Design Note – DN06001/D

ON Semiconductor

9 V to 36 Vin dc, Constant Current LED Driver

<table>
<thead>
<tr>
<th>Device</th>
<th>Application</th>
<th>Input Voltage</th>
<th>Output Power</th>
<th>Topology</th>
<th>I/O Isolation</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCP3063</td>
<td>DC-DC Constant Current LED Driver</td>
<td>9 Vdc to 36 Vdc</td>
<td>10 W</td>
<td>Non Inverting Buck Boost</td>
<td>None</td>
</tr>
</tbody>
</table>

**Circuit Description**

ON Semiconductor’s latest monolithic NCP3063 control circuit and family of e2PowerEdge bipolar transistors are combined to create a non inverting buck boost topology optimized to drive strings of LED’s at a constant current. A high side, low drop, current sensing scheme has been implemented, targeted for automotive and other high efficiency applications. The output from the current sense is used to vary the slope of the oscillator ramp and achieve duty cycle modulation, independent of the gated oscillator function provided on the IC.

**Key Features**

- Seamless buck or boost operation
- Constant current output with voltage clamp
- Low drop high side current sensing
- Baker clamp drive on external transistor for enhanced efficiency
- High frequency operation to enable cost effective magnetic and capacitive (e.g. MLCC) filter components
- Minimal ripple current through LED string

**Other Specifications**

<table>
<thead>
<tr>
<th>Output 1</th>
<th>Output 2</th>
<th>Output 3</th>
<th>Output 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Voltage</td>
<td>12 Vdc</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Ripple</td>
<td>200 mV</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Max Current</td>
<td>1 A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

- PFC (Yes/No): No
- Minimum Efficiency: 70%
- Cooling Method/Supply Orientation: Convection

September 2006, Rev. 1
www.onsemi.com
Design Notes

For low ripple current assume CCM operation. Switches Q1 and Q2 turn on for time D*Ts (D duty cycle, Ts switching period) charging inductor L1 from input Vin. When Q1 and Q2 turn off, diodes D1 and D2 deliver inductor energy to output Vout.

For the inductor flux (volt microsecond) to remain in equilibrium after each switching cycle, Vin*D*Ts must equal Vout*(1-D)*Ts, neglecting circuit losses. Hence voltage gain of buck boost is given by Vout = Vin*D/(1-D). When D=0.5, Vout = Vin.

Ripple current in inductor obtained from expression \( \Delta I(L1) = \frac{Vin*D*Ts}{L1}. \)

A value for L1 of 150 \( \mu \)H will maintain a +/-15% ripple current in a 700 mA application (3 watt LED’s) assuming Vin =12 V and 200 kHz operation (D*Ts = 0.5*5 \( \mu \)s).

The base current for Q1 and Q2 is determined by Vin/R3. (100:1 base drive good starting point but remember to include Vbe/R2 contribution). Q1 and Q2 are turned off passively via base resistors R2 and R4. To improve switch off times, switch Q2 may be held out of saturation by the Baker clamp created by diodes D3a and D3b. Several points of efficiency improvement may be achieved using this technique. Low drop current sensing is achieved across current sense resistor R8.

The constant output current is determined from the equation \( Io*R8 = \frac{(Vbe(Q3a)/R6)*R7}{Vo/R9 = 2*Vbe(Q3a)/R6}. \) Vclamp equals Vz(D4) + 1.25 V. Alternatively, if D4 is replaced with a resistor R11 then Vclamp = (1+R11/R1)*1.25 volts.
Converter Waveforms

Boost Mode from 8 Vin to 16 Vout

Buck Mode from 16 Vin to 8 Vout
Efficiency data of Buck-Boost converter between 8 Vin dc and 26 Vin dc driving LED strings at 350 mA and 700 mA

OSTAR4 driven at 350 mA

© 2006 ON Semiconductor.

Disclaimer: ON Semiconductor is providing this design note “AS IS” and does not assume any liability arising from its use; nor does ON Semiconductor convey any license to its or any third party’s intellectual property rights. This document is provided only to assist customers in evaluation of the referenced circuit implementation and the recipient assumes all liability and risk associated with its use, including, but not limited to, compliance with all regulatory standards. ON Semiconductor may change any of its products at any time, without notice.

Design note created by Dennis Solley, e-mail: dennis.solley@onsemi.com