



LED Lighting Solutions

TI LPP



LPP is Focused on Three Primary Markets and Multiple Secondary Markets

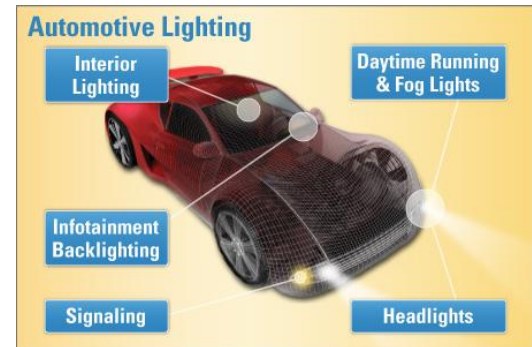
LED Bulb



Outdoor Area



Automotive

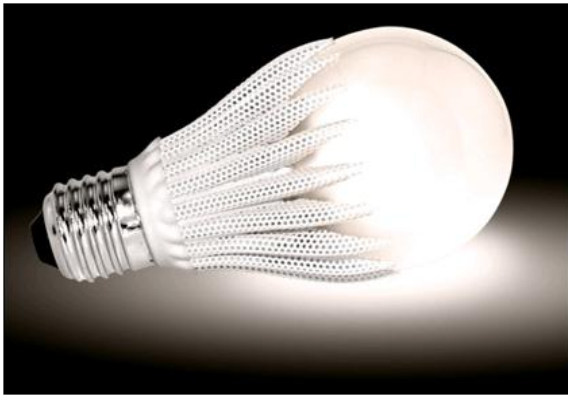


Secondary Focus

- Architectural
 - Wall washer,
 - Spot light, etc.
- Projection
 - Portable
 - Desktop

Lighting Market Evolution

Phase 1 (Now)



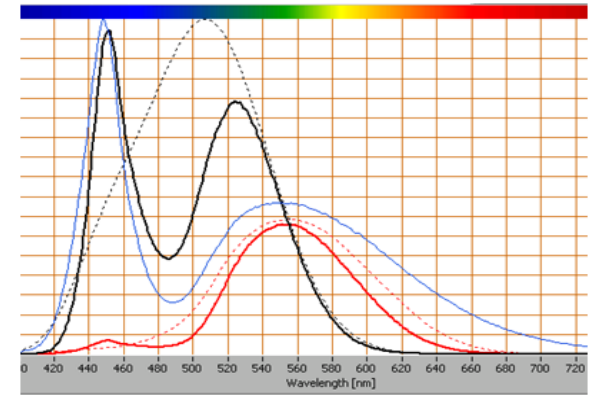
- Retrofit
- Raw Efficacy
- Lowest Cost
- Lifetime / Reliability

Phase 2 (1 – 5 Years)



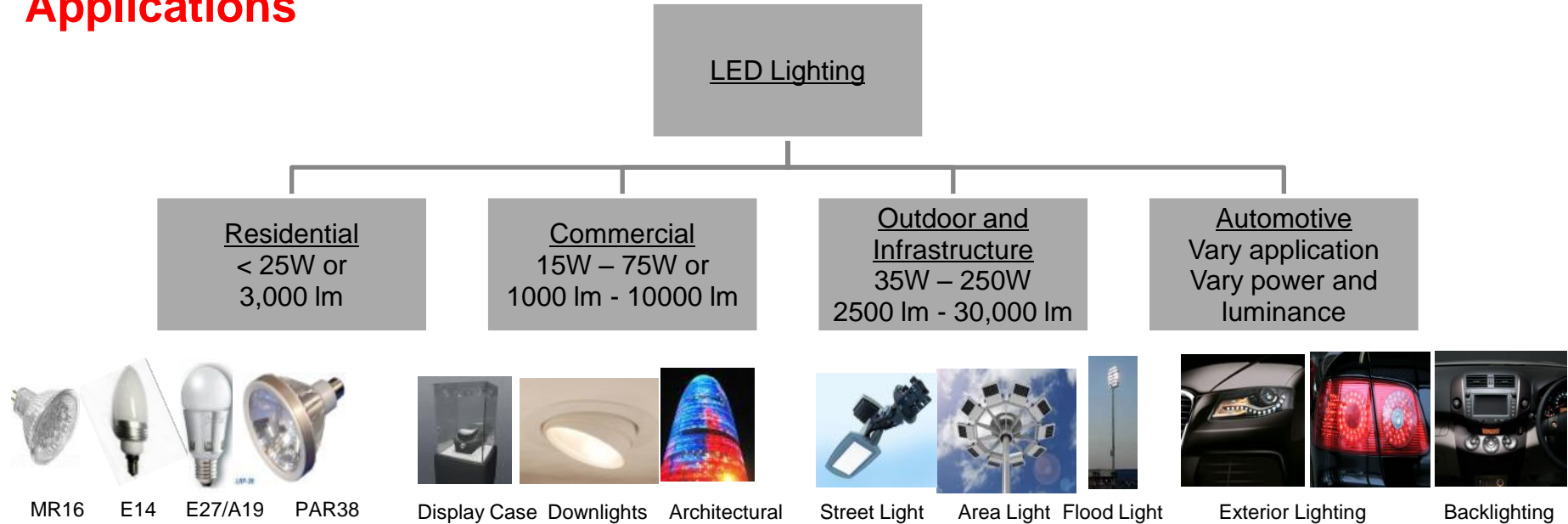
- Sensing & Detection
- Intelligence
- Communications
- Controls

Phase 3 (3 – 8 Years)



- Color / CCT Control
- Spectrum Shaping
- Ultra-Efficiency
- >50 Year Lifetime

LED General Illumination Applications



Low Cost, TRIAC Dimming, PFC, High Efficiency, Color Quality, Safety, Long Life

PFC, High Efficiency, Dimming, Early Payback, Color Quality, Safety, Maintenance, Eco-friendly

PFC, High Efficiency, Early Payback, High Brightness, Safety, Maintenance, Eco-friendly

High Efficiency, Safety, extreme stability and quantity

Driver Topologies
Buck, Boost, Buck Boost, SEPIC Single Stage Flyback

Driver Topologies
Buck, Boost, Buck Boost, SEPIC Single stage Flyback

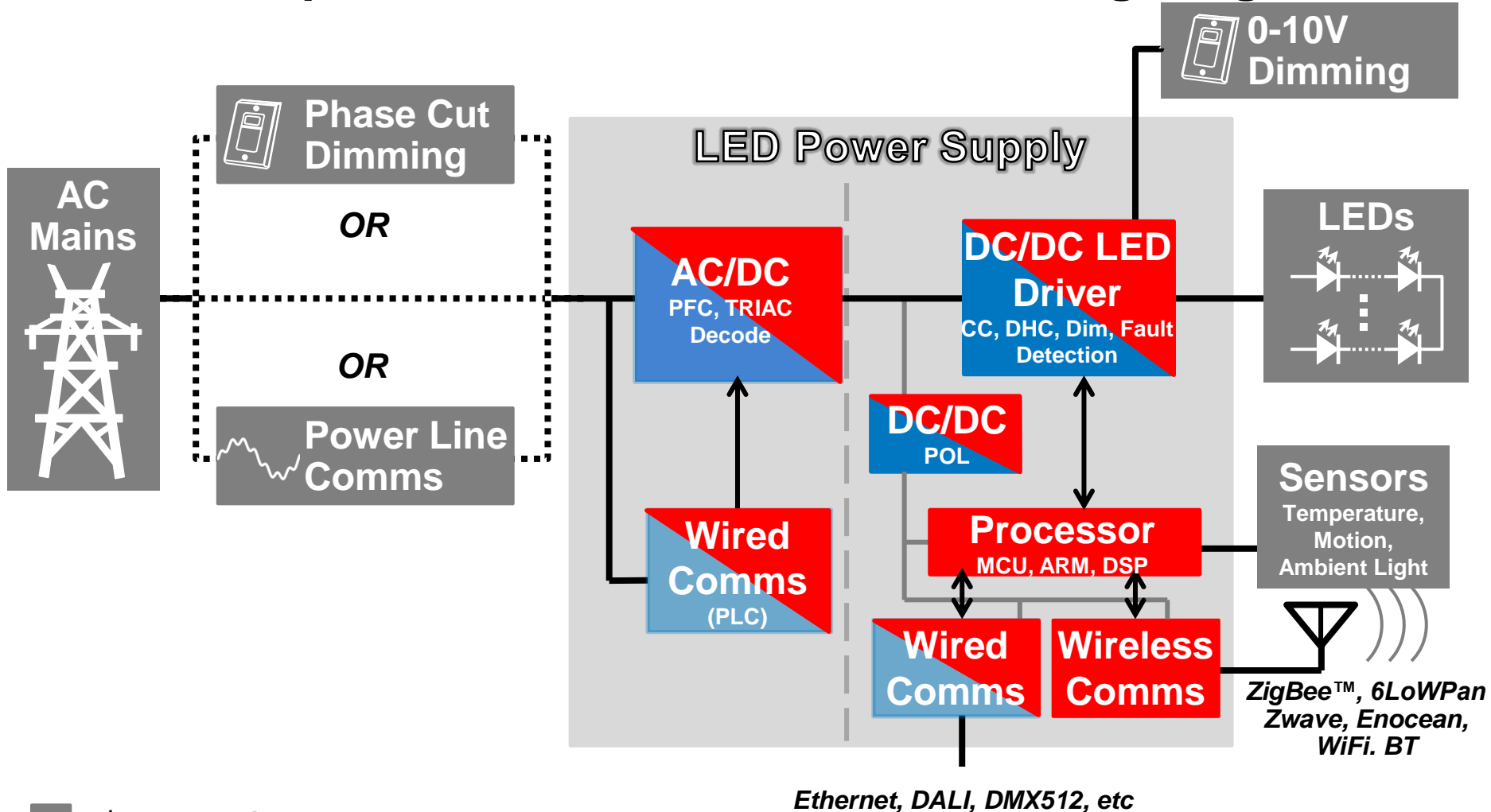
Driver Topologies
PFC Boost, Flyback Half-Bridge, Buck, Multi-string LLC

Driver Topologies
Buck, Boost, Bulk-Boost SEPIC

Solid State Lighting Product Synergy

National Semiconductor and Texas Instruments

Complete Product Portfolio for LED Lighting



3rd party solution

TI Lighting Power Products at a Glance

Light Bulbs & Low Power Luminaires

B10, GU10, A19, PAR20-38

- LM3445/8
- TPS92070
- LM3444
- LM3447(developing)
- TPS92001/2
- TPS92310
- TPS92010
- TPS92210

AC-DC Dimmable



AC-DC Front End



Buck Converters

Boost Converters

Boost + Linear Controllers

High Power Wide Area Luminaires

Street Light, High Bay, Parking, Pathway, Troffers

- UCC28810/1
- TPS92020
- TPS92210
- LM3450A
- LM3401/9
- LM3433/34
- LM3402/4/5/5A/6/7
- LM3414
- LM3430/31
- LM3410
- LM3421/3/4/9
- TPS40211
- LM3432
- LM3492
- LM3464
- LM3466



Automotive

Exterior, Interior & Infotainment backlighting

- LM3424Q
- LM3421Q/23Q/29Q
- LM3409Q
- LM3410Q
- LM3431Q



MR16, AR111

- LM3401
- LM3444
- LM3492
- TPS40211

Architectural, Wall Washers, Sconces, Downlights

- LM3450A
- TPS92070
- TPS92210



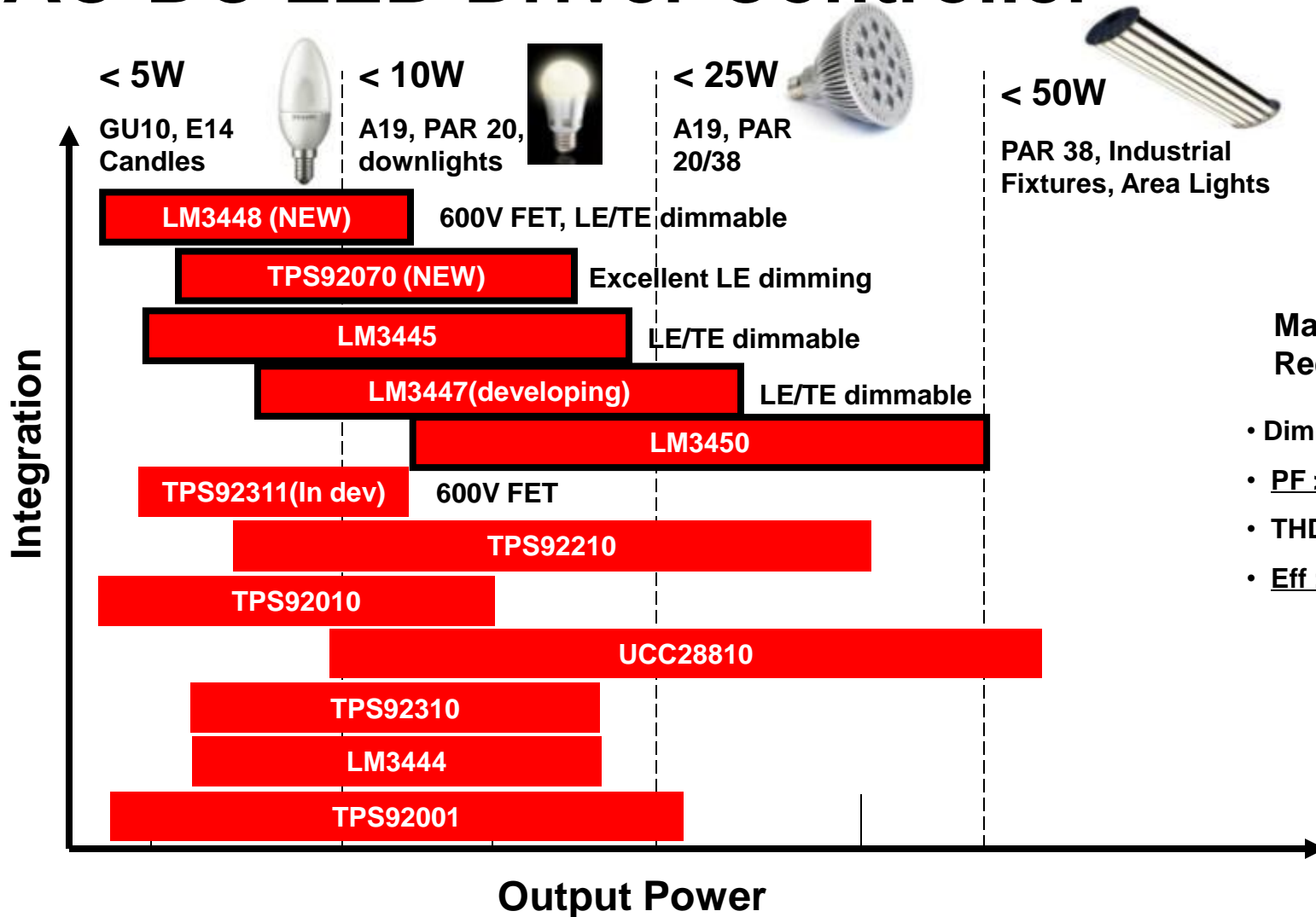
Buck Controllers

Boost Controllers

Multi-topology controllers

Linear

AC-DC LED Driver Controller



Market Base Requirements

- Dimming, dissipative
- PF > 80 %
- THD < 40%
- Eff > 65%

Integrated Dimmer Detection

Product Summary (14 ICs)

Device	Description	Type	Applications	Output Power	PFC
TPS92070 <i>(NEW)</i>	Dimmable AC/DC LED Lighting Driver Controller	AC/DC	<ul style="list-style-type: none"> •Retrofit Bulbs •Luminaire 	3-12W	>0.7
UCC25710 <i>(New)</i>	LLC Half-Bridge Controller	AC/DC	<ul style="list-style-type: none"> •LCD TV Backlighting •LED General Lighting 	30-150W	NA
TPS92310 (LM3440)	Single stage PFC LED Driver Controller	AC/DC	<ul style="list-style-type: none"> •Retrofit Bulbs •Luminaire 	3-20W	>0.9
LM3447	PSR Triac dimmable AC/DC LED driver	AC/DC	<ul style="list-style-type: none"> •Retrofit Bulbs •Luminaire 	6-20W	>0.9
TPS92311 (LM3441 developing)	Single stage PFC LED Driver Converter	AC/DC	<ul style="list-style-type: none"> •Retrofit Bulbs •Luminaire 	3-8W	>0.9
LM3444/ LM3445	AC/DC LED Driver	AC/DC	<ul style="list-style-type: none"> •Retrofit Bulbs •Luminaire 	3-20W	>0.7
LM3450/50A	AC/DC LED Driver with Active PFC and Phase Dim Decoder	AC/DC	<ul style="list-style-type: none"> •Retrofit Bulbs •Luminaire •Street Lighting 	10-50W	>0.9
TPS92001/2	General Purpose LED Lighting PWM Controller	AC/DC	<ul style="list-style-type: none"> •Retrofit Bulbs •Luminaire 	5-20W	> 0.8
TPS92210	Natural PFC LED Lighting Driver Controller	AC/DC	<ul style="list-style-type: none"> •Retrofit Bulbs •Luminaire 	5-30W	> 0.9
UCC28810/1	LED Lighting Power Controller	AC/DC	<ul style="list-style-type: none"> •Retrofit Bulbs •Luminaire •Street Lighting 	15-100W+	> 0.9

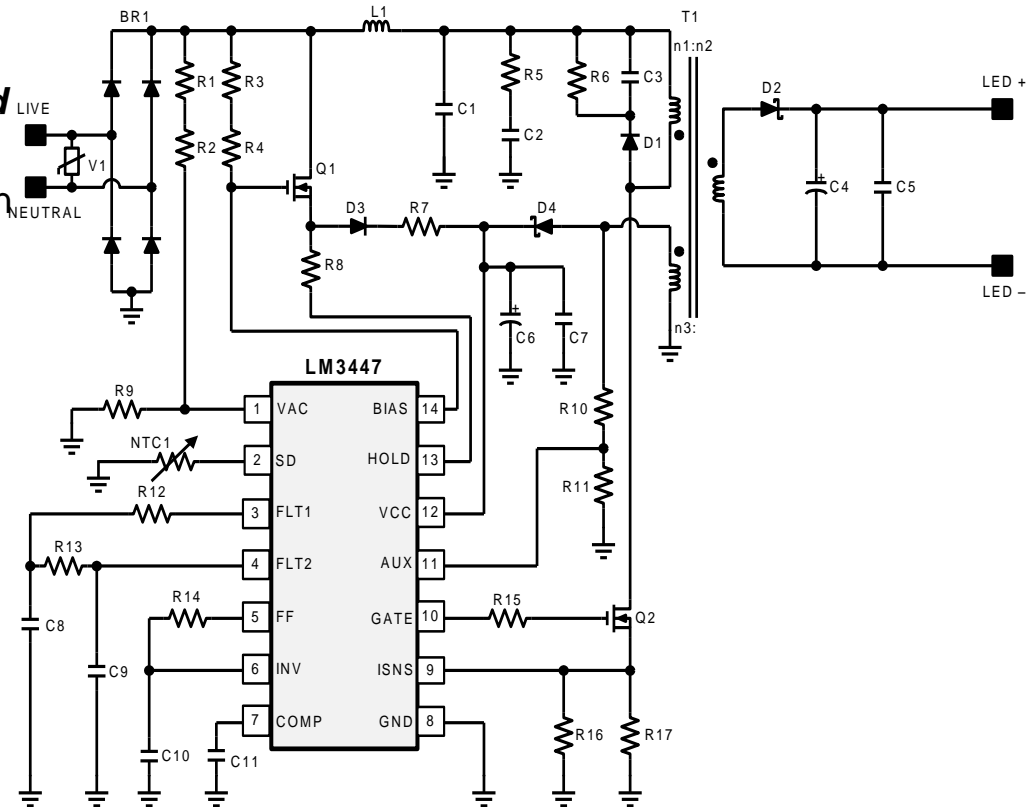
Offline (AC/DC) LED Lighting Solutions

LM3447

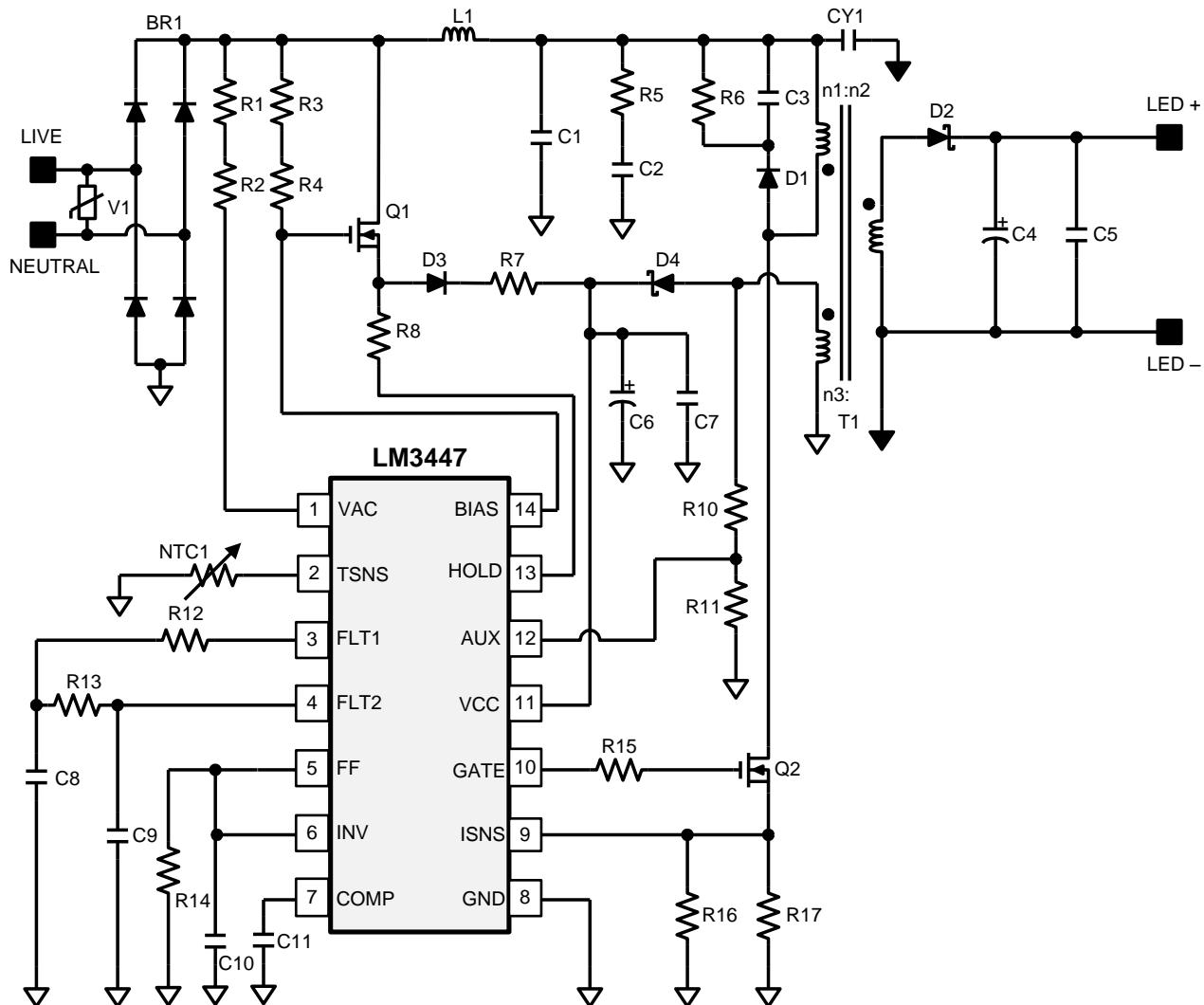
Phase Dimmable, Primary Side Sensing, QR Flyback Controller

Features

- Fixed frequency PWM controller for isolated Flyback topology
- Integrated phase angle decoding circuit
- **Constant power operation mode (based on input voltage feed-forward control)**
- Constant current operation mode (using an opto-isolator based feedback control)
- Output overvoltage protection based on VCC voltage
- Output short circuit protection based on current sense voltage
- Thermal shutdown
- TSSOP-14 package
- SOIC-16 package
- Quasi-Resonant mode operation
- Optional thermal foldback using VADJ
- Intelligent TRIAC hold circuitry enabling accurate zero crossing detection



LM3447 – Typical Application Circuit Constant Power Regulation



TPS92310 / TPS92311

Single stage PFC AC/DC controller for LED application

TPS92310

Single stage PFC AC/DC controller for LED application

Features

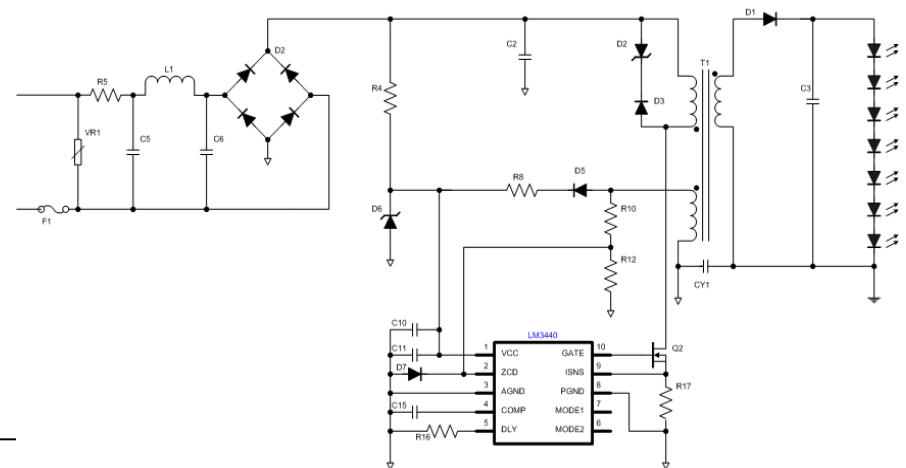
- Flexible Operating Modes: Constant On-Time, Peak Primary Current.
- Primary side current regulation
- Without control loop compensation
- Transformer Zero Energy Detection
- Discontinuous Conduction or Transition Mode Operation
- Advanced Over-Current Protection and Integrated Over-voltage Protection

Applications

- Residential LED Lighting Drivers: A19 (E26/27, E14), PAR30/38, GU10
- Lighting Applications: Light Bulb Replacement, General Lighting and Solid state lighting

Benefits

- Constant On-Time implements Single Stage Power Factor Correction (PFC)
- Without opto-coupler and secondly side regulation
- Design easily
- High Efficiency, Low EMI
- No Reverse Recovery Loss in Output Rectifier
- Protects Driver Against Fault Conditions



TPS92310EVM Specification

TPS92310	EVM-110VAC	EVM-220VAC	
Specification	Value	Value	Unit
Input voltage	85-132	180-264	VAC
LED config	5-7	5-7	series
Output current	350	350	mA
Output power	5-7	5-7	W
Topology	Flyback	Flyback	
Efficiency	85	85	%
Power Factor	>0.9	>0.9	
Current sensing	resistive	resistive	
Isolation	Yes	Yes	
Driver Dimemnsion	55 x 23 x 18	55 x 23 x 18	mm



TPS92310 GU10

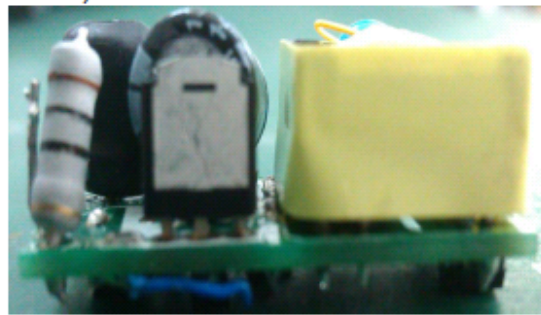
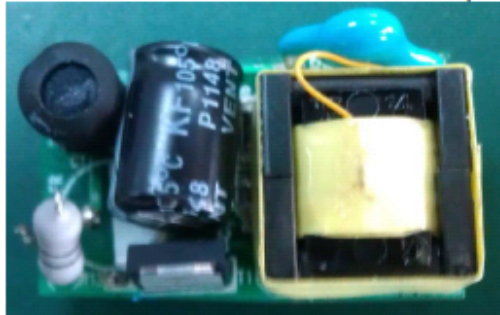


PMP4325: AC/DC LED Driver for GU10

Reference Design	TI Parts	V _{in}	P _o	V _o I _o	Topology	Dimming	Eff.
AC Input GU10 AC/DC LED Lighting Driver	TPS92310	85~277 Vac	4.2W	8V~13V 350mA	Isolated Flyback with primary current sense	no	>77%

Features

- Isolated flyback with primary current
- Low BOM cost
- Efficiency >79% at 230Vac input
- Out short-circuit protection(if need)
- Output over voltage protection: 20Vdc
- Output ripple current: <30% of output current
- Size: 30mmX18mmx10mm (ultra-slim)



Applications

- GU10 LED lighting
- Wall-wash LED lighting
- Commercial LED lighting



PMP4330: AC/DC LED Driver for T8 _China Power Reference design

Reference Design	TI Parts	V_{in}	P_o	V_o I_o	Topology	# of LED	Dimming	Eff.
<u>AC Input T8 AC/DC LED Lighting Driver</u>	TPS92310	85~265 Vac	18W	38V~42V 420mA	Isolated Flyback with Primary Side Regulator	12	no	89.2% At 230Vac

Features

- **Isolated Flyback with Primary Side Control**
- **Low total BOM cost**
- **Efficiency >89% at 230Vac input**
- **Output Short Circuit Protection**
- **Output Over Voltage/Open protection**
- **Output ripple current: <50% of output current**
- **Size: 256mmx17.6mmx11mm**

Applications

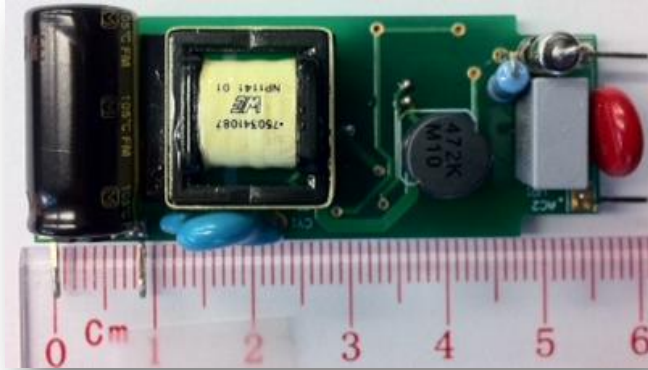
- **T8 tube LED lighting**



TPS92311EVM Specification

To be RTM in Mar 2012

TPS92311	EVM-110VAC	EVM-220VAC	
Specification	Value	Value	Unit
Input voltage	85-132	180-264	VAC
LED config	5-7	5-7	series
Output current	350	350	mA
Output power	5-7	5-7	W
Topology	Flyback	Flyback, CRM	
Efficiency	85	85	%
Power Factor	>0.9	>0.9	
Current sensing	resistive	resistive	
Isolation	Yes	Yes	
Driver Dimemnsion	55 x 23 x 18	55 x 23 x 18	mm



LM3445

TRIAC Dimmable Offline LED Driver

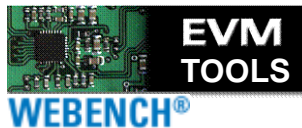


Features

- TRIAC Dimming Decoder for LED Dimming
- Master/Slave Operation
- Application Voltage Range (80-277Vac)
- Controls LED Currents of Greater than 1A
- Adjustable Switching Frequency
- Adaptive, Programmable Off-Time Control
- Thermal Shutdown, UVLO, Current Limit

Applications

- Dimmable Residential LED Lighting Drivers: A19 (E26/27, E14), PAR30/38, GU10
- Lighting Applications: Light Bulb Replacement, Wall Sconces, Wall Washers, Architectural and Display Lighting, Commercial Troffers and Downlights

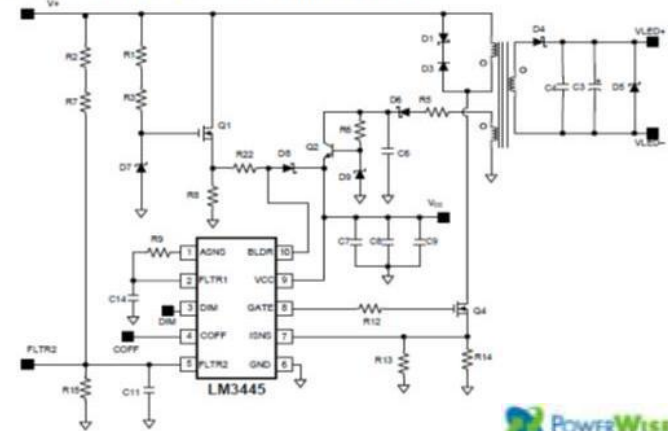


- LM3445-120VFLBK/NOPB (120V)
- LM3445-120VSMEV/NOPB (120V)
- LM3445-208277EV/NOPB (220-277V)
- LM3445-230VFLBK/NOPB (230V)
- LM3445-EDSNEV/NOPB(120V)

Benefits

- Integrated TRIAC Detection Reduces Component Count and Solution Size
- Single TRIAC Controls Multiple Strings with Consistent Dimming Performance
- Supports Residential and Commercial LED Lighting Applications
- Supports a Wide Variety of LED Configurations
- Stable Operation Over Varying Input Line Conditions
- Allows for Constant Output Ripple Current with no 120Hz Flicker
- Protects Against Faults and Abnormal Operating Conditions

LM3445 8W Isolated Evaluation Board Schematic



LM3445EVM Specifications

LM3445	LM3445-120VFLB	LM3445-230FLBK	LM3445-120SMEV	LM3445-208277EV	
Specification	Value	Value	Value	Value	Unit
Input Voltage	90-135	180-265	90-135	176-305	VAC
LED Configuration	4 - 8	4 - 10	6 - 13	8 - 16	Series
Output Current	364	350	350	500	mA
Output Voltage	13-27	13-27	19-42	25-52	VDC
Output Power	7.3	7.2	9	19	W
Topology	<i>Flyback</i>	<i>Flyback</i>	<i>Buck</i>	<i>Buck</i>	
Efficiency	79	81	84	78	%
Power Factor	0.95	0.93	n/a	n/a	
Dimming Input	<i>TRIAC</i>	<i>TRIAC</i>	<i>TRIAC</i>	<i>TRIAC</i>	
Dimming Level	0-100	0-100	0-100	0-100	%
Current Sensing	<i>Resistive</i>	<i>Resistive</i>	<i>Resistive</i>	<i>Resistive</i>	
Driver Dimensions	<i>tbd</i>	<i>tbd</i>	<i>tbd</i>	<i>tbd</i>	mm



LM3450/A

LED Drivers with Active PFC and Phase Dim Decoder



Features

- Active Power Factor Correction
 - Critical Conduction Mode with Zero Crossing Detection
- PWM Decoded from Forward and Reverse Phase Dimmer to 70:1 ratio using 500Hz PWM
- Easily Supports Multi-String Designs
- Integrated Dynamic Hold Circuitry

Applications

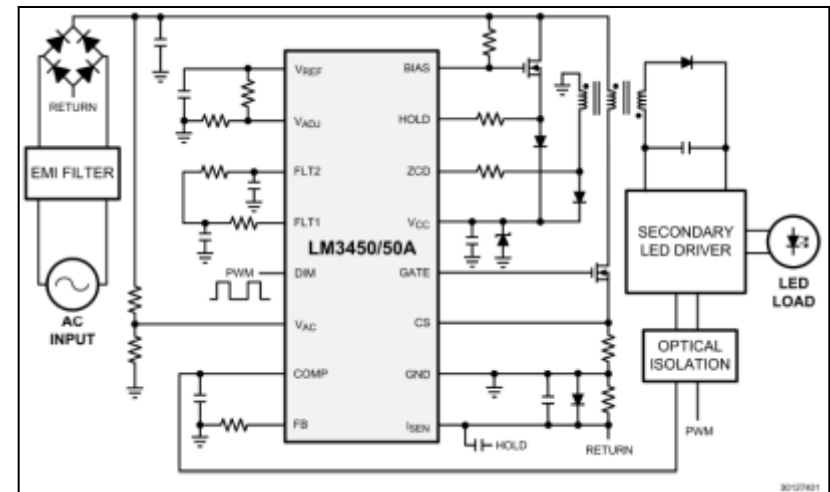
- Dimmable Downlights, Troffers, and Low Bay LED Lights
- Large Form Factor Bulb / Luminaire Designs



- LM3450AEV-120V30/NOPB (120V)
- LM3450AEV-230V30/NOPB (230V)
- LM3450EV120V15W/NOPB (120V)
- LM3450EV230V15W/NOPB (230V)

Benefits

- Achieves Industry Lighting PFC Requirements with Low EMI
- High Dimming Ratio for Lighting with No Visible LED Flicker
- Open-Drain DIM Signal Can Be Used Across Isolation Boundary to Control Light Output Using Multiple LED Driver ICs
- Ensures TRIAC remains in conduction for proper mapping of phase signal.



LM3450EVM Specifications



LM3450	LM3450AEV120V30	LM3450AEV230V30	LM3450EV120V15W	LM3450EV230V15W	
Specification	Value	Value	Value	Value	Unit
Input Voltage	90-135	180-265	90-135	180-265	VAC
LED Configuration	1-13	1-13	1-14	1-14	Series
Output Current	700	700	350	350	mA
Output Voltage	<45	<45	<45	<45	VDC
Output Power	30	30	15	15	W
Topology	<i>Flyback + Buck</i>	<i>Flyback + Buck</i>	<i>Flyback + Buck</i>	<i>Flyback + Buck</i>	
Efficiency	79	77	77	77	%
Power Factor	0.96	0.93	0.96	0.94	
Dimming Input	<i>TRIAC</i>	<i>TRIAC</i>	<i>TRIAC</i>	<i>TRIAC</i>	
Dimming Level	10-100	10-100	10-100	10-100	%
Current Sensing	<i>Resistive</i>	<i>Resistive</i>	<i>Resistive</i>	<i>Resistive</i>	
Driver Dimensions	<i>tbd</i>	<i>tbd</i>	<i>tbd</i>	<i>tbd</i>	mm



UCC25710

LLC Half-Bridge Controller for LED lighting



Features

- Single Stage approach for Multiple LED string Driver with global dimming
- LLC Resonant Half Bridge Topology
- Better than 1% LED string current matching
- PWM LED dimming control
- Programmable Dimming LLC ON/OFF Ramp Feature

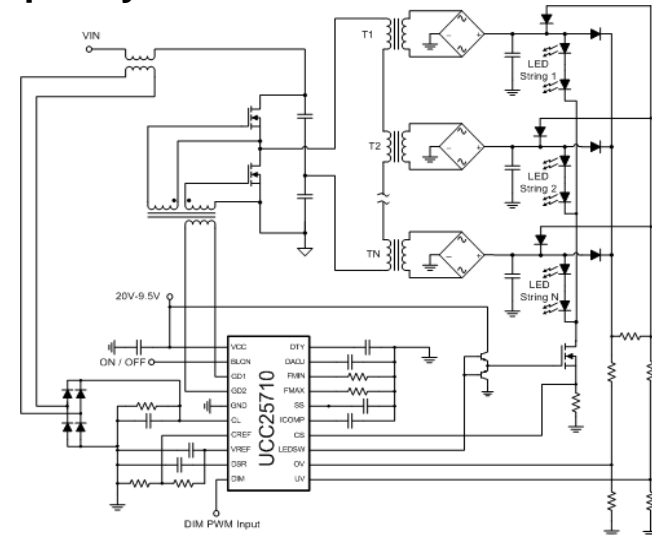
Applications

- LCD TV Backlighting
- Edge Lit LCD TV
- LED lighting
- Street lighting
- LLC Power Supplies

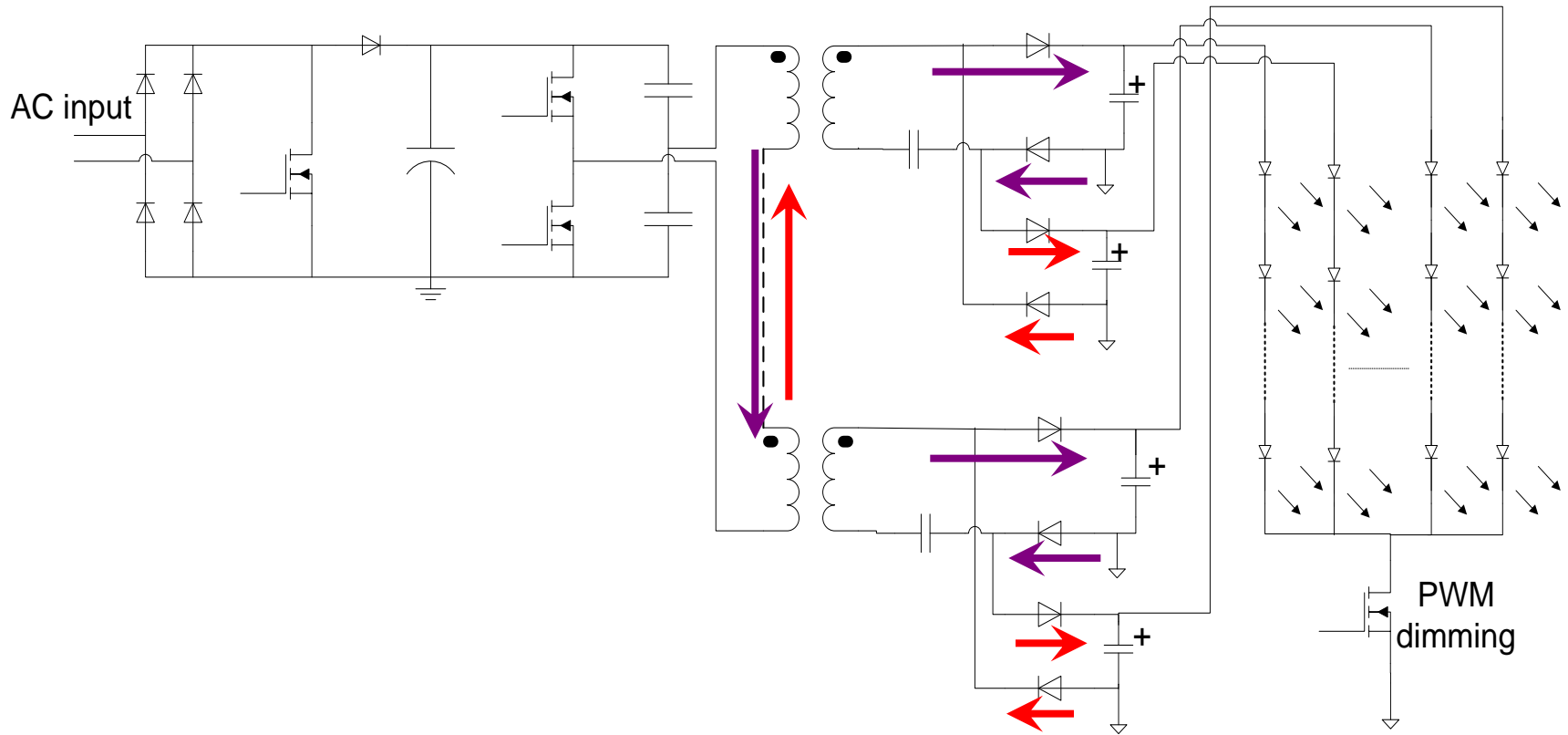


Benefits

- 50% Cost Reduction Compared to Individual Boost Regulator Approach
- 93% Plus Efficiency for Best In Class LED Backlighting Performance
- Provides Uniform Backlighting Providing Exceptional Picture Quality
- Provides Simple interface to System Micro for Intelligent Control
- Eliminates audible noise from PWM dimming frequency



Multi-Transformer Architecture for LED lighting (TI Patented)



One transformer control two LED strings!

PMP4302A: Multi-string LLC AC/DC Driver for general LED lighting

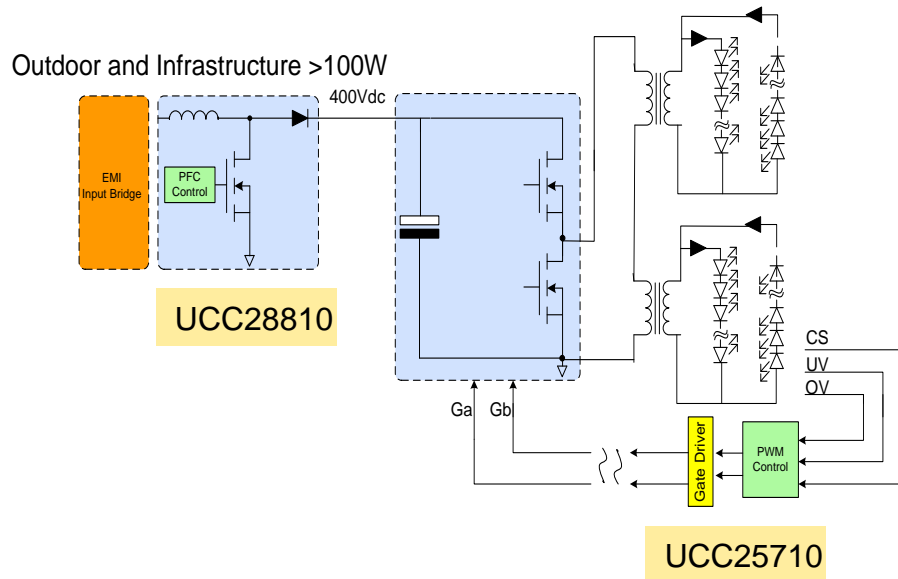
Reference Design	TI Parts	V_{in}	Output	Topology	Eff.	Dimming
PMP4302A: AC input Multi-string LLC converter for general LED lighting	UCC28810 <i>(TM PFC)</i> UCC25710 <i>(Multi-string LLC)</i> UCC28610 <i>(Aux Flyback)</i>	90V~264V	54V@500mA with 4 string	TM PFC+Multi-string LLC converter	92%	PWM dimming with CC2530 daughter board

Features

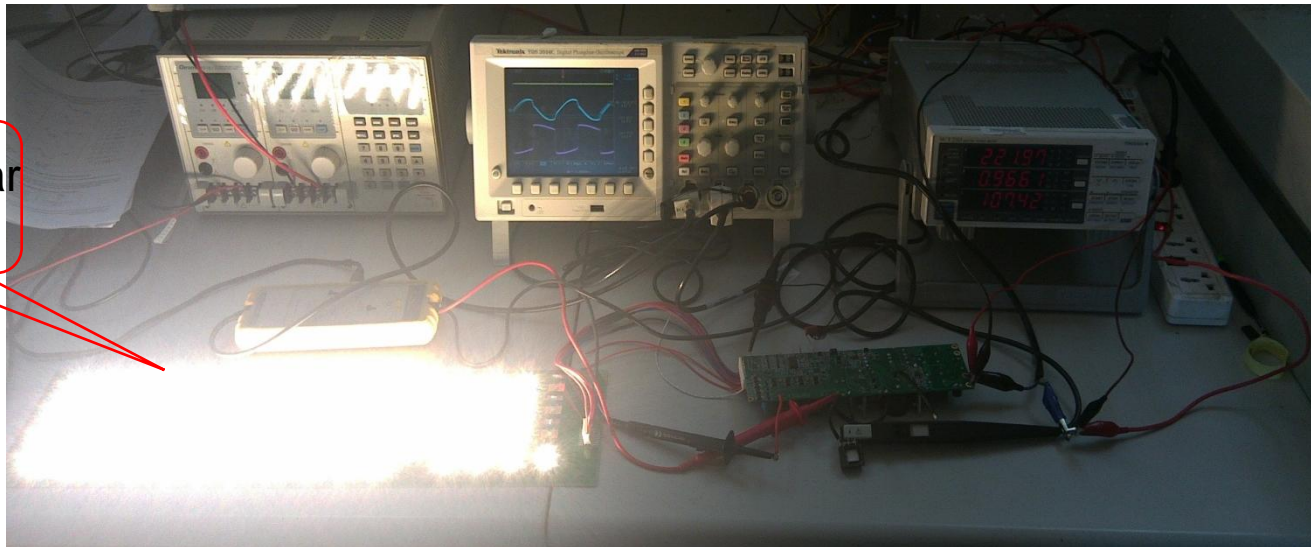
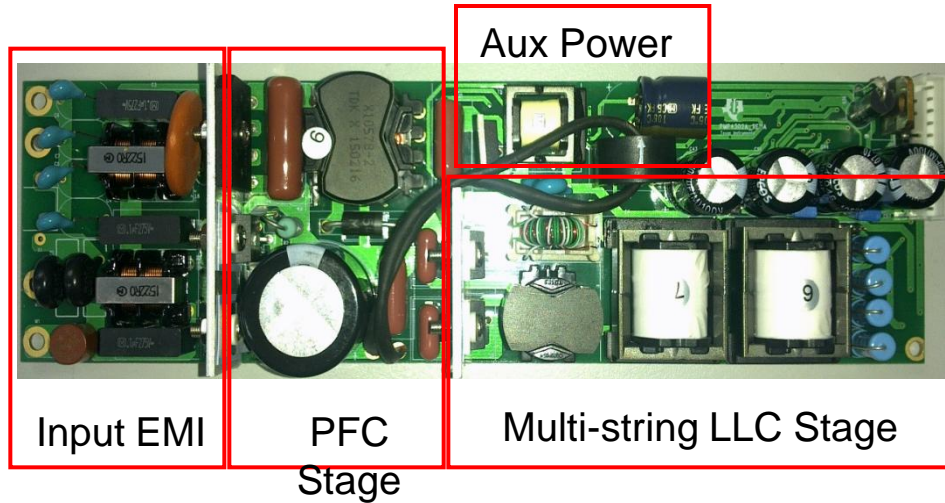
- Lowest cost than AC/DC + DC/DC
- Highest efficiency to 92%
- PWM dimming compatible
- Integrate LED open/short protection and over current protection

Applications

- General LED lighting and LED backlight TV



PMP4302A demo board



PMP4302A: Efficiency (TM PFC + Multi-string LLC + Aux power)



Dimming version

PMP4317: Single-string LLC AC/DC Driver for general LED lighting

Reference Design	TI Parts	V_{in}	Output	Topology	Eff.	Dimming
PMP4317: AC input single-string LLC converter for general LED lighting	UCC28810 <i>(TM PFC)</i> UCC25710 <i>(Multi-string LLC)</i> UCC28610 <i>(Aux Flyback)</i>	90V~2 64V	200V@700mA	TM PFC+single string LLC converter	94.5 %	PWM dimming with CC2530 daughter board Or 0~10V analog dimming

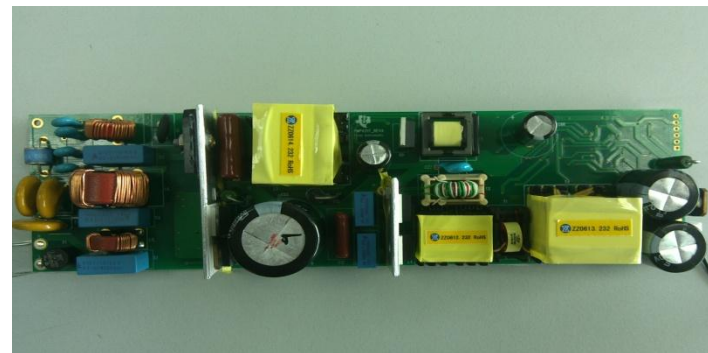
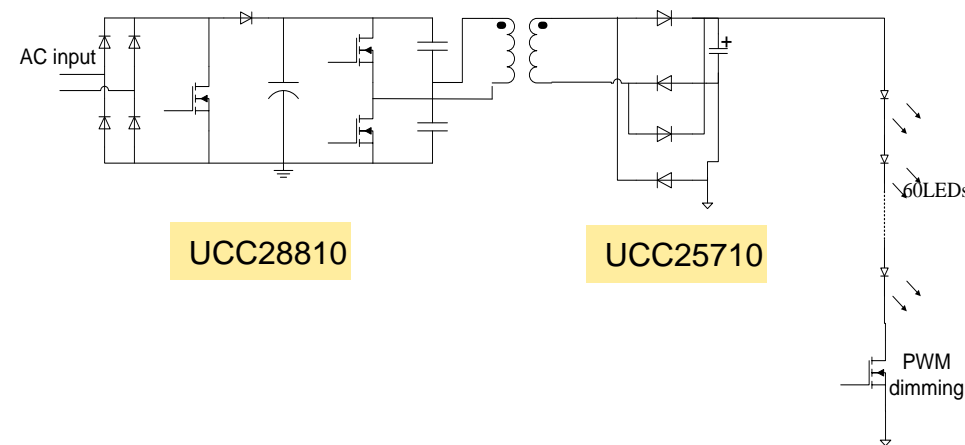
200V/700mA

Features

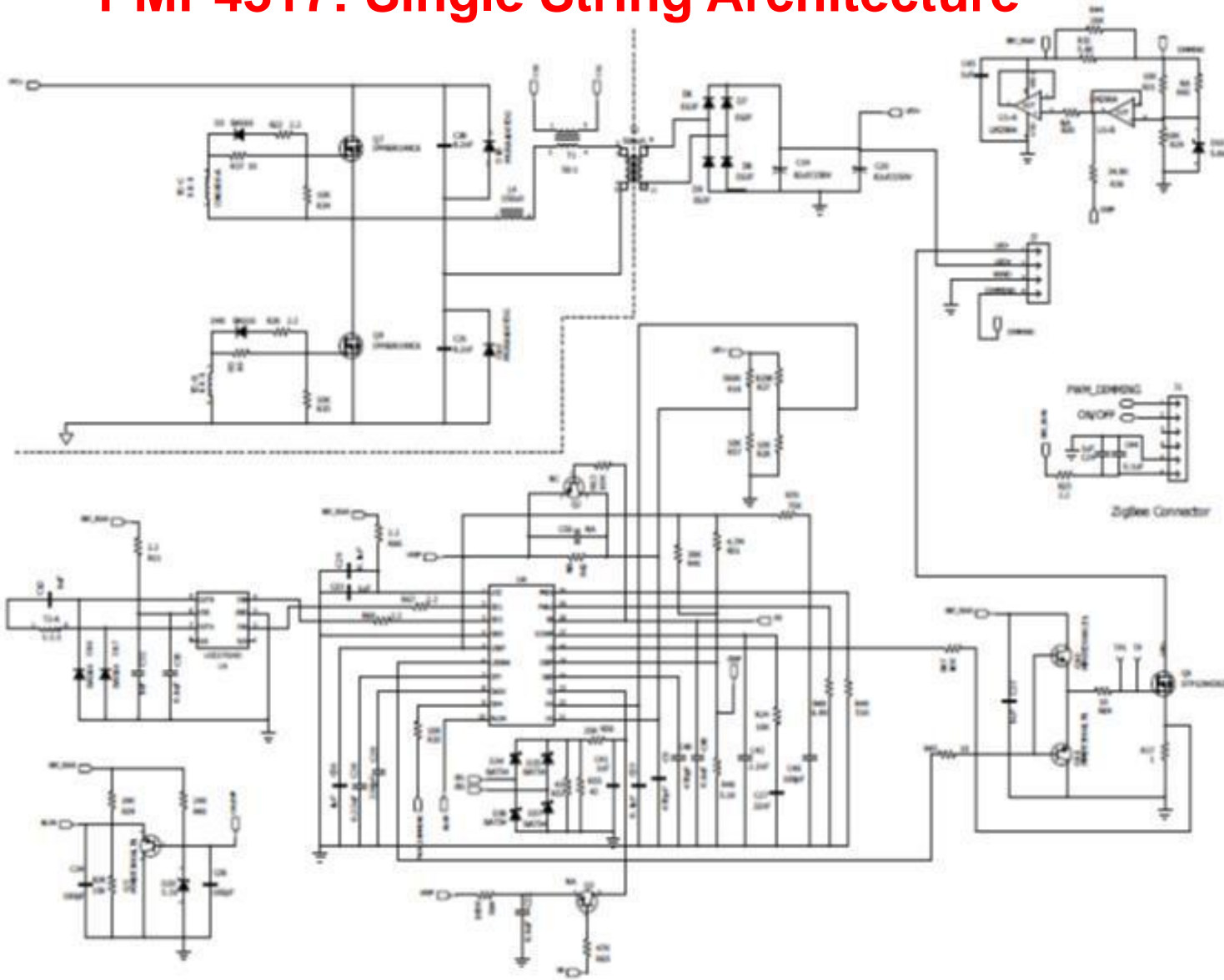
- Lowest cost
- Highest efficiency to 94%
- PWM and analog dimming compatible
- Integrate LED open/short protection and over current protection

Applications

- General LED lighting and LED backlight TV



PMP4317: Single String Architecture



TPS92210

PFC Offline LED Lighting Driver Controller

Features

- Flexible Operating Modes: Peak Primary Current, Constant On-Time, or both
- Cascoded MOSFET Configuration
- Works with TRIAC Dimmers
- Transformer Zero Energy Detection
- Discontinuous Conduction or Transition Mode Operation
- Advanced Over-Current Protection and Integrated Over-voltage Protection

Benefits

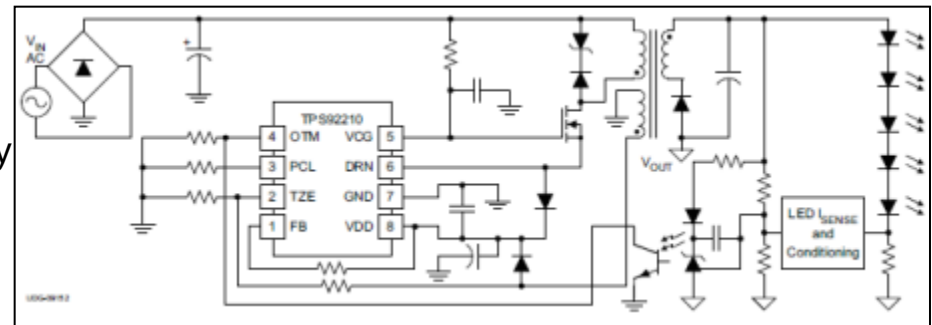
- Constant On-Time implements Single Stage Power Factor Correction (PFC)
- Fast start up; Line Surge Ruggedness Better Than Internal HV FET
- Continuous Exponential Dimming
- High Efficiency, Low EMI
- No Reverse Recovery Loss in Output Rectifier
- Protects Driver Against Fault Conditions

Applications

- Residential LED Lighting Drivers: A19 (E26/27, E14), PAR30/38, GU10
- Lighting Applications: Light Bulb Replacement, Sconces, Wall Washers, Architectural and Display Lighting, Commercial Troffers and Downlights



- TPS92210EVM-647 (110V)
- TPS92210EVM-613 (230V)





TPS92001/2

General Purpose LED Lighting Driver Controller

Features

- Ideal for Single Stage LED Driver Designs
- Isolated and Non-Isolated Topologies
- TRIAC Dimmable Application Circuit with Low External Component Count
- Convenient 5V Reference
- Two Under-Voltage Lockout Options (10V or 15V)
- Integrated Gate Drive: 0.4A Source / 0.8A Sink

Applications

- Residential LED Lighting Drivers: A19 (E26/27, E14), PAR30/38, GU10
- Lighting Applications: Light Bulb Replacement, Wall Sconces, Wall Washers, Architectural and Display Lighting, Commercial Troffers and Downlights

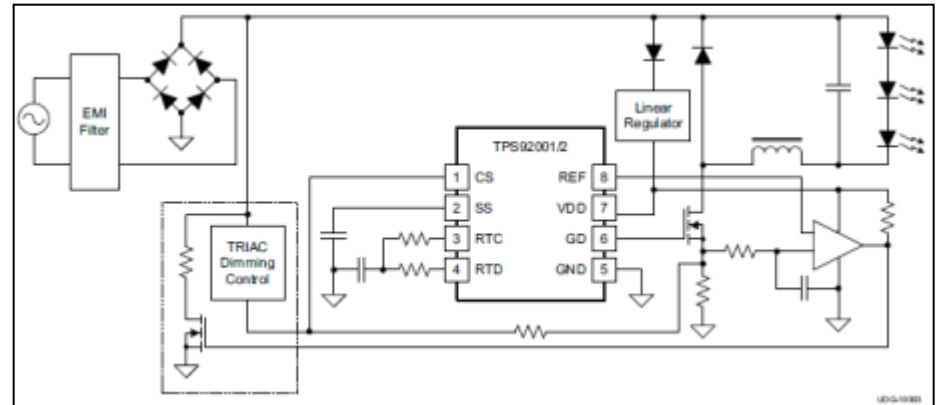
Benefits

- Power Factor >0.7
- Supports Wide Configuration of LED Loads
- Low Cost Deep Dimming Solution with Small Form Factor
- Power for MCU or Linear Circuits
- Protection from Abnormal Operating Conditions
- External Gate Drivers Not Required



**EVM
TOOLS**

•TPS92001EVM-645 (110V) **3Q11**



UCC28810/1

LED Lighting Power Controller (PFC)



Features

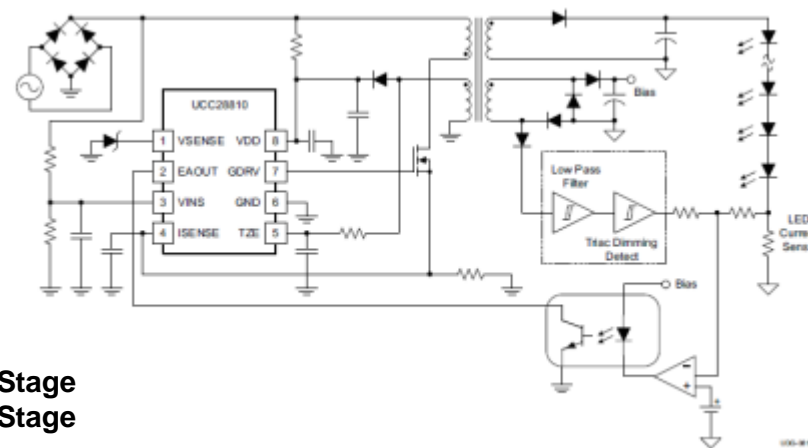
- Implements Single Stage Power Factor Correction
- Transformer Zero Energy Detection
 - Transition Mode Control
- Application Circuit Implements Phase-Cut Dimming
- Advanced Transient Response, Accurate Internal Vref, Low Start Up Current, 750mA Gate Drive
- UVLO, Over-Voltage, and Open-Loop Detection

Benefits

- Meets Power Factor Correction Standards for Lighting Products
- High Efficiency, Low EMI Performance
- Compatible with Large Installed base of TRIAC Based Dimmers
- Improves Reliability and Life Time of Lighting Fixture
- Protects Against Faults and Abnormal Conditions

Applications

- AC Input General Illumination, HB LED Applications
- PFC Front-End for Multi-Stage Lighting Designs



- UCC28810EVM-002 (Universal, 100W), Multi-Stage
- UCC28810EVM-003 (Universal, 110W), Multi-Stage

PMP4301: T10/T8 AC/DC LED Driver for Fluorescent Lamp

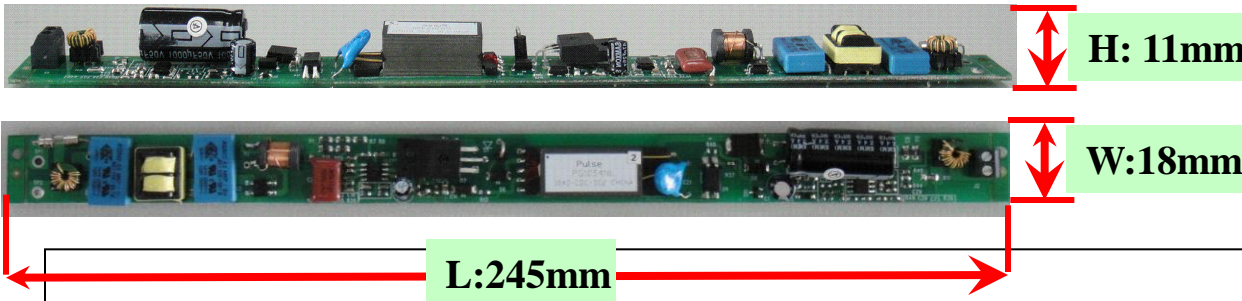
Reference Design	TI Parts	V_{in}	P_o	V_o I_o	Topology	Dimming	Eff.	PF
<u>AC Input T8 AC/DC LED Lighting Driver for fluorescent lamp</u>	UCC28810	90~ 264 Vac	20W	30V~42V 450mA	Isolated single Stage high PF Flyback with Transition Mode	PWM dimming for PMP4301A	>87%	>0.97

Features

- Specific transformer for T8 lighting form factor
- PWM dimming compatible
- Low BOM cost
- Efficiency >87% at 230Vac input
- Isolated single stage w/ PF>0.97 at 230Vac input
- Output over voltage protection: 45Vdc
- Output ripple current: <30% of output current
- Size: 245mmX18mmx11mm (ultra-slim)

Applications

- T8 and T10 tube LED lighting
- Wall-wash LED lighting
- Commercial LED lighting with PWM dimming



DC/DC LED Lighting Solutions

DC/DC LED Lighting Solutions

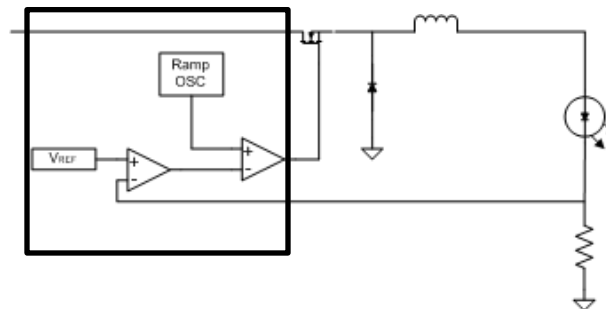
Boost		Buck		Linear	
Controllers	Converters	Controllers	Converters	Controllers	Converters
TPS40211*	LM3410	LM3401	TPS92510	LM3464/A	LM3466
LM3430	TPS61165	LM3409/HV	LM3402/HV		
LM3431/A	TPS61166	LM3421*	LM3404/HV		
	TPS61195	LM3423*	LM3406/HV		
	TPS61500	LM3424*	LM3405/A		
	LM3492	LM3429*	LM3407		
		LM3433	LM3414/HV		
		LM3434			

* Primary Topology Listed. Additional Topologies Supported.

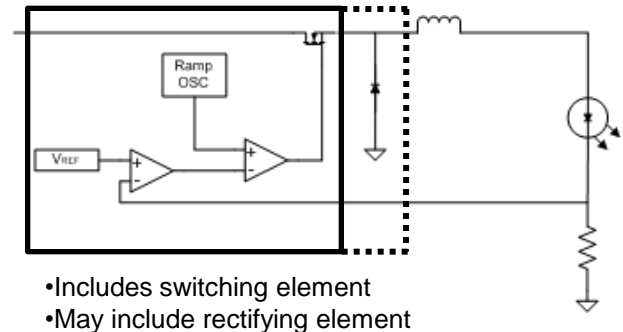
DC/DC LED Lighting Controllers vs. Converters

	Controller	Converter
Integration	External: <ul style="list-style-type: none"> • Switch(es) • Rectifying Element • Sense Resistor(s) 	Internal (can include): <ul style="list-style-type: none"> • Switch(es) • Rectifying Element • Sense Resistors • Integrated Protection Features
Flexibility	<ul style="list-style-type: none"> • Tunable Switching Frequency • Easier to Scale for Higher Output Power • Low Power Dissipation in IC Package 	<ul style="list-style-type: none"> • May be Fixed or Adjustable Switching Frequency • Limited Output Power Range • Limited IC Package Power Dissipation
Ease of Use	<ul style="list-style-type: none"> • 'Cookbook' of Equations to Select Component Values • Can be Intimidating for Novice Designer 	<ul style="list-style-type: none"> • Some Products 'Plug and Play' – Common Application Components Pre-Selected

Basic Buck Controller



Basic Buck Converter



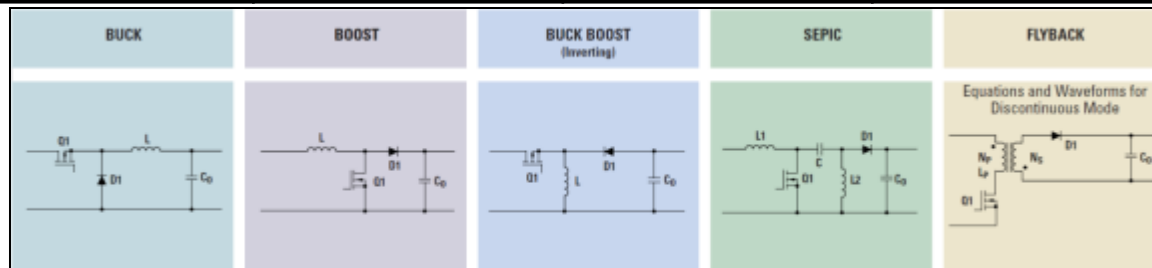
LED DC/DC Controller Summary

	TPS40211	LM3401	LM3409/ HV	LM3421/ LM3423	LM3424	LM3429	LM3430	LM3431	LM3433/ LM3434	LM3492
Package	10 MSOP	8 MSOP	10 MSOP	16TSSOP 20TSSOP	20TSSOP	14TSSOP	12LLP	28HTSSOP	24LLP	20TSSOP
FET	NMOS	PMOS	PMOS	NMOS	NMOS	NMOS	NMOS	NMOS	NMOS	NMOS
Vin Range	4.5-52V	4.5-30V	6-42/75V	4.5-75V	4.5-75V	4.5-75V	6-40V	5-36V	-9—14V -9—30V	4.5-65V
Vref	0.260V	0.200V	0.248V	Adjustable	Adjustable	Adjustable	1.25V	100-300mV (adj)	60mV	N/A
Fsw	ADJ Up to 1MHz	Variable up to 1.5MHz	Variable up to 1MHz	ADJ Up to 2MHz	ADJ Up to 2MHz	ADJ Up to 2MHz	ADJ Up to 2MHz	ADJ Up to 1MHz	ADJ Up to 1MHz	Variable up to 1MHz
Fsync	Yes	No	No	No	No	No	Yes	No	No	No
Adj Soft Start	Yes	n/a	n/a	No	No	No	Yes	Yes	Yes	Yes
OCP threshold	150mV	130mV	248mV	245mV	245mV	245mV	500mV	Adj	No	No
Topology	Boost, Flyback, SEPIC - Current mode	Buck - Hysteretic	Buck - Hysteretic	Buck, Boost, Buck-Boost, SEPIC	Buck, Boost, Buck-Boost, SEPIC	Buck, Boost, Buck-Boost, SEPIC	Boost – Current Mode Control	Boost – Current Mode Control	Buck – Current Mode Control	boost
Other Features			HS Current Sense	HS Current Sense, Flag, Err Tmr (23)	HS Current Sense, Thermal Foldback	HS Current Sense	Dynamic Headroom Control	3-Channel CC Sinks	Grounded Anode LED	Dynamic Headroom Control
Tj	-40°C to +125°C	-40°C to +125°C	-40°C to +125°C	-40°C to +125°C	-40°C to +125°C	-40°C to +125°C	-40°C to +125°C	-40°C to +125°C	-40°C to +125°C	-40°C to +125°C

Multi-Topology Controllers

Multi-Topology Controller Summary

	TPS40211	LM3421	LM3423	LM3424	LM3429
Package	10 MSOP	16TSSOP	20TSSOP	20TSSOP	14TSSOP
FET	NMOS	NMOS	NMOS	NMOS	NMOS
Vin range	4.5-52V	4.5-75V	4.5-75V	4.5-75V	4.5-75V
Vref	0.260V	Adjustable (50mV – 1.24V)	Adjustable (50mV – 1.24V)	Adjustable (50mV – 1.24V)	Adjustable (50mV – 1.24V)
Fsw	ADJ Up to 1MHz	ADJ Up to 2MHz	ADJ Up to 2MHz	ADJ Up to 2MHz	ADJ Up to 2MHz
Fsync	Yes	No	No	No	No
Adj Soft Start	Yes	No	No	No	No
OCP threshold	150mV	245mV	245mV	245mV	245mV
Topology	Boost, Flyback, SEPIC – Current mode	Buck, Boost, Buck-Boost, SEPIC	Buck, Boost, Buck-Boost, SEPIC	Buck, Boost, Buck-Boost, SEPIC	Buck, Boost, Buck-Boost, SEPIC
Other Features		HS Current Sense	HS Current Sense, LED Output Status Flag, Fault Flag, Fault Timer, PWM Polarity Pin	HS Current Sense, Thermal Foldback	HS Current Sense
Tj	-40°C to +125°C	-40°C to +125°C	-40°C to +125°C	-40°C to +125°C	-40°C to +125°C





TPS40211

4.5V to 52V Current Mode N-Ch Controller for LED Lighting

Features

- Supports Boost, Flyback and SEPIC Topologies
- 4.5 to 52V Input Voltage Range
- Programmable Switching Frequency (35kHz to 1MHz)
- Frequency Synchronization (with External Components)
- 260mV Internal Voltage Reference
- Integrated Low-Side Driver
- Programmable Over-Current Limit and Internal UVLO

Applications

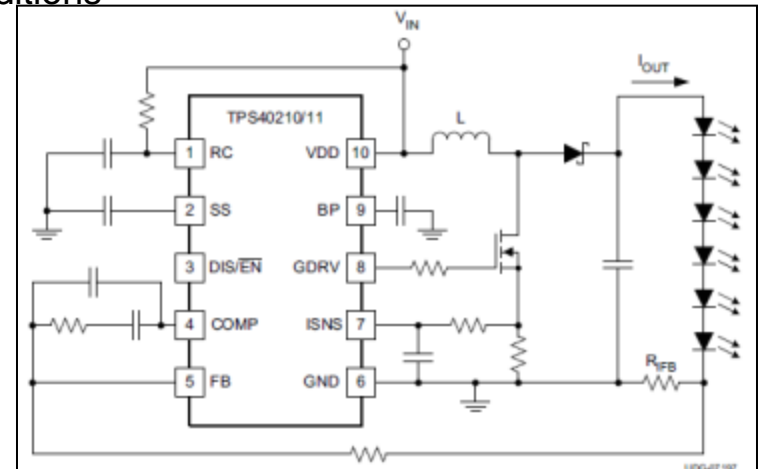
- High Current LED Drivers (Street Lighting, High Bay)
- LED Based MR-16 Light Bulb Replacement
- LED Backlighting

Benefits

- Suitable for a Wide Variety of LED Lighting Applications
- Can Drive Up To 14 Series HB LEDs
- Flexible Filter Design
- Can Operate with an External Clock
- Reduces Power Dissipation in Sense Resistor
- Reduces Component Count
- Protects Against Fault and Abnormal Operating Conditions



TPS40211EVM-352



LM3429

N-Channel Controller with for Const. Curr. LEDs



Features

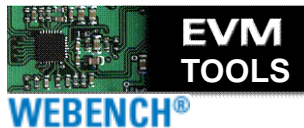
- Input Operating Range 4.5 to 75V and Buck, Boost, Buck-Boost, and SEPIC Configurations
- High Side Adjustable Current Sense
- Switching Frequency Adjustable to 2MHz. Can be Synchronized in Multi-Controller Applications
- Dimming: PWM and Analog
- UVLO, Over-Voltage, and Thermal Shutdown Protection

Benefits

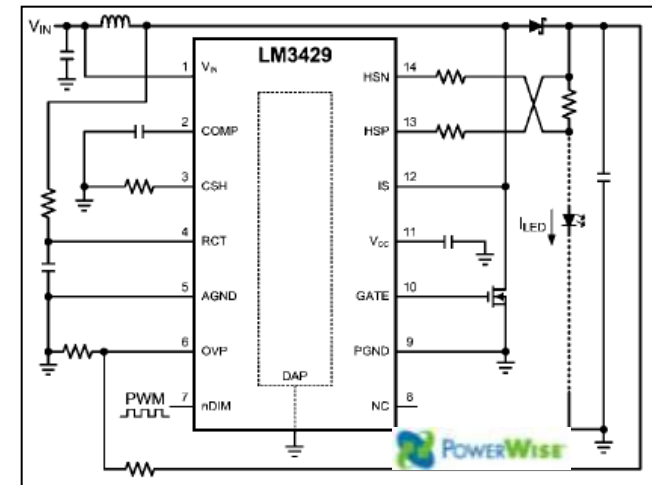
- Suitable for a Wide Variety of LED Applications
- Can Be Used for Analog Dimming Control
- Optimize for Efficiency, Size, or LED Ripple Current
- Flexible Options for Controlling LED Brightness
- Protects Against Faults and Abnormal Operating Conditions

Applications

- Indoor and Outdoor Area Lighting
- Automotive (Q100 Version Available)



- LM3429BKBSTEVAL/NOPB
- LM3429BSTEVAL/NOPB



Buck Controllers

Buck Controllers Summary

	LM3401	LM3409/HV	LM3433/ LM3434
Package	8 MSOP	10MSOP	24LLP
FET	NMOS	PMOS	NMOS
Vin range	4.5-35V	4.5-42/75V	-9—14V -9—30V
Vref	0.2V	Adjustable (200mV – 250mV)	60mV
Fsw	Up to 1MHz+	Up to 1MHz	ADJ Up to 1MHz
Fsync	No	No	No
Adj Soft Start	No	No	Yes
Topology	Bulk	Buck	Buck – Current Mode Control
Other Features		10,000:1 PWM Dimming Range	Grounded Anode LED
Tj	-40°C to +125°C	-40°C to +125°C	-40°C to +125°C

LM3401

Hysteretic PFET Controller For High Power LED Drive

Features

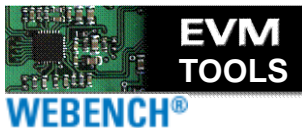
- 4.5V to 35V Input Operating Range
- Hysteretic Control for Speed and Simplicity
- 200mV Internal Voltage Reference
- High Speed CMOS Compatible Enable/Dim
- Programmable Current Limit
- No Output Capacitor Required

Applications

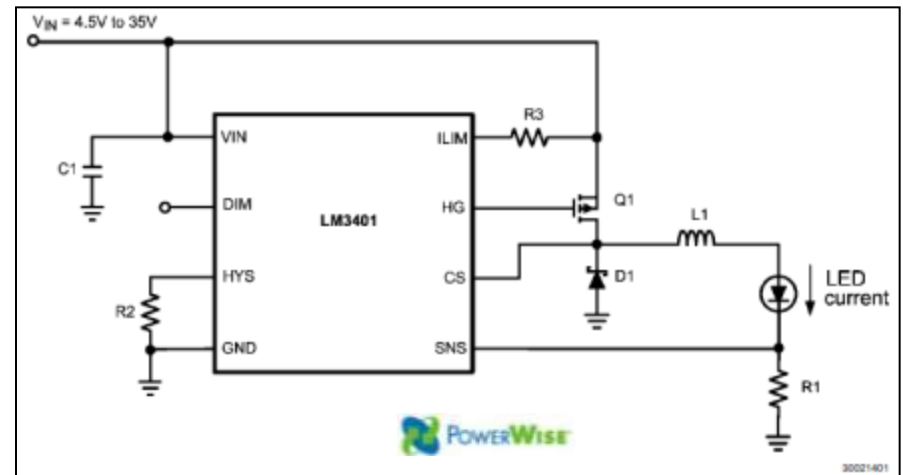
- High Current LED Drivers (Street Lighting, High Bay)
- LED Based MR-16 Light Bulb Replacement
- LED Backlighting

Benefits

- Suitable for a Wide Variety of LED Lighting Applications
- Controller Frequency Adjusts Based on Operating Conditions
- Low Power Dissipation in External Sense Resistor
- MCU Can be Used to Control LED Brightness
- Reduces Component Count

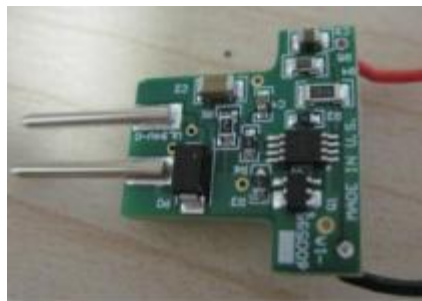


- LM3401-MR16DEMO/NOPB
- LM3401EVAL/NOPB



LM3401EVM Specifications

LM3401	LM3401-MR16DEMO		LM3401EVAL	
Specification	Value	Unit	Value	Unit
Input Voltage	12	VAC	4.5-35	VDC
LED Configuration	2	Series	1-10	Series
Output Current	1000	mA	up to 1000	mA
Output Voltage	6.2	VDC	up to VIN	VDC
Output Power	6.2	W	up to 35	W
Topology	Buck		Buck	
Efficiency	81	%	82% (700mA)	%
Power Factor	0.85		n/a	
Dimming Input	TRIAC		PWM	
Dimming Level	20-100	%	0-100	%
Current Sensing	Resistive		Resistive	
Driver Dimensions	tbd	mm	tbd	mm



Supports Cree MT-G LEDs

LM3409/LM3409HV

PFET Buck Controller of HB LEDs



Features

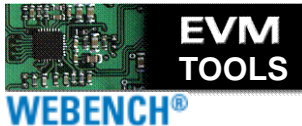
- VIN range from
 - 6V to 42V (LM3409)
 - 6V to 75V (LM3409HV)
- Can Supply 5A LED Current (1A Peak Gate Drive)
- Differential High-Side Current Sense (Adjustable from 0 to 248mV)
- Dimming Range
 - PWM: 10,000:1
 - Analog: 250:1
- Hysteretic with Controlled Off Time

Benefits

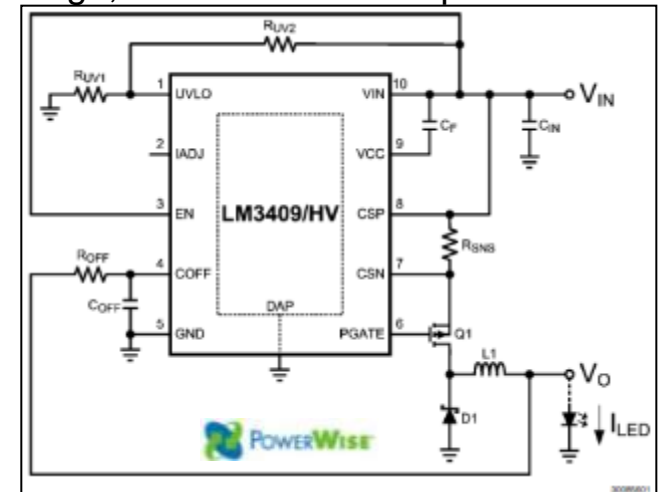
- Suitable for a Wide Variety of LED Applications
- Useful in Very High Light Output Applications
- LED Cathode Can Be Ground Connected
- PWM – Can Use MCU for Fine Brightness Adj
- Analog – No LED Flicker During Dimming
- Simplifies Design, Fast Transient Response

Applications

- Video Projectors
- Industrial Lighting, LED General Illumination
- LED Flashlights

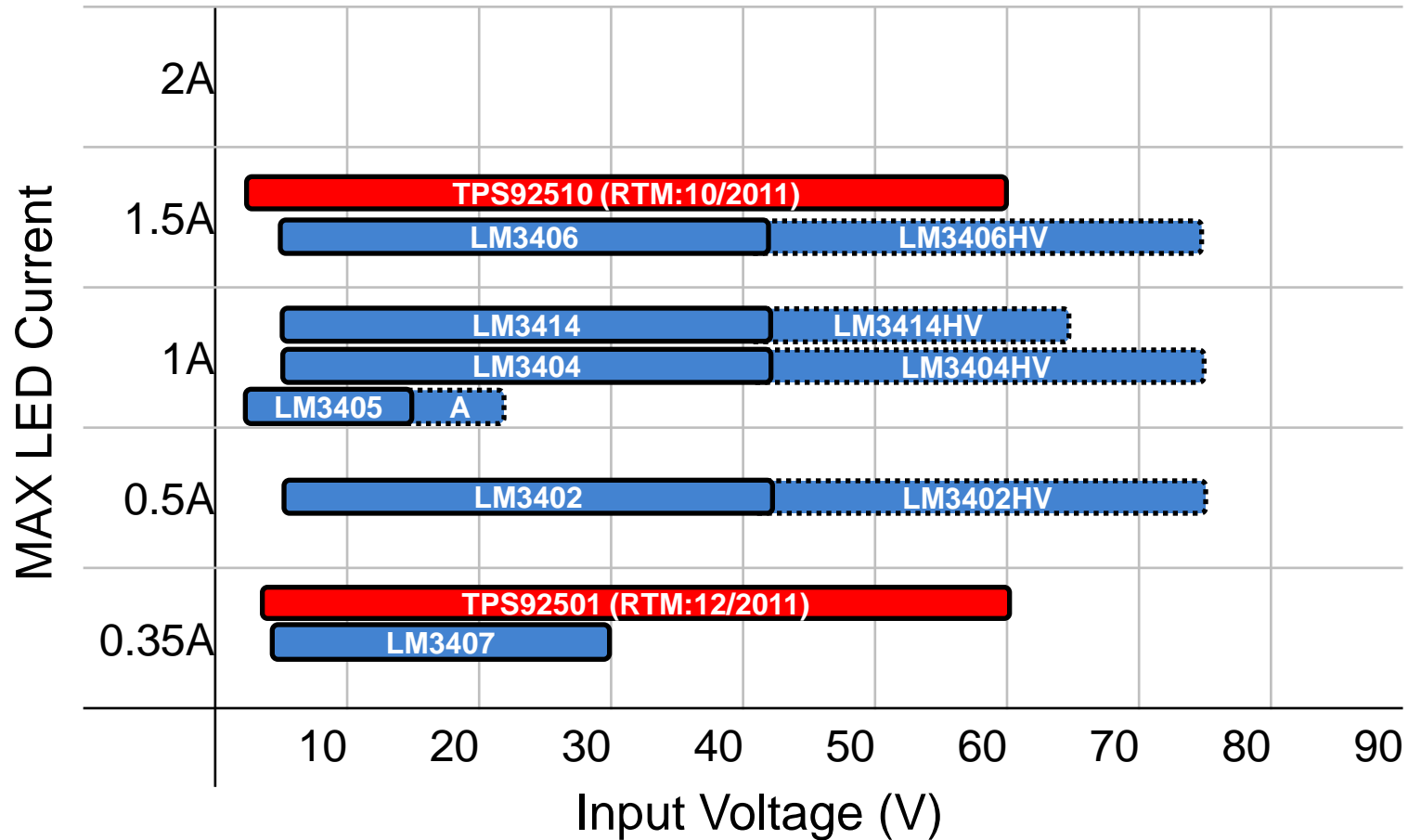


•LM3409EVAL/NOPB



Buck Converters for LED Lighting

DC/DC Buck Converters for LED Lighting



Buck LED Driver Summary

	TPS92510	LM3402/HV	LM3404/HV	LM3406/HV	LM3405/A	LM3407	LM3414/HV
Package	10 MSOP	8 MSOP 8 PSOP	8 MSOP 8 PSOP	14 HTSSOP	6 TSOT	8 MSOP	8 PSOP 8 LLP
Vin range	3.5-60V	6-42V 6-75V (HV)	6-42V 6-75V (HV)	6-42V 6-75V (HV)	3-15V 3-22V (A)	4.5-30V	4.5-42V 4.5-65V
Vref	200mV	200mV	200mV	200mV	205mV	198mV	n/a
Rds(on) (typ)	200mΩ	700mΩ	370mΩ	370mΩ	300mΩ	770mΩ	1.8Ω
Fsw	ADJ: 100k- 2.5MHz	Up to 2MHz	Up to 2MHz	Up to 2MHz	Fixed: 1.6MHz	ADJ: 300k- 1MHz	ADJ: 250k- 1MHz
Fsync	Yes	No	No	No	No	No	No
Adj Soft Start	No	No	No	No	No	No	No
OCP Limit	4A	0.735A	1.5A	2.1A	2A	0.42A	1.2A
Dimming	PWM	PWM	PWM	PWM	PWM	PWM, Analog	PWM, Analog
Topology	Non- Synchronous Buck	Non- Synchronous Controlled On- Time Buck	Non- Synchronous Controlled On- Time Buck	Non- Synchronous Controlled On- Time Buck	Non- Synchronous, Current Mode Buck	Floating (Inverted) Buck	Floating (Inverted) Buck
Other Features	Thermal Foldback	No Loop Compensation Required, Thermal S/D	No Loop Compensation Required, Thermal S/D	Thermal S/D	Internally Compensated, Thermal S/D	No Loop Compensati on Required, Thermal S/D	No Loop Compensation Required, Thermal S/D
Tj	-40°C to +125°C	-40°C to +125°C	-40°C to +125°C	-40°C to +125°C	-40°C to +125°C	-40°C to +125°C	-40°C to +125°C

TPS92510

Wide VIN Range Buck Driver for HB LED Lighting

coming soon!

4Q11

Features

- Input Operating Range: 3.5V to 60V
- IOUT up to 1.5A with Integrated MOSFET
- VREF = 200mV
- Thermal Foldback
- 100kHz to 2.5MHz Adjustable Switching Frequency
- PWM Dimming: 100Hz – 1kHz
- UVLO, Over-Current, and Over-Temperature Protection

Applications

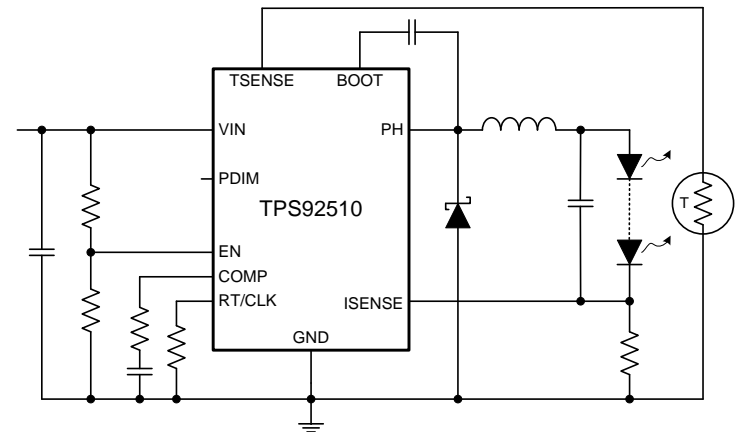
- Street Lighting, High-Bay Lighting, MR-16
- Emergency, Flash Lights
- Automotive Lighting

Benefits

- Suitable for a Wide Variety of LED Applications
- Reduced BoM and PCB Space
- Low Power Dissipation in Current Sense Resistor
- Improves LED Reliability and Maintains Reduced Light Output During High LED Temp. Conditions
- Flexible Inductor Selection
- Accurate Control of Light Intensity
- Protects IC During Fault and Abnormal Operating Conditions



• TPS92510EVM-011





LM3402/LM3402HV

0.5A Constant Current Buck Reg. for Driving HB LEDs

Features

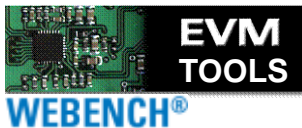
- VIN range from
 - 6V to 42V (LM3402)
 - 6V to 75V (LM3402HV)
- Hysteretic Operation with Controlled On-Time
- Integrated 0.5A N-Channel MOSFET
- PWM Dimming Input
- Over-Temperature, LED Open/Short Protection

Applications

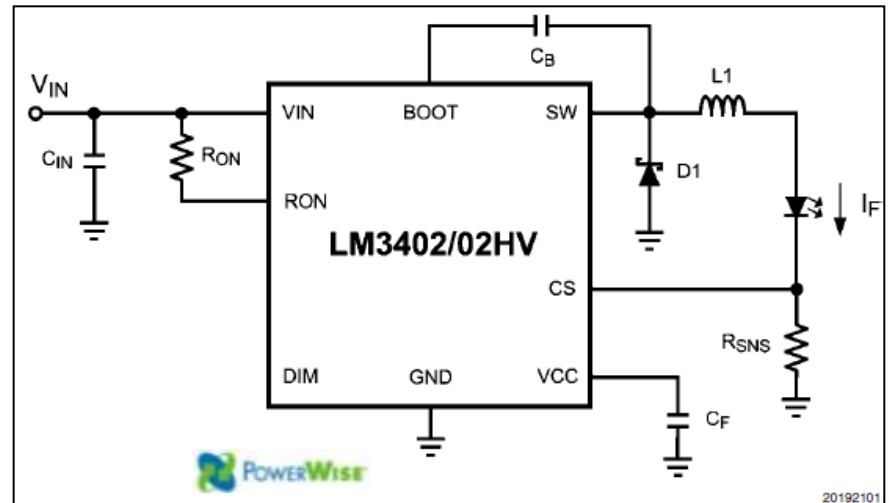
- LED General Illumination
- Industrial Lighting
- Automotive Lighting

Benefits

- Two voltage grades optimized for different application needs
- No Control Loop Compensation Required
- Easily Drives 1W HB LEDs
- Allows for External Source Such as a MCU to Control LED Brightness
- Protects Against Abnormal and Fault Conditions



•LM3402EVAL/NOPB



LM3404/LM3404HV

1A Constant Current Buck Reg. for Driving HB LEDs



Features

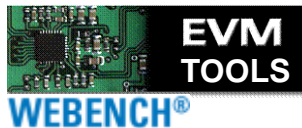
- VIN range from
 - 6V to 42V (LM3404)
 - 6V to 75V (LM3404HV)
- Hysteretic Operation with Controlled On-Time
- Integrated 1A N-Channel MOSFET
- PWM Dimming Input
- Over-Temperature, LED Open/Short Protection

Applications

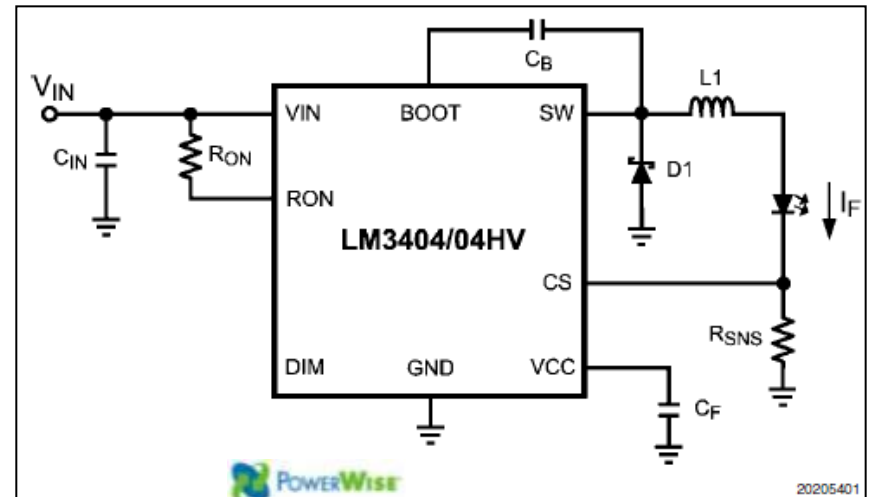
- LED General Illumination
- Industrial Lighting
- Automotive Lighting

Benefits

- Two voltage grades optimized for different application needs
- No Control Loop Compensation Required
- Easily Drives 3W HB LEDs
- Allows for External Source Such as a MCU to Control LED Brightness
- Protects Against Abnormal and Fault Conditions



- LM3404EVAL/NOPB
- LM3404FSTDIMEV/NOPB
- LM3404MREVAL



LM3406/LM3406HV

1.5A Constant Current Buck Reg. for Driving HB LEDs



Features

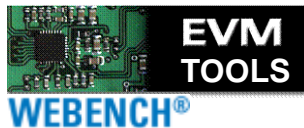
- VIN range from
 - 6V to 42V (LM3406)
 - 6V to 75V (LM3406HV)
- Hysteretic Operation with Controlled On-Time
- Up to 1.5A Constant Current Output
- PWM Dimming Input
- Over-Temperature, LED Open/Short Protection

Applications

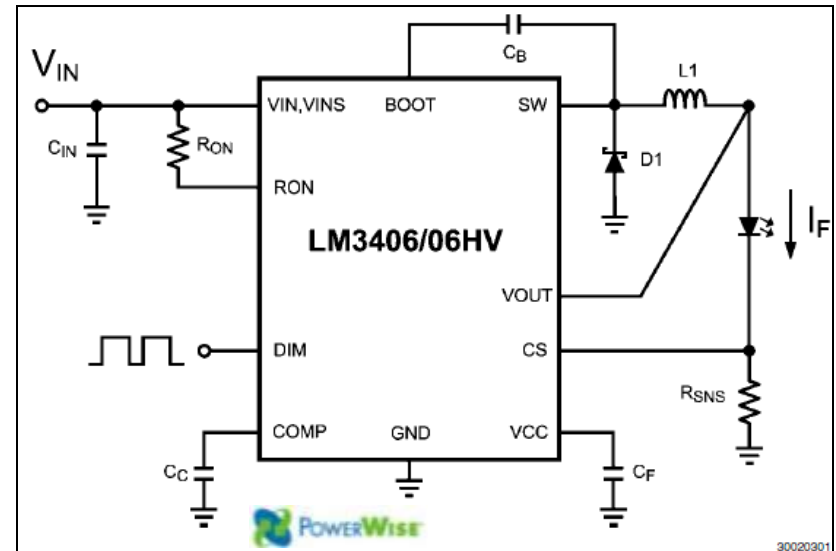
- LED General Illumination
- Industrial Lighting
- Automotive Lighting

Benefits

- Two Voltage Grades Optimized for Different Application Needs
- No Control Loop Compensation Required
- Easily Drives a Variety of HB LEDs
- Allows for External Source Such as a MCU to Control LED Brightness
- Protects Against Abnormal and Fault Conditions



•LM3406MHEVAL/NOPB



LM3414/LM3414HV

1A Floating Buck for Driving HB LEDs (No Sensing Resistor)



Features

- Input Operating Range
 - 4.5 to 42V (LM3414)
 - 4.5 to 65V (LM3414HV)
- Adjustable LED current: 350-1000mA
- Adjustable Switching Frequency: 250kHz to 1MHz
- Analog and PWM Dimming
- Internally Compensated
- UVLO, Thermal Shutdown and Open-Circuit Protection

Applications

- High Light Output Designs (Troffers, Architectural Lighting)
- MR-16 Replacement
- Automotive Lighting

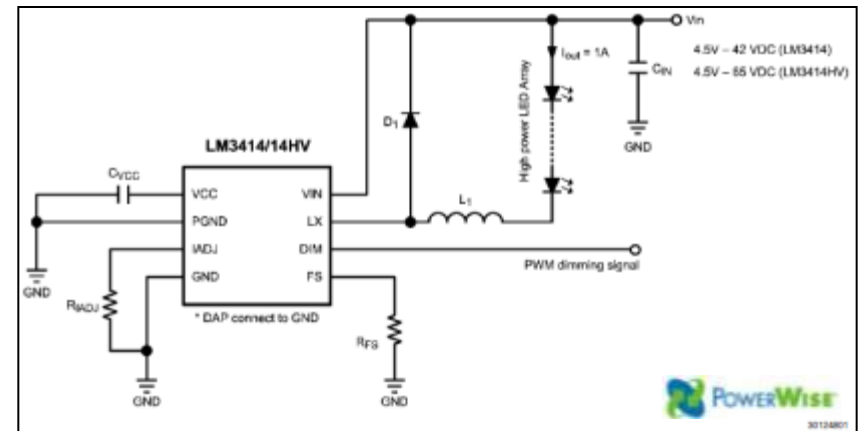


WEBENCH®

- LM3414VMREVAL/NOPB
- LM3414HVSDEVAL/NOPB

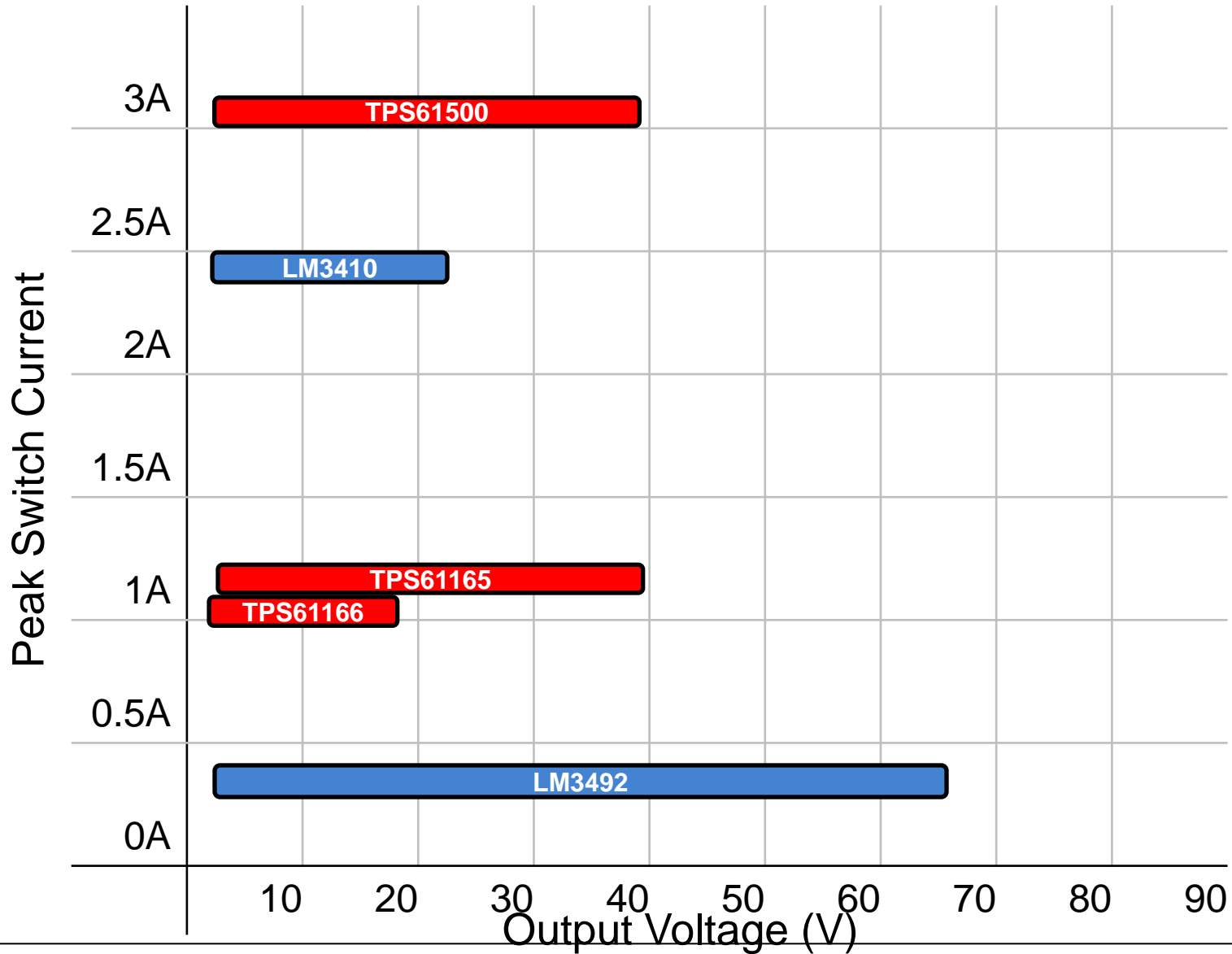
Benefits

- Two Voltage Grades Optimized for Different Application Needs
- Supports 1-3W HB LEDs
- Allows for Optimization of Efficiency Versus Inductor Size, Reduced EMI
- Up to 1/10 Switching Frequency (PWM)
- Simplifies Design and Reduces Component Count
- Protects Against Abnormal and Fault Conditions



Boost Converters for LED Lighting

DC/DC Boost Converters for LED Lighting



TPS61165

350mA, 90% Efficient, Boost HB LED Driver



Features

- Operating Voltage Ranges
 - V_{IN} : 3-18V
 - V_{OUT} : V_{IN} to 38V
- 1.2A Peak Switch Current
- Fixed Switching Frequency: 1.2MHz
- Dimming:
 - PWM Input (5kHz – 100kHz) Maps to Analog Dimming
 - EasyScale™
- UVLO, LED Open Detection, Current Limit and Thermal Shutdown

Applications

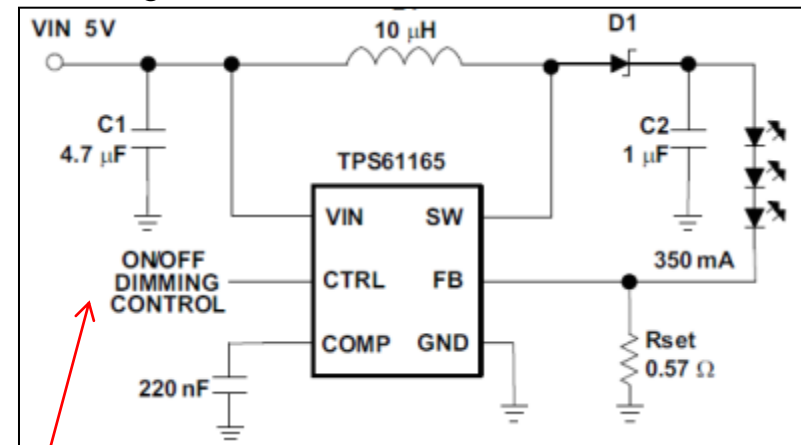
- LED General Illumination
- LED Flashlights
- LED Backlighting



- TPS61165EVM-283
- Design Tool: Analog Dimming using PWM

Benefits

- Suitable for Use in Battery, 12V, or 15V Systems
- Can be Used to Drive High Current LEDs
- Optimized for Compact Designs
- PWM Signal Lowers Internal Feedback Voltage Reducing Light Output
- One-wire Interface for Digital Brightness Control
- Protects Against Abnormal and Fault Conditions



PWM or EasyScale™

TPS61166

1A, Boost High Brightness LED Driver w/Integrated Diode

Features

- Operating Voltage Ranges:
 - $V_{IN(IC)}$: 2.5-6V, $V_{IN(BAT)}$: 4.5-10V
 - V_{OUT} : V_{IN} to 18V
- 1.1A Peak Switch Current
- Fixed Switching Frequency: 1.2MHz
- PWM Dimming: 60Hz-40kHz
- UVLO, Over-Voltage, Current Limit and Thermal Shutdown

Applications

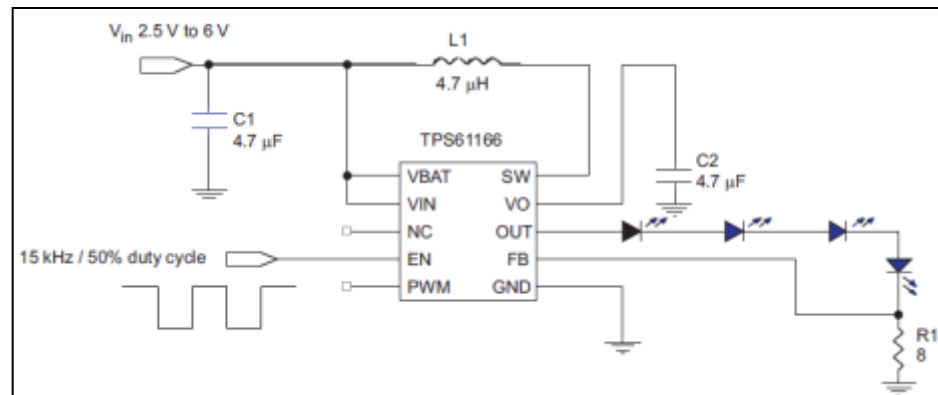
- LED General Illumination
- LED Flashlights
- LED Backlighting



- TPS61166EVM-446
- Design Tool for Analog Dimming Using A PWM Signal

Benefits

- Suitable for Use in Battery, or 9V Systems
- Can be Used to Drive High Current LEDs
- Optimized for Small External Components
- Output Capacitor Not Discharged During PWM Dimming, Reducing Audible Noise from Pulsed Currents.
- Protects Against Abnormal and Fault Conditions



LM3492

2-Channel Const. Current LED Driver w/ Integrated Boost Controller



Features

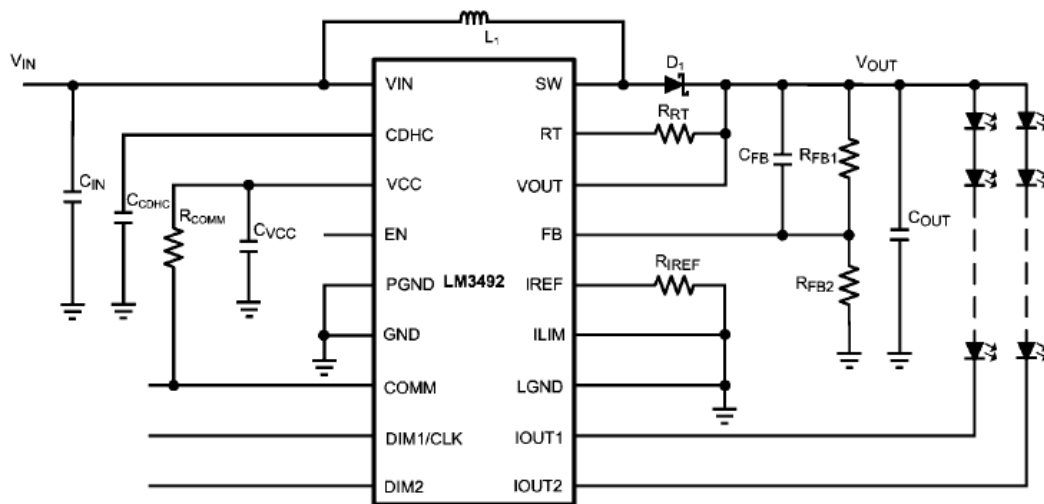
- Very wide input voltage ranged from 4.5V-65V
- Stable with ceramic and other low ESR capacitors with no audible noise
- No loop compensation required
- Programmable soft-start
- Nearly constant switching frequency programmable from 200 kHz to 1 MHz
- Over-Power protection

Applications

- Ultra-high contrast ratio 6.5"-10" LCD display backlight up to 28 LEDs
- AR111/ MR16
- Automotive (Q100 Version Available)

Benefits

- Programmable LED current from 50mA to 200mA
- 1000:1 contrast ratio at a dimming frequency of more than 3 kHz, minimum LED current pulse width is 300 ns
- Two individual dimmable LED strings up to 65V, total 15W
- Dynamic Headroom Control maximizes efficiency
- $\pm 3\%$ current accuracy



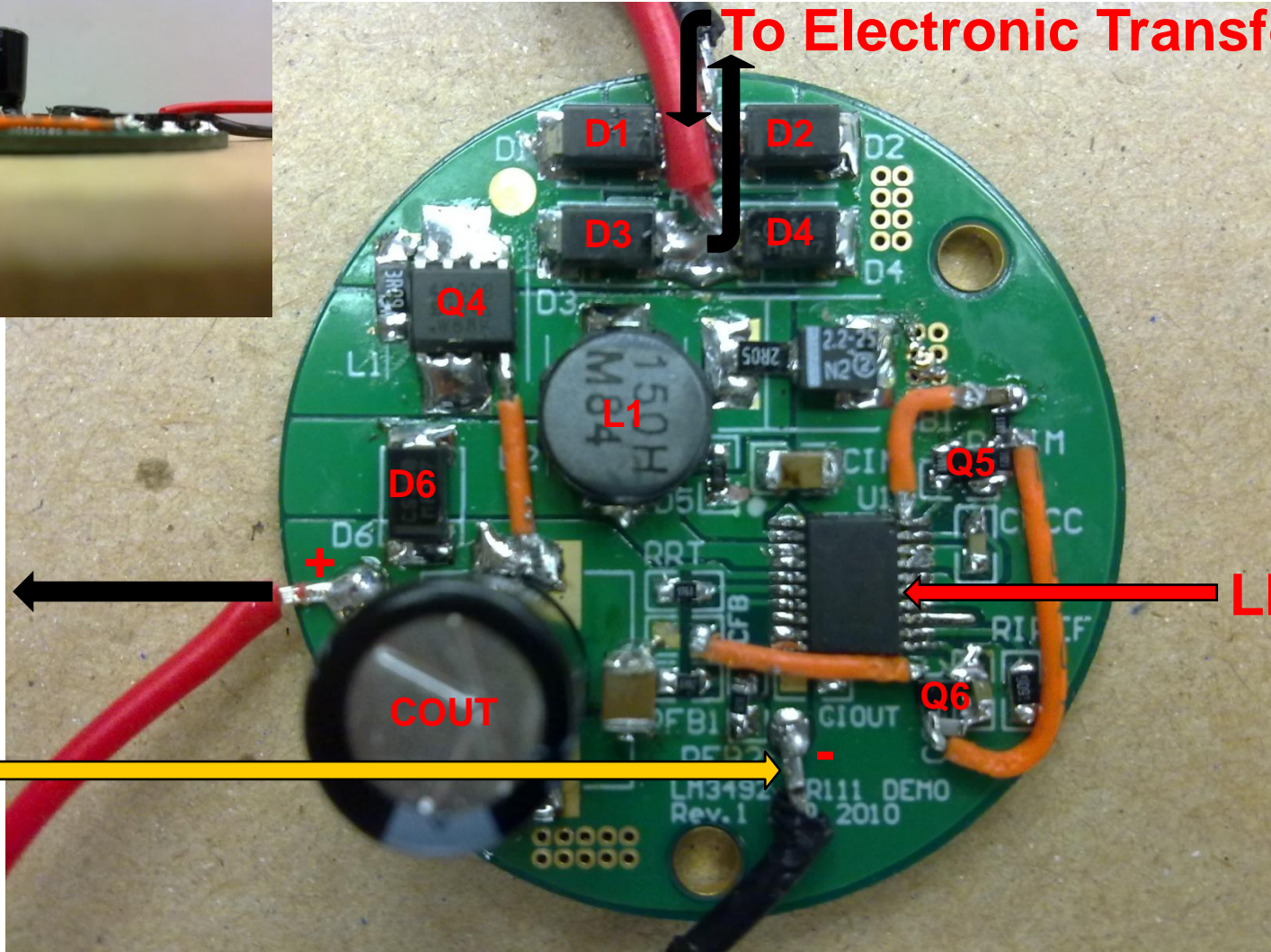
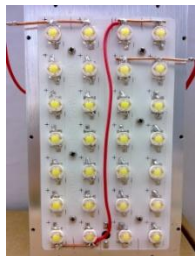
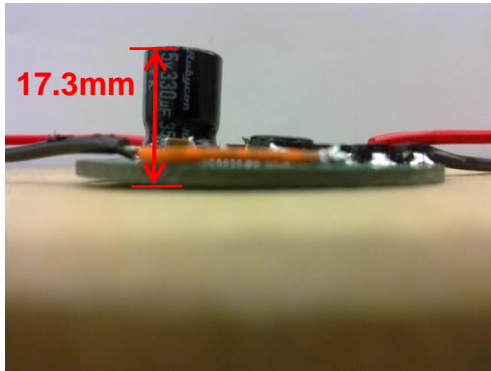
•LM3492EVAL/NOPB

WEBENCH®



Driving 250mA LED string with LM3492 For Application with E-Transformer

Components of System (MR16)

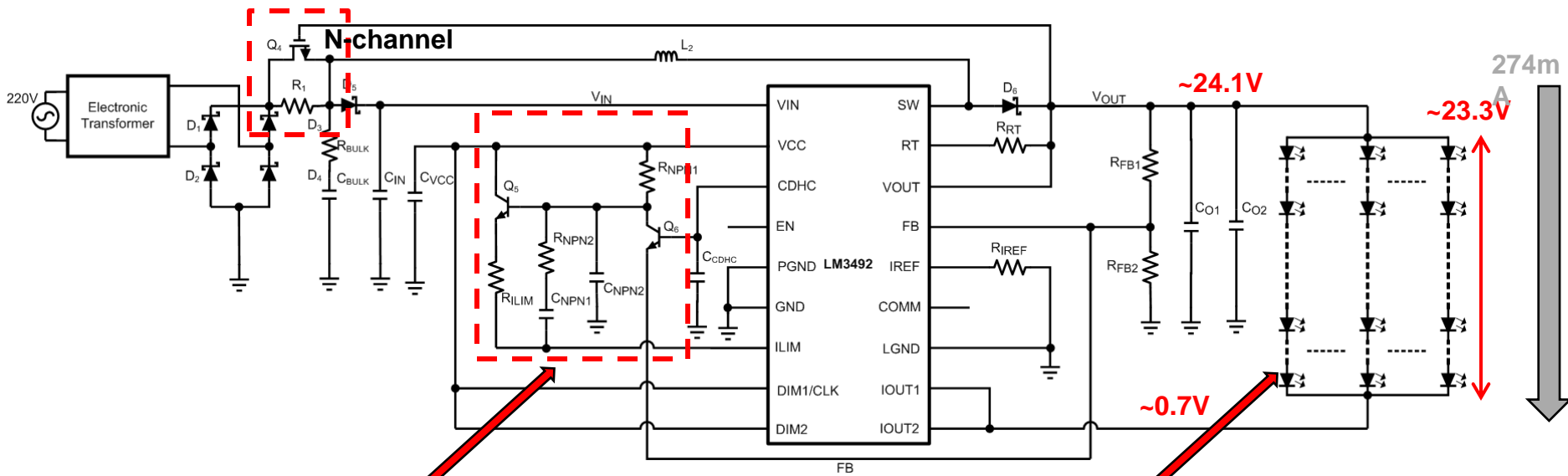


Diameter 40mm

Schematic (Version 2) Good Efficiency

Startup Inrush Current Suppression Circuitry

VIN = 12V DC



274m

~23.3V

~24.1V

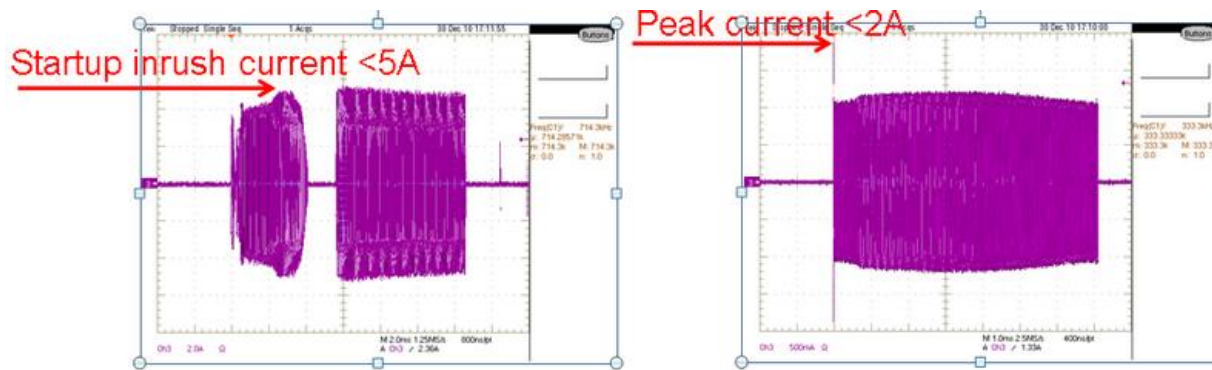
~0.7V

New Adaptive Current Limit Circuitry for various E-Transformers

Power LEDs String

Summary of Performance

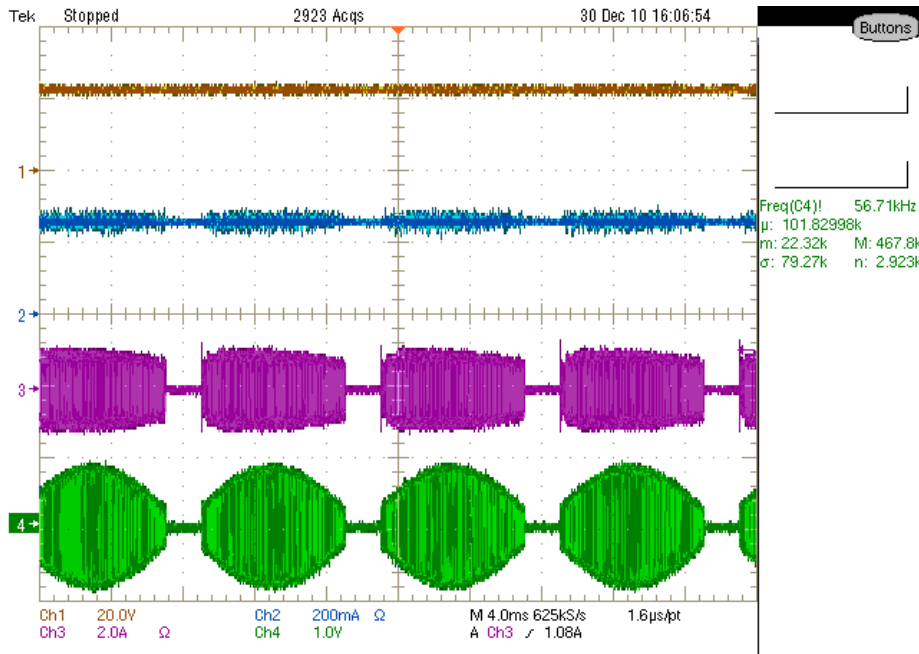
- Low inrush and operating current
 - Protect E-transformer



- **High Power Factor, up to 0.97**
 - Resemble an incandescent MR16 loading, i.e., like a resistive load
- **High Efficiency, up to 82%**

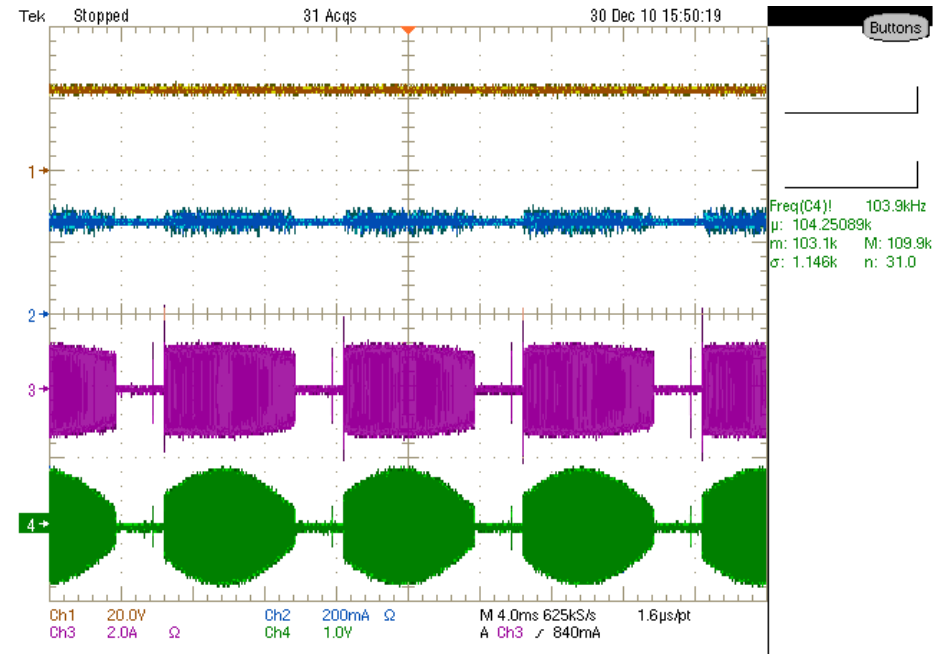
Electronic Transformer Waveform

Rio



CH1: LED Current
CH2: LED Voltage
CH3: Output Current from Transformer
CH4: Output Voltage from Transformer
(100mV * 200 = 20V/div)

Kengo



CH1: LED Current
CH2: LED Voltage
CH3: Output Current from Transformer
CH4: Output Voltage from Transformer
(100mV * 200 = 20V/div)

Constant Current LED String Drivers

LM3464/LM3464A

4-Channel High-Voltage, Constant Current LED Driver with Dynamic Headroom Voltage Monitoring



Features

- Wide Input Voltage Range
 - 12 to 60V (LM3464)
 - 12 to 95V (LM3464A)
- Dynamic Headroom Control
- Analog and PWM Dimming
- LED Open, LED Short Detection
- Thermal Detection with Foldback

Benefits

- Two voltage grades optimized for different application needs
- Provides Feedback to AC/DC Converter to Ensure Maximum Efficiency
- Optimize for LED Color Shift and Brightness Control
- Fault Flag Notifies MCU of Abnormal Condition
- Maintains LEDs ON, but at Reduced Brightness Until LED Over-Temperature Condition Clears.

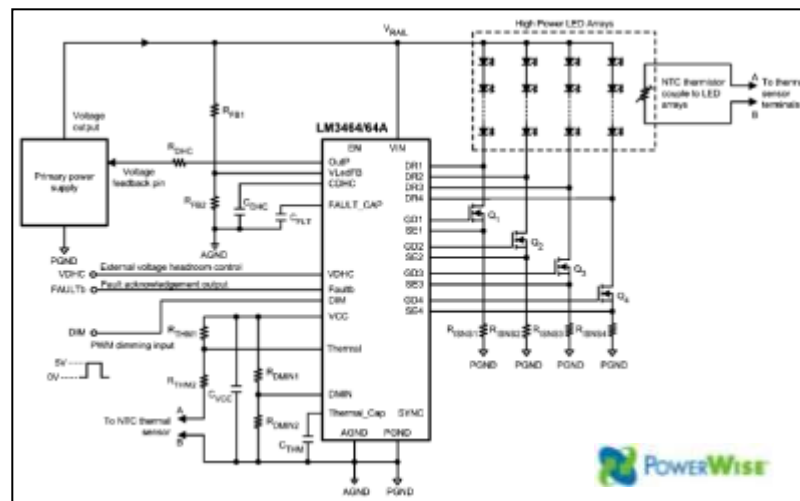
Applications

- LED Street Lighting, High-Bay Lighting
- Multi-String LED Luminaires



WEBENCH®

- LM3464-120V24W/NOPB
- LM3464EVAL/NOPB





TLC5960

8-Channel High-Voltage, Constant Current LED Driver with Intelligent Headroom Voltage Monitoring

Features

- Wide Input Voltage Range
 - V_{IN} : 10 to 28V
 - V_D : GND to 34V
- Intelligent Headroom Control
- Analog and PWM Dimming
- LED Open, LED Short, FET Open, and FET Short Detection
- IC Thermal Shutdown

Applications

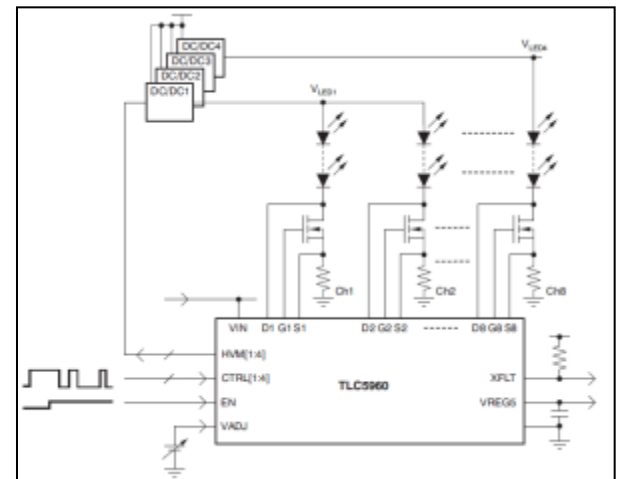
- LED Backlighting
- LED Street Lighting, High-Bay Lighting
- Multi-String LED Luminaires



•TLC5960 HVM Calculator

Benefits

- Operates from 12V or 24V Supplies
- Provides Feedback to DC/DC Converters to Ensure Maximum Efficiency
- Optimize for LED Color Shift and Brightness Control
- Fault Flag Notifies MCU of Abnormal Condition
- Protects Driver IC from Over-Temperature Conditions



LM3466

Smart Linear LED Driver for Multi-Channel LED Systems

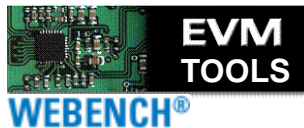


Features

- Wide Input Voltage Range: 6 to 70V
 - 70V, 1.5A MOSFET with 2A Limit
- Works with Constant Current Power Supplies
- Automatic Equalization
- LED Open, LED Short Detection
- Thermal Shutdown

Applications

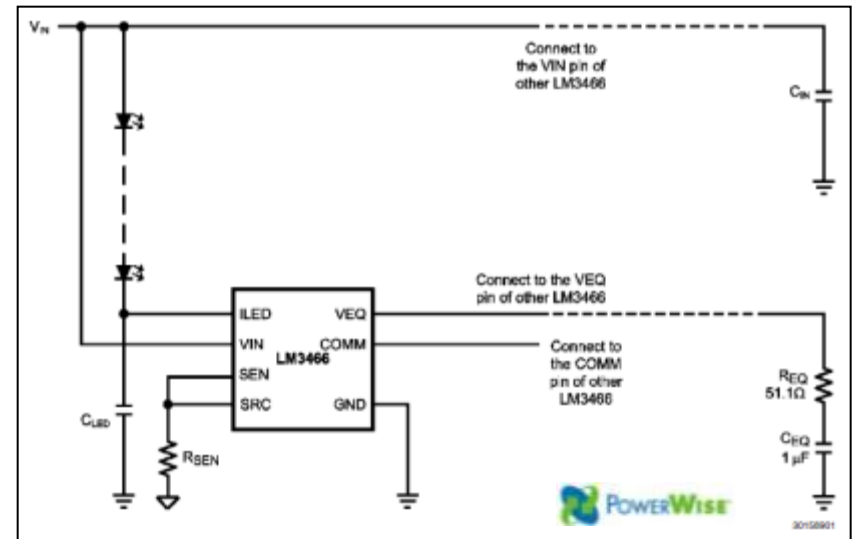
- LED Street Lighting, High-Bay Lighting
- Multi-String LED Luminaires



•tbd

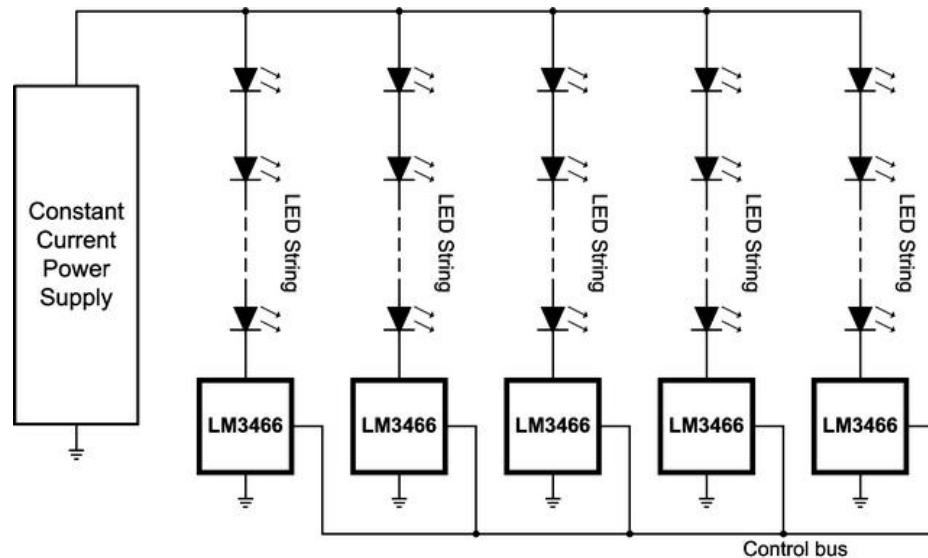
Benefits

- Support Up to 20 LEDs in Series
- Regulates LED String Current Based on User Settings
- Balances Current of Every Active String, Even if String Voltages Are Not Equal
- Fault Flag Notifies MCU of Abnormal Condition
- Protects LM3466 Against High-Temperature Conditions



LM3466: Dynamic Current Equalizer

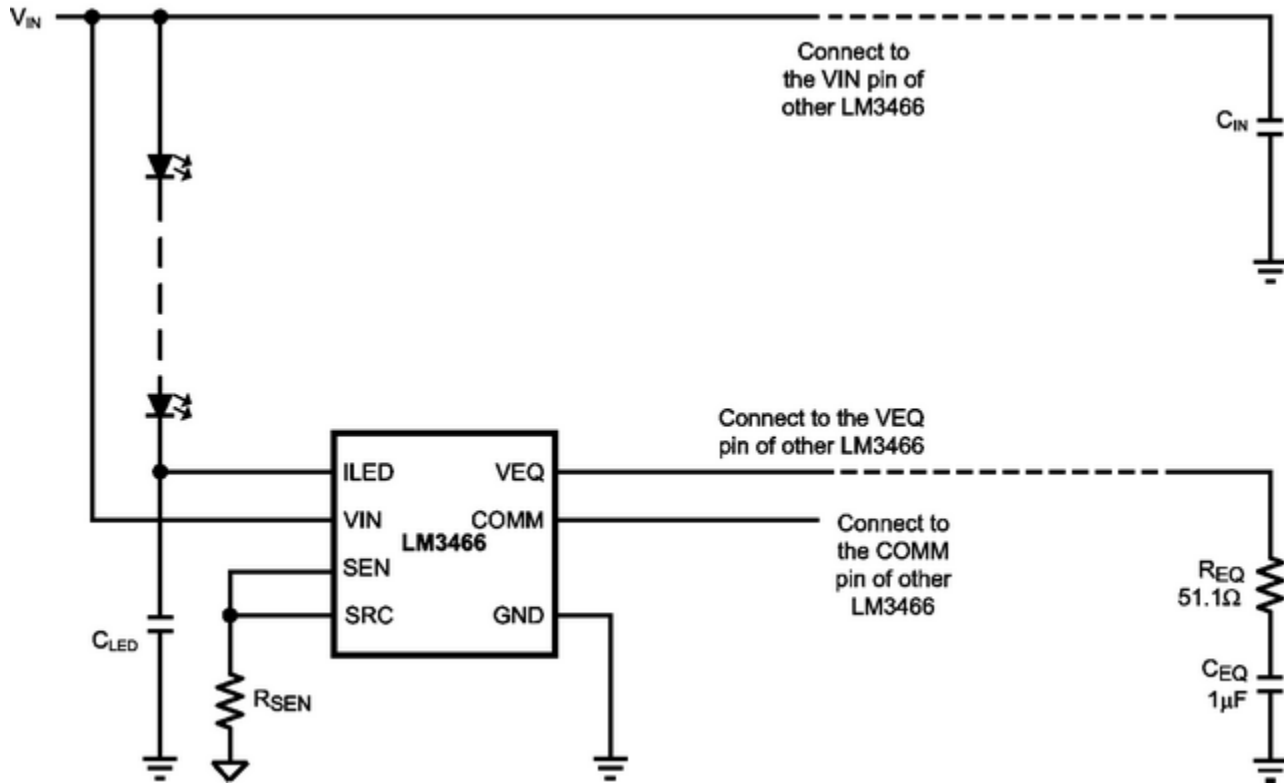
- LM3466 is a linear LED driver which acts like an intelligent ballast resistor.
- Each IC communicates with other IC's to equalize the current in each channel i.e., divides the current equally
- Application: high power fixture with multiple output channels and constant current power supply



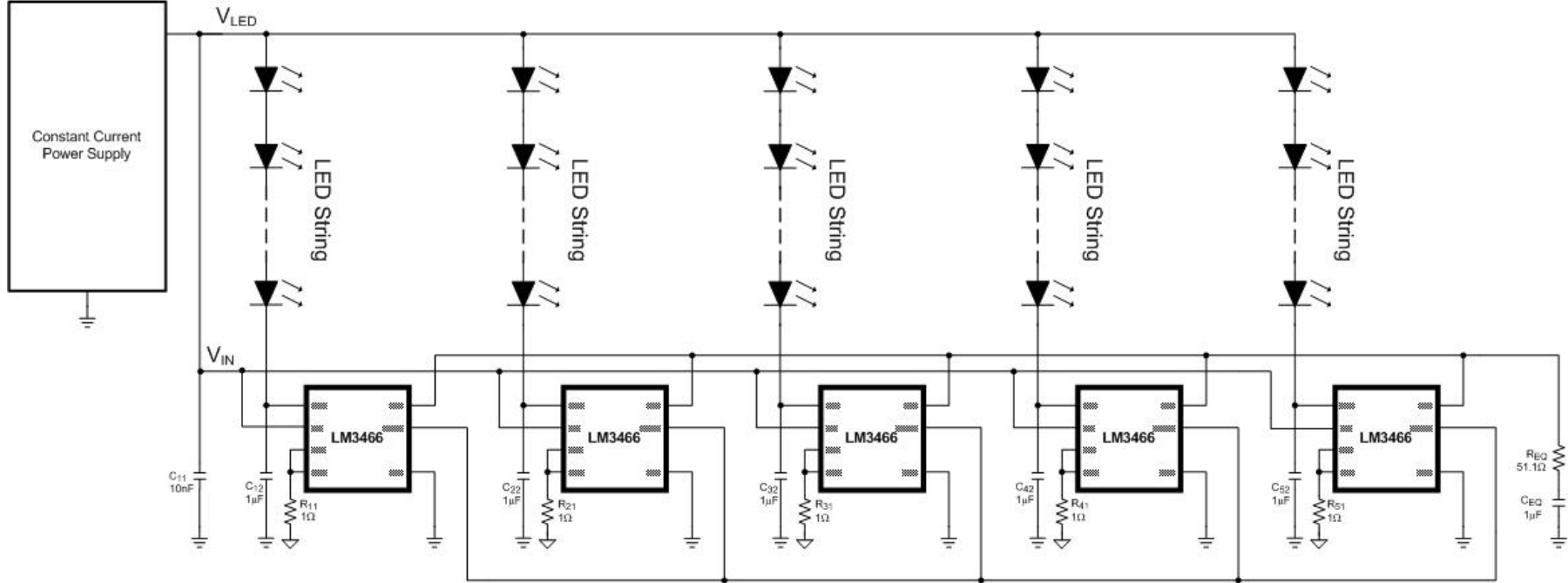
LM3466 Features

- Linear circuitry
 - No extra EMI
- Simple to use and design
 - Off-the-shelf constant current power supply + LM3466
- Wide input voltage range from 6V to 70V
 - Can extend >70V
- Flexible
 - The number of channel is not limited
 - To add 1 LED channel, just add 1 LM3466, 1 resistor, and 1 capacitors without further calculation required

LM3466 BUILDING BLOCK



TYPICAL APPLICATION



Thank you