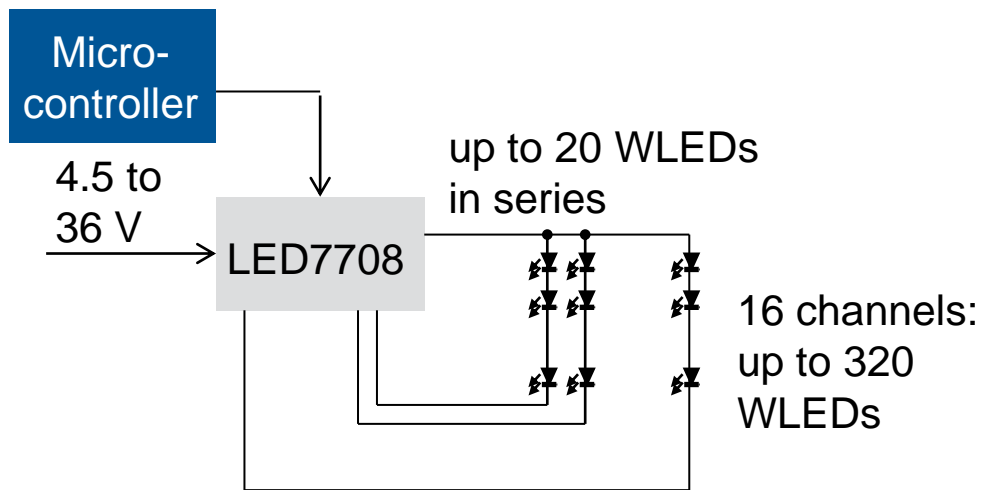
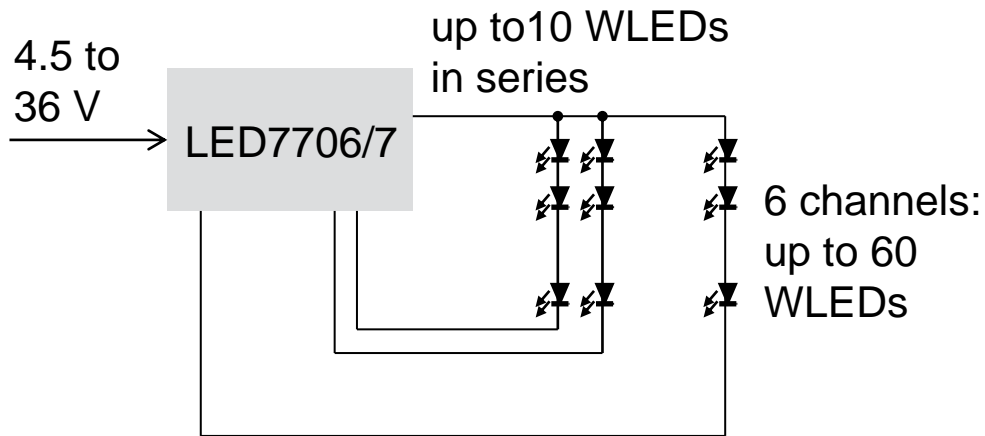


LED solutions for LCD backlighting



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

- 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
LED7708*,
STLA02, STLD40,
STLD41*,
STLED25,
PM6600

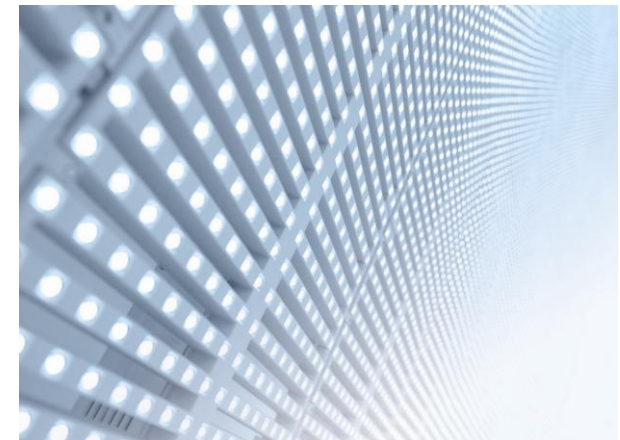
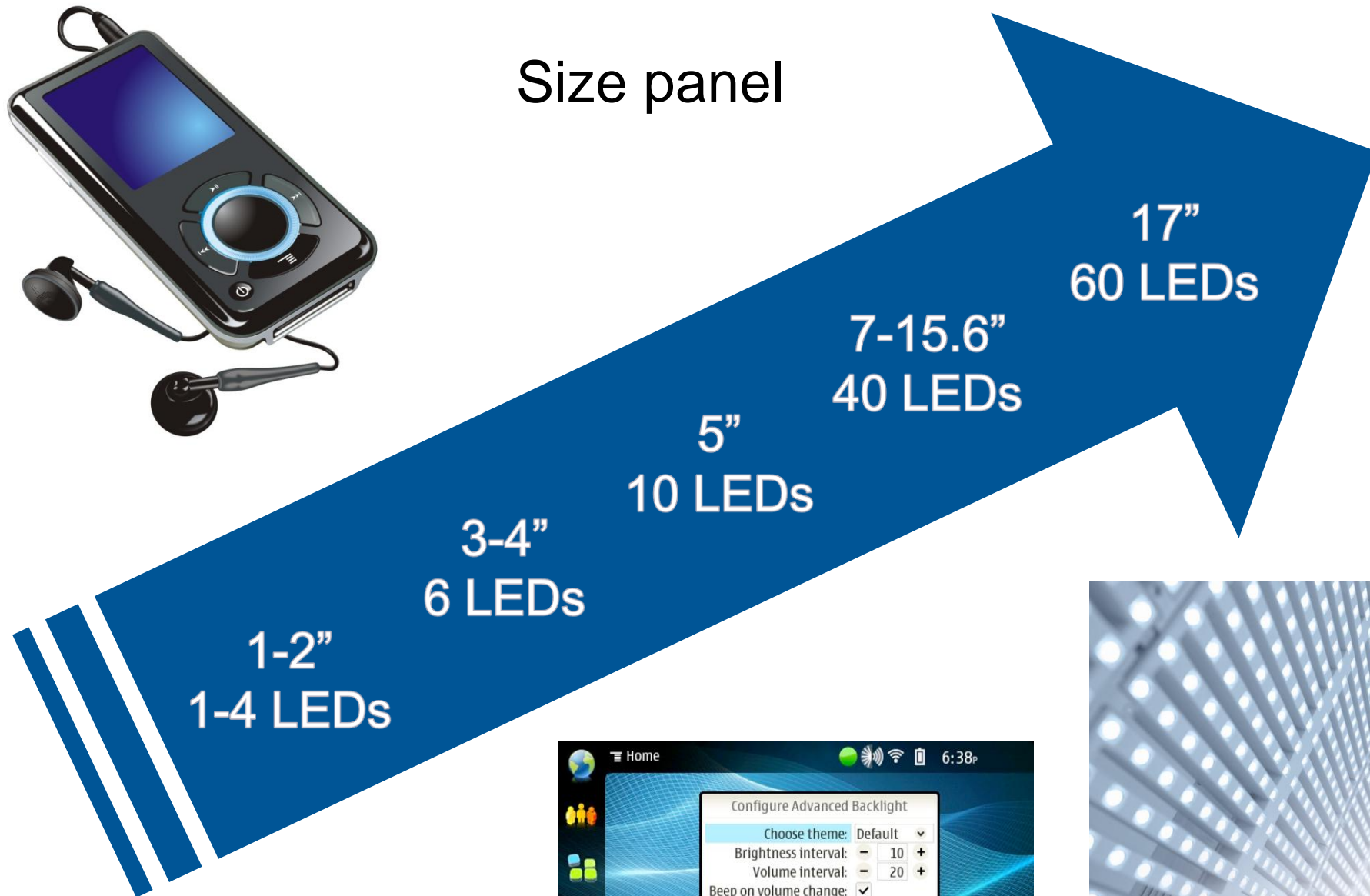
Topology and architecture flexibility

- Buck-boost improved efficiency
- High side control in boost topology for improved accuracy
- High frequency (2 MHz) operation with PWM control
- Chip scale packaging solutions
- Smallest application area



*Available in Q4/2011

Lighting management - backlight



LED drivers for backlighting



Part number	Drive (# of LEDs)	I _{out} (mA)	V _{in} range (V)	F _{sw} (MHz)	Notes
STLA02	6	20	2.5 to 18	2.3	Synchronous, PWM dimming
STLD40	10	20	3.0 to 5.5	0.5	Asynchronous, PWM dimming
STLD41*	40 (4 strings of 10)	120	3.0 to 21	1.8	Asynchronous, PWM dimming
STLED25*	10 (5 strings of 2)	25	2.3 to 5.5	2.5	Asynchronous, PWM dimming
LED7706	60 (6 strings of 10)	30	4.5 to 36	0.2 to 1	Ext. sync. capability, PWM dimming
LED7707	60 (6 strings of 10)	85	4.5 to 36	0.2 to 1	Ext. sync. capability, PWM dimming
LED7708*	160 (16 strings of 10)	85	3.6 to 36	0.25 to 1	Ext. sync. capability, PWM dimming
PM6600	60 (6 strings of 10)	32	4.7 to 28	0.2 to 1	Ext. sync. capability, PWM dimming

*Available in Q4/2011

STLA02 boost converter LED driver



Features:

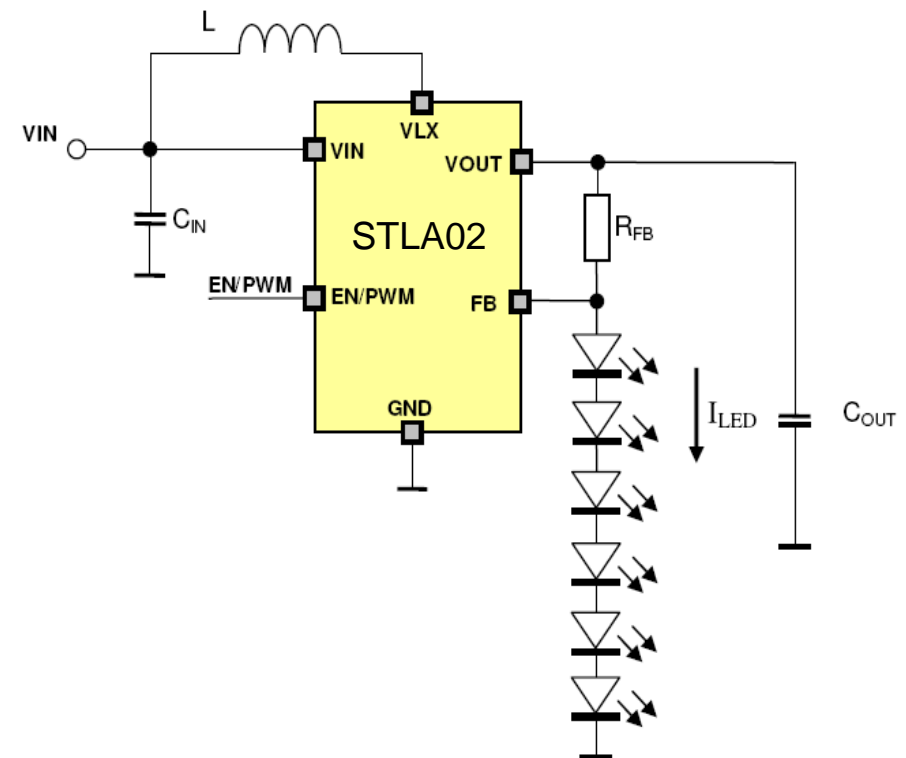
- Supply input range: 2.5 to 18V
- Synchronous rectification
- Output voltage: up to 27 V
- Drivers up to 6 LEDs in series
- High side current sensing
- Simple topology to connect LEDs
- LED current 20 mA
- 2.3 MHz frequency PWM control
- Enable and dimming current (300:1) with dedicated Pin
- Soft-start
- Over temperature and voltage protections
- Package DNF6 2 x 2 mm

ST advantages:

- High side configuration allows single layer PCB
- Synchronous rectification
- High switching frequency reduces size of external components
- Tiny package DFN 2 x 2

*See ST sales team for availability

Application schematic



STLA02 eval board*

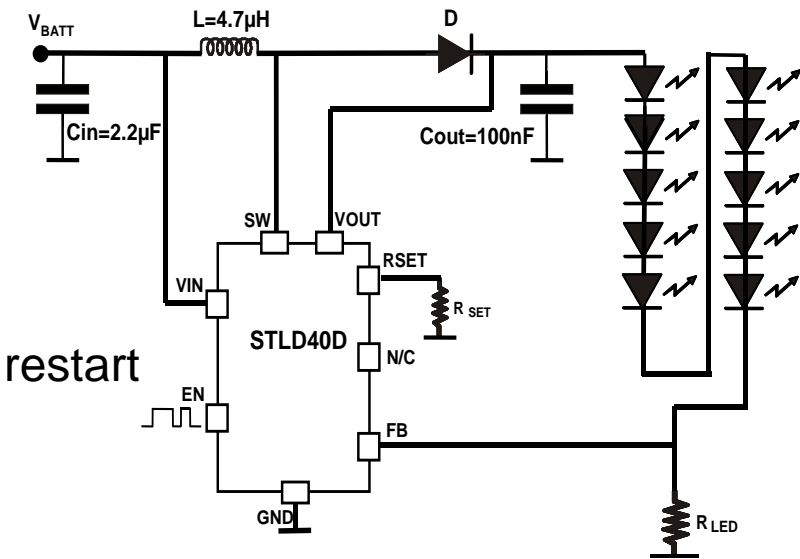
STLD40D WLED power supply



- w/evaluation board for large display backlight

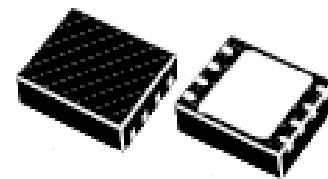
Features:

- Inductor switcher boost converter
- V_{IN} range: 3.0 to 5.5 Vdc
- High efficiency >80% over wide range of V_{IN} from 3-37 V
- Can drive up to 10 white LEDs in series
- Output current capability: 20 mA
- Enable pin with possibility of PWM dimming control
- Overvoltage and overtemperature protections with automatic restart
- PFM mode control
- Soft-start with adjustable peak current limit
- Small external inductor
- QFN 3 x 3 8 leads, 1 mm height



Typical applications:

- White LED supply for LCD backlight
- Mobile phones/smart phones
- PDAs and organizers
- Handheld POS
- Digital cameras
- MP3s
- Any handset powered by Li-ion battery



QFN8 (3 x 3 mm)



STEVAL-TLL001V1

Part #	Evaluation board	Vin	Ioutmax	Description	App notes
STLD40D	STEVAL-TLL001V1	3.0 to 5.5 V	20 mA	White LED power supply for large display backlight	AN2333

STLD41* – single channel WLED driver



■ White LED power supply

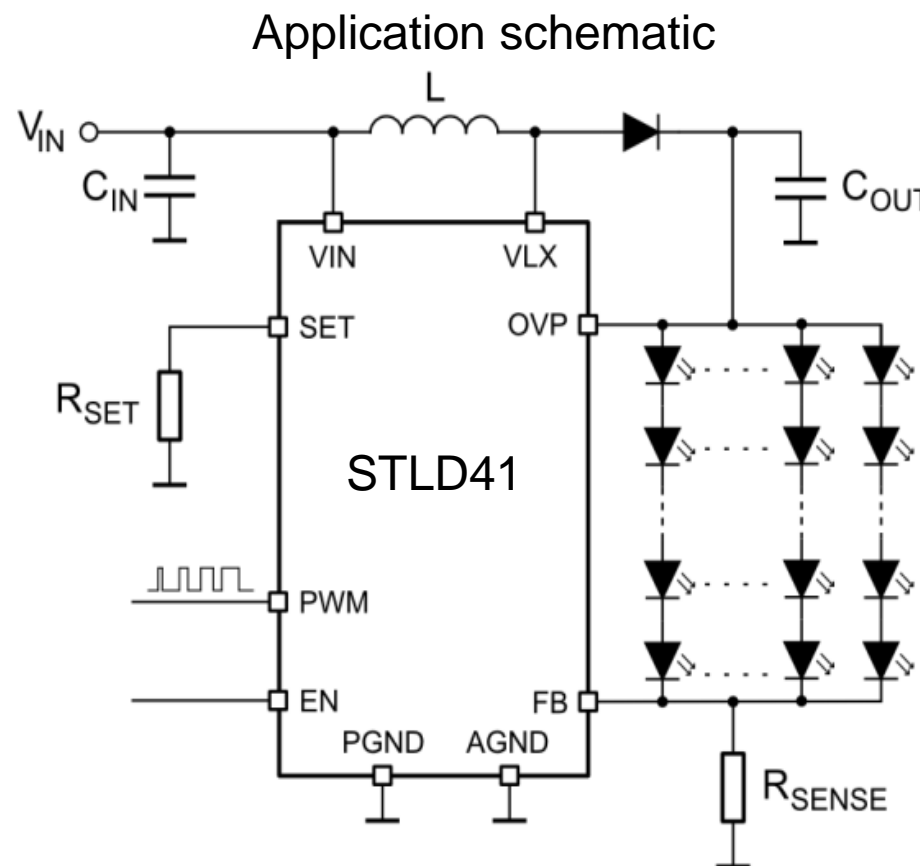
Features:

- White LED boost converter
- Drives up to 40 LEDs (4 strings of 10 LEDs)
- Vin range: 3.0 to 21 Vdc
- Operating V_{OUT} : ~38 V
- Output current capability: 120 mA 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 < 1 μ A.
- Package QFN 3 x 3, 8 leads

ST advantages:

- Low cost solution
- LED configuration flexibility
- Few external components needed

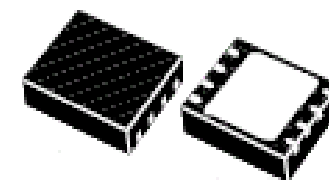
*Available in Q4/2011



Applications:

Mid-size LCD backlight:

- Tablets
- Mobile phones
- PDAs



QFN8 (3 x 3 mm)

STLED25* – 5 channel WLED driver



Features:

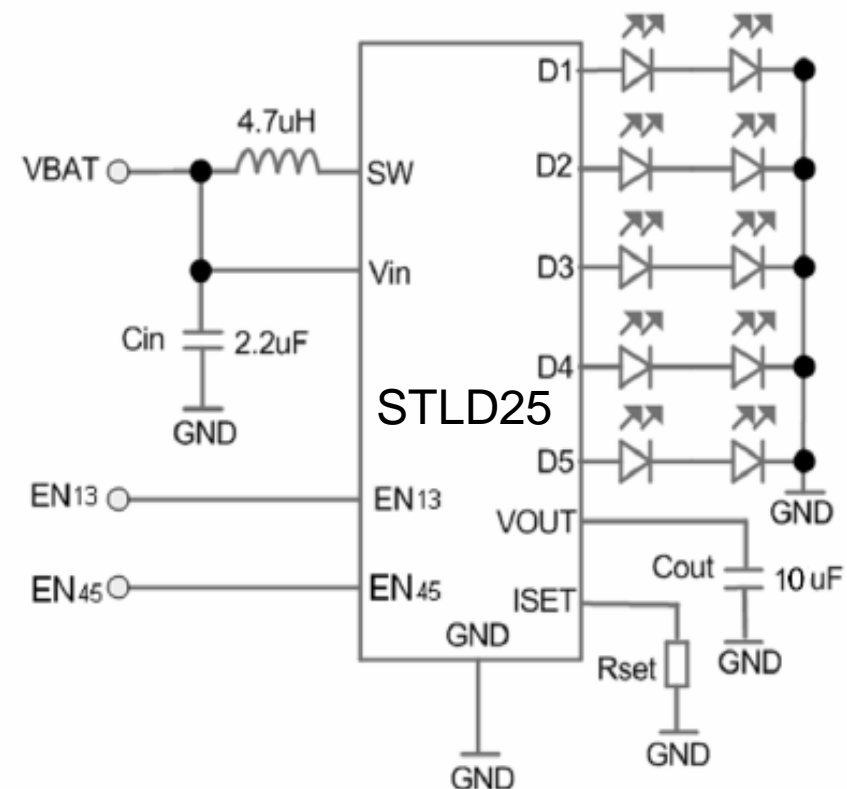
- Operating input voltage: from 2.3 to 5.5 V
- $\pm 7.5\%$ LED current accuracy
- Two LEDs in series, 5 channels to drive up to 10 LEDs
- High side current source
- Up to 125 mA of total LEDs current
- 90% efficiency at 100 mA
- PWM dimming with automatic shutdown time window
- 2.5 MHz switching frequency
- CSP 12 bumps 0.4 mm pitch 1.4 x 1.8 mm

Typical applications:

- LCD backlight with up to 10 LEDs
- Mobile phones
- PDAs

*Available in Q4/2011

Application schematic



CSP 1.4 x 1.8 mm 12 bumps 0.4 mm pitch

Using DC-DC switching regulators



- In driving LEDs

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-row applications

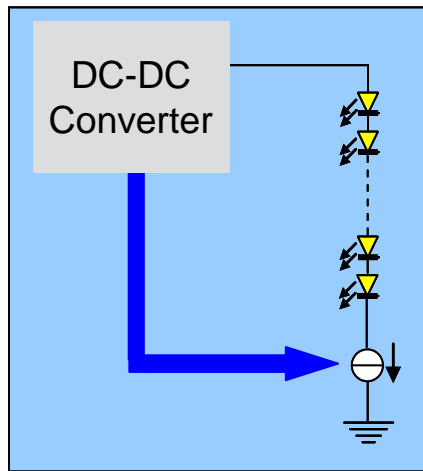
DC bus powered applications



Optimized LED driving solution

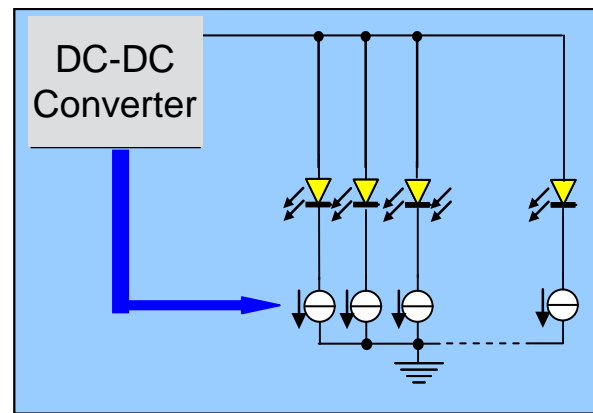


■ LED7706 and LED7707



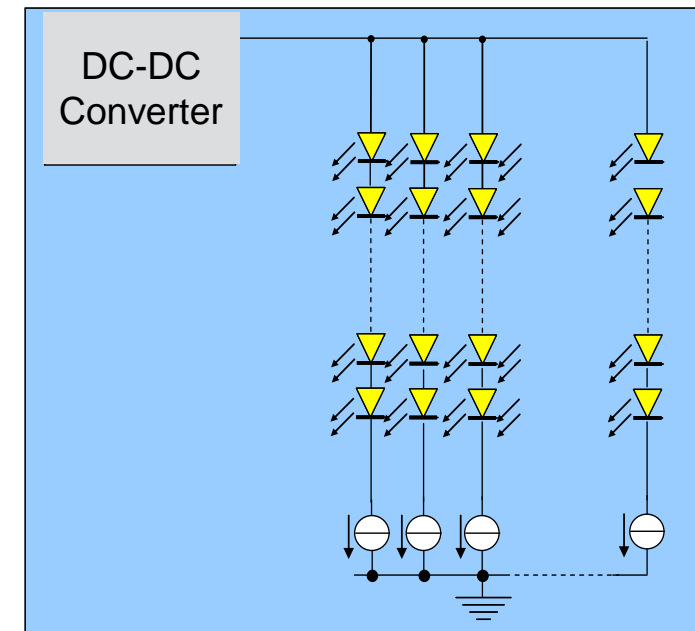
Serial

- ▲ Simpler architecture
- ▲ Brightness uniformity
- ▼ High voltage to manage



Parallel

- ▲ Low voltage
- ▼ High complexity due to current matching
- ▼ High power dissipation on current generators



Multiple channel

LED770x trade-off based on:

- technology availability (rated voltage)
- efficiency
- LED current regulation

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



Need for boost conversion

LED7706/7: LED controllers



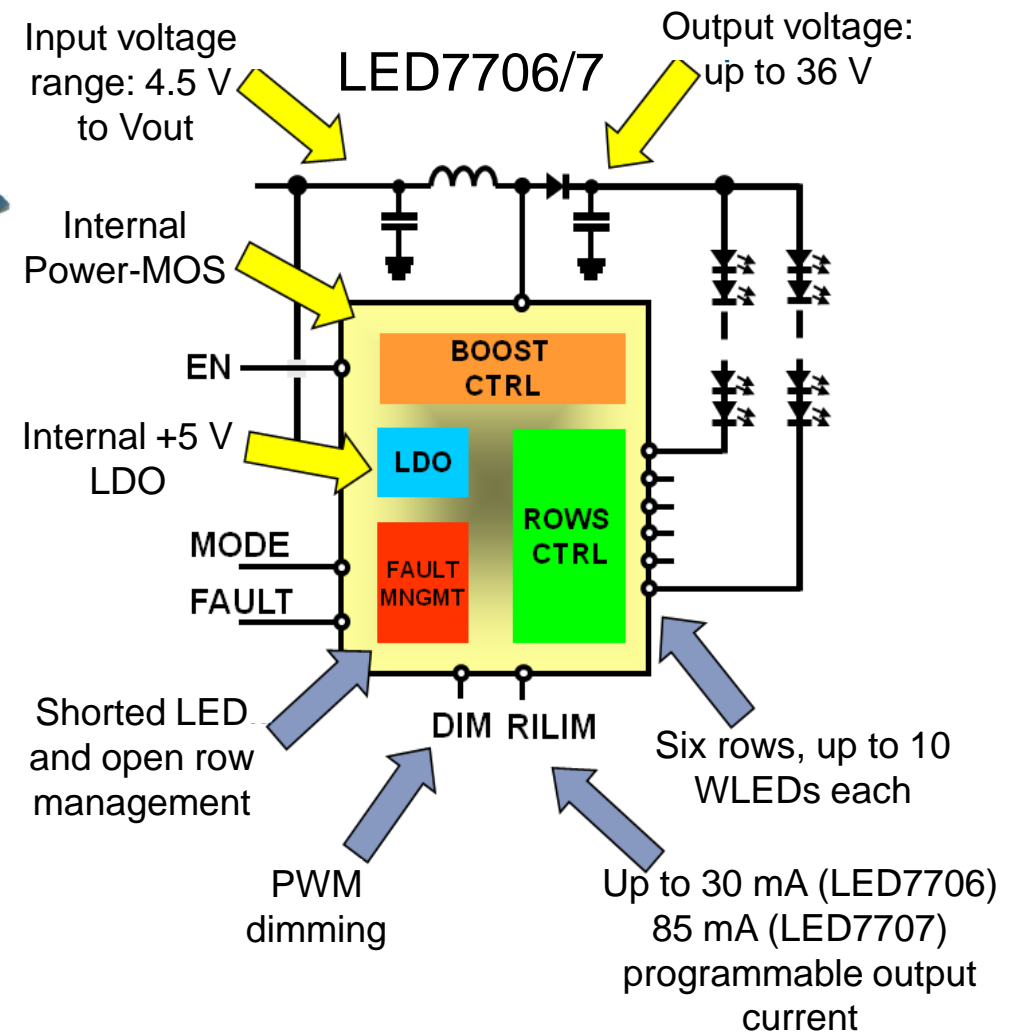
■ Main features

Boost section

- 4.5 to 36 V input voltage range
- Internal +5 V LDO
- Internal power MOSFET
- Up to 93% efficiency
- Up to 36 V output voltage
- 200 kHz to 1 MHz switching frequency
- Fixed F_{sw} 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 30 mA (LED7706)
 - Up to 85 mA (LED7707)
- PWM dimming
 - 500 ns minimum dimming on time (LED7706)
 - 10 μ s minimum dimming on time (LED7707)
- $\pm 2\%$ 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 solutions
 - High efficiency
 - Superior dimming capability
 - Complete and flexible fault management

LED7708* LED controller



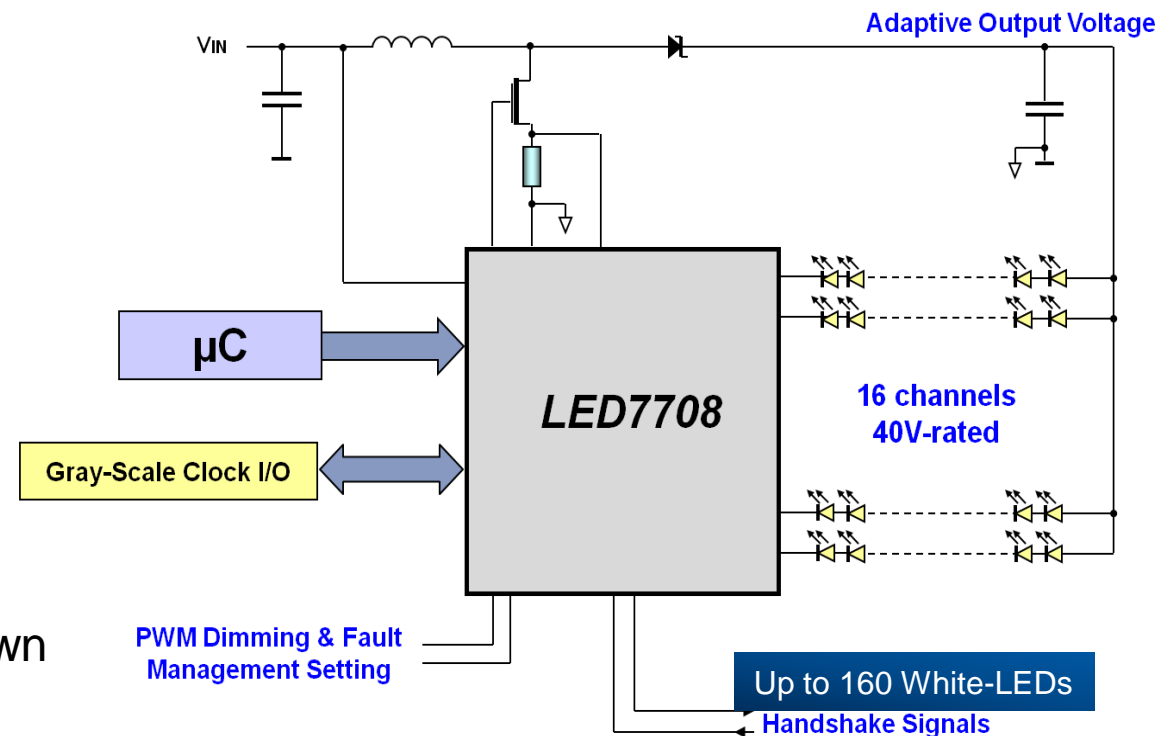
■ Main features

Boost controller section

- 3.6 to 36 V input voltage range
- Adaptive output voltage for high efficiency
- Internal +5 V LDO for gate driver supply
- Internal +3.3 V LDO for device supply
- High performance external MOSFET driver
- 250 kHz to 1 MHz switching frequency
- Fixed F_{SW} peak current mode control
- External sync for multi-device applications
- Programmable OV and OC protections
- Over temperature alert and thermal shutdown

LED array driver section

- 4-wire, 30 MHz serial interface
- 16-channels with 85 mA/ch current capability
- Selectable 12/16-bit gray scale
- Programmable gray scale latency
- Grouped or independent channel PWM control
- $\pm 1.5\%$ max channel-t-channel current matching
- LED short circuit and open channel fault detection and management
- Serial data formats: 16x16 bits, 1x256 bits 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

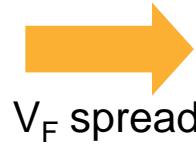
*Available in Q4/2011

LED770x: adaptive output voltage



- Minimizing power consumption

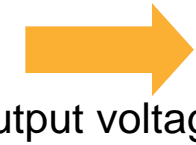
Fixed output voltage



V_F spread

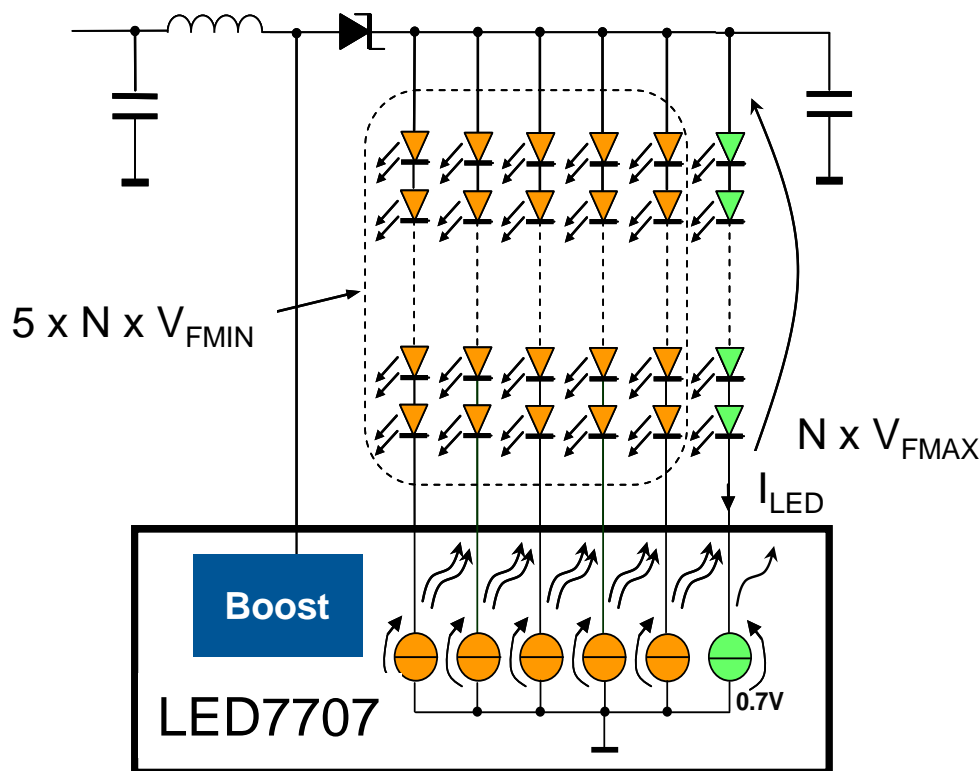
High power dissipation

Adaptive output voltage



Output voltage
depends on the active LED string
with highest V_F

Minimization of the power dissipation on
the current generators



Example:

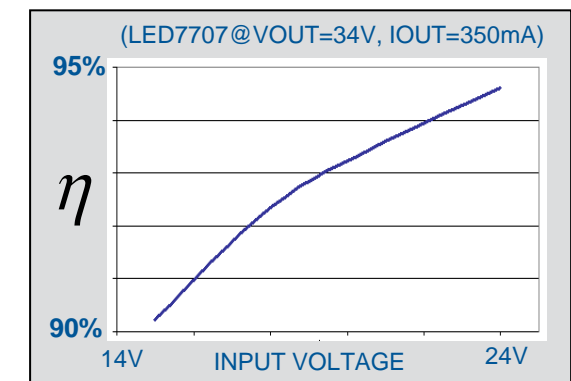
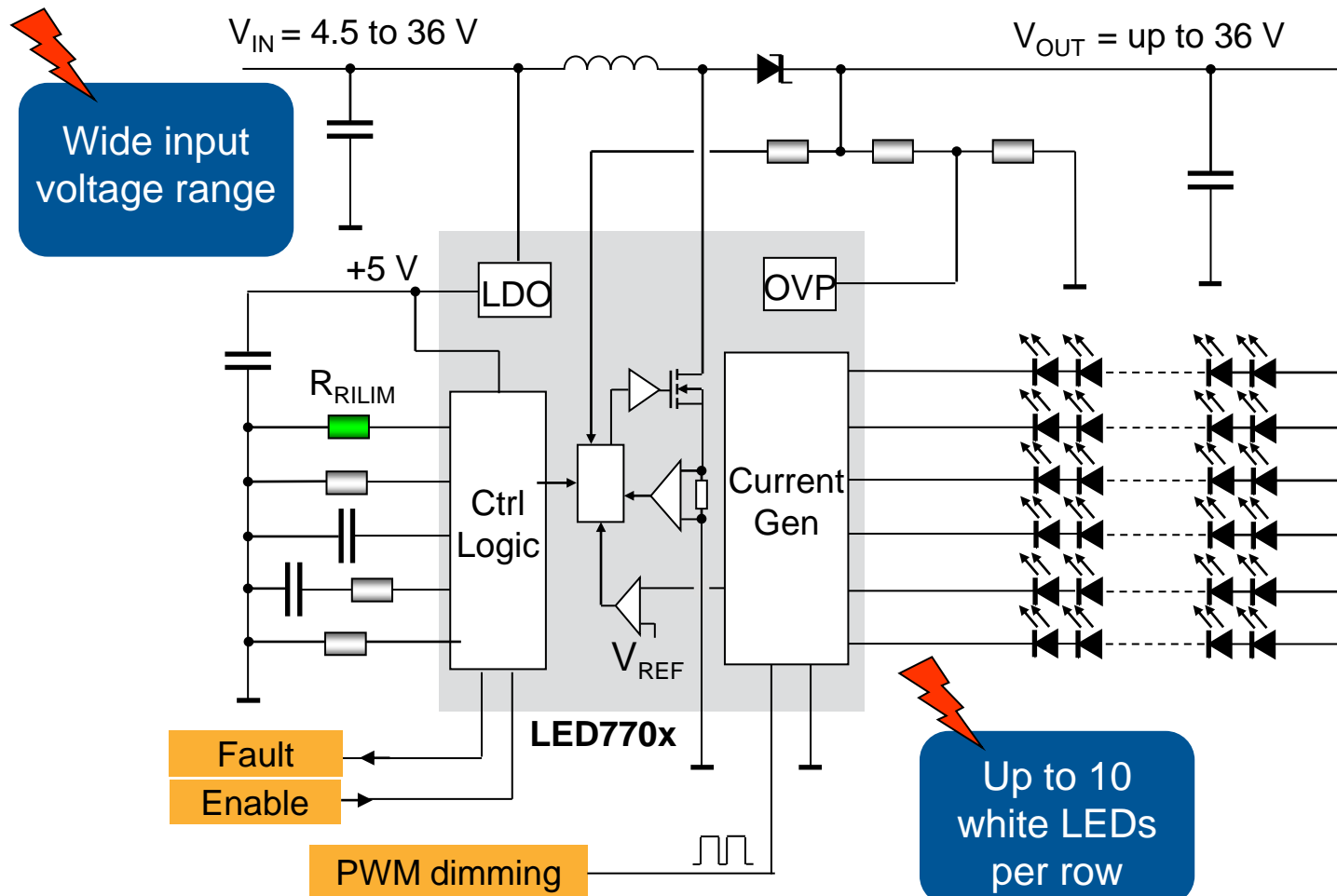
- $V_{IN} = 12\text{ V}$
- 6 strings of 8 LEDs
- $V_{F,LED} = 3.5 \pm 0.2\text{ V}$
- $f_{SW} = 600\text{ kHz}$
- $I_{ROW} = 75\text{ mA}$

$\eta = 84.2\%$ (fixed V_{OUT} approach)

$\eta = 87.3\%^*$ (adaptive V_{OUT} approach)

*0.5% lower for every 100 mV increase in the voltage across the master generators

LED770x: boost topology



Input voltage: 4.5 to 36 V
 Maximum RMS switch current: 2.5 A
 Parallelable channels for higher current (LED7707)

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

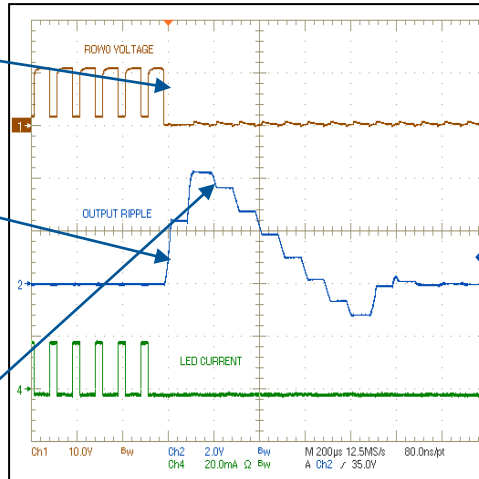
LED faults and dimming waveforms



1) Row0 opens

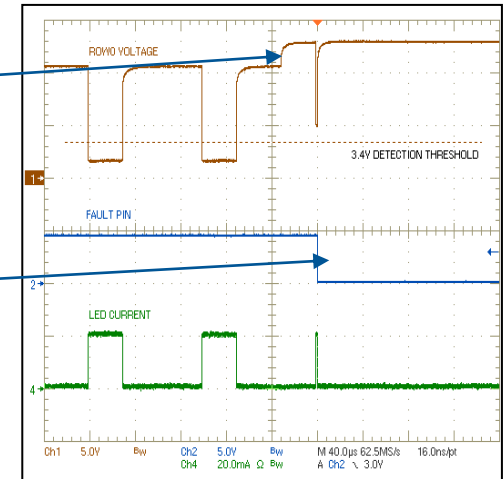
2) The output voltage increases

3) If 95% is crossed, the faulty row is disconnected



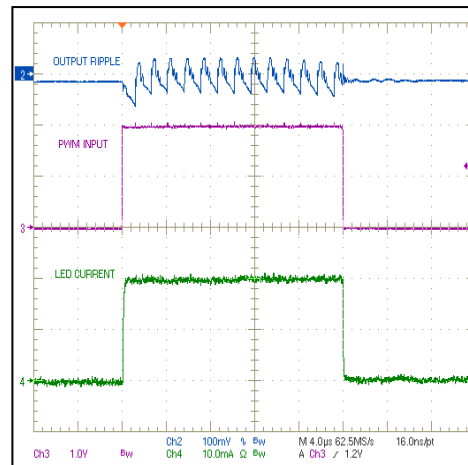
1) LED short circuit: the Row0 voltage increases

2) If the 3.4 V threshold is crossed, the device is turned off (Mode=0)

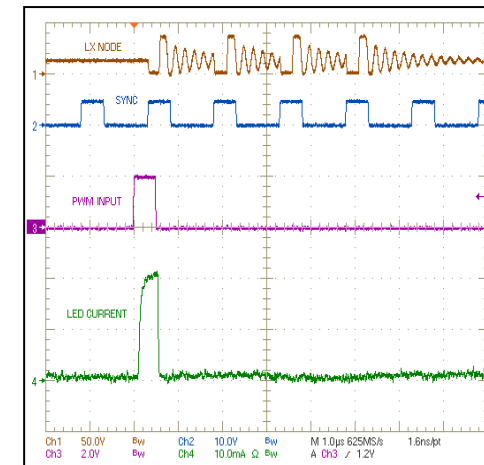


Detecting and managing faults in LED7706/7

20 µs dimming on-time



500 ns dimming on-time



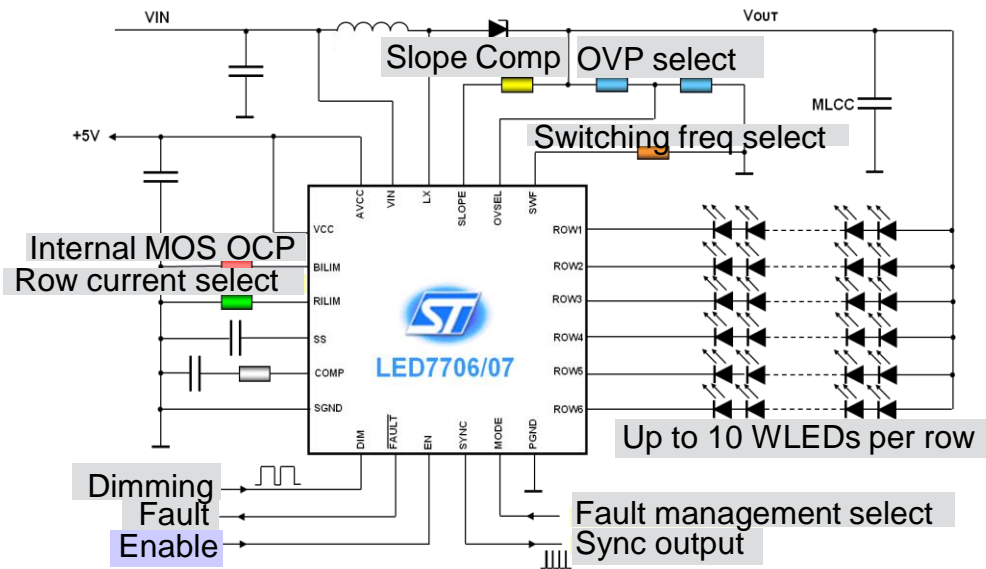
($f_{DIM} = 10 \text{ kHz}$, $D_{DIM} = 20\%$, $f_{SW} = 630 \text{ kHz}$, LED current = 20 mA)

Managing dimming waveforms in LED7706/7

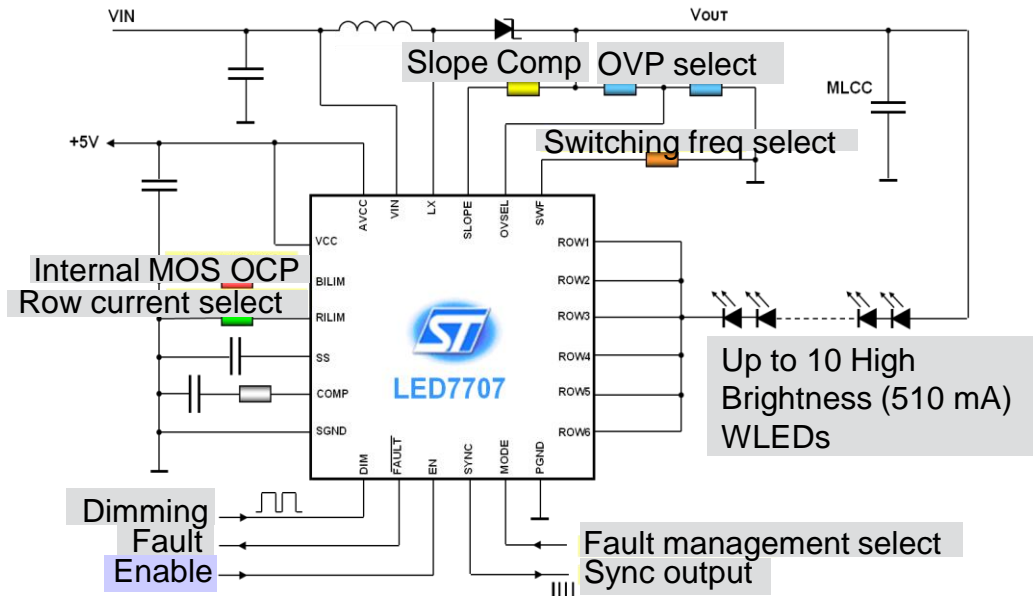
LED7706/7 LED driver application



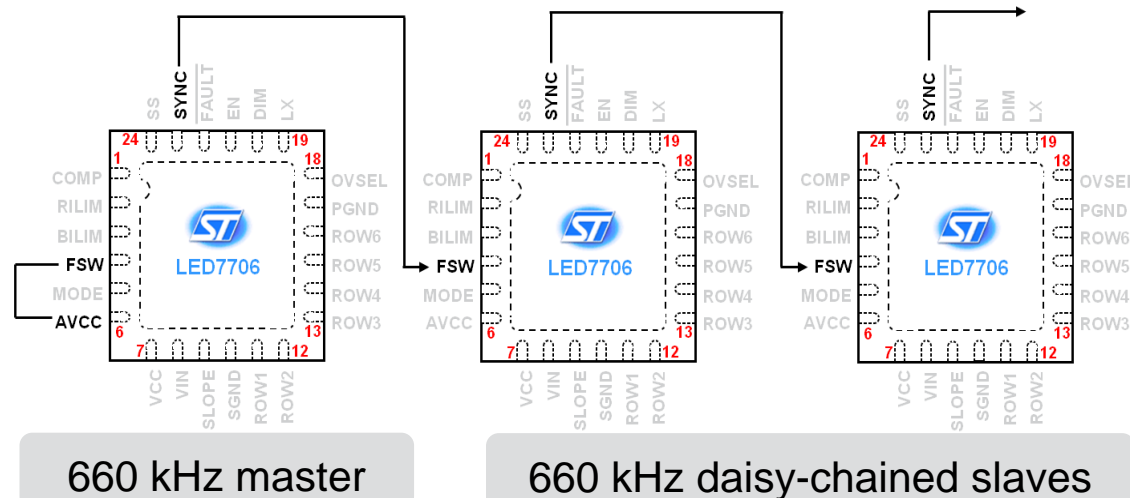
Examples



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 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 overvoltage protection
- Single ceramic output capacitor
- Non-latched thermal shutdown



STEVAL-ILL020V1



STEVAL-ILL021V1

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 μ s minimum dimming time at 1 kHz dimming frequency - LED7707
- $\pm 2.0\%$ current matching between rows
- LED failure (open and short circuit) detection

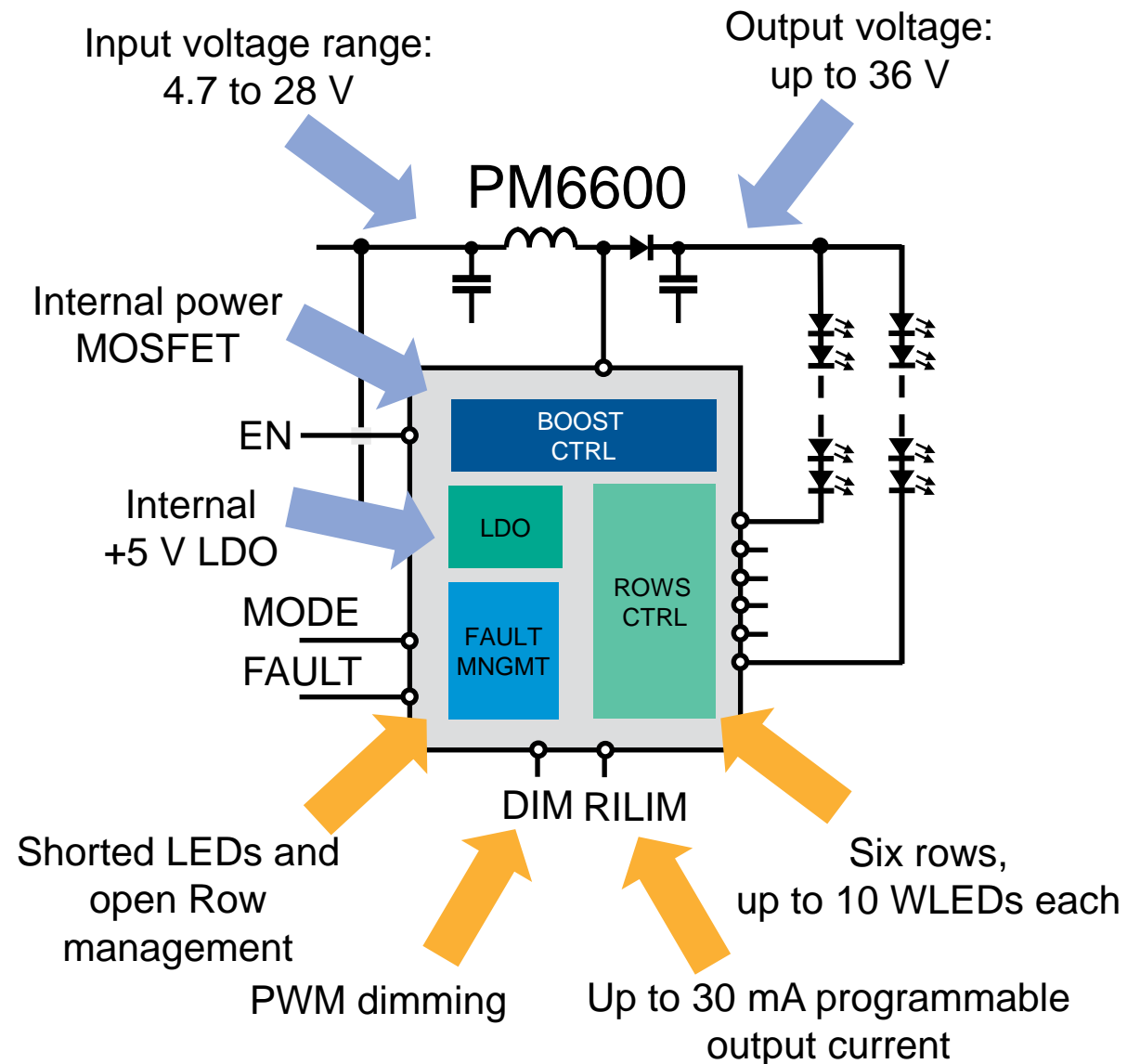
Part #	Evaluation board	Vin	Ioutmax	Description	App notes
LED7706	STEVAL-ILL020V1	4.5 to 36 V	20 mA per channel	LED driver with boost converter for LCD panels backlight	AN2809
LED7707	STEVAL-ILL021V1	4.5 to 36 V	60 mA per channel	LED driver with boost converter for LCD panels backlight	AN2810

PM6600 LED driver w/boost converter



■ Key features

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



PM6600 LED driver w/boost converter



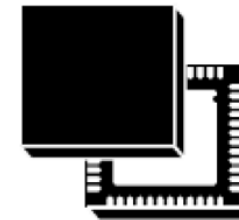
- Key benefits, typical applications and evaluation board

Key benefits

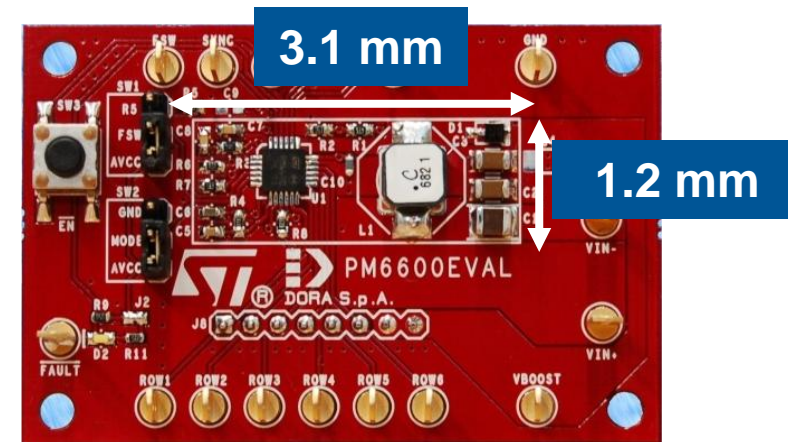
- Covers all mobile PC and netbook screen sizes (8" to 17")
- Superior brightness uniformity, with tight current matching
- Longer battery life with energy regulation compliancy (VESA-NEBL)
- Saves BOM cost, supporting MLCC output cap w/default values
- Space saving monolithic solution in 24-pin QFN4x4

Typical applications

- Notebook panels, netbooks, and netops
- Tablet PCs
- Battery/AC adapter supplied equipment



VFQFPN-24 4 x 4 mm²



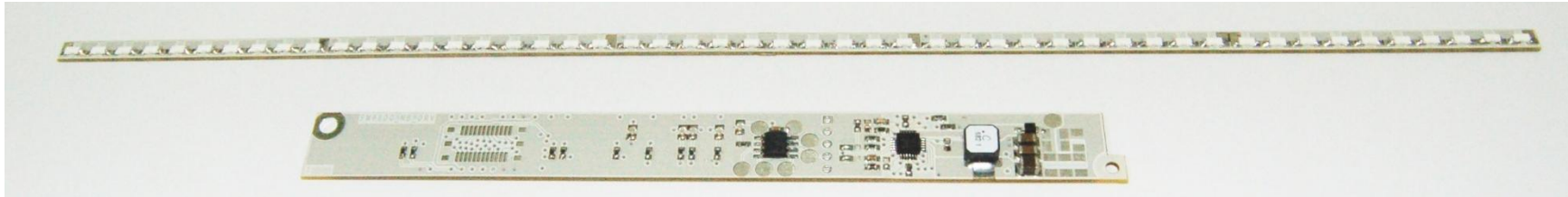
STEVAL-ISA056V1

Part #	Evaluation board	Vin	Ioutmax	Description
PM6600	STEVAL-ISA056V1	4.7 to 28 V	32 mA	6-row, 30 mA LED driver with boost

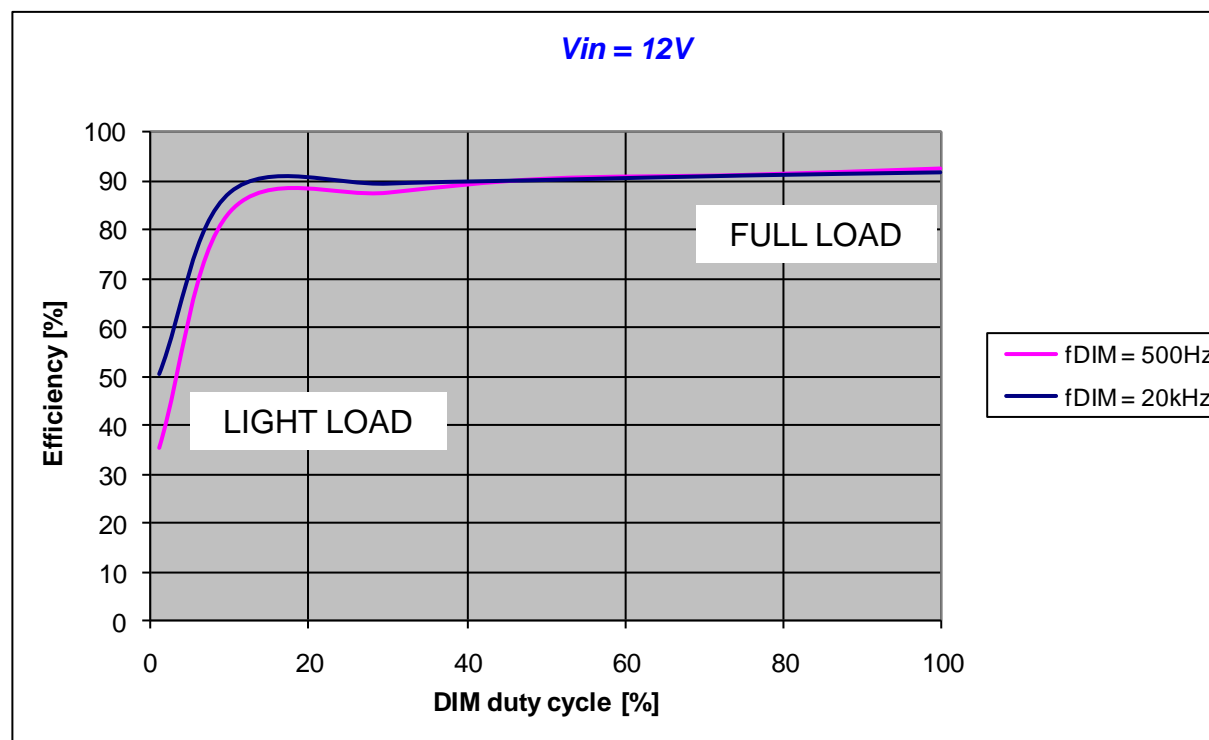
PM6600: higher efficiency – up to 93%



- WLEDs board + PM6600 save board space



- Save power in the whole dimming range



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

switching frequency: $f_{SW}=630\text{ kHz}$, $L=6.8\text{ }\mu\text{H}$

Driving LEDs using DC-DC converters



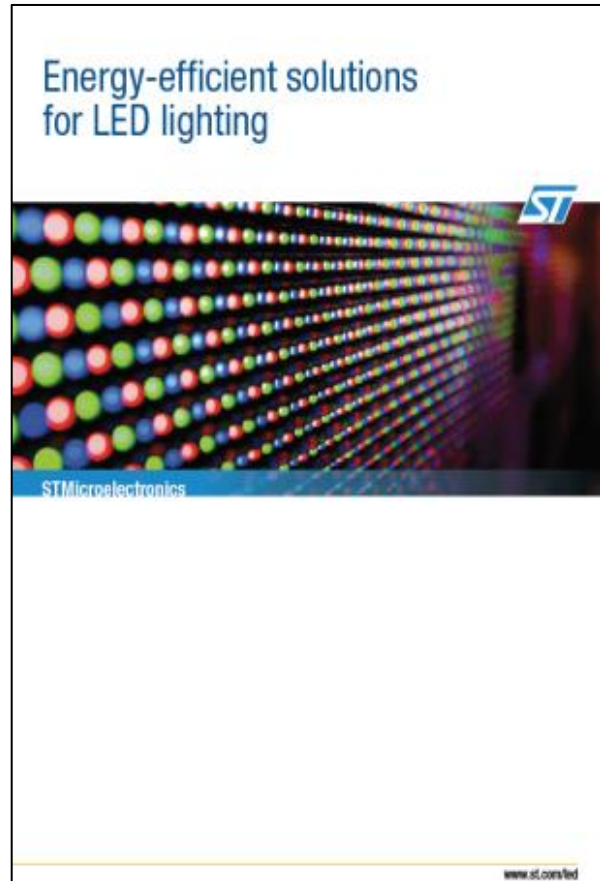
- Evaluation board summary

Part number	Order code	Vin	Ioutmax	Comments	AN
LED7706	STEVAL-ILL020V1	4.5 to 32 V	20 mA per channel	LED driver with boost converter for LCD panels backlight	AN2809
LED7707	STEVAL-ILL021V1	4.5 to 32 V	60 mA per channel	LED driver with boost converter for LCD panels backlight	AN2810
STLD40D	STEVAL-TLL001V1	3 to 5.5 V	up to 20 mA	White LED controller in boost topology	AN2333
PM6600	STEVAL-ISA056V1	4.7 to 48 V	32 mA	6-row, 30 mA LED driver with boost	TBD

st.com solutions for LCD backlighting



LED lighting brochure



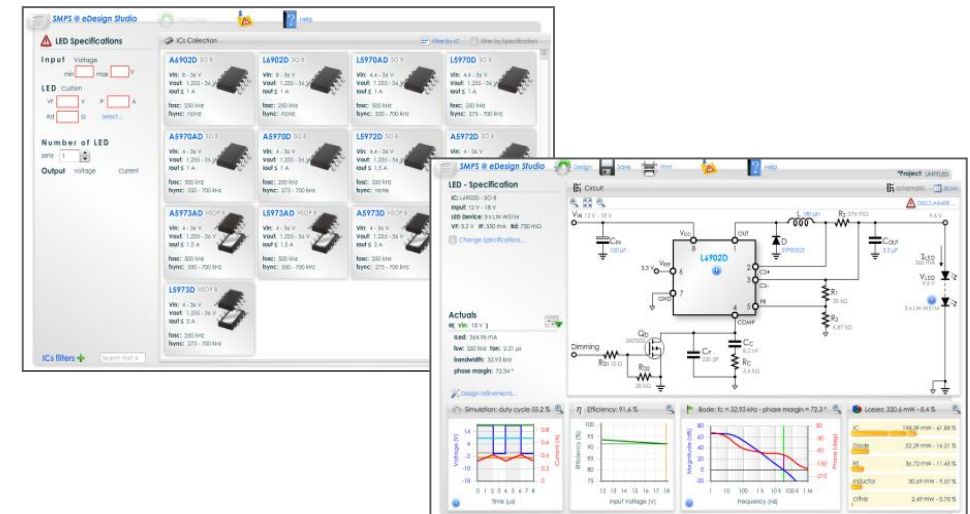
[http://www.st.com/internet/com/SALES_AND MARKETING_RESOURCES/MARKETING COMMUNICATION/MARKETING_BROCHURE/brlighting.pdf](http://www.st.com/internet/com/SALES_AND_MARKETING_RESOURCES/MARKETING_COMMUNICATION/MARKETING_BROCHURE/brlighting.pdf)

LED application web pages



<http://www.st.com/internet/com/segment/412.jsp>

eDesign Studio



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Thank you



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