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Enabling Green Power By Design

LED Lighting Market Shines Semiconductor Industry



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We are all together

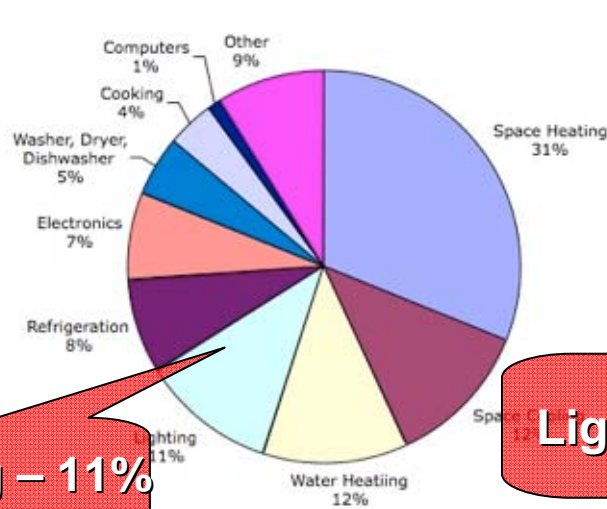
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- Save Energy
- Save Money
- Cut Co2
- ECO-friendly



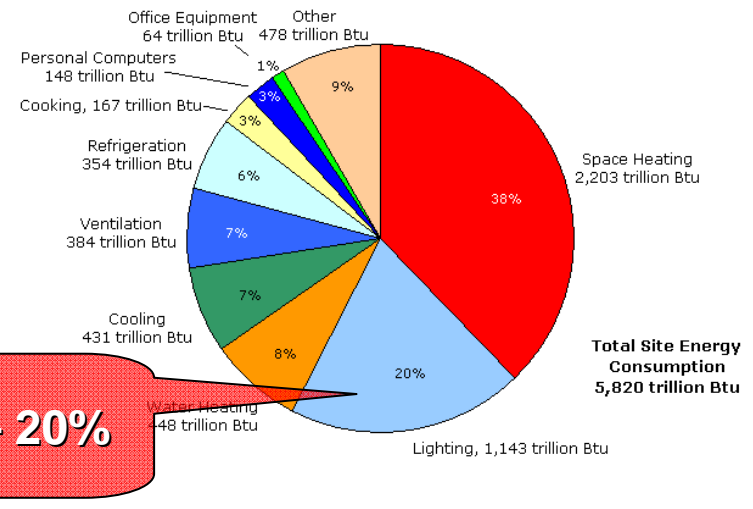
Energy Efficiency and US

- Lighting is a significant consumer of energy



Lighting – 11%

Residential Energy: 11% in Lighting



Lighting – 20%

Commercial Energy: 20% in Lighting

Source: National Academy of Science (2006)

Source: <http://www.eia.doe.gov/emeu/cbecs/cbecs2003/lighting/lighting1.html>

Energy-efficiency Regulations

- Global tighter energy-efficiency standards and regulations
- Wide range of government programs encourages the new technology to increase the energy-efficiency



http://www.eia.doe.gov/emeu/efficiency/appliance_standards.html

Effects of Mercury on the Environment



One teaspoon of *mercury* can contaminate a 20 acre lake *forever!*



Each year, an estimated 600 million fluorescent lamps are disposed of in U.S. landfills amounting to 30,000 pounds of mercury waste.*



The mercury from one fluorescent bulb can pollute 6,000 gallons of water beyond safe drinking levels.*



* www.lightbulbrecycling.com

Why LED Lamps?

	Incandescent Bulb	LED Lamp	Pros (+) / Cons (-)	Comments
Light Output	15 lm/W 60W bulb = 900 lumens	75 lm/W 12W = 900 lumens	5X (+)	Consumes 1/5th the energy used by incandescent bulb 12W LED lamp replaces a 60W incandescent bulb
Life Time	1,000 hours	≥ 25,000 hours	25X (+)	Incandescent bulb lasts ~6 months at 6hrs/day usage LED lamp can last ~12 years at 6hrs/day usage
Cost	\$0.25	\$30	120X (-)	
Payback Period*	-	2 years		

*Based on bulb use of 6 hours per day and utility rate of \$0.15/kWh; residential use

LED Operating Cost / Yr \$3.94
LED - 2 Yr Cost of ownership \$37.88

Incandescent bulb Op Cost / Yr \$19.71
Incandescent-2yr Cost of ownership \$39.92

- **LED bulb consumes five times less power than incandescent bulb**
- **LED bulb lasts ten to twenty times longer than incandescent bulb**
- **LED bulb cost may drop to US\$10 to US\$20 in 2011 versus current cost of US\$30**
- **Advanced control and remote monitoring/communication**
- **WW Legislative bans will phase out incandescent bulbs by 2012**



Incandescent Bulb

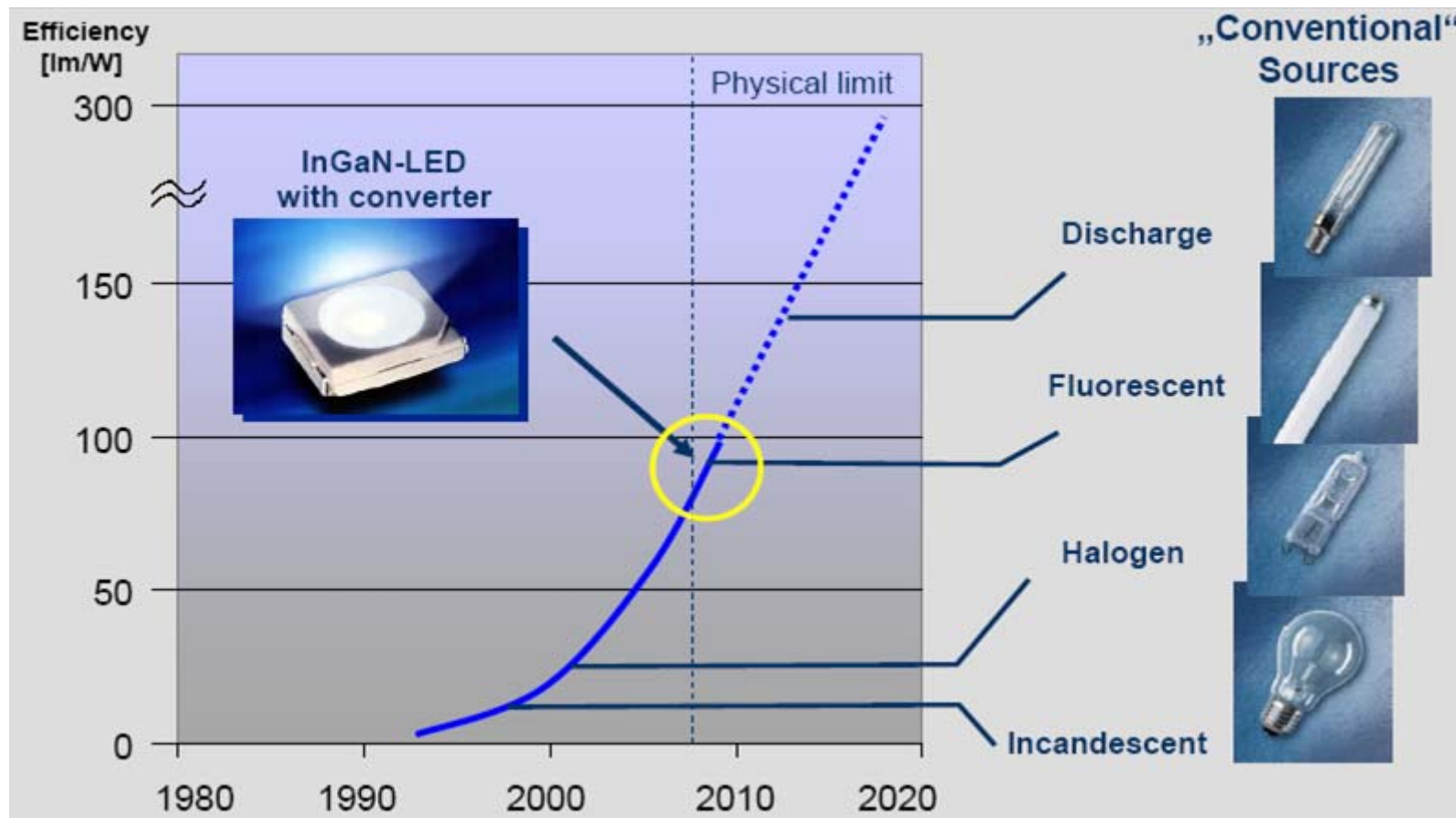


LED Lamp With LED Driver Electronics

Source : Energy Star, CANACCORD Adams, iWatt Internal

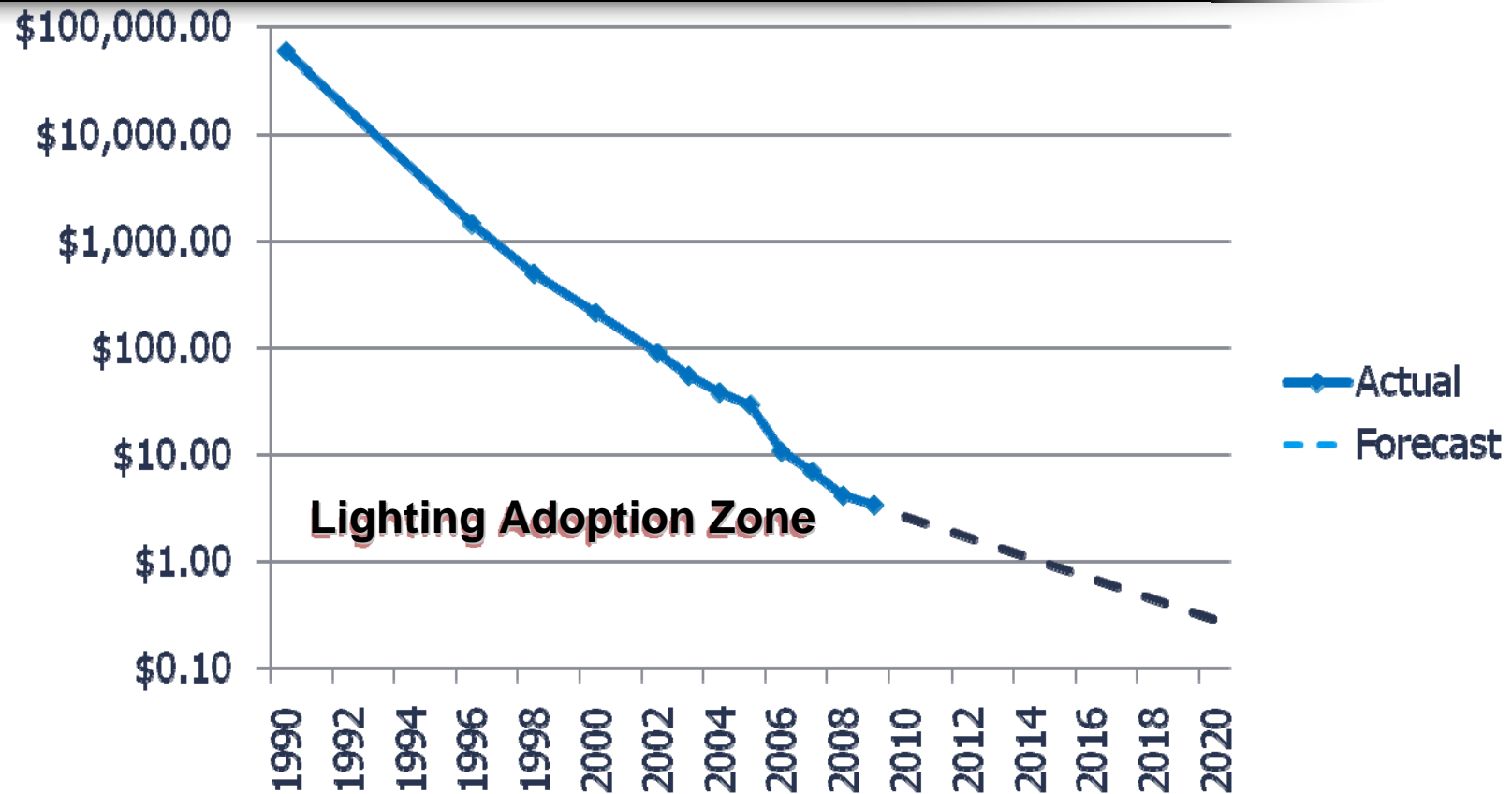
LED Lighting: More energy-efficiency and earth-friendly

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Source: OSRAM

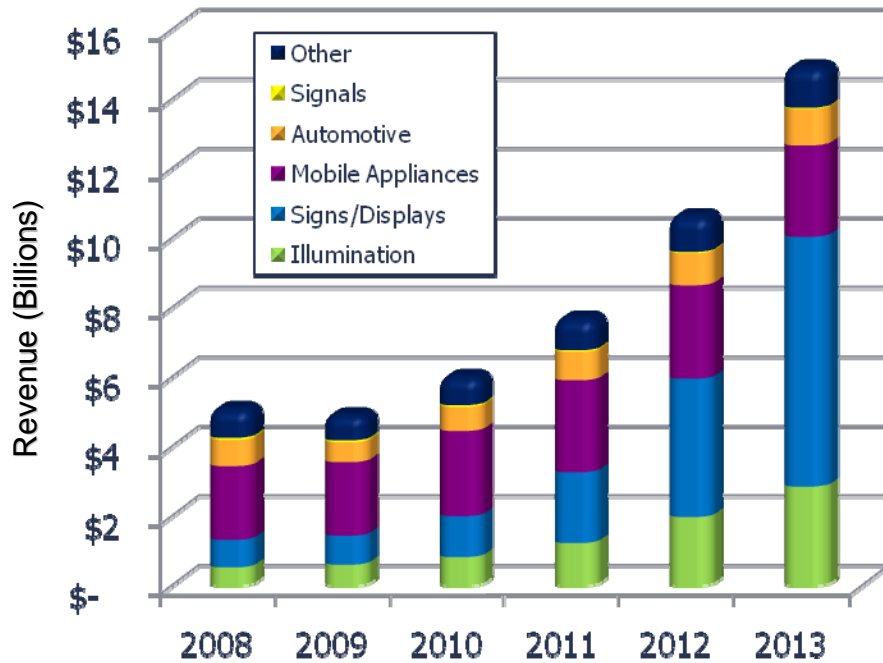
LED Cost per Thousand Lumens (k-lumen)



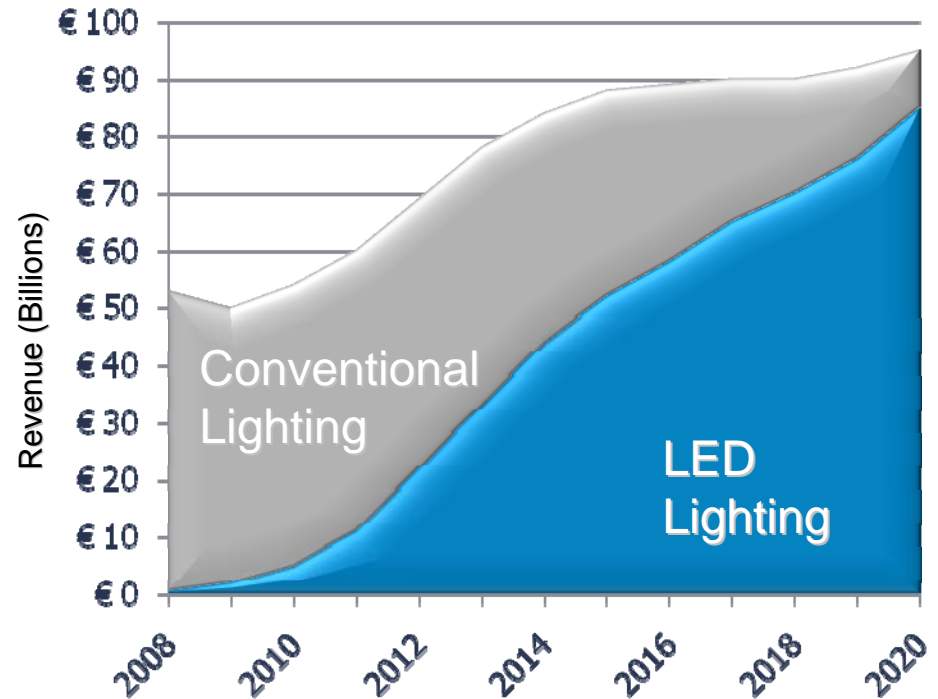
Different lighting applications turn on at different LED cost/lumen points

The Market Outlook

HB LED Market*



General Illumination Market**

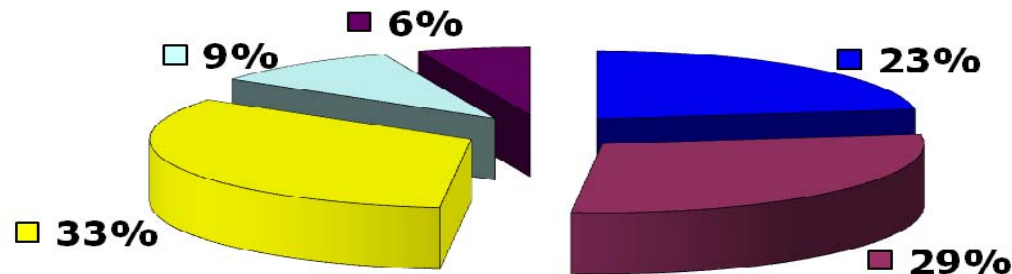


**LED market growth is being driven by two major trends:
 Notebook & TV Backlighting (short cycle)
 General Lighting (long cycle)**

* Strategies Unlimited 2008 / **Philips Lighting 2009

>\$100B WW Lighting Market

Geographically Distributed



■ AMERICAS ■ EMEA ■ ASIA ■ JAPAN ■ ROW

25 billion incandescent sockets in the world

- Broad Customer Base - very fragmented with the top 10 Lighting Luminaire Companies totaling ~22% of the total Market Share.
- Geographically balanced – though Asia dominates the consumer market.

LED Lighting Leaders Vary Widely

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Electronic Company = Lighting Company ?

Additional LED Lighting Leaders

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VARs
VARs



Korea Leaders



LED Makers



SHARP®

Panasonic
ideas for life

TOSHIBA

Japan Leaders



Technology Trends

Complete Solution for Reliable Street Light Lamp

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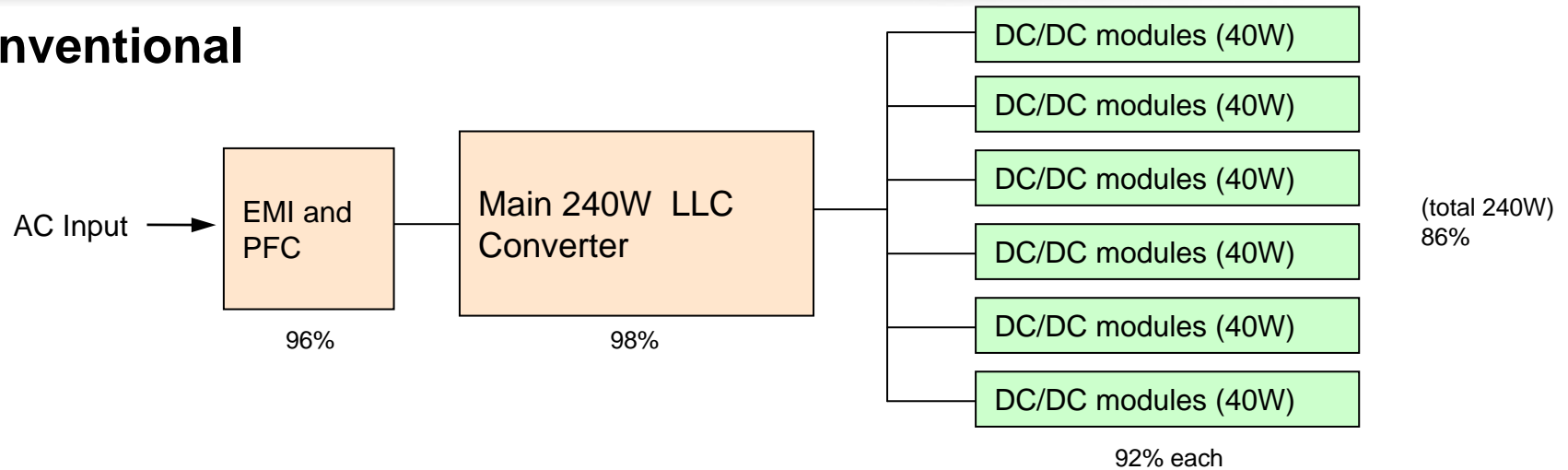
- ❑ **Weatherproof Design and Quality**
 - ✓ Wide Ambient Temperature Range -40°C to 55°C
- ❑ **High Reliable**
 - ✓ 50,000 hours life time
 - ✓ No electrolyte capacitor
 - ✓ Less inrush current
 - ✓ Immunity to lighting surge
- ❑ **Save more energy with high efficiency design**
 - ✓ High Power Factor 0.99
 - ✓ High Power Efficiency $>90\%$
- ❑ **Built-in intelligent digital communication**
 - ✓ Digital Dimming
- ❑ **Low-maintenance with modularization**
 - ✓ Modularization to replace each module
 - ✓ Built-in self-testing to expect life time
- ❑ **Low cost structure design**
 - ✓ Single-stage Power design, simple and reliable
 - ✓ LED modulation to easy for maintenance

Flexible Power Range 50W, 100W, 150W, 200W

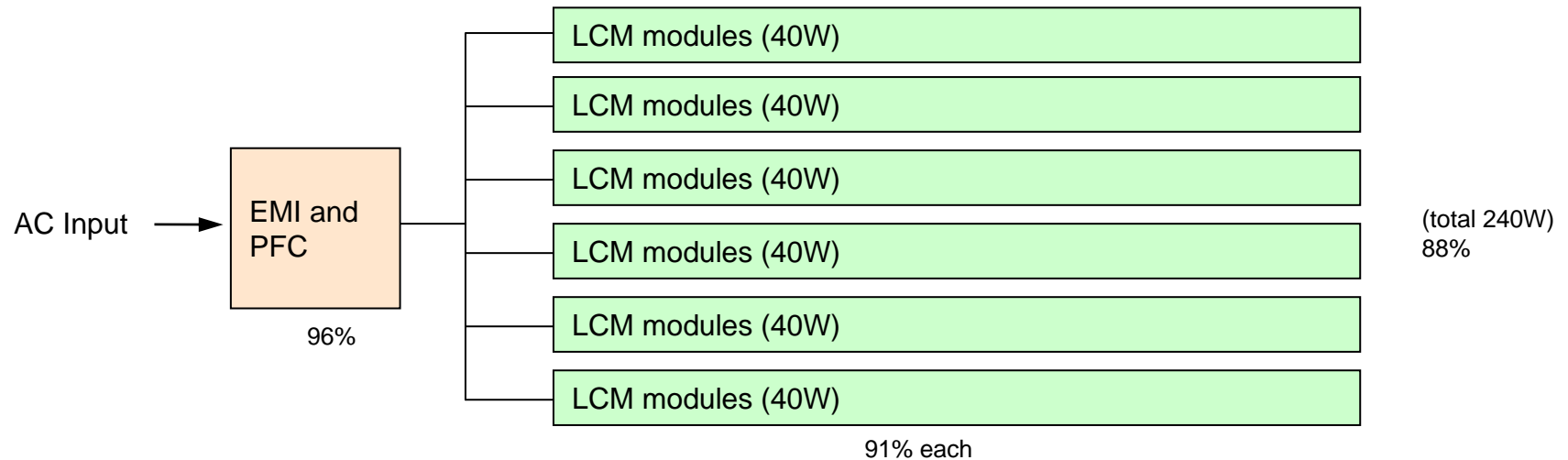


LCM solution

Conventional



LCM (LEDs Control Module) Solutions



Summary of Comparisons

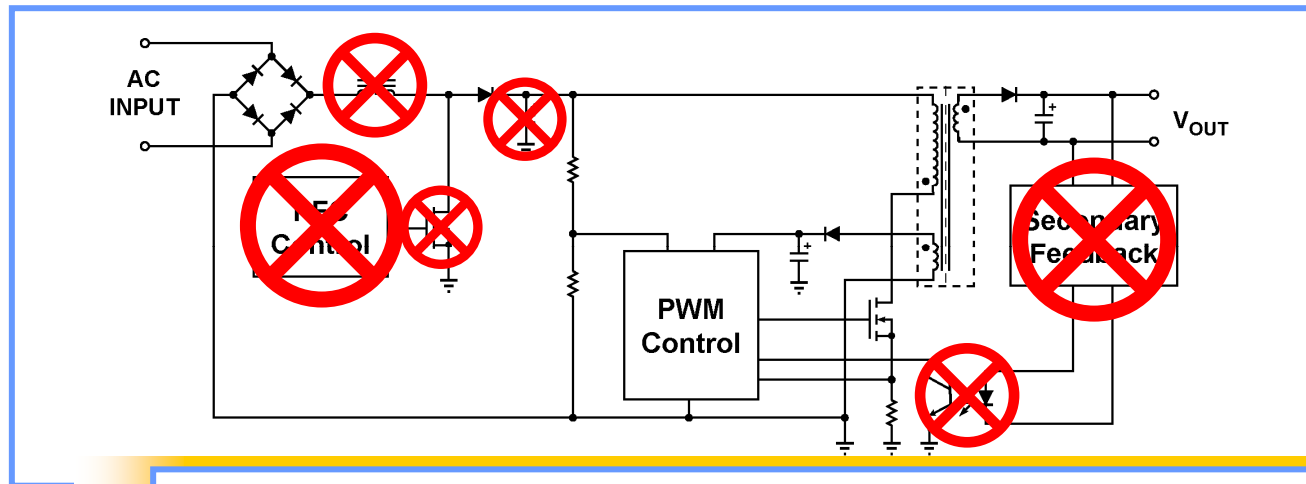
Item		Conventional PFC + 240W Isolated LLC Main + 6x DC/DC	LCM Solutions PFC + 6x 40W module (for isolation & CC)	Result
Cost (exclude PFC)		DC/DC module 40W (~UD2 each) 240W main isolated converter (USD4.0) Total cost UD2x6 + 4 or <u>16 (USD)</u>	40W isolated module (UD2.4 each). Main isolation = 0 Total cost UD2.4 x 6 or <u>14.4 USD</u>	Lower total BOM cost
Performances	Efficiency	(95%x98%x92%) or 86%	96%x91% or 88%	better efficiency
	Assembly	Main converter need to be scaled for different output level. (e.g. 80W, 120W, 180W, 200W, 240W, lot of variations.	Main converter is formed by each individual module and could be parallel connected to meet different power level.	more flexible
	Protections	Main converter 48V/6A will have high OCP is not adequate for protection against individual DC/DC modules. OVP & OTP need additional components added either main or DC/DC modules	Build in OTP, OCP, OVP in each channel without additional cost. OTP vs. NTC on SD pin OSP vs. Primary current limit OVP vs. Primary OVP loop on SD pin	Full system protections
Reliability (based on a 240W design)		Total number of converter : 8 A single 240W supply if failed could result complete lamp failure. (no redundancy)	Total number of converter : 7 Individual lamp driver failure rate is $1/\lambda$. The reliability factor improved by 6 times.	Higher reliability with redundancy

AC LED vs DC LED

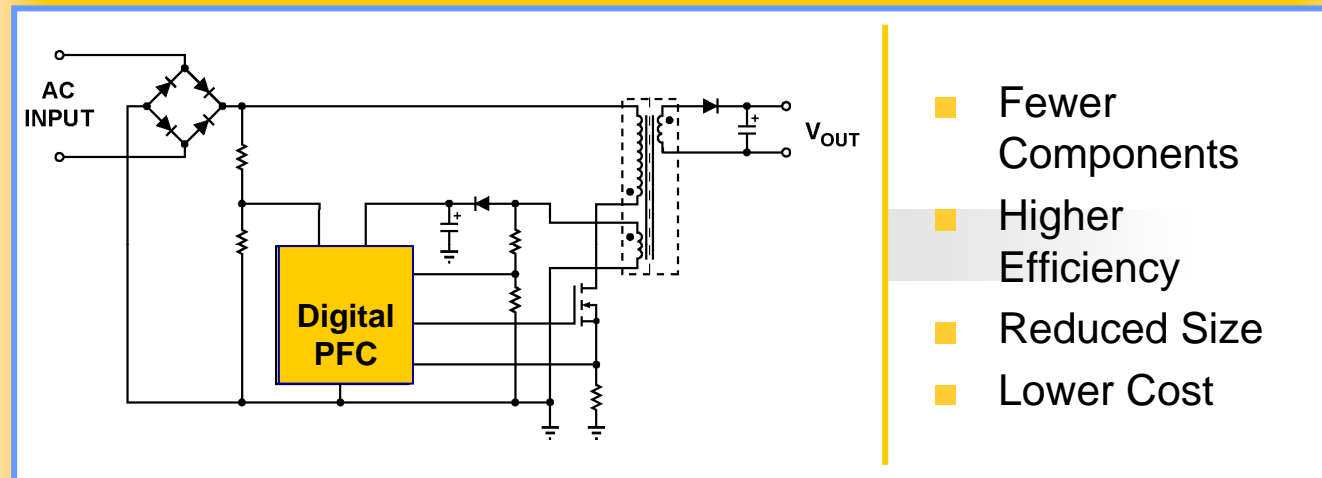
- AC-LED: promoted by Taiwan the Industrial Technology Research Institute (ITRI). It is initiated by Seoul semiconductor.
- AC-LED major benefits:
 - Operate on AC power without the need for a DC converter
 - Does not require power transformer, low cost, compact size and no electrostatic discharges
- AC-LED limitations
 - Lower luminous efficacy compared with DC-LED since AC-LED Chips works under high voltage lower-current (10mA)
 - Flicker, since AC-LED operates at the dynamic VI ranges. It will be hard to balance all the VI curve of LEDs chip
- AC-LED vs. DC-LED
 - AC-LED is best for low power spot light (more practically less than 3W), such as MR16, architectural lighting etc.
 - DC-LED is best suitable for high power general lighting; PAR20, PAR38, T8,T5 etc.

The Value of Digital Power Controller

Pure Analog



Digital Plus Advanced Analog



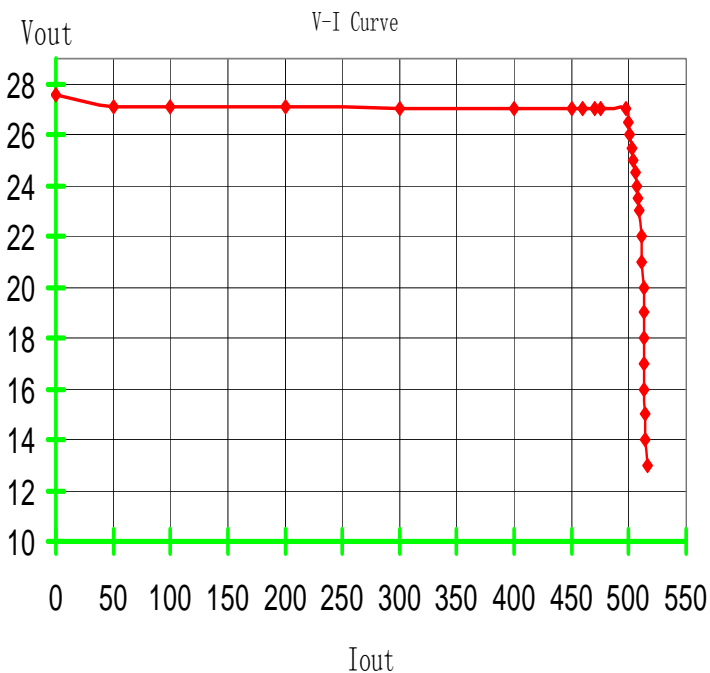
Tight LED Current Regulation Prevents Flicker With Noisy Line Voltage



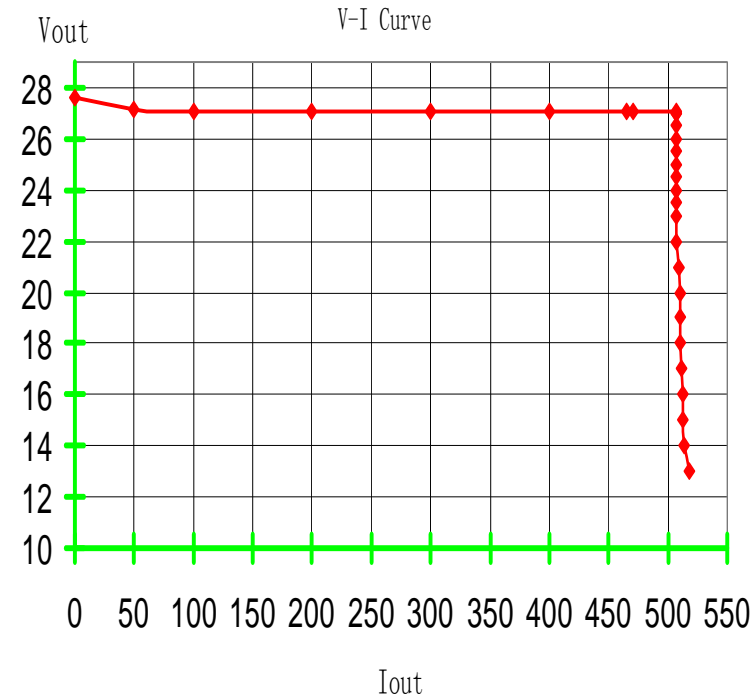
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$V_{IN}=90V_{AC}$, $T_{AMB}=25^{\circ}C$



$V_{IN}=130V_{AC}$, $T_{AMB}=25^{\circ}C$

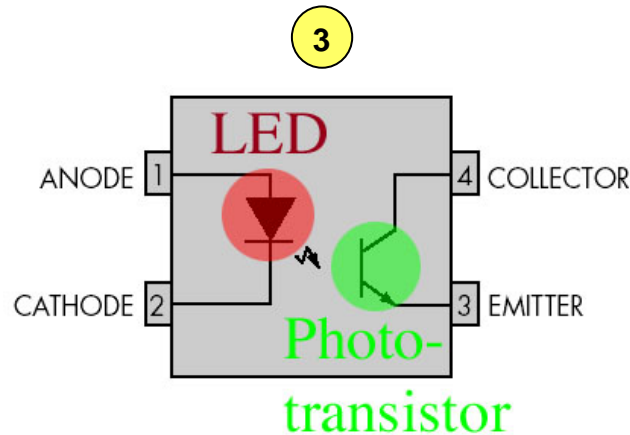


- Tight $\pm 5\%$ LED current regulation means constant brightness and no flicker during line sag or surge

Eliminating Opto-coupler Can Improve LED Driver Life Time



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TOSHIBA

TLP421

Recommended Operating Conditions

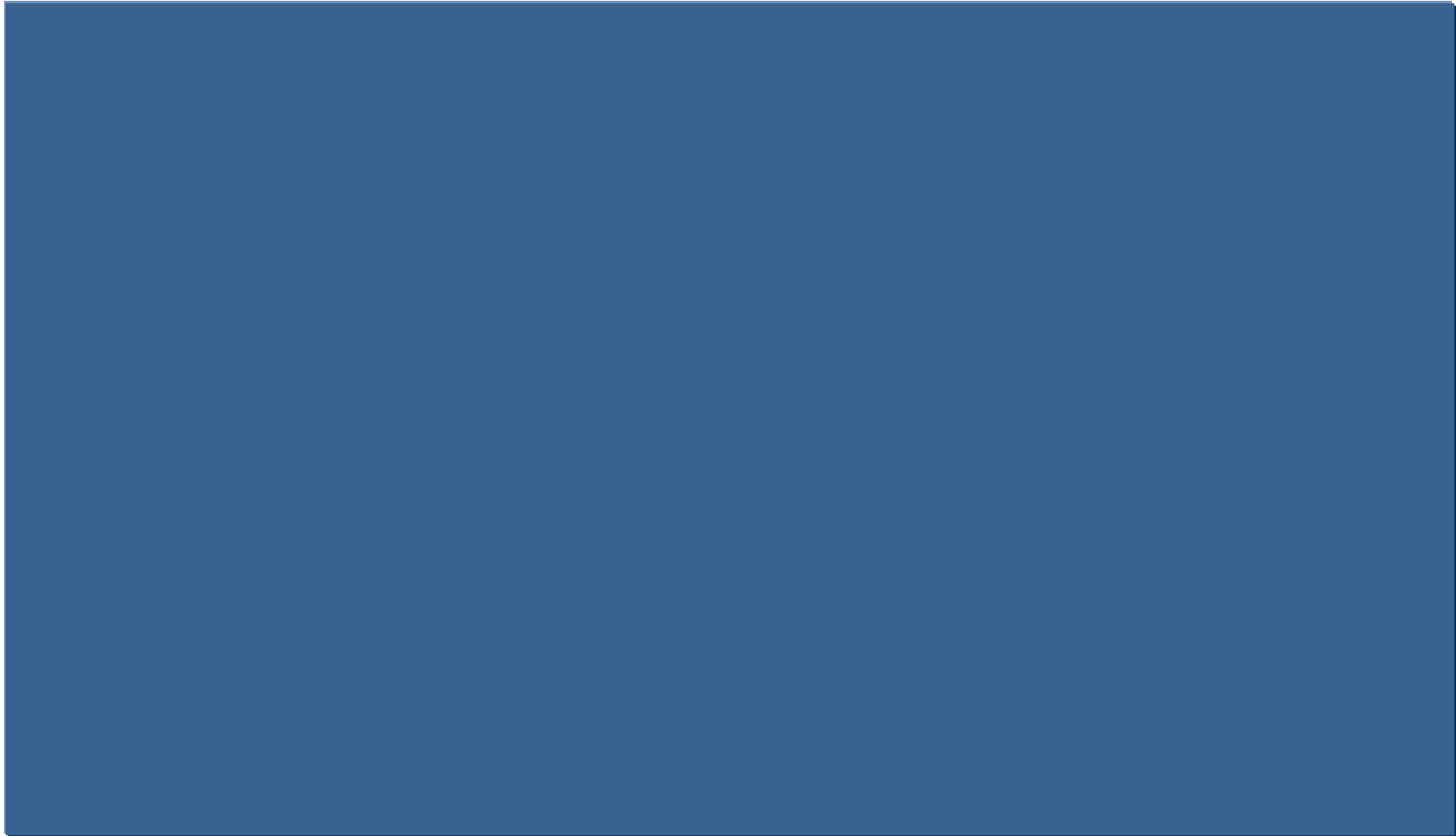
Characteristic	Symbol	Min	Typ.	Max	Unit
Supply voltage	V_{CC}	—	5	24	V
Forward current	I_F	—	16	25	mA
Collector current	I_C	—	1	10	mA
Operating temperature	T_{opr}	-25	—	85	°C

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.

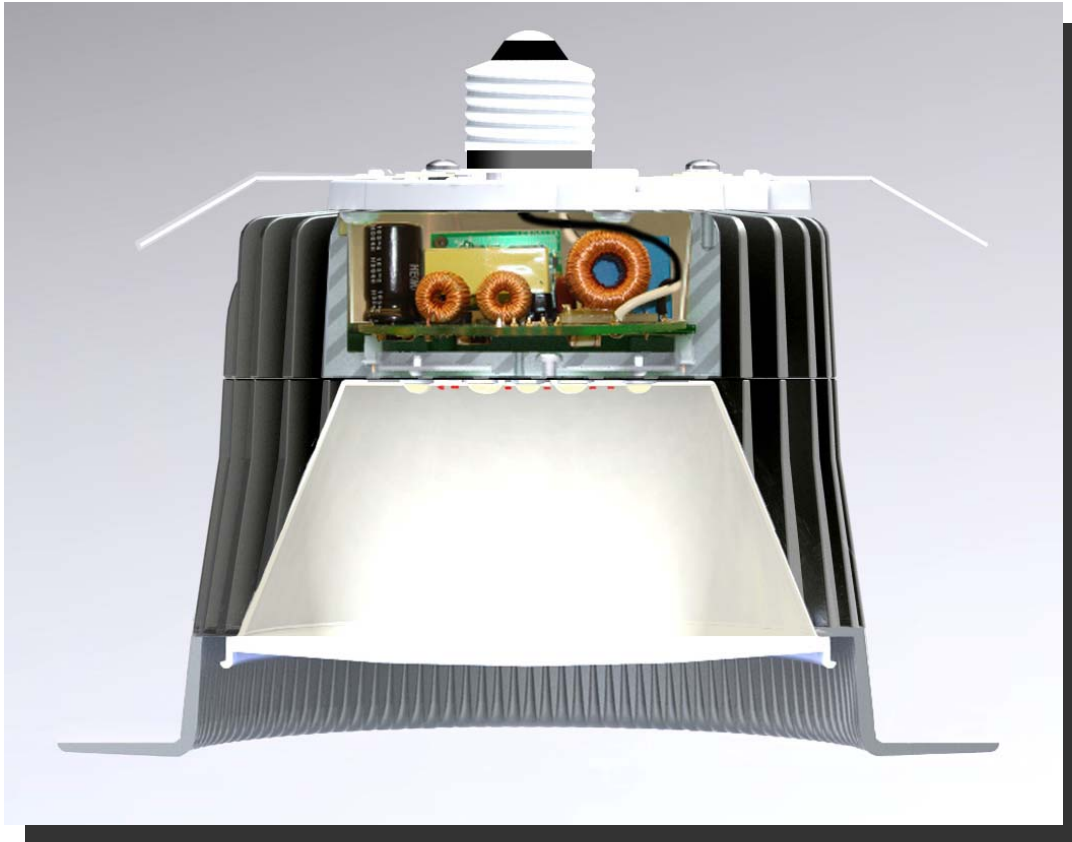
- Opto-coupler LED can degrade over time / high temperature, CTR (current transfer ratio) will change
- High current through LED can further degrade CTR
- Change in CTR can affect the stable operation of the power supply eventually leading to PS failure
- Most LED lighting customers are phasing out opto-couplers

Single Versus Two Stage PFC Controllers

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The Hidden Cost of LED Lighting



LED Fixture Costs

- LEDs 35%
 - Power Supply
 - Mechanicals
 - Drive Circuit
 - Optics
 - Labor & OHD
 - Using more efficient LEDs lowers thermal, optics and electronics total BOM cost
- 65%

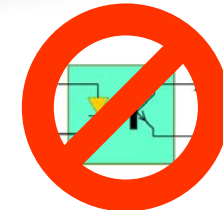
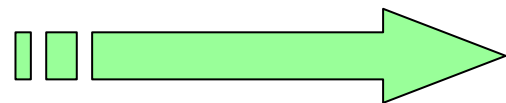
Non-LED costs are becoming more important to improving LED system cost/lumen

Market Needs For Next Generation LED Drivers

- High Power Factor (>0.9 mandated by Korea) and high efficiency dimmable LED drivers
- Seamless operation with all dimmers world wide
- Hot pluggable
- Multi-output drivers for color mixing
- Driving fewer series connected high current ($>1.5A$) HB LEDs will require secondary side synchronous rectification
- Eliminate electrolytic capacitor to increase lifetime
- Smallest size and fewest components
- Reduced BOM cost

LED Lighting AC/DC – Value Proposition

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No Opto-Coupler

High Quality LED Driver Solutions Must Ensure ...	iWatt LED Driver Solutions Provide ...
High Reliability	Open / Short LED protection SCP, OVP Current over shoot control, soft-start Current sense resistor protection
Meet ALL Safety, EMI And Regulatory Standards	Meets EN55015B, IEC61000-3-2 and other regulatory standards with extra margin for volume manufacturing High PFC designs
Long Life (High MTTF)	Primary side regulation eliminates opto-coupler. Increases lifetime due to no risk of opto-coupler failure or aging effect
Small Size	Reduced BOM count versus competitor solutions High switching frequency reduces size of magnetic components Smaller heat sink due to less thermal loss thanks to higher efficiency
High Performance	No visible or electronic flicker Constant brightness over line, load and temperature Fast start-up under 1sec Low power consumption in off mode Dimming control

Three New Dimmable LED Drivers Available Q4' 2010

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New!
ES
Q4'10

New!
ES
Q4'10

New!
ES
Q4'10



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- Save Energy
- Save Money
- Cut Co2
- ECO-friendly

21st Century Technology for 21st Century Needs