LED Lighting Solutions

Covering LED drivers, power management, communication, control, and sensing solutions for solid state lighting applications from ON Semiconductor.
# Table of Contents

## INTRODUCTION
- LED Technology ........................................ 3
- Driver Solutions ......................................... 3

## PORTABLES
- Low-Voltage Portable LED Driver Topologies ........... 4
- Charge Pump Topology ..................................... 5
- Inductive Boost and Buck Topology .................... 7
- Linear Topology ........................................... 8
- Camera Flash and Torch Light-Dedicated LED Drivers .. 9
- Multifunction LED Drivers ................................ 10
- RGB Illumination Drivers .................................. 10

## ADDRESSABLE SIGNAGE
- Intelligent LED Control for Signage and Architectural Lighting ............... 11
- 8 and 16 Channel Constant Current LED Sink Drivers ....................... 11
- 3-Channel Cascade-Capable Driver — CAT4103 .......................... 12
- 16-Channel LED Indicator Driver and Port Expander — CAT9532 & CAT9552 13

## MID-VOLTAGE
### General Lighting
- Mid-Voltage LED Driver Topologies .................... 14
- Linear LED Driver Solutions .............................. 15
- Constant Current Regulator (CCRs) for Displays and Channel Letters ...... 16
- Switching Driver Solutions ............................... 17
- LED MR16 Light Bulb ...................................... 18
- Solar-Powered LED Street Sign ............................ 18
- 12 V AC-DC Design for 3 and 4 LED Modules ................... 19

### Automotive
- Automotive Lighting Systems ........................... 20
- Front Lighting ............................................ 20
- Leveling and Swiveling for Front Lighting ................. 21
- Power Ballast and Dual LED Driver for Advanced LED Front Lighting Systems 22
- Linear Current Regulator and Controller for Automotive LED Rear Combination Lamps ........................................ 23
- Automotive LIN RGB LED Driver for Interior Lighting ................. 24
- Constant Current Regulators for Automotive Exterior and Interior Lighting 25
- Compact 350 mA Buck LED Driver — CAT4201 & CAT4201 .............. 26
- Multi-Topology, Constant Current Switching Regulator for High Brightness LEDs — NCV3065 & NCV3066 ........................ 26

## AC-DC
- AC Line Powered LED Driver Topologies .................. 27
- Non-Isoated Linear LED Driver Topology - CCRs .................... 28
- Low Current LED String Driver ................................ 28
- Low Cost TS LED Tube ..................................... 28
- Switching Regulators for AC-DC .......................... 29
- Up to 8 W LED Driver Ref Design for ENERGY STAR® Residential Lighting ... 29
- Switching Controllers for AC-DC ................................ 30
- Non-Isoated 25 W High Power Factor Buck-Boost LED Driver ........... 31
- Non-Isoated Offline Buck Controller — LVS026 ........................ 31
- Power Factor Correction for AC-DC ................................ 32
- Constant Current, Constant Voltage References .................... 32
- Line Dimmable PAR30 LED Lamp ................................ 33
- LED Power Supply for Street and Area Lighting .................... 34

## BACKLITITING
- Medium to Large LCD Panel Backlighting ................ 35
- 6-Channel LED Controller for Large Panel LED Backlighting — CAT4026 .... 36
- Highly Integrated LED Backlight Controller, Boost Converter — CAT4106 37
- High Voltage LED Driver — NCP1294 ................................ 38

## COMMUNICATION & SENSING
- Smart Lighting .............................................. 39
- Powerline Communication (PLC) Modems .................. 40
- KNX Transceivers ......................................... 41
- Motion Detector Passive Infrared Controller (PIR) — NCS36000 .......... 42
- Ambient Light & Proximity Sensors ........................ 43

## PROTECTION
- LED String Protection — NUD4700 ........................... 44
- In-Module ESD Protection of High Brightness LEDs .............. 45
- In-Module TVS Solutions for HBLED Protection ................ 46

## LED LIGHTING SUPPORT AT www.onsemi.com
- www.onsemi.com/led ...................................... 47
- GreenPoint® Design Simulation Tool ........................ 47

## Sales and Design Assistance ................................ 48
LED Technology

As the technology and light output of LEDs continues to improve, applications for color and white high-brightness LEDs are expanding into entirely new markets. Once primarily used as indicators, LED cost and performance levels have improved dramatically, allowing them to displace incandescent and fluorescent light sources in automotive applications, consumer electronics ranging from cellphones to LCD-TVs, architectural lighting, and general lighting. Over the next few years, LEDs will continue to transform the lighting marketplace with new and innovative solid state lighting (SSL) solutions that can take advantage of both their programmability and flexibility.

Driver Solutions

LEDs are inherently low voltage devices and depending on the color and current, the forward voltage of the LED can vary from less than 2 to 4.5 V. In addition LEDs need to be driven with a constant current to ensure the intensity and color desired. This requires power conversion and control solutions to interface to the various power sources, be it the AC line, a solar panel, a 12 V car battery, a DC power supply or low voltage AC system or even primary Alkaline and Ni-based cells or rechargeable Li-Ion battery cells.

ON Semiconductor has focused on applying our low voltage and high voltage technologies and our expertise in power management solutions to the challenges of solid state lighting; whether in portable display products, interior automotive lighting, or ballast for LED signage. In the following pages, examples will be provided for a number of different applications of solid state lighting for architectural, industrial, automotive and portable applications.
Low-Voltage Portable LED Driver Topologies

White LED and RGB tricolor LEDs are widely used for backlighting small color LCD panels and keyboards, as well as indicators. High brightness LEDs are used as flash light sources in cell phones and digital cameras. These applications require optimized solutions which can maximize battery lifetime, as well as minimize the PCB area and height. ON Semiconductor has a variety of solutions using linear, inductive, and charge pump topologies. The inductive solution offers the best overall efficiency, while the charge pump solution takes up a minimal amount of space and height due to the use of low profile ceramic capacitors as the energy transfer mechanism. Linear drivers are ideal for color indicator as well as simple backlighting applications.

Inductive Boost Topology

Charge Pump Topology

Linear Topology

* Pending 2H12.
Charge Pump Topology

Patented Quad-Mode® adaptive fractional charge pumps take LED driver performance to a new level by offering a 10% efficiency improvement and up to 65% smaller packaging, without the need for an additional capacitor.

Quad-Mode LED drivers deliver the high efficiency levels normally associated with inductor-based LED drivers, while eliminating the associated high-profile inductors and unwanted EMI. Most charge pump LED drivers offer three modes of operation corresponding to the ratio of the output voltage to the input voltage: 1x, 1.5x and 2x. The Quad-Mode architecture adds a fourth mode of operation, 1.33x, without the need for the additional capacitor required by all other four-mode charge pumps.

Features

- 4 charge pump modes: 1x, 1.33x, 1.5x, 2x
- 10% higher efficiency versus 3-mode charge pumps
- No additional capacitors
- No inductor

Charge Pump/White and RGB LED Drivers — for LCD Backlight, LED Flash/Torch and Indicator

<table>
<thead>
<tr>
<th>Device</th>
<th>Input Voltage Range (V)</th>
<th>Number of Outputs</th>
<th>Total Output Current (mA)</th>
<th>Regulation Mode</th>
<th>Charge Pump Operating Mode</th>
<th>LED/LED Current Matching, Typ</th>
<th>Dimming Method</th>
<th>Number of Current Level/Profile</th>
<th>Operating Quiescent Current, Typ (mA)</th>
<th>Shutdown Current (µA)</th>
<th>Package</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCP1840</td>
<td>3.0 - 5.5</td>
<td>8</td>
<td>240</td>
<td>Current</td>
<td>1x / 1.33x / 1.5x / 2x</td>
<td>±2%</td>
<td>I2C</td>
<td>32 / log</td>
<td>2.3</td>
<td>0.12</td>
<td>QFN-20</td>
<td>• Indicator application</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Individual PWM programmability per channel; 64 different PWM duty cycle settings</td>
</tr>
<tr>
<td>CAT3606</td>
<td>2.7 - 5.5</td>
<td>6</td>
<td>180</td>
<td>Current</td>
<td>1x / 1.5x</td>
<td>±1.5%</td>
<td>PWM</td>
<td>Depends on System</td>
<td>1</td>
<td>1 max</td>
<td>TQFN-16</td>
<td>• Backlight</td>
</tr>
<tr>
<td>CAT3616</td>
<td>2.7 - 5.5</td>
<td>6</td>
<td>186</td>
<td>Current</td>
<td>1x / 1.5x</td>
<td>±3%</td>
<td>Single Wire</td>
<td>32</td>
<td>0.5</td>
<td>1 max</td>
<td>TQFN-16</td>
<td>• Backlight</td>
</tr>
<tr>
<td>CAT3626</td>
<td>2.7 - 5.5</td>
<td>6</td>
<td>192</td>
<td>Current</td>
<td>1x / 1.5x</td>
<td>±3%</td>
<td>I2C</td>
<td>Depends on System</td>
<td>0.5</td>
<td>1 max</td>
<td>TQFN-16</td>
<td>• Backlight</td>
</tr>
<tr>
<td>CAT3636</td>
<td>2.2 - 5.5</td>
<td>6</td>
<td>192</td>
<td>Current</td>
<td>1x / 1.33x / 1.5x / 2x</td>
<td>±1%</td>
<td>Single Wire</td>
<td>32</td>
<td>0.5</td>
<td>1 max</td>
<td>TQFN-16</td>
<td>• Backlight</td>
</tr>
<tr>
<td>CAT3637</td>
<td>2.2 - 5.5</td>
<td>6</td>
<td>192</td>
<td>Current</td>
<td>1x / 1.33x / 1.5x / 2x</td>
<td>±1%</td>
<td>Single Wire</td>
<td>16</td>
<td>0.5</td>
<td>1 max</td>
<td>TQFN-16</td>
<td>• Backlight</td>
</tr>
<tr>
<td>CAT3649</td>
<td>2.4 - 5.5</td>
<td>6</td>
<td>150</td>
<td>Current</td>
<td>1x / 1.33x / 1.5x / 2x</td>
<td>±1.5%</td>
<td>Single Wire &amp; PWM</td>
<td>32</td>
<td>1.4</td>
<td>1 max</td>
<td>TQFN-16</td>
<td>• Backlight</td>
</tr>
<tr>
<td>CAT3604A</td>
<td>2.7 - 5.5</td>
<td>4</td>
<td>120</td>
<td>Current</td>
<td>1x / 1.5x</td>
<td>±3%</td>
<td>PWM</td>
<td>Depends on System</td>
<td>0.3</td>
<td>0.05 typ</td>
<td>TQFN-16</td>
<td>• Backlight</td>
</tr>
<tr>
<td>CAT3604V</td>
<td>2.7 - 5.5</td>
<td>4</td>
<td>120</td>
<td>Current</td>
<td>1x / 1.33x / 1.5x / 2x</td>
<td>±1.5%</td>
<td>PWM</td>
<td>Depends on System</td>
<td>1</td>
<td>1 max</td>
<td>TQFN-16</td>
<td>• Backlight</td>
</tr>
<tr>
<td>CAT3614</td>
<td>2.7 - 5.5</td>
<td>4</td>
<td>124</td>
<td>Current</td>
<td>1x / 1.5x</td>
<td>±3%</td>
<td>Single Wire</td>
<td>32</td>
<td>0.5</td>
<td>1 max</td>
<td>TDFN-12</td>
<td>• Backlight</td>
</tr>
<tr>
<td>CAT3644</td>
<td>2.2 - 5.5</td>
<td>4</td>
<td>100</td>
<td>Current</td>
<td>1x / 1.33x / 1.5x / 2x</td>
<td>±1.5%</td>
<td>Single Wire</td>
<td>6</td>
<td>1</td>
<td>1 max</td>
<td>TQFN-16</td>
<td>• Backlight</td>
</tr>
<tr>
<td>CAT3648</td>
<td>2.2 - 5.5</td>
<td>4</td>
<td>100</td>
<td>Current</td>
<td>1x / 1.33x / 1.5x / 2x</td>
<td>±1.5%</td>
<td>Single Wire</td>
<td>32</td>
<td>1</td>
<td>1 max</td>
<td>TQFN-16</td>
<td>• Backlight</td>
</tr>
<tr>
<td>NCP5623B/C</td>
<td>2.7 - 5.5</td>
<td>3 (Independent)</td>
<td>90</td>
<td>Current</td>
<td>1X, 2X</td>
<td>±0.5%</td>
<td>I2C</td>
<td>32 / quasi-log</td>
<td>0.35</td>
<td>0.8 typ</td>
<td>LLGA-12</td>
<td>• RGB illumination</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Built-in “gradual illumination”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• B &amp; C versions have different I2C addresses</td>
</tr>
<tr>
<td>CAT3643</td>
<td>2.2 - 5.5</td>
<td>3</td>
<td>90</td>
<td>Current</td>
<td>1x / 1.33x / 1.5x / 2x</td>
<td>±1.5%</td>
<td>Single Wire</td>
<td>6</td>
<td>1</td>
<td>1 max</td>
<td>TDFN-12, TQFN-16</td>
<td>• Backlight</td>
</tr>
</tbody>
</table>
Charge Pump/White and RGB LED Drivers — for LCD Backlight, LED Flash/Torch and Indicator (cont.)

<table>
<thead>
<tr>
<th>Device</th>
<th>Input Voltage Range (V)</th>
<th>Number of Outputs</th>
<th>Total Output Current (mA)</th>
<th>Regulation Mode</th>
<th>Charge Pump Operating Mode</th>
<th>LED-LED Current Matching, Typ</th>
<th>Dimming Method</th>
<th>Number of Current Level/Profile</th>
<th>Operating Quiescent Current, Typ (mA)</th>
<th>Shutdown Current, (µA)</th>
<th>Package</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAT3647</td>
<td>2.2 - 5.5</td>
<td>3</td>
<td>100</td>
<td>Current</td>
<td>1x / 1.33x / 1.5x / 2x</td>
<td>±1.5%</td>
<td>Single Wire</td>
<td>32</td>
<td>1 max</td>
<td>1 max</td>
<td>TQFN-16</td>
<td>• Backlight</td>
</tr>
<tr>
<td>CAT3612</td>
<td>3.0 - 5.5</td>
<td>2</td>
<td>300</td>
<td>Current</td>
<td>1x / 1.5x</td>
<td>±3%</td>
<td>Single Wire</td>
<td>32</td>
<td>0.5 max</td>
<td>1 max</td>
<td>TDFN-12</td>
<td>• Flash/Torch</td>
</tr>
<tr>
<td>CAT3224</td>
<td>2.0 - 5.5</td>
<td>2</td>
<td>4 A Flash, 400 mA Torch</td>
<td>Current</td>
<td>1x / 2x</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>6 max</td>
<td>1 max</td>
<td>TQFN-16</td>
<td>• Flash/Torch</td>
</tr>
<tr>
<td>NCP5612</td>
<td>2.7 - 5.5</td>
<td>2</td>
<td>60</td>
<td>Current</td>
<td>1X, 1.5X</td>
<td>±0.2%</td>
<td>S-Wire Link</td>
<td>16/ linear</td>
<td>0.6 max</td>
<td>1</td>
<td>LLGA-12</td>
<td>• Built-in “icon” dimming mode</td>
</tr>
<tr>
<td>CAT3661</td>
<td>2.0 - 5.5</td>
<td>1</td>
<td>10</td>
<td>Current</td>
<td>1x / 1.33x / 1.5x / 2x</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>0.13 max</td>
<td>1 max</td>
<td>TQFN-16</td>
<td>• Built-in “icon” dimming mode</td>
</tr>
<tr>
<td>NCP5603</td>
<td>2.85 - 5.5</td>
<td>1</td>
<td>200 mA DC, 350 mA pulse</td>
<td>Voltage</td>
<td>1X, 1.5X, 2X</td>
<td>–</td>
<td>PWM</td>
<td>Depends on system</td>
<td>2.5 typ</td>
<td></td>
<td>DFN-10</td>
<td>• Backlight</td>
</tr>
<tr>
<td>CAT3200</td>
<td>2.7 - 4.5</td>
<td>1</td>
<td>100</td>
<td>Voltage</td>
<td>2X</td>
<td>–</td>
<td>PWM</td>
<td>Depends on system</td>
<td>1.7 typ</td>
<td>1 typ</td>
<td>TSOT-23-6</td>
<td>• Backlight</td>
</tr>
<tr>
<td>CAT3200H</td>
<td>2.7 - 4.5</td>
<td>1</td>
<td>100</td>
<td>Voltage</td>
<td>2X</td>
<td>–</td>
<td>PWM</td>
<td>Depends on system</td>
<td>1.7 typ</td>
<td>1 typ</td>
<td>UDFN-8</td>
<td>• Backlight</td>
</tr>
</tbody>
</table>

• Built-in “icon” dimming mode
• OVP
• Short circuit protection
• Optimized for coin cell applications
• Backlight
• 4.5 / 5 V output
• Short circuit protection
• 2 MHz switching
• Soft-start
• Thermal shutdown
• Fixed V_out = 5 V and adjustable output
Inductive Boost and Buck Topology

Inductive-Boost White-LED Drivers — for Backlighting and Torch/Flash Applications

<table>
<thead>
<tr>
<th>Device</th>
<th>Input Voltage Range (V)</th>
<th>Max Output Volt, Typ (V)</th>
<th>Output Current (mA)</th>
<th>Condition</th>
<th>Number of LEDs/Configuration</th>
<th>Switching Mode/Frequency</th>
<th>Dimming Method</th>
<th>Efficiency (%)</th>
<th>Operating Quiescent Current, Typ (mA)</th>
<th>Shutdown Current, Typ (mA)</th>
<th>Notes</th>
</tr>
</thead>
</table>
| NCP1422  | 1.0 - 5.0               | 5                       | 800                 | Vout 3.3 V, Vin 2.5 V | 1 for flash                  | PFM, up to 1.2 MHz       | PWM            | 94             | 1.3 µA                              | 0.05                     | DFN-10
| CAT37    | 2.5 - 7                 | 20                      | 20                  | Vout 2.5 V              | 1 to 4 / Series              | 1.2 MHz           | PWM            | 84             | 0.5                                   | 1                        | Backlight, LT1937 pinout, Iw = 550 mA   |
| CAT32    | 2.0 - 7                 | 20                      | 20                  | Vout 1.8 V              | 1 to 4 / Series              | 1.2 MHz           | PWM            | 84             | 0.5                                   | 0.05                     | Backlight, LT1932 pinout, Iw = 550 mA   |
| CAT4137  | 2.2 - 5.5               | 24                      | 40                  | Vout 17 V, Vin 3.5 V    | 1 to 5 / Series              | 1 MHz              | PWM            | 87             | 0.4                                   | 0.1                      | Backlight, Iw = 350 mA                  |
| CAT4139  | 2.0 - 5.5               | 24                      | 50                  | Vout 14 V, Vin 3.0 V    | 1 to 5 / Series              | 1 MHz              | PWM            | 87             | 0.6                                   | 0.1                      | Backlight, Iw = 450 mA                  |
| NCP5005  | 2.7 - 5.5               | 24                      | 40                  | Over 5 LED, Vin 3.6 V   | 2 to 5 / series              | PFM, up to 2.25 MHz   | PWM            | 90             | —                                     | 0.3                      | Backlight, Iw = 450 mA                  |
| CAT4237  | 2.0 - 5.5               | 34                      | 30                  | Vout 30 V, Vin 3.6 V    | 1 to 8 / Series              | 1 MHz              | PWM            | 87             | 0.6                                   | 0.1                      | Backlight, Iw = 450 mA                  |
| CAT4238  | 2.0 - 5.5               | 38                      | 20                  | Vout 33 V, Vin 3.5 V    | 1 to 10 / Series             | 1 MHz              | PWM            | 87             | 0.6                                   | 0.1                      | Backlight, Iw = 450 mA                  |
| CAT4240  | 2.0 - 5.5               | 38                      | 250                 | Vout 30 V, Vin 5 V      | 1 to 10 / Series             | 1 MHz              | PWM            | 87             | 0.6                                   | 0.1                      | Backlight, Iw = 450 mA                  |
| CAT4252* | 2.5 - 5.5               | 24                      | 20                  | Vout 23 V, Vin 3.6 V    | 2 to 6 / Series              | 1.2 MHz           | 1-wire/32 levels | 88             | 1                                     | 0.1                      | Backlight, Built-in Schottky             |
| CAT4253* | 2.5 - 5.5               | 24                      | 20                  | Vout 23 V, Vin 3.6 V    | 2 to 6 / Series              | 1.2 MHz           | 1-wire/32 levels | 88             | 1                                     | 0.1                      | Backlight, Built-in Schottky             |
| CAT4157* | 2.5 - 5.5               | 24                      | 20                  | Vout 23 V, Vin 3.6 V    | 2 to 6 / Series              | 1.2 MHz           | 1-wire/32 levels | 88             | 1                                     | 0.1                      | Backlight, Same pinout as CAT4137       |
| CAT4158* | 2.5 - 5.5               | 24                      | 20                  | Vout 23 V, Vin 3.6 V    | 2 to 6 / Series              | 1.2 MHz           | PWM            | 88             | 1                                     | 0.1                      | Backlight, Same pinout as CAT4137       |
| CAT4258* | 2.5 - 5.5               | 48                      | 25                  | Vout 46 V, Vin 3.6 V    | 2 to 12 / Series             | 1.2 MHz           | 1-wire & PWM   | 88             | 1                                     | 0.1                      | Backlight, Noiseless PWM                |
| CAT4131* | 2.5 - 5.0               | 5.5                     | 1.5 A / 0.3 A       | Vout 3.4 V, Vin 3.6 V   | 1 to 5 / Series              | 2 MHz              | 1-wire/32 levels | 85             | 1                                     | 0.1                      | Flash/Torch, Synchronous Rectification |

* Pending 2H12.

Inductive-Buck White-LED Drivers — for Torch/Flash Applications

<table>
<thead>
<tr>
<th>Device</th>
<th>Input Voltage Range (V)</th>
<th>Max Output Volt, Typ (V)</th>
<th>Output Current (mA)</th>
<th>Condition</th>
<th>Number of LEDs/Configuration</th>
<th>Switching Mode/Frequency</th>
<th>Dimming Method</th>
<th>Efficiency (%)</th>
<th>Operating Quiescent Current, Typ (mA)</th>
<th>Shutdown Current, Typ (mA)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCP1529</td>
<td>2.7 - 5.5</td>
<td>3.9</td>
<td>1</td>
<td>Vout 1.2 V, Vin 3.6 V</td>
<td>1</td>
<td>PWM/PMF 1.7 MHz</td>
<td>PWM</td>
<td>96</td>
<td>28</td>
<td>0.3</td>
<td>TSO5P-5, uDFN-6</td>
</tr>
</tbody>
</table>

* Flash/Torch, Auto-switching between PWM and PFM mode at light load.
### Linear Topology

**Features**
- Dimming via 1-wire EZDim interface with 32 levels of dimming control
- 25 mA fixed current (B versions) or adjustable current (A versions)
- Zero current shutdown (< 1 μA)
- No switching supply noise
- Tightly matched current LED sinks
- Ultra-low headroom current sink
- Dropout voltage of 75 mV at 20 mA
- Low profile micro packaging

**Applications**
- Mobile handsets
- Still and video cameras
- Portable gaming
- Portable medical devices

---

**Linear White-LED Drivers for LCD Backlight**

<table>
<thead>
<tr>
<th>Device</th>
<th>No of Channels</th>
<th>Current</th>
<th>Available Packages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fixed (25 mA)</td>
<td></td>
</tr>
<tr>
<td>CAT4002A</td>
<td>2</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>CAT4003B</td>
<td>3</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>CAT4004A</td>
<td>4</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>CAT4004B</td>
<td>4</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Adjustable (2 to 4 mA)</td>
<td></td>
</tr>
<tr>
<td>CAT4002A</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>CAT4003B</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>CAT4004A</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>CAT4004B</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
Camera Flash and Torch Light-Dedicated LED Drivers

LEDs for camera phones, smart phones, and XENON bulb replacement, are scaling up in light output to meet the needs of higher performance camera imagers.

Camera Flash and Torch Light-Dedicated LED Drivers

<table>
<thead>
<tr>
<th>Device</th>
<th>Topology</th>
<th>Input Voltage Range (V)</th>
<th>Output Current</th>
<th>Output</th>
<th>Package</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAT3224</td>
<td>Charge Pump</td>
<td>2.5 - 5.5</td>
<td>2 channels at 2 A each in Flash mode (4 A total); 2 channels at 200 mA each in Torch mode</td>
<td>2 channels</td>
<td>TQFN-16</td>
<td>• Dual Cell Supercapacitor Balancing</td>
</tr>
<tr>
<td>CAT4131*</td>
<td>Inductive Boost</td>
<td>2.5 - 5.0</td>
<td>1.5 A flash; 0.3 A torch</td>
<td>1 channel</td>
<td>TQFN-16</td>
<td>• 1-wire EZDim programmable LED current with 32 dimming levels</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Synchronous Rectification</td>
</tr>
<tr>
<td>CAT4134</td>
<td>Inductive Boost</td>
<td>2.6 - 4.2</td>
<td>250 mA per channel (up to 3 LEDs in series per channel)</td>
<td>2 channels</td>
<td>TDFN-12</td>
<td>• Dual Frequency Mode 1.2 MHz and 900 kHz</td>
</tr>
<tr>
<td>CAT3612</td>
<td>Charge Pump</td>
<td>3.0 - 5.5</td>
<td>150 mA per channel</td>
<td>2 channels</td>
<td>TDFN-12</td>
<td>• 1-wire EZDim programmable LED current with 32 dimming levels</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Efficiency up to 90%</td>
</tr>
</tbody>
</table>

* Pending 2H12.
### Multifunction LED Drivers

<table>
<thead>
<tr>
<th>Device</th>
<th>Function*</th>
<th>Main Backlight LED Driver</th>
<th>Sub Backlight LED Driver</th>
<th>RGB LED Driver 1</th>
<th>RGB LED Driver 2</th>
<th>External Control</th>
<th>Auto Blinking</th>
<th>LED Driver/Torch</th>
<th>Flash Mode/Pulse</th>
<th>Topology</th>
<th>Serial Control</th>
<th>Package</th>
<th>Notes</th>
</tr>
</thead>
</table>
| LV5219LG  | T, SB, RGB| 6-Ch (3/4/5-Ch Avail)     | 2-Ch                     | R,G,B Independent ON/OFF | R,G,B Independent ON/OFF | ✓                | ✓             | 3-Ch             | Inductive Boost  | FLGA-49      |               |          | • 17 LED channels total  
• LED current programmable:  
  - MB, SB, RGB: 32 steps  
  - Torch: 16 steps  
• Main LED auto luminance control  
• External brightness control |
| LV5231CS  | F, MB, RGB| 6-Ch (4/5-Ch Avail)       | –                        | R,G,B Independent ON/OFF | R,G,B Independent ON/OFF | ✓                | ✓             | 4-Ch             | Inductive Boost  | I2C Control Bus | WLP-40      |               | • 16 LED channels total  
• LED current programmable:  
  - MB: 64 steps  
  - RGB: 32 steps  
  - Flash: 16 steps  
• LED Diagnostic  
• External brightness control |
| LV5207LP  | MB, RGB   | 4-Ch (3-Ch Avail)         | –                        | R,G,B Independent ON/OFF | –                 | ✓                | –             |                  | Charge Pump      | VCT-24        |               |          | • 7 LED channels total  
• LED current programmable in 32 steps |
| LV5216CS  | MB, RGB   | 6-Ch (3/4/5-Ch Avail)     | –                        | R,G,B Independent ON/OFF | –                 | ✓                | ✓             | –                | Charge Pump      | WLP-36        |               |          | • 7 LED channels total  
• LED current programmable:  
  - MB, RGB: 32 steps  
  - Auto Luminance Control:  
  228 steps  
• Main LED auto luminance control  
• External brightness control |

* F=Flash light;  T=Torch light;  RGB=Illumination;  MB=Main LCD screen backlight;  SB=Secondary LCD screen backlight

### RGB Illumination Drivers

<table>
<thead>
<tr>
<th>Device</th>
<th>Input Voltage Range (V)</th>
<th>RGB LED Driver #1</th>
<th>RGB LED Driver #2</th>
<th>No of Channels</th>
<th>Auto Blinking</th>
<th>Camera Flash LED Driver</th>
<th>Interface</th>
<th>Package</th>
<th>Notes</th>
</tr>
</thead>
</table>
| LV5213LP  | 3.0 to 4.5              | 3-channels with independent ON/OFF of the RGB colors | –                                          | 3              | –             | –                       | 3-Wire SPI | VCT-16   | • Individual current level programmability (32 levels) per channel  
  • 12 mA total for the 3 channels |
| LV5217LP  | 3.0 to 4.5              | 3-channels with independent ON/OFF of the RGB colors | –                                          | 3              | –             | –                       | I2C       | VCT-16   | • Individual current level programmability (128 levels) per channel  
  • 25 mA total for the 3 channels |
| LV5223GR  | 3.0 to 4.5              | 3-channels with independent ON/OFF of the RGB colors | 3-channels with independent ON/OFF of the RGB colors | 9              | ✓             | 2-Ch                    | I2C       | VCT-28   | • Built-in Charge Pump  
  • 3 additional outputs GPO |
| LV5226CS  | 3.0 to 4.5              | 3-channels with independent ON/OFF of the RGB colors | 3-channels with independent ON/OFF of the RGB colors | 6              | ✓             | –                       | 4-wire SPI | WLP-48   | • 4 high-side P-channel switches  
  • 1 additional output GPO |
| LV5230LG  | 3.0 to 4.5              | 17x7 dot matrix LED driver:  
  Column (anode) P-channel driver, 17 channels  
  Row (cathode) N-channel driver, 7 channels | –                                          | ✓ (Auto Scroll, etc.)                  | –             | I2C                     | FLGA-49   |          | • 25 mA max per dot |

LED Lighting Solutions
ADDRESSABLE SIGNAGE

Intelligent LED Control for Signage and Architectural Lighting

Addressable signage and architectural lighting make wide use of LEDs utilizing the broad range of available LED colors and their long operating lifetime. In architectural lighting, the use of LEDs allows vivid colors in lighting facades and enhancement of structural details. In moving signage applications, information can be updated in real time traffic displays, video images, and advertising. ON Semiconductor offers a series of linear solutions that can accurately regulate LED current and have programmable interfaces to allow software control.

LED Controllers

<table>
<thead>
<tr>
<th>Device</th>
<th>Vin (V)</th>
<th>LEDs</th>
<th>Iout per Channel (mA)</th>
<th>Dropout Voltage (mV)</th>
<th>Shutdown Current Max (µA)</th>
<th>Dimming Interface</th>
<th>Features</th>
<th>Packages</th>
<th>Architectural</th>
<th>Signage</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAT310</td>
<td>5.5</td>
<td>10</td>
<td>50</td>
<td>–</td>
<td>–</td>
<td>4-Wire</td>
<td>–</td>
<td>S0IC-20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAT4008</td>
<td>3.0 - 5.5</td>
<td>8</td>
<td>100</td>
<td>300 @ 30 mA</td>
<td>1</td>
<td>4-Wire</td>
<td>Thermal Shutdown; UVLO</td>
<td>S0IC-16, TSSOP-16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAT4016</td>
<td>3.0 - 5.5</td>
<td>16</td>
<td>100</td>
<td>300 @ 30 mA</td>
<td>1</td>
<td>4-Wire</td>
<td>Thermal Shutdown; UVLO; Up to 6 V operation on LED pins</td>
<td>QSOP-24, S0IC-24, TQFN-24, TSSOP-24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAT4116*</td>
<td>3.0 - 5.5</td>
<td>16</td>
<td>100</td>
<td>300 @ 20 mA</td>
<td>1</td>
<td>4-Wire</td>
<td>Thermal Shutdown; UVLO; Up to 25 V operation on LED pins</td>
<td>TSSOP-24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAT4101</td>
<td>3.0 - 5.5/25</td>
<td>8</td>
<td>1000</td>
<td>500 @ 1 A</td>
<td>1</td>
<td>PWM</td>
<td>Thermal Shutdown; UVLO</td>
<td>T0-263-5</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>CAT4103</td>
<td>3.0 - 5.5/25</td>
<td>6 x 3</td>
<td>175</td>
<td>400 @ 175 mA</td>
<td>1</td>
<td>PWM</td>
<td>3 Independent Current Sinks; Cascadable</td>
<td>SOIC-16</td>
<td>❌</td>
<td></td>
</tr>
<tr>
<td>CAT4104</td>
<td>3.0 - 5.5/25</td>
<td>6 x 4</td>
<td>175</td>
<td>400 @ 175 mA</td>
<td>1</td>
<td>PWM</td>
<td>Thermal Shutdown; UVLO</td>
<td>SOIC-8, TDFN-8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAT4109</td>
<td>3.0 - 5.5/25</td>
<td>6 x 3</td>
<td>175</td>
<td>400 @ 175 mA</td>
<td>5</td>
<td>PWM</td>
<td>3 Independent Current Sinks</td>
<td>SOIC-16</td>
<td>✔</td>
<td></td>
</tr>
</tbody>
</table>

* Pending 2H12.

8 and 16 Channel Constant Current LED Sink Drivers

**Features**
- ±1.5% typical channel matching
- Up to 100 mA drive per channel
- 300 mV dropout at 30 mA
- Robust protection (UVLO, thermal shutdown)
- Cascadable 25 MHz capable 4-wire data interface

**Applications**
- Intelligent vehicle signs
- Scrolling banners
- Billboard signs
- Marque signs
- Gaming and pachinko
- Sports scoreboards
3-Channel Cascade-Capable Driver with Independent Current Control – CAT4103

**Features**
- Up to 25 V per string
- Robust protection (UVLO, thermal shutdown)
- RGB Drivers can be individually controlled or cascaded
- Drivers to support currents of up to 175 mA per channel

**Applications**
- Accent lighting
- Color mixing
- Effects lighting
- Mood lighting

**Resources**
- Evaluation Board: CAT4103AEVB

**Features**
- Up to 25 V per string
- Robust protection (UVLO, thermal shutdown)
- RGB Drivers can be individually controlled or cascaded
- Drivers to support currents of up to 175 mA per channel

**Applications**
- Accent lighting
- Color mixing
- Effects lighting
- Mood lighting

**Resources**
- Evaluation Board: CAT4103AEVB
16-Channel \textsuperscript{2}C LED Indicator Driver and Port Expander – CAT9532 & CAT9552

Features

- 16 LED drivers with dimming control
- 256 brightness steps
- 16 open drain outputs drive 25 mA each
- Programmable blink rates
- I/Os can be used as general purpose I/Os
- 400 kHz \textsuperscript{2}C bus compatible
- 8 address expansion selections

Applications

- Single board computers
- Telecom equipment
- Office machines
- Appliance control panels
- Gaming
- Alarm systems
- Point of sale displays
Mid-Voltage LED Driver Topologies

Many LED applications are powered from an offline AC-DC supply, a battery, or an electronic transformer with a low voltage AC output. In addition, some of these power sources, such as lead acid batteries, are loosely regulated. As a result, there is a need for LED driver solutions that can operate over a broad range of input voltage and can be configured in various topologies to support the LED load requirements. Depending on the LED current and operating conditions, this could involve either a linear or switching regulator LED driver solution.

Applications
- Landscape lighting
- Low voltage track lighting
- Solar powered lighting
- Automotive
- Emergency vehicles
- Marine applications
- 12 Vac/Vdc MR16
- Airplane interiors
- Sign backlighting
- Channel letters and signs

<table>
<thead>
<tr>
<th>Power</th>
<th>Application</th>
<th>Voltage &amp; Regulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offline AC Regulated Adapter</td>
<td>Low to medium volume applications, reduces safety requirements</td>
<td>Common voltages of 12, 24, 36, 48 Vdc, regulation to ±5%</td>
</tr>
<tr>
<td>Lead Acid Battery</td>
<td>Automotive, solar powered, marine</td>
<td>Loose regulation, 8-14 Vdc; Wider for automotive, 7-27 Vdc</td>
</tr>
<tr>
<td>12 Vdc &amp; 12 Vac</td>
<td>Common in interior, track lighting, outdoor, landscaping applications</td>
<td>Loose if magnetic ballast, tight to ±5% if electronic ballast, minimum load may be required; plus cable losses</td>
</tr>
</tbody>
</table>

Boost (Step-Up) Topology

Buck (Step-Down) Topology

Linear Topology
Linear LED Driver Solutions

Linear solutions are the preferred approach for many lighting applications, as they are simple, straightforward to design, and allow the LEDs to be driven with a tightly regulated current, regardless of LED forward voltage or input supply variation. Because the LED drivers are linear, they must be matched to the power dissipation requirements of the application. ON Semiconductor offers a wide range of constant current linear LED drivers whose current levels span from 10 mA to 1 A.

### Constant Current Regulators – Dimming with External BRT

**Input**

<table>
<thead>
<tr>
<th>VDD</th>
</tr>
</thead>
</table>

**Output**

| GB1, GB2, VSS |

**Ambient Light Sensor**

| NOA1211 |

**Control**

| Anode |

**Photo Diode**

| h, ν |

| Vak, ANODE–CATHODE VOLTAGE (V) |

| 16 | 17 | 18 | 19 | 20 | 21 | 22 |

**I_{reg(SS)}, STEADY STATE CURRENT (mA)**

| 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**TA = 25°C**

**TA = 85°C**

| DC Test Steady State, Still Air |

**Linear LED Drivers**

<table>
<thead>
<tr>
<th>Device</th>
<th>Operating Voltage Range (V)</th>
<th>Channel Output Current (mA)</th>
<th>Typical Current Tolerance</th>
<th>Number of Channels</th>
<th>Adjustable</th>
<th>Dimming Control</th>
<th>Typical Dropout (V)</th>
<th>Operating Temperature Range (°C)</th>
<th>Package(s)</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAT4101</td>
<td>3.0 to 25</td>
<td>1000</td>
<td>±2%</td>
<td>1</td>
<td>Y</td>
<td>PWM</td>
<td>500 mV @ 1000 mA</td>
<td>–40 to +85</td>
<td>D2PAK</td>
<td>Thermal Shutdown, UVLO</td>
</tr>
<tr>
<td>CAT4104</td>
<td>3.0 to 25</td>
<td>175</td>
<td>±2%</td>
<td>4</td>
<td>Y</td>
<td>PWM</td>
<td>400 mV @ 175 mA</td>
<td>–40 to +85</td>
<td>SOIC-8, TDFN-8</td>
<td>Thermal Shutdown, UVLO</td>
</tr>
<tr>
<td>NCV7680</td>
<td>6 to 16</td>
<td>35</td>
<td>±10% @ 35 mA</td>
<td>8</td>
<td>Y</td>
<td>Ext</td>
<td>1</td>
<td>–40 to +125</td>
<td>SOIC-16 EP</td>
<td>AEC-Q101 qualified</td>
</tr>
<tr>
<td>NSI50350AS</td>
<td>2 to 50</td>
<td>350</td>
<td>±10%</td>
<td>1</td>
<td>N</td>
<td>Ext</td>
<td>2.0</td>
<td>–40 to +125</td>
<td>SMC</td>
<td>AEC-Q101 qualified</td>
</tr>
<tr>
<td>NSI50350AD</td>
<td>2 to 50</td>
<td>350</td>
<td>±10%</td>
<td>1</td>
<td>N</td>
<td>Ext</td>
<td>2.0</td>
<td>–40 to +125</td>
<td>DPAK</td>
<td>AEC-Q101 qualified</td>
</tr>
<tr>
<td>NSIC2050B</td>
<td>1.8 to 120</td>
<td>50</td>
<td>±15%</td>
<td>1</td>
<td>N</td>
<td>Ext</td>
<td>1.8</td>
<td>–40 to +125</td>
<td>SMB</td>
<td>AEC-Q101 qualified</td>
</tr>
<tr>
<td>NSIC2030B</td>
<td>1.8 to 120</td>
<td>30</td>
<td>±15%</td>
<td>1</td>
<td>N</td>
<td>Ext</td>
<td>1.8</td>
<td>–40 to +125</td>
<td>SMB</td>
<td>AEC-Q101 qualified</td>
</tr>
<tr>
<td>NSIC2020B</td>
<td>1.8 to 120</td>
<td>20</td>
<td>±15%</td>
<td>1</td>
<td>N</td>
<td>Ext</td>
<td>1.8</td>
<td>–40 to +125</td>
<td>SMB</td>
<td>AEC-Q101 qualified</td>
</tr>
<tr>
<td>NSI45030Z</td>
<td>1.8 to 45</td>
<td>30</td>
<td>±15%</td>
<td>1</td>
<td>N</td>
<td>Ext</td>
<td>1.8</td>
<td>–40 to +125</td>
<td>SOT-233</td>
<td>AEC-Q101 qualified</td>
</tr>
<tr>
<td>NSI45030AZ</td>
<td>1.8 to 45</td>
<td>30</td>
<td>±10%</td>
<td>1</td>
<td>N</td>
<td>Ext</td>
<td>1.8</td>
<td>–40 to +125</td>
<td>SOT-223</td>
<td>AEC-Q101 qualified</td>
</tr>
<tr>
<td>NSI45030A</td>
<td>1.8 to 45</td>
<td>30</td>
<td>±10%</td>
<td>1</td>
<td>N</td>
<td>Ext</td>
<td>1.8</td>
<td>–40 to +125</td>
<td>SOD-123</td>
<td>AEC-Q101 qualified</td>
</tr>
<tr>
<td>NSI45030</td>
<td>1.8 to 45</td>
<td>30</td>
<td>±15%</td>
<td>1</td>
<td>N</td>
<td>Ext</td>
<td>1.8</td>
<td>–40 to +125</td>
<td>SOD-123</td>
<td>AEC-Q101 qualified</td>
</tr>
<tr>
<td>NSI45025Z</td>
<td>1.8 to 45</td>
<td>25</td>
<td>±15%</td>
<td>1</td>
<td>N</td>
<td>Ext</td>
<td>1.8</td>
<td>–40 to +125</td>
<td>SOT-223</td>
<td>AEC-Q101 qualified</td>
</tr>
<tr>
<td>NSI45025AZ</td>
<td>1.8 to 45</td>
<td>25</td>
<td>±10%</td>
<td>1</td>
<td>N</td>
<td>Ext</td>
<td>1.8</td>
<td>–40 to +125</td>
<td>SOT-223</td>
<td>AEC-Q101 qualified</td>
</tr>
<tr>
<td>NSI45025A</td>
<td>1.8 to 45</td>
<td>25</td>
<td>±10%</td>
<td>1</td>
<td>N</td>
<td>Ext</td>
<td>1.8</td>
<td>–40 to +125</td>
<td>SOD-123</td>
<td>AEC-Q101 qualified</td>
</tr>
<tr>
<td>NSI45025</td>
<td>1.8 to 45</td>
<td>25</td>
<td>±15%</td>
<td>1</td>
<td>N</td>
<td>Ext</td>
<td>1.8</td>
<td>–40 to +125</td>
<td>SOD-123</td>
<td>AEC-Q101 qualified</td>
</tr>
<tr>
<td>NSI45020A</td>
<td>1.8 to 45</td>
<td>20</td>
<td>±10%</td>
<td>1</td>
<td>N</td>
<td>Ext</td>
<td>1.8</td>
<td>–40 to +125</td>
<td>SOD-123</td>
<td>AEC-Q101 qualified</td>
</tr>
<tr>
<td>NSI45020</td>
<td>1.8 to 45</td>
<td>20</td>
<td>±15%</td>
<td>1</td>
<td>N</td>
<td>Ext</td>
<td>1.8</td>
<td>–40 to +125</td>
<td>SOD-123</td>
<td>AEC-Q101 qualified</td>
</tr>
</tbody>
</table>
### Linear LED Drivers (cont.)

<table>
<thead>
<tr>
<th>Device</th>
<th>Operating Voltage Range (V)</th>
<th>Channel Output Current (mA)</th>
<th>Typical Current Tolerance</th>
<th>Number of Channels</th>
<th>Dimming Control</th>
<th>Typical Dropout (V)</th>
<th>Operating Temperature Range (°C)</th>
<th>Package(s)</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSI45015W</td>
<td>1.8 to 45</td>
<td>15</td>
<td>±20%</td>
<td>1</td>
<td>N</td>
<td>1.8</td>
<td>-40 to +125</td>
<td>SOD-123</td>
<td>AEC-Q101 qualified</td>
</tr>
<tr>
<td>NSI55010Y</td>
<td>1.8 to 45</td>
<td>10</td>
<td>±30%</td>
<td>1</td>
<td>N</td>
<td>1.8</td>
<td>-40 to +125</td>
<td>SOD-123</td>
<td>AEC-Q101 qualified</td>
</tr>
<tr>
<td>NSI45090JD</td>
<td>1.8 to 45</td>
<td>90 to 160</td>
<td>±15%</td>
<td>1</td>
<td>Y</td>
<td>1.8</td>
<td>-40 to +125</td>
<td>DPAK</td>
<td>AEC-Q101 qualified</td>
</tr>
<tr>
<td>NSI45060JD</td>
<td>1.8 to 45</td>
<td>60 to 100</td>
<td>±15%</td>
<td>1</td>
<td>Y</td>
<td>1.8</td>
<td>-40 to +125</td>
<td>DPAK</td>
<td>AEC-Q101 qualified</td>
</tr>
<tr>
<td>NSI45035JZ</td>
<td>1.8 to 45</td>
<td>35 to 70</td>
<td>±15%</td>
<td>1</td>
<td>Y</td>
<td>1.8</td>
<td>-40 to +125</td>
<td>SOT-223</td>
<td>AEC-Q101 qualified</td>
</tr>
<tr>
<td>NSI45020JZ</td>
<td>1.8 to 45</td>
<td>20 to 40</td>
<td>±15%</td>
<td>1</td>
<td>Y</td>
<td>1.8</td>
<td>-40 to +125</td>
<td>SOT-223</td>
<td>AEC-Q101 qualified</td>
</tr>
<tr>
<td>NUD4001</td>
<td>2.0 to 30 (60 V Surge)</td>
<td>500</td>
<td>±3%</td>
<td>1</td>
<td>Y</td>
<td>1.4</td>
<td>-40 to +125</td>
<td>SOIC-8</td>
<td>Can be used with an external transistor</td>
</tr>
<tr>
<td>NUD4011</td>
<td>5 to 200</td>
<td>70</td>
<td>±3%</td>
<td>1</td>
<td>Y</td>
<td>5</td>
<td>-40 to +125</td>
<td>SOIC-8</td>
<td>Can be used with an external transistor</td>
</tr>
</tbody>
</table>

### Constant Current Regulator (CCRs) Linear LED Drivers for Displays and Channel Letters

#### Features
- Low startup voltage
- Tight current regulation regardless of $V_{f}$ variation
- Negative temperature coefficient protects LEDs

#### Resources
- Sample Kit: CCR2KIT/S

---

#### Constant Current Regulator (CCRs) Linear LED Drivers

<table>
<thead>
<tr>
<th>Device</th>
<th>Max Anode-to-Cathode Voltage ($V_{AK}$) (V)</th>
<th>Voltage Overhead ($V_{in} - V_{LEDs}$) (V)</th>
<th>Constant Current $I_{reg}$ (@ $V_{AK} = 7.5$ V) (mA)</th>
<th>Current Tolerance Over Voltage</th>
<th>Max Junction Temperature (°C)</th>
<th>Packages</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSI45xxx</td>
<td>45</td>
<td>1.8</td>
<td>Fixed: 15, 20, 25, 30</td>
<td>±15%, ±10%</td>
<td>150</td>
<td>SOD-123, SOT-223</td>
</tr>
<tr>
<td>NSI50xxx</td>
<td>50</td>
<td>2.0</td>
<td>Fixed: 10, 30</td>
<td>±10%</td>
<td>175</td>
<td>SMC, DPAK</td>
</tr>
<tr>
<td>NSIC20xx</td>
<td>120</td>
<td>1.8</td>
<td>Fixed: 20, 30, 50</td>
<td>±15%</td>
<td>175</td>
<td>SMB</td>
</tr>
<tr>
<td>NSI45xxxJ</td>
<td>45</td>
<td>1.8</td>
<td>Adjustable: 20 to 40</td>
<td>±15%</td>
<td>150</td>
<td>SOT-223, DPAK</td>
</tr>
</tbody>
</table>

* Pending 2H12: xxx in the device number represents the current level.

---

**NSI45025 vs Competing Devices @ 25 mA**

- **NSI45025AT1G**: Reaches Regulation Quickly
  - Turns On Quickly
  - Peak Output Power: 28.5 W

---

**Enabling Energy Efficient Solutions**

---

**LED Lighting Solutions**

---

**MID-VOLTAGE GENERAL LIGHTING**

---

**Page 16**
### Switching Driver Solutions

#### Wide Input Voltage LED Driver Selector

- **Vin < 40 V**
  - SEPIC/Buck-Boost
    - Vout = Vin
    - NCP3065/6
  - Step-Up (Boost)
    - Vout > Vin
    - Is < 1.3 A
      - NCP3065/6 Boost Controller
      - NCP3163 Boost Converter Up to 3 A Switch
    - NCP3065/6 Boost Controller
    - NCL30105 Boost Controller
  - Step-Down (Buck)
    - Vout < Vin
    - <350 mA
      - CAT4201 Hysteretic Buck Converter
    - Design Note: DN06031/D
    - NCP3065/6 Buck Controller
    - NCL30100 Buck Controller
  - NCP3065/6 Boost Controller

- **Vin > 40 V**
  - Yes
  - NCP3065/6 Boost Controller
  - NCL30160 Boost Converter
  - NCL30105 Boost Controller

- **Is > 1.3 A**
  - NCP3065/6 Boost Controller
  - NCP3065/6 Buck Controller
  - NCL30105 Buck Controller

---

<table>
<thead>
<tr>
<th>Device</th>
<th>Switching Frequency</th>
<th>Topology</th>
<th>Vin Range (V)</th>
<th>Switch Current (A)</th>
<th>Controller</th>
<th>Automotive Qualified Device</th>
<th>Packages</th>
<th>Application</th>
<th>Evaluation Board</th>
<th>Documentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCP3065</td>
<td>Up to 200</td>
<td>Buck, Boost, Buck/Boost</td>
<td>30 to 40</td>
<td>1.5</td>
<td>*</td>
<td>NCV3065</td>
<td>SOIC-8, DFN-8</td>
<td>Buck 3 A</td>
<td>NCP30653ABCKGEVB</td>
<td>Reference Design: TND373/D</td>
</tr>
<tr>
<td>NCP3066</td>
<td>250</td>
<td>Buck, Boost, Buck/Boost</td>
<td>30 to 40</td>
<td>1.5</td>
<td>*</td>
<td>NCV3066</td>
<td>SOIC-8, DFN-8</td>
<td>SEPIC 350 mA, 700 mA, 1 A</td>
<td>NCP3066GSEPGEVB</td>
<td>Application Note: AND8298/D</td>
</tr>
<tr>
<td>NCP3163</td>
<td>Up to 200</td>
<td>Buck, Boost, Buck/Boost</td>
<td>25 to 40</td>
<td>3.4</td>
<td></td>
<td>NCV3163</td>
<td>SOIC-16W, DFN-18</td>
<td>Boost 700 mA</td>
<td>NCP3163BSTEVB</td>
<td>Design Note: DN06041/D</td>
</tr>
<tr>
<td>MC33163</td>
<td>Up to 50</td>
<td>Buck, Boost, Buck/Boost</td>
<td>25 to 40</td>
<td>3.4</td>
<td></td>
<td>NCV3163</td>
<td>SOIC-16</td>
<td>Inverter 500 mA</td>
<td>NCP3163INVGEVB</td>
<td>Design Note: DN06047/D</td>
</tr>
<tr>
<td>CAT4201</td>
<td>50 - 1000</td>
<td>Buck</td>
<td>70 to 36</td>
<td>0.7</td>
<td></td>
<td>CAN4201</td>
<td>TSSOP-23-5</td>
<td>Buck 300 mA</td>
<td>CAT4201AVGEB</td>
<td>Design Note: DN06067/D</td>
</tr>
<tr>
<td>NCP1034</td>
<td>Up to 500</td>
<td>Buck</td>
<td>80 to 100</td>
<td>–</td>
<td>✓</td>
<td>NCV3163</td>
<td>SOIC-16</td>
<td>Buck 5 A, 5 Vout</td>
<td>NCP1034BCBKGEVB</td>
<td>Design Note: DN06041/D</td>
</tr>
<tr>
<td>CS5171/3</td>
<td>280 / 560</td>
<td>Boost or SEPIC</td>
<td>27 to 30</td>
<td>1.5</td>
<td></td>
<td>NCV5171/3</td>
<td>SOIC-8</td>
<td>Boost 400 mA, 5 Vout</td>
<td>CS5171BSTEVB</td>
<td>Design Note: DN06047/D</td>
</tr>
<tr>
<td>NCP1294</td>
<td>1000</td>
<td>Buck, Boost, Buck/Boost</td>
<td>33 to 72</td>
<td>–</td>
<td>✓</td>
<td>TSSOP-16, SOIC-16</td>
<td>High Voltage LED Driver (24 Vin to 110 Vout @ 100 mA)</td>
<td>NCP1294BCKGEVB</td>
<td>Design Note: DN060162/D</td>
<td></td>
</tr>
<tr>
<td>NCL30100</td>
<td>Up to 700</td>
<td>Buck</td>
<td>635 to 18</td>
<td>–</td>
<td>✓</td>
<td>TSSP-6</td>
<td>Buck 700 mA MR16 LED bulb</td>
<td>NCL30100D4LMGEVB</td>
<td>Design Note: DN060162/D</td>
<td></td>
</tr>
<tr>
<td>NCL30105</td>
<td>Up to 500</td>
<td>Buck</td>
<td>Up to 22</td>
<td>–</td>
<td>✓</td>
<td>SOIC-8</td>
<td>Up to 80 V Input, 350 mA Buck LED Driver</td>
<td>NCL30105GEVB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NCL30160</td>
<td>Up to 1.4 MHz</td>
<td>Buck</td>
<td>63 to 40</td>
<td>1</td>
<td>–</td>
<td>SOIC-8</td>
<td>Up to 40 V, 1 A Buck LED Driver</td>
<td>NCL30160GEVB</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. For switching regulators, this current is used to calculate LED current based on Vin conditions. * Can be configured as a controller.

---

**Resources**

- Application
- Evaluation Board
- Documentation
LED MR16 Light Bulb

**NCL30100, Fixed Off-Time Step-Down LED Driver Controller**
- Quasi-fixed OFF time, peak current hysteretic control method thus requiring no compensation components
- Low Side N-FET switch topology
- Intended for continuous conduction mode operation, thus no output capacitor is needed
- >500 kHz operation
- ±5% typical current regulation tolerance
- \( V_{CC} \) operation from 6.3 to 18 V

**NCL30160 — Constant Current Step-Down LED Driver for High Power LEDs**
- 30 mΩ integrated MOSFET
- 100% duty cycle for high efficiency
- Input voltage: 6.3 V to 40 V
- Switching frequency: Up to 1.4 MHz
- Dedicated PWM dimming pin/low power shutdown
- No control loop compensation required
- 1.5 A average current capability

**Resources**
- Evaluation Boards
  - NCL30100ADLMGEVB: MR16 form factor
  - NCL30100ASLDGEVB: PWM dimmable

Solar-Powered LED Street Sign

**NCL30160 — Constant Current Step-Down LED Driver for High Power LEDs**
- 30 mΩ integrated MOSFET
- 100% duty cycle for high efficiency
- Input voltage: 6.3 V to 40 V
- Switching frequency: Up to 1.4 MHz
- Dedicated PWM dimming pin/low power shutdown
- No control loop compensation required
- 1.5 A average current capability

**Resources**
- Evaluation Board: NCL30160GEVB
12 V AC-DC Design for 3 and 4 LED Modules

The circuit described in the DN06048/D Design Note is intended for driving multi-die LED modules like the Sharp ZENIGATA™, Cree XLamp™ MC-E, and other LEDs in low voltage 12 Vac/Vdc applications. The forward voltage of the modules overlaps the input voltage range, so a single switch buck-boost configuration is used.

**Features**
- Small size
- Wide input and output operation voltage
- Regulated output current
- Open LED protection
- Output short circuit protection

**Applications**
- MR16 bulbs
- Landscape lighting
- Transportation lighting

**Resources**
- Design Note DN06048/D
- Reference Design: TND373/D
- Evaluation board: NCP3065BBGEVB, buck-boost MR16

---

![Sharp ZENIGATA LED Module](image1)

![Cree XLamp MC-E LED](image2)

![Reference Design Demo Board](image3)

![Reference Design Block Diagram](image4)

![I_out versus Vac Input](image5)

![MR16 LED Module](image6)
Automotive Lighting Systems

ON Semiconductor offers standard products and custom devices for automotive lighting applications. The company leads the market for Xenon driver ASICs and developed the defacto standard stepper driver for headlight levelling and swiveling.

Front Lighting

The majority of automobiles on the road today are equipped with halogen lights for the high-beam (HB) and low-beam (LB) functions - the main front lighting functions. Halogen LB typically consumes 55 W, and provides ~1,000 lumen. HID technology - introduced over ten years ago - consumes 35 W, and provides ~3,500 lumen. Because of the high intensity and risk of glare to approaching traffic, some countries require automatic leveling of the LB, plus a high pressure cleaning device. Over time, HID lights will integrate the HB function into bi-xenon solutions.

While halogen technology continues to be viable for front lighting, automotive designs increasingly use LED lighting. LED lighting offers enhanced styling options, enables 'instant-on' lighting, and allows brightness control from 0% to 100% power.

Another important aspect for automotive front lighting is beam swiveling for Advanced Frontlighting Systems (AFS), to optimize the visibility in curves, and Adaptive Driving Beam (ADB), to adapt the beam to real-time situations. Stepper motors provide the primary controls for AFS and ADB.

ON Semiconductor offers a full range of products, from generic bulb driver solutions to stepper drivers, LED drivers, and Xenon drivers, that are specifically designed for front lighting.
Leveling and Swiveling for Front Lighting

The AMIS-30623 single-chip micro-stepping motor driver, with integrated controller and LIN interface, enables the design of dedicated mechatronic solutions connected remotely with a LIN master. The device receives positioning instructions through the bus and subsequently drives the motor coils to the desired position, using configurable parameters for current, speed, acceleration, and deceleration. AMIS-30623 also detects motor stalling.

NCV70521 and NCV70522 are single-chip micro-stepping motor drivers with current translation table and SPI interface. NCV70522 also includes an embedded 5 V regulator and a watchdog reset. The devices act as peripheral drivers, receiving ‘Next Micro-Step’ commands from a microcontroller, and synchronizing the motor coil-current with the desired speed. The integrated SPI bus allows parameter setting and diagnostics feedback.
Power Ballast and Dual LED Driver for Advanced LED Front Lighting Systems

The NCV78663* single-chip, intelligent LED driver for front lighting enables single-module control of high beams, low beams, daytime running lights, position lights, cornering lights, turn indicators, and fog lights. With integrated digital dimming, SPI programmable settings, and build-in diagnostics, the NCV78663 offers an integrated, energy efficient solution for comprehensive front lighting control.

Features – NCV78663

- System integrated solution with few external components.
- Buck-boost topology
- LED current regulator
  - Constant average current
  - Efficient integrated buck switches (high-side)
  - Current up to 2 A
  - Extended diagnostics: detection of open circuit or failing driver, short, over-current protection, single LED failures
  - Thermal protection
- System customization by SPI interface and/or OTP-settings
  - Multiple system configurations with one device
  - Fewer module versions for OEM
  - Better EMC behavior, without extra filtering
    - Low EMC from battery
    - Low EMC to LED string
  - High overall efficiency (>90%)
- Evaluation kit available

* Pending 2H12.
**Linear Current Regulator and Controller for Automotive LED Rear Combination Lamps**

**Features - NCV7680**
- Constant current outputs for LED string drive
- Open LED string diagnostic with open−drain output
- Slew rate control eliminates EMI concerns
- On−chip 1 kHz tail PWM dimming
- Over-voltage and over-temperature set back power limitation

Automotive battery systems have wide variations in line supply voltage. Low dropout is a key attribute for providing consistent LED light output at low line voltage.

The NCV7680 consists of eight linear programmable constant current sources. System design with the NCV7680 allows for two brightness levels, one for stop and one for tail illumination. Optional PWM control - the preferred method for dimming LEDs - can also be implemented. The PWM generator's fixed frequency provides flicker−free illumination. Optional external ballast FET allows for power distribution on designs requiring high currents.

To support the common RCL configuration of LED strings, the NCV7680 provides eight matched outputs for individual string drive, with current set by a single resistor. Individual string drive ensures equal current distribution between the strings.

The NCV7680 can function as a standalone device or in conjunction with additional support circuitry for more complex systems. When operating in combination with a boost controller, additional LEDs may be connected to a string.
Automotive LIN RGB LED Driver for Interior Lighting

The LIN Bus (Local Interconnect Network) is an inexpensive serial communications protocol, which is used within current automotive network architectures. It is a relatively slow communication system intended to monitor sensor devices or actuators in today’s cars.

The NCV7430, LIN RGB LED Driver, combines a LIN transceiver together with a RGB LED driver and memory. It is a single-chip RGB driver intended to monitor for dedicated multicolor LED applications in Automotive interior lighting. It contains a LIN interface (slave) for parametric programming of LED color and intensity. The device receives instructions through the LIN bus and subsequently drives the LEDs independently.

The NCV7430 acts as a slave on the LIN bus and the master can request specific status information (parameter values and error flags). The LIN address of the NCV7430 can be programmed in the internal memory of the device.

The NCV7430 is fully compatible with automotive requirements.

### Features — NCV7430*

**RGB LED Driver**
- 3 independent LED current regulators
- LED currents programmable with external resistors
- Power dissipation option with external ballast transistor
- LED temperature compensation with external sense circuit
- Modulation control for 3 LEDs (with calibration)

**LIN Interface**
- LIN physical layer according to LIN 2.1/SAE J2602
- OTP-programmable device node number and group address
- Diagnostics and status information about LEDs

**Protection and Diagnostics Over-Current Detection**
- Short circuit detection to GND and VBB
- Open LED detection
- High temperature warning and shutdown
- Retry mode on error detection

**Power Saving**
- Sleep mode supply current 20 μA
- Compliant with 14 V automotive systems

**EMI Compatibility**
- LIN Bus integrated slope control
- EMC reduced LED modulation mode

---

* Pending 2H12.
Constant Current Regulators for Automotive Exterior and Interior Lighting

The two-terminal linear constant current regulators (CCRs) are simple, economical, and robust devices that provide an effective solution for regulating current in cost-sensitive LED applications. The devices require no external components, allowing them to be implemented as high or low-side regulators. These devices regulate output current over a wide range of input voltage, and are designed with a negative temperature coefficient to protect LEDs from thermal runaway at extreme voltage and operating temperature.

**Features**
- Regulated current provides constant brightness over wide voltage range
- Negative temperature coefficient protects LEDs in high ambient conditions
- Available with multiple maximum operating voltages (45 V, 50 V, and 120 V) to withstand battery load dump

**Applications**
- Exterior Lighting — CHMSL (Center High Mounted Stop Lighting)
- Interior Lighting — Dome light, vanity mirror light, glove box

**Resources**
- Sample Kit: CCR2KIT/S

---

### Device Specifications

<table>
<thead>
<tr>
<th>Device</th>
<th>Max Anode-to-Cathode Voltage (V&lt;sub&gt;AK&lt;/sub&gt;) (V)</th>
<th>Voltage Overhead (V&lt;sub&gt;K&lt;/sub&gt; - V&lt;sub&gt;LEDs&lt;/sub&gt;) (V)</th>
<th>Constant Current I&lt;sub&gt;reg&lt;/sub&gt; @ V&lt;sub&gt;AK&lt;/sub&gt; = 7.5 V (mA)</th>
<th>Current Tolerance Over Voltage</th>
<th>Max Junction Temperature (°C)</th>
<th>Packages</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSI45xxx</td>
<td>45</td>
<td>1.6</td>
<td>Fixed: 15, 20, 25, 30</td>
<td>±15%, ±10%</td>
<td>150</td>
<td>SOD-123, SOT-223</td>
</tr>
<tr>
<td>NSI50xxx</td>
<td>50</td>
<td>2.0</td>
<td>Fixed: 10, 350</td>
<td>±10%</td>
<td>175</td>
<td>SMC, DPAK</td>
</tr>
<tr>
<td>NSIC20xx</td>
<td>120</td>
<td>1.8</td>
<td>Fixed: 20, 30, 50</td>
<td>±15%</td>
<td>175</td>
<td>SMB</td>
</tr>
<tr>
<td>NSI45xxxJ</td>
<td>45</td>
<td>1.6</td>
<td>Adjustable 20 to 40 35 to 70 60 to 100 90 to 160 200 to 350*</td>
<td>±15%</td>
<td>150</td>
<td>SOT-223, DPAK</td>
</tr>
</tbody>
</table>

* Pending 2H12. xxx in the device number represents the current level.
Compact 350 mA Buck LED Driver — CAV4201 & CAT4201

Features
- AEC-Q100 qualified as CAV4201
- Patented average current regulation architecture
- Drives up to 7 LEDs in series from 24 V
- Handles transients up to 40 V
- Power efficiency >94%
- Current limit and thermal protection
- Open LED protection
- Thin SOT-23-5

Applications
- Transportation lighting
- MR16 bulbs
- Light bars
- Architectural lighting
- Signage
- Solar powered lighting

Resources
- Evaluation Board: CAT4201AEVB

Multi-Topology, Constant Current Switching Regulator for High Brightness LEDs — NCV3065 & NCV3066

Features
- LED drive current up to 1.5 A
- External switch to improve efficiency
- PWM and analog dimming
- Handles transients up to 40 V
- NCV3066: same as NCV3065 but with On/Off control
- AEC-Q100 qualified as NCV3065/6

Resources

<table>
<thead>
<tr>
<th>Device</th>
<th>Application</th>
<th>Evaluation Board</th>
<th>Documentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCP/NCV3065</td>
<td>Buck 3 A</td>
<td>NCP30653ABCKGEVB</td>
<td>Application Note: AND8298/D</td>
</tr>
<tr>
<td>NCP/NCV3065</td>
<td>Buck-Boost 350 mA, 550 mA MR-16 LED bulb</td>
<td>NCP3065BBGEVB</td>
<td>Reference Design: TND373/D</td>
</tr>
<tr>
<td>NCP/NCV3065</td>
<td>SEPIC 350 mA, 700 mA, 1 A MR-16 LED bulb</td>
<td>NCP3065D1SLDGEVB</td>
<td>Design Note: DNO633/D</td>
</tr>
<tr>
<td>NCP/NCV3065</td>
<td>SEPIC 350 mA &amp; 700 mA</td>
<td>NCP3065D2SLDGEVB</td>
<td>Design Note: DNO631/D</td>
</tr>
<tr>
<td>NCP/NCV3065</td>
<td>SEPIC 700 mA</td>
<td>NCP3065D3SLDGEVB</td>
<td>Design Note: DNO631/D</td>
</tr>
<tr>
<td>NCP/NCV3065</td>
<td>Buck with external P-channel MOSFET</td>
<td>NCP3065D5BCGKEVB</td>
<td>Application Note: AND8298/D</td>
</tr>
<tr>
<td>NCP/NCV3065</td>
<td>Boost 1.5 A</td>
<td>NCP306550B5TGEVB</td>
<td>Application Note: AND8298/D</td>
</tr>
<tr>
<td>NCP/NCV3066</td>
<td>SEPIC 350 mA, 700 mA, 1 A</td>
<td>NCP30660FSEPGEVB</td>
<td>Application Note: AND8298/D</td>
</tr>
<tr>
<td>NCP/NCV3066</td>
<td>Buck 3 A</td>
<td>NCP30663BCGKEVB</td>
<td>Application Note: AND8298/D</td>
</tr>
<tr>
<td>NCP/NCV3066</td>
<td>Boost &lt;1 A</td>
<td>NCP30663CBSTGEVB</td>
<td>Application Note: AND8298/D</td>
</tr>
<tr>
<td>NCP/NCV3065</td>
<td>General</td>
<td>Design Worksheet: NCP3065 DWS.XLS</td>
<td></td>
</tr>
<tr>
<td>NCP/NCV3066</td>
<td>General</td>
<td>Design Worksheet: NCP3066 DWS.XLS</td>
<td></td>
</tr>
</tbody>
</table>
AC Line Powered LED Driver Topologies

There are numerous topologies for driving LEDs off the AC mains, depending on the requirements of the application (size, efficiency, power factor, power delivered, drive current). Fortunately, ON Semiconductor provides a wide range of power solutions, whether the application is a 5 W LED under-cabinet light or a 150 W LED streetlight.

- Non-Isolated Linear Driver
- Single-Stage Flyback LED Driver
- Non-Isolated Buck Driver
- Single-Stage Flyback LED Driver
- Dual-Stage Power Factor Corrected Isolated LED Driver
Non Isolated Linear LED Driver Topology — Constant Current Regulators (CCRs)

Low Current LED String Driver

**Features**
- LED Driver: CCR NSIC2020 (120 V, 20 mA)
- Constant current as AC voltage increases
- No delay in turn on after LED threshold voltage is reached
- Bright LEDs at low voltages
- LEDs protected from voltage surge

**Applications**
- LED light bulbs
- Rope lights
- Cove lighting

**Resources**
- Sample Kit: CCR2KIT/S

<table>
<thead>
<tr>
<th>Device</th>
<th>Max Anode-to-Cathode Voltage (V&lt;sub&gt;AK&lt;/sub&gt;) (V)</th>
<th>Voltage Overhead (V&lt;sub&gt;LEDs&lt;/sub&gt; - V&lt;sub&gt;AK&lt;/sub&gt;) (V)</th>
<th>Constant Current&lt;sub&gt;reg&lt;/sub&gt; (@ V&lt;sub&gt;AK&lt;/sub&gt; = 7.5 V) (mA)</th>
<th>Current Tolerance Over Voltage</th>
<th>Max Junction Temperature (°C)</th>
<th>Packages</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSI45xxx</td>
<td>45</td>
<td>1.8</td>
<td>Fixed: 15, 20, 25, 30</td>
<td>±15%, ±10%</td>
<td>150</td>
<td>SOT-223, SOD-123</td>
</tr>
<tr>
<td>NSI50xxx</td>
<td>50</td>
<td>2.0</td>
<td>Fixed: 10, 350</td>
<td>±10%</td>
<td>175</td>
<td>SMC, DPAK</td>
</tr>
<tr>
<td>NSIC20xx</td>
<td>120</td>
<td>1.8</td>
<td>Fixed: 20, 30, 50</td>
<td>±15%</td>
<td>175</td>
<td>SMB</td>
</tr>
<tr>
<td>NSI45xxxJ</td>
<td>45</td>
<td>1.8</td>
<td>Adjustable: 20 to 40, 35 to 70, 60 to 100, 90 to 160, 200 to 350*</td>
<td>±15%</td>
<td>150</td>
<td>SOT-223, DPAK</td>
</tr>
</tbody>
</table>

* Pending 2H12. *xxx in the device number represents the current level.

Low Cost T5 LED Tube

**Features**
- LED Driver: CCR NSIC2050 (120 V, 50 mA)
- Direct AC drive of LEDs
- No leakage current
- Current regulation to protect LEDs

**Resources**
- Sample Kit: CCR2KIT/S

<table>
<thead>
<tr>
<th>Performances</th>
<th>Input Power (W)</th>
<th>Power Factor</th>
<th>Driver Board</th>
<th>Light Output (Lux)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCR Direct AC Drive with LEDs</td>
<td>7.1</td>
<td>0.92</td>
<td>6 Parts</td>
<td>3,370</td>
</tr>
</tbody>
</table>
Switching Regulators for AC-DC

Switching Regulators for Isolated Flyback and Non-Isolated Converters

<table>
<thead>
<tr>
<th>Device</th>
<th>Max Output Power</th>
<th>Mode</th>
<th>Switch Voltage (Vdc)</th>
<th>Peak Current Limit (mA)</th>
<th>Typ (^2)</th>
<th>Min HV Startup (Vdc)</th>
<th>Frequency Options (kHz)</th>
<th>Dynamic Soft Supply</th>
<th>Freq. Filtering</th>
<th>Brake Margin</th>
<th>Soft-Start</th>
<th>Freq. Foldback</th>
<th>Over Power Compensation</th>
<th>Package(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCP1010</td>
<td>4</td>
<td>Current</td>
<td>700</td>
<td>100</td>
<td>22</td>
<td>30</td>
<td>65, 100, 130</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>PDIP-7, SOT-223</td>
<td></td>
</tr>
<tr>
<td>NCP1011</td>
<td>11</td>
<td>Current</td>
<td>700</td>
<td>250</td>
<td>11</td>
<td>30</td>
<td>65, 100, 130</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>PDIP-7, SOT-223</td>
<td></td>
</tr>
<tr>
<td>NCP1012</td>
<td>11</td>
<td>Current</td>
<td>700</td>
<td>350</td>
<td>11</td>
<td>30</td>
<td>65, 100, 130</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>PDIP-7, SOT-223</td>
<td></td>
</tr>
<tr>
<td>NCP1014/15</td>
<td>17</td>
<td>Current</td>
<td>700</td>
<td>450</td>
<td>11</td>
<td>30</td>
<td>65, 100</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>PDIP-7, SOT-223</td>
<td></td>
</tr>
<tr>
<td>NCP1027/28</td>
<td>20</td>
<td>Current</td>
<td>700</td>
<td>800</td>
<td>5.6</td>
<td>30</td>
<td>65, 100</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>PDIP-7</td>
<td></td>
</tr>
<tr>
<td>NCP1072*</td>
<td>11</td>
<td>Current</td>
<td>700</td>
<td>250</td>
<td>11</td>
<td>30</td>
<td>65, 100, 130</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>PDIP-7, SOT-223</td>
<td></td>
</tr>
<tr>
<td>NCP1075*</td>
<td>19</td>
<td>Current</td>
<td>700</td>
<td>450</td>
<td>11</td>
<td>30</td>
<td>65, 100, 130</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>PDIP-7, SOT-223</td>
<td></td>
</tr>
</tbody>
</table>

* Pending 1H12. 1. Maximum Power Output with DSS 2. Typical at 25°C 3. Gullwing package available on Demand 4. Gullwing SMD DIP-7 5. NCP1015 & NCP1028 have no DIP on VCC

NCP1014 Configured as a Constant Current Isolated Offline LED Driver

Up to 8 W LED Driver Reference Design for ENERGY STAR® Residential Lighting

This circuit has been specifically optimized to meet the ENERGY STAR SSL Luminaire requirements for residential lighting applications, which require a minimum power factor of 0.7.

**Features**
- Isolated flyback based upon NCP1014, power limited to 8 W
- Power factor > 0.8 @ 115 Vac
- Wide input (90 to 305 Vac) and output operation voltage 350 – 1000 mA
- Regulated output current
- Protections (open LED, output short circuit)
- Linear dimming control

**Applications**
- Desk lamps
- Under-cabinet lighting
- Step lighting
- Pendant lights

**Resources**
- Reference Design: TND371/D
- Evaluation Board: NCP1014LEDGTGEVB
- Design Note: DN06051/D
Switching Controllers for AC-DC

Switching Controllers versus Switching Regulators

- Controllers are typically used for power levels > 25 W
- Controllers offer more flexibility in selecting the high voltage MOSFET that is most suitable for a given application and power output
- Can be used in isolated flyback converters and non-isolated converters

Switching Controllers for Isolated and Non-Isolated Buck, Buck/Boost Converters

<table>
<thead>
<tr>
<th>PWM Method</th>
<th>Device</th>
<th>Control Mode</th>
<th>Switching Frequency (Hz)</th>
<th>Frequency Jittering (%)</th>
<th>HV Startup</th>
<th>Dynamic Self Supply</th>
<th>Short Circuit Protection</th>
<th>Brown-out Protection</th>
<th>OVP Protection</th>
<th>Soft Start (ms)</th>
<th>Drive Capability Source/Sink (mA)</th>
<th>Temperature (°C)</th>
<th>Package(s)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NCP1200</td>
<td>Current</td>
<td>40, 60, 100</td>
<td>±0.7</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>1</td>
<td>250 / 250</td>
<td>-25 to +125</td>
<td>-200 / 200</td>
<td>SOIC-8, PDIP-8</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NCP1203</td>
<td>Current</td>
<td>40, 60, 100</td>
<td>±0.7</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>1</td>
<td>250 / 250</td>
<td>-40 to +125</td>
<td>-200 / 200</td>
<td>SOIC-8, PDIP-8</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NCP1218</td>
<td>Current</td>
<td>65, 100</td>
<td>±11 ±7.5</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>1</td>
<td>4.8 / 500</td>
<td>-40 to +125</td>
<td>0 to +125</td>
<td>SOIC-7</td>
<td>Adjustable Max duty cycle</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NCP1219</td>
<td>Current</td>
<td>65, 100</td>
<td>±11 ±7.5</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>1</td>
<td>4.8 / 500</td>
<td>-40 to +125</td>
<td>0 to +125</td>
<td>SOIC-7</td>
<td>±5% current sense accuracy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NCP1230</td>
<td>Current</td>
<td>100</td>
<td>±6.4</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>1</td>
<td>2.5 / 500</td>
<td>-40 to +125</td>
<td>0 to +125</td>
<td>SOIC-8, PDIP-7</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NCP1234/6</td>
<td>Current</td>
<td>65, 100</td>
<td>±6</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>1</td>
<td>4 / 500 / 500</td>
<td>-40 to +125</td>
<td>0 to +125</td>
<td>SOIC-7</td>
<td>Timer-based short circuit protection</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NCP1237/8</td>
<td>Current</td>
<td>65, 100, 130</td>
<td>±6</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>1</td>
<td>4 / 1000 / 1000</td>
<td>-40 to +125</td>
<td>0 to +125</td>
<td>SOIC-7</td>
<td>Timer-based short circuit protection</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NCP1250/1</td>
<td>Current</td>
<td>65, 100, 130</td>
<td>±6</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>1</td>
<td>4 / 300 / 500</td>
<td>-40 to +125</td>
<td>0 to +125</td>
<td>SOIC-7</td>
<td>Timer-based short circuit protection</td>
<td></td>
</tr>
</tbody>
</table>

Fixed Frequency

PWM Method | Device | Control Mode | Max Output Power (W) | Frequency Comp Max On Time (µs) | Frequency Comp Min Off Time (µs) | HV Startup | Dynamic Self Supply | Short Circuit Protection | Brown-out Protection | OVP Protection | Soft Start (ms) | Drive Capability Source/Sink (mA) | Temperature (°C) | Package(s) | Comments |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NCL30000</td>
<td>Current</td>
<td>85 to 305</td>
<td>50</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>3.8 / 500</td>
<td>-40 to +125</td>
<td>0 to +125</td>
<td>SOIC-8</td>
<td>OVP and OVT protection</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NCL30002*</td>
<td>NCL30000*</td>
<td>85 to 305</td>
<td>50</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>3.8 / 500</td>
<td>-40 to +125</td>
<td>0 to +125</td>
<td>SOIC-8</td>
<td>OVP and OVT protection</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LV5026*</td>
<td>NCL30000*</td>
<td>85 to 305</td>
<td>30</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>3.8 / 500</td>
<td>-40 to +125</td>
<td>0 to +125</td>
<td>SOIC-8</td>
<td>OVP and OVT protection</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LV5029**</td>
<td>NCL30000*</td>
<td>85 to 305</td>
<td>30</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>3.8 / 500</td>
<td>-40 to +125</td>
<td>0 to +125</td>
<td>SOIC-8</td>
<td>OVP and OVT protection</td>
<td></td>
</tr>
</tbody>
</table>

1. When DSS is used.

Switching Controllers for Non-Isolated Buck Converters

<table>
<thead>
<tr>
<th>Device</th>
<th>Vin (Vac)</th>
<th>Max Output Power (W)</th>
<th>TRIAC Dimming</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCL30000</td>
<td>85 to 305</td>
<td>50</td>
<td>✓</td>
<td>Can also be used in isolated single PFC flyback</td>
</tr>
<tr>
<td>NCL30002*</td>
<td>85 to 305</td>
<td>50</td>
<td>✓</td>
<td>Optimized for high Power Factor applications</td>
</tr>
<tr>
<td>LV5026*</td>
<td>85 to 305</td>
<td>30</td>
<td>✓</td>
<td>• PWM and analog dimming</td>
</tr>
<tr>
<td>LV5029**</td>
<td>85 to 305</td>
<td>30</td>
<td>✓</td>
<td>• PWM and analog dimming</td>
</tr>
</tbody>
</table>

* Pending 1H12. ** Pending 2H12.
Non-Isolated 25 W High Power Factor Buck-Boost LED Driver

Features
- 90-305 Vac Non-Isolated Buck-Boost Topology
- Maintains tight current regulation over a wide range of LED voltage
- Constant on-time provides high Power Factor and low THD
- 90% Efficiency and PF > 0.95
- Line Dimming Capable
- Thermal Foldback with Auto-Recovery

Non-Isolated Offline Buck Controller – LV5026

Features
- Various dimming control (TRIAC, analog & PWM)
- Selectable switching frequency (50 kHz or 70 kHz)
- Low noise switching system
- Short-circuit protection
- Soft start function
- Built-in TRIAC stabilization function

Applications
- Wall sconces
- Task lighting
- Step lighting
- LED bulb replacements

<table>
<thead>
<tr>
<th>Device</th>
<th>TRIAC Dimming</th>
<th>Digital (PWM) Dimming</th>
<th>Analog Dimming</th>
<th>Improved Power Factor</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>LV5026M*</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>SOIC-10</td>
</tr>
<tr>
<td>LV5029M**</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>SOIC-10</td>
</tr>
</tbody>
</table>

* Pending 1H12. ** Pending 2H12.
### Switching Controllers for Isolated Resonant Half-Bridge Converters

<table>
<thead>
<tr>
<th>PWM Method</th>
<th>Device</th>
<th>Control Mode</th>
<th>Switching Frequency (kHz)</th>
<th>HV Startup</th>
<th>Short Circuit Protection</th>
<th>Overvoltage Protection</th>
<th>Soft Start</th>
<th>Thermal Shutdown</th>
<th>Temperature (°C)</th>
<th>Package(s)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resonant Half Bridge</td>
<td>NCP1392/3</td>
<td>Voltage</td>
<td>Adjustable to 250</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>-40 to +125</td>
<td>SOIC-8</td>
<td>Fixed dead time options, PFC okay, 100 ms startup timer</td>
</tr>
<tr>
<td></td>
<td>NCP1397</td>
<td>Voltage</td>
<td>Adjustable to 250</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>-40 to +125</td>
<td>SOIC-16</td>
<td>Enhanced soft start, dual level current protection</td>
</tr>
</tbody>
</table>

### Switching Combo Controllers for Isolated Converters

<table>
<thead>
<tr>
<th>Device</th>
<th>Topology</th>
<th>Function</th>
<th>Vin (Vac)</th>
<th>Max Output Power (W)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCP1928*</td>
<td>Isolated Flyback Converter</td>
<td>CRM PFC + fixed frequency flyback converter</td>
<td>85 to 305</td>
<td>60 to 150</td>
<td>Frequency jittering for softened EMI signature, Frequency foldback then soft-skip™ for improved performance in standby</td>
</tr>
<tr>
<td>NCL30051</td>
<td>Isolated Resonant Half-Bridge Converter</td>
<td>CRM PFC + half-bridge converter</td>
<td>85 to 305</td>
<td>60 to 250</td>
<td>Half-bridge stage with 600 V high side gate drive</td>
</tr>
</tbody>
</table>

* Pending 2H12.

### Power Factor Correction for AC-DC

<table>
<thead>
<tr>
<th>Device</th>
<th>Topology</th>
<th>Conduction Mode</th>
<th>Control</th>
<th>HV Start-up</th>
<th>Overvoltage Protection</th>
<th>Undervoltage Protection</th>
<th>Current Limit</th>
<th>Power Limit</th>
<th>Brown Out</th>
<th>In-Rush Detect</th>
<th>Package(s)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCP1607</td>
<td>Non-Isolated Boost</td>
<td>Critical</td>
<td>Voltage</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SOIC-8</td>
<td>Enhanced fault protection</td>
</tr>
<tr>
<td>NCP1608</td>
<td>Non-Isolated Boost</td>
<td>Critical</td>
<td>Voltage</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SOIC-8, PDIP-8</td>
<td>Wide dynamic power range</td>
</tr>
<tr>
<td>NCP1611/12</td>
<td>Non-Isolated Boost</td>
<td>CCFF**</td>
<td>Current</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td>SOIC-8, SOIC-10</td>
<td>**CCFF control scheme combines energy savings with safe handling of fault conditions</td>
</tr>
<tr>
<td>NCP1654</td>
<td>Non-Isolated Boost</td>
<td>Continuous</td>
<td>Average Current</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td>SOIC-8, PDIP-8</td>
<td>65/133/200 kHz versions</td>
</tr>
<tr>
<td>NCP1652A</td>
<td>Isolated Single-Stage Flyback</td>
<td>Continuous</td>
<td>Average Current</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td>SOIC-16</td>
<td>Active clamp option</td>
</tr>
<tr>
<td>NCL30000</td>
<td>Isolated Single-Stage Flyback, Non-Isolated Buck</td>
<td>Critical</td>
<td>Average Current</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td>SOIC-8</td>
<td>TRIAC dimming compliant</td>
</tr>
<tr>
<td>NCL30001</td>
<td>Isolated Single-Stage Flyback</td>
<td>Continuous</td>
<td>Average Current</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td>SOIC-16</td>
<td>–</td>
</tr>
<tr>
<td>NCL30002*</td>
<td>Non-Isolated Buck</td>
<td>Critical</td>
<td>Constant on-time, Peak current</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td>SOIC-8</td>
<td>TRIAC dimming compliant</td>
</tr>
</tbody>
</table>

* Pending 3H12. **CCFF: Current Controlled Frequency Foldback. Note: All devices have a temperature range of -40 to +125 °C.

### Constant Current, Constant Voltage References

<table>
<thead>
<tr>
<th>Device</th>
<th>V(Ref) Typ (V)</th>
<th>Tolerance (%)</th>
<th>Iq Typ (mA)</th>
<th>Iq Min (µA)</th>
<th>VCC Max (V)</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCP4300A</td>
<td>2.6</td>
<td>1</td>
<td>–</td>
<td>80</td>
<td>36</td>
<td>SOIC-8</td>
</tr>
<tr>
<td>NCS1002</td>
<td>2.5</td>
<td>0.4</td>
<td>0.4</td>
<td>75</td>
<td>36</td>
<td>SOIC-8</td>
</tr>
</tbody>
</table>

### Resources
- Application Note AND8395/D
**Line Dimmable PAR30 LED Lamp**

**Features**
- Input voltage:
  - 115 V Lamp: 90 - 135 Vac
  - 230 V Lamp: 180 - 265 Vac
- 11 W Nominal Pout (24.5 V @ 450 mA)
- 8 LEDs in series / 3 strings in parallel
- Power Factor: >0.96
- Efficiency: >83%
- Intended for ENERGY STAR® requirements for integral LED lamps v1.4 (115 V version only)
- CRM (Critical Conduction Mode) isolated flyback topology
- Scalable controller-based architecture
- PFC > 0.9
- TRIAC and trailing edge dimmable

**Applications**
- Down lights
- LED par bulbs
- Low bay lighting
- LED power supplies

**Resources**
- Application Notes: AND8448/D, AND8451/D, AND8463/D, AND8462/D
- Design Note: DN05010/D
- Reference Design: TND398/D
- Evaluation Boards:
  - NCL30000LED1GEVB: 15 W, 350 mA, 100/115 Vac TRIAC Dimmer
  - NCL30000LED2GEVB: 15 W, 350 mA, 220/240 Vac TRIAC Dimmer
  - NCL30000LED3GEVB: 17 W, 350 mA, 90 to 305 Vac, Non Dimmable

**Performance of PAR30 Lamps**

<table>
<thead>
<tr>
<th>Lamp Version</th>
<th>RC Damper Present</th>
<th>Input Power (W)</th>
<th>PF</th>
<th>%THD</th>
<th>Output Current (mA)</th>
<th>Output Volts (Vdc)</th>
<th>Output Power (W)</th>
<th>Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>115</td>
<td>Yes</td>
<td>12.91</td>
<td>0.98</td>
<td>10.2</td>
<td>452</td>
<td>23.61</td>
<td>10.67</td>
<td>82.7</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>12.72</td>
<td>0.99</td>
<td>6.5</td>
<td>452</td>
<td>23.60</td>
<td>10.67</td>
<td>83.9</td>
</tr>
<tr>
<td>230</td>
<td>Yes</td>
<td>13.00</td>
<td>0.87</td>
<td>23.4</td>
<td>453</td>
<td>23.60</td>
<td>10.69</td>
<td>82.2</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>12.59</td>
<td>0.97</td>
<td>11.2</td>
<td>453</td>
<td>23.44</td>
<td>10.62</td>
<td>84.4</td>
</tr>
</tbody>
</table>
LED Power Supply for Street and Area Lighting

Generating the light needed to replace an HID or HPS lamp requires a large array of LEDs. LEDs can be configured in various arrangements depending on the end product. There are two different approaches:

**Approach 1**

One approach converts the AC input into a regulated DC output voltage that powers multiple parallel LED strips.

**Approach 2**

The second approach provides a regulated constant current to drive the LEDs directly, thus eliminating the linear or DC-DC conversion stage built in to the light strips. This is illustrated in application note AND9040/D and design note DN05015/D, where the NCL30051 is used to convert 90-265 Vac into a constant current in a power factor corrected half-bridge resonant power supply.

**Features — Approach 2**

- **Universal Input:** 90 – 265 Vac (305 Vac with component change)
- **Pout Maximum:** 60 W (the NCL30051 is capable of power up to 250 W with component changes)
- **Power Factor:** PF > 0.9 (50–100% of load with dimming)
- **Harmonic Content:** IEC61000-3-2 class C compliance
- **Efficiency:** > 90% with Iout = 1000 mA / Vf = 35 to 45 V
- **CC Iout Range:** 0.7 – 1.5 A
- **Vout Range:** 35 – 50 V
- **Intended for ENERGY STAR® Luminaires v1.1 specification (effective April 01, 2012)**
- **Protection Features:** output open and short circuit protection, over temperature, over current protection – auto recovery, over voltage protection – input (OVP bulk voltage)
- **Dimming**
  - Two-step bi-level analog
  - 1 – 10 V analog voltage input, 1 = minimum, 10 V is 100% on
  - PWM dimming. Frequency 200 to 400 Hz. Dimming range > 20:1
Medium to Large LCD Panel Backlighting

As LED performance and cost have improved, they are now displacing CCFL lamps in medium and large LCD backlighting applications such as notebooks, monitors, LCD-TVs, personal navigation systems, photo frames, and medical equipment. Besides eliminating mercury, the use of LEDs allows the design of thinner displays, and improves overall power consumption and lifetime. Integrating an ambient light sensor can further contribute to energy savings while enhancing the user’s viewing experience.

<table>
<thead>
<tr>
<th>Device</th>
<th>Topology</th>
<th>VIN (V)</th>
<th>LEDs</th>
<th>Total I_{OUT Max} (mA)</th>
<th>I_{SW-LIM} (mA)</th>
<th>V_{OUT Max} (V)</th>
<th>Dimming Interface</th>
<th>Package (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAT4237</td>
<td>Inductive Boost</td>
<td>2.0 - 5.5</td>
<td>8</td>
<td>40</td>
<td>450</td>
<td>32</td>
<td>PWM</td>
<td>TSOT-23-5</td>
</tr>
<tr>
<td>NCP5021</td>
<td>Inductive Boost</td>
<td>2.7 - 5.5</td>
<td>8</td>
<td>50</td>
<td>800</td>
<td>28</td>
<td>I^2C</td>
<td>µQFN-16</td>
</tr>
<tr>
<td>CAT4238</td>
<td>Inductive Boost</td>
<td>2.0 - 5.5</td>
<td>10</td>
<td>30</td>
<td>450</td>
<td>38</td>
<td>PWM</td>
<td>TSOT-23-5</td>
</tr>
<tr>
<td>CAT4240</td>
<td>Inductive Boost</td>
<td>2.0 - 5.5</td>
<td>10</td>
<td>300</td>
<td>850</td>
<td>38</td>
<td>PWM</td>
<td>TSOT-23-5</td>
</tr>
<tr>
<td>CAT4106</td>
<td>Inductive Boost / Linear</td>
<td>3.0 - 5.5 / 25</td>
<td>10 x 4</td>
<td>700</td>
<td>1000</td>
<td>36</td>
<td>PWM</td>
<td>TSSOP-16, TQFN-16</td>
</tr>
<tr>
<td>CAT4026</td>
<td>6-Channel Linear</td>
<td>-0.3 to 7</td>
<td>Varies</td>
<td>External Transistors</td>
<td></td>
<td></td>
<td>PWM, Analog</td>
<td>SO-28</td>
</tr>
</tbody>
</table>
6-Channel LED Controller for Large Panel LED Backlighting – CAT4026

The CAT4026 is a large panel LED controller designed to control 6 constant current high voltage LED strings. Control circuitry monitors the lowest cathode voltage and generates a feedback control signal. Two approaches can be implemented: either a voltage feedback signal is fed into an external DC-DC converter; or a current feedback control is fed directly the main power supply,* which is usually a half-bridge resonant power supply converter. Each LED channel current is accurately controlled by sensing an external resistor and controlling a low cost bipolar transistor. LED current in all 6 channels can be controlled by PWM dimming or analog dimming. Fault detection and robust protection is provided for every possible fault scenario on the LED strings.

**Features**
- Voltage feedback control to external DC-DC converter
- Current feedback control to main power supply half-bridge resonant converter*
- PWM and analog dimming
- Zero current shutdown mode
- Auto-recovery fault detection (all modes)
- Shorted cathode-ground (SCG) fault protection
- Shorted cathode-anode (SCA) fault protection
- Open cathode-anode (OCA) fault protection
- Over-voltage protection (OVP)
- Thermal shutdown protection

**Applications**
- Large LCD panels backlighting (e.g. LED-TV)
- LED general lighting
- High bay lighting

* Complete power supply reference design for half-bridge resonant converter also available from www.onsemi.com
Highly Integrated LED Backlight Controller, Boost Converter and 4 Channel Driver — CAT4106

**Features**
- Drives up to 40 (4 x 10) - 36 V per string
- 1 MHz DC-DC boost converter with OVP
- Low dropout LED channels, 500 mV at 175 mA
- Tight channel-to-channel current matching
- Up to 2 kHz PWM dimming interface
- Programmable short and open LED detection
- Thermal shutdown
- Exposed pad packaging, TQFN-16 and TSSOP-16

**Applications**
- Notebooks
- Monitors
- Tablets
- Small LCD-TVs
- Test equipment
- Medical instruments
- Touch panels

**Resources**
- Evaluation Board CAT4106AGEVB
High Voltage LED Driver – NCP1294

LEDs are replacing CCFL lamps as the light source of choice for large LCD panel backlighting. The circuit described in this design note provides constant current to a long string of LEDs (Vf ranging from 190 to 230 V) from a single 24 V input. A constant current regulated flyback topology was chosen over a multi-stage boost or a boost plus multiple linear driver channels to improve overall system efficiency and ensure accurate current matching of the LEDs. Beyond being mercury free, when properly driven and controlled, LEDs can offer a >10x improvement in dimming range over traditional CCFL dimming. This superior dimming range is demonstrated in the design note. This design, based on the robust, flexible NCP1294 controller includes open LED and shorted output protection for safe handling of fault conditions.

**Features**
- 1 MHz frequency capability
- 1 A sink/source gate drive
- Programmable pulse-by-pulse overcurrent protection
- Programmable soft start

**Resources**
- Design Note DN06062/D

**Applications**
- Monitors
- LCD-TVs
- Test equipment
- Medical instruments
- Touch panels

---

**Efficiency vs Dim Duty Cycle**

**LED PWM Dimming Curve**

**Reference Design Block Diagram**
Smart Lighting

Smart Lighting involves communication and sensing functions to be able to remotely control (turn on or off, dim or change color) and monitor (remote diagnostic) one or multiple light fixtures in a building, a street or simply at home. Smart Lighting also provides a light fixture with the intelligence to make adjustments based on conditions such as occupancy or ambient light.

Communication can be implemented wirelessly or by using the existing powerline infrastructure. Powerlines make up the largest copper infrastructure in the world. There are electrical outlets at every corner of a home or office building, making it an all-encompassing network. Given that all lighting fixtures connect to a powerline to convert electricity to light, Powerline Communication (PLC) has become a logical way to serve as the primary communication and control link.

For example, two-way communication between a centralized control center and street lights can be implemented to form a fully networked intelligent street light system. This enables municipalities, power utility companies and commercial entities to remotely dim the light output of their street lights, and therefore to reduce the overall energy consumption of their street light network. Two-way communication can be easily implemented on the power line by using PLC modems (on page 40).

Light fixtures in an office building can be controlled by using the KNX network over an existing twisted pair wiring using KNX transceivers (on page 41).

Ambient Light Sensors such as the NOA1302 (on page 43) and PIR (Passive Infrared) Detectors such as the NCS36000 (on page 42) can also be used to control the light output of street lighting.
**Powerline Communication (PLC) Modems**

**Features**
- Robust narrowband PLC modem up to 10kBauds
- Compliant with stringent international standards (FCC, CENELEC, IEC61334-5-1)
- Operation on Low Voltage and Medium Voltage network
- Programmable 32-bit ARM Cortex M0 MCU
- Embedded PHY + MAC
- Best in class BOM cost
- Ultra Low Power

<table>
<thead>
<tr>
<th>Device</th>
<th>Max Baudrate per Channel</th>
<th>Number of Channels</th>
<th>Concelec Band</th>
<th>Embedded MCU</th>
<th>Integrated Power Amplifier</th>
<th>Max Temp</th>
<th>Operation</th>
<th>Auto Baudrate</th>
<th>Robust Mode</th>
<th>Packages</th>
<th>Programmable Software</th>
<th>Program Memory Option</th>
<th>Available Embedded Software Stack</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMIS30585</td>
<td>1200</td>
<td>1</td>
<td>A</td>
<td>ARM7</td>
<td>—</td>
<td>85 °C</td>
<td>AC Only</td>
<td>—</td>
<td>—</td>
<td>PLCC</td>
<td>—</td>
<td>ROM</td>
<td>IEC61334-5-1 PLAN</td>
<td>Metering</td>
</tr>
<tr>
<td>AMIS49587</td>
<td>2400</td>
<td>1</td>
<td>A,B</td>
<td>ARM7</td>
<td>—</td>
<td>85 °C</td>
<td>AC Only</td>
<td>—</td>
<td>—</td>
<td>PLCC, QFN</td>
<td>—</td>
<td>ROM</td>
<td>IEC61334-5-1 PLAN +</td>
<td>Metering</td>
</tr>
<tr>
<td>NCN49597</td>
<td>4800</td>
<td>2</td>
<td>A,B,C,D</td>
<td>CortexM0</td>
<td>—</td>
<td>125 °C</td>
<td>AC, DC*</td>
<td>Yes</td>
<td>Yes</td>
<td>QFN</td>
<td>Yes</td>
<td>ROM</td>
<td>IEC61334-5-1 PLAN +</td>
<td>Metering</td>
</tr>
</tbody>
</table>

RAM
- IEC61334-5-1 PLAN + Metering
- Multicarrier IEC61334-5-1 PLAN + Metering, PLAN backward compatible
- Single/Multicarrier KNX
- Solar, Lighting, HAN, HID
- Full Custom
- Smart Grid, others

| NCN49599* | 4800                     | 2                  | A,B,C,D       | CortexM0     | —                           | 125 °C   | AC, DC   | Yes           | Yes          | QFN      | Yes                  | ROM                  | IEC61334-5-1 PLAN +     | Metering          |

RAM
- IEC61334-5-1 PLAN + Metering
- Multicarrier IEC61334-5-1 PLAN + Metering, PLAN backward compatible
- Single/Multicarrier KNX
- Solar, Lighting, HAN, HID
- Full Custom
- Smart Grid, others

* Pending 2H12.
**KNX Transceivers**

KNX is a standardized (EN 50090, ISO/IEC 14543), OSI-based network communications protocol for intelligent buildings. KNX is the successor to, and convergence of, three previous standards: the European Home Systems Protocol (EHS), BatiBUS, and the European Installation Bus (EIB or Instabus).

**KNX Open Standards**
- EN 50090: European Standard
- ISO/IEC 14543-3: International Standard
- GB/Z 20965: Chinese Standard

**Applications**
- Connects appliances and sensors, especially for climate and light control to the 9600 Baud KNX twisted pair (TP) bus inside a building
- TP bus provides data communication and power supply

### KNX Transceivers Specifications

<table>
<thead>
<tr>
<th>Device</th>
<th>DC-DC Converters</th>
<th>20 V Regulator</th>
<th>Triple Power Mode</th>
<th>Embedded MAC + LLC</th>
<th>KNX Host Interface</th>
<th>Package</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCN5120*</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>NCN5121**</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>NCN5110**</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>NCN5111**</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

* Pending 1H12. **Pending 2H12. Note 1: LLC = Logical Link Control layer of the OSI-based communications network.

---

**Diagram:**
- KNX network shows main distribution, 230 V power, twisted pair (TP), power-line (PL), radio frequency (RF), power supply, and various devices like washing machine, oven, heating, security, and lighting.
- KNX open standards and applications are illustrated with connectivity and functionality of devices in a building context.

---

---
Motion Detector Passive Infrared Controller (PIR) – NCS36000

- Passive infrared controller circuit for the lighting and occupancy sensing market
- Amplifies and conditions signal from PIR sensor

**Features**
- 3.0 – 5.75 V operation
- Integrated low noise 2-stage amplifiers
- Internal voltage reference to drive sensor
- Internal oscillator with external RC
- Single or dual pulse detection
- Digital filter to minimize false alarms
- Direct drive of LED and relay

**Benefits**
- Lower BOM cost than comparable discrete solutions
- Extremely flexible solution
- Customer can customize digital filtering
- Customer can customize analog processing
- Designed for wide range of occupancy sensors
Ambient Light & Proximity Sensors

Features

• Design flexibility/customization (i.e., EEPROM if desired for trimming)
• 0.0125 lux detection with customizable filtering (i.e., Photopic Light Response)
• Dark current and temperature compensation
• Lowest power consumption per resolution bit
• I2C Interface (including High Speed Mode) and no effect on bus during power down

<table>
<thead>
<tr>
<th>Device</th>
<th>Description</th>
<th>Operating Voltage Range (V)</th>
<th>Operating Temp Range (°C)</th>
<th>Light Sensitivity Range (Lux)</th>
<th>Interface</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOA1211</td>
<td>Analog Ambient Light Sensor with Dark Current Compensation</td>
<td>2.0 to 5.5</td>
<td>-40 to +85</td>
<td>-0.01 to 100K</td>
<td>Analog</td>
<td>CUDFN-6</td>
</tr>
<tr>
<td>NOA1212*</td>
<td>Analog Ambient Light Sensor with Dark Current Compensation and high gain mode</td>
<td>2.0 to 5.5</td>
<td>-40 to +85</td>
<td>-0.01 to 100K</td>
<td>Analog</td>
<td>CUDFN-6</td>
</tr>
<tr>
<td>NOA1302*</td>
<td>Digital Ambient Light Sensor with I2C Interface</td>
<td>3.0 to 3.6</td>
<td>-40 to +85</td>
<td>0.4 to 100K</td>
<td>I2C (Standard and Fast Modes)</td>
<td>CTSSOP-8</td>
</tr>
<tr>
<td>NOA1305*</td>
<td>Digital Ambient Light Sensor with I2C Interface and Dark Current Compensation</td>
<td>2.0 to 3.6</td>
<td>-40 to +85</td>
<td>0.125 to 100K</td>
<td>I2C (Standard and Fast Modes)</td>
<td>CUDFN-6</td>
</tr>
<tr>
<td>NOA1306**</td>
<td>Digital Ambient Light Sensor with I2C Interface and high gain mode</td>
<td>2.0 to 3.6</td>
<td>-40 to +85</td>
<td>0.01 to 20K</td>
<td>I2C (Standard and Fast Modes)</td>
<td>CUDFN-6</td>
</tr>
<tr>
<td>NOA1312**</td>
<td>Digital Ambient Light Sensor with I2C Interface, high precision</td>
<td>2.4 to 3.6</td>
<td>-40 to +85</td>
<td>-0.1 to 16K</td>
<td>I2C (Standard and Fast Modes), 3 slave addresses</td>
<td>CUDFN-6</td>
</tr>
<tr>
<td>NOA2301**</td>
<td>Digital Proximity Sensor with Interrupt</td>
<td>2.3 to 3.6</td>
<td>-40 to +85</td>
<td>-</td>
<td>I2C (Standard, Fast and High-Speed Modes)</td>
<td>CUDFN-6</td>
</tr>
<tr>
<td>NOA2302**</td>
<td>Digital Slave Proximity Sensor with Interrupt</td>
<td>2.3 to 3.6</td>
<td>-40 to +85</td>
<td>-</td>
<td>I2C (Standard, Fast and High-Speed Modes)</td>
<td>CUDFN-6</td>
</tr>
<tr>
<td>NOA3301*</td>
<td>Digital Proximity Sensor with Ambient Light Sensor and Interrupt</td>
<td>2.3 to 3.6</td>
<td>-40 to +85</td>
<td>-0 to 64K</td>
<td>I2C (Standard, Fast and High-Speed Modes)</td>
<td>CUDFN-8</td>
</tr>
<tr>
<td>NOA3402*</td>
<td>Digital Proximity Sensor and Ambient Light Sensor</td>
<td>2.3 to 3.6</td>
<td>-40 to +85</td>
<td>-0 to 64K</td>
<td>I2C (Standard, Fast and High-Speed Modes)</td>
<td>CUDFN-8</td>
</tr>
<tr>
<td>NOA3309**</td>
<td>Digital Proximity Sensor with Ambient Light Sensor and IR emitter</td>
<td>2.3 to 3.6</td>
<td>-40 to +85</td>
<td>-0 to 52K</td>
<td>I2C (Standard, Fast and High-Speed Modes)</td>
<td>8-Lead</td>
</tr>
</tbody>
</table>

* Pending 1H12. ** Pending 2H12.
LED String Protection — NUD4700

The preferred method of driving LEDs is to have them in strings of LEDs in series, so that currents in the strings are matched for equal brightness. Although LEDs are very reliable, if any single LED were to fail OPEN, the entire string goes dark, because the LEDs within a string are connected in series. This is unacceptable for high-reliability applications such as street lighting. To solve this issue the NUD4700, from ON Semiconductor, is placed across each LED, and functions as a shunt bypass protector in the event of an LED failing as an OPEN circuit. This ensures that the remainder of the string stays lit.

**Key Requirements**
- Low ON-state resistance, high OFF-state resistance and high reliability

**Features**
- High ON-state current capability
- Low off-state leakage
- Ability to auto-reset to off-state if LED heals
- Low and repeatable response time

**Benefits**
- High reliability, enables longevity of string and fixture
- Capable of operating in high current strings

**High Reliability Applications**
- Street lights
- Tunnel lighting
- Architectural lighting
- High-bay lighting
- Train and runway lights

**Key Specifications**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Typ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off-state leakage ($V_{Anode} = 5$ V)</td>
<td>$I_{LEAK}$</td>
<td>$100 \mu A$</td>
</tr>
<tr>
<td>Breakover Voltage ($I_{BR} = 1$ mA)</td>
<td>$V_{BR}$</td>
<td>$7.5$ V</td>
</tr>
<tr>
<td>Holding Current ($V_{Anode} = 10$ V, $I_{initial} = 100$ mA)</td>
<td>$I_h$</td>
<td>$6.0$ mA</td>
</tr>
<tr>
<td>Latching Current ($V_{Anode} = 10$ V)</td>
<td>$I_L$</td>
<td>$35$ mA</td>
</tr>
<tr>
<td>On-State Voltage ($I_{T} = 350$ mA)</td>
<td>$V_T$</td>
<td>$1.0$ V</td>
</tr>
<tr>
<td>On-State Voltage ($I_{T} = 750$ mA)</td>
<td></td>
<td>$1.0$ V</td>
</tr>
<tr>
<td>On-State Voltage ($I_{T} = 1000$ mA)</td>
<td></td>
<td>$1.0$ V</td>
</tr>
</tbody>
</table>
In-Module ESD Protection of High Brightness LEDs

Die Level Products for Co-Packaging With HBLED under Optical Dome

During the assembly process and during end-user operation, sensitive HBLED die are susceptible to harmful electro-static discharge (ESD) strikes. Further, during assembly in lamps and light-fixtures, HBLED modules are subject to high-voltage ESD strikes that can destroy them. In-module silicon transient-voltage suppressor (TVS) die provide the protection needed to eliminate failures and enable the creation of robust HBLED modules for various applications. In-module silicon TVS die come in two forms: as sub-mounted protectors and as side-mounted die.

Key Requirements
- ESD protection capability, small footprint for side-mounted protector, low profile

Features
- Ability to withstand high levels of ESD strikes
- Low thermal resistance
- Small footprint (side-mount)
- Low profile (side-mount)
- Ability to protect HBLED die during module assembly, and HBLED modules during fixture assembly

Benefits
- Prevention of HBLED failure during module assembly and fixture assembly
- Thermal protection and heat-dissipation capability (sub-mount)
- Minimal light-absorption (side-mount)

Typical Specifications for Side-Mounted Protector

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Typ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wafer diameter (for the case of wafer-sales)</td>
<td>—</td>
<td>150 mm</td>
</tr>
<tr>
<td>Die length</td>
<td>L</td>
<td>250 mm</td>
</tr>
<tr>
<td>Die width</td>
<td>W</td>
<td>250 mm</td>
</tr>
<tr>
<td>Bondpad diameter</td>
<td>—</td>
<td>190 mm</td>
</tr>
<tr>
<td>Positive polarity breakdown voltage (current = 1 mA)</td>
<td>VCL+</td>
<td>+7.5 V</td>
</tr>
<tr>
<td>Negative polarity breakdown voltage (current = 1 mA)</td>
<td>VCL-</td>
<td>-7.5 V</td>
</tr>
<tr>
<td>Leakage Current (at 4 V, 25°C)</td>
<td>ILEAK</td>
<td>100 nA</td>
</tr>
<tr>
<td>ESD Withstand Voltage (HBM)</td>
<td>VESD</td>
<td>±8 kV</td>
</tr>
</tbody>
</table>
Enabling Energy Efficient Solutions

In-Module TVS Solutions for HBLED Protection

<table>
<thead>
<tr>
<th>Capability</th>
<th>Options</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Die-thickness</td>
<td>100 mm, 150 mm, 200 mm, and 250 mm</td>
<td>Sub-monts and side-monts</td>
</tr>
<tr>
<td></td>
<td>(4, 6, 8, and 10 mils)</td>
<td>–</td>
</tr>
<tr>
<td>Top Electrodes</td>
<td>aluminium</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>copper</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>gold</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>aluminium-free gold</td>
<td>No Aluminium in the system</td>
</tr>
<tr>
<td>Back-Metal</td>
<td>gold</td>
<td>With a thin TiW barrier</td>
</tr>
<tr>
<td></td>
<td>Gold-Tin (Au-Sn)</td>
<td>80%-20% ratio by weight</td>
</tr>
<tr>
<td></td>
<td>TiNiAg</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>bare silicon</td>
<td>For same-side electrodes</td>
</tr>
<tr>
<td>Delivery</td>
<td>unsawn wafers</td>
<td>Customer responsible for backmetal &amp; saw</td>
</tr>
<tr>
<td></td>
<td>sawn wafers on blue Nitto tape and frame</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>sawn wafers on UV tape and frame</td>
<td>–</td>
</tr>
<tr>
<td>Electrical</td>
<td>unidirectional TVS: (+V_z, -1V)</td>
<td>V_z ranges from 5 V to 200 V</td>
</tr>
<tr>
<td>Performance</td>
<td>bidirectional TVS (+Vzp, -Vzn)</td>
<td>Vzp and Vzn range from 7 V to 200 V</td>
</tr>
<tr>
<td></td>
<td>HBM IEC 61000-4-2</td>
<td>ESD standards supported</td>
</tr>
</tbody>
</table>

Sub-Mounted ESD and Thermal Protector
(Wirebonds are Optional)

Conventional Side-Mounted ESD Protector

Flip-Chip, Side-Mounted ESD Protector

Unidirectional TVS

Bidirectional TVS
GreenPoint® Design Simulation Tool

Features

- Interactive design and verification environment; including component selection, design generation, simulation and analysis, BOM, and download of schematic.
- Highly efficient simulation engine. Each design iteration can be simulated in just several seconds or a few minutes. The resulting waveforms, such as Bode plots or voltage graphs, can be analyzed with an included waveform viewer.
- SIMetrix is a mixed-signal circuit simulator based on SPICE developed by the University of California at Berkeley
- SIMPLIS (SIMulation for Piecewise Linear System) is a circuit simulator designed for rapid modeling of switching power systems
- Available online and offline. The offline version is a node-restricted version of the SIMetrix/SIMPLIS simulator.
## INTERNATIONAL

<table>
<thead>
<tr>
<th>REGION</th>
<th>CITY</th>
<th>PHONE</th>
</tr>
</thead>
<tbody>
<tr>
<td>GREATER CHINA</td>
<td>Beijing</td>
<td>86-10-8577-8200</td>
</tr>
<tr>
<td></td>
<td>Hong Kong</td>
<td>852-2689-0088</td>
</tr>
<tr>
<td></td>
<td>Shenzhen</td>
<td>86-755-8209-1128</td>
</tr>
<tr>
<td></td>
<td>Shanghai</td>
<td>86-21-5131-7108</td>
</tr>
<tr>
<td></td>
<td>Taipei, Taiwan</td>
<td>886-2-2377-9911</td>
</tr>
<tr>
<td>FRANCE</td>
<td>Paris</td>
<td>33 (0) 03-26-41-00</td>
</tr>
<tr>
<td>GERMANY</td>
<td>Munich</td>
<td>49 (0) 89-93-0808-0</td>
</tr>
<tr>
<td>INDIA</td>
<td>Bangalore</td>
<td>91-98-808-86706</td>
</tr>
<tr>
<td>ISRAEL</td>
<td>Ramat Gan</td>
<td>972 (0) 9-9909-111</td>
</tr>
<tr>
<td>ITALY</td>
<td>Milan</td>
<td>39 02 9239311</td>
</tr>
<tr>
<td>JAPAN</td>
<td>Tokyo</td>
<td>81-3-5817-1050</td>
</tr>
<tr>
<td>KOREA</td>
<td>Seoul</td>
<td>82-2-2190-3500</td>
</tr>
<tr>
<td>MALAYSIA</td>
<td>Penang</td>
<td>60-4-6463877</td>
</tr>
<tr>
<td>SINGAPORE</td>
<td>Singapore</td>
<td>65-6442-1226</td>
</tr>
<tr>
<td>SLOVAKIA</td>
<td>Piestany</td>
<td>421 33 790 2450</td>
</tr>
<tr>
<td>UNITED KINGDOM</td>
<td>Slough</td>
<td>44 (0) 1753 70 1676</td>
</tr>
</tbody>
</table>

---

**For a comprehensive listing of ON Semiconductor Sales Offices, please visit:**

[www.onsemi.com/salesupport](http://www.onsemi.com/salessupport)

---

**ON Semiconductor Distribution Partners**

- AMSC Co.: [www.amsc.co.jp](http://www.amsc.co.jp) (81) 422 54 6022
- Arrow Electronics: [www.arrow.com](http://www.arrow.com) (800) 777-2776
- Amnet: [www.en.amnet.com](http://www.en.amnet.com) (800) 332-8638
- Daiwa Distribution Ltd.: [www.daiwa.com](http://www.daiwa.com) (852) 2341 3351
- Dig-Key: [www.digkey.com](http://www.digkey.com) (800) 344-4539
- EBV Elektronik: [www.evb.com/en/locations.html](http://www.evb.com/en/locations.html) (49) 8211 774-0
- Fuji Electric Co.: [www.fujielec.co.jp](http://www.fujielec.co.jp) (81) 3 3614 1411
- Future & FMI Electronics: [www.futureelectronics.com/contact](http://www.futureelectronics.com/contact) 1-800-FUTURE1 (388-8731)
- KH Electronics Inc.: [www.khelec.com/kor](http://www.khelec.com/kor) (62) 42 471 8521
- Marubun: [www.marubun.co.jp](http://www.marubun.co.jp) (81) 3 3639 5630
- Mitsui Electronics Inc.: [www.misbt.com](http://www.misbt.com) (81) 3 6403 5900
- Mouser Electronics: [www.mouser.com](http://www.mouser.com) (800) 346-6873
- Newark/Farnell: [www.farnell.com/onsemi](http://www.farnell.com/onsemi) (800) 4 NEWARK
- Segyung Brister Co.: [www.brister.com](http://www.brister.com) (62) 2 3218 1511
- Tawwon Inc.: [www.tawwon.net](http://www.tawwon.net) (82) 2 6679 0000
- Tokyo Electron Device Co.: [www.teldevice.co.jp](http://www.teldevice.co.jp) (81) 45 443 4000
- World Peace Industries Co.: [www.wpi-group.com](http://www.wpi-group.com) (852) 2365 4860
- WT Microelectronics Co.: [www.wtmc.com](http://www.wtmc.com) (852) 2950 0820

---

**AMERICAS REP FIRMS**

- **Alabama**
  - Huntsville: e-Components (256) 533-2444
- **Brazil**
  - Countrywide: Ammon & Rizos (+55) 11-4688-1960
- **California**
  - Bay Area: L2 (408) 453-5000
- **Canada**
  - Eastern Canada: Astec (905) 607-1444
  - Western Canada: Silfore (503) 977-8267
- **Connecticut**
  - Statewide: Paragon Electronic Systems (603) 645-7630
- **Florida**
  - Statewide: e-Components (888) 468-2444
- **Georgia**
  - Atlanta: e-Components (888) 468-2444
- **Illinois**
  - Hoffmann Estates: Stan Clothier Company (847) 781-4010
- **Indiana**
  - Fishers: Bear VAI (317) 570-0707
- **Iowa**
  - Cedar Rapids: Essig & Associates (319) 363-8703
- **Kansas**
  - Overland Park: Stan Clothier Company (913) 894-1675
- **Maine**
  - Statewide: Paragon Electronic Systems (603) 645-7630
- **Maryland**
  - Columbia: Third Wave Solutions (410) 290-5990
- **Massachusetts**
  - Statewide: Paragon Electronic Systems (603) 645-7630
- **Mexico**
  - Countrywide: Ammon & Rizos (+55) 11-4688-1960
- **Michigan**
- **Minnesota**
  - Eden Prairie: Stan Clothier Company (952) 944-3456
- **Missouri**
  - St. Charles: Stan Clothier Company (636) 916-3777
- **New Hampshire**
  - Statewide: Paragon Electronic Systems (603) 645-7630
- **New Jersey**
  - Statewide: S.J. Metro (516) 942-3222
- **New York**
  - Binghamton: TriTech - Full Line Rep (607) 722-3580
  - Jericho: S.J. Metro (516) 942-3222
  - Rochester: TriTech - Full Line Rep (585) 385-6500
- **North Carolina**
  - Raleigh: e-Components (888) 468-2444
- **Ohio**
  - Brecksville: Bear VAI Technology (440) 526-1991
- **Oregon**
  - Portland: SiForce Technical (503) 917-6267
- **Puerto Rico**
  - Countrywide: e-Components (888) 468-2444
- **Rhode Island**
  - Statewide: Paragon Electronic Systems (603) 645-7630
- **Vermont**
  - Statewide: Paragon Electronic Systems (603) 645-7630
- **Washington**
  - Bellevue: SiForce Technical (425) 990-4701
- **Wisconsin**
  - Evansville: Stan Clothier Company (608) 882-0686
  - Oconomowoc: Stan Clothier Company (608) 882-0686

---

**For additional information, please contact your local Sales Representative**

---

**ON Semiconductor Website:** [www.onsemi.com](http://www.onsemi.com)

**LITERATURE FULFILLMENT:**

- Literature Distribution Center for ON Semiconductor
  - P.O. Box 5163, Denver, Colorado 80217 USA
  - Phone: 303-675-2175 or 800-344-3860 Toll Free USA/Canada
  - Fax: 303-675-2176 or 800-344-3867 Toll Free USA/Canada
  - Email: literature@onsemi.com

**LITERATURE ORDERING INFORMATION**

- For a comprehensive listing of ON Semiconductor Sales Offices, please visit: [www.onsemi.com/salesupport](http://www.onsemi.com/salessupport)

---

**ON Semiconductor** is a trademark of Semiconductor Components Industries, LLC (SCILLC) and is registered in the US and other countries.

**SCILLC** has a policy of continuous improvement. SCILLC reserves the right to make changes without further notice to any products herein. SCILLC makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does SCILLC assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation, special, consequential or incidental damages. Use and application are customer's responsibility. All operating parameters, including “typicals” must be validated for each customer application by customer's technical experts. SCILLC does not convey any license under its patent rights, nor does SCILLC assume any liability arising out of the design or manufacture of the part. SCILLC is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.