LED Lighting Solutions

Covering LED drivers, power management, interface, sensing, and protection solutions for solid state lighting applications from ON Semiconductor.
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 smart phones 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.
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.

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

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

Resources
- Design Note DN06062/D

[Graphs and diagrams showing efficiency vs dim duty cycle, LED PWM dimming curve, and reference design block diagram]
### Discrete Devices for LED Backlighting

**D1 Schottky Barrier Diode for DC-DC Converter**

<table>
<thead>
<tr>
<th>Device</th>
<th>$V_R$ Max (V)</th>
<th>$I_D$ Max (A)</th>
<th>$V_F$ Max (V)</th>
<th>$I_R$ Max (mA)</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>SB80W06T</td>
<td>60</td>
<td>8</td>
<td>0.6 @ $I_R$ = 3 A</td>
<td>0.1 @ $V_R$ = 30 V</td>
<td>DPAK, IPAK</td>
</tr>
<tr>
<td>SB80W10T</td>
<td>100</td>
<td>8</td>
<td>0.8 @ $I_R$ = 3 A</td>
<td>0.1 @ $V_R$ = 50 V</td>
<td>DPAK, IPAK</td>
</tr>
<tr>
<td>RD0106T</td>
<td>600</td>
<td>1</td>
<td>1.3 @ $I_R$ = 1 A</td>
<td>0.01 @ $V_R$ = 600 V</td>
<td>DPAK, IPAK</td>
</tr>
<tr>
<td>RD0306T</td>
<td>600</td>
<td>3</td>
<td>1.5 @ $I_R$ = 3 A</td>
<td>0.01 @ $V_R$ = 600 V</td>
<td>DPAK, IPAK</td>
</tr>
</tbody>
</table>

**Q1 Bipolar Transistor Current Balance Switch**

<table>
<thead>
<tr>
<th>No of LEDs in Series</th>
<th>$V_{CEO}$ (V)</th>
<th>$I_C$ (A)</th>
<th>Polarity</th>
<th>$h_{FE}$</th>
<th>$V_T$ (Dual)</th>
<th>$I_T$ (mA)</th>
<th>$SOT-89$</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>30</td>
<td>0.7</td>
<td>NPN</td>
<td>300-800</td>
<td>CPH6538</td>
<td>3002CH</td>
<td>PCP1203</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.5</td>
<td>NPN</td>
<td>200-500</td>
<td>CPH6539</td>
<td>3002CH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>50</td>
<td>0.5</td>
<td>NPN</td>
<td>300-800</td>
<td>CPH3216</td>
<td>3002CH</td>
<td>2SC5964</td>
<td>2SC5706</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.5</td>
<td>NPN</td>
<td>200-500</td>
<td>CPH3216</td>
<td>3002CH</td>
<td>2SC5964</td>
<td>2SC5706</td>
</tr>
<tr>
<td>20</td>
<td>60</td>
<td>3.0</td>
<td>NPN</td>
<td>300-600</td>
<td>CPH3216</td>
<td>3002CH</td>
<td>2SC5964</td>
<td>2SC5706</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.0</td>
<td>PNP</td>
<td>300-600</td>
<td>CPH3216</td>
<td>3002CH</td>
<td>2SC5964</td>
<td>2SC5706</td>
</tr>
<tr>
<td>25</td>
<td>100</td>
<td>1.0</td>
<td>NPN</td>
<td>140-400</td>
<td>CPH3240</td>
<td>3002CH</td>
<td>2SC5964</td>
<td>2SC5964</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.0</td>
<td>PNP</td>
<td>140-400</td>
<td>CPH3140</td>
<td>3002CH</td>
<td>2SC5964</td>
<td>2SC5964</td>
</tr>
<tr>
<td>40</td>
<td>160</td>
<td>0.7-1.5</td>
<td>NPN</td>
<td>140-400</td>
<td>CPH3240</td>
<td>3002CH</td>
<td>2SC5964</td>
<td>2SC5964</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.7</td>
<td>PNP</td>
<td>140-400</td>
<td>CPH3240</td>
<td>3002CH</td>
<td>2SC5964</td>
<td>2SC5964</td>
</tr>
<tr>
<td>50</td>
<td>200</td>
<td>0.7</td>
<td>NPN</td>
<td>200-560</td>
<td>CPH3240</td>
<td>3002CH</td>
<td>2SC5964</td>
<td>2SC5964</td>
</tr>
</tbody>
</table>
## Q1 MOSFET Current Balance Switch

<table>
<thead>
<tr>
<th>Device</th>
<th>No of LEDs in Series</th>
<th>Polarity</th>
<th>V\textsubscript{DSS} (V)</th>
<th>I\textsubscript{P} (A)</th>
<th>V\textsubscript{Drive} (V)</th>
<th>R\textsubscript{DS(on)}</th>
<th>@ V\textsubscript{DS}</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>@ V\textsubscript{DS}</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Typ</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Max</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Package</td>
</tr>
<tr>
<td>MCH6445</td>
<td>14</td>
<td>N-Channel</td>
<td>60</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>81 mΩ</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>114 mΩ</td>
</tr>
<tr>
<td>MCH3486</td>
<td>14</td>
<td>N-Channel</td>
<td>60</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>155 mΩ</td>
</tr>
<tr>
<td>CPH6442</td>
<td>14</td>
<td>N-Channel</td>
<td>60</td>
<td>6</td>
<td>4</td>
<td>4</td>
<td>46 mΩ</td>
</tr>
<tr>
<td>CPH6444</td>
<td>14</td>
<td>N-Channel</td>
<td>60</td>
<td>4.5</td>
<td>4</td>
<td>4</td>
<td>81 mΩ</td>
</tr>
<tr>
<td>CPH6445</td>
<td>14</td>
<td>N-Channel</td>
<td>60</td>
<td>3.5</td>
<td>4</td>
<td>4</td>
<td>132 mΩ</td>
</tr>
<tr>
<td>PCP1403</td>
<td>14</td>
<td>N-Channel</td>
<td>60</td>
<td>4.5</td>
<td>4</td>
<td>4</td>
<td>132 mΩ</td>
</tr>
<tr>
<td>PCP1405</td>
<td>50</td>
<td>N-Channel</td>
<td>250</td>
<td>0.6</td>
<td>4</td>
<td>4.5</td>
<td>5 Ω</td>
</tr>
<tr>
<td>CPH3461</td>
<td>50</td>
<td>N-Channel</td>
<td>250</td>
<td>0.35</td>
<td>4</td>
<td>4.5</td>
<td>5 Ω</td>
</tr>
<tr>
<td>PCP1402</td>
<td>50</td>
<td>N-Channel</td>
<td>250</td>
<td>1.2</td>
<td>10</td>
<td>10</td>
<td>1.8 Ω</td>
</tr>
<tr>
<td>SFT1452</td>
<td>50</td>
<td>N-Channel</td>
<td>250</td>
<td>3</td>
<td>10</td>
<td>10</td>
<td>1.8 Ω</td>
</tr>
</tbody>
</table>

## Q2 MOSFET for DC-DC Converter

<table>
<thead>
<tr>
<th>Device</th>
<th>V\textsubscript{DSS} (V)</th>
<th>I\textsubscript{P} (A)</th>
<th>P\textsubscript{D} (W)</th>
<th>@ V\textsubscript{DS}</th>
<th>R\textsubscript{DS(on)}</th>
<th>C\textsubscript{SS} (µF)</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCH3486</td>
<td>60</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>155 mΩ</td>
<td>217 mΩ</td>
<td>310</td>
</tr>
<tr>
<td>CPH6445</td>
<td>60</td>
<td>3.5</td>
<td>1.6</td>
<td>4</td>
<td>132 mΩ</td>
<td>185 mΩ</td>
<td>310</td>
</tr>
<tr>
<td>MCH6445</td>
<td>60</td>
<td>4</td>
<td>1.5</td>
<td>4</td>
<td>81 mΩ</td>
<td>114 mΩ</td>
<td>505</td>
</tr>
<tr>
<td>PCP1403</td>
<td>60</td>
<td>4.5</td>
<td>3.5</td>
<td>4</td>
<td>132 mΩ</td>
<td>185 mΩ</td>
<td>310</td>
</tr>
<tr>
<td>CPH6444</td>
<td>60</td>
<td>4.5</td>
<td>1.6</td>
<td>4</td>
<td>81 mΩ</td>
<td>114 mΩ</td>
<td>505</td>
</tr>
<tr>
<td>CPH6442</td>
<td>60</td>
<td>6</td>
<td>1.6</td>
<td>4</td>
<td>46 mΩ</td>
<td>65 mΩ</td>
<td>1040</td>
</tr>
<tr>
<td>2SK3703</td>
<td>60</td>
<td>30</td>
<td>2</td>
<td>10</td>
<td>20 mΩ</td>
<td>26 mΩ</td>
<td>1780</td>
</tr>
<tr>
<td>ATP212</td>
<td>60</td>
<td>35</td>
<td>40</td>
<td>4.5</td>
<td>25 mΩ</td>
<td>37 mΩ</td>
<td>1820</td>
</tr>
<tr>
<td>2SK3816</td>
<td>60</td>
<td>40</td>
<td>1.65</td>
<td>10</td>
<td>20 mΩ</td>
<td>26 mΩ</td>
<td>1780</td>
</tr>
<tr>
<td>BBL4001</td>
<td>60</td>
<td>74</td>
<td>35</td>
<td>10</td>
<td>4.7 mΩ</td>
<td>6.1 mΩ</td>
<td>6900</td>
</tr>
<tr>
<td>ATP214</td>
<td>60</td>
<td>75</td>
<td>60</td>
<td>4</td>
<td>9.2 mΩ</td>
<td>14 mΩ</td>
<td>4850</td>
</tr>
<tr>
<td>ATP404</td>
<td>60</td>
<td>95</td>
<td>70</td>
<td>4.5</td>
<td>7.5 mΩ</td>
<td>10.5 mΩ</td>
<td>6400</td>
</tr>
<tr>
<td>ATP401</td>
<td>60</td>
<td>100</td>
<td>90</td>
<td>4.5</td>
<td>3.7 mΩ</td>
<td>5.2 mΩ</td>
<td>14500</td>
</tr>
<tr>
<td>2SK4066</td>
<td>60</td>
<td>100</td>
<td>1.65</td>
<td>10</td>
<td>3.6 mΩ</td>
<td>4.7 mΩ</td>
<td>12500</td>
</tr>
<tr>
<td>2SK4094</td>
<td>60</td>
<td>100</td>
<td>1.75</td>
<td>10</td>
<td>3.8 mΩ</td>
<td>5 mΩ</td>
<td>12200</td>
</tr>
<tr>
<td>NDRA170N06A</td>
<td>60</td>
<td>170</td>
<td>90</td>
<td>10</td>
<td>2.5 mΩ</td>
<td>3.3 mΩ</td>
<td>15800</td>
</tr>
<tr>
<td>ATP405</td>
<td>100</td>
<td>40</td>
<td>70</td>
<td>10</td>
<td>25 mΩ</td>
<td>33 mΩ</td>
<td>4000</td>
</tr>
<tr>
<td>NDPL070N10B</td>
<td>100</td>
<td>70</td>
<td>72</td>
<td>10</td>
<td>9.8 mΩ</td>
<td>12.8 mΩ</td>
<td>2010</td>
</tr>
<tr>
<td>NDPL100N10B</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>10</td>
<td>6.7 mΩ</td>
<td>8.7 mΩ</td>
<td>2950</td>
</tr>
<tr>
<td>NDRA100N10B</td>
<td>100</td>
<td>100</td>
<td>110</td>
<td>10</td>
<td>6.3 mΩ</td>
<td>8.2 mΩ</td>
<td>2950</td>
</tr>
<tr>
<td>NDPL180N10B</td>
<td>100</td>
<td>180</td>
<td>2.1</td>
<td>10</td>
<td>2.7 mΩ</td>
<td>3.5 mΩ</td>
<td>6950</td>
</tr>
<tr>
<td>NDRA180N10B</td>
<td>100</td>
<td>180</td>
<td>200</td>
<td>10</td>
<td>2.5 mΩ</td>
<td>3.3 mΩ</td>
<td>6950</td>
</tr>
<tr>
<td>CPH3461</td>
<td>250</td>
<td>0.35</td>
<td>1</td>
<td>4.5</td>
<td>5 Ω</td>
<td>6.5 Ω</td>
<td>140</td>
</tr>
<tr>
<td>PCP1405</td>
<td>250</td>
<td>0.6</td>
<td>3.5</td>
<td>4.5</td>
<td>5 Ω</td>
<td>6.5 Ω</td>
<td>140</td>
</tr>
<tr>
<td>PCP1402</td>
<td>250</td>
<td>1.2</td>
<td>3.5</td>
<td>10</td>
<td>1.8 Ω</td>
<td>2.4 Ω</td>
<td>210</td>
</tr>
<tr>
<td>SFT1452</td>
<td>250</td>
<td>3</td>
<td>26</td>
<td>10</td>
<td>1.8 Ω</td>
<td>2.4 Ω</td>
<td>210</td>
</tr>
<tr>
<td>NDOP010N25AZ</td>
<td>250</td>
<td>10</td>
<td>52</td>
<td>10</td>
<td>320 mΩ</td>
<td>420 mΩ</td>
<td>980</td>
</tr>
</tbody>
</table>
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 smart 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.
# Charge Pump Topology

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>Regulatıon 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>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>1</td>
<td>2.5 typ</td>
<td>DFN-10</td>
<td>Backlight 4.5 / 5 V output Short circuit protection</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 Backlight Built-in &quot;gradual illumination&quot; B &amp; C versions have different I2C addresses</td>
</tr>
</tbody>
</table>

# 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>Max 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 (µA)</th>
<th>Package</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCP1422</td>
<td>1.0 - 5.0</td>
<td></td>
<td>800</td>
<td>Vout 3.3 V, Vin 2.5 V</td>
<td>1 for flash</td>
<td>PFM, up to 1.2 MHz</td>
<td>PWM</td>
<td>94</td>
<td>1.3 µA</td>
<td>0.05</td>
<td>DFN-10</td>
<td>Flash/Torch Internal synchronous rectification</td>
</tr>
<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/PFM 1.7 MHz</td>
<td>PWM</td>
<td>96</td>
<td>28</td>
<td>0.3</td>
<td>TSOP-5, uDFN-6</td>
<td>Flash/Torch Auto-switching between PWM and PFM mode at light load</td>
</tr>
<tr>
<td>NCP5005</td>
<td>2.7 - 5.5</td>
<td></td>
<td>24</td>
<td>Over 5 LED, Vin 3.6 V</td>
<td>2 to 5/ series</td>
<td>PFM, up to 2.25 MHz</td>
<td>PWM</td>
<td>90</td>
<td>–</td>
<td>0.3</td>
<td>TSOP-5</td>
<td>Backlight Isw = 350 mA</td>
</tr>
<tr>
<td>LV52204</td>
<td>2.7 - 5.5</td>
<td></td>
<td>40</td>
<td>Vout 30 V, Vin 3.7 V</td>
<td>2 to 10 / Series</td>
<td>600 kHz</td>
<td>1-wire &amp; PWM</td>
<td>90</td>
<td>3</td>
<td>0.1</td>
<td>UDFN-6</td>
<td>Backlight Isw = 750 mA</td>
</tr>
<tr>
<td>LV52207</td>
<td>2.7 - 5.5</td>
<td></td>
<td>40</td>
<td>Vout 30 V, Vin 3.7 V</td>
<td>2 to 10 / Series</td>
<td>600 kHz/1.2 MHz</td>
<td>1-wire &amp; PWM</td>
<td>90</td>
<td>3</td>
<td>0.1</td>
<td>WLP-9</td>
<td>Backlight Isw = 750 mA</td>
</tr>
</tbody>
</table>
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</td>
<td>Low to medium volume applications, reduces safety</td>
<td>Common voltages of 12, 24, 36, 48 Vdc,</td>
</tr>
<tr>
<td>Regulated Adapter</td>
<td>requirements</td>
<td>regulation to ±5%</td>
</tr>
<tr>
<td>(Sealed) Lead Acid</td>
<td>Automotive, solar powered, marine</td>
<td>Loose regulation, 8-14 Vdc; Wider</td>
</tr>
<tr>
<td>Battery</td>
<td></td>
<td>for automotive, 7-27 Vdc</td>
</tr>
<tr>
<td>12 Vdc &amp; 12 Vac</td>
<td>Common in interior, track lighting, outdoor,</td>
<td>Loose if magnetic ballast, tight to ±5%</td>
</tr>
<tr>
<td></td>
<td>landscaping applications</td>
<td>if electronic ballast, minimum load may</td>
</tr>
<tr>
<td></td>
<td></td>
<td>be required; plus cable losses</td>
</tr>
</tbody>
</table>

**Boost (Step-Up) Topology**

**Buck (Step-Down) Topology**

**Linear Topology**
### Switching Driver Solutions

#### Wide Input Voltage LED Driver Selector

Vin < 40 V

<table>
<thead>
<tr>
<th>Device</th>
<th>Switching Frequency Typ (kHz)</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>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCP3065/6</td>
<td>Up to 200</td>
<td>Buck, Boost, Buck/Boost</td>
<td>3 to 40</td>
<td>1.5 **</td>
<td>NCV3065</td>
<td>SOIC-8, DFN-8, PDIP-8</td>
<td>Buck 3 A</td>
<td>NCP30653BAKEGBV&lt;br&gt;Application Note: AND6298/D</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Buck-Boost 350 mA, 550 mA MR16 LED bulb</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SEPIC 350 mA &amp; 700 mA MR16 LED bulb</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Buck with external P-channel MOSFET</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NCP3065D1SLDGEVB&lt;br&gt;Design Note: DN06031/D</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NCP3065SOBCKGEVB&lt;br&gt;Application Note: AND8298/D</td>
</tr>
<tr>
<td>NCP3066</td>
<td>250</td>
<td>Buck, Boost, Buck/Boost</td>
<td>3 to 40</td>
<td>1.5 **</td>
<td>NCV3066</td>
<td>SOIC-8, DFN-8, PDIP-8</td>
<td>SEPIC 350 mA, 700 mA MR16 LED bulb</td>
<td>NCP3066D3SLDGEBV&lt;br&gt;Application Note: AND8298/D</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Buck 3 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Buck &lt;1 A</td>
</tr>
<tr>
<td>NCP3163</td>
<td>Up to 200</td>
<td>Buck, Boost, Buck/Boost</td>
<td>2.5 to 40</td>
<td>3.4</td>
<td>NCV3163</td>
<td>SOIC-16W, DFN-18</td>
<td>Boost 700 mA</td>
<td>NCP3163BSTEVB&lt;br&gt;Application Note: AND8298/D</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Buck 3 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Inverter 500 mA</td>
</tr>
<tr>
<td>MC33163</td>
<td>Up to 50</td>
<td>Buck, Boost, Buck/Boost</td>
<td>2.5 to 40</td>
<td>3.4</td>
<td>–</td>
<td>SOIC-16</td>
<td></td>
<td>NCP3163INVGEVB&lt;br&gt;Application Note: AND8298/D</td>
</tr>
<tr>
<td>NCP1034</td>
<td>Up to 500</td>
<td>Buck</td>
<td>8 to 100</td>
<td>–</td>
<td>–</td>
<td>SOIC-16</td>
<td>Buck 5 A, 5 Vout</td>
<td>NCP1034BC6VGBEVB&lt;br&gt;Design Note: DN06041/D&lt;br&gt;Design Note: DN06047/D</td>
</tr>
<tr>
<td>CS5171/3</td>
<td>280 / 560</td>
<td>Boost or SEPIC</td>
<td>2.7 to 30</td>
<td>1.5</td>
<td>–</td>
<td>SOIC-8</td>
<td>Boost 400 mA, 5 Vout</td>
<td>CS5171B8SGEVB&lt;br&gt;Design Note: DN06041/D&lt;br&gt;Design Note: DN06047/D</td>
</tr>
<tr>
<td>NCP1294</td>
<td>1000</td>
<td>Buck, Boost, Buck/Boost</td>
<td>4.7 to 100</td>
<td>–</td>
<td>–</td>
<td>TSSOP-16, SOIC-16</td>
<td>High Voltage LED Driver (24Vin to 110Vout @ 100 mA)</td>
<td>NCP1294D0SLDGEVB&lt;br&gt;Design Note: DN06062/D</td>
</tr>
<tr>
<td>NCL30100</td>
<td>Up to 700</td>
<td>Buck</td>
<td>6.35 to 18</td>
<td>–</td>
<td>–</td>
<td>TSOP-6</td>
<td>Buck 700 mA MR16 LED bulb</td>
<td>NCL30100AO4LMEGBV&lt;br&gt;Buck 700 mA PWM dimmable LED driver&lt;br&gt;NCL30100BSLGEVB</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>High Voltage Input, 350 mA Buck LED Driver</td>
<td>NCL30105DGEBV&lt;br&gt;NCL30105SPEVB&lt;br&gt;NCL30105LGEVB</td>
</tr>
<tr>
<td>NCL30160</td>
<td>Up to 1.4 MHz</td>
<td>Buck</td>
<td>6.5 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&lt;br&gt;NCL30160SPEVB&lt;br&gt;NCL30160LGEVB</td>
</tr>
<tr>
<td>NCL30161</td>
<td>Up to 2.4 MHz</td>
<td>Buck</td>
<td>6.3 to 40</td>
<td>–</td>
<td>–</td>
<td>DFN-10</td>
<td></td>
<td>NCL30160LGEVB</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.
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**

Linear LED Driver Solutions

<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;AK&lt;/sub&gt; - V&lt;sub&gt;LED&lt;/sub&gt;) (V)</th>
<th>Constant Current tolerance (@ V&lt;sub&gt;AK&lt;/sub&gt; = 7.5 V) (mA)</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>
</tr>
<tr>
<td>NSI50xxx</td>
<td>50</td>
<td>1.8</td>
<td>Fixed: 10, 350</td>
<td>+10%</td>
<td>175</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>
</tr>
<tr>
<td>NSI45xxxJ</td>
<td>45</td>
<td>1.8</td>
<td>Adjustable</td>
<td>±15%</td>
<td>150</td>
</tr>
<tr>
<td>NSI50150AD</td>
<td>50</td>
<td>1.8</td>
<td>150 to 350</td>
<td>±10%</td>
<td>175</td>
</tr>
</tbody>
</table>

NOTE: xxx in the device number represents the current level.
### Linear LED Driver Solutions (continued)

#### Fixed Linear LED Drivers

<table>
<thead>
<tr>
<th>Device</th>
<th>Channel Output Current (mA)</th>
<th>Operating Voltage Range (V)</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>NSI50350AS</td>
<td>350</td>
<td>1.8 to 50</td>
<td>±10%</td>
<td>1</td>
<td>Ext</td>
<td>1.8</td>
<td>-40 to +125</td>
<td>SMC</td>
<td>AEC-Q101 qualified</td>
</tr>
<tr>
<td>NSI50350AD</td>
<td>350</td>
<td>1.8 to 50</td>
<td>±10%</td>
<td>1</td>
<td>Ext</td>
<td>1.8</td>
<td>-40 to +125</td>
<td>DPAK</td>
<td>AEC-Q101 qualified</td>
</tr>
<tr>
<td>NSIC2050JB</td>
<td>50</td>
<td>1.8 to 120</td>
<td>±15%</td>
<td>1</td>
<td>Ext</td>
<td>1.8</td>
<td>-40 to +125</td>
<td>SMB</td>
<td>AEC-Q101 qualified</td>
</tr>
<tr>
<td>NSIC2030JB</td>
<td>30</td>
<td>1.8 to 120</td>
<td>±15%</td>
<td>1</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>30</td>
<td>1.8 to 45</td>
<td>±10%</td>
<td>1</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>30</td>
<td>1.8 to 45</td>
<td>±10%</td>
<td>1</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>NSI45030</td>
<td>30</td>
<td>1.8 to 45</td>
<td>±10%</td>
<td>1</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>25</td>
<td>1.8 to 45</td>
<td>±15%</td>
<td>1</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>25</td>
<td>1.8 to 45</td>
<td>±10%</td>
<td>1</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>25</td>
<td>1.8 to 45</td>
<td>±10%</td>
<td>1</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>25</td>
<td>1.8 to 45</td>
<td>±10%</td>
<td>1</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>20</td>
<td>1.8 to 45</td>
<td>±15%</td>
<td>1</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>20</td>
<td>1.8 to 45</td>
<td>±10%</td>
<td>1</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>NSIC2020JB</td>
<td>20</td>
<td>1.8 to 120</td>
<td>±15%</td>
<td>1</td>
<td>Ext</td>
<td>1.8</td>
<td>-40 to +125</td>
<td>SMB</td>
<td>AEC-Q101 qualified</td>
</tr>
<tr>
<td>NSI45015W</td>
<td>15</td>
<td>1.8 to 45</td>
<td>±20%</td>
<td>1</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>NSI50010Y</td>
<td>10</td>
<td>1.8 to 50</td>
<td>±30%</td>
<td>1</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>

#### Adjustable Linear LED Drivers

<table>
<thead>
<tr>
<th>Device</th>
<th>Channel Output Current (mA)</th>
<th>Operating Voltage Range (V)</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>NSI50150AD</td>
<td>150 to 350</td>
<td>1.8 to 50</td>
<td>±10%</td>
<td>1</td>
<td>Ext</td>
<td>1.8</td>
<td>-40 to +125</td>
<td>DPAK</td>
<td>AEC-Q101 qualified</td>
</tr>
<tr>
<td>NSI45090JD</td>
<td>90 to 160</td>
<td>1.8 to 45</td>
<td>±15%</td>
<td>1</td>
<td>Ext</td>
<td>1.8</td>
<td>-40 to +125</td>
<td>DPAK</td>
<td>AEC-Q101 qualified</td>
</tr>
<tr>
<td>NSI45060JD</td>
<td>60 to 100</td>
<td>1.8 to 45</td>
<td>±15%</td>
<td>1</td>
<td>Ext</td>
<td>1.8</td>
<td>-40 to +125</td>
<td>DPAK</td>
<td>AEC-Q101 qualified</td>
</tr>
<tr>
<td>NSI45035JZ</td>
<td>35 to 70</td>
<td>1.8 to 45</td>
<td>±15%</td>
<td>1</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>NSI45020JZ</td>
<td>20 to 40</td>
<td>1.8 to 45</td>
<td>±15%</td>
<td>1</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>NSM4002MR6</td>
<td>1 to 200</td>
<td>1.4 to 45</td>
<td>±3%</td>
<td>1</td>
<td>Ext</td>
<td>1.4</td>
<td>-40 to +125</td>
<td>SC-74</td>
<td>Can be used with an external transistor</td>
</tr>
<tr>
<td>NUD4001</td>
<td>500</td>
<td>2.0 to 30 (60 V Surge)</td>
<td>±3%</td>
<td>1</td>
<td>Ext</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>70</td>
<td>5 to 200</td>
<td>±3%</td>
<td>1</td>
<td>Ext</td>
<td>5</td>
<td>-40 to +125</td>
<td>SOIC-8</td>
<td>Can be used with an external transistor</td>
</tr>
<tr>
<td>NCV7680</td>
<td>35</td>
<td>6 to 16</td>
<td>±10% @ 35 mA</td>
<td>8</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>LV5237JA</td>
<td>Constant mode 5 to 100 Open drain 100</td>
<td>VDD 3.3 - 12.8</td>
<td>±7%</td>
<td>9</td>
<td>PWM 256 steps</td>
<td>0.7</td>
<td>-25 to +85</td>
<td>SSOP-24</td>
<td>General purpose</td>
</tr>
<tr>
<td>LV5239TA</td>
<td>Constant mode 5 to 50 Open drain 100</td>
<td>VDD 3.3 - 12.8</td>
<td>±7%</td>
<td>24</td>
<td>PWM 256 steps</td>
<td>0.7</td>
<td>-25 to +85</td>
<td>TQFP-48</td>
<td>General purpose</td>
</tr>
<tr>
<td>LV5234</td>
<td>Constant mode 5 to 100 Open drain 100</td>
<td>VDD 4.5 - 5.5</td>
<td>±5.5%</td>
<td>9</td>
<td>PWM 256 steps</td>
<td>0.7</td>
<td>-25 to +75</td>
<td>SSOP-30</td>
<td>General purpose</td>
</tr>
<tr>
<td>LV5235</td>
<td>Constant mode 5 to 50 Open drain 100</td>
<td>VDD 4.5 - 5.5</td>
<td>±5.5%</td>
<td>16</td>
<td>PWM 256 steps</td>
<td>0.7</td>
<td>-25 to +75</td>
<td>SSOP-44J</td>
<td>General purpose</td>
</tr>
<tr>
<td>LV5236</td>
<td>Constant mode 5 to 50 Open drain 100</td>
<td>VDD 4.5 - 5.5</td>
<td>±5.5%</td>
<td>24</td>
<td>PWM 256 steps</td>
<td>0.7</td>
<td>-25 to +75</td>
<td>SSOP-44J</td>
<td>General purpose</td>
</tr>
</tbody>
</table>
Lamp Drivers Based on Constant Current Regulators

- 120 Vac low cost CCR circuit
- Dimmable
- THD below 20%
- All surface mount components
- Passes EMI without filter

- Compact universal input for low power
- Constant LED current from 80 to 280 Vac
- Requires only 48 V of LEDs

- Dusk-to-dawn dimming module
- Compatible with all CCR circuits
- Uses all surface mount components
- Provides 30 second hysteresis
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 6.35 to 18 V

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

Adjustable Current Sense Threshold
Adjustable Off Time Control
Zener Regulator Can Extend Operating Range >18 V

LEDs Are Connected to Vin
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
The circuit described in the DN06048/D Design Note is intended for driving multi-die LED modules like the Sharp mini-ZENIGATA™, 12 V Cree XLamp® XT-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
Automotive Lighting Systems

ON Semiconductor offers standard products and custom devices for automotive lighting applications, has developed the defacto standard stepper driver for headlight leveling and swiveling, and is a leader in LED exterior lighting solutions.

Front Lighting

Automotive designs predominantly use LED lighting, which 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, that are specifically designed for exterior front lighting.
Front Lighting — Power Ballast and Dual LED Driver for Advanced LED

The NCV78763 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 NCV78763 offers integrated, energy efficient solutions for comprehensive front lighting control.

Features — NCV78763

- System integrated solution with few external components.
- Buck-boost topology
- LED current regulator
  - Constant average current
  - Efficient integrated buck switches (high-side)
  - Current per output up to 1.6 A
- Extended diagnostics: detection of open circuit or failing driver, short, over-current protection, single LED failures
- Thermal protection
- System customization by SPI interface
  - 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%)
Front Lighting – Leveling and Swiveling

The NCV70628 is a single-chip micro-stepping motor driver with position controller and control/diagnostic interface, making it ideal for dedicated mechatronics solutions, connected remotely through a LIN master.

The NCV70514 is a micro-stepping motor driver that is fully compatible with automotive voltage requirements, and is especially well-suited for use in applications with fluctuating battery supplies.
Front Lighting – Small Signal Solutions for Pixel (Matrix) Control

Today’s adaptive front lighting systems (AFLS) utilize a combination of sensors, motors, and a LED matrix to adjust the direction and intensity of the light beam. One AFLS method involves blanking of certain LED strings within the matrix, which can be controlled by a combination of small signal components such as Low V\text{CE(sat)} bipolar transistors and digital transistors (BRT – bias resistor transistor).

The collector of the NPN digital transistor is connected to the base of the Low V\text{CE(sat)} PNP transistor, thereby forming an ultra-low saturation voltage (V\text{CE(sat)}) and high current gain capability of the combination. The high current gain allows this combination to be driven directly from an MCU or PMU’s control outputs, reducing overall system complexity and cost.

---

Features

- AEC-Q101 discrete & Mixed Element Array (MEA) components
- Low V\text{CE(sat)} ensures shunting of LED
- Simplifies circuit design & reduces component count
- PCB space saving with 2 mm x 2 mm wettable flank DFN packaging

---

<table>
<thead>
<tr>
<th>Device</th>
<th>V\text{CEO} (V)</th>
<th>I\text{C} (A)</th>
<th>V\text{CE(sat)} (V)</th>
<th>Description</th>
<th>Package(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSV60100DMTW</td>
<td>-60</td>
<td>1.0</td>
<td>-0.35</td>
<td>60 V, 1 A Dual PNP Low V\text{CE(sat)} BJT</td>
<td>WDFN-6 WF</td>
</tr>
<tr>
<td>NSV60200DMTW</td>
<td>-60</td>
<td>2.0</td>
<td>-0.45</td>
<td>60 V, 2 A Dual PNP Low V\text{CE(sat)} BJT</td>
<td></td>
</tr>
<tr>
<td>NSV20200DMTW</td>
<td>-20</td>
<td>2.0</td>
<td>-0.39</td>
<td>20 V, 2 A Dual PNP Low V\text{CE(sat)} BJT</td>
<td></td>
</tr>
<tr>
<td>NSVMUN5214D</td>
<td>50</td>
<td>0.1</td>
<td>0.25</td>
<td>Dual NPN BRT, R1 = 10k\Omega, R2 = 47k\Omega</td>
<td>SC-88 (SOT-363)</td>
</tr>
<tr>
<td>NSVBC114YDXW6</td>
<td>50</td>
<td>0.1</td>
<td>0.25</td>
<td>Dual NPN BRT, R1 = 10k\Omega, R2 = 47k\Omega</td>
<td>SOT-563</td>
</tr>
</tbody>
</table>
RCL, DRL, CHMSL Lighting – Linear LED Pre-Driver

NCV7691 and NCV7692 are pre-drivers intended for linear drive of LEDs. They can operate from the car battery, and multiple LED strings can be driven by a single device.

Features

- NCV7691 Open Load detection threshold level: 9.5 V rising, 8.8 V falling
- NCV7692 Open Load detection threshold level: 5.1 V rising, 4.95 V falling
- Constant Current Output for LED String Drive External Programming Current Resistor
- Wide Current Range using External Bipolar Device
- Multiple LED String Control
- Pulse Width Modulation (PWM) Control
- Negative Temperature Coefficient (NTC) Current Control
- Open LED String & Short-Circuit LED String Diagnostic
- Overvoltage Set Back Power Limitation
Rear Lighting — Linear Current Regulators/Controllers

For Rear Combination Lamps, Daytime Running Lights, Fog Lights, CHMSLs, Turn Signals

The NCV7683 is a 8-channel linear programmable constant current source with common reference, designed for the regulation and control of LED-based lighting.

- Allow for two programmed levels for Stop and Tail illumination, or optional external PWM
- Slew rate control to eliminate EMI concerns
- Sequencing functionality

The NCV7685 is a 12-channel linear programmable constant current source with common reference, designed for the regulation and control of LED-based lighting.

- Allow for 128 duty cycle levels, adjustable with I2C-programmable PWM
- 3.3 V voltage reference for loads up to 1 mA
- OTP bank for stand-alone operation (2 configurations)

<table>
<thead>
<tr>
<th>Device</th>
<th>Channels</th>
<th>V_I Max (V)</th>
<th>I_O Max (mA)</th>
<th>Max LEDs in Series</th>
<th>Max LEDs in Parallel</th>
<th>Package(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCV7683</td>
<td>8</td>
<td>40</td>
<td>200</td>
<td>4</td>
<td>24</td>
<td>SSOP-24 NB EP</td>
</tr>
<tr>
<td>NCV7685</td>
<td>12</td>
<td>40</td>
<td>60</td>
<td>4</td>
<td>12</td>
<td>SSOP-24 NB EP</td>
</tr>
</tbody>
</table>
**Interior Lighting — LIN RGB LED Driver**

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
- Supports auto-addressing

**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
Interior Lighting and Center High Mount Stop Lamp (CHMSL) – Constant Current Regulators

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

Resources
- Sample Kit: CCR2KIT/S

<table>
<thead>
<tr>
<th>Device</th>
<th>Max Anode-to-Cathode Voltage (V)</th>
<th>Voltage Overhead (V)</th>
<th>Constant Current @ V = 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>NSV45xxx</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>NSV50xxx</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>NSVC20xx</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>NSV45xxxJ</td>
<td>45</td>
<td>1.8</td>
<td>Adjustable 20 to 40, 35 to 70, 60 to 100, 90 to 160, 150 to 350</td>
<td>±15%</td>
<td>150</td>
<td>SOT-223, DPAK</td>
</tr>
</tbody>
</table>

NOTE: xxx in the device number represents the current level.
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.
# AC Line Powered LED Driver Line Up

<table>
<thead>
<tr>
<th>Category</th>
<th>Topology</th>
<th>Device</th>
<th>Dimming</th>
<th>Startup</th>
<th>PSR</th>
<th>PFC</th>
<th>Mode</th>
<th>Package</th>
<th>Key Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC-DC</td>
<td>Low Voltage Buck</td>
<td>NCL30100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TSOP-6</td>
<td>MR16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FL7760</td>
<td>A/P</td>
<td></td>
<td></td>
<td></td>
<td>CCM</td>
<td>SSOT-6</td>
<td>Wide analog dimming, 70 V</td>
</tr>
<tr>
<td>Direct AC Driver</td>
<td>Buck</td>
<td>NCL30170</td>
<td>A/P</td>
<td>HV JFET</td>
<td></td>
<td></td>
<td>Linear</td>
<td>SOIC-10 NB</td>
<td>Shunt type controller</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FL7701</td>
<td>A/P</td>
<td>HV JFET</td>
<td></td>
<td></td>
<td>CCM</td>
<td>SOIC-8</td>
<td>Low eBOM counts</td>
</tr>
<tr>
<td></td>
<td>Boost</td>
<td>NCL30167</td>
<td>PC</td>
<td>Cascade</td>
<td></td>
<td></td>
<td>CRM</td>
<td>SOIC-10 NB</td>
<td>Professional phase-cut dimming</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NCL30095</td>
<td>PC</td>
<td>Cascade</td>
<td></td>
<td></td>
<td>CRM</td>
<td>SOIC-14</td>
<td>400 V switcher</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NCL30073</td>
<td>PC</td>
<td></td>
<td></td>
<td></td>
<td>CRM</td>
<td>TSOP-6</td>
<td>Low eBOM counts</td>
</tr>
<tr>
<td>Boost-Boost</td>
<td>SEPIC Flyback</td>
<td>NCL30188</td>
<td>CC</td>
<td></td>
<td></td>
<td></td>
<td>QR</td>
<td>SOIC-8</td>
<td>CC tolerance &lt;=±3%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NCL30288</td>
<td>CC</td>
<td></td>
<td></td>
<td></td>
<td>QR</td>
<td>SOIC-8</td>
<td>Small form factor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FL7734</td>
<td>PC</td>
<td>CC</td>
<td></td>
<td></td>
<td>DCM</td>
<td>SOIC-16</td>
<td>Professional phase-cut dimming</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NCL30185</td>
<td>Step</td>
<td>CC</td>
<td></td>
<td></td>
<td>QR</td>
<td>SOIC-8</td>
<td>Conventional switch dimming</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NCL30186</td>
<td>CC</td>
<td></td>
<td></td>
<td></td>
<td>QR</td>
<td>SOIC-10 NB</td>
<td>Non-phase-cut dimming</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NCL30188</td>
<td>CC</td>
<td></td>
<td></td>
<td></td>
<td>QR</td>
<td>SOIC-8</td>
<td>CC tolerance &lt;=±3%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NCL30288</td>
<td>CC</td>
<td></td>
<td></td>
<td></td>
<td>QR</td>
<td>SOIC-8</td>
<td>Small form factor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FL7733A</td>
<td>HV JFET</td>
<td>CC</td>
<td></td>
<td></td>
<td>DCM</td>
<td>SOIC-8</td>
<td>CC tolerance &lt;=±3%, good THD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FL7740</td>
<td>HV JFET</td>
<td>CV</td>
<td></td>
<td></td>
<td>DCM</td>
<td>SOIC-10</td>
<td>CV &lt;=±3%/PF, Pstdby &lt;0.3 W, smart lighting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NCL30386</td>
<td>A/P</td>
<td>HV JFET</td>
<td>CC/CC</td>
<td></td>
<td>QR</td>
<td>SOIC-10 NB</td>
<td>CC/CC (&lt;±2%), low THD, smart lighting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NCL30388</td>
<td>A/P</td>
<td>HV JFET</td>
<td>CC/CC</td>
<td></td>
<td>QR</td>
<td>SOIC-8</td>
<td>CC/CC (&lt;±2%), low THD</td>
</tr>
<tr>
<td>Boost PFC</td>
<td></td>
<td>NCP1622</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CRM</td>
<td>TSOP-6</td>
<td>Voltage mode, no ZCD winding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NCL2801</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CRM</td>
<td>SOIC-8</td>
<td>Current mode, low THD, frequency foldback</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NCP1654</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CRM</td>
<td>SOIC-8</td>
<td>Current mode, optional frequency</td>
</tr>
<tr>
<td>Half-Bridge</td>
<td>Voltage</td>
<td>FLS1600</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SIP-9</td>
<td>500 V switcher</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FLS1700</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>FLS1800</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>FLS2100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>NCP1399/13992</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Current</td>
<td>SOIC-16 NB</td>
<td>High performance current mode LLC resonant</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NCL30059</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SOIC-8</td>
<td>Wide Vout simple LLC resonant half bridge</td>
</tr>
<tr>
<td>2 Stage Combo</td>
<td>Boost + Flyback</td>
<td>NCL30030</td>
<td>HV JFET</td>
<td></td>
<td></td>
<td></td>
<td>CRM+QR</td>
<td>SOIC-16 NB</td>
<td>Pstdby &lt;0.3 W</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FL7921</td>
<td>HV JFET</td>
<td></td>
<td></td>
<td></td>
<td>CRM+QR</td>
<td>SOIC-16L NB</td>
<td>THD &lt;10%</td>
</tr>
<tr>
<td>Gate Driver</td>
<td>Low Side</td>
<td>FL3100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SOT-23</td>
<td>Easy PWM dimming interface</td>
</tr>
<tr>
<td></td>
<td>High Side Only</td>
<td>FAN73611</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SOIC-8</td>
<td>600 V floating switch driver</td>
</tr>
<tr>
<td></td>
<td>Half Bridge</td>
<td>FAN7380/2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SOIC-8</td>
<td>600 V half bridge gate driver</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FL73282</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SOIC-8</td>
<td>900 V half bridge gate driver</td>
</tr>
<tr>
<td>Phase-Cut Dimmer</td>
<td>Back to Back</td>
<td>FL5150</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SOIC-10L NB</td>
<td>Self bias universal phase-cut dimmer control</td>
</tr>
<tr>
<td>Control</td>
<td>AC Switches</td>
<td>FL5160</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SOIC-10L NB</td>
<td>Self bias universal phase-cut dimmer control</td>
</tr>
</tbody>
</table>

Direct AC LED Driver Solution

NCL30170 Power Scalable Direct AC LED Controller

Features

- Accurate LED CC regulation: <±1%
- Workable for constant power regulation
- Selectable LED channel counts
- High PF & low THD : >0.99 / <10%
- Proprietary active PC dimmer control technology
- Wide analog dimming range: 5~100%
- HV startup current source

Benefits

- Excellent light uniformity
- High design flexibility
- Easy power scalability 5~300 W
- Overpass global standard
- Excellent phase-cut dimmer compatibility
- Flexible smart lighting design
- Fast start up & low eBOM

Other Features

- Protections
  - Input Over Voltage Protection
  - RCS Short Protection
  - Thermal Shutdown

Market & Applications

- LED Light - PAR, Down, Tube, Flat, Ceiling, Flood, High Bay, Street light
  - Non-Dimming, Phase-Cut Dimming
  - Analog Dimming (0-10)

Ordering and Package Information

<table>
<thead>
<tr>
<th>Device</th>
<th>Features</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCL30170A</td>
<td>VDIM: 0 - 3 V</td>
<td>SOIC-10</td>
</tr>
<tr>
<td>NCL30170B</td>
<td>VDIM: 0 - 1.5 V</td>
<td>SOIC-10</td>
</tr>
</tbody>
</table>
Non-Isolated Step-up Phase-Cut Dimmable Solution

NCL30167 PFC Boost Switching Regulator for Phase-Cut Dimming LED Lighting Driver
NCL30095 PFC Boost Switching Regulator Switcher for Phase-Cut Dimming LED Retrofit

Features
- Cascade architecture
- Integrated ZCD detection
- Direct phase angle detection monitoring
- NTC based thermal foldback
- Internal 400 V MOSFET (only NCL30095)

Other Features
- Near-unity power factor
- Crm constant on-time control architecture
- Accurate current regulation ±2% typical
- Cycle-by-cycle current limiting
- Open LED string protection
- Shorted winding protection
- Vcc overvoltage protection
- −40 to +125°C operation

Benefits
- Fast start up & self bias without Vdd supply circuit
- No auxiliary winding needed
- SSL7A compliant
- Extends product lifetime
- Low BOM counts

Market & Applications
- Phase-Cut Dimming LED driver
- Phase-Cut Dimming LED retrofit

Ordering and Package Information

<table>
<thead>
<tr>
<th>Device</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCL30167</td>
<td>SOIC-10</td>
</tr>
<tr>
<td>NCL30095</td>
<td>SOIC-14</td>
</tr>
</tbody>
</table>
Energy Efficient Innovations

Step-Down Phase-Cut Dimmable Solution

FL7734 Universal Input Phase-Cut Dimming Single Stage PSR Controller

Features
- Universal Input \( \Phi \)-cut dimmable
- Controllable I\textsubscript{IN} minimum
- Controllable dimming curve
- \(<\pm 1\%\) line regulation PSR control
- RCS short and open protection

Benefits
- Universal input design
- Meets SSL7A & ENERGY STAR®
- Good light uniformity and low BOM
- High system reliability

Other Features
- High PF, Low THD : >0.9/<20
- Fast < 0.3 s start-up (@ Small phase angle)
- LED Short Protection (SCP)
- LED Open Protection (OVP-VS, OVP-VDD)
- Output Diode Short Protection (OCP)
- Over Temperature Protection (TSD)

Market & Applications
- Phase-Cut Dimming LED Light
  - A19, PAR30/38, Down Light
  - Indoor Flat, Ceiling light

Ordering and Package Information

<table>
<thead>
<tr>
<th>Device</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>FL7734MX</td>
<td>SOIC-16</td>
</tr>
</tbody>
</table>

8 ~ 60 W Universal Input Drivers

Evaluation Boards and Design Tools Available
Step Dimming Driver with Mechanical Wall Switch

NCL30185 Step Dimmable QR PSR Current Mode Controller for LED Lighting

Features

- Precise current regulation accuracy (±2% typical)
- Quasi-resonant control
- Adjustable thermal foldback
- 3 step dimmable (70/25/5%)
- Programmable OVP

Other Features

- Current control insensitive to normal transformer variation
- Wide Vcc range (9.4-26 Vdc) to support extend VF range
- Output diode and shorted winding protection
- Cycle-by-cycle current limiting
- Open LED and shorted output protection
- Built-in Vcc overvoltage protection
- 12 V nominal gate drive clamp
- -40 to +125°C operation

Market & Applications

- LED bulbs and tubes
- LED drivers
- LED luminaires

Benefits

- Avoids over specifying LEDs to achieve lumen output
- Higher efficiency
- Improved driver reliability
- Dimming with conventional on/off wall switch
- User can set over voltage protection level

Ordering and Package Information

<table>
<thead>
<tr>
<th>Device</th>
<th>Protections</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCL30185A</td>
<td>Latched Fault</td>
<td>SOIC-8</td>
</tr>
<tr>
<td>NCL30185B</td>
<td>Auto Recoverable</td>
<td>SOIC-8</td>
</tr>
</tbody>
</table>

Evaluation Boards and Design Tools Available
Analog Dimming Single Stage Solution

NCL30186 QR PSR Current Mode Controller for LED Lighting with Smart Analog/Dimming Capability

### Features
- Precise current regulation accuracy (±2% typical)
- Quasi-resonant control
- Adjustable thermal foldback
- Analog or PWM dimming
- Wide Vcc range

### Other Features
- Current control insensitive to normal transformer variation
- Wide Vcc range (9.4-26 Vdc) to support extend VF range
- Output diode and shorted winding protection
- Cycle-by-cycle current limiting
- Open LED and shorted output protection
- Vcc overvoltage protection
- 12 V nominal gate drive clamp
- –40 to +125°C operation

### Market & Applications
- Non-Phase-Cut Dimming LED Lighting
  - A19, PAR30/38, Down Light
  - Indoor Flat, Ceiling light

### Benefits
- Avoids over specifying LEDs to achieve lumen output
- Higher efficiency
- Improved driver reliability
- Supports smart lighting
- Supports wide LED forward voltage range

### Ordering and Package Information

<table>
<thead>
<tr>
<th>Device</th>
<th>Protections</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCL30186A</td>
<td>Latched Fault</td>
<td>SOIC-8</td>
</tr>
<tr>
<td>NCL30186B</td>
<td>Auto Recoverable</td>
<td>SOIC-8</td>
</tr>
</tbody>
</table>

8 W Smart Light Driver
60 W 0-10 Dimming Driver

Evaluation Boards and Design Tools Available
Analog Dimming Single Stage Solution

NCL30386 HV CC/CV PFC PSR PWM Controller for LED Lighting with Analog/PWM Dimming Capability

Features

• Precise current regulation accuracy (±2% typical)
• Precise voltage regulation accuracy (±2% typical)
• Integrated HV startup current source
• Analog and PWM signal input for analog dimming

Other Features

• High PF (>0.95) and Low THD (<10%) at universal input
• Wide VCC range (9.2 - 26 VDC) to support extend Vf range
• Dynamic Self Supply for wide operation range
• Quasi-resonant control for high efficiency
• Abundant protections – brown-out, OVP, RCS-, Output-, Diode-, Winding- short Protection & TSD

Market & Applications

• Non-Phase-Cut Dimming LED Lighting
  • A19, PAR30/38, Down Light
  • Indoor Flat, Ceiling light

Benefits

• Avoids over specifying LEDs to achieve lumen output
• Stable startup at cold temperature
• Fast startup & low standby power
• Precise CC control at dimming condition
• Wide dimming operation range
• Selectable dimming curve – linear & quadratic

Ordering and Package Information

<table>
<thead>
<tr>
<th>Device</th>
<th>Features</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCL30386A1</td>
<td>DSS-ON</td>
<td>SOIC-10</td>
</tr>
<tr>
<td>NCL30386B1</td>
<td>DSS-OFF</td>
<td>SOIC-10</td>
</tr>
</tbody>
</table>

Evaluation Boards Available

60 W 0-10/PWM Dimming Driver
Analog Dimming Single Stage Solution

NCL30388 HV CC/CV PFC PSR PWM Controller for LED Lighting

Features
- Precise current regulation accuracy (±2% typical)
- Precise voltage regulation accuracy (±2% typical)
- Integrated HV startup current source
- High PF (>0.95) and low THD (<10%) at universal input

Other Features
- Wide VCC range (9.2 - 26 Vdc) to support extend Vf range
- Dynamic Self Supply for wide operation range
- Quasi-resonant control for high efficiency
- Abundant protections – brown-Out, OVP, RCS-, Ouput-, Diode-, Winding- short Protection & TSD

Market & Applications
- Non-Phase-Cut Dimming LED Lighting
- A19, PAR30/38, Down Light
- Indoor Flat, Ceiling light

Benefits
- Avoids over specifying LEDs to achieve lumen output
- Stable startup at cold temperature
- Fast startup & Low standby power
- Easy to overpass global standard

Ordering and Package Information

<table>
<thead>
<tr>
<th>Device</th>
<th>Features</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCL30388A1</td>
<td>DSS-ON</td>
<td>SOIC-10</td>
</tr>
<tr>
<td>NCL30388B1</td>
<td>DSS-OFF</td>
<td>SOIC-10</td>
</tr>
</tbody>
</table>

Evaluation Boards Available

60 W LED Lighting Driver
Low Profile Light Engine CC Solution

NCL30288 Power Factor Corrected Primary Side Controller

Features
- Precise current regulation accuracy (±3% typical)
- Quasi-resonant control
- Active Power Factor Correction
- Robust protection suite
- Universal mains (90-305 V)
- <22 BOM components

Other Features
- <10% THD @ 230 Vac
- <500 ms Start Up Time
- Output Ripple <40% Pk to Pk
- Dual OVP protection
- No optocoupler needed for isolated topology
- Wide Vcc range (9.4-26 Vdc) to support extend VF range
- –40 to +125°C operation

Benefits
- Avoids over specifying LEDs to achieve lumen output
- Higher efficiency
- Exceeds global power quality standards for lighting
- Eases safety testing
- Wide operating coverage
- Low profile design

Market & Applications
- Non Dimming LED light
- Non-Phase-Cut Dimming LED lighting

Ordering and Package Information

<table>
<thead>
<tr>
<th>Device</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCL30288BSN</td>
<td>TSOP-6</td>
</tr>
</tbody>
</table>

Non-isolated buck-boost topology can also be supported

20 WT Lamp Driver

Evaluation Boards and Design Tools Available
PFC+QR PWM Combo Solution for General Light Engine

FL7921 Voltage Mode CRM PFC+QR PWM Combo

Features
- HV start up
- THD optimizer
- Over power compensation

Benefits
- Fast start up
- High PF/low THD
- Wide input/output operating range

Other Features
- PFC function always ON regardless of PWM load condition for high PF at light load
- Internal minimum tOFF 8 µs for QR PWM stage
- Internal 9.5 ms Soft-Start time for PWM
- Brown-out protection
- Auto-recovery OCP, OLP, OTP & OVP
- Adjustable OTP with external NTC through RT pin

Market & Applications
- Non Dimming LED light driver
- Analog Dimming LED light driver

Ordering and Package Information

<table>
<thead>
<tr>
<th>Device</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>FL7921RMX</td>
<td>SOIC-16</td>
</tr>
</tbody>
</table>

Evaluation Boards and Design Tools Available

100 W Analog Dimmable Driver
PFC+QR PWM Combo Solution for General Light Engine

*NCL30030 Current Mode CRM PFC+QR PWM Combo IC*

**Features**
- Multiplier
- Digital boost follower
- Programmable thermal shutdown

**Benefits**
- Improved THD performance
- Improved efficiency for wide mains applications
- Protects supply from overheating

**Other Features**
- High voltage pin for fast startup time and line sensing
- 4 ms Soft-Start timer
- Feed-forward for improved operation across line/load
- PFC off control for smart lighting applications
- -40 to +125°C for outdoor lighting applications

**Market & Applications**
- Non Dimming LED light driver
- Analog Dimming Dimming LED light driver

**Ordering and Package Information**

<table>
<thead>
<tr>
<th>Device</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCL30130B1</td>
<td>SOIC-16</td>
</tr>
<tr>
<td>NCL30130B2</td>
<td>SOIC-16</td>
</tr>
<tr>
<td>NCL30130B3</td>
<td>SOIC-16</td>
</tr>
</tbody>
</table>

**Evaluation Boards and Design Tools Available**

150 W Analog/PWM Dimmable Driver
PFC Boost Controller Solution

NCL2801 Ultra-low THD Current Mode CrM PFC Controller

Features
- Valley count frequency foldback
- Dynamic response enhancer
- Soft/fast OVP
- THD enhancer
- Line level feed-forward
- Protections
  - Brown Out
  - Thermal Shutdown
  - OVP
  - Over Current limitation
  - Pin open/short protection

Benefits
- Maximize efficiency over wide load range
- Lower output undershoot
- Lower output overshoot
- Improve THD performance
- Optimal loop gain in universal input
- High system reliability

Other Features
- Wide Vcc (10.5 ~ 28 V) range/ 3 Vcc startup level
- Trans-conductance error amp (OTA)
- High drive capability: +500/-800 mA

Market & Applications
- Analog/PWM Dimmable LED Drivers
- PFC front end supplies requiring excellent THDi

Ordering and Package Information

<table>
<thead>
<tr>
<th>Device</th>
<th>Soft OVP (%)</th>
<th>Fast OVP (%)</th>
<th>Vcc Start (V)</th>
<th>DRE (After Start)</th>
<th>DRE (Before Start)</th>
<th>Brown Out</th>
<th>Line Range Detect</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCL2801CDA</td>
<td>✔</td>
<td>107</td>
<td>12.5</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>SOIC-8</td>
</tr>
<tr>
<td>NCL2801CDB</td>
<td>✔</td>
<td>107</td>
<td>12.5</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>SOIC-8</td>
</tr>
<tr>
<td>NCL2801CFA</td>
<td>✔</td>
<td>107</td>
<td>10.5</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>SOIC-8</td>
</tr>
</tbody>
</table>

200 W Boost PFC Driver
High Efficiency LCC Half Bridge Solution for Ultra Wide Output Driving

NCL30059 High Voltage Half-Bridge Controller for LED Lighting Application

Features
- Minimum frequency adjust accuracy 3%
- Brown-out input
- 100 ms PFC delay timer

Other Features
- Wide operating frequency range: 25 kHz ~ 250 kHz
- Adjustable brown out protection
- Low start up current of 50 µA
- Latched input
- Thermal shut down function

Market & Applications
- High power in/out door light
- Flood light
- Street light

Benefits
- Keeps operation in the right region & simplifies design
- Simple PFC association, design flexibility
- Allows PFC out voltage to stabilize before device operation

Evaluation Board Highlights
- 90 – 277 VAC Input, 0-50 VDC Output
- >0.95 PF, <20% THD @ Universal Input
- >90% Total Efficiency
- <±2% precise CC tolerance

Ordering and Package Information

<table>
<thead>
<tr>
<th>Device</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCL30059B</td>
<td>SOIC-8</td>
</tr>
</tbody>
</table>

Under preparing 100 W low BOM PFC+LCC half bridge driver
Smart Lighting Luminaries Light Engine Solution

*FL7740* – Single Stage CV PSR PWM + *FL7760* – Wide ADIM Buck PWM

**FL7740 Features**
- Wide input voltage range (80 ~ 382 V\textsubscript{AC})
- <200 ms start up time with integrated HV startup JFET
- CV tolerance (avg.): <±2 %
- CV overshoot and undershoot under transient: <±10 %
- $P_{\text{Standby}}$: <0.15 W @ no load, <0.3 W @ 10 mA I\textsubscript{OUTMCU}<$0.4$ W @ 20 mA I\textsubscript{OUTMCU}
- Selectable PF optimizer
  - Without PF optimizer (PF/THD)
    >0.9/<10% @ full load & universal input
    >0.8/<10% @ half load & universal input
  - With PF optimizer
    >0.9/<10% @ full load & universal input
    >0.9/<20% @ half load & universal input

**FL7760 Features**
- Wide input range (8 ~ 70 V\textsubscript{DC})
- Constant current mode operation
- Hysteresis control with fixed reference
- Wide dimming range
  - Analog dimming: 5 ~ 100 %
  - PWM dimming: 1 ~ 100% (@ 2 kHz)
- High switching frequency up to 1 MHz
- High source/sink current of 1.5 A/2.5 A
- Cycle-by-cycle current limit
- Low operating current (150 $\mu$A)
- Thermal shutdown
- Over current protection
- Small outline package (SOT-23-6L)

**Ordering and Package Information**

<table>
<thead>
<tr>
<th>Device</th>
<th>Features</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>FL7740MX</td>
<td></td>
<td>SOIC-10</td>
</tr>
<tr>
<td>FL7760AM6X</td>
<td>Quadratic Dim.</td>
<td>SSOT-6</td>
</tr>
<tr>
<td>FL7760BM6X</td>
<td>Linear Dim</td>
<td>SSOT-6</td>
</tr>
</tbody>
</table>

**Evaluation Board & Design Tools available**
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.

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

Ambient Light Sensors and PIR (Passive Infrared) Detectors such as the NCS36000 can also be used to control the light output of street lighting.
### PLC Modems/Power Line Driver

<table>
<thead>
<tr>
<th>Device</th>
<th>Function</th>
<th>Features</th>
<th>Package(s)</th>
</tr>
</thead>
</table>
| NCN49599 | PLC S-FSK Modem; A - D Band | • ARM Cortex M0  
• Baud rate: 4800 Bauds  
• S-FSK modulation  
• Hardware embedded MAC + PHY  
• Embedded 1.2 A, 2-stage power amplifier with current limitation and thermal protection | QFN-56 |
| NCN49597 | PLC S-FSK Modem; A - D Band | • ARM Cortex M0  
• Baud rate: 4800 Bauds  
• S-FSK modulation  
• Hardware embedded MAC + PHY | QFN-52 |
| AMIS49587 | PLC S-FSK Modem; A & B Band | • ARM7TDMI, 24 MHz core  
• Baud rate: 2400 Bauds  
• S-FSK modulation  
• Hardware embedded MAC + PHY | QFN-52 |
| NCS5651 | Power Line Driver; Class AB | • Low distortion power line driver with optimized interface for PLC modems  
• Capability to drive 2.0 A peak into reactive loads  
• Current shutdown minimizes power consumption during power down state  
• Rail-to-Rail Drop of Only ±1 V with Iout = 1.5 A | QFN-20 EP |
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 – wired or wireless – to the 9600 Baud KNX twisted pair (TP) bus inside a building

---

**RF**

<table>
<thead>
<tr>
<th>Multi/Ready</th>
<th>AX8052F143</th>
</tr>
</thead>
<tbody>
<tr>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>

**Twisted Pair**

<table>
<thead>
<tr>
<th></th>
<th>NCNS121</th>
<th>NCNS110</th>
<th>NCNS130</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency Increase</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>10/20 mA Bus Current Consumption</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>5 to 40 mA Bus Current Consumption</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>KNX Bus Current Limitation</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>PHY + MAC Layer (TPUART Compatible)</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>PHY Layer (Analog Only)</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>3.3 V Fixed DC/DC</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Adjustable DC/DC</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>20 V LDO</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Analog Monitor Output</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>
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
### Power-Over-Ethernet (PoE) Controllers

**Features – NCP1083**

NCP1083, consisting of fully compliant PoE functionality and DC-DC controller, may be used to drive LED lamps. Additionally, lamps may be controlled remotely through PoE.

- Emits white color of ~2700°K
- LED lamp overall maximum power output 33 W
- Peak efficiency ~89%
- LED lamp powered by PSE directly over NCP1083 load switch circuitry; DC-DC controller can provide 3.3 V, 5 V or 15 V power supply
- Delivers 25.5 W for PoE+ IEEE 802.3at and up to 40 W in proprietary applications
- Supports IEEE two event classification
- Best-in-class cable ESD and thermal characteristics

### IEEE 802.3at + Auxiliary, 40 W

- Auxiliary input voltage range from 9.0 V to 57 V
- Integrated DC-DC converter controller implements highly efficient power conversion at low output voltages in conjunction with auxiliary voltage input
- LED drivers operate in buck operation mode, switching frequency about 1.05 MHz, PWM dimming frequency 16 kHz
- DC-DC controller working frequency up to 500 kHz, fly-back topology used
- Under-voltage startup level set to 38 V, or programmable down to 8.5 V; current limit 970 mA

### NCP1083

- Emits white color of ~2700°K
- LED lamp overall maximum power output 33 W
- Peak efficiency ~89%
- LED lamp powered by PSE directly over NCP1083 load switch circuitry; DC-DC controller can provide 3.3 V, 5 V or 15 V power supply
- Delivers 25.5 W for PoE+ IEEE 802.3at and up to 40 W in proprietary applications
- Supports IEEE two event classification
- Best-in-class cable ESD and thermal characteristics

<table>
<thead>
<tr>
<th>Device</th>
<th>Description</th>
<th>Topology</th>
<th>Control Mode</th>
<th>VCC Min (V)</th>
<th>VCC Max (V)</th>
<th>PD Typ (W)</th>
<th>Ron Typ (Ω)</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCP1080</td>
<td>PoE-PD Controller and DC-DC Converter</td>
<td>Flyback</td>
<td>Current</td>
<td>0</td>
<td>57</td>
<td>15</td>
<td>0.6</td>
<td>TSSOP-20</td>
</tr>
<tr>
<td>NCP1081</td>
<td>PoE-PD Controller and DC-DC Converter</td>
<td>Flyback</td>
<td>Current</td>
<td>0</td>
<td>57</td>
<td>40</td>
<td>0.6</td>
<td>TSSOP-20</td>
</tr>
<tr>
<td>NCP1082</td>
<td>PoE-PD Controller and DC-DC Converter, with Auxiliary Supply Support</td>
<td>Flyback</td>
<td>Current</td>
<td>0</td>
<td>57</td>
<td>15</td>
<td>0.6</td>
<td>TSSOP-20</td>
</tr>
<tr>
<td>NCP1083</td>
<td>PoE-PD Controller and DC-DC Converter, with Auxiliary Supply Support</td>
<td>Flyback</td>
<td>Current</td>
<td>0</td>
<td>57</td>
<td>40</td>
<td>0.6</td>
<td>TSSOP-20</td>
</tr>
<tr>
<td>NCP1090</td>
<td>PoE-PD Interface Controller</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>57</td>
<td>15</td>
<td>0.5</td>
<td>SOIC-8, TSSOP-8</td>
</tr>
<tr>
<td>NCP1091</td>
<td>PoE-PD Interface Controller with Programmable UVLO</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>57</td>
<td>15</td>
<td>0.5</td>
<td>SOIC-8, TSSOP-8</td>
</tr>
<tr>
<td>NCP1092</td>
<td>PoE-PD Interface Controller with Vaux Support</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>57</td>
<td>15</td>
<td>0.5</td>
<td>SOIC-8, TSSOP-8</td>
</tr>
<tr>
<td>NCP1093</td>
<td>PoE-PD Interface Controller</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>57</td>
<td>25</td>
<td>0.5</td>
<td>DFN-10</td>
</tr>
<tr>
<td>NCP1094</td>
<td>PoE-PD Interface Controller with Vaux Support</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>57</td>
<td>25</td>
<td>0.5</td>
<td>DFN-10</td>
</tr>
</tbody>
</table>
Energy Efficient Innovations

Serial NOR Flash for Smart LED Lighting

Smart LED systems require NOR Flash for over-the-air firmware updates, in order to minimize risks from disconnection.

Features

- Faster data rewrite (Sector Erase/Page Program)
- Lower power consumption with efficient rewrite operation
- 20-year data retention with no data deterioration
- Consistent Sector Erase operation time (tSE) over device lifetime
- Industry’s fastest WRITE performance minimizes system risk during field firmware upgrades

Smart LED Block Diagram

<table>
<thead>
<tr>
<th>Device</th>
<th>Density</th>
<th>Power Supply (V)</th>
<th>Sector Erase Time (ms)</th>
<th>Page Program Time (ms)</th>
<th>Read/Write Current (mA)</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>LE25S20</td>
<td>2 Mb</td>
<td>1.65 - 1.95</td>
<td>80</td>
<td>3</td>
<td>6 Read; 15 Write</td>
<td>SOIC-8, VSOIC-8</td>
</tr>
<tr>
<td>LE25U20A</td>
<td>2 Mb</td>
<td>2.3 - 3.6</td>
<td>80</td>
<td>4</td>
<td>6 Read; 15 Write</td>
<td>SOIC-8, VSOIC-8, WDFN-8</td>
</tr>
<tr>
<td>LE25U40C</td>
<td>4 Mb</td>
<td>2.3 - 3.6</td>
<td>80</td>
<td>4</td>
<td>6 Read; 15 Write</td>
<td>SOIC-8, VSON-8, VDFN-8</td>
</tr>
<tr>
<td>LE25S40</td>
<td>4 Mb</td>
<td>1.65 - 1.95</td>
<td>80</td>
<td>6</td>
<td>6 Read; 15 Write</td>
<td>SOIC-8, VSOIC-8, VDFN-8, VSON-8</td>
</tr>
<tr>
<td>LE25W81</td>
<td>8 Mb</td>
<td>2.45 - 3.6</td>
<td>100</td>
<td>0.3</td>
<td>6 Read; 15 Write</td>
<td>VSON-8, VDFN-8</td>
</tr>
<tr>
<td>LE25S81A</td>
<td>8 Mb</td>
<td>1.65 - 1.95</td>
<td>15</td>
<td>0.3</td>
<td>5 Read; 4.5 Erase</td>
<td>SOIC-8, VSOIC-8</td>
</tr>
<tr>
<td>LE25S161</td>
<td>16 Mb</td>
<td>1.65 - 1.95</td>
<td>15</td>
<td>0.4</td>
<td>4.5 Read; 4.5 Erase</td>
<td>SOIC-8, VSOIC-8, UDFN-8, WLCSP-8</td>
</tr>
</tbody>
</table>

Smart LED Block Diagram
A typical solid-state lighting application contains strings of LEDs. Without LED shunts in place, an open circuit failure will cause an entire string of LEDs to go dark. Many applications require high reliability in order to prevent costly early replacement or safety hazards. LED shunts ensure that despite an LED failure, the remainder of the string stays lit. When all LEDs are functioning the low leakage of an LED shunt ensures that it consumes very little power. Once an LED fails the shunt allows current to flow around the failed LED in a matter of nanoseconds. Their current range and tight voltage specifications ensure that ON Semiconductor LED shunts are compatible with all LED drivers.

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

**Features**
- High ON-state current capability
- Low off-state leakage
- Low and repeatable response time

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

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

<table>
<thead>
<tr>
<th>Device</th>
<th>Current Range @ $T_a = 25^\circ C$ (mA)</th>
<th>Minimum Breakdown Voltage (V)</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUD4700</td>
<td>70 to 1300</td>
<td>5.5</td>
<td>POWERMITE®</td>
</tr>
<tr>
<td>HBL5006</td>
<td>50 to 350</td>
<td>6.2</td>
<td>SOD-323, SOD-523, SOD-923</td>
</tr>
<tr>
<td>HBL1015</td>
<td>140 to 500</td>
<td>8.0</td>
<td>TSOP-5</td>
</tr>
<tr>
<td>HBL1025</td>
<td>140 to 500</td>
<td>11.5</td>
<td>TSOP-5</td>
</tr>
</tbody>
</table>

**HBL1015 and HBL1025 Shunts for Multiple LEDs**
Power Over Ethernet (POE) Surge and ESD Protection

Protects Networks Against ESD and Line Surge Events

Advantages
- 24 A IEC 61000-4-2 Surge protection
- 30 kV IEC 61000-4-5 ESD protection
- Supports 802.3at Type 2 “PoE+”

Benefits
- Flexible design
- Space saving SOIC-8 package

POE Protector

<table>
<thead>
<tr>
<th>Device</th>
<th>Function</th>
<th>Vdc (V)</th>
<th>Clamp Voltage @ 24 A (V)</th>
<th>Surge Ipp 8/20 (μs)</th>
<th>ESD Contact/Air (kV)</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSP5804*</td>
<td>Protector</td>
<td>58</td>
<td>&lt;80</td>
<td>50</td>
<td>&gt;30</td>
<td>SOIC-8</td>
</tr>
<tr>
<td>DF10S2</td>
<td>Full Bridge</td>
<td>70</td>
<td>&gt;1000</td>
<td>85</td>
<td>Protected by NSP5804</td>
<td>PDIP-4 GW</td>
</tr>
</tbody>
</table>

* Pending 3Q19
ON Semiconductor Technical Support
www.onsemi.com/support

For a comprehensive listing of ON Semiconductor Sales Offices, Distributors, and Rep Firms, please visit:

AMERICAS REP FIRMS

Alabama  Huntsville  e-Components  (256) 533-2444
Brazil  Countrywide  Ammon & Rizos  (+55) 11-4688-1960
California  Bay Area  Electec  (408) 496-0760
Canada  Eastern Canada  Astec  (905) 607-1444
Connecticut  Statewide  Paragon Electronic Systems  (603) 645-7630
Florida  Statewide  e-Components  (888) 468-2444
Georgia  Atlanta  e-Components  (888) 468-2444
Illinois  Statewide  Matrix – Design Technology  (952) 400-1070
Indiana  Fishers  Bear VAI  (317) 570-0707
Iowa  Statewide  Matrix – Design Technology  (319) 362-6824
Maine  Statewide  Paragon Electronic Systems  (603) 645-7630
Maryland  Columbia  Mechtronics Sales  (410) 309-9600
Massachusetts  Statewide  Paragon Electronic Systems  (603) 645-7630
Mexico  Countrywide  Ammon & Rizos  (+55) 11-4688-1960
Minnesota  Eden Prairie  Matrix – Design Technology  (952) 400-1070
Missouri  Belton  Matrix – Design Technology  (816) 589-2308
Nebraska  Statewide  Matrix – Design Technology  (816) 589-2308
New Hampshire  Statewide  Paragon Electronic Systems  (603) 645-7630
New Jersey  Statewide  S.J. Metro  (916) 942-3232
New York  Binghamton  TriTech – Full Line Rep  (607) 722-3580
North Carolina  Raleigh  e-Components  (888) 468-2444
North Dakota  Statewide  Matrix – Design Technology  (952) 400-1070
Ohio  Brecksville  Bear VAI Technology  (440) 526-1991
Puerto Rico  Countrywide  e-Components  (888) 468-2444
Rhode Island  Statewide  Paragon Electronic Systems  (603) 645-7630
South Dakota  Statewide  Matrix – Design Technology  (952) 400-1070
Vermont  Statewide  Paragon Electronic Systems  (802) 645-7630
Wisconsin  Statewide  Matrix – Design Technology  (952) 400-1070

Sales and Design Assistance from ON Semiconductor

ON Semiconductor Distribution Partners

Allied Electronics  www.alliedelec.com  (800) 433-5700
ALTIMA Company, Mactron, Inc.  www.alt.mactron.co.jp/about/english.html  (81) 45 476 2155
Arrow Electronics  www.arrow.com  (800) 777 2776
Avnet  www.avnet.com  (800) 332-8638
Daisy Distribution Ltd.  www.daisyh.com  (852) 2341 3355
Digi-Key  www.digikey.com  (800) 344-4539
EBV Elektronik  www.ebv.com/en/locations.html  (49) 8121 774-0
Future & F&I Electronics  www.futureelectroics.com/contact  1-800-FUTURE1  (388-8731)
Mouser Electronics  www.mouser.com  (800) 346 6873
Narayen & Farrell  www.nfarrel.com/onsemi  (800) 4-NEWARK
GS Electronics Co., Ltd.  www.gselectron.com  Japanese: (81) 3 3255 5985
Promote Electronic Co.  www.promote.com.tw  (886) 2 2659 0303
Raydon Corporation  www.raydon.com.cn  (81) 3 5396 6310
Ryson Company Limited  www.ryson.co.jp/eng  (81) 3 3862 2635
RS Components  www.rs-components.com  (44) 153 644 4414
Segway Belizean Co.  www.belizestone.com  (82) 2 3218 1511
Serial Microelectronics, HK  www.serialos.com.hk  (852) 2790 8220
World Peace Industries Co.  www.wpi-group.com  (852) 2365 4860
WT Microelectronics Co.  www.wtmecc.com  (852) 2950 0820
Yunson Electronics  www.yunson.com.tw  (886) 2 2659 8368

ON Semiconductor and the ON Semiconductor logo are trademarks of Semiconductor Components Industries, LLC (SCICLLC) or its subsidiaries in the United States and/or other countries. Any reference to these ON Semiconductor trademarks and/or names is for identification purposes only and does not constitute an intent to license such trademarks and/or names. Other product names used in this document are trademarks and/or registered trademarks of their respective owners.

PUBLICATION ORDERING INFORMATION

www.onsemi.com/pubs/purchase.html

ON Semiconductor and the ON Semiconductor logo are trademarks of Semiconductor Components Industries, LLC dba ON Semiconductor or its subsidiaries in the United States and/or other countries. Any reference to these ON Semiconductor trademarks and/or names is for identification purposes only and does not constitute an intent to license such trademarks and/or names. Other product names used in this document are trademarks and/or registered trademarks of their respective owners.

ON Semiconductor Sales and Design Assistance Phone: 421 33 790 2910

For additional information, please contact your local Sales Representative.

www.onsemi.com/support