Introduction

The LED7707 LED driver from STMicroelectronics consists of a high-efficiency monolithic boost converter and six controlled current generators (rows), specifically designed to supply LED arrays used in the backlighting of LCD panels. The device can manage an output voltage up to 36 V (i.e. ten white-LEDs per row). The generators can be externally programmed to sink up to 85 mA and can be dimmed via a PWM signal (1% of minimum dimming duty-cycle at 1 kHz can be managed). The device allows detection and management of open and shorted LED faults, and permits unused rows to be left floating. Basic protections (output overvoltage, internal MOSFET overcurrent and thermal shutdown) are provided.
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1 LED7707 main features

1.1 Boost section
- 4.5 V to 36 V input voltage range
- Internal power MOSFET
- Internal +5 V LDO for device supply
- Up to 36 V output voltage
- Constant frequency peak current-mode control
- 250 kHz to 1 MHz adjustable switching frequency
- External sync for multi-device application
- Pulse-skip power saving mode at light load
- Programmable soft-start
- Programmable OVP (overvoltage protection)
- Single ceramic output capacitor
- Non-latched thermal shutdown

1.2 Backlight driver section
- Six rows with 85 mA maximum current capability (adjustable)
- Up to 10 WLEDs per row
- Parallelable rows for higher current
- Row disable option
- Less than 10 μs minimum dimming time
- ±2% current matching between rows
- LED failure (open and short-circuit) detection
2 LED7707 demonstration board

The LED7707 demonstration board has been designed to manage six strings of 8 to 10 white LEDs each. 

Table 1 summarizes the board features and Figure 2 shows the LED7707 demonstration board schematic. The input voltage range is limited to 32 V because of the 35 V rated input capacitor. An extended operating input voltage range (up to 36 V) can be achieved by using a 50 V-rated MLCC.

Table 1. LED7707 performance summary

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum input voltage</td>
<td></td>
<td>6 V</td>
</tr>
<tr>
<td>Maximum input voltage</td>
<td></td>
<td>32 V</td>
</tr>
<tr>
<td>Output voltage</td>
<td>$V_{IN} &lt; V_{BOOST} &lt; 36$ V</td>
<td></td>
</tr>
<tr>
<td>Output OVP threshold</td>
<td>R1=510 kΩ, R2=16 kΩ</td>
<td>38 V</td>
</tr>
<tr>
<td>Internal MOSFET OCP</td>
<td>R7=360 kΩ</td>
<td>3.3 A</td>
</tr>
<tr>
<td>Boost section switching frequency</td>
<td>FSW pin to AVCC</td>
<td>660 kHz</td>
</tr>
<tr>
<td></td>
<td>FSW pin to $R5=330$ kΩ</td>
<td>825 kHz</td>
</tr>
<tr>
<td>Minimum dimming on-time</td>
<td>400 Hz$&lt;$FDIM$&lt;$20 kHz</td>
<td>10 µs</td>
</tr>
<tr>
<td>Output current (each row)</td>
<td>$R6=24$ kΩ</td>
<td>75 mA</td>
</tr>
<tr>
<td>Output current accuracy</td>
<td>±2%</td>
<td></td>
</tr>
<tr>
<td>Efficiency</td>
<td>$V_{IN}=12$ V, $V_{BOOST}=34$ V, $FSW=660$ kHz</td>
<td>91%</td>
</tr>
</tbody>
</table>

Figure 2. LED7707 demonstration board schematic
# Component list

## Table 2. LED7706 demonstration board component list

<table>
<thead>
<tr>
<th>Qty</th>
<th>Component</th>
<th>Description</th>
<th>Package</th>
<th>Part-number</th>
<th>MFR</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C1</td>
<td>Ceramic, 35 V, X5R, 20%</td>
<td>SMD 1210</td>
<td>UMK325BJ106KM-T</td>
<td>Taiyo Yuden</td>
<td>10 µF</td>
</tr>
<tr>
<td>2</td>
<td>C2, C3</td>
<td>Ceramic, 50 V, X7R, 20%</td>
<td>SMD 1206</td>
<td>GRM31CR71H475KA88B</td>
<td>Murata</td>
<td>4.7 µF</td>
</tr>
<tr>
<td>1</td>
<td>C4</td>
<td>Ceramic, 50 V, X7R, 20%</td>
<td>SMD 1206</td>
<td></td>
<td>N.M.</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>C5</td>
<td>Ceramic, 25 V, X5R, 20%</td>
<td>SMD 0603</td>
<td></td>
<td>Standard</td>
<td>1 µF</td>
</tr>
<tr>
<td>1</td>
<td>C6</td>
<td>Ceramic, 25 V, X5R, 20%</td>
<td>SMD 0603</td>
<td></td>
<td>Standard</td>
<td>100 nF</td>
</tr>
<tr>
<td>1</td>
<td>C7</td>
<td>Ceramic, 25 V, X5R, 20%</td>
<td>SMD 0603</td>
<td></td>
<td>Standard</td>
<td>3.3 nF</td>
</tr>
<tr>
<td>1</td>
<td>C8</td>
<td>Ceramic, 25 V, X5R, 20%</td>
<td>SMD 0603</td>
<td></td>
<td>Standard</td>
<td>4.7 nF</td>
</tr>
<tr>
<td>1</td>
<td>C9</td>
<td>Ceramic, 25 V, X5R, 20%</td>
<td>SMD 0603</td>
<td></td>
<td>Standard</td>
<td>N.M.</td>
</tr>
<tr>
<td>1</td>
<td>C10</td>
<td>Ceramic, 25 V, X5R, 20%</td>
<td>SMD 0402</td>
<td></td>
<td>Standard</td>
<td>220 pF</td>
</tr>
<tr>
<td>1</td>
<td>C11</td>
<td>Ceramic, 25 V, X5R, 20%</td>
<td>SMD 0603</td>
<td></td>
<td>Standard</td>
<td>4.7 nF</td>
</tr>
<tr>
<td>1</td>
<td>C12</td>
<td>Ceramic, 25 V, X5R, 20%</td>
<td>SMD 0603</td>
<td></td>
<td>Standard</td>
<td>N.M.</td>
</tr>
<tr>
<td>1</td>
<td>C13</td>
<td>Ceramic, 25 V, X5R, 20%</td>
<td>SMD 0603</td>
<td></td>
<td>Standard</td>
<td>N.M.</td>
</tr>
<tr>
<td>1</td>
<td>R1</td>
<td>Chip resistor, 0.1 W, 1%</td>
<td>SMD 0603</td>
<td></td>
<td>Standard</td>
<td>510 kΩ</td>
</tr>
<tr>
<td>1</td>
<td>R2</td>
<td>Chip resistor, 0.1 W, 1%</td>
<td>SMD 0603</td>
<td></td>
<td>Standard</td>
<td>16 kΩ</td>
</tr>
<tr>
<td>1</td>
<td>R3</td>
<td>Chip resistor, 0.1 W, 1%</td>
<td>SMD 0603</td>
<td></td>
<td>Standard</td>
<td>2.4 kΩ</td>
</tr>
<tr>
<td>1</td>
<td>R4</td>
<td>Chip resistor, 0.1 W, 1%</td>
<td>SMD 0603</td>
<td></td>
<td>Standard</td>
<td>4.7 Ω</td>
</tr>
<tr>
<td>1</td>
<td>R5</td>
<td>Chip resistor, 0.1 W, 1%</td>
<td>SMD 0603</td>
<td></td>
<td>Standard</td>
<td>330 Ω</td>
</tr>
<tr>
<td>1</td>
<td>R6</td>
<td>Chip resistor, 0.1 W, 1%</td>
<td>SMD 0603</td>
<td></td>
<td>Standard</td>
<td>24 kΩ</td>
</tr>
<tr>
<td>1</td>
<td>R7</td>
<td>Chip resistor, 0.1 W, 1%</td>
<td>SMD 0603</td>
<td></td>
<td>Standard</td>
<td>360 kΩ</td>
</tr>
<tr>
<td>1</td>
<td>R8</td>
<td>Chip resistor, 0.1 W, 1%</td>
<td>SMD 0603</td>
<td></td>
<td>Standard</td>
<td>680 kΩ</td>
</tr>
<tr>
<td>2</td>
<td>R9, R10</td>
<td>Chip resistor, 0.1 W, 1%</td>
<td>SMD 0603</td>
<td></td>
<td>Standard</td>
<td>100 kΩ</td>
</tr>
<tr>
<td>1</td>
<td>R11</td>
<td>Chip resistor, 0.1 W, 1%</td>
<td>SMD 0603</td>
<td></td>
<td>Standard</td>
<td>1.2 kΩ</td>
</tr>
<tr>
<td>1</td>
<td>R12</td>
<td>Chip resistor, 0.1 W, 1%</td>
<td>SMD 0603</td>
<td></td>
<td>Standard</td>
<td>N.M.</td>
</tr>
<tr>
<td>1</td>
<td>R13</td>
<td>Chip resistor, 0.1 W, 1%</td>
<td>SMD 0603</td>
<td></td>
<td>Standard</td>
<td>N.M.</td>
</tr>
<tr>
<td>1</td>
<td>L1</td>
<td>68 μH, 75 mH, 5.8 A</td>
<td>7x7mm</td>
<td>XPL7030-682ML</td>
<td>Coilcraft</td>
<td>6.8 μH</td>
</tr>
<tr>
<td>1</td>
<td>D1</td>
<td>Schottky, 40 V, 1 A</td>
<td>DO216-AA</td>
<td>STPS1L40M</td>
<td>ST</td>
<td>STPS1L40M</td>
</tr>
<tr>
<td>1</td>
<td>D2</td>
<td>Red LED, 3 mA</td>
<td>SMD 0603</td>
<td></td>
<td>Standard</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>D3</td>
<td>Signal Schottky</td>
<td>SOD-523</td>
<td>BAS69</td>
<td>ST</td>
<td>N.M.</td>
</tr>
<tr>
<td>1</td>
<td>U1</td>
<td>Integrated circuit</td>
<td>QFN4x4</td>
<td>LED7707</td>
<td>ST</td>
<td>LED7707</td>
</tr>
<tr>
<td>1</td>
<td>J2</td>
<td>PCB pad jumper</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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</table>
4 Component assembly and layout

Table 2. LED7706 demonstration board component list (continued)

<table>
<thead>
<tr>
<th>Qty</th>
<th>Component</th>
<th>Description</th>
<th>Package</th>
<th>Part-number</th>
<th>MFR</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>J8</td>
<td>Header 8</td>
<td>SIL 8</td>
<td></td>
<td>Standard</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>SW1, SW2</td>
<td>Jumper 3</td>
<td>SIL 3</td>
<td></td>
<td>Standard</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>SW3</td>
<td>Pushbutton</td>
<td>6x6mm</td>
<td>FSM4JSMAT</td>
<td>TYCO</td>
<td></td>
</tr>
</tbody>
</table>

Figure 3. Top side component placement

Figure 4. Bottom side test points
5  I/O interface

The LED7707 demonstration board is equipped with the test points described in Table 3.

Table 3.  LED7707 demonstration board test points description

<table>
<thead>
<tr>
<th>Test point</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIN+</td>
<td>Input voltage, positive terminal</td>
</tr>
<tr>
<td>VIN-</td>
<td>Input voltage, negative terminal</td>
</tr>
<tr>
<td>GND</td>
<td>Reference ground</td>
</tr>
<tr>
<td>ROW1 to ROW6</td>
<td>Current generator output</td>
</tr>
<tr>
<td>VBOOST</td>
<td>Boost regulator output voltage</td>
</tr>
<tr>
<td>DIM</td>
<td>PWM dimming input</td>
</tr>
<tr>
<td>EN</td>
<td>Enable input (active high)</td>
</tr>
<tr>
<td>SYNC</td>
<td>Synchronization output</td>
</tr>
<tr>
<td>FSW</td>
<td>Synchronization input</td>
</tr>
<tr>
<td>FAULT</td>
<td>Fault signal, active low</td>
</tr>
</tbody>
</table>

6  Recommended equipment

- 4.5 V to 32 V, 2 A capable power supply
- Digital multi-meters
- 20 MHz oscilloscope
- Signal generators for PWM dimming and synchronization clock (optional)

7  Configuration

The LED7707 demonstration board allows the user to choose the desired mode of operation using the SW1 and SW2 selectors (refer to the configuration description in the following paragraphs). A red LED is connected to the FAULT pin to easily monitor its status; if this option is not required, the monitor LED can be disconnected opening the J2 jumper.

7.1  SW1 fixed or adjustable switching frequency (FSW pin)

The SW1 selector is used to choose between the fixed switching frequency (660 kHz) and a user-defined switching frequency in the range 250 kHz to 1 MHz (see Figure 5). When placed in the “down” position, the fixed switching frequency is selected.
If SW1 is in the “up” position, the switching frequency is given by:

\[
F_{SW} = 2.5 \cdot R_5
\]

Equation 1

The R5 resistor is set to 330 k\(\Omega\) \((F_{SW} = 825 \text{ kHz})\) and can be changed by the user.

### 7.2 SW2 fault management mode (MODE pin)

The SW2 selector is used to connect the MODE to AVCC or ground. When the jumper is set to the upper position, the MODE pin is connected to ground and the corresponding fault management is summarized in the first column of Table 4.

Otherwise, when SW2 is set to the “down” position, the MODE pin is connected to AVCC and the corresponding fault management is summarized in the second column of Table 4.
7.3 SW3 enable function

The terminals of switch SW3 are connected on one side to the EN pin and on the other side to ground. Therefore, when the switch is not pressed, the EN pin is floating, which implies that the device is working. Pressing the SW3 pin connects the EN pin to ground. When SW3 is released, the device re-starts (a soft-start is performed). The SW3 switch can be activated whenever a new startup is required or to escape a latched condition.

### Table 4. Fault management summary

<table>
<thead>
<tr>
<th>Fault</th>
<th>MODE to GND</th>
<th>MODE to VCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal MOSFET overcurrent</td>
<td>Fault pin HIGH&lt;br&gt;Power MOSFET turned off</td>
<td></td>
</tr>
<tr>
<td>Output overvoltage</td>
<td>FAULT pin LOW&lt;br&gt;Power MOSFET turned off (hysteretic regulation)</td>
<td></td>
</tr>
<tr>
<td>Thermal shutdown</td>
<td>FAULT pin LOW. Device turned off.&lt;br&gt;Automatic restart after 30 °C temperature drop.</td>
<td></td>
</tr>
<tr>
<td>LED short-circuit</td>
<td>Fault pin LOW&lt;br&gt;Device turned OFF (100 µA masking time), latched condition (Vth=4.0 V)</td>
<td></td>
</tr>
<tr>
<td>Open row(s)</td>
<td>Fault pin LOW&lt;br&gt;Device turned off at first occurrence, latched condition</td>
<td>FAULT pin HIGH&lt;br&gt;Faulty row(s) disconnected (100 µs masking time)</td>
</tr>
</tbody>
</table>
8 Test setup

An appropriate white LED array is required as a load to correctly evaluate the LED7706. Figure 7 shows a possible assembly of the LED7707 with a WLED test board. This demonstration board includes 60 white LEDs (150 mA), switches, jumpers and test points which can be used to easily perform functional testing of the LED7707.

Figure 7. LED7707 demonstration board and white LED test board assembly

Figure 8 shows the complete test setup.

Figure 8. LED7707 demonstration board test setup
Getting started

The following step-by-step instructions are provided as a guide for quick evaluation of the performance of the LED7707 demonstration board.

9.1 Quick startup

1. Working in an ESD-protected environment is highly recommended. Check all wrist straps and ESD mat earth connections before handling the LED7707 board
2. Connect the power supply to the LED7707 board and insert the A-meter as shown in Figure 8. Connect a V-meter between VBOOST and ground to monitor the output voltage
3. Connect the white LEDs array to the row1-row6 and VBOOST terminals of the LED7707 board
4. Set the PWM signal (500 Hz, 5% duty-cycle, 3.3 V CMOS logic levels) on a signal generator and connect it to the DIM input
5. Set SW1 and SW2 in the “down” position (fixed frequency and MODE to AVCC). Do not change jumpers settings when the board is powered
6. Set the input voltage to 12 V
7. Turn-on the PWM generator
8. Turn-on the VIN supply. The device turns on
9. Vary the input voltage within the range 6 V - 32 V
10. Set the input voltage to 12 V
11. Vary the dimming duty-cycle from 1% to 100%
12. Check the shape of the row current at 10 us dimming on-time

Note: When used for rowx current measurement, some autoranging A-meters can trigger open-row or shorted-LED fault detection during the automatic scale selection procedure.

Caution: Disabling the auto-ranging option on the A-meter is recommended.
9.2 Open and shorted WLEDs fault testing

1. Set the input voltage to 12 V
2. Set the dimming duty-cycle to 20%
3. Set SW1 and SW2 in the “up” position
4. Turn-on the PWM generator and the supply in sequence
5. Disconnect the rows in sequence and compare the behavior of the LED7707 to Table 4
6. Restore all row connections and press the SW3 pushbutton on the LED7707 board to reset the device
7. Short one or more WLEDs and compare the LED7707 behavior to Table 4
8. Press the SW3 pushbutton on the LED7707 board
9. Turn-off the power supply and set the SW2 selector to the “up” position (MODE to ground)
10. Turn-on the power supply and repeat steps 5 through 8
11. Remove all shorted WLEDs and leave ROW1 and ROW2 floating
12. Turn-on the power supply. The floating rows are ignored
13. Turn-off the PWM generator
14. Turn-off the power supply

9.3 Device synchronization

1. Set the PWM dimming signal to 100%
2. Remove the jumper from the SW1 selector to leave the FSW pin floating
3. Connect an external 700 kHz clock generator (0 V-1 V logic levels, 30% duty-cycle) between the FSW test point and ground. Refer to Figure 9
4. Turn-on the PWM generator
5. Turn-on the power supply. The device remains off until the FSW pin is low
6. Turn-on the clock generator. The device turns on
7. Monitor the SYNC output and verify the synchronization (the SYNC output is a replica of the FSW signal)
8. Turn-off the PWM generator
9. Turn-off the clock generator
10. Turn-off the power supply
9.4 Efficiency measurements

Figure 10 shows the setup used to perform the efficiency measurements. The efficiency in this device is typically defined as the ratio between the power provided to the load (current flowing through the LEDs multiplied by the voltage across the LEDs) and the total input power. The power dissipated in the current generators is correctly considered as a power loss. This way of calculating the efficiency implies that the voltage across the LEDs is the same for all the strings. However this is not true. The power delivered to the load should be calculated as follows:

Equation 2

\[
P_{\text{LOAD}} = \sum_{i=1}^{6} V_{\text{STRING}_i} \cdot I_{\text{STRING}_i}
\]

where \(V_{\text{STRING}_i}\) is the voltage across the LEDs in row \(i\), whereas \(I_{\text{STRING}_i}\) is the current flowing through the row \(i\). To facilitate the measurement, the voltage drop of all the generators is equalized by connecting them together. In this condition, the power provided to the LEDs is simple to calculate:

Equation 3

\[
P_{\text{LOAD}} = V_{\text{STRING}} \cdot I_{\text{STRING}}
\]

where \(V_{\text{STRING}}\) is the voltage across the parallelized channels, whereas \(I_{\text{STRING}}\) is the total current delivered to the load (the sum of the current of the six channels). Since all the
channels are in parallel, a single string of 700 mA-rated LEDs is required as load (Figure 10).

Figure 10. Efficiency measurement setup

![Efficiency measurement setup diagram]

Figure 11 and 12 shows two efficiency measurements versus the duty cycle of the dimming signal at two different input voltages.

Figure 11. Efficiency vs. DIM duty cycle, $V_{\text{IN}}=12\,\text{V}$, 6 rows, 10 white LEDs in series, $I_{\text{OUT}}=360\,\text{mA}$

Figure 12. Efficiency vs. DIM duty cycle, $V_{\text{IN}}=24\,\text{V}$, 6 rows, 10 white LEDs in series, $I_{\text{OUT}}=360\,\text{mA}$
10 Revision history

Table 5. Document revision history

<table>
<thead>
<tr>
<th>Date</th>
<th>Revision</th>
<th>Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>26-May-2009</td>
<td>1</td>
<td>Initial release</td>
</tr>
</tbody>
</table>
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