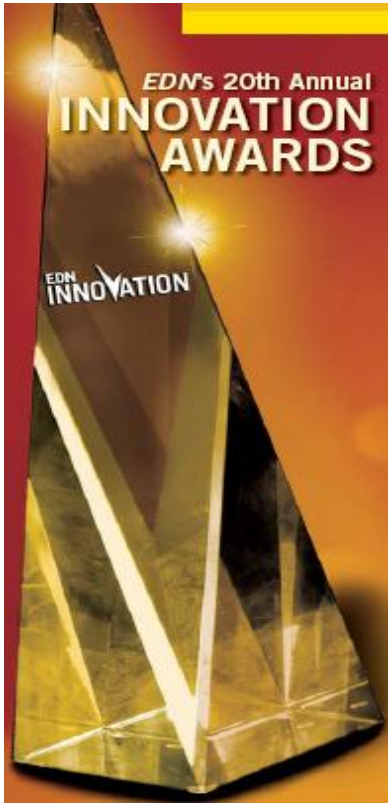

Welcome
2011 iWatt
China Seminar
ACDC
LED
1688
1689
1692
1690
1691
1696
1698
!!!
1700
1810
3610
3612
3614
3620

What's New in 2010!

iW3610
Award
The most Innovative Product in 2010

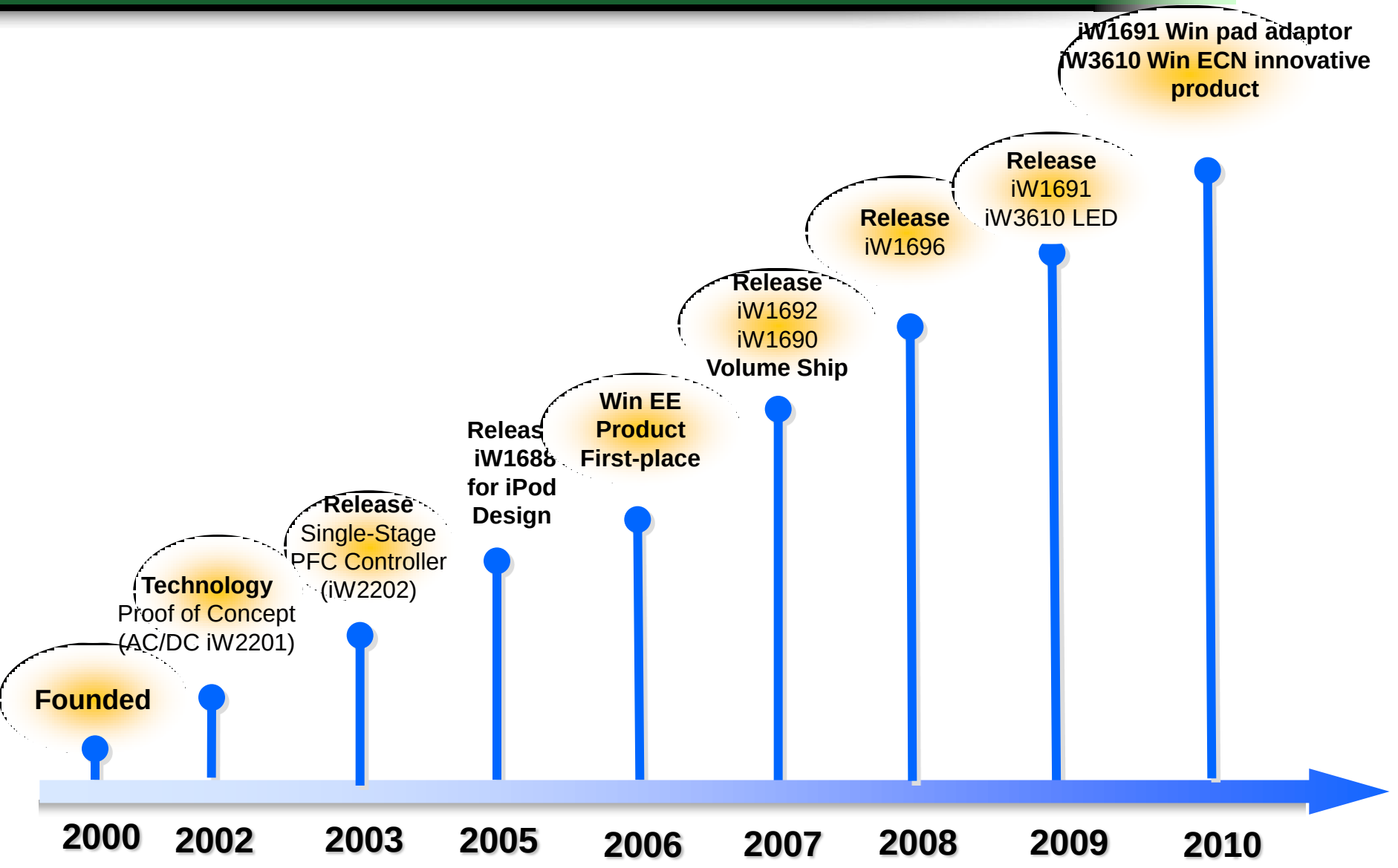


iWatt Solution Inside

Gartner | 2010
COOL VENDOR

Cool Vendors in Semiconductors, 2010
iWatt | Ozmo Devices | Physware | SiliconBlue Technologies | Tabula

iWatt History



iWatt Operations - Global Presence

- 100 Employees (80 Engineers)
- U.S. Based Development
- Asia Based Direct (20+ Engr) Technical Support
- Turn-Key Fabless / Virtual Manufacturing Model

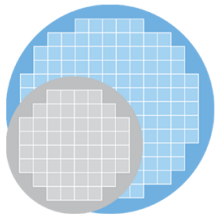
Manufacturing Suppliers - 2011

- Fab 8AB qualified since 2006
- Fab 8E qualified in 2010
- Additional Fab in qualification

Qualified

UMC - Fab 8AB, 8E
Hsinchu, Taiwan

UMC THE SoC SOLUTION FOUNDRY



ASE-SH
Shanghai, China

ASE GROUP

Turnkey Supply

SOIC-8
SOIC-8-EP

Unisem
Ipoh, Malaysia

unisem

Turnkey Supply

SOT23-5
SOT23-6

ASE-CL
Chung-Li, Taiwan

ASE GROUP

Turnkey Supply

QFP
QFP-EP
SOIC-8-EP

Proven Digital Power Control Technology

- **The first company to release Digital Power Control IC's for ac/dc offline**
  - ***iW1689, iW1692, iW1690, iW1696, iW1698, iW1691 & iW1710.***
  - ***LED offline drivers iW3620, iW3610, iW3612, iW3614***

- Provides Total System Solutions for low-power adapters and chargers with low cost and high performance
  - **Patented digital primary-feedback control technology with Tight CV regulation**
  - **Patented Constant Current (CC) regulation with primary-feedback**

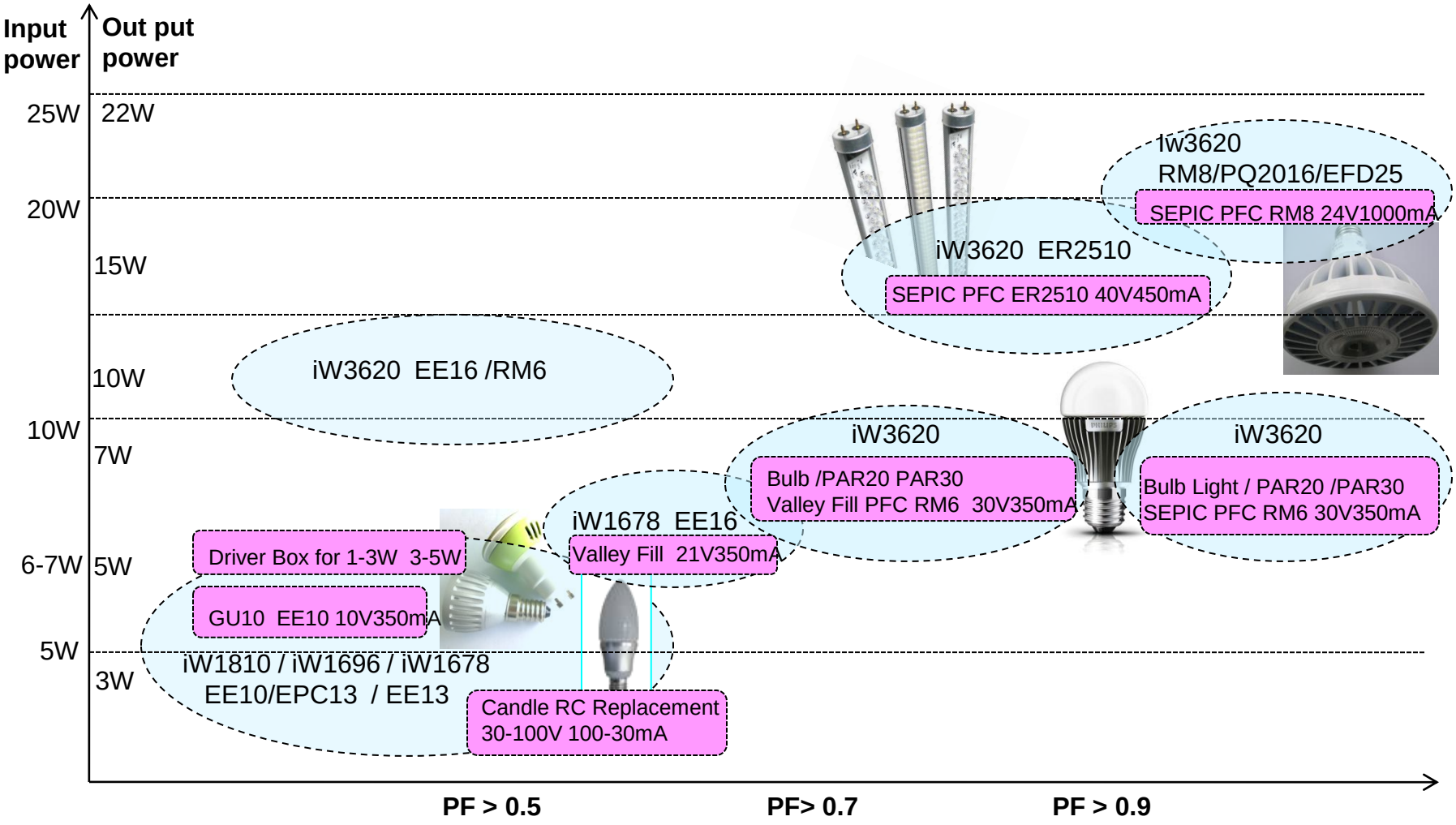
iWatt LED driver product___ Non-dimmable

iWatt
Intelligent AC-DC and LED Power™

iWatt Digital Power LED Lighting Driver Selection Guide

	Non-Dimmable					
Applications	**3W**		**Up to 5W**	**Up to 30W**	**Up to 30W**	**Up to 30W**
	Low-power Low-cost Small-size		**High-power density Valley fill PFC**	**High-power density**	**High-power density Valley fill PFC**	**High-power density High PF**
	E14, GU10		**GU10 Bulb PAR20**	**GU10 Bulb PAR20-PAR38**	**GU10 Bulb PAR20PAR38**	**GU10 Bulb PAR20PAR38**
Part Numbers	**iW1696/1678**	**iW1810**	**iW1678**	**iW3620**	**iW3620**	**iW3620**
External Drive	BJT STBV42/3DD3020	Integrated 800V BJT	BJT STBV42/3DD3020	Mosfet 2A	Mosfet 4A/5A	Mosfet 4A/5A
Switching Frequency	40kHz/64KHz	64KHz	64kHz	up to 130kHz	up to 130kHz	up to 130kHz
Package	SOT23-5	SOIC8	SOT23-5	SOIC8	SOIC8	SOIC8
Efficiency	>78% @3w	>78% @3w	>79% @5w	>85% @10w	>85% @10w	>85% @10w
CC tolerance	5%	5%	5%	5%	5%	7%
Isolated/ Non-isolated	Both	Both	Both	Both	Both	Both
Primary-feedback,	Yes	Yes	Yes	Yes	Yes	Yes
Power Factor			>0.8 Passive		>0.8 Passive	>0.8--0.9,SEPIC
Proposed transformer	EE10/ EPC13/EE13	EE10/ EE13/EPC13	EE13/ EPC13/EE16/	EE16 RM6/RM8/PQ2016	EE16 RM6/RM8/PQ2016	RM6/RM8/PQ2016

iWatt LED driver solution__ Non-dimmable



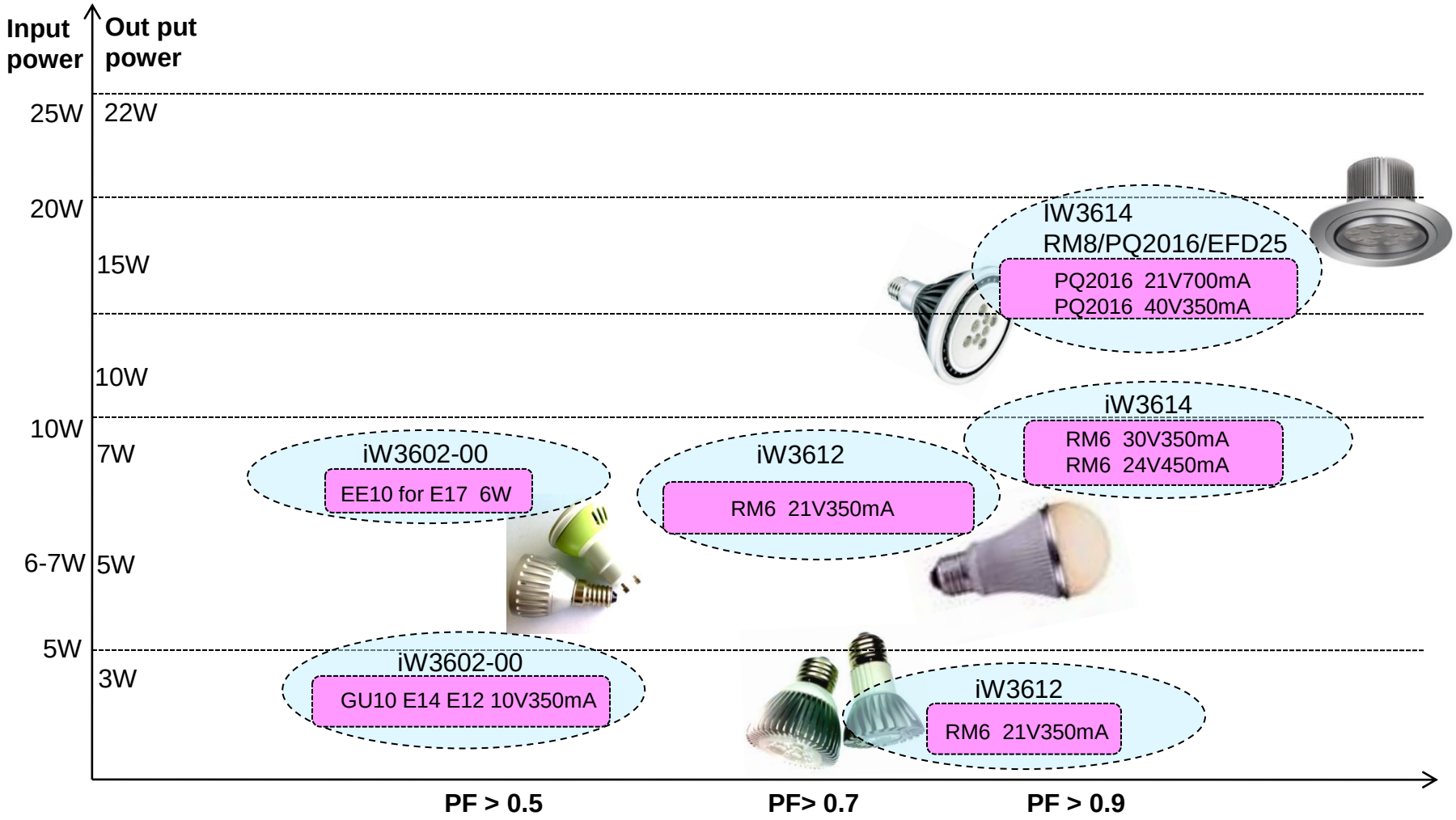
iWatt LED Driver product ____ Dimmable

iWatt
Intelligent AC-DC and LED Power™

iWatt Digital Power LED Lighting Driver Selection Guide

	Dimmable					
Applications	3W-7W		Up to 30W	Up to 30W	Up to 30W	Up to 30W
	Low power		High- Power density	High- Power density	High- Power density	High- Power density
	GU10 / Candle		Bulb PAR	Bulb PAR T8	Bulb PAR T8	Bulb PAR T8
Part Numbers	**iW3602-00**	**iW3602-01**	**Iw3610-00/01**	**iW3612-00**	**iW3612-01**	**iW3614**
Optimized for	100v/120V	120V/230V	100/V120V/230V	100-120V	230V	100V/120V/230V
Chopping PFC	No Chopping	Chopping PFC	Chopping PFC	Chopping PFC	Chopping PFC	Chopping PFC
Fly back MOSFET	MOSFET 1A/ 2A	MOSFET 1A / 2A	MOSFET 2A-4A	MOSFET 2A-4A	MOSFET 2A-4A	MOSFET 2A-4A
Chopping MOSFET	MOSFET 2A	MOSFET 2A	MOSFET 2A	MOSFET 2A	MOSFET 2A	MOSFET 2A
Switching Frequency	Up to 200KHz	Up to 200KHz	Up to 200kHz	Up to 200kHz	Up to 200kHz	Up to 200kHz
IC Package	SOIC8	SOIC8	SOIC8	SOIC8	SOIC8	SOIC8
Efficiency	>75% @3W Non-isolated	>75% @3W Isolated	>80% @3W Isolated	>82% @10W Isolated	>82% @10W Isolated	>82% @15W Isolated
CC tolerance	5%	5%	5%	5%	5%	5%
Power Factor	0.5-0.6	>0.7	>0.7	>0.7	>0.7	>0.9
Isolated/ Non-isolated	Both	Both	Both	Both	Both	Both
Proposed transformer	EE10/ EPC13	EE10/ EE13/EE16/RM6	RM6/ EE16/ RM6/	RM6/RM8/PQ2016	RM6/RM8/PQ2016	RM6/RM8/PQ2016

iWatt LED Driver solution ___ Dimmable



iWatt

Intelligent AC-DC and LED Power™

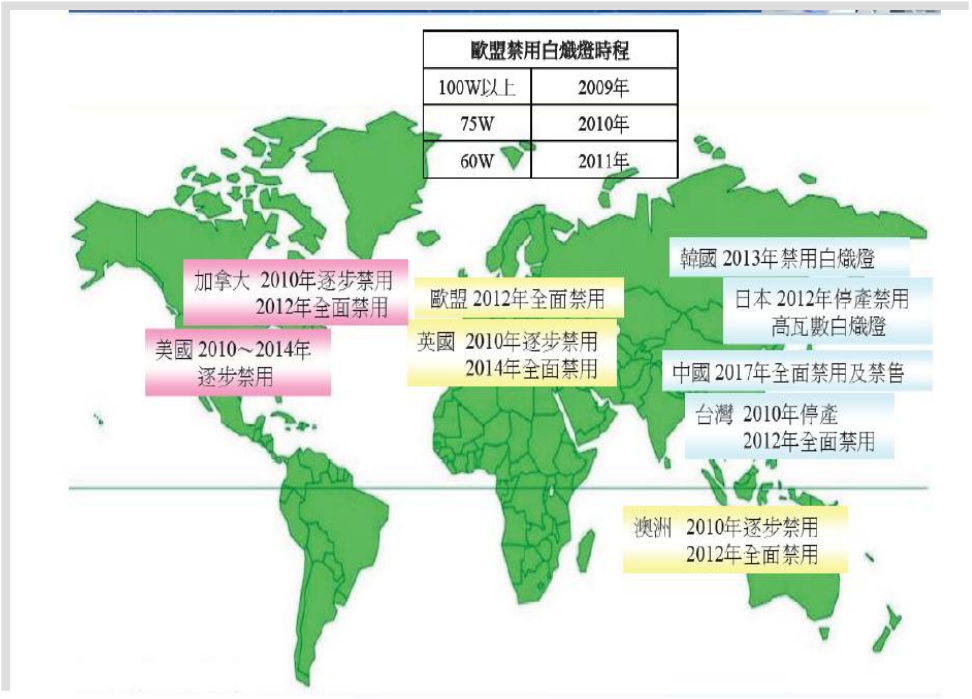
What's New?
LED Driver

For Energy Saving and Environment friendly

iWatt
Intelligent AC-DC and LED Power™

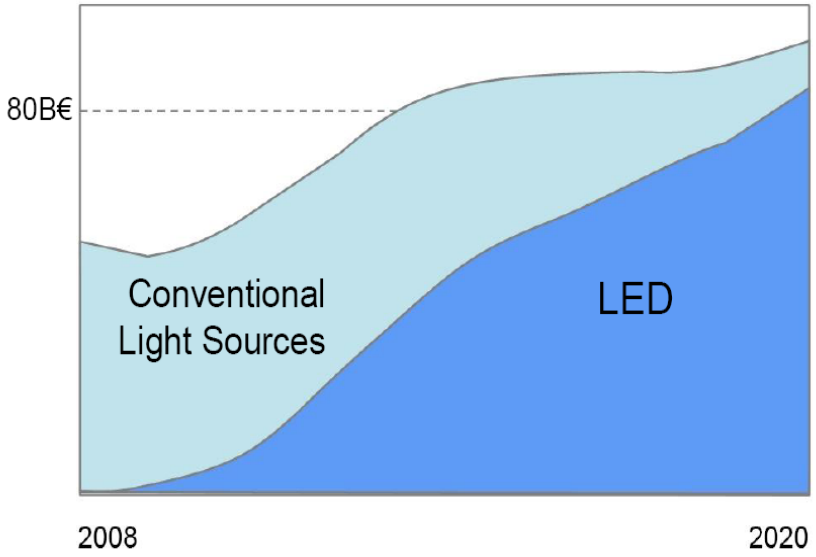
Jan 27 1880 / Edison

Replaced b y

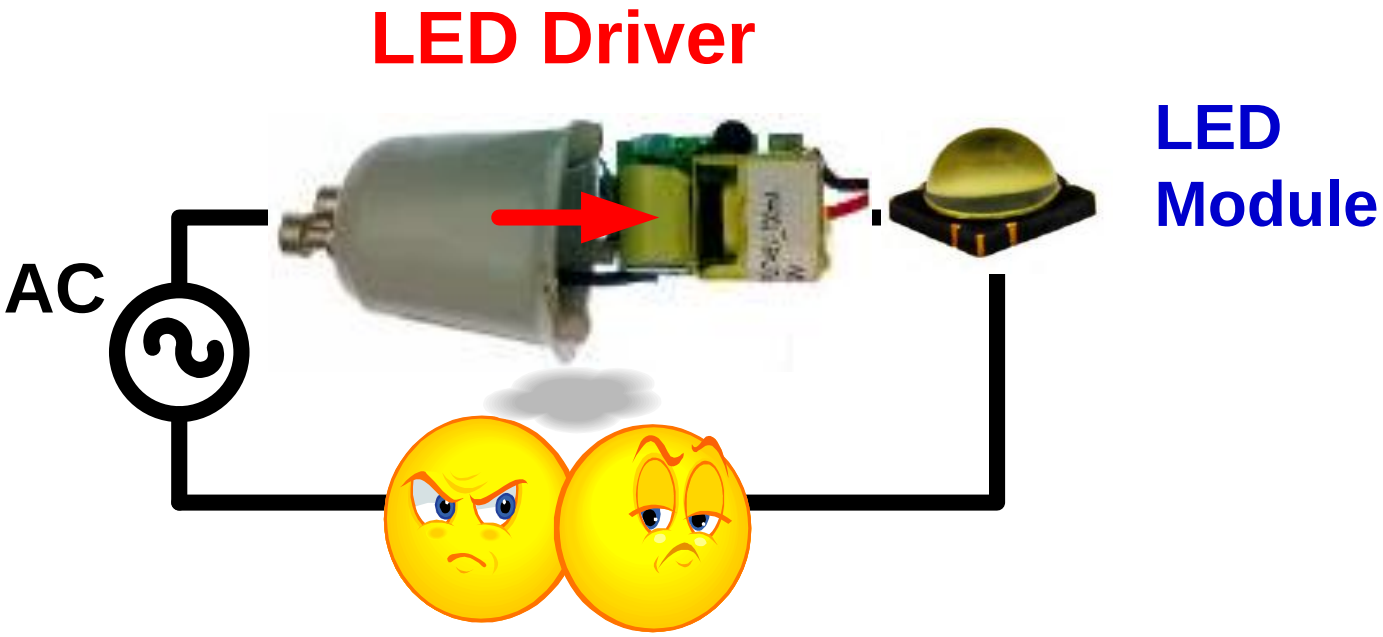


Global Market Value Roadmap

Presented by Philips, September 24, 2009, at Lighting Analyst's Day



LED Driver, A Weakest Link



LED Driver, Blamed as the Weakest Link

Unreliable Flickering Short Lifetime Expensive

Here, the definition of "LED Driver", a power module to generate the voltage or current to driver LED module from AC mains; AC LED doesn't need to have LED driver according to this definition

What is the solution you are looking for

1) Where is the end-customer (Country), Who is the end customer ?

   Input voltage and other additional requirement for input

2) Used for what kind of lamp& Lighting? GU10 PAR16 PAR20 PAR30 PAR38 Bulb light down light…

   How big is the PCB size, what is the environment for operation

3) Safety standard and EMC standard and other standard

   IEC/UL, Surge, EMI, Harmonic, PF

4) What is the LED load , How many , what kind of the LEDs….

   Output voltage and current ,

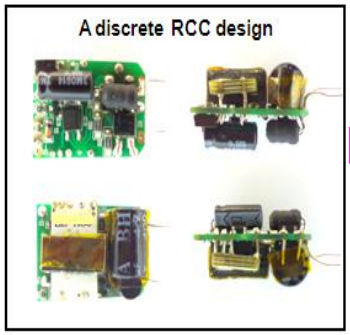
   Expected driver efficiency

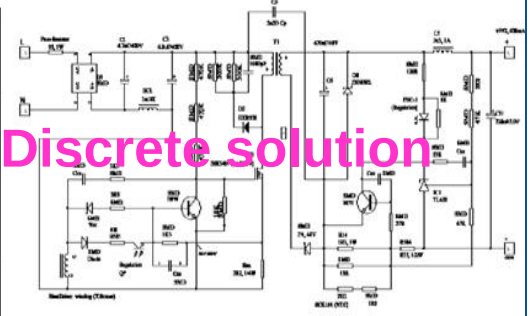
   Ripple current

5) Dimmable or non-dimmable

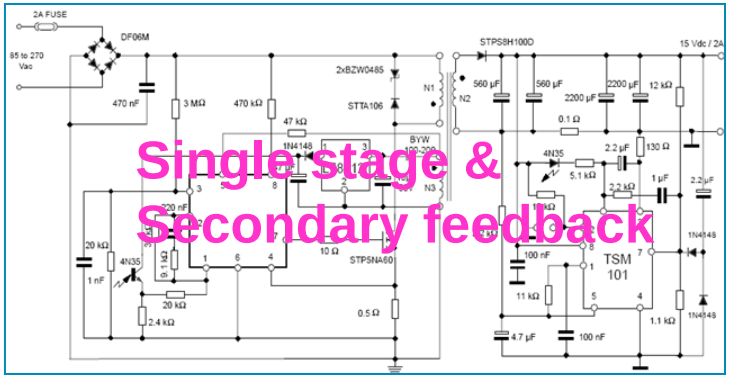
   Dimmer List , dimmer type ; Expected dimming range

iWatt PSR solution __ CC& CV

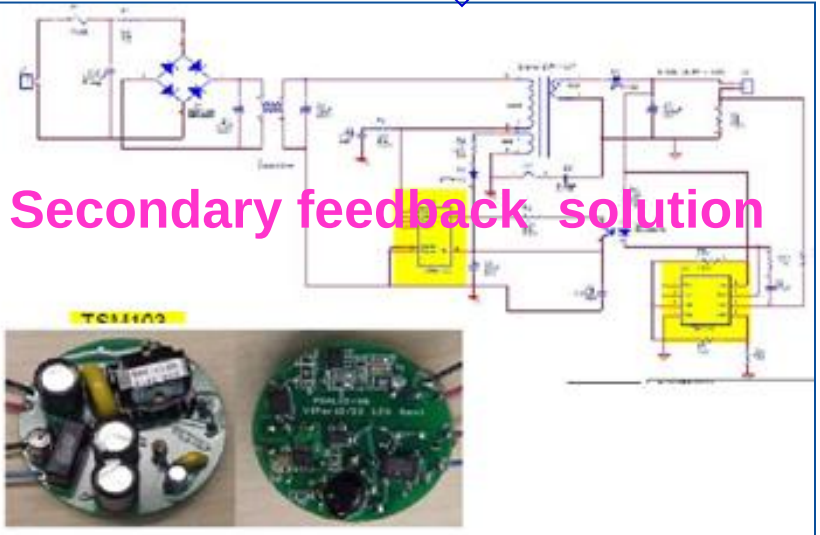




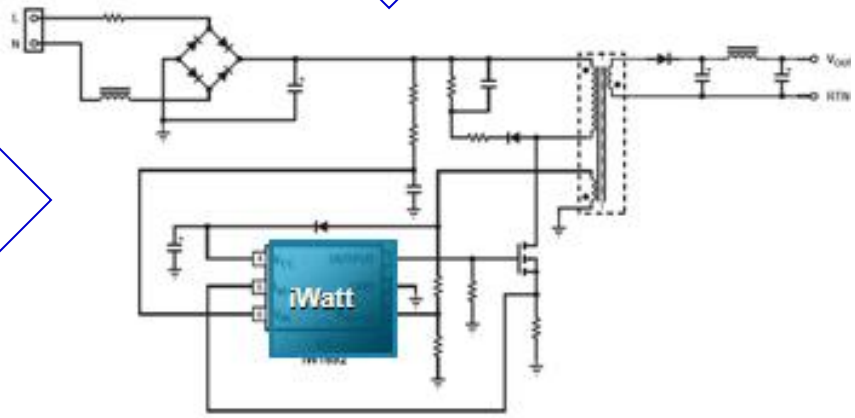
Discrete solution



Single stage & Secondary feedback



Secondary feedback solution

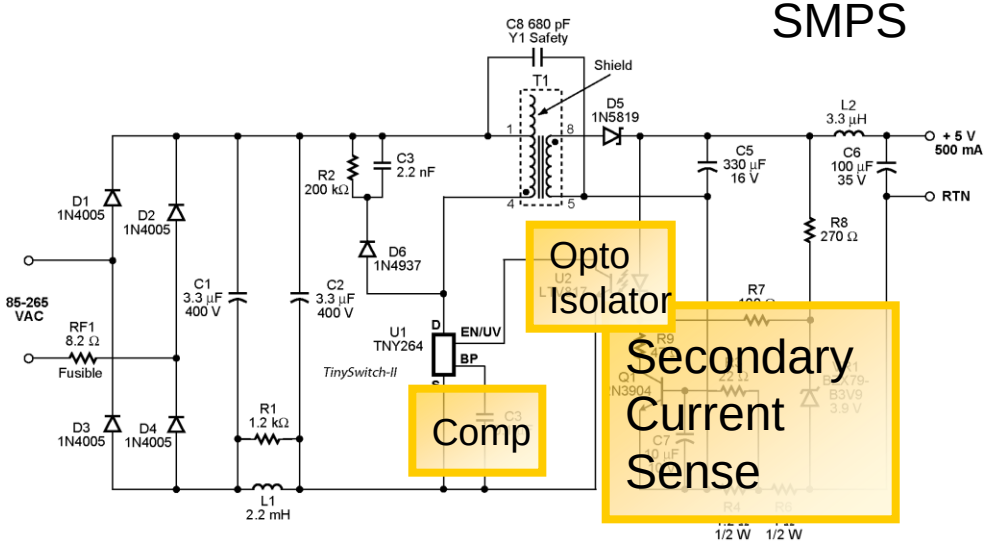


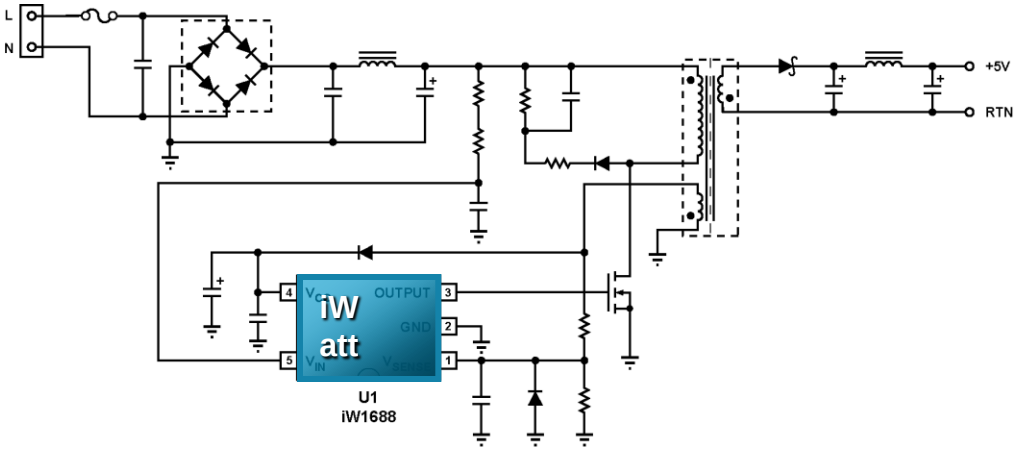
Why Primary Feedback?

Benefits:

- Line Isolation
  - Easy for small size design
  - Easy for heat spread
  - Easy to meet safety regulation
- More reliable and longer life time
  - No opto
  - No Y-cap
- High Efficiency design
  - Isolated current transformer is easy to optimized the efficiency

SMPS





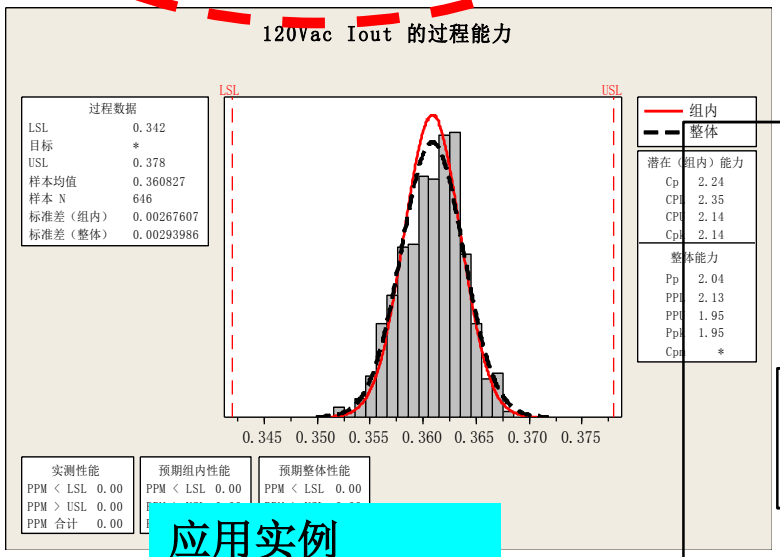
Best accurate constant current mode

$$I_o = \frac{I_{pri\_pk} N_{ps}}{2} \frac{T_{rst}}{T_s}$$

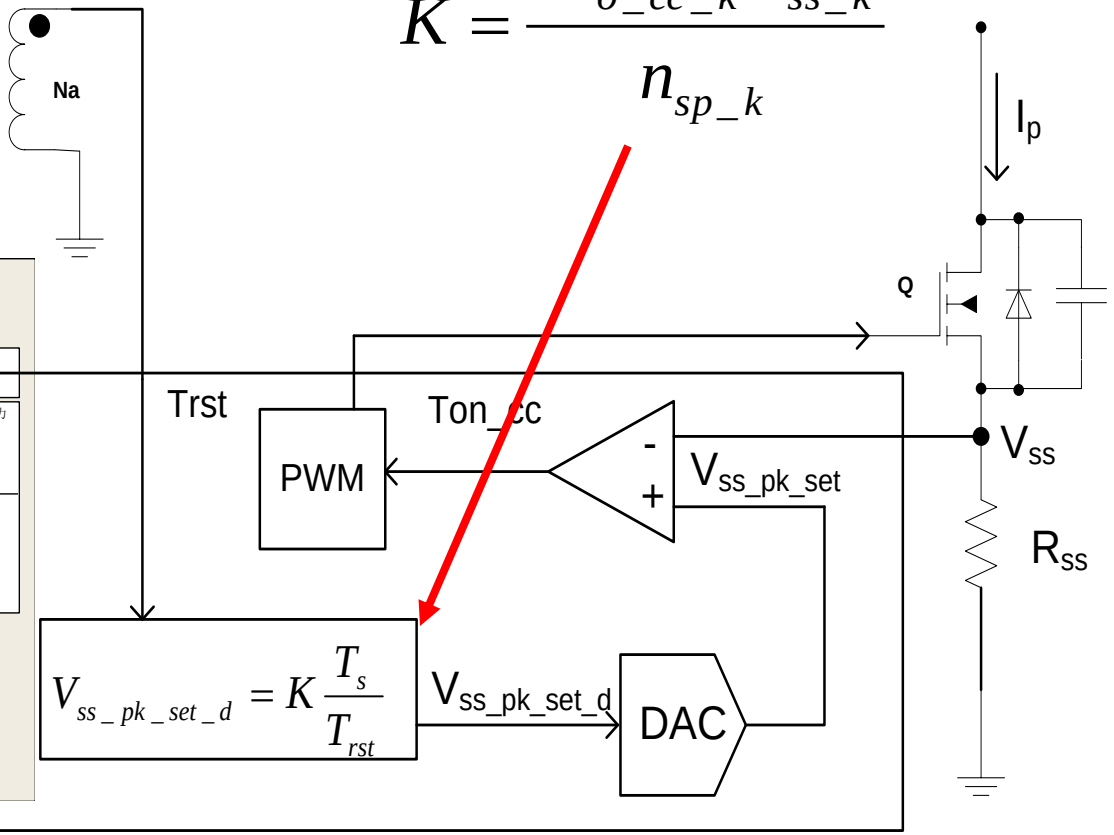
$$I_{pri\_pk} = \frac{2I_o}{N_{ps}} \frac{T_s}{T_{rst}}$$

Directly use primary current information.

$$K = \frac{2I_{o\_cc\_k} R_{ss\_k}}{n_{sp\_k}}$$



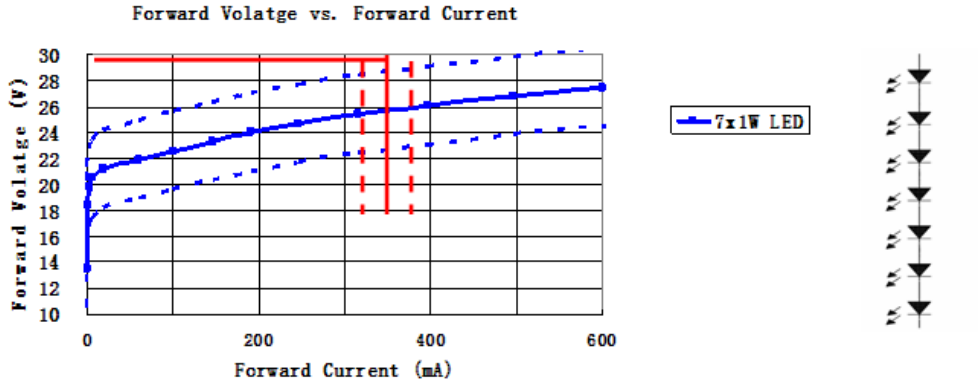
应用实例



Why need constant current for LED

- **Should limit LEDs junction temperature for reliability**

Typical and Maximum / Minimum V-I Characteristic of 7 X1W LED



- **Compact lighting(Lamp) design need small size heatsink**

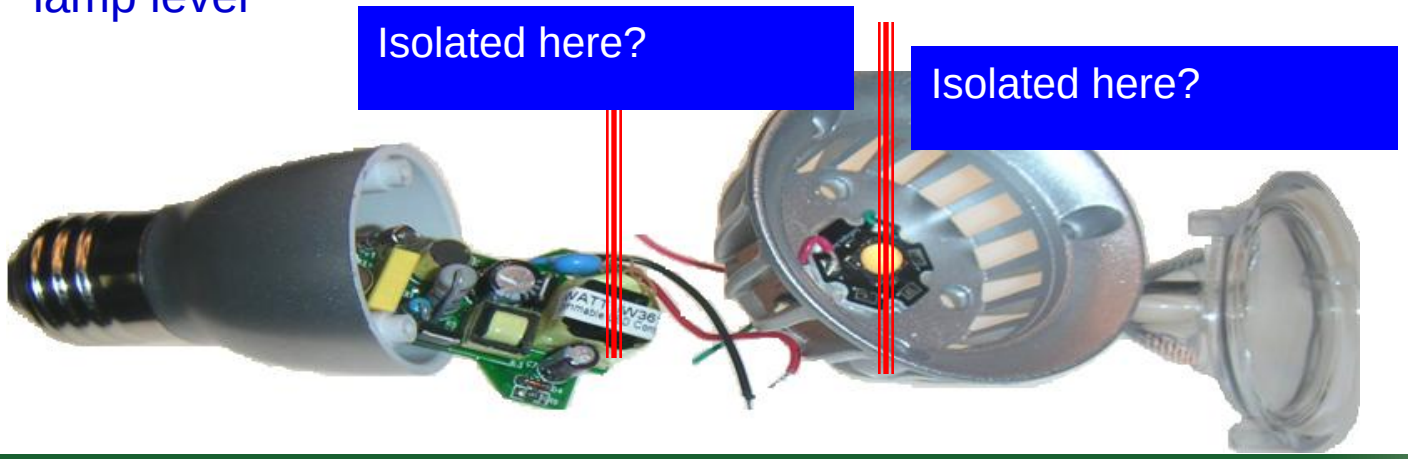
  Temperature power and lumens

- **Same lumens level for high volume mass production**

Need isolated or Non-isolated ?

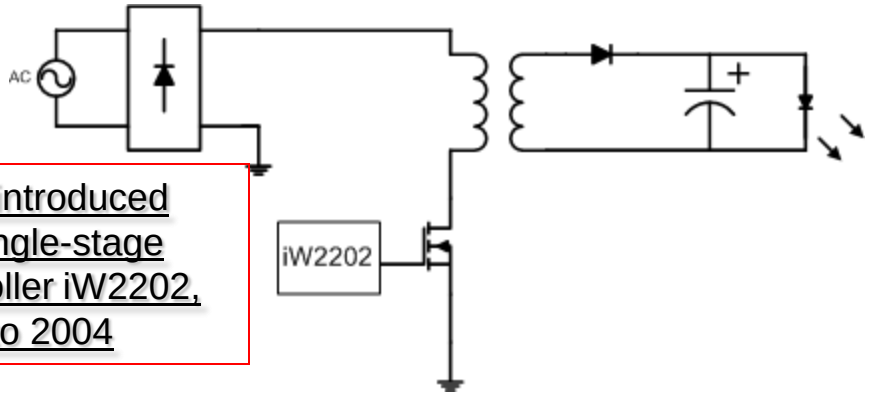
- Safety requirement for lamp
  - Isolated lighting product
- Isolated driver
  - Easy for thermal design，
  - Easy for safety design
- Non-isolated driver
  - Possible to for high efficiency
  - Possible for small size driver
  - Additional cost for isolated at lamp level

Isolated drivers	Non-isolated drivers
Suitable for high-power high-current low-voltage	Suitable for low-power high-voltage low-current
More components, less power efficiency	Simple, low cost
Easy for mechanical design and thermal management	Easy for electric driver board design
Easy for EMI design, Easy for Safety	Challenges for EMI and safety



Single-stage Vs 2-stage

- Basic Flyback: Single-stage Solution

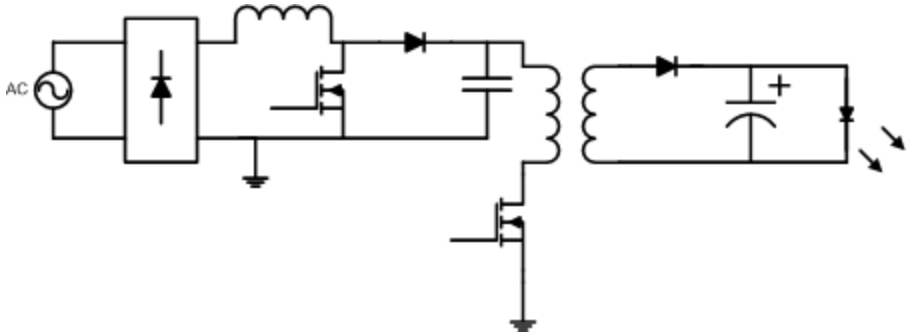


iWatt introduced the single-stage controller iW2202, back to 2004

Advantage
- Simple
- No High-voltage bulk e-cap

Disadvantage
- Concerns of invisible flicker < 150Hz
- Line frequency ripple current
- Lightning Surge
- Hot-swap
- Large Output Capacitor
- Hard to start-up

- Boost + Flyback: Two-stage solutions



Advantage
- Easy for impedance balance between dimmer and LED current regulation

Disadvantage
- More components

Ripple current and Flicker & E-flicker

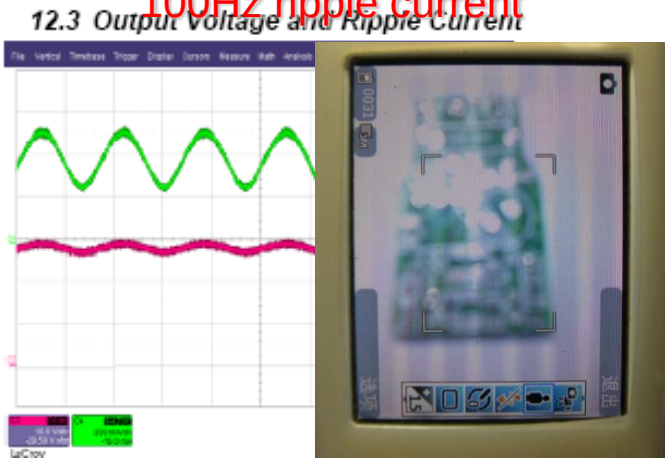
- **With ripple current, but no flicker**
- **High ripple current and low frequency ripple will get flicker**
- **Visible flicker and E-flicker**

IEEE Standard P1789

Biological Effects and Health Hazards From Flicker, Including Flicker That Is Too Rapid To See

2/15/10
IEEE Standard P1789
http://grouper.ieee.org/groups/1789/

Digital flicker from 100Hz ripple current



Purpose of Report: The goal of this report is to perform and objective scientific summary of the effects on human health for both visible and invisible flicker with attention drawn to implications for the design of LED lighting. Specifically, contributions of this report include making the reader aware of

1. Risks of seizures due to flicker in frequencies within the range ~3-~70Hz;
2. Health concerns due invisible (not perceivable) flicker at frequencies below ~165Hz including, but not limited to, headaches, migraines, impaired ocular motor control, and impaired visual performance;
3. The differences between "visible" flicker and "invisible" flicker and any relation to health risks;
4. A few, typical driving approaches in LED lighting that may produce flicker.

What is the key for reliability

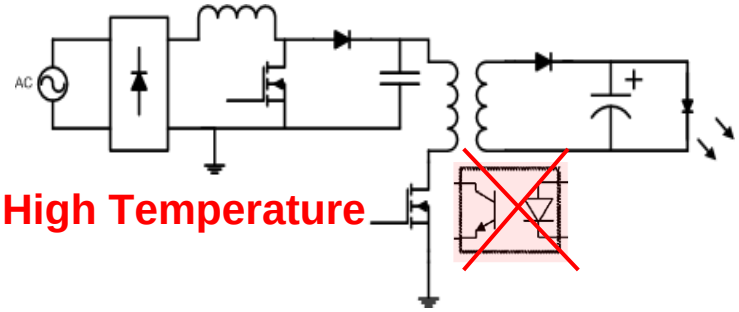
Components stress and quality

De-rating for : voltage stress, peak current, maximum reverse voltage, maximum dissipation power …….

Quality:

Temperature

E-cap， Opto-coupler ， semiconductor (SOA) , magnetic (Saturate)



$$Lc = L_0 \times 2^{(\frac{T_0 - T_C}{10})} \times (\frac{V_o}{V_C}) \times 2.5$$

Lifetime calculation

Protection

OVP， Surge protection, OTP , OCP , OPP , Short circuit protection

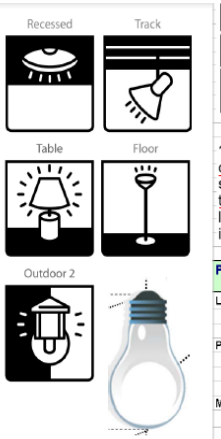
Hi-power factor Vs E-CAP Vs Ripple current

- **Energy star for PF: 0.5, 0.7, 0.9**
- **IEC61000-3-2 for PF and THD**

IEC61000-3-2 Class C

7.3 Limits for Class C equipment

7.3.1 Lighting equipment



ENERGY STAR® Program Requirements for Integral LED Lamps
ENERGY STAR Eligibility Criteria

Final – December 3, 2009

1) SCOPE: These criteria apply to integral LED lamps[2], defined as a lamp with LEDs, an integrated LED driver, and an ANSI standardized base designed to connect to the branch circuit via an ANSI standardized lampholder/socket. These criteria include integral LED lamps of non-standard form, and those intended to replace standard general service incandescent lamps, decorative (candelabra style) lamps, and reflector lamps. Other types of replacement lamps may be added in the future as improvements to LED technology make LED use in other replacement lamp types viable.

Parameter	Specifications
Lumen Maintenance (L_{70})	15,000 to 25,000 hours depending on type of lamp
Power Factor	
For ≤ 5W and low voltage lamps	No minimum specification
For > 5W lamps	≥ 0.7
Minimum operating temperature	
Residential (outdoor)	≤ -20°C
Output operating frequency	≥ 120Hz
EMI/RFI	FCC 47 CFR part 15
Noise	Class A sound rating

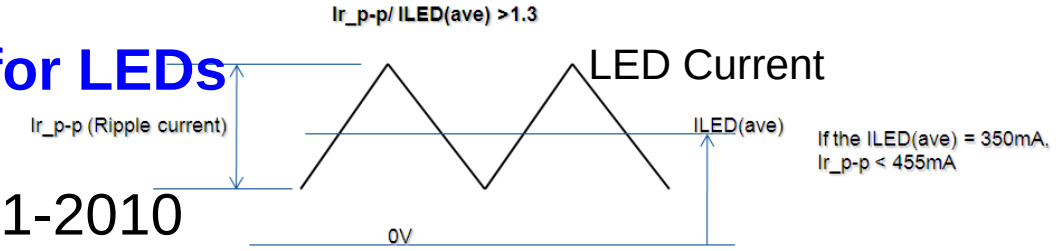
- **Korea need PF>0.9 THD<30%**

E-CAP ⇕ E=½ CV^2

In order to avoid flicker,
a)difference of the peak output current for each half cycle(AC) should be less than 4%
b)Ripple ratio of the lamp current should be less than "1.3"
ripple frequency should be > 100Hz

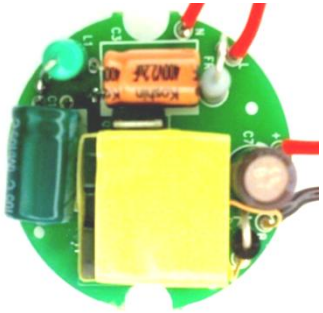
- **High ripple current get flicker**
- **High ripple loss reliability for LEDs**

Japan:
JEL 801-2010

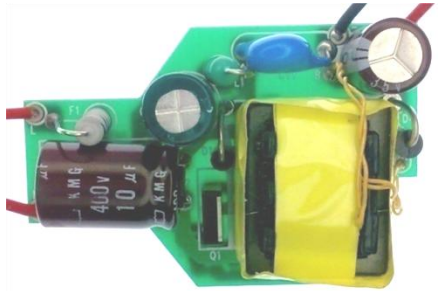


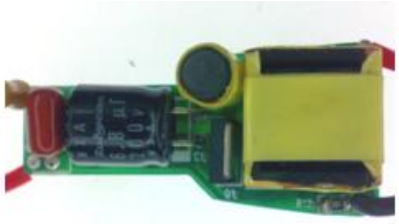
Demo design for LED applications

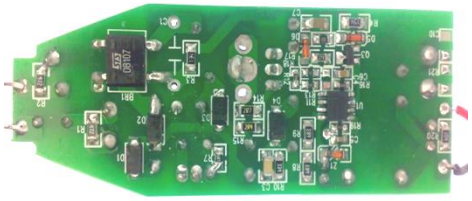
1W-30W
Dimmable and Non-dimmable
Isolated and Non-isolated
General PF and High PF



Down Light



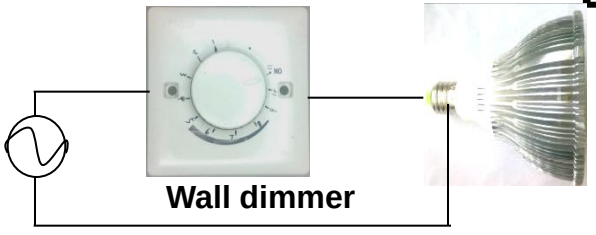




GU10

GU10

E14



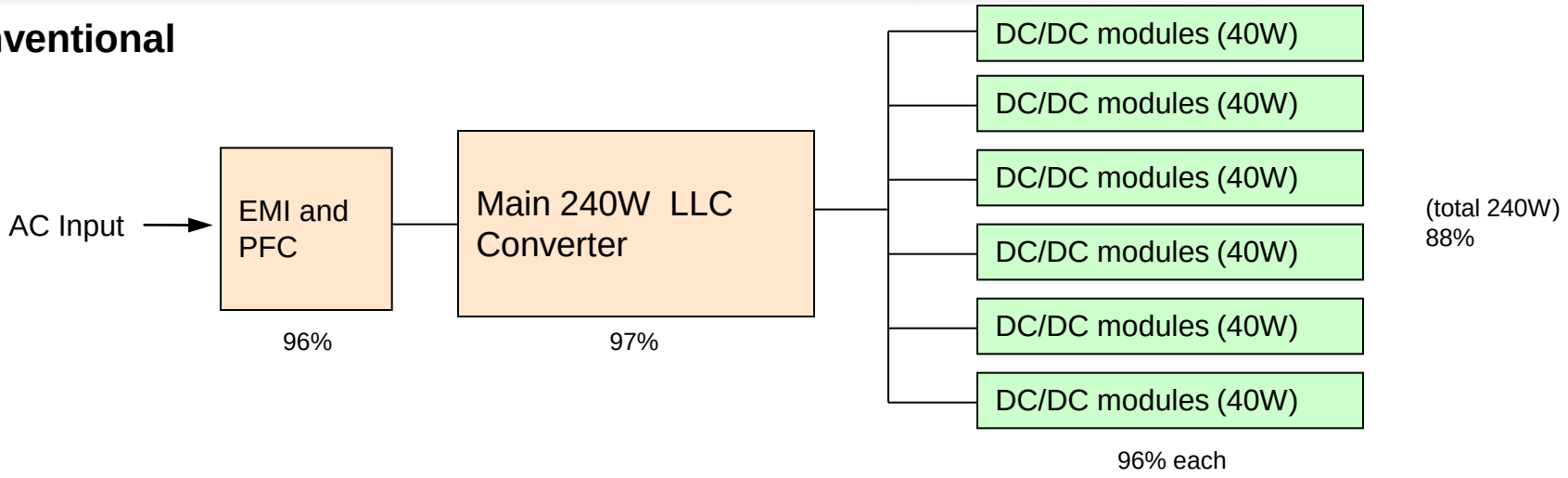
Wall dimmer

LED Tube lighting

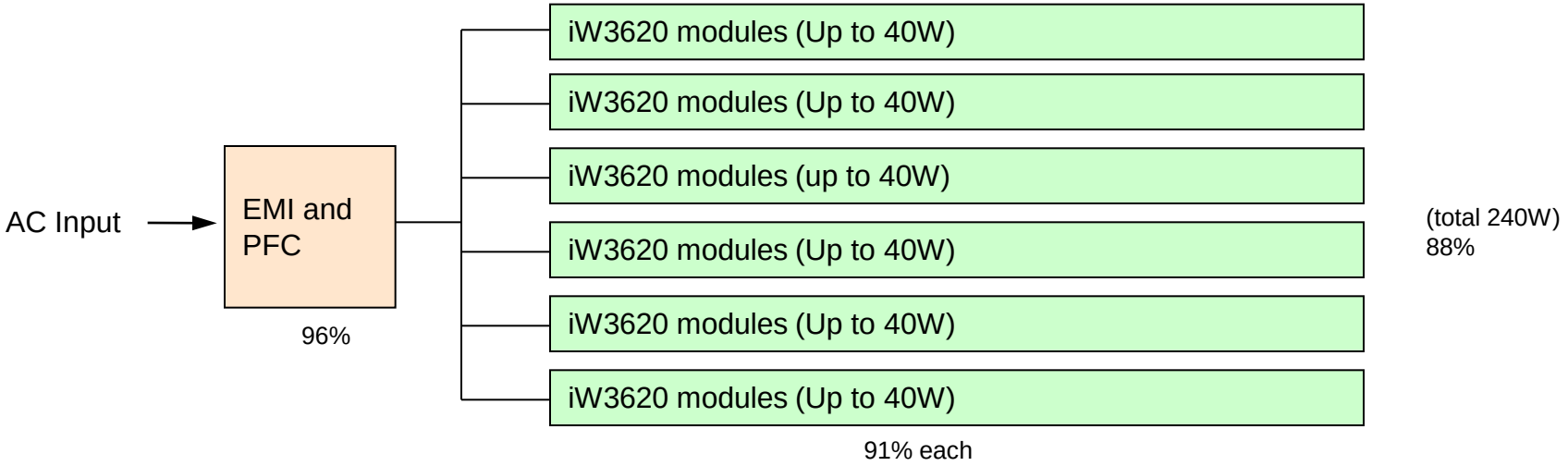
240W Road Lamp Design with DC/DC modules

iWatt multi-drive vs. standard main + DC/DC modules

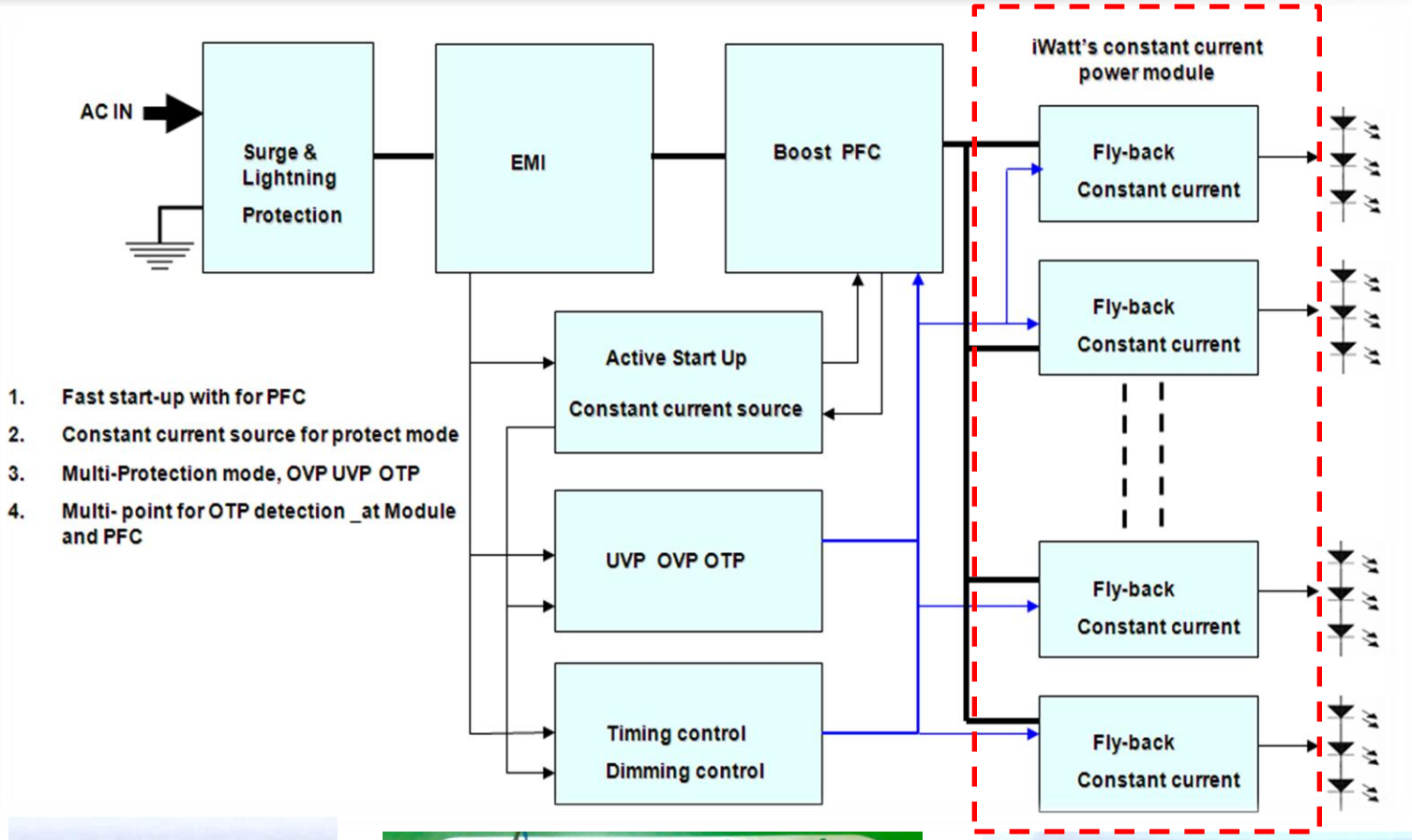
Conventional



iWatt with individual multi-drive 3620 modules

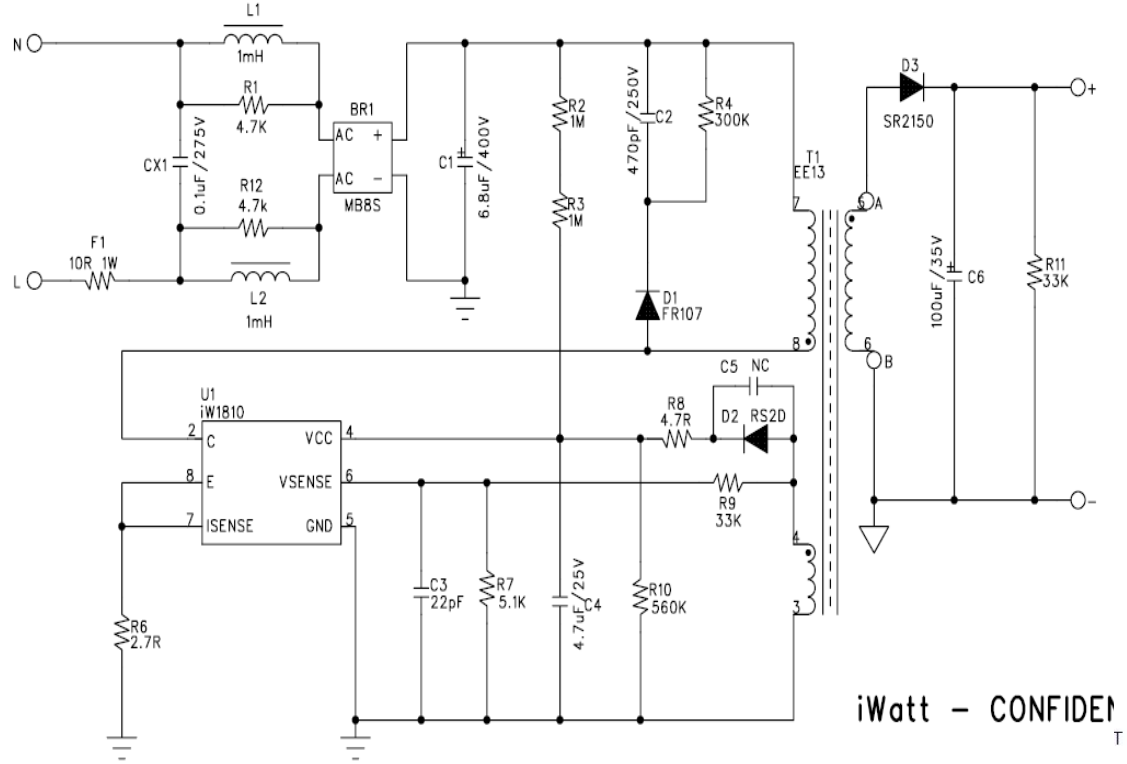


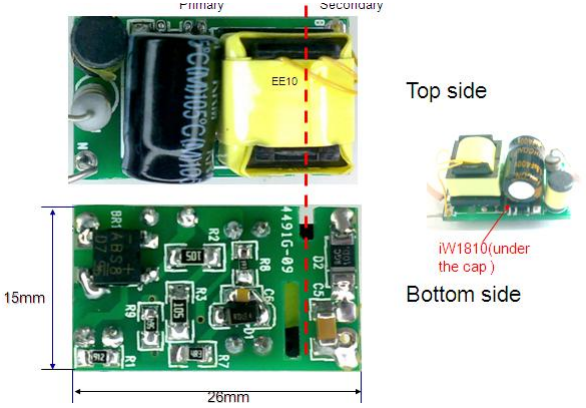
iW3620 power module for street light application



Iw3620
Power module

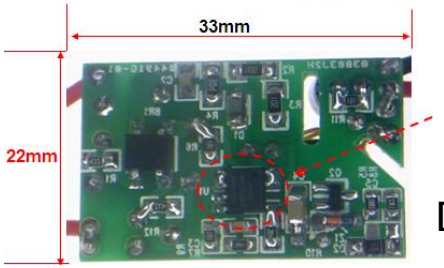
iW1810 integrated 800V BJT for 1-4W LED Driver





GU10

E14



Diver Box

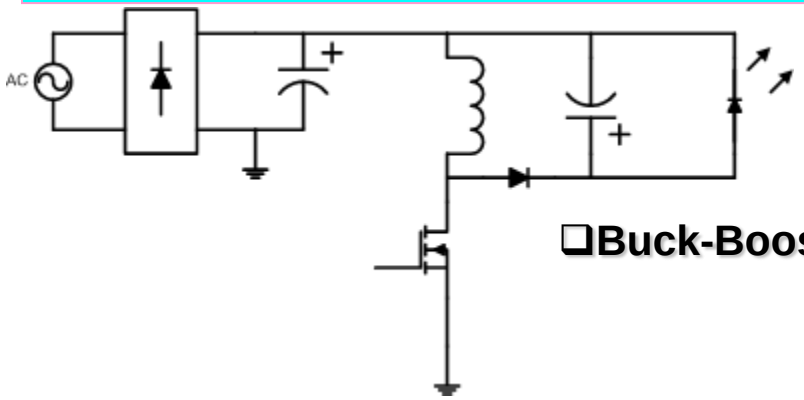
- **Frequency 64KHz, 800V BJT**
- **High efficiency ,Small size, Low cost**
- **High accurate for CC mode , 3%**
- **Competitor: PI LNK 60x**

High cost, CC tolerance 8-15 %, mosfet (EMI radiation), OTP

How to get non-isolated with iWatt chip

Non-isolated

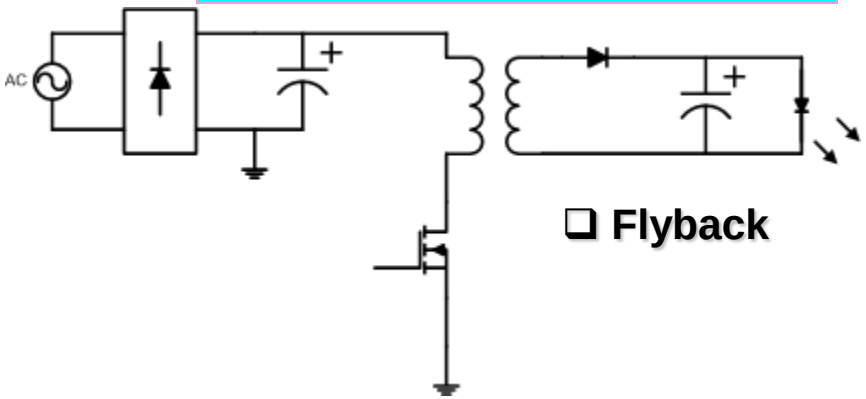
iWatt apps for high voltage & low current



❑Buck-Boost

Isolated

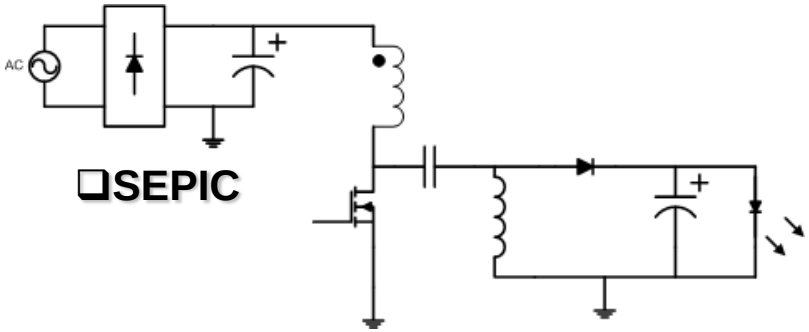
Iwatt PSR isolated fly back



❑ Flyback

Non-isolated

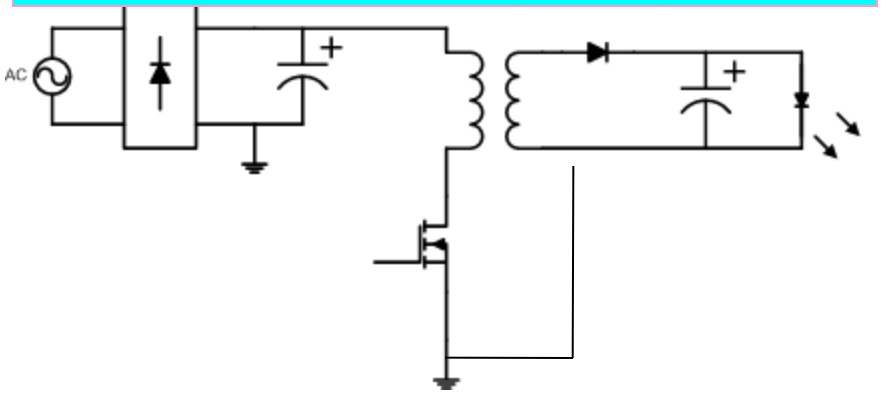
iWatt apps for boost - buck



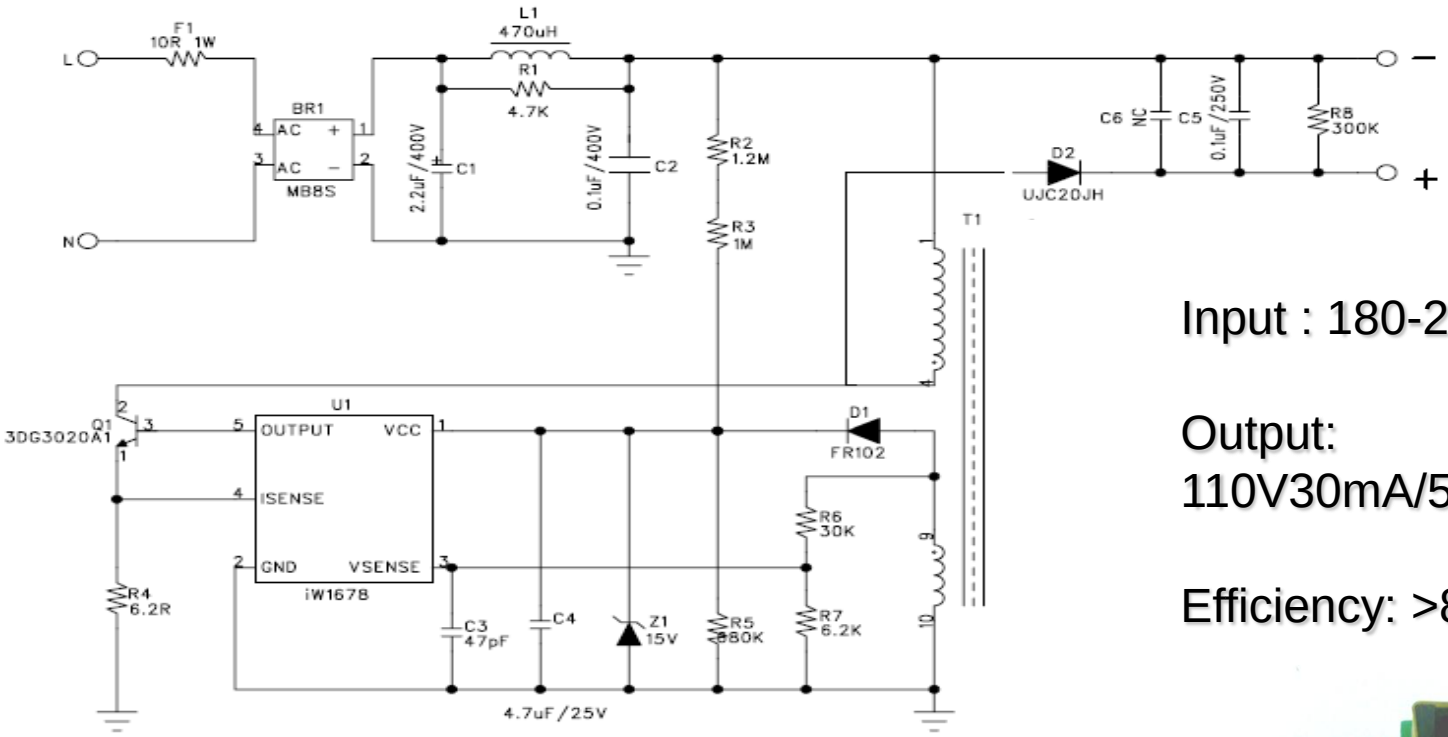
❑SEPIC

Non-isolated

iWatt apps for low voltage & big current



iW1678/1810 Non-isolated for 1-6W LED Driver

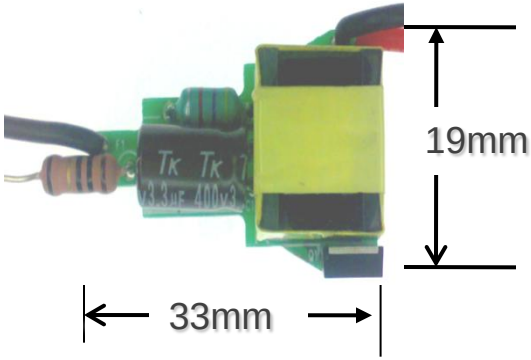


Adobe Acrobat 7.0 Document

Input : 180-264Vac;

Output:
110V30mA/50V80mA

Efficiency: >88%

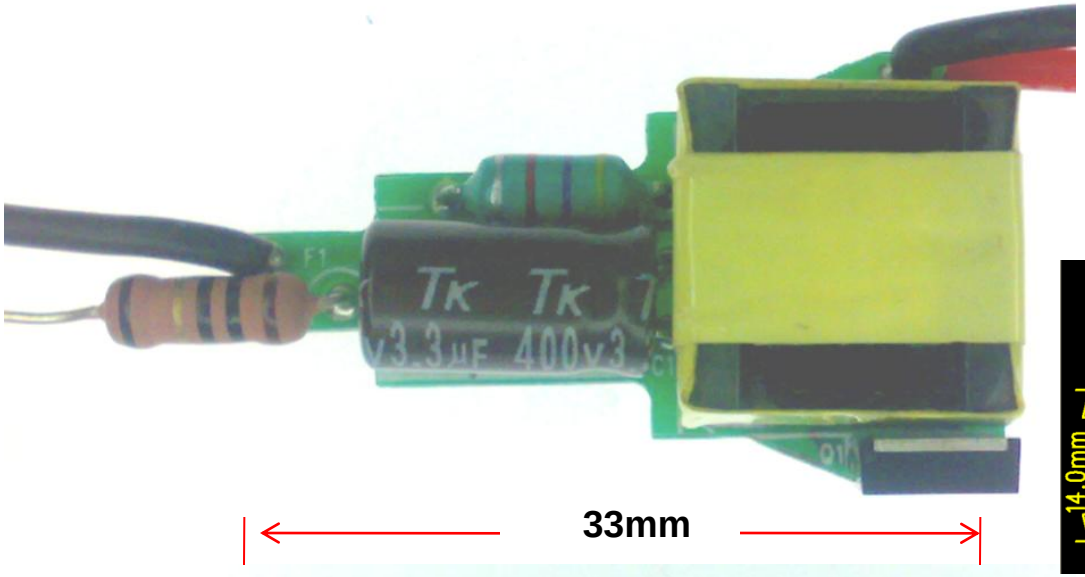


- **Operation frequency 64KHz, drive BJT**
- **Easy for wide input application**
- **High efficiency small size, low cost**
- **Possible for RC replacement**
- **Competitor: PI LNK304, loose CC tolerance**

详细应用请参考iWatt demo 设计

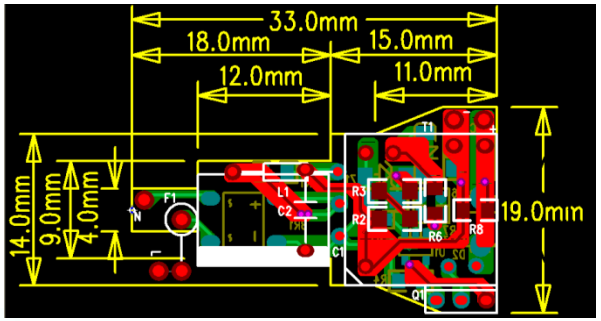
Demo design for RC replacement 1-4W__small size

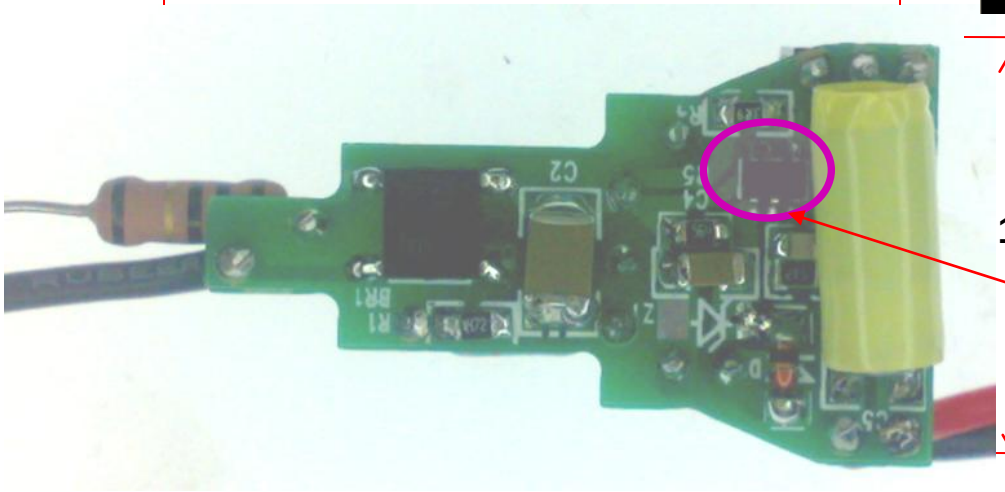
AC
Input



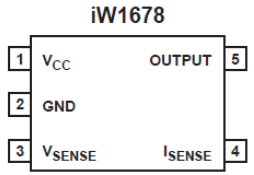
DC output

To LED





iw1678-00



SOT-23 Package

Demo design for RC replacement 1-4W_Low BOM cost

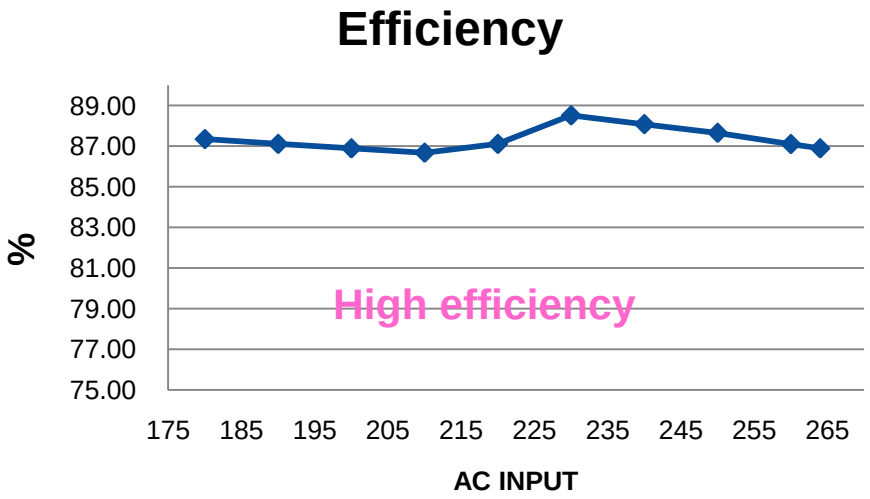
Item	Qty.	Ref.	Description
1	1	C2	0.1uF,400V,CBB
2	1	C1	2.2uF,400V E-CAP,105℃
3	1	C3	47pF,50V,SMD-0603
4	1	C4	4.7uF,25V,SMD-1206
5	1	C5	0.1uF,250V,CBB
6	1	D1	FR102,1A,100V,SMD,
7	1	D2	UGC20GH;2A/600V;SMD
8	1	R1	4.7KΩ+/-5%,SMD-0805
9	1	R2	1.2MΩ+/-5%,SMD-1206
10	1	R3	1MΩ+/-5%,SMD-1206
11	1	FR1	10Ω FUSE Resistor-1W
12	1	R4	6.2Ω+/-5%,SMD-0805
13	1	R5	680KΩ+/-5%,SMD-0805
14	1	R6	30KΩ+/-1%,SMD-0805
15	1	R7	6.2KΩ+/-1%,SMD-0805
16	1	R8	300KΩ+/-5%,SMD-0805
17	1	L1	470uH ,1/2W
18	1	U1	iw1678-00 SOT23-5
19	1	T1	EPC13 Transformer
20	1	Q1	3DD3020A1 TO-251
21	1	BR1	ABS8

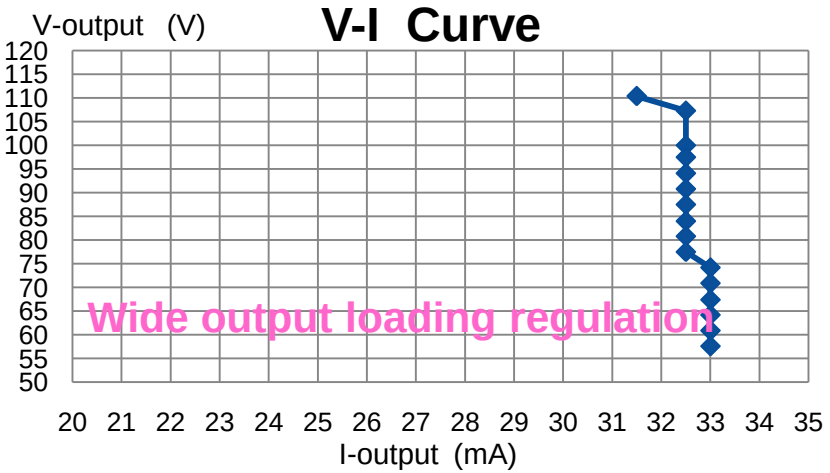
Demo design for RC replacement 4W _performance

(AC input 180~264Vac, Output 33 LEDs)

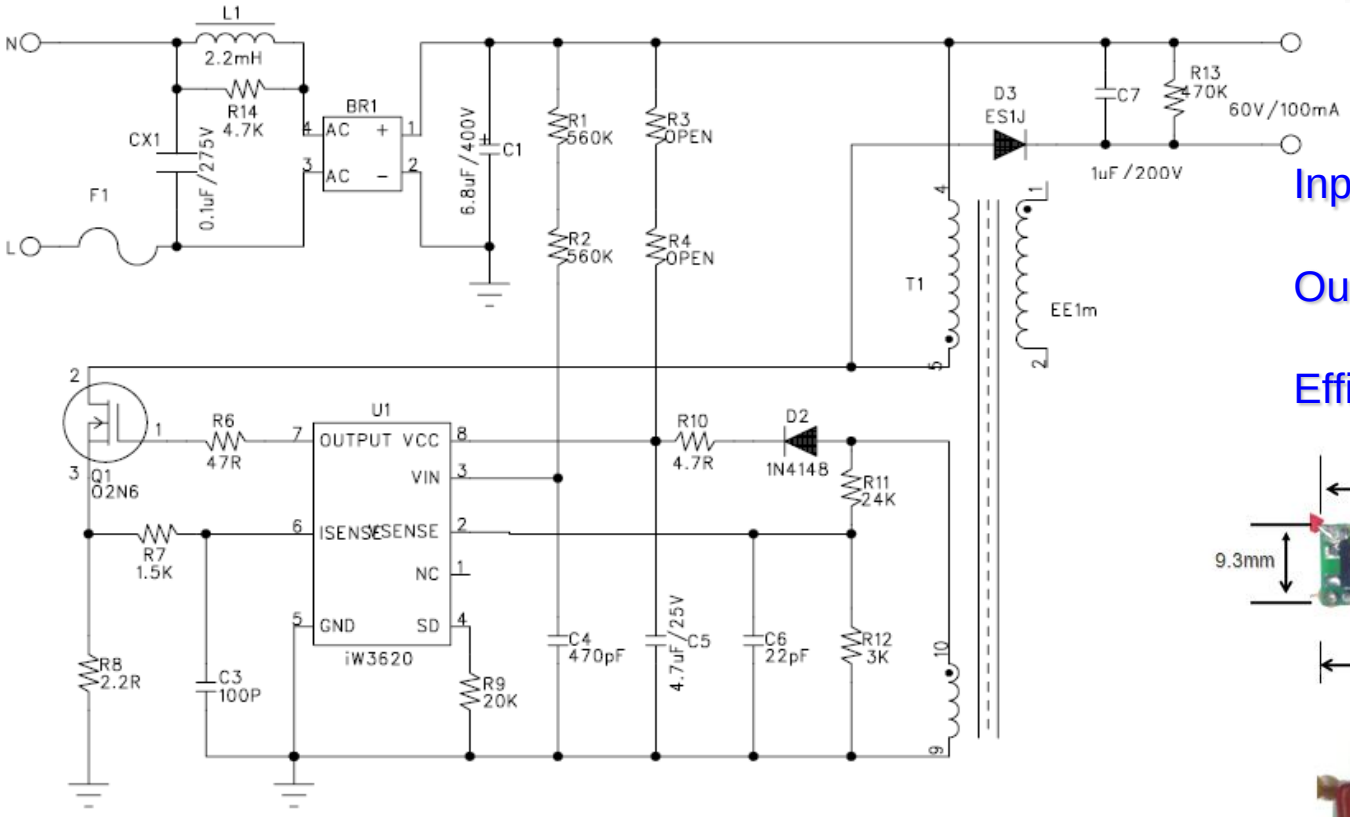
#of LEDS	Vin (V)	Pin (W)	Vout (V)	Iout (A)	efficiency %
16LEDS	180	4.03	110	0.032	87.34
	190	4.03	109.7	0.032	87.11
	200	4.04	109.7	0.032	86.89
	210	4.05	109.7	0.032	86.68
	220	4.03	109.7	0.032	87.11
	230	4.09	109.7	0.033	88.51
	240	4.11	109.7	0.033	88.08
	250	4.13	109.7	0.033	87.65
	260	4.16	109.8	0.033	87.10
	264	4.17	109.8	0.033	86.89

Best line regulation





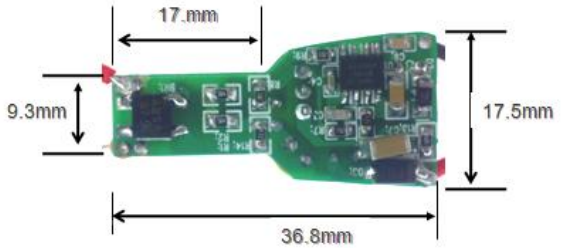
iW3620 for small size non-isolated application



Input : 90-264V;

Output: 60V100mA

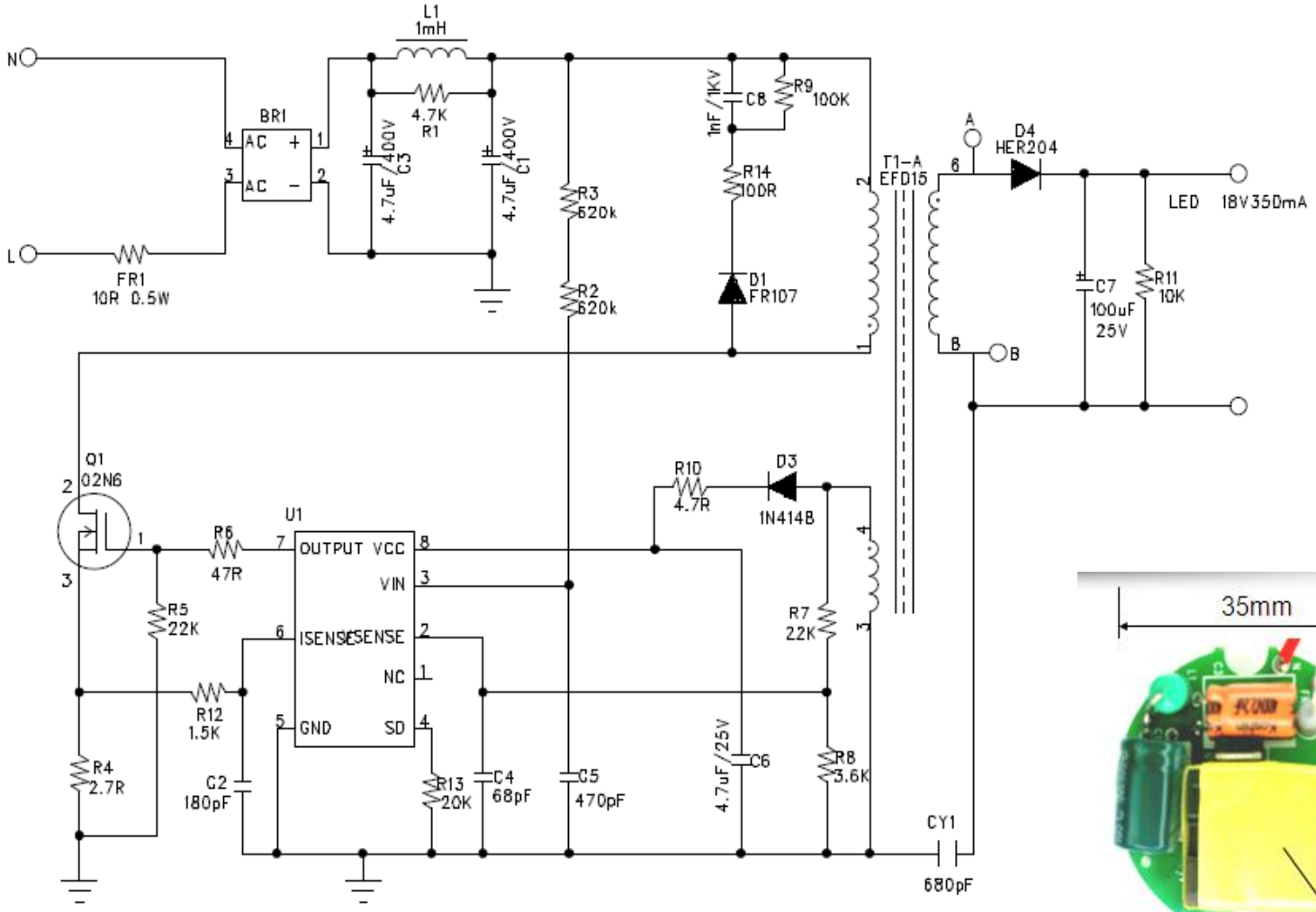
Efficiency: >88%



- **iW3620工作频率高达130KHz, 外置MOSFET**
- 轻松适用于宽输入电压,**4-20W**输出应用
- 高效率,小体积, 低成本,
- 输出恒流精度达**3%**

详细应用请参考iWatt demo 设计

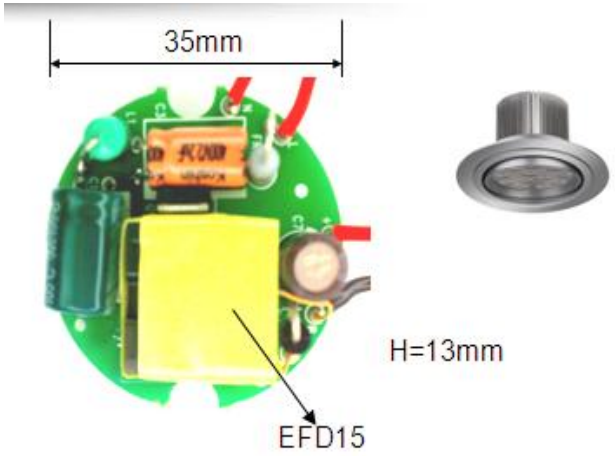
iW3620 for compact isolated LED driver



Input : 90-264V;

Output: 18V350mA

Efficiency: >83%



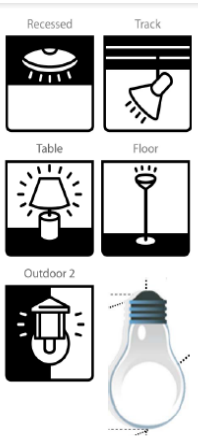
Hi-power factor and E-CAP and ripple current

- **Energy star for PF: 0.5, 0.7, 0.9**
- **IEC61000-3-2 for PF and THD**

IEC61000-3-2 Class C

7.3 Limits for Class C equipment

7.3.1 Lighting equipment



ENERGY STAR® Program Requirements for Integral LED Lamps
ENERGY STAR Eligibility Criteria

Final – December 3, 2009

1) **SCOPE:** These criteria apply to integral LED lamps[2], defined as a lamp with LEDs, an integrated LED driver, and an ANSI standardized base designed to connect to the branch circuit via an ANSI standardized lampholder/socket. These criteria include integral LED lamps of non-standard form, and those intended to replace standard general service incandescent lamps, decorative (candelabra style) lamps, and reflector lamps. Other types of replacement lamps may be added in the future as improvements to LED technology make LED use in other replacement lamp types viable.

Parameter	Specifications
Lumen Maintenance (L_{70})	15,000 to 25,000 hours depending on type of lamp
Power Factor	
For ≤ 5W and low voltage lamps	No minimum specification
For > 5W lamps	≥ 0.7
Minimum operating temperature	
Residential (outdoor)	≤ -20°C
Output operating frequency	≥ 120Hz
EMI/RFI	FCC 47 CFR part 15
Noise	Class A sound rating

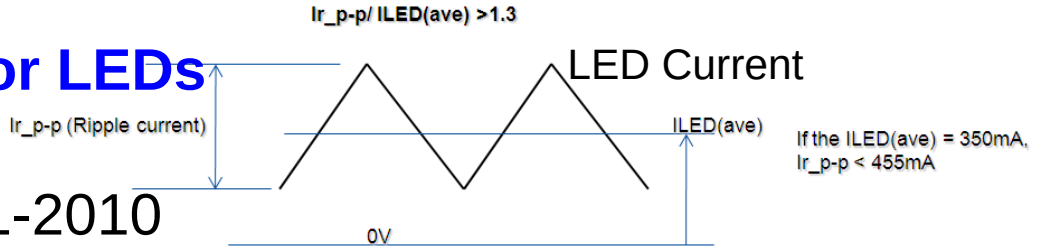
- **Korea need PF>0.9 THD<30%**

E-CAP ⇕ E=½ CV^2

In order to avoid flicker,
a)difference of the peak output current for each half cycle(AC) should be less than 4%
b)Ripple ratio of the lamp current should be less than "1.3"
ripple frequency should be > 100Hz

- **High ripple current get flicker**
- **High ripple loss reliability for LEDs**

Japan:
JEL 801-2010



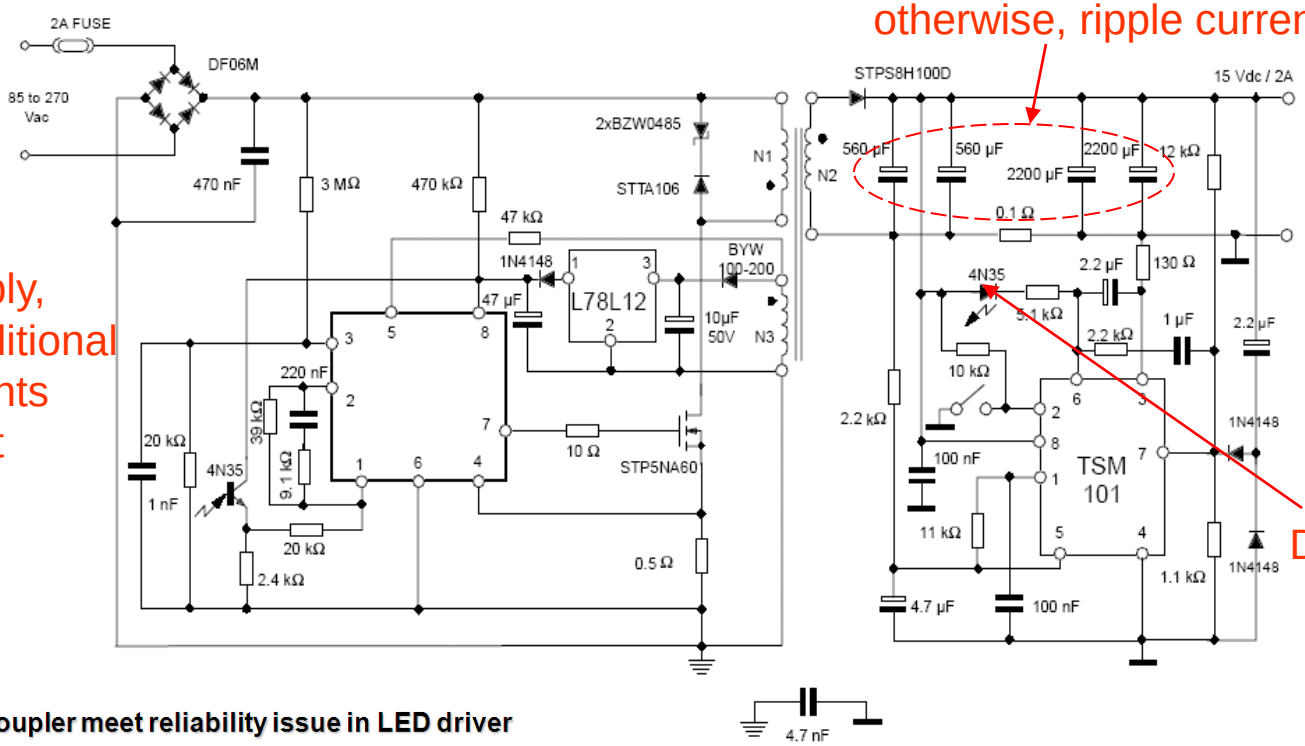
Comparing with true PFC solution

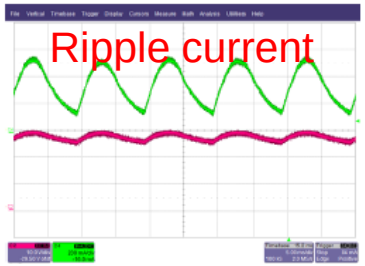
iWatt
Intelligent AC-DC and LED Power™

A. Impact cost and PCB size

B. Probably, need additional components surge test

C. Huge e-cap as output filter, otherwise, ripple current is very high





D. Secondary control for CC/CV mode,

Opto is necessary

Opto-coupler meet reliability issue in LED driver

- Opto-coupler is not recommended for high temperature
- Most LED light customers have phased into None opto-coupler solution (PSR solution)

Internal temperature is around 90-110°C

TOSHIBA TLP421

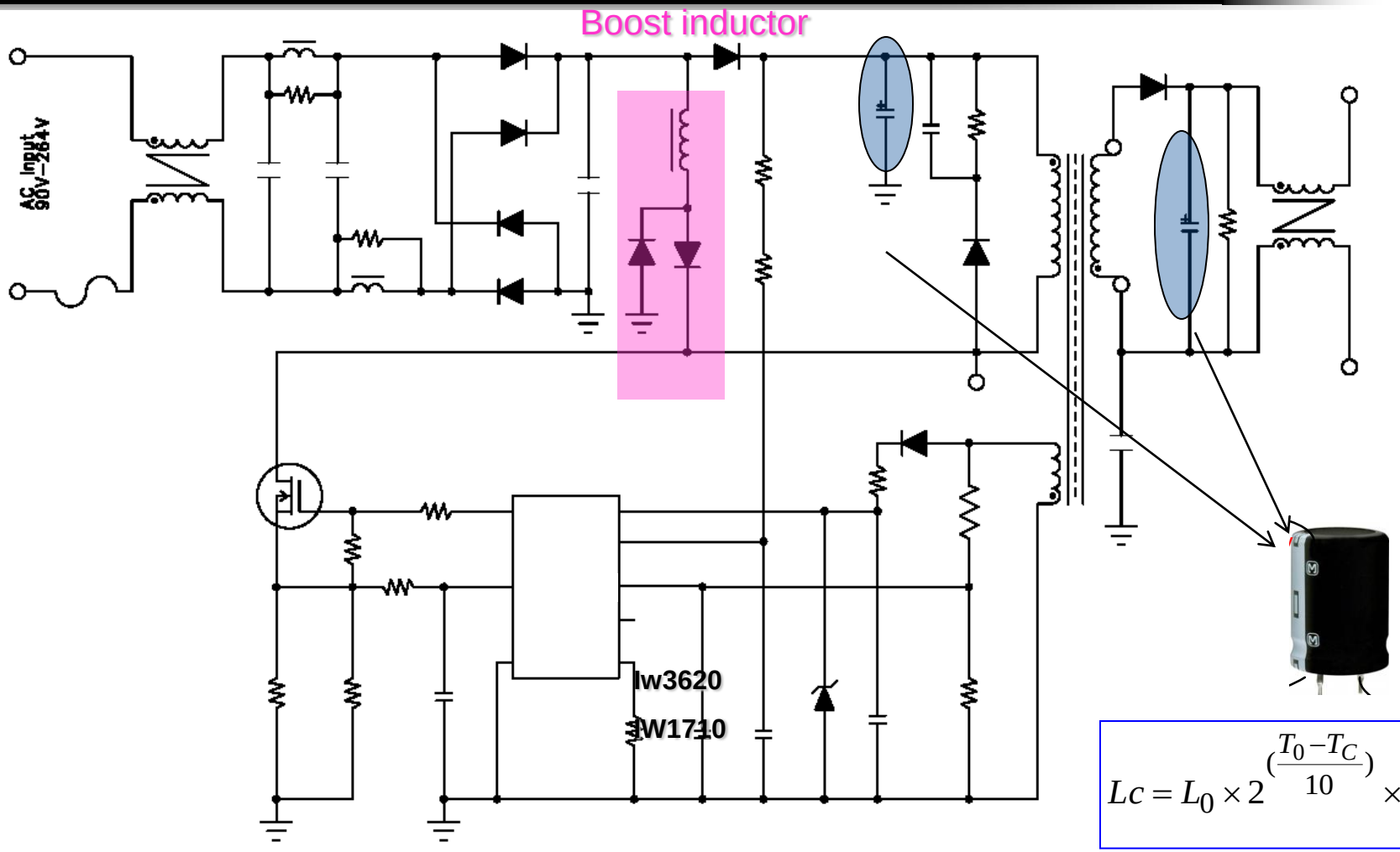
Recommended Operating Conditions

Characteristic	Symbol	Min	Typ.	Max	Unit
Supply voltage	V_{CC}	—	5	24	V
Forward current	I_F	—	16	25	mA
Collector current	I_C	—	1	10	mA
Operating temperature	T_{opr}	-25	—	85	°C

Note: Recommended operating conditions are given as a design guideline to obtain expected performance of the device. Additionally, each item is an independent guideline respectively. In developing designs using this product, please confirm specified characteristics shown in this document.

E. Weak Protection at single fault mode, for example, opto-coupler open

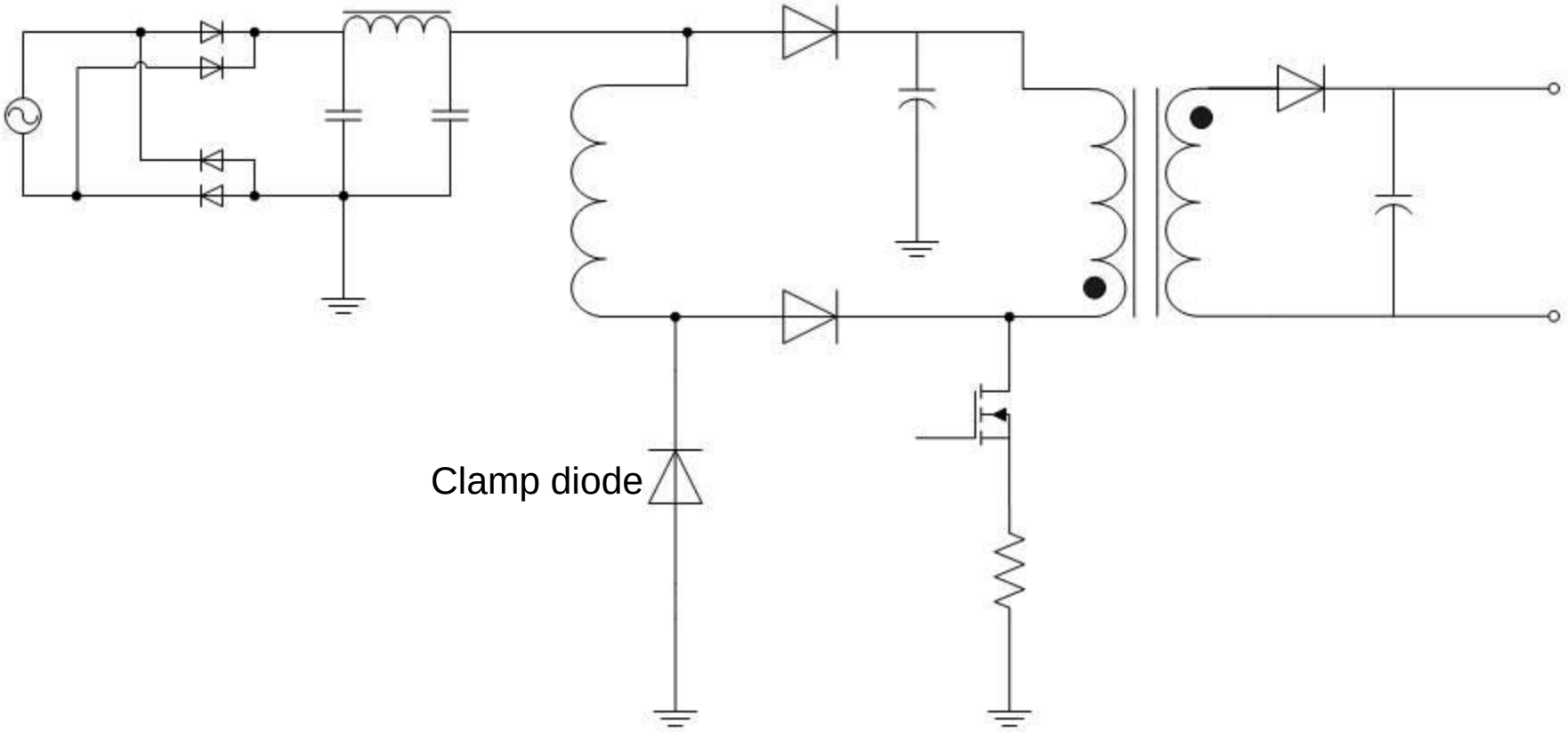
iW3620 SEPIC Schematic



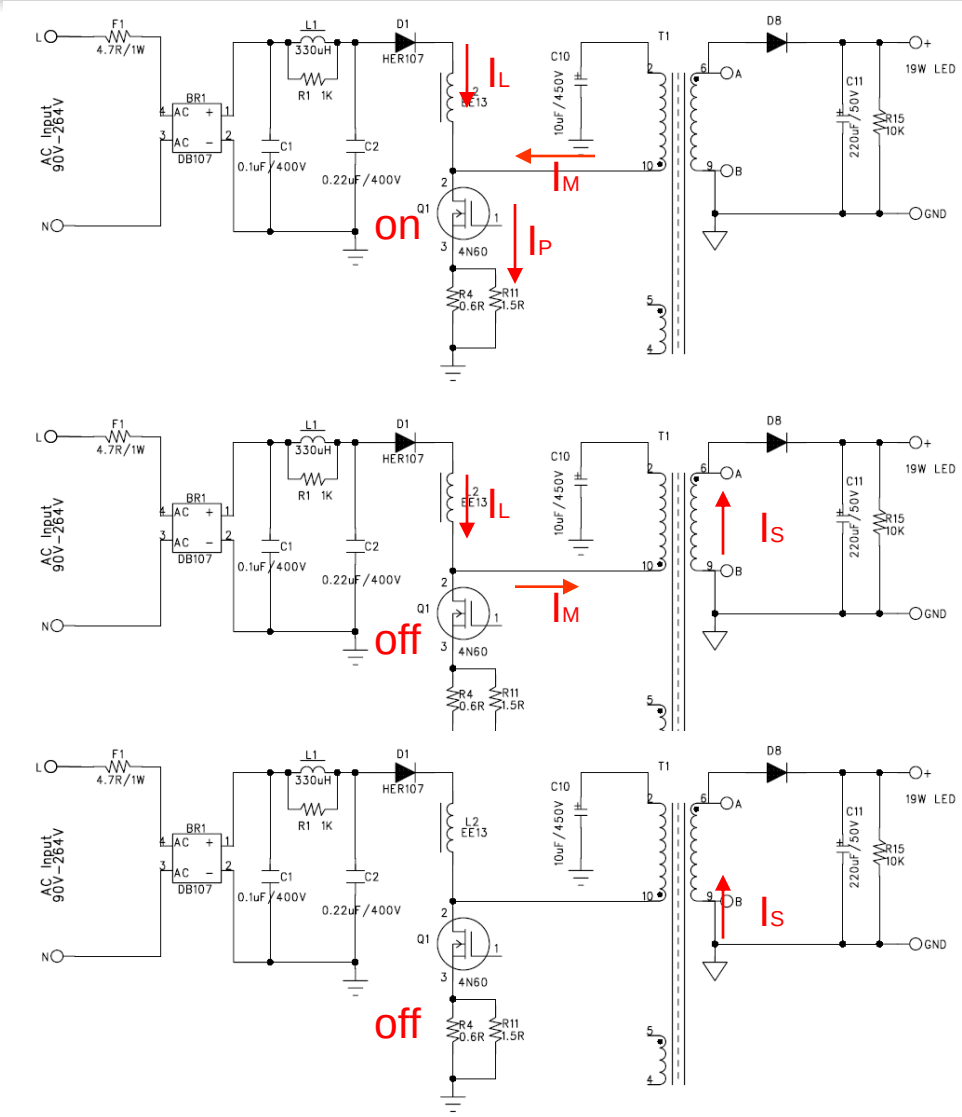
$$Lc = L_0 \times 2^{(\frac{T_0 - T_C}{10})} \times (\frac{V_o}{V_C}) \times 2.5$$

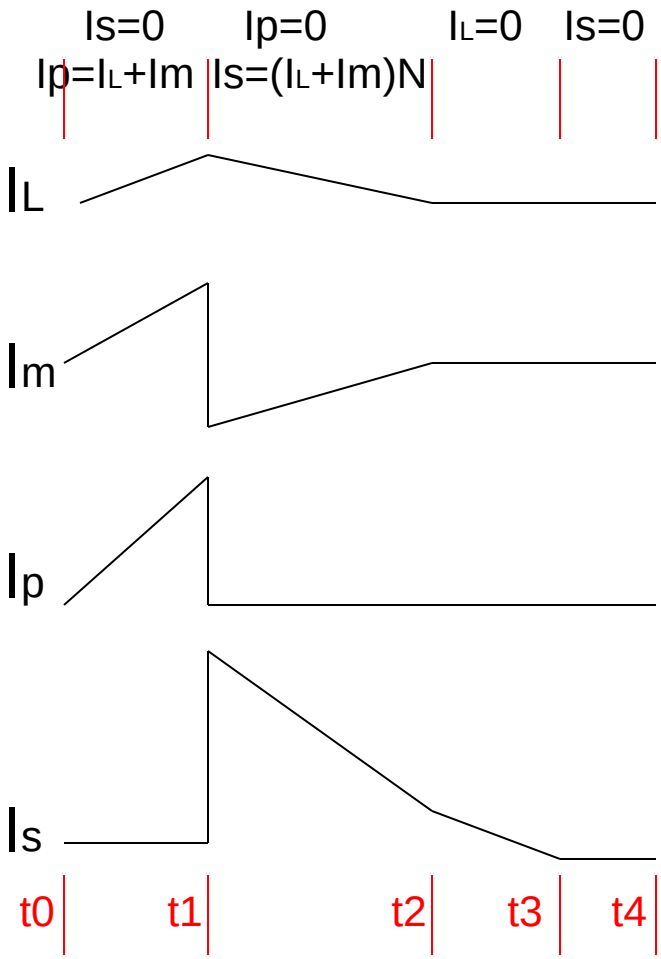
Lifetime calculation

iW3620 SEPIC circuit

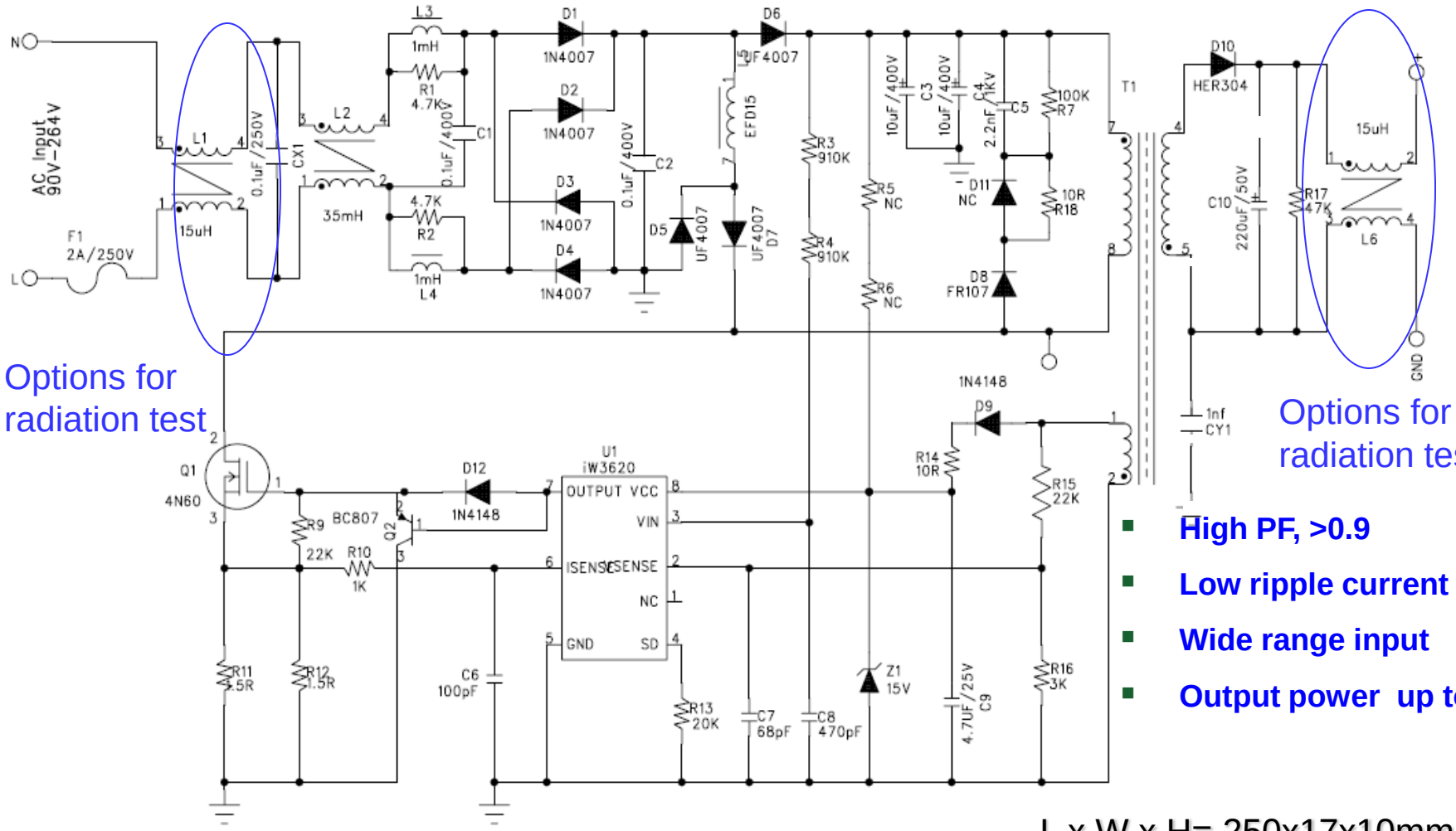


iW3620 SEPIC--Theory of operation





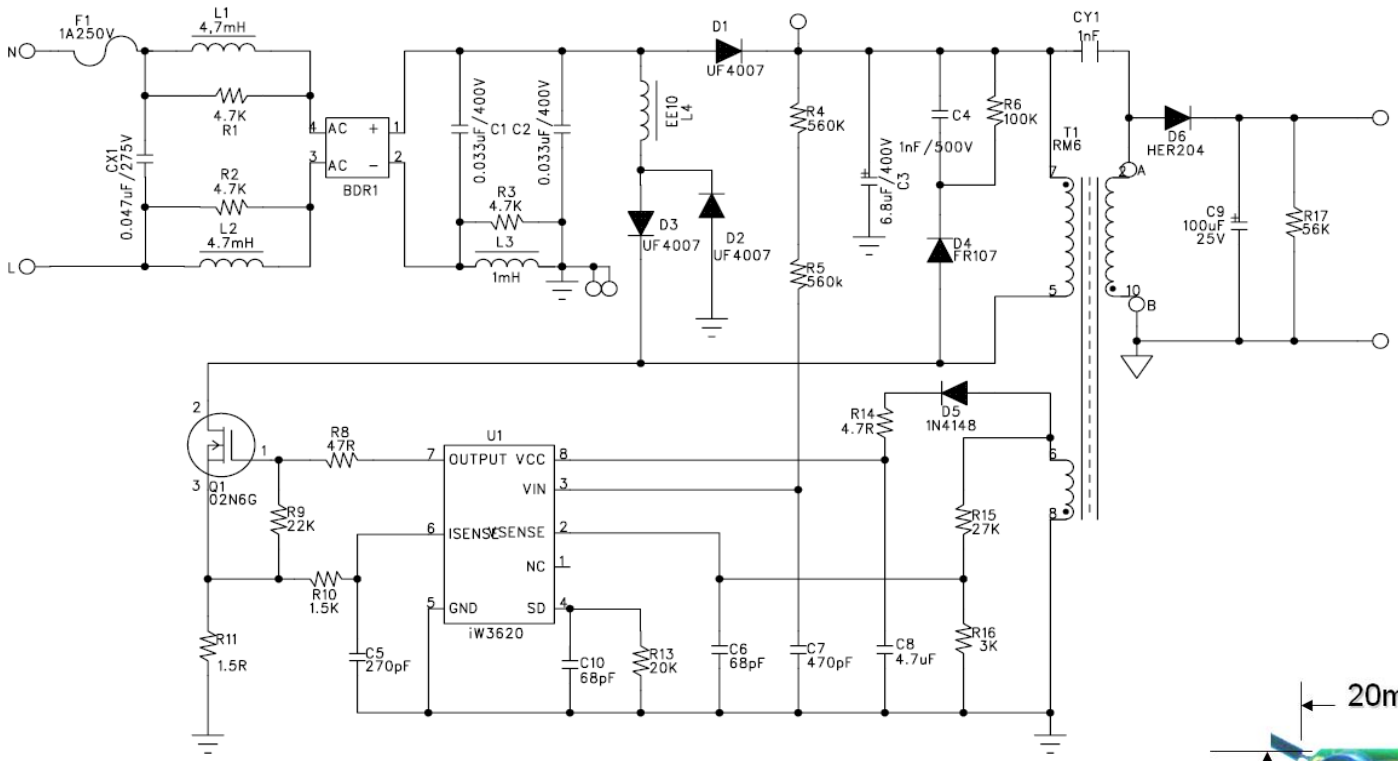
iW3620 SEPIC design for Hi-PF T8 driver

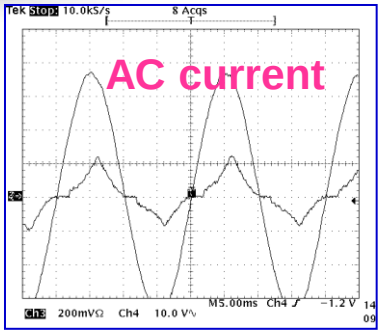


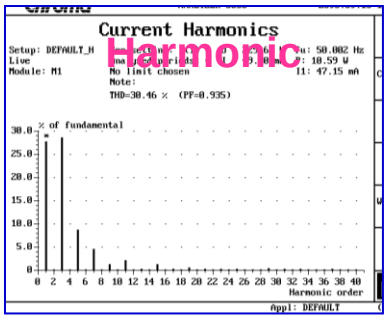
- **High PF, >0.9**
- **Low ripple current , <30%**
- **Wide range input**
- **Output power up to 30W**

L x W x H= 250x17x10mm

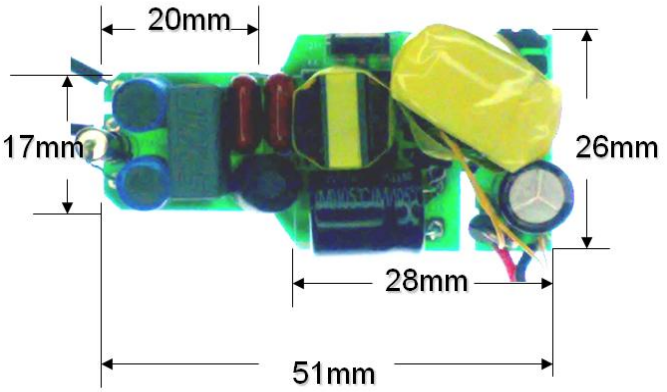
iW3620 SEPIC design for Hi-PF Bulb & PAR







- **Simple solution for Hi-PF and constant current output**
- **Universal input and low output ripple current**
- **Best surge test performance**



详细应用请参考iWatt demo 设计

Everybody is looking for dimmable solution

iWatt
Intelligent AC-DC and LED Power™

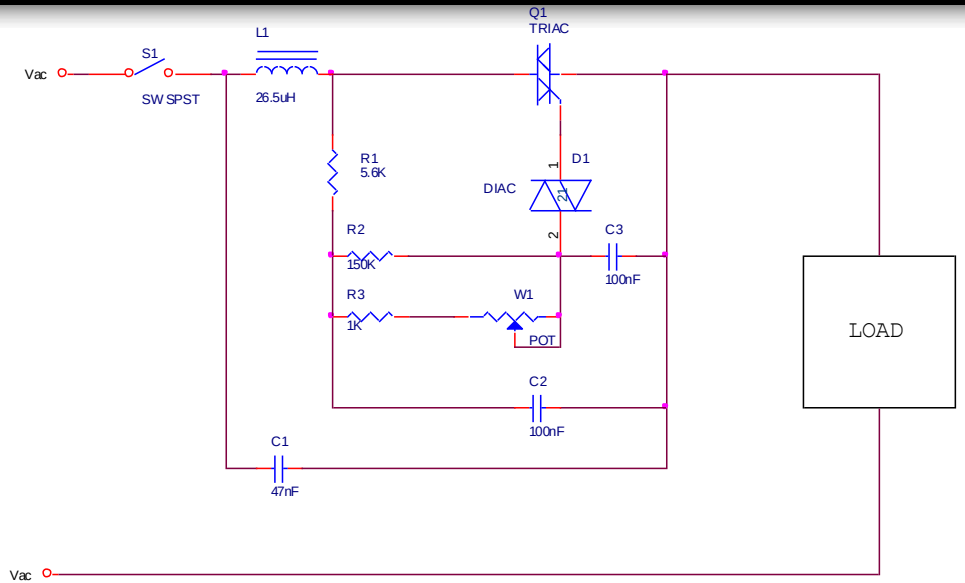
- High quality light control, >150Hz Dimming Frequency
- High Dimmer Compatibility: Smooth, seamless,
- Tolerate more line distortion and surge with tight LED Current
- Parallel with more lamps per dimmer
- Hot-swap driver module and Emitter

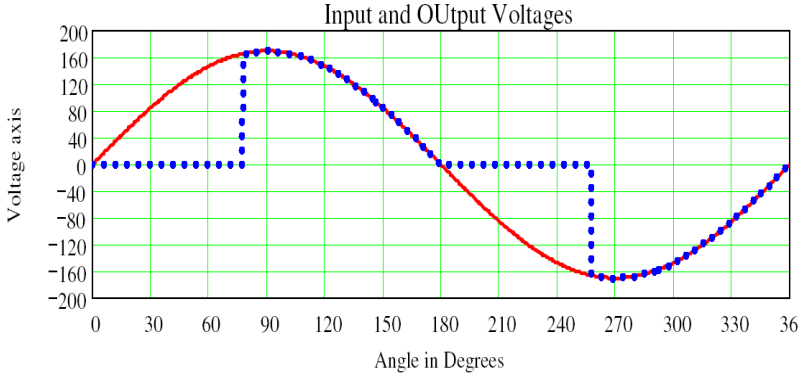
iWatt
Enabling Green Power By Design

CAN DO !

- PF>0.7, High η, All-dim
- PF>0.9, Low THD, All-dim
- Low PF, Simple, Low-cost
- Non-isolated and isolated
- Low ripple and None flicker
- Small size and High efficiency

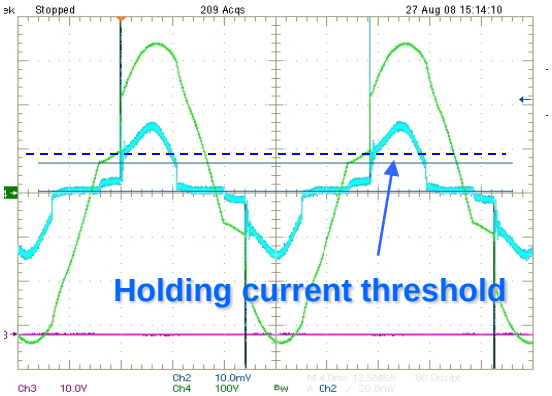
Leading edge dimmer ___ TRIAC dimmer





Adjustable resistor of W1 and C3 are the single elements phase shift network. When the voltage across the C3 reaches the break over voltage of DIAC, c3 is partially discharged into Triac gate through DIAC. The Triac is then trigged into conduction mode for the reminder of cycle. However, the Triac has the minimum gate trigger current (IGT) to turn the triac on. It also requires the minimum holding current to hold the triac on once conducting. When the current drops below the holding current, the triac turns off.

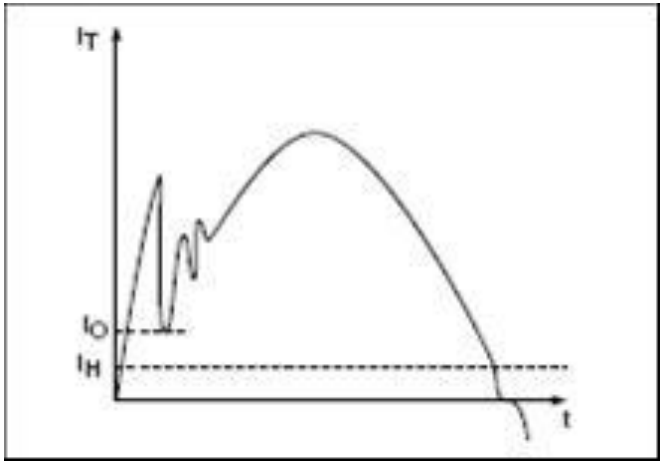
Leading edge dimmer works with incandescence



Knowing Triac

Latching current IL

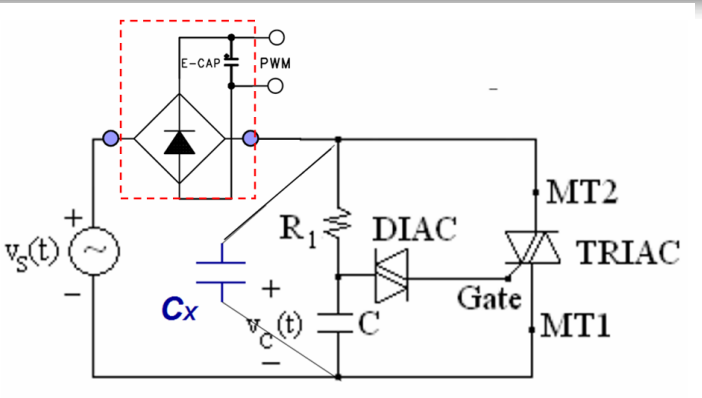
If the triac is triggered by a gate current at the beginning of a mains half cycle, the load current will build up gradually from zero. The gate current must not be removed before the triac is latched ON otherwise it will return to the blocking state. Latching occurs when the load current reaches IL. The gate pulse must therefore be present until the load current has reached IL. The gate pulse duration must be specified at the lowest expected operating temperature for guaranteed triggering. If IO > IH. The TRIAC remains turned on. But if IO falls below IH, the TRIAC will be blocked.



Holding current IH

As the load current reduces towards the end of a mains half cycle, a current, IH, will be reached when the triac is no longer latched. It will cease to conduct in the absence of a gate current.

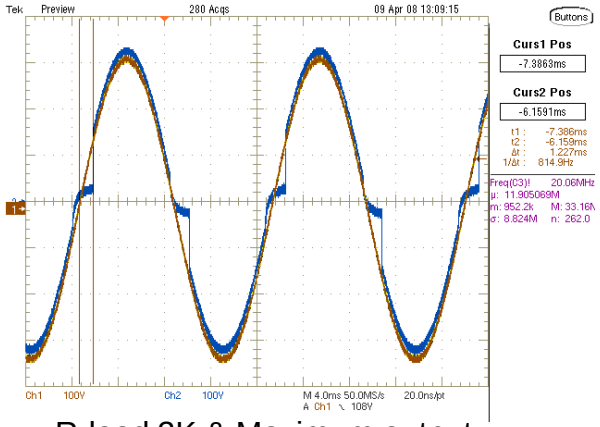
What will happen when working for capacitance load



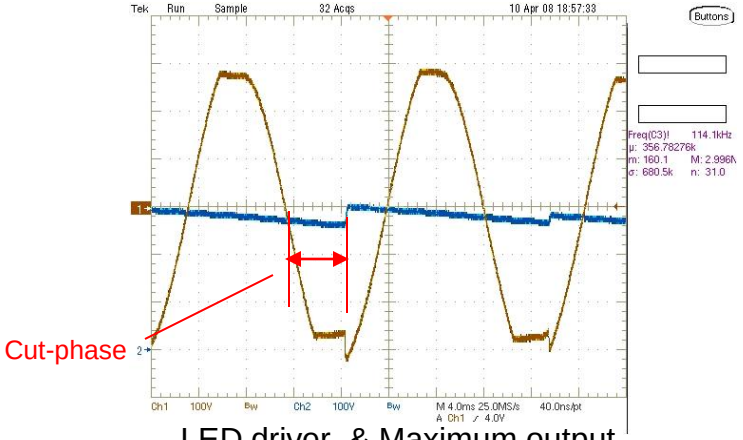
R=R1+ Equal impedance of bridge rectifier

The impedance is very high before the bridge is on,

After the bridge rectifier turn on, the impedance will be very low



R-load 2K & Maximum output



LED driver & Maximum output

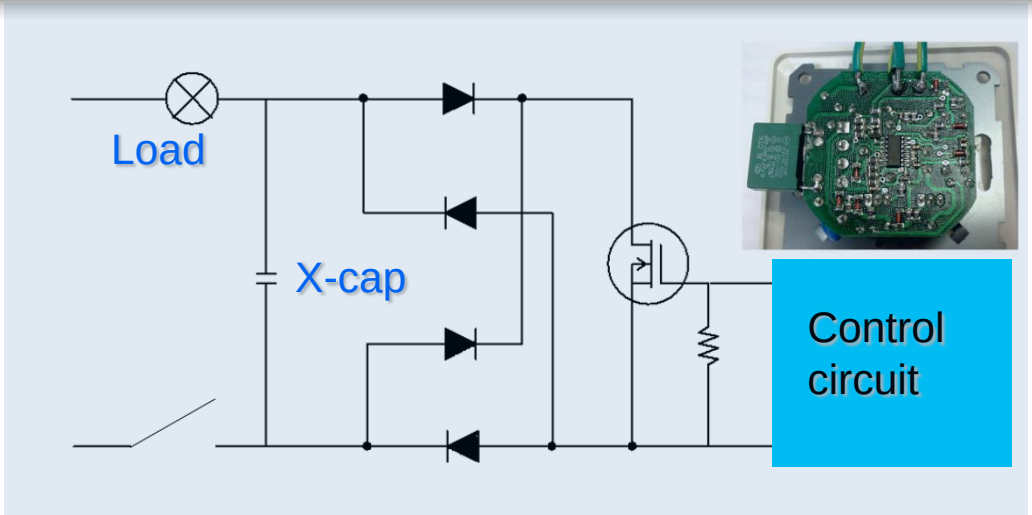
Dimming range from 90% to 20%, depending on variable dimmer design

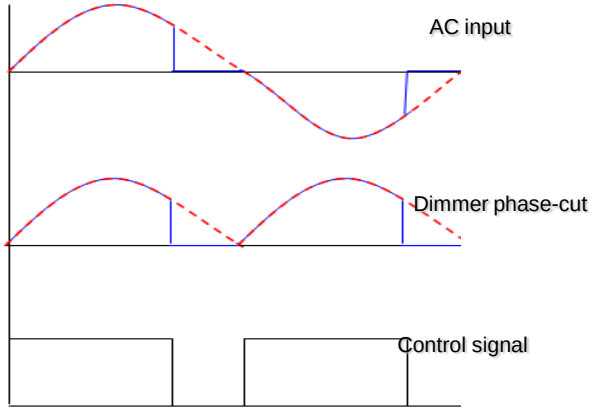
The dimming range is 20 Degree to 150 Degree (or 180Degree)

The minimum cut-phase will be higher than R load condition, and the maximum cut-phase will be higher than R-load condition too.

The range for dimming is almost 90Degree to 150 Degree

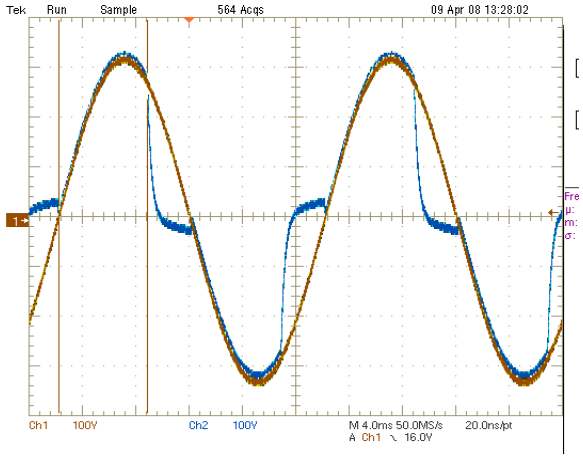
Trailing edge dimmer





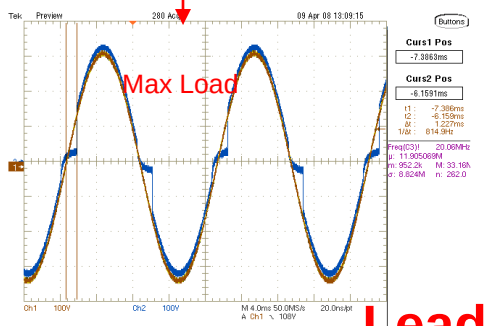
- Trailing edge dimmer is designed for e-transformer, normally power for 100W-500W；
- With timing circuit to control the on-time after zero across ；
- Hard to detect the OFF point at falling edge as lot of dimmer has internal X-cap (For EMI and protection)

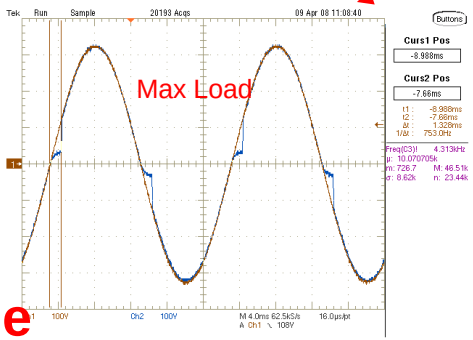
Trailing edge dimmer works with resistance load

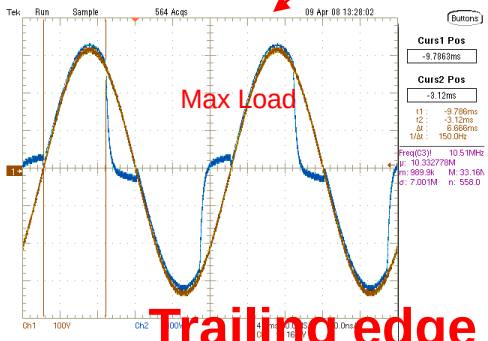


Variable dimmers working with R-Load

Panasonic WMS549	Merlin Gerin S460	Merlin Gerin S460A	CLIPSAL	Merten	Trailing edge
					
CX=0.068uF C=0.047uF	CX=0.047uF C=0.033uF	CX=0 C=0.047uF	CX=0.1uF C=0.027uF	CX=0.1+0.47uF C=0.027uF	CX=0.1uF C=0.047uF

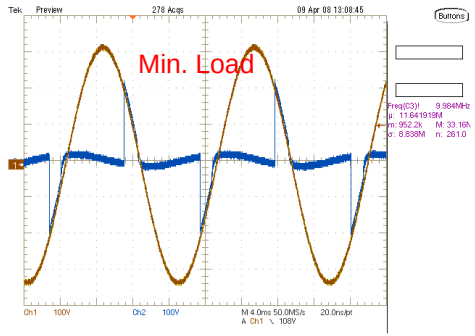


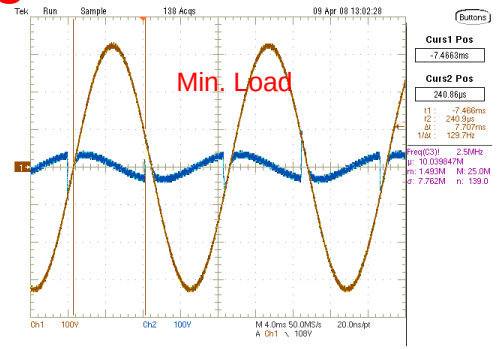


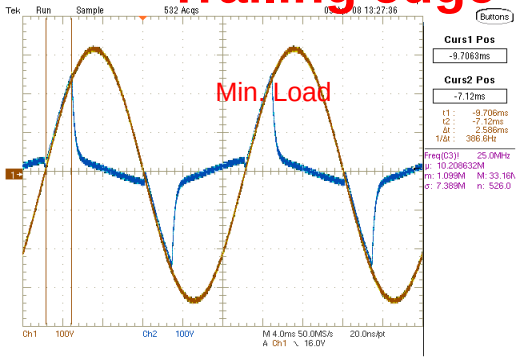


Leading edge

Trailing edge

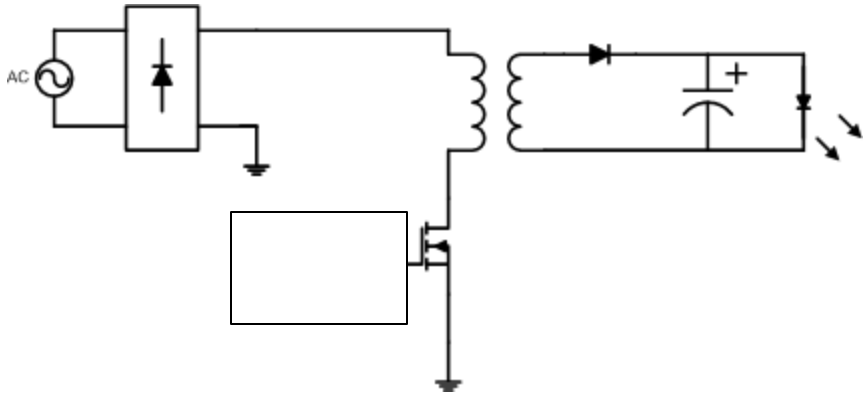


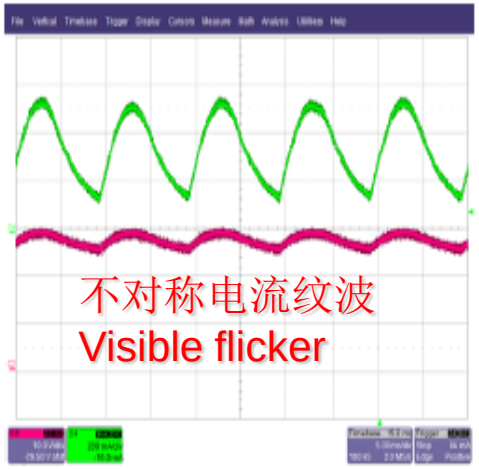




Single stage dimmable solution

- Basic Fly back: Single-stage Solution





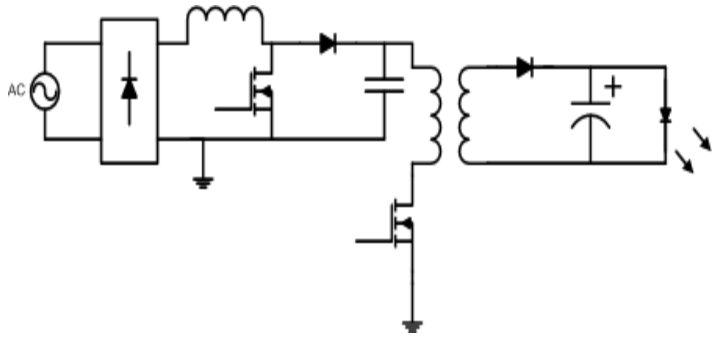
Concerning:
High ripple current and big E-cap at output side

E=½ CV^2

Visible flicker and e-flicker

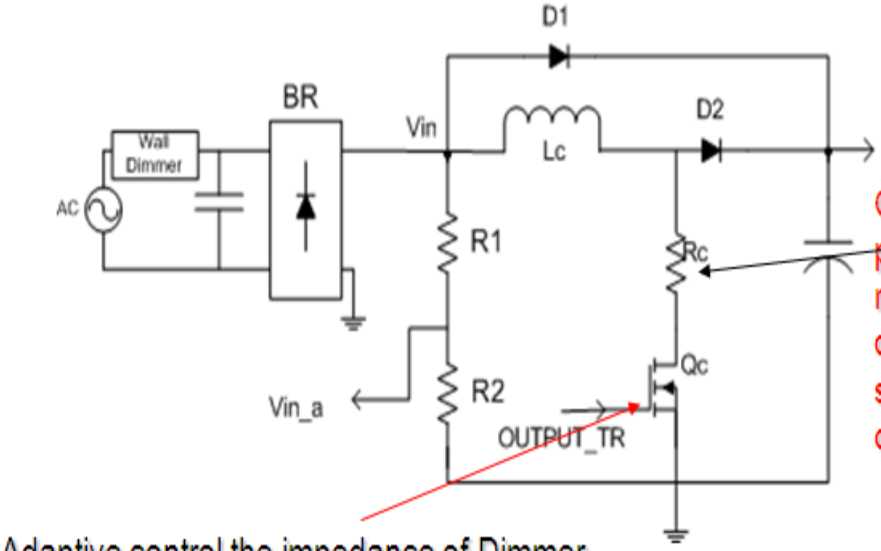
High repeatable AC current when TRAIC fire on at 90’C

iW3610/iW3612/3602/3614 digital chopping circuit



- Boost + Fly back: Two-stage solutions

- **Unique Method to Configure the Dimmer Type**
- **Provide the Pure resistive impedance to Wall Dimmer**
- **Line current shape to improve power factor**
- **Reduce AC-cycle Inrush current**



Chopping Resistor to provide the pure resistance load for dimmer when Lc is saturated by the long on-time of Qc

Adaptive control the impedance of Dimmer

Industry Recognition:
Dimmable LED controller iW3610 most innovative product

EDN INNOVATION

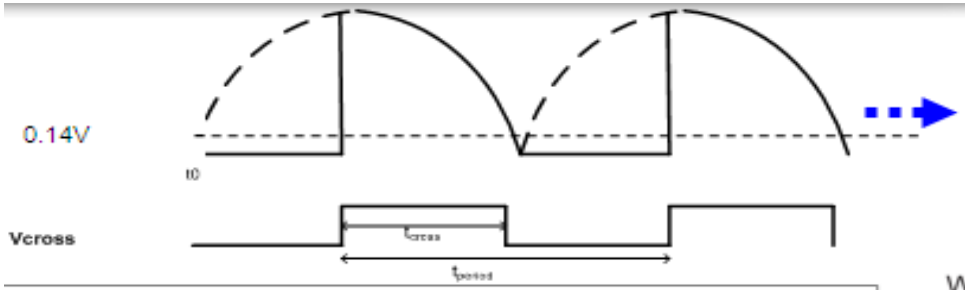
最具兼容性的控制方法, 最精简的两级控制方案

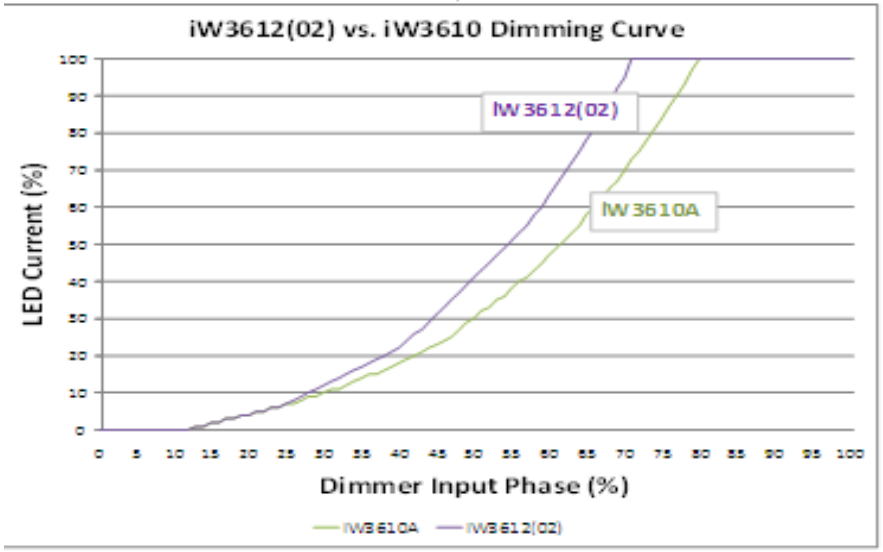
Dimmer phase-cut detection and dimming control

- **Average voltage measurement –-Other competitor**

  Phase-cut -- Rectifier -- RC Filter -- Average

- **Phase detection and duty measurement-----iWatt**



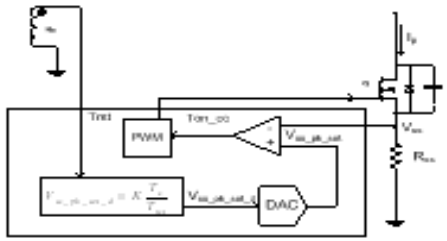


$$Dimmer\_phase = \frac{Tcross}{Tperiod}$$

$$D_{RATIO} = \text{Dimmer Phase} \times K_1 - K_2$$

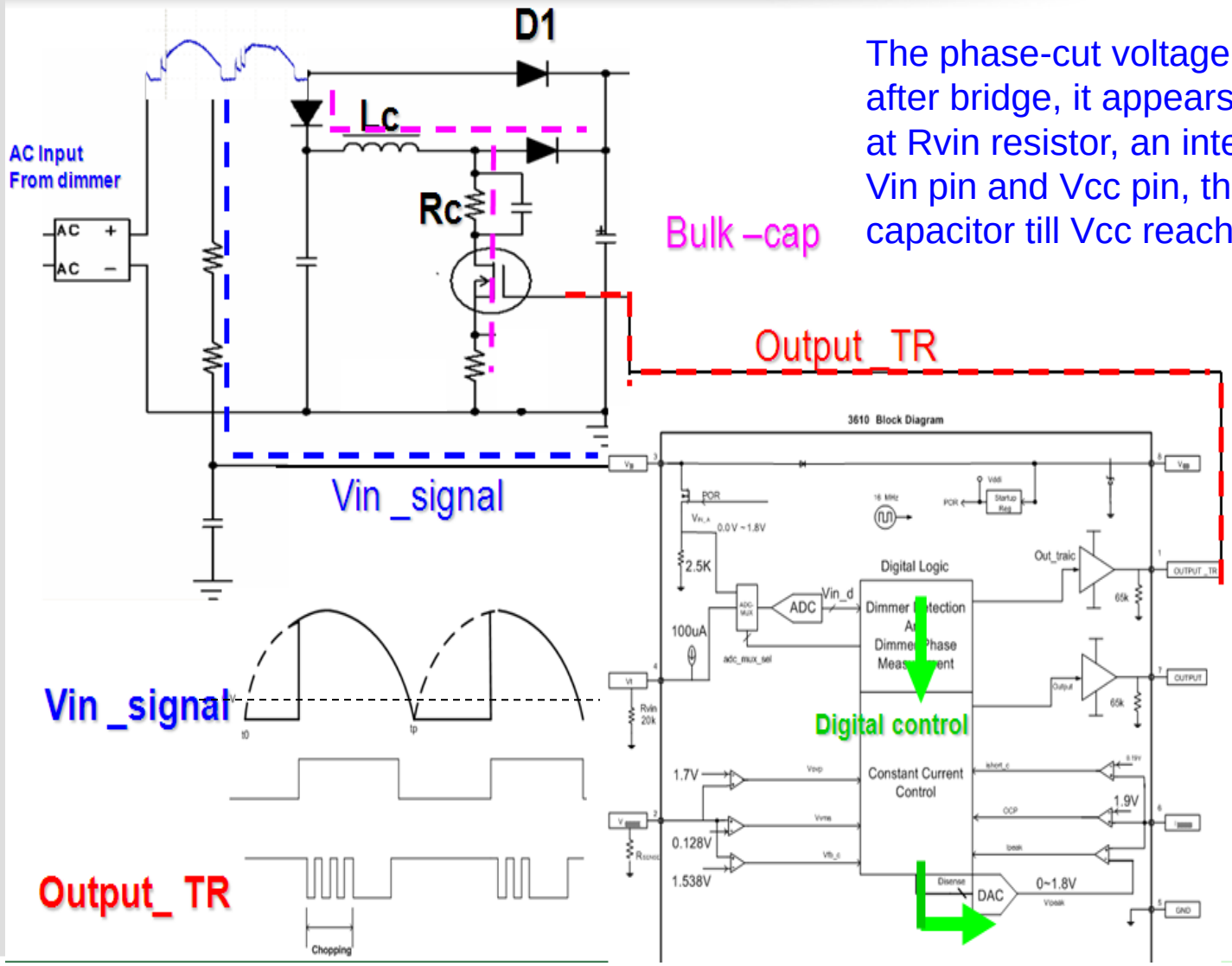
Where, K_1 is set to 1.74 and K_2 is set to 0.23

Adjust the reference voltage of Peak Current Sense comparator



LED Current $I_o = \frac{I_{pri\_pk} N_{ps}}{2} \frac{T_{rst}}{T}$

Start up and dimmer configuration



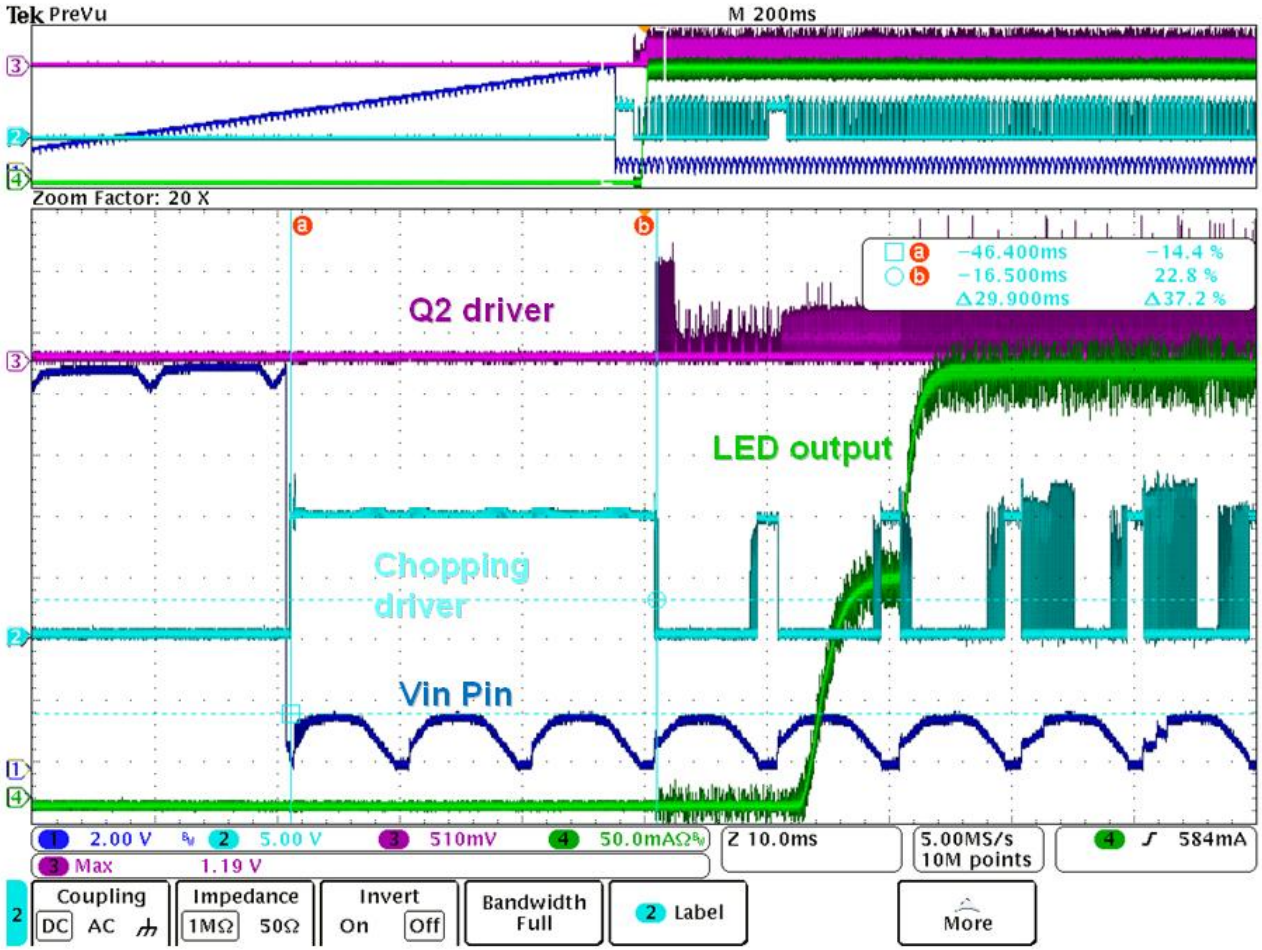
The phase-cut voltage comes from dimmer, after bridge, it appears as 100Hz(or120Hz) at Rvin resistor, an integral diode between Vin pin and Vcc pin, the current charge Vcc capacitor till Vcc reach 12V.

IC start to workand turn on the MOSFET of Vin pin, Vin pin voltage will be a scale of input voltage

IC measure Vin voltage to understand what is real input voltage and phase-cut duty

Power on and phase detection

正常起机波形　Start waveform



After power on, Vcc is charged to 12V,
IC start working, Q2 will be full turn on 3 cycles to configurative dimmer , will check the dimmer type

If Q2 keeps turning on , resistance impedance is present. It help for dimmer detection

After FLAYBACK working 20 cycles, will be configuration again to double confirm the dimmer type

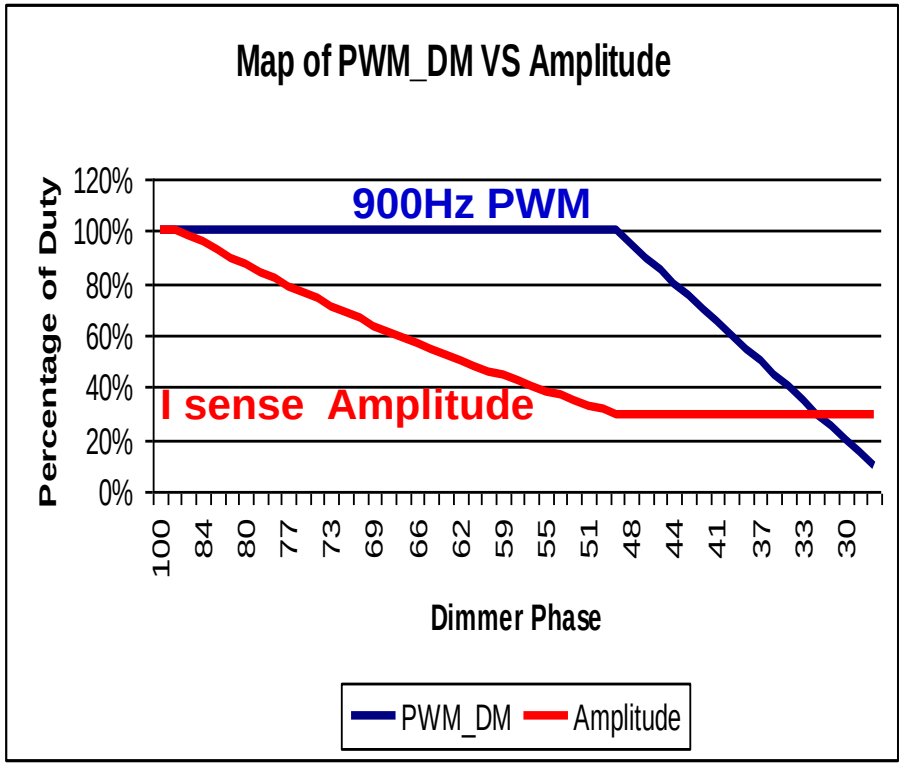
Supported dimmer list—Parts

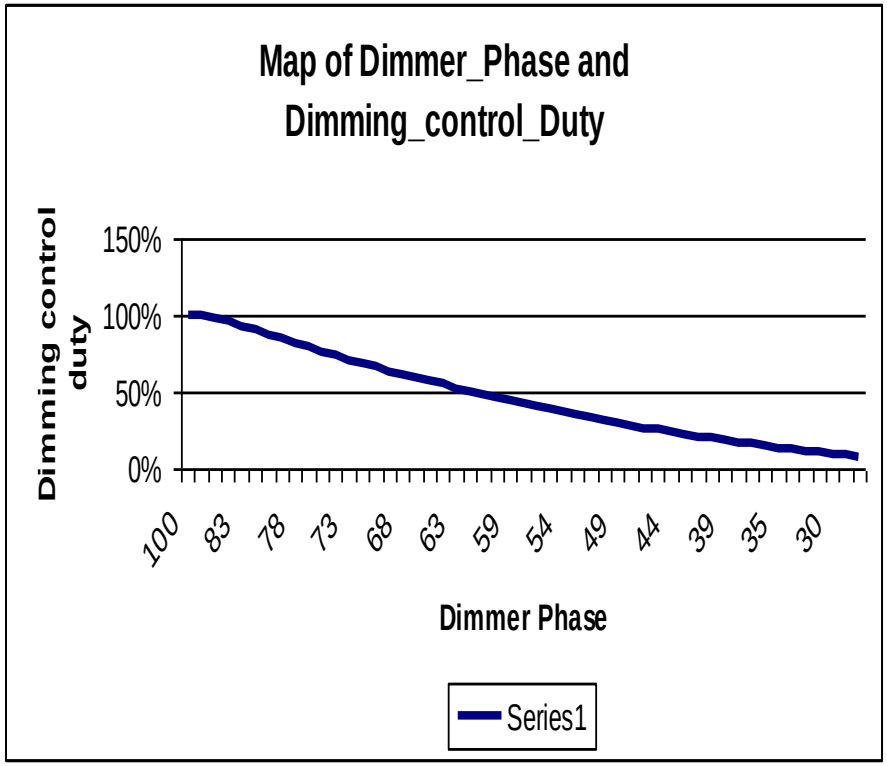
iWatt
Intelligent AC-DC and LED Power™

Dimmer Low Line (120V/100V)					
#	Producer	Vlot/Freq	Model	Ctl. Type	MAX
1	Leviton	120/60	IPI 06	Leading	600
2	Lutron	120/60	S-600	Leading	600
3	Lutron	120/60	DV-600P	Leading	600
4	Lutron	120/60	LG-600	Leading	600
5	Lutron	120/60	DV-603	Leading	600
6	Lutron	120/60	GL-600	Leading	600
7	Leviton	120/60	6161	Leading	600
8	Lutron	120/60	DNG-600	Leading	600
9	Lutron	120/60	S-603	Leading	600
10	Lutron	120/60	AY-600	Leading	600
11	Lutron	120/60	TG-600	Leading	600
12	Lutron	120/60	Q-600	Leading	600
13	Leviton	120/60	RTD01	Leading	600
14	Lutron	120/60	NTLV-600	Leading	600
15	Leviton	120/60	6633P	Leading	600
16	Leviton	120/60	6684	Leading	600
17	Lutron	120/60	SLV-600	Leading	600
18	Lutron	120/60	NTELV-600	Trailing	600
19	Lutron	120/60	SELV-300	Trailing	300
20	Lutron	120/60	DVELV-300	Trailing	300
21	Leviton	120/60	RPI 06	Leading	600
22	Leviton	120/60	6615P	Trailing	300
23	Leviton	120/60	6681	Leading	600
24	Leviton	120/60	6631	Leading	600
25	Panasonic	100/50	NQ20345	Leading	300
26	Panasonic	100/50	WN575259	Leading	500
27					
28					
29					

Dimmer: High Line (220V)					
#	Producer	Vlot/Freq	Model	Ctl. Type	MAX
1	Busch	230/50	2247	Leading	500
2	Busch	230/50	2250U	Leading	600
3	NIKO	230/50		Leading	300
4	TCL	230/50	K9051	Leading	630
5	JUNG	230/50	266GDE	Leading	500
6	Everflourish	230/50	EF700DA	Leading	300
7	KOSLO	230/50		Leading	600
8	SIEMENS	230/50	5TC0200	Leading	
9	MK	230/50	TG1000	Leading	
10	OPUS	230/50	852-390	Leading	
11	Clipsal	230/50	32E450L	Leading	450
12	Merten	230/50	5725	Leading	
13	Busch	230/50	2200-UJ	Leading	
14	Busch	230/50	6513U	Trailing	420
15	SIEMENS	230/50	5TC8284	Trailing	600
16	Vadsbo	230/50	TD350	Trailing	350
17	Merten	230/50	5771	Trailing	315
18	Clipsal	230/50	32E450T	Trailing	450
19	WUYUN	230/50		Leading	400
20	FLUSH	230/50	DPI	Leading	
21	Anchor	230/50		Leading	
22	Schneider	230/50		Leading	
23	Clipsal	230/50	32E450UM	Leading/	450
24	DUMI	230/50	DW700DA	Leading	300
25	Sologic	230/50			400W
26	OSPEL	230/50			400W
27	EMC	230/50	PROP400U		400W
28	SICHERUNG	230/50	8085		
29	BREKER	230/50	283010		400W

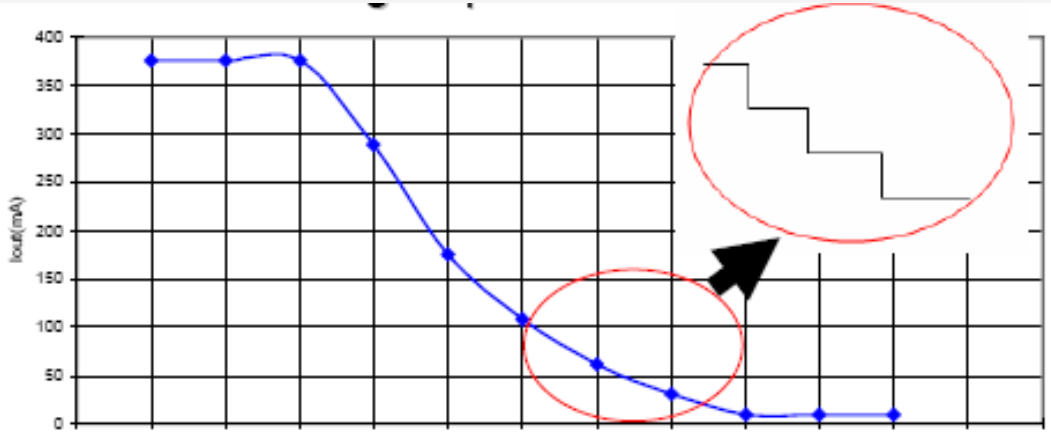
Mapping of Dimmer_ phase Vs Dimming control duty





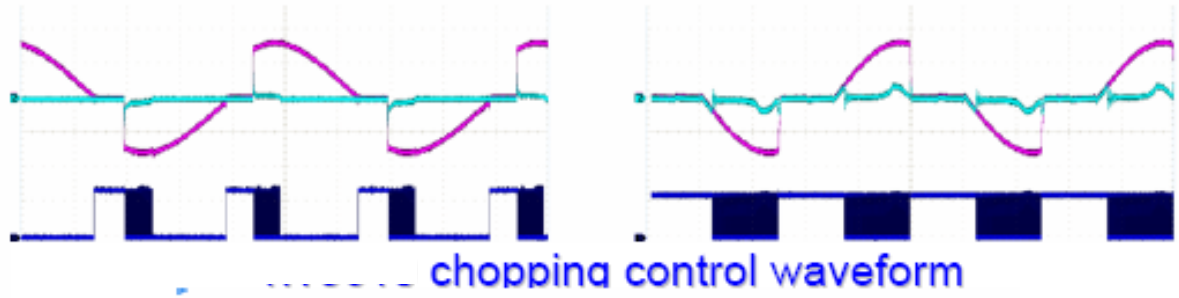
- High efficiency for all power level
- Ultra low and stable dimming level

Digital dimming Eliminate Flicker

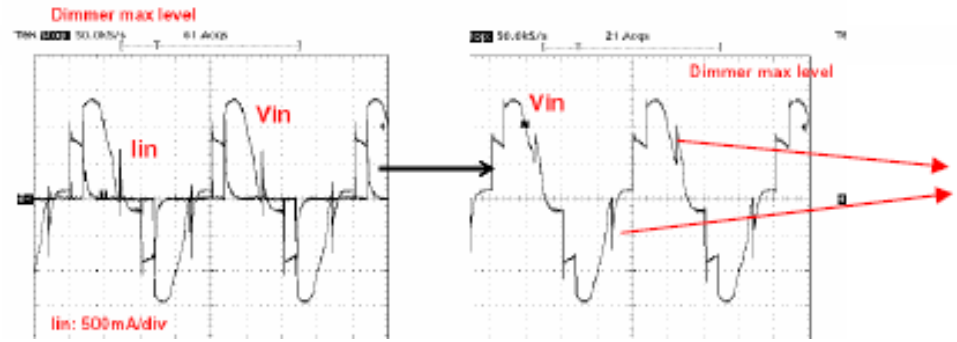


- Digital mapping of dimming control for wide range of dimming output
- Monotonic (digital step) dimming control eliminates flicker

- Leading-edge dimmers
- Trailing-edge dimmers



chopping control waveform



- Multi-Chopping mode for dimmer means better compatibility
- Prevents multi-firing of TRIAC dimmer and eliminates flicker

Other solutions cause TRIAC multi-firing, which causes flicker

Support multi-lamp parallel mode

- Parallel operation mode at end-user, No-flicker
- Reliability for parallel operation mode, No-damaged

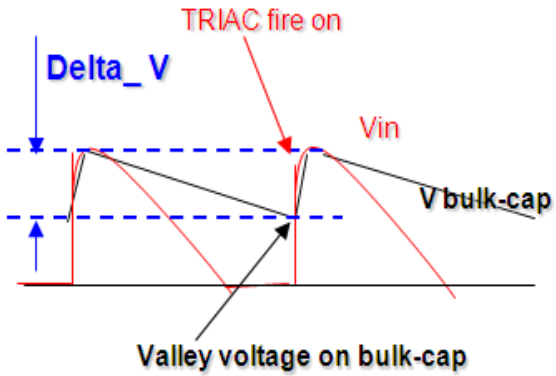
Repeatable peak current ???

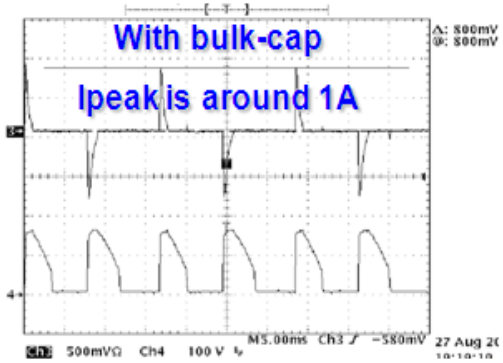
P__ dimmer x K > P_ lamp x N / PF (K=0.5~0.7)

- Better dimming performance, same dimming level for each lamp

Each lamp can get accurate phase-cut duty

Each lamp can get better CC tolerance at 100% output

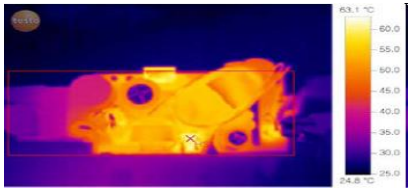




Over temperature protection

- **OTP is an important function for LED Lighting**

E17, small size for 7W power



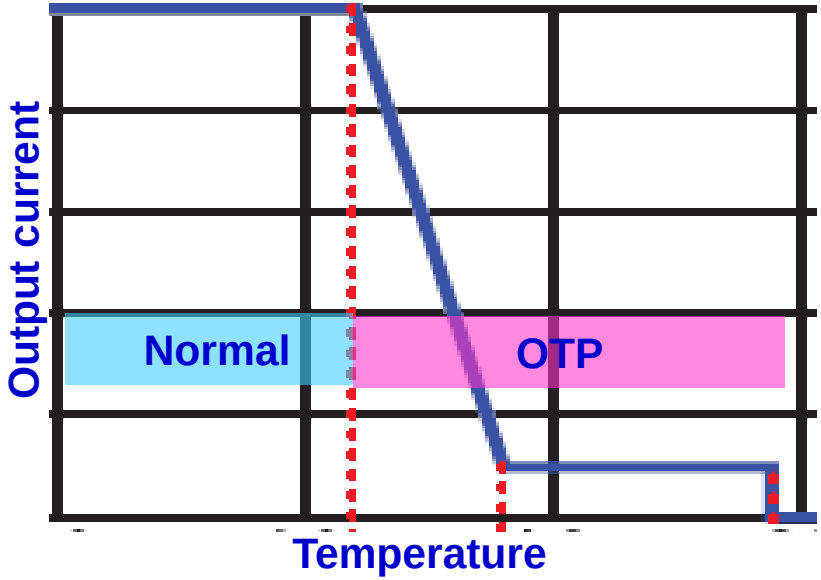
Lighting fixture and can

- **Cut-off OTP (Integrated by IC)---**Not good enough

Shut down suddenly

Non-adjustable OTP

- **Programmable OTP Curve**



iW3612/3614 programmed OTP function

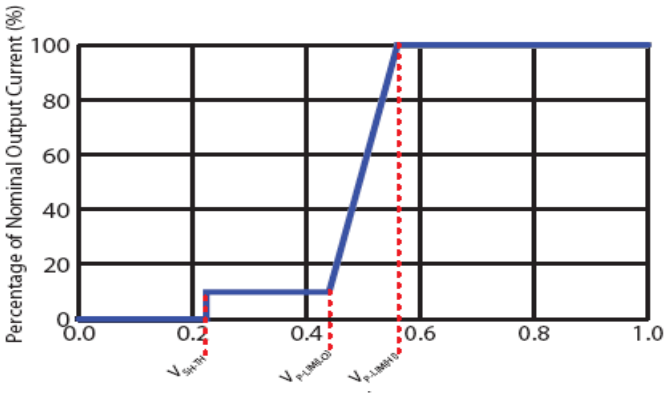
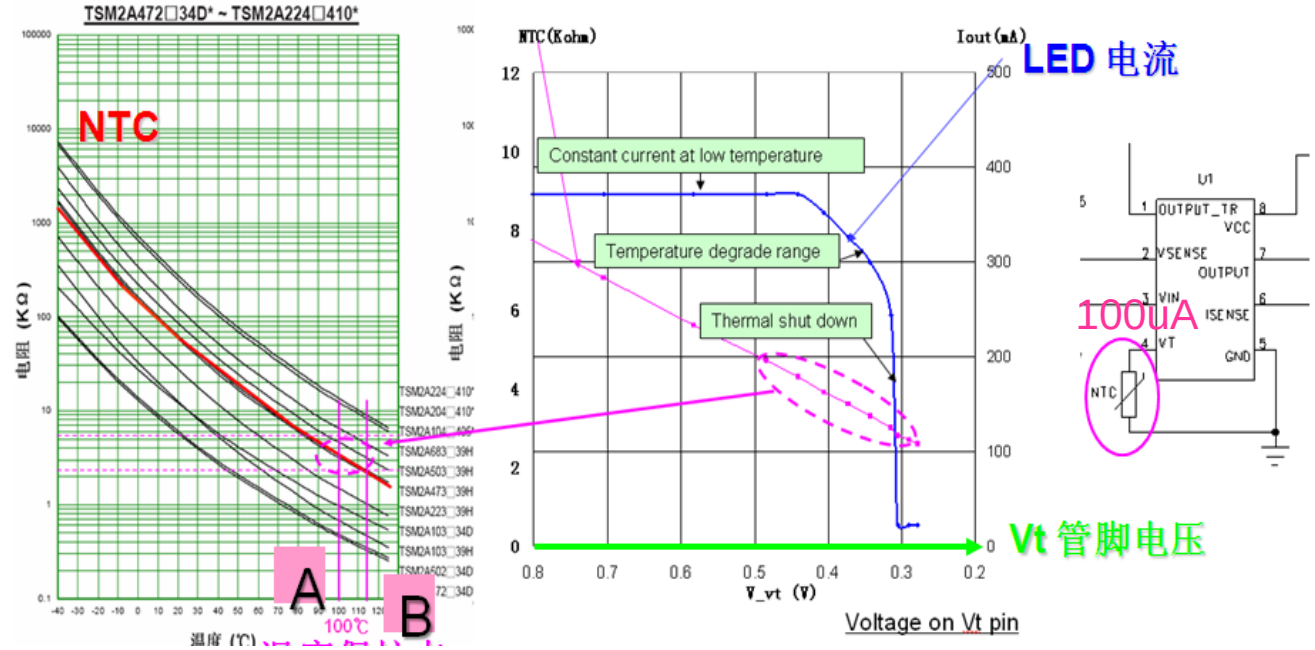


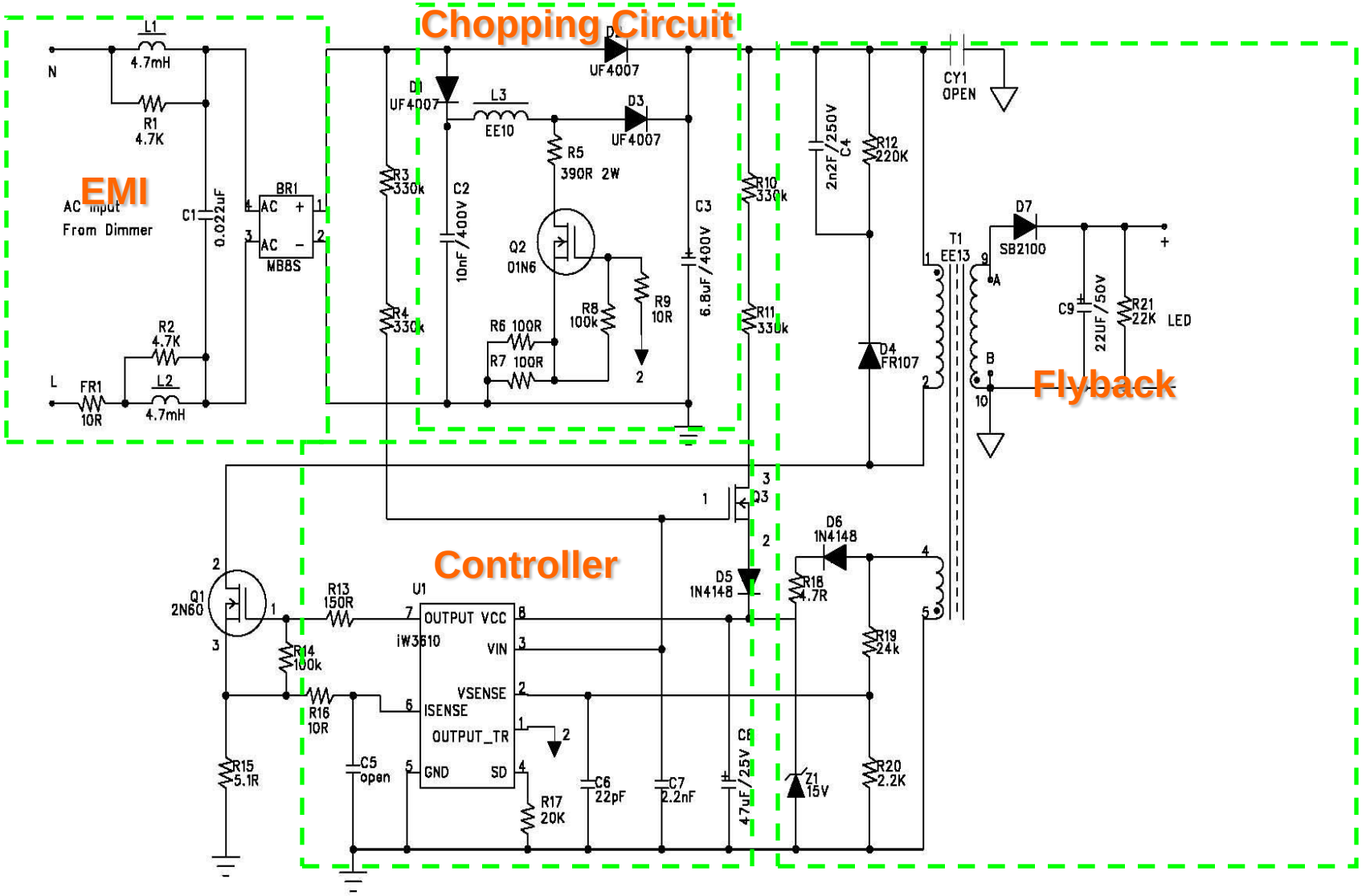
Figure 9.12 : V_T Pin Voltage vs. % of Nominal Output Current for Options -00 and -01

	iW3612/3614/3602
Power limit start (V)	0.56
Power limit min (V)	0.44
Power limit range	100% - 10%-1%
Over-Temperature Shutdown (V)	0.22

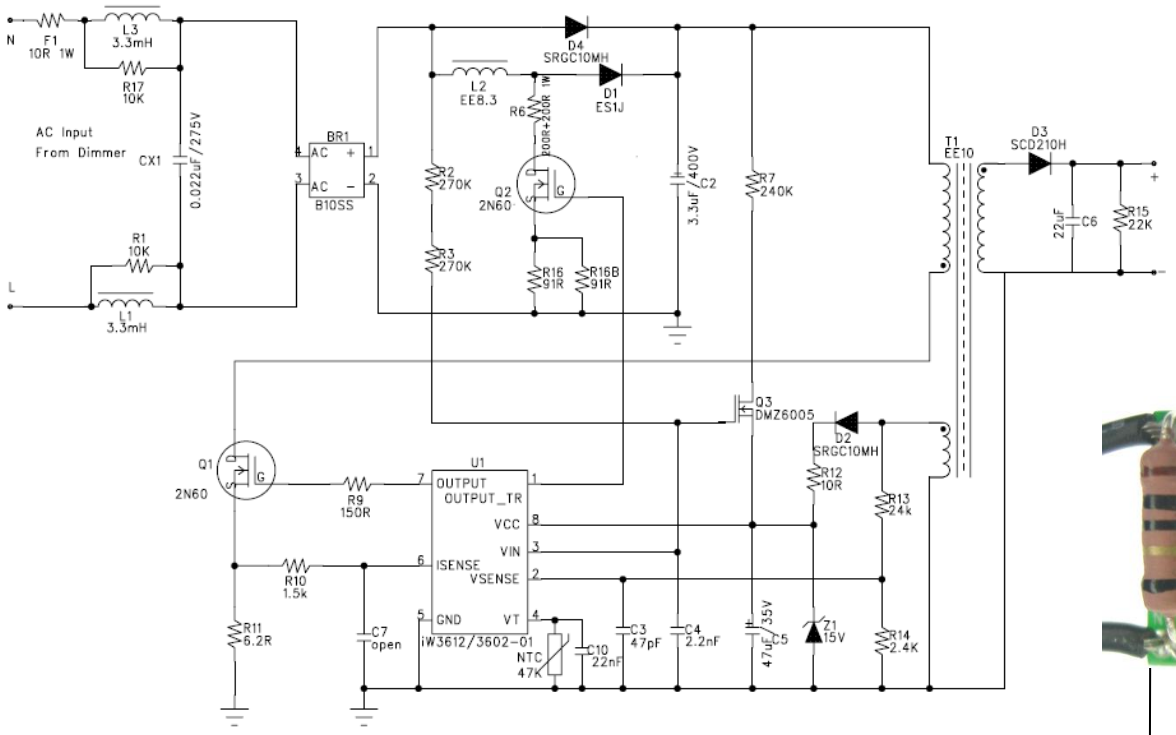


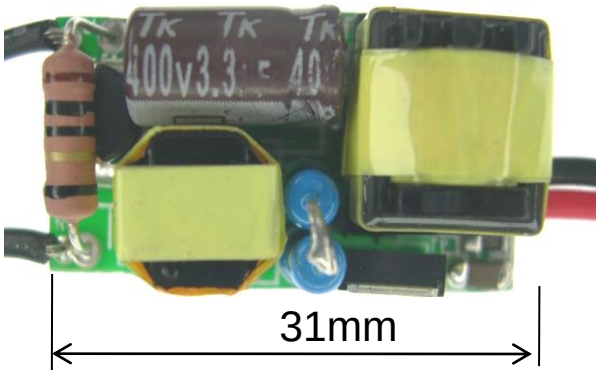
- If temperature reach the first threshold point, LED current will be decreased as linear curve, power consumer will be decreased too
- If temperature continues going up to another threshold point , output current will reduce to 10％
- Choose NTC to set the OTP point

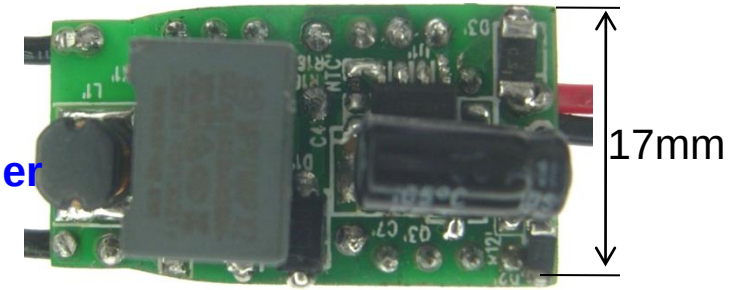
Full Schematic 3602 3612 3614



Small size dimmable design for GU10 3W-4W



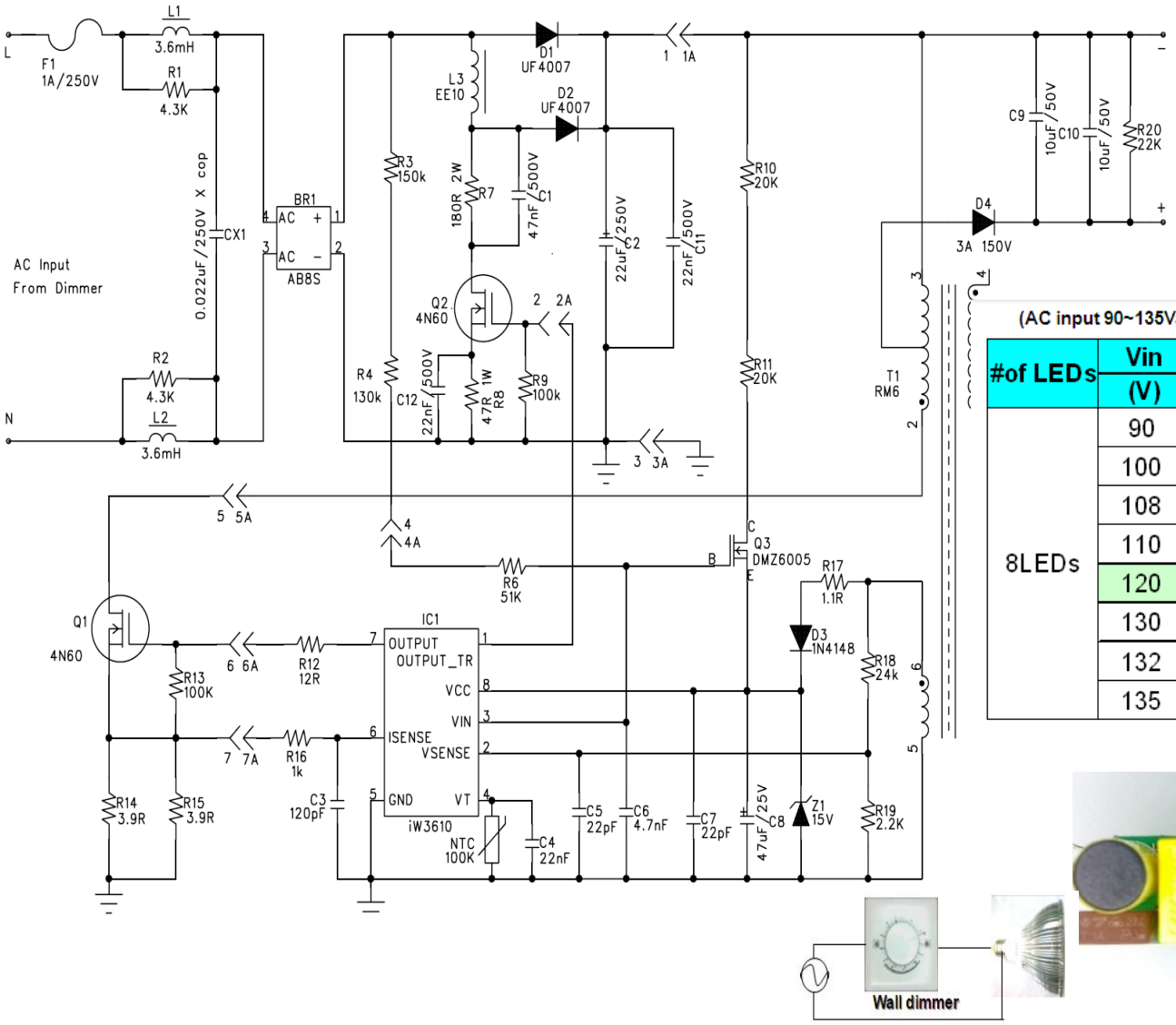


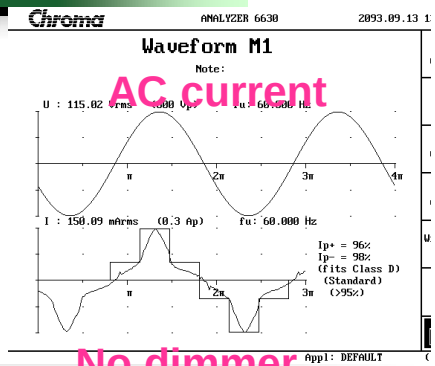


- **Power factor >0.7**
- **Low ripple current <30%**
- **Dimmable with Leading and trailing edge dimmer**
- **Small size for GU10 and candle**

High efficiency & Non-isolated_3W-20W Buck boost

iWatt
Intelligent AC-DC and LED Power™



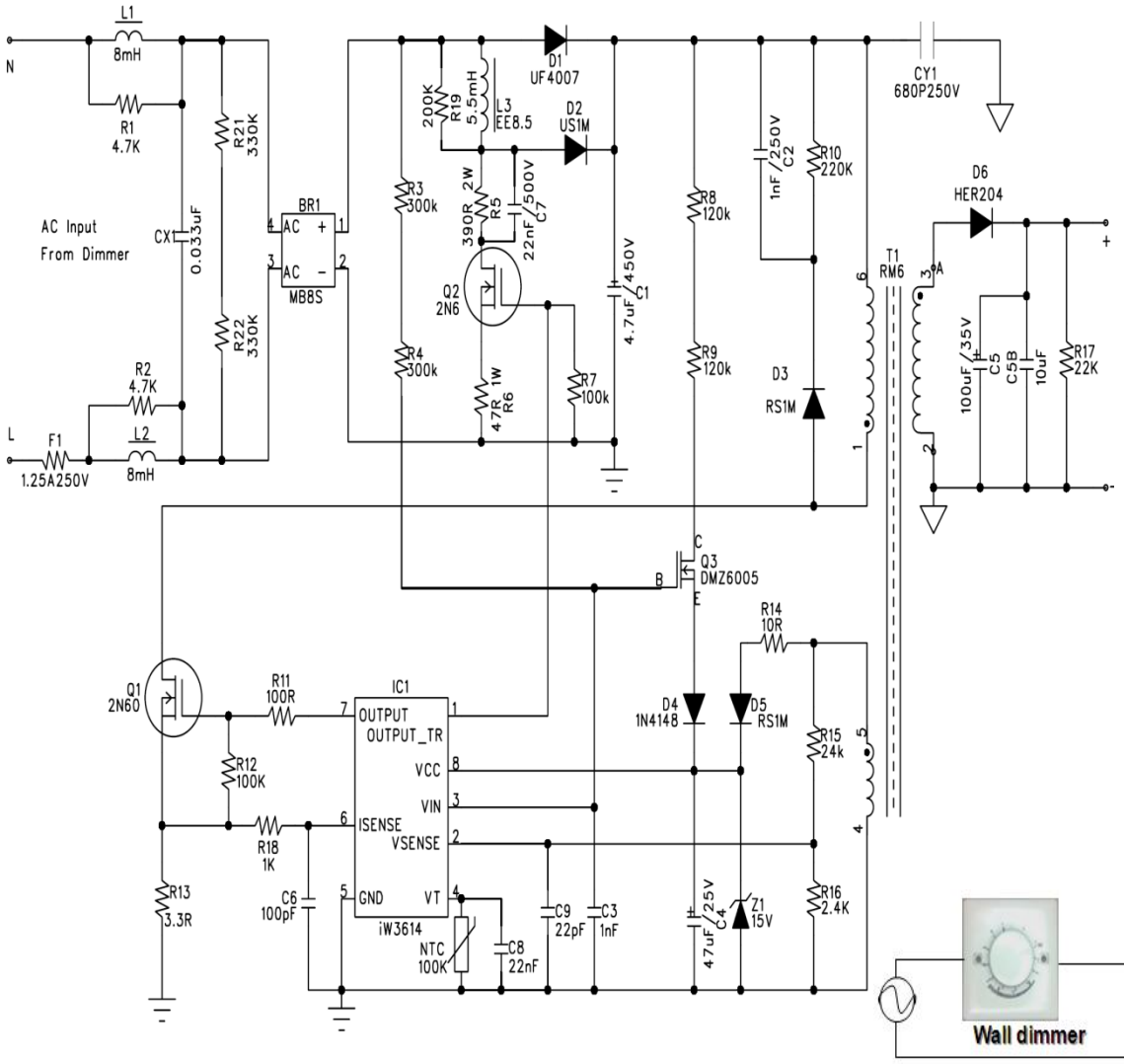


(AC input 90~135Vac,Output 8 LEDs)

#of LEDs	Vin (V)	Pin (W)	Vout (V)	Iout (A)	efficiency	PF
8LEDs	90	17.76	27.50	0.507	78.51%	0.916
	100	17.04	27.43	0.503	80.97%	0.928
	108	16.50	27.29	0.503	83.19%	0.931
	110	16.43	27.37	0.500	83.29%	0.932
	120	15.93	27.30	0.496	85.00%	0.924
	130	15.70	27.36	0.496	86.44%	0.903
	132	15.66	27.36	0.496	86.66%	0.903
	135	15.53	27.31	0.495	87.05%	0.889

A60 Bulb light demo design _10W

iWatt
Intelligent AC-DC and LED Power™



No dimmer

#of LEDs	Vin (V)	Pin (W)	Vout (V)	Iout (A)	efficiency	PF
7LEDs	180	10.55	23.87	0.362	81.90%	0.980
	190	10.40	23.78	0.361	82.54%	0.987
	200	10.36	23.7	0.361	82.58%	0.987
	210	10.31	23.66	0.361	82.84%	0.986
	220	10.29	23.61	0.361	82.83%	0.983
	230	10.31	23.58	0.360	82.34%	0.979
	240	10.30	23.57	0.361	82.61%	0.974
	250	10.25	23.51	0.361	82.80%	0.966
	260	10.24	23.48	0.360	82.55%	0.955
	264	10.23	23.45	0.360	82.52%	0.949