2010 | TI Asia Technology Day

Light Your LED Effectively

_Texas Instruments LED Lighting Driver Solutions

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Texas Instruments

Agenda

- High Brightness LEDs for Lighting
- TI Solutions for General LED Lighting
- TI Solutions for LED Backlight TV Power Supply

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- High Brightness LEDs for Lighting
- TI Solutions for General LED Lighting
- TI LED Solutions for Backlight TV Power Supply

The Challenges of Efficient Lighting

60 W

850 lm

1.000 h

10W

~ 700 lm

~ 50.000h

6W

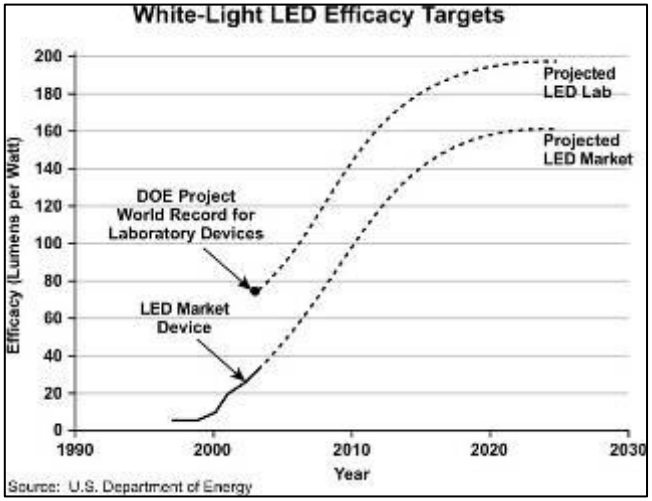
850 lm

50.000h

Engineering Challenges

- Cost
- Early Failures
- Color & Consistency
- Thermal Management
- EMI
- Dimming
- Timers
- Photo Sensors

Inspect every 6 mths

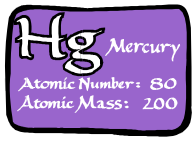


- White-light LED Efficacy just now approaching CFL's
- Driver CAGR 15% - Illumination CAGR >150%

LED Lighting Market Drivers

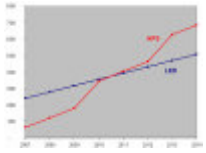
- The movement of the Green economy:
- High cost of energy

- Legislation is essentially banning incandescent lighting sources.
- Health and Environmental concerns



- Maintenance & reliability value proposition of LED lighting systems
- Total cost of ownership

- Performance Advancements of LED lighting systems



Lighting Technologies Comparison

Incandescent

- Very inexpensive
- Great color
- Very short lifetime
- Extremely inefficient

Fluorescent

- Inexpensive
- Efficient
- Contains mercury
- Difficult to dim/control
- Problems in cold temps

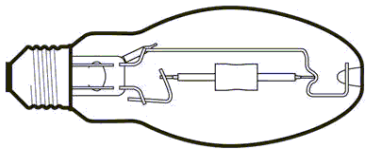
Compact Fluorescent

- Energy efficient
- Contains mercury
- High price vs. incand.
- Problems in cold temps

Halogen

- Great color
- Focused light
- Very short lifetime
- Inefficient

High Intensity Discharge



- Inexpensive
- Efficient
- Long start time
- Poor color

Light Emitting Diodes

- Energy Efficient
- Long Life
- Rugged
- No Heavy Metals
- Fast Start Time
- No UV/IR effects (in most cases)
- Directional Light
- Low Total Cost of Ownership
- Technology/Cost improvements
- Thermal Considerations
- Initial Fixture/Bulb Cost

Power Conversion – White Light Sources

Power Conversion for "White" Light Sources

	Incandescent† (60W)	Fluorescent† (Typical linear CW)	Metal Halide‡	LED*
Visible Light	8%	21%	27%	15-25% #
IR	73%	37%	17%	~ 0%
UV	0%	0%	19%	0%
Total Radiant Energy	81%	58%	63%	15-25%
Heat (Conduction + Convection)	19%	42%	37%	75-85%
Total	100%	100%	100%	100%

† IESNA Handbook ‡ Osram Sylvania

Source: US DOE - EERE

The conducted heat creates a heat removal problem not presented in traditional lighting technologies. This is typically achieved via metal heat sinks.

Agenda

- High Brightness LEDs for Lighting
- TI Solutions for General LED Lighting
- TI Solutions for LED Backlight TV Power Supply

LED General Illumination

Applications

LED Lighting

Residential	Commercial	Outdoor and Infrastructure
< 25W or 3,000 lm	15W – 75W or 1000 lm - 10000 lm	35W – 250W 2500 lm - 30,000 lm


MR16


E14


E27/A19


PAR38


Display Case


Retail Display


Architectural

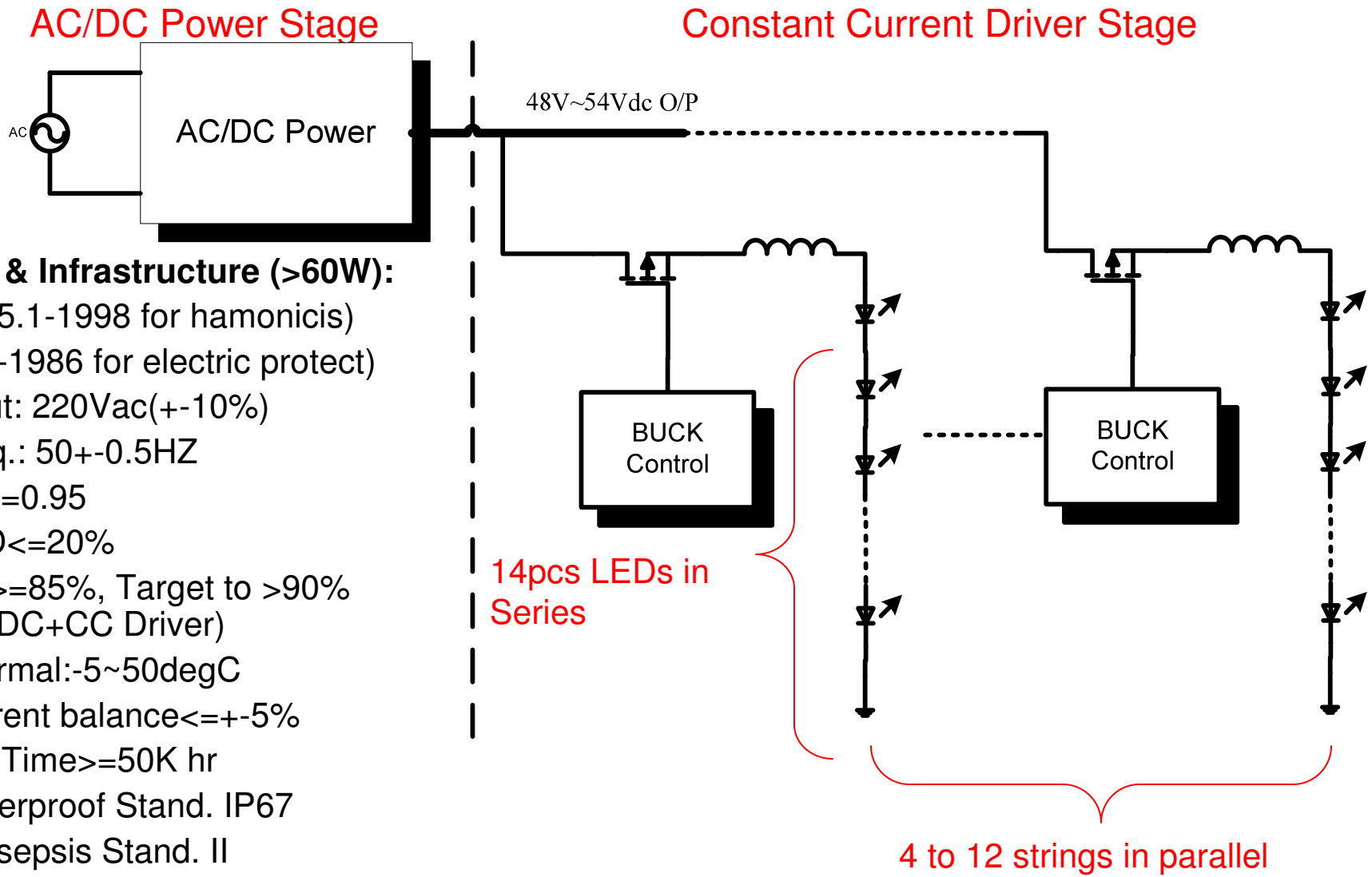

Street Light


Area Light


Flood Light

	Residential	Commercial	Outdoor and Infrastructure
Careabouts	**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**
Devices	TPS92010 TPS92210 TPS92001/2	UCC28810 UCC28811 TPS92020	UCC28810 UCC28811 TPS92020 UCC28061
Tools	TPS92010EVM-592 (110V) *TPS92010EVM-631 (230V)* TPS92210EVM-613	UCC28810EVM-002 UCC28810EVM-003	UCC28810EVM-003

LED Lighting Topology in China



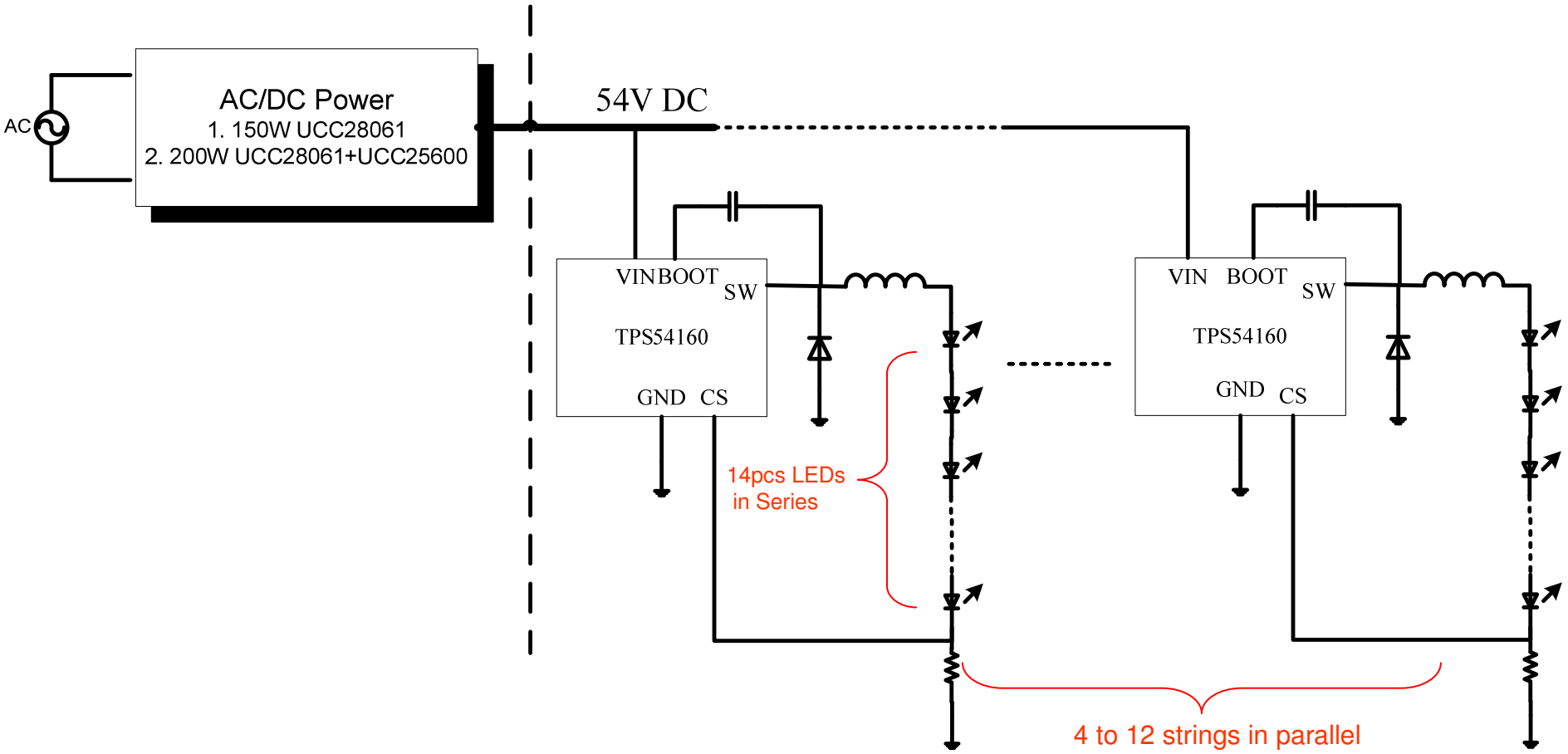
Outdoor & Infrastructure (>60W):

(GB17625.1-1998 for hamonicis)

(GB7001-1986 for electric protect)

- Input: 220Vac(+-10%)
- Freq.: 50+-0.5HZ
- PF>=0.95
- THD<=20%
- Eff.>=85%, Target to >90% (ACDC+CC Driver)
- Thermal:-5~50degC
- Current balance<=+-5%
- Life Time>=50K hr
- Waterproof Stand. IP67
- Antisepsis Stand. II

General Street LED Lighting Solution 1



TPS54160

3.5 to 60V Input 1.5A DC/DC Converter - SWIFT™

Features

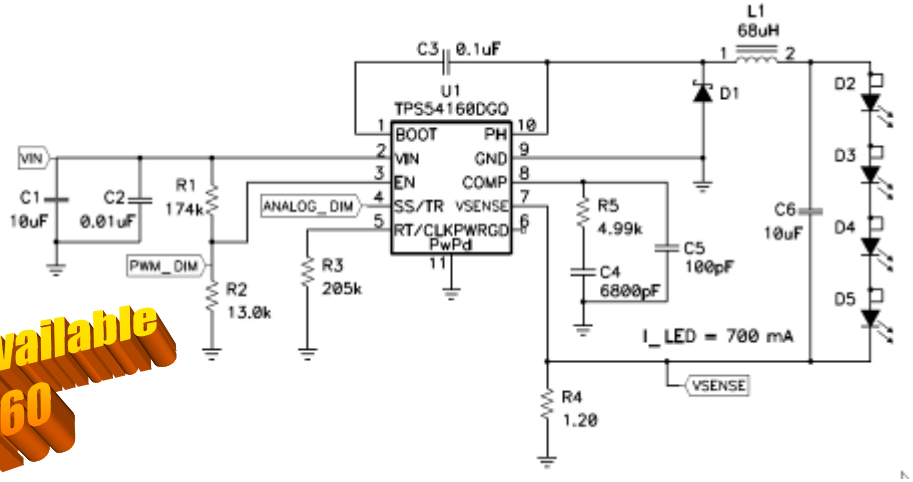
- Output Voltage Adjustable Down to 0.8V
- Integrated 200 mΩ High Side MOSFET
- Pulse Skipping Eco-Mode™ with 116uA Operating and 1.3uA Shutdown Current
- 300 kHz to 2.5 MHz Switching Frequency
- Synchronizes to External Clock
- Adjustable Slow Start Time
- PG, Enable, and Track Pin
- Adjustable UVLO
- Available in 10MSOP PowerPAD™ Package

Benefits

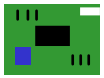
- Supports Low Output at 1% Initial Accuracy
- High Efficiency at Full 1.5-A Load Current
- High Efficiency under Light Load Conditions Extends Battery Life and Saves Energy
- Small Filter Size or Low Duty Cycle Support
- Eliminates Beat Noise
- Reduces Inrush Currents During Startup
- Easily Implement Sequencing Schemes
- Program Turn On Voltage Threshold
- Small Packaging Saves Space

Applications

- Aftermarket Automotive Accessories: Video, GPS, Entertainment
- 12V, 24V and 48V Industrial and Commercial Distributed Power Systems



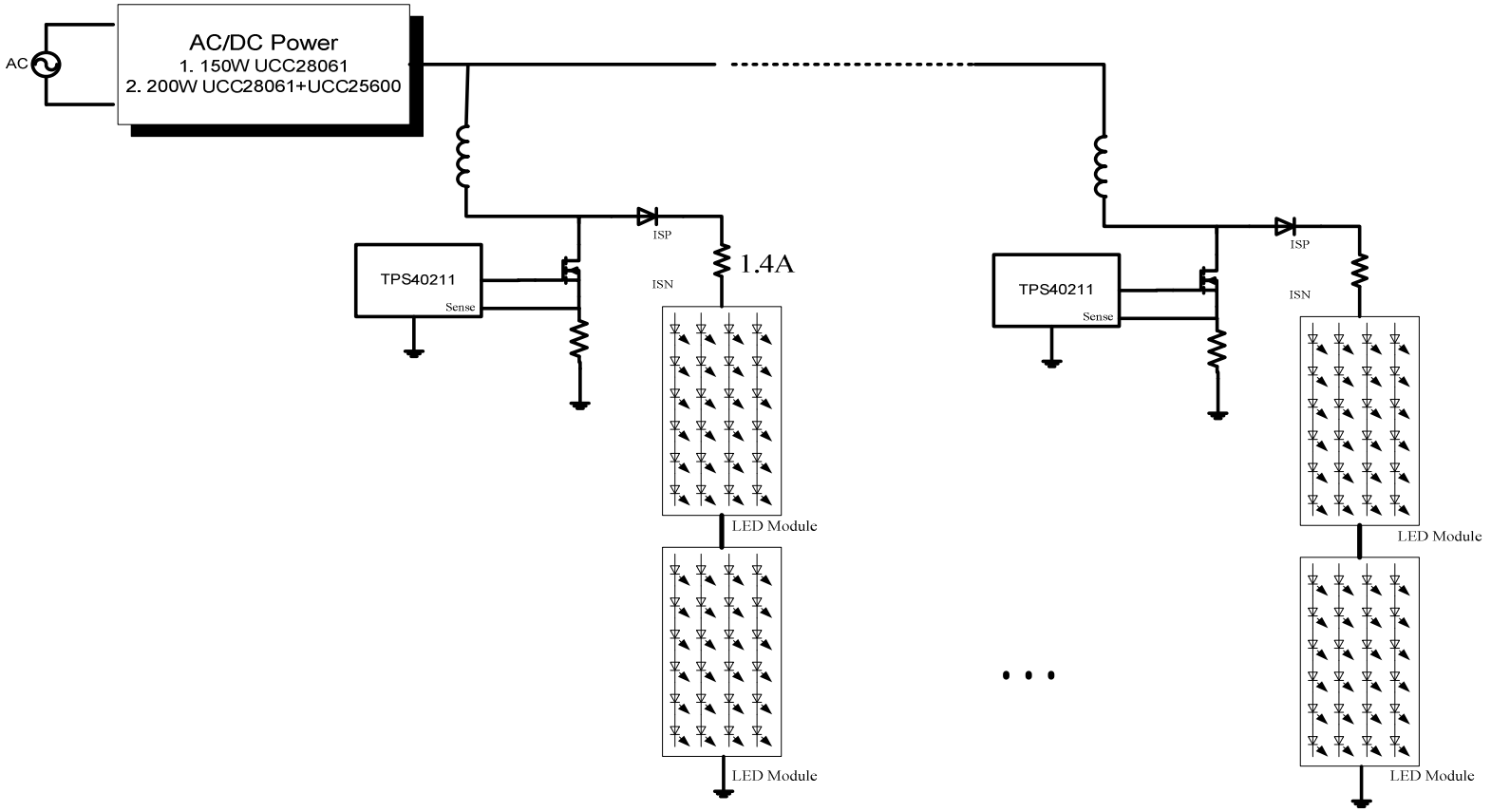
EVM/Tool



TPS54160EVM-535
Switcher-Pro Tool

2A Version Available
TPS54260

General Street LED Lighting Solution 2



TPS40211

Fixed-Frequency Current-Mode Controller for Boost, Flyback and SEPIC

Features

- Wide Input Operating Voltage: 4.5 V to 52 V
- Programmable Switching Frequency
  - 35k to 1MHz
- Frequency Synchronization
  - (requires external components)
- Closed Loop Soft Start
- 260mV Voltage Reference
- Internal Under-Voltage Lockout
  - 300mV Hysteresis
- Integrated Low Side Driver
- Programmable Over-current Protection

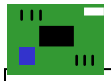
Benefits

- Allows designs up to 14 LEDs in series
- Flexible Filter Design
- Allow to syn. off a system clock
- Prevents inrush current
- Enables use of small I_{SENSE} resistors with lower power dissipation
- Design and implementation flexibility
- Fewer external components
- Protects the device upon string short

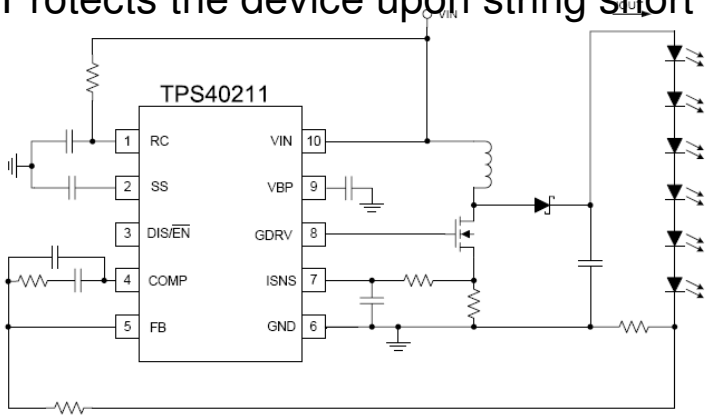
Applications

- High-Current LED Drivers
- LED Lighting Solutions
- LED Backlighting

EVM/Tool



TPS40211EVM-352



TLC5960 Intelligent 8 channels linear LED Driver with Headroom Voltage Monitor

Features

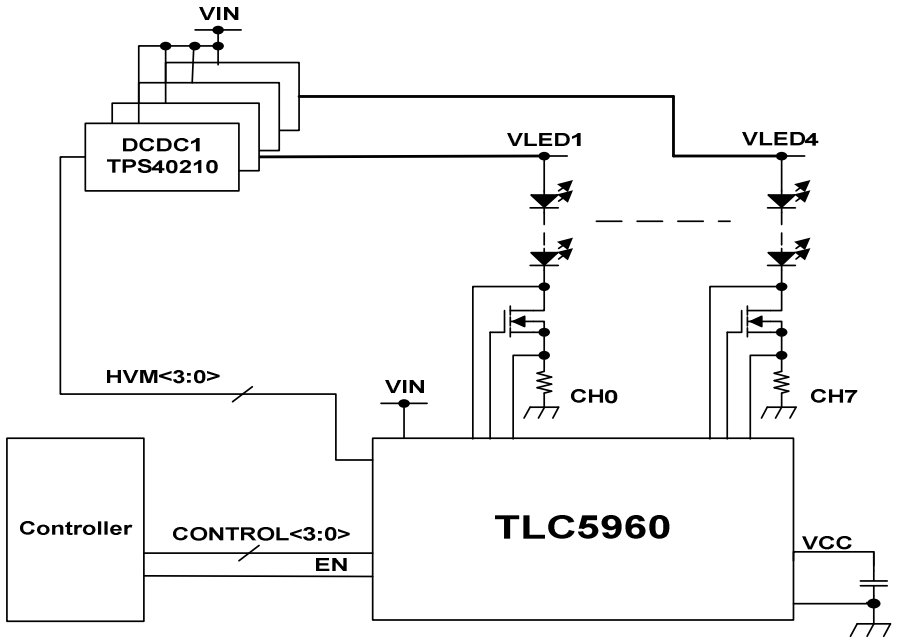
- 8 Channel External FET Control
- 38V Abs. Max Voltage Sensing
- 24V Operating Voltage, 30V Abs. Max VIN
- Integrated LDO
- Integrated Under Voltage Lock Out (UVLO)
- Four Headroom Voltage Monitor Feedbacks (HVM)
- LED/FET Open Protection, FET Short Protection
- Thermal Shutdown Protection
- Min. 5uS resolution PWM gate control
- TLC5960/61 (PWM Control/ Serial Interface ON/OFF)
- 38 pin TSSOP Package 

Applications

- LED Backlight
- LED Signage
- Architectural Lighting

Benefits

- 4 head room voltage monitor feedbacks, FET controller for lower power dissipation on board
- Robustness; Full system diagnosis capability: LED/FET Open and FET Short Detection

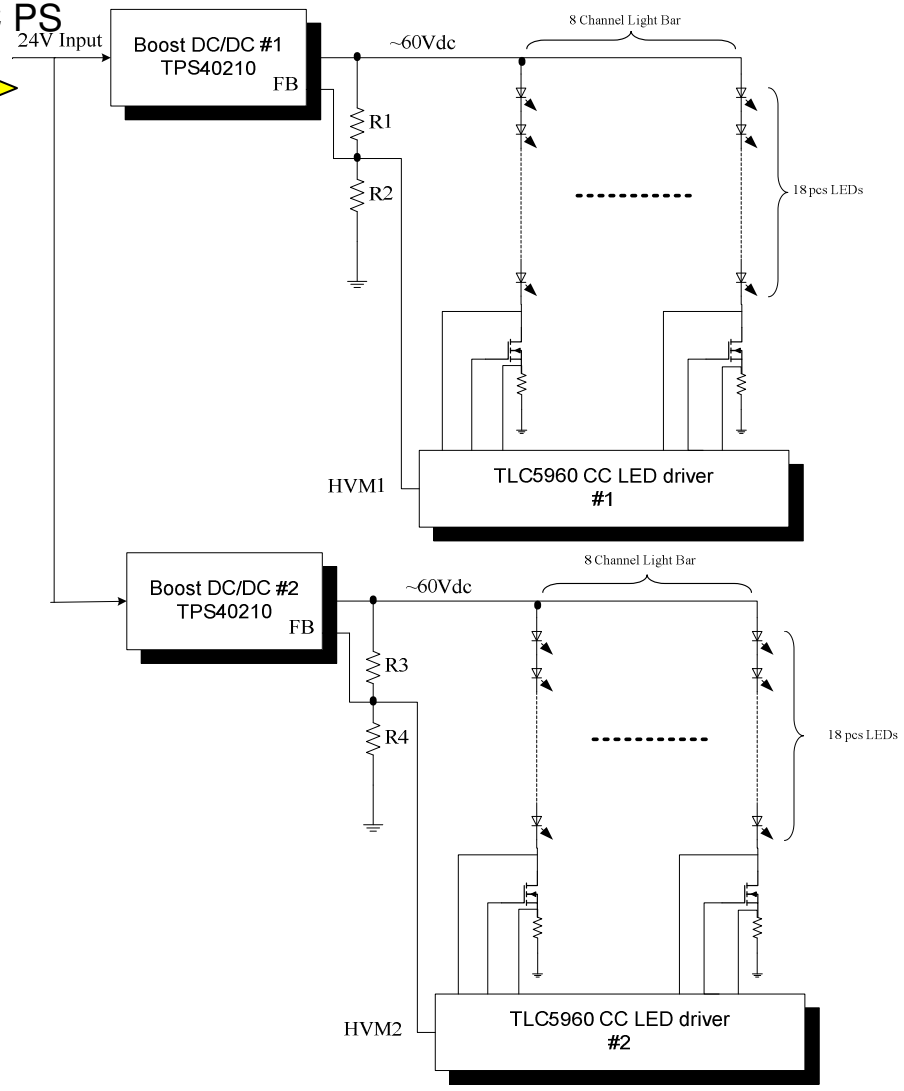


White LED Intelligent Linear Constant Current Driver

24V Input from Ultra-slim AC/DC PS

Detail Specification:

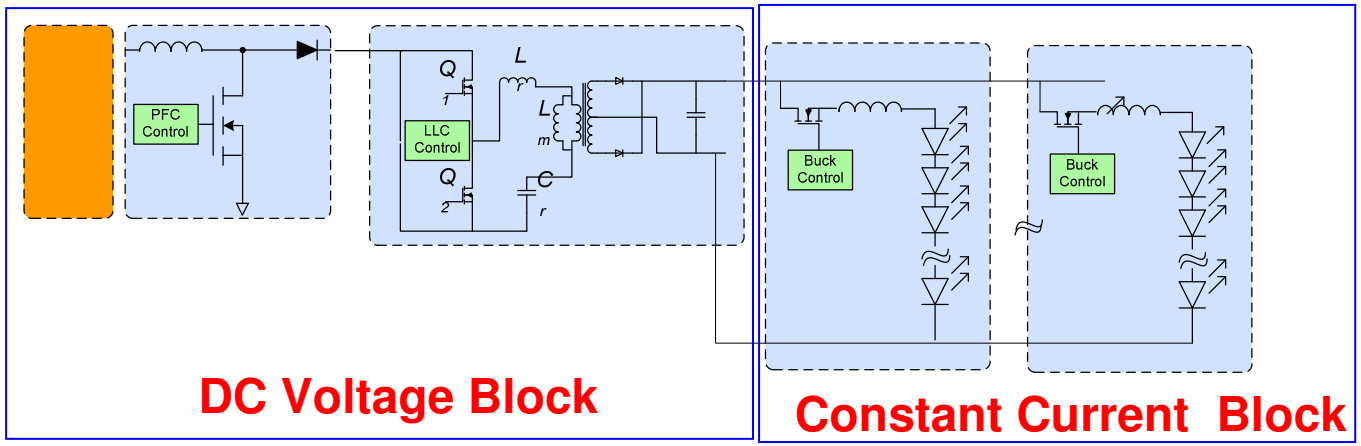
- Input: 24Vdc
- Power Output: LED strings: 16 channel x~60V with 18pcs 120mA LED per string
- PCB board specs 2 Layer PCB X-Y dimensions (max) - 10"x10" Height (max) - 10mm (not including PCB thickness)
- Dimming range- 1-100%
- LED current matching spec - <3% for full dimming range
- LED Protection (short, open, over current, under current, under voltage etc.)
- Operating temperature: 0degC ~ 50DegC and storage temperature: -20degC ~80DegC



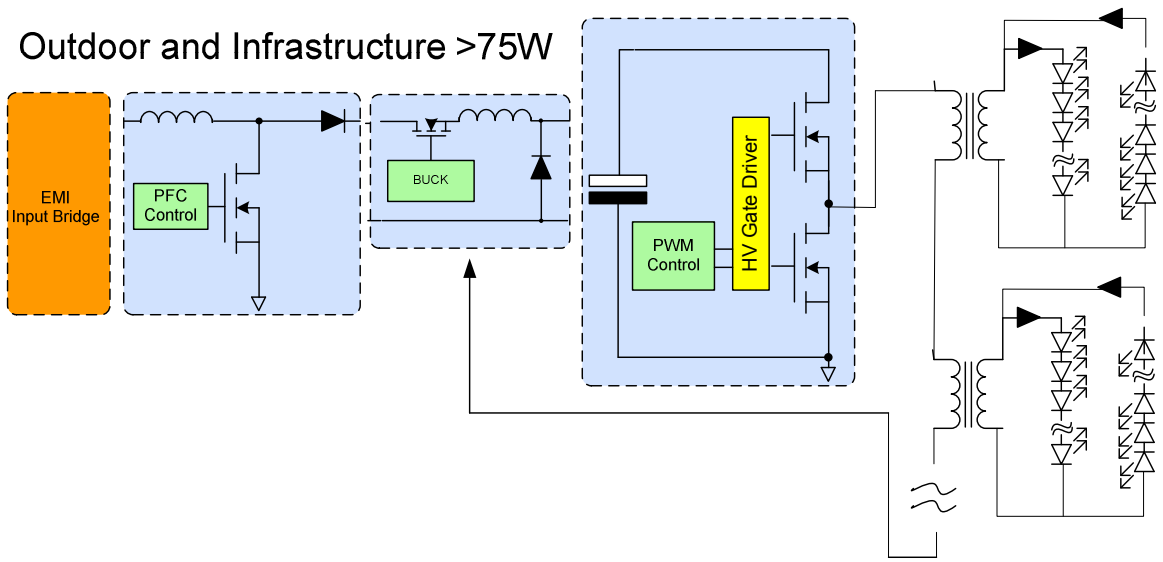
LED Lighting Block Diagrams

Outdoor & Infrastructure

Outdoor and Industrial >60W



Outdoor and Infrastructure >75W



Typical Controllers

UCC25600

UCC28061

UCC28810

UCC28811

Constant Current:

TPS54160

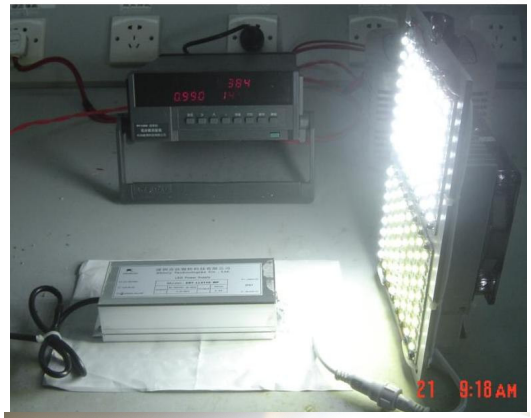
TPS40211

TLC5960

DRV9812+MSP430

AC input 150W Single stage AC/DC for street LED lighting

Reference Design	TI Parts	V_{in}	Po	Vo	Topology	Eff.	PF
AC Input UCC28061 single stage AC/DC LED lighting power supply	UCC28061	90-264 Vac	150 W	48V or 54V	Single Stage Interleaved QR-Flyback with power factor correction	>90%	>0.95



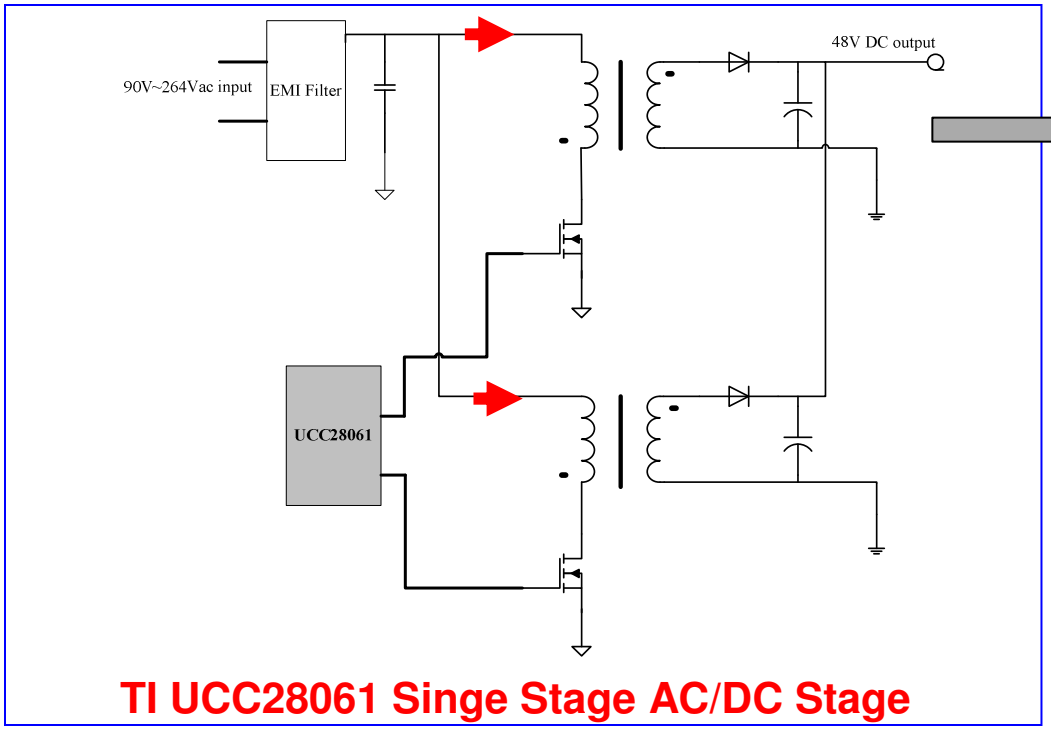
Features

- Single stage with high PF>0.95, THD<20%
- Low cost for LED lighting AC/DC stage
- No 450V bulk capacitor with high reliability and long life time
- Interleaved QR-Flyback with ripple cancellation
- Single chip solution and easy design
- High efficiency >90%
- Low inrush current
- Turn key Solutions

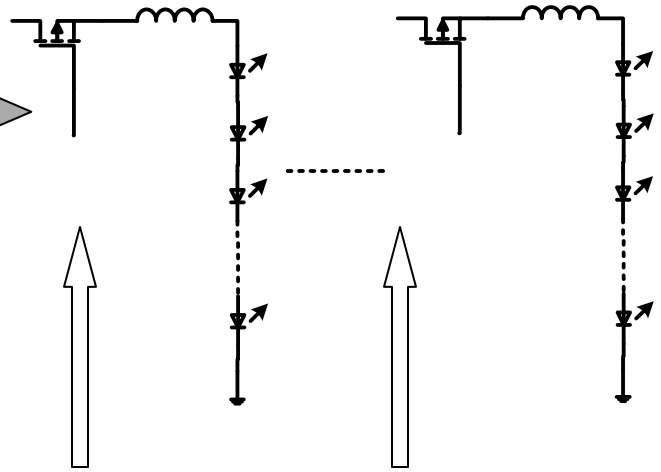
Applications

- Street & Roadway LED Lighting

AC Input 150W Street LED Lighting Block Diagram



TI UCC28061 Singe Stage AC/DC Stage



TPS54160 CC LED Driver

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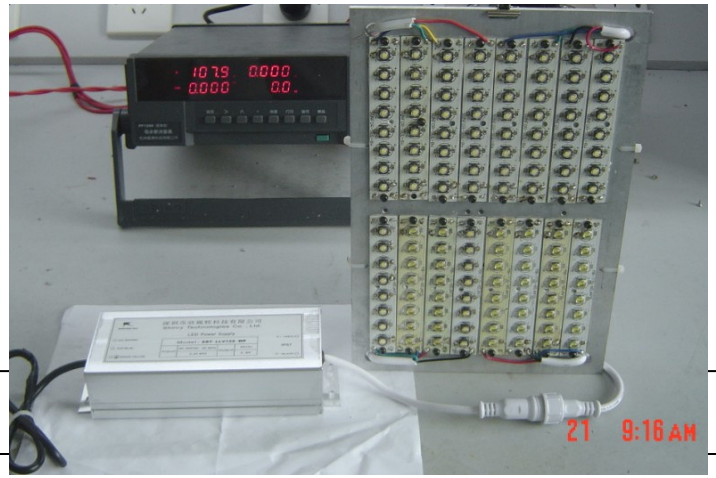
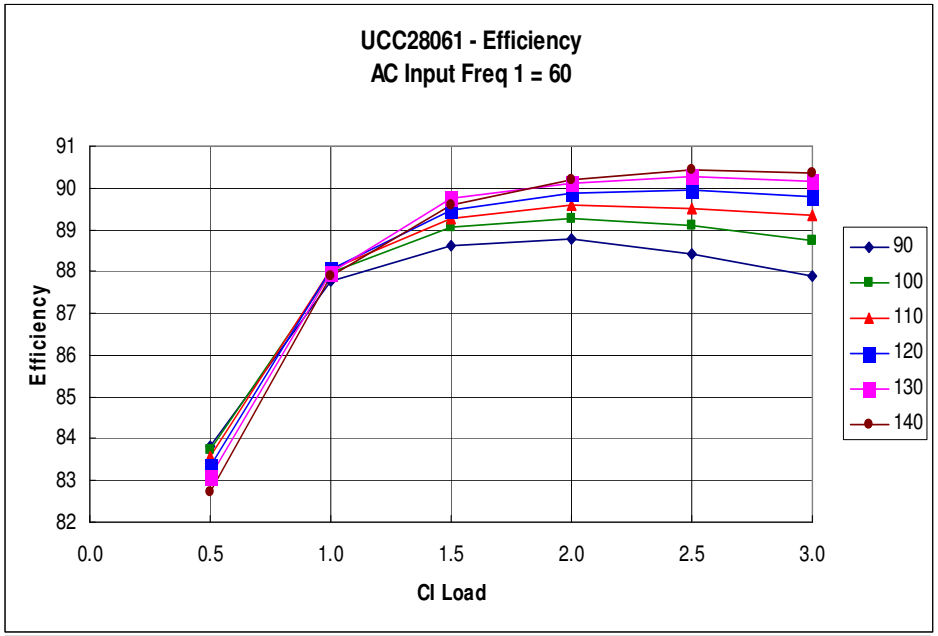
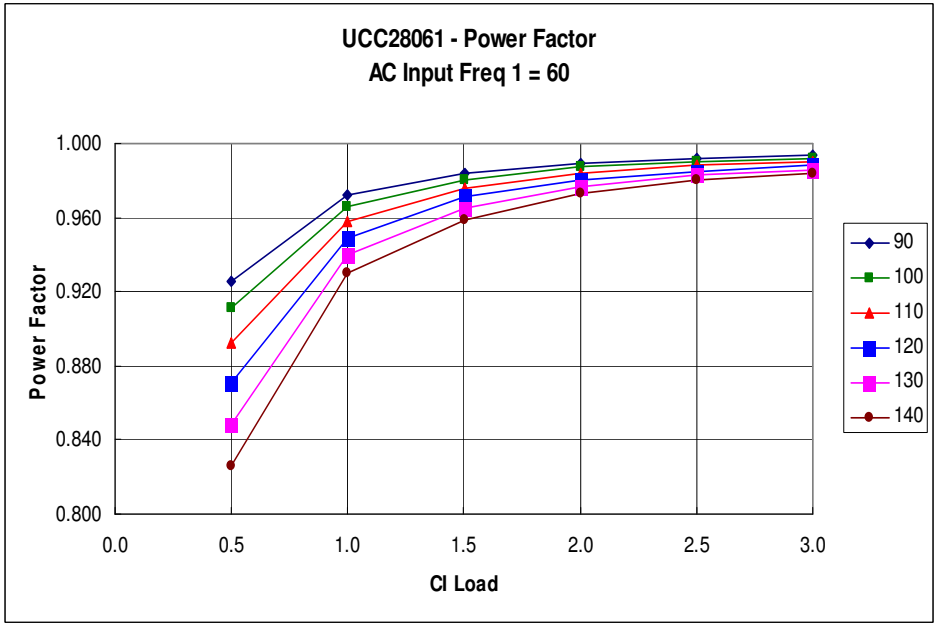
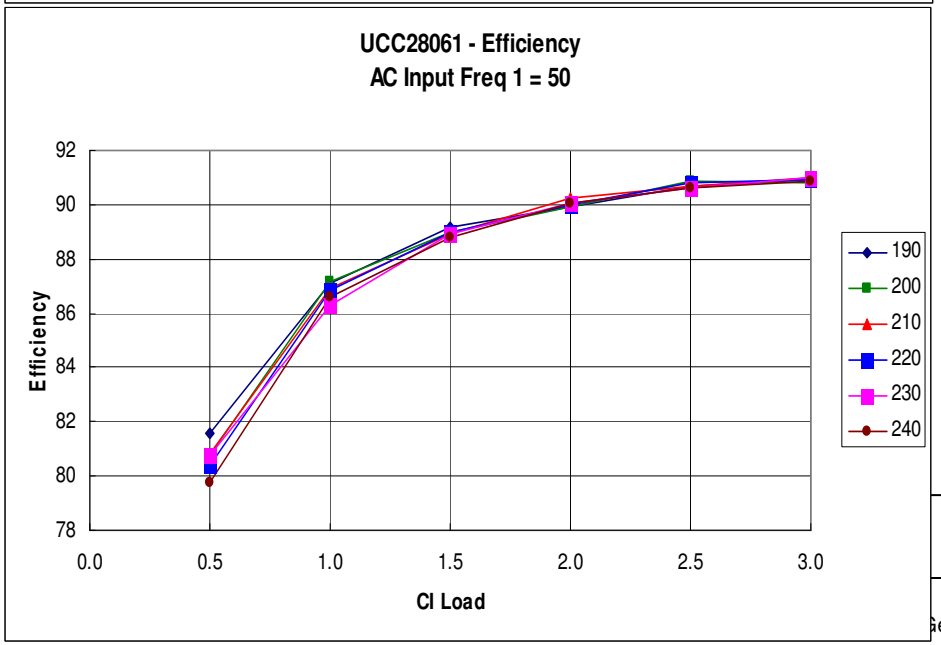
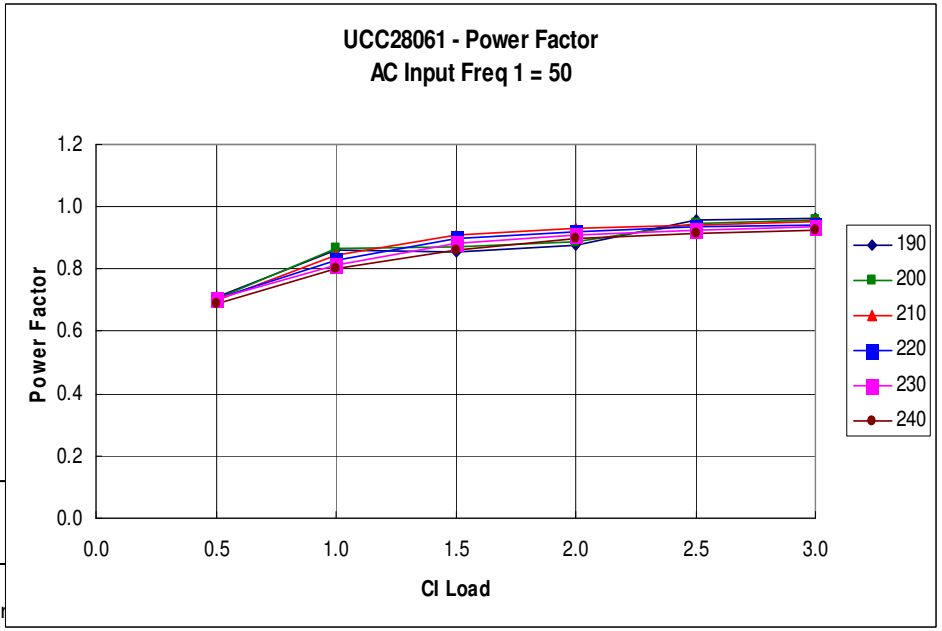


AC Input 150W Street LED Lighting
Test Report

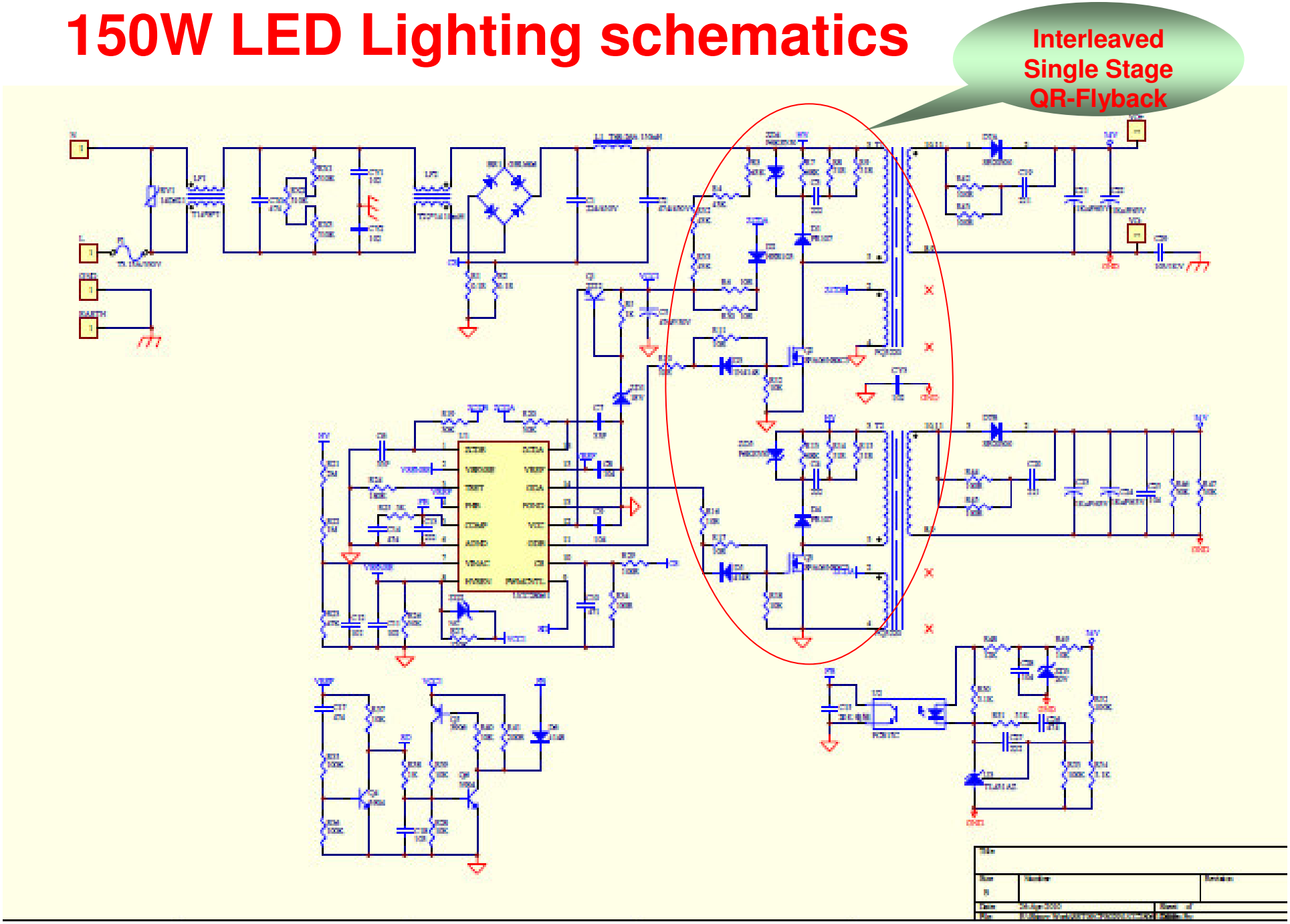






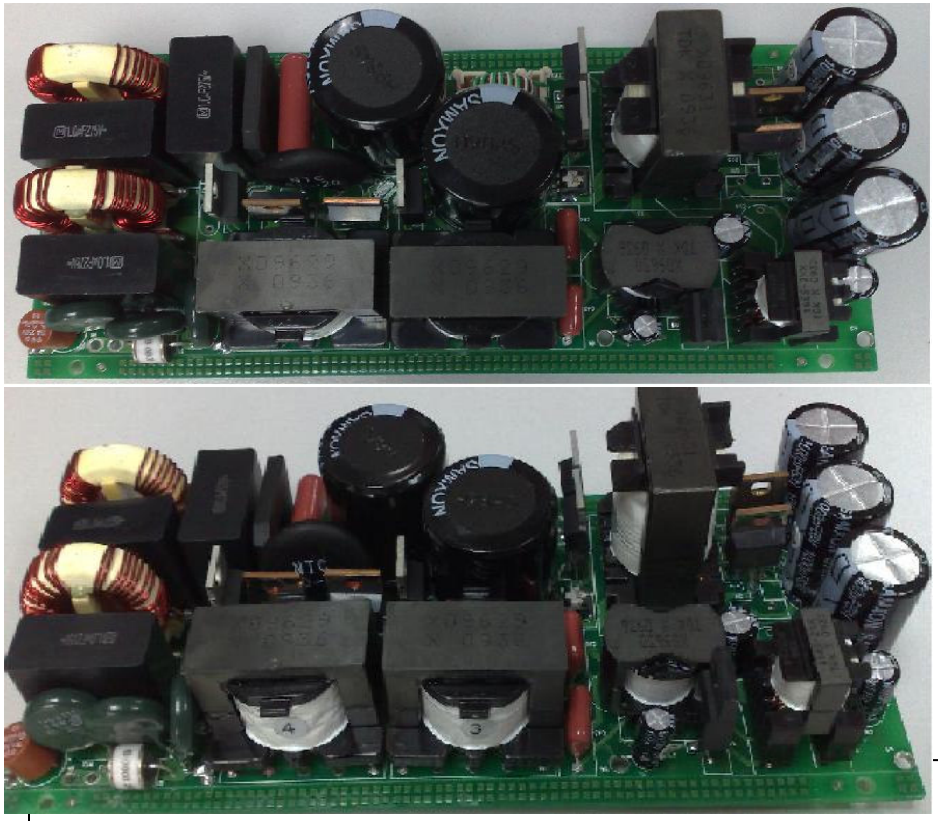


150W LED Lighting schematics



AC Input 200W Two Stage AC/DC for Street LED Lighting

Reference Design	TI Parts	V_{in}	Po	Vo Io	Topology	Eff.	PF
AC Input 200W AC/DC Power supply for Street LED lighting	UCC28061 UCC25600 UCC3813	90-305 Vac	200W	54V 3.7A	Interleaved TM PFC+ LLC control with high eff.	>93%	>0.95



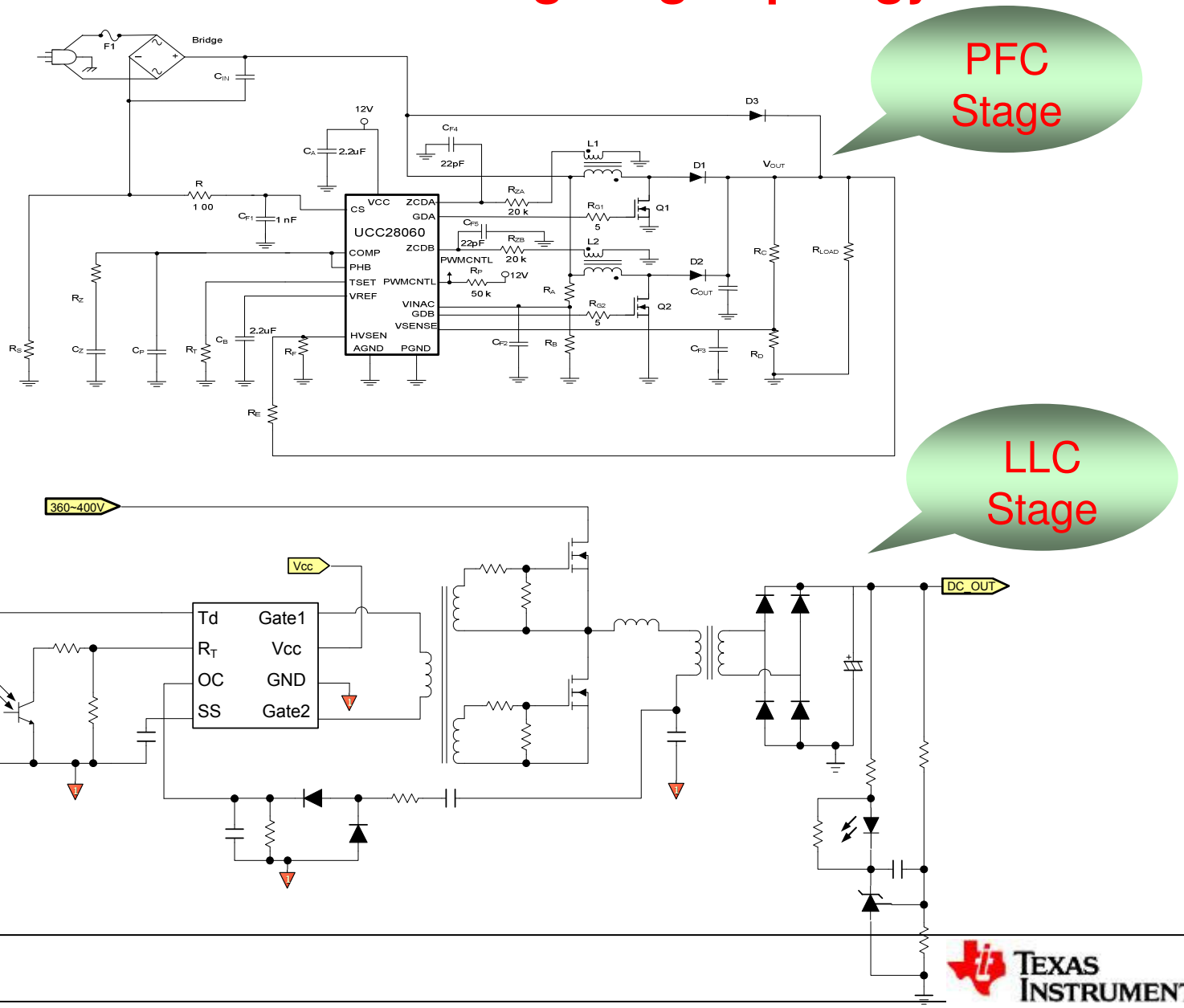
Features

- Interleaved TM PFC + LLC control with high efficiency>93%
- Safety UL8750
- PCB size: 168mm * 65mm *37mm

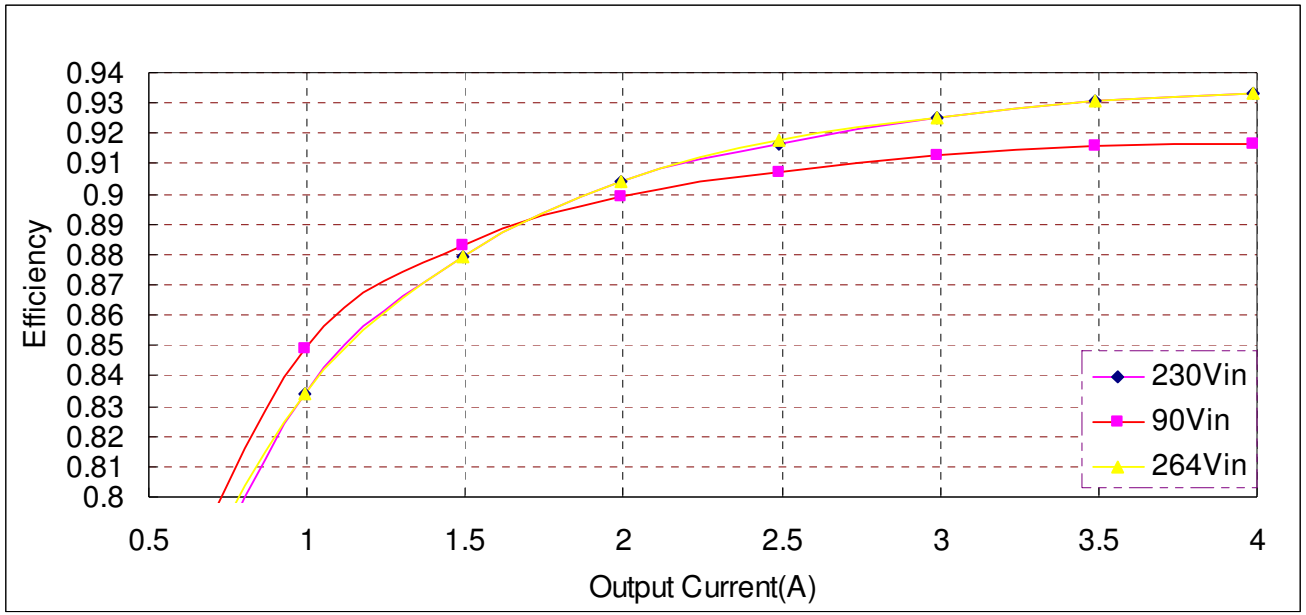
Applications

- High Way LED Lighting
- High Bay Industrial LED Lighting

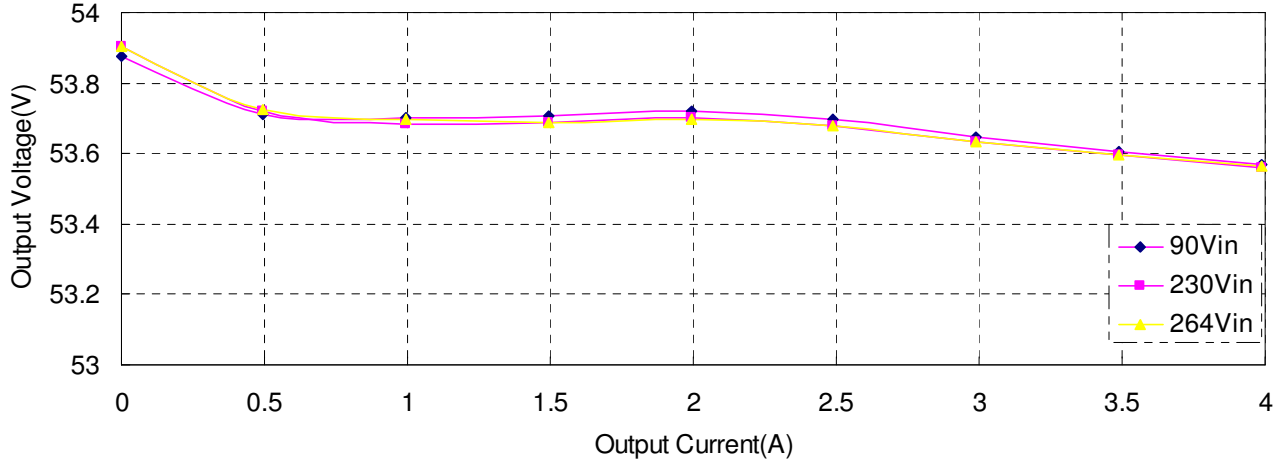
200W AC/DC for Street LED Lighting Topology



200W AC/DC for Street LED Lighting Test Report



Efficiency

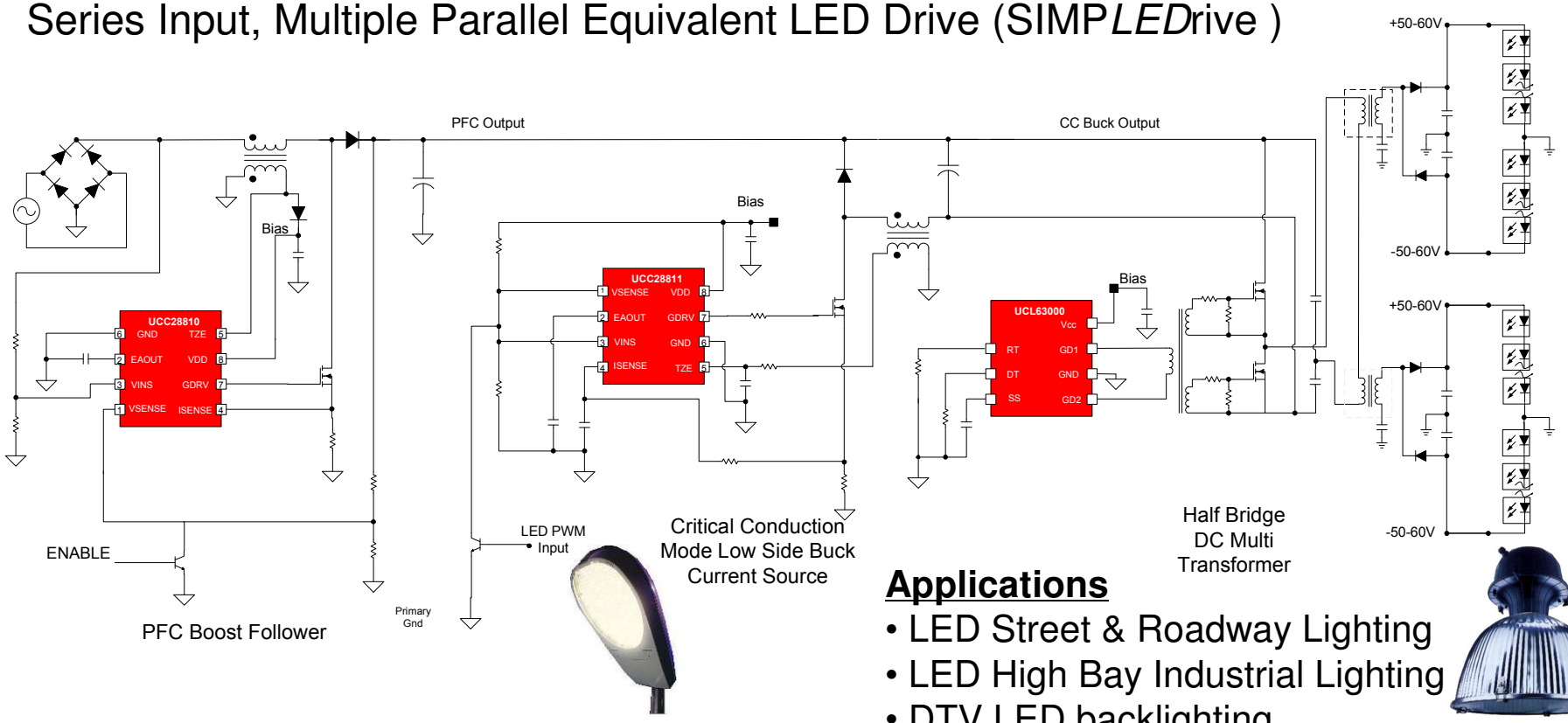


Load regulation

UCC28810 EVM003 - SIMP*LED*rive

Description	Parts	Vin (AC) Range	Vout (DC) Range	# of LEDs	Iout max.	Pout (max)	Eff.	PFC	ISO	Dimming In	Dimming Out	Contact	EVM
UCC28810 EVM003 100W Isolated Multi-string LED lighting driver w/ multiple tranformers	UCC28810 UCC28811 UCC25600	90 265	22 60V	4X (7-15)	500 mA	100W	91%	Y	Y	PWM	PWM	Jim Aliberti	Nov-09

Series Input, Multiple Parallel Equivalent LED Drive (SIMP*LED*rive)

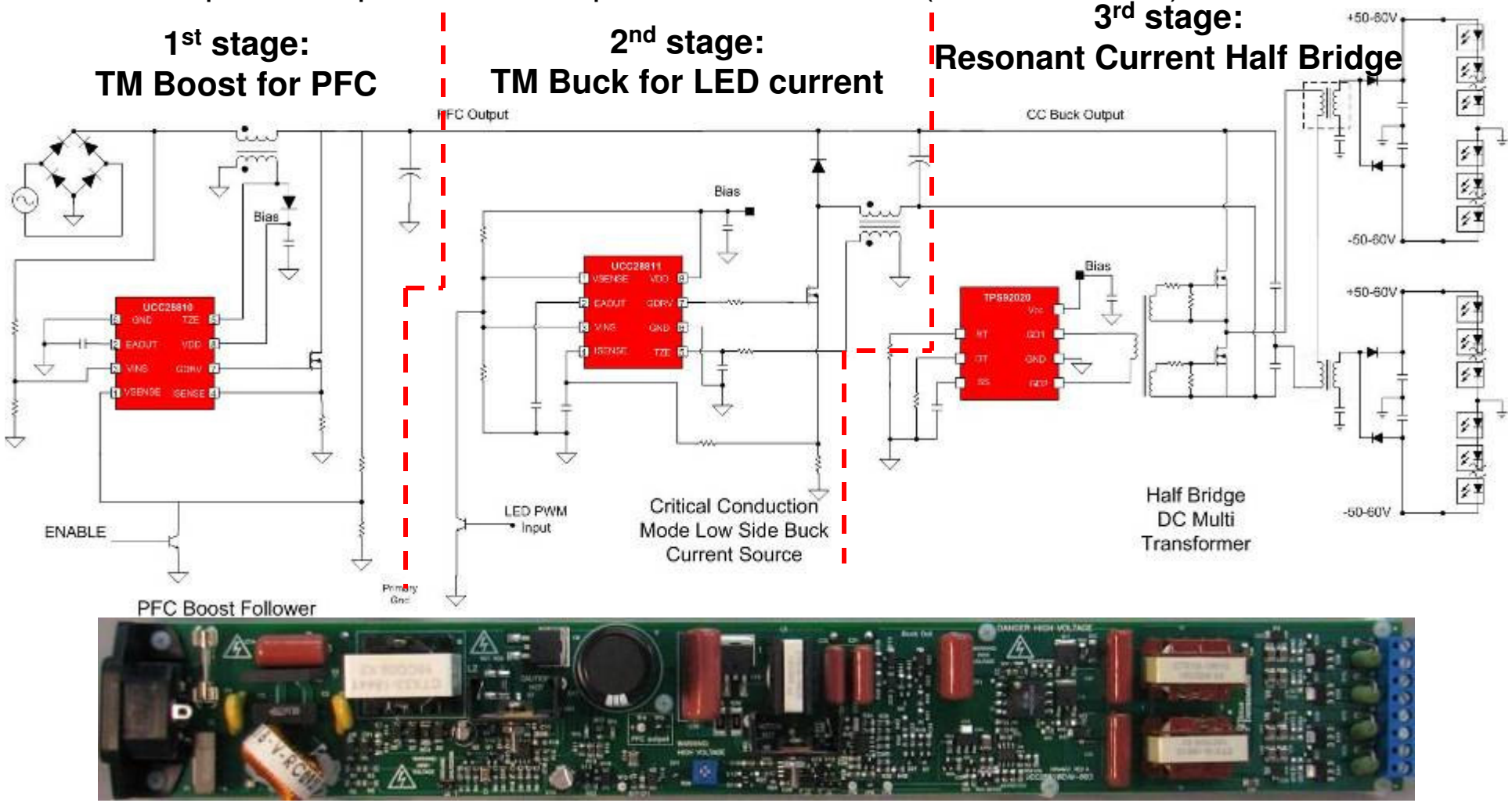


Applications

- LED Street & Roadway Lighting
- LED High Bay Industrial Lighting
- DTV LED backlighting

UCC28810EVM-003 - SIMP*LED*rive™

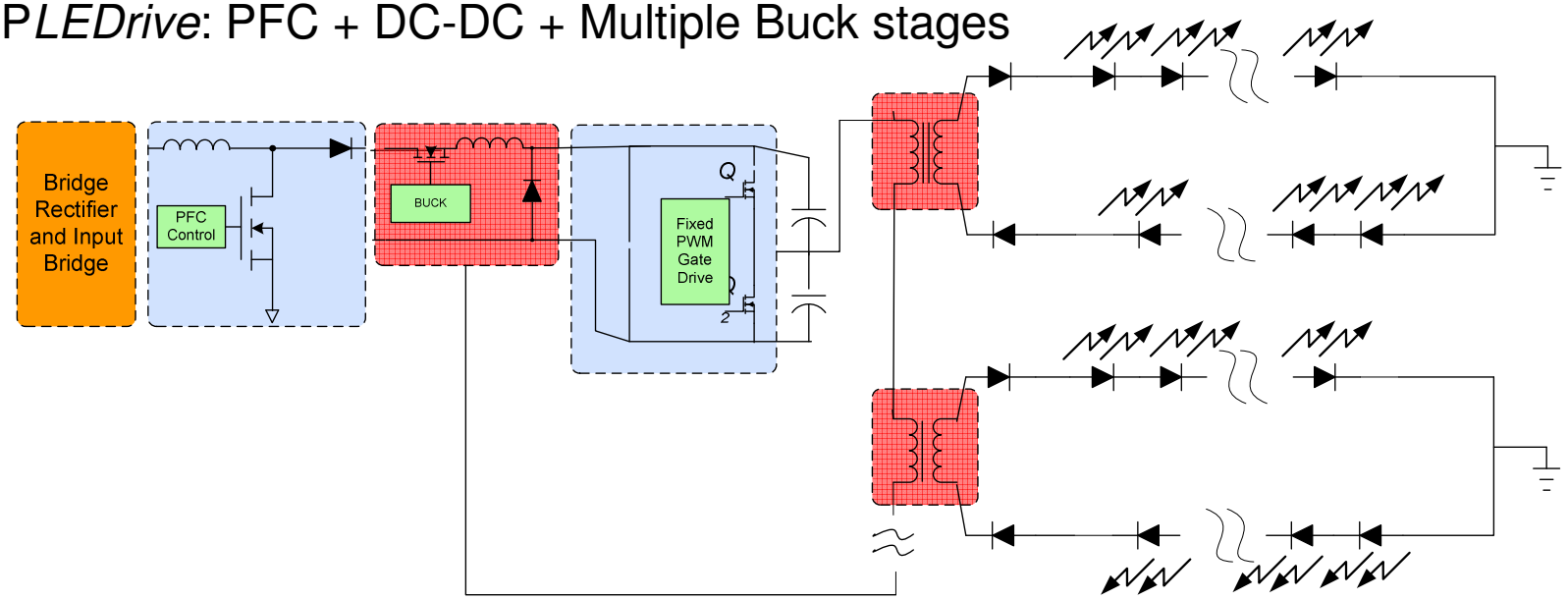
Series Input, Multiple Parallel Equivalent LED Drive (SIMP*LED*rive)



http://focus.ti.com/docs/toolsw/folders/print/ucc28810evm-003.html

High Light Output Drivers – PFC + Buck + Multiple

SIMP*LEDrive*: PFC + DC-DC + Multiple Buck stages



PFC Stage	- Required in any implementation
Low Side Buck	- Provides constant LED Current and main control
Series Transformers	- Provides constant current to each LED string

Benefit:

- One control section for all string currents,
- lower part count, higher reliability and lower cost

Drawback:

- All strings will be dimmed simultaneously (if individual dimming is required)

UCC28810EVM-003 Specification

Specification	Value	Unit
LED configuration	4 x 15	
Input Voltage	90 to 264	VAC
Efficiency	90	%
Power	100	W
Power Factor	0.97	
Output Voltage	54.5	VDC
Output Current	500	mA
LF Output Ripple	0	mVpp
Isolation	Yes	

Specification	Value	Unit
Dimming Input	PWM	
Dimming Level	10 to 100	%
Current Sensing	Res	
Temp. Range	-20 to 80	^{o}C
Lifetime*	40,000	Hrs
EMC Regulation	No	
Safety Regulation	Yes**	
Driver Dimensions	370 x 51	mm

Note: *Lifetime assumes 35^{o}C internal temp. rise from ambient.

** Designed with reinforced isolation to UL60950 but not certified

UCC28810EVM-003 Design Tool

SIMP*LED* rive Isolated LED driver

Input user values in green cells. Schematics and BoM's can be found on subsequent work sheets

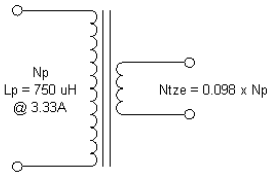
DESIGN REQUIREMENTS		
INPUT SPECIFICATIONS		
Minimum input voltage	90	Vrms
Maximum input voltage	265	Vrms
Minimum line frequency	47	Hz
LED LOAD SPECIFICATIONS		
LED maximum voltage drop	3.99	Vdc
LED nominal voltage drop	3.5	Vdc
LED minimum voltage drop	3.1	Vdc
LED operating current	0.8	A
Number of LED's	30	
DESIGN ASSUMPTIONS		
PFC Stage		
Minimum PFC switching frequency	22	kHz
Over ride Buck min input	Yes	
PFC Min Output	240	V
Enter a voltage between 158V and 400V		
Buck Stage		
Buck Min switching frequency	80	kHz

USER SELECTED COMPONENT PARAMETERS			
PFC Inductor, L2			
	Target	Actual	
L2 Inductance at Peak Bias Current	815	750	uH
Turns ratio, np = 1, ntze =	> 0.096	0.098	
PFC Current Sense, R20, R21			
Target value for R20	0.463	Ohm	
Minimum power rating for R20	0.54	W	

Core selection and winding configuration to be determined by magnetics manufacturer

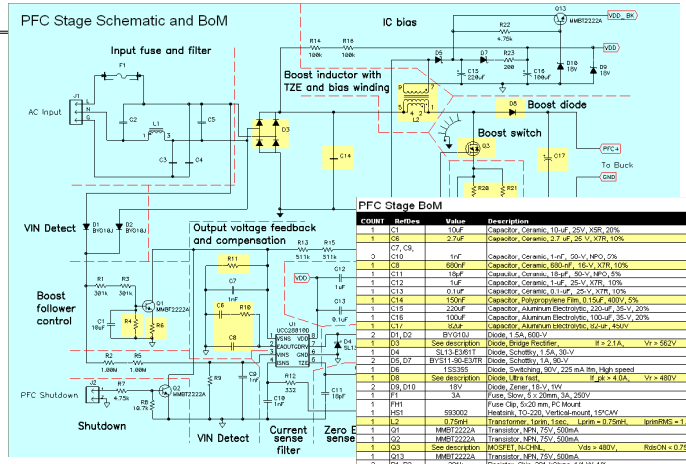
Boost PFC Inductor

Topology:	Boost	
Switching frequency	23.9	kHz
Maximum volt x microseconds	2501	Vus
Energy Storage	4.17E-03	J
Primary Peak current:	3.33	A
Primary RMS current	1.48	A
Secondary RMS current	0.5	A
Primary Inductance	750	uH
Primary to secondary turns ratio	0.098	



Buck Inductor

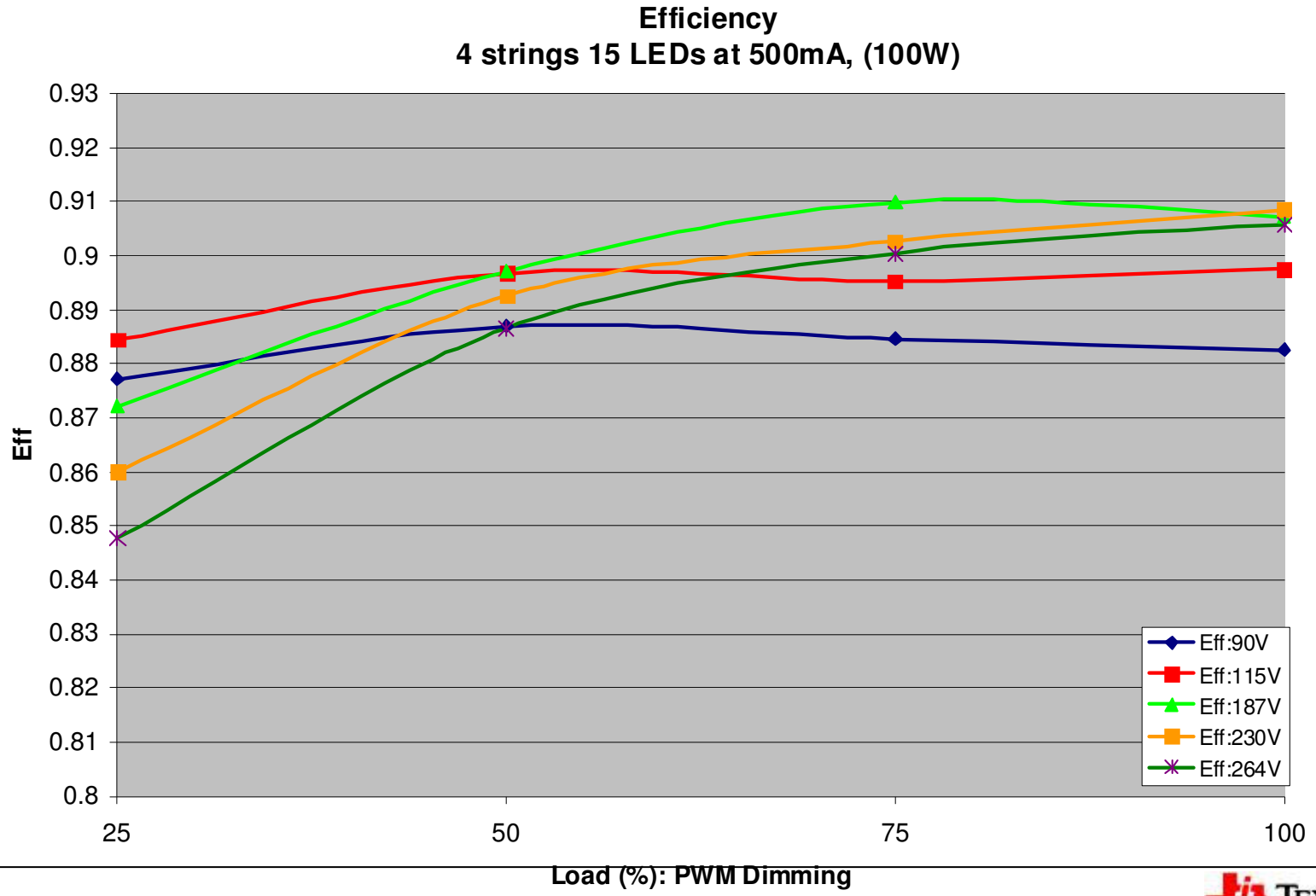
Topology:	Buck	
Switching frequency	89.7	kHz
Maximum volt x microseconds	640	Vus
Energy Storage	7.37E-04	J
Primary Peak current:	1.92	A
Primary DC current	0.80	A
Secondary RMS current	0.01	A
Primary Inductance	400	uH
Primary to secondary turns ratio	0.083	



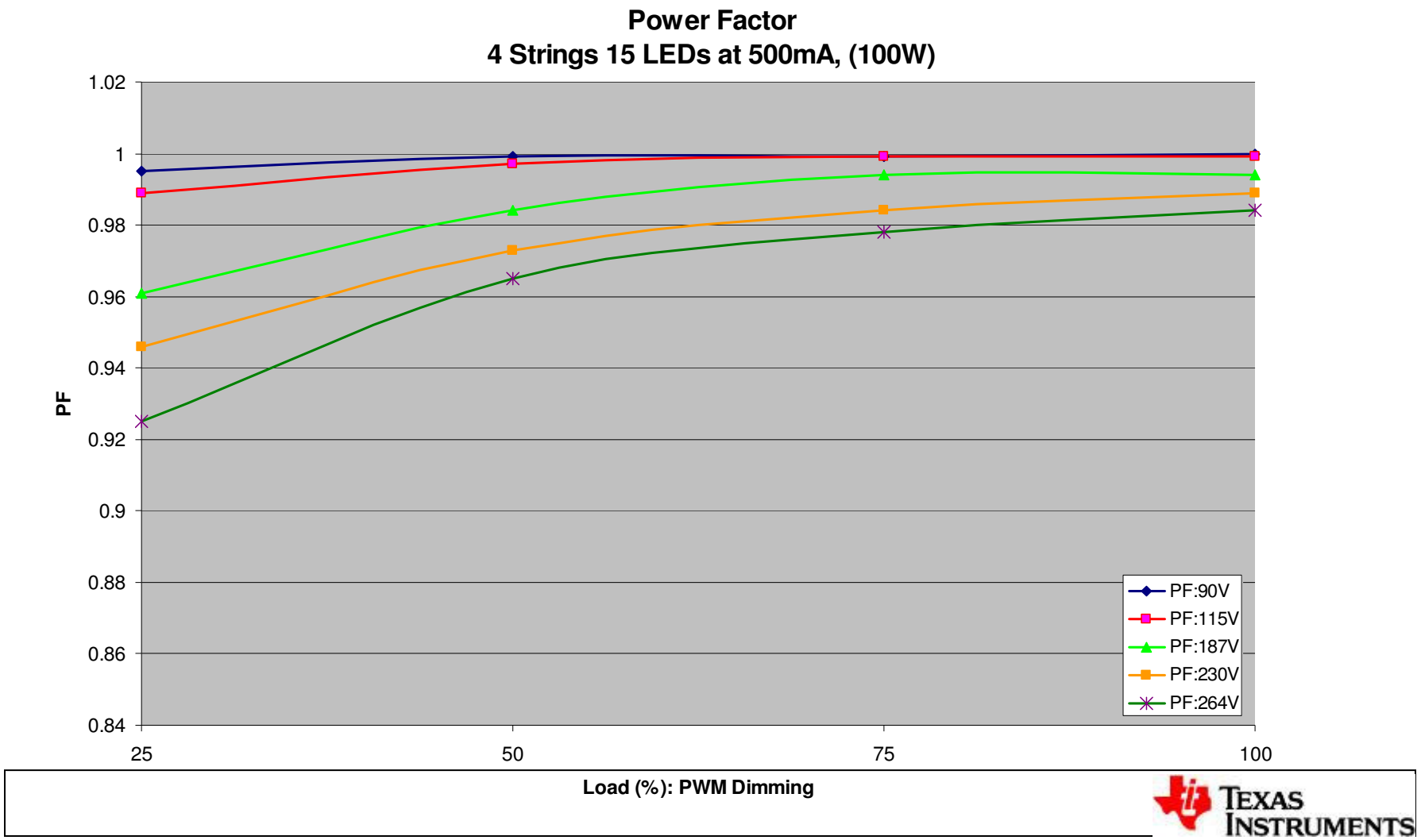
PFC Stage BoM

COUNT	RefDes	Value	Description	Size	Part Number	MFR	Comment
1	C1	10uF	Capacitor, Ceramic, 10-uF, 25V, X5R, 20%	1206	Std	Std	
1	C6	2.7uF	Capacitor, Ceramic, 2.7 uF, 25 V, X7R, 10%	0805	Std	Std	
0	C7, C9, C10	1nF	Capacitor, Ceramic, 1-nF, 50-V, NPO, 5%	0805	Std	Std	
1	C8	680nF	Capacitor, Ceramic, 680-nF, 16-V, X7R, 10%	0805	Std	Std	
1	C11	18pF	Capacitor, Ceramic, 18-pF, 50-V, NPO, 5%	1206	Std	Std	
1	C12	1uF	Capacitor, Ceramic, 1-uF, 25-V, X7R, 10%	0805	Std	Std	
1	C13	0.1uF	Capacitor, Ceramic, 0.1-uF, 25-V, X7R, 10%	0805	Std	Std	
1	C14	150nF	Capacitor, Polypropylene Film, 0.15uF, 400V, 5%		EOW- family	Panasonic	
1	C15	220uF	Capacitor, Aluminum Electrolytic, 220-uF, 35-V, 20%	8mm x 11.5mm	Std	Std	
1	C16	100uF	Capacitor, Aluminum Electrolytic, 100-uF, 35-V, 20%	6.3mm x 11.5mm	Std	Std	
1	C17	82uF	Capacitor, Aluminum Electrolytic, 82-uF, 450V				
2	D1, D2	BYG10J	Diode, 1.5A, 600-V	SMA	BYG10J	Std	
1	D3	See description	Diode, Bridge Rectifier, If > 2.1A, Vr > 562V			Std	
1	D4	SL13-E3/61T	Diode, Schottky, 1.5A, 30-V	SMA	SL13-E3/61T	Std	
2	D5, D7	BYS11-90-E3/TR	Diode, Schottky, 1A, 90-V	SMA	BYS11-90-E3/TR	Std	
1	D6	1SS355	Diode, Switching, 90V, 225 mA If, High speed	SOD-323	1SS355	Rohm	
1	D8	See description	Diode, Ultra fast, If_pk > 4.0A, Vr > 480V				
2	D9, D10	18V	Diode, Zener, 18-V, 1W	SMA	SMAZ18-13	Std	
1	F1	3A	Fuse, Slow, 5 x 20mm, 3A, 250V	20mm x 5mm	Std	Std	
1	FH1		Fuse Clip, 5x20 mm, PC Mount		01.000056H	Wickmann	
1	HS1	593002	Heatsink, TO-220, Vertical-mount, 15°C/W	12.5mm x 24mm	593002B03400G	Aavid	
1	L2	0.75mH	Transformer, Iprim, Isec, Lprim = 0.75mH, IprimRMS = 1.48A, Np:Ns = 1:0.098				
1	Q1	MMBT2222A	Transistor, NPN, 75V, 500mA	SOT-23	MMBT2222A	Std	
1	Q2	MMBT2222A	Transistor, NPN, 75V, 500mA	SOT-23	MMBT2222A	Std	
1	Q3	See description	MOSFET, N-CHNL, Vds > 480V, RdsON < 0.75 Ohm, Coss < 176 pF				
1	Q13	MMBT2222A	Transistor, NPN, 75V, 500mA	SOT-23	MMBT2222A	Std	
2	R1, R3	301k	Resistor, Chip, 301-kOhms, 1/4-W, 1%	1206	Std	Std	
2	R7, R5	1.78M	Resistor, Chip, 1.78-MOhm, 1/4-W, 1%	1206	Std	Std	
1	R4	4.02k	Resistor, Chip, 4.02-kOhms, 1/8-W, 1%	0805	Std	Std	
1	R6	4.02k	Resistor, Chip, 4.02-kOhms, 1/8-W, 1%	0805	Std	Std	
1	R7	4.75k	Resistor, Chip, 4.75-kOhms, 1/8-W, 1%	0805	Std	Std	
1	R8	10.7k	Resistor, Chip, 10.7 kOhms, 1/8 W, 1%	0805	Std	Std	
1	R9	24.3k	Resistor, Chip, 24.3-kOhms, 1/8-W, 1%	0805	Std	Std	
1	R10	6.62k	Resistor, Chip, 6.62-kOhms, 1/8-W, 1%	0805	Std	Std	
1	R11	11k	Resistor, Chip, 11-kOhms, 1/8-W, 1%	0805	Std	Std	
1	R12	332	Resistor, Chip, 332-Ohms, 1/8-W, 1%	0805	Std	Std	
2	R13, R15	511k	Resistor, Chip, 511-kOhms, 1/4-W, 1%	1206	Std	Std	
2	R14, R16	100k	Resistor, Chip, 100-kOhms, 1/4-W, 1%	1206	Std	Std	
1	R18	21.5k	Resistor, Chip, 21.5-kOhms, 1/8-W, 1%	0805	Std	Std	
1	R19	10	Resistor, Chip, 10.0-Ohms, 1/8-W, 1%	0805	Std	Std	
1	R20	0.4	Resistor, Chip, 0.48-Ohms, > 0.54-W, 1%		Std	Std	
0	R21	open	Open		Std	Std	
1	R22	4.70k	Resistor, Chip, 4.70-kOhms,1/8-W, 1%	0805	Std	Std	
1	R23	.33U	Resistor, Chip, .33U-Ohms,1/2-W, 5%	2010	Std	Std	
1	U1	UCC28810D	IC, LED Lighting Power Controller	SO8	UCC28810D	TI	
2	C2, C5	0.1uF	Capacitor, Metalized Polyester Film, 0.1-uF, 275VAC, 10%, X2	17.5mm x 5.5mm	Std	Std	EMI testing required to finalize these components
2	C3, C4	1000pF	Capacitor, Ceramic Disc, 1000-pF, 250V, Y1/X1	10mm x 8mm	ECK-ANA102MB	Panasonic	
1	L1	330uH	Inductor, Differential Mode, 2A				

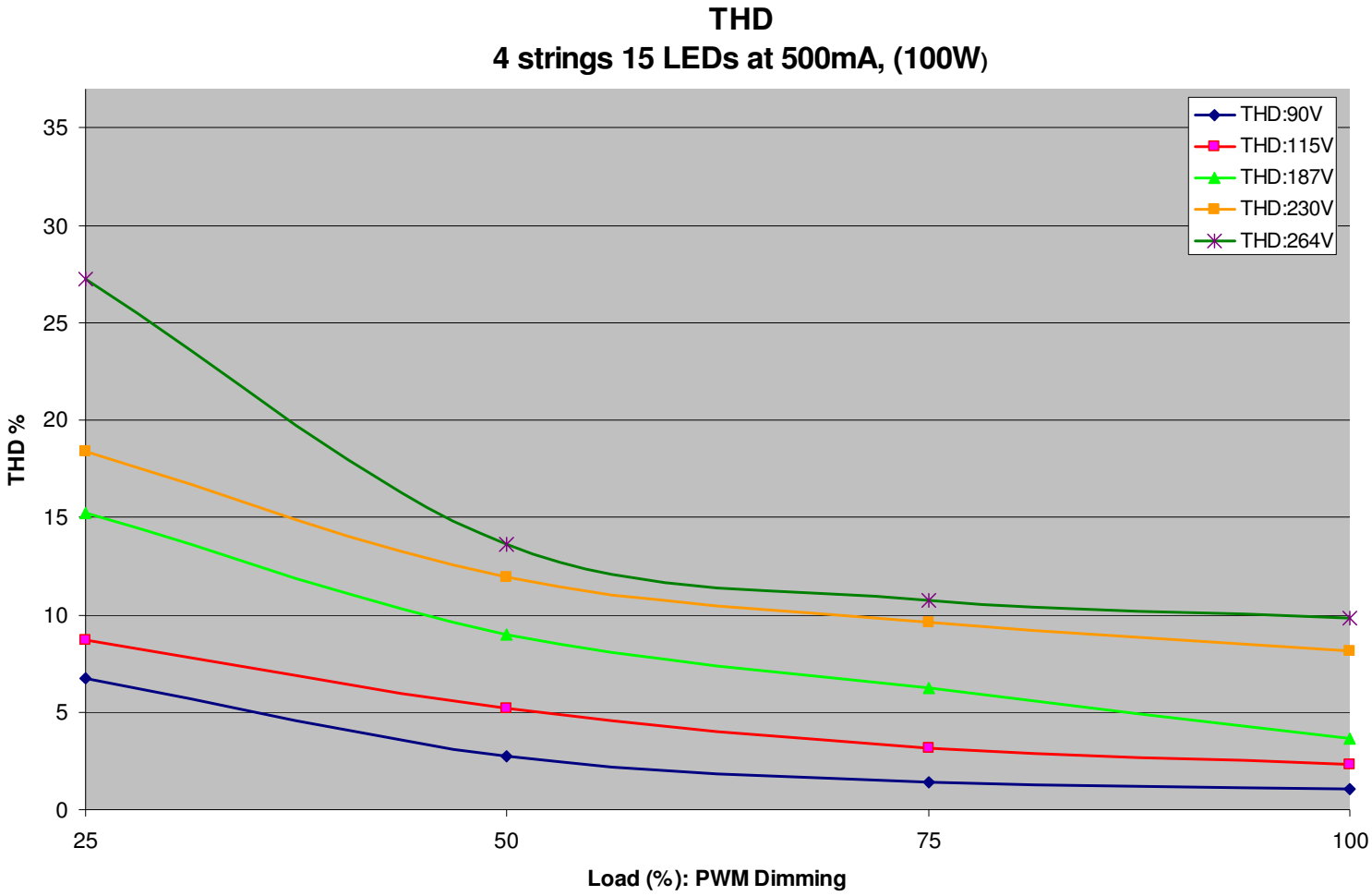
Efficiency of SIMPLEDrive - Multi-string Driver UCC28810 EVM003 Preliminary Test Results:



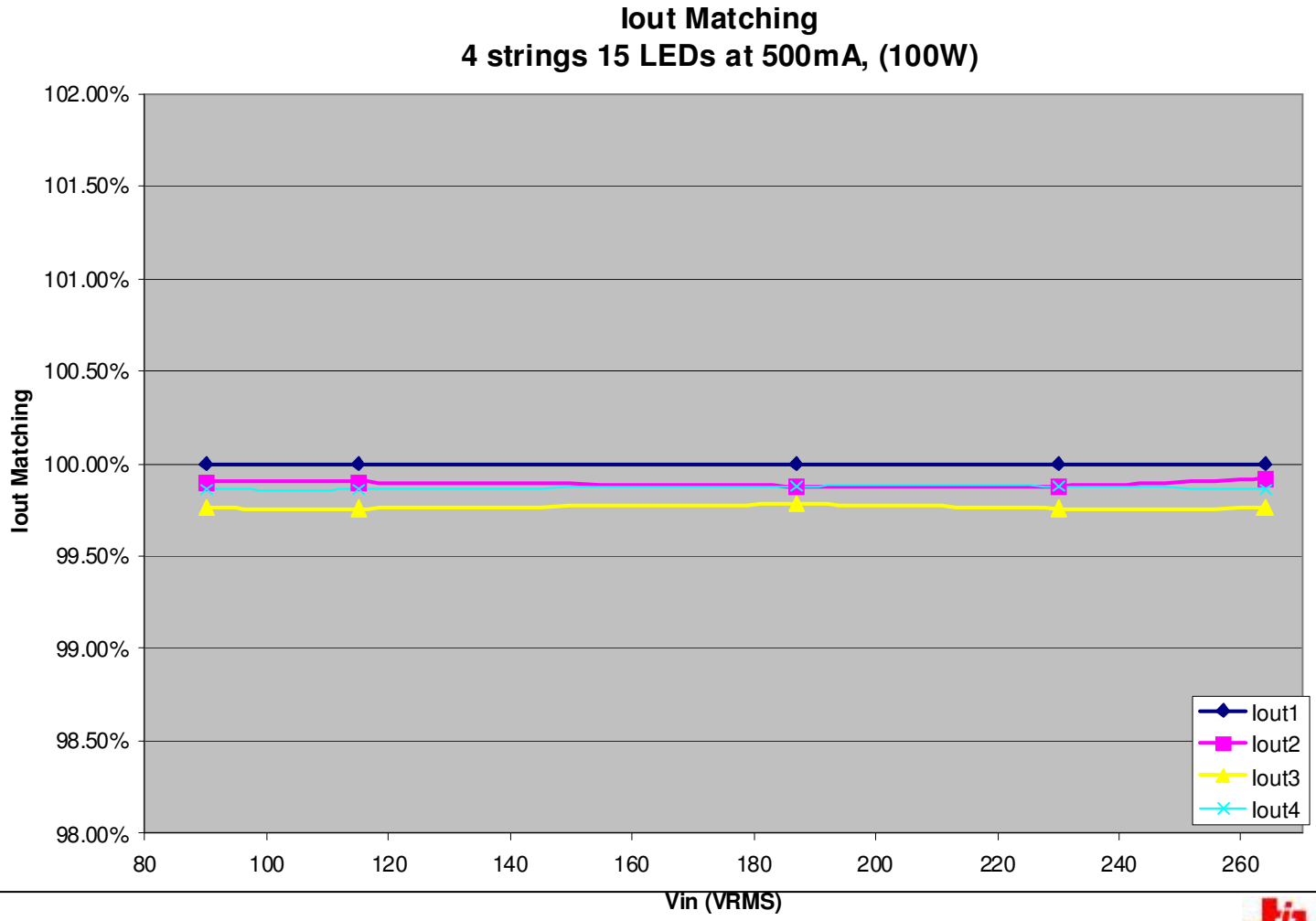
Power Factor of SIMPLEDrive - Multi-string Driver UCC28810 EVM003 Preliminary Test Results:



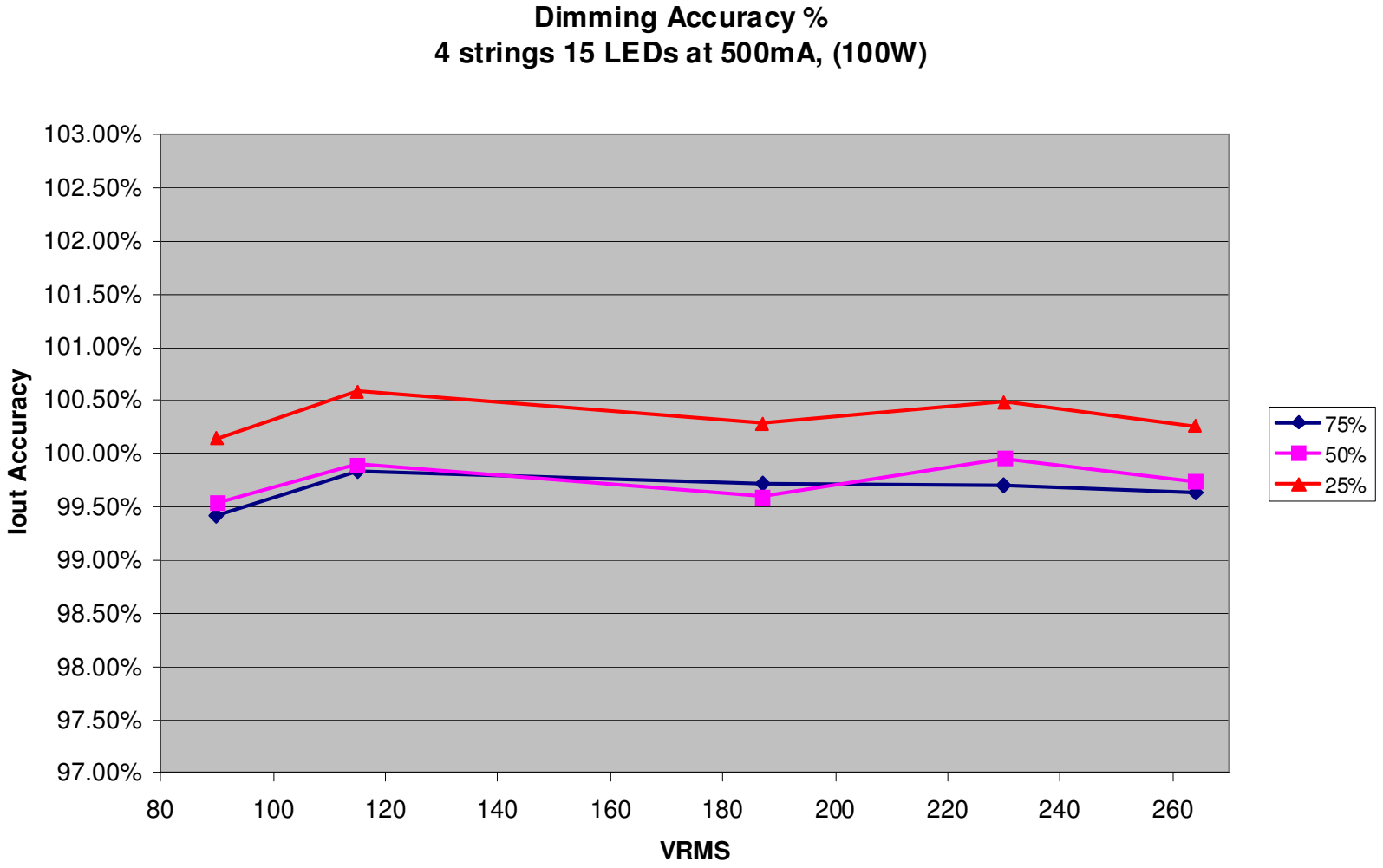
Total Harmonic Distortion of SIMPLEDrive UCC28810 EVM003 Preliminary Test Results:



LED String Current Matching of SIMPLEDrive UCC28810 EVM003 Preliminary Test Results:

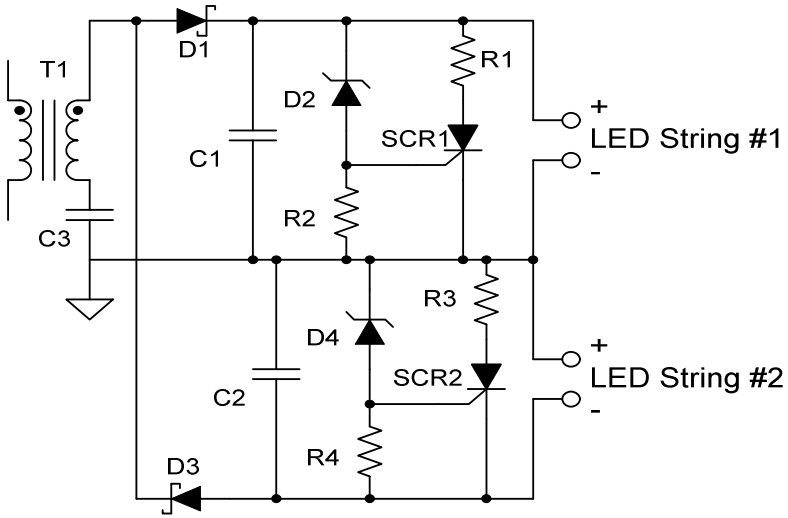


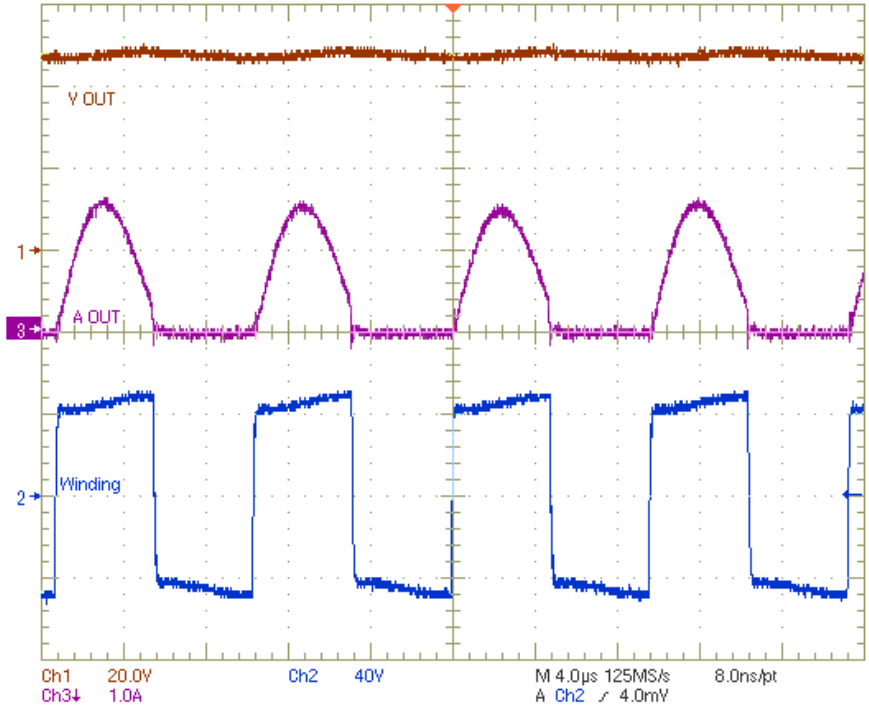
LED String Dimming Accuracy of SIMPLEDrive UCC28810 EVM003 Preliminary Test Results:



UCC28810EVM-003 Open String Protection

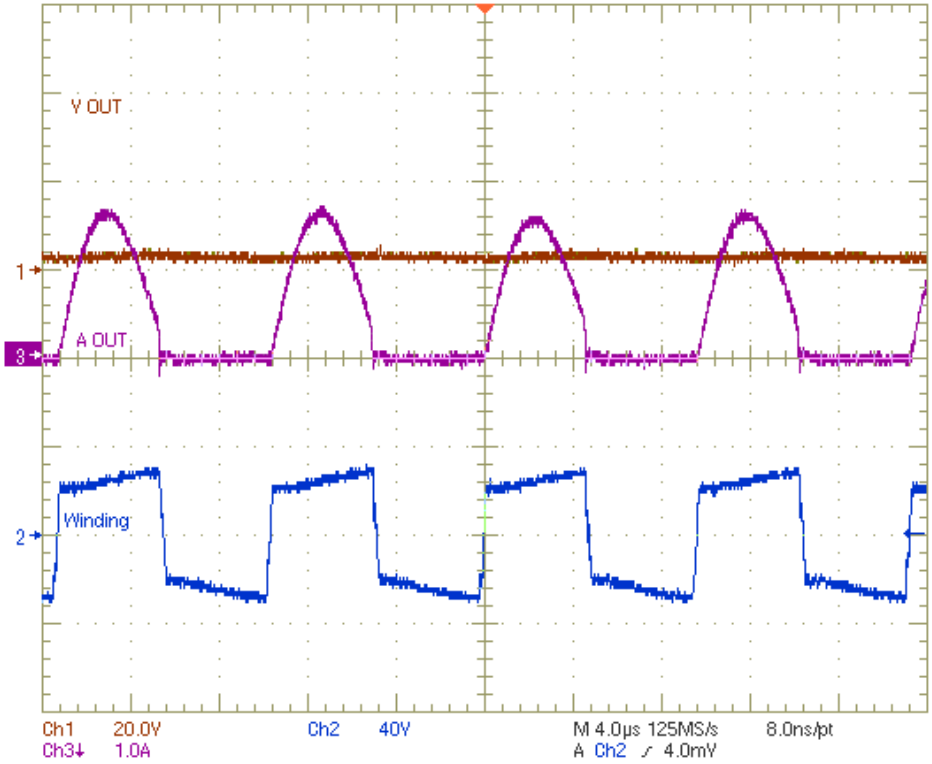
- If one string fails the other remain on.
- Each output incorporates a zener and SCR crowbar circuit
  - D2, SCR1, R1 and R2
- When string fails, zener voltage is exceeded and SCR latches on
- Transformer continues to deliver current to SCR and LED String #2





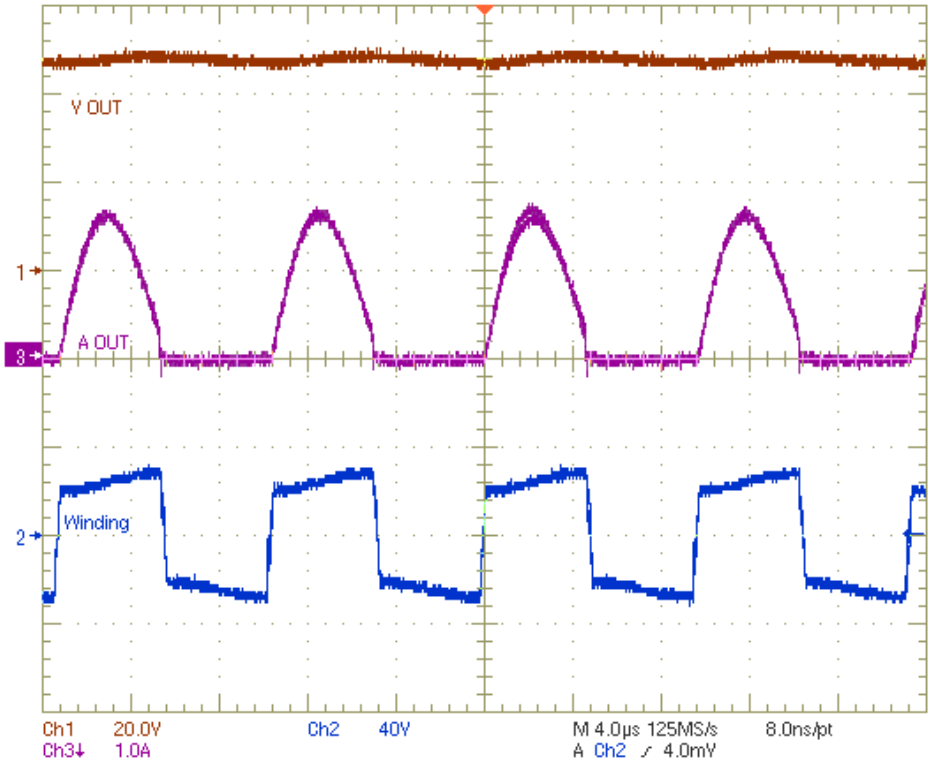
Waveforms During Normal Operation

UCC28810EVM-003 Open String Protection



LED String #1 Waveforms when Open Circuit

- VOUT and winding voltage clamped
- AOUT, transformer current continues to flow

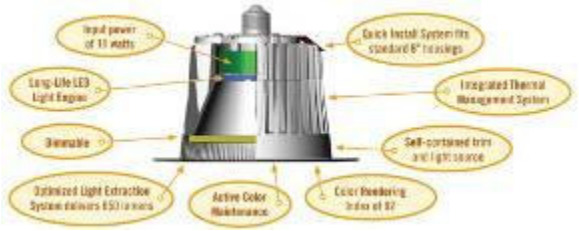


LED String #2 waveforms when LED String #1 is Open Circuit

- VOUT OK, winding voltage clamped
- AOUT, transformer current continues to flow

Residential Lighting LED Driver Solutions

- < 30W
- Low Cost
- TRIAC Dimming
- Power Factor Correction
- High Efficiency
- Color Quality
- Safety
- Long Life



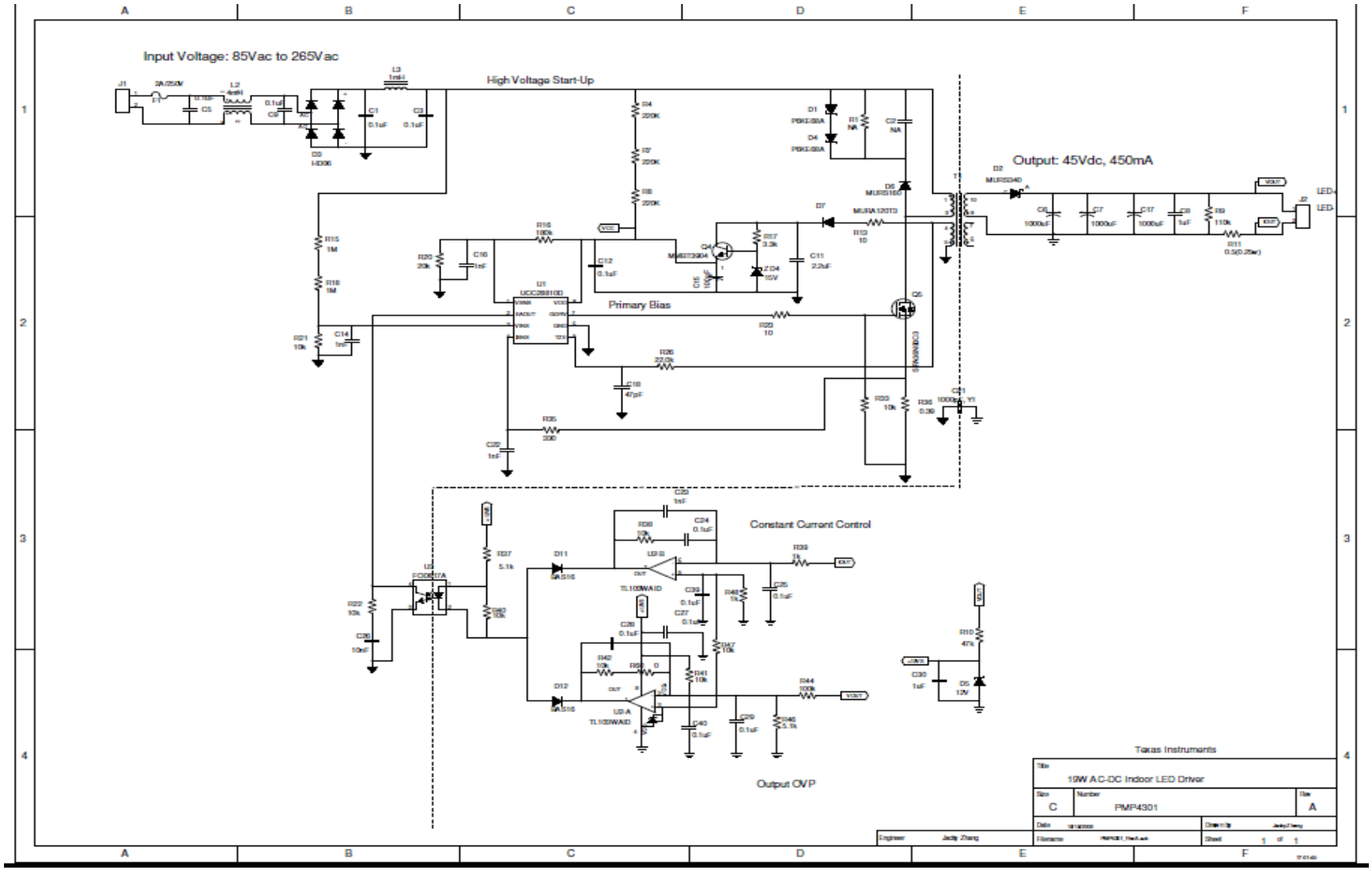
T10/T8 AC/DC LED Lighting Driver for Fluorescent Lamp

Reference Design	TI Parts	V_{in}	Po	Vo Io	Topology	Eff.	PF
AC Input T10 AC/DC LED Lighting Driver for fluorescent lamp	UCC28811	90-305 Vac	20W	30V~42V 450mA	Singe Stage high PF QR-Flyback	>85%	>0.95

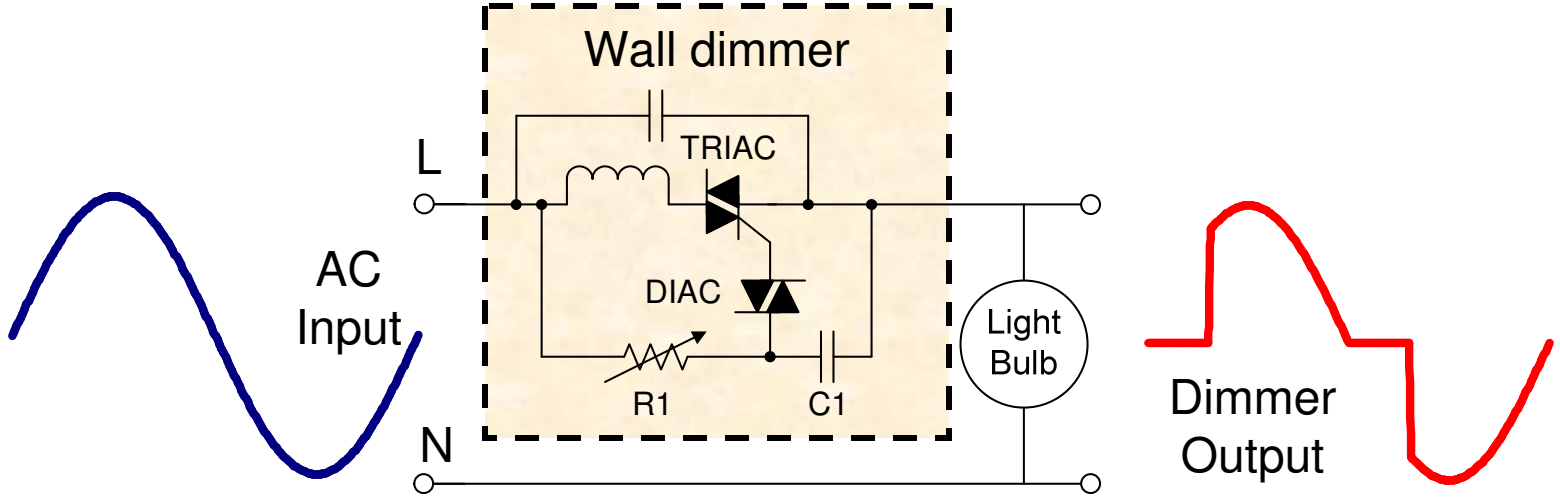
Features

- Efficiency >85% at 230Vac input
- Topology: isolated Flyback with power factor correction
- PF>90% at 230Vac input
- Size: 245mmX18mmx12mm
- Output over voltage protection: 45Vdc
- Output ripple current: <30% of output current

UCC28811 T8/T10 Schematics



The Trouble with TRIACs



- Start of AC cycle TRIAC initially off
  - C1 charges through R1 and light bulb
- When voltage on C1 exceeds DIAC threshold voltage the TRIAC conducts
  - R1 controls when TRIAC turns ON, dimming function
- Light bulb load must maintain TRIAC holding current
  - TRIAC turns off close to zero crossing and cycle repeats
- LED lights do not always consume enough power to keep TRIAC ON
  - Need to solve this with extra circuitry

Special care is required when making LED lighting compatible to standard TRIAC dimmers

TPS92210
Natural PFC LED lighting driver controller

Features

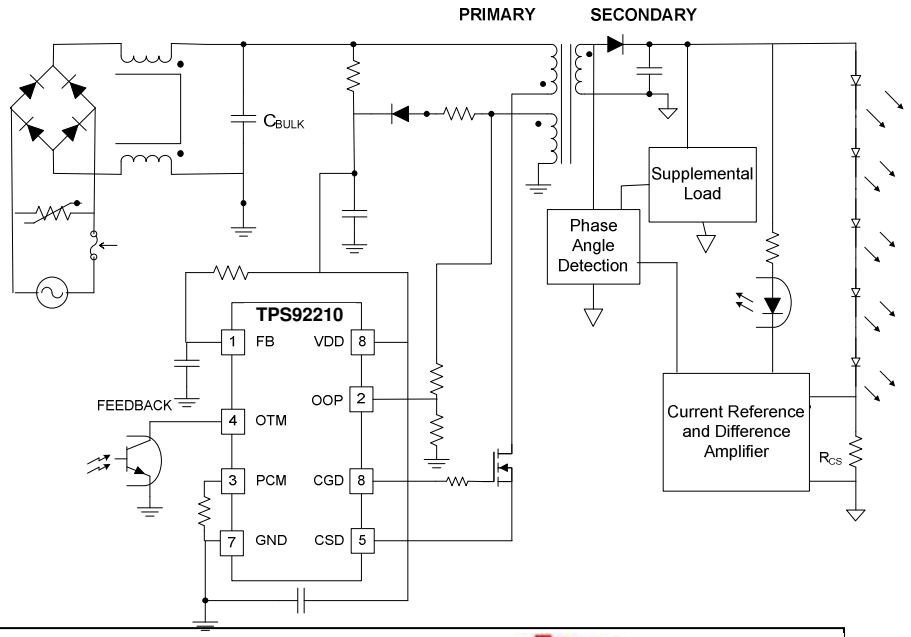
- Flexible Operation Modes: Peak Primary Current, Constant On-Time or both
- Cascoded MOSFET Configuration
- Works with TRIAC dimmers
- DCM or TM operation
- Advanced Overcurrent Protection

Applications

- Residential LED Lighting Drivers
  - A19 (E27/26, E14), PAR30/38, GU10
- Drivers for Wall Sconces, Pathway and Overhead Lighting
- Drivers for Wall Washing, Architectural and Display Lighting
- Commercial Troffers and Downlights

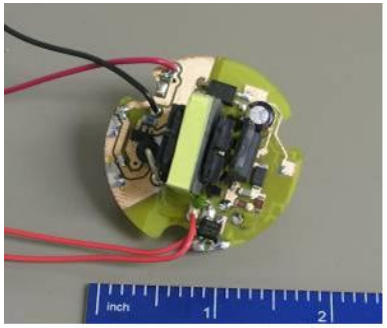
Benefits

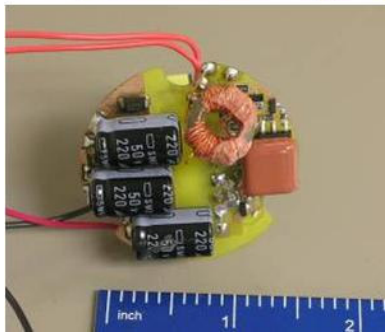
- Constant On-Time implements single stage PFC
- Fast and easy start up
- Line Surge Ruggedness better than Internal HV FET
- Continuous linear dimming
- Proven applications with TRIAC dimmers
- High Efficiency, low EMI
- No reverse recovery loss in output rectifier
- Smaller Size and Lower System Cost



12.5W AC/DC LED Lighting Driver w/ TRIAC dimming

Reference Design	TI Parts	V_{in}	Po	Vo Io	Topology	Eff.	PF
AC Input AC/DC LED Lighting Driver for fluorescent lamp	TPS92210	90-130Vac Or 210~240 VAC	12.5 W	38VV 350mA	Singe Stage high PF Flyback	>85%	>0.95





Features

- TRIAC dimming solution Compatible with standard TRIAC Dimmers - 0% to 100%
- High PFC with on time modulation
- Cascode drive for main switch

Applications

Residential LED Lighting Drivers

A19 (E27/26, E14),
PAR30/38, GU10

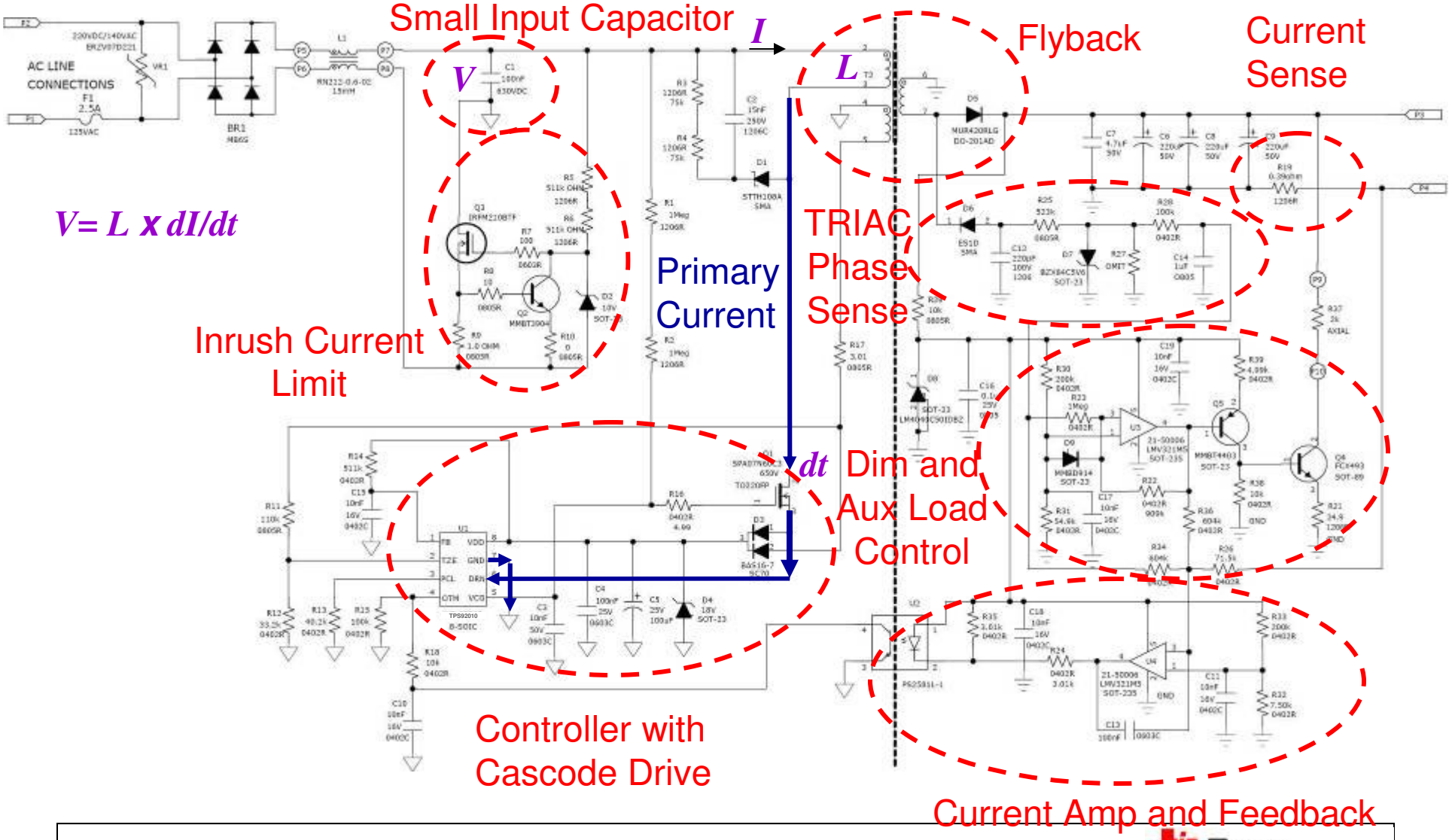
TPS92210EVM Specification

Specification	Value	Unit
LED configuration	9-11	
Input Voltage	90-130	VAC
Efficiency	85	%
Power	12.5	W
Power Factor	0.99	
Output Voltage	38	VDC
Output Current	350	mA
LF Output Ripple	300	mVpp
Isolation	2500	VAC

Specification	Value	Unit
Dimming Input	TRIAC	
Dimming Level	0-100	%
Current Sensing	Res	
Current Ref Accuracy	3	%
Temp. Range	-20 to 50	^{o}C
Lifetime*	35000	Hrs
Turn on time	150	mS
EMC Regulation	FCC B	
Safety Regulation		
Driver Dimensions	34 dia	mm

Note: *Lifetime assumes 35^{o}C internal temp. rise from ambient.

TPS92210EVM Schematic



TPS92010 8-Pin High Efficiency
Offline LED Lighting Controller

Features

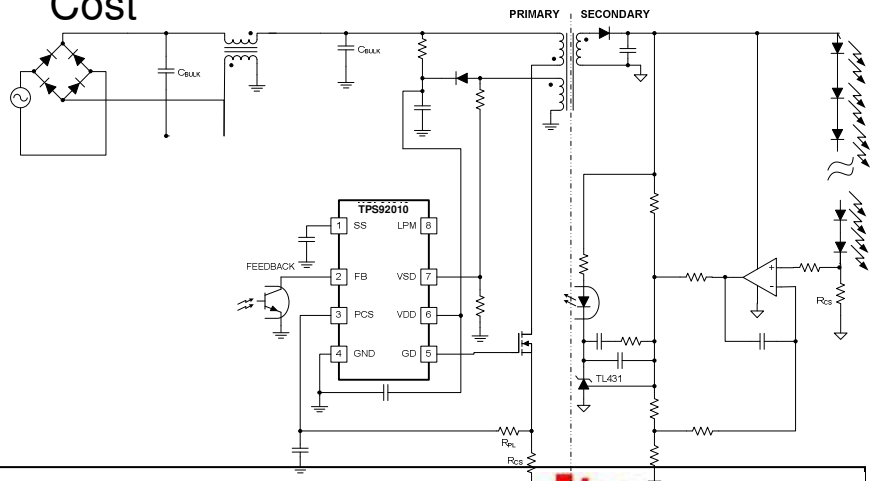
- High Efficiency LED Lighting Current
  - Quasi resonant and low power modes
- High Performance TRIAC Dimming with Application Circuit
- Programmable Overvoltage Protection
- Internal Over-temperature Protection
- Current Limit Protection
  - Cycle-by-Cycle Power Limit
  - Primary Side Overcurrent Hiccup Restart Mode
- TrueDrive Gate Drive 1A sink, 0.75A Source

Benefits

- 87% Achievable Efficiency – Higher than Standard Flyback Topologies
- Less than 400mW Standby Current Allows Efficient Deep Dimming
- 20% More Efficient Dimming compared with Other Methods
- Safely Shuts Down Driver if Open or Over Temperature Condition is present
- Protects Driver from Abnormal Conditions
- Lower Switching Losses Reducing System Cost

Applications

- Residential LED Lighting Drivers
  - A19 (E27/26, E14), PAR30/38, GU10
- Drivers for Wall Sconces, Pathway and Overhead Lighting
- Drivers for Wall Washing, Architectural and Display Lighting



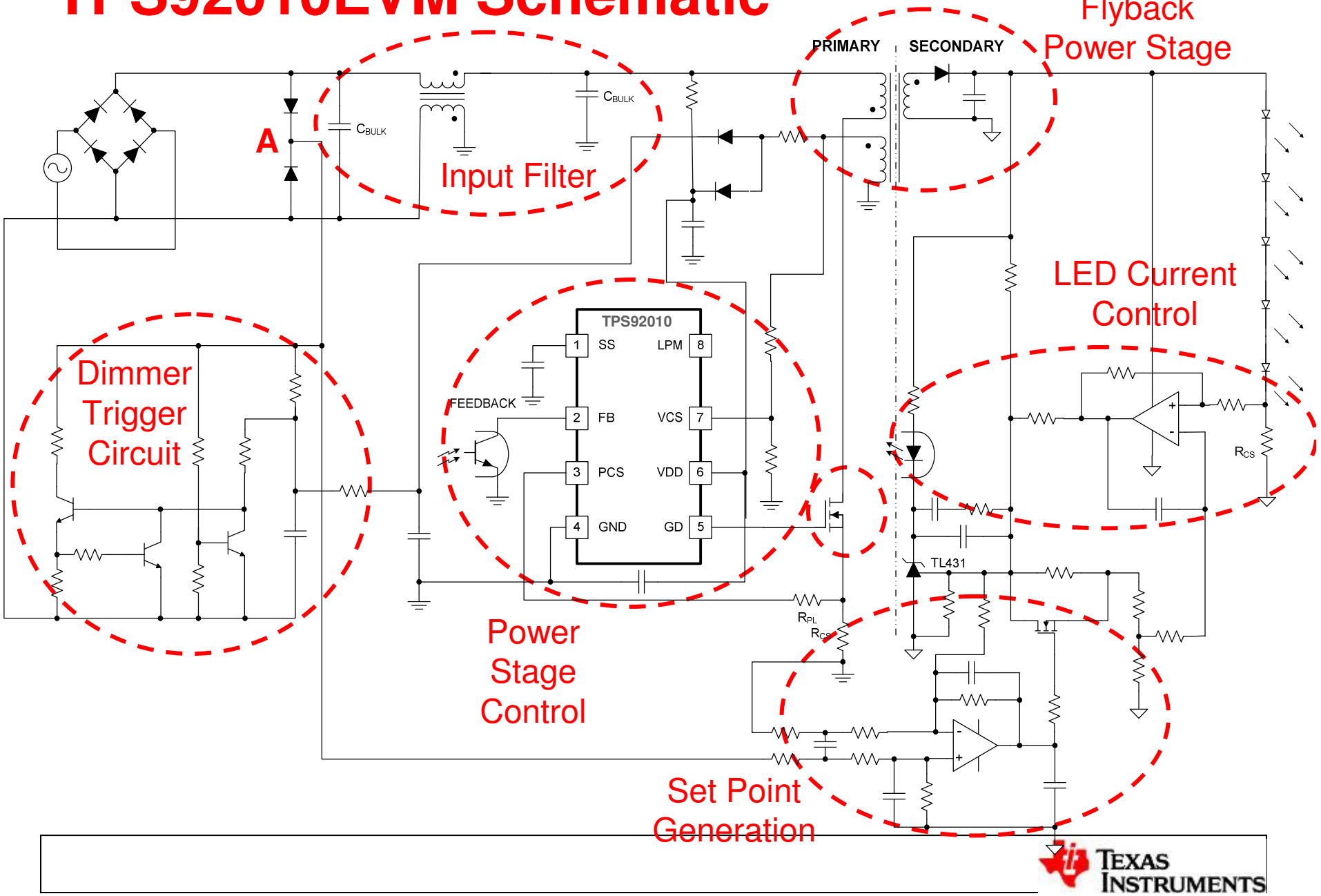
TPS92010EVM Specification

Specification	Value	Unit
LED configuration	3-5 Ser.	
Input Voltage	100 - 130	VAC
Efficiency	80	%
Power	7	W
Power Factor	0.55	
Output Voltage	9 - 18	VDC
Output Current	325	mA
LF Output Ripple	0	mVpp
Isolation	Yes	

Specification	Value	Unit
Dimming Input	Triac	
Dimming Level	0-100	%
Current Sensing	Res.	
Current Ref Accuracy	3	%
Temp. Range	-20 to 50	°C
Lifetime*	35000	Hrs
Turn on time	150	mS
EMC Regulation	FCC B	
Safety Regulation	No	
Driver Dimensions	60 X 20	mm

Note: *Lifetime assumes 35°C internal temp. rise from ambient.

TPS92010EVM Schematic

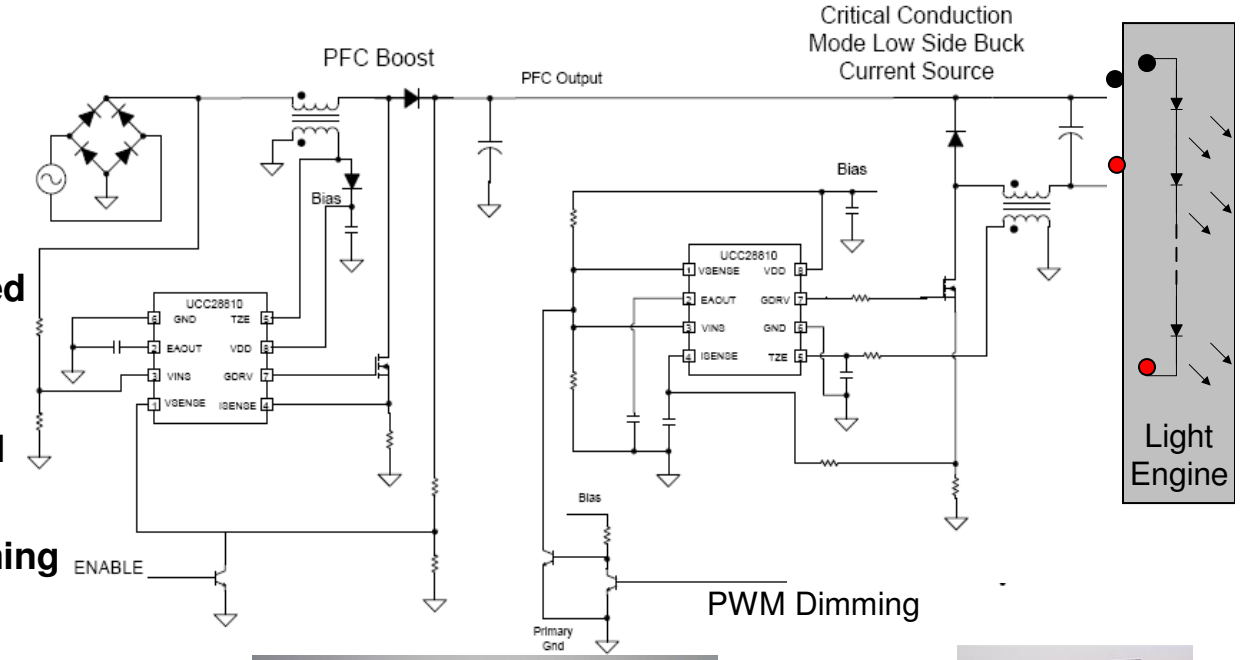


High Efficiency LED Street Light
UCC28810-EVM002 Reference Design

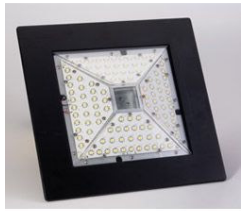
Description	Parts	Vin (AC) Range	Vout (DC) Range	# of LEDs	Iout max.	Pout (max)	Efficiency	PFC	ISO	Dimming In	Dimming Out	Contact	EVM
UCC28810 EVM002 100W LED lighting Driver	UCC28810 UCC28811	90 265	55 100	15-30	900 mA	100W	93%	Y	N	PWM	PWM	Jim Aliberti	Yes

Key Benefits:

- **Active Power Factor 0.99**
- **High efficiency > 94%**
- **Extremely robust**,
  - **the LEDs are well protected**
- **Extremely simple to use**:
  - **TM Buck inherently stable**
  - **no compensation required**
- **Fast LED Current Response**
  - **well suited for PWM Dimming**
- **Universal Range Input voltage**
- **High Reliability, long life**
- **Design tool to calculate key parameters for changes in LED Current, # of LEDs or Vin**



UCC28810 EVM002



Agenda

- High Brightness LEDs for Lighting
- TI Solutions for General LED Lighting
- TI Solutions for LED Backlight TV Power Supply

LED Backlight Solution for Large Panel TV

LCD TV (Direct Backlight)

RGB LED

- Piccolo F2802x/3x + DRV9812

White LED

- TPS40210+TLC5940/1

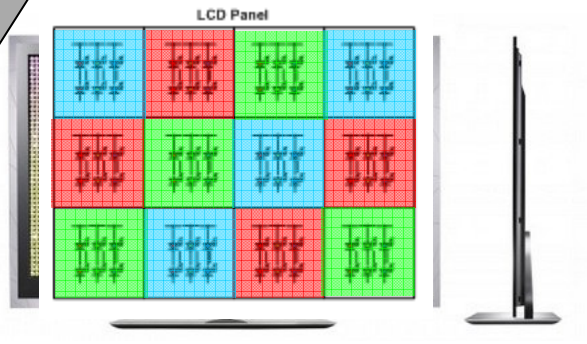


Fig. Direct-Type w/ Local Dimming

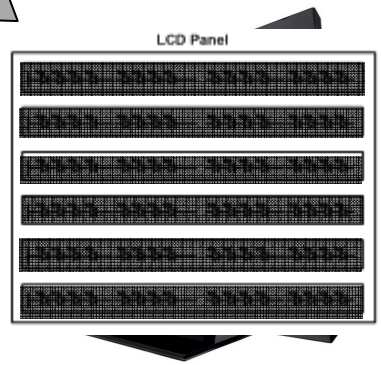


Fig. Direct-Type w/o Local Dimming

LCD TV (Edge Backlight)

White LED

- UCC28051+UCC25600+UCC28610+ TLC5960/1 + TPS40210 #1
- UCC28051 + UCC25600+UCC28610 (multi-transformer solutions) #2

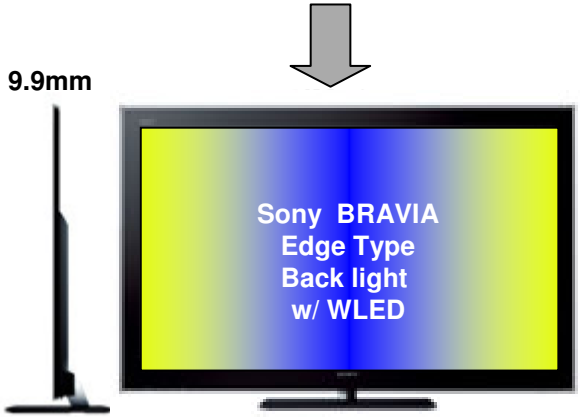
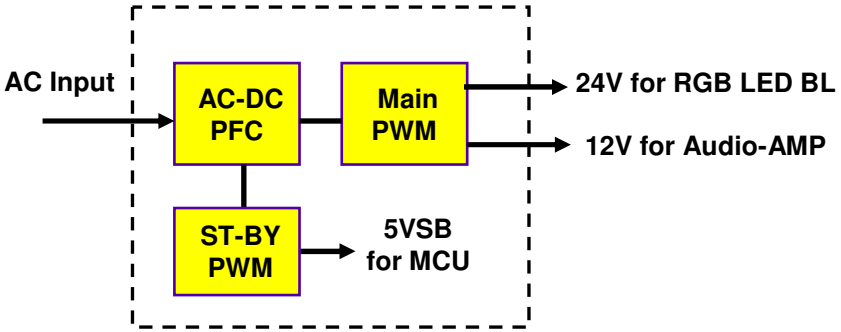
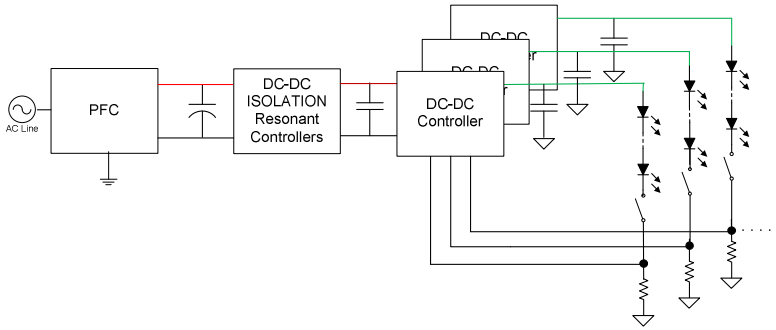


Fig. Edge-Type Backlight

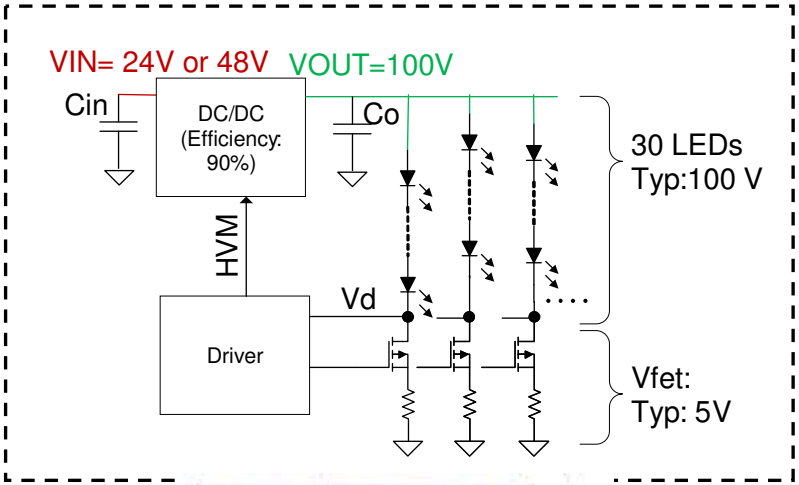
White LED Backlighting for DTV (Edge Type)

AC/DC Power Board





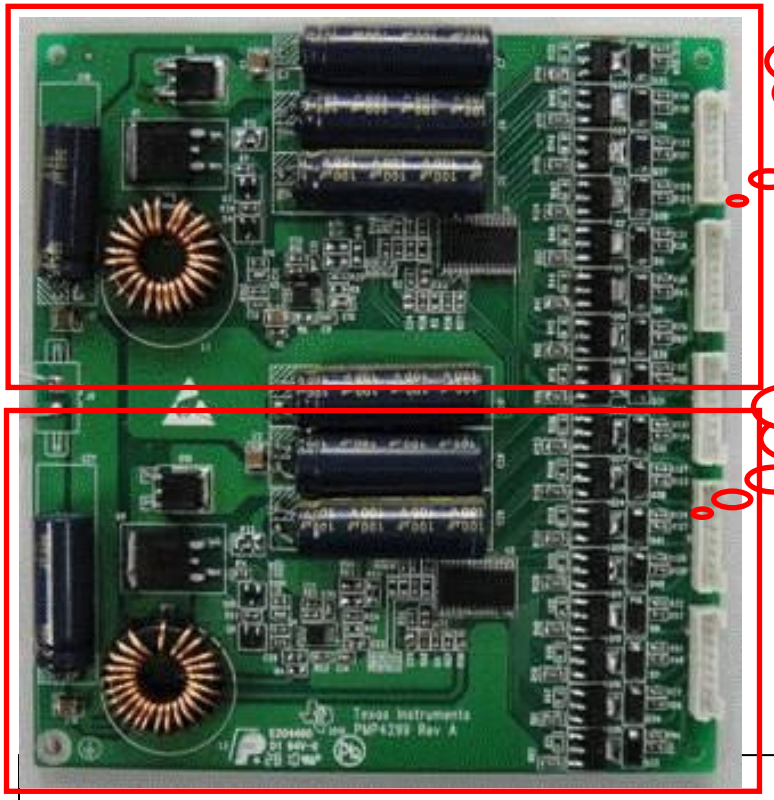
LED Driver for Backlighting



Solution	Size	Major Advantages	Interface	Status
TLC5960/61	32”~60”	8 Channel External FET Control, LED/FET Open Protection, Four Headroom Voltage Monitor Feedbacks (HVM) TLC5960/61 (PWM Control/ Serial Interface ON/OFF)	PWM/ Serial Interface	Aug 2010 MP
TPS40210	32”~60”	4.5V~52Vin DC/DC Boost Controller, Programmable Fsw (35K to 1MHz		Production

White LED Backlight TV Constant Current Driver

Reference Design	Designer	TI Parts	V_{in}	Output	Topology	Eff.	Dimming
PMP4299: **White LED Backlight TV Constant Current Driver**	Jacky Zhang	TPS40210 TLC5960	24Vdc	16 channel ~60V output with 120mA per string	DC/DC Boost+ Intelligent switching linear regulator	>91 %	PWM or Analog



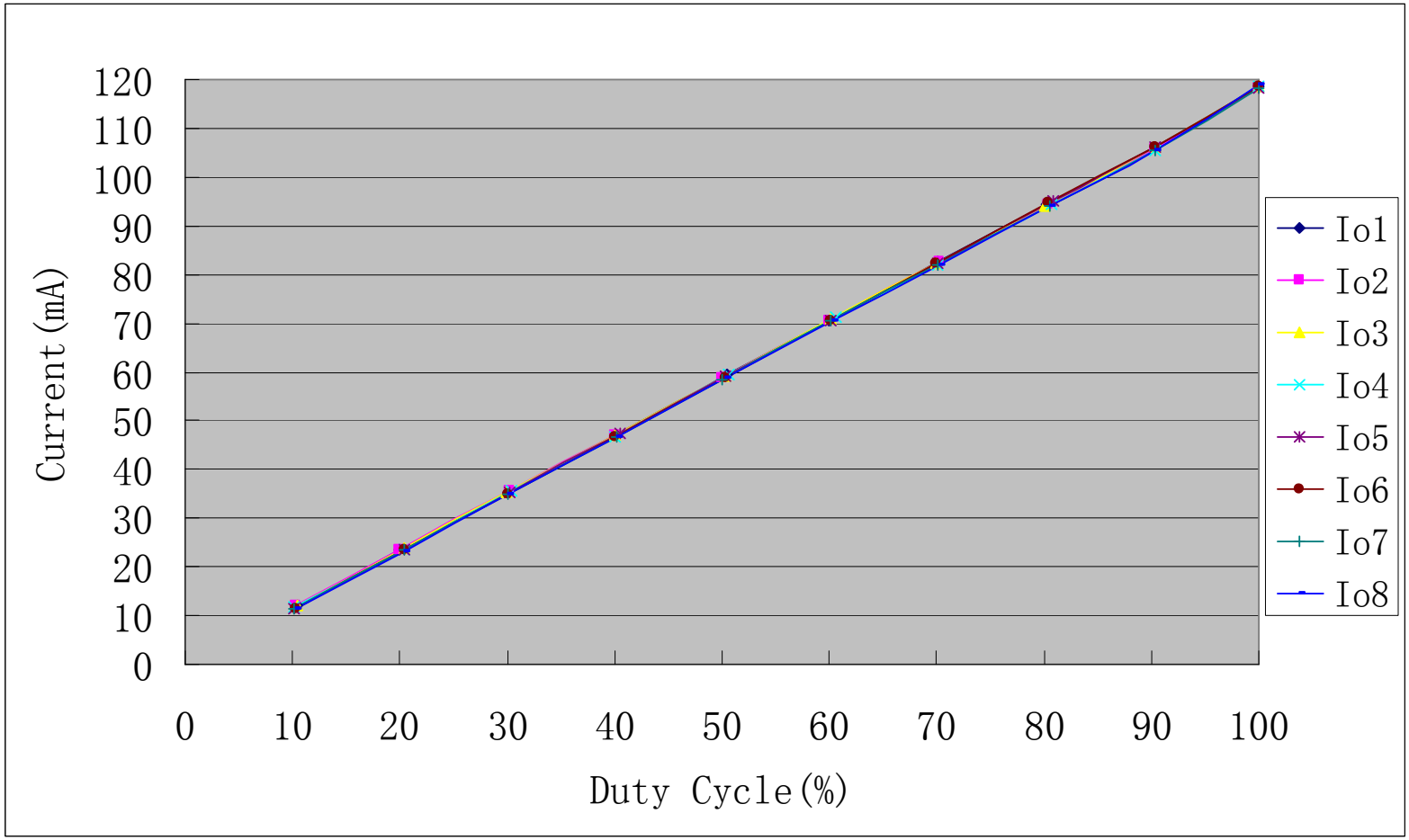
Features

- Intelligent Headroom Voltage Monitor (HVM) Feedbacks to improve efficiency;
- 8 Channel External FET Control with easy PWM dimming or analog dimming
- Fast PWM dimming response
- LED/FET Open Protection, FET Short Protection

Applications

- Edge type white LED backlight TV
- General LED lighting

White LED Backlight TV Constant Current Driver_ Current matching with 1%~100%PWM dimming



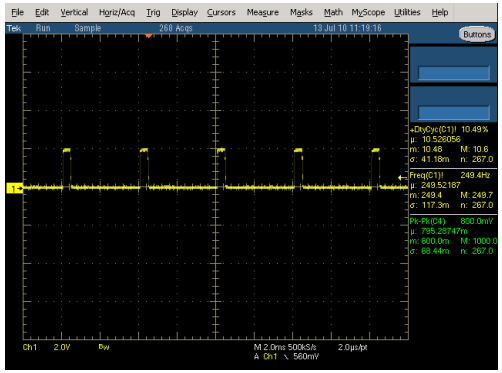
Vin=24Vdc, PWM dimming frequency=240Hz
PWM dimming frequency from 10%~100%

White LED Backlight TV Constant Current Driver_ Current matching with 10% PWM dimming

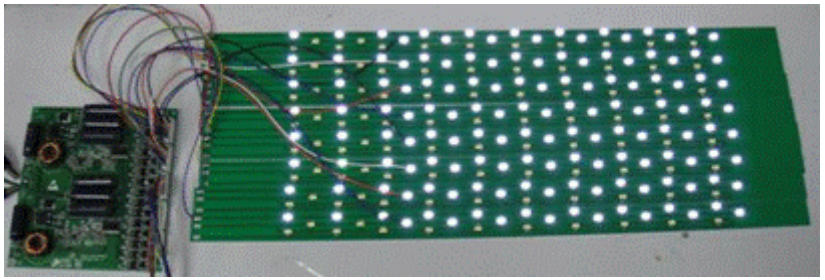
TPS40210 output voltage

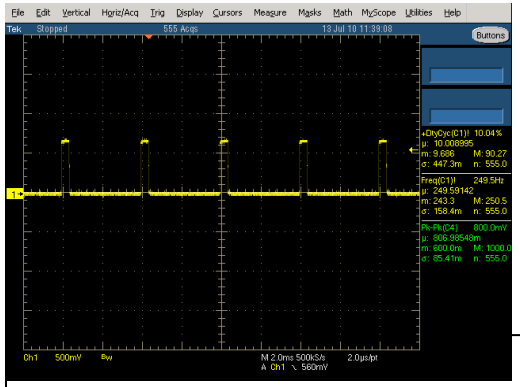
HVM optimize LED driver input voltage

TLC5960 Enable signal



TLC5960 Vg voltage





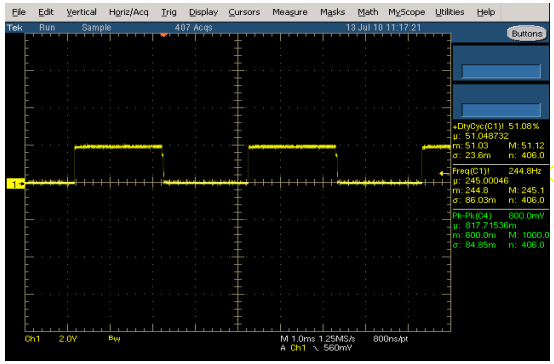
TLC5960 Vs voltage

White LED Backlight TV Constant Current Driver_ Current matching with 50% PWM dimming

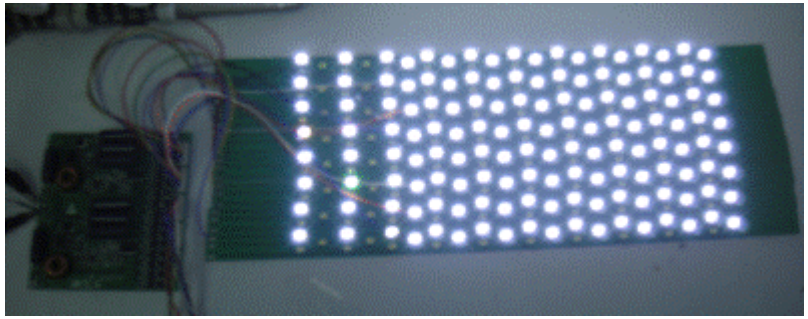
TPS40210 output voltage

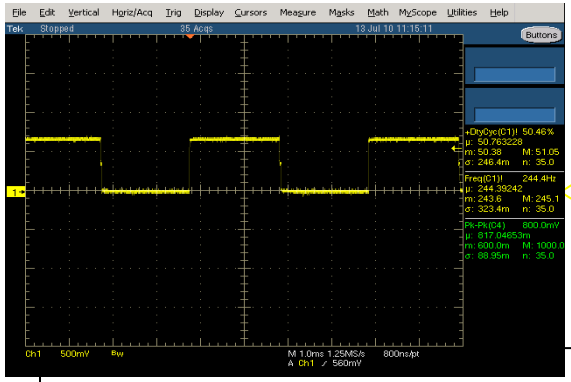
HVM optimize LED driver input voltage

TLC5960 Enable signal



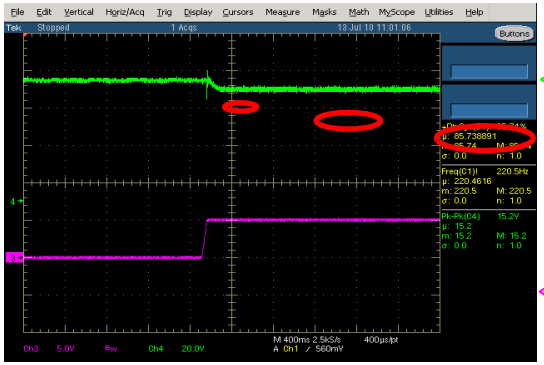
TLC5960 Vg voltage





TLC5960 Vs voltage

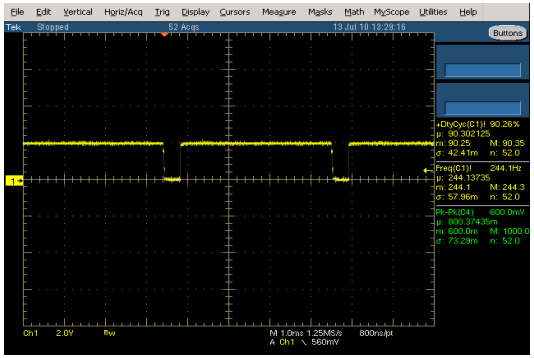
White LED Backlight TV Constant Current Driver_ Current matching with 90% PWM dimming



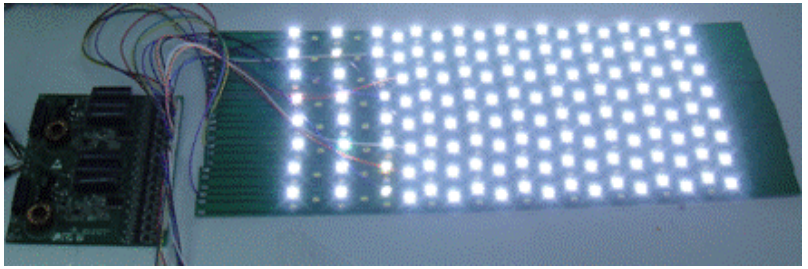
TPS40210 output voltage

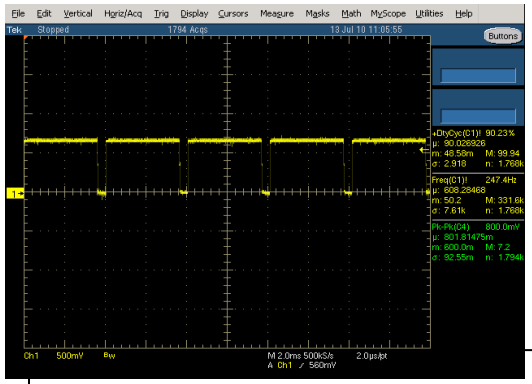
HVM optimize LED driver input voltage

TLC5960 Enable signal



TLC5960 Vg voltage

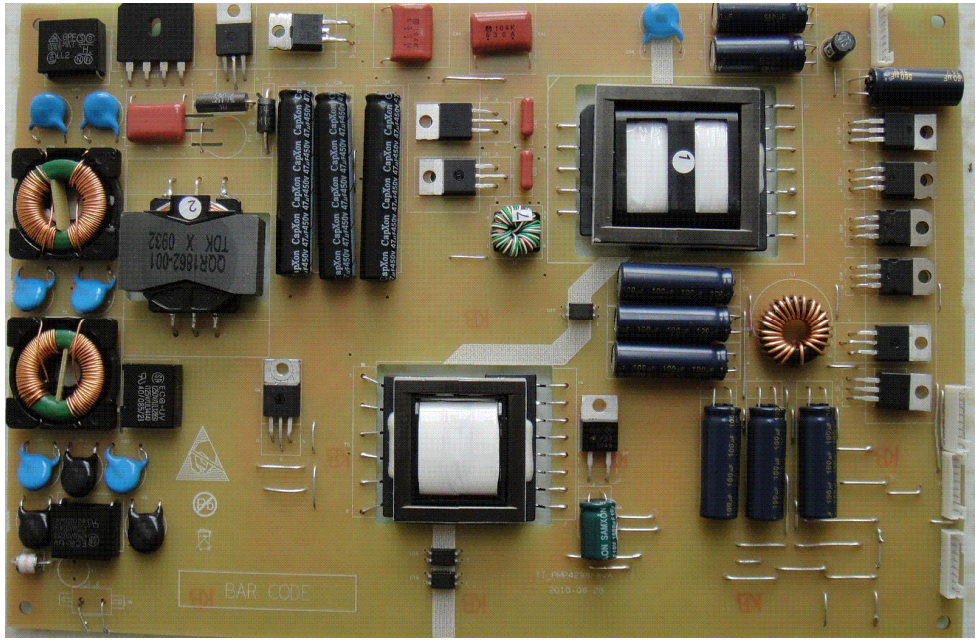




TLC5960 Vs voltage

PMP4298: Edge Type LED Backlight TV LIPS (LCD Integrated Power Supply)

Reference Design	TI Parts	V_{in}	Output	Topology	Eff.	Dimming
PMP4299: **Edge Type LED Backlight TV LIPS**	UCC28051 UCC25600 UCC28610 TPS40210 TLC5960	90Vac~265Vac	8 channel with 80V/120mA for LED 24V@2A for audio 5V@3A for system 5V@1A for standby	TM PFC+LLC converter +Boost DC/DC + intelligent linear regulator	>85%	PWM or Analog

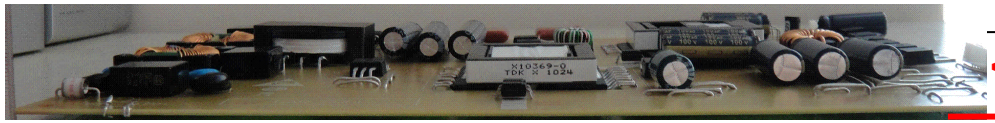


Features

- High flexible design with LED driver and AC/DC power supply for edge type LED backlight TV
- Ultra-slim with height less than 10mm
- Low standby power

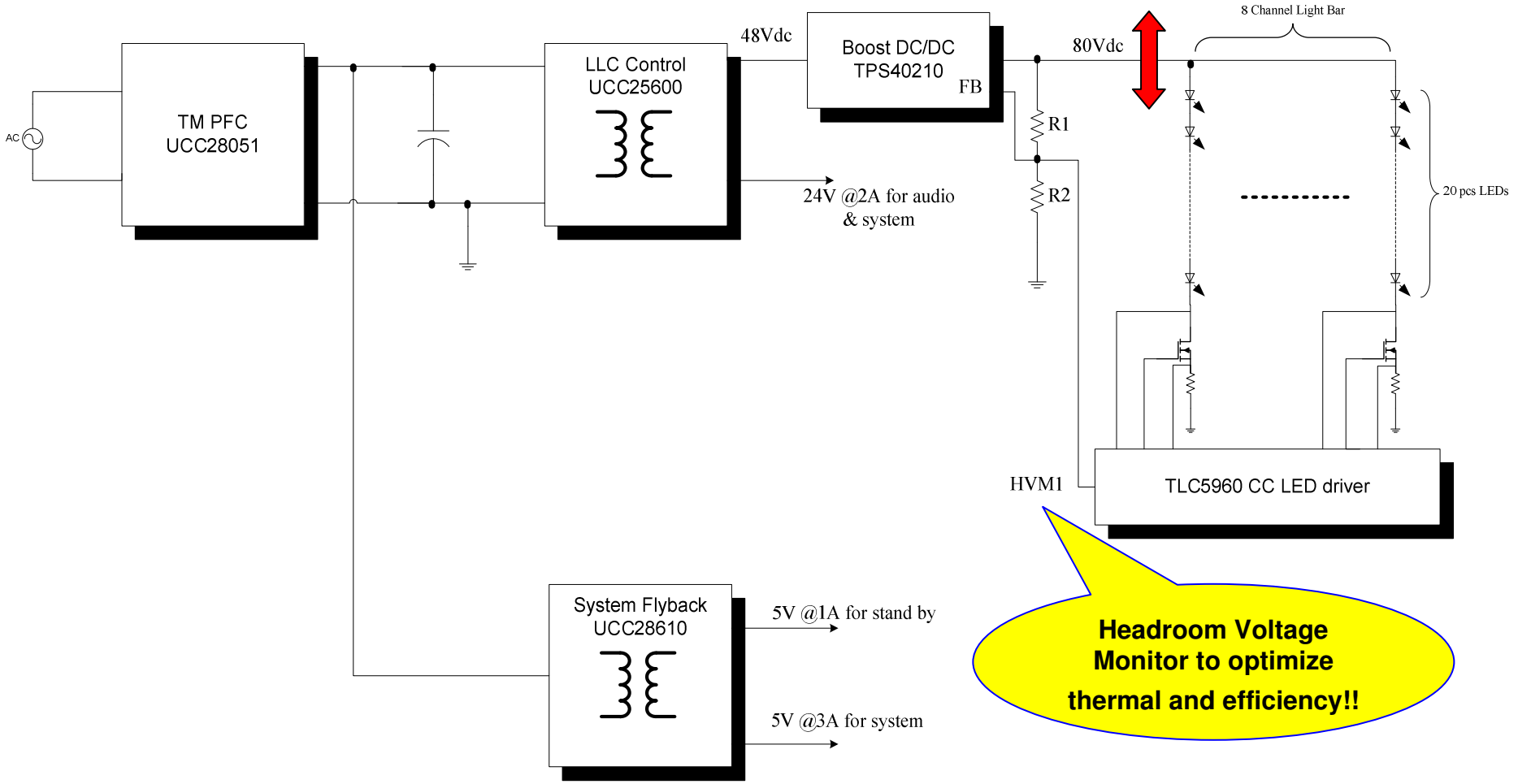
Applications

- Edge type white LED backlight TV



<10mm

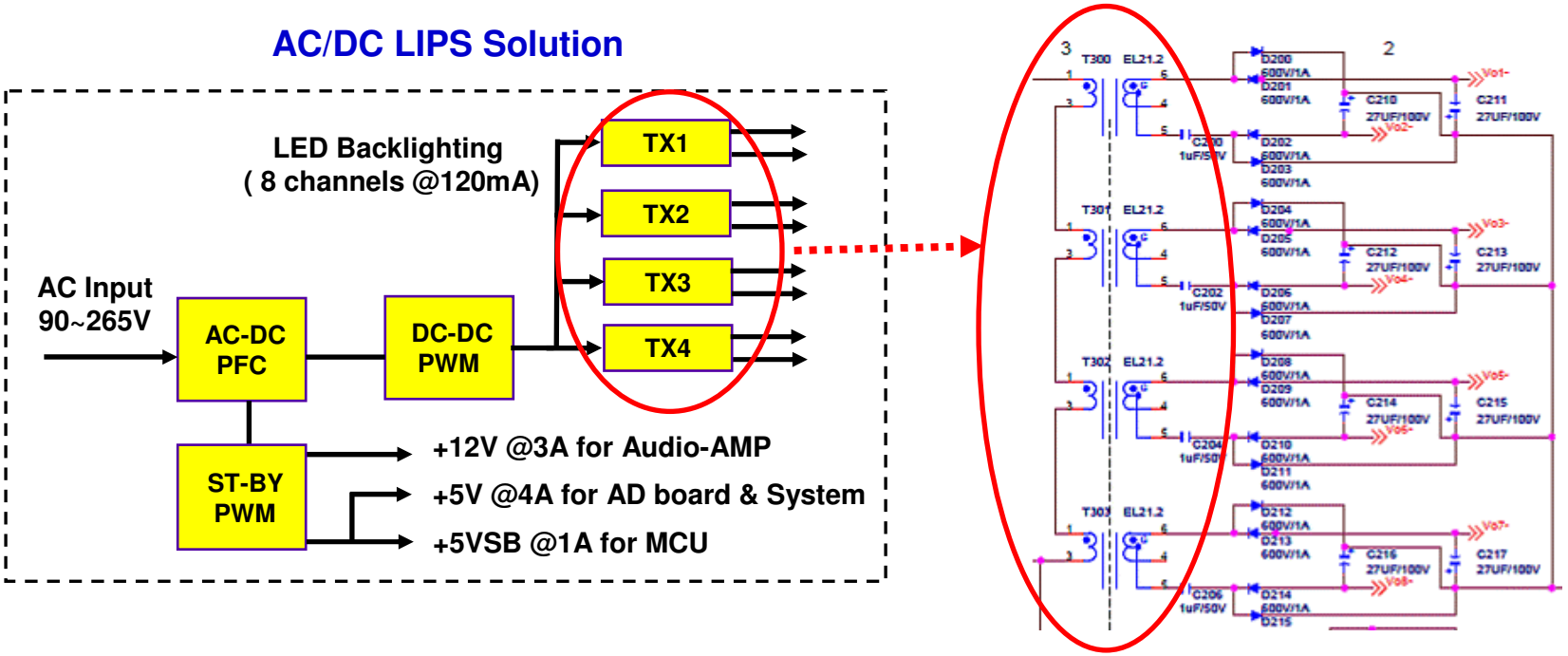
PMP4298:150W slim LIPS Demo reference design (Edge Type #1)

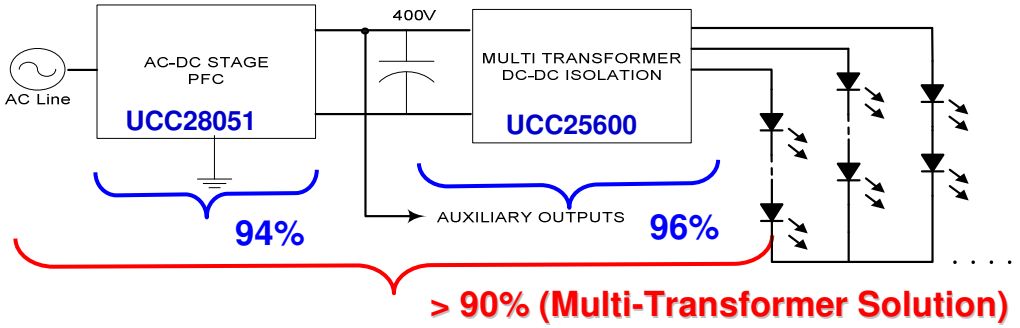


PMP4298: Project specs. for LED BLU TV LIPS

1. Input: 150W Universal AC input power supply (85-265VAC, 47-63 Hz)
2. >85% efficiency from AC to LED backlight at 220VAC input
3. Power Output:
   - LED strings: 8 channel x80V with 20pcs 120mA LED per string
   - Audio and system: 24V@2A
   - System: 5V@3A
   - Standby power: 5V@1A
4. Minimum 20ms hold up time when input line shunt off
5. Input standby power < 300mW with 5V/30mA output (On board switch to trigger standby mode)
6. PCB board specs Single Layer PCB X-Y dimensions (max) - 10"x10" Height (max) - 10mm
7. Dimming range- 1-100% (250KHz dimming frequency)
8. LED current matching spec - <3% for full dimming range
9. Flyback stage output regulation tolerance- <+/-5% over load
10. LED Protection (short, open, over current, under current, under voltage etc.)
11. TLC5960 Headroom Voltage Monitor (HVM) to optimize the efficiency and thermal

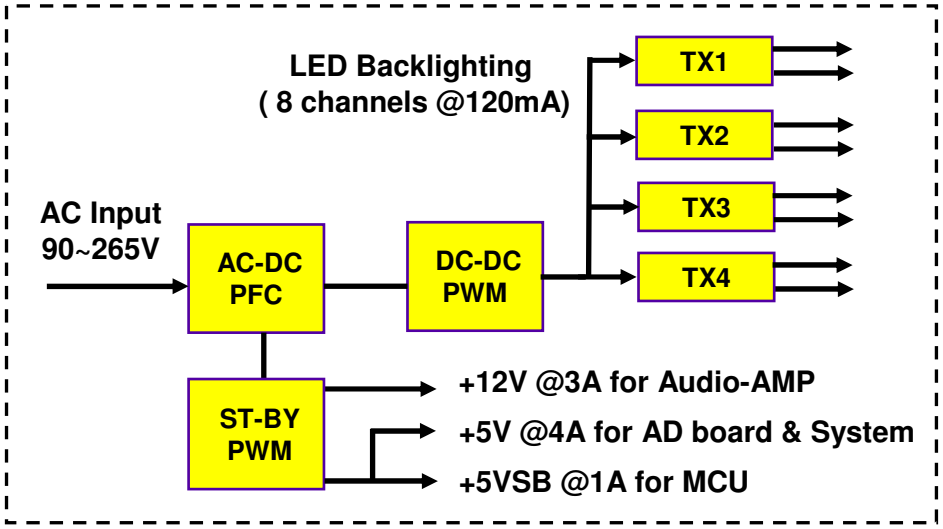
Multi-Transformer LED Backlight LIPS for DTV (Edge Type #2)

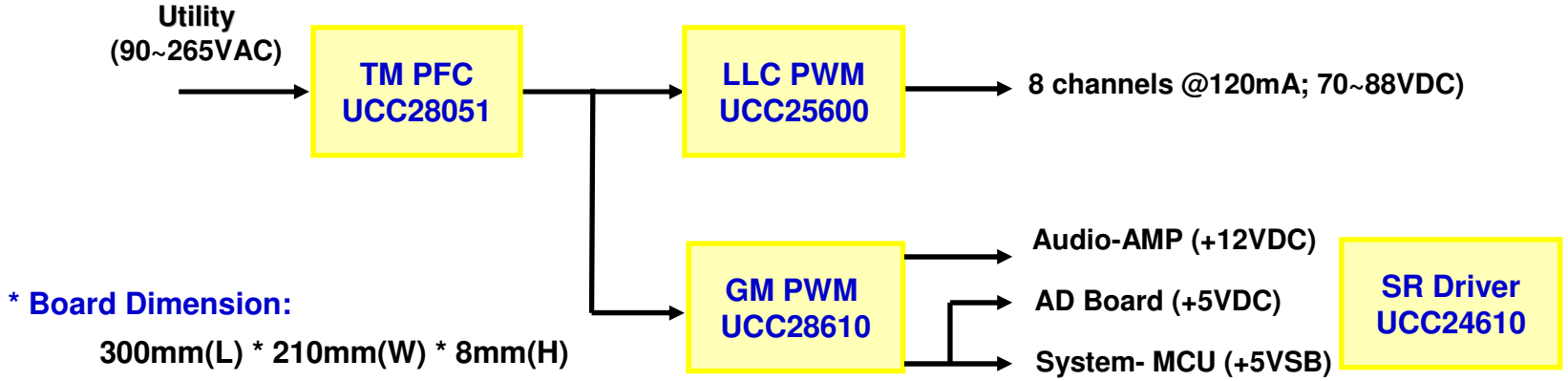




150W Slim LED-TV Power Reference Design

AC/DC LIPS Solution

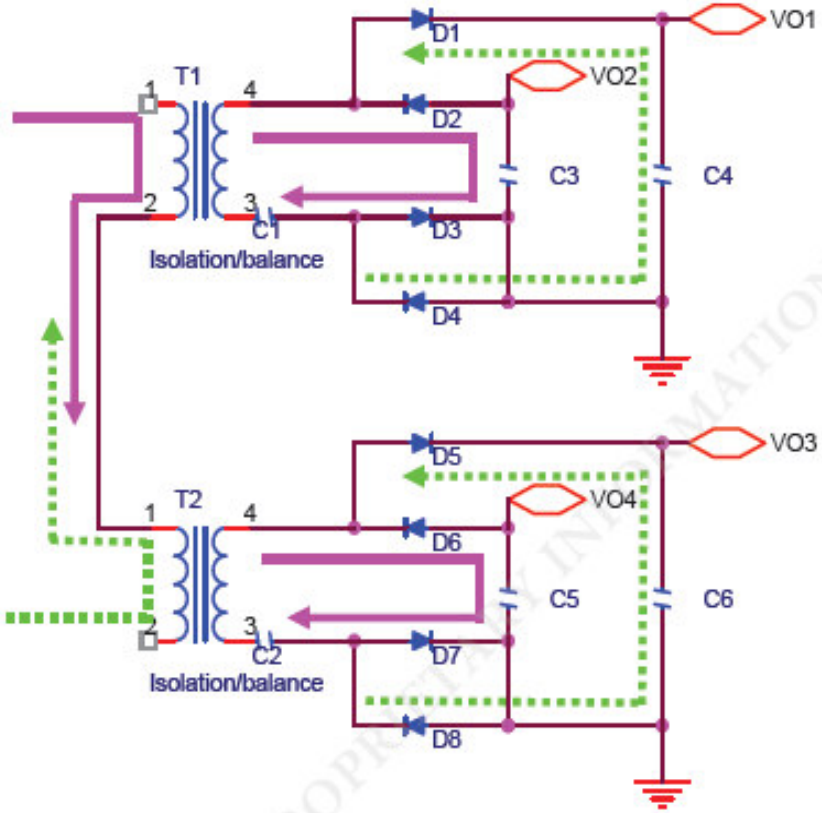


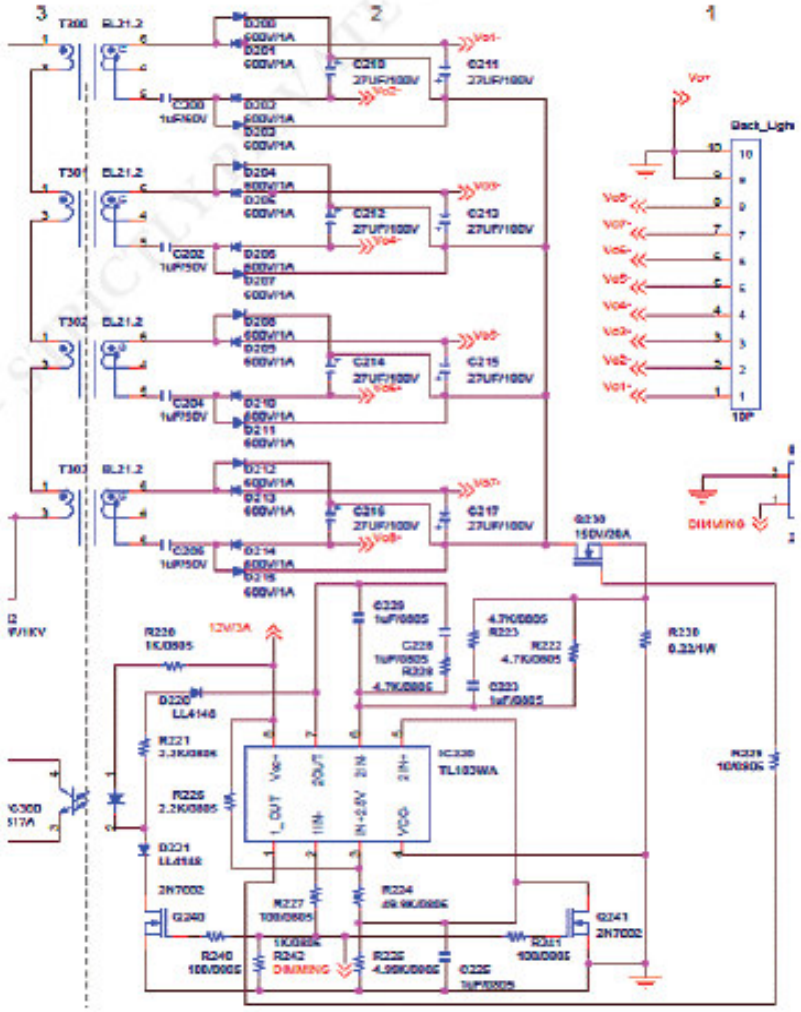


*** Board Dimension:**

300mm(L) * 210mm(W) * 8mm(H)

Multi-Transformer Architecture (*TI Patented*)





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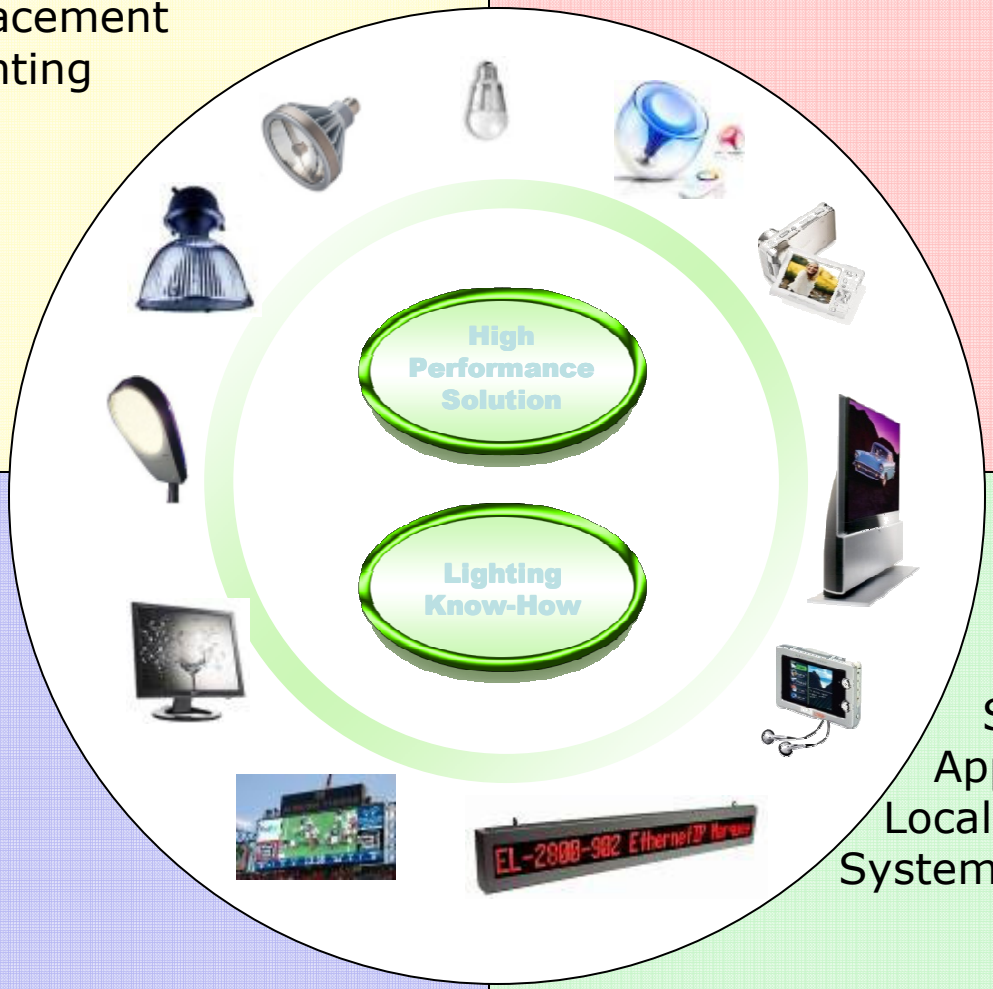

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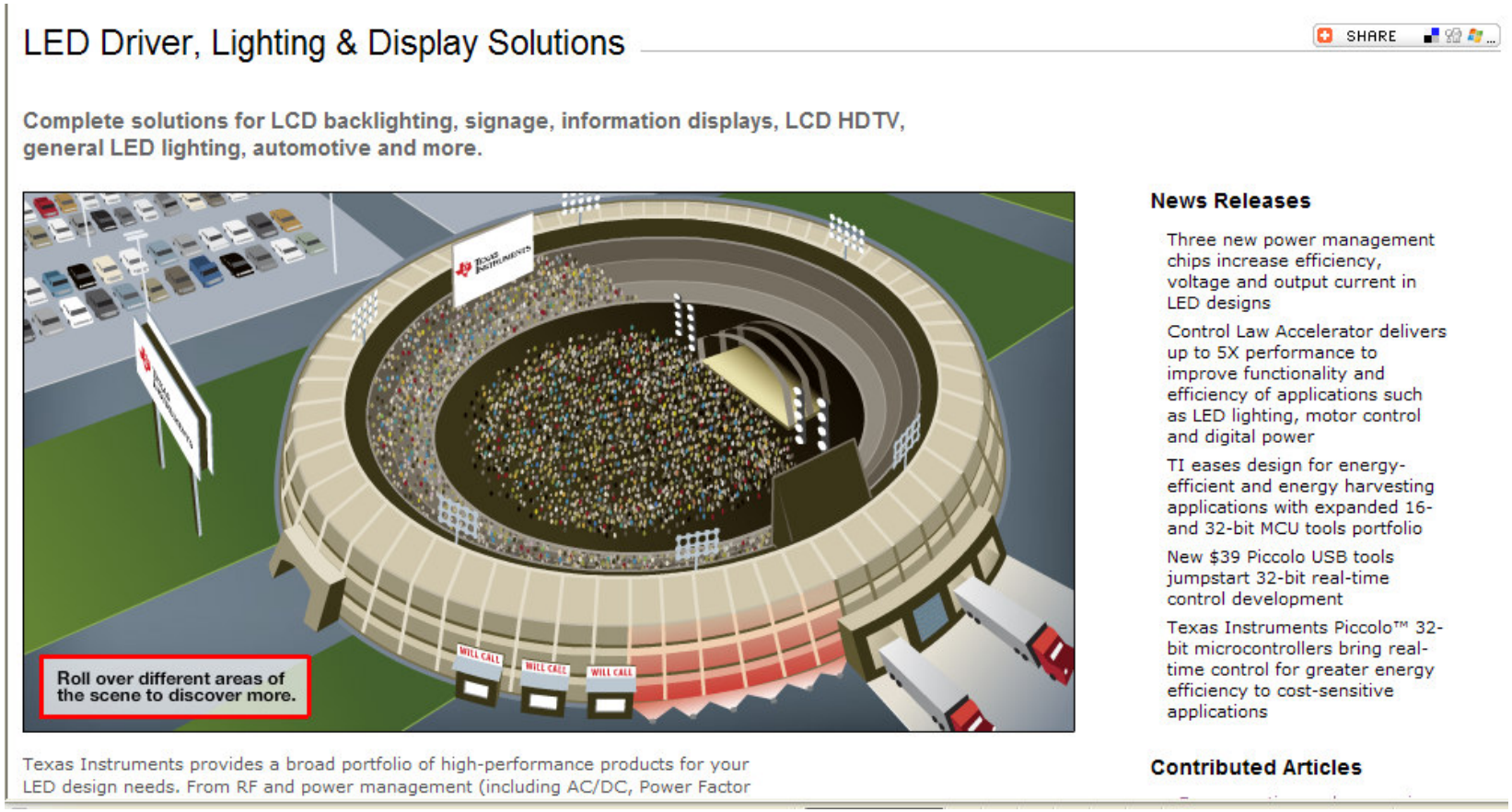

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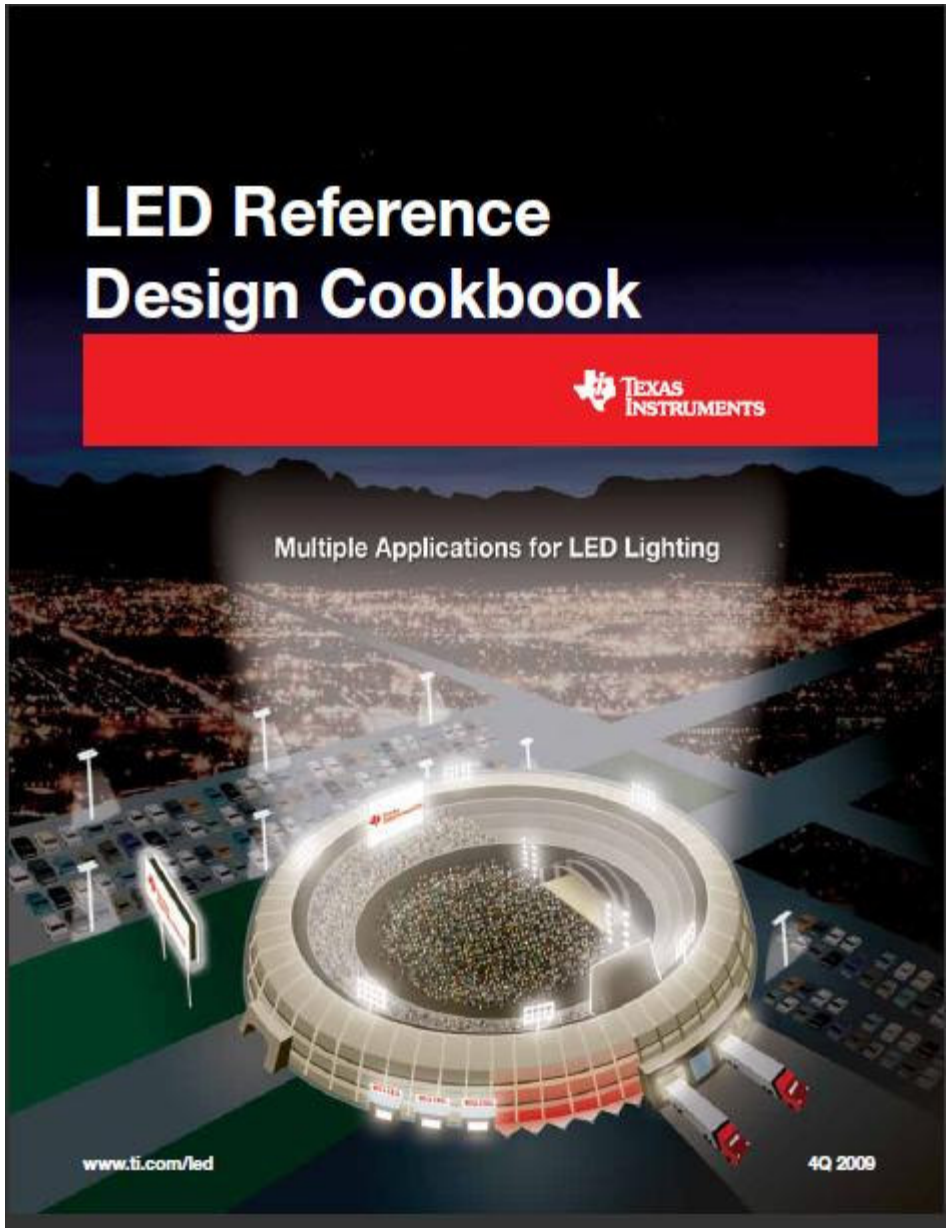

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