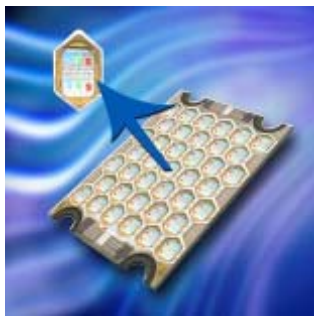
Selection. Service. Support.

ON Semiconductor®

LED Lighting Solutions





Agenda

- LED Lighting Category
- AC-DC LED Solutions
- DC-DC LED Solutions
- Torch LED Solutions
- Summary

LED Lighting Category

1. AC-DC LED Solutions

   PAR bulbs for E14, E27 specification, down light, desk lamp, street lighting

2. DC-DC LED Solutions

   MR11, MR16, DC-DC part of street lighting

3. Torch LED Solutions

   Low voltage, low power Boost / Buck Drivers

LED Bulb

3 W PAR16

3x2 W PAR20

10 W PAR30

15 W PAR30

15 W PAR38

22 W PAR38

1 W G13

3 W GU10

1 W MR11

3 W MR16

3 W Down Light

9 W Down Light

15 W Down Light

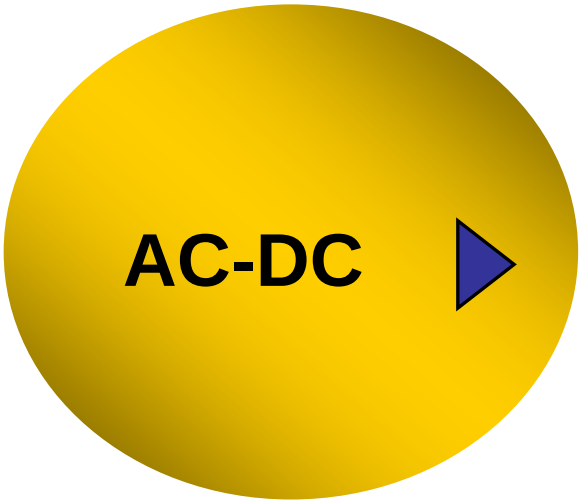
1 W LED Reading Lamp

100 W LED Street Light

Agenda

- LED Lighting Category
- AC-DC LED Solutions
- DC-DC LED Solutions
- Torch LED Solutions
- Summary

AC-DC Lighting Solutions



G13/GU10/PAR16/PAR20(1 W-8 W)

PAR30/PAR38/Down Light(8 W-25 W)

Area Lighting(50 W-150 W)

Area Lighting(100 W-300 W)

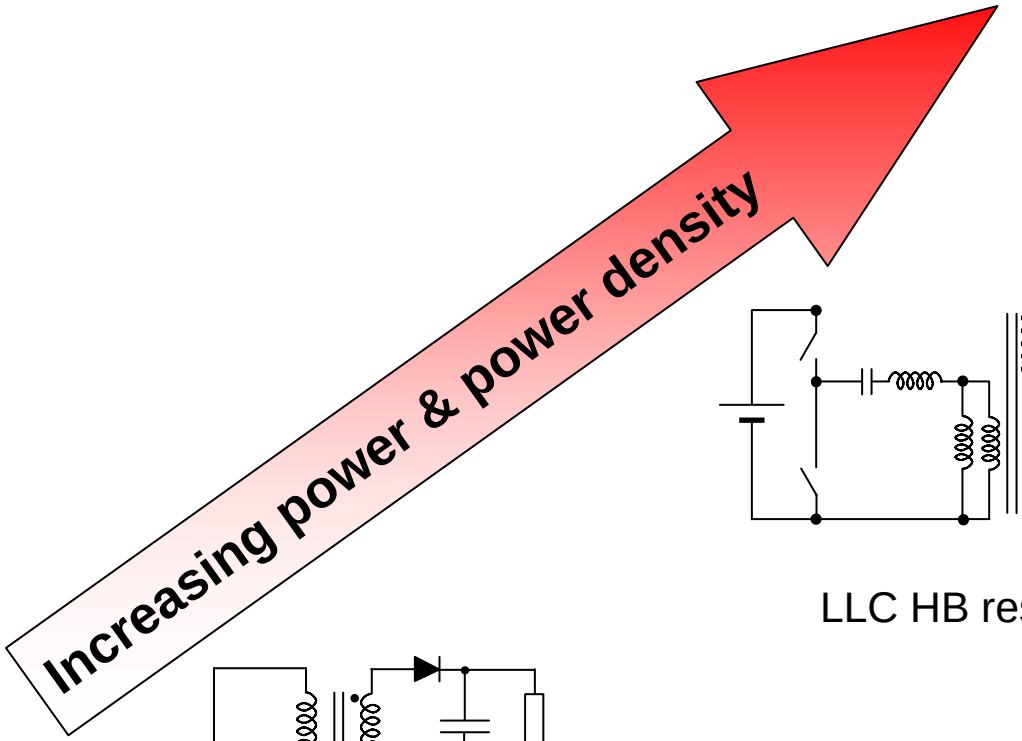
What Solutions We Can Offer

- ON Semiconductor provide a wide range of LED drivers and PFC controllers for LED lighting
- Various LED applications solutions for isolated and non isolated design requirements
- Single stage and two stages PFC controllers for those applications requiring harmonic content (IEC61000-3-2) and power factor
- Focus of 2009 product development:

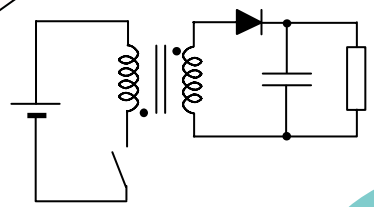
  Various high efficiency complete AC-DC and DC-DC solutions

  Various high efficiency TRIAC dimmer control solutions

Isolated Topology by Power Range



LLC HB resonant topology

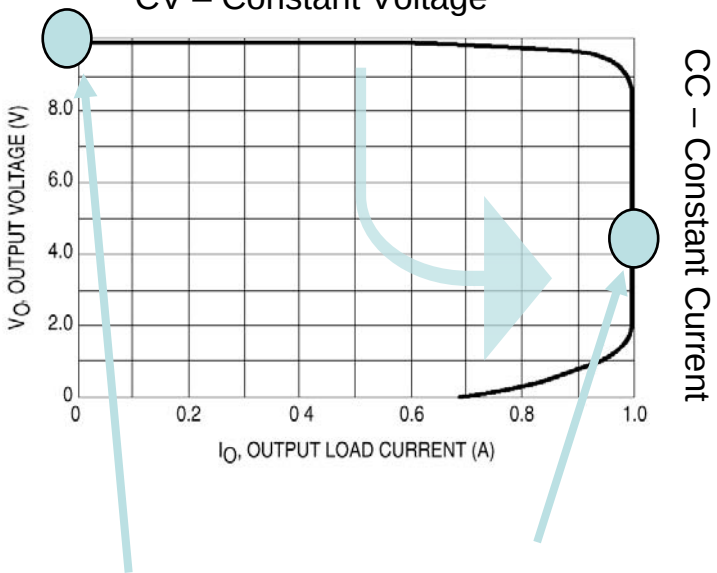


flyback

Flyback is the standard choice for Low-medium power <100 W and LLC is best choice for highest efficiency

Low Power LED Driver Characteristics

CV – Constant Voltage



CC – Constant Current

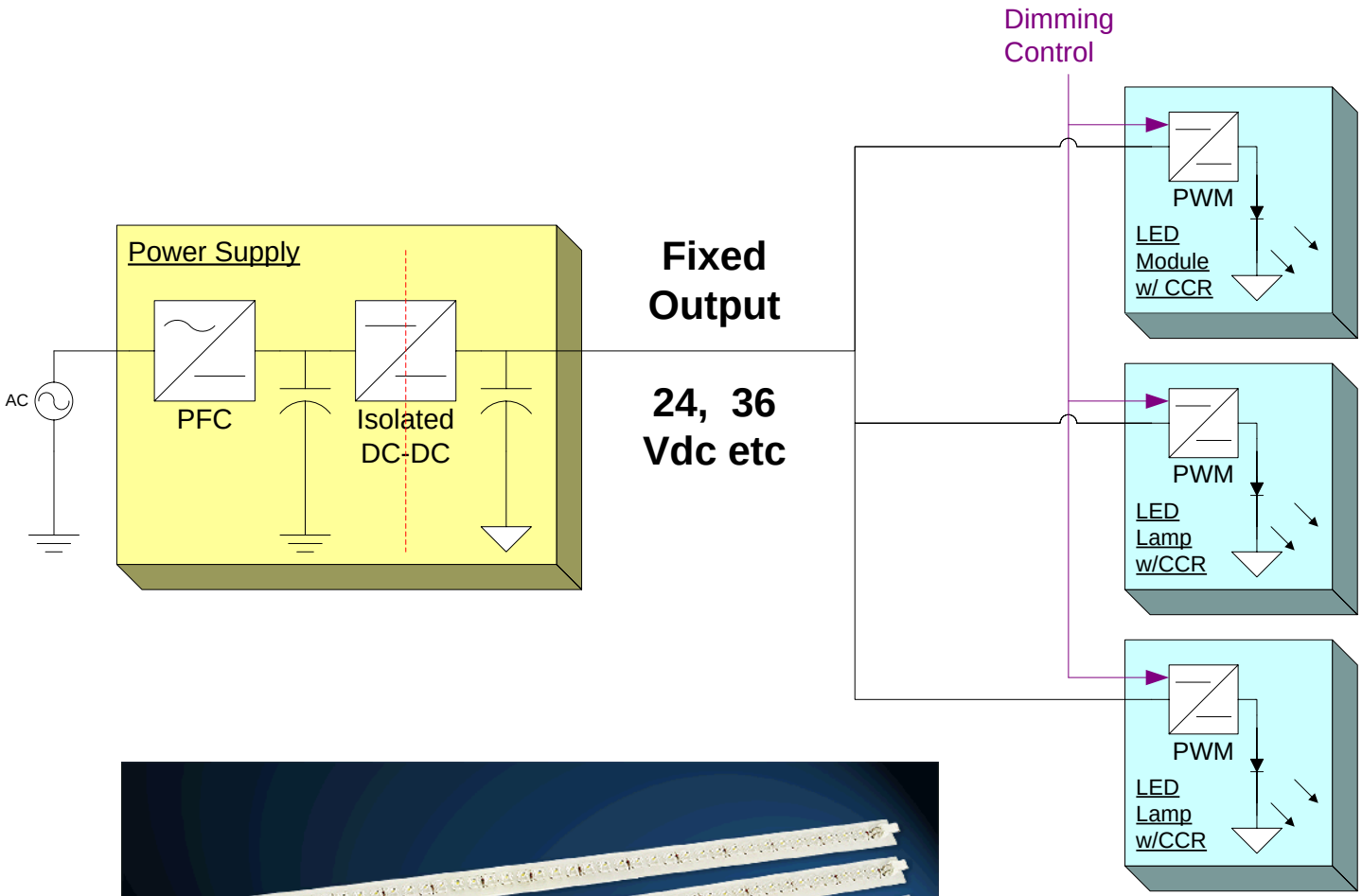
Output is voltage clamped across a range of current

•Output can be designed to have tight current limited

•The output voltage depends on the LED forward voltage

- Power supplies for low power LED normally operates as Constant Current (CC) output
- A constant voltage (CV) output protects the circuit when open circuit

Example of a Distribution LED Configuration



1 W-8 W Application Requirement

Specifications:

- Input voltage: 90V~264 Vac(LL/HL)
- Power range:1 W-8 W
- Efficiency: 80%
- Protection: short circuit& overvoltage
- Constant current: 350 mA; 700 mA

Applications:

- G13/GU10/PAR16/PAR20/Downlight

Supporting Document:

- DN06027/D; DN06051/D; AND8328-D

Product: NCP1015

NCP1015 – Self-supplied Monolithic Switcher

Value Proposition

NCP101X series offers everything needed to build a rugged and low-cost power supply. It integrates a fixed-frequency (65-100-130 kHz) current-mode controller and a **700 V MOSFET**.

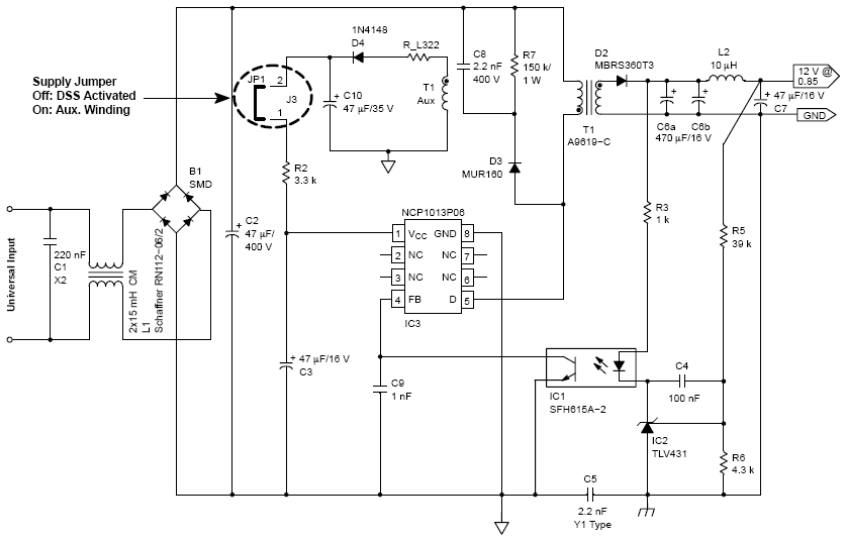
Unique Features

- 22Ω & 11Ω Rdson
- I peak from 100 to 450 mA
- Skip mode
- **Internal HV start-up featuring Dynamic Self Supply (DSS)**

Benefits

- Broad type of applications
- Improved efficiency in light load
- Clean & loss less start-up sequence, less components

Application Data



8 W/15 W Universal Mains Adapter

Others Features

- Short circuit protection Independent of the aux. winding when the DSS is used
- Soft start: 1 ms
- **Internal switching frequency: 65, 100 and 130 kHz**
- **Frequency jittering when the DSS is used**

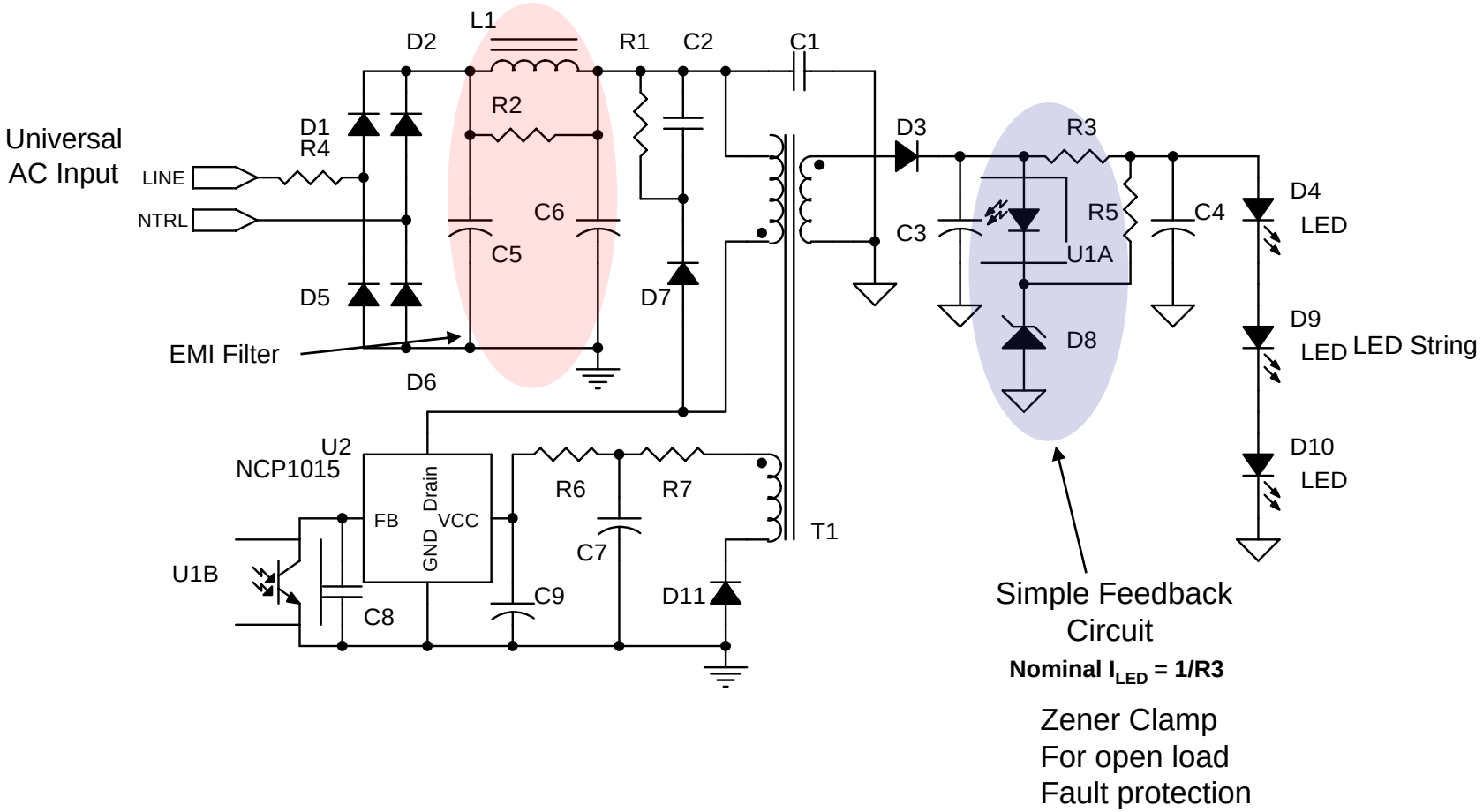
Market & Applications

- **Low power AC-DC LED driver**
- Low power AC adapters
- Auxiliary / standby PSU for desktop and flat TVs
- Low Power Open frame (DVD, STB)
- White goods / E meters

Ordering & Package Information

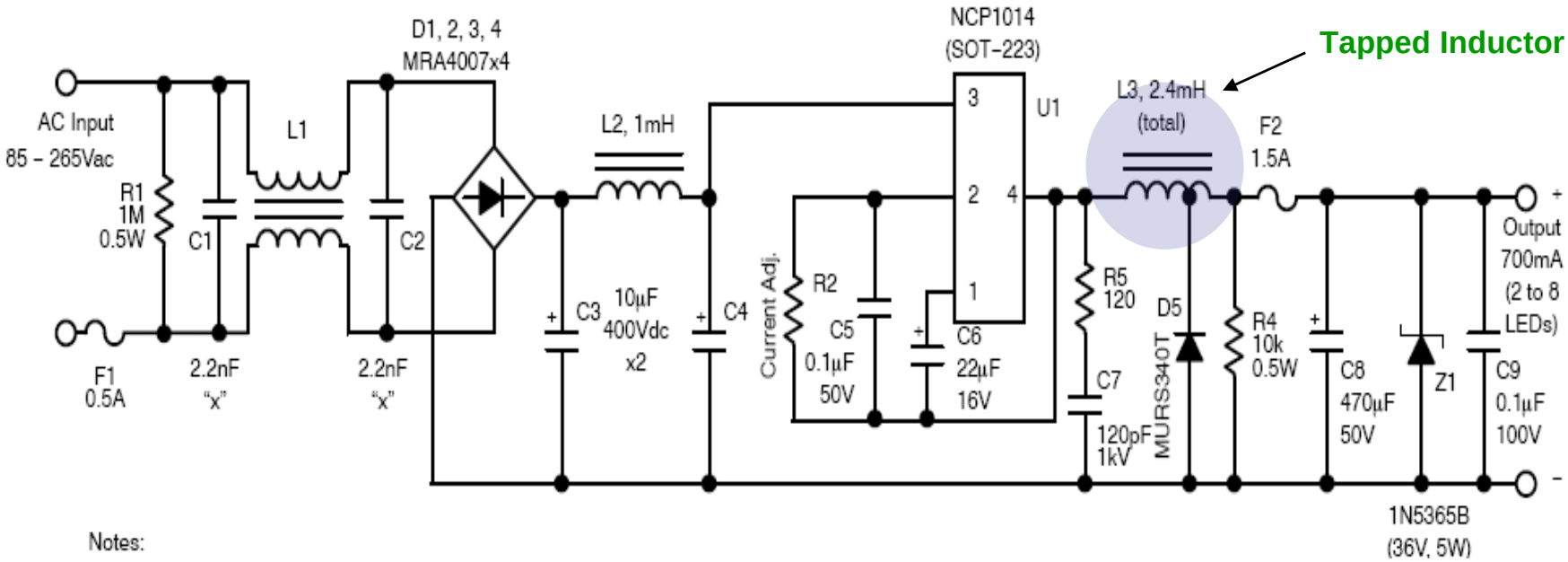
- SOT223, PDIP7 and SMD PDIP7

1 W-8 W Solution Using NCP1015 (Isolated)



NCP1015 8 W @ 85-264 Vac

1 W-8 W Solution Using NCP1015 (Non-Isolated)



NCP1015 1-8 W @ 85-265 Vac

8 W-25 W Application Requirement (without PFC)

Specifications:

- Input voltage: 90~132 Vac or 185~264 Vac (or universal line)
- Power range: 8 W-25 W
- Efficiency: 80%
- No PF requirement
- Protection: short circuit& overvoltage
- Constant current: 350 mA; 700 mA; 1 A

Application:

- PAR30/PAR38/Downlight

Supporting Document:

- DN06006/D; DN06040/D; DN06050/D

Product: NCP1028/NCP1351

NCP1028 – Enhanced Monolithic Switcher

Value Proposition

The NCP1028 offers a new solution targeting output power levels from a few watts up to **15 W** in a universal mains flyback application.

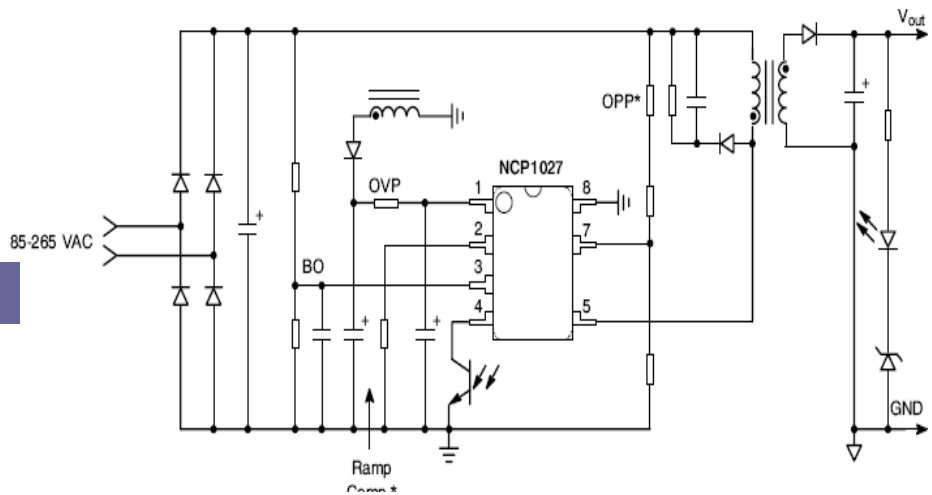
Unique Features

- 5.8 Ω Rdson
  I peak: 800 mA
- Skip mode
- **Short circuit protection**

Benefits

- Broad type of applications
- Improved efficiency in light load
- Independent of the aux winding

Application Data



15 W/25 W Universal Line

Others Features

- **Internal HV start-up**
- Soft start: 1 ms
- Internal switching frequency: 65 & 100 kHz
- **Over Power Compensation**
- **Internal ramp compensation**
- Latch input PIN
- **Brownout protection against low mains**

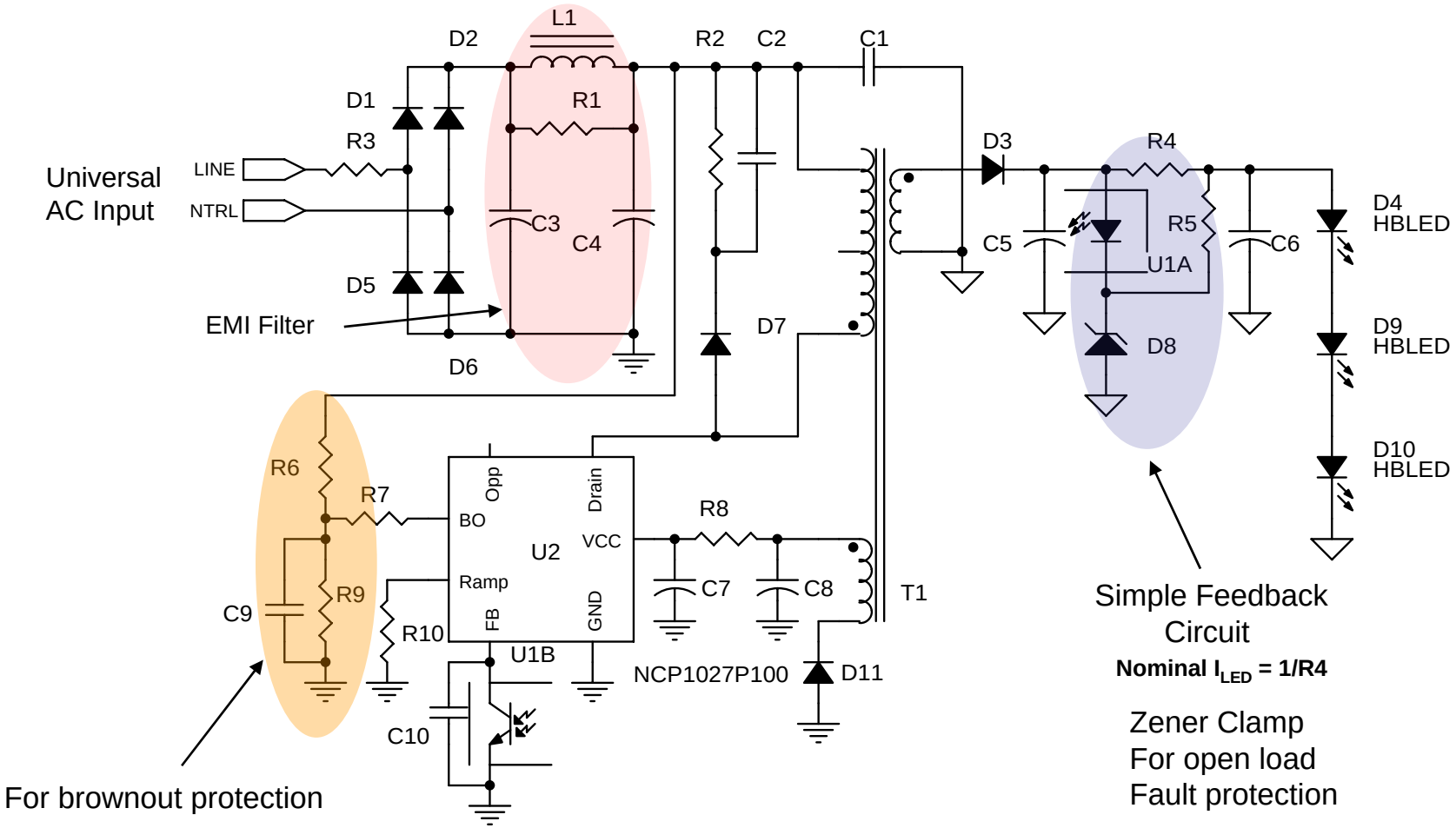
Market & Applications

- Medium power AC adapters
- Auxiliary / standby PSU for desktop and flat TVs
- Low Power Open frame (DVD, STB)

Ordering & Package Information

- NCP1028P065G & NCP1028P100G PDIP7

8 W-15 W Solution Using NCP1028



NCP1028 15 W @ 90-264 Vac

NCP1351 – Fixed On Time Controller

Value Proposition

The NCP1351 is a current-mode controller targeting low power off-line flyback Switched Mode Power Supplies (SMPS) where total cost is of utmost importance

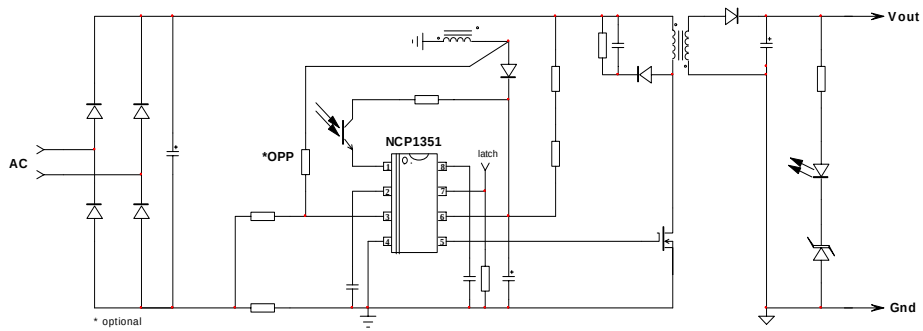
Unique Features

- **Quasi fixed Ton, variable Toff**
- **Frequency foldback** with Peak Current Compression
- Short circuit protection (latched A & C or auto-recovery B & D)

Benefits

- Natural frequency foldback
- Noise free & improved efficiency in light load
- Independent of the aux. winding

Application Data



Simple and compact design

Others Features

- C and D options accommodate large output power transients (printers)
- Primary or secondary side regulation
- **Latch input**
- Low start-up current
- **Natural frequency jittering**
- **Negative current sensing with programmable current sense resistor**
- **Extended Vcc range: 28 V**

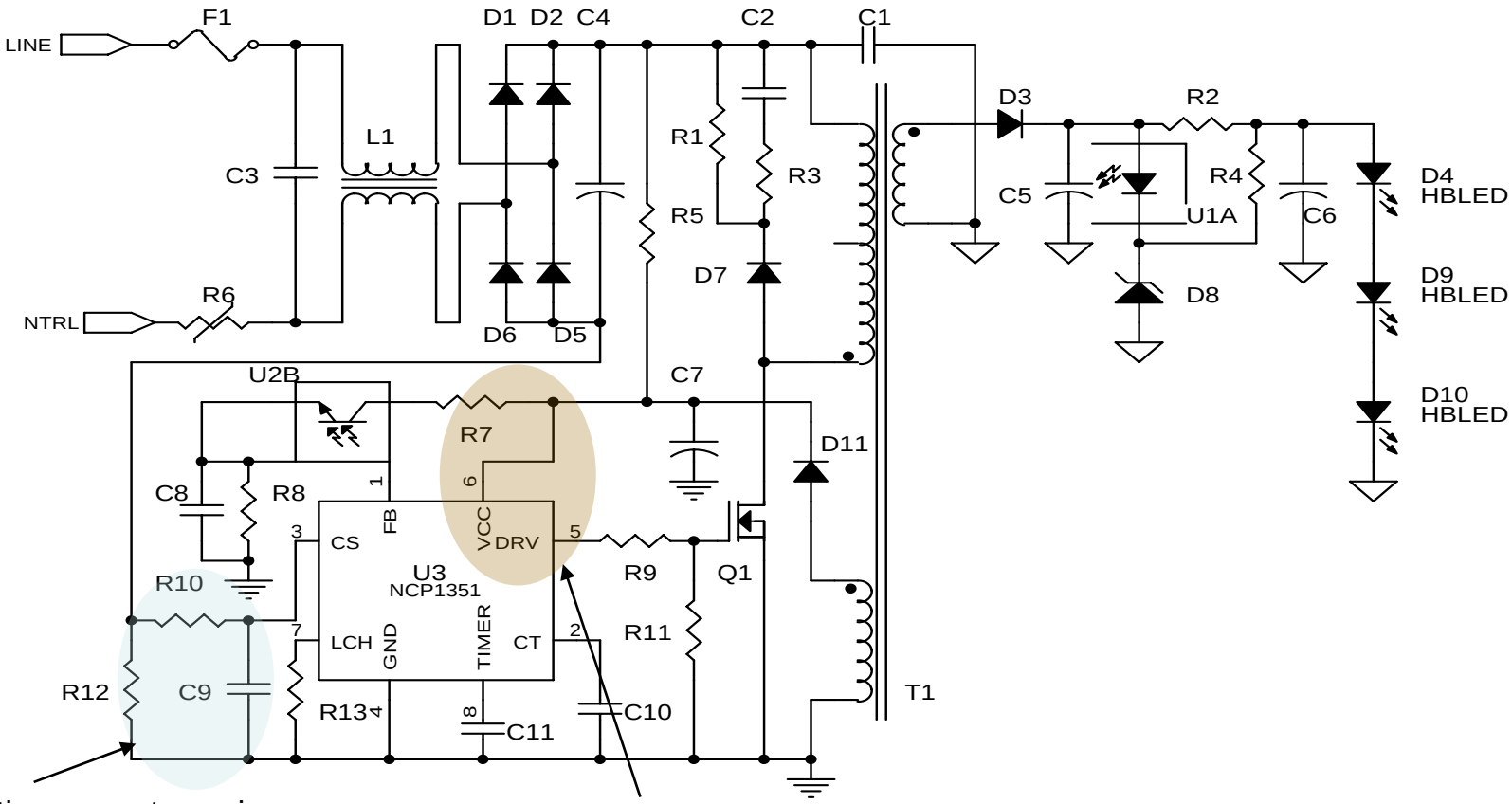
Market & Applications

- **LED Power Supplies**
- Offline Adapters

Ordering & Package Information

- NCP1351XDR2G: SOIC8
- NCP1351XDR2G: PDIP8
- X = A, B, C ,D

8 W-25 W Solution Using NCP1351



Negative current sensing to improve the efficiency

Wide Vcc range to 28V

NCP1351 25 W @ 90-264 Vac

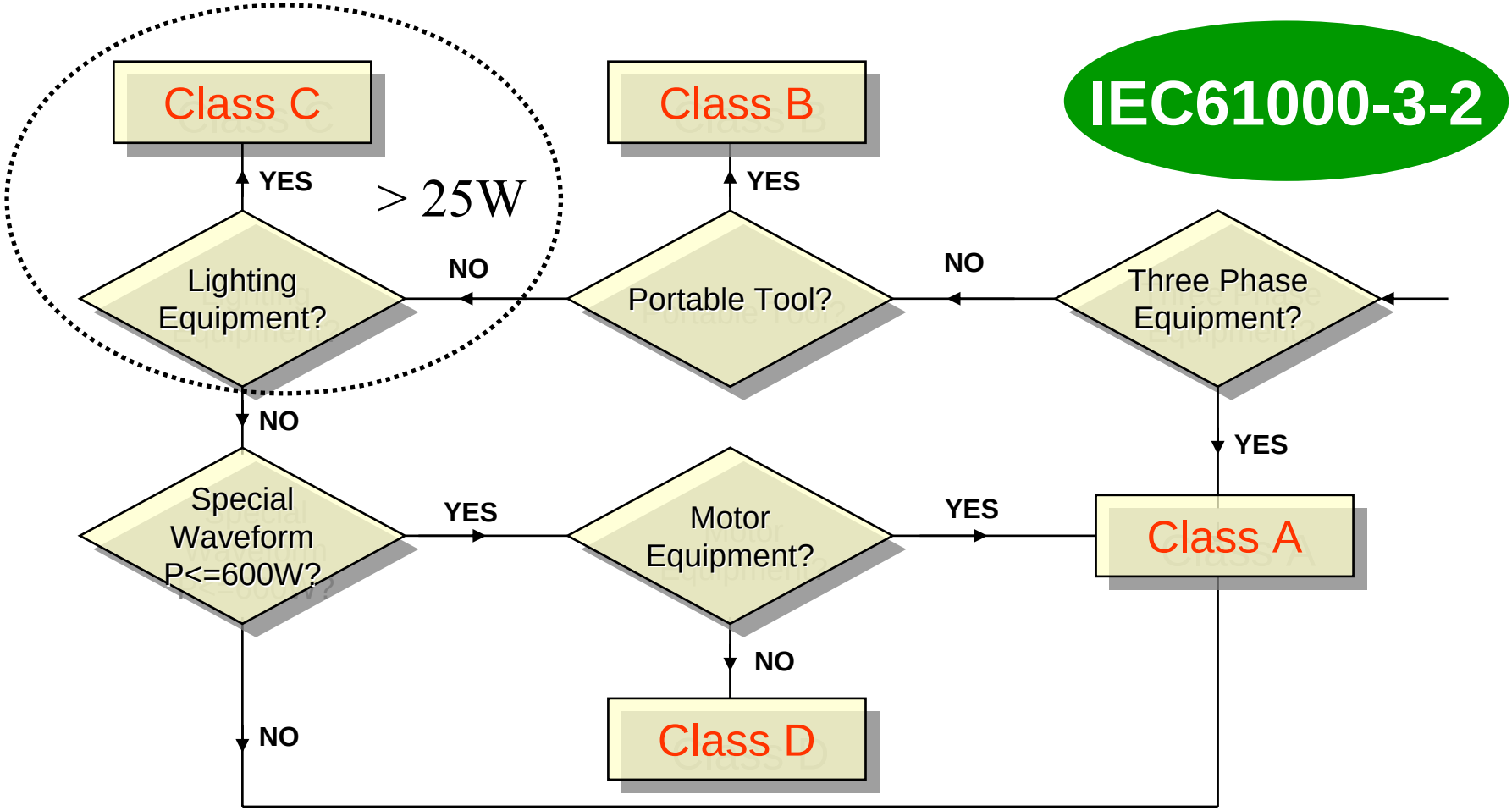
Does the LED Driver need Good PF?

- IEC (EU) requirements dictate THD performance for Lighting (over 25 W), other international standards apply depending on the region

- US DOE ENERGYSTAR™ 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, undercabinet lights and desk lamps for example
  - >0.7 for residential applications
  - >0.9 for commercial applications

- While not absolutely mandated in the for lighting in all countries, it may be required based on the application:
  - Utilities drive major commercial uses to have high PF at the facility level
  - Moreover when utilities owns/service the streetlight it is in their interest to have good power factor, typically > 0.95+

Harmonic Content Standards (PF)



8 W-25 W Application Requirement (with PFC)

Specifications:

- Input voltage: 90 V~264 Vac (LL/HL)
- Power range:8 W-25 W
- PF:>0.9
- Efficiency: 80%
- Protection: short circuit & Overvoltage
- Constant current: 350 mA; 700 mA; 1 A

Application:

- PAR30/PAR38/Downlight

Product: NCP1607/8

NCP1607 – Cost Effective PFC Controller

Value Proposition

The NCP1607 is a **Critical conduction Mode** (CRM) power factor controller specifically designed for use as a pre-converter in electronic ballast, ac adapters and other low to mid power off-line converters (typically up to 250 W)

Unique Features

- Pin to pin compatible with industry standards
- **Adjustable Over Voltage Protection with low current level options (OVP)**
- **Open loop protection**

Benefits

- Reduce design efforts
- Design flexibility & rugged design, NCP1607B further reduces losses
- Rugged design

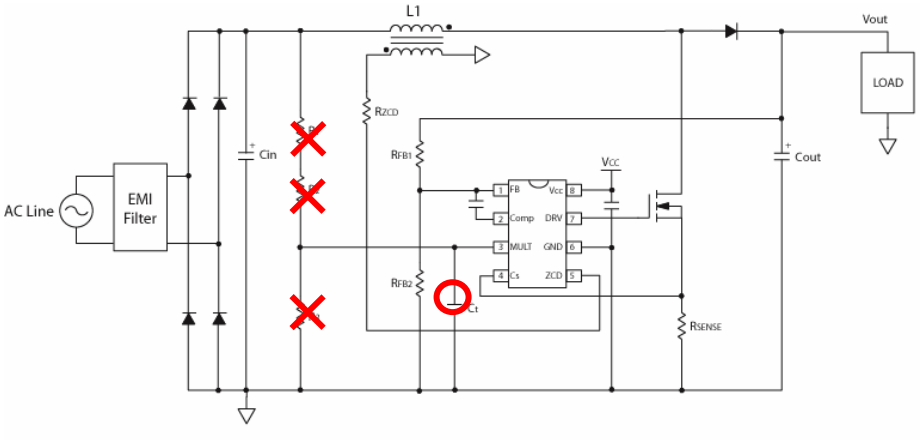
Others Features

- High Precision Voltage Reference (±1.5% over the VCC and Temp. ranges)
- **Built-in OCP with 2 voltage thresholds options**
- Inhibition capability
- Less than 50 µA start up current
- Drive capability 500/ 800 mA (source/sink)

Market & Applications

- Electronic Light Ballast
- AC adapters
- **LED Power Supplies/Drivers**

Application Data

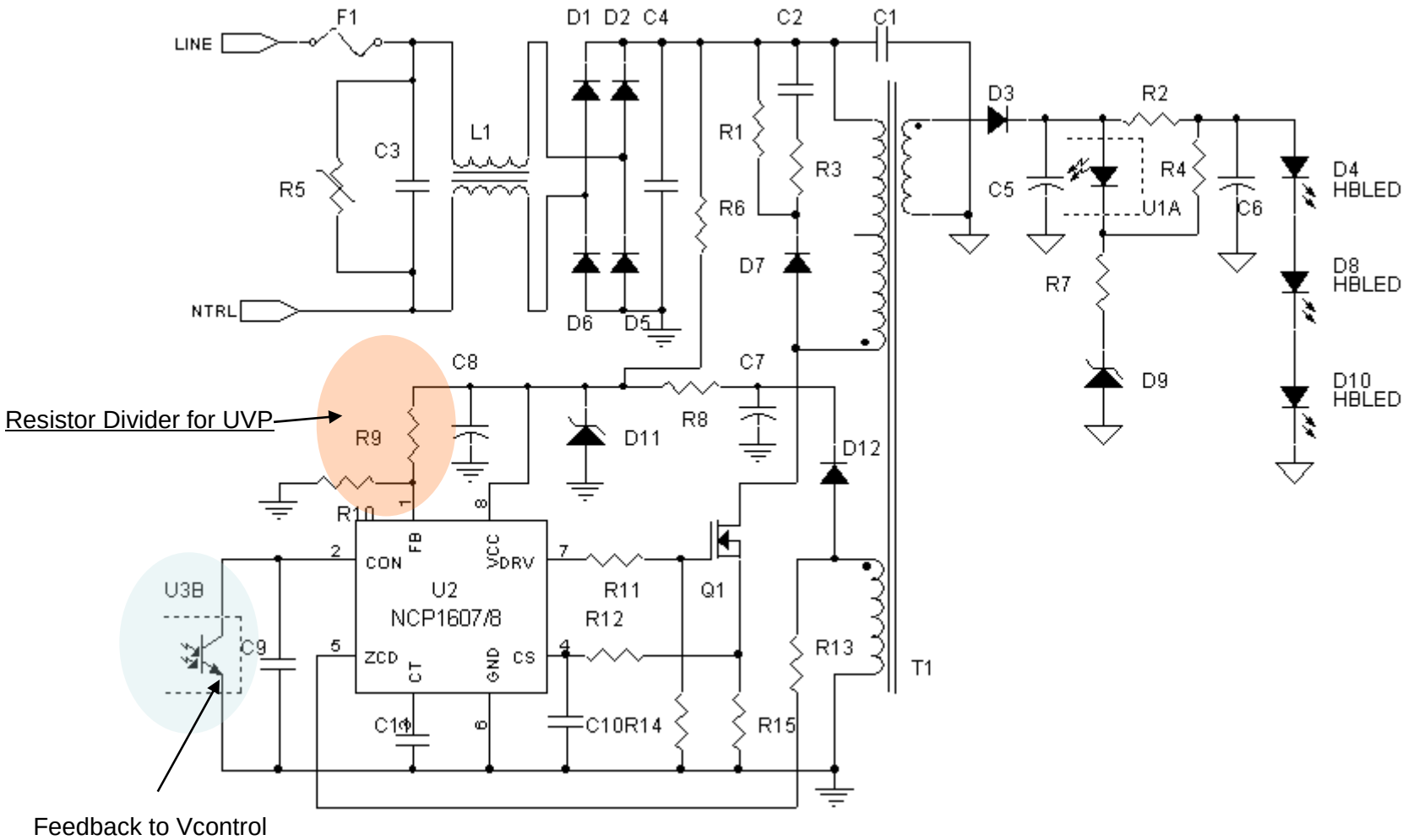


- **3 resistors to remove / adjust**
- **Ct cap value to adjust**

Ordering & Package Information

- NCP1607BDR2G: SOIC-8

8 W-25 W Solution Using NCP1607/8



NCP1607/8 25 W @ 85-135 Vac or 185-264 Vac

50 W-200 W Application Requirement

Specifications:

- Input voltage: 90 V~264 Vac(LL/HL)
- Power range:50 W-150 W
- PF:>0.9
- Efficiency: 85%
- Protection: short circuit& overvoltage
- Constant current: 350 mA; 700 mA; 1 A

Applications:

- Street lighting
- High power area lighting

Products: NCP1652
NCP1607/8 + NCP1377
NCP1607/8 + NCP1396
NCP1901

NCP1652 – Improved Single Stage PFC

Value Proposition

NCP1652 has drive signals for active clamp or synchronous rectification to achieve optimum efficiency. Protective features (brownout, OCP, OVP), HV start-up and external ramp compensation enable easy implementation.

Unique Features

- Drive signals with prog. dead time
- Voltage Feed Forward
- **Over-current,**
- **Over-power limit**

Benefits

- Allows driving active clamp / synch rectifier
- Improved loop response
- Rugged design

Others Features

- **Frequency Jittering for reduced EMI signature**
- **Brown-out Protection**
- **Soft-skip** below 30% Iout reduces noise
- **CCM/DCM operation**
- **Adj Frequency from 20 kHz to 250 kHz**

Application Data

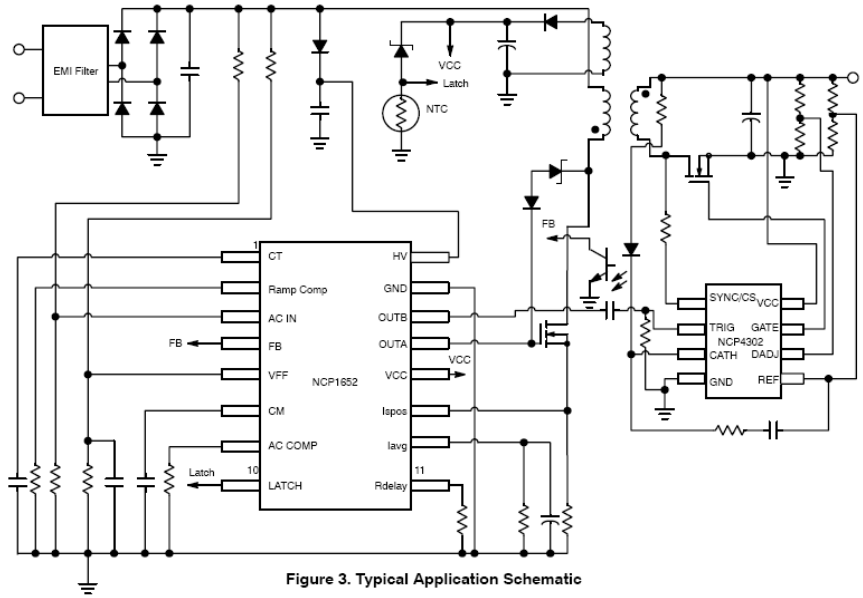


Figure 3. Typical Application Schematic

Market & Applications

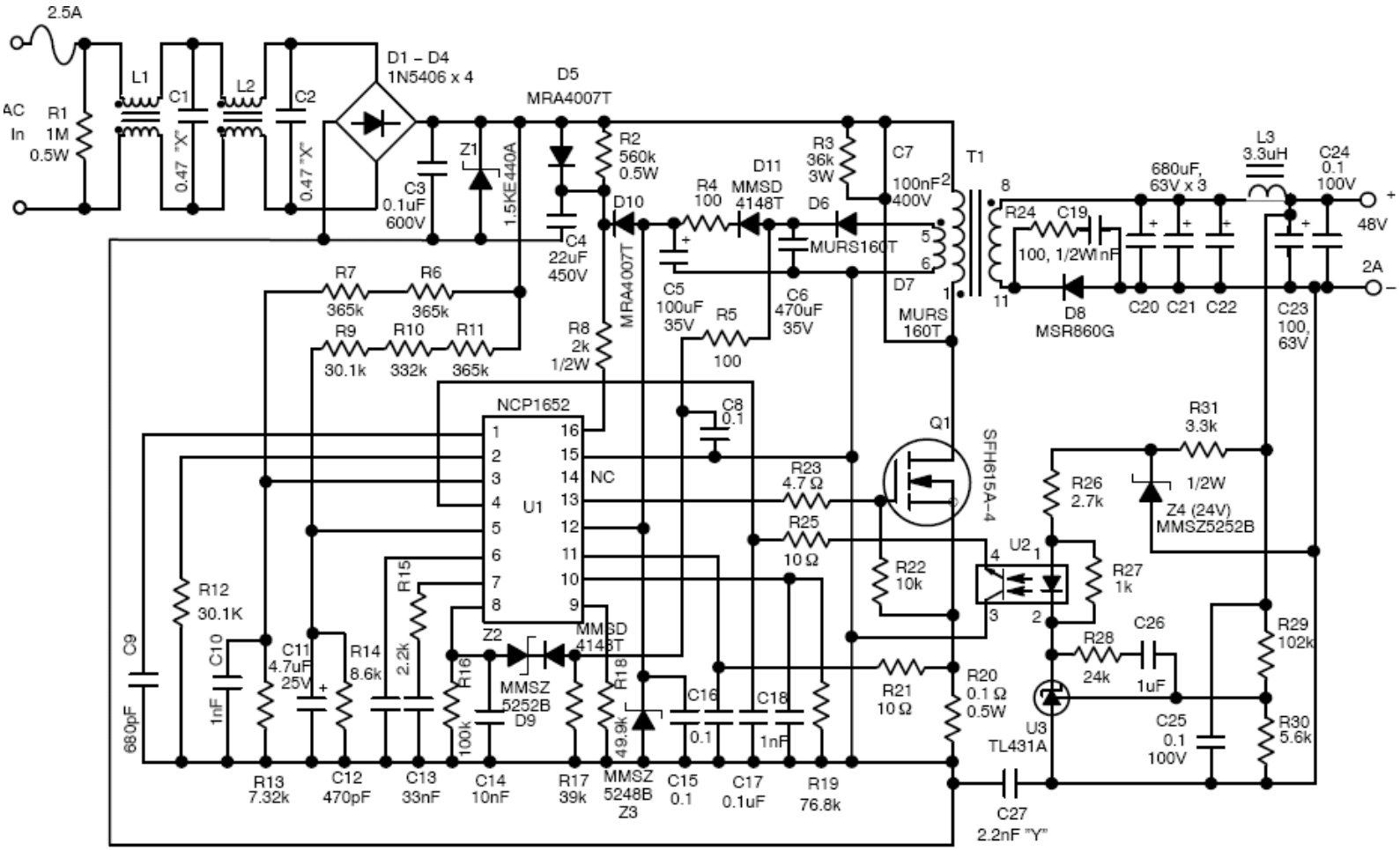
- High-power Adapters
- **LED Power Supplies and LED Drivers**
- High Powered Battery Chargers

Ordering & Package Information

- NCP1652DWR2G: SO-20 WB
- NCP1652DR2G: SO-16

ON Semiconductor

50 W-150 W Solution Using NCP1652



NCP1652 150 W @ 85-135 Vac or 185-264 Vac

NCP1377 – Current Mode Controller for Quasi Resonant Operation

Value Proposition

The NCP1377 combine a true current mode modulator and a demagnetization detector to ensure full Critical Conduction Mode in any load/line conditions and minimum drain voltage switching (Quasi-Resonant operation).

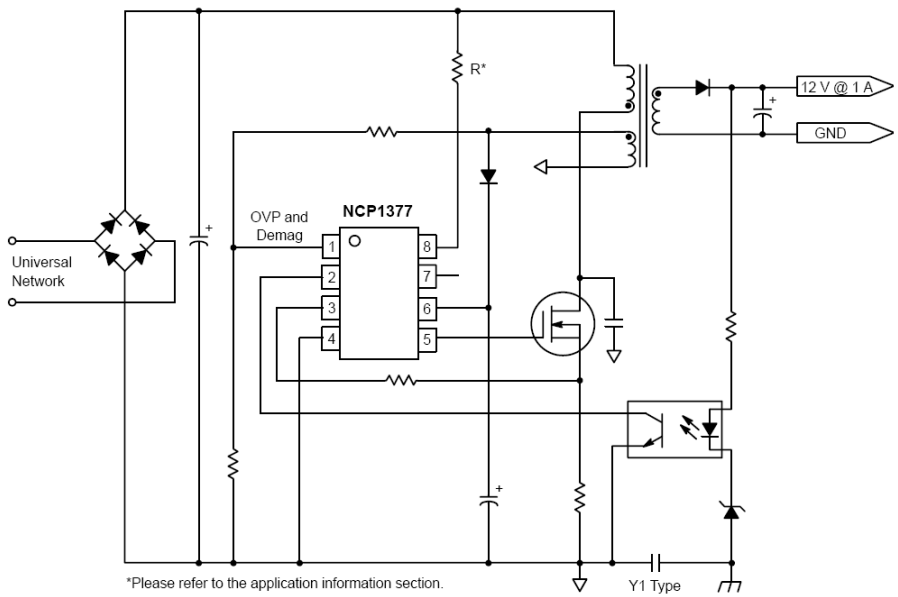
Unique Features

- **Quasi Resonant operation**
- Adjustable skip mode
- **Internal HV start-up**

Benefits

- Minimize EMI radiation and capacitive losses
- Improved efficiency in light load
- Clean & loss less start-up sequence, less components

Application Data



Others Features

- Under Voltage Lock-out
  - NCP1377: 7.6 V to 12.8 V typ
- Soft start : 1 ms
- **Latch input**
- Minimum off-time
  - NCP1377 = 8 µs

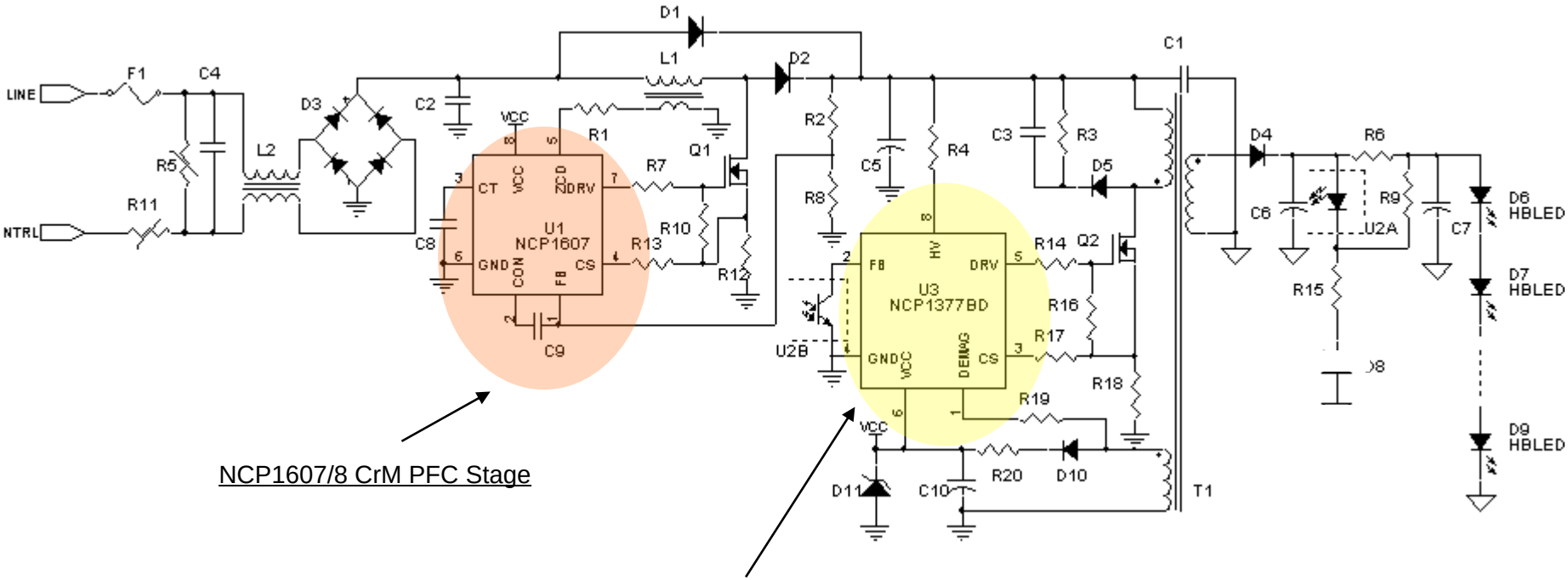
Market & Applications

- **LED Power Supplies and LED Drivers**
- AC adapters
- Open frame PSU (DVD, STB)
- Auxiliary power supplies

Ordering & Package Information

- NCP1377DR2G : SOIC8
- NCP1377PG : PDIP8

50 W-150 W Solution Using NCP1607/8 & NCP1377



NCP1607/8 CrM PFC Stage

NCP1377 QR Mode DC-DC Stage

NCP1607/8 and NCP1377 150 W @ 90-264 Vac

Ultra High Efficiency LED Power Supplies

- Significant interest in very high efficiency topologies for LED lighting
  - >90% Efficient at relatively low power levels (<50 W)
  - New topologies are required to achieve these solutions
  - Move from flyback topology to resonant half bridge topology to take advantage of zero voltage switching (ZVS) topologies
- These efficiency targets are even higher external power supply standards like ENERGYSTAR which require >87% at 49W, note PFC is not required until 75 W
- Fortunately, ON has been developing efficient resonant mode half bridge solutions that can be applied to LED Power solutions

NCP1396–High Performance Resonant Mode (LLC) Controller

Value Proposition

On top of integrating the key features of a good resonant controller, the NCP1396 integrates the High voltage Half Bridge drivers.

Unique Features

- Built-in drivers
- Adjustable & accurate minimum frequency
- Fast and slow fault detection, Broken FB loop detection

Benefits

- Compact design
- Keeps the converter in the right region & ease the design
- Robust and rugged power supply & help to be compliant with safety standards

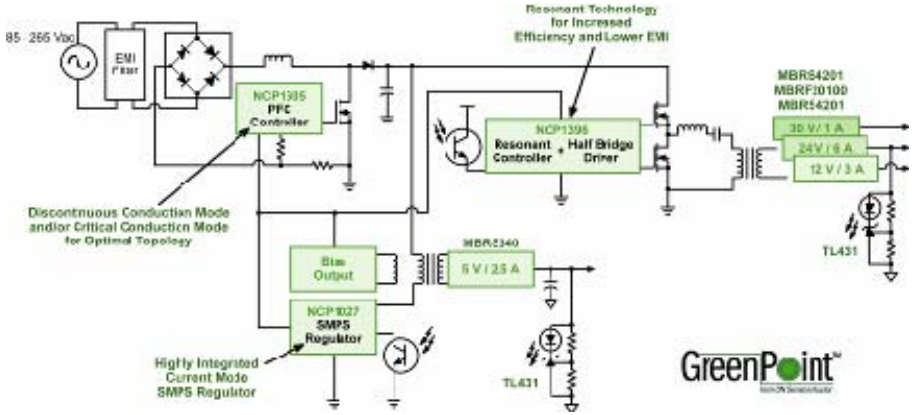
Others Features

- **Latch PIN, brownout**
- Adjustable dead-time
- Adjustable soft start
- Enable capability
- -40 to 125 ℃ junction temperature operation range

Market & Applications

- Flat TVs
- **High Power LED Power Supplies**
- High power AC adapters

Application Data



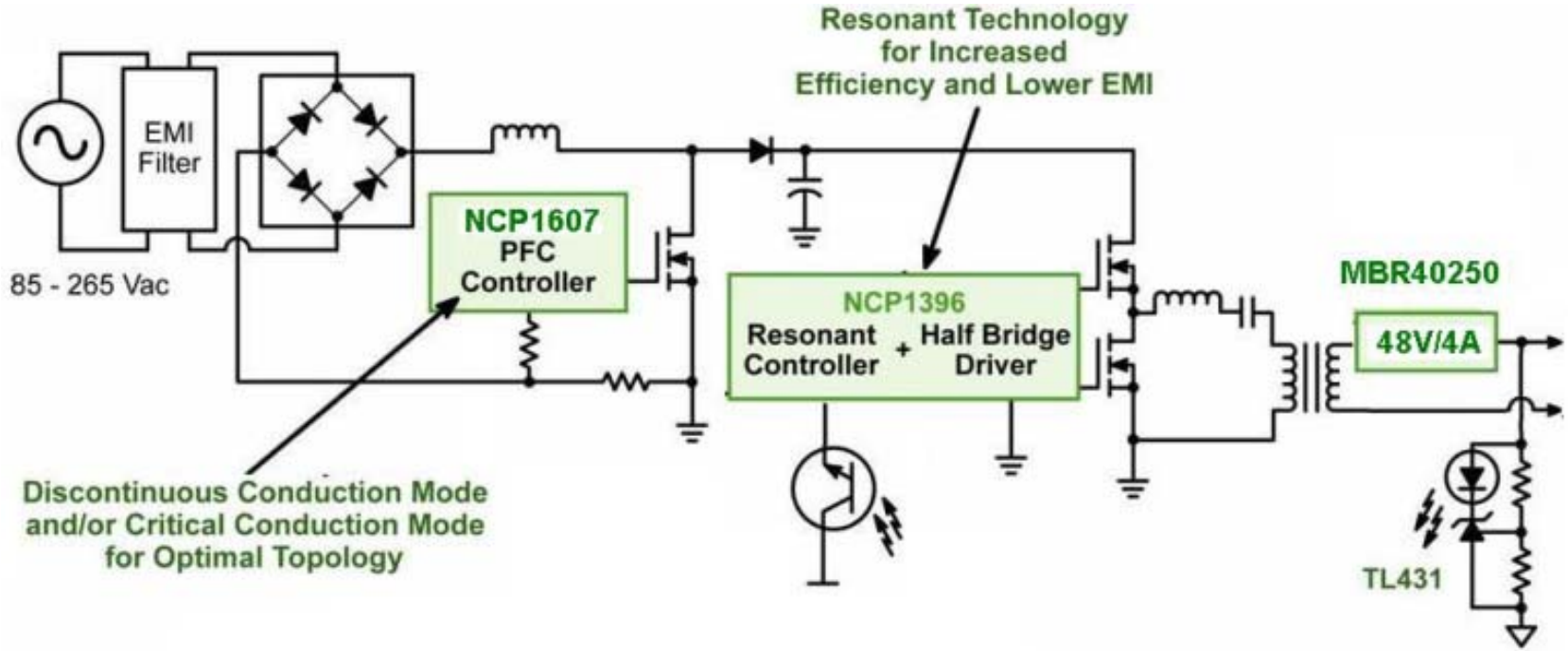
220 W LCD TV Reference Design

NCP1396A (12 V Startup), NCP1396B (10 V Startup)

Ordering & Package Information

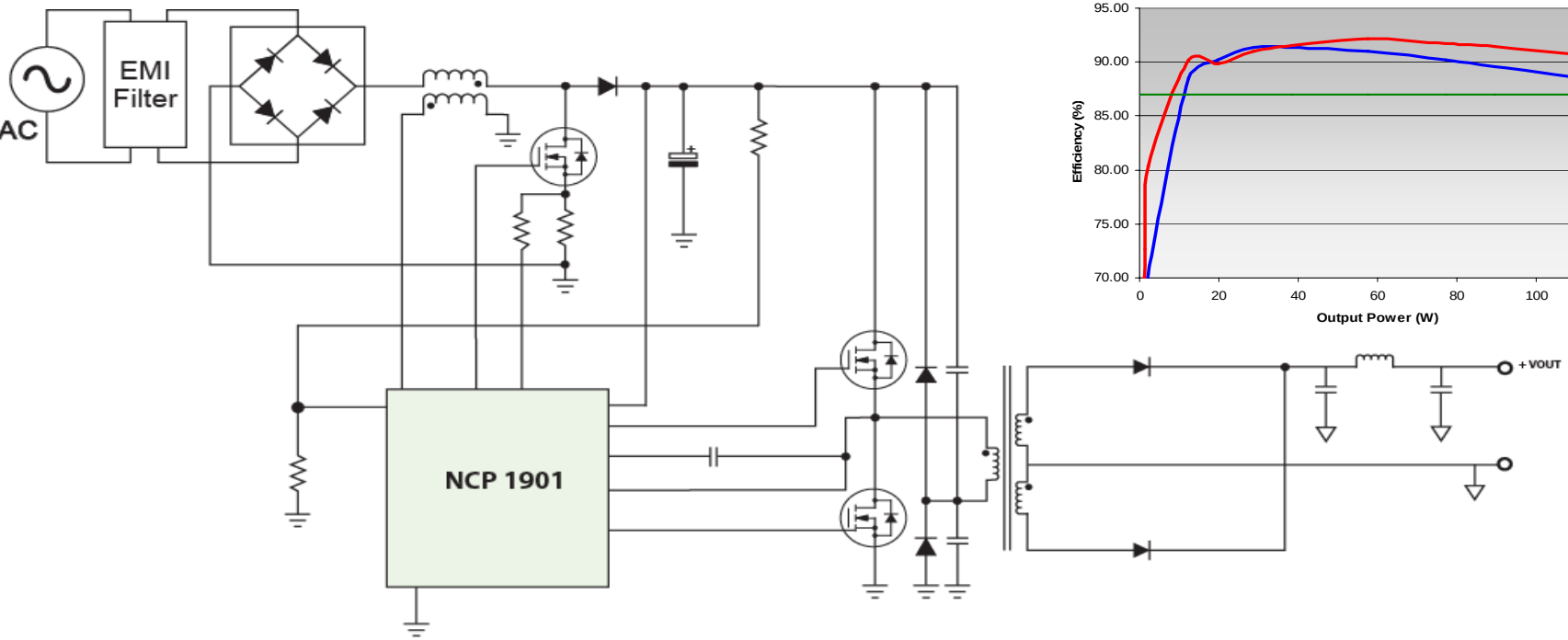
- NCP1396APG, NCP1396BPG: PDIP-16
- NCP1396ADR2G, NCP1396BDR2G: SOIC-16

100 W-200 W Solution Using NCP1607 & NCP1396



NCP1607and NCP1396 @ 90-264 Vac

100 W-200 W Solution Using NCP1901, Newest HB Resonant + PFC

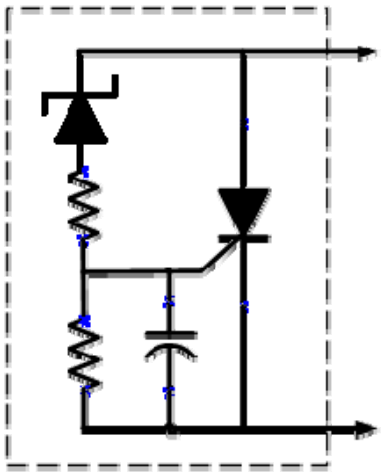


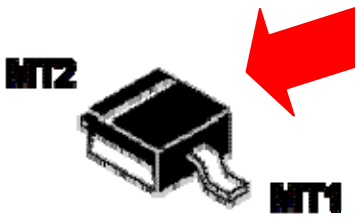
- Half-bridge stage operates at a fixed frequency and duty ratio to reduce switching losses.
- Primary side regulation, no feedback loop necessary!
- Regulation is achieved by modulating the input voltage of the HB power stage.
- Overcurrent condition is detected on the primary side.
- Extremely low EMI and switching losses

NCP1901 @ 90-264 Vac

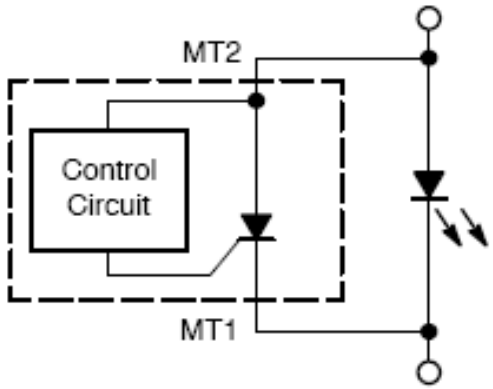
LED Lighting Protection

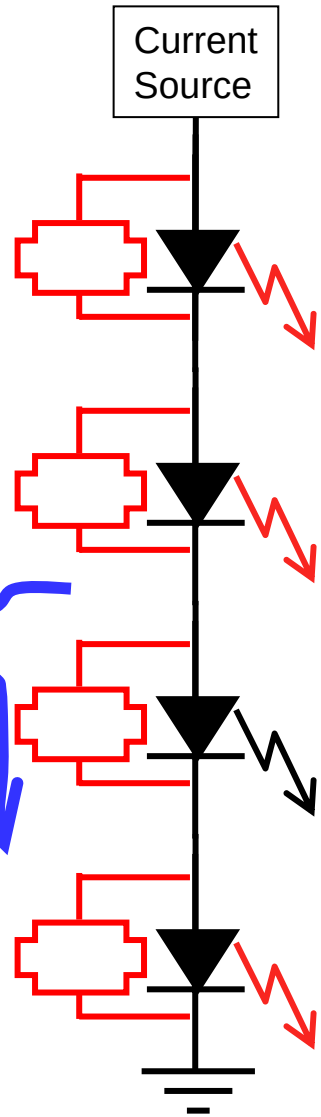
- **Protects operation in the event of an open LED fault**
- **Supports >1 A with proper heat sinking**
- **Improve reliability of LED lighting effectively**





NUD4700 in
PowerMite Package





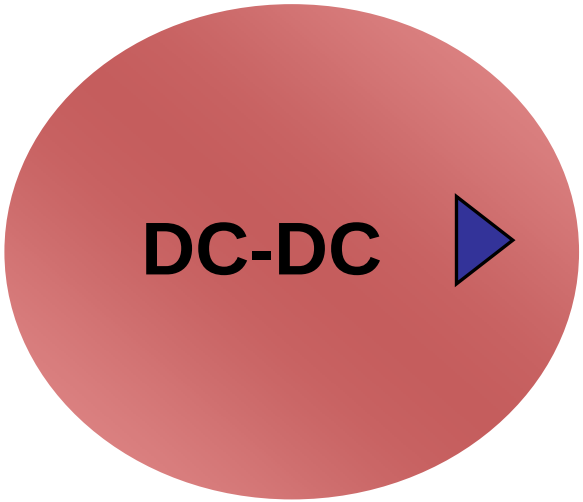
Summary of AC-DC LED Driving Solutions

- 1 W-8 W Solution Using NCP1015
- 1 W-8 W Solution Using NCP1015 (Non-Isolated)
- 8 W-15 W Solution Using NCP1028
- 8 W-25 W Solution Using NCP1351
- 8 W-25 W Solution Using NCP1607/8
- 50 W-150 W Solution Using NCP1652
- 50 W-150 W Solution Using NCP1607/8&NCP1377
- 100 W-200 W Solution Using NCP1607/8&NCP1396
- 100 W-200 W Solution Using NCP1901

Agenda

- LED Lighting Category
- AC-DC LED Solutions
- DC-DC LED Solutions
- Torch LED Solutions
- Summary

DC-DC Lighting Solutions



1 W-3 W MR11/MR16 Buck LED Driver

1 W-20 W Boost LED Driver

20 W-60 W High Power DC-DC LED Driver

Torch LED Driver

DC-DC 1 W-3 W Application Requirement

Specifications:

- Input voltage: 5V~28 Vdc
- Efficiency: ≥ 90%
- Constant current: 350 mA; 700 mA;
- Frequency: up to 500 kHz~2 MHz;
- Temp: -40~125 ℃

Application:

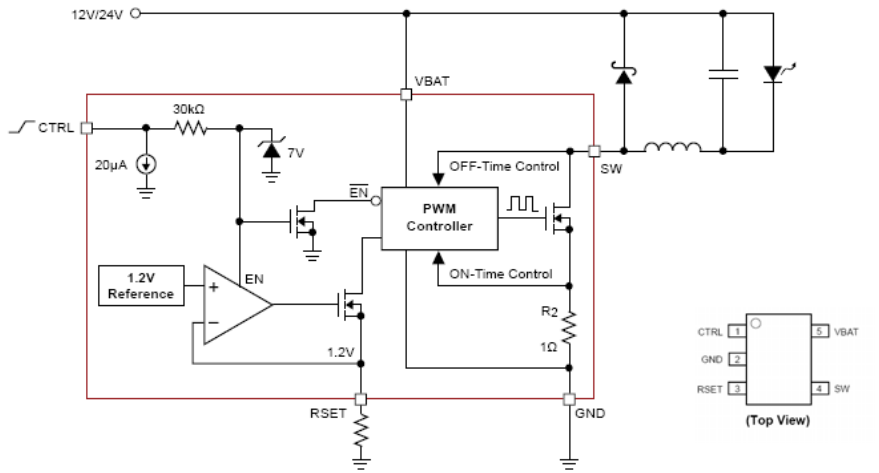
- MR11/MR16

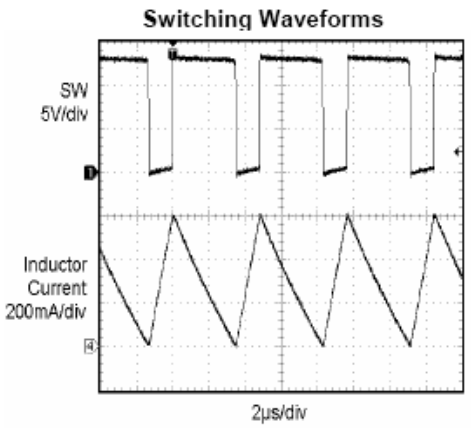
Product: CAT4201

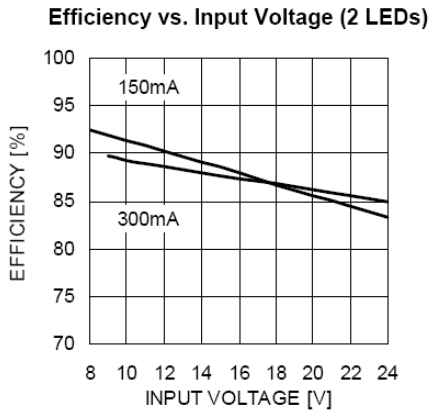
CAT4201 Buck LED Driver

- **Functionality**
  - **LED drive current up to 350 mA**
  - 12 V and 24 V system compatible
  - Handles transients up to 40 V
  - Enable Pin
  - **Power efficiency up to 94 percent**
  - **Drives up to 7 LEDs in series (24 V systems)**
- **Fully Protected**
  - Current limit and thermal protection
  - Open LED Protection
- **Patented switching control architecture**
  - **Reduces system complexity**
  - **Critical Conduction Operation**
  - **Improves efficiency**
- **Packaging**
  - 5-lead thin SOT-23-5 (1mm height)

Simplified Block Diagram

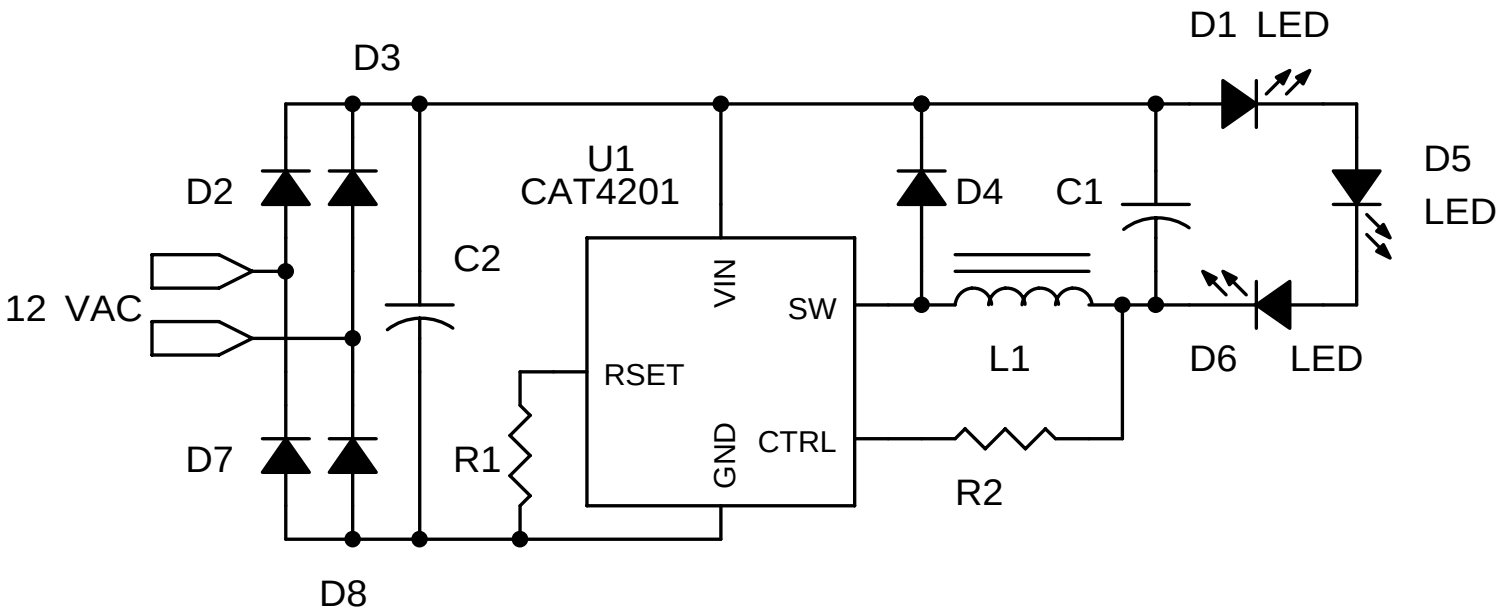






ON Semiconductor

1 W-3 W DC-DC Solution Using CAT4201



CAT4201 3 W @ 12 Vac

CAT4201: Evaluation Board

Figure 1. CAT4201EVAL2 with LED Module

Cascadable LED Panels (1Watt) 'Daisy-Chain'

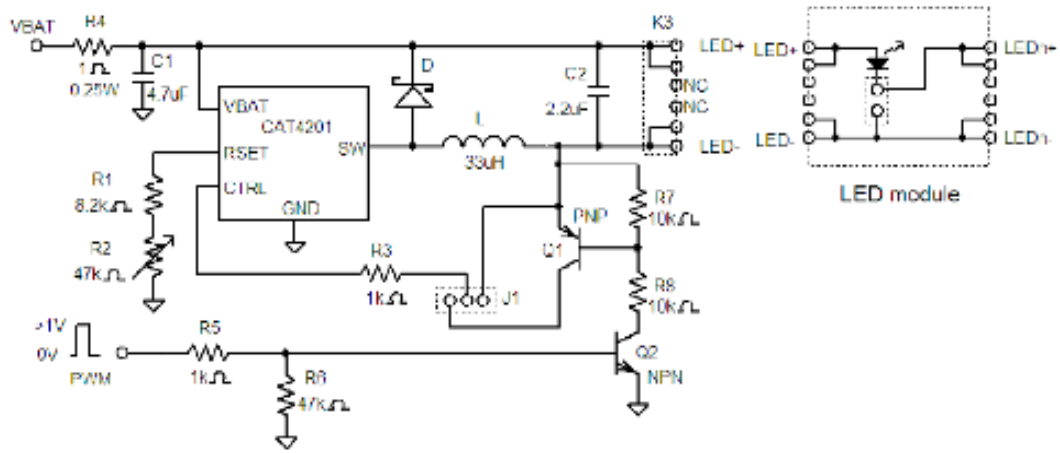


Figure 2. CAT4201EVAL2 Schematic

1 W-20 W DC-DC Boost Application Requirement

Specifications:

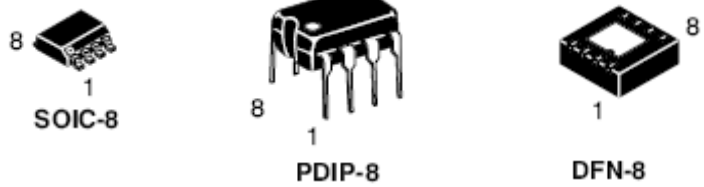
- Input voltage: 5 V~40 Vdc
- Efficiency: $\geqslant$ 85%
- Constant Current: 350 mA; 700 mA;
- Frequency: up to 250kHz;

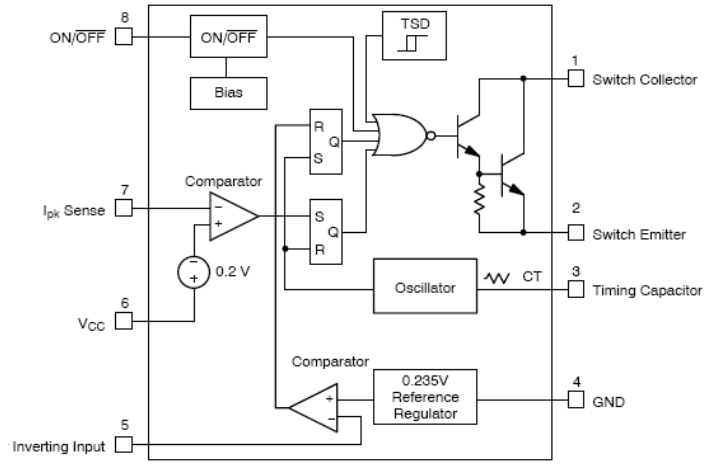
Application:

- DC-DC LED Driver

Product: NCP3065/6

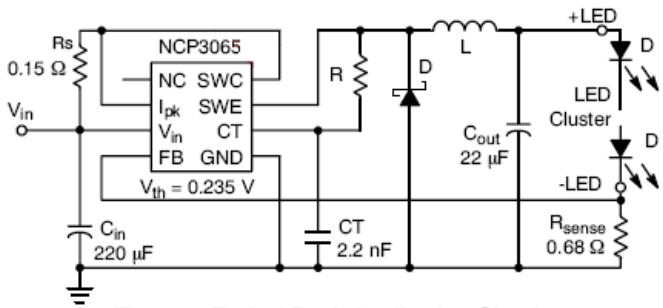
NCP/NCV3065/6 – Multi-mode LED Driver Buck / Boost / SEPIC / Inverter



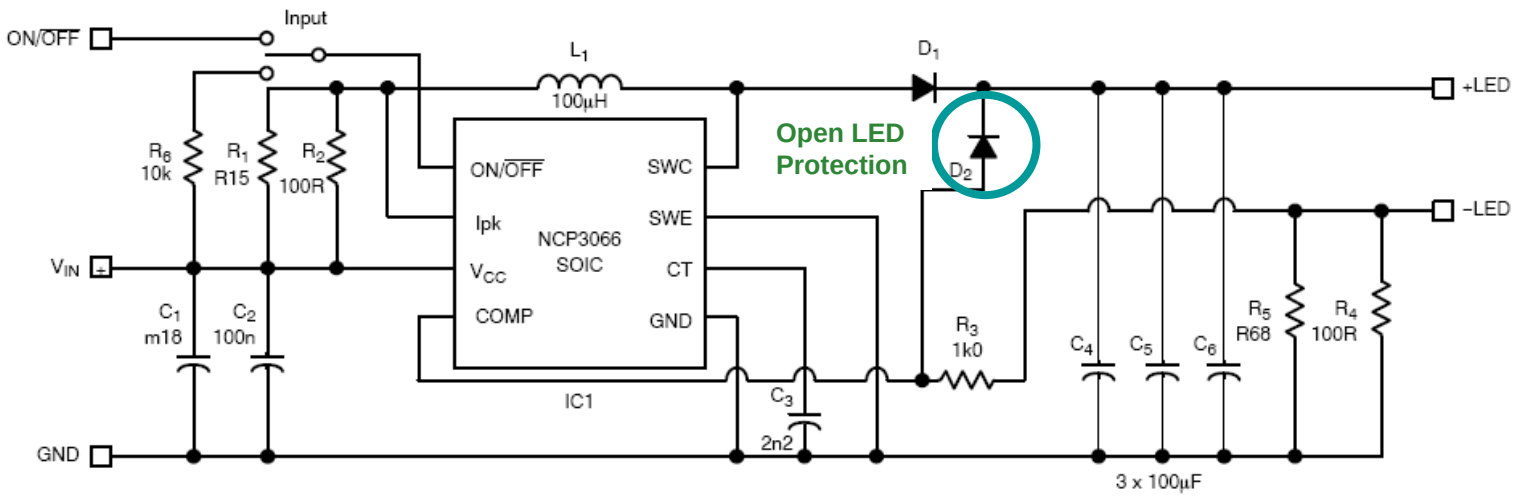


NCP3066

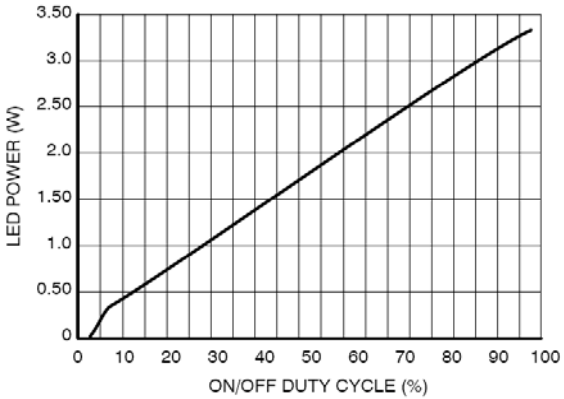
- Integrated 1.5 A Switch
- Input Voltage Range from 3.0 to 40 V
- Low Feedback Voltage of 235 mV
- Cycle-by-Cycle Current Limit
- No Control Loop Compensation Required
- Frequency of Operation Adjustable up to 250 kHz
- Operation With All Ceramic Output Capacitors or No Output Capacitance
- Analog and Digital PWM Dimming Capability
- Internal Thermal Shutdown with Hysteresis
- NCV Automotive version available
- NCP/NCV3066 has Enable pin



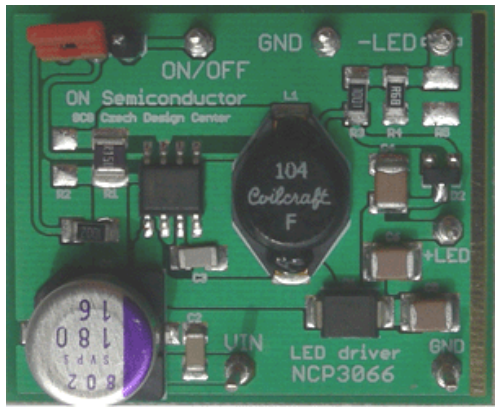
NCP3066 Boost LED Configuration



AND8289 discusses boost LED Driver Circuits



Dimming Performance



NCP3066SCBSTGEVB Demo Board

20 W-60 W DC-DC LED Driver Requirement

Specifications:

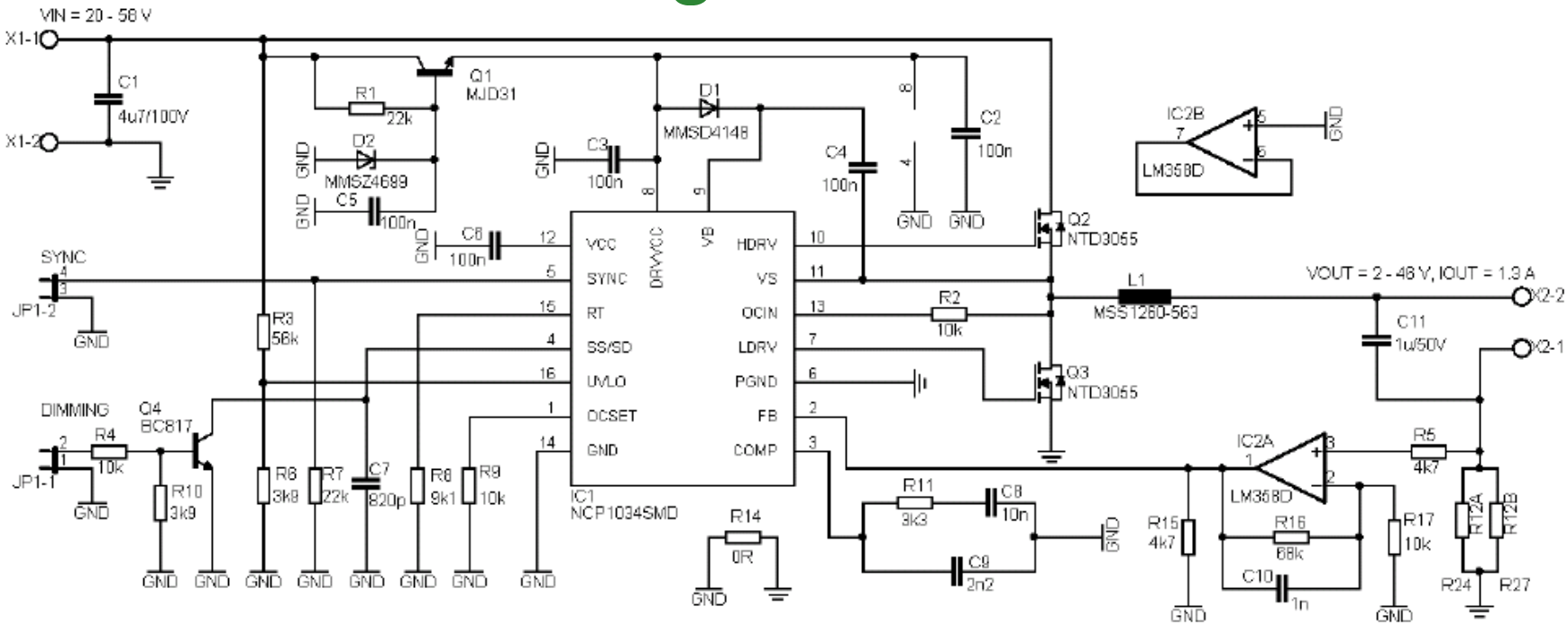
- Input Voltage: 20 V~58 Vdc
- Output voltage:2 V~46Vdc
- Efficiency: $\geqslant$ 90%
- Constant Current: 350 mA; 700 mA;1 A
- Frequency: 400 kHz;

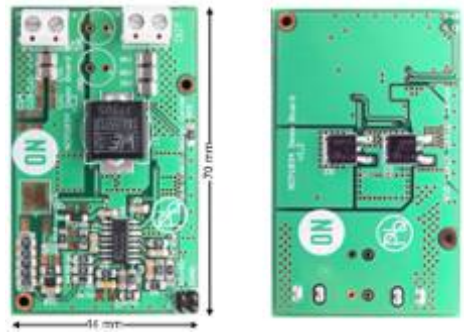
Application:

- Street lighting secondary side DC-DC LED diver

Product No: NCP1034

20 W-60 W DC-DC Driver Solution Using NCP1034





NCP1034 20-60 W @ 20 V-58 Vdc

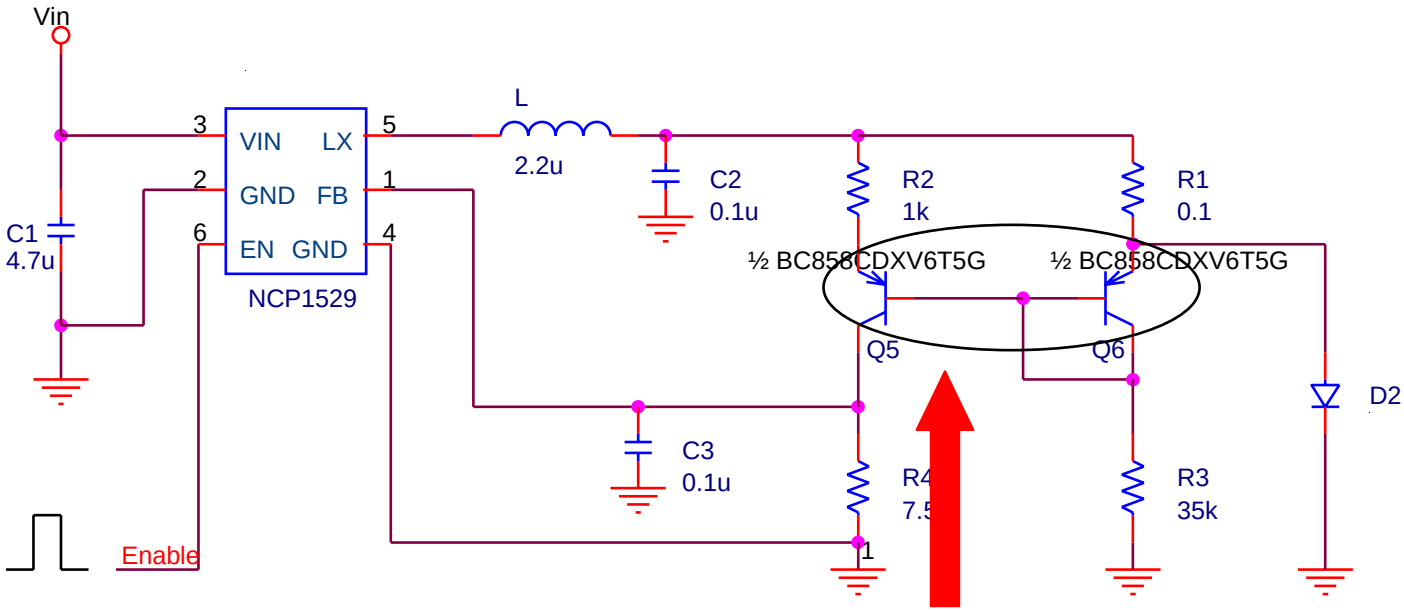
Demo Board

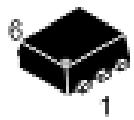
Low Power Consumption Constant Current Sensing Method

NCP1529 with small-signal transistor to reduce feedback voltage

LED current = VFB x R2 / (R1 x R4). With the chosen value, we get: 1A

R3 is a biasing resistor, it does not directly impact the current. The value has been chosen to have roughtly the same current in the bipolar transistors.





BC858CDXV6T1G is dual BJT for current Sensor.

Summary of DC-DC LED Driver Solutions

- 1 W-3 W DC-DC Buck Solution Using CAT4201
- 1 W~20 W DC-DC Boost Solution Using NCP3066
- 20 W-60 W DC-DC Driver Solution Using NCP1034

Agenda

- LED Lighting Category
- AC-DC LED Solutions
- DC-DC LED Solutions
- Torch LED Solutions
- Summary

Torch DC-DC Lighting Solutions

Torch DC-DC

Torch Boost DC-DC Driver
Torch Buck DC-DC Driver

1 W~3 W Torch Boost LED Driver Requirement

Specifications:

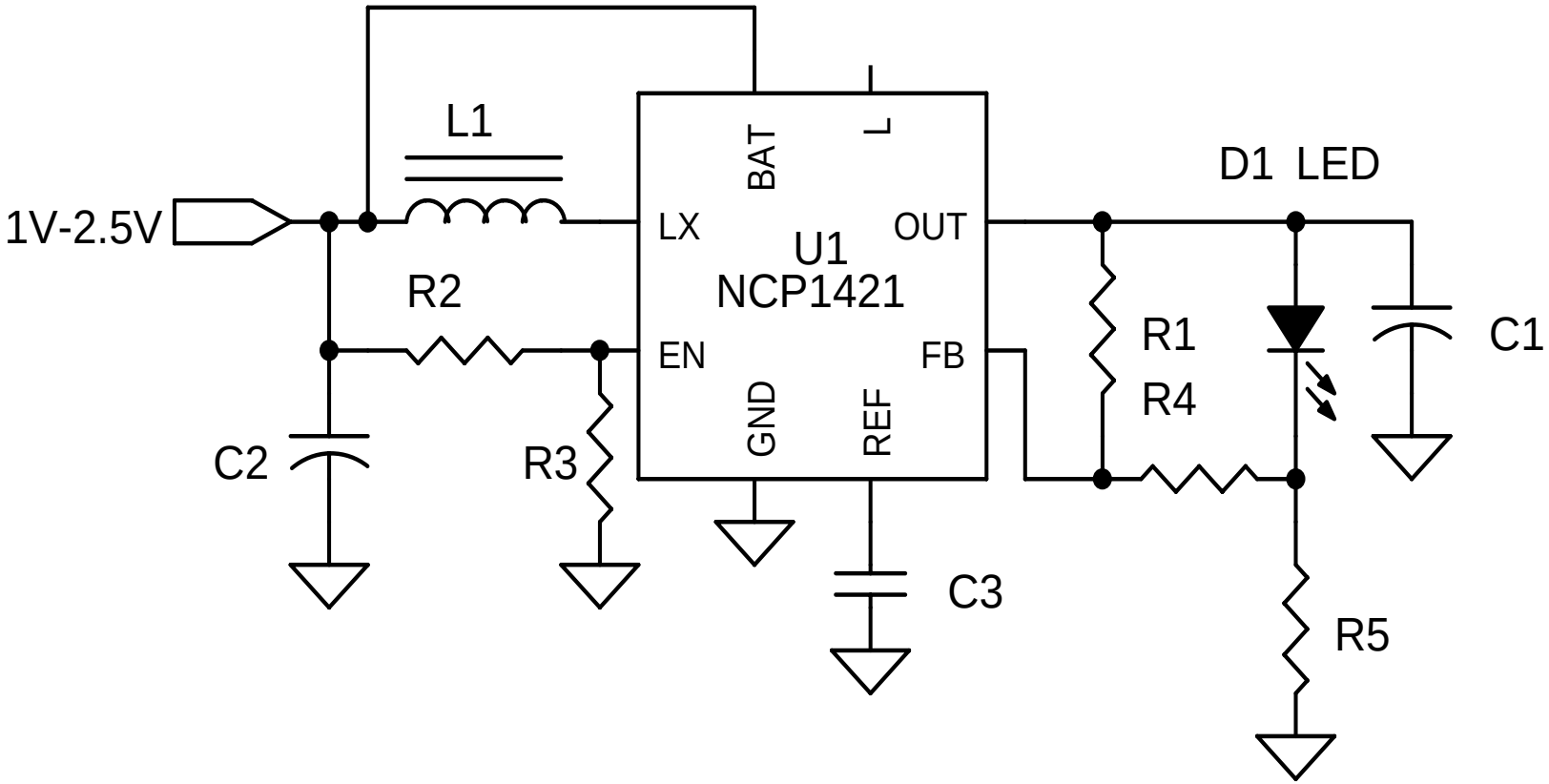
- Input Voltage: 1 V~2.5 Vdc
- Efficiency: ⩾ 90%
- Constant Current: 350 mA;600 mA;
- Frequency: up to 1.2 MHz;

Application:

- Torch DC-DC LED Diver

Product: NCP1421

1 W~3 W Torch Boost Solution Using NCP1421



NCP1421 3 W @ 1 V-2.5 Vdc

1 W~3 W Torch Buck LED Driver Requirement

Specifications:

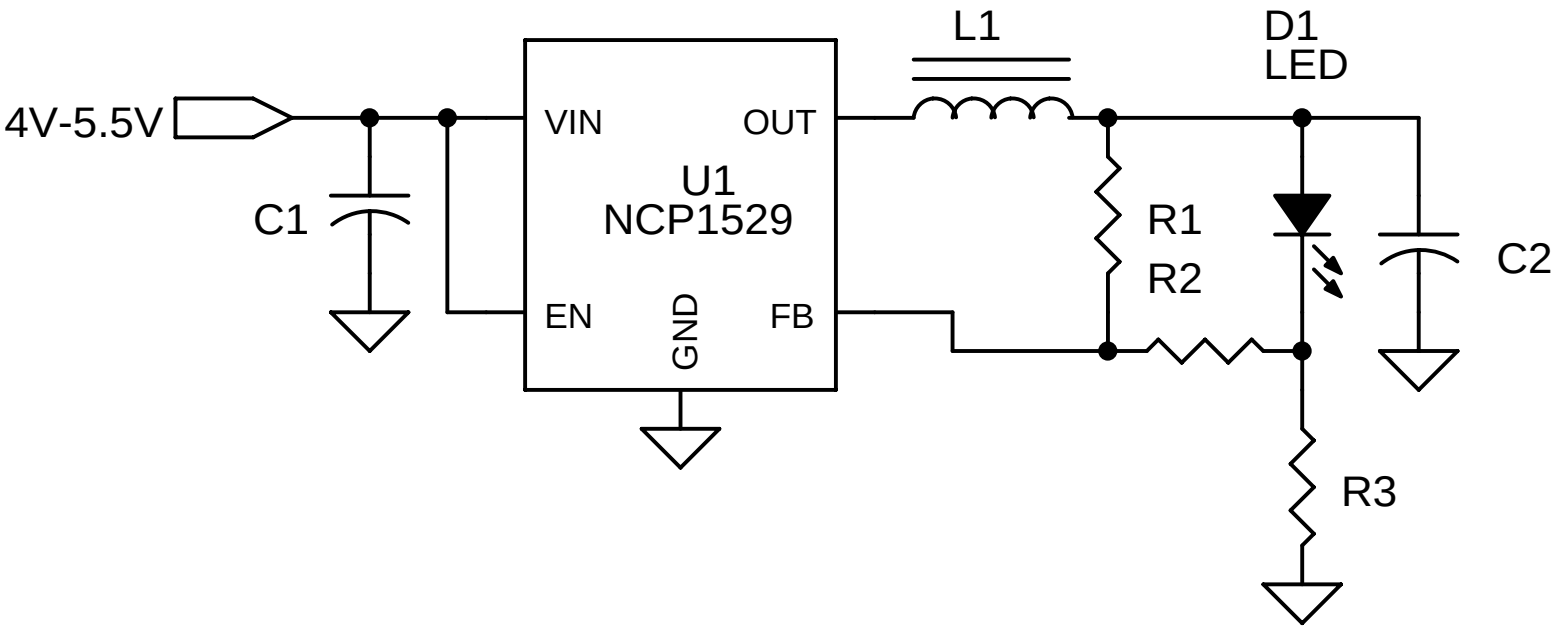
- Input Voltage: 4 V~5.5 Vdc
- Efficiency: ⩾ 90%
- Constant Current: 350 mA;600 mA;
- Frequency: up to 1.7 MHz;

Applications:

- Torch DC-DC LED Diver

Product: NCP1529

1 W~3 W Torch Buck Solution Using NCP1529



NCP1529 3 W @ 4 V-5.5 Vdc

Summary of Torch LED Solutions

- 1 W~3 W Torch Boost Solution Using NCP1421
- 1 W~3 W Torch Buck Solution Using NCP1529

Agenda

- LED Lighting Category
- AC-DC LED Solutions
- DC-DC LED Solutions
- Torch LED Solutions
- Summary

Summary

- Solid State Lighting is evolving rapidly with the emergency of cost effective ultra high brightness power LEDs
- High efficient constant current drive architecture is key to driving LEDs
- A wide variety of power solutions is required depending on input voltage, bulb and LED configuration
- To achieve a robust product requires a system oriented approach taking into account electrical, thermal and optical considerations
- Currently ON Semiconductor provides high efficiency complete AC-DC and DC-DC solutions for LED lighting
- ON Semiconductor is determined to new technology development, providing customers with better and higher efficiency LED lighting solutions

Thank you!

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