Innovative LED Lighting Electronic Design

_新型多串半桥谐振高效LED驱动解决方案及其应用

Add Speaker’s Name Here

Texas Instruments

LED General Illumination

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

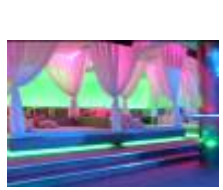

MR16


E14


E27/A19


PAR38


Display Case


Retail Display


Architectural


Street Light


Area Light


Flood Light

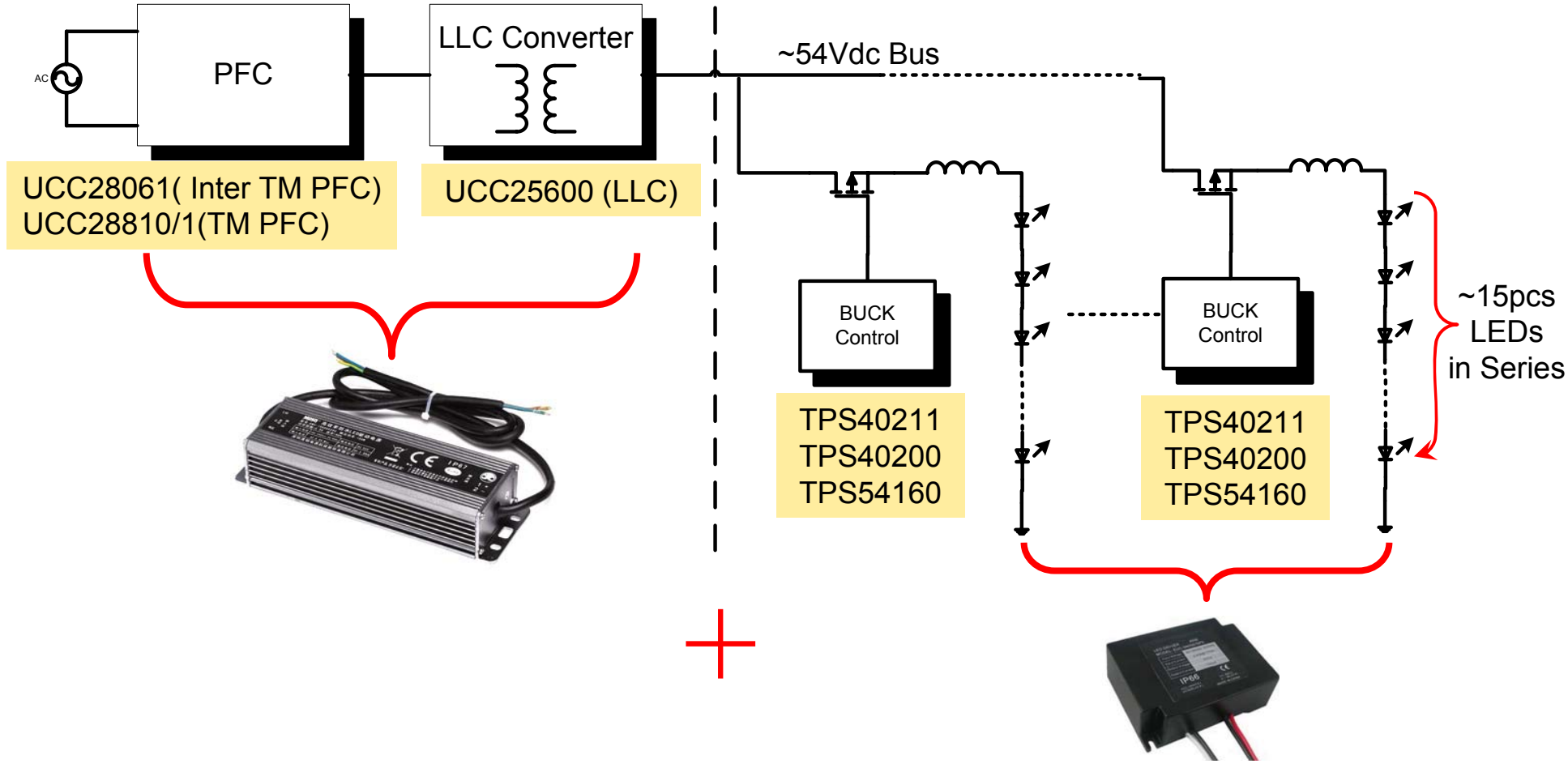
	Residential	Commercial	Outdoor and Infrastructure
Careabouts	**Low Cost, TRIAC Dimming, PFC, High Efficiency, Color Quality, Safety, Long Life**	**PFC, High Efficiency, Dimming, Early Payback, Color Quality, Safety, Maintenance, Eco-friendly**	**PFC, High Efficiency, Early Payback, High Brightness, Safety, Maintenance, Eco-friendly**
Devices	TPS40211 (MR16) TPS92210 (Ioslated) TPS92001 (non-isolated) **new** **TPS92070 (Two stages)**	UCC28810 (Tube lighting) UCC28811(Tube lighting) **new** **UCC25710**	**new** **UCC25710** UCC28810/1TPS92020 **new** **TPS92510**
Tools	TPS92010EVM-592 (110V) *TPS92010EVM-631 (230V)* TPS92210EVM-613	UCC28810EVM-002 UCC28810EVM-003	UCC28810EVM-003 UCC25710

Texas Instruments

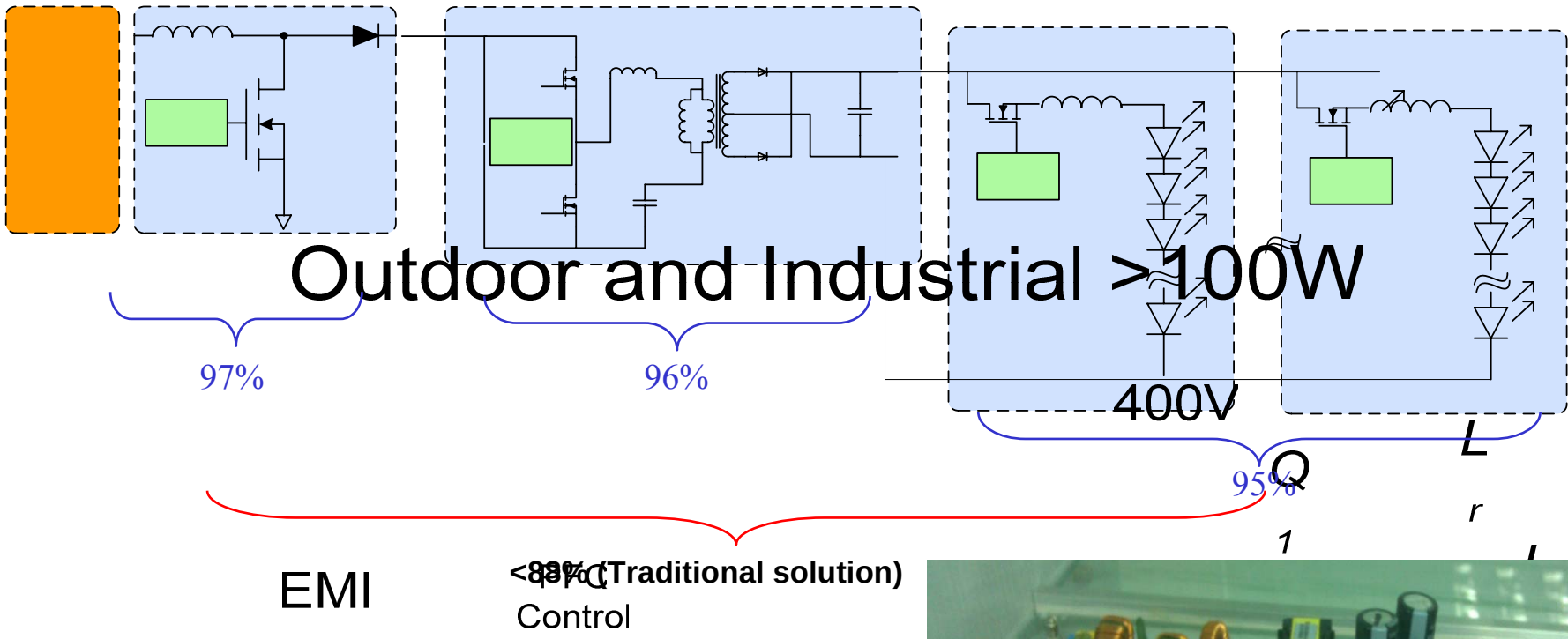
Typical High Watt (>100W) LED Lighting Driver Topology

1. AC/DC Power Stage

2. Constant Current Driver Stage

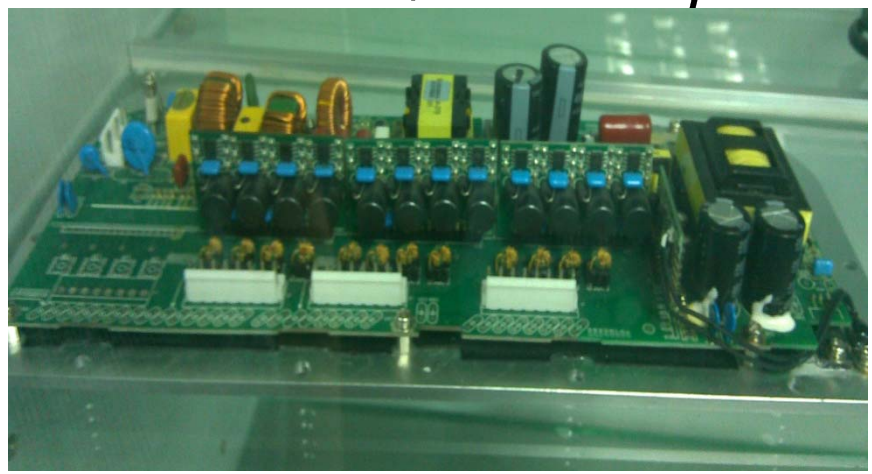


High Watt (>100W) LED Lighting Efficiency Budget



Conventional Topology Issues:

☹ High cost: PFC+LLC+CC BUCK (multi-chips!!)
☹ Low efficiency (<~88%)
☹ Low reliability (many components' counts)
☹ EMI issues



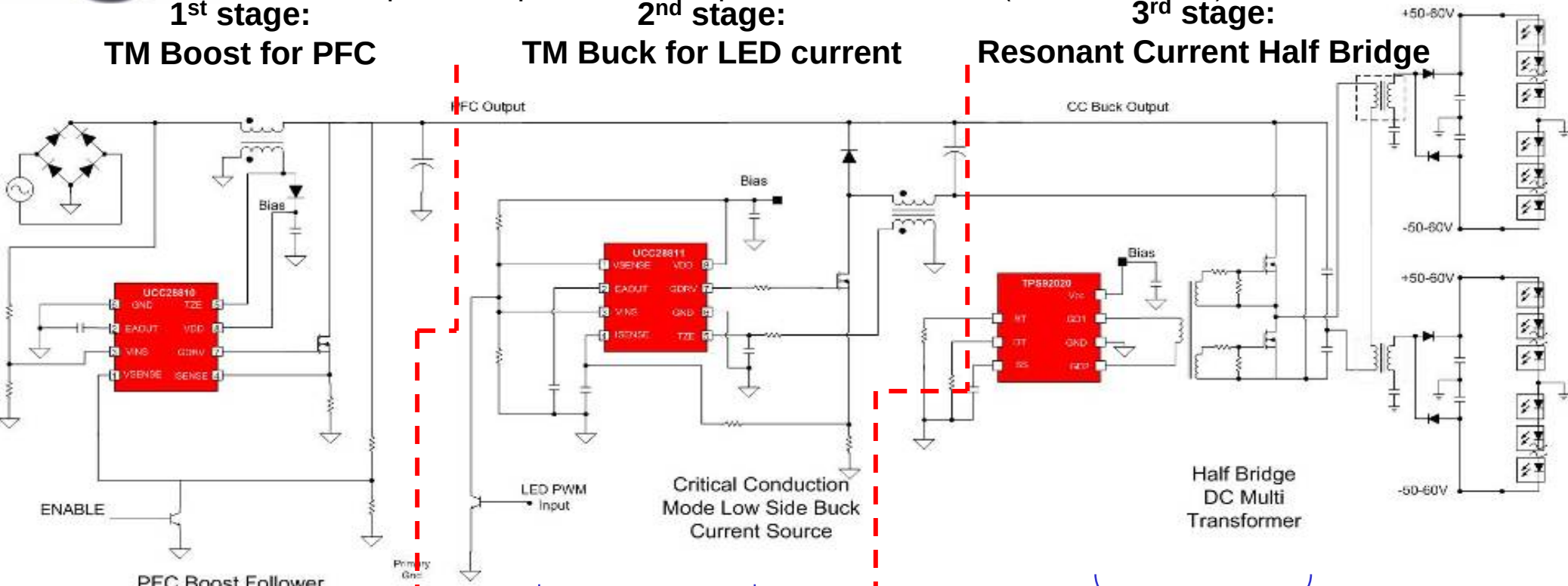
TI UCC28810EVM-003 - SIMPLEDrive™

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

1st stage:
TM Boost for PFC

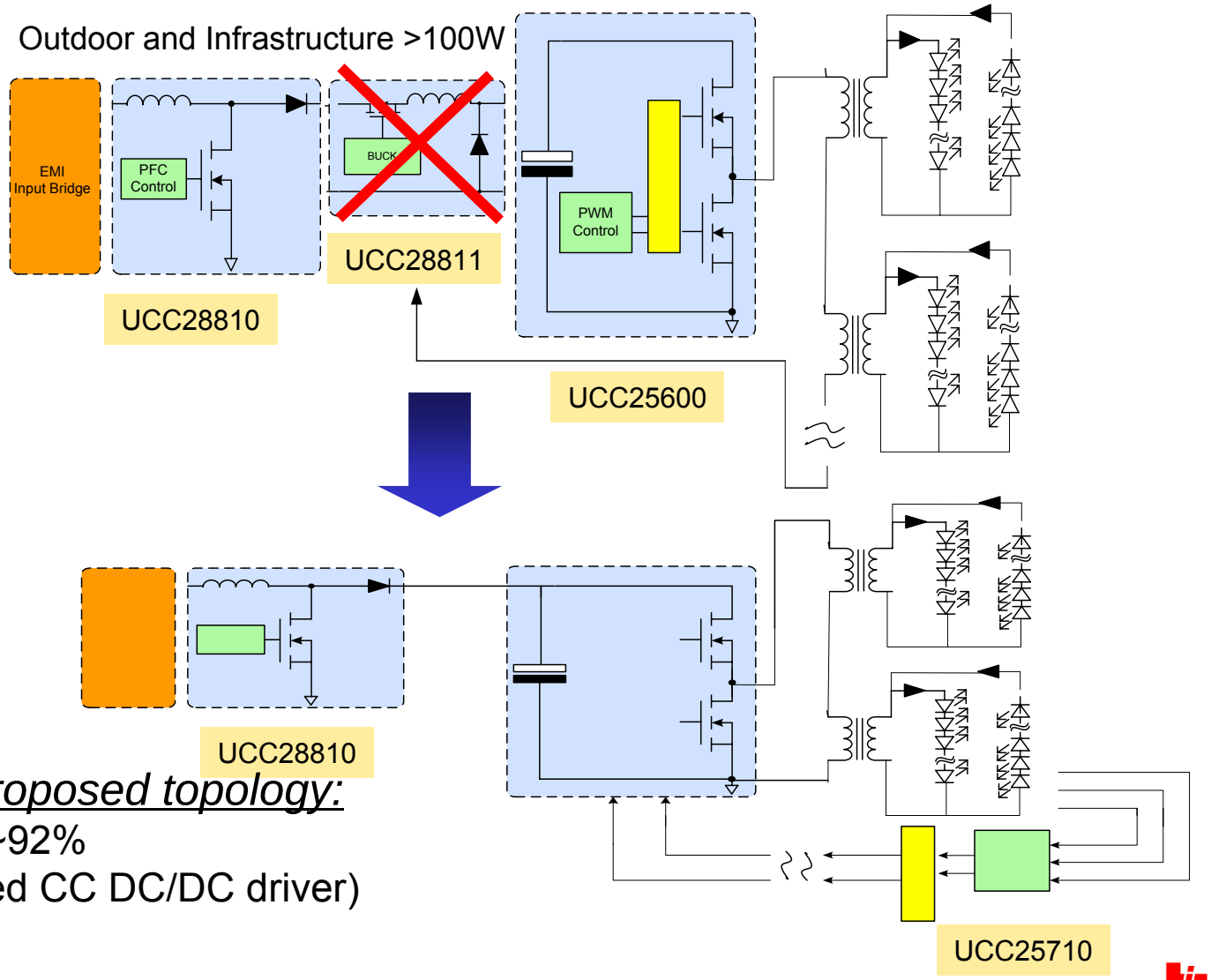
2nd stage:
TM Buck for LED current

3rd stage:
Resonant Current Half Bridge



>93% (Three stages multi-string transformer solution)

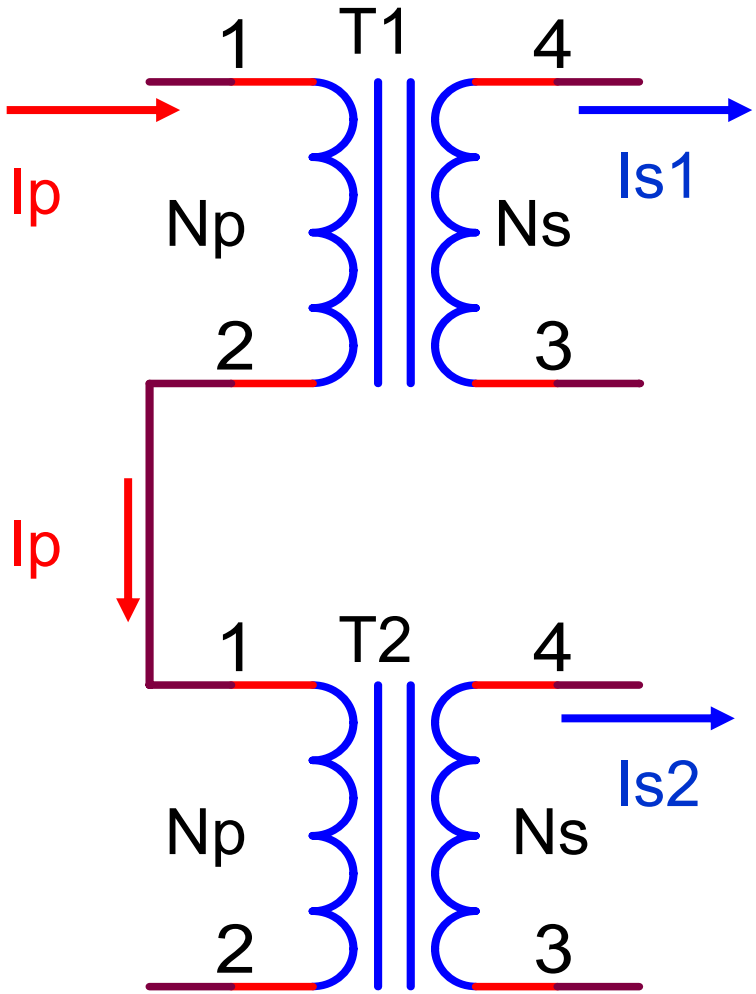
Innovative two stages multi-string LLC topology for LED lighting



Benefits for the proposed topology:

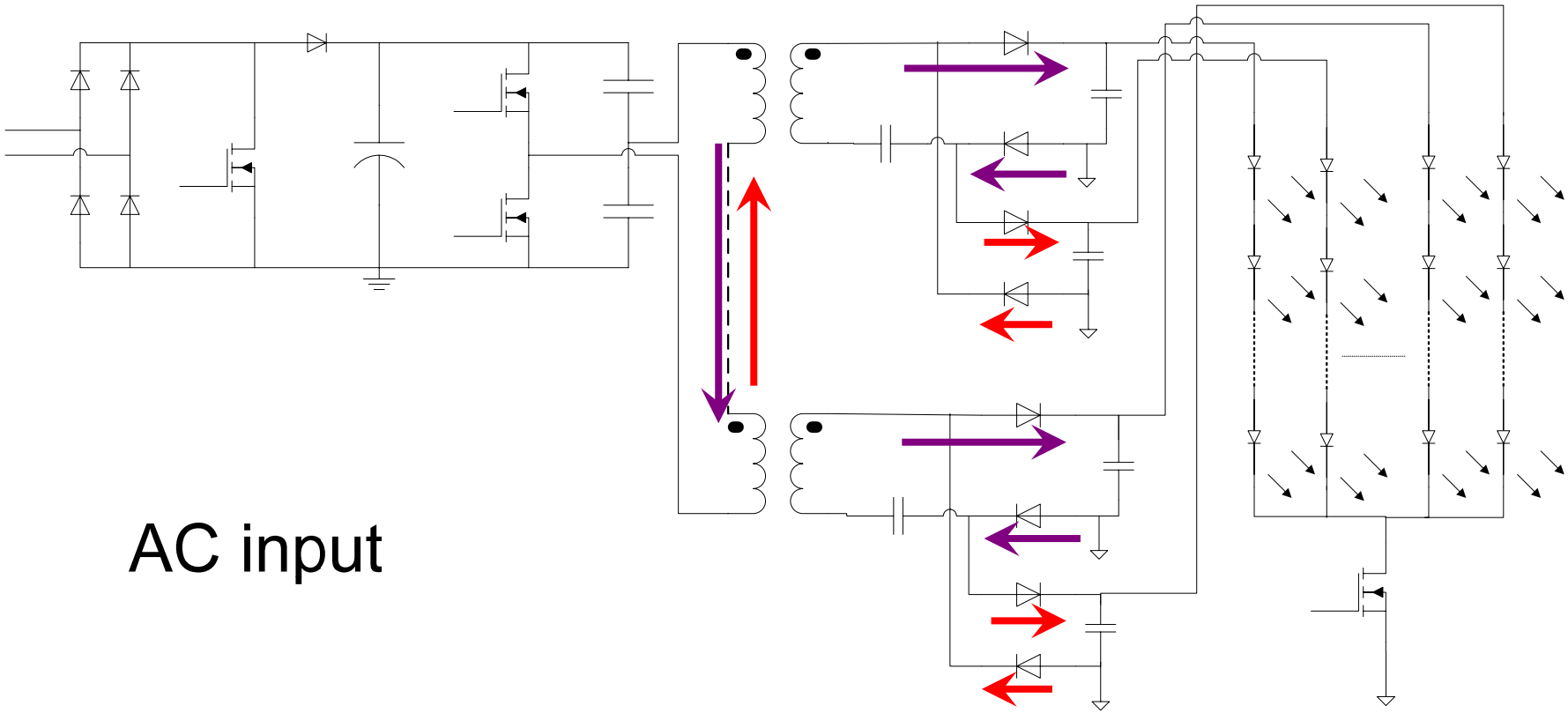
- ☺ High efficiency ~92%
- ☺ Low cost (no need CC DC/DC driver)
- ☺ High reliability
- ☺ Easy EMI
- ☺ PWM or analog dimming compatible

Why Transformer Can Balance Current



- Transformer current is in reverse proportion to turn ratio
- Ip/Np = Is/Ns; Is=Ns*Ip/Np
- When transformer primary is connected together, their primary current must be the same
- When T1 is the same as T2 because of transformer operation principle their secondary current is the same
- Is1=Np*Ip/Ns=Is2

Multi-Transformer Architecture (TI Patented)



AC input

One transformer control two LED strings!

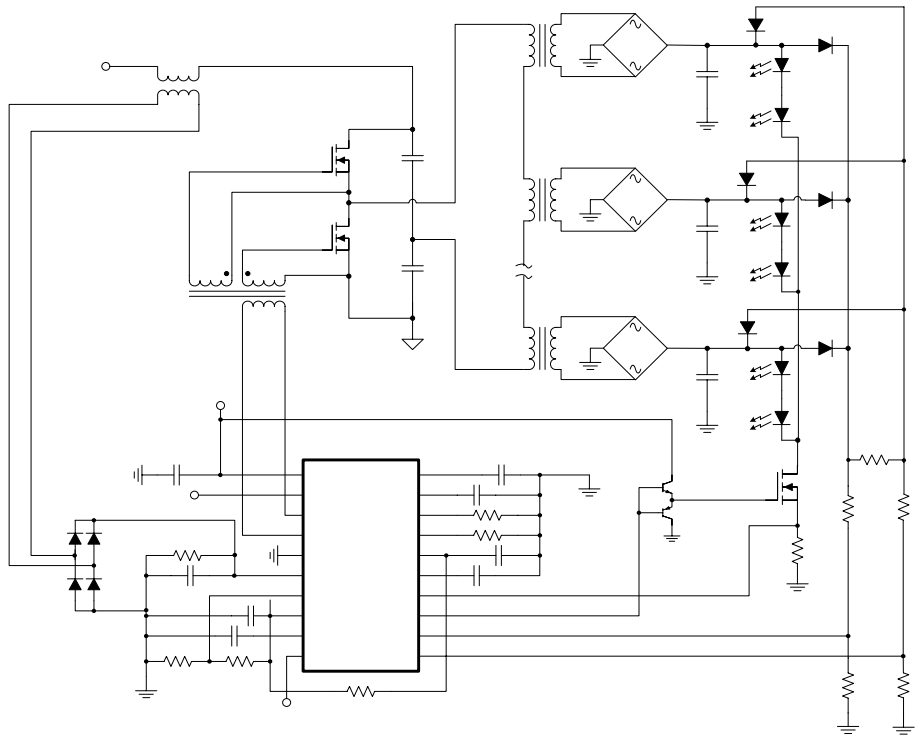
UCC25710: LED driver Controller IC

Features

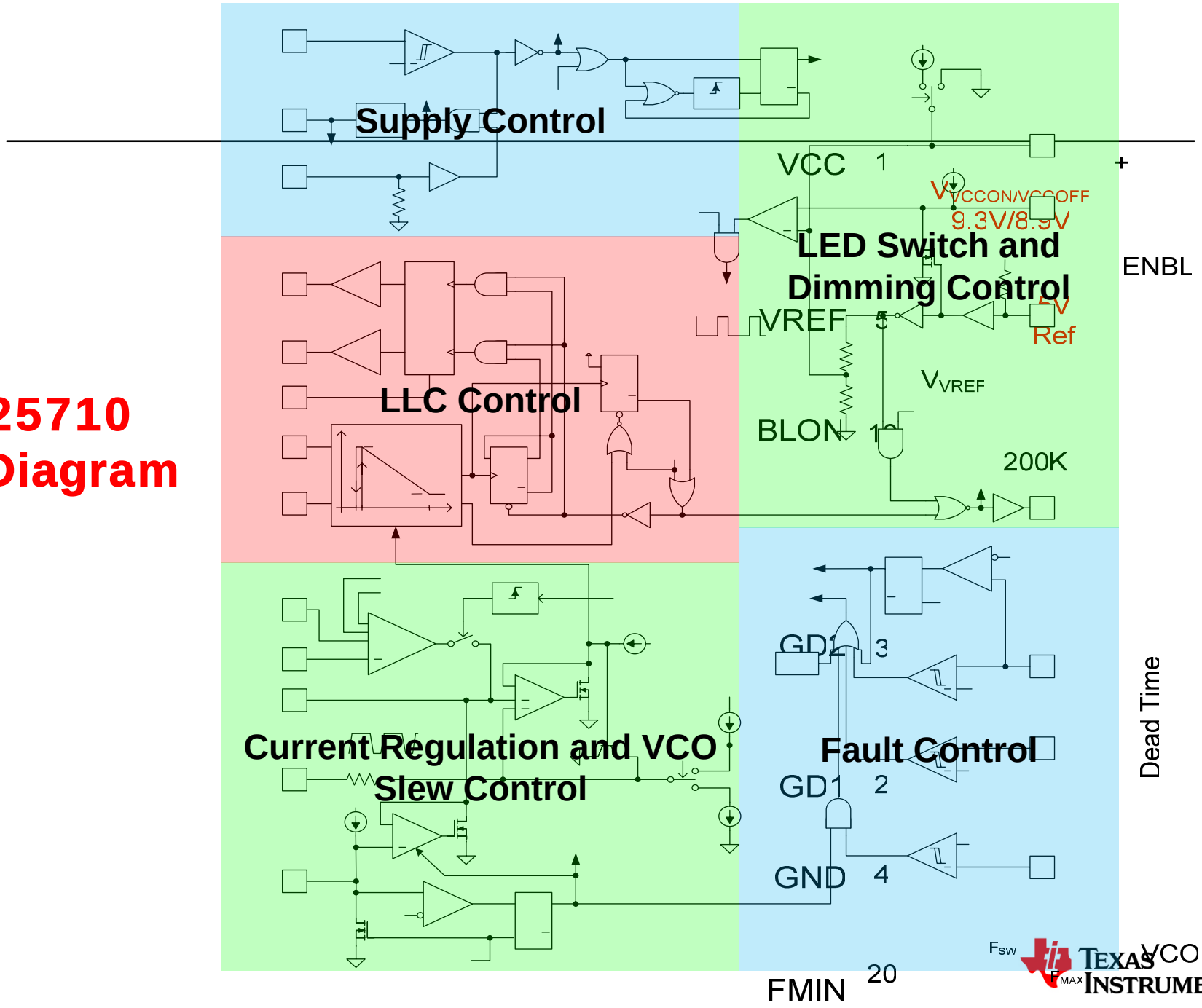
- **Industry first single chip LLC controller for driving multiple LED strings directly from PFC output**
- **Adjustable Fmin (3% accuracy), and Fmax 6% (accuracy)**
- **Closed Loop LED String Current Control**
- **PWM Dimming Input**
- **LLC and Series LED Switch Control for Dimming**
- **Programmable Dimming LLC ON/OFF Ramp for Elimination of Audible Noise**
- **Closed Loop Current Control at Low Dimming Duty-Cycles**
- **Programmable Soft Start**
- **Accurate VREF for Tight Output Regulation**
- **Over-voltage and Under-voltage and Input Over-current Protection with Auto-restart Response**
- **Second Over-current threshold with Latch-off Response**
- **+400-mA/-800mA Gate Drive Current**
- **Low Start-Up and Operating Currents**
- **20 pin SO Lead (Pb)-Free Package**

Applications

- General LED Lighting
- LED TV Backlighting

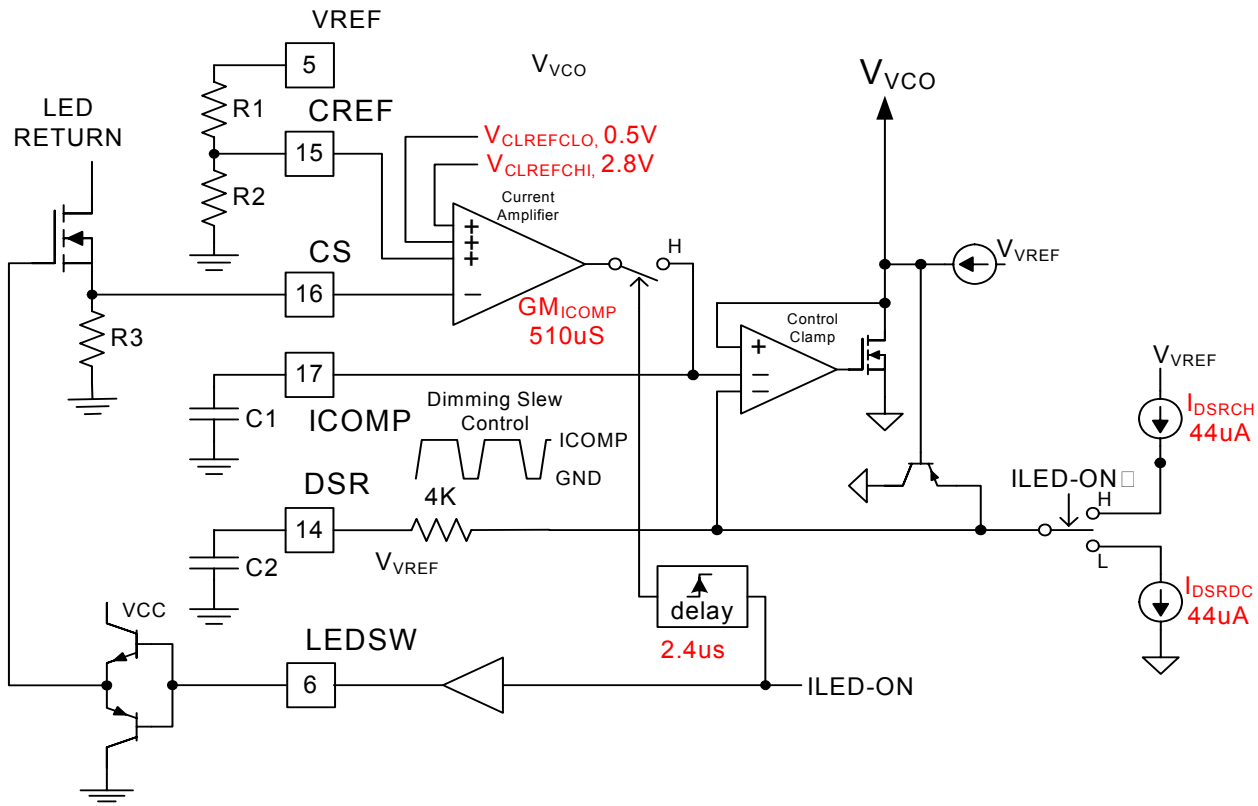


UCC25710 Block Diagram



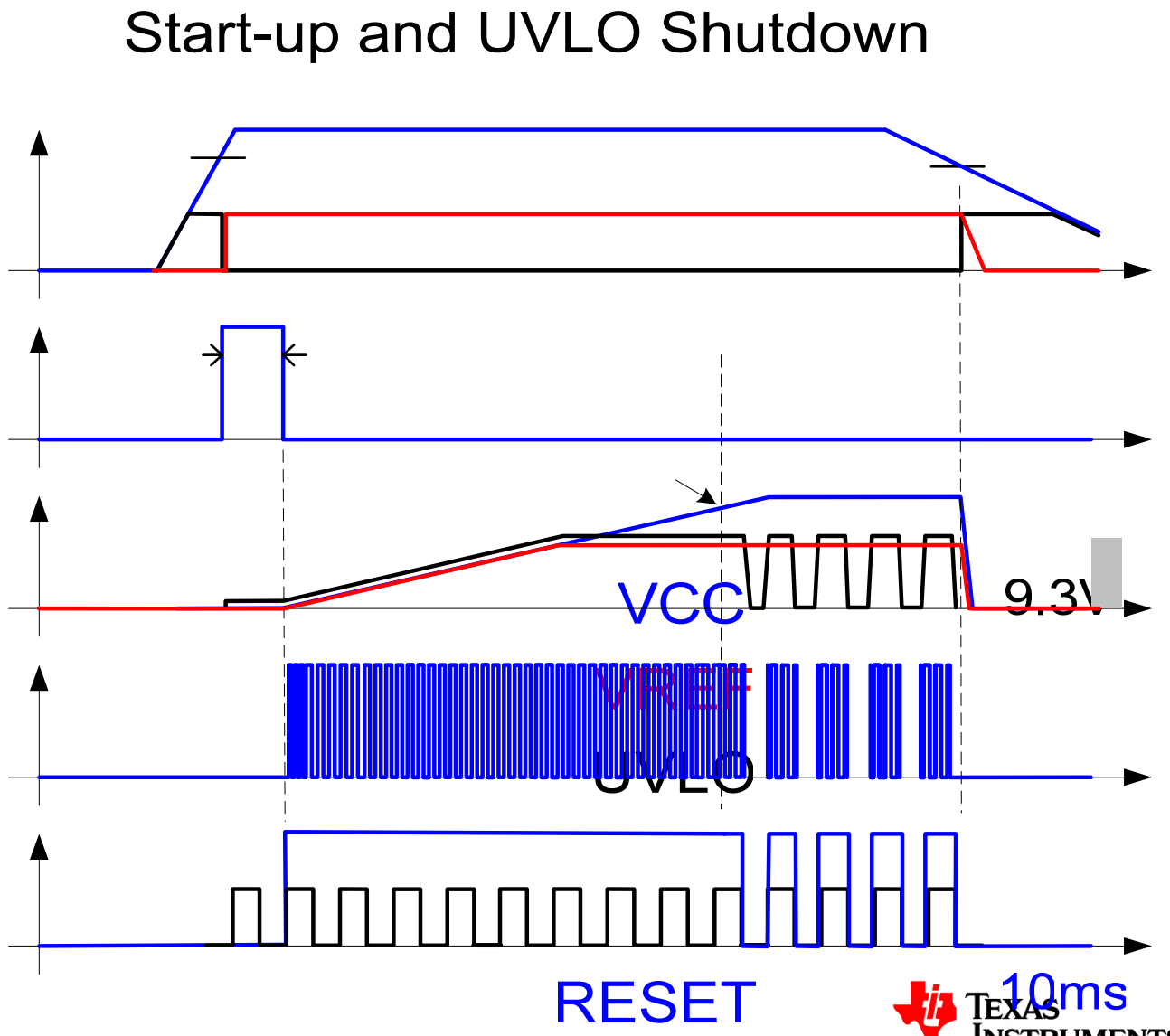
UCC25710: DIMMING – LLC ON/OFF TRANSITION & CURRENT CONTROL

- The DIM input controls the ILED-ON an ILED-ON` signals.
- DSR capacitor C2 and internal 44uA currents control the slew rate of V_{VCO} during dimming off and on transitions.
  - Turn-off: DSR is discharged to GND by 44uA
  - Turn-on: DSR is charged to ICOMP by 44uA. Charge level is clamped to 1Vbe above ICOMP
- Control Clamp output, V_{VCO}, tracks the lower of ICOMP and DSR
- ICOMP is only driven by GM amp during LED-ON times.
- During LED-OFF times the ICOMP voltage is held by C1



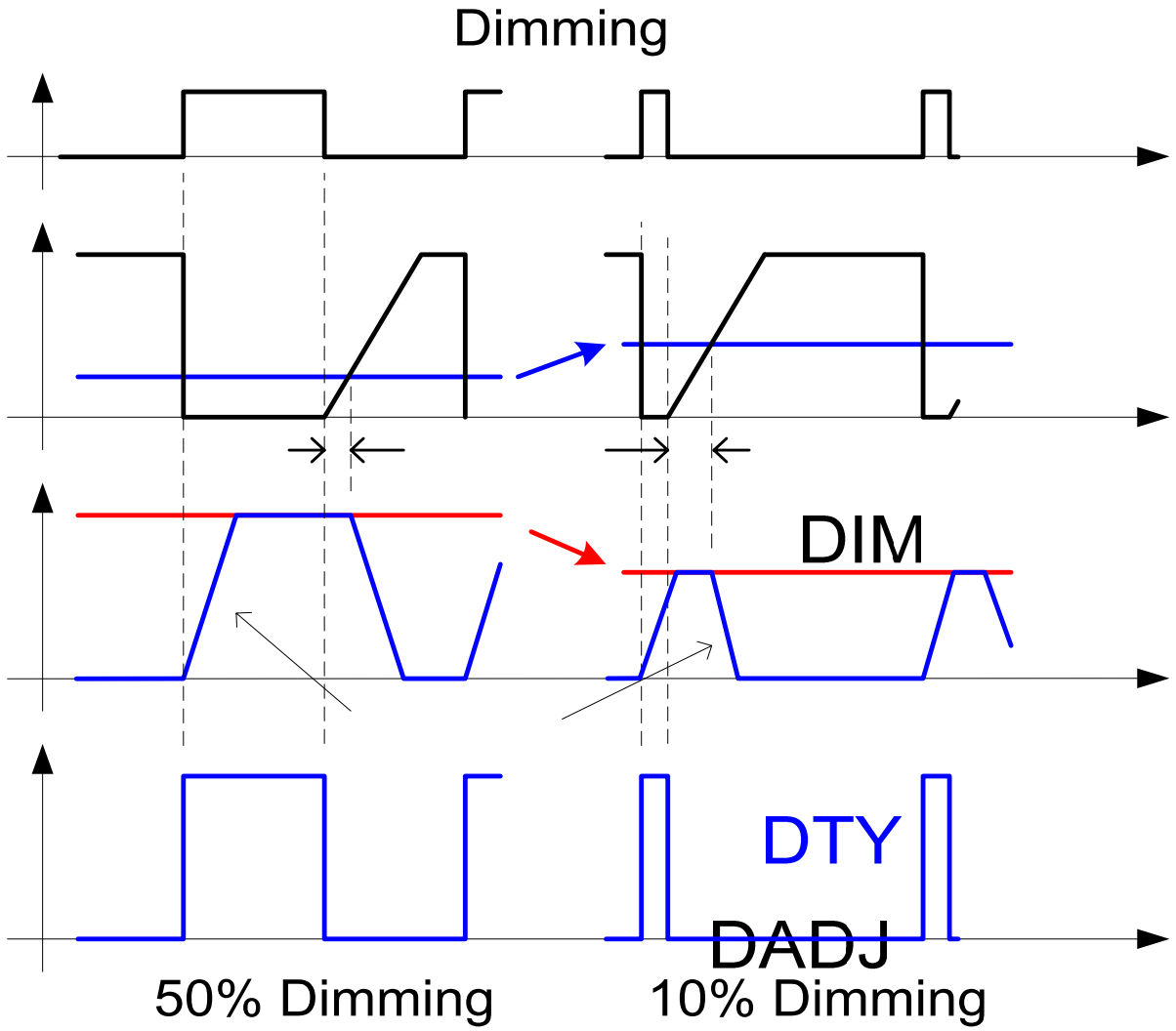
UCC25710: START-UP & DIM WAVEFORMS

- 10ms RESET initiates Soft-Start (SS)
- LLC Soft-Start, VCO control is clamped to SS until SS > ICOMP
- Dimming is disabled during SS
- DSR cap is used to limit LLC control slew rate during dimming
- ICOMP voltage is maintained during dimming



UCC25710: DIMMING – WAVEFORMS

- DIM input controls LEDSW
- DIM input triggers soft turn-on and turn-off of LLC converter
- LLC on-time is extended
- On-time extension is proportional to 1-D, D is dimming duty-cycle
- Extended on-time allows ICOMP to maintain current regulation at low D



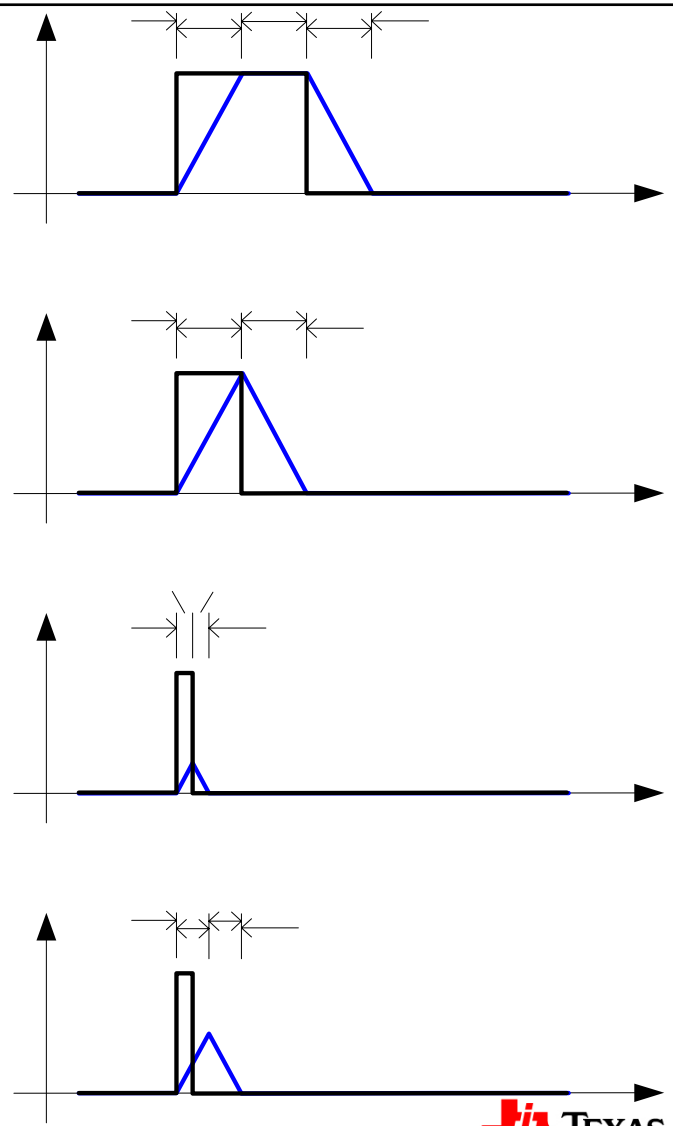
UCC25710: LOW DUTY-CYLE ILLUSTRATION

1. LLC reaches power level equal to pedestal LED current in region B. Power is under delivered in region A, but is compensated for in region C

2. Region B is zero, but sum of A+C still deliveries correct energy.

3. Energy delivered in region A + C is too low, loop is open and realized peak LED current will drop

4. On-time is extended. A + C energy/pulse is correct to maintain same peak LED current



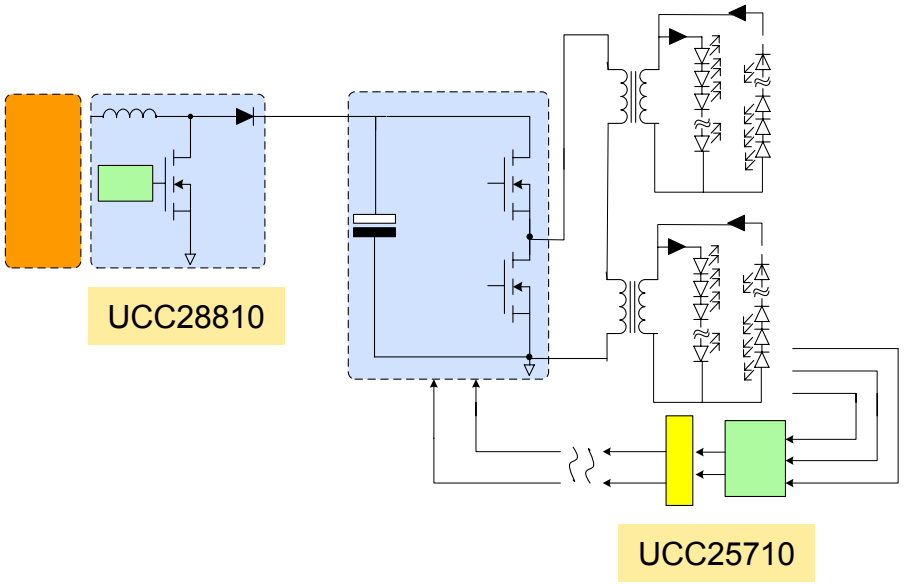
UCC25710: FAULT MANAGEMENT

- Faults
  - OV – highest LED string voltage
  - UV – lowest LED string voltage
  - CL(1V) – input current signal over-current
  - CL(2V) – input current signal latch-off
  - TSD – Chip thermal shutdown

- Response
  - OV, CL(1V) & TSD: The LLC converter and LEDSW are turned off. When the fault clears a RESET and SS are initiated.
  - UV: The LLC converter and LEDSW are turned off. A RESET and SS are immediately initiated, repeatedly, until fault clears.
  - CL(2V): The LLC and LEDSW are latched off until UVLO recycles.
  - During RESET the LLC converter and LEDSW are OFF
  - During SS the LLC converter and LEDSW are ON, i.e. no DIMMING

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 *(TM PFC)* UCC25710 *(Multi-string LLC)* UCC28610 *(Aux Flyback)*	90V~264V	54V@500mA with 4 string	TM PFC+Multi-string LLC converter	92%	PWM dimming

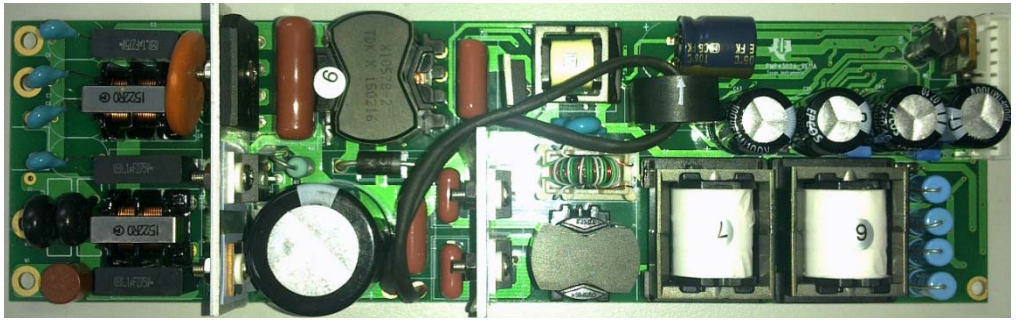


Features

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

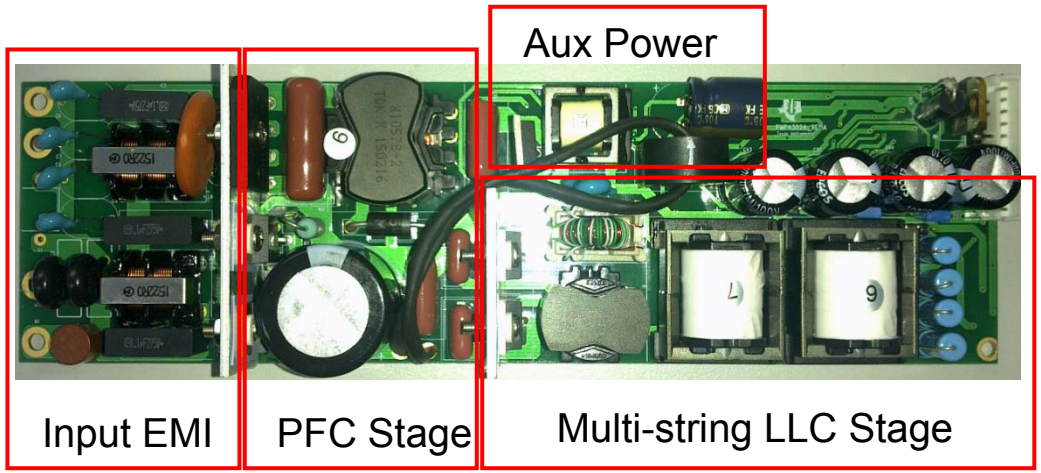
Applications

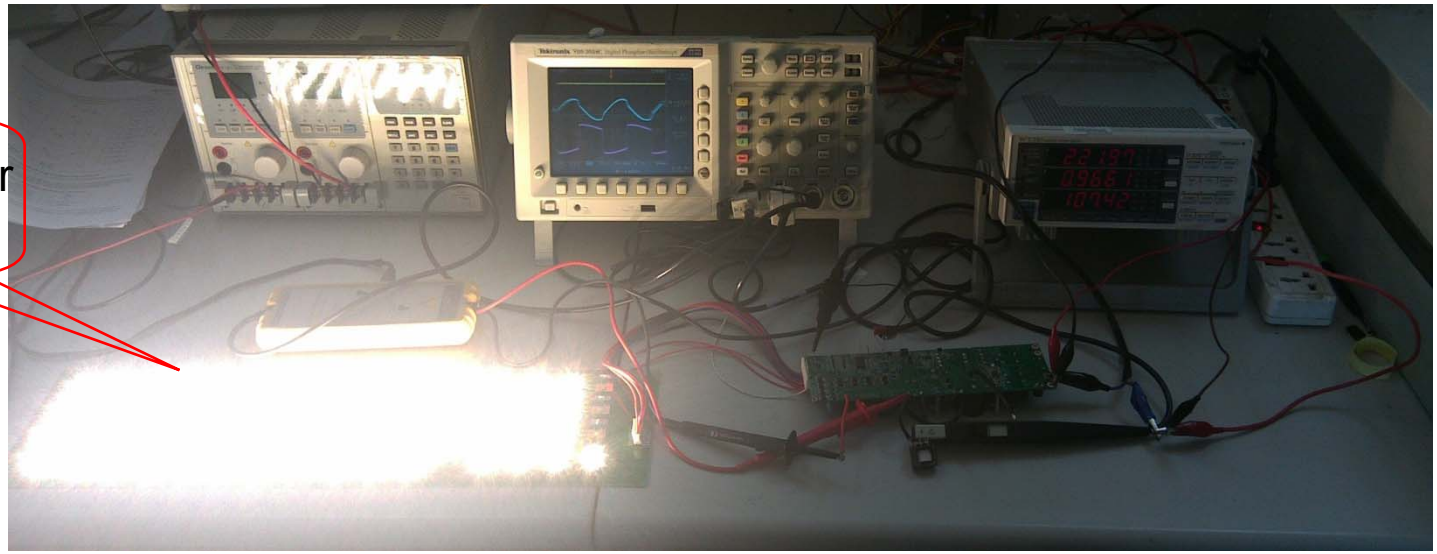
- General LED lighting and LED backlight TV



Outdoor and Infrastructure > 100W

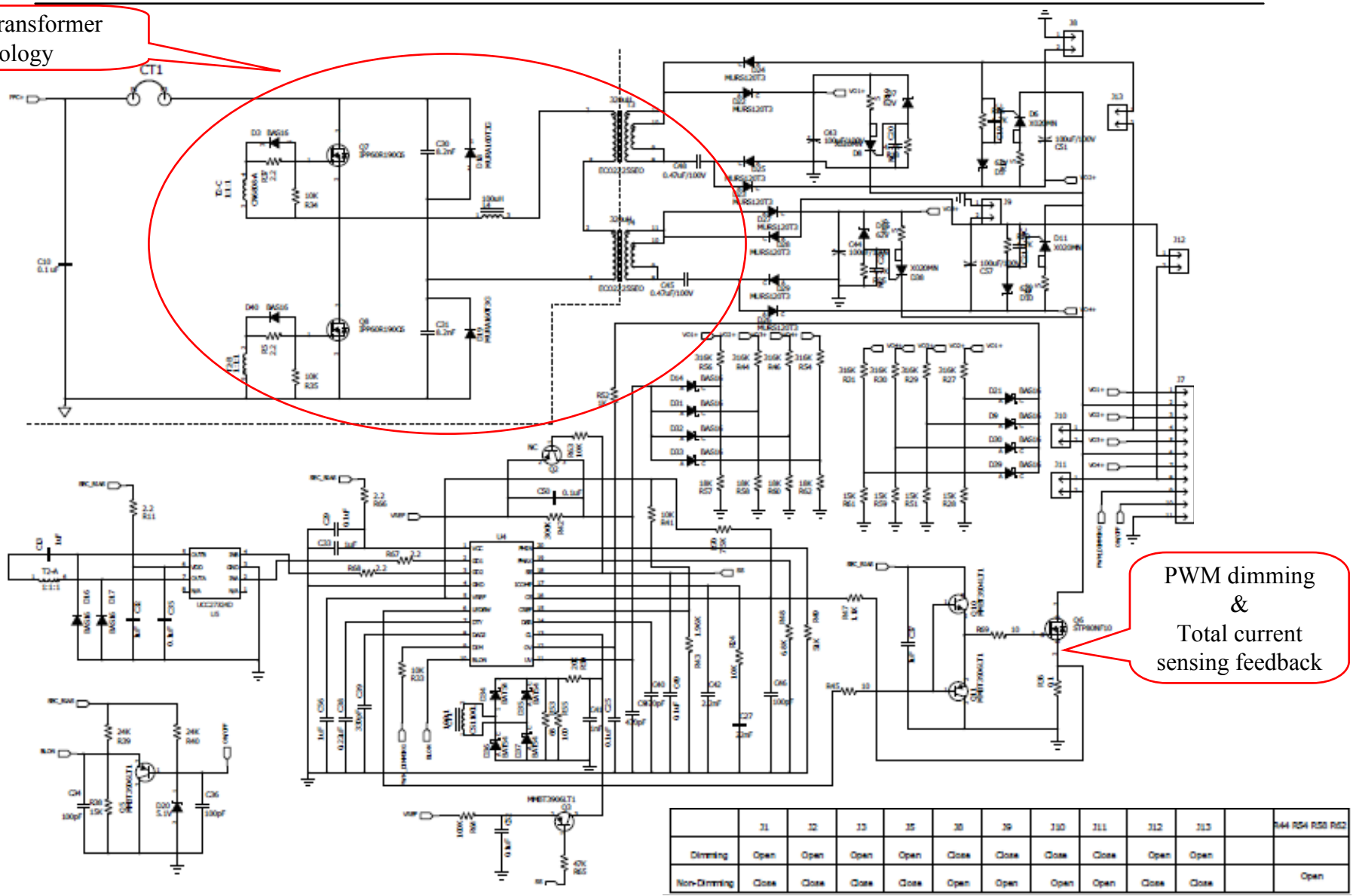
PMP4302A demo board





PMP4302: Schematics for UCC25710 after PFC stage

Multi-string transformer
LLC topology



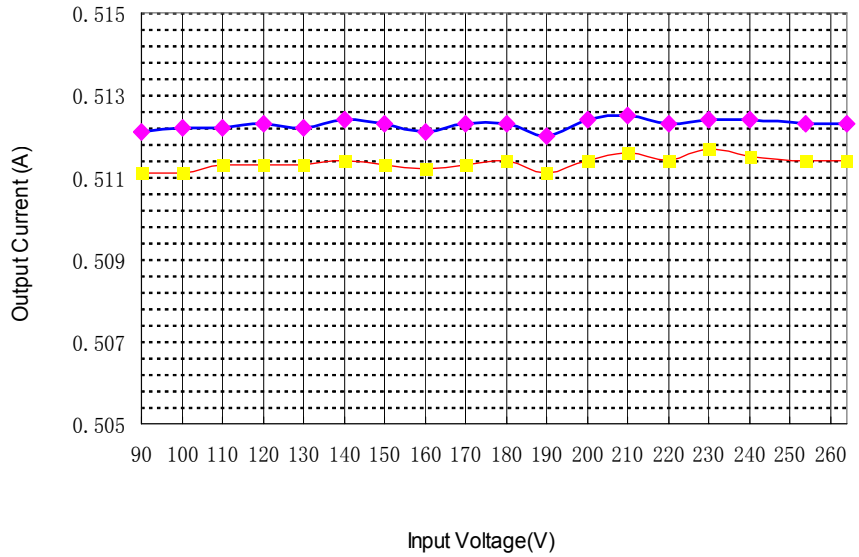
	J1	J2	J3	J5	J8	J9	J10	J11	J12	J13		R44 R54 R58 R62
Dimming	Open	Open	Open	Open	Close	Close	Close	Close	Open	Open		
Non-Dimming	Close	Close	Close	Close	Open	Open	Open	Open	Close	Close		Open

PMP4302A: LED current output tolerance

230V ac input

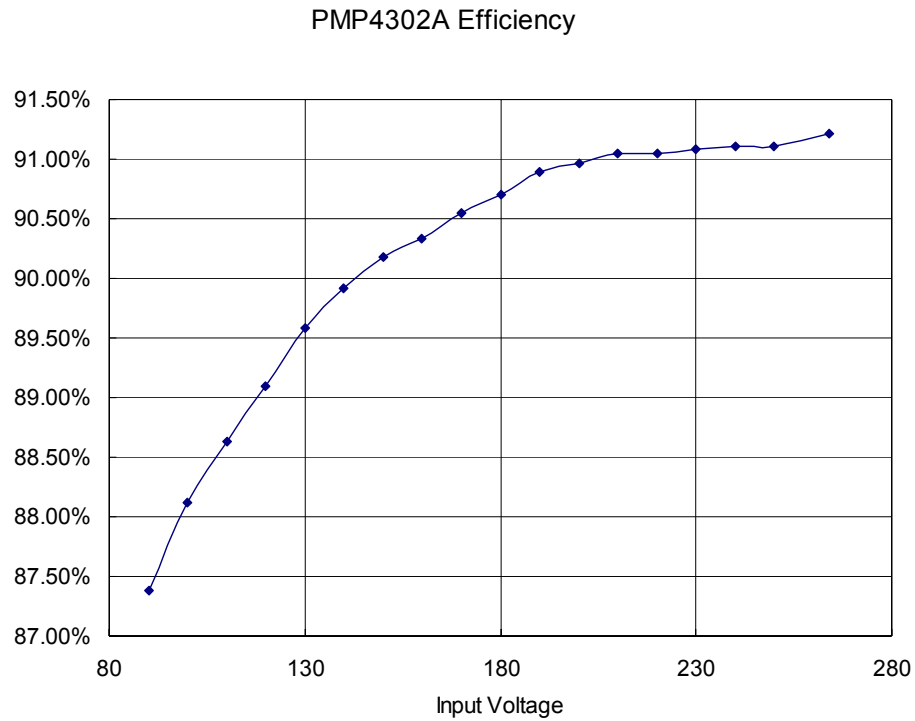
PWM Dimming	Io1	Io2	Io3	Io4	%
1%	4.9	4.8	5	5.1	3.030
2%	10	9.8	10.4	10.3	2.962
5%	25.2	24.1	25.2	25.1	2.208
10%	50.4	49.7	51.5	51.3	1.774
20%	100.9	100.1	102.7	102.5	1.280
30%	151.4	150.4	154.1	153.6	1.214
40%	201.9	200.9	205.1	204.9	1.033
50%	252.4	251.1	256.4	255.8	1.043
60%	302.9	301.4	307.7	307	1.033
70%	353.5	351.8	358.6	357.8	0.956
80%	403.9	402.2	409.7	408.8	0.923
90%	454.3	452.2	461.1	460.1	0.973
99%	499.3	496.7	507.2	506.2	1.045
100%	503.9	501.4	512.4	511.7	1.084

LED output current Vs Input voltage w/ 100% dimming



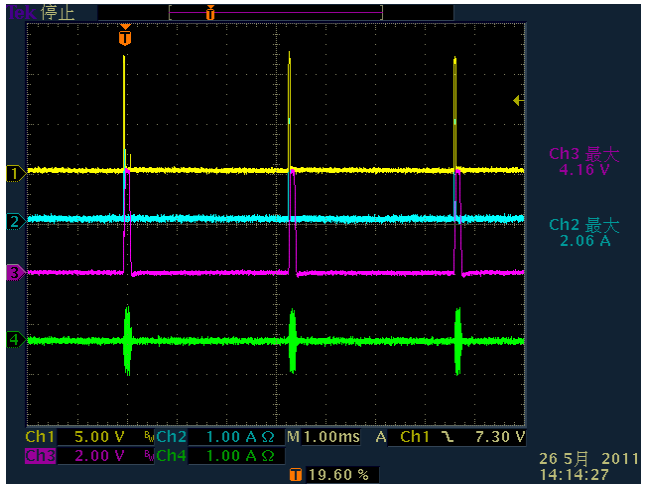
Current tolerance can achieve <+-3% with dimming range from 1% to 100%

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

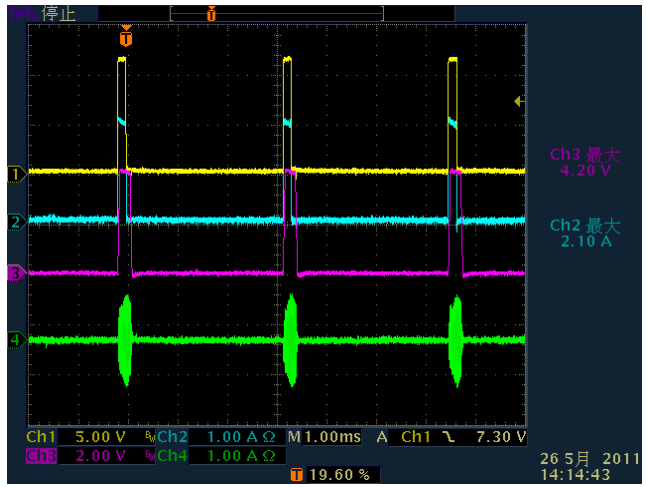


Dimming version

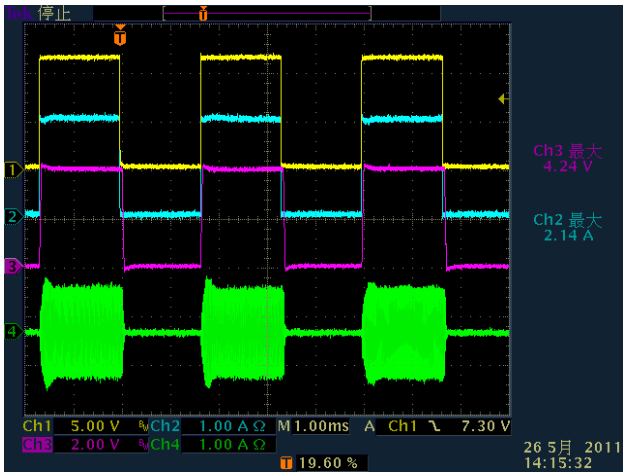
PMP4302: waveforms



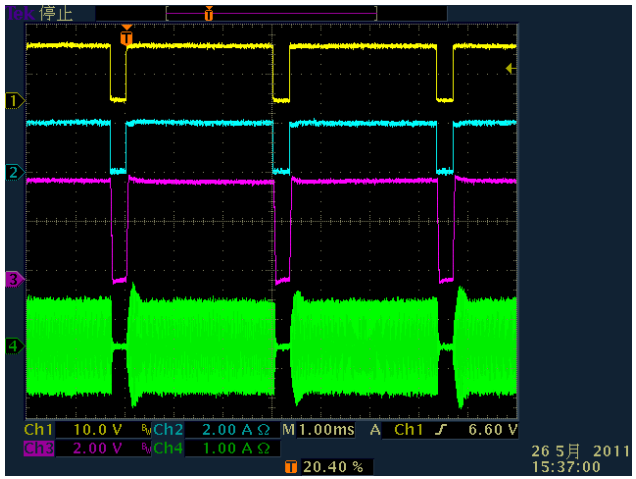
1% dimming



5% dimming



50% dimming



90% dimming

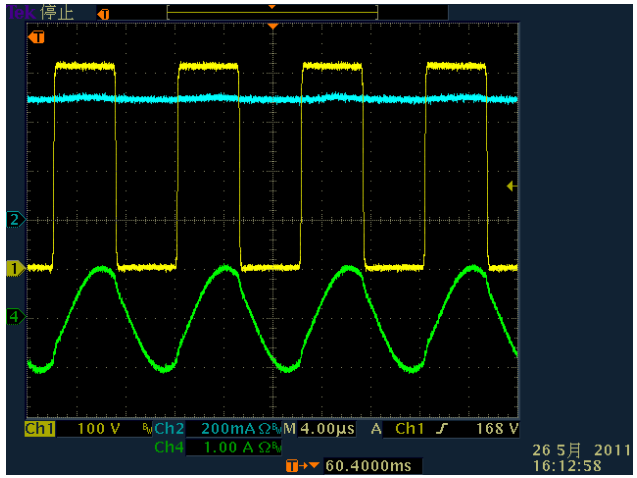
CH1: LEDSW MOSFET Vgs 5V/Div

CH2: LED Output Current 1A/Div

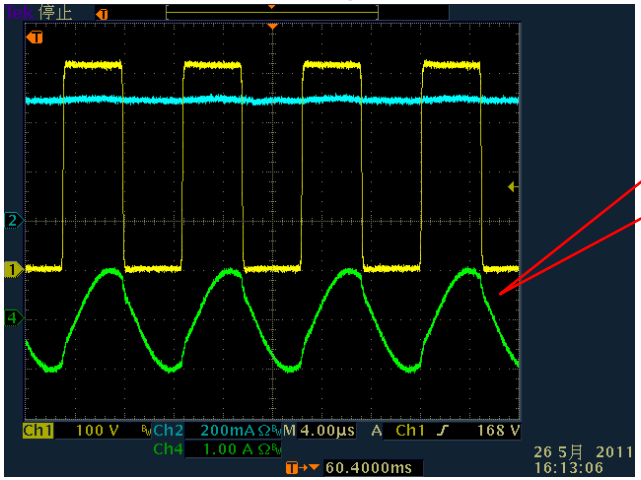
CH3: DSR 2V/Div

CH4: Primary Current 1A/Div

PMP4302: waveforms

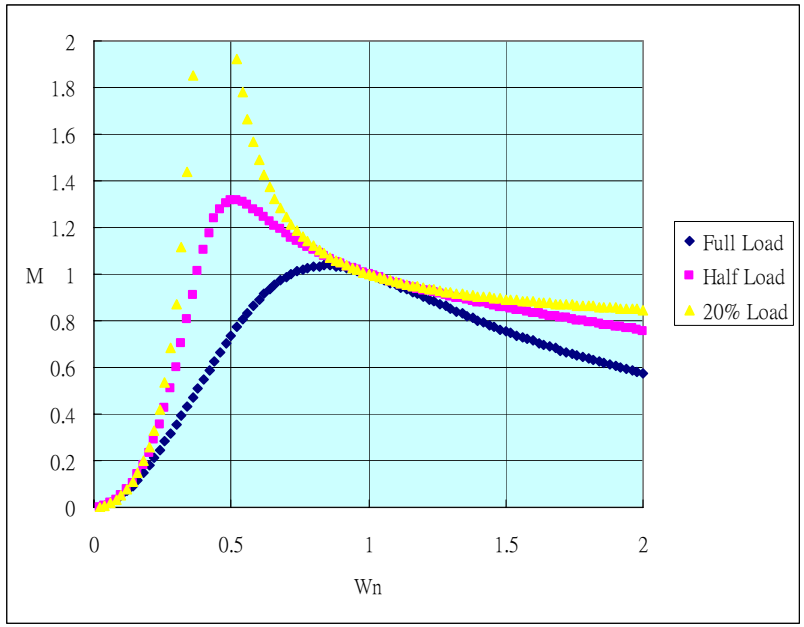


90Vac input



230Vac input

CCM to get better current tolerance

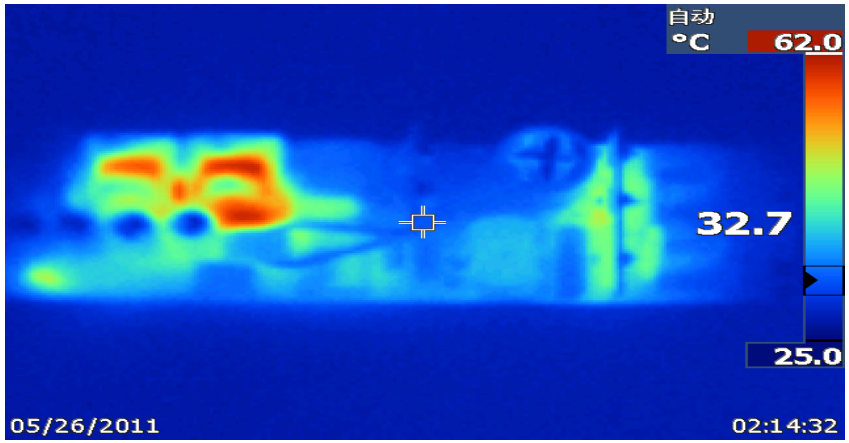


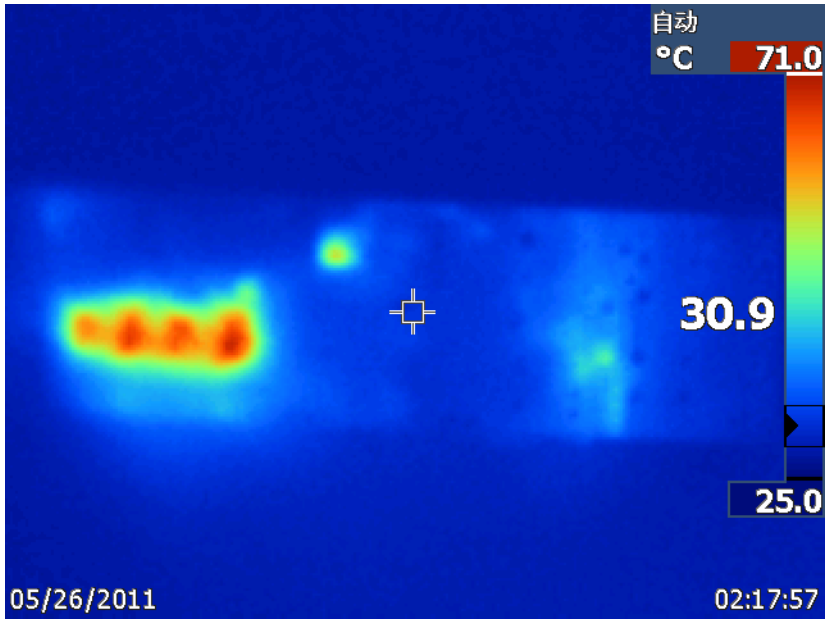
Lm/Lk=6
Fs=100KHz
Q=0.7

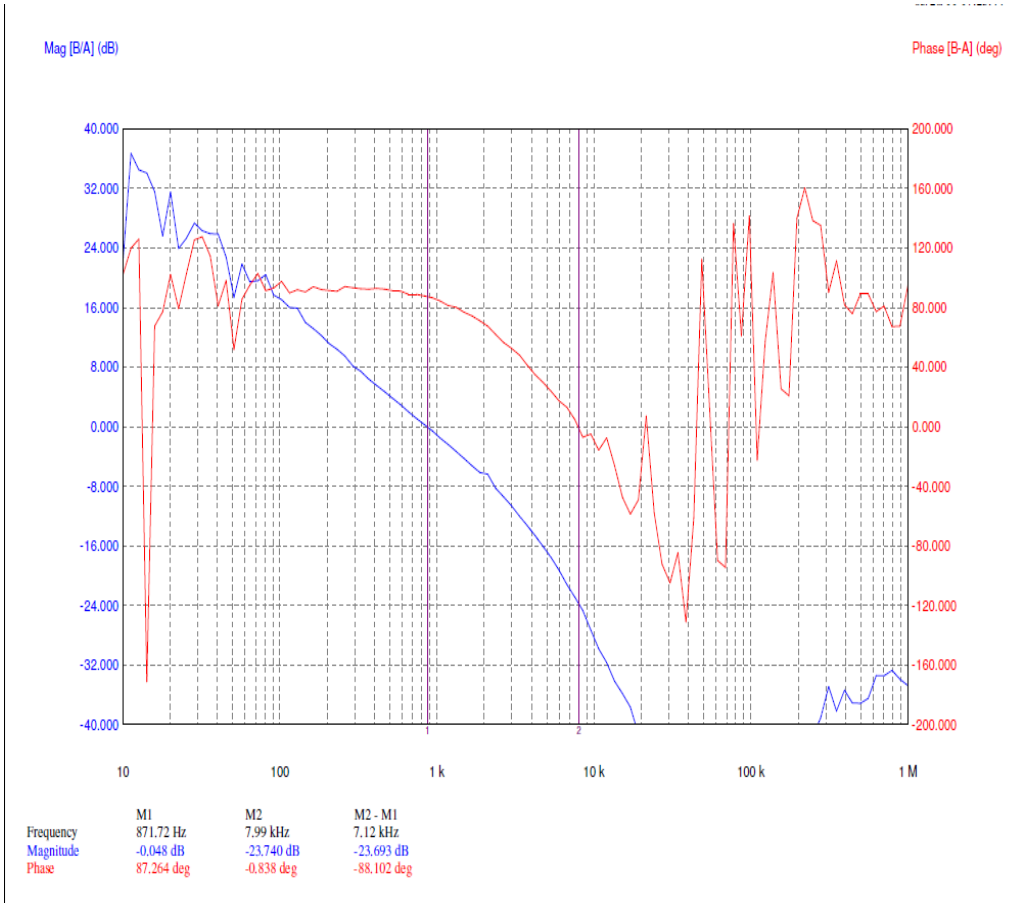
Lm1+Lm2=640uH
Lr=100uH
Cr=30nF

CH1: Primary MOSFET Vds 100V/Div
CH2: LED Output Current 200mA/Div
CH4: Primary Current 1A/Div

PMP4302: Thermal and Bode Plot

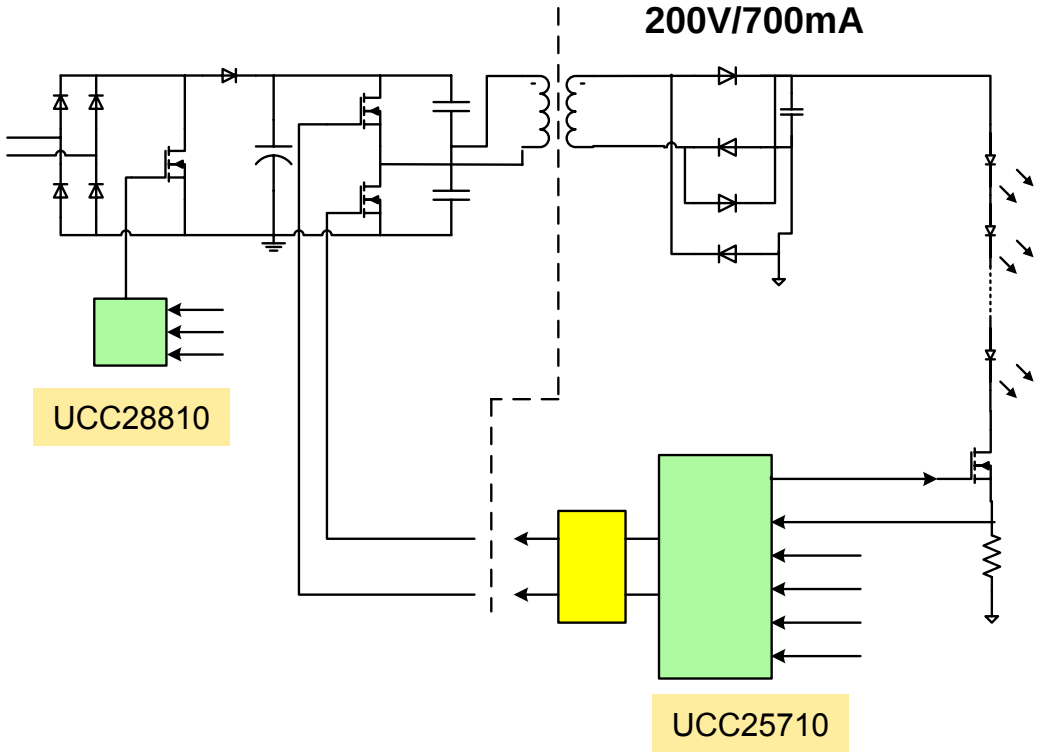






PMP4317: Single-string LLC AC/DC Driver for general LED lighting

Reference Design	TI Parts	V_{in}	Output	Topology	Eff.	Dimming
PMP4317: **AC input single-string LLC converter for general LED lighting**	UCC28810 *(TM PFC)* UCC25710 *(Multi-string LLC)* UCC28610 *(Aux Flyback)*	90V~264V	200V@700mA	TM PFC+single string LLC resonant converter	95%	PWM dimming with CC2530 daughter board Or 0~10V analog dimming

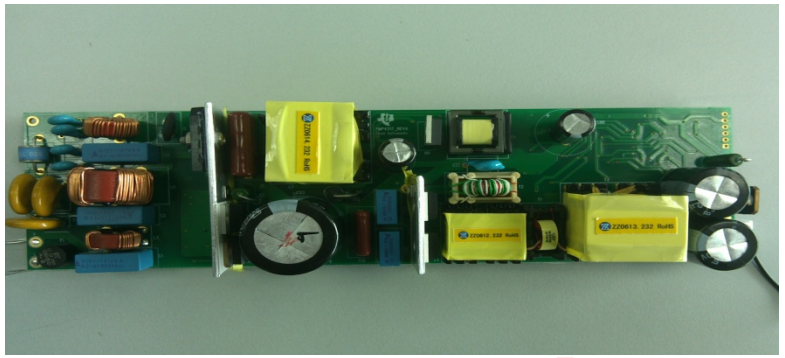


Features

- Lowest cost
- Highest efficiency to 95%
- PWM and analog dimming compatible
- Integrate LED open/short protection and over current protection

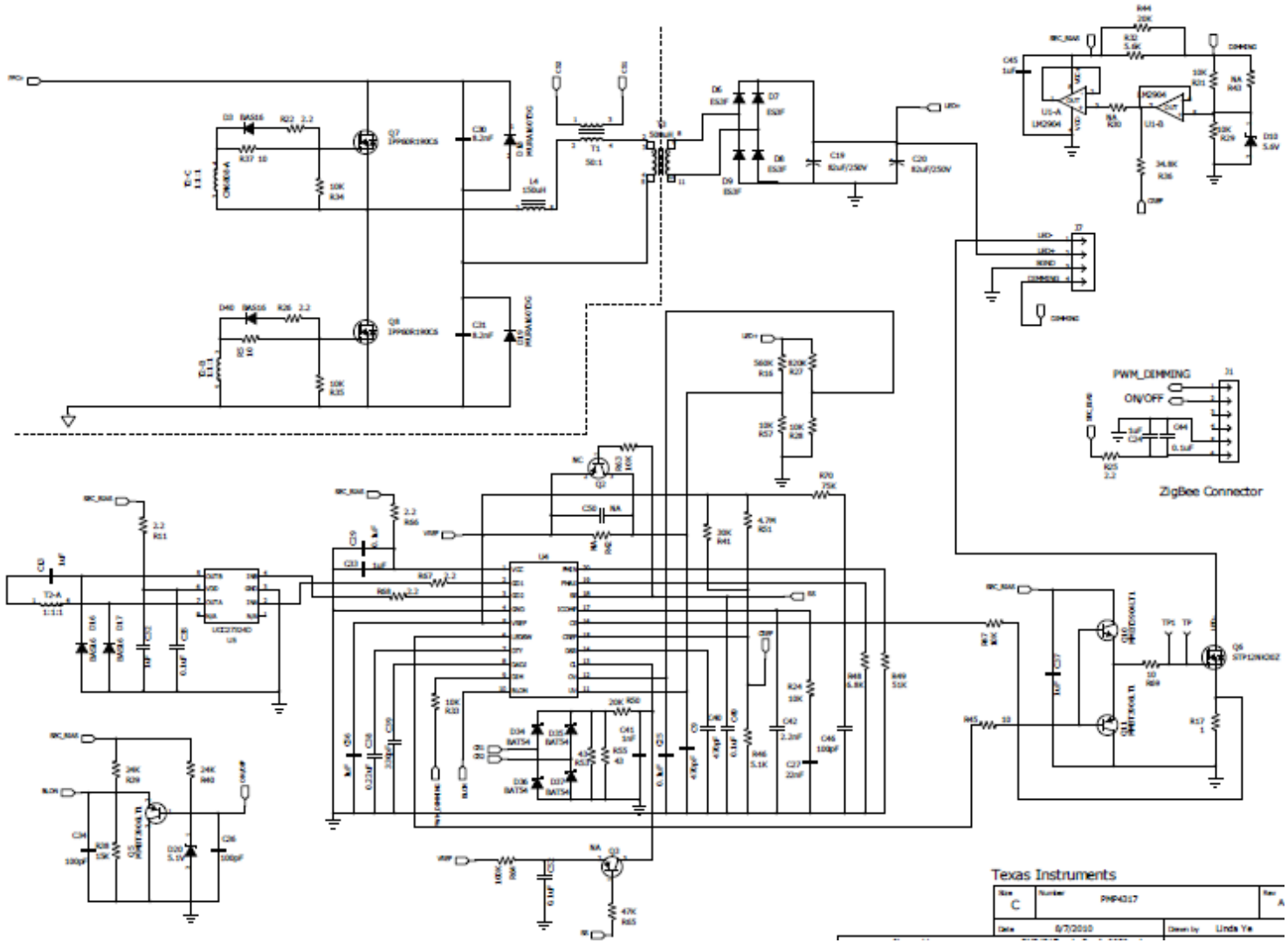
Applications

- General LED lighting and LED backlight TV



The POWER Behind Your Designs

PMP4317: Single String Architecture

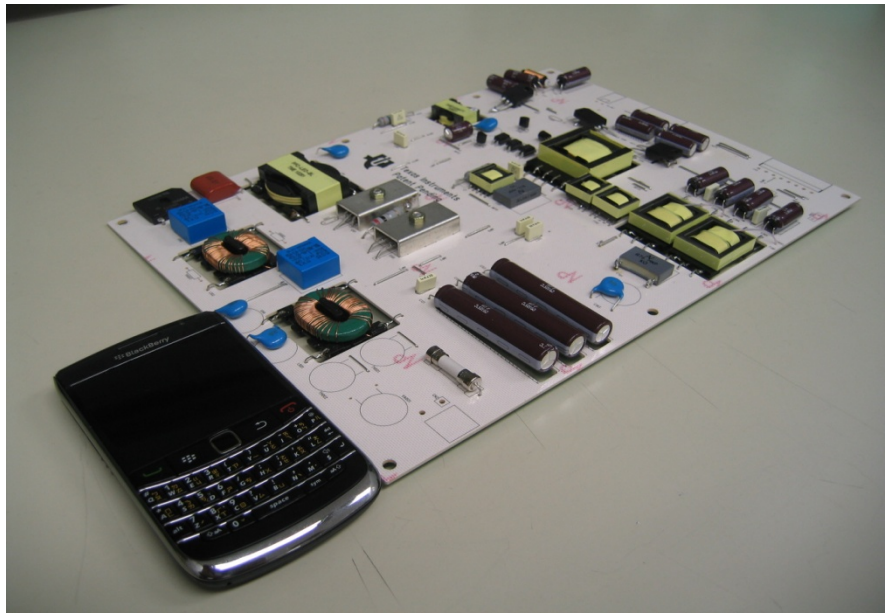


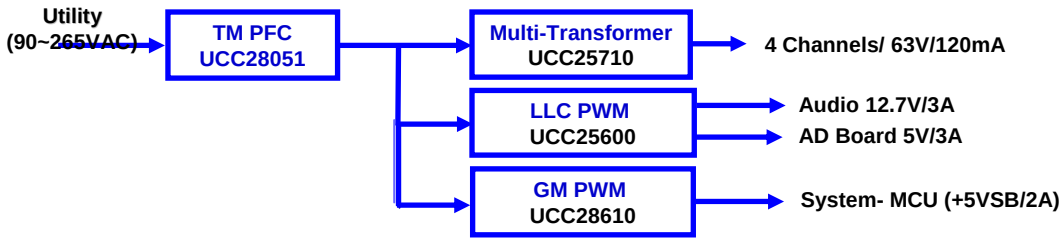
Texas Instruments

PMP6251: LED Backlighting for Edge-Lite / Group Dimming Digital TV Application

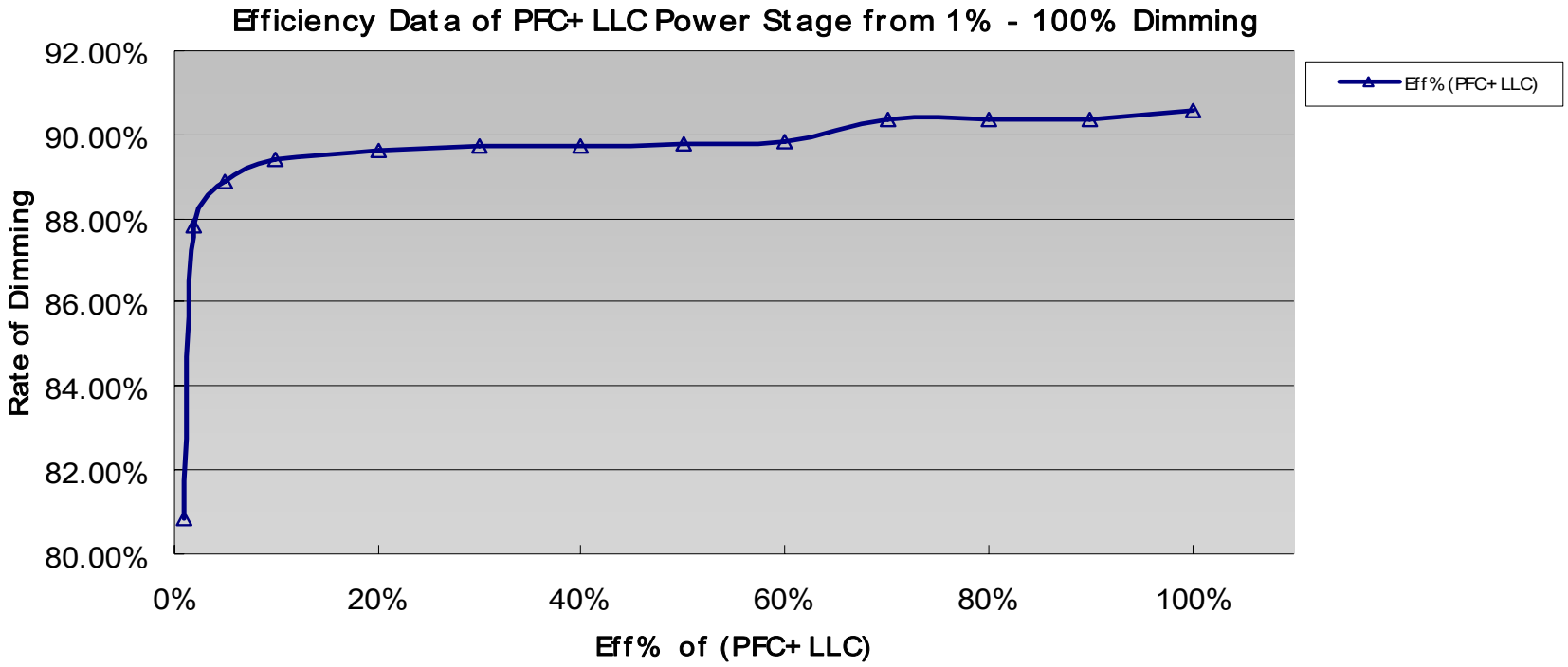
Reference design Features

- Support to universal 90~264Vac range
- LED 4 outputs @120mA, 63V, 5Vsb@1A, 5V@3A, 13V@3A
- Eff 83.7%@110Vac, 85.2%@240Vac
- Secondary side 120Hz blanking control for dimming
- 8mm height and 6mmheight for LED magnetic component
- Board dimension 300mm(L) * 200mm(W) * 8mm(H)
- LED output common + and LED OVP and UVP
- Integrated the protection ckt to reduce the solution part count.
- Dedicated controller for edge-lit/ group dimming base on the LLC topology – **UCC25710**
- Providing design package – Schematic, Gerbo file, PCB file, Magnetic components…





PMP6251: PFC+ Multi-string LLC Efficiency



Efficiency exclude standby Power Converter at full load condition ~ 90%

Summary

- *UCC25710 with multi-transformer LLC topology can achieve:*

☺ High efficiency

☺ Low total BOM cost with high reliability

☺ PWM or analog dimming compatible

☺ Output LED strings open/short protection

☺ Input over current protection

☺ Support 1%~100% dimming range

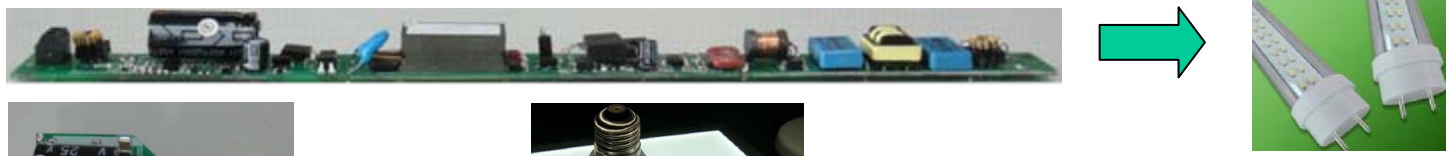
☺ Easy EMI

TI LED Driver Reference Design Solution

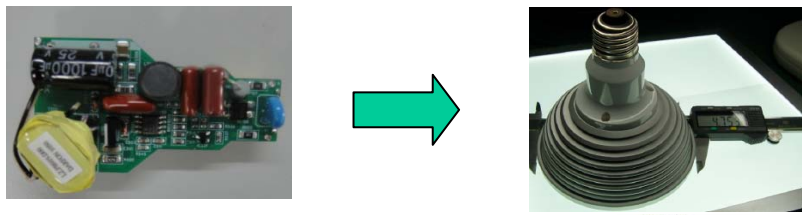
Reference Design	TI Parts	Application	P_{out}	V_{in}	Output
PMP6300:12Vac input MR-16 LED (SEPIC) Reference Design	TPS40211	MR16	3W	12Vac	11V 350mA
PMP4301: AC input, **T10/T8** LED Driver for Fluorescent Lamp	UCC28810 TL103	Commercial Tube Lighting	19 W	90-264 V_{ac}	40V 450 mA
PMP4304A: AC input, 7W TRIAC dimming LED lighting Driver	TPS92210	PAR lighting w/ TRIAC	7 W	90-264 V_{ac}	16V~25V 350 mA
PMP4306: AC Input 150W single stage AC/DC Power supply for Street LED lighting	UCC28061	Street LED lighting for outdoor	150W	90-264 V_{ac}	54V 3A
PMP4288: AC Input 200W AC/DC Power supply for Street LED lighting	UCC28061 UCC25600	Street LED lighting for outdoor	200 W	90-264 V_{ac}	54V 3.7A
PMP4302A: AC Input 110W AC/DC Power supply for Street LED lighting with multistring LLC	UCC28810 UCC25710	Street LED lighting	110W	90-264 V_{ac}	54V 500mAx4

MR16: PMP6300

Commercial: PMP4301/A/B



Residential: PMP4304



Outdoor: PMP4302A

Visit www.ti.com/led for more LED driver reference designs

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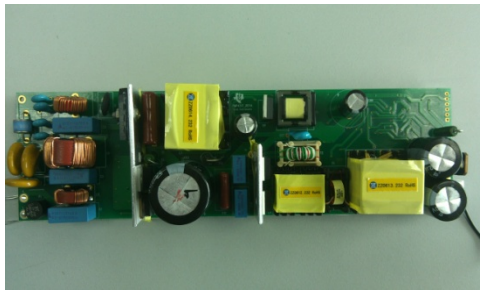
TI LED Driver Reference Design Solution (cont')

Reference Design	TI Parts	Application	P_{out}	V_{in}	Output
PMP4317: AC Input 150W AC/DC Power supply for Street LED lighting with single string LLC and high voltage output	UCC28810 UCC25710 UCC28610	Street LED lighting	150W	90-264 V_{ac}	200V 700mA

Outdoor:
PMP4317



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

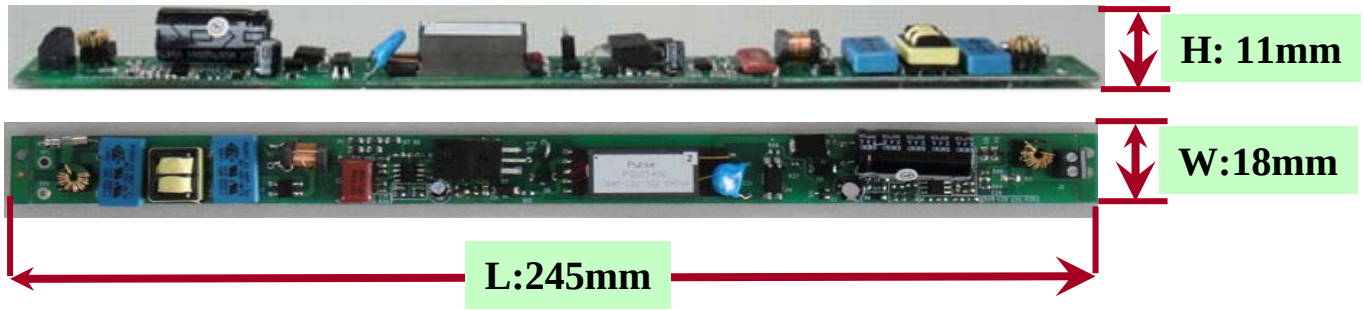
Reference Design	TI Parts	V_{in}	Po	Vo Io	Topology	Dimming	Eff.	PF
AC Input T8 AC/DC LED Lighting Driver for fluorescent lamp	UCC28810	90~ 264 Vac	20W	30V~42V 450mA	Isolated singe Stage high PF Flyback with Transition Mode	PWM dimming	>87%	>0.97

Features

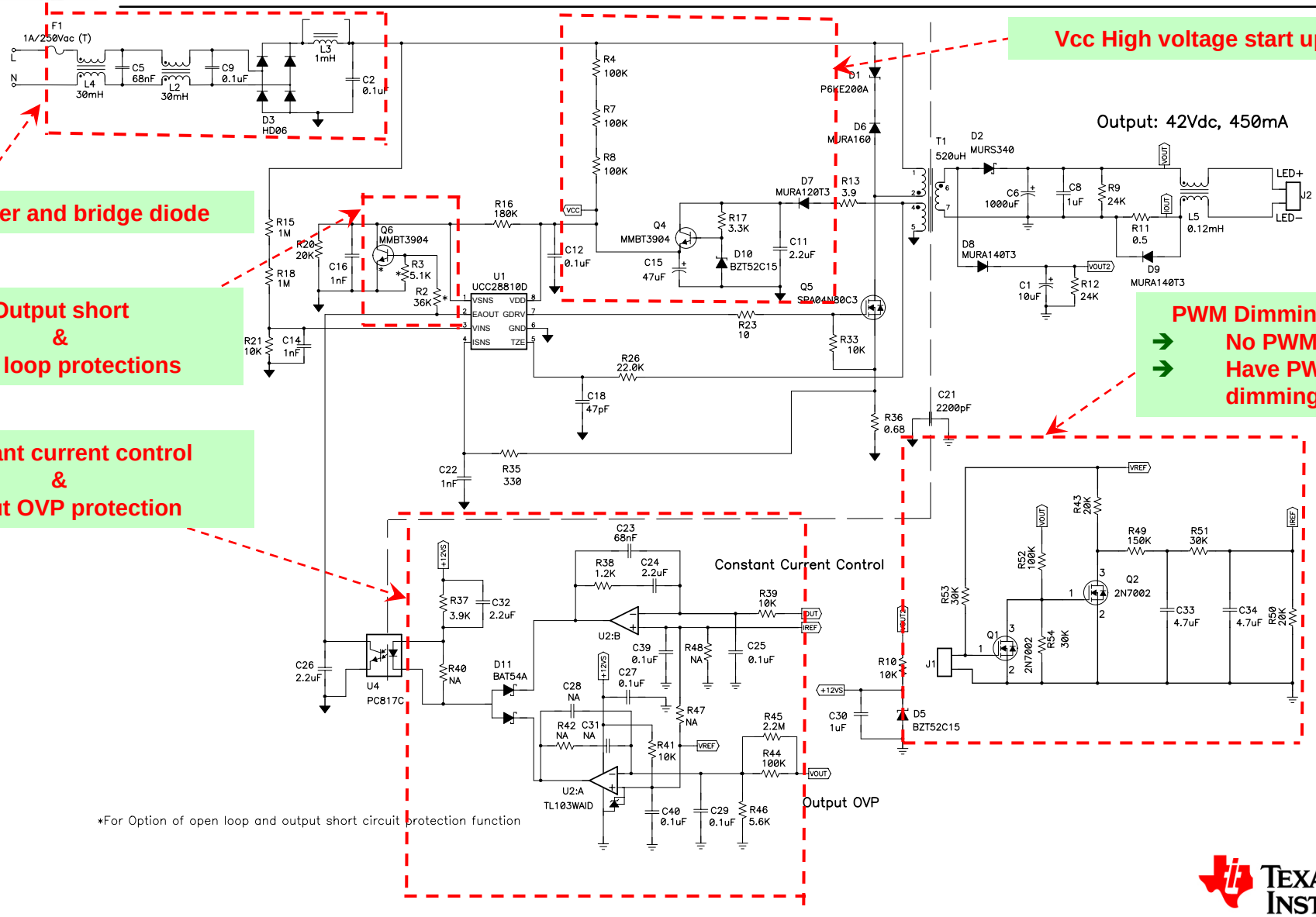
- Specific transformer for T8 lighting form factor
- PWM dimming compatible
- Low BOM cost
- Efficiency >87% at 230Vac input
- Isolated single stage w/ PF>0.97 at 230Vac input
- Output over voltage protection: 45Vdc
- Output ripple current: <30% of output current
- Size: 245mmX18mmx11mm (ultra-slim)

Applications

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



PMP4301: Schematics of Single Stage PFC with UCC28810



PMP4304: 7W TRIAC dimming LED lighting Driver

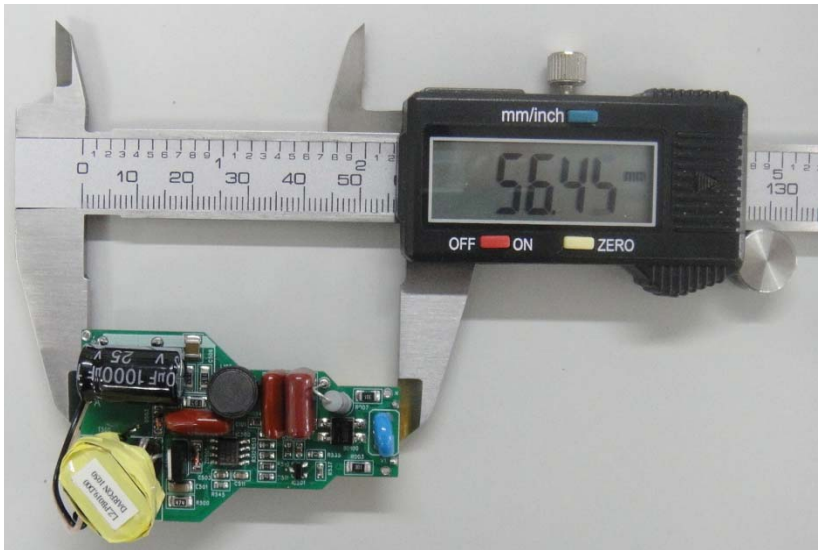
Reference Design	TI Parts	V_{in}	Po	Vo Io	Topology	Eff.	PF
AC Input 7W AC/DC LED Lighting Driver /w TRIAC dimming	TPS92210 TL431	180-265 Vac	7W	16V~25V 350mA (5~7 LEDs)	Singe Stage high PF with TRIAC dimming	~80%	>0.95

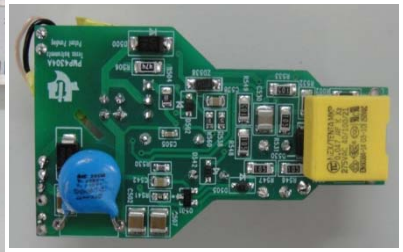
Features

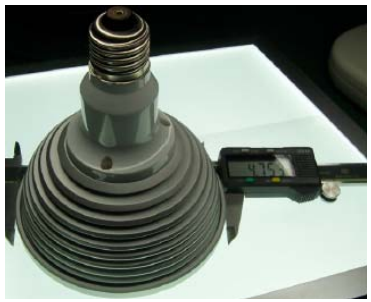
- **50** components counts with low BOM cost
- TRIAC dimmable solutions without flicking
- Primary side controls without opto-coupler
- Constant On-time control with high power factor

Applications

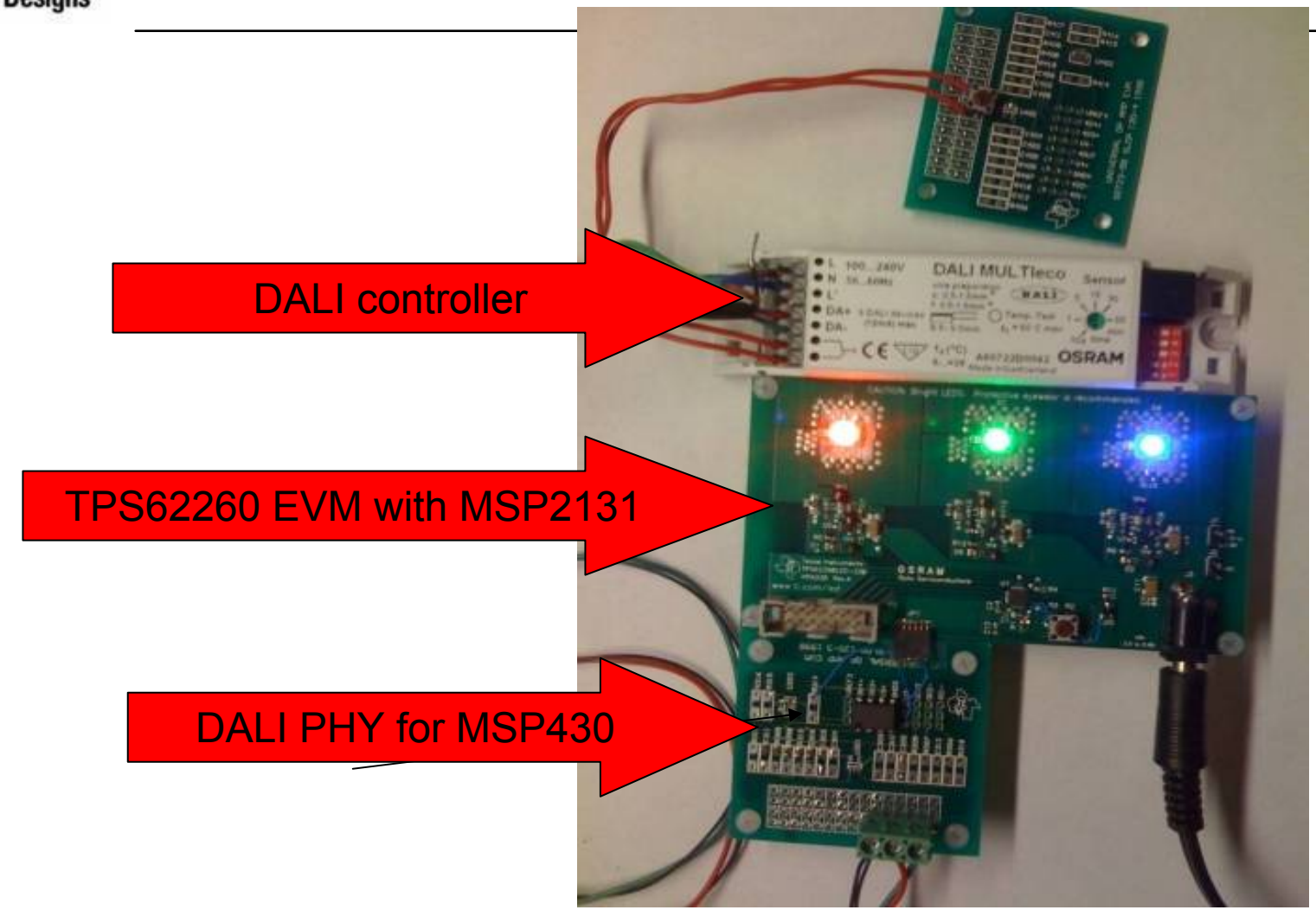
- PAR20/30/38 LED Lighting
- Small form factor indoor Lighting







DALI Demo and Evaluation Platform



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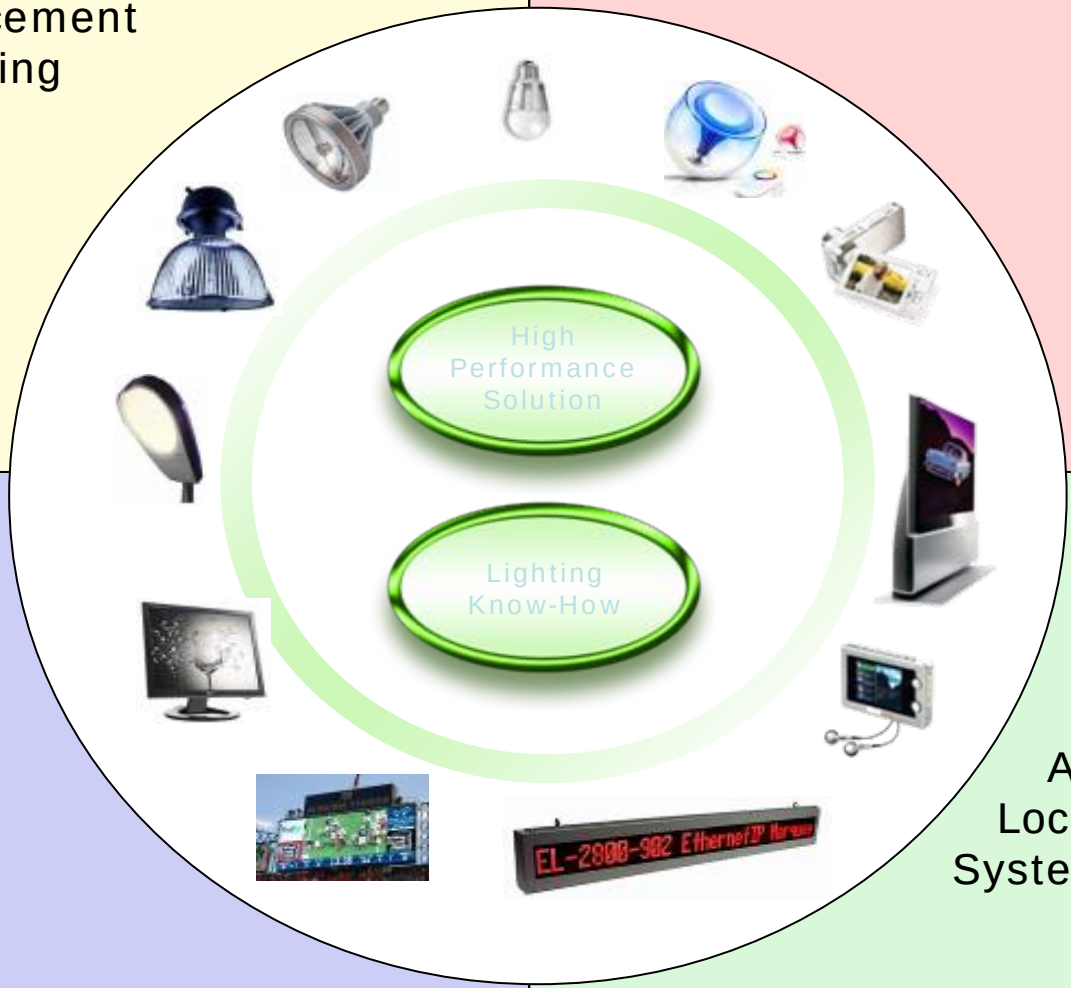

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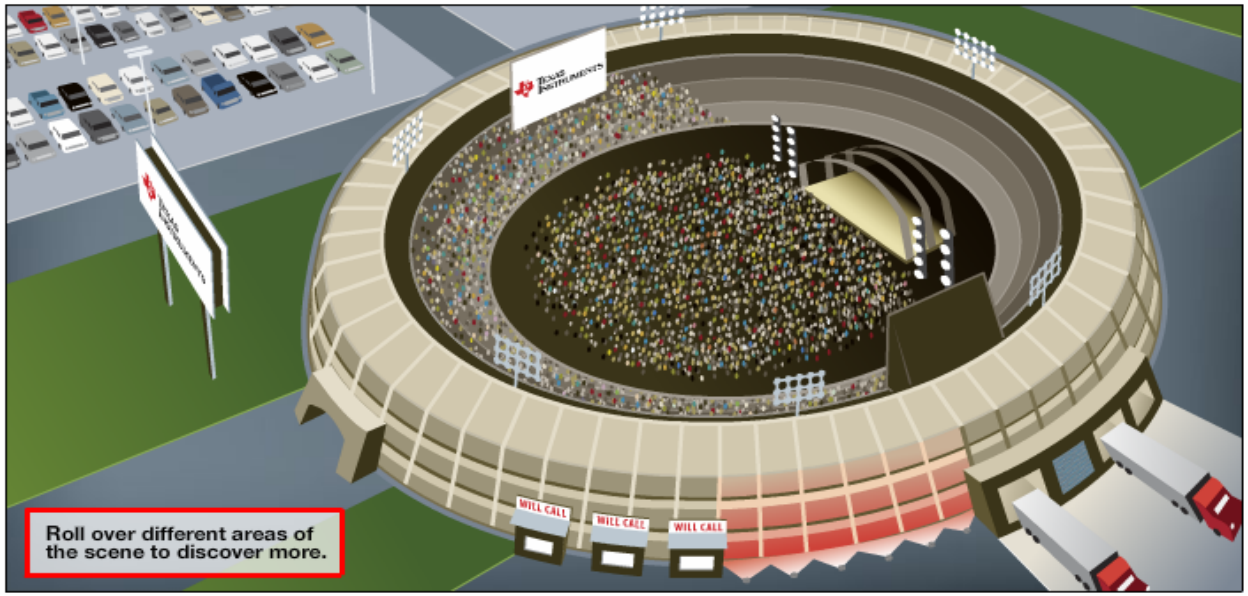

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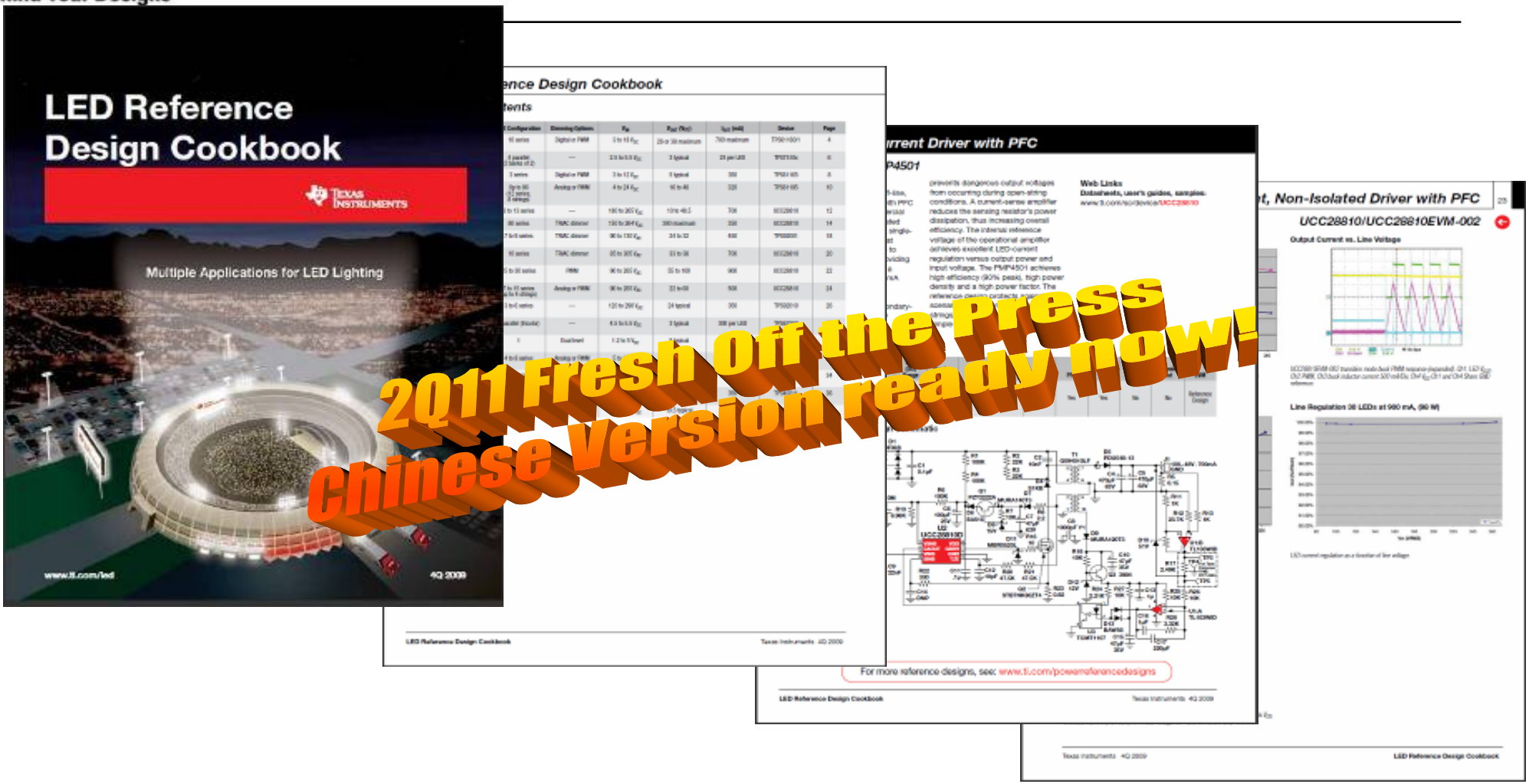

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