LED Solutions for LCD Backlighting
LED Solutions for LCD Backlighting

ST Position:
- #1 in Lighting Segment*
- #2 in Power Management**

ST Expertise:
- System Solutions
- Technology Integration and Innovation
- Excellent Technical Support

*STMicroelectronics, Datapoint and Darnell - 2008
**iSupply - 2010
Contents

- LED Solutions for LCD Backlighting
  - LED Array Driver Features/Benefits
    - Error Detection/Diagnostics
    - Auto Power Savings/Shutdown
    - PWM Dimming
    - External Synchronization Capability
  - System Evaluation Boards and Tools
    - LEDs Driver with Boost Converter for LCD Panels Backlight
    - White LED Controller in Boost topology
    - 6-row, 30 mA LED driver with Boost
LED Solutions for LCD Backlighting

LCD backlighting applications:
- LED TVs
- PC monitors
- Notebooks
- Netbooks
- Mid to Large-sized LCDs

LED7706/07/08, STLA02, STLD40/41 PM6600

Topology and architecture flexibility
- Buck-Boost improved efficiency
- High side control in Boost topology for improved accuracy
- High Frequency (2MHz) operation with PWM control
- Chip scale packaging solutions
- Smallest application area
Lighting Management - Backlight

**Size Panel**

- **1-2”** 6 LEDs
- **3-4”** 10 LEDs
- **5”** 40 LEDs
- **7-15.6”** 60 LEDs
- **17”** 60 LEDs

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## LED Drivers for Backlighting

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Drive (# of LEDs)</th>
<th>Iout (mA)</th>
<th>Vin range (V)</th>
<th>Fsw (MHz)</th>
<th>Notes</th>
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<td>STLA02</td>
<td>6</td>
<td>20</td>
<td>2.5-18</td>
<td>2.3</td>
<td>Synchronous, PWM Dimming</td>
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<td>STLD40</td>
<td>10</td>
<td>20</td>
<td>3.0-5.5</td>
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<td>Asynchronous, PWM Dimming</td>
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<td>STLD41</td>
<td>40 (4 strings of 10)</td>
<td>120</td>
<td>3.0-21</td>
<td>1.8</td>
<td>Asynchronous, PWM Dimming</td>
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<tr>
<td>STLD25</td>
<td>10 (5 strings of 2)</td>
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<td>2.3-5.5</td>
<td>2.5</td>
<td>Asynchronous, PWM Dimming</td>
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<td>LED7706</td>
<td>60 (6 strings of 10)</td>
<td>30</td>
<td>4.5-36</td>
<td>0.2-1</td>
<td>Ext. Sync. Capability, PWM dimming</td>
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<tr>
<td>LED7707</td>
<td>60 (6 strings of 10)</td>
<td>85</td>
<td>4.5-36</td>
<td>0.2-1</td>
<td>Ext. Sync. Capability, PWM dimming</td>
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<tr>
<td>LED7708</td>
<td>160 (16 strings of 10)</td>
<td>85</td>
<td>3.6-36</td>
<td>0.25-1</td>
<td>Ext. Sync. Capability, PWM dimming</td>
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<tr>
<td>PM6600</td>
<td>60 (6 strings of 10)</td>
<td>32</td>
<td>4.7-28</td>
<td>0.2-1</td>
<td>Ext. Sync. Capability, PWM dimming</td>
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</table>
STLA02 Boost Converter LED Driver

Features:
- Supply Input range 2.5V – 18V
- Synchronous rectification
- Output voltage up to 27V
- Drivers up to 6 LEDs in series
- High side current sensing
- Simple Topology to connect LEDs
- LED current 20mA
- 2.3MHz Freq PWM control
- Enable and Dimming current (300:1) with dedicated Pin
- Soft Start
- Over Temperature and Voltage protections
- Package DNF6 2x2 mm

ST advantages:
- High side configuration allows single layer PCB
- Synchronous rectification
- High switching frequency reduces size of external components
- Tiny package DFN2x2

STLA02 EVAL Board
See ST Sales team for availability
**STLD40D W-LED Power Supply**

w/Evaluation board for Large Display Backlight

**Features:**
- Inductor switcher boost converter
- Vin range: 3.0Vdc to 5.5Vdc
- High efficiency >80% over wide range of Vin from 3-37V
- Can drive up to 10 white LEDs in series
- Output Current capability 20mA
- Enable pin with possibility of PWM dimming control
- OVP and OVT protections with automatic restart
- PFM mode control
- Soft start with adjustable peak current limit
- Small external inductor
- QFN 3x3 8 leads 1mm Height

**Typical applications:**
- White Led supply for LCD backlight
- Mobile phone/smart phones
- PDA and organizers
- Handheld POS
- Digital camera
- MP3
- Any handsets powered by Li-ion battery

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<th>Ioutmax</th>
<th>Description</th>
<th>App Notes</th>
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<tr>
<td>STLD40D</td>
<td>STEVAL-TLL001V1</td>
<td>3.0-5.5V</td>
<td>20mA</td>
<td>White LED power supply for large display backlight</td>
<td>AN2333</td>
</tr>
</tbody>
</table>
STLD41 – Single Channel WLED Driver

White LED Power Supply

Features:
- White LED boost converter
- Drives up to 40 LEDs (4 strings of 10 LEDs)
- Vin range: 3.0Vdc to 21Vdc
- Operating Vout: ~38V
- Output Current capability 120mA adjustable by single resistor
- PWM/PFM Control Mode (1.8 MHz)
- High efficiency w/2 or 3 Li+ cells
- Adjustable peak current
- Separate PWM dimming and enable pins
- Over voltage and over temperature protections
- Soft start
- Low shutdown current < 1µA.
- Package QFN 3x3-8 leads

STT advantages:
- Low cost solution
- LED configuration flexibility
- Few external components needed

APPLICATIONS:
- Mid-size LCD backlight
  - Tablet
  - Mobile phone
  - PDAs

New – Available in 2017
STLD25 - 5 Channel WLED Driver

Features:
- Operating input voltage from 2.3V to 5.5V
- ± 7.5% LED current accuracy
- Two LEDs in series, 5 channels to drive up to 10 LEDs
- High side current source
- Up to 125mA of total LEDs current
- 90% efficiency at 100mA
- PWM Dimming with automatic shutdown time window
- 2.5MHz switching frequency
- CSP 12 bumps 0.4mm pitch, 1.4x1.8mm

Typical Applications:
- LCD backlight with up to 10 LEDs
- Cellular phones
- PDAs
Monolithic solutions offer high efficiency and compactness, wide input voltage range, high current capability for a variety of applications, and high dimming performance for superior brightness uniformity.

- LED770x
- Boost for multi-rows applications
- DC BUS powered applications
Optimized LED driving solution

LED7706 and LED7707

NEED FOR BOOST CONVERSION

- Typical input bus available $\rightarrow$ 24V
- LEDs to drive $\rightarrow$ up to 10 (e.g. considering 40V technology)

LED770x Trade-off based on:
- technology availability (rated voltage)
- efficiency
- LED current regulation

- simpler architecture
- brightness uniformity
- high voltage to manage

- low voltage
- high complexity due to current matching
- high power dissipation on current generators

Serial

Parallel

Multiple channel
LED7706/7: LED Controllers

MAIN FEATURES
- **Boost section**
  - 4.5V to 36V Input Voltage range
  - Internal +5V LDO
  - Internal Power-MOSFET
  - Up to 93% Efficiency
  - Up to 36V Output Voltage
  - 200kHz to 1MHz Switching Frequency
  - Fixed F<sub>SW</sub> Peak Current Mode control
  - Programmable Soft-Start Duration
  - Programmable OV and OC Protections
  - Single Ceramic Output Capacitor
  - External sync for multi-device application

- **Backlight driver section**
  - Six ROWs capable of driving multiple LEDs in series (e.g. up to ten WLEDs per ROW)
  - Programmable Output Current per ROW
    - Up to 30mA (LED7706)
    - Up to 85mA (LED7707)
  - PWM Dimming
    - 500ns minimum dimming ON time (LED7706)
    - 10uS minimum dimming ON time (LED7707)
  - 2% Current Matching between ROWs
  - Shorted LED Fault Detection
  - Open ROW Fault Detection
  - Capability to Disconnect Unused ROWs

Ideal for:
- Backlighting for Medium and Large LCD panels
  - Monolithic and flexible solution
  - High efficiency
  - Superior dimming capability
  - Complete and flexible fault management
LED7708 LED Controller

MAIN FEATURES

Boost controller section
- 3.6V to 36V Input Voltage range
- Adaptive output voltage for high efficiency
- Internal +5V LDO for gate driver supply
- Internal +3.3V LDO for device supply
- High performance external MOSFET driver
- 250kHz to 1MHz Switching Frequency
- Fixed $F_{SW}$ Peak Current Mode control
- External sync for multi-device application
- Programmable OV and OC Protections
- Over-temp alert and thermal shutdown

LED array driver section
- 4-wire, 30MHz serial interface
- 16-channels with 85mA/ch current capability
- Selectable 12/16-bit gray-scale
- Programmable gray-scale latency
- Grouped or independent channel PWM control
- 1.5% max channel-t-channel current matching
- LED short-circuit and open-channel fault detection and management
- Serial data formats: 16x16 bits, 1x256bits or 1x192 bits

Ideal for:

Backlighting for LCD TVs
- Advanced local dimming performance
- Adaptive LEDs voltage regulation
- Flexible solution
- High efficiency
- Superior brightness control
- Complete and smart fault management

Available in 2011
LED770x: Adaptive Output Voltage

Minimizing the power consumption

- **Fixed output voltage**
  - Higher power dissipation
  - *V*<sub>F</sub> spread
- **Adaptive output voltage**
  - Output voltage depends on the active LED string with highest *V*<sub>F</sub>

Example:
- **V**<sub>IN</sub> = 12V
- 6 strings of 8 LEDs
- *V*<sub>F,LED</sub> = 3.5 0.2V
- *f*<sub>SW</sub> = 600kHz
- *I*<sub>ROW</sub> = 75mA

\[ \eta = 84.2\% \] (fixed *V*<sub>OUT</sub> approach)

\[ \eta = 87.3\% * \] (adaptive *V*<sub>OUT</sub> approach)

*0.5% lower every 100mV of increase of the voltage across the master generators
Input voltage: 4.5V to 36V
Maximum RMS switch current: 2.5A
Parallelable channels for higher current (LED7707)

\[ I_{LED} = \frac{K_R}{R_{RILIM}} \]

LED current: up to 85mA/ch (LED7707)
Channel to channel current mismatch: \( \pm 2\% \)
Up to 20kHz PWM dimming (1%-100%, LED7706)

Wide input voltage range
High efficiency
PWM Dimming

Fault Enable

(\( LED7707@VOUT=34V, IOUT=350mA \))

\( \eta \)

95%
90%
85%
80%
75%
70%
65%
60%
55%
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
14V INPUT VOLTAGE 24V
Detecting and Managing Faults in LED7706/7/8

1) ROW0 Opens
2) The output voltage increases
3) If 95% is crossed, the faulty ROW is disconnected

1) LED Short Circuit: the ROW0 Voltage Increases
2) If the 3.4V threshold is crossed, the device is turned off (MODE=0)

20µs Dimming On-Time
500ns Dimming On-Time

(f_{DIM}=10kHz, D_{DIM}=20%, f_{SW}=630kHz, LED current=20mA)

Managing Dimming Waveforms in LED7706/7/8
LED7706/7 LED Driver Application Examples

 Typical application schematic

 High-Brightness LED driving solution

 Multi-device applications with external Synchronization
LED7706/7 LED Driver w/Boost Converter

Evaluation Board Solution

Key Features:

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
- 200/250 kHz to 1 MHz adjustable switching frequency (LED7706/7)
- External sync for multi-device application
- Pulse-skip power saving mode at light load
- Programmable soft-start
- Programmable OVP protection
- Single ceramic output capacitor
- Non-latched thermal shutdown

LED driver section
- Six rows with 30/85 mA maximum current capability (adjustable) LED7706/7
- Up to 10 white LEDs per row
- Rows disable option
- Less than 500 ns minimum dimming time (1% minimum dimming duty-cycle at 20 kHz dimming frequency - LED7706,
- Less than 10 μs minimum dimming time at 1kHz dimming frequency - LED7707
- 2.0% current matching between rows
- LED failure (open and short circuit) detection

Typical Applications:
- LCD monitors & TV Panels
- PDAs Panel Backlight
- GPS Panel Backlight
- Emergency Lightning

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<td>STEVAL-ILL020V1</td>
<td>4.5V to 36V</td>
<td>20mA /ch</td>
<td>LEDs Driver with Boost Converter</td>
<td>AN2809</td>
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<tr>
<td>LED7707</td>
<td>STEVAL-ILL021V1</td>
<td>4.5V to 36V</td>
<td>60mA/ch</td>
<td>LEDs Driver with Boost Converter</td>
<td>AN2810</td>
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PM6600 LED Driver w/Boost Converter

and Evaluation Board

Key features
- 6 rows with up to 10 LEDs/row (60 LEDs)
- Monolithic solution up to 36V output voltage
- Programmable LED current up to 32 mA at highest precision/matching accuracy
- Supports analog and digital dimming
- Boost Fsw from 200Khz to 1MHz and high efficiency at light load
- Pulse-skip power saving mode at light load
- LED failure (open and short circuit) detection
- Soft-start, programmable OVP protection, thermal shutdown
- Internal power MOSFET, reducing space and application cost
- Ceramic output capacitor supported

Key benefits
- Covers all mobile PC and netbook screen sizes (8” to 17”)
- Superior brightness uniformity, with tight current matching
- Longer battery life with energy regulation compliancy (VESA-NEBL)
- Saves BOM cost, supporting MLCC output cap w/default values
- Space-saving monolithic solution in 24-pin QFN4x4

Typical applications
- Notebook panels, netbooks, and nettops
- Tablet PCs
- Battery/AC adapter supplied equipment

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<td>4.7 - 28V</td>
<td>32mA</td>
<td>6-row, 30 mA LED driver with boost</td>
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PM6600: Higher Efficiency – up to 93%

- WLEDs board + PM6600 save board space

- Save Power in whole dimming range

\[
\text{Vin} = 12V
\]

\[
\begin{array}{c|c|c}
\text{DIM duty cycle [%]} & \text{Efficiency [%]} & \\
0 & 0 & \\
20 & 10 & \\
40 & 20 & \\
60 & 30 & \\
80 & 40 & \\
100 & 50 & \\
\end{array}
\]

- \( V_{IN}=12V, \ V_{OUT}=34V \) (6x 10WLEDs 100mV \( V_F \) Spread), \( I_{LED}=20mA \)

- Switching Frequency: \( f_{SW}=630kHz, \ L=6.8\mu H \)
## Driving LEDs using DC-DC converters

### Evaluation Boards Summary

<table>
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<tr>
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<td>TBD</td>
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LED Solutions for LCD Backlighting on ST.COM

LED Lighting Brochure


LED Application web pages


Add LCD Backlighting block diagram here

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Thank you