LED Lighting Reference Design Cookbook

TEXAS INSTRUMENTS

LED Street Lighting

LED Industrial Lighting

LED Office Lighting

Residential/Commercial LED Lighting

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LED Lighting Reference Design Cookbook

Helping You Solve Your Lighting Design Challenges

The LED Lighting Reference Design Cookbook is designed to provide you with a valuable tool to help you solve your lighting design needs. Customers seeking the latest in innovative and affordable LED lighting solutions can benefit from TI's broad product portfolio of AC/DC, DC/DC, LED drivers, power management devices, wireless and wired interface control and embedded processors.

Designers have the option of not only controlling the power stage, but regulating LED currents as well, eliminating the need for multiple components and reducing system cost. Systems can be designed to accurately control voltage and current regulation for precise light intensity and color mixing, temperature monitoring to prevent thermal runaway, intelligent/ adaptive dimming, and fault detection (over voltage/current, blown string). Communication with external systems is also possible via power-line communication (PLC), wireless technology or interfaces.

LED lighting designers are challenged with meeting their efficiency and reliability goals faster in advanced lighting designs. TI's lighting portfolio is helping designers achieve their goals at a faster rate.

To see the TI solutions for general lighting, signage, backlighting and automotive, all complimented by a comprehensive customer support network, visit: **www.ti.com/led**

TI has Solutions for Your Lighting Challenges:

- Precision channel-to-channel and chip-to-chip accuracy to create the best hue and luminance in your RGB message boards and video displays

- Controllers to power and dim high brightness white or RGB LEDs for architectural luminaries and portable lighting

- Powering arrays of HB LEDs off an AC source for use in street lighting and replacing high-intensity discharge (HID) lamps

- Highly integrated ZigBee® transceivers and SoC solutions for wireless lighting control and home automation

LED Lighting Overview

TI is a global market leader that leverages a rich history in Lighting expertise, combines it with analog and embedded processing portfolios, and delivers all of the building blocks for complete system solutions. Choose TI for broadest expertise, breadth of selection, and comprehensive support for efficient, reliable, cost-effective power conversion, communication and smart sensing and control solutions.
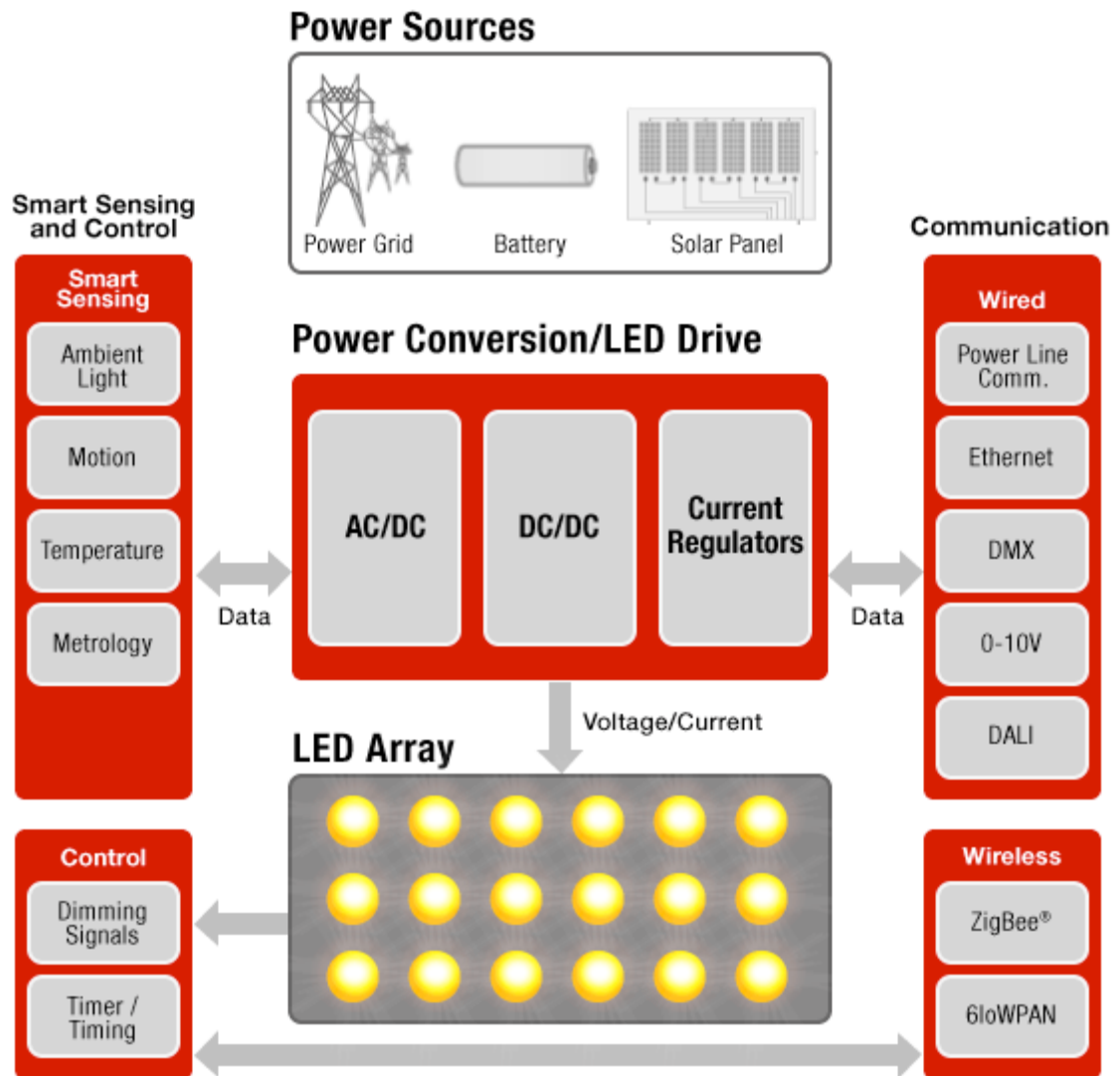
www.ti.com/led

➔ *Product Overview*

AC/DC Analog LED Drivers

Device	Description	Type	Applications	Output Power (W)	PFC
TPS92070	Dimmable AC/DC LED Lighting Driver Controller	AC/DC	Retrofit Bulbs Luminaire	3 to 12	>0.7
TPS92010	High-Efficiency, Offline LED Lighting Controller	AC/DC	Retrofit Bulbs Luminaire	3 to 12	>0.55
TPS92001/2	General Purpose LED Lighting PWM Controller	AC/DC	Retrofit Bulbs Luminaire	5 to 20	>0.8
TPS92210	Natural PFC LED Lighting Driver Controller	AC/DC	Retrofit Bulbs Luminaire	5 to 30	>0.9
UCC28810/1	LED Lighting Power Controller	AC/DC	Retrofit Bulbs Luminaire Street Lighting	15 to 100	>0.9
TPS92020	Resonant-Switching Driver Controller for LED Lighting	DC/DC	High-Light Output 2 or 3 Stage	80	—

New products are listed in **bold red.**

Selection Guide

Device	V_{IN} (min) (V)	V_{IN} (max) (V)	LED Voltage (max) (V)	Switching Frequency (kHz)	DC/DC or AC/DC Control	Isolated Applications	Non-Isolated Applications	Topology	LED Configuration	Dimming	PFC	EVM	Package(s)
TPS61165	3	18	38	1,200	DC/DC	—	✔	Boost	Series/Parallel	PWM	—	✔	6 SON 6 SOT-23
TPS61166	2.5	10	17	1,200	DC/DC	—	✔	Boost	Series/Parallel	PWM	—	✔	10 SON
TPS61195	4.5	21	45	1,000	DC/DC	—	✔	Boost	Series/Parallel	PWM	—	✔	28 WQFN
TPS61500	2.9	18	38	2,200	DC/DC	—	✔	Boost	Series/Parallel	PWM or PWM-to-Analog	—	✔	14 HTSSOP
TPS92510	3.5	60	57	2,500	DC/DC	—	✔	Buck	Series/Parallel	PWM	—	✔	10 MSOP
TPS40211	4.5	52	52	1,000	DC/DC	—	✔	Boost/SEPIC	Series/Parallel	PWM/Analog	—	✔	10 MSOP 10 SON
TPS92001	9	19	Configurable	100	AC/DC	✔	✔	Flyback/Buck	Series/Parallel	TRIAC	✔	✔	8 MSOP 8 SOIC
TPS92002	14	19	Configurable	100	AC/DC	✔	✔	Flyback/Buck	Series/Parallel	TRIAC	✔	—	8 MSOP 8 SOIC
TPS92010	6.3	21	Configurable	130	AC/DC	✔	✔	Flyback	Series/Parallel	TRIAC	—	✔	8 SOIC
TPS92020	11.5	18	Configurable	350	DC/DC	✔	✔	Half-Bridge	Multi-String	PWM	—	✔	8 SOIC
TPS92070	9	21.5	Configurable	146	AC/DC	✔	✔	Flyback	Series/Parallel	TRIAC	✔	✔	16 TSSOP
TPS92210	9	20	Configurable	140	AC/DC	✔	✔	Flyback	Series/Parallel	TRIAC	✔	✔	8 SOIC
UCC28810	15.4	18	Configurable	140	AC/DC	✔	✔	Flyback	Series/Parallel	TRIAC	✔	✔	8 SOIC
UCC28811	12	18	Configurable	140	AC/DC	✔	✔	Flyback	Series/Parallel	PWM/Analog	✔	✔	8 SOIC

New products are listed in **bold red.** *Preview products are listed in* **bold blue.**

Wireless Communications

TI's new CC2530 is a true system-on-chip solution tailored for IEEE 802.15.4, ZigBee®, ZigBee RF4CE and Smart Energy applications. With its high operating temperature of up to 125° C, the CC2530 is ideal for Lighting applications.

Product	Description	Operating Temperature	Protocol
CC2530	Second Generation System-on-Chip Solution for 2.4 GHz	125° C	IEEE 802.15.4/ZigBee

Product Overview →

Microcontroller (MCU) for Advanced Lighting Solutions

TI's MCU lighting solutions give designers efficient, flexible and scalable intelligent lighting management and control. TI's portfolio of MCU hardware and software platforms speeds design and development enabling designers to adopt advanced communications and features such as power line communications or 6loWPAN to control lighting designs. In addition, using a digital approach for functionality such as digital power, communications/control, and motion or ambient light sensing can move hardware features into software which increases flexibility.

To get started with TI's broad suite of MCU solutions for your LED and other lighting design and control needs visit below for our demonstration platforms and development kits. Or click the direct links to learn specifically about intelligent lighting and communications control or digitally powered lighting.

MCU	Benefits	Applications
MSP430™16-Bit Ultra-Low Power MCUs	• Ultra-low power consumption • Integrated intelligent peripherals • Ease of use	• Wireless Communications/Control (ZigBee, 6loWPAN, 802.15.4, SimpliciTI™, etc.) • Wired Communications/Control (DALI, DMX-512, KNX, etc.)
C2000™ 32-Bit Real-Time MCUs	• 32-bit performance for real-time control • Lower system cost • Ease of use • Packaging and price for cost sensitive applications	• Digital Power • Power line Communications
Stellaris® ARM® Cortex™-M3-Based MCUs	• ARM® Cortex™-M3 • Advanced	• Ethernet Control • Wired Communications/Control (DALI, DMX-512, etc.)

Digital Power Based on Microcontroller Solutions

TI provides designers with a portfolio of controllers to solve any lighting digital power system design challenge. Whether designing for isolated or non-isolated solutions from AC/DC to DC/DC, TI's flexible, customizable and intuitive portfolio enables a variety of solution.

Product	Features	Packages
F28x Piccolo Series	The F2802x Piccolo™ family of microcontrollers provides the power of the C28x™ core coupled with highly integrated control peripherals in low pin-count devices	TSSOP (DA) 38

Intelligent Lighting/ Communications and Control

Intelligent lighting is the ability to reduce the amount of light and/or energy used so that only the right amount of light is delivered exactly when and where it is needed. Digital control of LEDs using MCUs allows developers to take advantage of the unique characteristics of LEDs, such as long life, high dimming ratio, energy efficiency and vibration resistance, and to quickly and easily deliver intelligent lighting solutions. Digital control can be achieved via wired or wireless communications through a number of different communication standards. Texas Instruments offers microcontroller solutions for all your LED lighting design and control needs, including demonstration platforms and development kits.

Solutions/Protocol	Product	Tool/Kit/Demo/Platform	For more information:
DALI	MSP430™ MCU	TPS62660 LED-338 EVM	For DALI app note: www.ti.com/daliappnote
DMX-512	MSP430 MCU / Stellaris®	DMX-512 apps note/Third-party design	MSP430 - Demo code and reference design is available upon request at Technical Support.
Power Line Communication	C2000™ MCUs	TMDSPLCKIT - V2	Stellaris - Available through third-party Golden IC Technology Co., Ltd. - support@golden-ic.com
ZigBee®/802.15.4	MSP430F54xxA	MSP430F5438 Experimenter's Board	www.ti.com/plc
KNX/KNX-RF	MSP430	N/A	www.ti.com/msp430f5438 Available through 3rd parties; for more information visit: TAPKO Technologies GmbH Weinzierl Engineering GmbH
6loWPAN	CC430(MSP430 MCU + Low-Power RRF)	Third-party design	Available through third-party Sensinode.
Ethernet	Stellaris®	Ethernet development and evaluation kits	www.ti.com/stellariskits
General-use MCU(user interface, system supervisor, etc.)	MSP430 MCU	Development and evaluation kits	www.ti.com/msp430

➔ *Retrofit Lighting - A19/E27*   NEW!

TPS92001 PMP5163G – Offline, 10-W Dimmable LED Driver
PMP5163G is a non-isolated, inverted buck LED driver with small form factor suitable for A19/E27 and designs with 9 LEDs at an operating current of 310 mA.

Web Links
Datasheets, user's guides, samples:
www.ti.com/tool/PMP5163
www.ti.com/product/TPS92001

Design Specifications

Topology	Converter Type AC or DC	LED Configuration	Number of LEDs per String (typ)	Number of LED Strings (typ)	Input Voltage Range			Output Voltage Range (typ)	Output Current (typ)	Typ Power Output (W)	Peak Efficiency (%)	PFC	Isolated/ Non-Isolated	Dimmable	Dimming Input
					(min)	(typ)	(max)								
Inverted Buck	AC	Series	9	1	108	120	132	29	310 mA	9	84	0.86	Non-Isolated	Yes	TRIAC

Efficiency
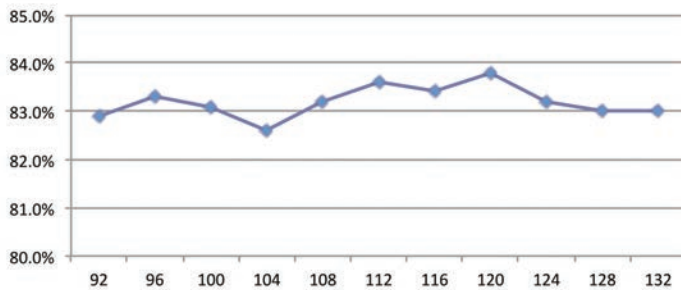
Power Factor

LED Current

23% change in current over 43% change in input voltage.
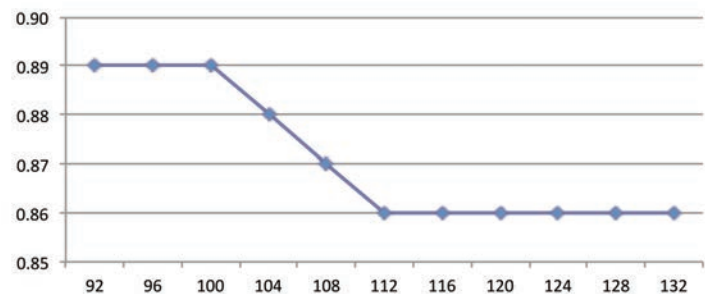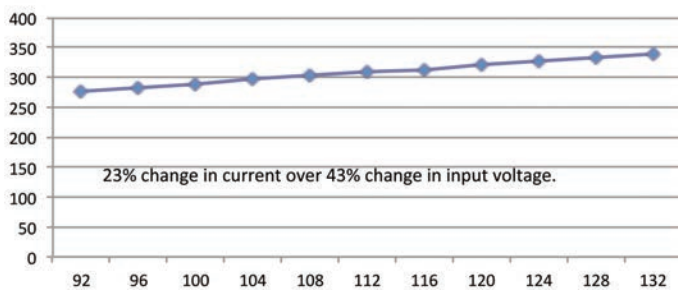
PMP5163G Board
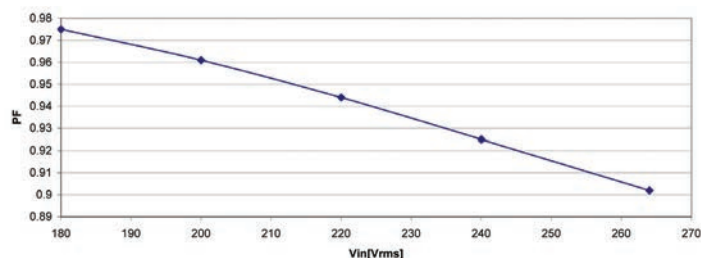

For more reference designs, see: www.ti.com/powerreferencedesigns
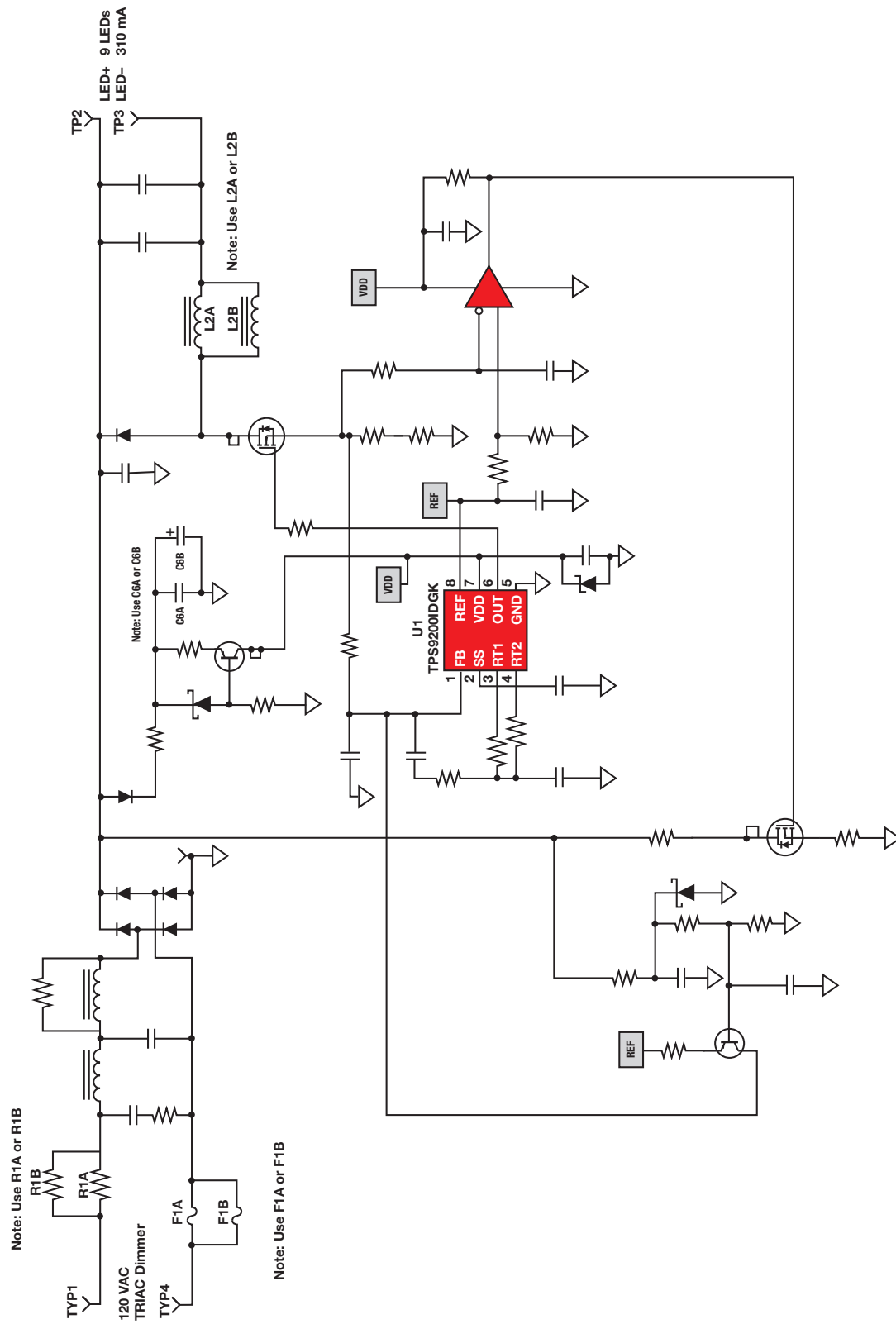
Retrofit Lighting - A19/E27

For more reference designs, see: www.ti.com/powerreferencedesigns

➜   *Retrofit Lighting - A19/E27*   NEW!

TPS92001 PMP6648C – Offline, Dimmable 10-W LED Driver

PMP6648C a non-isolated, boost LED driver with small form factor suitable for A19/E27 and E26/27 designs with 3 high voltage LEDs at an operating current of 34 mA.

Web Links
Datasheets, user's guides, samples:
www.ti.com/tool/**PMP6648**
www.ti.com/product/**TPS92001**

Design Specifications

| Topology | Converter Type AC or DC | LED Configuration | Number of LEDs per String (typ) | Number of LED Strings (typ) | Input Voltage Range | | | Output Voltage Range (typ) | Output Current (typ) | Typ Power Output (W) | Peak Efficiency (%) | PFC | Isolated/Non-Isolated | Dimmable | Dimming Input |
					(min)	(typ)	(max)								
Boost	AC	Series	3	1	108	120	132	300	34 mA	10.2	>90	>0.9	Non-Isolated	Yes	TRIAC
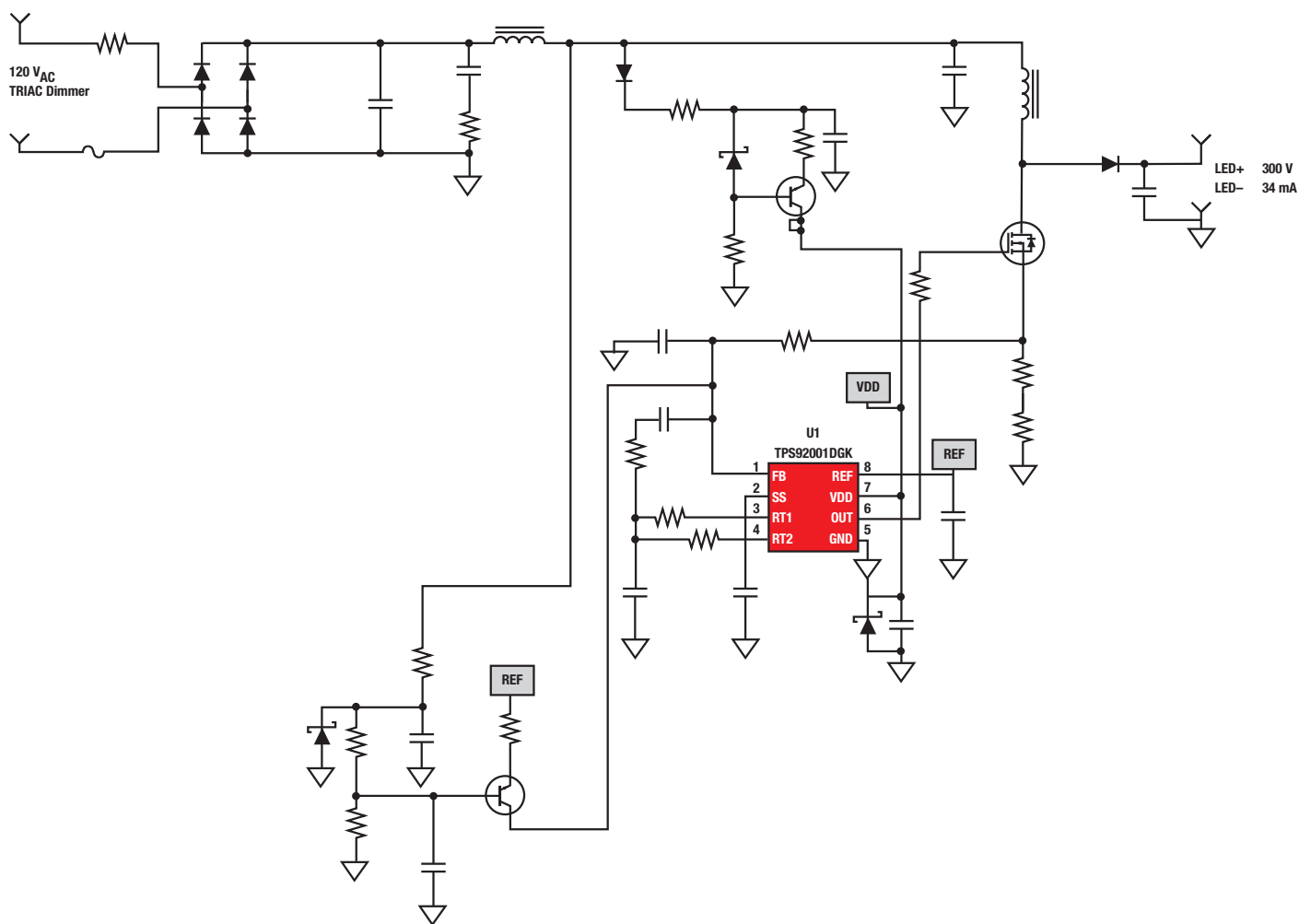
For more reference designs, see: www.ti.com/powerreferencedesigns

Output Voltage and Current
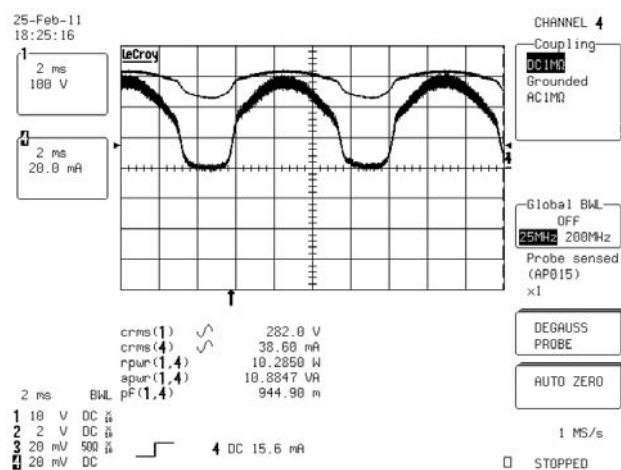
PMP6648C Board
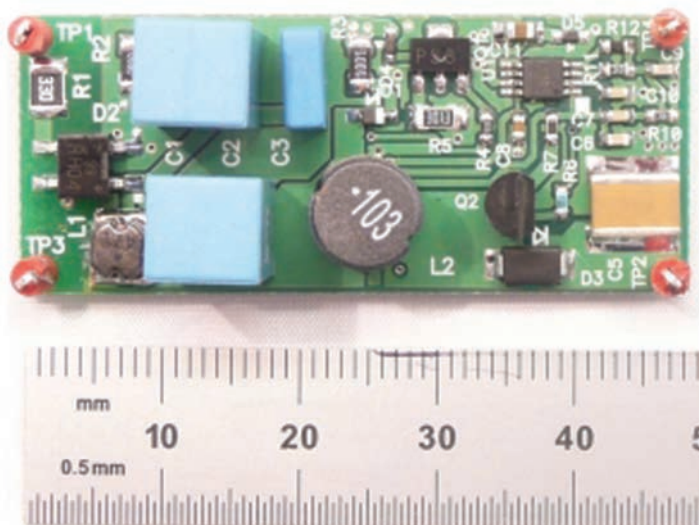
For more reference designs, see: www.ti.com/powerreferencedesigns

➔ *Retrofit Lighting - PAR30/38* NEW!

TPS92210 PMP4304A – Offline, High Power Factor, TRIAC Dimmable 7-W LED Driver

PMP4304A is an isolated primary-side control PFC flyback LED driver with small form factor and low component count for PAR and BR LED lighting applications.

Web Links

Datasheets, user's guides, samples:
www.ti.com/tool/**PMP4304**
www.ti.com/product/**TPS92210**

Design Specifications

| Topology	Converter Type AC or DC	LED Configuration	Number of LEDs per String (typ)	Number of LED Strings (typ)	Input Voltage Range			Output Voltage Range (typ)	Output Current (typ)	Typ Power Output (W)	Peak Efficiency (%)	PFC	Isolated/ Non-Isolated	Dimmable	Dimming Input
					(min)	(typ)	(max)								
PFC Flyback	AC	Series	6	1	160	220	264	20	300 mA	81	83	>0.9	Isolated	Yes	TRIAC

**Power Factor vs. Input Line
PMP4304 6-LED Driver without Dimmer**

**Efficiency vs. Input Line
PMP4304 6-LED Driver without Dimmer**
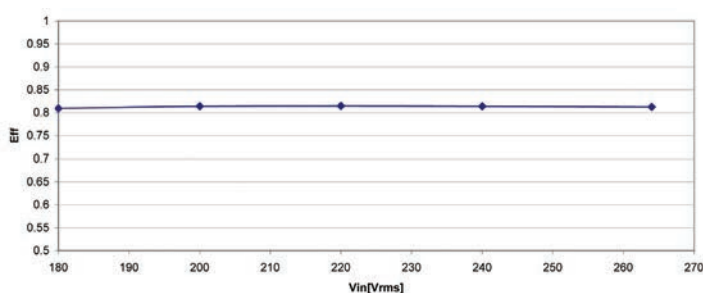
**Output Current vs. Input Line
PMP4304 6-LED Driver without Dimmer**
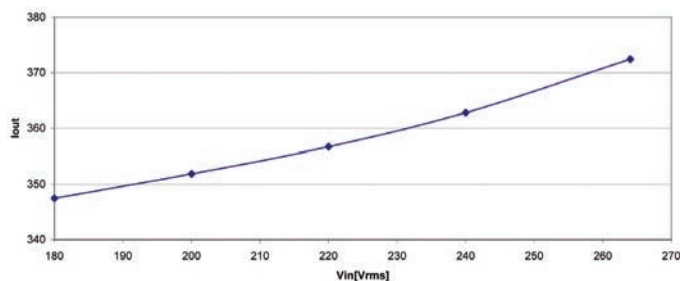
**LED Current vs. Dimmer Conduction Angle
PMP4304 6-LED Driver with Clipsal Dimmer**
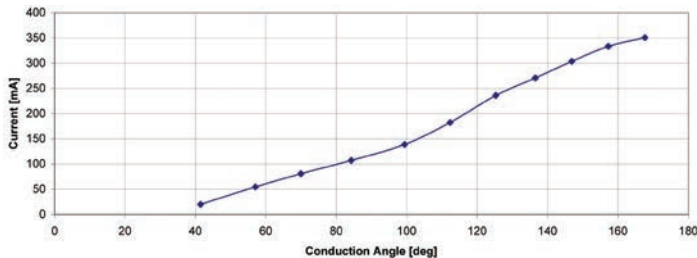
TPS4304A Board
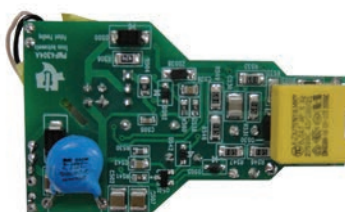
For more reference designs, see: www.ti.com/powerreferencedesigns

IC500
TPS92210

OTM		VCG
PCL		DRN
TZE		GND
FB		VDD
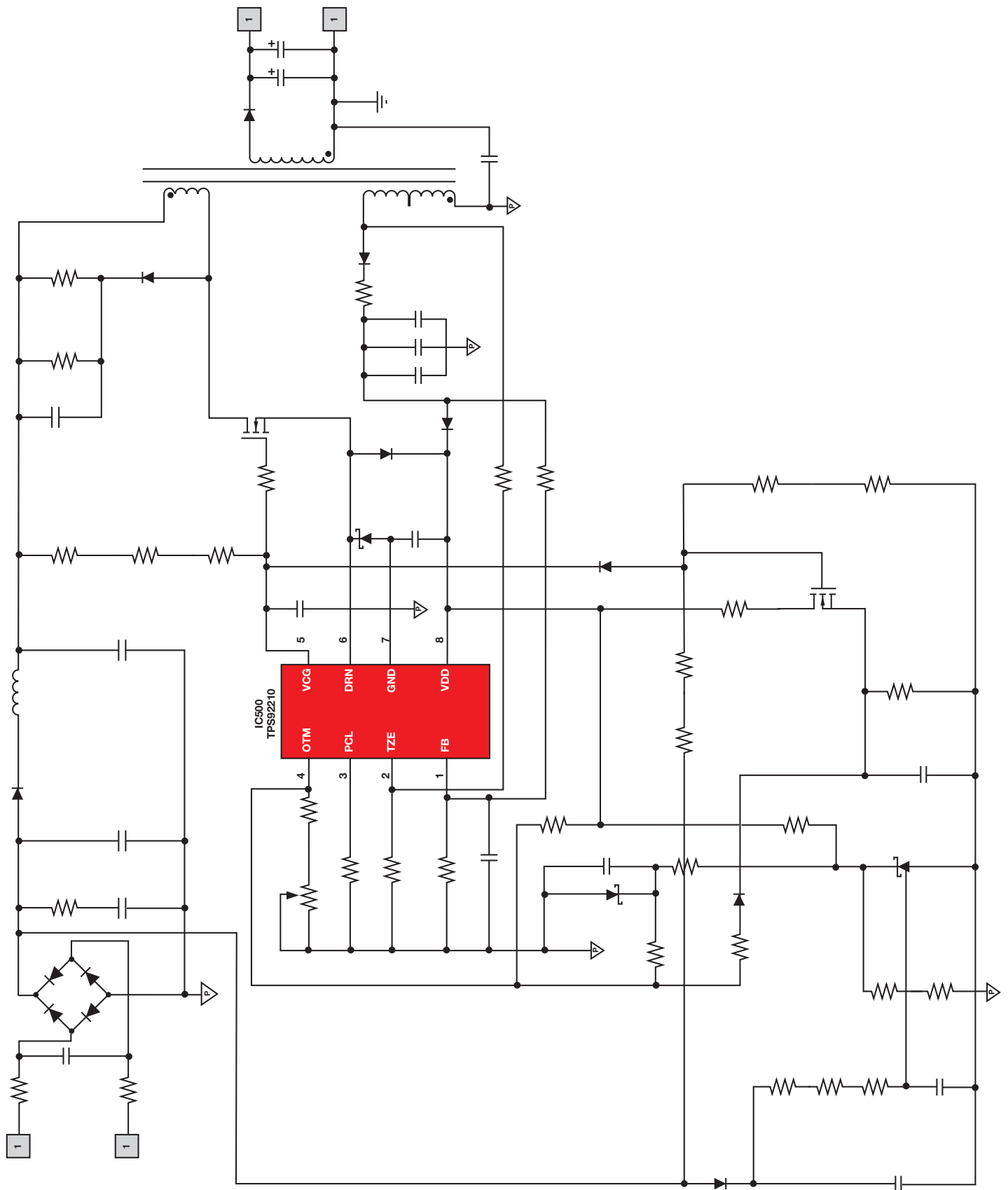
→ *Retrofit Lighting - PAR30/38*

TPS92010 PMP3522

The PMP3522 is a reference design that utilizes the TPS92010 high efficiency LED lighting driver controller.

Residential downlighting has seen a great deal of transition to more efficient sources of light. Compact CFLs have become a mainstay in residential lighting, but as the lifetime cost of LED lamps falls, all the more low-power, small-form-factor designs will be needed. This reference design is an under-10-W, non-isolated SEPIC LED driver specifically laid out for residential downlighting.

Key Features
• Single-stage SEPIC, PFC + LED current regulation
• Low-cost, low-component count
• Drives 3 to 6 LEDs at 350 mA

Web Links
Datasheets, user's guides, samples:
www.ti.com/tool/**PMP3522**
www.ti.com/product/**TPS92010**

Design Specifications

Parameter	Minimum	Typical	Maximum	Unit
Input voltage	120	—	290	V_{AC}
Output voltage	—	—	24	Volts
Output current	—	0.350	—	Amp

PMP3522 Schematic
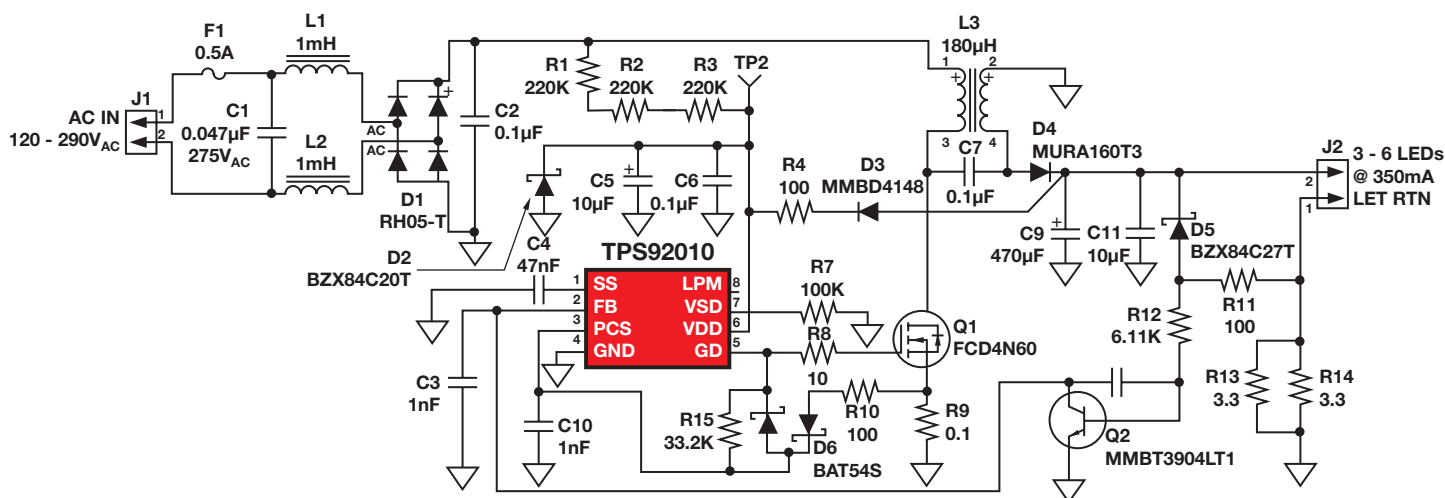
For more reference designs, see: www.ti.com/powerreferencedesigns

Laid Out for Bulb Replacement
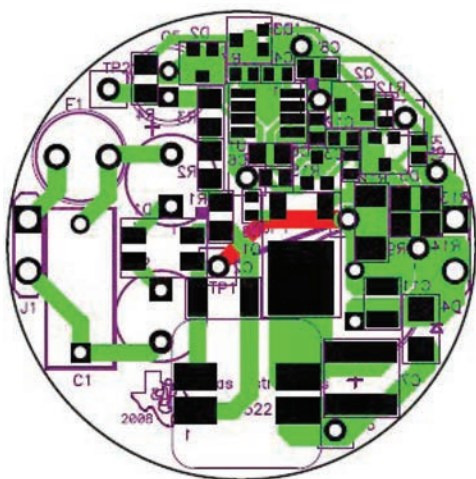
Control Loop Frequency
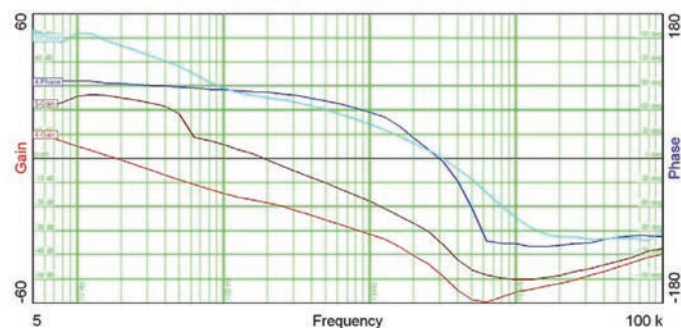
Regulation

Efficiency

For more reference designs, see: www.ti.com/powerreferencedesigns

Reference Designs

→ *Retrofit Lighting - PAR30/38* NEW!

TPS92210 PMP6304 – Offline, High Power Factor, TRIAC Dimmable 10-W LED Driver

PMP6304 is an isolated PFC flyback LED driver with low component count for PAR and BR LED lighting applications.
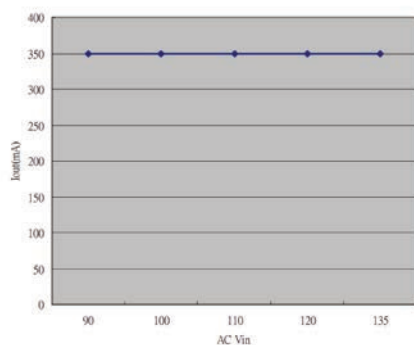
Web Links

Datasheets, user's guides, samples:
www.ti.com/tool/**PMP6304**
www.ti.com/product/**TPS92210**

Design Specifications

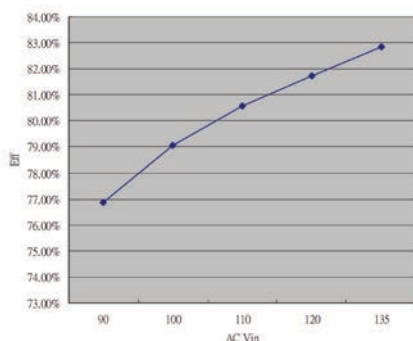| Topology	Converter Type AC or DC	LED Configuration	Number of LEDs per String (typ)	Number of LED Strings (typ)	Input Voltage Range			Output Voltage Range (typ)	Output Current (typ)	Typ Power Output (W)	Peak Efficiency (%)	PFC	Isolated/ Non-Isolated	Dimmable	Dimming Input
					(min)	(typ)	(max)								
PFC Flyback	AC	Series	9	1	176	220	264	30	350 mA	10	82	>0.9	Isolated	Yes	TRIAC
PFC Flyback	AC	Series	9	1	88	110	132	30	350 mA	10	81	>0.9	Isolated	Yes	TRIAC
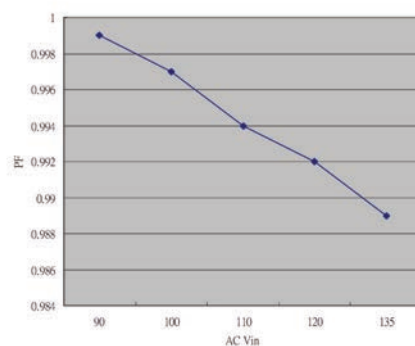
Low Line Output Current
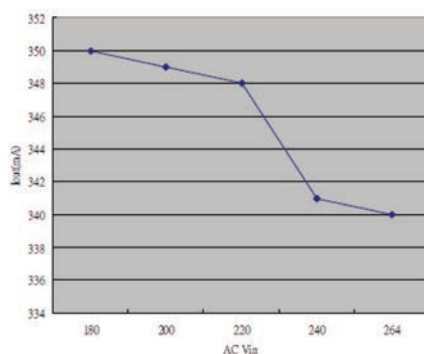

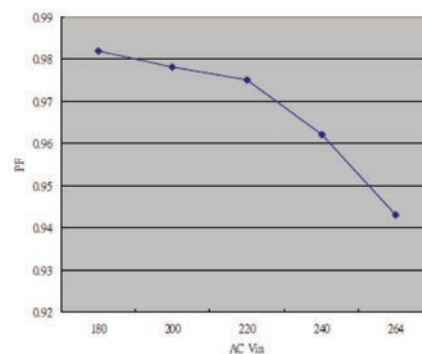### Low Line Power Factor

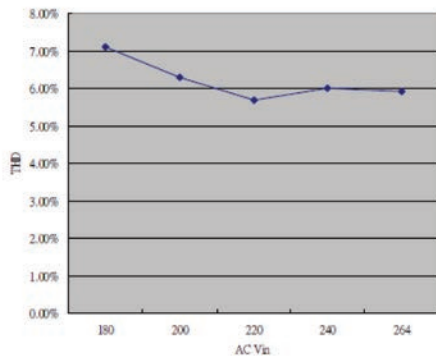### Low Line Total Harmonic Distortion
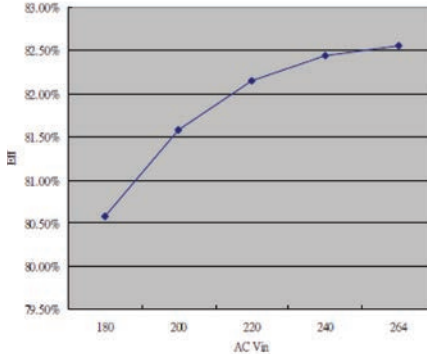

Low Line Efficiency

High Line Output Current

High Line Power Factor

High Line Total Harmonic Distortion

High Line Efficiency

Patent Pending

For more reference designs, see: www.ti.com/powerreferencedesigns

IC560
TL103WA

UF4004
D550

BD1
T1

FD2
FD

FD1
FD

PC500

R539

R539 Applied Between
PC500 Pin 3 and Pin 4
Directly

IC500
TPS92210

OTM VCG
PCL DRN
TZE GND
FB   VDD
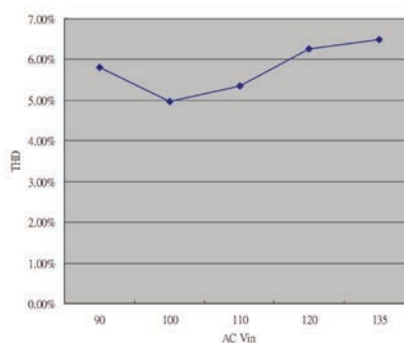
→ *Retrofit Lighting - PAR30/38*

TPS92210 PMP6001 – Offline, High Power Factor, Non-Dimmable 13-W LED Driver

PMP6001 is an isolated PFC flyback LED driver with minimal component count for PAR and BR LED lighting applications.

Web Links

Datasheets, user's guides, samples:
www.ti.com/tool/**PMP6001**
www.ti.com/product/**TPS92210**

Design Specifications

Topology	Converter Type AC or DC	LED Configuration	Number of LEDs per String (typ)	Number of LED Strings (typ)	Input Voltage Range			Output Voltage Range (typ)	Output Current (typ)	Typ Power Output (W)	Peak Efficiency (%)	PFC	Isolated/Non-Isolated	Dimmable	Dimming Input
					(min)	(typ)	(max)								
PFC Flyback	AC	Series	11	1	90	—	265	38	350 mA	13	82	>0.9	Isolated	Yes	TRIAC

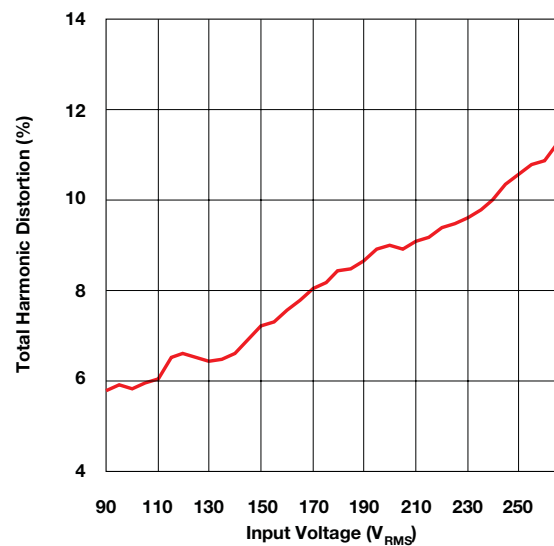### Efficiency vs. Input Voltage
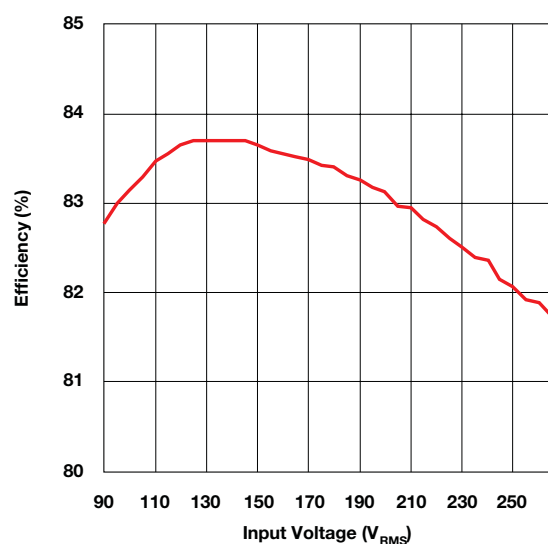
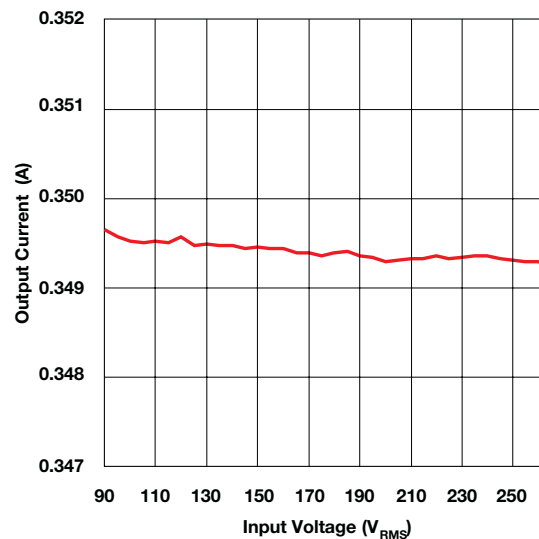### Power Factor vs. Input Voltage
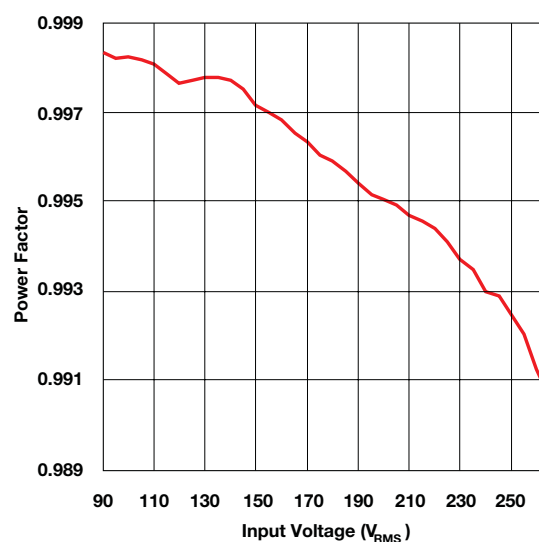
Total Harmonic Distortion vs. Input Voltage

Output Current vs. Input Voltage

Retrofit Lighting - PAR30/38
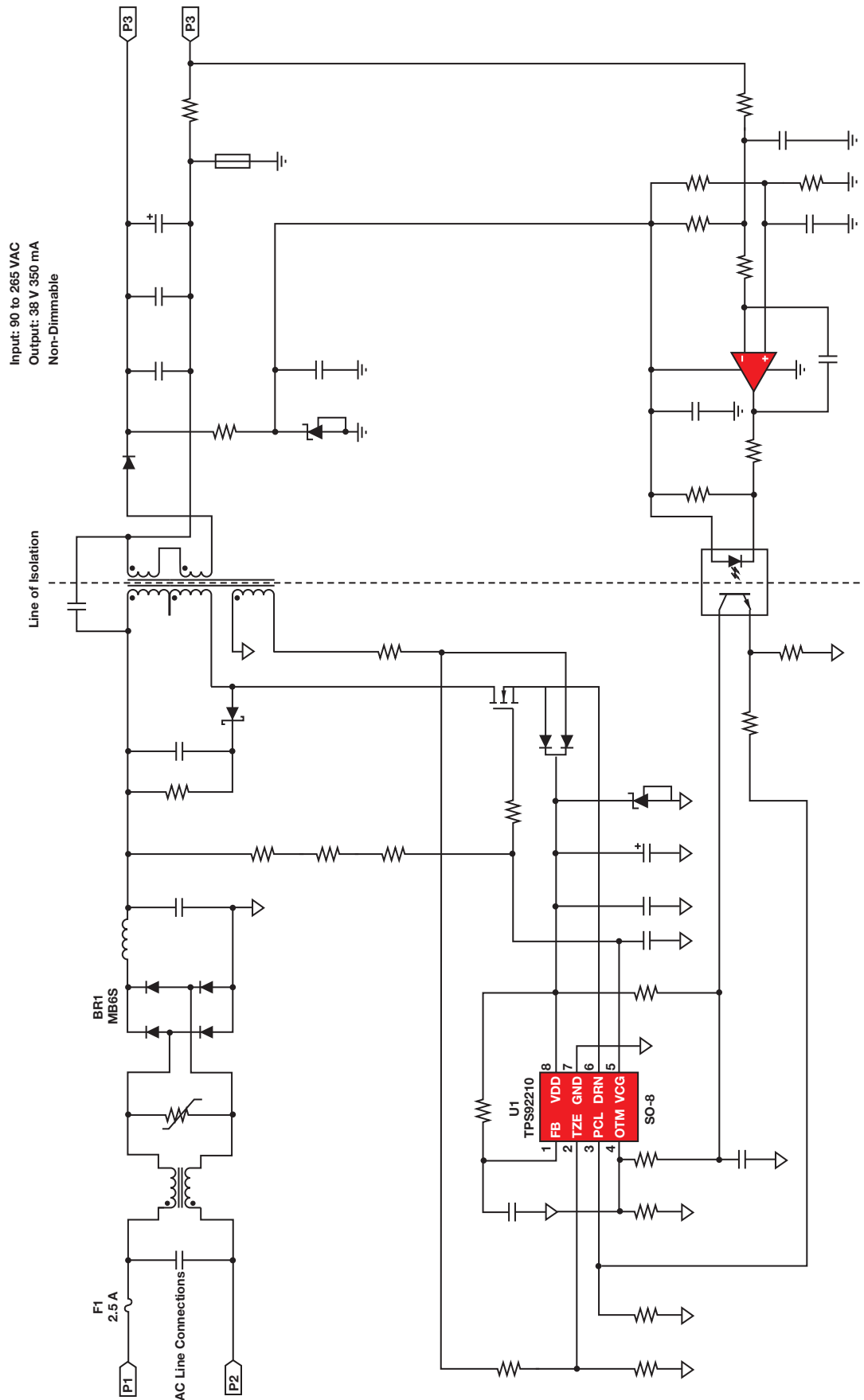
Input: 90 to 265 VAC
Output: 38 V 350 mA
Non-Dimmable

Line of Isolation

BR1
MB6S

F1
2.5 A

AC Line Connections

P1

P2

P3

P3

U1
TPS92210

1	FB	VDD	8
2	TZE	GND	7
3	PCL	DRN	6
4	OTM	VCG	5

SO-8

For more reference designs, see: www.ti.com/powerreferencedesigns

→ *Retrofit Lighting - T8* **NEW!**

UCC28810 PMP5682A - Offline, PMW Dimmable High Efficiency, 25-W LED Tube Driver

The PMP5682A has been designed to replace a T8 fluorescent tube. It accepts the high line input (184 V to 265 V_{AC}) and supplies two strings in parallel, 104 LEDs max per string; each string has a nominal current of 40 mA. The first stage performs the PFC function while the second stage delivers a 80 mA constant dimmable current. High efficiency and particular shape of the PCB make this design suitable for the tube replacement.

Web Links
Datasheets, user's guides, samples:
www.ti.com/tool/**PMP5682**
www.ti.com/product/**UCC28810**

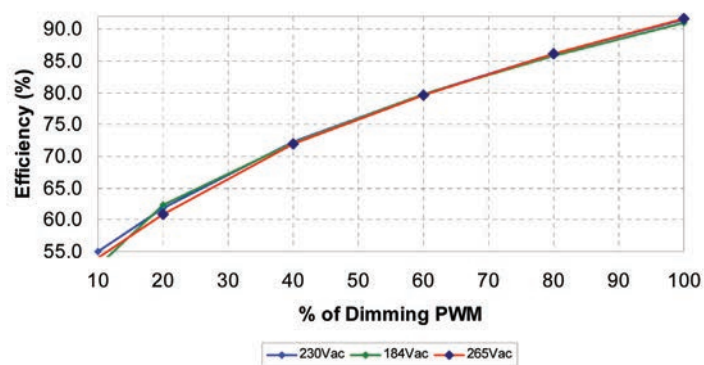### Design Specifications

| Topology	Converter Type AC or DC	LED Configuration	Number of LEDs per String (typ)	Number of LED Strings (typ)	Input Voltage Range			Output Voltage Range (typ)	Output Current (typ)	Typ Power Output (W)	Peak Efficiency (%)	PFC	Isolated/ Non-Isolated	Dimmable	Dimming Input
					(min)	(typ)	(max)								
TM Boost + TM Buck	AC	Series/Parallel	104	2	184	230	265	30	350 mA	10	91	<0.9	Non-Isolated	Yes	PWM

Input: 184 to 265 VAC
TP1
AC Line Connections
TP2

Output: 450 V @ 73 mA

TP3

U1
UCC28810D

1	VSENSE	VDD	8
2	EAOUT	GDRV	7
3	VINS	GND	6
4	ISENSE	TZE	5

Fsw = 130 KHz

Built Using PMP5623 PWB
Ref. Des. >99 Were Added On the Board
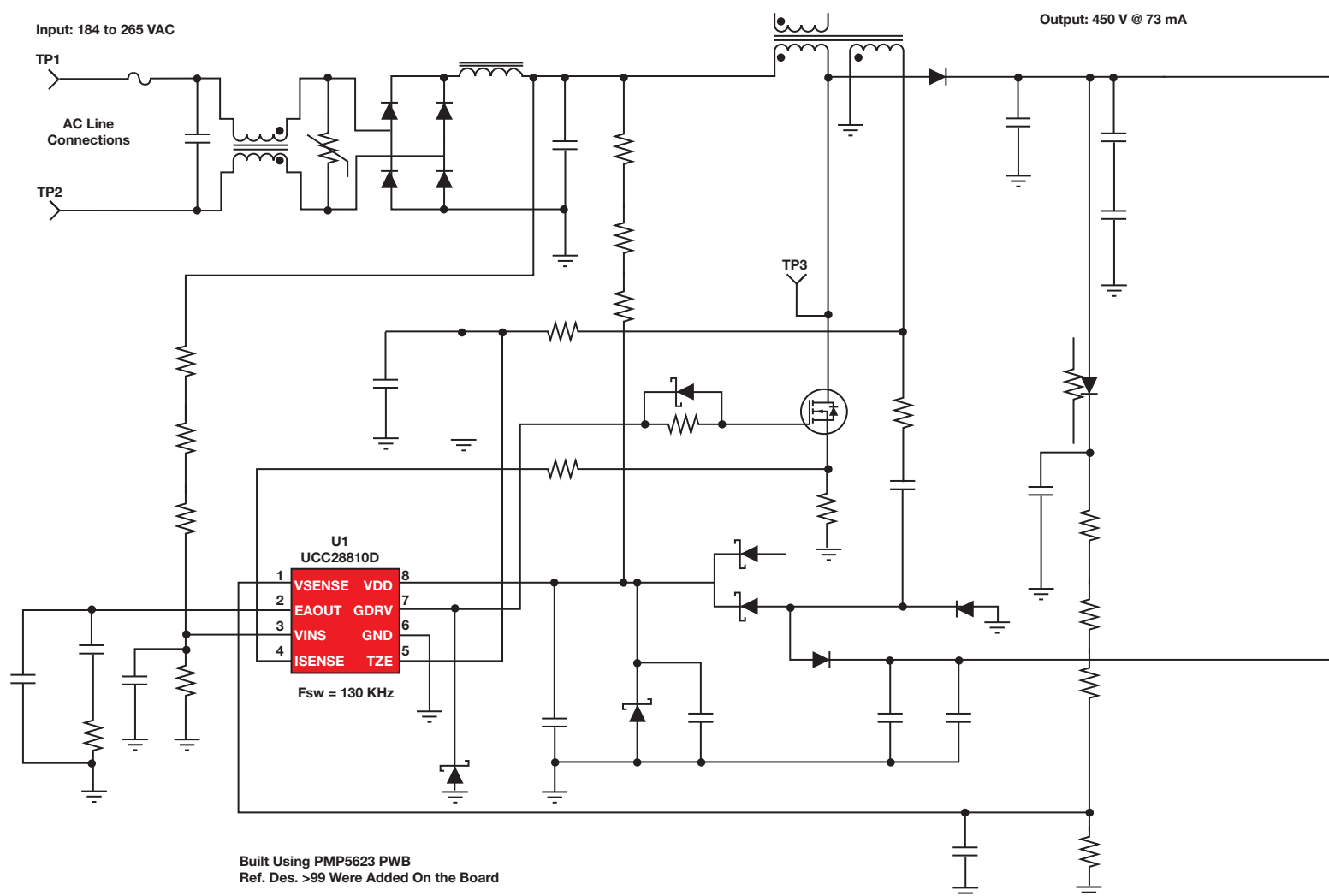
Retrofit Lighting - T8

Efficiency

Power Factor

312 V @ 80 mA
2 Strings of 104 LEDs, 2 x 40 mA

TP4

TP5
LED+ Out

Warning High Voltage FromBoost

TP7

TP8
LED– Out

TP6

TP9

PWM
Dimming

U3
UCC28810D

1	VSENSE	VDD	8
2	EAOUT	GDRV	7
3	VINS	GND	6
4	ISENSE	TZE	5

Fsw = 130 KHz
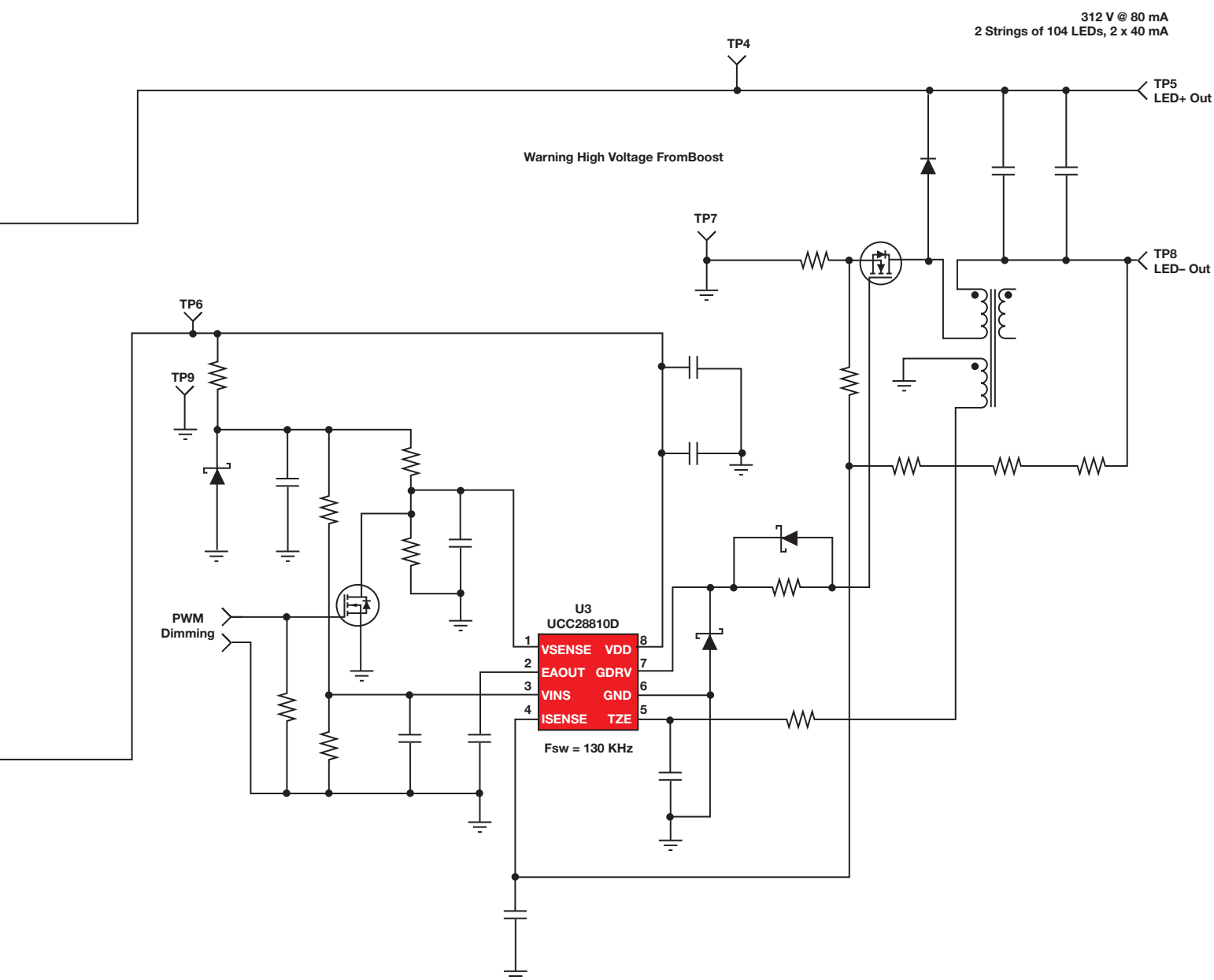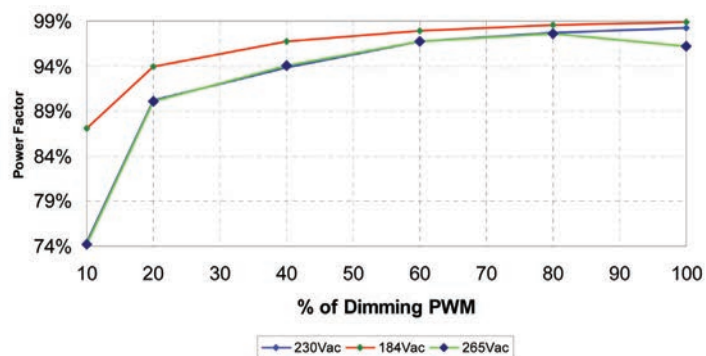
→ *Retrofit Lighting - T8* NEW!

TPS92210 PMP3672 - Offline, PFC Buck 18-W to 20-W LED Tube Driver

The PMP3672 has been designed to replace a T8 fluorescent tube. It accepts universal line input (90 V to 265 V$_{AC}$) and supplies 720 mA LED current.

Web Links
Datasheets, user's guides, samples:
www.ti.com/tool/**PMP3672**
www.ti.com/product/**TPS92210**

Design Specifications

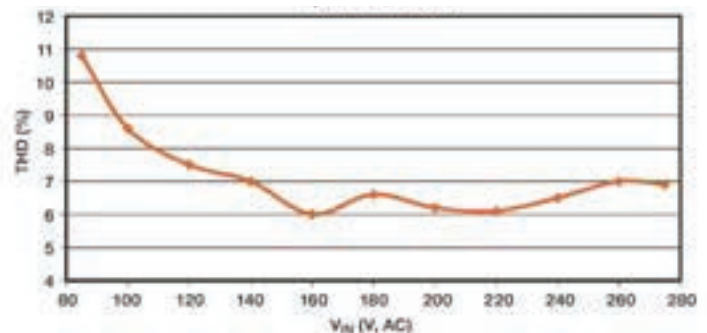| Topology	Converter Type AC or DC	LED Configuration	Number of LEDs per String (typ)	Number of LED Strings (typ)	Input Voltage Range			Output Voltage Range (typ)	Output Current (typ)	Typ Power Output (W)	Peak Efficiency (%)	PFC	Isolated/ Non-Isolated	Dimmable	Dimming Input
					(min)	(typ)	(max)								
PFC Buck	AC	Series/ Parallel	8	24	90	—	265	24	720 mA	20	82	>0.9	Non-Isolated	No	—

LED Current Regulation
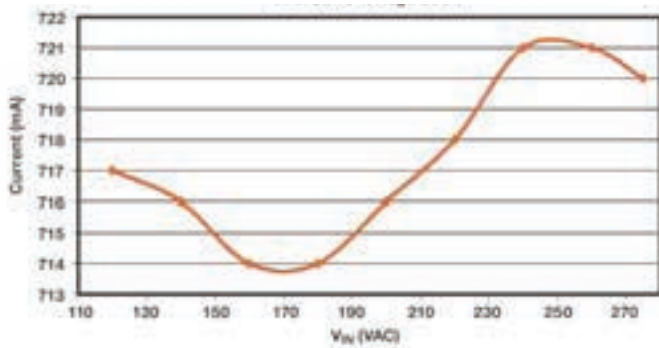
Efficiency
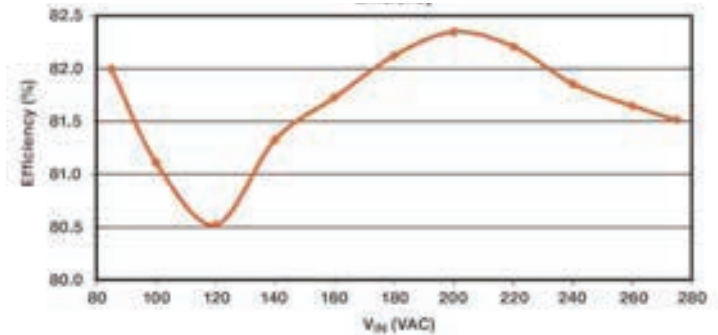
Power Factor
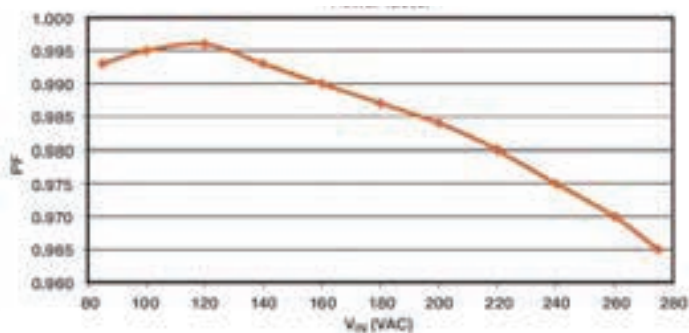
### Input Current THD

PMP3672 Board

For more reference designs, see: www.ti.com/powerreferencedesigns
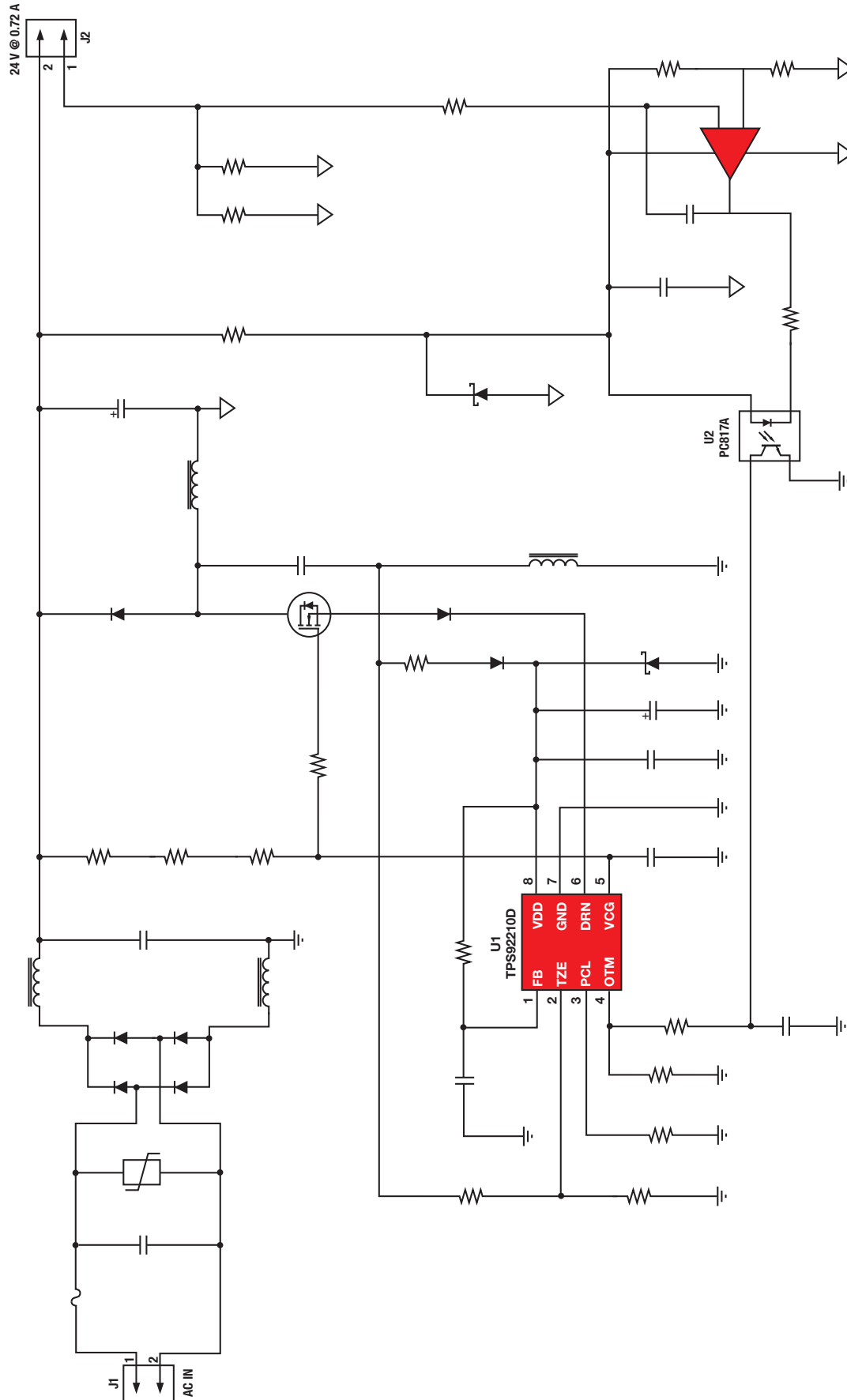
24 V @ 0.72 A

J2
2 1

U2
PC817A

U1
TPS92210D

FB VDD 8
TZE GND 7
PCL DRN 6
OTM VCG 5
1 2 3 4

J1
1 2
AC IN

For more reference designs, see: www.ti.com/powerreferencedesigns

➔ *Retrofit Lighting - T8* **NEW!**

TPS92210 PMP6306 - Offline, High Power Factor, Isolated 18-W Tube LED Driver

PMP6306 is an isolated PFC flyback LED driver for LED tube lighting applications. It accepts universal line inputs and supplies 450 mA at up to 40 V.

Web Links
Datasheets, user's guides, samples:
www.ti.com/tool/**PMP6306**
www.ti.com/product/**TPS92210**

Design Specifications

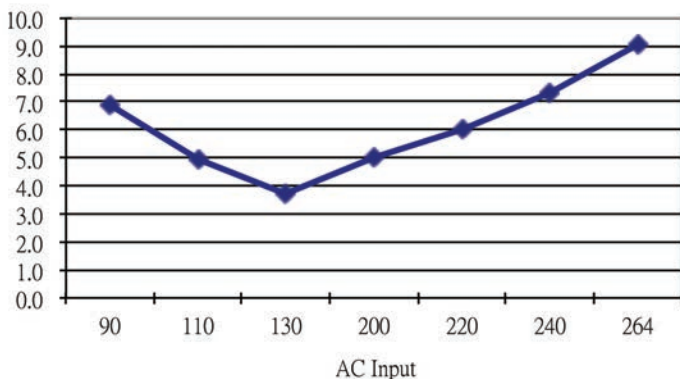| Topology	Converter Type AC or DC	LED Configuration	Number of LEDs per String (typ)	Number of LED Strings (typ)	Input Voltage Range			Output Voltage Range (typ)	Output Current (typ)	Typ Power Output (W)	Peak Efficiency (%)	PFC	Isolated/ Non-Isolated	Dimmable	Dimming Input
					(min)	(typ)	(max)								
PFC Flyback	AC	Series	12	1	90	—	265	40	450 mA	18	86	>0.85	Isolated	No	—

Efficiency
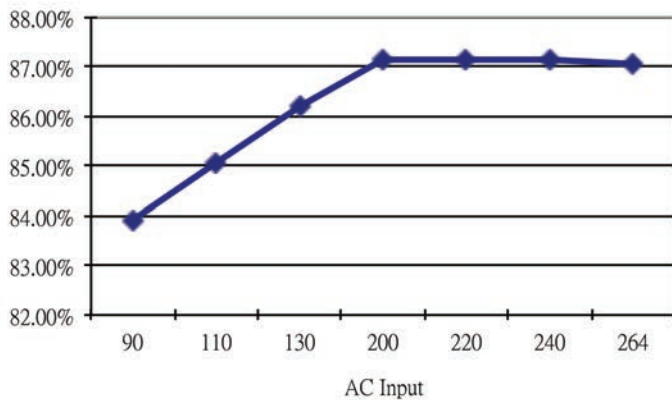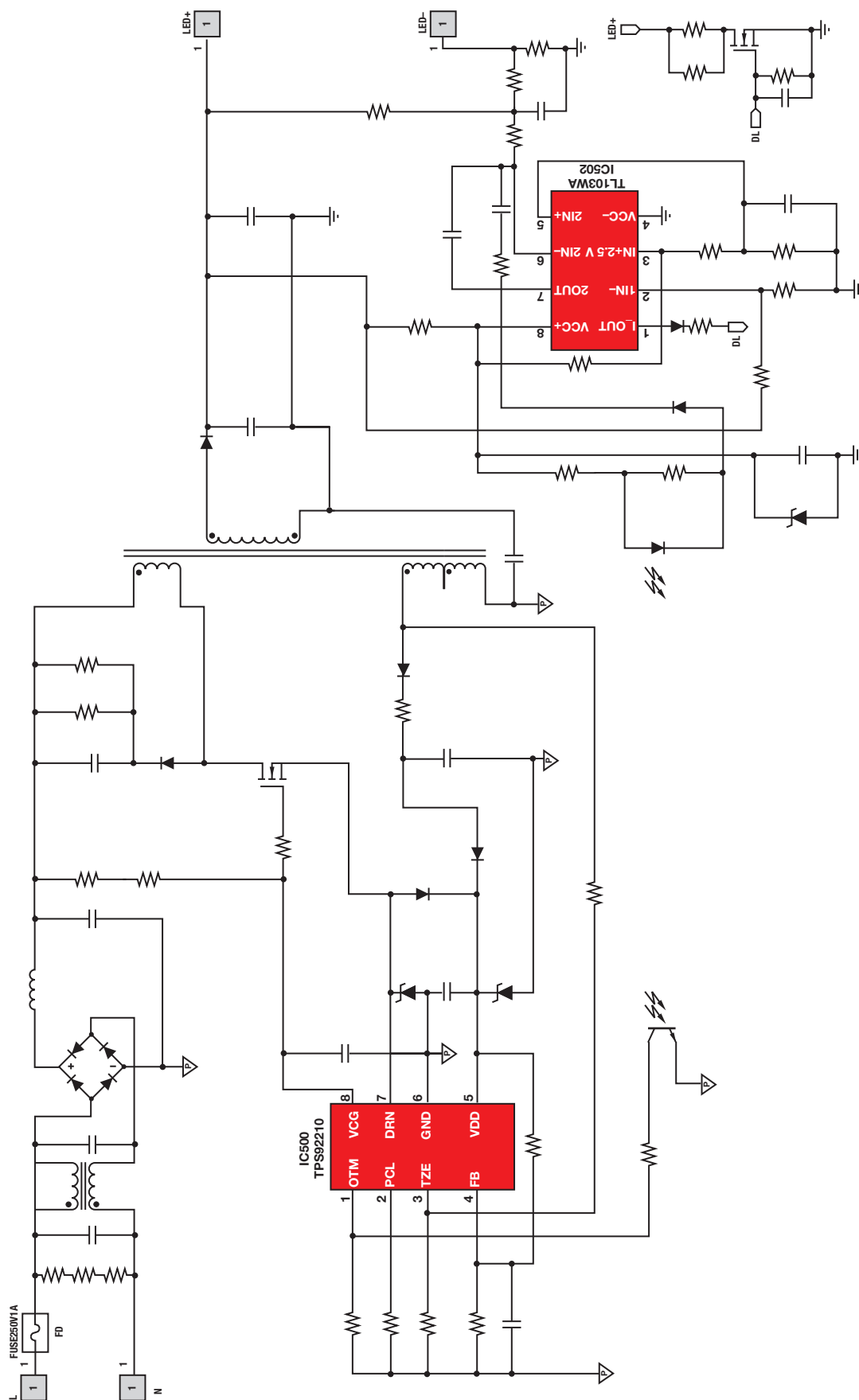

Power Factor
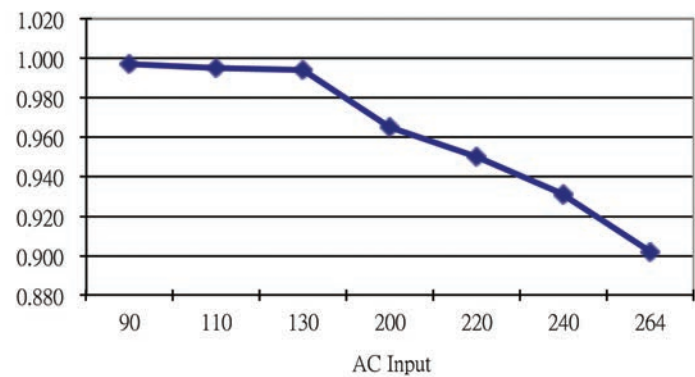
THD (%)

PMP6306 Board
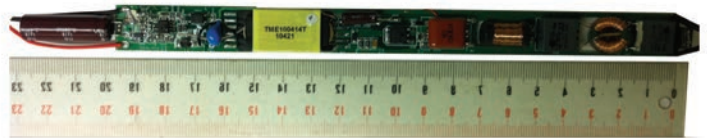
For more reference designs, see: www.ti.com/powerreferencedesigns

For more reference designs, see: www.ti.com/powerreferencedesigns

➔ *Retrofit Lighting - MR-16* NEW!

TPS40211 PMP6300 – MR-16 Boost

PMP6300 is a boost based MR-16 solution designed to operate with 1 to 3 LEDs at 700 mA.

**Web Links**

Datasheets, user's guides, samples:
www.ti.com/tool/PMP6300
www.ti.com/product/TPS40211

Design Specifications

Topology	Converter Type AC or DC	LED Configuration	Number of LEDs per String (typ)	Number of LED Strings (typ)	Input Voltage Range			Output Voltage Range (typ)	Output Current (typ)	Typ Power Output (W)	Peak Efficiency (%)	PFC	Isolated/ Non-Isolated	Dimmable	Dimming Input
					(min)	(typ)	(max)								
Boost	AC or DC	Series	3	1	8	—	15	10	700 mA	7	71	>0.8	Non-Isolated	Yes	TRIAC

12 V_{DC} Efficiency
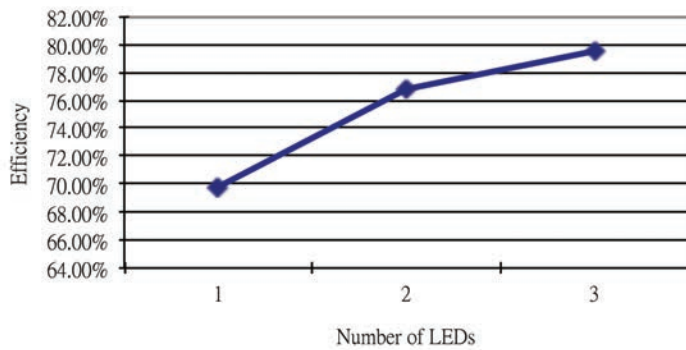
12 V_{AC} Efficiency
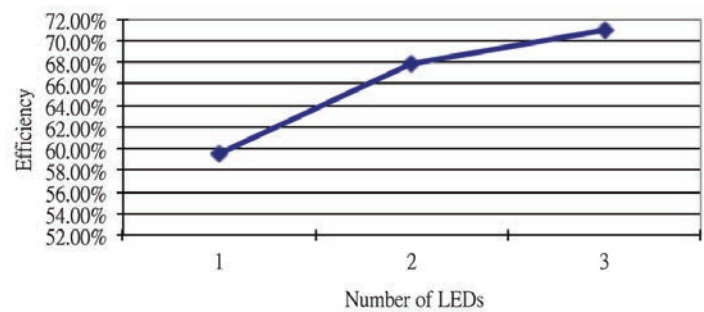
12 V_{DC} Output Current Accuracy
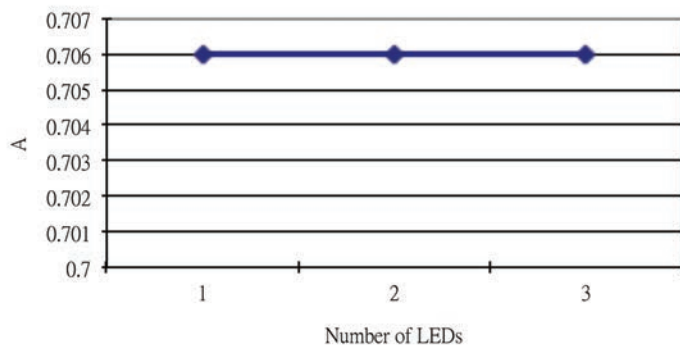
12 V_{AC} Output Current Accuracy
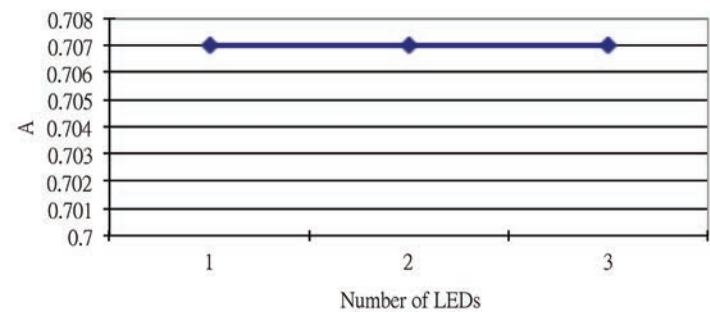
12 V_{AC} Power Factor
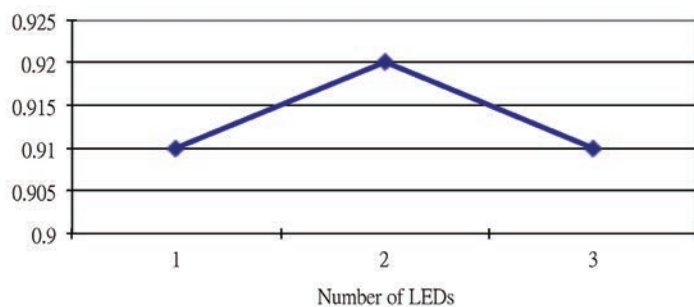
PMP6300 Board
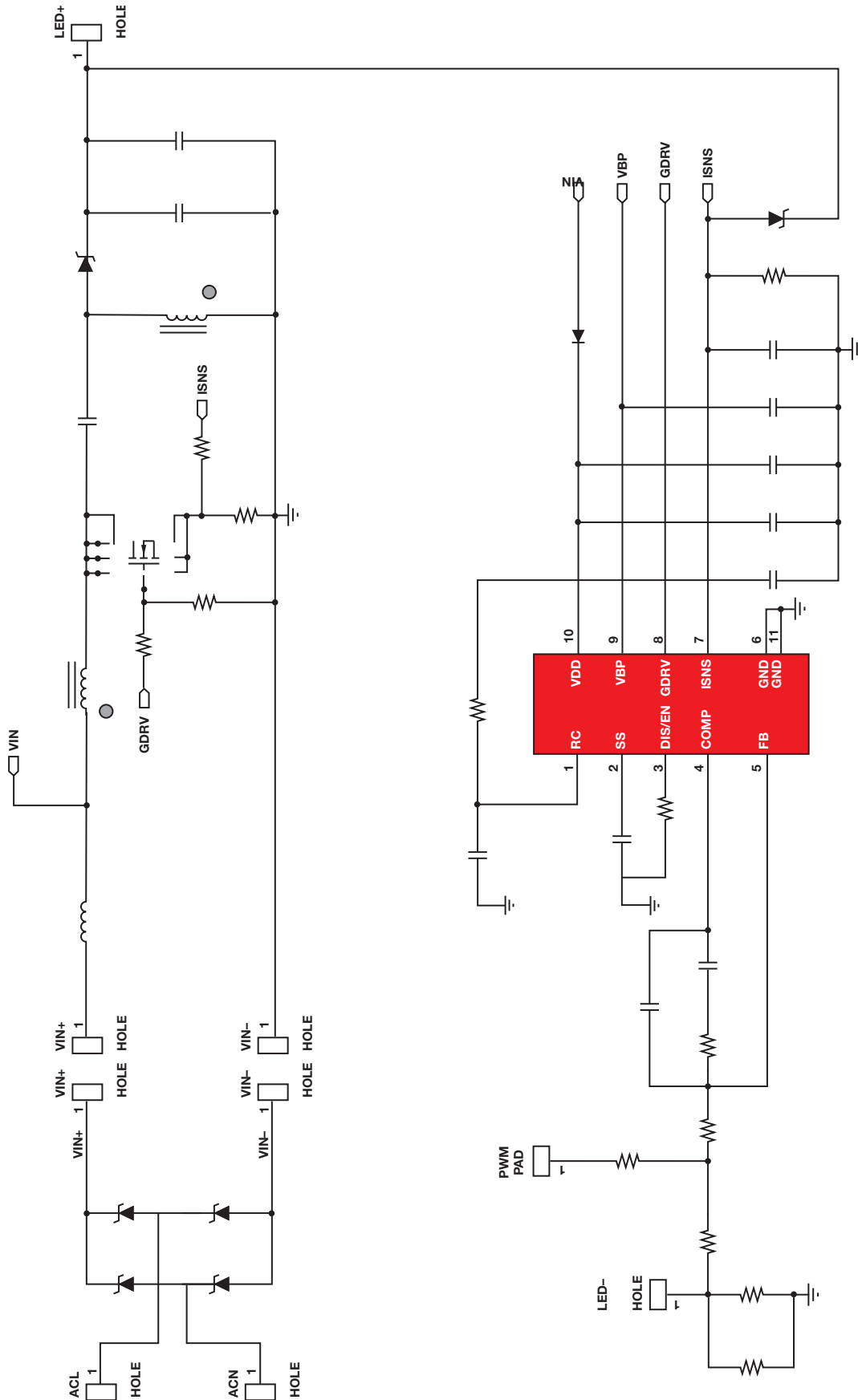
For more reference designs, see: www.ti.com/powerreferencedesigns

Reference Designs

➔ *Retrofit Lighting - MR-16* **NEW!**

TPS54260 PMP6004 – MR-16 Buck Reference Design
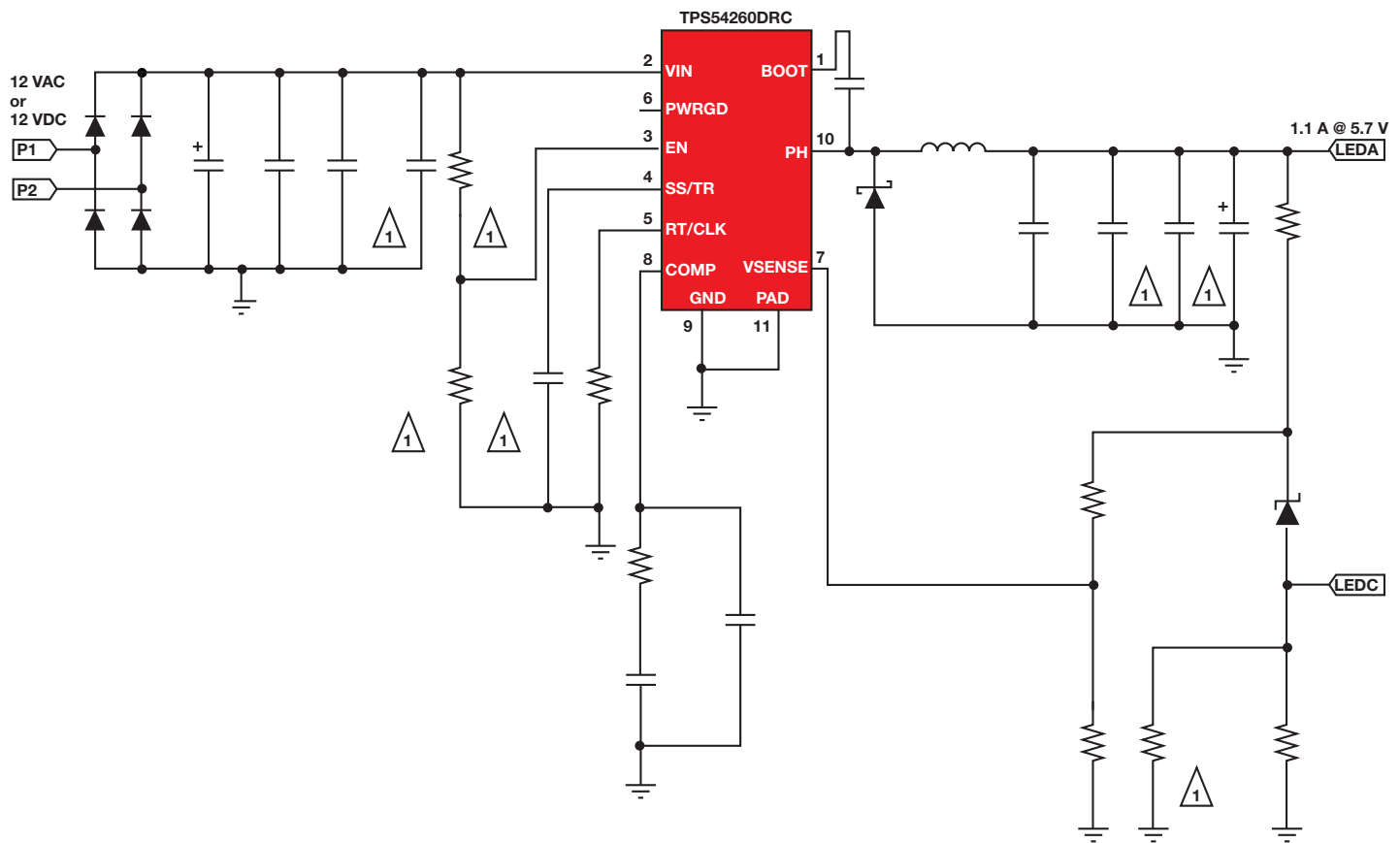PMP6004 is a buck based MR-16 solution designed to operate with 1 to 2 LEDs at 1000 mA.

Web Links
Datasheets, user's guides, samples:
www.ti.com/tool/**PMP6004**
www.ti.com/product/**TPS54260**

Design Specifications

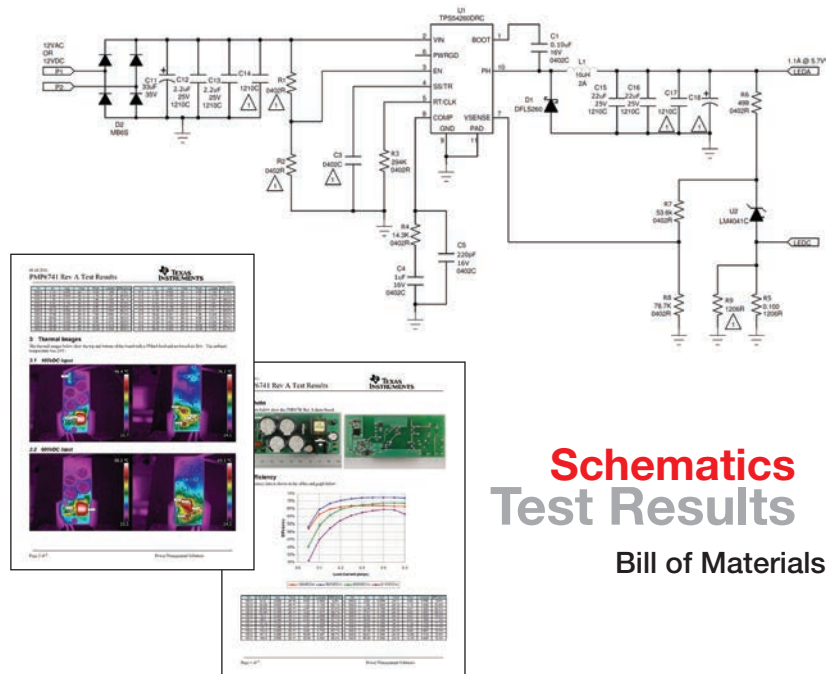| Topology	Converter Type AC or DC	LED Configuration	Number of LEDs per String (typ)	Number of LED Strings (typ)	Input Voltage Range (min)	(typ)	(max)	Output Voltage Range (typ)	Output Current (typ)	Typ Power Output (W)	Peak Efficiency (%)	PFC	Isolated/ Non-Isolated	Dimmable	Dimming Input
Buck	AC or DC	Series	1	1	8	—	15	5.7	1,000 mA	6	80	>0.85	Non-Isolated	Yes	TRIAC

PMP6004 Board

For more reference designs, see: www.ti.com/powerreferencedesigns

PowerLab™ Power Reference Design Library

- The industry's most extensive collection of tested power management reference designs.

- Hundreds of power management designs for a wide range of applications and power conversion topologies.

- Reference designs include both isolated and non-isolated designs for lighting, telecommunication, computing, consumer electronics and more.

www.ti.com/powerlab

Schematics
Test Results
Bill of Materials

288 Results found

Compare Selected   Export to Spreadsheet

To sort/re-order/resize columns, drag-&-drop or click column headers.

	Design	Title	Input Voltage Range (Min)	Input Voltage Range (Max)	Output Voltage	Output Current	Output Power	Isolated/Non-Isolated	Input Type	Application(s)	Topology
	PMP1090	Sync Buck for MFP (5V @ 2A,3.3V @ 2	22	26	Multiple	2	Multiple	Non-Isolated	DC	Computers and Peripherals	Sync Buck
	PMP1129	Flyback for Automotive (16V @ 5A)	8	36	16.8	5	84	Non-Isolated	DC	Transportation and Automo	Flyback
	PMP1143	Isolated Flyback for Router Gate Way	85	265	12	3	36	Isolated	AC	Communications and Telecc	Flyback
	PMP1171	Sync Buck (3.3V @ 2A,1.2V @ 6.5A)	11	24	Multiple	Multiple	Multiple	Non-Isolated	DC	Communications and Telecc	Sync Buck

The PowerLab™ library includes an interactive and powerful search engine for design engineers looking for a proven and tested solution to their power supply requirements. This interactive search tool allows engineers to find designs by application, topology, input type, input voltage or output voltage.

PowerLab™ Power Reference Designs Selection Tool   **www.ti.com/powerlab**

→ *LED Driver/Ballast*   **NEW!**

TPS92210 PMP6305 – Offline, High Power Factor, Isolated 25-W LED Driver

PMP6305 is an isolated PFC flyback LED driver for LED tube lighting applications. It accepts universal line inputs and supplies 450 mA at up to 40 V.

Web Links
Datasheets, user's guides, samples:
www.ti.com/tool/**PMP6305**
www.ti.com/product/**TPS92210**

Design Specifications

| Topology	Converter Type AC or DC	LED Configuration	Number of LEDs per String (typ)	Number of LED Strings (typ)	Input Voltage Range (min)	(typ)	(max)	Output Voltage Range (typ)	Output Current (typ)	Typ Power Output (W)	Peak Efficiency (%)	PFC	Isolated/ Non-Isolated	Dimmable	Dimming Input
PFC Flyback	AC	Series	10	1	176	220	264	35	700 mA	25	83	>0.9	Isolated	Yes	TRIAC
PFC Flyback	AC	Series	10	1	88	110	132	35	700 mA	25	84	>0.9	Isolated	Yes	TRIAC
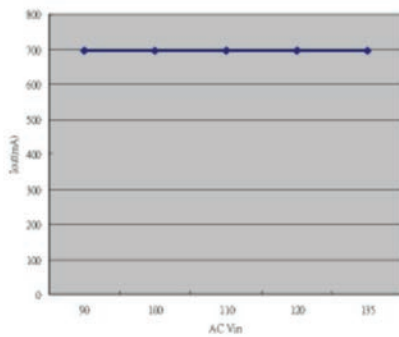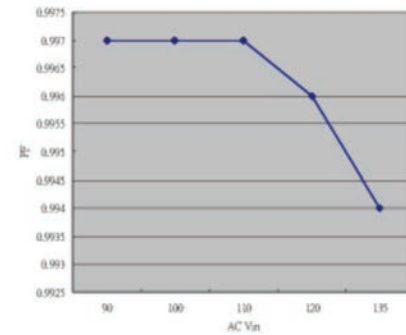
Low Line Output Current
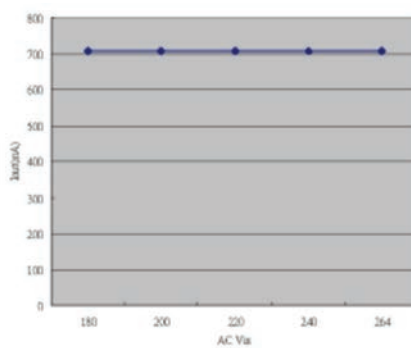

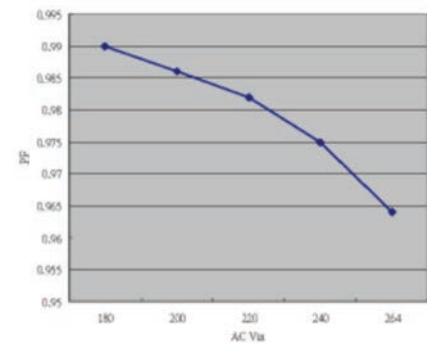### Low Line Power Factor

Low Line Total Harmonic Distortion
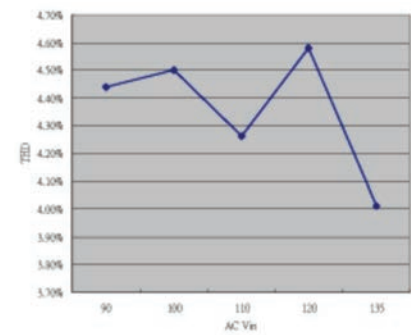
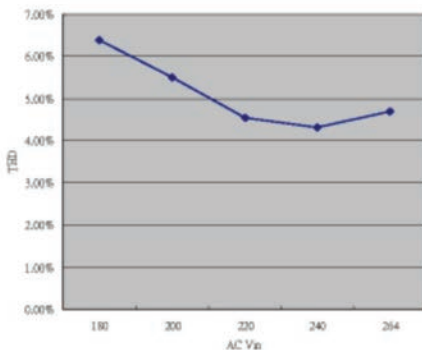### Low Line Efficiency
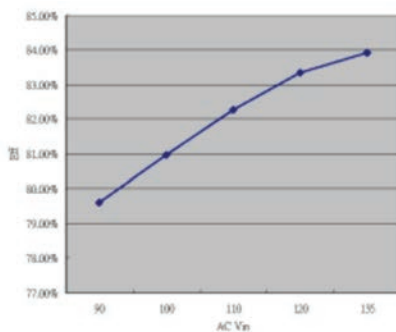
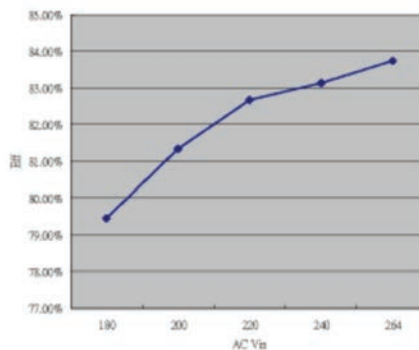### High Line Output Current

High Line Power Factor

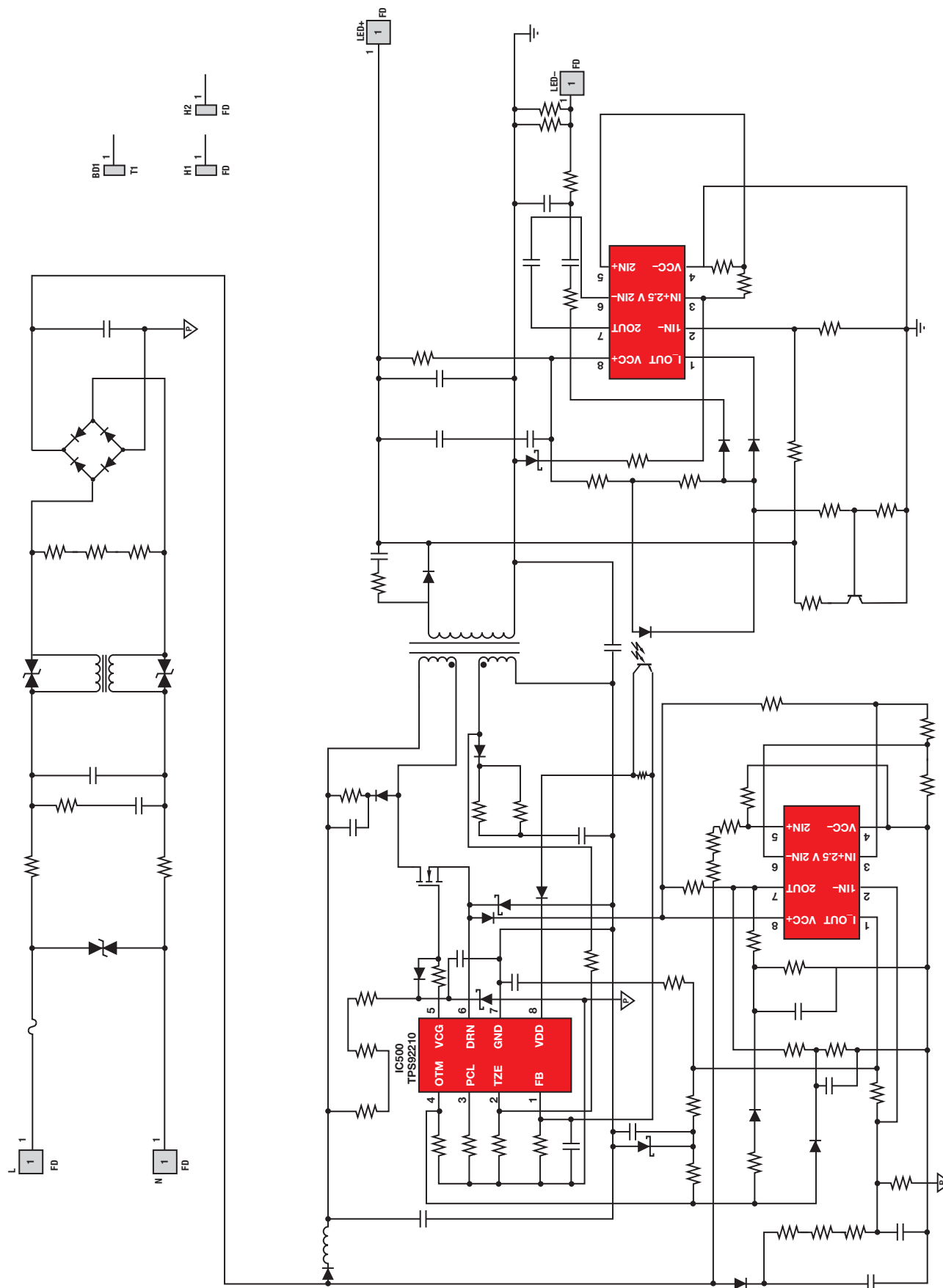### High Line Total Harmonic Distortion

High Line Efficiency

For more reference designs, see: www.ti.com/powerreferencedesigns

Reference Designs

→ *LED Driver/Ballast* **NEW!**

UCC28810 PMP5732B – Offline, High Power Factor, Isolated 50-W LED Driver

PMP5732B is an isolated PFC flyback LED driver for LED ballast/power supply applications. It accepts universal line inputs (85 to 305 V) and supplies 1.5 A at up to 40 V.

Web Links
**Datasheets, user's guides, samples:**
www.ti.com/tool/**PMP5732**
www.ti.com/product/**UCC28810**

Design Specifications

Topology	Converter Type AC or DC	LED Configuration	Number of LEDs per String (typ)	Number of LED Strings (typ)	Input Voltage Range			Output Voltage Range (typ)	Output Current (typ)	Typ Power Output (W)	Peak Efficiency (%)	PFC	Isolated/ Non- Isolated	Dimmable	Dimming Input
					(min)	(typ)	(max)								
PFC Flyback	AC	Series	10	1	85	—	305	36	1,500 mA	50	83	>0.9	Isolated	Yes	Analog

Efficiency
The efficiency is shown in the graph below. For simplicity and accuracy of measurements, the data was measured using a DC input with a resistive load.
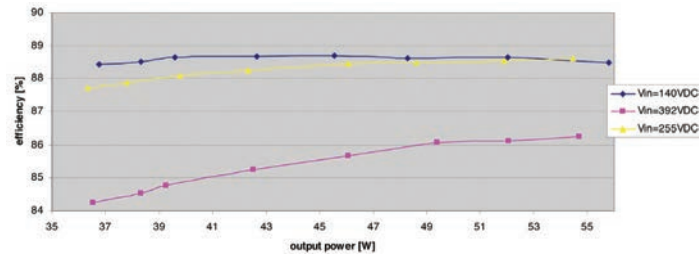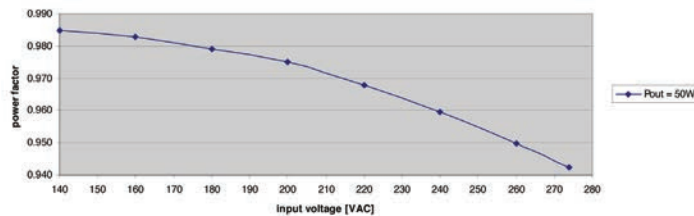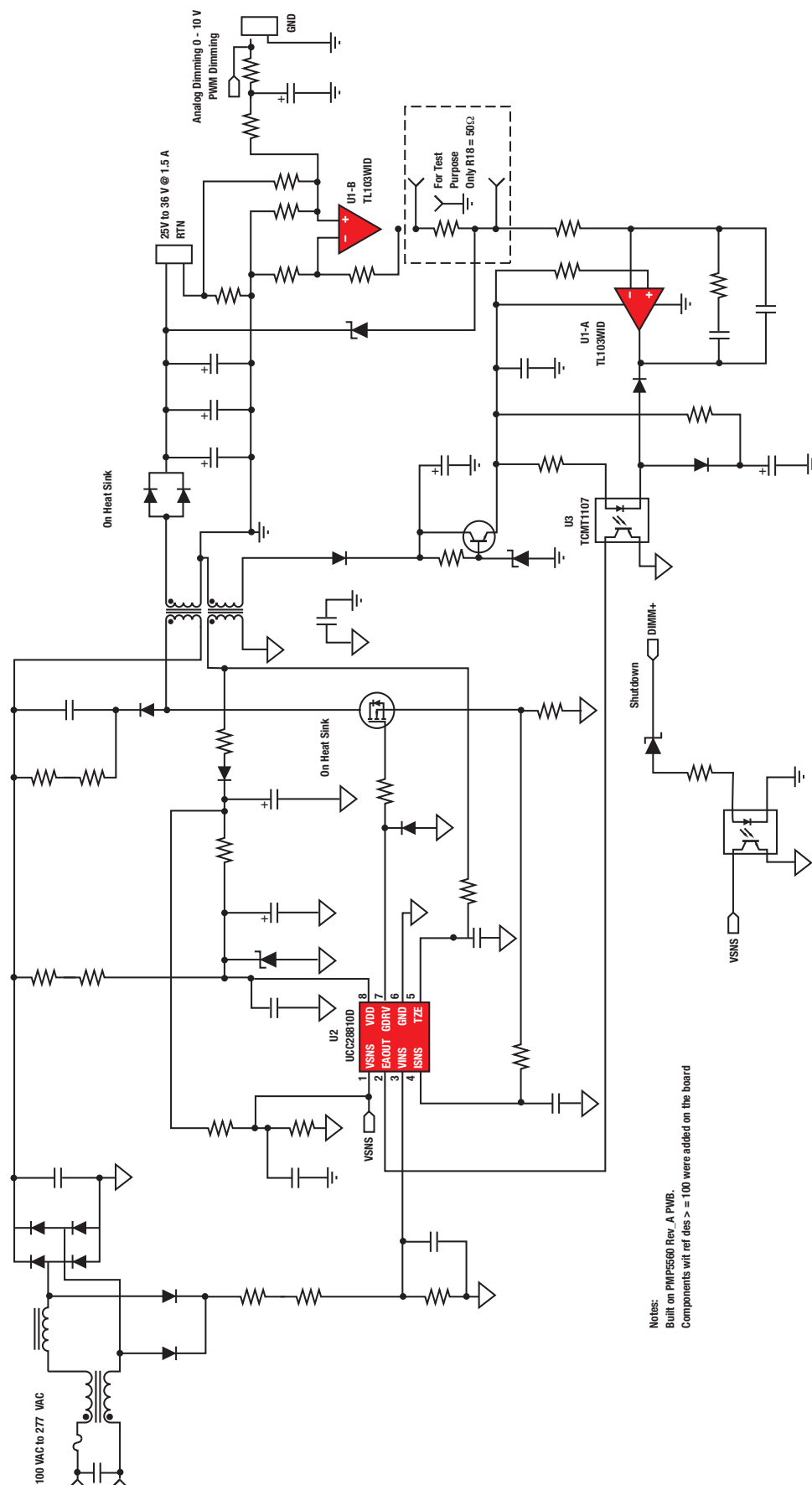

Output Current Regulation
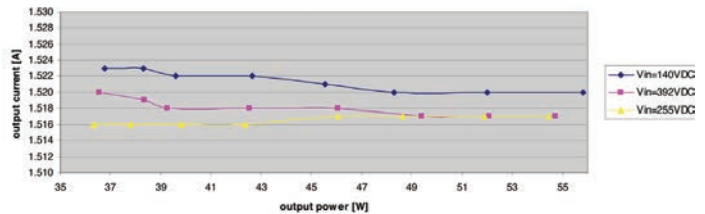
Power Factor
Load = LEDs (V_{OUT} = 33 V, I_{OUT} - 1.5 A)

For more reference designs, see: www.ti.com/powerreferencedesigns

→ *LED Driver/Ballast*

UCC28810 PMP4501 - Offline, 34-W LED Driver with PFC

The PMP4501 is an isolated, off-line, AC-to-DC LED-current driver with PFC for applications such as commercial fixture lighting and general isolated LED drivers. The PMP4501 is a single-stage flyback PFC converter that delivers up to 34 W with a 180- to 265-V_{AC} input voltage while providing a 10- to 48-V output voltage at a constant output current of 700 mA ±2%.

The PMP4501 implements secondary-side current control for the LED string. Overvoltage protection prevents dangerous output voltages from occurring during open-string conditions. A current-sense amplifier reduces the sensing resistor's power dissipation, thus increasing overall efficiency. The internal reference voltage of the operational amplifier achieves excellent LED-current regulation versus output power and input voltage. The PMP4501 achieves high efficiency (90% peak), high power density and a high power factor. The reference design protects against scenarios with open and short LED strings, and the control stage is a simple and robust design.

Key Features
- Isolated single stage LED driver
- Naturally high PFC
- 90% efficient
- Universal input voltage range
- 700-mA output current
- Low LED ripple current

Web Links
Datasheets, user's guides, samples:
www.ti.com/tool/**PMP4501**
www.ti.com/product/**UCC28810**

Design Specifications

Description	Parts	V_{IN} (AC) Range	V_{OUT} (DC) Range	Number of LEDs	I_{OUT} (max)	P_{OUT} (max)	Eff.	PFC	ISO	Dimming In	Dimming Out	EVM
UCC28810 PMP4501 34-W Secondary side current loop	UCC28810 TL103W	180 265	10 V 48.5 V	3-13	700 mA	34 W	90%	Yes	Yes	No	No	Reference Design

PMP4501 Reference Design Schematic
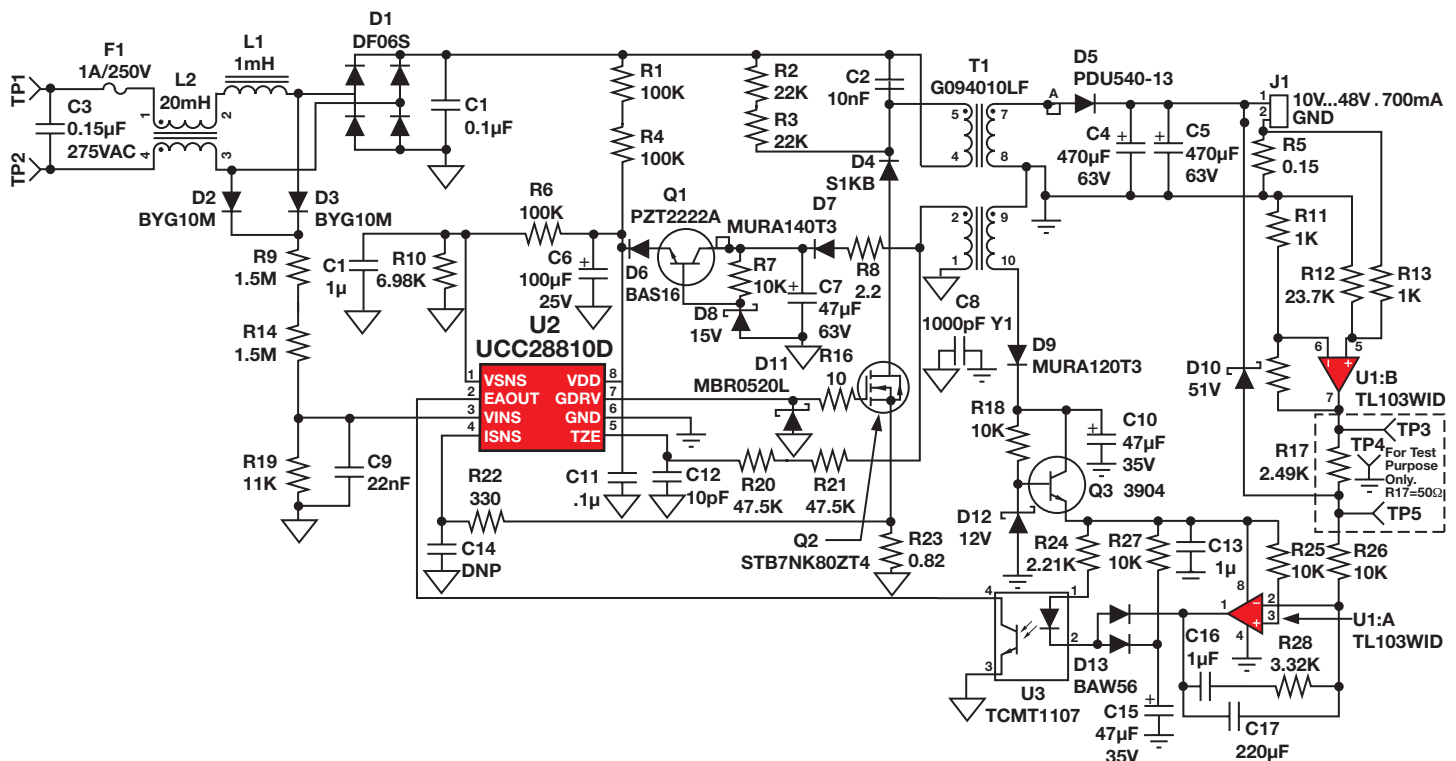
For more reference designs, see: www.ti.com/powerreferencedesigns

PMP4501 Board
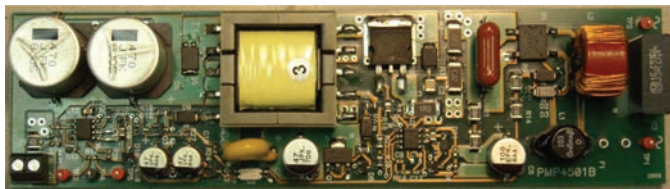
I$_{OUT}$ Regulation vs. Rectified-Equivalent Line Voltage and Output Power
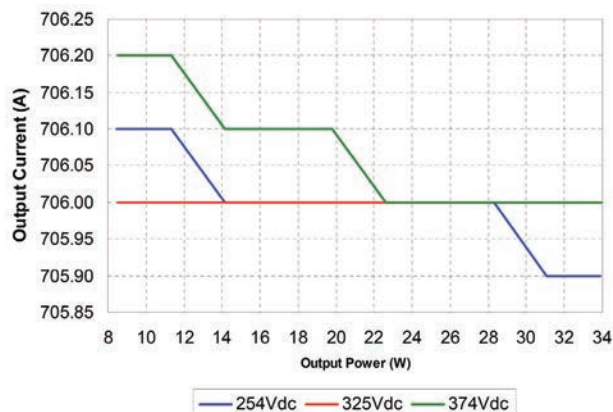
Efficiency vs. Rectified-Equivalent Line Voltage and Output Power
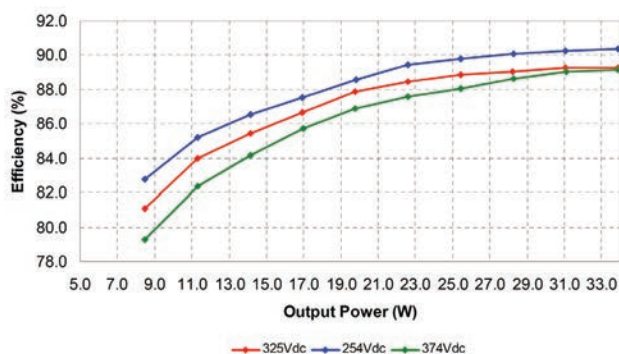
Output Current Ripple. Input Voltage = 230 V$_{AC}$, Output Voltage = 48 V @ 700 mA
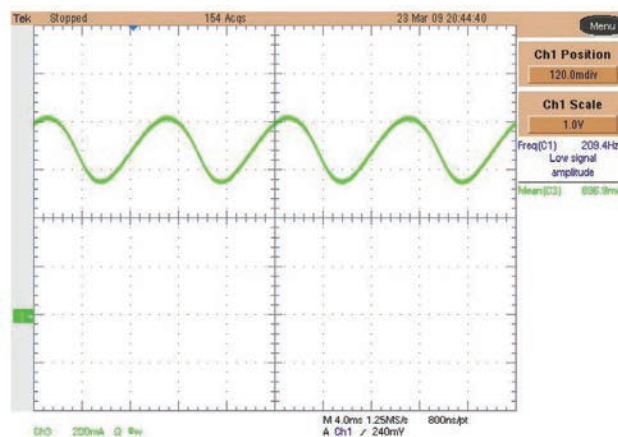
Power Factor vs. Line Voltage and Output Power
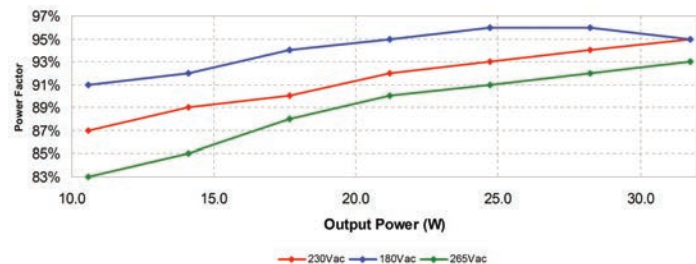
AC Input Current and Voltage at Full Load and Nominal Input Voltage
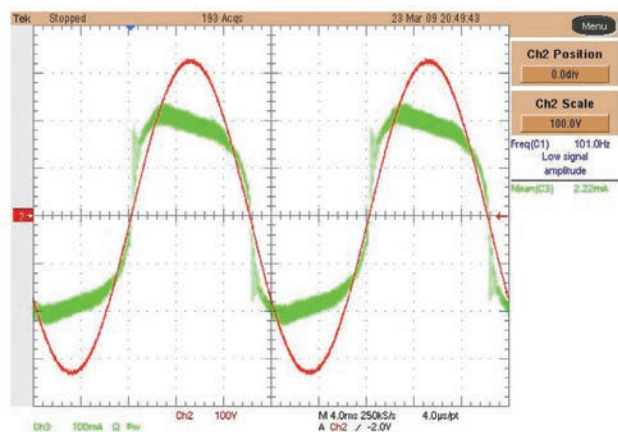
→   ## *LED Streetlight*

UCC28810 PMP3976 - 100-W, Offline PFC SEPIC LED Driver

The PMP3976 circuit shown below was designed for a commercial LED lighting fixture. The SEPIC topology has the advantage over a flyback converter in that it clamps the switching waveforms on the power semiconductor, allowing the use of lower voltage and hence more efficient parts. This provides an estimated 2% improvement in efficiency in this application. Additionally, there is less ringing in the SEPIC, making EMI filtering easier.

Key Features
- Non-isolated single LED string driver
- 92% efficient solution
- SEPIC control boosts for high voltage
- Natural single stage with >0.9 PFC
- Low-cost solution with few external parts
- Meets European harmonic requirements

Web Links
Datasheets, user's guides, samples:
www.ti.com/tool/**PMP3976**
www.ti.com/product/**UCC28810**

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

Design Specifications

Parameter	Minimum	Typical	Maximum	Unit
Input voltage	150	—	264	V_{AC}
Output voltage	—	—	300	Volts
Output current	—	0.350	—	Amp

PMP3976 Schematic

150VAC to 240VAC Input


For more reference designs, see: www.ti.com/powerreferencedesigns

PMP3976 Rev B Demo Board

Power Factor

The circuit is built on a PMP3976 Rev A PWB.

For more reference designs, see: www.ti.com/powerreferencedesigns

Reference Designs

→ *LED Streetlight*

Efficiency
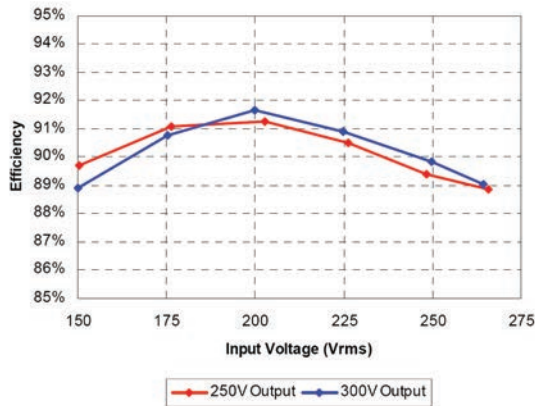
Thermal Image
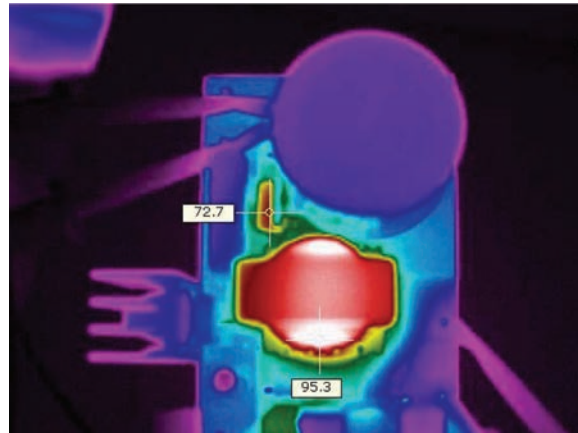
The image above shows a thermal image of the board. The ambient temperature was 26º C with no forced air flow. The input was 230 V_{AC}.

Efficiency and Power Factor

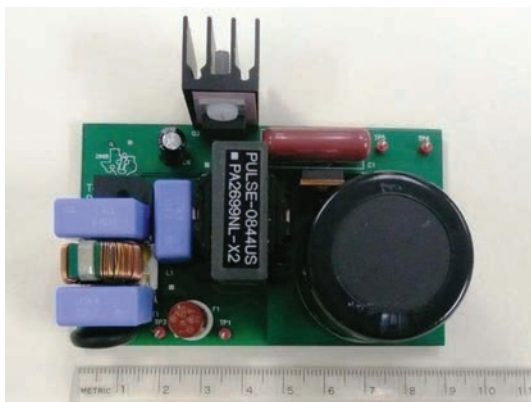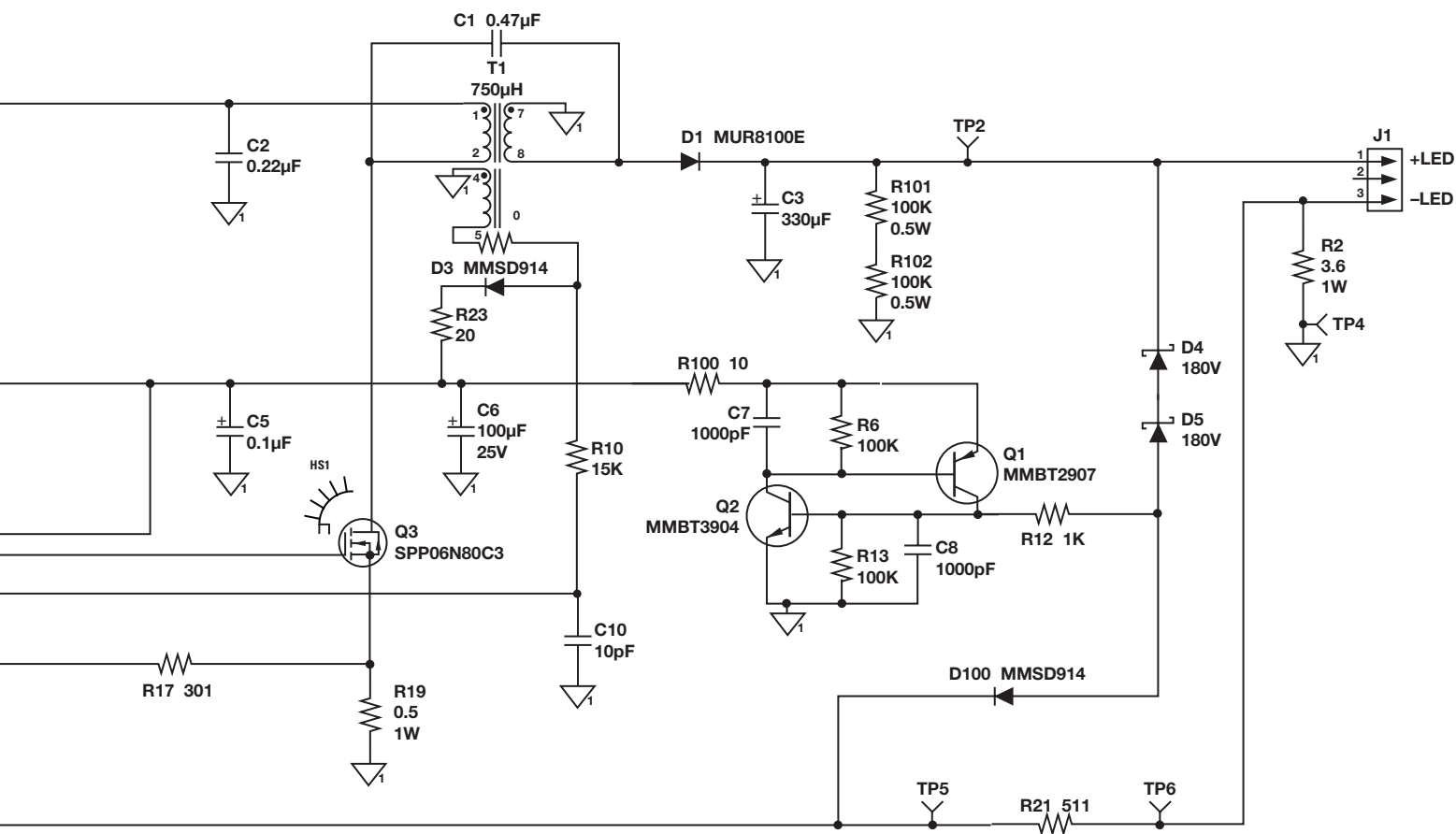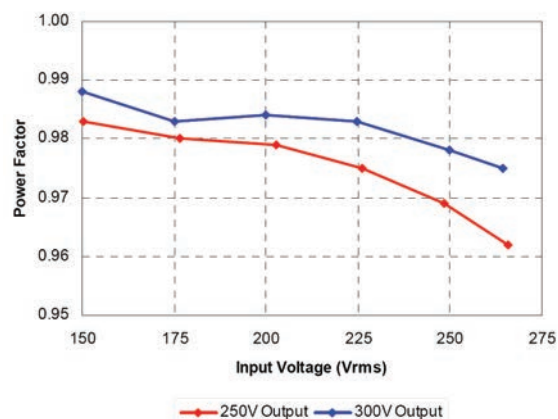| I_{OUT}	V_{OUT}	V_{IN}	L_{IN}	PF	P_{OUT}	Losses	Efficiency %
0.349	245.5	150.4	0.646	0.983	85.65	9.827	89.7
0.349	245.4	176.4	0.544	0.980	85.64	8.398	91.1
0.349	245.3	202.6	0.473	0.979	85.61	8.208	91.3
0.350	245.3	226.3	0.430	0.975	85.86	9.201	90.5
0.350	245.3	248.4	0.399	0.969	85.86	10.184	89.4
0.350	245.3	265.7	0.378	0.962	85.86	10.763	88.9

Harmonic Content

The harmonic content and the EN61000-3-2 Class C (lighting equipments) Limits are shown above; input voltage was set to 230 V_{AC}.

I_{OUT}	V_{OUT}	V_{IN}	L_{IN}	PF	P_{OUT}	Losses	Efficiency %
0.348	303.9	149.9	0.803	0.988	105.75	13.168	88.9
0.349	303.3	175.2	0.677	0.983	105.85	10.742	90.8
0.349	303.8	199.9	0.588	0.984	106.03	9.634	91.7
0.349	303.3	224.8	0.527	0.983	105.85	10.604	90.9
0.349	303.2	249.8	0.482	0.978	105.82	11.938	89.9
0.349	303.0	264.2	0.461	0.975	105.75	13.004	89.0

For more reference designs, see: www.ti.com/powerreferencedesigns

Frequency Response

The frequency response of the feedback loop is shown in the plot above. The input was set to 220 V_{AC}. The lower gain plot was taken with a 300 V output. The upper gain plot was taken with a 250 V output.

Diode Voltage Waveform
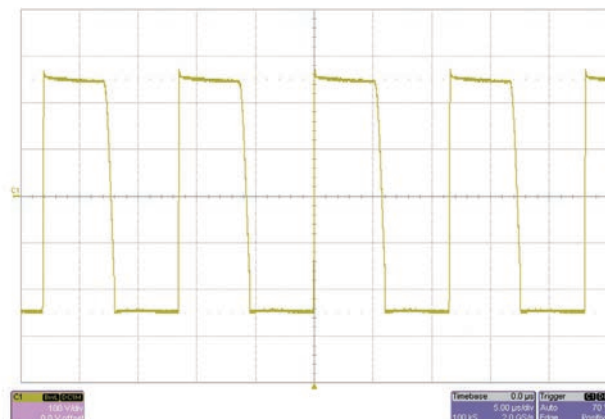
The image above shows the voltage on the anode of D1. The input was set to 250 V_{DC}.

Line Voltage and Current Waveform
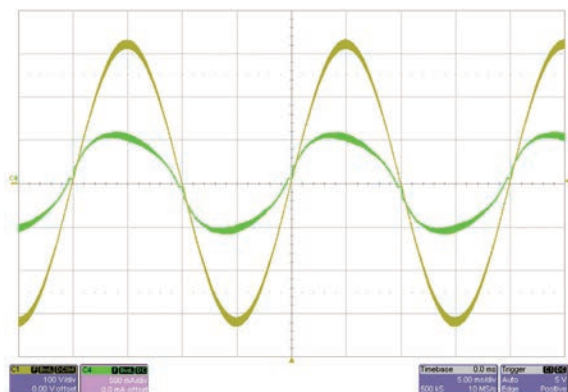
The image above shows the input voltage and current. The input voltage was 230 V_{AC}.

Inductor Winding Currents
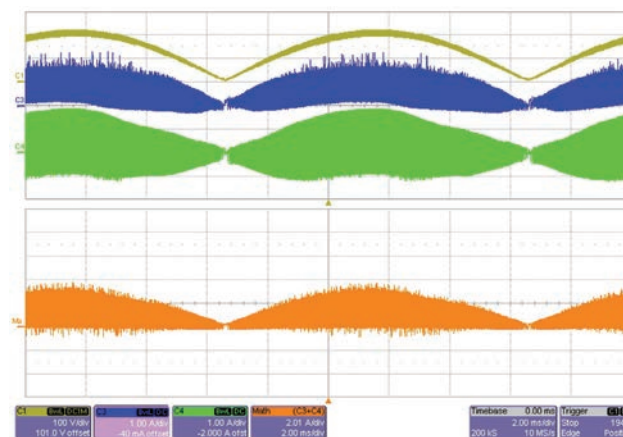
MOSFET Voltage Waveform
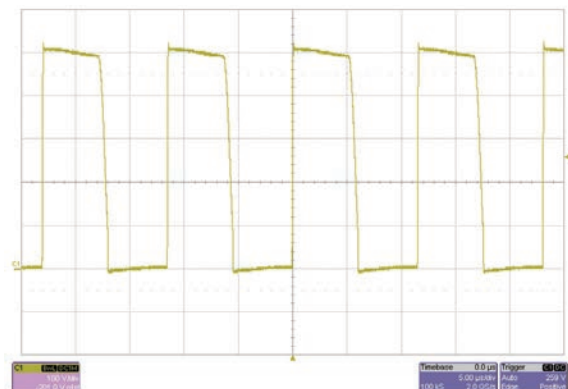
The image above shows the drain-to-source voltage on Q3. The input was set to 250.
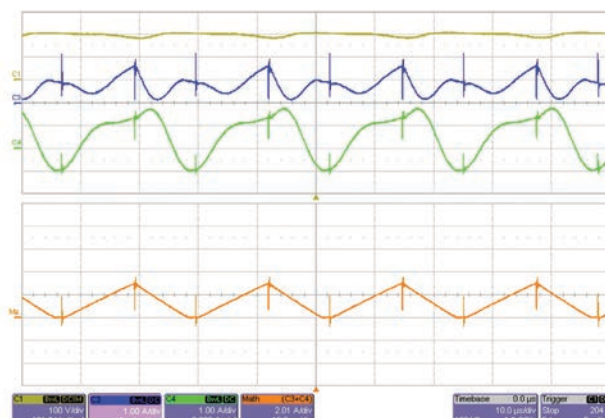
The two images above show the currents in the individual windings of the inductor.

Reference Designs

→ ## DC LED Lighting

TPS40211 PMP4026

The circuit shown below was designed with an automotive input-voltage range. The driver was built to operate under low-power to nominal battery conditions and to survive load-dump incidents. The application, powered directly from V_{BAT}, can have a string of up to ten 700-mA LEDs in series or two parallel strings with up to ten 350-mA LEDs in each string.

An additional reference design is available. This design is a 700-mA, nonsynchronous boost current regulator for an LED driver. It has an 8- to 18-V input and a 20- to 35-V output.

Key Features
- Wide 4.5- to 52-V input range
- Low-cost non-synchronous boost
- High efficiency from low 260-mV V_{REF}
- Simple loop compensation
- Supports versatile SEPIC topology

Web Links
Datasheets, user's guides, samples:
www.ti.com/tool/**PMP4026**
www.ti.com/product/**TPS40211**

It can be found along with a demonstration board at:
http://**focus.ti.com/docs/toolsw/ folders/print/tps40211evm-352.html**

Design Specifications

Parameter	Minimum	Typical	Maximum	Unit
Input voltage	9	—	16	V_{DC}
Output voltage	—	—	40	Volts
Output current	—	0.700	—	Amp
Switching frequency	—	150	—	kHz

PMP4026 Schematic

For more reference designs, see: www.ti.com/powerreferencedesigns

Startup

The input voltage was set at 12 V, with 0.15 (LED) + 1 (resistor) A load on the outputs.

Output Ripple Current
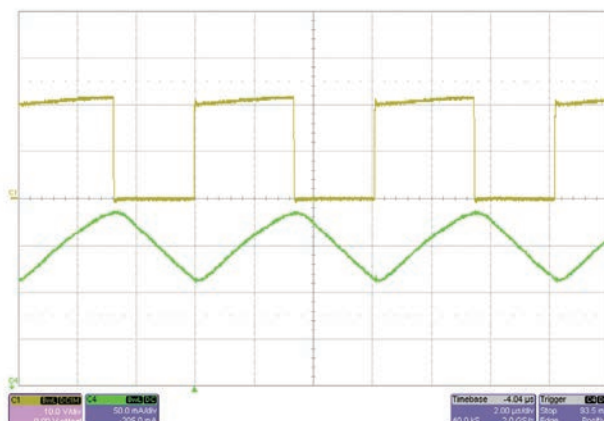
The image was taken with a 1.15 A/20 V load. Top waveform is FET drain, bottom is LED current.

Efficiency
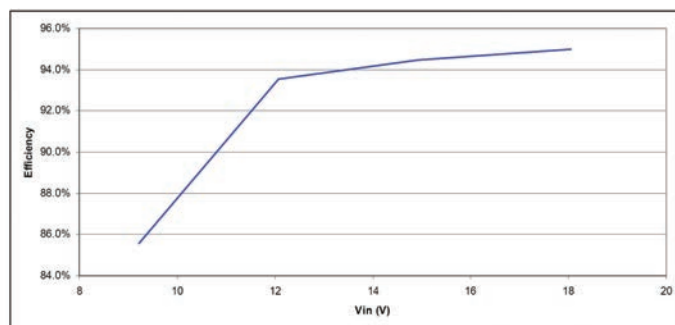
Total output current was 1.15 A, output voltage was 20 volts.

Control Loop Frequency Response: 12 V input; 1.15 A Load
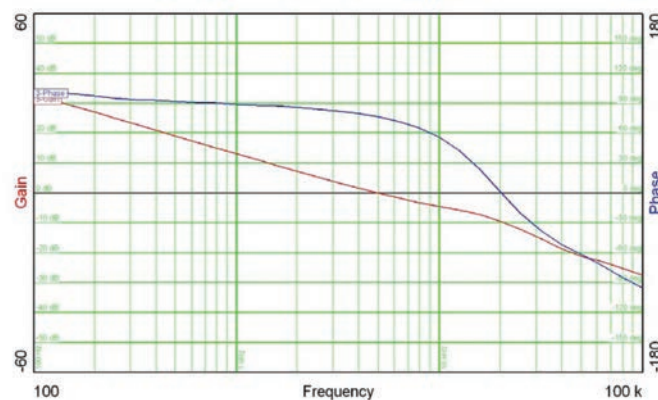
Load Regulation of Outputs
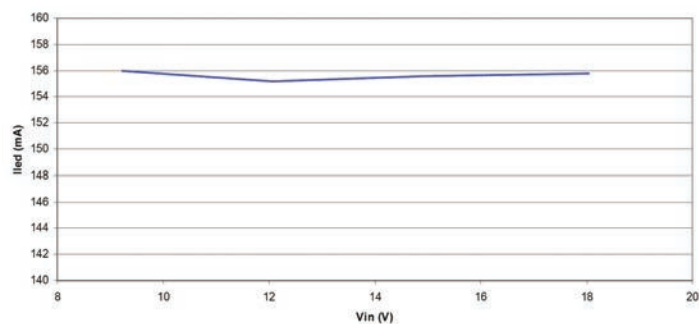
Load Transients
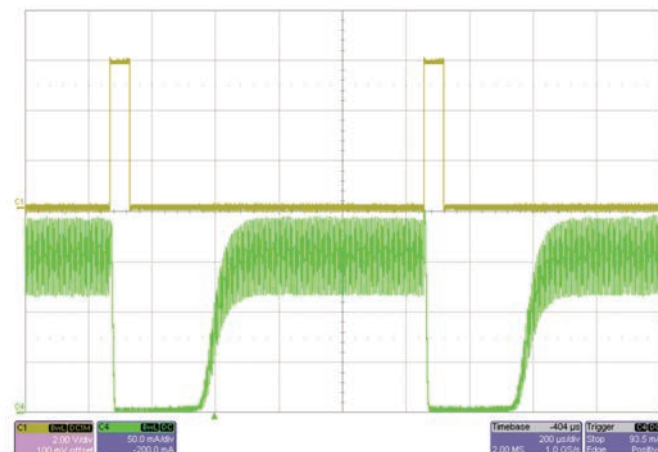
Output response to driving TP%. The input voltage was set to 12 V.

➔   ## DC LED Lighting

TPS40211 PMP3943 - Wide-Input DC Voltage SEPIC Driver

The TPS40211 is a wide-input-voltage (4.5- to 52-V) nonsynchronous boost controller. It is suitable for topologies that require a grounded source n-channel FET such as boost, flyback, SEPIC and various LED-driver applications. The TPS40211 features a programmable soft start; overcurrent protection with automatic retry; and a programmable oscillator frequency. Current-mode control provides improved transient response and simplified loop compensation. The feedback pin has a reference voltage of 260 mV to help reduce the power usage and cost of the sense resistor.

The PMP3943 circuit shown below was designed with an automotive input-voltage range. The driver was built to operate under low-power battery conditions and to survive load-dump incidents. The TPS40211 was chosen for this application due to its low feedback voltage and wide input-voltage range.
An additional reference design is available. This design is a 700-mA, nonsynchronous boost current regulator for an LED driver. It has an 8- to 18-V input and a 20- to 35-V output.

Key Features
• Wide 4.5- to 52-V input range
• Low-cost non-synchronous boost
• High efficiency from low 260-mV V_{REF}
• Simple loop compensation
• Supports versatile SEPIC topology

Web Links
Datasheets, user's guides, samples:
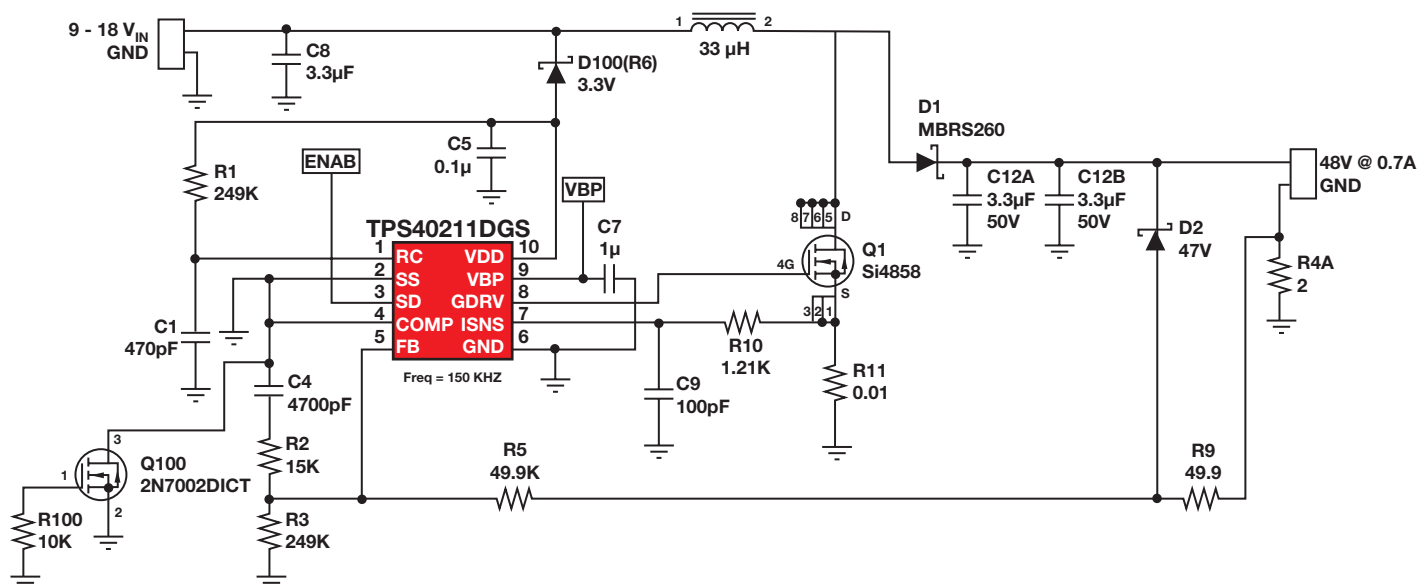www.ti.com/tool/**PMP3943**
www.ti.com/product/**TPS40211**

It can be found along with a demonstration board at:
www.ti.com/product/**TPS40211evm**

Design Specifications

Parameter	Minimum	Typical	Maximum	Unit
Input voltage	8	—	40	Volts
Output voltage	—	13	—	Volts
Output current	—	0.350	—	Amp
Switching frequency	—	300	—	kHz

PMP3943 Schematic
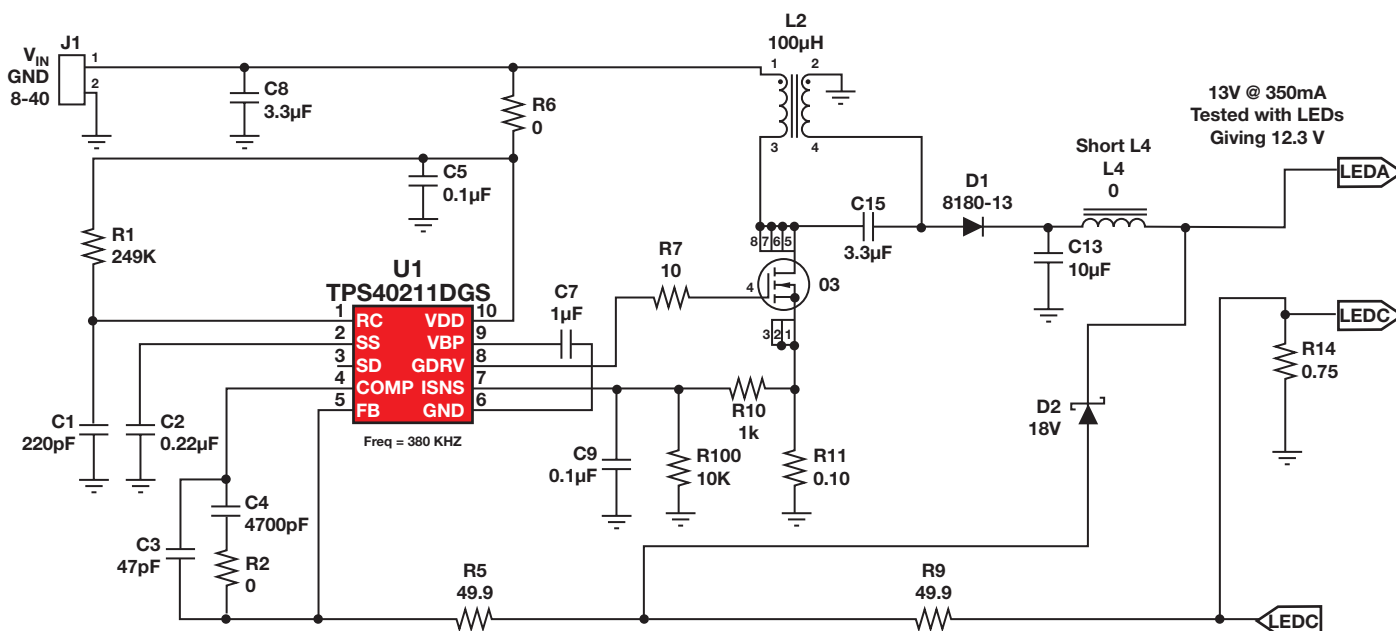
For more reference designs, see: www.ti.com/powerreferencedesigns

Current Loop Frequency Response

Current regulation loop Bode Plot:

PMP3943: LED driver off 8-40Vin 12.3Vout at 341mA
C4=4700pF, R2=0 Current loop Bode plot TPS40211
run 1 at 8Vin crossover at 360Hz with 90+ degrees
phase margin; -180 degrees at 6.6kHz with 7dB gain
margin
run 2 at 40Vin crossover at 1kHz with 88 degrees
margin
-180 degrees at 6kHz with 10dB gain margin
Josh Mandelcorn July 18, 2008 Venable 3120
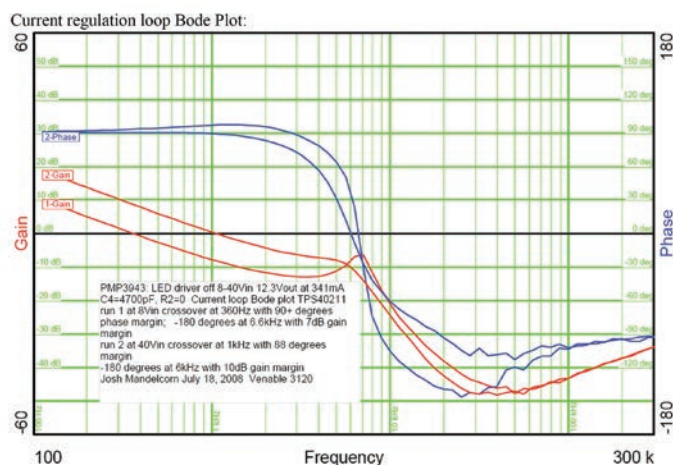
3 Green and 1 Red OSRAM LEDs Used as Load for Vf About 12 V

V_{IN} Volts	I_{IN} mA	V_{OUT1} Volts	I_{OUT1} mA	Efficiency %
40.22	123.6	12.27	341.8	84.4
20.11	238.5	12.27	341.3	87.3
7.93	619.4	12.27	341.3	85.3

Regulation and efficiency: 25 degrees Celsius ambient. Target I_{OUT} was 350 mA, hence actual current is 2.5% low.

When Diode Load is Opened, V_{OUT} Goes to About 18 V

V_{IN} Volts	I_{IN} mA	V_{OUT1} Volts	I_{OUT1} mA
40.42	8.79	18.44	0
20.08	10.75	18.41	0
8.00	19.12	18.40	0

Short Circuit: Output Current Holds Steady

V_{IN} Volts	I_{IN} mA	V_{OUT1} Volts	I_{OUT1} mA
40.14	21.24	0.694	341.6
20.06	34.20	0.694	341.5
8.00	77.70	0.694	341.4

For more reference designs, see: www.ti.com/powerreferencedesigns

→ ## Low Voltage Buck Boost for LED Torch

TPS63000 PMP3038

The TPS63000 provides a power-supply solution for products that use a two- or three-cell alkaline, NiCd or NiMH battery, or a one-cell Li-Ion or Li-Polymer battery. The buck-boost converter is based on a fixed-frequency PWM controller that uses synchronous rectification to obtain maximum efficiency. The maximum average current in the switches is limited to a typical value of 1800 mA, and the converter can be disabled to minimize battery drain. During shutdown, the load is disconnected from the battery. The device is packaged in a 10-pin QFN PowerPAD™ (DRC) package measuring 3 x 3-mm.

The PMP3038 circuit was designed for a torch or rugged flashlight. Most torch applications still use alkaline

batteries with a common configuration of two or three cells in series that have a maximum voltage of 5 V. During operation, the V_{BAT} drops below the V_f of the LED, and the TPS63000 automatically switches from buck mode to boost mode to create the constant current needed for the LED. The TPS63000 can boost from voltages as low as 1.2 V. A switch that brings R4 into or out of the feedback loop provides a dimming mechanism for the flashlight to toggle between 300 and 600 mA.

Key Features
- Buck-boost converter topology
- Ideal for battery applications
- 1.8-A output capability
- Auto buck- boost mode switching
- Dual LED brightness levels
- Operates down to 1.2 V

Web Links
Datasheets, user's guides, samples:
www.ti.com/tool/**PMP3038**
www.ti.com/product/**TPS63000**

Design Specifications

Parameter	Minimum	Maximum	Unit
Input voltage	1.2	5	V_{DC}
Output voltage	—	5	Volts
Output current	300	600	mAmp
Switch frequency	—	1.5	MHz

PMP3038 Schematic

Low Voltage Buck Boost for LED Torch

Output Current Graphs with DC Coupling
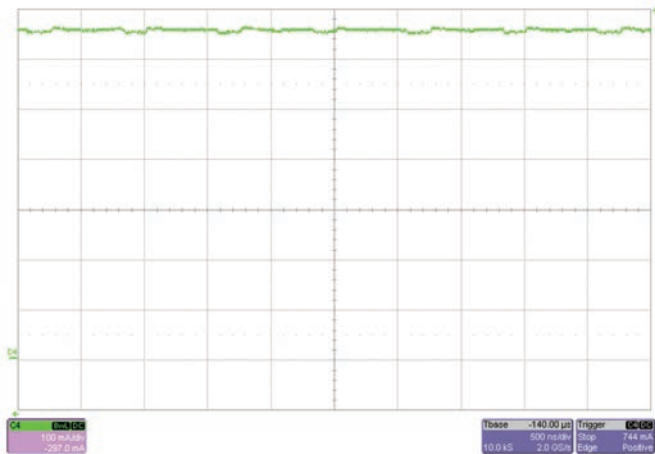
Output current with V_{IN} = 3 V.

Control Loop Response Graphs

Control loop response with 0.63 A.
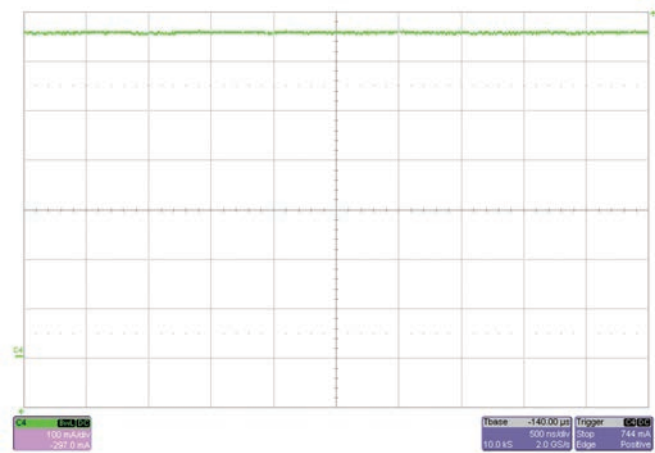
Output current with V_{IN} = 4 V.
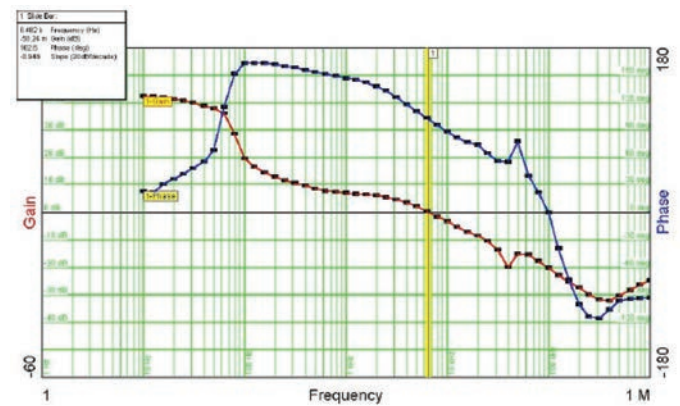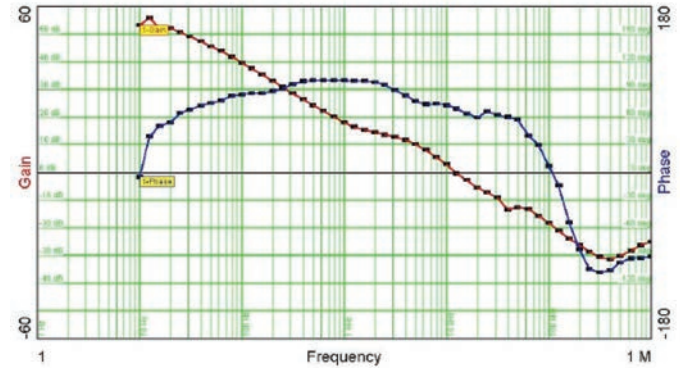
Control loop response with 0.32 A.

Efficiency Curve for I_O = 0.32 A and I_O = 0.62 A
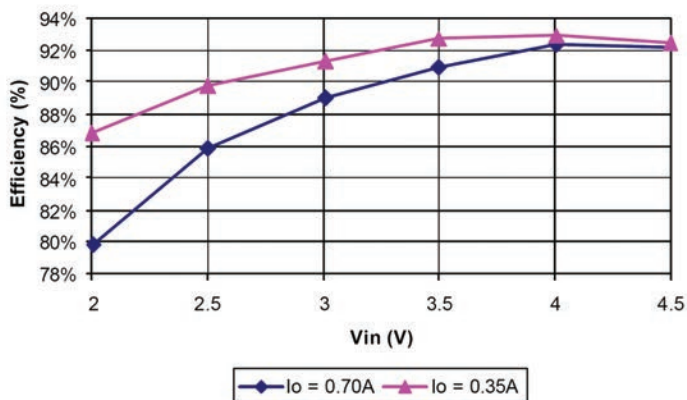
Efficiency.

Turn On with 0.63 A

Reference Designs
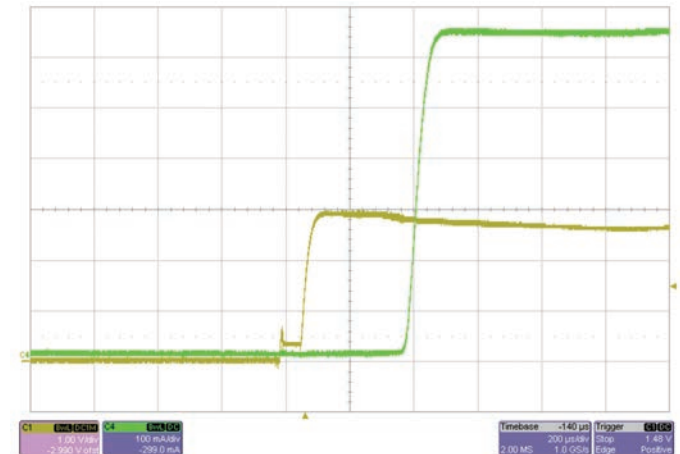
➔ *Boost Driver with Integrated Power Switch*

TPS61500
The TPS61500 is a monolithic switching regulator with an integrated 3-A, 40-V power switch. It is an ideal driver for high-brightness 1- or 3-W LEDs. The device has a wide input-voltage range to support applications with input voltage from multicell batteries or regulated 5-V to12-V power rails.

The LED current is set with an external sense resistor, R3, and with feedback voltage that is regulated to 200 mV by a current-mode PWM control loop, as shown in the schematic below. The device supports analog and pure PWM dimming methods for LED brightness control. Connecting a capacitor to the DIMC pin configures the device to be used for analog dimming, and the LED current varies in proportion to the duty cycle of an external PWM signal. Floating the DIMC pin configures the

IC for pure PWM dimming, with the average LED current being the PWM signal's duty cycle times a set LED current.

The device features a programmable soft-start function to limit inrush current during start-up and has other protection features built in, such as pulse-by-pulse overcurrent limiting, overvoltage protection and thermal shutdown. The TPS61500 is available in a 14-pin HTSSOP package with PowerPAD™.

Key Features
- Supports boost topology
- Integrated 3-A 40-V power switch
- Supports PWM or AM dimming
- Protection features:
  - Pulse by pulse
  - Thermal shutdown

Web Links
Datasheets, user's guides, samples:
www.ti.com/tool/**TPS61500evm-369**
www.ti.com/product/**TPS61500**

LED Current vs. Input Supply and LED Number

Input Supply	5 V	12 V
LED number 4	1000 mA	2000 mA
LED number 6	600 mA	1200 mA
LED number 8	450 mA	1000 mA

Note: Assumption that LED forward voltage is 3.5V, and TPS61500's conversion efficiency is 85%.

Typical Application Schematic
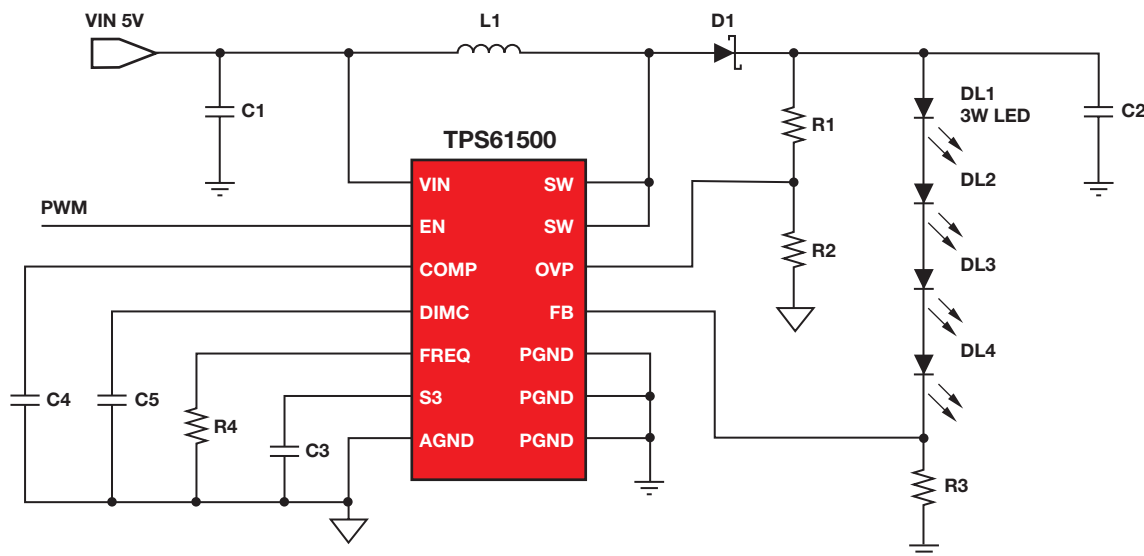
For more reference designs, see: www.ti.com/powerreferencedesigns

Efficiency vs. Output Current
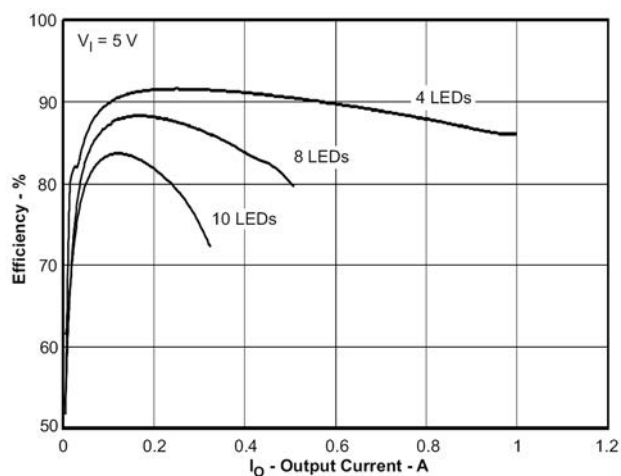
PWM Dimming Application Circuit: Circuit for the TPS61500 to Perform Analog Dimming Using an Injected Analog Signal
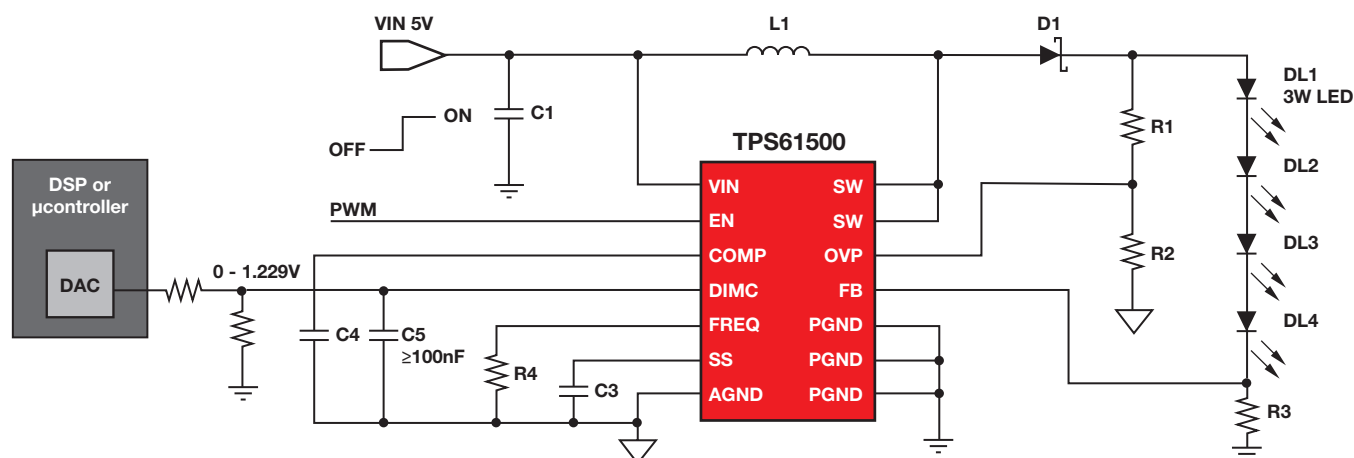
Analog Dimming by External DAC: Pure PWM Dimming Method
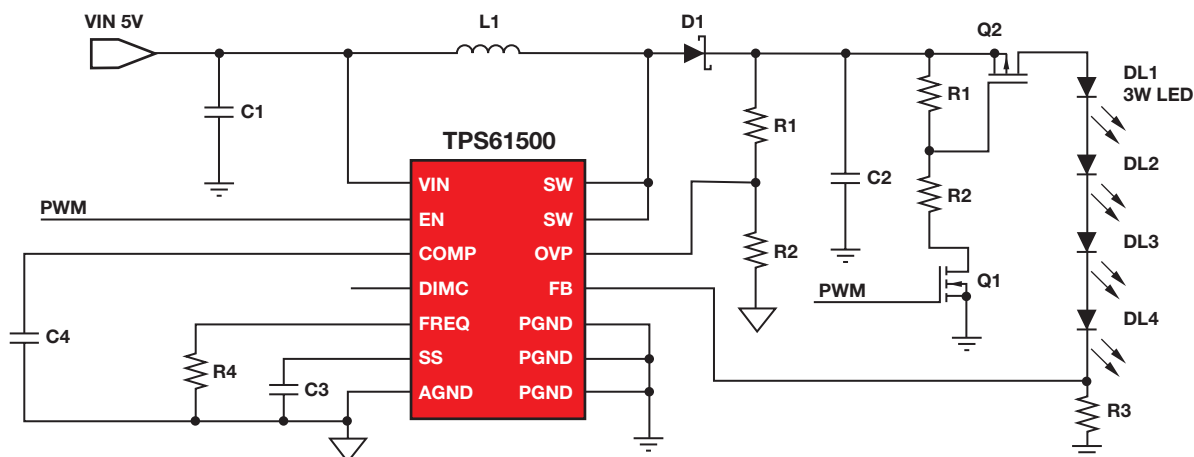
→ TRIAC Dimmable LED Lighting

TPS92010EVM

This design uses the TPS92010 8-pin, high-efficiency off-line LED lighting controller. This controller incorporates many features, such as frequency fold-back and a low-power mode, to implement a low-cost, high-efficiency flyback converter.

An application of this converter is retrofitting lightbulbs with LEDs. The converter can drive 3 to 5 high-brightness LEDs in series with a constant current of 0.35 A.

The flyback topology is chosen because it allows a lower component count and lower cost than other topologies. LED current is sensed directly to ensure its tight regulation. A special circuit for compatibility with TRIAC dimmers adjusts the output current linearly, avoiding any stroboscopic effects or audible noise that might otherwise occur. The TPS92011 is designed for low-power lighting applications that do not require power-factor correction.

Key Features
- AC/DC TRIAC dimmable LED reference design
- Ideal for residential lighting
- 3- to 12-W applications
- High efficiency
- TI lossless dimming circuit for a cooler, lower-power system during deep dimming

Web Links
Datasheets, user's guides, samples:
www.ti.com/tool/**TPS92010evm-592**
www.ti.com/tool/**TPS92010evm-631**
www.ti.com/product/**TPS92010**

Design Specifications (120 V Shown)

| Parameter	Minimum	Typical	Maximum
Input voltage (V_{AC})	100	120	130
Output voltage (V_{DC})	9	—	18
Output current (A)	—	0.35	—
Efficiency (%)	—	80	—

Efficiency without Dimmer

Efficiency with Dimmer

Dimming Performance
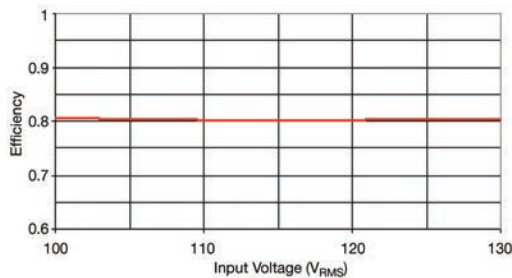
Output Current Regulation
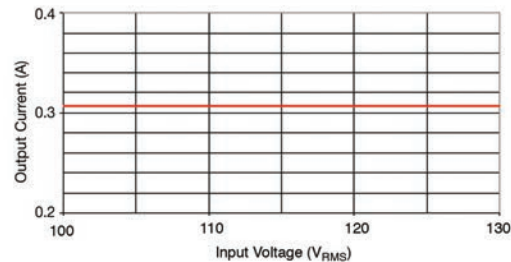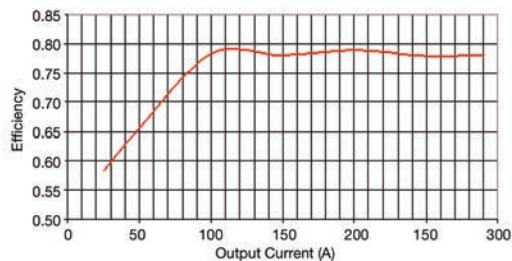
Adjusting the Output Current

Output Current (A)	R15 (Ω)	R17 (Ω)	R1 (Ω)	R42 (Ω)
0.20	1,000	150	330	1,000
0.225	1,200	86	390	1,000
0.25	1,200	220	470	1,000
0.275	1,000	560	680	680
0.30	1,500	220	680	680
0.325	1,500	330	470	1,500
0.35	1,000	1000	820	1,000
0.40	1,800	470	1,000	1,000
0.45	2,200	390	1,500	1,000
0.50	2,700	220	1,500	1,000
0.60	3,300	150	1,500	1,500
0.70	3,900	270	2,200	1,500
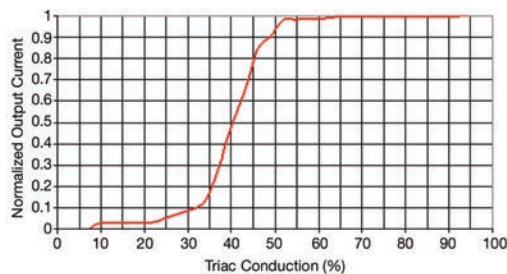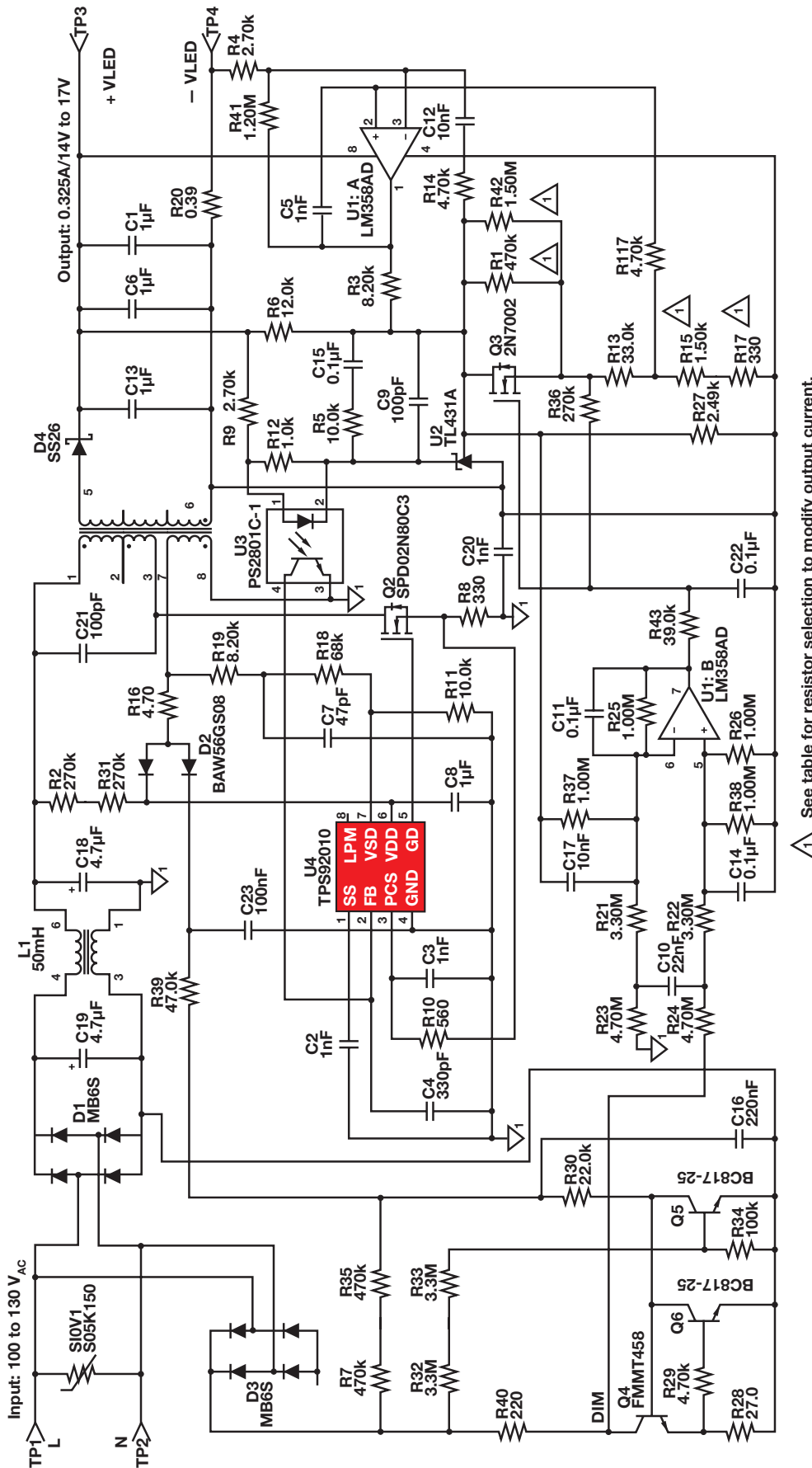
See table for resistor selection to modify output current.

For more reference designs, see: www.ti.com/powerreferencedesigns

→ *Dimmable LED Lighting Driver for Lightbulb Retrofit Apps*

TPS92210EVM

The TPS92210EVM is a natural power-factor-correction (PFC) LED lighting driver controller with advanced energy features to provide high-efficiency control for LED lighting applications. The TPS92210EVM is capable of providing a high power factor, TRIAC dimming, load protection and extended life in a small space at low cost.

The TPS92210EVM employs quasi constant "on" time that enables single-stage PFC in an isolated flyback configuration. Intended for low-power lighting applications, it can be packaged in a variety of ways, including individual lamp designs and generic PCB form factors for many types of lighting. The driver preserves dimmer holding current and features dual-slope output control to improve dimming linearity when used with common TRIAC-based phase-control dimmers. The TPS92210 controller is programmed to operate at a fixed frequency with a constant "on" time for the internal switch that drives the primary power FET.

Key Features
- AC/DC TRIAC dimmable LED driver with PFC
- Ideal for residential lighting
- Single stage (PFC and LED current regulation)
- 12- to 25-W applications
- Deep TRIAC dimming capability

Web Links
www.ti.com/tool/**TPS92210evm-613**
www.ti.com/tool/**TPS92210evm-647**
www.ti.com/product/**TPS92210**

Description	Parts	V_{IN} Range		V_{OUT} (DC) Range		Number of LEDs	I_{OUT} (max)	P_{OUT} (max)	Eff.	PFC	ISO	Dimming In	Dimming Out
TPS92210EVM-613	TPS92210	184	265	30	36	9 to 10	350 mA	12	87	Yes	Yes	TRIAC	Exponential
TPS92210EVM-647	TPS92210	85	144	19	32	6 to 10	350 mA	12	85	Yes	Yes	TRIAC	Exponential

TPS92210EVM Block Diagram
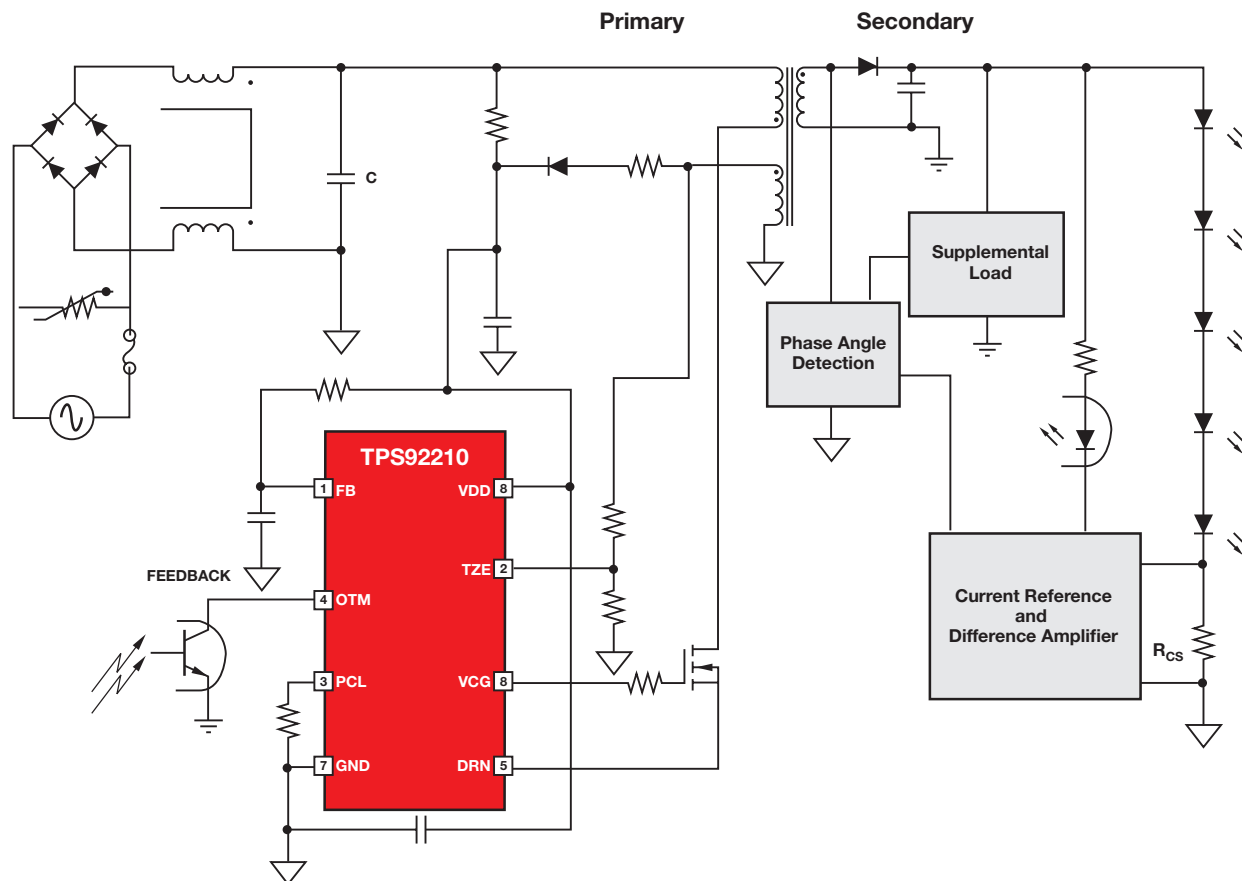
For more reference designs, see: www.ti.com/powerreferencedesigns

Dimmable LED Lighting Driver for Lightbulb Retrofit Apps

Efficiency
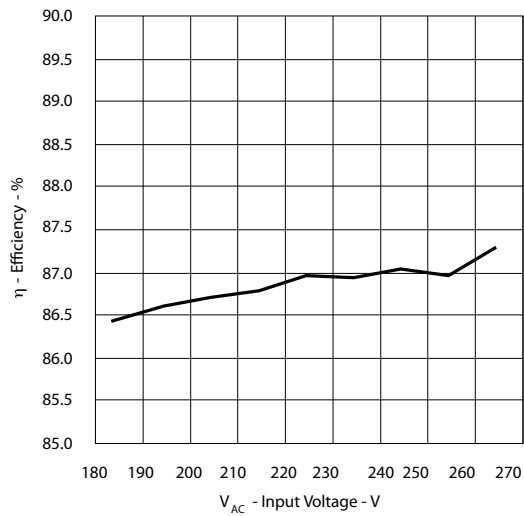
Load Regulation
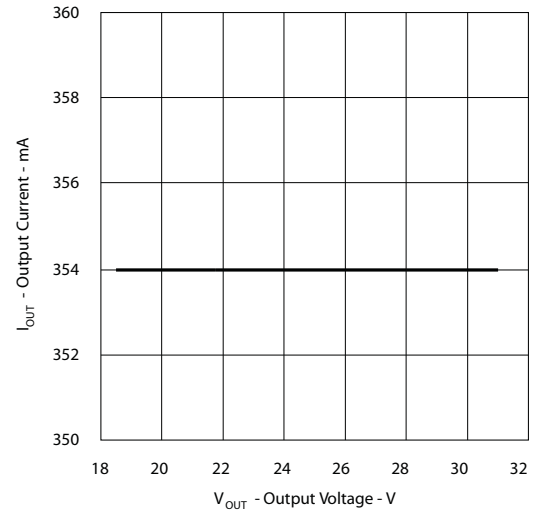
Line Regulation
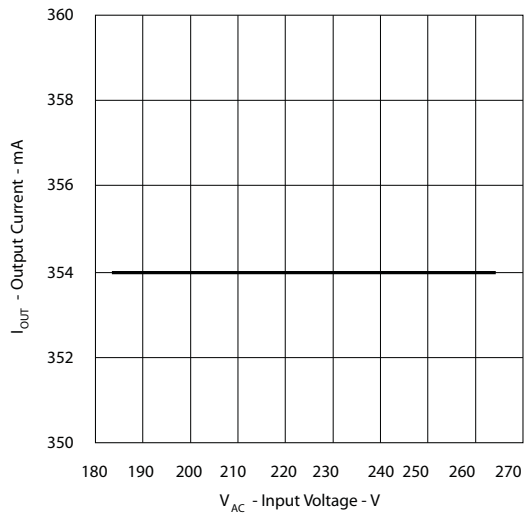
Bode Plot
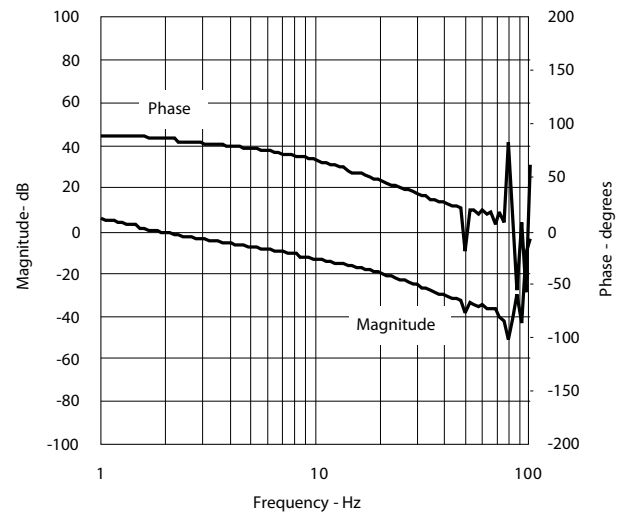
Power Factor
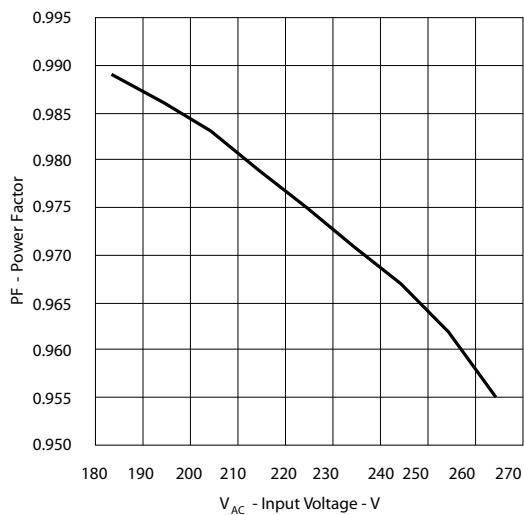
TRIAC Dimmer Performance
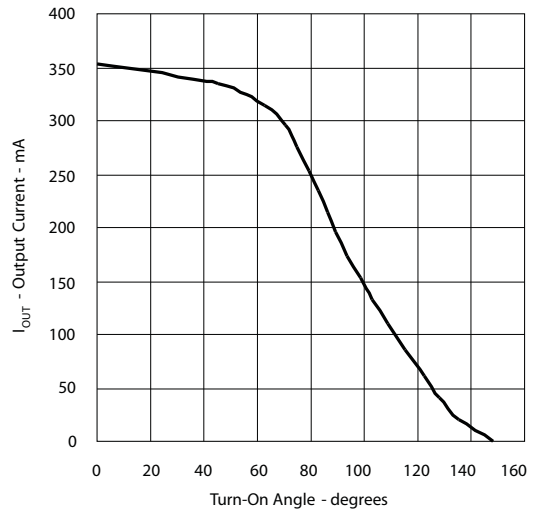
→ ## 100-Watt, Constant-Current, Non-Isolated Driver with PFC

UCC28810/UCC28810-EVM-002

The UCC28810EVM-002 evaluation module (EVM) is a constant-current non-isolated power supply for LED lighting applications that require high brightness, such as street, parking or area lighting. The reference design converts the universal mains (90 to 265 V_{RMS}) to a 0.9-A constant-current source to drive a 100-W LED load.

The UCC28810EVM-002 is a two-stage design. The first stage, a transition-mode circuit with PFC, ensures that the design meets various standards such as the EN61000-3-2. The PFC circuit converts the AC input to a regulated DC voltage, which can be configured as a boost-follower PFC or a fixed output voltage. The boost-follower PFC tracks the AC input's peak voltage for increased efficiency at low-line operation. The PFC's DC output voltage is then regulated to a fixed value in the region of 396 V_{DC}. The second stage of the design also uses transition mode but is configured as a buck converter. It converts the PFC output voltage to a fixed 0.9-A current to drive an LED load. The second stage accepts PWM dimming inputs (either externally or from an onboard circuit) and appropriately toggles itself on or off.

Key Features
- High-power AC/DC LED driver with PFC
- Ideal for street, parking or area lighting
- Universal-input, non-isolated design
- Tightly regulated LED current
- PWM dimming, 200 Hz to 1 kHz
- High efficiency through dimming
- Active power-factor correction

Web Links
Datasheets, user's guides, samples:
www.ti.com/tool/**UCC28810evm-002**
www.ti.com/product/**UCC28810**

Design Specifications

Description	Parts	V_{IN} (AC) Range	V_{OUT} (DC) Range	Number of LEDs	I_{OUT} (max)	P_{OUT} (max)	Eff.	PFC	ISO	Dimming In	Dimming Out	EVM
UCC28810 EVM002 100-W	UCC28810	90	55	15 to 30	900 mA	100 W	93%	Yes	No	PWM	PWM	Yes
LED lighting driver	UCC28811	265	100	15 to 30	900 mA	100 W	93%	Yes	No	PWM	PWM	Yes

UCC28810EVM-002 Block Diagram
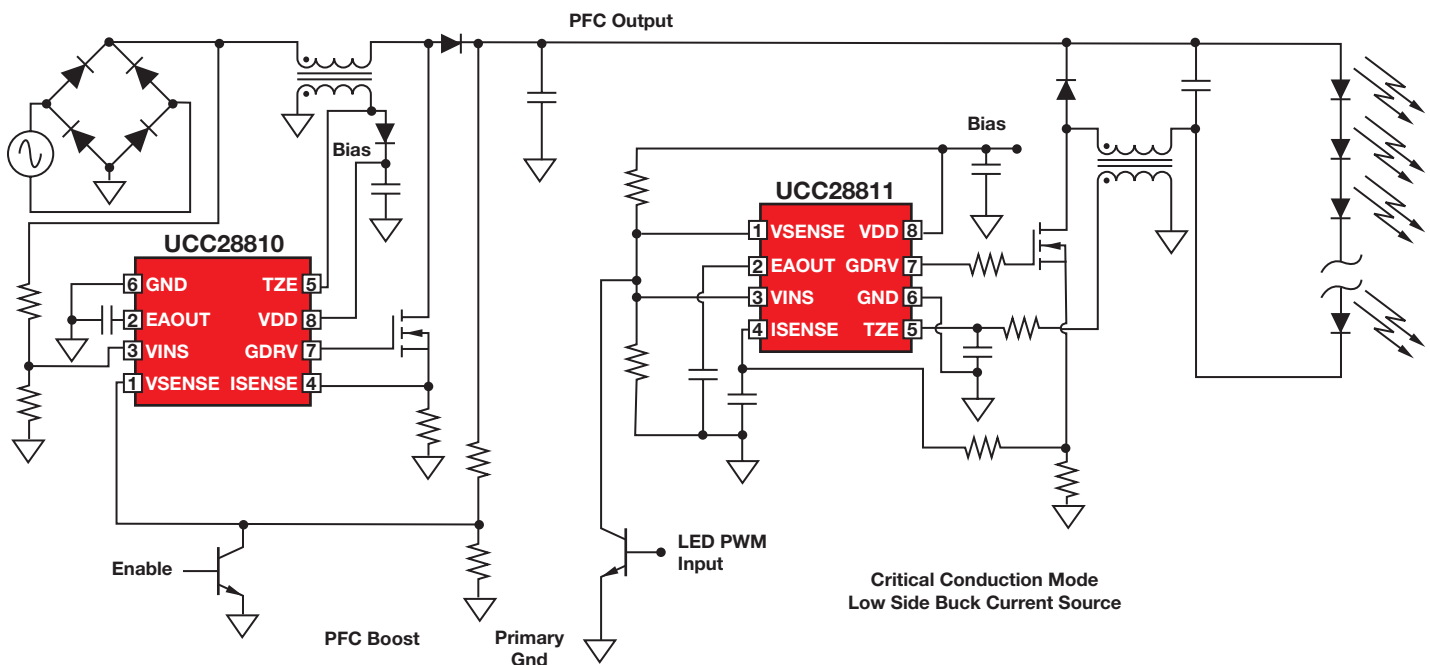
For more reference designs, see: www.ti.com/powerreferencedesigns

100-Watt, Constant-Current, Non-Isolated Driver with PFC

Efficiency and Power Factor vs. Line Voltage
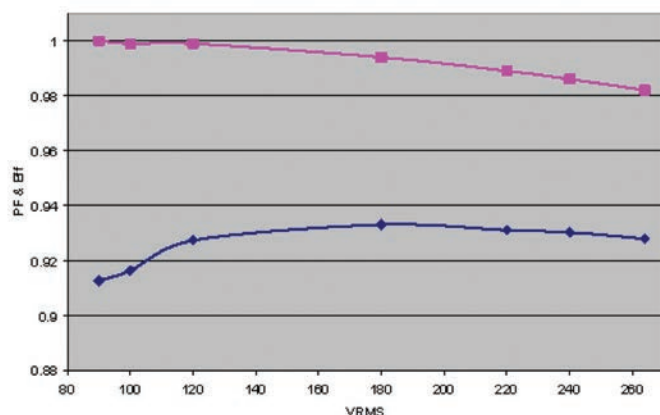
UCC28810EVM-002 efficiency and power factor vs. line voltage 30 Cree XRE LED's at 900 mA.

Line Regulation 30 LEDs at 900 mA, (98 W)
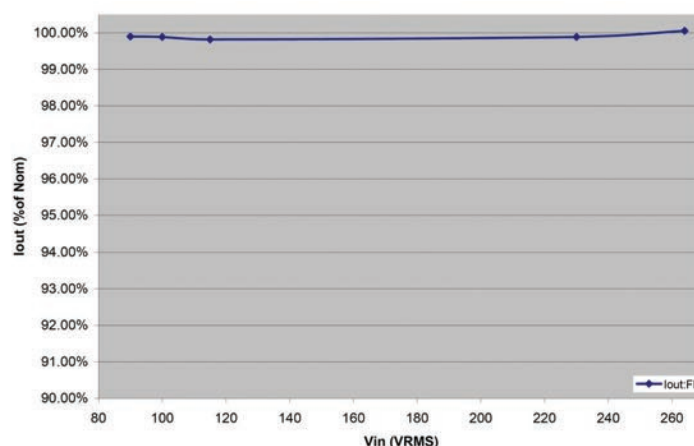
LED current regulation as a function of line voltage.

PWM Dimming Waveforms
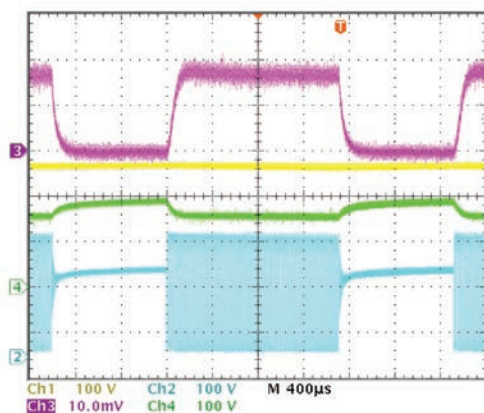
UCC28810EVM-002 transition mode buck PWM response. Ch1: Buck V$_{IN}$, Ch2: Buck V$_{DS}$, Ch3: LED current (0.5 A/Div), Ch4: LED voltage. Ch1 and Ch4 share GND reference.

PWM Dimming Response
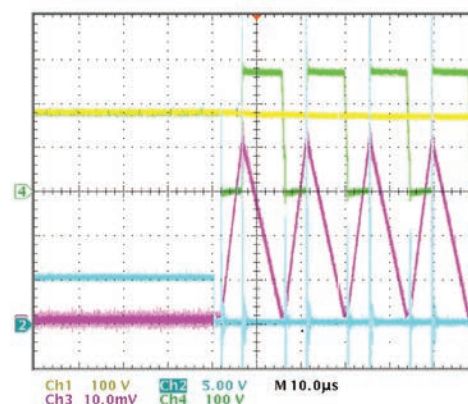
UCC28810EVM-002 transition mode buck PWM response (expanded). Ch1: LED V$_{OUT}$, Ch2 PWM, Ch3 buck inductor current 500 mA/Div, Ch4 V$_{DS}$ Ch1 and Ch4 Share GND reference.

THD Factor vs. Line Voltage
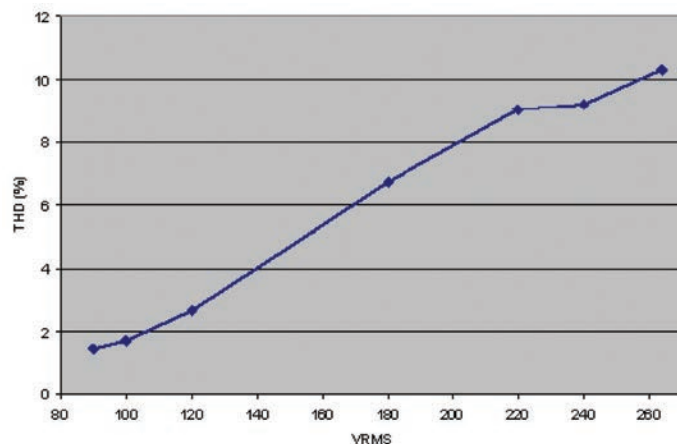
UCC28810EVM-002 THD vs. line voltage 30 Cree XRE LED's at 900 mA.

110-Watt, Constant-Current, Isolated Driver with PFC

UCC28810/UCC28810EVM-003

The UCC28810EVM-003 evaluation module (EVM) is an off-line AC-to-DC LED current driver with PFC for applications such as street, high-bay, and medium- or large-infrastructure lighting. The UCC28810EVM-003 is a three-stage converter design that delivers up to 110 W. The first stage is a universal input boost-PFC circuit providing a 305- to 400-VDC output. The second stage is a low-side buck circuit providing the controlled current source, and the third stage is a series of two half-bridge DC/DC transformers that provides isolation of multiple LED strings.

This patent-pending solution provides an easily scalable and cost-effective method of driving multiple LED strings. The UCC28810EVM-003 implements single-reference current control and universal dimming (via AM or PWM) for all LEDs. The reference design effectively drives a large number of LEDs connected in series, but the voltage on the LED strings is safe (low) and isolated from the AC line. The multistring architecture is more cost-effective than an architecture with a constant voltage plus a buck stage for each LED string. The LED-driver architecture is readily scalable to very high power levels. Excellent LED current matching between strings is achieved with this architecture. The UCC28810EVM-003 achieves high efficiency (91%), high power density and a high power factor. The control stage is a simple and robust design, and the EVM protects against scenarios with open and short LED strings.

Key Features
• Simp*LED*rive™ high-power dimmable AC/DC LED driver with PFC
• Ideal for street, high-bay or infrastructure lighting
• Isolated from the AC line
• Readily scalable to higher power levels
• LED current matching between strings
• High efficiency and power density
• Active power-factor correction

Web Links
Datasheets, user's guides, samples:
www.ti.com/tool/**UCC28810evm-003**
www.ti.com/product/**UCC28810**

Design Specifications

Description	Parts	V_{IN} (AC) Range	V_{OUT} (DC) Range	Number of LEDs	I_{OUT} (max)	P_{OUT} (max)	Eff.	PFC	ISO	Dimming In	Dimming Out	EVM
UCC28810 EVM003 100-W isolated multi-string LED lighting driver w/multiple transformers	UCC28810 UCC28811 TPS92020	90, 265	22 V, 60 V	4X (7 to 15)	500 mA	110 W	91%	Yes	Yes	PWM	PWM	Jul-09

UCC28810EVM-003 Block Diagram

110-Watt, Constant-Current, Isolated Driver with PFC

Efficiency vs. Line Voltage

PR896/PR791
Efficiency
4 strings 15 LEDs at 500mA, (100W)

UCC28810EVM-003 efficiency vs. line voltage and load 4 x 15 Cree XRE LED's at 500 mA.

I$_{OUT}$ Matching vs. Line Voltage

PR896/PR791
Iout Matching
4 strings 15 LEDs at 500mA, (100W)

UCC28810EVM-003 I$_{OUT}$ matching vs. line voltage 4 x 15 Cree XRE LED's at 500 mA.

Power Factor vs. Line Voltage

PR896/PR791
Power Factor
4 Strings 15 LEDs at 500mA, (100W)

UCC28810EVM-003 power factor vs. line voltage 4 x 15 Cree XRE LED's at 500 mA.

UCC28810EVM-003 AC Input Current During PWM Dimming

Ch1: V$_{BUCK}$+, Ch2: Buck V$_{DS}$, Ch3: AC line current 1 A/Div, Ch4: V$_{BUCK}$ - Ch1 and Ch 4 share GND reference.

TPS92070EVM *NEW!*

Description

The TPS92070EVM-648 is designed to demonstrate the TPS92070 Dimmable Quasi-Resonant LED Lighting Controller in a typical LED driver application. The TPS92070EVM-648 uses 180 V_{AC} to 240 V_{AC} input to drive five high brightness LEDs with a drive current of 370 mA.

Web Links

www.ti.com/tool/**TPS92070evm-648**
www.ti.com/tool/**TPS92070evm-682**
www.ti.com/product/**TPS92070**
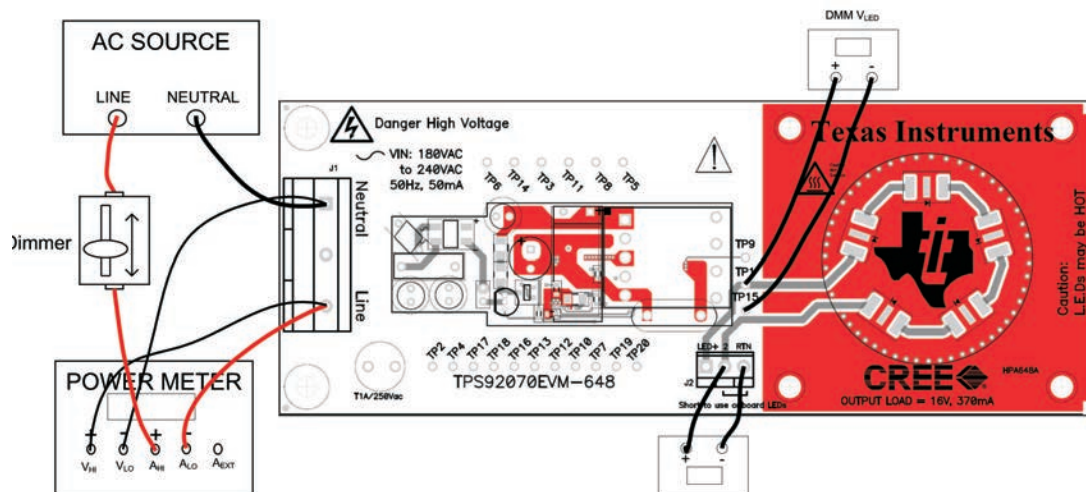
Description	Parts	V_{IN} Range		V_{OUT} (DC) Range		Number of LEDs	I_{OUT} (max)	P_{OUT} (max)	Eff.	PFC	ISO	Dimming In	Dimming Out
TPS92070EVM-648	TPS92070	180	265	15	17	5	370 mA	6	83%	Yes	Yes	TRIAC	Exponential
TPS92070EVM-682	TPS92070	85	144	Preview						Yes	Yes	TRIAC	Exponential
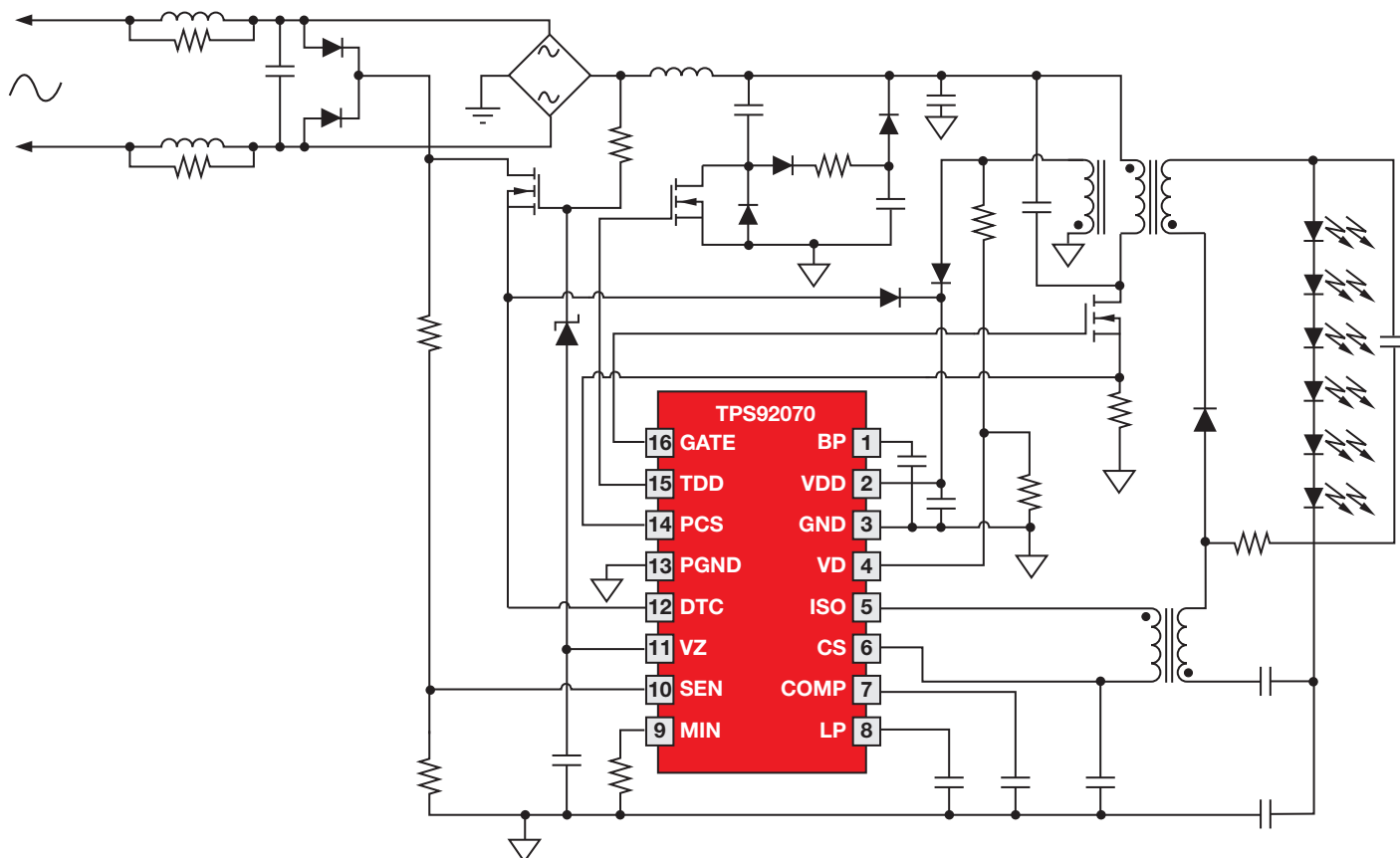
TPS40211EVM

Description

The TPS40211EVM-352 evaluation module (EVM) is a fixed frequency, (300 kHz), non-synchronous boost converter providing fixed 700-mA output at 20 V to 35 V from a 8-V to 18-V input source. The EVM is designed to start up from a single supply, so no additional bias voltage is required for start-up. The module uses the TPS40211 Non-Synchronous Current Mode Control Boost Controller with integral N-channel FET driver.

TPS40211EVM-352 is designed to use a loosely regulated 12-V (8 V to 18 V) source to produce a regulated current driver at 700 mV for constant current loads such as high-brightness LEDs. TPS40211EVM-352 is designed to demonstrate the TPS40211 in a typical LED Driver for 6 to 10 LEDs while providing a number of test points to evaluate the performance of the TPS40211 in a given application. The EVM can be modified to other input voltages or output currents by changing some of the components.

Web Links

www.ti.com/tool/**TPS40211evm-352**
www.ti.com/product/**TPS40211**
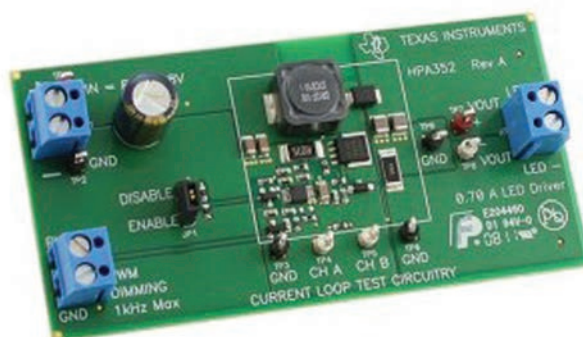
Description	Parts	V_{IN} Range		V_{OUT} (DC) Range		Number of LEDs	I_{OUT} (max)	P_{OUT} (max)	Eff.	PFC	ISO	Dimming In	Dimming Out
TPS40211EVM-352	TPS40211	8	18	20	35	6 to 10	700 mA	25 W	94%	No	No	PWM	PWM

For more reference designs, see: www.ti.com/powerreferencedesigns

→ *TMS320C2000™ PLC Modem Evaluation Kit*

TMDSPLCKIT-V1

Power-line communication (PLC) is an inexpensive way to add lighting control to existing or new buildings and infrastructures without laying down new control cabling. The TMDSPLCKIT-V1 is a PLC evaluation kit based on the C2000™ series of real-time microcontrollers. It operates in both OFDM and S-FSK modulation schemes and has data rates of up to 76.8 kbps.

The kit comes with an easy-to-use GUI that makes testing the communications link intuitive and simple.

Specifications
- OFDM and S-FSK modulation schemes
- Data rates of up to 76.8 kbps for one phase (phase selection is provided)
- PLC system on module (SoM) with interface to host controller (I^{2}C, SPI, SCI)
- Compatible with CENELEC EN50065 and IEC 6100-3 standards
- Operating frequency range: 24 to 94.5 kHz CENELEC A band. B band to release in 1Q10.
- Universal AC-voltage input (85 to 270 V$_{AC}$)

Web Links
www.ti.com/**plcevm**

Datasheets, user's guides, samples:
www.ti.com/product/**OPA564** or
www.ti.com/product/**PGA112**

TMDSPLCKIT-V1 Block Diagram
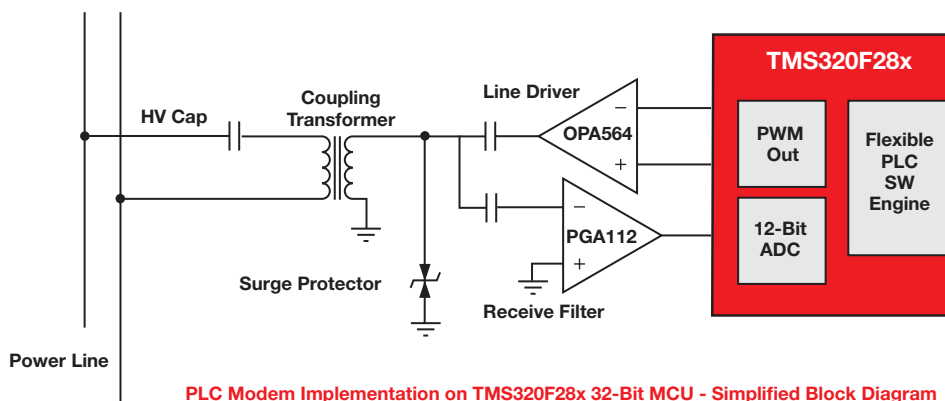
PLC Modem Implementation on TMS320F28x 32-Bit MCU - Simplified Block Diagram

For more reference designs, see: www.ti.com/powerreferencedesigns

TMS320C2000™ PLC Modem Evaluation Kit

PLC Data Signal
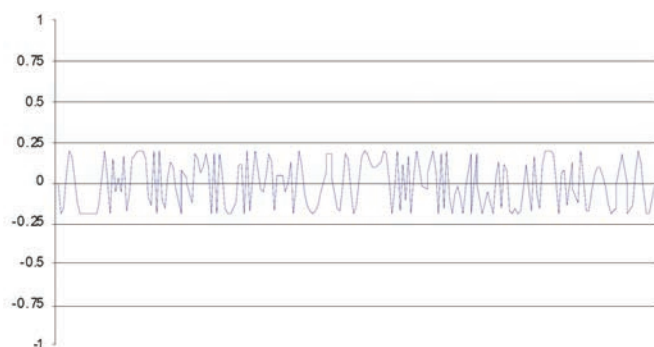
50- or 60-Hz Power Line
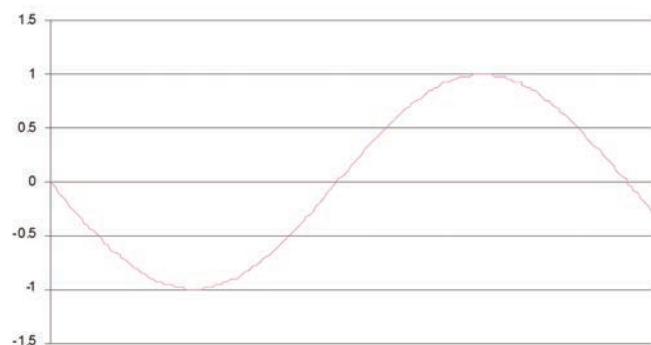
PLC Signal Modulated Onto the Power Line 50/60 Hz
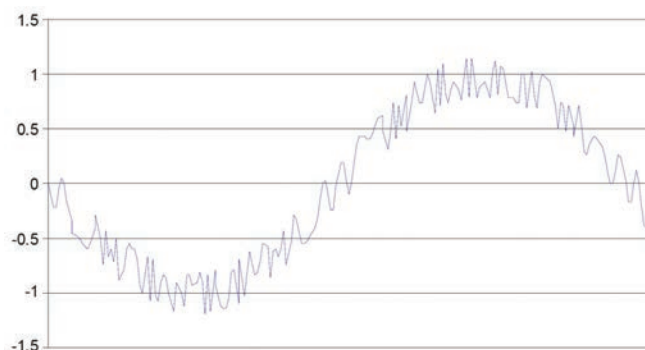
For more reference designs, see: www.ti.com/powerreferencedesigns

→ *Digital Addressable Lighting Interface (DALI)*

DALI Implementation with the MSP430™ MCU

Intelligent lighting control can provide large efficiency gains and energy savings. The digital addressable lighting interface (DALI) standard is becoming increasingly popular for this application.

The DALI evaluation kit enables the designer to run DALI on the popular MSP430 series of microcontrollers. Software libraries and hardware reference files are provided to allow quick evaluation and development with the DALI standard.

Specifications
• Full hardware reference files, including schematics, Gerber files and BOM
• Full software libraries
• Support for the entire DALI command set, including bidirectional commands

Web Links
Application Note:
www.ti.com/lit/**SLAA422**

MSP430-Based DALI Reference Design

For more reference designs, see: www.ti.com/powerreferencedesigns

Wireless-Controlled Triple LED Driver

TPS62260LED

Residential and commercial lighting can take advantage of the additive color mixing of red, green and blue LEDs. This reference design demonstrates how to remotely manage the color output of an LED lamp with a low-power wireless controller. The color is generated by three LEDs (red, green and blue). An MSP430™ ultra-low-power microcontroller controls the brightness of each LED with constant current generated by three TPS62260 buck converters, one for each LED.

The color look-up table takes the form of an array stored in the MSP430. Whenever the rotary encoder is turned, new red, green and blue values are read from the array and used to generate the three PWM output signals. Currently 252 values are stored, which can be changed if desired. A decimal value of 100 switches the LED off, and a value of 65535 produces a mark-space ratio of 100%. When the 5-V supply is applied, the design goes into a demonstration mode where the values stored in the array are read and output in sequence in an infinite loop. As soon as the rotary encoder is turned, the sequence stops and a particular fixed color value can be selected.

There is a pin header that can be used to plug in the RF board from the MSP430 Wireless Development Tool (the eZ430-RF2500), which is separately available. With this additional module, the lamp's colors can be controlled remotely via the wireless RF interface.

If a designer prefers to reprogram the MSP430, a separate MSP430 flash emulation tool can be ordered, such as the MSP-FET430UIF. More information on the eZ430-RF2500 and MSP-FET430UIF tools can be found respectively at:

http://**focus.ti.com/docs/toolsw/ folders/print/ez430-rf2500.html** and http://**focus.ti.com/docs/toolsw/ folders/print/msp-fet430uif.html**

Key Features
- Wireless RGB color mixing
- Ultra-low-power MSP430 controller
- Wireless development tool available

Web Links
Datasheets, user's guides, samples:
www.ti.com/product/**TPS62260**

EVM:
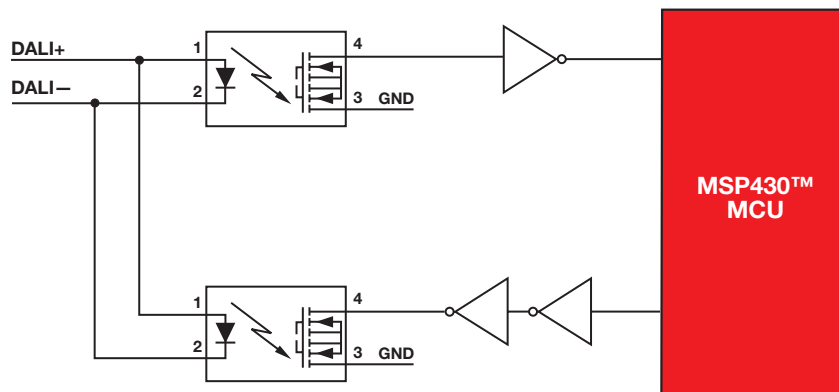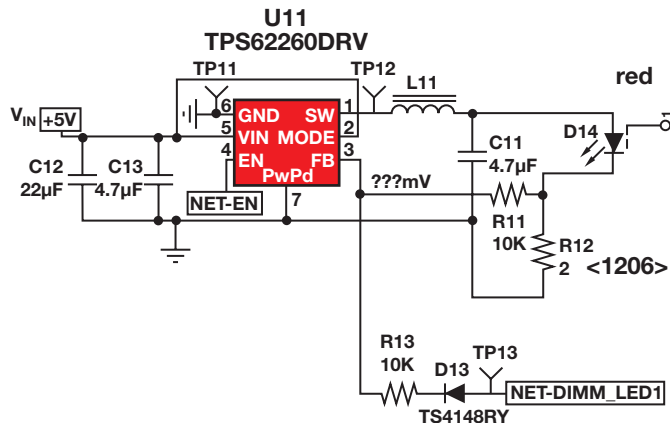www.ti.com/**tps62260led-338**

Design Specifications

Parameter	Minimum	Typical	Maximum	Unit
Input voltage	4.5	5	5.5	V_{DC}
Output current	—	0.300	—	Amp

TPS62260LED-338 Schematic

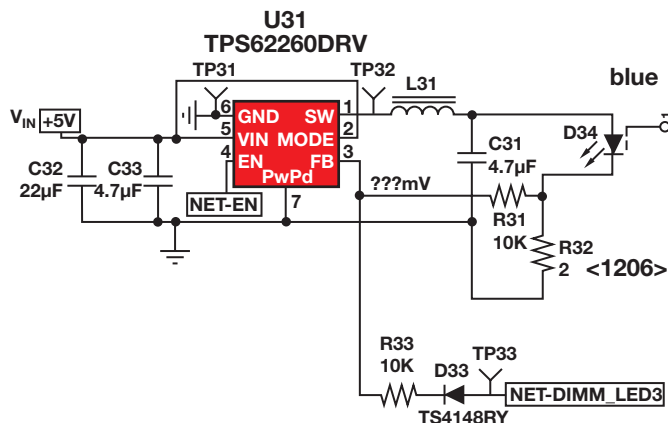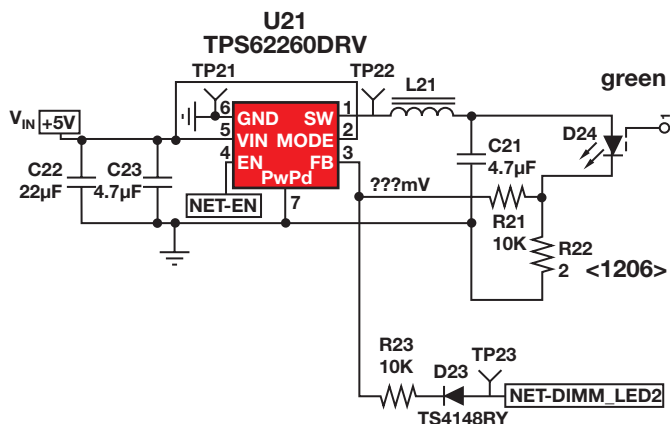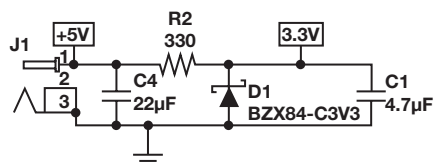For more reference designs, see: www.ti.com/powerreferencedesigns

➔   *Wireless-Controlled Triple LED Driver*

Red LED   **Blue LED**

Green LED

For more reference designs, see: www.ti.com/powerreferencedesigns

NEW!

Multi-DC/DC Color LED Kit

TMDSRGBLEDKIT

The Multi-DC/DC Color LED Kit includes all of the hardware and software to start experimenting and developing a digitally controlled multi-DC/DC LED lighting system. This kit is based on the Piccolo microcontroller and the controlCARD development platform. One Piccolo MCU is able to directly control eight separate DC/DC power stages as well as up to eight LED strings of various LED types and string lengths. The development board takes 12 to 24 $_{VDC}$ input and employs six Boost and two SEPIC DC/DC power stage topologies to drive LED strings. The six separate Boost stages drive two RGB LED strings,

controlling the red, green, and blue color components of each RGB LED string. The two SEPIC stages drive two white LED strings. Alternatively, up to eight separate white LED strings could be driven via the eight separate power stages. An included graphical user interface allows users to quickly begin the evaluation process by providing simplified control to adjust power stage current levels for experimentation with brightness and color mixing. Furthermore, through controlSUITE™, the kit includes closed loop, open source software examples for the control of the DC/DC power stages and LED lighting stages. The kit hardware is also completely open

source, with the gerbers, schematics, and BOMs all available for free. For more information, please see the quick start guide for the kit.
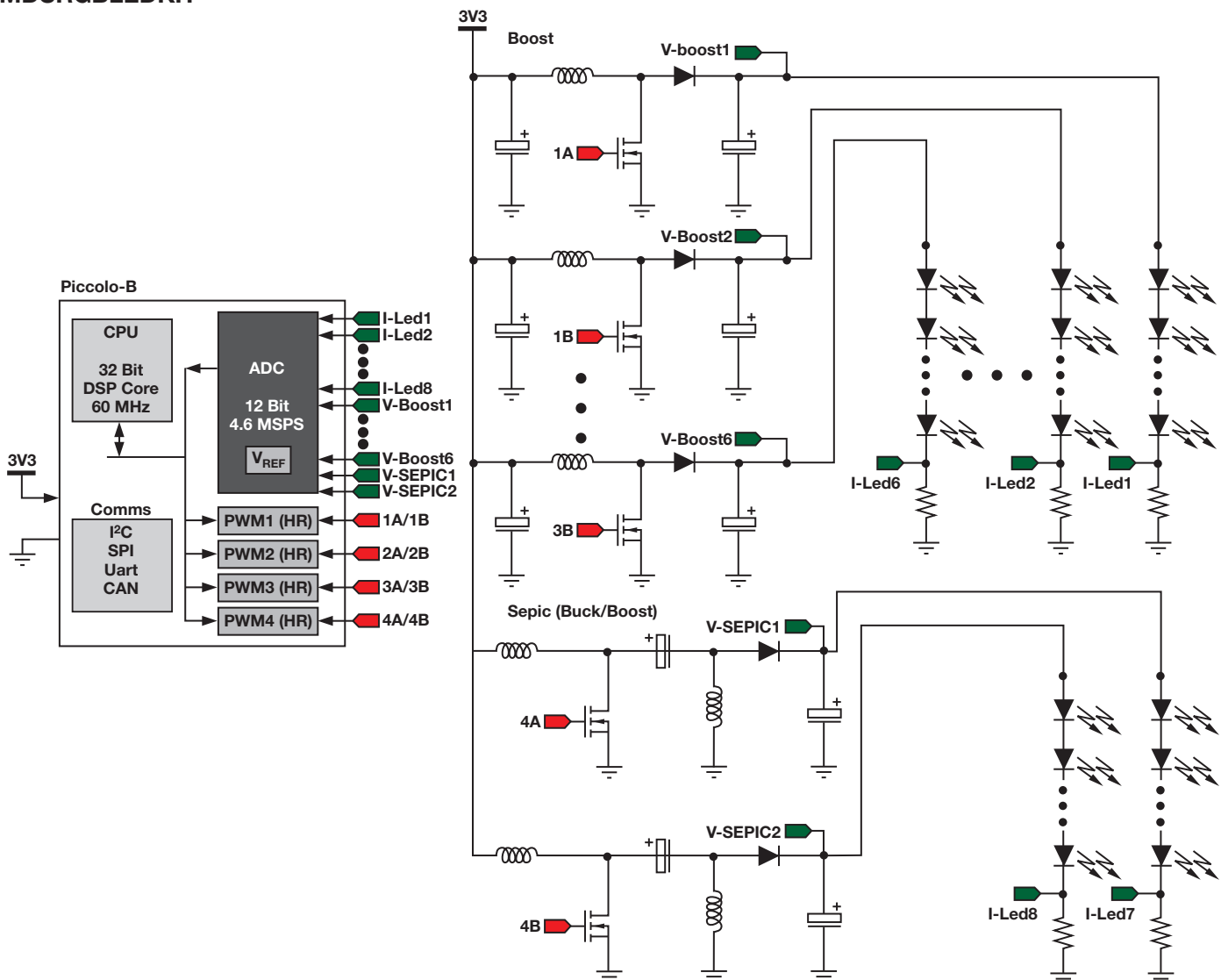
Key Features
• Input voltage: 12 to 24 V
• Output voltage:
• Six boost stages: 24 to 50 V
• Two SEPIC stages: 6 to 50 V
• Output current: 400 mA, ±0.5% (higher currents available by changing external MOSFET)
• Digital power with Piccolo™ real-time MCU

Web Links
www.ti.com/tool/**TMDSRGBLEDKIT**

TMDSRGBLEDKIT

→ *AC Input Multi-String Lighting Kit with Power-Line Communications* NEW!

TMDSIACLEDCOMKIT

The AC input multi-string lighting kit accepts universal AC input and can control up to six LED strings. The AC input is converted to DC and then an onboard MCU converts this DC voltage to the string voltage through an isolated LLC DC/DC. The string voltage is adjust-able to make it easy to use one design to cover many different requirements for string lengths, types of LEDs and number of strings. LEDs can be dimmed either through PWM to keep constant color or through the adjusting string voltage. In addition, it is a communica-tions/control platform and has power line communications, DALI, DMX-512 and low power RF lighting control.

Key Features

- Input voltage: 85 to 277 V_{AC}
- Output: 200 W, six independently dimmable strings, 28 to 36 V, 1.25 A per string
- Communications supported: Power line communications, DALI, DMX-512, low power RF
- Digital power with Piccolo real-time MCU
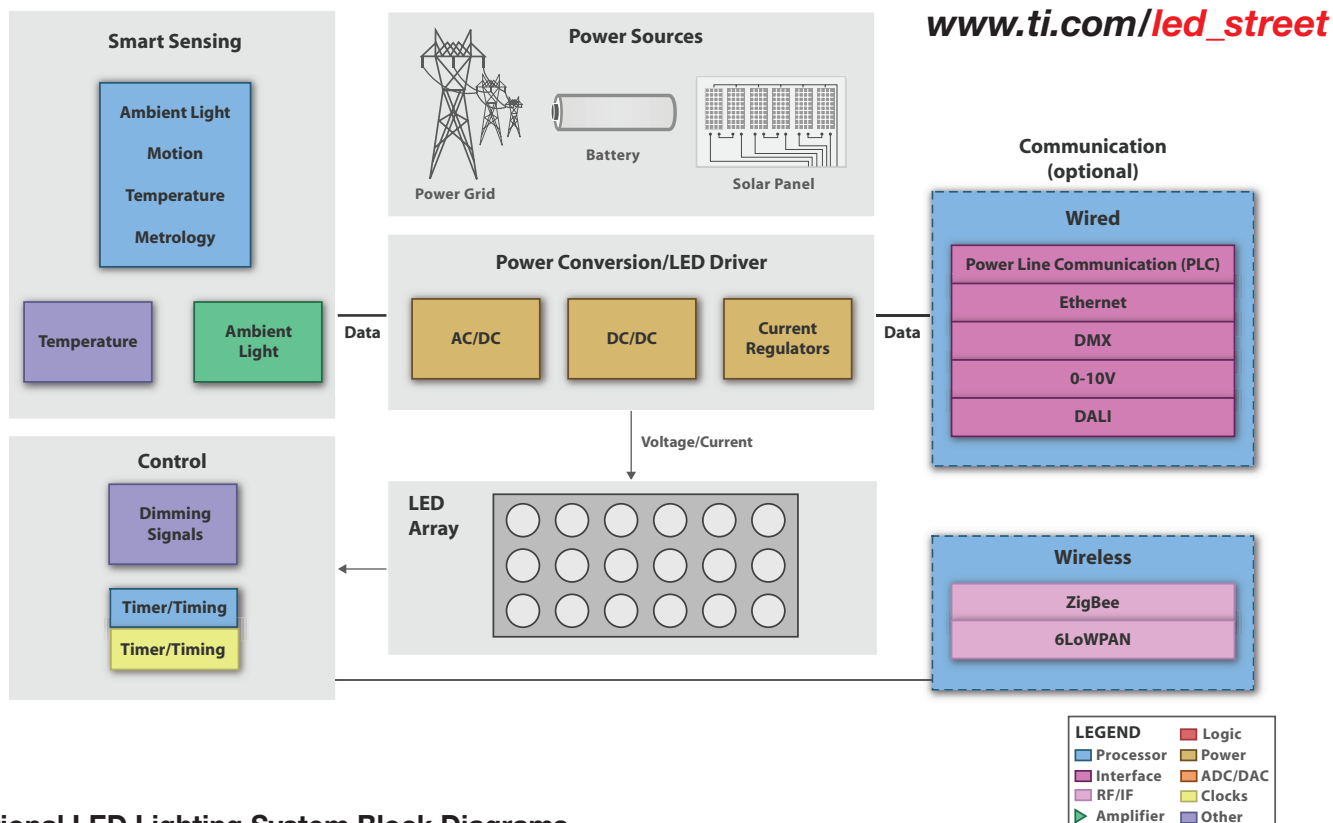
TMDSIACLEDCOMKIT
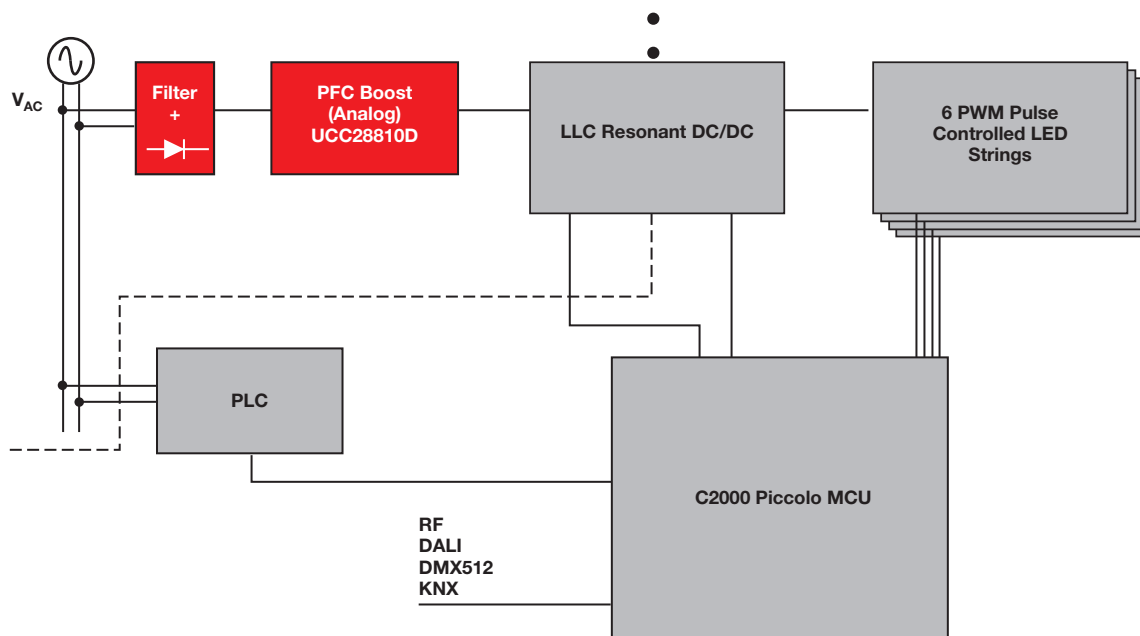
For more reference designs, see: www.ti.com/powerreferencedesigns

Streetlight/AreaLight/HighBay/MidBay

TI's system block diagrams provide comprehensive technical resources for the development of LED Lighting application and end equipment solutions. Find block diagrams, application notes, tools and software and other related information.

www.ti.com/led_street

Smart Sensing

- Ambient Light
- Motion
- Temperature
- Metrology

Temperature

Ambient Light

Power Sources

Power Grid

Battery

Solar Panel

Communication (optional)

Wired
- Power Line Communication (PLC)
- Ethernet
- DMX
- 0-10V
- DALI

Power Conversion/LED Driver

Data

AC/DC

DC/DC

Current Regulators

Data

Voltage/Current

Control

Dimming Signals

Timer/Timing

Timer/Timing

LED Array

Wireless
- ZigBee
- 6LoWPAN

LEGEND

Processor	Logic
Interface	Power
RF/IF	ADC/DAC
Amplifier	Clocks
	Other

Additional LED Lighting System Block Diagrams

Architectural Lighting	www.ti.com/**led_arch**
Bulb Replacement	www.ti.com/**led_bulb**
Down Light/Low Bay	www.ti.com/**led_downlight**
General	www.ti.com/**led_gen**
Multi String LED Driver	www.ti.com/**led_multistring**

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DLP® Products	www.dlp.com	Energy and Lighting	www.ti.com/energy
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