安森美半导体
ON Semiconductor®

LED通用照明应用

LEDs in General Lighting Applications

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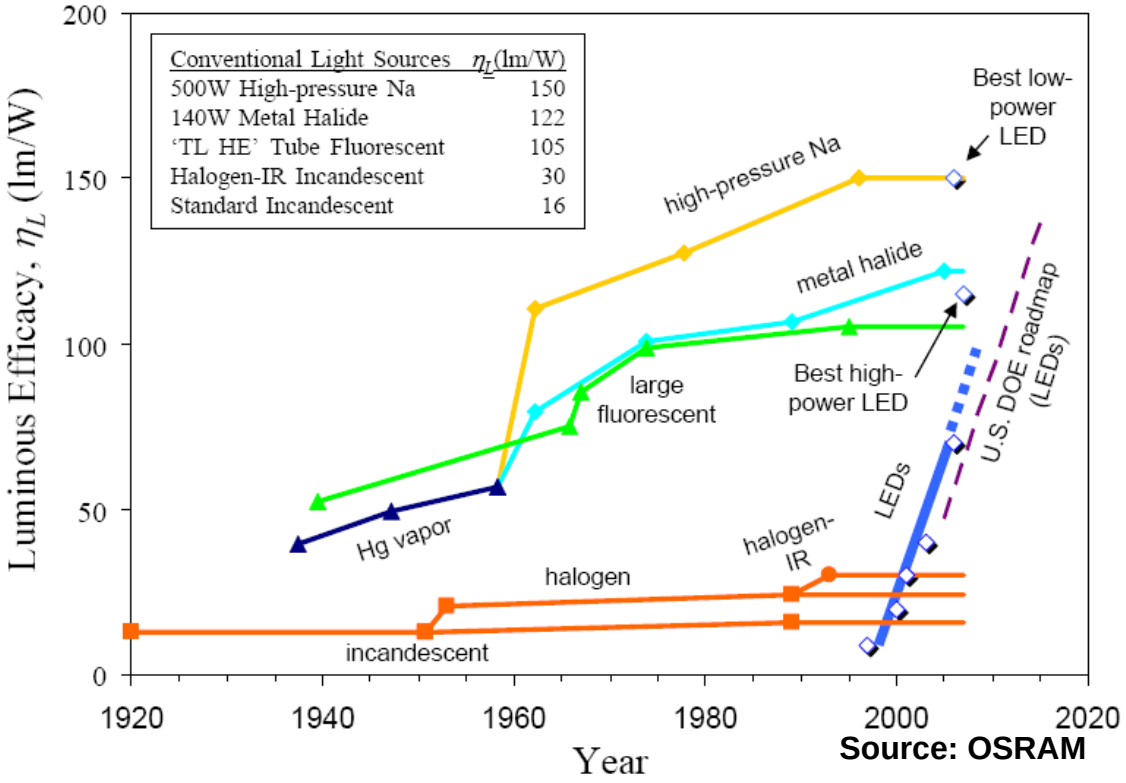
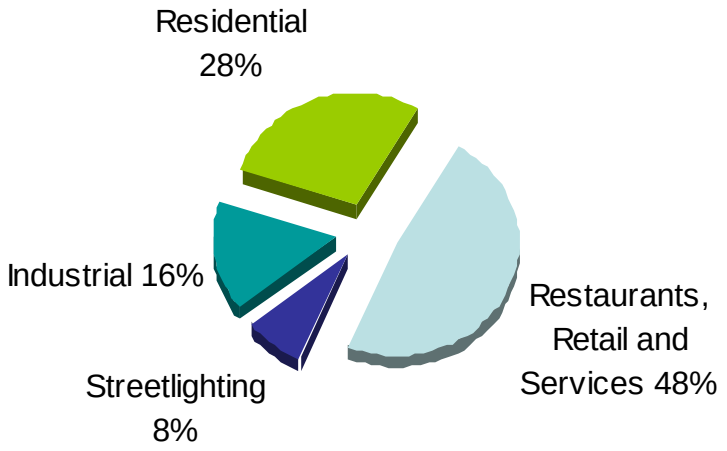
照明世界概览 World of Lighting

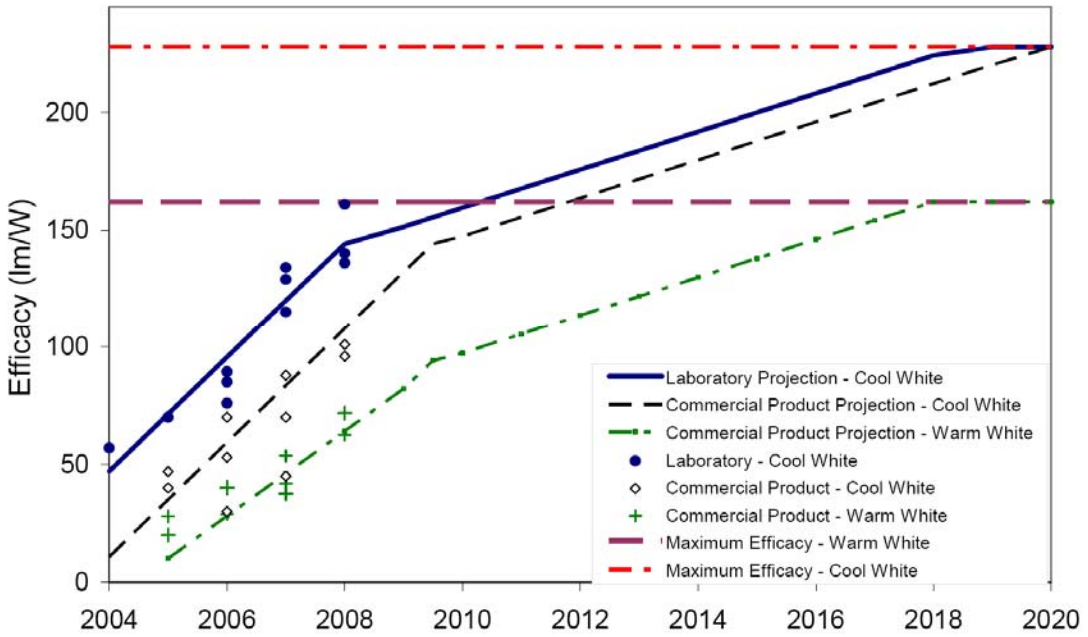
- 全世界约有20-22%的电能用于照明，其中40%是白炽灯照明，每年消耗的电能达2,000太瓦时(TWh)(等于20,000亿千瓦时) ~ 20-22% of electrical energy is used for lighting of which 40% is for incandescent lighting, this represents 2000 TWh/year





超过70%的电能用于住宅市场之外的领域
>70% of the Energy Usage is Outside of the Residential Market↑

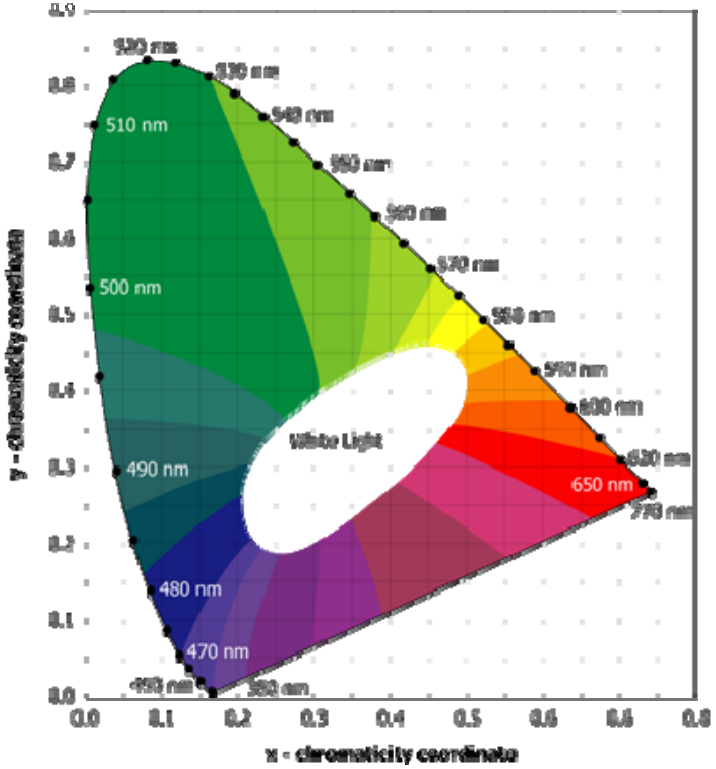
LED技术预测及影响
LED Technology Forecast and Impact



US DOE January 2009

LED光学特性
LED Optical Characteristics

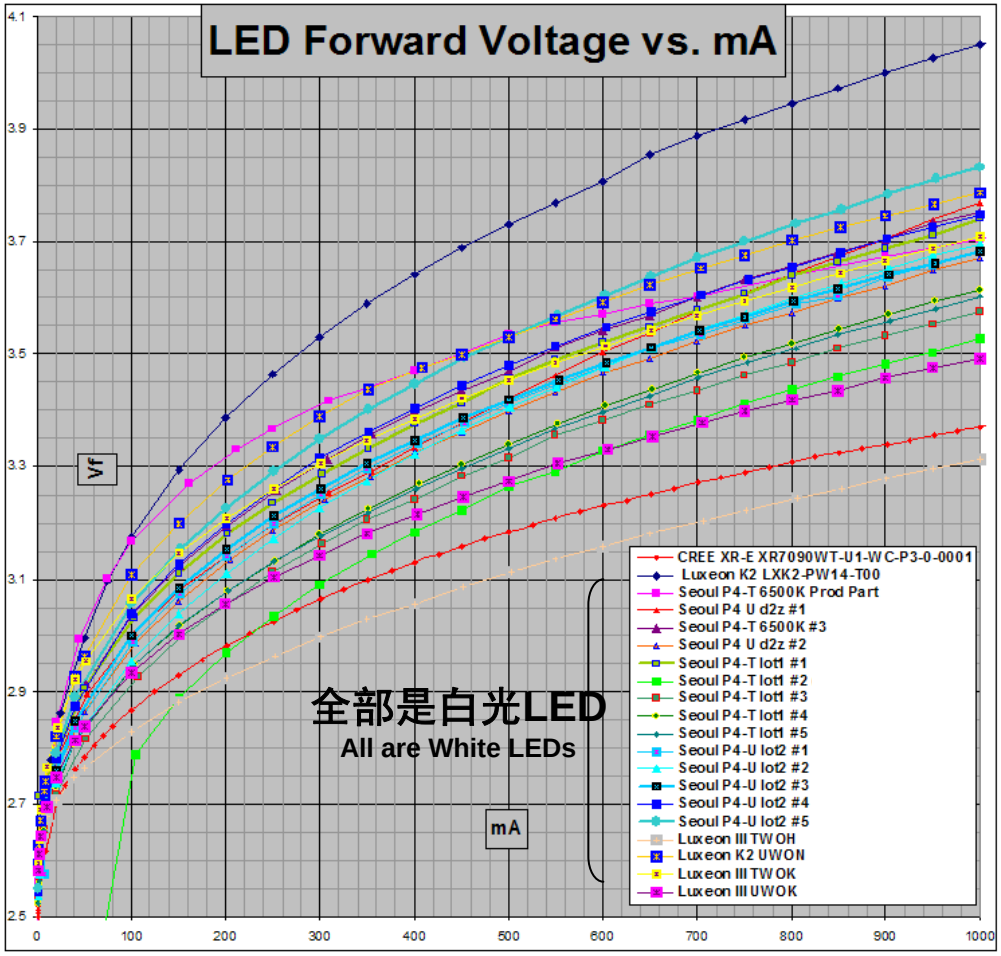
- 染色性 Chromaticity
  - 有些人定义为黑体曲线上或附近白色区域中的“框” Some defined “box” in the white area on or near the Black Body Locus
  - LED的Bin尺寸(x、y匹配)因供应商而异 Bin sizes (x, y coordinates) varies by supplier



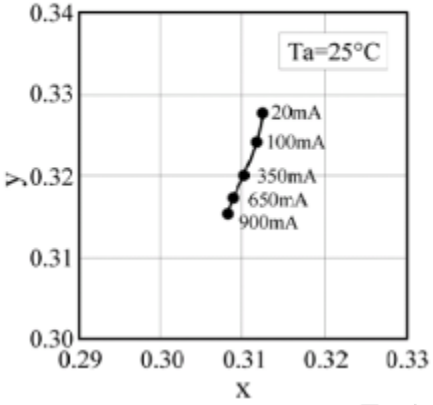
Group Code	Min. Luminous Flux @ 350 mA (lm)	Max. Luminous Flux @ 350 mA (lm)
M2	39.8	45.7
M3	45.7	51.7
N2	51.7	56.8
N3	56.8	62.0
N4	62.0	67.2
P2	67.2	73.9
P3	73.9	80.6
P4	80.6	87.4
Q2	87.4	93.9

- 亮度(光通量) Brightness (luminous flux)
  - –所有“光”输出至一个球面 All the “light” output into a sphere
  - –要考虑到人眼对不同波长光的敏感度问题 Factors in human sensitivity to light of different wavelengths

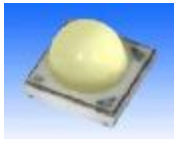
LED驱动的挑战 Challenges of Driving LEDs



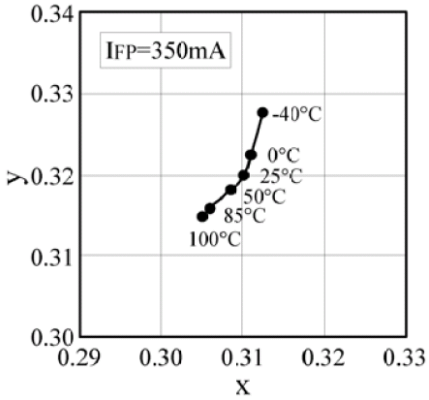
■ Forward Current vs. Chromaticity Coordinate



■ Ambient Temperature vs. Chromaticity Coordinate



Nichia Rigel NJSW036AT

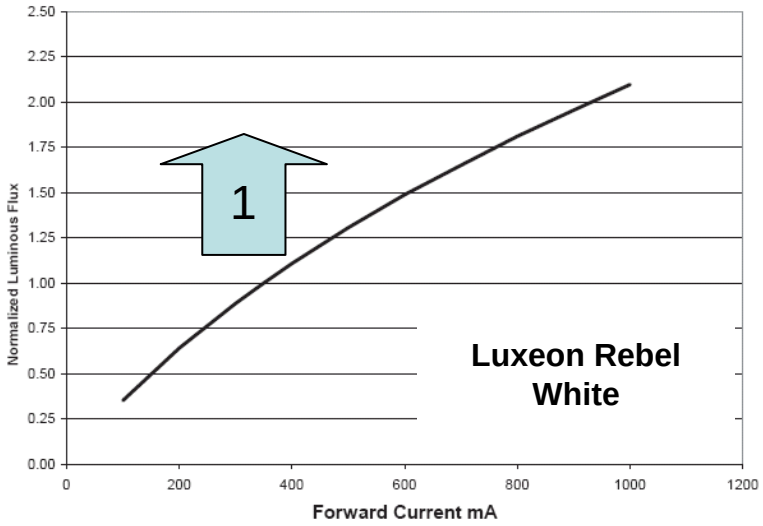


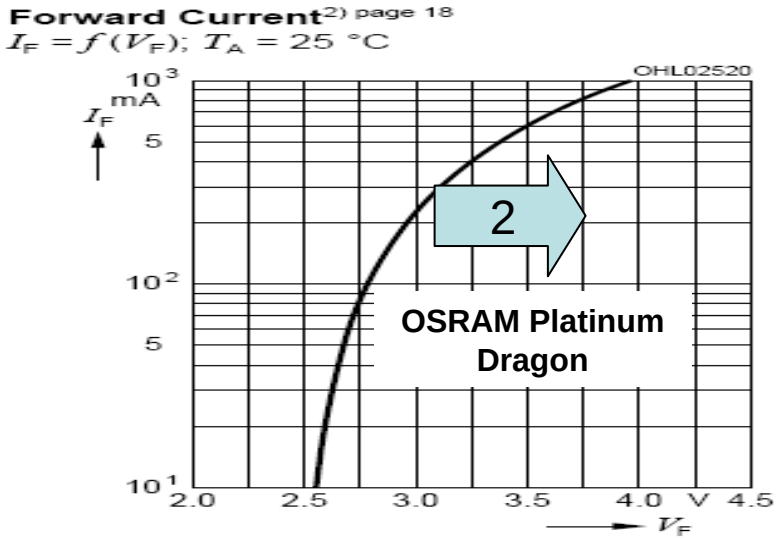
– 正向电压因颜色、电流及温度而异 Forward voltage varies by color, current & temperature

– “色点”随着电流及温度而改变，其中红色及琥珀色LED的表现更明显 “Color point” shifts with current and temperature, more pronounced with Red and Amber

操作参数的关系 Operating Relationship

电气、光学及热学 Electrical, Optical & Thermal

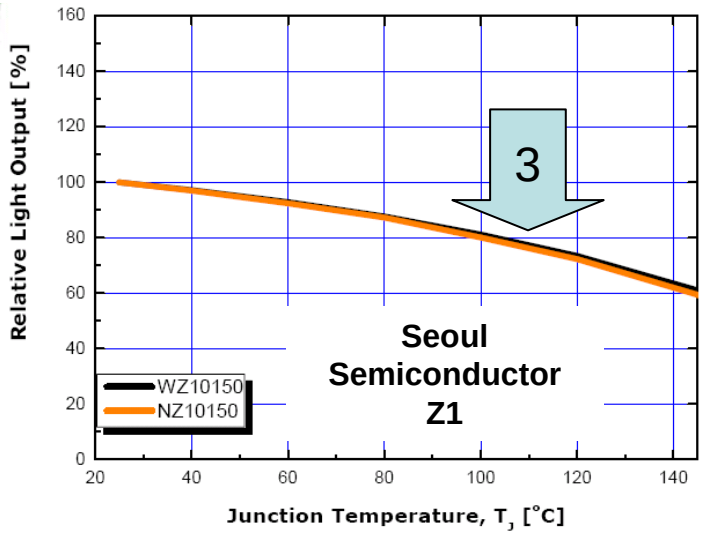




3) 功率越大则结温度升高，从而降低光通量(光输出)
Higher power raises Tj, reduces flux (light out)

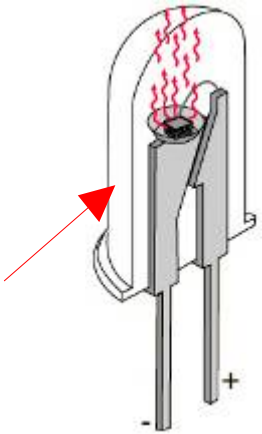
1) 驱动电流增加，光通量也增加
Increasing drive current, increases flux

2) 电流越大，正向电压及功率也越大
Higher current, increases Vf & power



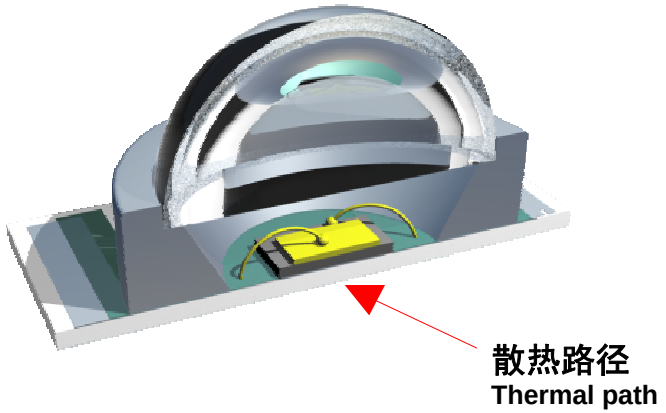
散热路径对LED寿命至关重要
Thermal Path is Critical to LED Lifetime

5 mm LED



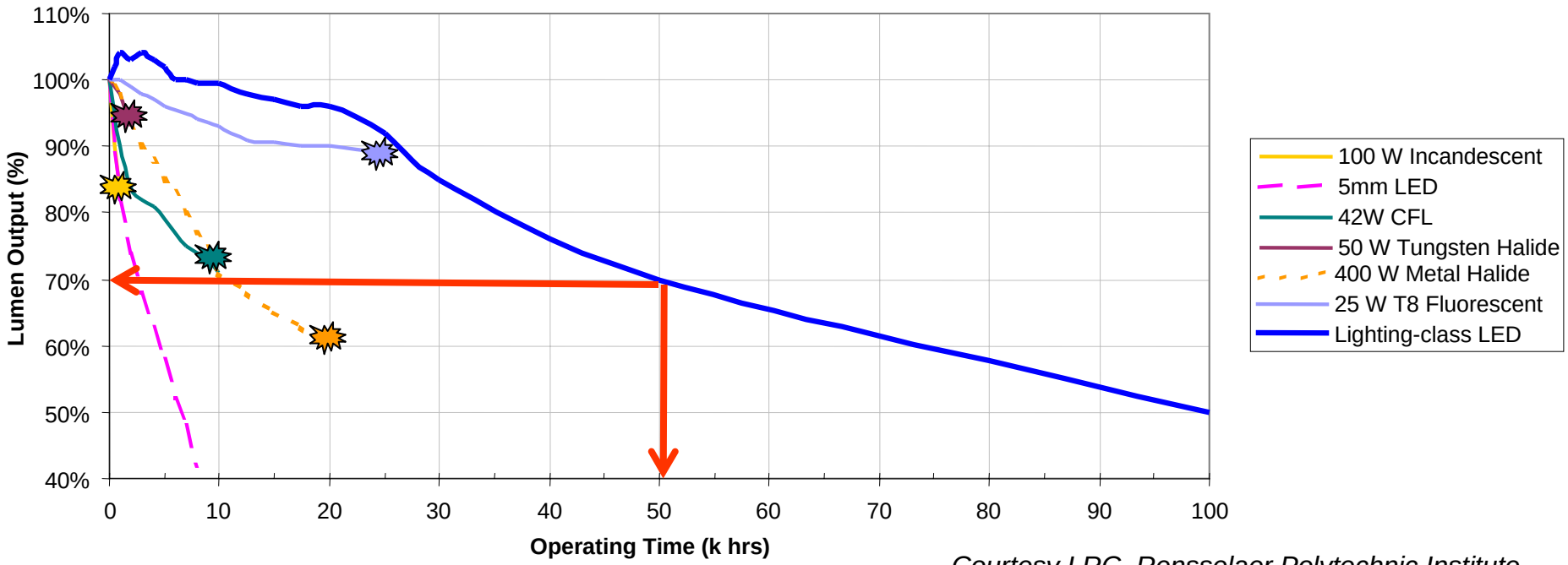
- 5 mm灯几乎没有散热路径 5 mm lamps have almost no thermal path
- 典型热阻>350℃/W Rth >350 ºC/W typical
- 芯片结温度(T_J)与磷最终会烧坏自身 Chip (T_J) and phosphor can essentially cook themselves

照明级LED
Lighting-class LED



- 照明级LED设计适合高温工作 Lighting-class LEDs are designed for high temp operation
- 典型热阻<10℃/W Rth <10 ºC/W typical
- 采用良好散热设计的话，灯能够很好地保持数据表中列出的参数 Lamp can stay within data sheet parameters with good thermal design

LED的寿命 LED Lifetime

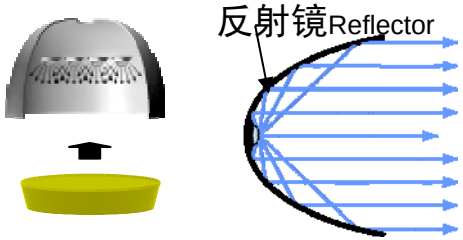


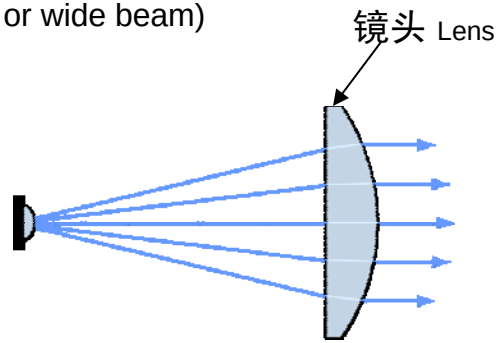
Courtesy LRC, Rensselaer Polytechnic Institute

- 所有传统光源的性能都会随着时间的推进而退化，即使LED也是如此 All conventional light sources dim over time, even LEDs
  - 标准光源失效(灯丝开路等) Standard light sources fail (open filament etc)
  - 恰当设计的话，LED性能退化速度较温和 Properly designed LEDs dim gracefully
- 寿命终结(EOL)基于流明维持率(L70)，它是工作温度的一个函数 End of life is based on Lumen Maintenance (L70) which is a function of operating temperature

应用驱动LED选择
Application Drives LED Selection

- 照明的区域/图案？ What is the area/pattern to be lit?
  - 线性槽带或路径 Linear strip or path
  - 点 Spot
  - 区域 Area
- 光学考虑因素(窄或宽光束) Optics considerations (narrow or wide beam)
  - 扩散板 Diffuser
  - 反射镜 Reflector
  - 镜头 Lens

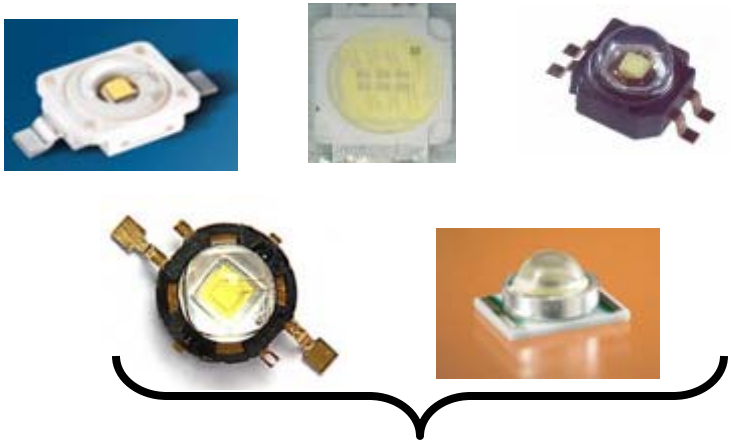


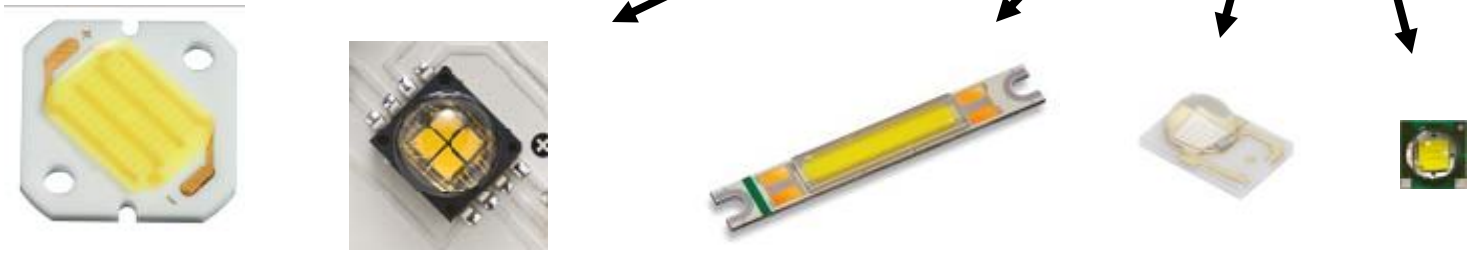


- 热密度及散热 Thermal density and heat removal
- 尺寸及灯具外观 Size and lit appearance

LED封装趋势 LED Packaging Trends

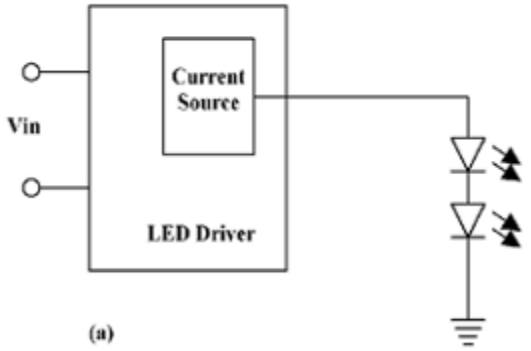
- 尺寸更小 Smaller size
- 多个大功率芯片 Multi-high power chips
- 多个较小芯片 Multi-small chips
- 涂磷方法 Phosphor coatings methods
- 更高瓦特数的封装 Higher wattage packages
- 沉积硅树脂主镜头系统 Deposited silicone primary lens systems





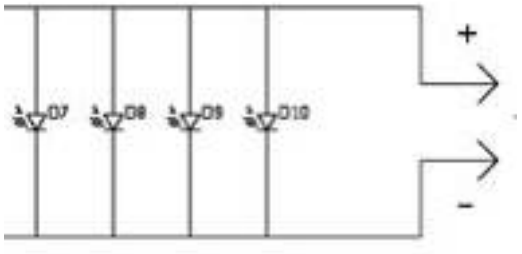
LED排列
Arrangement of LEDs

- 强烈建议驱动单串LED，因为这样提供最佳的电流匹配，而与正向电压变化和输出电压“漂移”无关 Driving single strings of LEDs is highly preferred as it provides ideal current matching independent of forward voltage variation, Vout “floats”

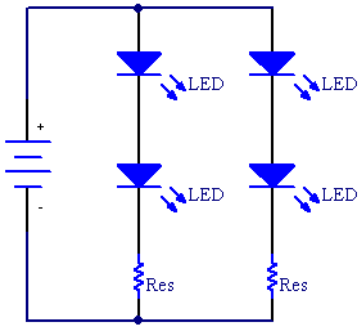


串联 Series

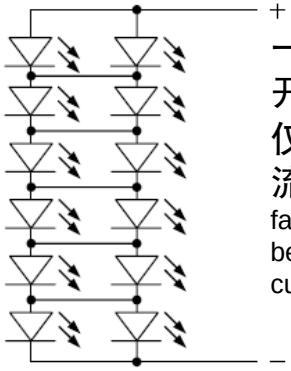
- 用户确实也会采用并联/串联组合方式来配置LED Users do configure LEDs in Parallel/Series combinations
  - –需要“匹配的”LED正向电压 Requires “matched” LED forward voltages
  - –如果某个LED失效开路，其余LED可能会过驱动
  - –交叉连接和多路并联技术尝试减轻发生故障的风险并迫使两个LED拥有相同电压 Cross connecting and multiple parallel techniques try to mitigate the risk of a fault and force both LEDs to have the same vc



并联 Parallel



串-并联 Series-Parallel



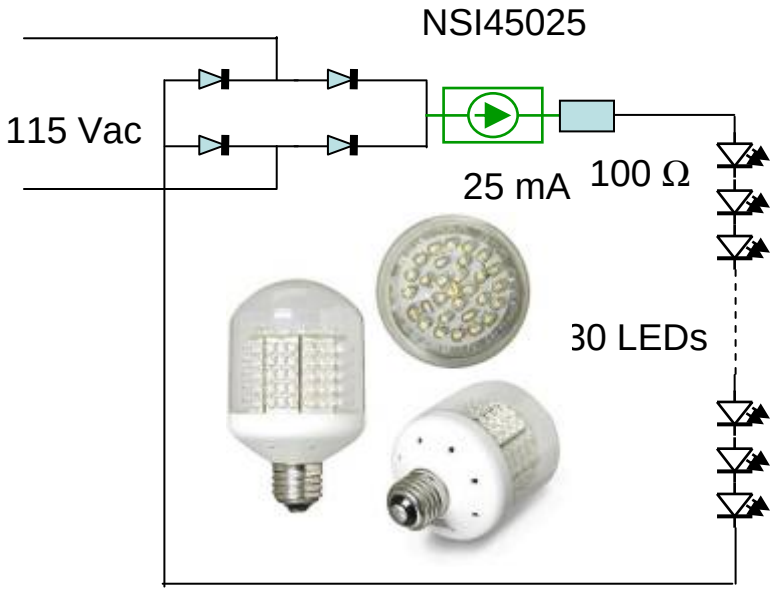
一旦某个LED失效开路，其余LED中仅有一个的驱动电流会翻倍 If a LED fails open, only 1 LED will be have 2x the drive current

交叉连接 Cross connect

低电流驱动器示例
Example of a Low Current Driver

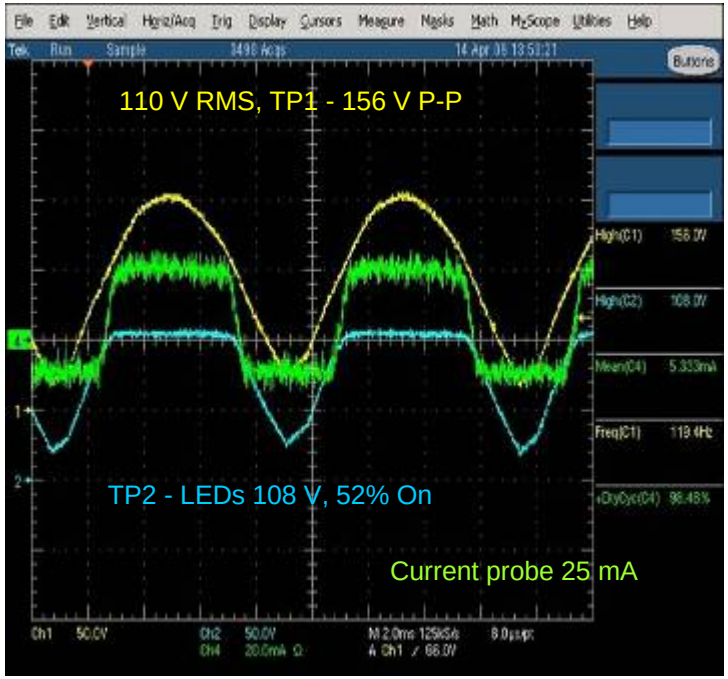
特性 Features

- 交流电压增加时仍保持恒流 Constant current as AC voltage increases
- 达到LED阈值电压后LED导通无延迟 No delay in turn on after LED threshold voltage is reached
- 低电压时LED保持明亮 Bright LEDs at low voltages
- 保持LED免受电压浪涌影响 LEDs protected from voltage surge

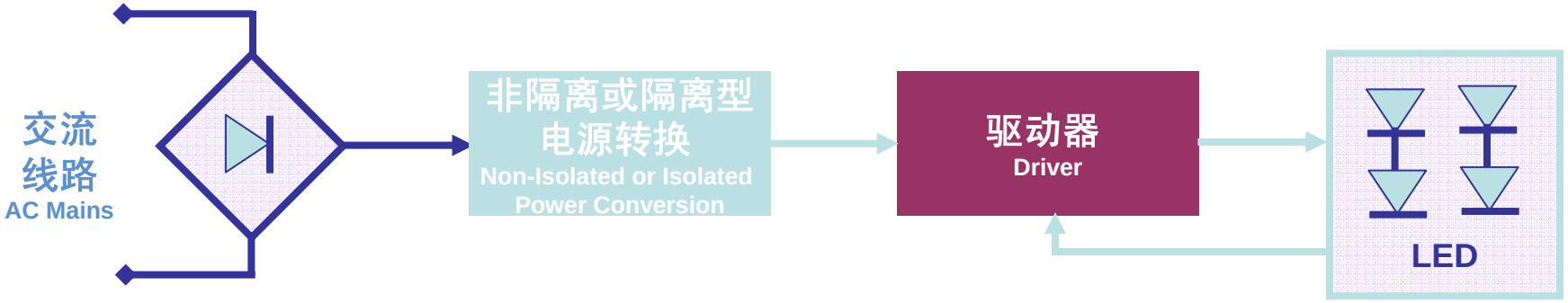


新系列的简单双端恒流稳压器(CCR) **New family of simple 2 terminal Constant Current Regulators (CCR)**

- 20、25及35 mA电流 20, 25, and 35 mA current
- SOT123及SOT223封装 SOT123 and SOT223 packages
- 最大工作电压45 V 45 V maximum operation



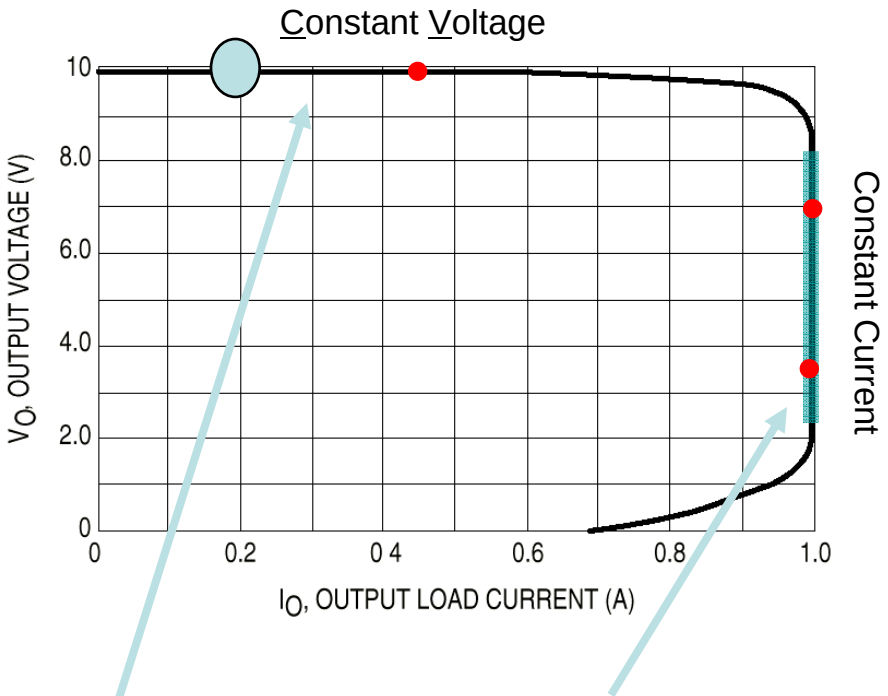
LED驱动器基础知识 LED Driver Basics



- 驱动器的主要功能，就是在工作条件范围下限制电流，而无论输入条件和输出正向电压如何变化 The primary function of a driver is to limit the current regardless of input condition and forward voltage variation across a range of operating conditions
- 交流-直流电源转换与驱动器稳压能集成为单个驱动器或分为两个段 AC-DC power conversion and driver regulation can be merged together into a single driver or separated into two stages
- LED排列方式及光源规范决定基本的驱动器要求 The arrangement of LEDs and the luminaire specifications dictate the fundamental driver requirements
- 隔离方案表示交流线路电压与LED之间没有物理上的电气连接 Isolated solutions means there is no physical electrical connection between the AC line voltage and the LEDs

驱动器工作
Driver Operation

- 恒压及恒流区域 Constant Voltage and Constant Current Regions
- 电流和/或电压稳压范围因特定驱动器/设计而异 Range of current and/or voltage regulation is driver/design specific
- 驱动器“恒定”电流特性可能不具备完美的关系曲线 Driver “constant” current behavior may not have a textbook relationship
- 某些驱动器的设计用于恒定功率，故LED正向电压决定输出电流 Some drivers are designed for constant power so LED forward voltage determines current



输出电压在宽电流范围下稳压或钳位 Output is voltage Regulated or clamped across a range of current

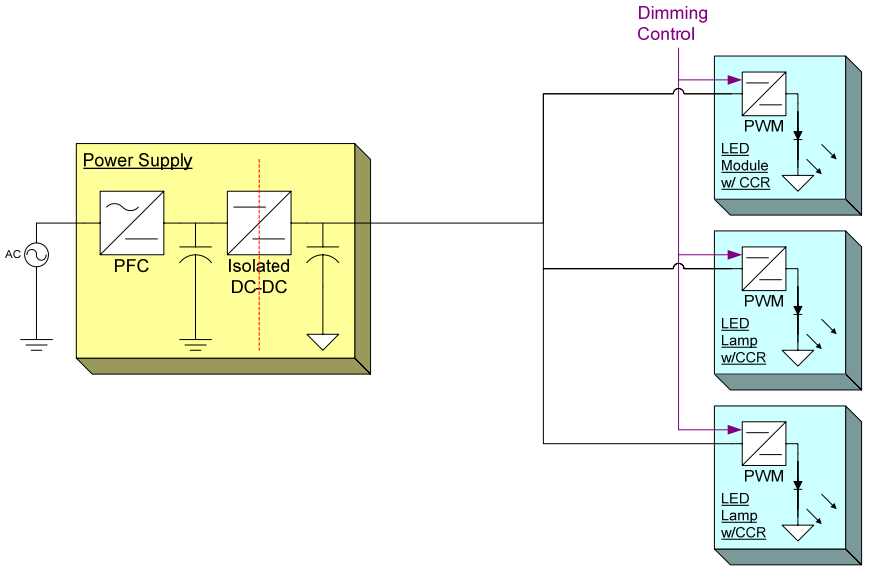
•输出能设计为拥有紧密限流 Output can be designed to have tight current limited

•输出电压取决于LED正向电压 The output voltage depends on the LED forward voltage

基本配置
Basic Configurations

- 在集成式配置中，电源转换与恒流驱动器均位于灯具内 In a integral configuration, the power conversion and constant current driver are all within the light fixture
  - LED光源与驱动器紧密耦合 Tight coupling of LED light source to the driver
  - 能效极优 Optimum efficiency
  - 安装简单 Simplifies installation

- 在分布式配置中，交流-直流电源转换与驱动器分隔开来 In a distributed configuration, the ac-dc power conversion is separate from driver (s)
  - 适合轨道或天花板照明 Modular applications like track and cove lighting
  - 简化安全事项 Simplifies safety considerations
  - 增加灵活性 Increases flexibility



不同功率等级的离线式LED应用-基于当今LED性能

Offline LED Applications by Power Level Based on Today's LED Performance

- 低功率 Low Power
  - 1-12 W
  - 橱窗内照明 Under-cabinet lighting
  - 台灯 Desk Lamps
  - 重点照明 Accent
  - 家电 Appliances
  - 替代灯泡 A lamp Bulb Replacement

- 中等功率 Medium Power
  - 8-40 W
  - 嵌灯 Down Lighting
  - 射灯(PAR38)及同类灯具 Spot Light (PAR38) Equivalent
  - 装饰灯具 Decorative Light Fixtures
  - 系船柱 Bollards
  - 吊扇 Ceiling Fans
  - 冷藏柜及电冰箱灯 Freezer and Refrigerator Lights
  - 高能效LED电源(镇流器) High Efficiency LED Supplies (ballasts) (24V/ 48V)

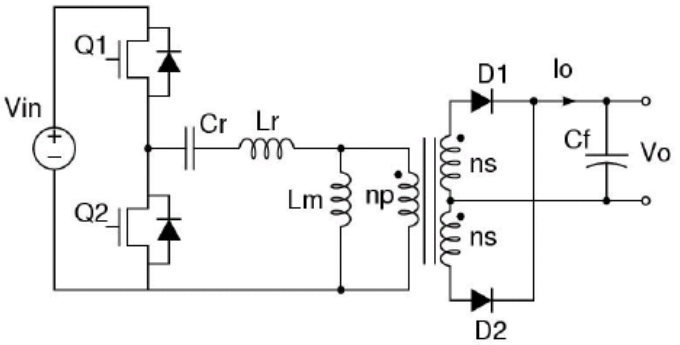
- 大功率 High Power
  - >40 W
  - 区域照明 Area Lighting
    - 街灯 Street Lights
    - 荧光灯 Fluorescent Lights
    - 替代高强度气体放电灯 HID Replacement
  - 高能效LED电源(镇流器) High Efficiency LED Supplies (ballasts) (24V/ 48V)

考虑因素
Factors to Consider

- 输出功率 Output Power
  - LED正向电压范围 Range of LED forward voltage
  - 电流-目标值，最大值 Current – target, maximum
  - LED排列 LED arrangement
- 电源 Power Source
  - 115 Vac, 通用输入(美国/欧盟)Universal (US/EU), 工业规范 Industrial – 208/277 Vac或其它 or other
  - 低压照明(景观、轨道等) Low Voltage Lighting (landscape, track etc)
  - 太阳能/电池 Solar / Battery
- 功能要求 Functional Requirements
  - 调光-PWM，0-10 V模拟、TRIAC、无线、DALI、专有方案及其它 Dimming – PWM, 0 - 10 V, Triac, Wireless, DALI, Proprietary, Other
  - 模拟、数字或多级调光 Analog, Digital, or multi-level dimming
  - 照明控制-常亮、动作、定时器 Lighting Control – occupancy, motion, timer
- 其它要求 Additional Requirements
  - 能效 Efficiency
  - 功率因数 Power Factor
  - 尺寸 Size
  - 成本 Cost
  - 故障处理(短路、开路、过载、过温) Fault handling (short circuit, open circuit, overload, over temperature
  - 标准-安全性标准 Standards – Safety (UL,CSA,VDE)
  - “能源之星” Energy Star
  - 可靠性 Reliability
- 其它考虑因素 Other Considerations
  - 机械连接 Mechanical connections
  - 安装 Installation
  - 维修/替换 Repair / Replacement
  - 寿命周期 Lifecycle
  - 物流 Logistics

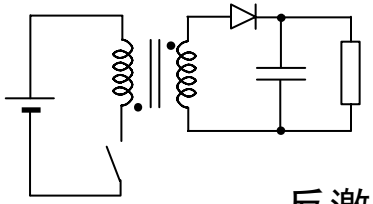
不同功率范围的隔离拓扑结构
Isolated Topology by Power Range

功率及功率密度升高 Increasing power & Power Density



LLC半桥谐振拓扑结构
LLC HB resonant topology

反激是低功率应用的最佳选择；
双电感加单电容谐振(LLC)最适合极高能效应用
Flyback is the best choice for Low power and LLC is best choice for highest efficiency



反激
flyback

离线LED专用标准
Offline LED Specific Standards

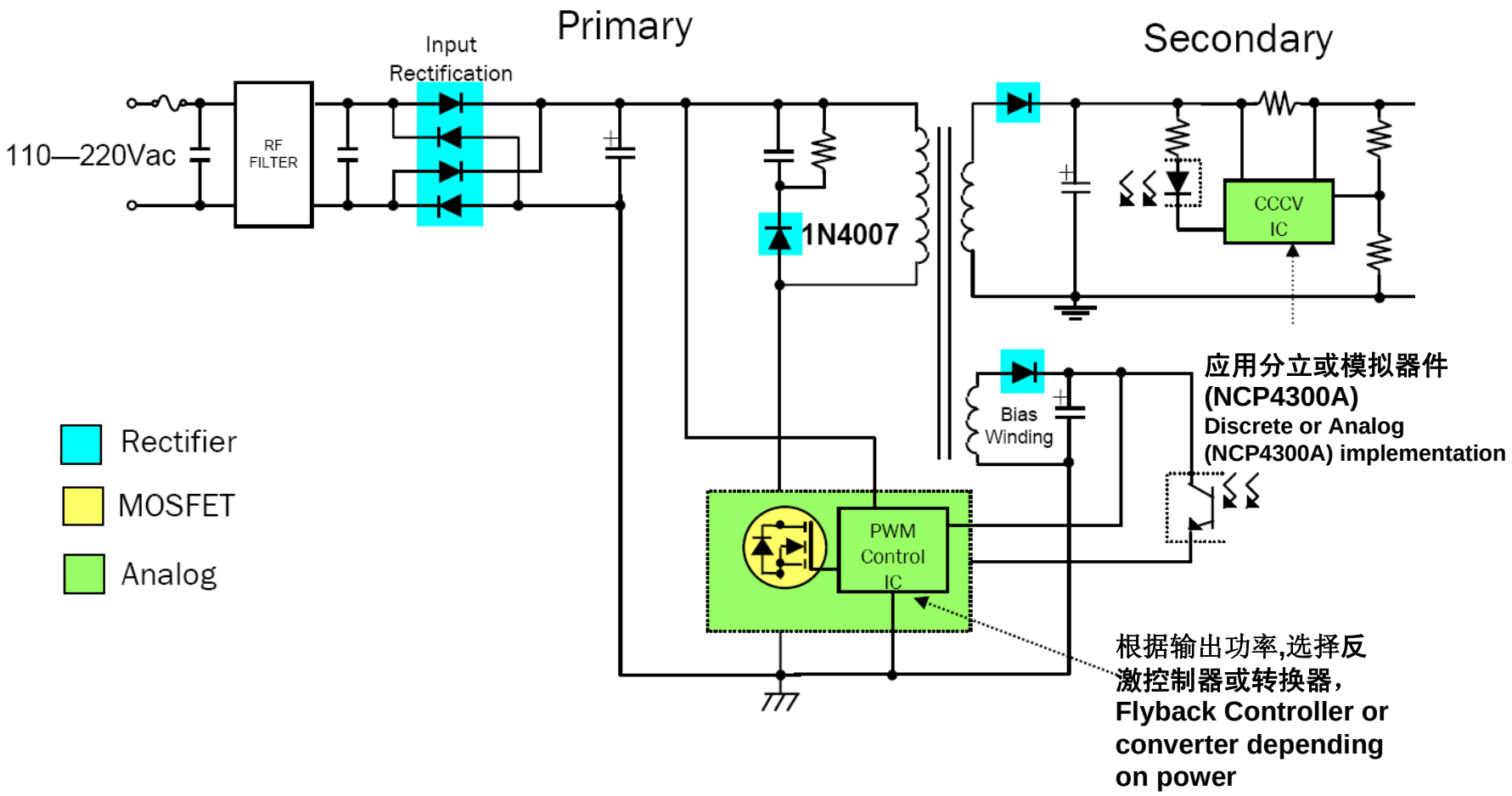
- “能源之星”固态照明(SSL)规范(1.1版-2009年2月) ENERGYSTAR™ SSL Specification (Version 1.1 -2/2009)
  - –基于光源的界定，针对特定产品的要求，含功率因数(PF)要求 Luminaire based limits, product specific requirements including power factor
  - –无针对标准墙式插头适配器的“关闭状态”功率要求规则，带智能控制器的设备(这些应用中要求为待机能耗低于0.5 W)例外，需遵从FCC 47 CFR Part 15/18规范的电磁干扰(EMI)及射频干扰(RFI)要求 No “off state” power requirement rules out standard wall plug adapters, exception are devices with smart controls, standby < 0.5 W in those cases Electromagnetic & RFI per FCC 47 CFR Part 15/18

- IEC 61347-2-13 (5/2006) – LED模块直流或交流供电电子控制装置要求，包括：
  Requirements for DC or AC supplied electronic control gear for LED Modules include:
  - –最大安全工作输出电压 Maximum SELV operating output voltage <= 25V rms (35.3 Vdc)
  - –不同故障条件下“恰当”/安全的工作： “Proper” /Safe operation under various fault conditions:
    - •LED开路测试，两倍额定LED或模块功率测试 No LEDs testing and 2x the rated LEDs or modules
    - •输出短路 Output short circuited
  - –故障条件下不冒烟或易燃 No smoke emission or flammability under malfunction

- ANSI C82.xxx LED驱动器规范正在制定中 ANSI C82.xxx LED Driver specification in development

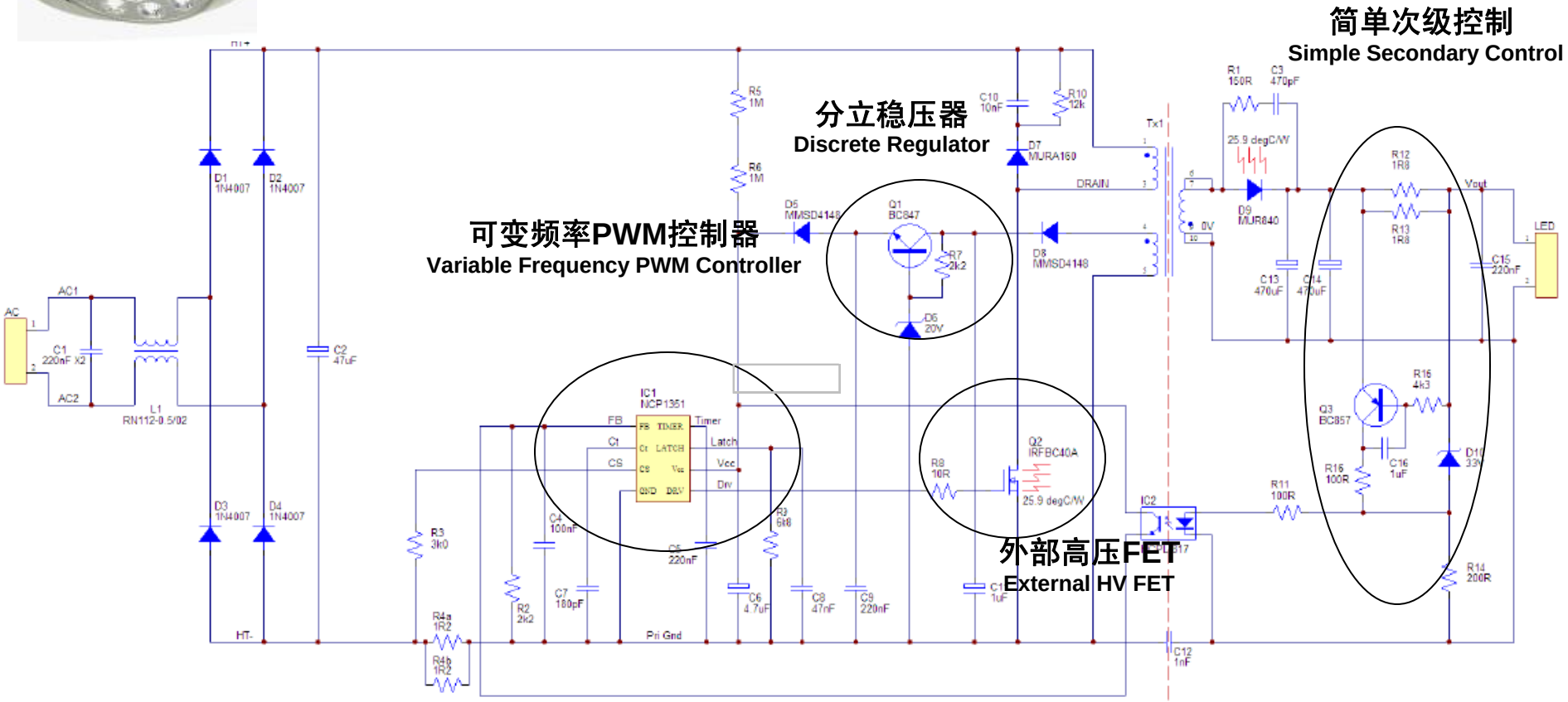
- 安全性标准 Safety – UL, CSA etc - UL1310 (Class 2) / UL 60950 / UL1012
  - –更多信息参见附录 See appendix for more information

基本离线拓扑结构
Basic Offline Topology



大于20 W的通用NCP1351控制器

20 W+ Universal NCP1351 Controllers

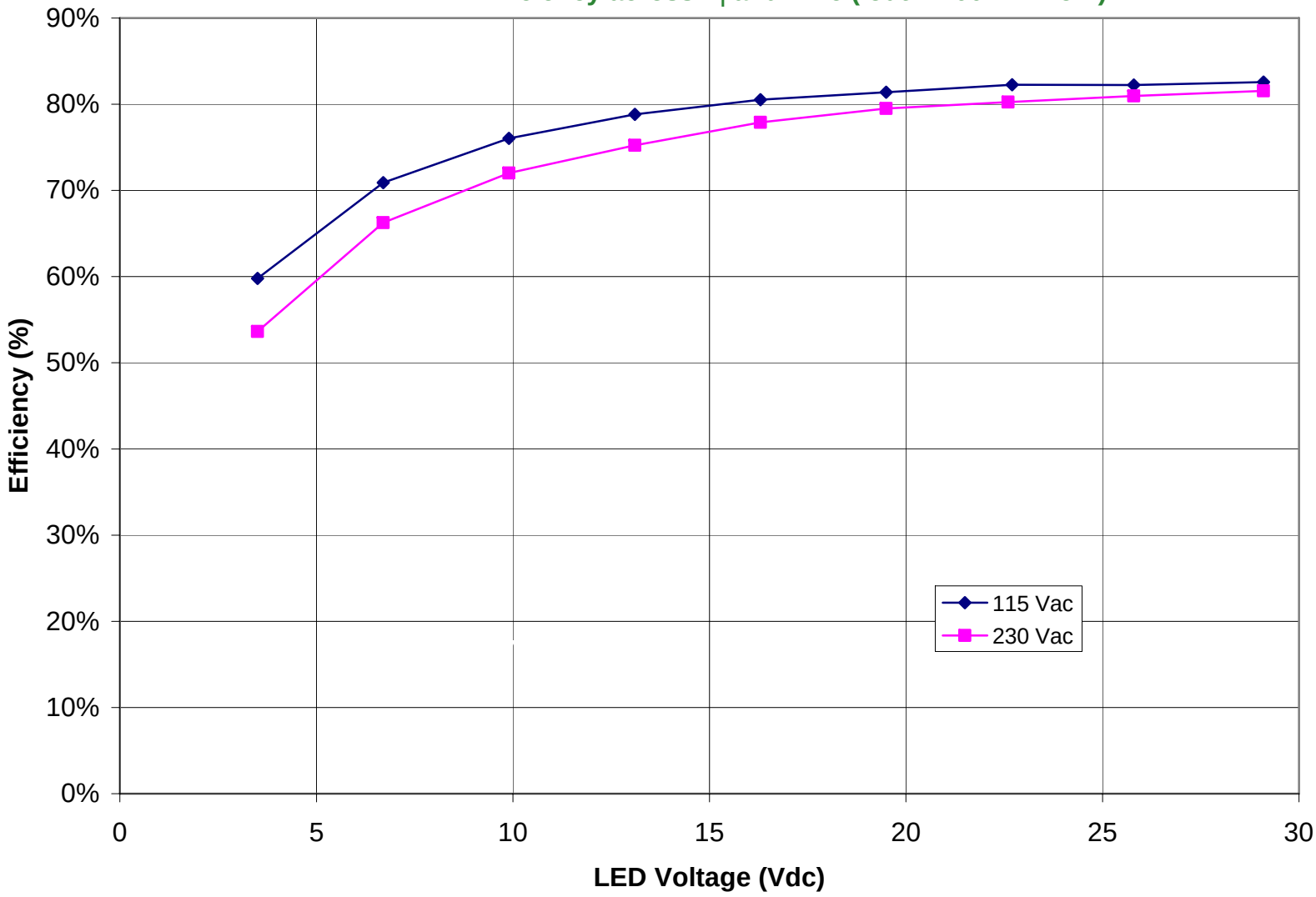


- 示例基于NCP1351 20 W通用输入(DN06040) Example based on NCP1351 20 W Universal input (DN06040)
- 能支持350 mA至1 A电流，设计针对700 mA，33 Vdc条件 Can support 350 mA to 1 A, design set for 700 mA, 33 Vdc

NCP1351LED演示板性能 NCP1351LED Demo Board Performance

不同正向电压及线路输入电压时的能效(额定输出电流=700 mA)

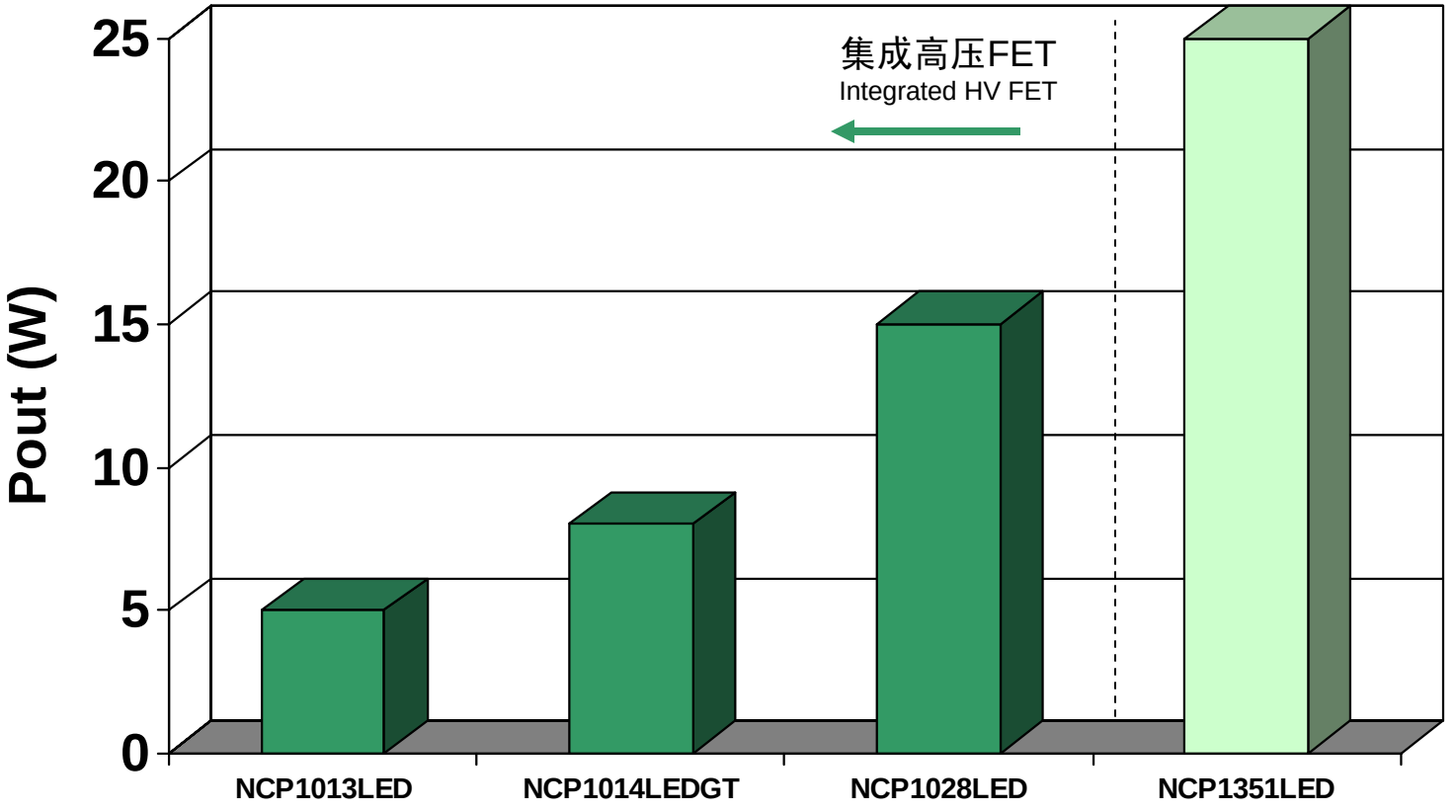
Efficiency across V_f and Line (Iout = 700 mA nom)

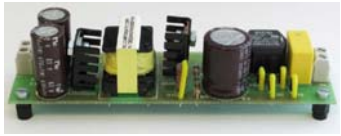


低功率LED驱动器演示板功率范围

Range of Low Power LED Driver Demo Boards

输出功率基于90-265 Vac输入范围 Pout based on 90-265 Vac input range





非隔离离线降压配置
Non-isolated Offline Buck Configuration

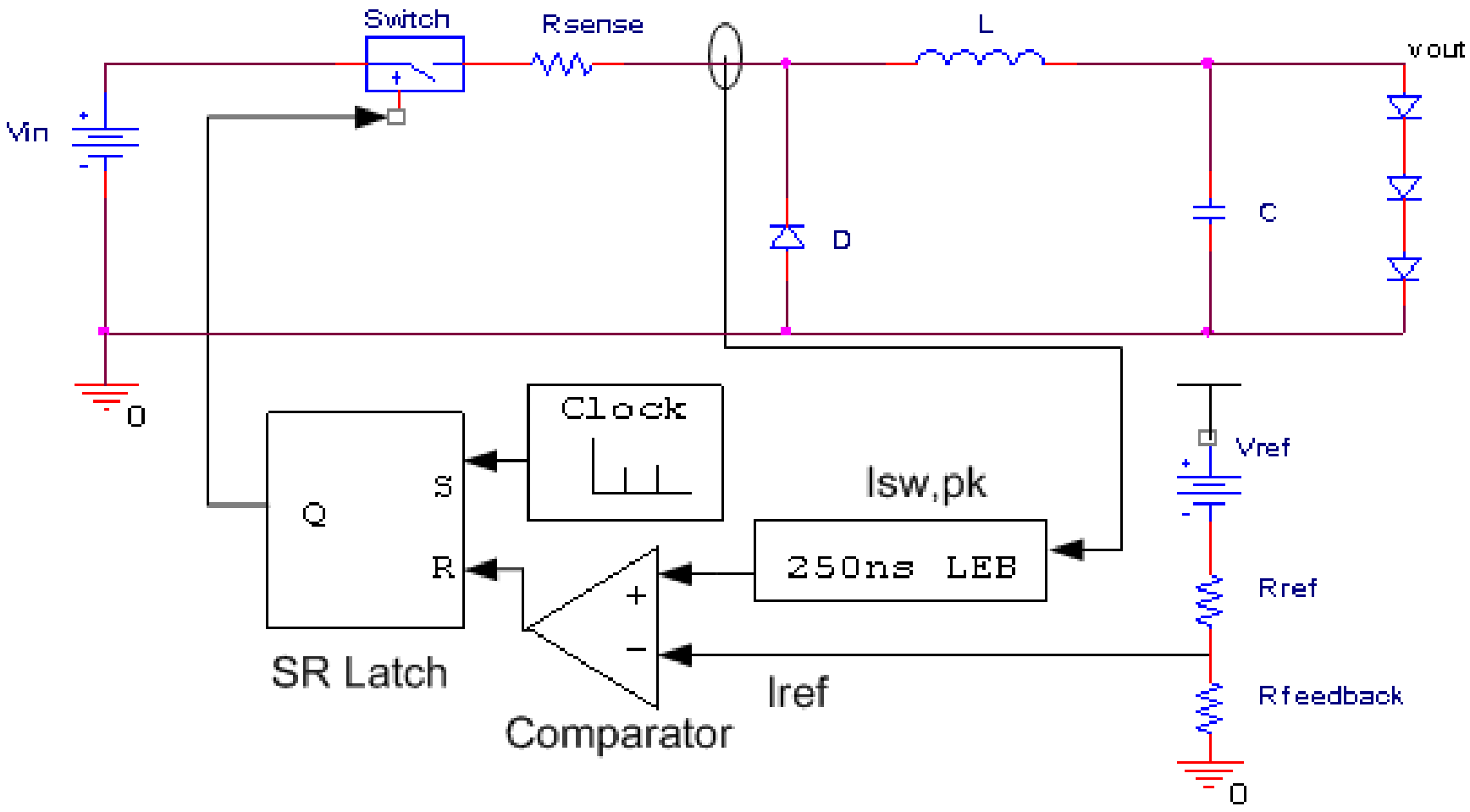
- 峰值电流控制拓扑结构工作在深度连续导电模式(CCM) Peak current controlled topology operating in deep continuous conduction

- 原因 Why:
  - 可选择省去大电解输出电容 Option to eliminate need for large electrolytic output capacitor
  - 简单控制机制，带有“良好的”稳流效果 Simple control scheme with “good” current regulation
  - 能够充分利用安森美半导体动态自供电(DSS)能力的优势，真接从交流线路为驱动器供电 Can take advantage of the ON Semiconductor DSS capability to power driver directly from the line

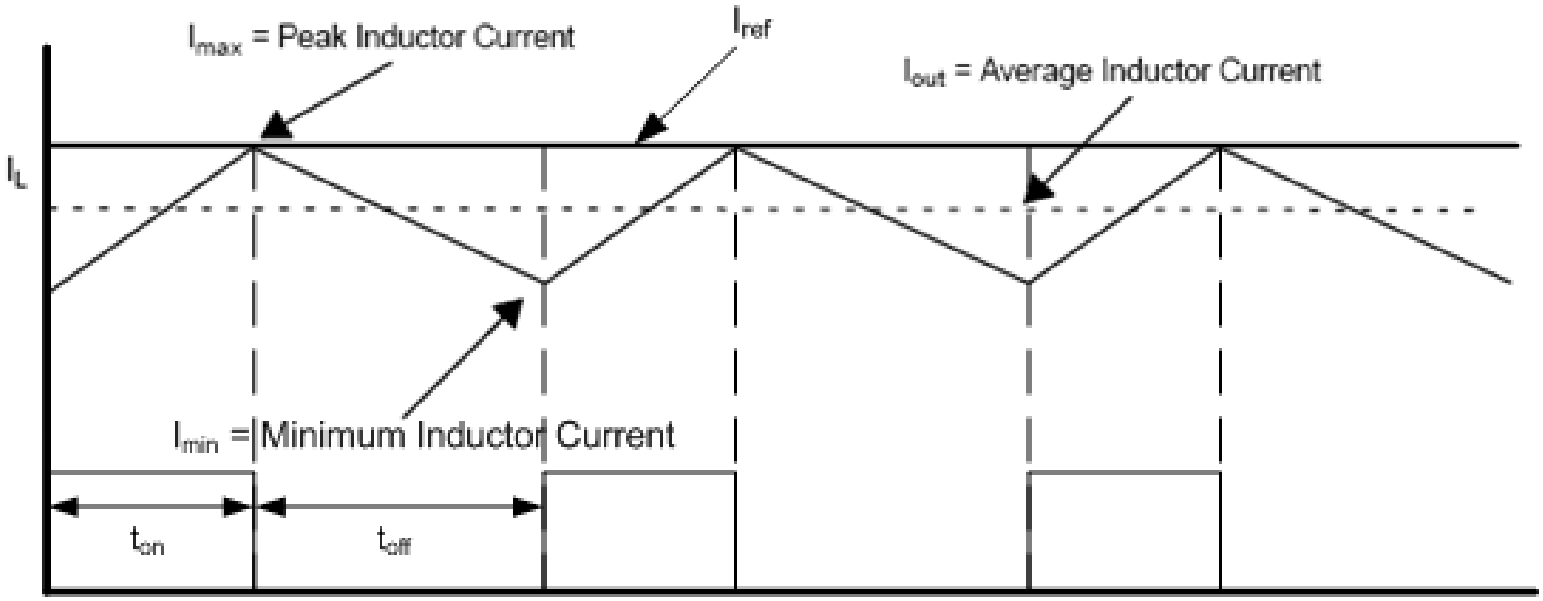
- 应当根据LED数量来优化电路 Circuit should be optimized for the number of LEDs

峰值电流控制(PCC)降压反转式BUCK

Inverted Peak Current Control Buck



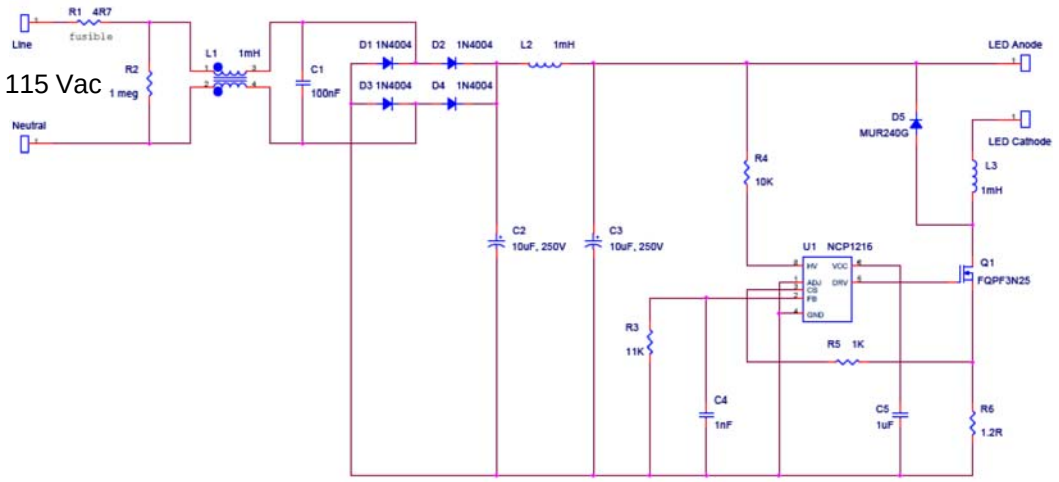
峰值电流稳流-控制谷底
Regulate Peak – Control Valley

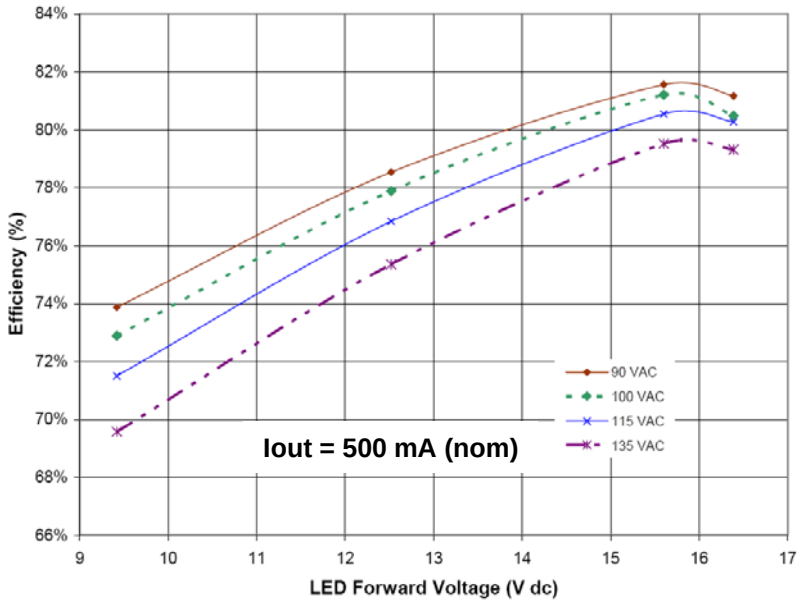


- 连续导电模式(CCM) Continuous Conduction Mode
  - 电流始终流过电感 Current is always flowing through the inductor
- L = (VIN,MAX – VOUT) * (VOUT / VIN,MAX) * (1/fs) *(1/ (%Ripple * Iout))
- 必须注意最短导通时间(LEB + Tpd + MOSFET关闭时间) Must respect minimum on-time (LEB + Tpd + MOSFET turn-off time)

示例：NCP1216峰值电流控制(PCC)降压电路

Example: NCP1216 PCC Buck Circuit



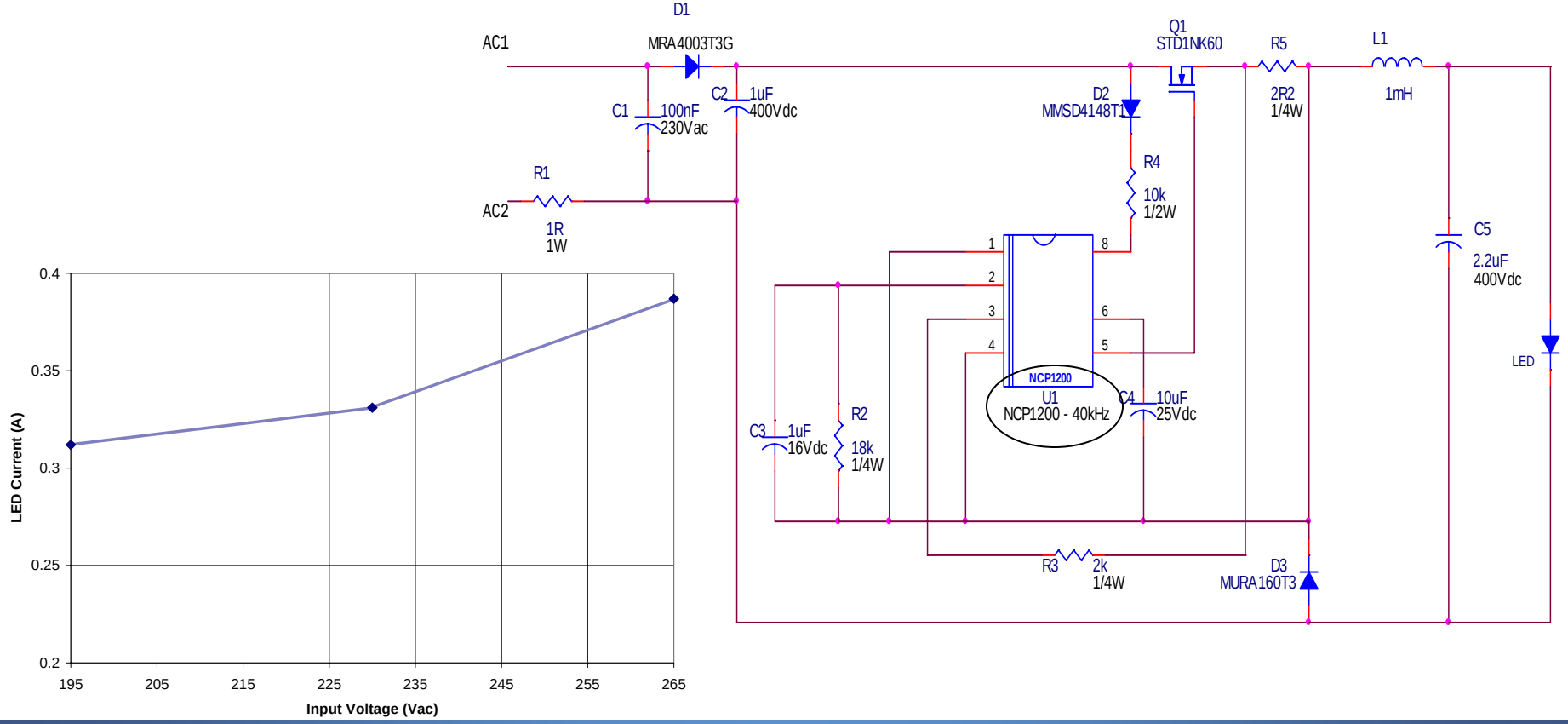


- NCP1216直接采用交流主电源供电，简单启动及工作 NCP1216 is directly powered from the ac mains simplifying startup and operation
- 能效由输出功率(电流，LED数量)、外部元件选择(FET、电感、整流器)及开关频率确定 Efficiency is a function of output power (current, # LEDs), external component selection (FET, inductor, rectifier) and switching frequency
- 可藉光耦合器调光，用于安全隔离 Dimmable through opto-coupler for safety isolation
- 提供DN06050设计文件，这设计文件展现了包括EMI滤波在内的性能 DN06050 Design Note available demonstrates performance including EMI filtering

230 Vac应用考虑因素

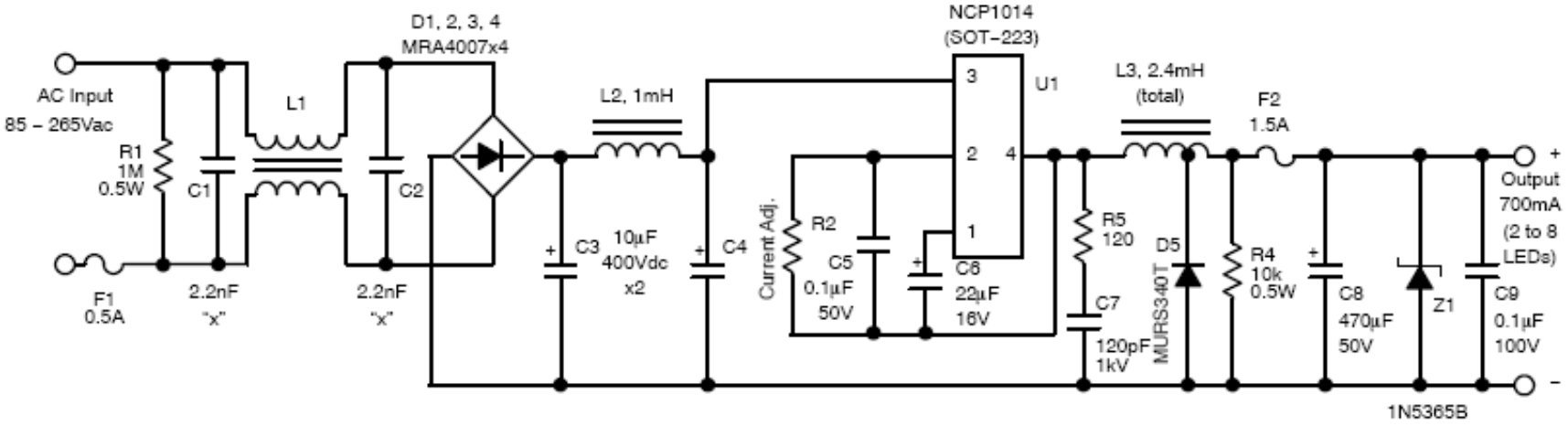
Considerations for 230 Vac Applications

- 高压驱动小串LED导致占空比极窄 Driving small strings of LEDs at high voltages results in extremely narrow duty cycles
- 开关控制器在感测到电流前会有200至400 ns的前沿消隐(LEB)电路 Switching controllers have leading edge blank circuit of 200-400 ns before current is sensed
- 必须降低开关频率以恰当工作，并以半波整流输入电压将输入电压保持为最低 Switching frequency must be reduced for proper operation and input voltage is kept to a minimum with a half wave rectified input circuit



抽头电感方案 Tapped Inductor Approach

扩展占空比，增加输出电流 Extends Duty Ratio, Increase Iout



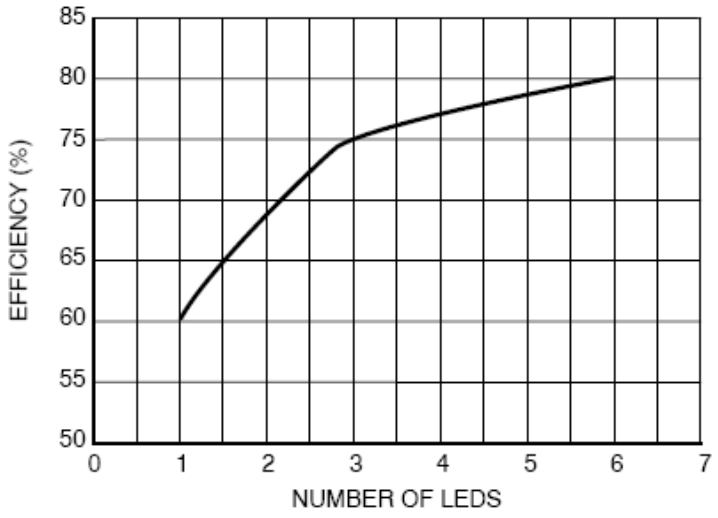


Figure 4. Efficiency versus Number of Series LEDs (120 Vac Input)

AND8328/D

700 mA LED Power Supply Using Monolithic Controller and Off-Line Current Boosted (Tapped Inductor) Buck Converter

离线LED驱动器功率因数要求
Power Factor Requirements for Offline LED Drivers

- 欧盟的国际电工联盟(IEC)规定了(功率大于25 W的)照明总谐波失真(THD)要求，其它地区也有其它的不同国际标准 IEC (EU) requirements dictate THD performance for Lighting (over 25 W), other international standards apply depending on the region

- 美国能源部“能源之星”项目固态照明(SSL)规范包含强制的功率因数校正(PFC)要求，而不论是何种功率等级。这是一种自愿性标准，应用于特定产品，如嵌灯、橱柜灯及台灯 US DOE ENERGY STAR™ includes mandatory PFC for Solid State Lighting regardless of the power level. This is a voluntary standard and applies to a specific set of products such as down lights, under cabinet lights and desk lamps for example
  - 住宅应用功率因数高于0.7 >0.7 for residential applications
  - 商业应用功率因数高于0.9 >0.9 for commercial applications

- 虽然不是所有国家在LED照明方面都有强制要求，但某些应用可能有要求
  While not absolutely mandated in the for lighting in all countries, it may be required based on the application:
  - 公共事业机构大力推动拥有高功率因数的产品在公用设施中的商业应用 Utilities drive major commercial uses to have high PF at the facility level
  - 此外，公用事业机构拥有/维护街灯时，是否拥有高功率因数(通常高于0.95+)取决于他们自己的意愿 Moreover when utilities owns/service the streetlight it is in their interest to have good power factor, typically > 0.95+

IEC C类限制
Class C Limits

这类限制适用于功率超过25 W的照明设备

This class applies to lighting equipment exceeding 25 W

Harmonic Order n	Maximum Value expressed as a percentage of the fundamental input current
2	2
3	30*λ
5	10
7	7
9	5
11 < n <= 39	3

λ is the circuit power factor

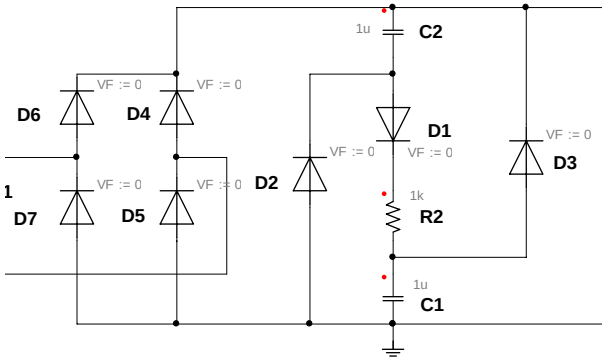
这标准相当于总谐波失真(THD)<35%(功率因数约为0.94)。
实际上，照明设备电源通常的目标是THD<20%

The standard equates to a THD<35% (PF around 0.94).
In practice, lighting equipment suppliers may target THD<20%.

改善反激电路的功率因数
Improving Power Factor for Flyback Circuits

- 传统反激转换器的功率因数约为0.5至0.55 Traditional Flyback converters have a PF of ~0.5-0.55

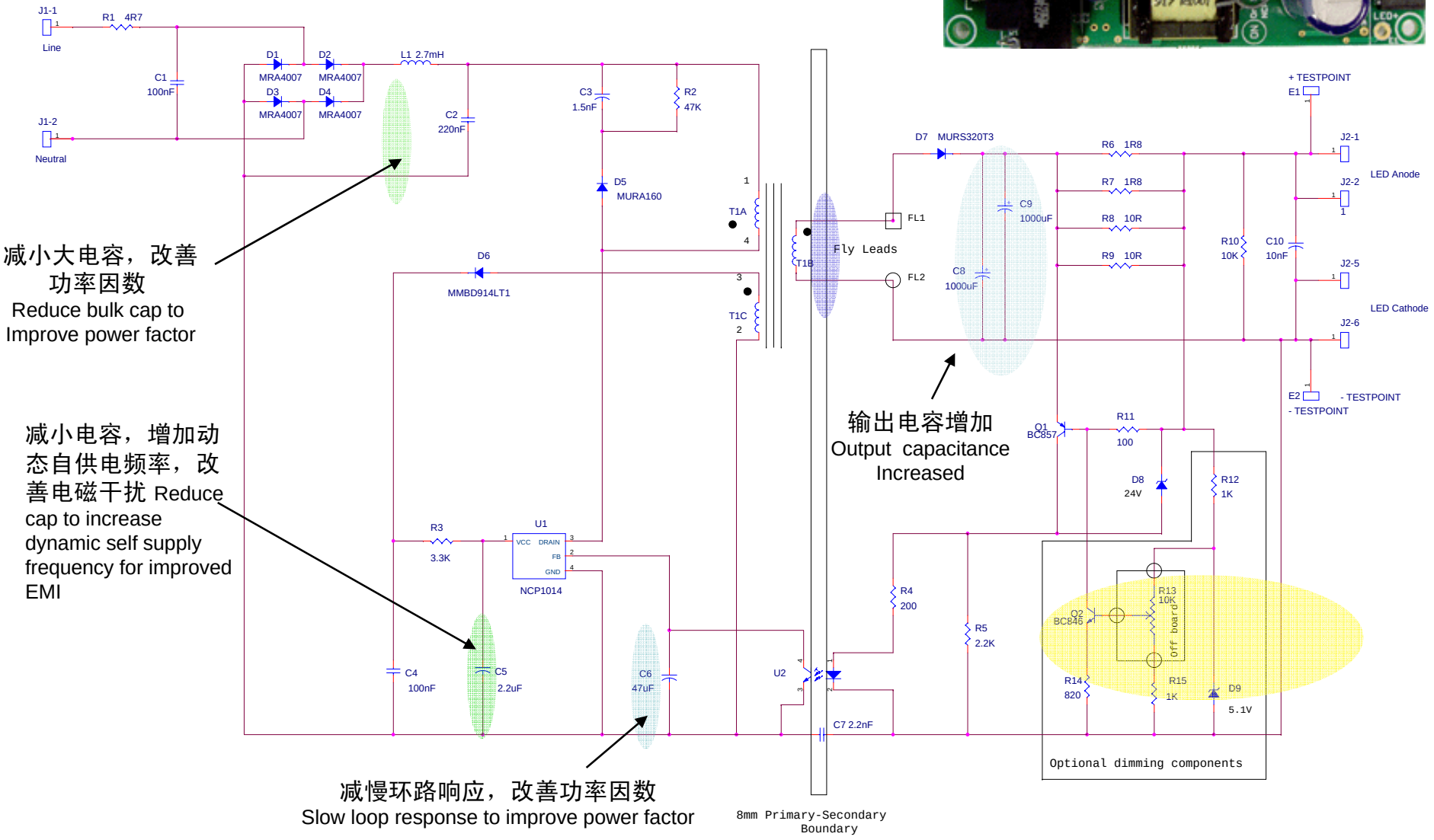
- 将低功率应用的功率因数改善至大于0.7，并不要求采用新拓扑结构，仅需优化电路 Improving this to > 0.7 for low power applications does not require new topologies, just circuit optimization
  - 无源技术(谷底填充) Passive technique (Valley-Fill)
  - 安森美半导体“半正矢”反激优化
    ONSEMI “haversine” flyback optimization
  - 临界导电模式(CrM)反激 Critical Conduction Mode Flyback



- 对于象街灯这样的大功率应用而言，通常使用专用功率因数控制电路 For high power applications like street lights, a dedicated PFC boost stage is normally used

NCP1014GTG演示板

NCP1014GTG Demo Board



减小大电容，改善功率因数
Reduce bulk cap to Improve power factor

减小电容，增加动态自供电频率，改善电磁干扰 Reduce cap to increase dynamic self supply frequency for improved EMI

输出电容增加
Output capacitance Increased

减慢环路响应，改善功率因数
Slow loop response to improve power factor

“半正矢”反激性能
Performance of “Haversine” Flyback

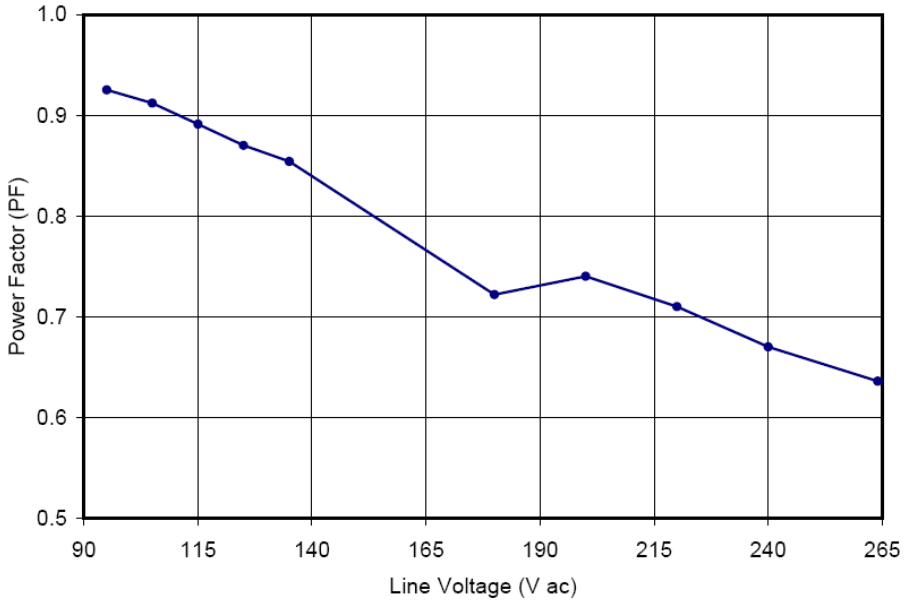


Figure 5: Power Factor vs. Line Voltage
Ta = 20 ºC, Pout = 8.0 W

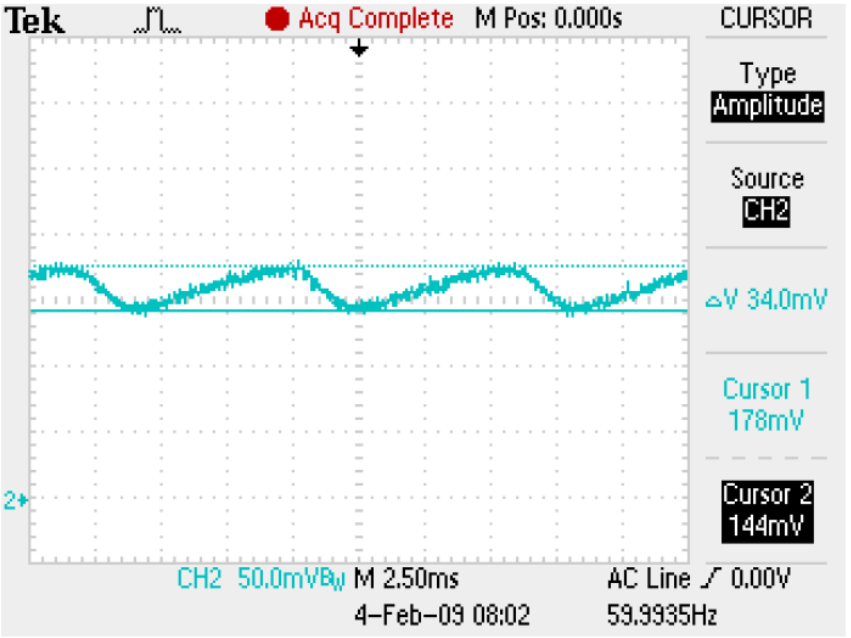


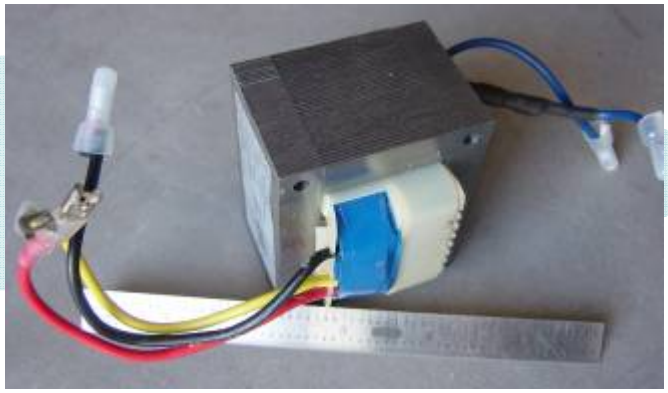
Figure 4: LED Current (3.33 A/volt)
Ripple = 113 mA (p-p)

•DN06051设计笔记阐述了如何使用“半正矢”反激优化技术来修改NCP1014，使其提供大于0.8的更高功率因数，轻松满足美国“能源之星”的住宅照明要求 DN06051 design note illustrates how to modifying the NCP1014 for higher PF > 0.8 using the “haversine” flyback optimization which easily meets US Residential Energystar Requirements

演示：NCP1014GTG便携台灯
Demo: NCP1014GTG Portable Desk Lamp

台灯 Desk Lamp

35 W卤素灯 35 W Halogen



磁变压器 Magnetic Transformer

带PFC的NCP1014 LED驱动器
NCP1014 LED Driver with PF Correction

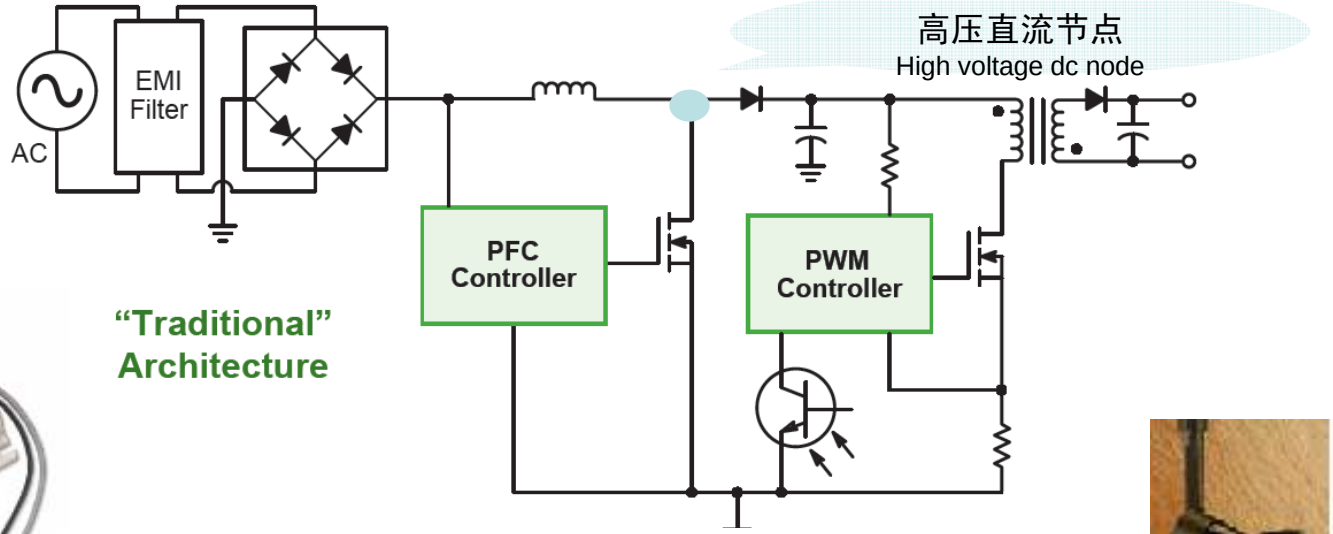
4 LED Cree MC-E 多芯片阵列 Multichip Array

光源 Light Source	Pin (W) @ 120 Vac	照明亮度 Illuminance (Lux)*	功率因数 Power Factor
卤素灯 Halogen (35 W bulb)	41.7 W	744	0.961
4 LED台灯 Quad LED	10.9 W	795	0.857

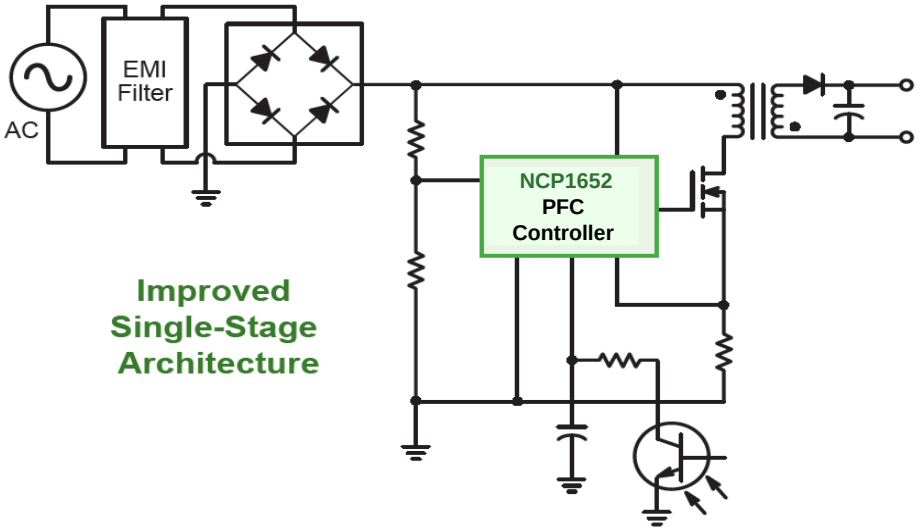
性能测试小结 Summary of Results
* Illuminance measures at 0.5 m

实现高功率因数及低失真

Achieving High Power Factor and Low Distortion



"Traditional" Architecture

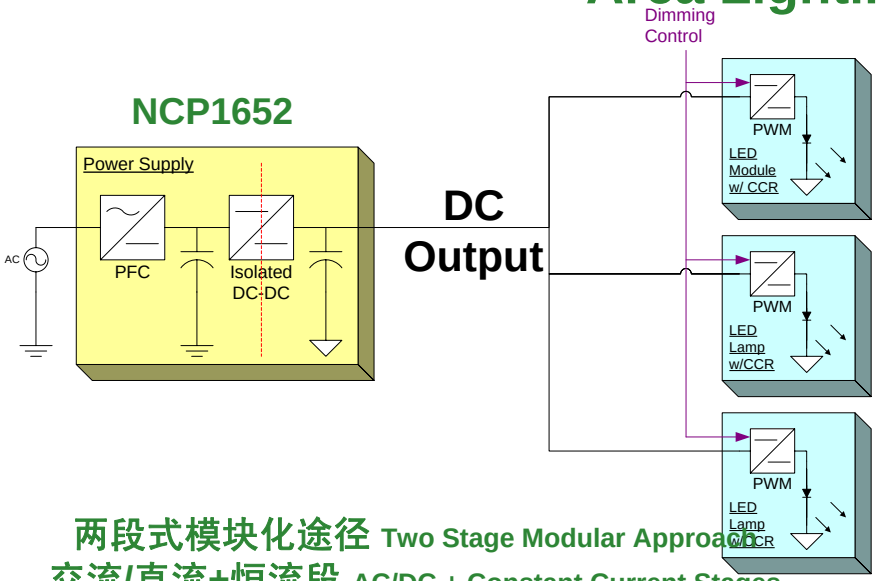


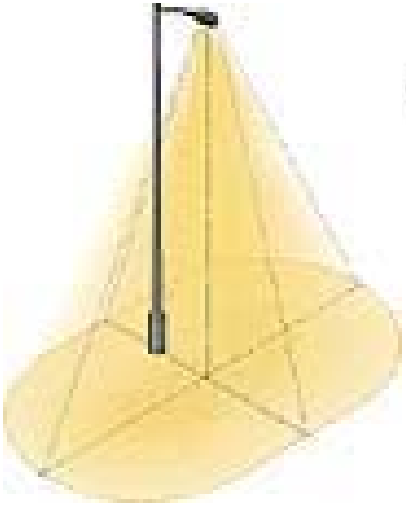
Improved Single-Stage Architecture

简化电路图，未画次级端控制

condary side control is not draw for simplicity

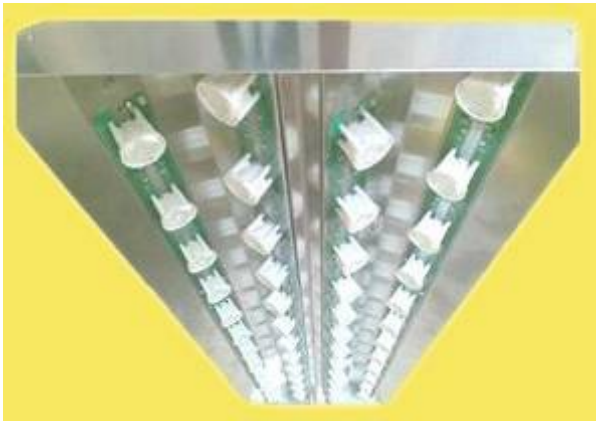
区域照明考虑因素
Area Lighting Considerations





两段式模块化途径 Two Stage Modular Approach

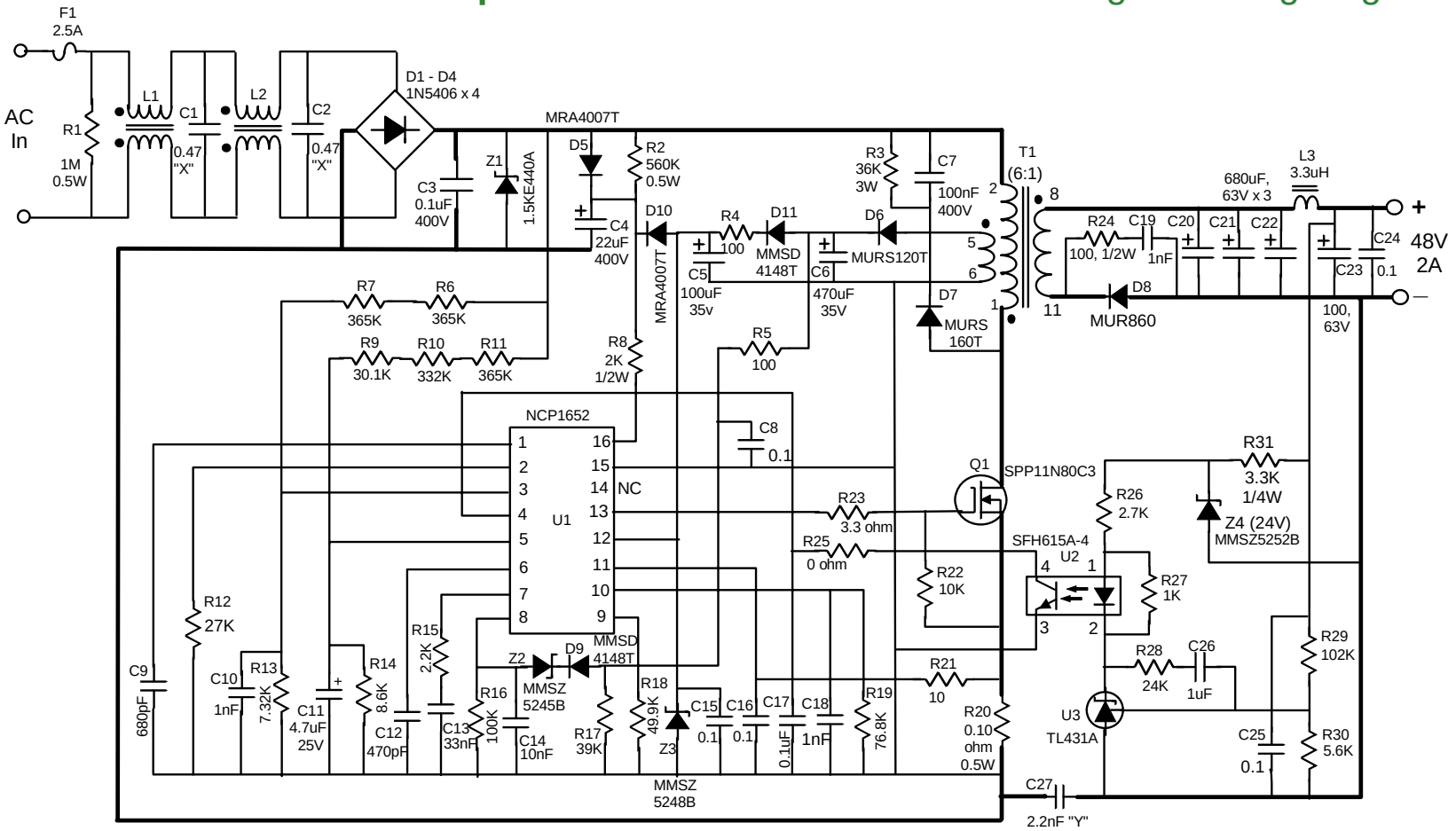
交流/直流+恒流段 AC/DC + Constant Current Stages



- 光输出显著变化 Light output varies significantly
  - –杆高及间距 Poll Height and Spacing
  - –交通流量类型(住宅区，市中心) Type of Traffic Flow (residential, city center)
- 区域照明所要求的功率范围及发光等级 Significant range of power and light levels required for area lighting
- 一项基本设计能够藉增加LED光条来在光输出方面向上或向下扩展 One basic design can be scaled up or down in light output by adding LED light bars
- 采用模块化途径的光条可现场升级 With a modular approach light bars are field upgradeable

NCP1652 48 V固定输出电路图-极适合固定电压区域照明

NCP1652 48 V Fixed Output Schematic - Ideal for Fixed Voltage Area Lighting

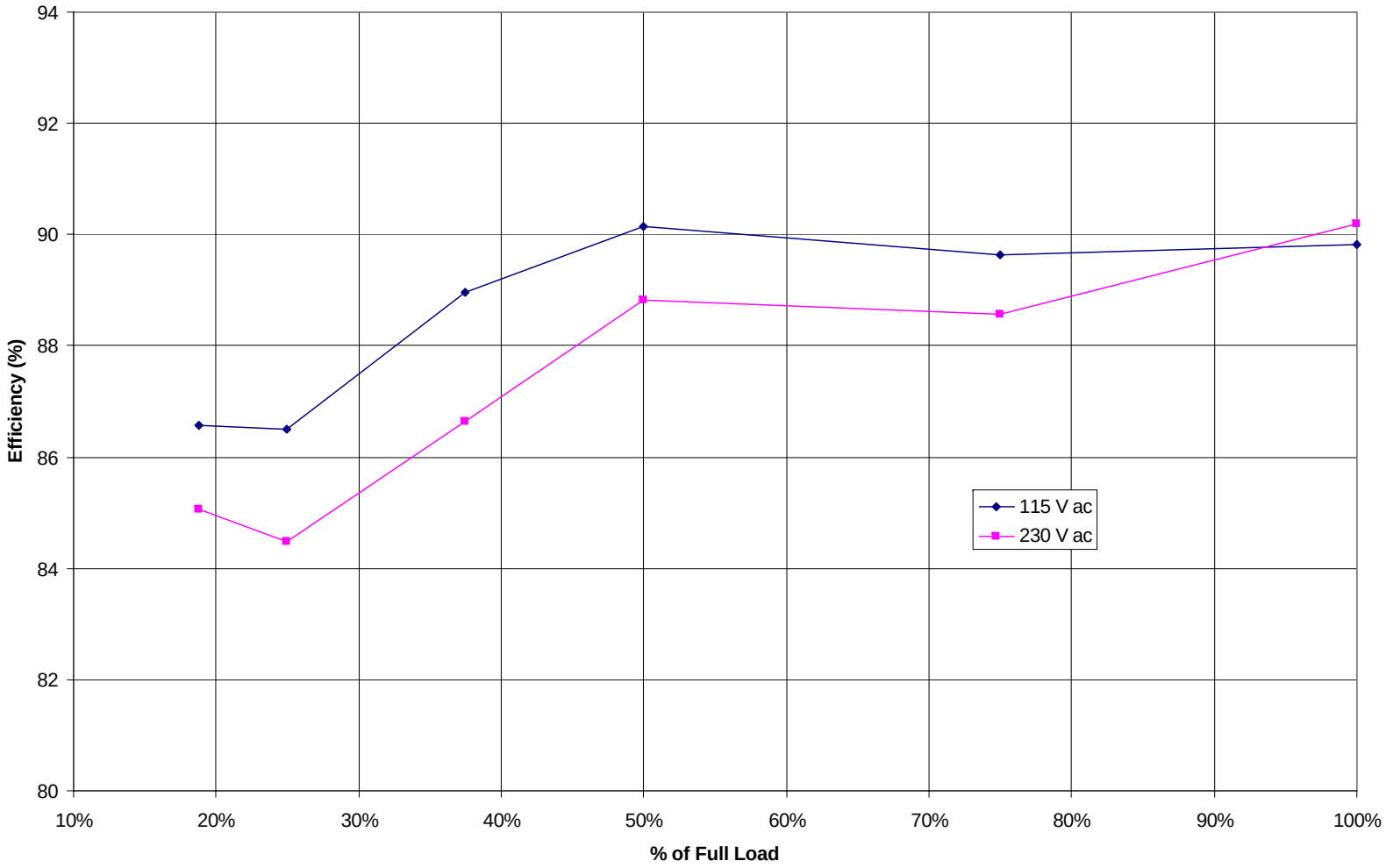


AND8394/D

A 48 V, 2 A High Efficiency, Single Stage, Isolated Power Factor Corrected Power Supply for LED

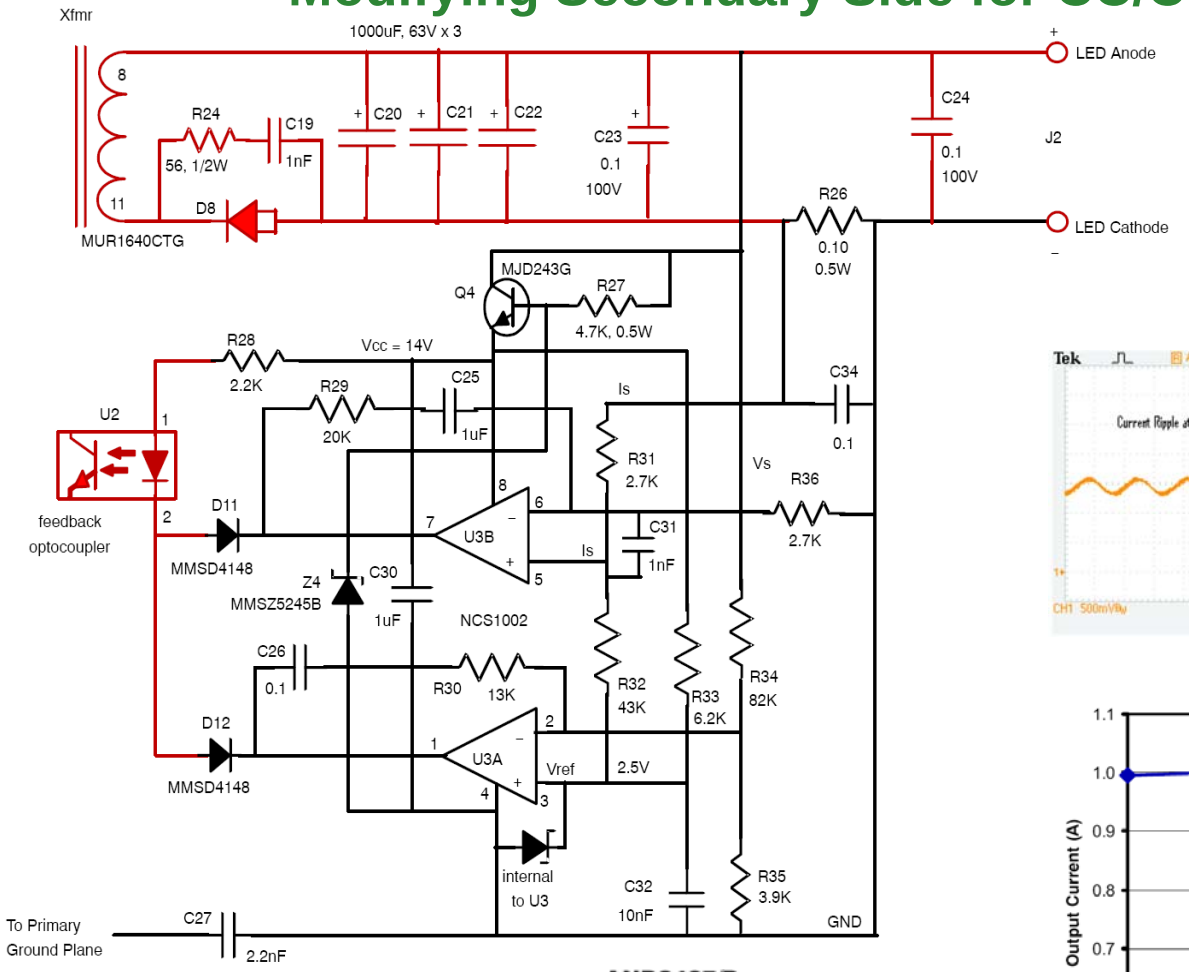
NCP1652能效测试结果 NCP1652 Efficiency Results

输出配置 Configuration: 48 V / 2 A



为恒流/恒压工作修改次级端

Modifying Secondary Side for CC/CV Operation



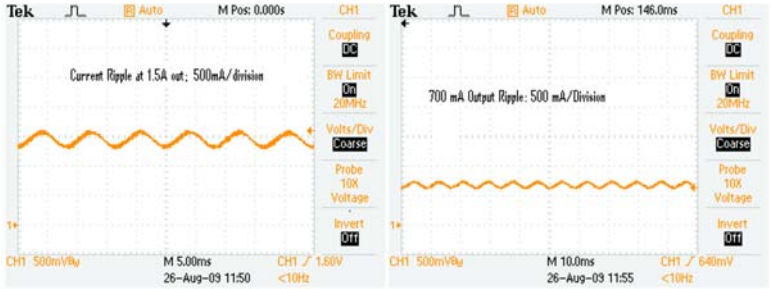
AND8427/D

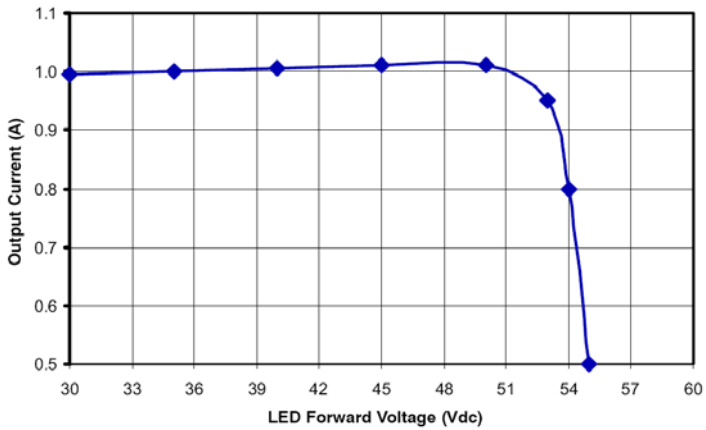
A Constant Current Adjustable 0.7 A to 1.5 A, Up to 55 Vdc Single Stage Power Factor Corrected LED Power Supply

Efficiency

Iout (CC)	120 Vac input	230 Vac input
1.50 A	87%	87.5%
1.25 A	87%	87.5%
1.00 A	86%	86.5%
0.70 A	85.5%	86.0%

V_f = 45 Vdc





NCL30000 CRM 隔离反激

NCL30000 CRM Isolated Flyback

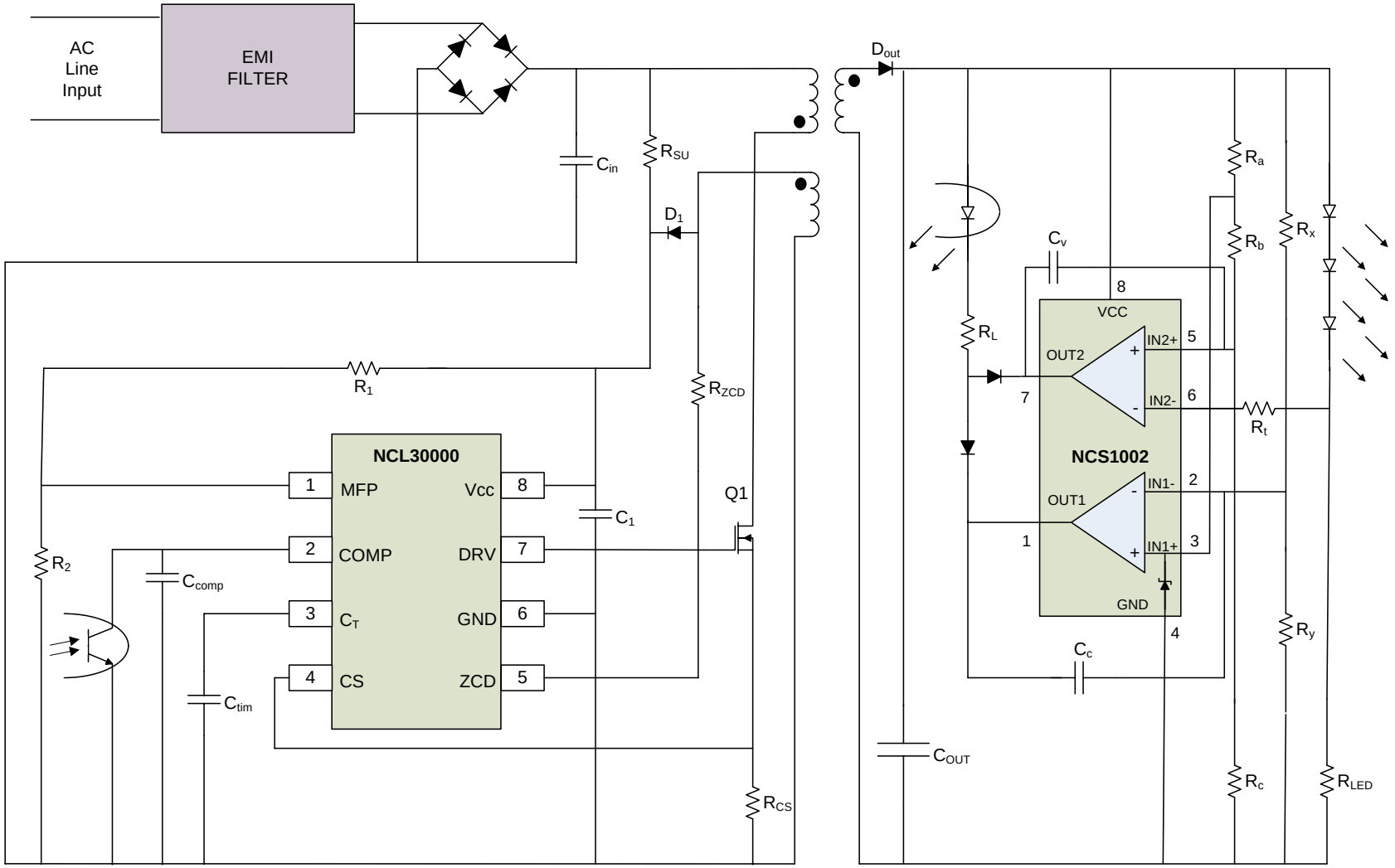
- 低功率(5-20 W)应用也需要高功率因数 Low Power (5-20 W) also need high power factor
  - LED驱动器/镇流器 LED Drivers/Ballasts
  - 嵌灯/射灯/户外照明 Downlights / Spot Lights / Outdoor Lighting

- 关键目标 Key Objectives
  - 直接驱动LED，带精确恒流输出控制 Directly drive LEDs with tight constant current output regulation
  - 更高功率因数：>0.9，IEC C类谐波含量要求 High Power Factor >0.9, IEC Class C Harmonic Content
  - 5至15 W输出功率的低功率等级时，能效高于80%；典型能效83% Greater than 80% efficiency at low power levels 5-15 W Pout, 83% typical
  - 可扩展支持宽范围的功率LED和输出电流 Scale-able to handle a range of power LEDs and current levels
  - 能支持现有调光方案(TRIAC及尾缘) Can support existing dimming solutions (TRIAC and Trailing Edge)

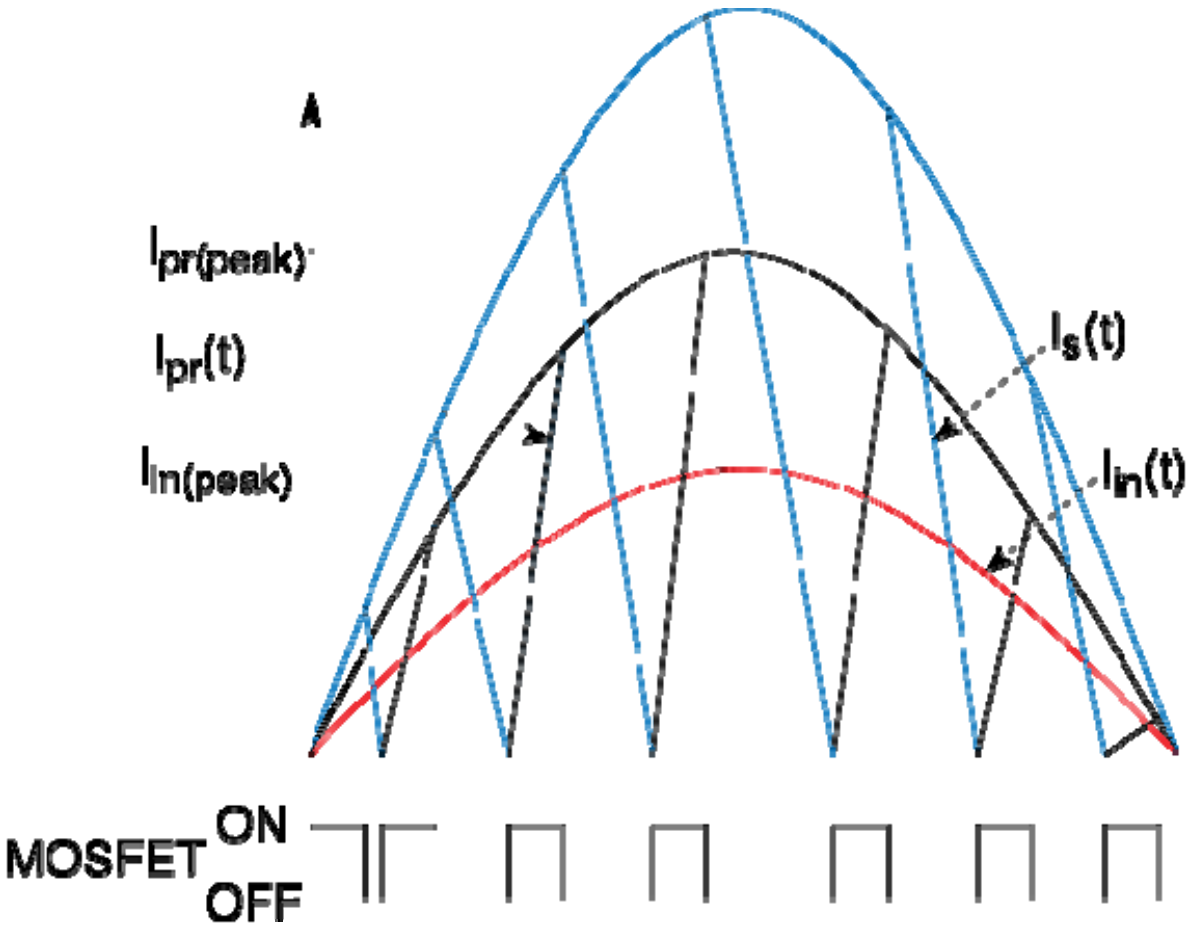
- 使用固定导通时间临界连续导电模式(CrM) 和反激拓扑结构的单级结构实现高功率因数. Design approach to achieve high power factor in a single stage uses a critical conduction mode (CrM) fixed on-time flyback topology

NCL30000基本应用框图

NCL30000 Basic Application Diagram



工作原理
Theory of Operation



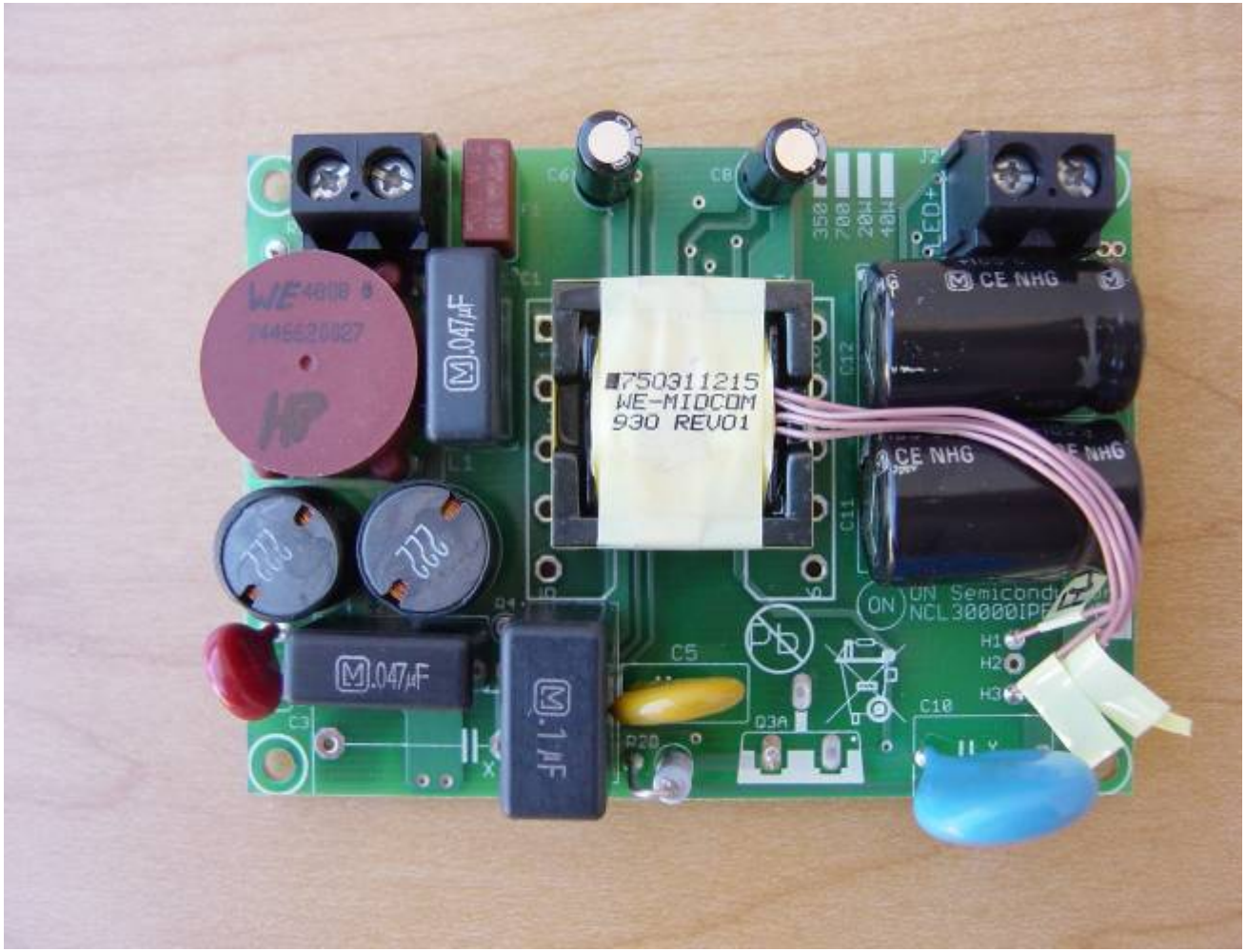
- 固定导通时间控制产生正弦输入电流相位 Fixed on-time control results in sinusoidal input current in phase
- 关键要求 Key Requirements
  - 输入电容必须极低 Input capacitance must be very low
  - 控制带宽必须较低(<20 Hz)，从而在线路周期内维持恒定导通时间 Control bandwidth must be low (<20 Hz) to maintain constant on-time over a line cycle
- 次级反馈用于控制在不同输入电压及负载条件下的导通时间 Secondary feedback controls on-time based on line and load

NCL30000演示板要求
NCL30000 Demo Requirements

- 旨在提供350 mA电流并驱动多个LED(4到15个)的LED驱动器应用。可改变元件支持700 mA或更高输出电流 Intended to supply 350 mA and drive a wide range of LEDs (4-15) LED driver applications. Component selections to support 700 mA or higher output current
- 参考设计功率为小于20 W、电路板能支持更大变压器以用于更大功率的应用
  Reference design is targeting <20 W with this transformer, board can also support larger transformer for higher power
- 方案可扩展用于不同功率等级 Scalable solution for different power levels
  - –115 Vac版本 115 Vac Version - 90-130 Vac
  - –230 Vac版本 230 Vac Version -180-265 Vac
  - –90-305 Vac版本 90 – 305 Vac – 扩展至通用输入范围，支持277 Vac Extended universal included 277 Vac – 无TRIAC控制 no Triac control
- 对于TRIAC调光而言，必须针对特定数量的LED调节导通时间，从而实现最佳的调光性能。默认LED数量是12个 For Triac Dimming, on time has to be adjusted for a specific number of LEDs to achieve best dimming performance. Default is 12 LEDs
- 完善的保护功能 Robust Protection
  - –LED开路保护、短路保护、过载保护 Open LED, Shorted Output, Overload

NCL30000演示板

NCL30000 Demo Board

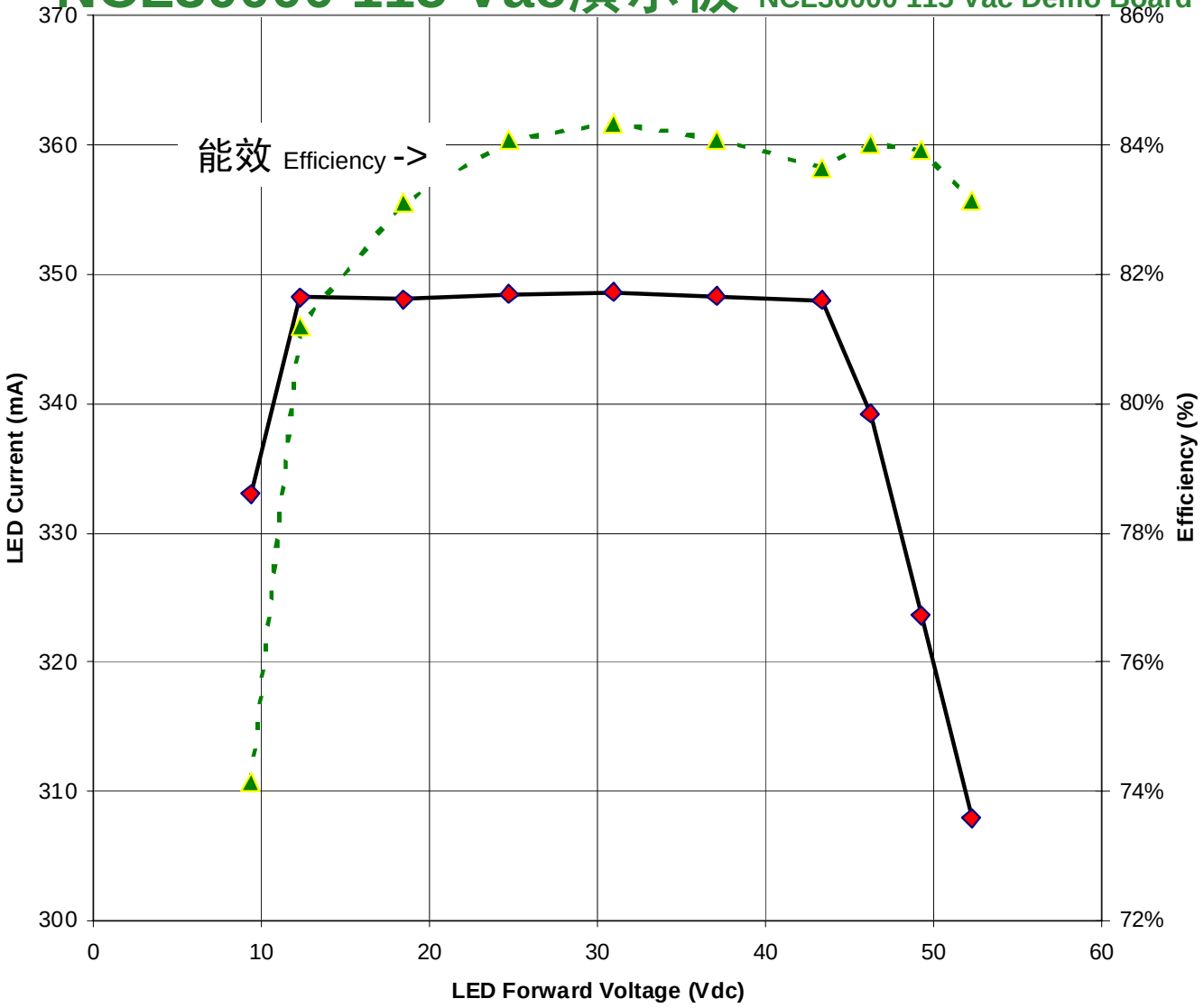


双变压器安装位适合15 W/30 W设计

Dual transformer footprints for 15 W / 30 W Designs

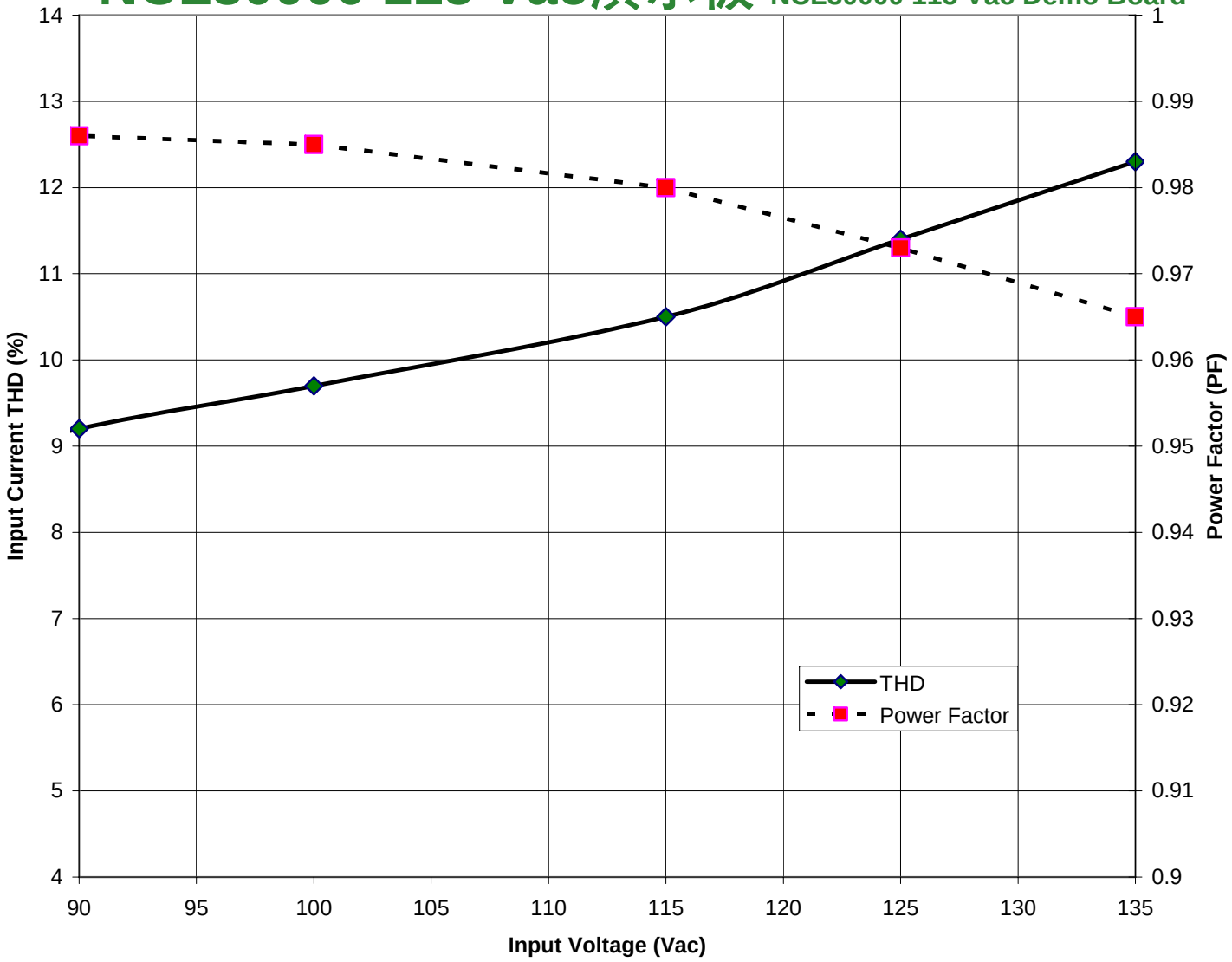
不同负载等级下的能效及电流 Efficiency and Current Regulation versus Load

NCL30000 115 Vac演示板 NCL30000 115 Vac Demo Board



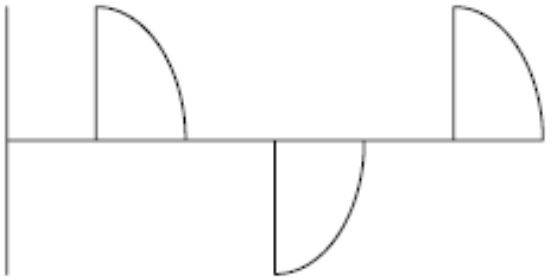
功率因数及谐波失真 Power Factor and Harmonic Distortion

NCL30000 115 Vac演示板 NCL30000 115 Vac Demo Board



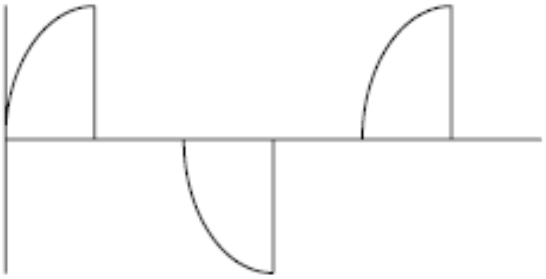
电源线可调光LED驱动器
Line Dimmable LED Drivers

- TRIAC调光器(前沿，后沿)旨在用于阻性负载，连接至电子变压器时工作表现极糟 Triac dimmers (leading edge, phase cut) are intended for resistive loads and tend to behave badly when connected to an electronic transformer



- 某些制造商有“专用”调光器-用于诸如低压轨道照明等应用中的电子变压器 Some manufacturers have “specialized” dimmers –for electronic transformers such as low voltage track lighting

- 对于商业应用而言，还有基于晶体管的调光器，采用下降沿控制(三线连接) Moreover for commercial applications there are also transistor based dimmers that have falling edge control (three wire connection)



Typical voltage waveform of a transistor dimmer

- 住宅及零售应用中常见TRIAC调光 Triac dimming is common in residential and retail application

匹配LED驱动器与调光器
Matching LED Driver to Dimmer

•典型开关电源反馈系统致力于在宽输入电压范围下维持恒定输出，方式是提高占空比或在本案例中是延长导通时间 A typical switch mode power supply feedback system will attempt to maintain constant output over a wide range of input voltage by increasing duty cycle or in this case on time

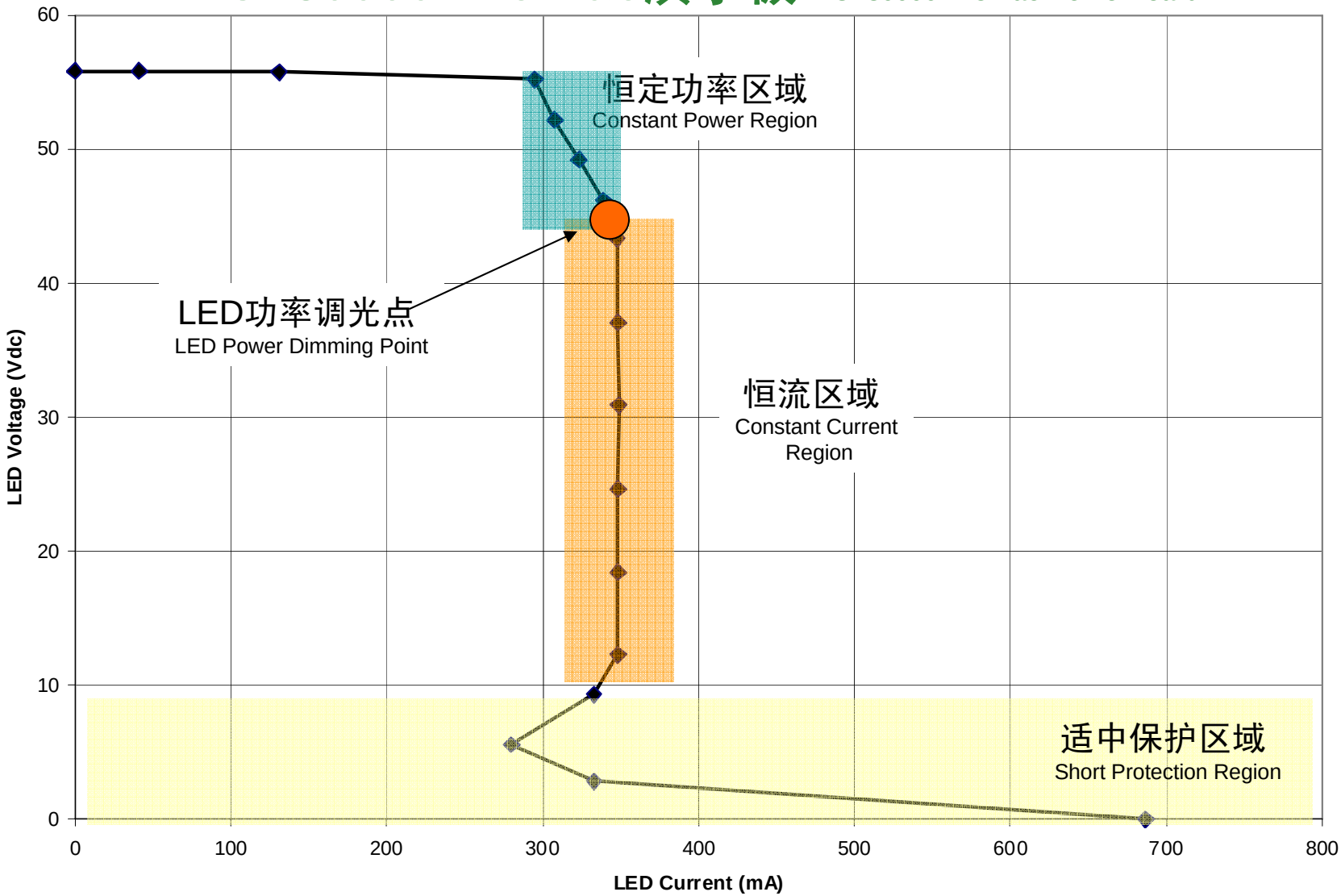
•对于线路调光而言，LED电流应当相对于均方根(RMS)输入电压的降低成比例地下降 For line dimming, LED current should reduce proportionately to reduction of the RMS input voltage

•设定最大导通时间来限制额定LED串的功率 The maximum on time is set to limit the power at the nominal LED string power

•调光期间，控制器将不能增加导通时间，故会以可预期的方式出现自然调光 During dimming, the controller will not be able to increase on time, so natural dimming of the LED occurs in a predictable manner

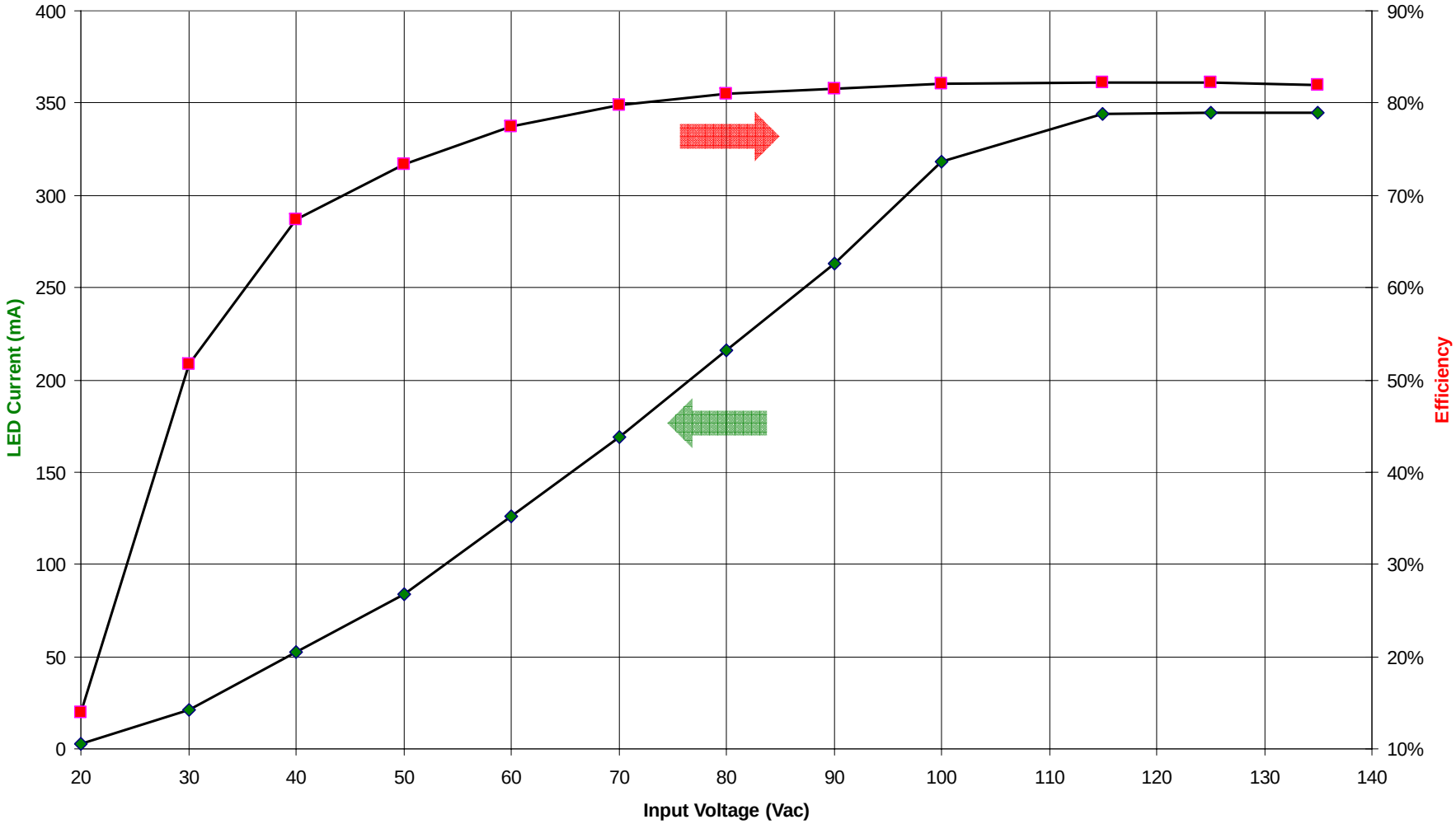
不同负载时的能效与电流 Efficiency and Current Regulation versus Load

NCL30000 115 Vac演示板 NCL30000 115 Vac Demo Board



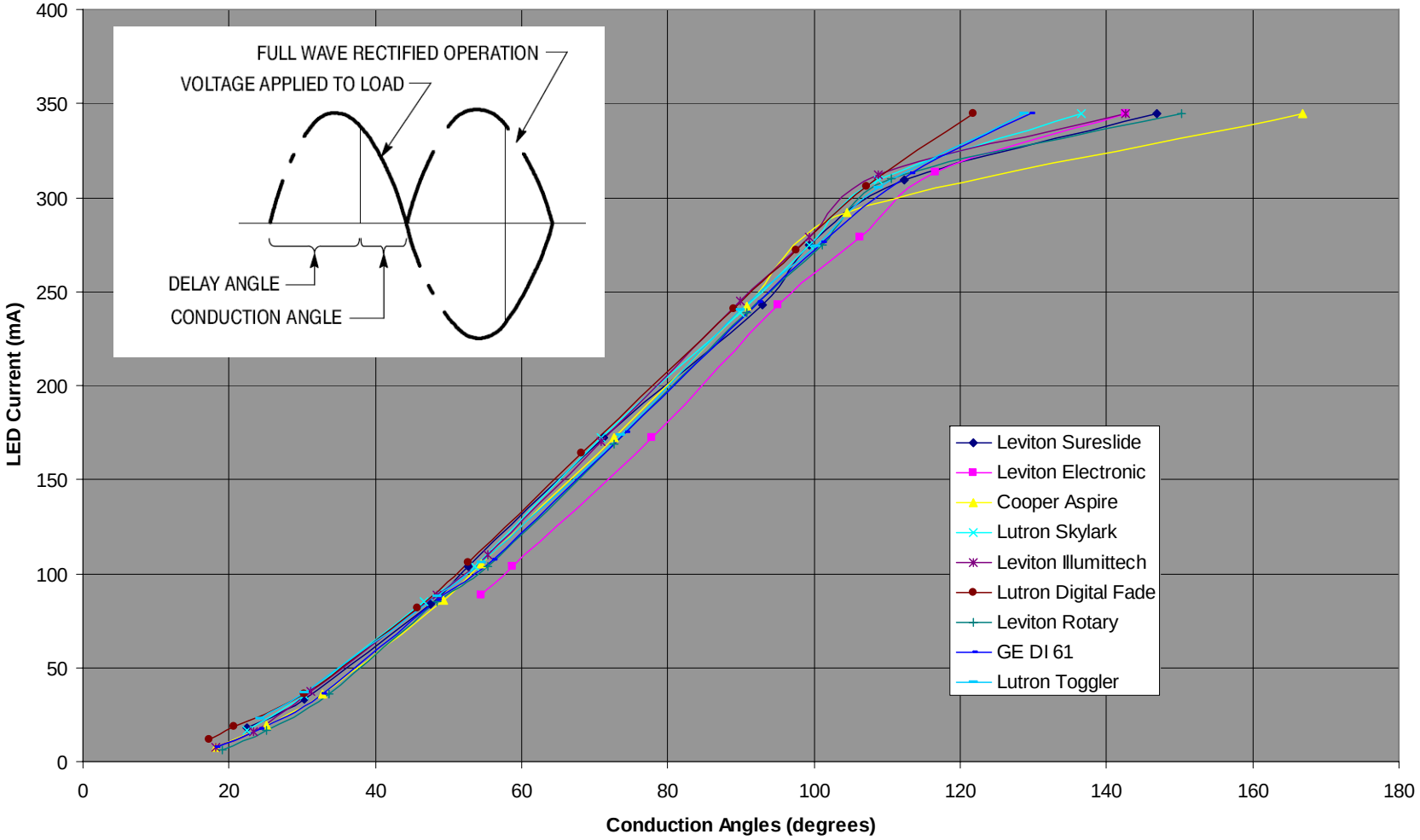
NCL30000 350 mA隔离反激能效和调光测试 Isolated Flyback

115 Vac / 12 LED / TRIAC调光版本 Triac Dimming Version



NCL30000 350 mA隔离反激调光测试 Isolated Flyback

115 Vac线路调光控制-串联12颗LED 115 Vac Line Dimming Control - 12 LEDs in Series

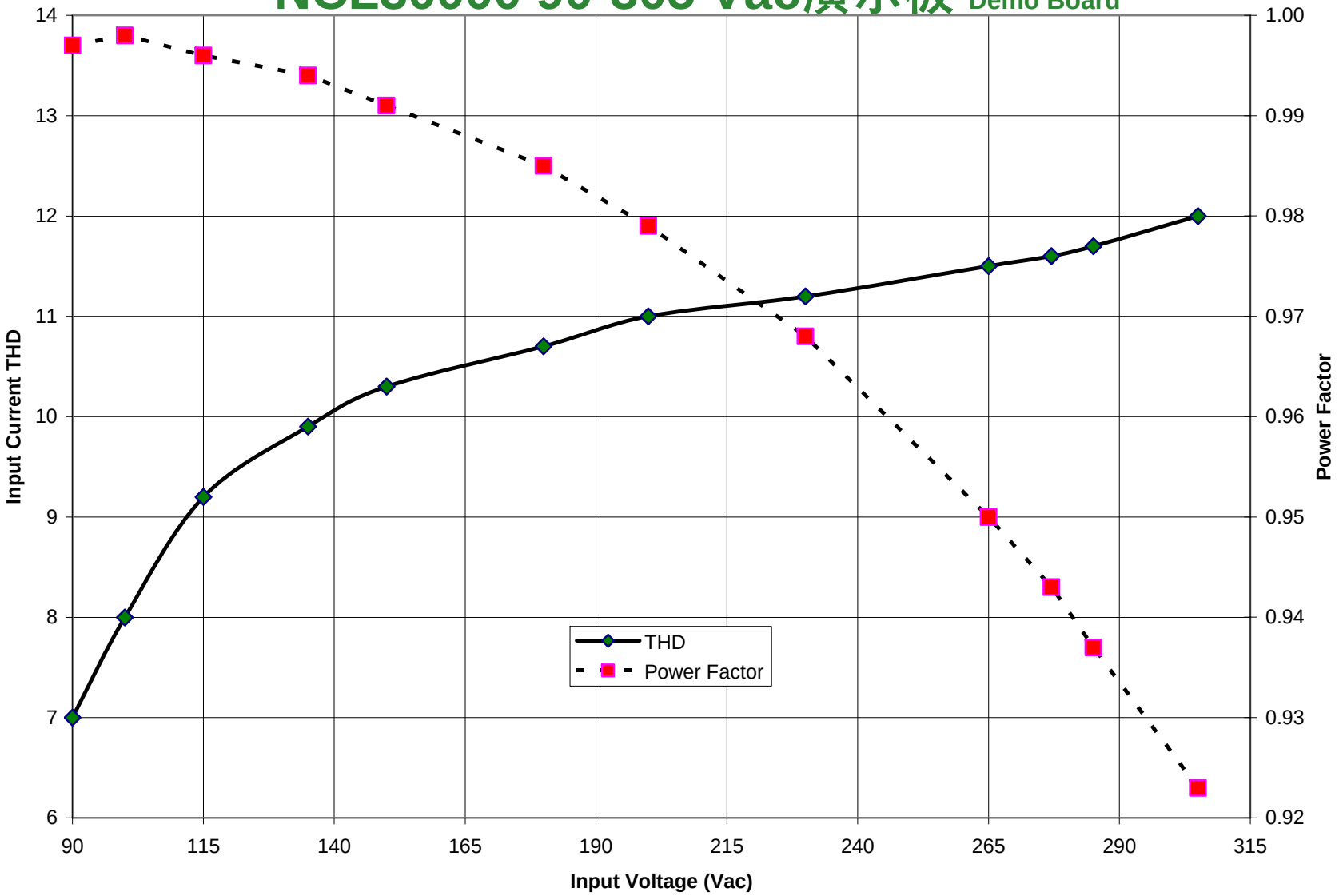


TRIAC及晶体管调光评论
Comments on Triac and Transistor Dimming

- 如图所示，调光范围高度取决于墙式调光器的特性 As illustrated, dimming range is highly dependent on the characteristics of the wall dimmer
- TRIAC调光器原本设计用于白炽灯，且负载比LED灯高很多(高4到5倍) Triac dimmers were originally designed for incandescent lamps and presented a much higher load (4-5x higher) than a LED replacement down-light
- 不利的是，每个制造商的调光器特性都不同 Unfortunately each manufacturer has different dimmer characteristics
- 随着LED照明进军主流应用，我们预计调光器制造商将开始优化他们用于LED应用的产品 As LED lighting enters the mainstream we would expect dimmer manufacturers to start optimizing their products to LEDs

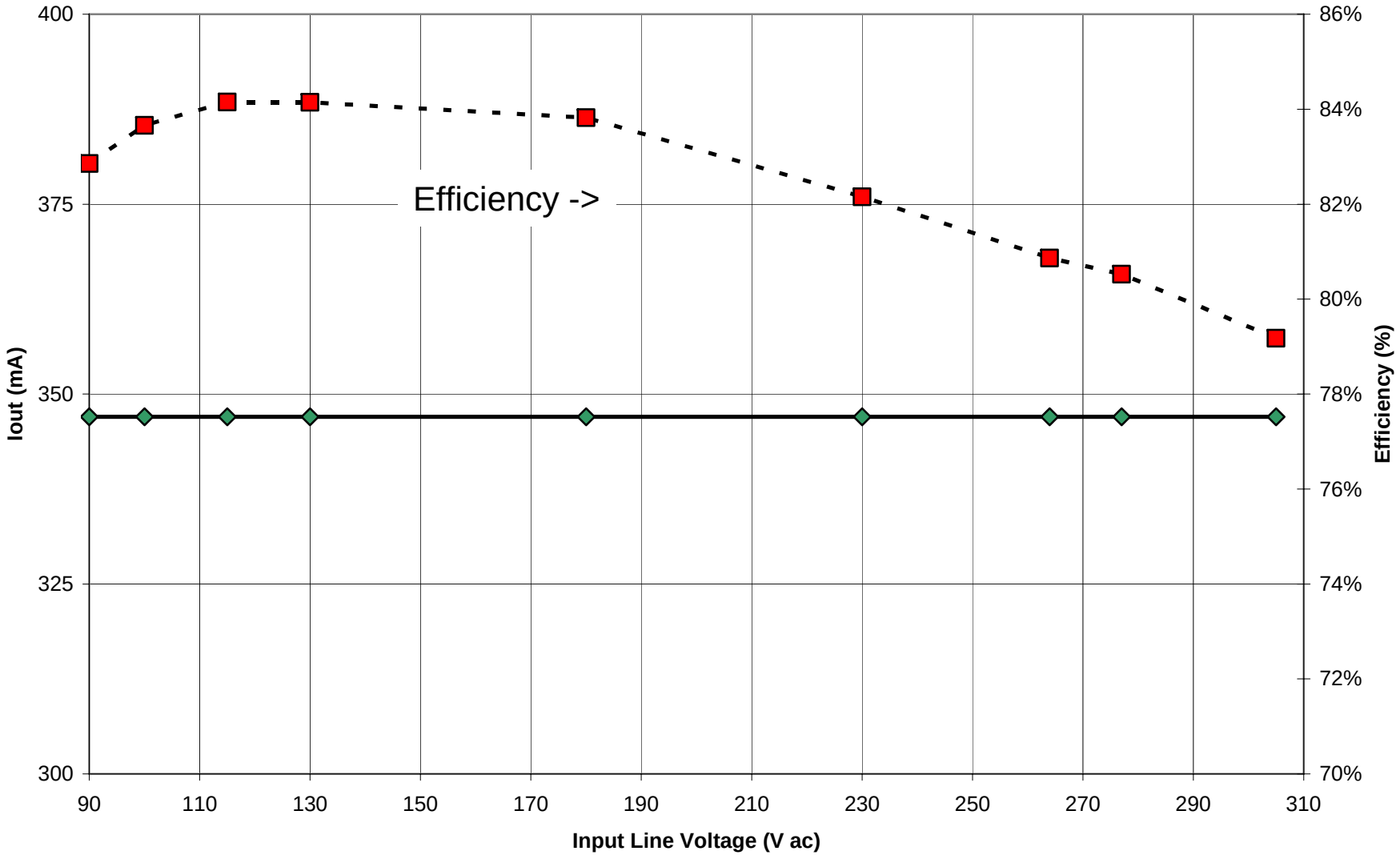
功率因数及谐波失真 Power Factor and Harmonic Distortion

NCL30000 90-305 Vac演示板 Demo Board



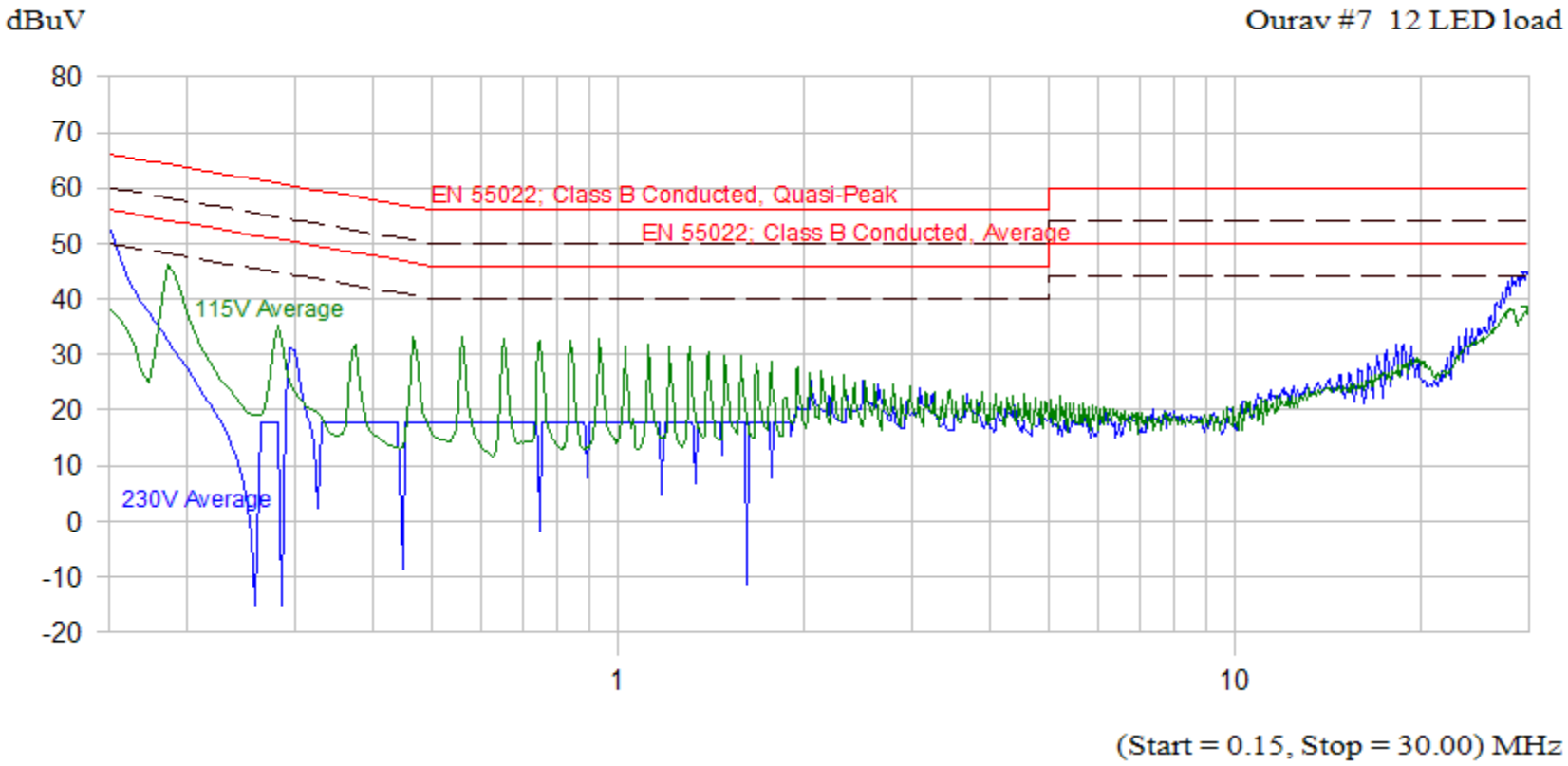
不同负载对应的能效及稳流 Efficiency and Current Regulation versus Load

NCL30000 90-305 Vac演示板 Demo Board (Vout = 12 LEDs, 37 Vdc)

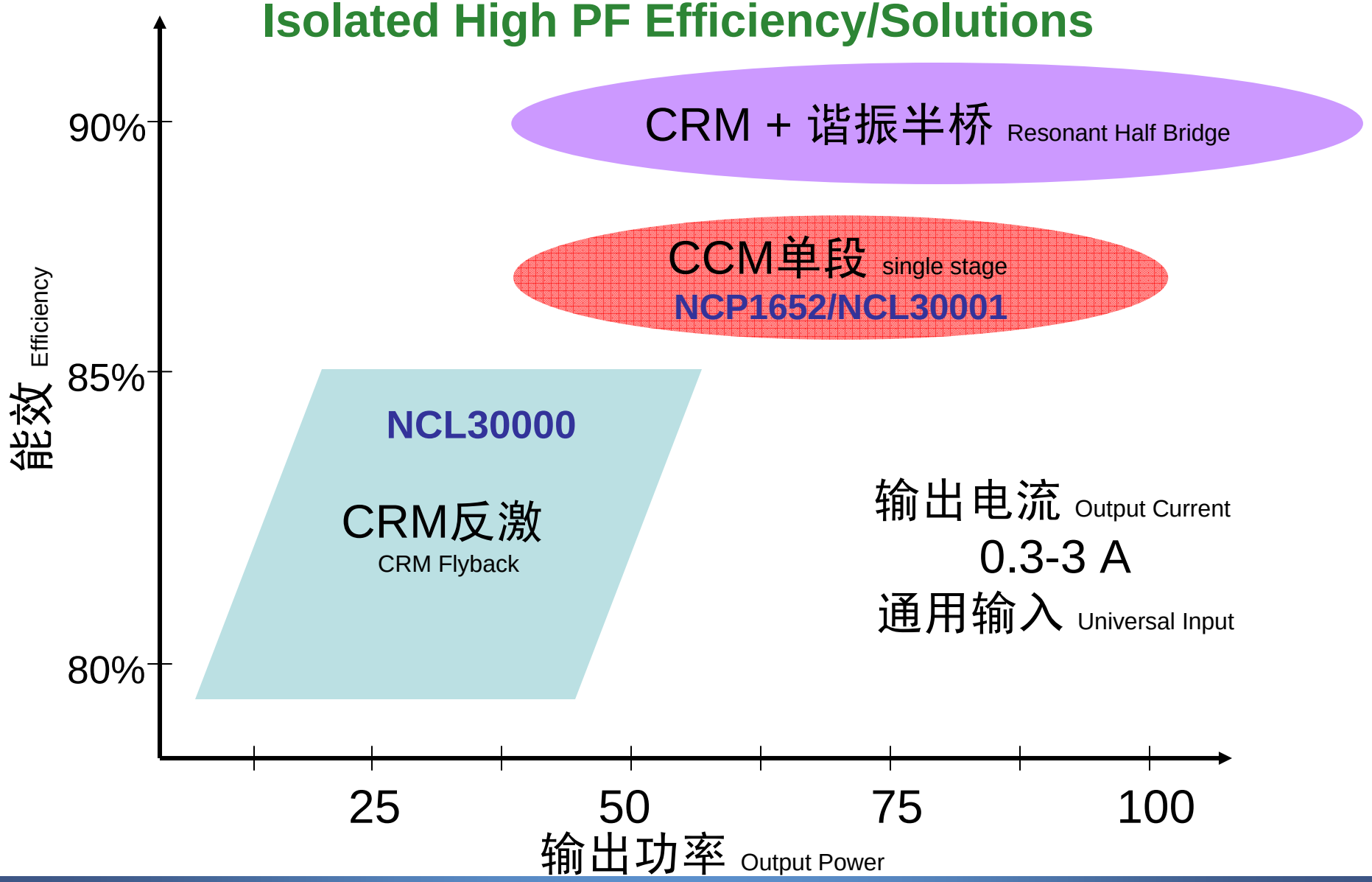


电磁干扰(EMI)性能 EMI Performance

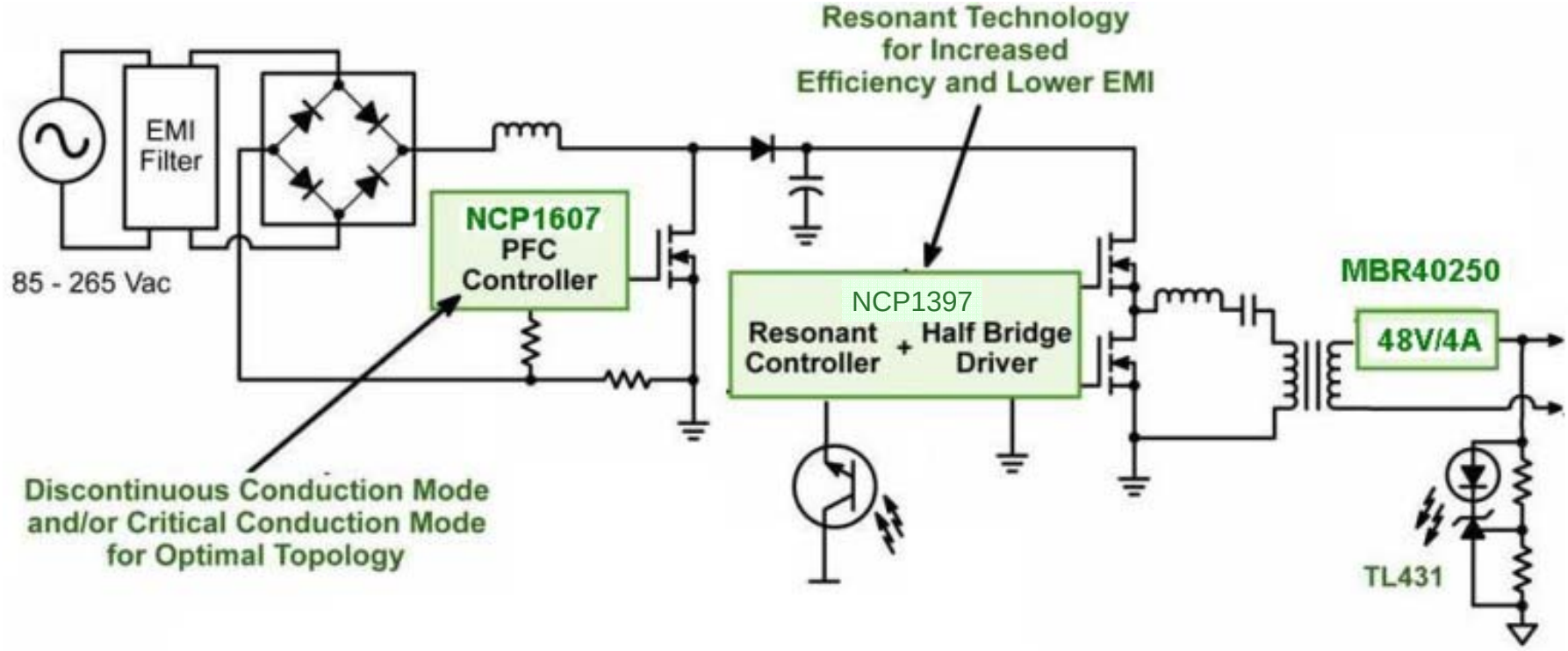
NCL30000演示板(90-305 Vac版) NCL30000 Demo Board (90-305 Vac Version)



不同功率/能效的高功率因数隔离拓扑结构的方案
Isolated High PF Efficiency/Solutions

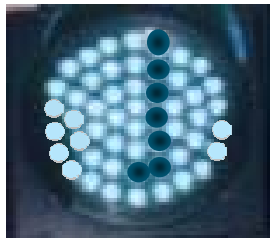


100-200 W CRM/LLC大功率街灯电源方案
100-200 W CRM/LLC High Power Streetlight Supply



5万小时LED寿命固然不错，但… 50k hours of LED life is great but ….

偶尔会有失效 Occasionally there can be failures



产生原因 Caused by. . .

- ✓LED早期失效 LED infant mortality
- ✓装配部分缺陷 Assembly Partial Defects
- ✓瞬态条件 Transients

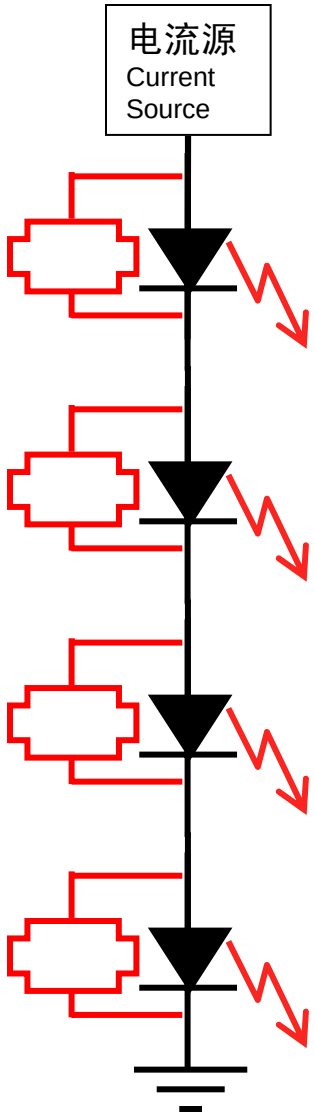
某些应用属于 Some Application Are. . .

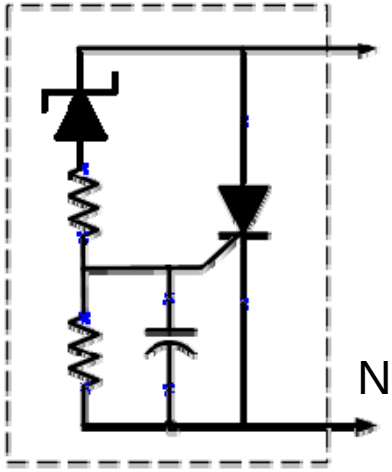
- ✓ 关键应用 Mission Critical
- ✓ 安全悠关 Safety Dependent
- ✓ 难于维护 Difficult Access

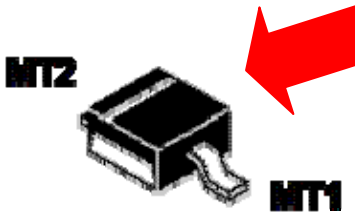
NUD4700 LED分流保护 NUD4700 LED Shunt Protection

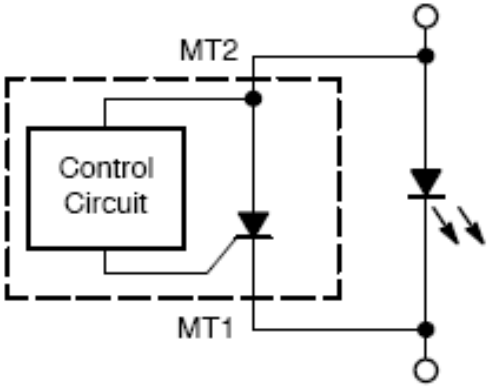
•**发生LED开路故障的事件时保护器件工作** Protects operation in the event of an open LED fault

•**恰当地散热即可支持>1 A电流** Supports up to 1 A with proper heat sinking





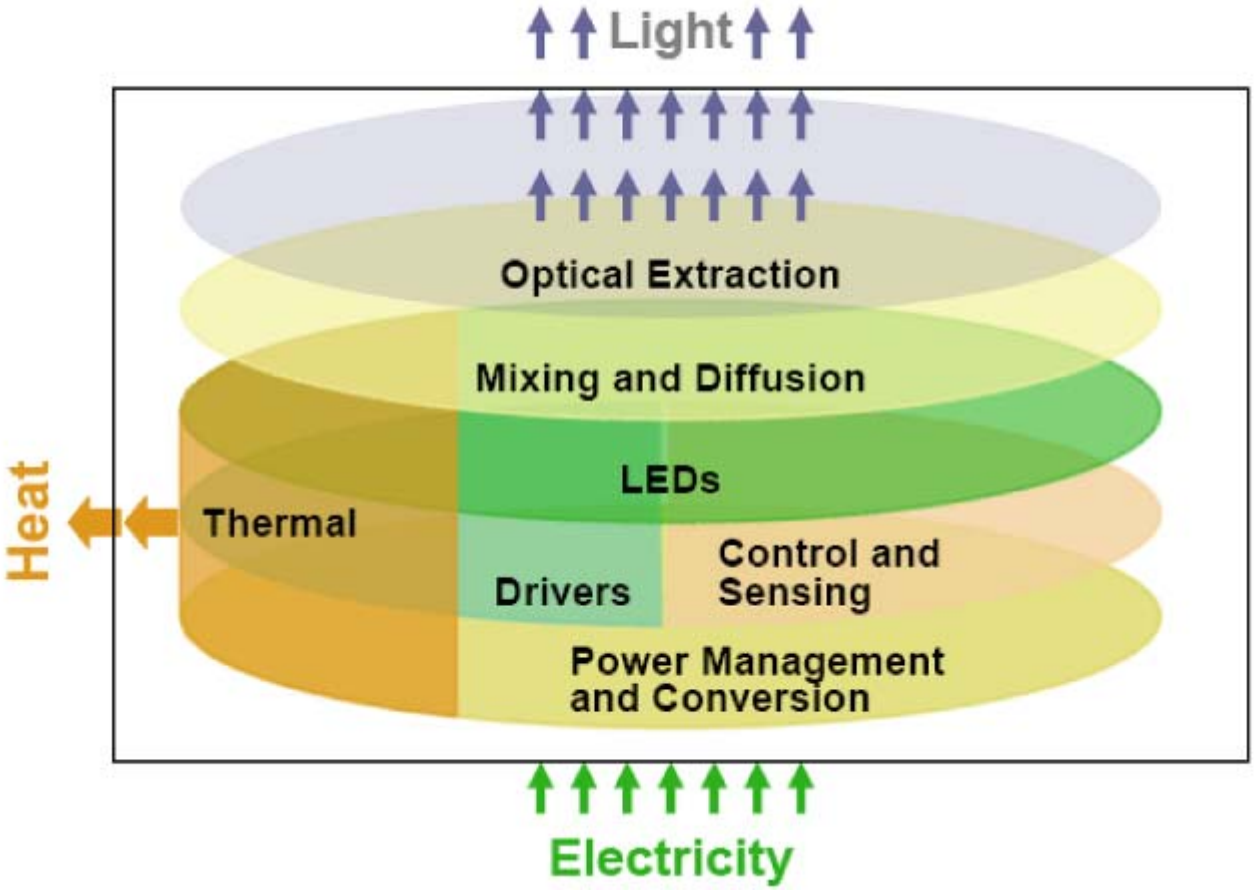




NUD4700采用PowerMite封装
NUD4700 in PowerMite Package

必须以系统途径来设计LED照明

LED Lighting Must be approached as a system



总结 Summary

- 随着新LED的推出，离线LED电源解决方案继续快速演变 Offline LED power solutions continue to evolve in a rapid manner as new LEDs are introduced
- 离线解决方案多种多样，适合不同功率等级、特性及性能 Variety of offline solutions depending on power level, features, and performance
- 安森美半导体提供完整系列的PFC和PWM控制器及转换器，适合宽范围的LED电源应用 ON has a complete portfolio of PFC and PWM controllers and converters to address range of LED power applications
- 访问安森美半导体网站www.onsemi.cn，了解我们针对特定交流线路供电LED应用推出的新参考设计 Visit the ONSEMI website to see what new reference designs are being introduced optimized for specific AC line powered LED applications

For More Information

- View the extensive portfolio of power management products from ON Semiconductor at www.onsemi.com
- View reference designs, design notes, and other material supporting the design of highly efficient power supplies at www.onsemi.com/powersupplies