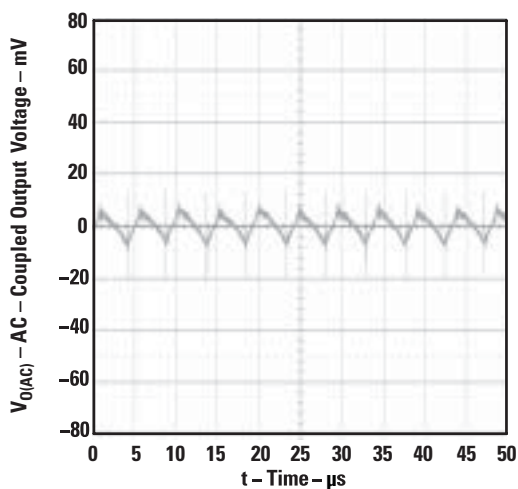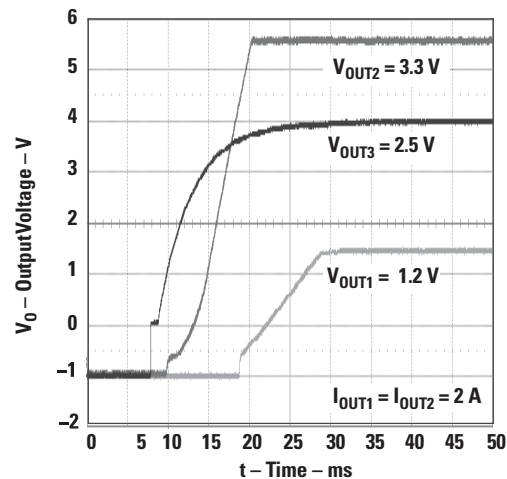### Evaluation Module TPS75003EVM-092
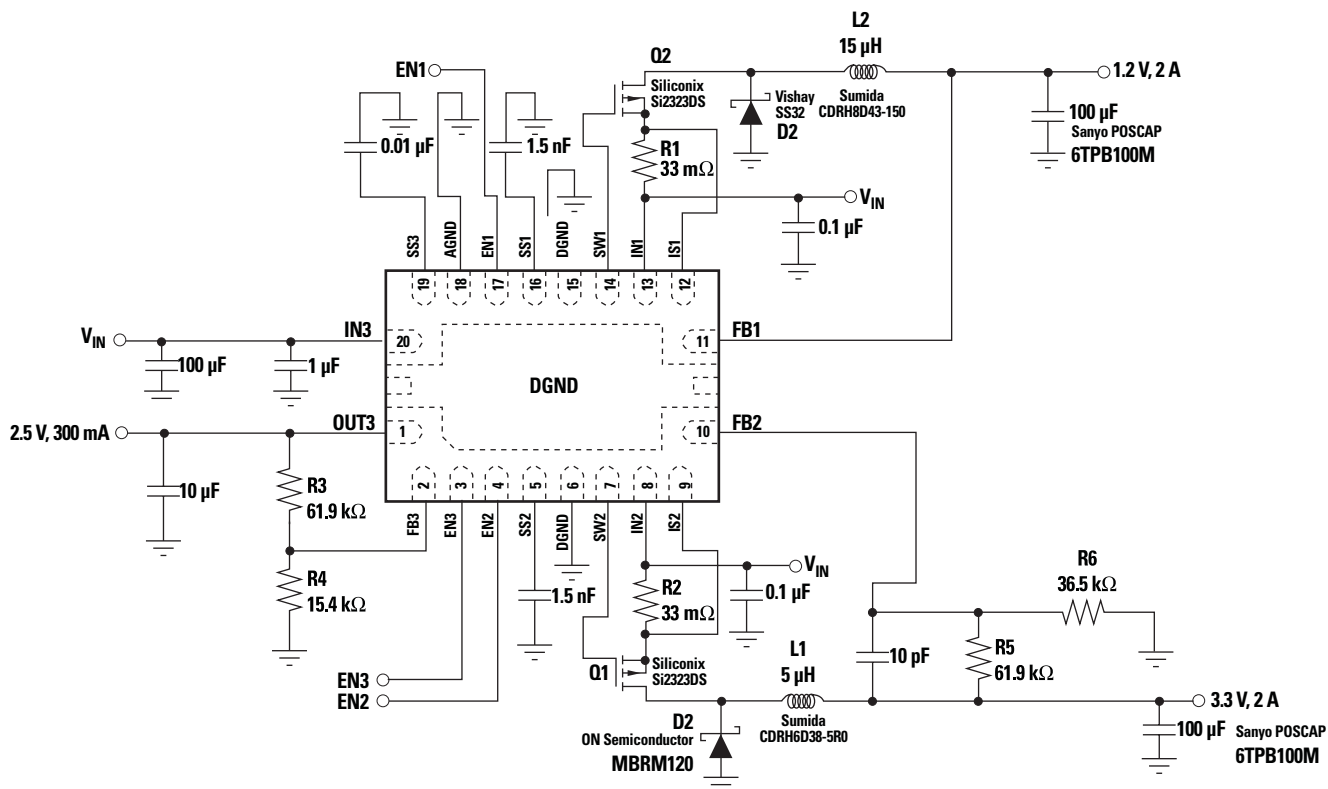
Converter Provides Dual 2-A Buck Outputs and 300-mA Regulator

Efficiency
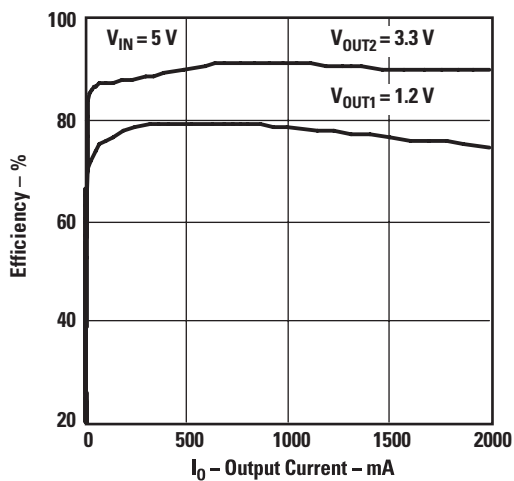
Output Ripple (V_{OUT} = 1.2 V, I_{OUT} = 2 A)

Output Ripple (V_{OUT} = 3.3 V, I_{OUT} = 2 A)

Output Voltage vs. Time (EN2 = V_{OUT3}, EN1 = V_{OUT2})

Flexible, Wide Input Range 3-A Buck Converter for 12-V and 24-V Inputs

Description

The TPS40200 is a flexible non-synchronous controller with a built-in 200-mA driver for P-channel FETs. The circuit operates with inputs up to 52 V with a power-saving feature that turns off driver current once the external FET has been fully turned on. The circuit operates with voltage-mode feedback and has feed-forward input-voltage compensation that responds instantly to input voltage change. The integral 700-mV reference is trimmed to 1%, providing the means to accurately control low voltages and supports many of the features of more complex controllers. Clock frequency, soft start, and overcurrent limit are each easily programmed by a single, external component. The part has undervoltage lockout, and can be easily synchronized to other controllers or a system clock to satisfy sequencing and/or noise-reduction requirements. Ultra-wide-input operating range makes this controller suitable for a wide range of low-current applications.

Web Links:
Reference Designs:
www.ti.com/powerreferencedesigns
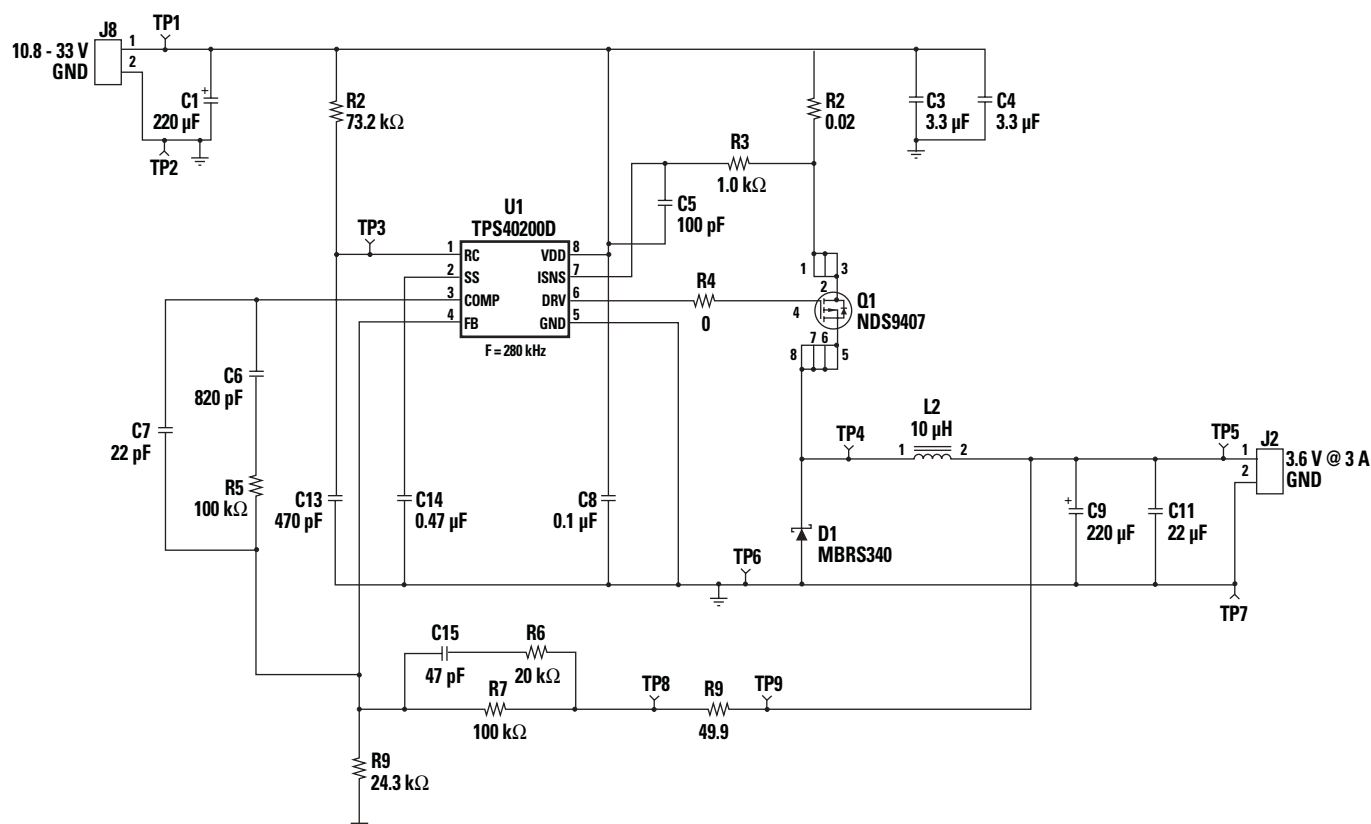
Datasheets, User's Guides, Samples, Software:
www.ti.com
Part Number Search: **TPS40200**

Specifications

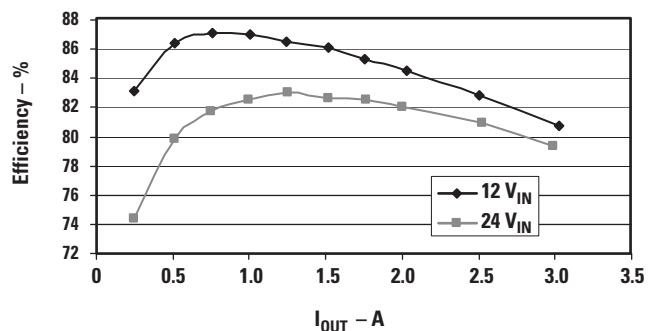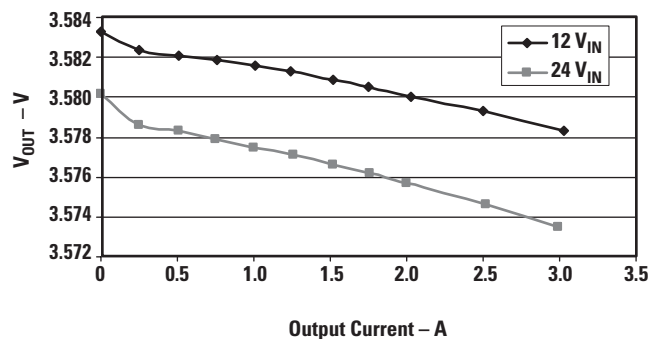| Parameter	Test Conditions	Min	Typ	Max	Unit
Input Voltage		10.8		33	V
Output Voltage		3.45	3.6	3.75	V
Load Current		0		3	A
Switching Frequency		250	280	310	kHz
Output Ripple Voltage				40	mV/$_{PPK}$

Reference Design PMP1510

Flexible, Wide Input Range 3-A Buck Converter for 12-V and 24-V Inputs

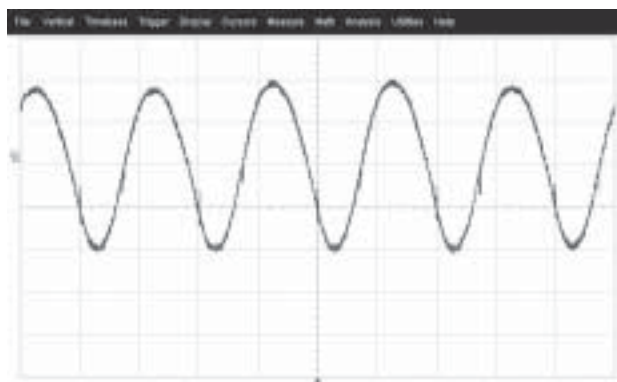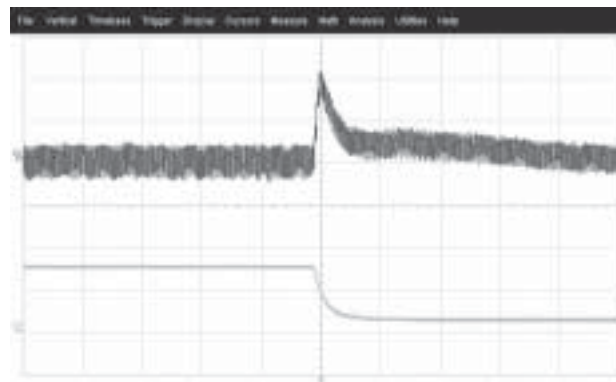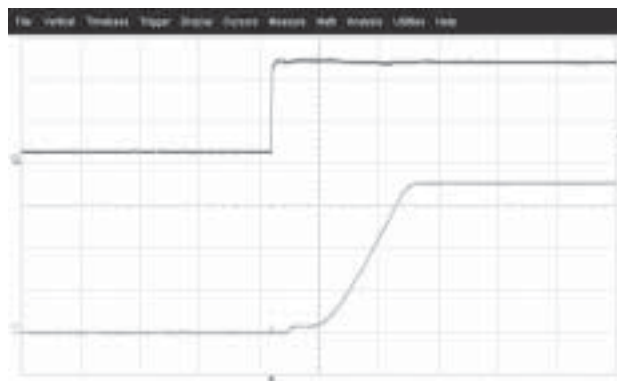Efficiency

Load Regulation

Output Ripple (V_{OUT} = 3.65 V, I_{OUT} = 3 A)
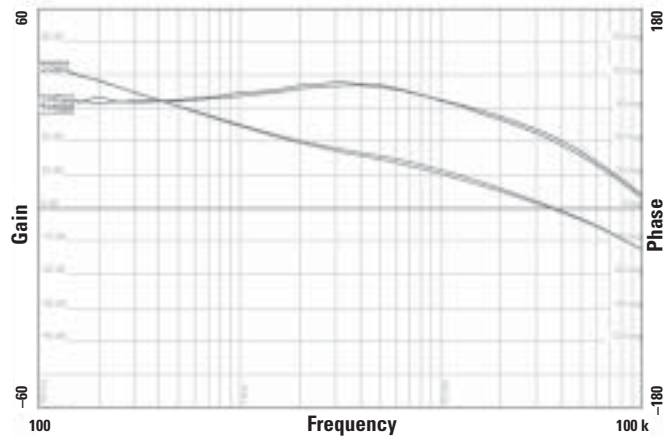

Load Transient (V_{IN} = 3.6, Load Current = .5 A and 3 A)

Start Up (V_{IN} = 12 V, V_{OUT} = 3.6 V)

Control Loop (V_{IN} = 33 V, Gain 1) (V_{IN} = 10.8 V, Gain 2)

→ 5-V Input, 1.6-A Output, Non-Synch. Buck Converter with Minimal External Components

Description

The TPS40222EVM-001 evaluation module (EVM) is a non-synchronous buck converter with a 4.5-V to 8-V input range with a built in N-channel power FET, that can deliver 1.6 A of output current. The EVM is designed to operate with a minimum of components and yet has the features of more complex buck converters.

The TPS40222EVM-001 is designed to use a 4.5- to 8-V input voltage to produce a high current, regulated 1.4 V output at up to 1.6 A of load current. This application board is designed to demonstrate the TPS40222 in a typical voltage bus to low-voltage application while providing a number of test points to evaluate the performance of the IC. The EVM can be modified to support output voltages from 0.8 V to 6.3 V by changing a single resistor. The TPS402224EVM-001 has been built with the internal clock operating at 1.25 MHz.

Web Links:
Reference Designs:
www.ti.com/powerreferencedesigns

Datasheets, User's Guides, Samples, Software:
**www.ti.com**
Part Number Search: **TPS40222**

Specifications					
Parameter	Test Conditions	Min	Typ	Max	Unit
Input Voltage Range		4.5		8	V
No-Load Input Current	V_{IN} = 5 V, I_{OUT} = 0 A, R_5 = 120 Ω (10-mA Load)		11		mA
Output Voltage	R2 = 10.0 k, R_1 = 7.5 k	1.35	1.40 8	1.44	V 2
Output Voltage Ripple	V_{IN} = 5 V, I_{OUT} = 1.0 A		10		mV_{PP}
Output Load Current		0		1.6	A
Output Over Current			2.6		A
Switching Frequency		1.0	1.25	1.5	MHz
Peak Efficiency	V_{OUT} = 3.3 V, 0.1 A < I_{OUT} < 1.0 A V_{5V_IN} = 5 V		90		%
Full Load Efficiency	V_{OUT} = 1.25 V, I_{OUT} = 1.6 A V_{5V_IN} = 5.0 V		74		%

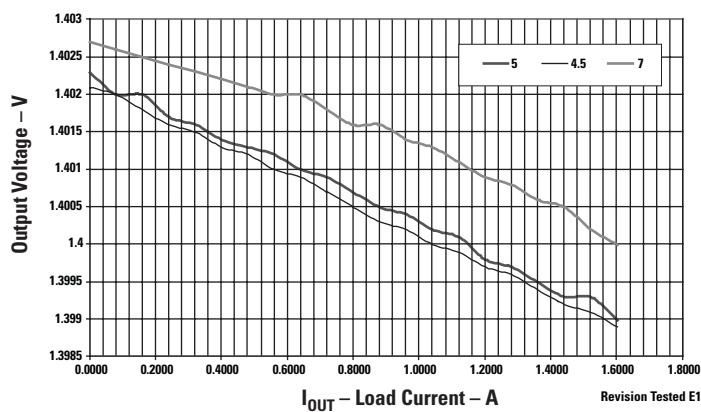### Evaluation Module TPS40222EVM-001
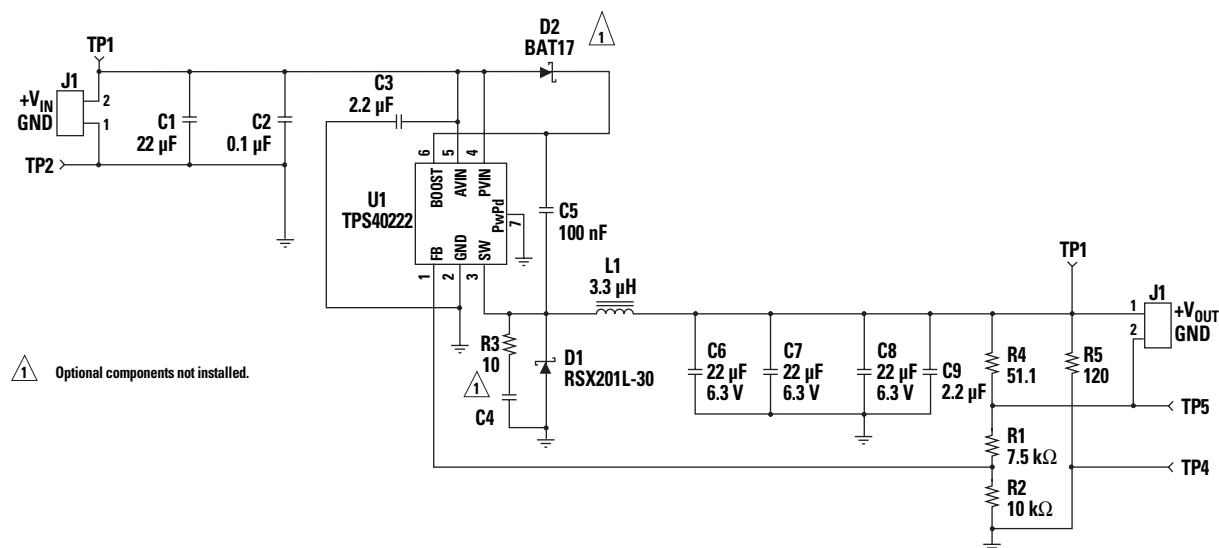
5-V Input, 1.6-A Output, Non-Synch. Buck Converter with Minimal External Components
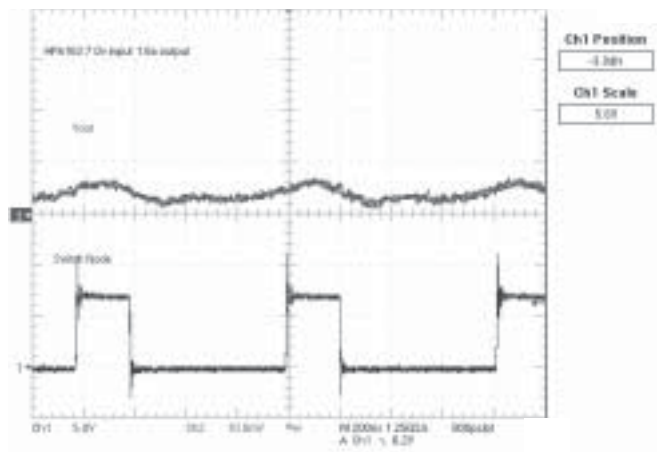
Efficiency vs. Load (V$_{IN}$ = 5, V$_{OUT}$ = 1.25)
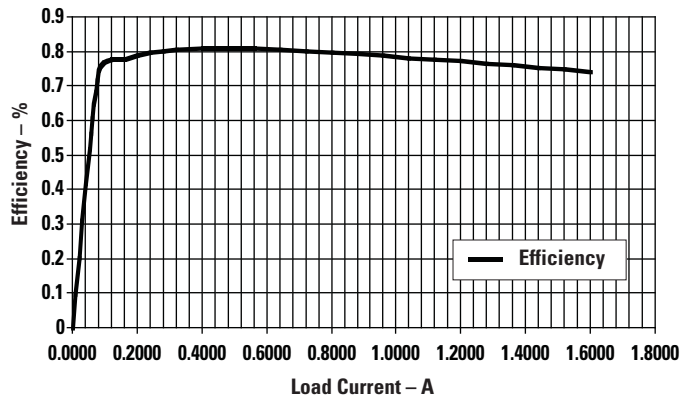
Line and Load Regulation

Typical Ripple Voltage

Small, 3-A Integrated MOSFET Buck Converter from a 12-V or 15-V Input

Description

The TPS5430 DC/DC converter is designed to provide up to a 3-A output from a typical bus voltage of 12 V or 15 V. This evaluation module is designed to demonstrate the small PCB areas that may be achieved when designing with the TPS5430 regulator and does not reflect the high input voltages that may be used when designing with this part. The switching frequency is internally set at a nominal 500 kHz. The high-side MOSFET is incorporated inside the TPS5430 package along with the gate-drive circuitry. The low drain-to-source on resistance of the MOSFET allows the TPS5430 to achieve high efficiencies and helps to keep the junction temperature low at high output currents. The compensation components are provided internal to the IC whereas an external divider allows for an adjustable output voltage. Additionally, the TPS5430 provides an enable input. The absolute maximum input voltage is 24 V.

Web Links:
Reference Designs:
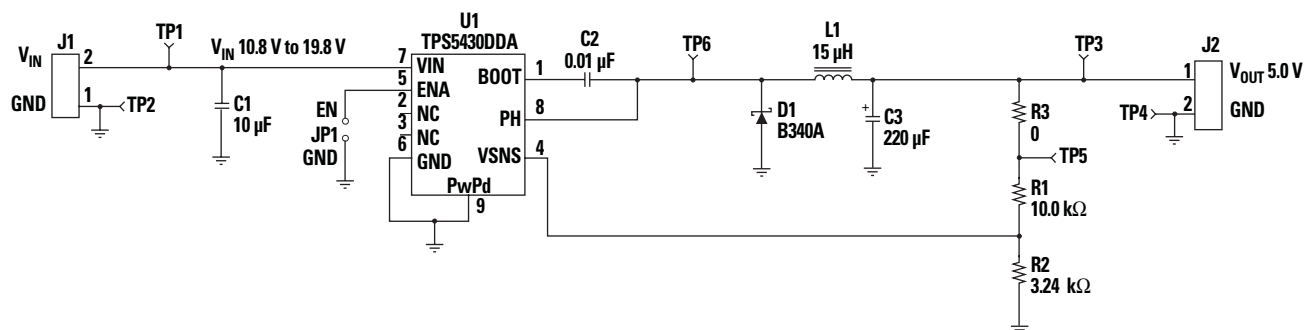**www.ti.com/powerreferencedesigns**

Datasheets, User's Guides, Samples:
**www.ti.com**
Part Number Search: **TPS5430**

Specifications					
Parameter	Test Conditions	Min	Typ	Max	Unit
Input Voltage		10.8	12 or 15	19.8	V
V_{OUT}			5.0		V
I_{OUT}		0		3	A
Switching Frequency			500		kHz
Output Ripple	Full Load		20		mV_{PP}
Efficiency	12 V_{IN}, 1 A Load		92.3%		%

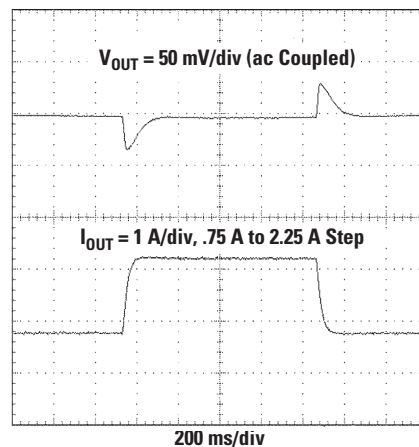## Evaluation Module TPS5430EVM-136

Small, 3-A Integrated MOSFET Buck Converter from a 12-V or 15-V Input
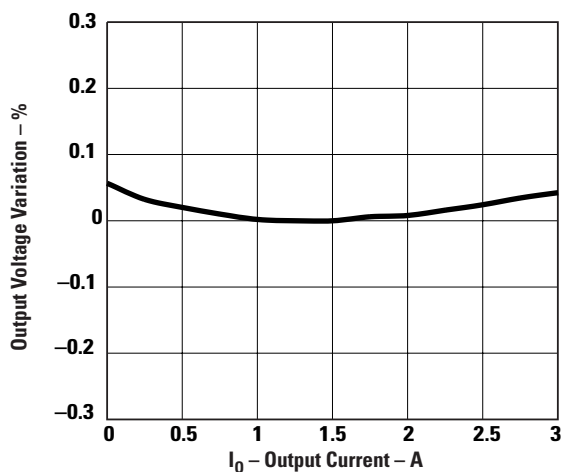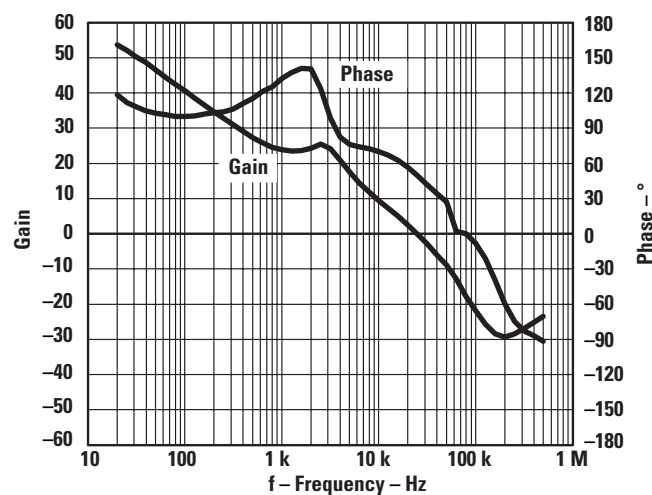
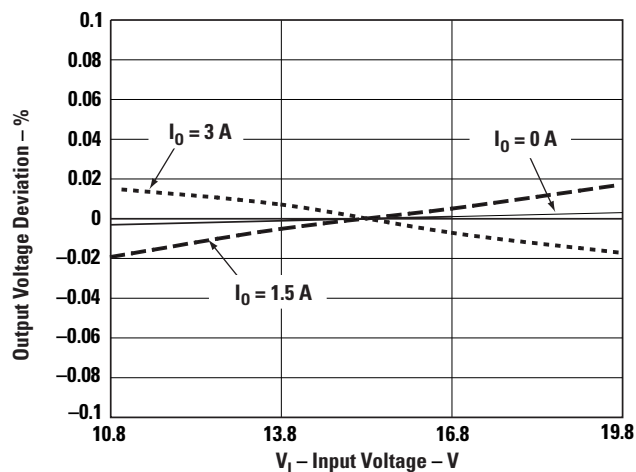Efficiency vs. Output Current
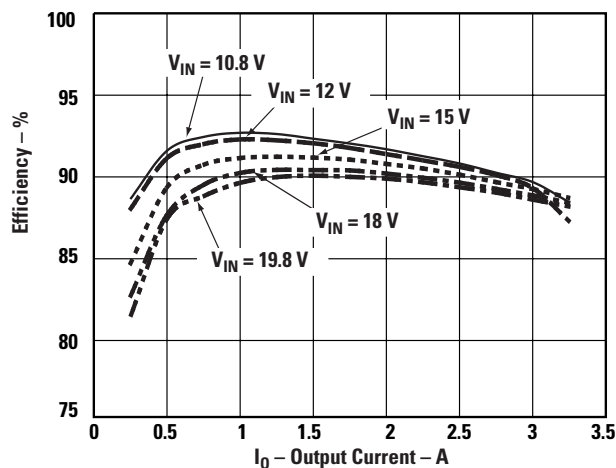
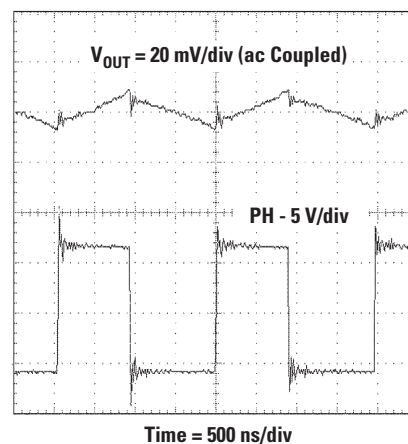Load Transient

Load Regulation vs. Output Current

Measured Loop Response

Line Regulation vs. Input Voltage

Output Voltage Ripple

Integrated Buck Converter Plus LDO for DDR and DDR2

Description

The TPS51116 provides a complete power supply solution for both DDR/SSTL-2 and DDR2/SSTL-18 memory systems. It integrates a synchronous buck controller with a 3-A sink/source tracking linear regulator. The TPS51116 offers the lowest total solution costs where system space is at a premium. This reference design operates from a 12-V rail and can provide a V_{DDQ} voltage of either 2.5 V (DDR) or 1.8 V (DDR2) at 6-A maximum. The V_{TT} output voltage (1.25 V or 0.9 V) is supplied from an internal linear regulator and is equal to half of the V_{DDQ} output. This output voltage can either source or sink 3-A maximum and is supplied by the V_{DDQ} output. The synchronous buck controller operates at 400 kHz using a pseudo-constant frequency PWM with an adaptive on-time control and implements current mode control.

Web Links:
Reference Designs:
**www.ti.com/powerreferencedesigns**

Datasheets, User's Guides, Samples:
www.ti.com
Part Number Search: **TPS51116**

Specifications					
Parameter	Test Conditions	Min	Typ	Max	Unit
Input Voltage		10.8	12	13.2	V
Output Voltage (V_{DDQ})		2.425	2.5	2.575	V
Output Voltage Tol (V_{TT})	$V_{TT} = V_{DDQ}/2$	−40	0	40	mV
Load Current (V_{DDQ})		0		6	A
Load Current (V_{TT})		−3		3	A
Switching Frequency			400		kHz
Output Ripple Voltage	$V_{IN} = 12$ V; $I_O = 9$ A		25	40	mV$_{PP}$
Efficiency 1	$V_{IN} = 12$ V; $I_O = 9$ A		92		%
Efficiency 2	$V_{IN} = 12$ V; $I_O = 4.5$ A		92		%

Reference Design PMP1516
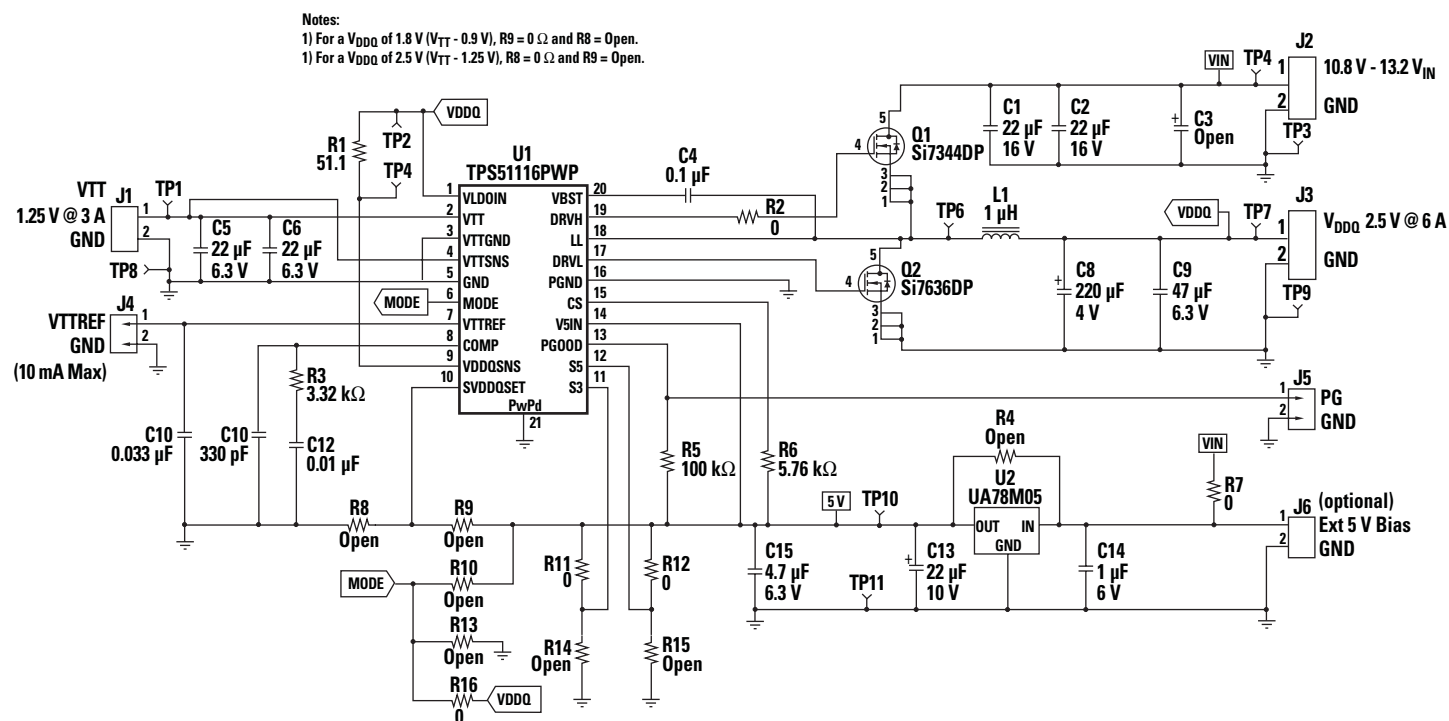
Integrated Buck Converter Plus LDO for DDR and DDR2

Efficiency

Control Loop
V_{IN} = 12 V; I_O = 4 A

Voltage Tracking
Top Trace: V_{TT} x 2 (1.25 V x 2)
Bottom Trace: V_{DDQ}

Turn On: 0.5 V/div, 200 µS/div
V_{IN} = 12 V; 2.5 V @ 4 A, 1.25 V @ 1 A,

Output Ripple: 20 mV/div, 1µS/div
V_{IN} = 12 V; 2.5 V @ 9 A
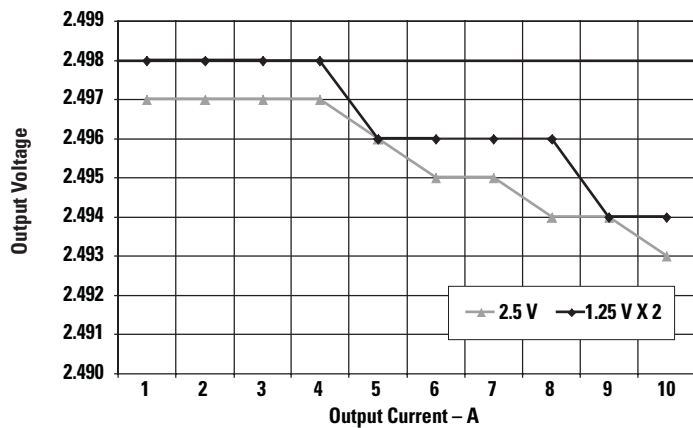
Transient Response
Top Trace: 2.5 V @ 50 mV/div
Bottom Trace: I_O @ 2 A/div

Reference Design Cookbook II for Power Management Products
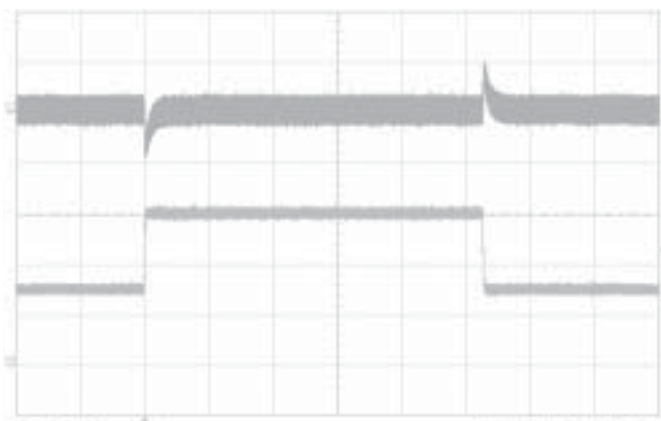
→ ## IEEE 802.3af PD Controller with Integrated DC/DC

Description

This reference design uses a TPS23750 in an isolated, discontinuous mode flyback converter for Power-over-Ethernet (PoE) applications. An input voltage of 34 to 57 VDC is converted to 12 V at 1 A at efficiencies up to 84%. The high level of integration of the TPS23750 provides a small, cost effective solution for PoE applications.

The TPS23750 integrates the functions of a PoE Powered Device (PD) switch and a primary side DC/DC PWM controller. The PoE front end is IEEE802.3af compliant and contains all necessary functions including detection, classification, undervoltage lockout, and inrush current limit, plus the integrated input switch. The PWM section supports isolated flyback and forward topologies, as well as non-isolated, low-side-switch buck topologies.

Web Links:

Reference Designs:
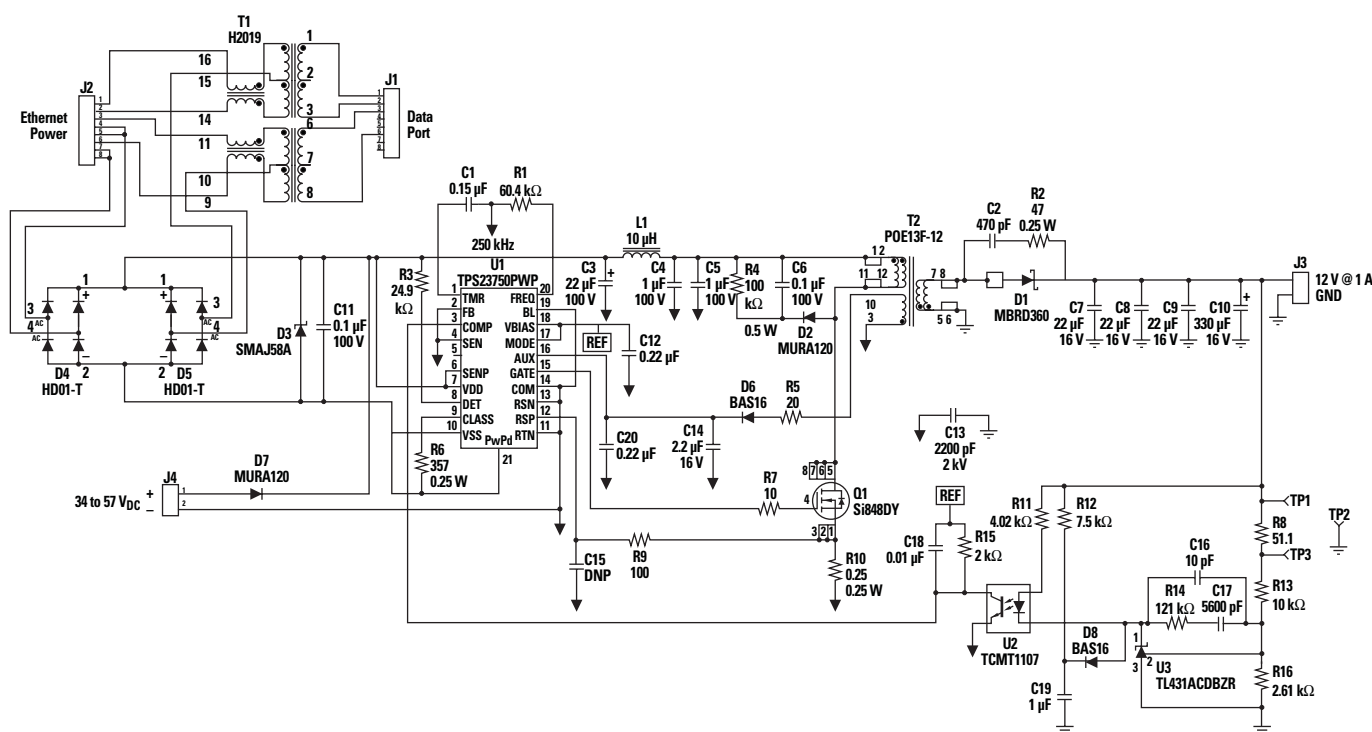**www.ti.com/powerreferencedesigns**

Datasheets, User's Guides, Samples:
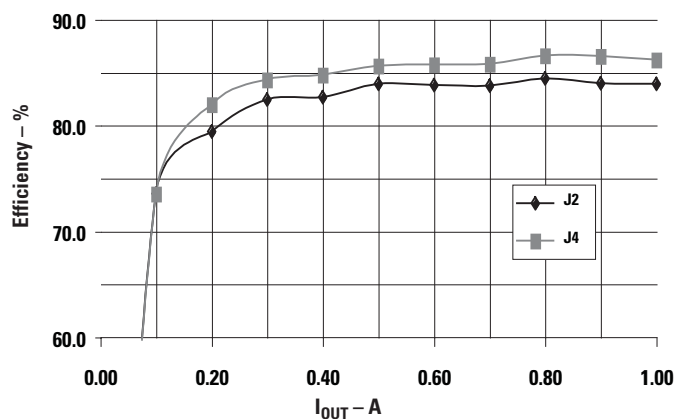**www.ti.com**
Part Number Search: **TPS23750**

Specifications

Parameter	Test Conditions	Min	Typ	Max	Unit
Input Voltage		34	48	57	VDC
Output Voltage		11.6	12.0	12.4	VDC
Load Current		0	1		A
Switching Frequency			250		kHz
Output Voltage Ripple	V_{IN} = 48 VDC, I_{OUT} = 1 A		80		mV
Efficiency	V_{IN} = 48 VDC, I_{OUT} = 1 A		84		%

Reference Design PMP1360

Efficiency (V$_{IN}$ = 48 V) (J2 = System Efficiency)

Load Step (3 = 1 ms, 100 mV) (4 = 1 ms, .50 A)
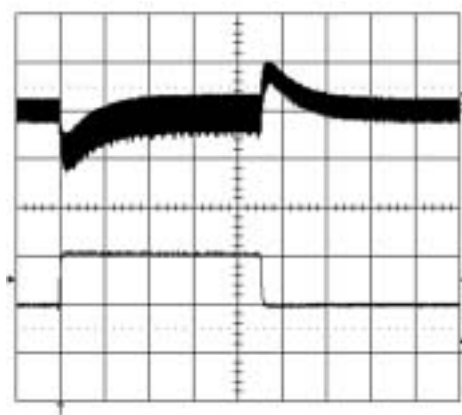
Control Loop (3-kHz Bandwidth, 90 Degrees)
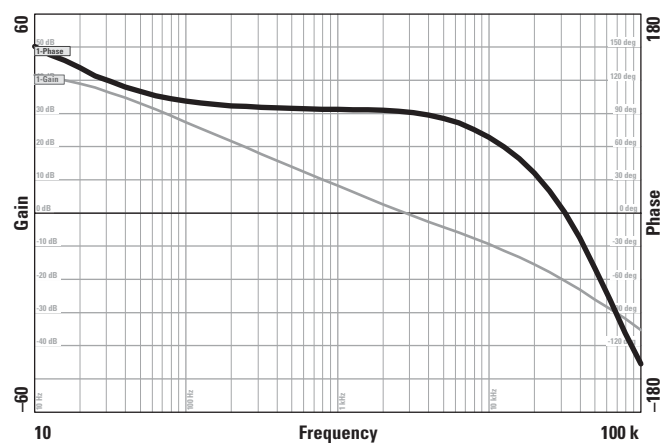
Output Ripple (V$_{IN}$ = 48 V, 1-A Load Across C10)
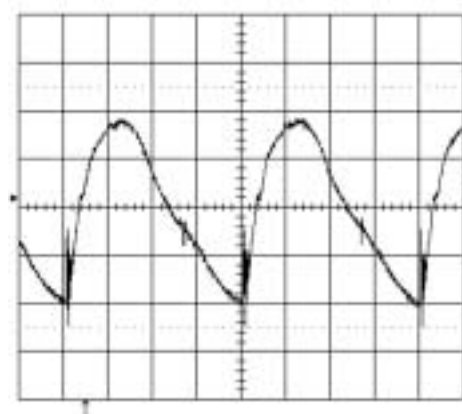
Input Ripple (V$_{IN}$ = 48 V, 1-A Load Across J2-1 and 3)
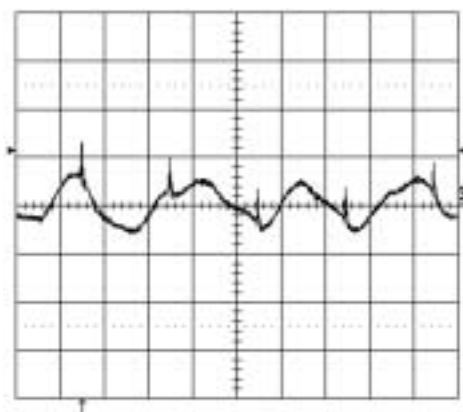
Turn On Response (V$_{IN}$ = 48 V) (0-A Load)
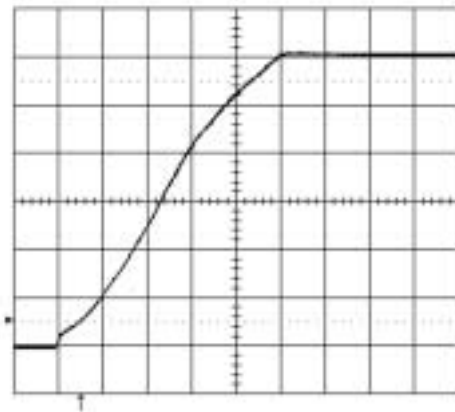
Negative Clamp Converter Provides 10 A at 12 V from a –48-V Telecom Input

Description

This reference design uses the UCC2897 current mode, active clamp, PWM controller to generate an isolated 12-V/10-A output from a standard –48-V telecom input. Hot swap inrush protection is provided by the TPS2391 hot-swap controller. The self-driven synchronous rectifiers allow this design to achieve efficiencies above 93%. A secondary current-sense resistor provides accurate current limit and output voltage fold back. Remote sensing is also provided, allowing accurate regulation at the point of load.

Web Links:

Reference Designs:
www.ti.com/powerreferencedesigns

Datasheets, User's Guides, Samples:
www.ti.com
Part Number Search: **UCC2897**

Specifications					
Parameter	Test Conditions	Min	Typ	Max	Unit
Input Voltage		−36	−48	−72	V
Output Voltage		11.78	12.15	12.51	V
Load Current		0		10	A
Switching Frequency		180	200	220	kHz
Output Ripple Voltage	V_{IN} = −48 V; I_0 = 10 A		200	250	mV$_{PP}$
Efficiency	V_{IN} = −48 V; I_0 = 7 A		93.4		%
	V_{IN} = −48 V; I_0 = 10 A		93.0		%

Reference Design PMP1714
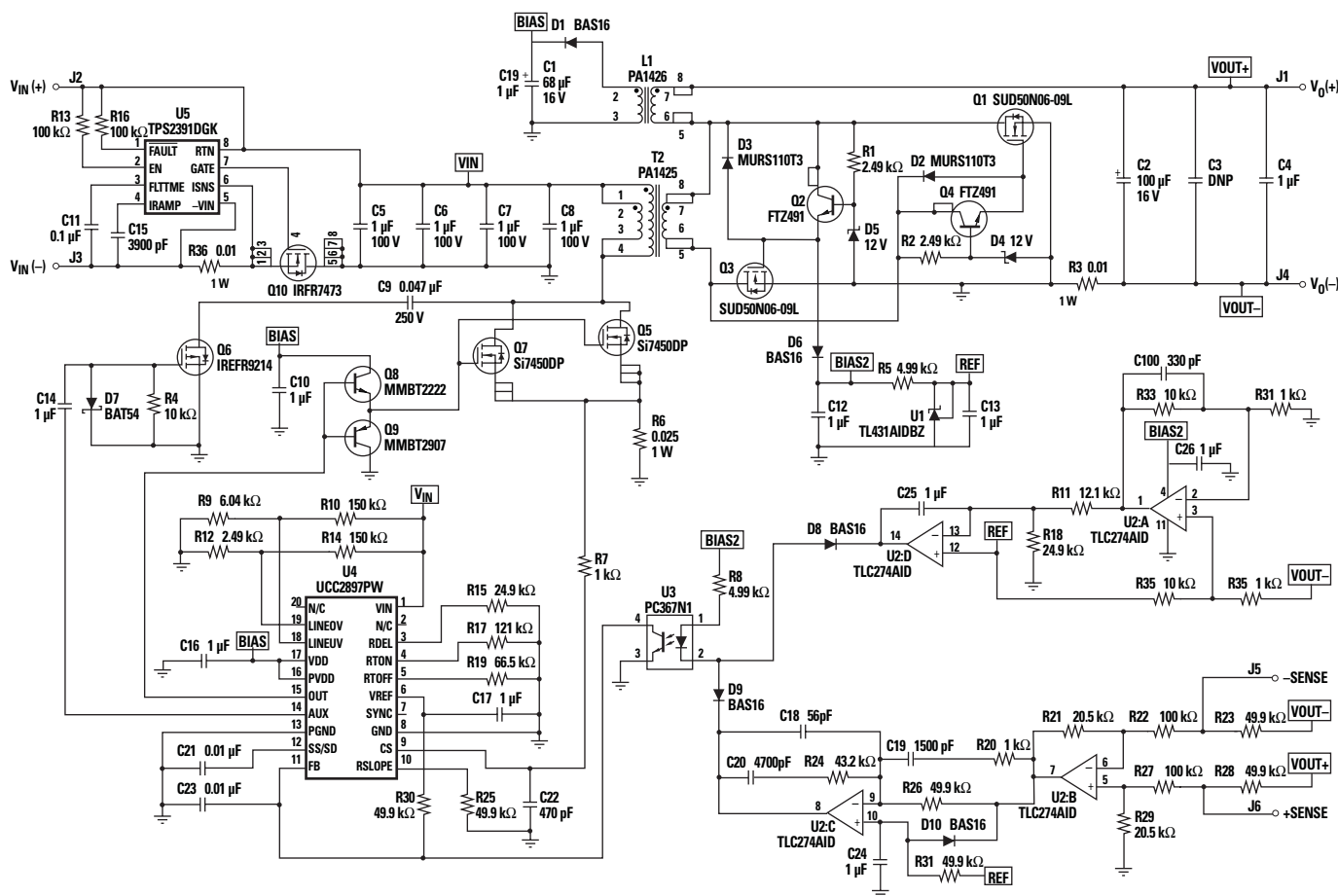
Negative Clamp Converter Provides 10 A at 12 V from a –48-V Telecom Input

Efficiency
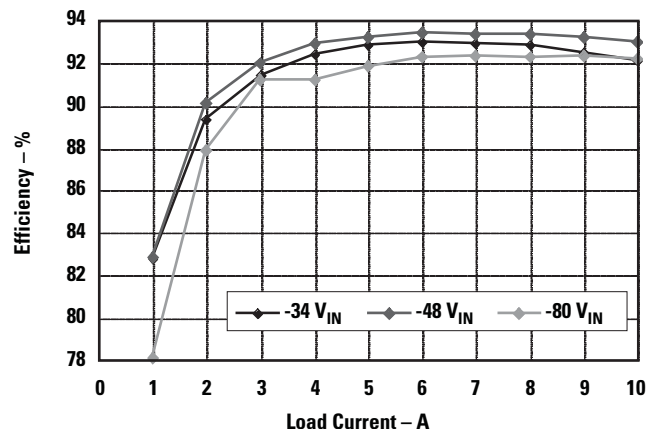
Output Ripple (V_{IN} = –48 V; I_O = 10 A; 100 mV/div; 2 µs/div)
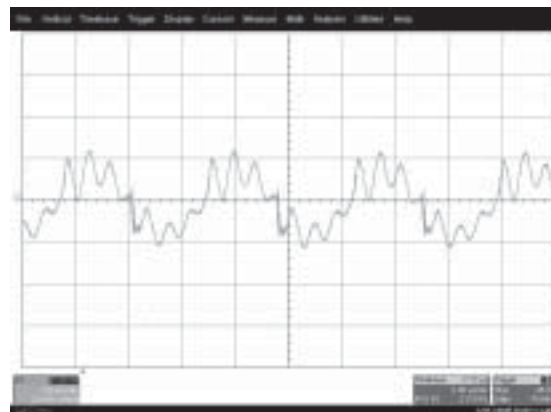
Control Loop (V_{IN} = –48 V; I_O = 10 A)

Turn On (V_{IN} = –48 V; No Load)
Channel 1: V_{OUT}; 5 V/div; 5 ms/div

Transient Response
Top Trace: V_O @ 500 mV/div, 200 µs/div
Bottom Trace: I_O @ 2 A/div, 200 µs/div

UCC3807

→ *Boost Converter Provides 12 V from 4.5-V to 5.5-V V$_{IN}$ at 1 A*

Description

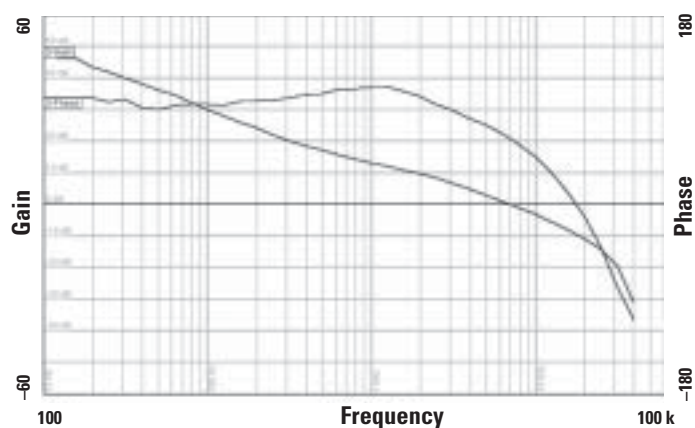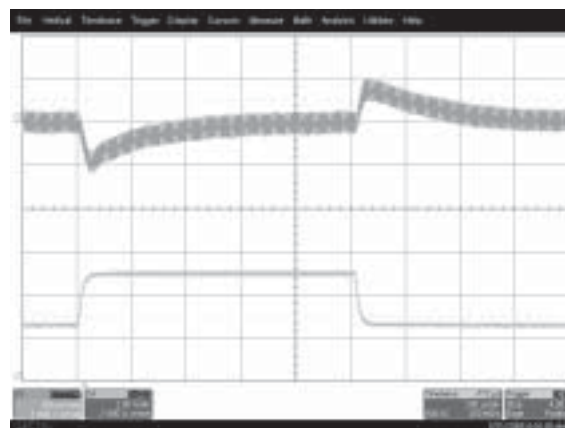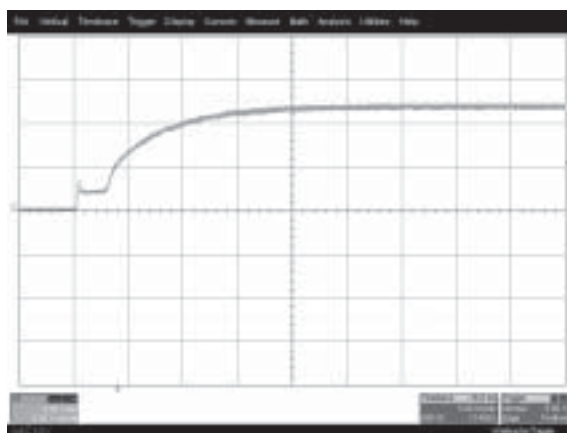The UCC3807 family of high-speed, low-power ICs contains all of the control and drive circuitry required for off-line and DC/DC fixed-frequency current-mode switching power supplies with minimal external parts count. In addition, the UCC3807 has the a programmable maximum duty cycle, which makes it easier to implement the boost topology.

Web Links:

Reference Designs:
www.ti.com/powerreferencedesigns

Datasheets, User's Guides, Samples:
www.ti.com
Part Number Search: **UCC3807**

Specifications					
Parameter	Test Conditions	Min	Typ	Max	Unit
Input Voltage			4.5	5.5	V
Output Voltage		11.88	12	12.12	V
Load Current		0		1	A
Switching Frequency		180	200	220	kHz
Output Ripple Voltage	V$_{OUT}$ = 12 V			10	mV/$_{PPK}$

Reference Design PMP1545
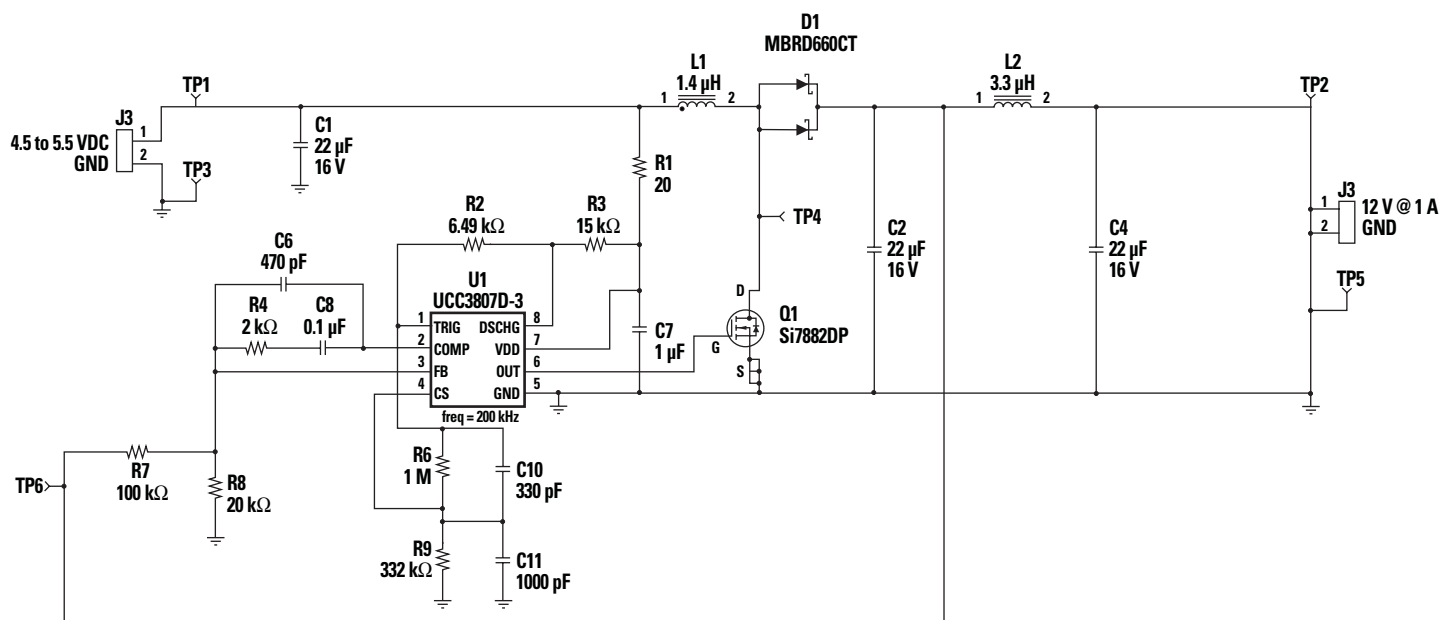
Boost Converter Provides 12 V from 4.5-V to 5.5-V V$_{IN}$ at 1 A

Efficiency (V$_{IN}$ = 12 V)
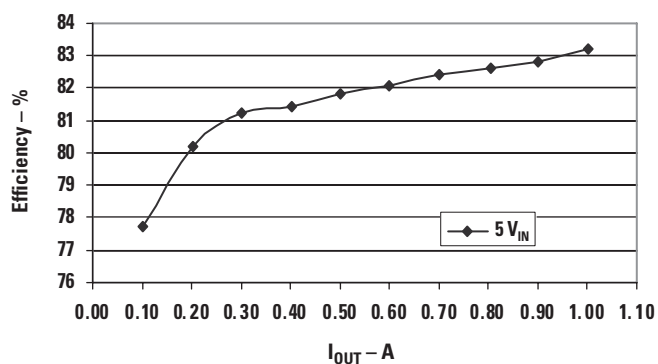
Start Up (V$_{IN}$ = 5 V, V$_{OUT}$ = 12 V, Loaded to 0 A)
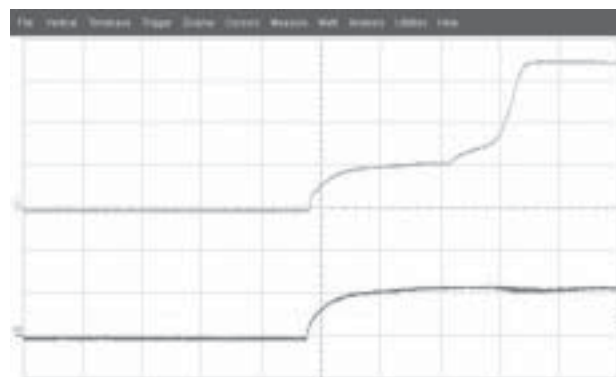
Load Regulation
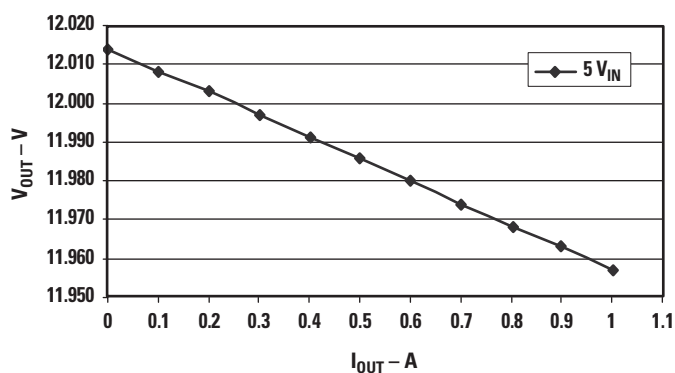
Load Transient (V$_{IN}$ = 5 V, V$_{OUT}$ = 12 V, Pulsed to 0.1 A and 1 A)
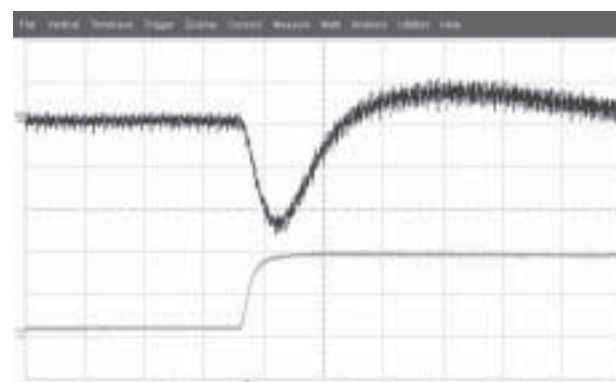
Control Loop (V$_{IN}$ = 5 V, Gain 1, 1 A, Phased 90 Degrees)
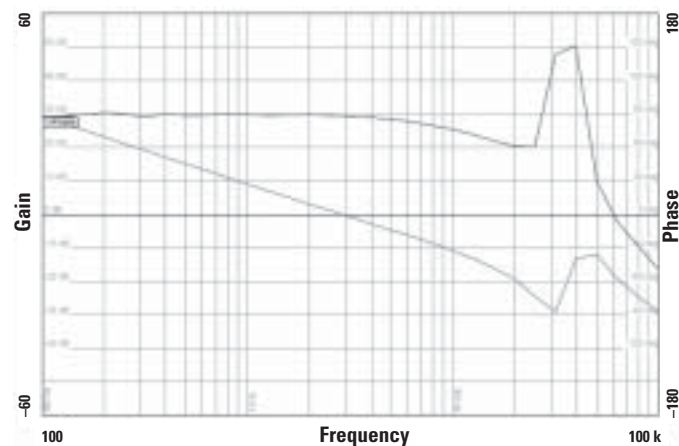
Load Transient (V$_{IN}$ = 5 V, V$_{OUT}$ = 12 V, Pulsed to 0.1 A and 1 A)
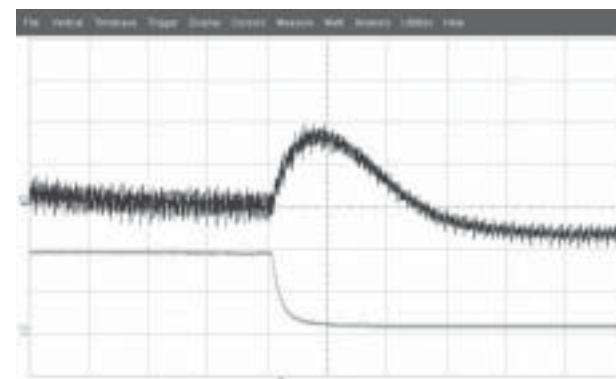
→ *Advanced Multi-Chemistry and Multi-Cell Battery-Pack Charger*

Description

The bq2472x family is a synchronous battery-pack charger and path selector with a high level of integration for portable applications. The output voltage, charge current and input current limit are programmable via a simplified SBS-like SMBus interface. It can provide up to 8 A of charge current from an input 8 V to 28 V for 3-cell or 4-cell Li-Ion or Li-Pol applications. The dynamic power management (DPM) function SMBus interface modifies the charge current depending on system load conditions, avoiding ac adapter overload. High-accuracy current-sense amplifiers enable accurate measurement of either the charge current or the ac adapter current, allowing termination of nonsmart packs and monitoring of overall system power.

Web Links:
Reference Designs:
www.ti.com/powerreferencedesigns

Datasheets, User's Guides, Samples:
www.ti.com
Part Number Search: **bq24721**

Specifications					
Parameter	Test Conditions	Min	Typ	Max	Unit
Input Voltage		13		24	V
Battery Regulation Voltage		12		19.2	V
Charge Current (Average)		0	3	6	A
Adapter Input Current (Average)		0		7	A
Switching Frequency			300k		Hz
Efficiency	V_{IN} = 19.5 V, V_{BAT} = 12.6 V; I_O = 3000 mA		93		%

Evaluation Module bq24721EVM
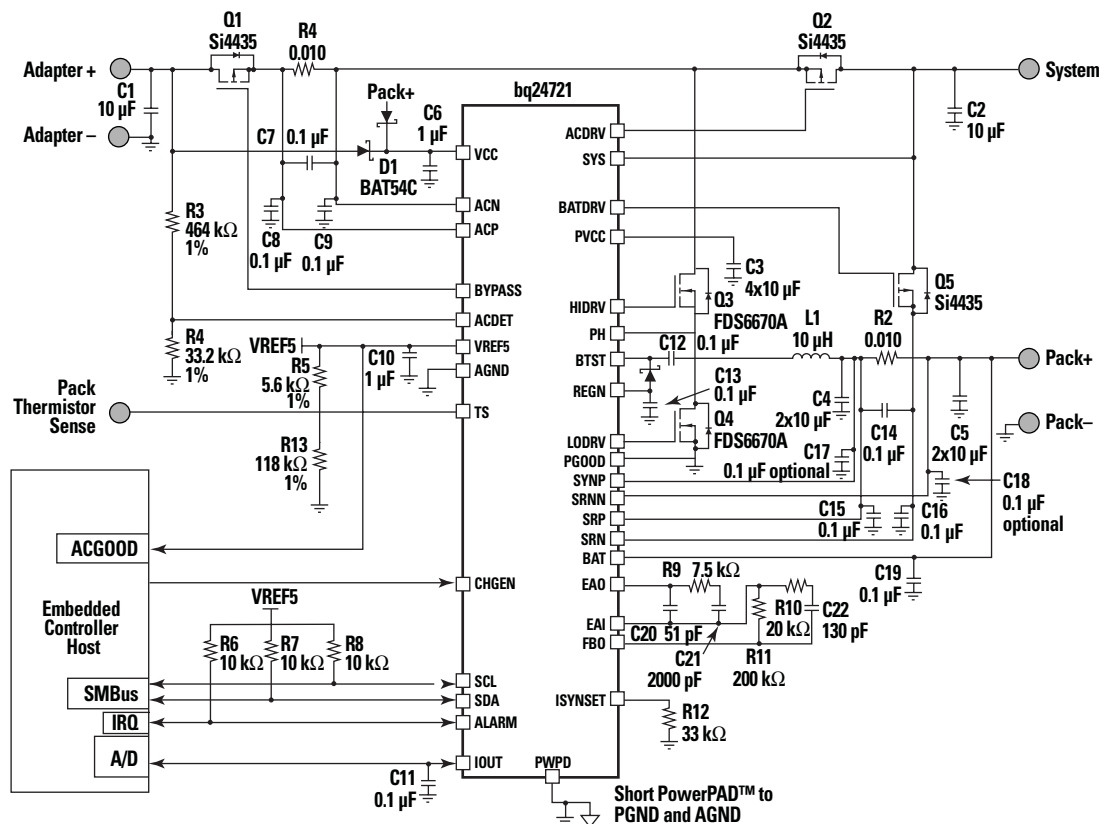
Advanced Multi-Chemistry and Multi-Cell Battery-Pack Charger

Efficiency vs. Battery Charge Current
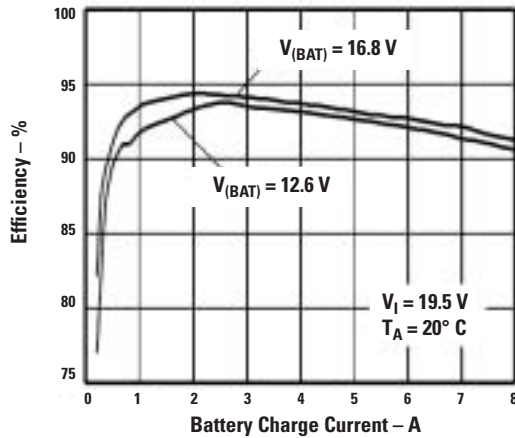
Battery Removal (Constant Current Mode)
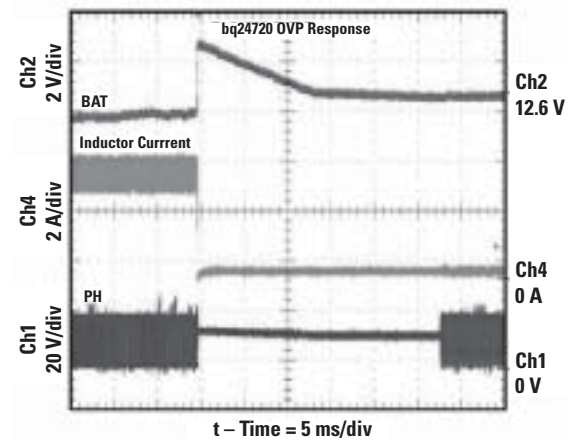
Transient System Load
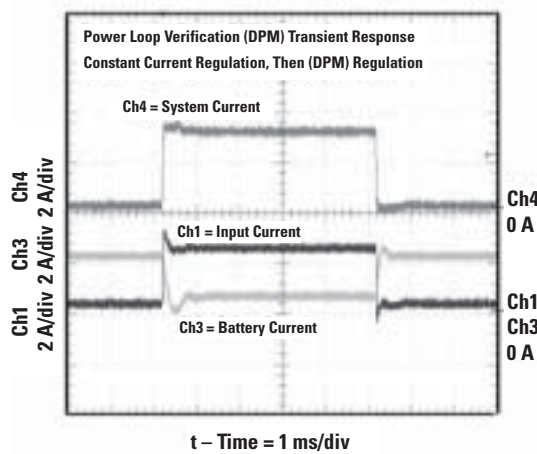
Soft-Start Charge Current
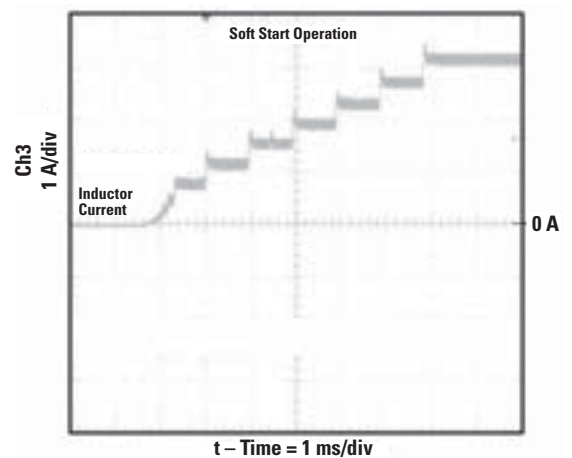
→ *Digital Half-Bridge Converter*

Description

The UCD8220 is a digitally managed push-pull analog PWM controller to be used in digitally managed power supplies using a microcontroller or the TMS320™ DSP family. The UCD8220 is a double-ended PWM controller configured with push-pull drive logic. Systems using the UCD8220 device close the PWM feedback loop with traditional analog methods, but the UCD8220 controller includes circuitry to interpret a time-domain digital pulse train "CLK Signal". The pulse train sets the operating frequency and maximum duty-cycle limit which are used to control the power-supply operation. This eases implementation of a converter with high-level control features without the added complexity or possible PWM resolution limitations of closing the control loop in the discrete time domain. The UCD8220 reference design is a half-bridge topology switching at 600 kHz. It operates from the standard telecom input range of 36 V to 75 V and produces 12 V at 100 W.

Web Links:

Reference Designs:
www.ti.com/powerreferencedesigns

Datasheets, User's Guides, Samples:
www.ti.com
Part Number Search: **UCD8220**

Specifications					
Parameter	Test Conditions	Min	Typ	Max	Unit
Input Voltage		36	48	75	V
Output Voltage			12		V
Load Current		3		8.33	A
Switching Frequency	Output Ripple		600		kHz
Output Ripple Voltage			20		mV$_{PP}$
Efficiency	V_{IN} = 48; I_0 = 5 A		90.5		%
	V_{IN} = 48; I_0 = 8.33 A		90		%

Reference Design UCD8220

Note: The power stage and the remainder of the control circuitry is available on www.ti.com in the UCD8220 product folder.

Efficiency vs. Output Current (V_{OUT} = 12 V)

Clock and V_{OUT} Soft Start (V_{IN} = 48 V, I_{OUT} = 5 A)
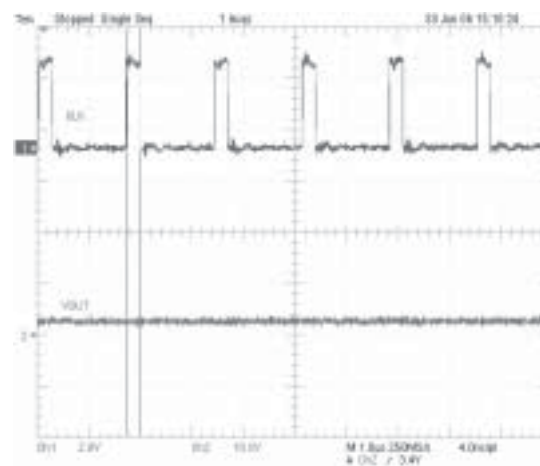
UCD8220EVM Magnitude and Phase Plot
(V_{IN} = 48 V, I_{OUT} = 8.3 A)
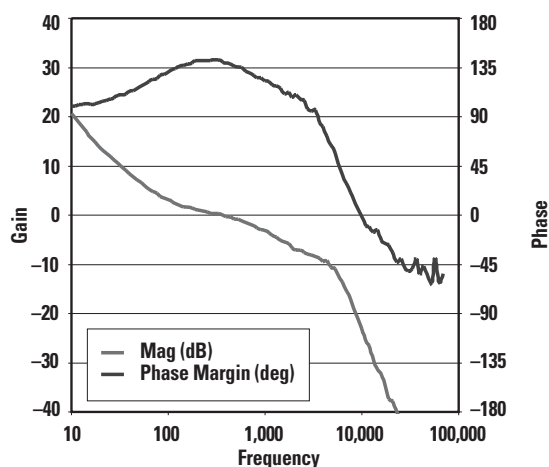
Transient Response (V_{IN} = 48 V, I_{OUT} = 3 A to 8 A)
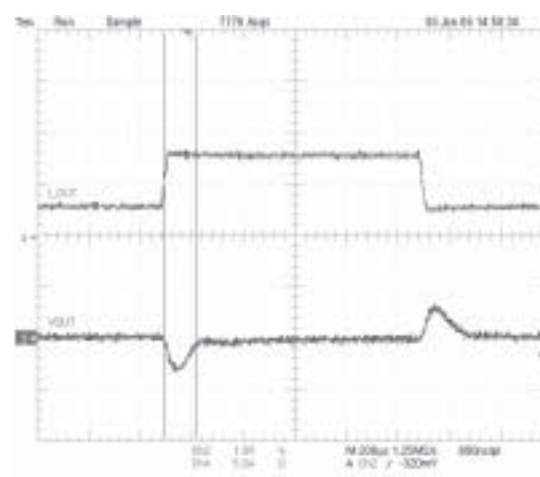
Clock and V_{OUT} During Soft Start (V_{IN} = 48 V, I_{OUT} Set to 5 A)
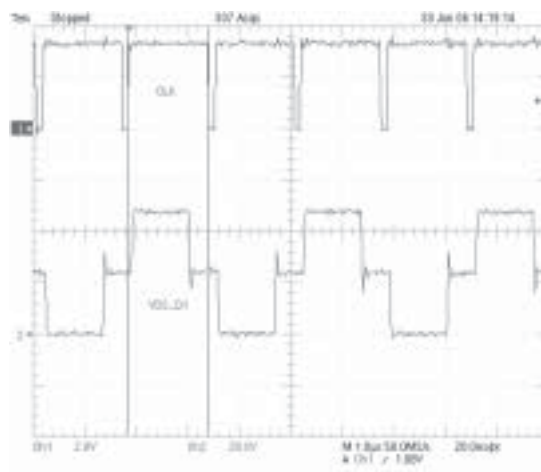
V_{OUT} Ripple (V_{IN} = 48 V, I_{OUT} = 5 A)
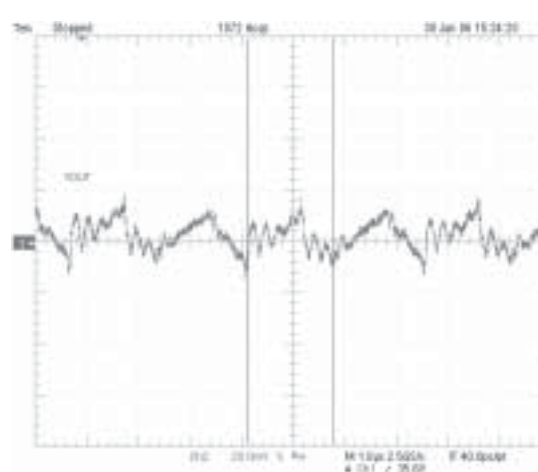
Information at Your Fingertips
www.ti.com/selection

TI has a full line of selection guides to help in your design process:
- *Amplifier and Data Converter*
- *Clocks and Timing*
- *DSP*
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- *MSP430*
- *Power Management*

www.ti.com/aaj-sgad

Download the current Analog Applications Journal (and past issues) to make your design challenges easier.
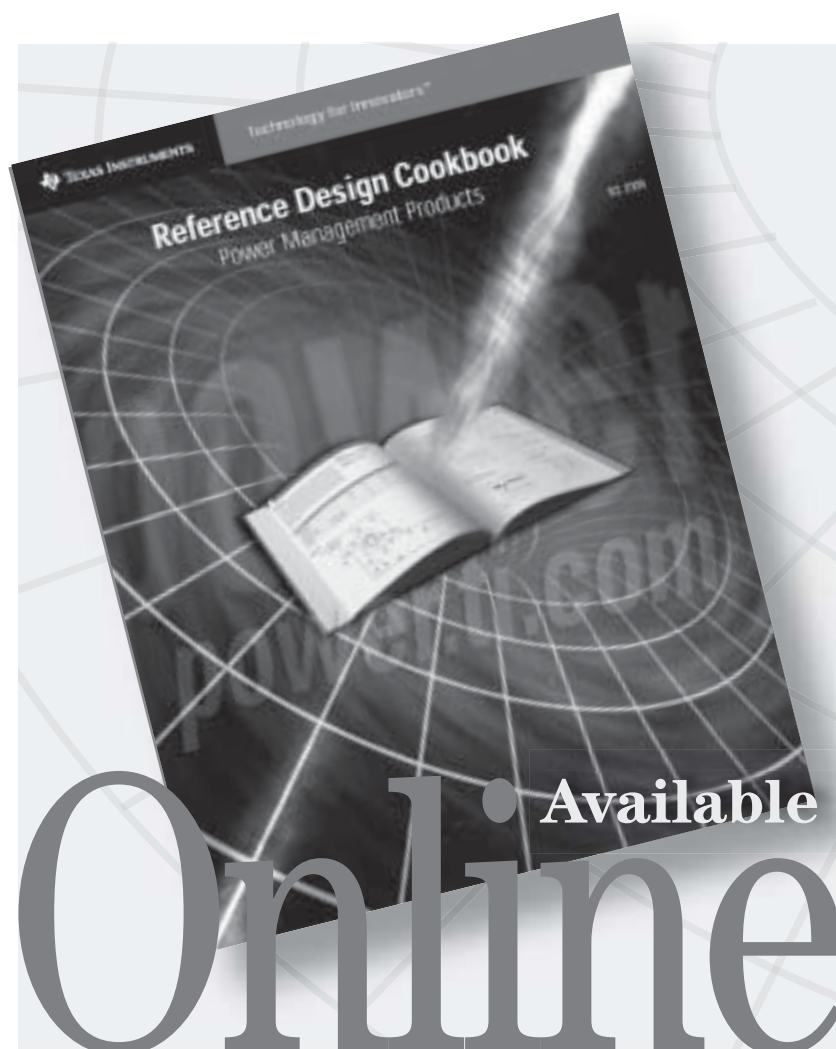
Reference Design **Cookbook I** for Power Management Products

TI introduced its first **"cookbook"** of power management reference designs in 3Q 2005. In this catalog, you will find many complete reference designs with tables, schematics and waveforms. A few of the designs included are:
• Synchronous Buck Converter
• Inverting Buck-Boost Converter
• 5-V, 1-A Boost Converter
• SEPIC High-Frequency Controller
• Negative-Output Flyback Converter
• Triple-Output Flyback PWM Controller
• Lithium-Ion Charger

This cookbook and other reference designs are available on TI's power management reference design website at: **www.ti.com/powerreferencedesigns**

Also, check out TI's "Power Quick Search" tool at **power.ti.com** for recommended power solutions across DC/DC conversion and PWM controller products based on user input criteria.

Thanks for using TI's **Design Reference Cookbook II**.
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