Power conversion [2/2]

Lighting

Power and analog key program
• **Power conversion**
  
  - **SMPS**
    - Main topologies quick roundup
    - Power Factor Correction
    - PWM (offline & HV DCDC)
    - Low Voltage DC-DC Converters
  
  - **Lighting**
    - **Fluorescent ballast**
      - Analog driven
      - Digital driven / advanced
    - **HID**
    - **LED / DISPLAY DRIVER**
      - DC / DC driven
      - Offline driven
      - Display control
Analog driven ballast for fluorescent lamps:

- fully controlled pre-heating/ignition
- Relamp
- End-of-life
- PFC

in a single chip

- STTH106
- STTH306

STx3NK60Z
STx4NK60Z
STx6NK60Z
STx9NK60ZD
STD5NM60
STD4NK50ZD
STD5NK52ZD

L65585
L6561
L6562
L6563

L6569
L6571
L6574

STC03DE120
STC0DE150
Digital driven ballast for fluorescent lamps

- multipower system (lamp recognition)
- dimming (energy saving and ambient light)

---

**Input Filter**

**Power Factor Corrector**

**µC for ballast + PFC control**

**HV level shifter**

**TD220 and TD221**
- LS Driver
- TPR
- 3.3V/5V Supply

**Communication Interface**

**L6561**
- L6562
- L6563

**OR**

**ST7DALI**
- ST7FLite2
- ST7FLIT19B
- ST7FLite0

**L6382**
- L6384
- L6385
- L6386
- L6387
- L6388
Advanced digital driven ballast for fluorescent lamps

- multipower system (lamp recognition)
- dimming (energy saving and ambient light)

**L6382**

- Input Filter
- HV level shifter
  - HV start-up
  - \( \mu \text{C supply (3.3 or 5V)} \)
  - 2 LS drivers
- \( \mu \text{C feedback} \)
  - multipower system (lamp recognition)
  - dimming (energy saving and ambient light)

ST7DALI
ST7FLite2
ST7FLIT19B
ST7FLite0

Communication Interface
✓ PFC stage complete and reliable
✓ OVP* and feedback disconnection protection
✓ Anti choke saturation protection (allows the use of smaller PFC chokes)*
✓ Complete and independent programmability of frequencies and intervals*
✓ End of life*, rectification effect, capacitive mode and hard switching detection**
✓ Integrated bootstrap diode
✓ Shutdown pin*

* Updated Feature
** New Feature
PFC section: features

- **MULTIPLIER:**
  - sinusoidal reference
  - superior PF performance
  - Wide range-Mains operation optimized (THD optimizer)

- **ERROR AMPLIFIER**
  - Compensation network
  - E/A inverting input
  - Static OVP

- **ZCD network**
  - MULTIPLIER:
  - sinusoidal reference
  - superior PF performance
  - Wide range-Mains operation optimized (THD optimizer)

- **GATE DRIVER:**
  - 300mA source (typ)
  - 600mA sink (typ)

- **CURRENT SENSE:**
  - current mode control (1V clamp)
  - choke saturation protection*
  - leading edge blanking

- **"TM" type**

- **L6585DE**
  - Dynamic OVP
  - Feedback disconnection
  - IC shut down

- **AC MAINS HB INPUT**

- **Dynamic OVP**
  - Feedback disconnection
  - IC shut down

- **Current Sense:**
  - current mode control (1V clamp)
  - choke saturation protection*
  - leading edge blanking

- **Gate Driver:**
  - 300mA source (typ)
  - 600mA sink (typ)

* Updated Feature
** New Feature
HB Section: Normal Starting sequence

\[ I_{\text{PRE}} = \frac{1.328}{C_{\text{OSC}} \cdot (R_{\text{RUN}} || R_{\text{PRE}})} \]

\[ T_{\text{PRE}} = 4.83 \cdot \frac{C_D}{I_{\text{CH}}} + R_D \cdot C_D \cdot \ln \frac{4.63}{1.52} \]

\[ T_{\text{IGN}} = 3 \cdot C_{\text{IGN}} \cdot R_{\text{PRE}} \]

\[ f_{\text{RUN}} = \frac{1.328}{R_{\text{RUN}} \cdot C_{\text{OSC}}} \]
1. **Ignition**: Controlled lamp voltage/current
   - **Double threshold**:
     - **LOW (1.6V)**: frequency increasing and Fast Tch cycle timing (externally programmable) to limit the current in case of broken lamp or too old lamp. Noise immune overcurrent detection method is used.
     - **HIGH (2.75)**: IC stops immediately in case of capacitive mode caused by choke saturation.

2. **Run mode**: 3 levels Over-current protection
   - **Triple threshold**:
     - **LOW (0.9V)**: frequency increasing and Tch cycle timing to limit the current. Noise immune overcurrent detection method is used.
     - **MIDDLE (1.6V)**: IC stops immediately when a long (300ns) hard switching pulse is detected (Capacitive Mode protection – Lamp disconnection).
     - **HIGH (2.75)**: IC stops after 350 subsequent hard switching pulses (40ns) in order to prevent capacitive mode due to operation close to resonance.
HB Section: End of Life protection (EOL)

- Compliant with both standard ballast configurations without circuit change (using EOLP pin)
- Precise and programmable thresholds for the EOL intervention
- Filtering to delete noise effects
Support material

- Datasheet
- Demo board: STEVAL-ILB005V2
- IC Application Notes: AN2870 “Combo IC for ballast control”
- Developing software

**STEVAL-ILB005V2**
Start Window Highlights

- User Friendly Interface
- Many IC solutions available (Combo IC, L6574, L6569 or discrete)
- Most Used Lamp model available
- Three main input voltage range selectable
- Warm or Cold Ignition design
- PFC design
- Dimming feature (under development)
IPS & POWER CONVERSION - agenda

• **Power conversion**
  
  – **SMPS**
    • Main topologies quick roundup
    • Power Factor Correction
    • PWM (offline & HV DCDC)
    • Low Voltage DC-DC Converters
  
  – **Lighting**
    • Fluorescent ballast
      – Analog driven
      – Digital driven / advanced
  
  – **HID**
  
  – **LED / DISPLAY DRIVER**
    – DC / DC driven
    – Offline driven
    – Display control
HID lamps

• **Metal Halide (MHD)**
  – high efficacy,
  – excellent color rendition,
  – long service life, and
  – good lumen maintenance.
  – outdoor applications and in commercial interiors

• **High pressure sodium lamps (HPS)**
  – energy efficient.
  – yellow/orange light
  – extremely good lumens per watt.
  – poor colors render
  – exceptionally long service life (up to 40,000 hours)

• **Mercury Vapor Mercury**
  – Poor colors rendering
Ballast for high intensity discharge (HID) lamps

- half / full bridge configuration
- low frequency PWM (lamp resonance)
- lamp current control

Viper16/17

L6561, L6562A, L6563

L6384E, L6385E, L6386E, L6387E, L6388E

MOSFET (NM family)
IGBT (NC family)

ST7 µC FAMILY
Sales description

STEVAL-ILH001V1

**Documentation:** AN2747 on Internet

- Input voltage: 90 - 265Vrms
- PFC working in a fixed off-time mode
- Ballast efficiency higher than 90%
- Output stage: Full Bridge working in continuous conduction mode
- Lamp driven with low frequency (160Hz) square waveform
- Lamp current controlled by high frequency (40kHz) buck converter

**Key Products:**
- STF20NM50N
- STG10NB60SD
- L6385E
- L6562N
- VIPer12AS – E
- STP12NM50FP
- STTH806TTI
- STTH1L06
- ST7FLITE39F2M3

**Typical Applications:**
- Street Lighting
- Retail Lighting
- Warehouses
- Industrial Lighting

**Board Purpose:**
To show full electronic solution replacing magnetic ballast with better efficiency and feature set
70W HID Lamp Ballast based on L6569A and L6562A

Features:

- 50/60 Hz 88V ~ 264V wide input voltage range
- Easily drive of a 70W metal halide lamp
- PFC working in Fixed-On-Time.
- Two-stage topology
  - Warming up state for start-up
  - Illuminate in steady state
- Dual Buck-Converter solution
  - Lamp driven with low frequency (200Hz) HB buck converter
  - Lamp current controlled by high frequency HB buck converter
  - Load power control technique
- Ballast efficiency higher than 88%

Driver: L6385ED
IPS & POWER CONVERSION - agenda

• Power conversion
  – SMPS
    • Main topologies quick roundup
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  – Lighting
    • Fluorescent ballast
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    • HID
    • LED / DISPLAY DRIVER
      – DC / DC driven
      – Offline driven
      – Display control
How to control LED Light output

There are two basic principles how the light output of the LED can be controlled. Since the light brightness is proportional to the current, both methods are dealing with current regulation. The first and the easiest way is to control the LED current itself, with the principal sketch in Figure 1, where current is changed proportionally with the dimming signal. Disadvantage of this analog control is that there can be a significant change of color (wavelength difference could be several nanometers) in deep dimming (less that 10%). This potential disadvantage is compensated by a very simple control circuit (usually a simple potentiometer is enough).

Figure 1. Analog current control

Figure 2. Average current control by PWM

The second method is based on an average current control (digital control) as can be seen in Figure 2. The current is switched between zero and the nominal current with a frequency higher than 100Hz (to avoid flickering). The change of duty cycle and hence the average current change will be seen as a brightness change, because human eye reaction is slow enough to "integrate" the light output and it will not be noticed as a blinking.

This method avoids the color change problem, but on the other hand it needs more sophisticated control circuits (usually a microcontroller or another simple PWM generator).
PFC: even when LEDs are used, EN 61000-3-2 is valid for LED-Lighting too!

=> At output power $\geq 25$W only with active PFC (Power Factor Correction) is this norm achievable.
Solution for Color LED displays based on STP24DP05 and STM32

Advanced display LED array drivers, control and reference designs
Application examples

**Signs**
- Full-color
- Monochrome

**Signals**
- Traffic
- Other

**Automotive**
- Automobile exterior (stop/tail/turn lights)
- Automobile interior (instrumental panel and dashboard)
- Truck and bus exterior

**Display backlighting**
- PDAs, MP3 players and digital camera backlight
- Mobile phones displays
- Keyboard backlight
- Other displays

**Specialty illumination**
- Flashlights, headlights
- Architectural and design lighting
- Emergency lighting
- Water features and pools

**Home Appliance**
- System Indicator lights

**Advertising**
- Information panels
- Special light effects in shop windows

**Industrial application**
Applications for LED Display Drivers

Color LED displays, panels and signs
- Colored traffic signs
- RGB lighting for gaming and gambling machines
- RGB LED matrix displays
- LED advertisement billboards
- Graphic boards
- Variable message signs
LED Array
Big panel, LED display, Traffic signs,…

Switch Mode Power Supply → DC Bus → Current Control and Driver → LED Displays

- Viper Family Current Mode CPWM Controller
- Microcontroller ST7, STM8S, STM32
- STP04CM05
- STP08CP05
- STP08DP05
- STP16CP05
- STP16DP05
- STP16CPS05
- STP24DP05
LED array sink drivers

Features:

• Low voltage power supply 3.0 to 5.5V
• Voltage capability at Outputs: 20V
• 4, 8, 16, 24 constant current output channels
• Adjustable output current through external resistor
• Serial data in / parallel data out
• Serial out changes state on the raising edges of clock
• Up to 30MHz clock frequency
• 3.3V micro driver-able
• Output current 3 – 500mA (depending on type of STPxxyy05)
• Thermal protection
• Auto Power save at STPxxCPS05
• LED failure detection at STPxxDP05
• Available in high thermal efficiency TSSOP exposed PAD
<table>
<thead>
<tr>
<th>Part</th>
<th>Vin [VDC]</th>
<th>Iout [mA]</th>
<th>Vout [VDC]</th>
<th>No of channel</th>
<th>Remark</th>
<th>Ref Design</th>
<th>App Note</th>
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<tbody>
<tr>
<td>STP04CM05</td>
<td>3.3 to 5.5</td>
<td>50 to 500</td>
<td>16</td>
<td>4</td>
<td>SPI; dimmable current sink, PWM dimming, thermal protection</td>
<td>STEVAL-ILL009V1 STEVAL-ILL009V3 STEVAL-ILL009V4</td>
<td>AN2531</td>
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<tr>
<td>STP08CP05</td>
<td>4.5 to 5.5</td>
<td>5 to 100</td>
<td>20</td>
<td>8</td>
<td>SPI; dimmable current sink, thermal protection</td>
<td>(STEVAL-ILL003V1) (STEVAL-ILL003V2)</td>
<td>AN2141</td>
</tr>
<tr>
<td>STP08DP05</td>
<td>3.3 to 5.5</td>
<td>5 to 100</td>
<td>20</td>
<td>8</td>
<td>error detection; SPI; dimmable current sink, thermal protection</td>
<td>STEVAL-ILL002V(1)/3 STEVAL – ILL002V(2)/4</td>
<td>AN2415</td>
</tr>
<tr>
<td>STP16CP05</td>
<td>4.5 to 5.5</td>
<td>5 to 100</td>
<td>20</td>
<td>16</td>
<td>SPI; dimmable current sink, thermal protection</td>
<td>STEVAL-ILL003V(1)/2</td>
<td>AN2141</td>
</tr>
<tr>
<td>STP16CPS05</td>
<td>4.5 to 5.5</td>
<td>5 to 100</td>
<td>20</td>
<td>16</td>
<td>SPI; dimmable current sink, thermal protection Auto Power Save</td>
<td>STEVAL-ILL003V(1)/2</td>
<td>AN2141</td>
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<tr>
<td>STP16DP05</td>
<td>3.0 to 5.5</td>
<td>5 to 100</td>
<td>20</td>
<td>16</td>
<td>error detection; SPI; dimmable current sink, thermal prot</td>
<td>STEVAL-ILL015V1</td>
<td>AN2141</td>
</tr>
<tr>
<td><strong>STP24DP05</strong></td>
<td><strong>3.0 to 5.5</strong></td>
<td><strong>5 to 100</strong></td>
<td><strong>20</strong></td>
<td><strong>16</strong></td>
<td><strong>error detection; SPI; 3 current source values, dimmable current sink, thermal prot</strong></td>
<td><strong>STEVAL-ILL015V1</strong></td>
<td><strong>AN2141</strong></td>
</tr>
<tr>
<td>STPIC6A259</td>
<td>4.5 to 5.5</td>
<td>350</td>
<td>33</td>
<td>8</td>
<td>SPI; Automotive</td>
<td></td>
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<tr>
<td>STPIC6C595</td>
<td>4.5 to 5.5</td>
<td>250</td>
<td>33</td>
<td>8</td>
<td>SPI; Automotive</td>
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<td></td>
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<tr>
<td><strong>M5450x / M548x</strong></td>
<td><strong>4.75 to 13</strong></td>
<td><strong>25</strong></td>
<td><strong>13</strong></td>
<td><strong>34 / 35</strong></td>
<td><strong>Adjustable current sink</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
STP24DP05
Limitation on current solutions for full-color Display

Complicated PCB routing
Advantages of 24-channel solution

- RGB grouping
- Individual current setting for each color channel

STP24DP05

24-bit Shift Register
Constant Current Drivers

Thermal Shut-Down

Individual current setting for each color channel
STP24DP05 Basic Features

Key Features
- Accept 3.3v and 5v micro driver
- 8 x 3 Channel groups of constant current output channels
- Adjustable output current through one external resistor for each group of 8-channel
- Short and Open Output Error Detection via SPI and flag pin
- Serial Data IN / Parallel Data OUT
- SPI Serial Interface
- Gradual Output Delay
- Thermal Shutdown with flag pin
- Excellent Current Accuracy
- Output Current: 5-80mA
- 25MHz Clock Frequency

TQFP48
Purpose of Reference Designs of LED Array

- Aimed to customers working on applications with high number of low power LEDs
  - either color or monochromatic
- **Open software architecture - easily integrates Demo**
  - USB and JTAG programming connectivity to use the board as a simple development tool
- **Gerber Files, PC Software,... : available**

- **Here as example : STEVAL-ILL015V1**
  - 6-rows 30mA LEDs driver with buck regulator
  - Applications: Indoor or outdoor use, LED advertisement billboards, Graphic boards, Colored traffic signs, Variable message signs…
  - Key Products: STP24DP05, STM32F103, ST1S10
  - Documentation: AN2841, UM0574 & UM588 published
Firmware modes:
• 8-bit resolution mode for each color → 16 million colors demonstration
• Animated text menu:
  Simple game, Wave color demo, Solid color demo, LED diagnostic

Software features:
• USB interconnection, Virtual comport driver used
• LED diagnostic during any running firmware demo
• Demoboard firmware mode control by on-screen buttons instead of on-board buttons
Functionality #2 - LED dimming using shift registers

Shift Register LED Driving Principle

Cascading Principle

Application Know-how
Example for 4-channels – 8bit resolution dimming

Output 1

4% Duty Cycle

Output 2

14% Duty Cycle

Output 3

3% Duty Cycle

Output 4

99% Duty Cycle

256 LEVELS

1111 or new data

DATA

1111

1101

0101

0001

0000

T_{SW\_PWM}
STEVAL-ILL015V1
Functionality #2 - LED dimming using shift registers

Look-up table
PWM waveforms for each LED stored in RAM

RAM

SPI

LED Driver

---

Data

CLK

LE

time

time

buffer1

buffer2
Make the designer’s life easier!

Library key features:

- source files for **STM32** and **STM8**
- peripheral pre-setting (timer, DMA, SPI) to requested values
- timer running on background (interrupt (STM8) or interrupt + DMA (STM32))
- simple addition of customer foreground and background tasks
- brightness and color of each LED defined by three (R, G, B) variables
Functionality # 3: Output Error Detection

Case One: LED Shorting
Case Two: LED Shorting
Case Three: Short To GND or Vo

Vo=LEDs voltage supply

Normal Mode Serial Data

Entering in Error Detection Mode Serial Data

Normal Mode Serial Data

OR

Error Detection Serial Data Result
Tools and Documents

• Reference Design STEVAL-ILL015V1
• Application Note: AN2841
• User Manuals:
  – UM0574 HW
  – UM0588 C Firmware library
• Datasheets
  – STP24DP05
  – STM32F103
  – ST1S10
**STP16CPS05: Autoshutdown functionality:**
A hypothetical case...

- $I_{DD\ (ON)} = 11.7\text{mA (typ)}$
- $I_{DD\ (Shut-down)} = 100\text{uA (typ)}$

$I_{CC\ (SHUT-DOWN)}$ is **117 times less** than $I_{CC\ (ON)}$

### Power Savings – An example
- LED panel size: $10\text{m} \times 5\text{m}$
- Estimated number of LED Drivers: $10,000\text{ pcs}$
- LED drivers active at any one time: $\sim 20\%$

- **✗** Using std LED driver → All 10,000 will consume high current (approx 117 A)
- **✓** Using STP16CPS05 → Only 2,000 will consume high current (approx 23 A)

**Power savings using STP16CPS05 is $\sim 80\%$**
32 LED array evaluation board (without diagnostic) based on advanced logic STP16CP05 and STP16CPS05

Features:
• 32 LED Matrix is driven
• Adjustable Brightness
• Led current regulation
• Adjustable blinking speed
• Different blinking modes
• Animated text
• Input voltage from 5V to 35V
• DC/DC Pre-regulator for high efficiency

Key Products:
✓ STP16CP05
✓ STP16CPS05
✓ ST7FLITE09
✓ L5970D
✓ L78L33

Typical Applications:
✓ LED Information Panels
✓ LED Displays
✓ Traffic Signs
✓ Signals
✓ Decorative Lighting
✓ Home Appliances (White Goods)

Documentation:
AN2141

STEVAL-ILL003V2
40 LED array evaluation board (with diagnostic) based on advanced logic STP08DP05

**Features:**
- 40 OSRAM BLUE LED Matrix is driven
- Open and Short Line error detection
- Adjustable Brightness
- Led current regulation
- Adjustable blinking speed
- Different blinking modes
- Animated text
- DC/DC Pre-regulator for high efficiency

**Key Products:**
- ST7FLITE
- STP08DP05
- ST232
- L5970D

**Documentation:** AN2141, AN2415, AN2478

**STEVAl-ILL002V3**

**Typical Applications:**
- LED Information Panels
- LED Displays
- Traffic Signs
- Signals
- Decorative Lighting
- Home Appliances (White Goods)

**OSRAM LEDs**
40 LED array evaluation board (with diagnostic) based on advanced logic STP08DP05

Features:
- 40 TOSHIBA GREEN LED Matrix is driven
- Open and Short Line error detection
- Adjustable Brightness
- Led current regulation
- Adjustable blinking speed
- Different blinking modes
- Animated text
- DC/DC Pre-regulator for high efficiency

Documentation: AN2141, AN2415, AN2478

Key Products:
- ST7FLITE
- STP08DP05
- ST232
- L5970D

Typical Applications:
- LED Information Panels
- LED Displays
- Traffic Signs
- Signals
- Decorative Lighting
- Home Appliances (White Goods)

Vishay LEDs
AC/DC single package drivers
VIPer+ with minimum stand-by consumption
Offline LED Driver
Illumination, Architectural Lighting, General Lighting

- Peak Clamp: PKC-136
- Ultra fast 200V, 300V, 400V diodes

- Viper Family: Viper12/22A, Viper17 (+), Viper27 (+), Viper53
- TSM family: TSM101, TSM102, TSM103, TSM104
- N-Channel MOSFET
- Current Mode PWM Controller
- Quasi-Resonant Controller

- Offline Isolated Solution

Application notes:
AN1916, AN2042, AN2067, AN2011, AN1059, AN1060
# Offline LED Driver

- Illumination
- Architectural & design lighting
- Emergency lighting
- Water features and pools

<table>
<thead>
<tr>
<th>INPUT</th>
<th>OUTPUT</th>
<th>Main ST-Parts</th>
<th>Remark</th>
<th>Ref Design</th>
<th>App Note</th>
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<tbody>
<tr>
<td>Vin [VAC]</td>
<td>lout [mA]</td>
<td>Vout [VDC]</td>
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<td></td>
<td></td>
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<tr>
<td>90 to 264</td>
<td>350</td>
<td>3.0 to 15</td>
<td>VIPer12A &amp; TSM103</td>
<td>Insulated output constant current source</td>
<td>STEVAL-ILL005V1</td>
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<tr>
<td>90 to 264</td>
<td>350</td>
<td>6.0 to 27</td>
<td>VIPer22 &amp; TSM103</td>
<td>Insulated output constant current source</td>
<td>STEVAL-ILL006V1</td>
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<td>85 to 135 or 185 to 265</td>
<td>350</td>
<td>3.5 to 28</td>
<td>VIPer22 &amp; TSM104</td>
<td>Insulated output Dimmable current source</td>
<td>STEVAL-ILL001V1</td>
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<td>176 to 264</td>
<td>500</td>
<td>3.5 - 7(max) *</td>
<td>Viper17 &amp; TSM103W</td>
<td>non-insulated Constant current source</td>
<td>STEVAL-ILL017V1</td>
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<td>82 to 265</td>
<td>200 to 1000</td>
<td>5 to 40</td>
<td>VIPer53 &amp; TSM101</td>
<td>Insulated output Dimmable current source</td>
<td>Schematic and layout</td>
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<tr>
<td>90 to 265</td>
<td>Up to 700</td>
<td>Up to 48</td>
<td>L6562A &amp; TSM1052</td>
<td>Insulated PFC &amp; current source</td>
<td>EVL6562A-35WFLB</td>
</tr>
<tr>
<td>88 to 265</td>
<td>350 or 700 or 1000</td>
<td>Up to 48</td>
<td>L6562A &amp; HV-Pwr MOSFETs &amp; rectifier</td>
<td>80W LED Driver Non–insulated SMPS: PFC &amp; Modified Buck</td>
<td>STEVAL-ILL013V1</td>
</tr>
</tbody>
</table>

* Limited Vout in STEVAL-ILL017V1, VIPer17 can provide also up to 15V and 350mA
Low Power Offline LED Driver Topologies

• **Buck converter**
  – Q1 at high side requires a floating gate-drive
  – Inherent L-C filter provides low ripple current
  – Very short duty cycle with big Vin to Vout ratio

• **Modified or inverted buck converter**
  – Q1 at low side, the gate-drive is referred to ground
  – Vout is referred to high side
  – Inherent L-C filter provides low ripple current
  – Very short duty cycle with big Vin to Vout ratio

• **Flyback converter**
  – Flyback transformer is required. It also provides bias for Q1 & Vaux for PWM controller
  – Low input current and optimized duty cycle also with big Vin to Vout ratio
VIPer22A Application Example

Application described in AN1916

- Isolated flyback configuration
- Constant current output (350mA)
- Output voltage from 5.7V to 27V
- 8 LEDs can be driven with 350mA output current (Vf = 3.4V)

VIPer22A LED DRIVER

<table>
<thead>
<tr>
<th>Vin =90V</th>
<th></th>
<th>Vin =264V</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.6</td>
<td>9.2</td>
<td>358</td>
</tr>
<tr>
<td>15.6</td>
<td>24</td>
<td>359</td>
</tr>
<tr>
<td>19.5</td>
<td>29.5</td>
<td>360</td>
</tr>
<tr>
<td>22.9</td>
<td>35</td>
<td>360</td>
</tr>
<tr>
<td>25.2</td>
<td>38</td>
<td>360</td>
</tr>
<tr>
<td>27.3</td>
<td>41</td>
<td>361</td>
</tr>
</tbody>
</table>

Evaluation Board: STEVAL-ILL006V1
Dimmable Evaluation Board: STEVAL-ILL001V1
2W not-insulated Offline Constant Current LED driver
- The PCB dimension is important
- No line isolation is required

The specification is as following

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC input</td>
<td>220 VAC +/- 20%</td>
</tr>
<tr>
<td>Output current</td>
<td>500 mA</td>
</tr>
<tr>
<td>Output voltage</td>
<td>7 VDC maximum</td>
</tr>
<tr>
<td>Dimension</td>
<td>30 mm x 30 mm</td>
</tr>
<tr>
<td>Isolation from mains</td>
<td>Not required</td>
</tr>
<tr>
<td>Topology</td>
<td>Constant current source</td>
</tr>
</tbody>
</table>
STEVAL-ILL017V1: Miniature size
• Not isolated (common ground)
• R9 & R12, the output-current sensing resistor
• R7 & C7 compensation circuit of U2 in order to drive Q1 properly
• Bridge R10 & R11 to provide 0.3V reference from Vref in pin 3 of U2
• Q1 the buffer stage to feed signal to U1
STEVAL-ILL017V1: Load efficiency and standby power

- Efficiency [%]
  - 1 LED
  - 2 LEDs

- Standby Power [W]

Graphs showing efficiency and standby power vs. Vin [V].
- VIPER17HN
  - Offline high voltage converter (115 KHz)
- TSM103W
  - Dual operational amplifier and voltage reference
- STPS2H100A
  - Power Schottky rectifier
- STTH1R06A
  - Turbo 2 ultrafast high voltage rectifier
- BAT46JFILM
  - Small signal Schottky diode
- AN2811
  - Application note of STEVAL-ILL017V1
More application fields

- Applicable fields
  - Fridge / Refrigerator
  - Night light for indoor use
  - Guiding indicator
Concept is based on the capability of modulating the Input Current according the mains voltage; it is done thanks to the Viper Current limit internal circuit and to the external resistor divider composed by $RH$ and $RL$ connected between the input, CONT pin and ground.

Input capacitor, $C_2$, is ceramic and only 10 nF.
The three figures show input and output voltage and current obtained from the schematic described in the previous page used to supply 3x1 W series Led.

Vin = 180 Vac  
PF = 0.944

Vin = 230 Vac  
PF = 0.917

Vin = 265 Vac  
PF = 0.882
AC/DC high efficient solutions for general lighting and street lighting
Offline LED Driver (Non-/Isolated)
Illumination, Architectural Lighting, General Lighting

Ultra fast 200V, 300V, 400V diodes
Peak Clamp
PKC-136

Current Mode PWM Controller
Quasi-Resonant, TM PFC Controller
Resonant Controller

N-Channel MOSFET
Viper Family
Viper12A
Viper22A
Viper53
Viper17

TSM family
TSM101
TSM102
TSM103
TSM104

Application notes
AN2838
UM0670
L6565 Quasi Resonant Controller

- Current mode quasi resonant PWM controller
- Micropower start-up current (< 75 uA)
- Low quiescent current (3 mA typ.)
- ZCD input for QR operation
- Frequency foldback function
- Line voltage feedforward function
- Pulse-by-pulse overcurrent protection
- 2nd overcurrent level with latched shutdown
- Disable function
- Internal current sense RC filter
- Package: SO-8 / Minidip8

For LED application it is used as a standard fly-back converter with current regulator on the secondary side (e.g. with TSM10xW )
L6562AT PFC Controller

- Guaranteed for extreme temp range (outdoor – Streetlighting)
- Transition-Mode controller of PFC
- Proprietary Multiplier for min THD
- Micropower start-up current (< 30 uA)
- Low quiescent current (2.5 mA typ.)
- ZCD input for TM operation
- Very precise adjustable output OVP
- 1% internal reference
- On Chip Filter on current sense
- Pulse-by-pulse overcurrent protection
- Disable function
- Internal current sense RC filter
- Package: SO-8 / Minidip8

For LED application it is used as a standard fly-back converter with current regulator on the secondary side (e.g. with TSM10xW)
Modified buck (step-down)

- Suitable for applications
  - not isolated
  - not requiring PF
  e.g. emergency light, traffic light...
- MOS referred to ground and not to $V_{IN}$
  (low voltage driver)
- Open loop operation
  (frequency accuracy required)
- Working range:
  $nV_{LED} < V_{IN(MIN)}$
- $D = nV_{LED} / V_{IN}$
L656x Application
Modified Non-Isolated Buck Controller for LED Supply

- Flexible Number of LEDs IN SERIES (eg. 30 x 1W GOLDEN DRAGON)
- E.g. Vin = 110Vac or 230V
- Measured efficiency ~ 90% (but application fine tuning is still necessary, e.g. MOS, DIODE)

![Diagram of L656x Application](image)

GREEN: LED CURRENT
BLUE: SENSE RESISTOR VOLTAGE
Non-Insulated Offline LED Driver for Fashionable Lighting (1/2)

Input:
- Active PFC
- Wide input voltage range (88 – 264VAC)

Output:
- Current source 350, 700mA, 1000mA adjustable mean value
- Output power 80W
- Max current ripple ±100mA
- Dimmable 0 – 100%

Dimension
- 60 x 130 x 27 mm

Efficiency (prototype)
- ~90%
Non-Insulated Offline LED Driver for Fashionable Lighting (2/2)

PFC for >25W Input

STEVAL-ILL013V1 Demoboard on stock May

Offline LED Driver
L6562A Insulated High PF AC/DC LEDs Driver 35W

**EVL6562A-35WFLB**

**AN2838**

New

- Line voltage range: 90 to 265 Vac
- Minimum Line frequency \(f_L\): 47-63 Hz
- Regulated output voltage: 48V
- Rated output power: 35 W
- Power Factor (Load ≥ 50%): 0.9 minimum
- Minimum efficiency: 85% at full load
- Maximum \(2f_L\) output voltage ripple: 1.5V pk-pk / 0.39 Vrms \((@V_{in}=90\text{ Vac}, P_{out}=35\text{ W})\)
- Maximum ambient temperature: 50 °C
- Conducted EMI: In acc. with EN55022 Class-B
- Surge rejection: Surge Test 2.5kV
- Primary to secondary insulation: 4 kV
- PCB type and size: Double Side, 35 um, FR-4, 120 x 82 mm
L6562A Insulated High PF AC/DC LEDs Driver 35W
• **L6562A in fly-back topology addresses medium power LED applications offering:**
  – *Cheap and flexible Insulated Single Stage conversion*
  – *PF greater than 0.9*
  – *NO electrolytic input capacitor*
  – *NO electrolytic output capacitor if its value allows the use of ceramics*

• **Key Components:**
  – *L6562A(T), TSM1052, STP5NK80ZFP, STTH1L06, STTH3R02*

• **Tools:**
  – *EVL6562A-35WFLB (voltage output can be expanded to Curr Ctrl)*
  – *AN2838*
New trend for High power Street lights is based on LEDs due to:

- reliable and safe
- technically advanced
- economical
- environmentally friendly
- convenient for maintenance
- save energy
- improve light quality
Comparison Lighting Quality with LED and HPS lamps

Source: Osram Opto Semiconductor
Comparison Lighting Quality with LED and HPS lamps

New LED lamp

Old HPS lamp
Current solutions in the market are facing some main bottlenecks:

- **Life time of the solution**: after 1.5 years a lot of failures in LED and power supplies. One of the most critical components in the power supply is the E-CAP.

- **Wide range of temperature operation**: still a lot of problems in sustaining adverse weather operating conditions and power dissipation

- **Market maturity**: This business has a very high potential but it is still in the demand creation phase and waiting for the adoption form local governments.
ST addresses all these bottlenecks with a solution based on PFC+LLC.

- PFC L6562AT
- LLC L6599AT

ac mains 85–305 Vac

48 V/130W

L6562AT and L6599AT are guaranteed over -40 to +125 degrees making them suitable for reliable power supply with very aggressive form factor easily fitting all the current street lamp solutions.
Schematic of Streetlighting PFC + Resonant Circuit

Suitable for 120W Streetlighting, sizeable to 250W
Streetlighting PFC + Resonant Circuit

• **Key components:**
  – PFC L6562AT
  – Resonant Controller L6599AT
  – MOSFETs: STP21NM50N, STP8NM60N
  – Ultrafast Diode: STTH3L06U
  – Schottky Diodes: STPS1015DCG

• **Tools:**
  – Reference board in design
  – AN in preparation
Switching DC/DC up to 2.8A supply and control for general lighting and automotive
# Low Voltage LED-Driver

Where $\text{Vin} < \text{V(LED)}$ use **Step Up** topology*. Where $\text{Vin} > \text{V(LED)}$ use **Step Down** topology*.

<table>
<thead>
<tr>
<th>Input [VDC]</th>
<th>Output [VDC]</th>
<th>ST-Part</th>
<th>Remark</th>
<th>Ref Design</th>
<th>App Note</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vin</strong></td>
<td><strong>Vout</strong></td>
<td><strong>Iout</strong> [mA]</td>
<td><strong>ST-Part</strong></td>
<td><strong>Remark</strong></td>
<td><strong>Ref Design</strong></td>
</tr>
<tr>
<td>2.5 to 5.0</td>
<td>Up to 18.5</td>
<td>20 40</td>
<td>L6920</td>
<td>Step up current control</td>
<td>STEVAL-TLL001V1</td>
</tr>
<tr>
<td>0.6 to 5.5</td>
<td>2 to 5.2</td>
<td>500</td>
<td>LED7706 LED7707</td>
<td>1 x Step up; 6 x linear current sink, dimmable</td>
<td>EVALED7706 EVALED7707</td>
</tr>
<tr>
<td>4.5 to 36</td>
<td>Up to 36</td>
<td>6 X 30 6 X 85</td>
<td>L6920</td>
<td>Step up current control</td>
<td>STEVAL-ILL008V1</td>
</tr>
<tr>
<td>8.0 to 18</td>
<td>2.5 to 14</td>
<td>1000-2800</td>
<td>L6726+ STS8DNH3LL</td>
<td>Step down current control dimmable</td>
<td>STEVAL-ILL023V1</td>
</tr>
<tr>
<td>8.0 to 36</td>
<td>1.235 to 34</td>
<td>1000</td>
<td>L6902</td>
<td>Step down current control dimmable</td>
<td>STEVAL-ILL010V1</td>
</tr>
<tr>
<td>4.4 to 36</td>
<td>1.2 to 35</td>
<td>2500</td>
<td>L5973</td>
<td>Step down current control</td>
<td>STEVAL-ILL007V1</td>
</tr>
<tr>
<td>8.0 to 55</td>
<td>3.3 to 50</td>
<td>1000</td>
<td>L4976</td>
<td>Step down current control</td>
<td>STEVAL-ILL014V1</td>
</tr>
<tr>
<td>e.g. 100</td>
<td>&lt;Vin</td>
<td>e.g. 700</td>
<td>L6562 + PowerMOS</td>
<td>Modified Buck. Vin; Vout; Iout depend on PowerMOS mainly</td>
<td>Schematics available</td>
</tr>
</tbody>
</table>

## Linear current source

<table>
<thead>
<tr>
<th>Input [VDC]</th>
<th>Output [VDC]</th>
<th>ST-Part</th>
<th>Remark</th>
<th>Ref Design</th>
<th>App Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5 to 40</td>
<td>4.5 to 40</td>
<td>500 1500 2000</td>
<td>STCS05 STCS1 STCS2</td>
<td>Linear constant current source. PWM dimming up to 50kHz</td>
<td>STEVAL-ILL014V1</td>
</tr>
</tbody>
</table>

* for buck/boost ref. AN1891 and AN1518
Step-down topology
Signage, Torch, portable lighting

**Power Schottky Diode**

**Monolithic Step-down Synchronous Regulator**

- L6902
- L597X
- L497X
- ST1S10

- L6925
- L6926

Application notes:
- AN1891
- AN1941
- AN 2129
L6902D and Automotive A6902
Up to 1A switching regulator, with adjustable current limit

- Step-down switching regulator
- Up to 1A output current
- 5% output current accuracy
- Adjustable current limit
- Thermal shutdown
- 250KHz internally fixed frequency
- Precise 3.3V (±2%) reference voltage
- Operating input voltage from 8V to 36V
- Output voltage adjustable from 1.235V to 34V
- Protection against feedback disconnection
• Designed for 350mA LEDs
• Easily modification for higher current
• Fully dimmable board
• Analog dimming
• Digital (PWM) dimming
• Maximum output voltage limited
• 5 LEDs can be driven with 700mA output current (Vf = 4.4V)
• 6 LEDs can be driven with 350mA output current (Vf = 4V)

• Reference Documentation : AN 2129

More LED applications in AN 1891, AN 1941
L597x Family
Step down switching regulator

- 4.4V to 36V input voltage
- Internal P-channel DMOS transistor (with a typical $R_{ds}$ on of 250mΩ).
- adjustable output from 1.25V
- 250kHz or 500kHz internally fixed frequency
- 3.3V reference available (L5972D)
- Inhibit for zero current consumption (except L5972D)
- Internal current limiting
- Protection against feedback disconnection
- Thermal shutdown and Synchronization

**L5970D**
1A switch in SO8

**L5970AD**
1A Switch in SO8
500kHz switching frequency

**L5972D**
2A switch in SO8 (4 ground leads)

**L5973D**
2.5A switch in HSO8

**L5973AD**
2A switch in HSO8
500kHz switching frequency
L597x Application Schematic

Circuit for driving up to 6 LEDs

<table>
<thead>
<tr>
<th>Efficiency</th>
<th>1 LED</th>
<th>2 LEDs</th>
<th>3 LEDs</th>
<th>4 LEDs</th>
<th>5 LEDs</th>
<th>6 LEDs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vin=12V</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iout=350mA</td>
<td>76%</td>
<td>89%</td>
<td>93.5%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vin=18V</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iout=350mA</td>
<td>83.5%</td>
<td>90%</td>
<td>95%</td>
<td>90%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vin=24V</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iout=350mA</td>
<td>86.5%</td>
<td>90%</td>
<td>94.5%</td>
<td>97.5%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Application described in AN 1891
• LED bulb based on halogen MR16.
• Solution has very small footprint.
• ST’s solution uses the L5970.
• This board is intended to work with a 12V\textsubscript{AC} input (works 4.4V < Vin < 36V).
• This board is shown driving a single 3W white LED.
• The board can also drive a 1W or future higher wattage LED with some resistor changes.
• Order Code: STEVAL-ILL007V1
• Application Note [AN2259](#)
Main Characteristics:

- Input voltage $V_{in}$: 5 - 30V DC (limited by transil)
- Switching Frequency 500KHz
- Output current: $I_{out} = 1A$, optionally 350mA or 700mA by jumper setting
- Output voltage $V_{out} < V_{in}$
- Short circuit, over temperature protection
- Drives 1000 lumen OSTAR with 1A at $V_{in}>24V$
L597x Family

- More than 2A in small SO8 package with minimum external component count
- P-channel power MOS: no bootstrap capacitor
- Wide input voltage range (4.4V up to 36V)
- High switching frequency (250KHz/500KHz, sync up to 700KHz*)
- Inhibit pin*
- Embedded protection features
- Typ $R_{DSon}=250\, \Omega$

<table>
<thead>
<tr>
<th>Device</th>
<th>Package</th>
<th>$Ipk$ [A]</th>
<th>$Iout$ [A]</th>
<th>$Vin$ (V)</th>
<th>$Vout$ (V)</th>
<th>$Fsw$ [KHz]</th>
<th>Extra functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>L5970D</td>
<td>SO8</td>
<td>1.5</td>
<td>1</td>
<td>4.4V to 36V</td>
<td>0.5V to Vin</td>
<td>250</td>
<td>Inhibit, Vref, Sync</td>
</tr>
<tr>
<td>L5970AD</td>
<td>SO8</td>
<td>1.5</td>
<td>1</td>
<td>4.4V to 36V</td>
<td>0.5V to Vin</td>
<td>500</td>
<td>Inhibit, Vref, Sync</td>
</tr>
<tr>
<td>L5972D</td>
<td>SO8</td>
<td>2</td>
<td>1.5</td>
<td>4.4V to 36V</td>
<td>1.23V to Vin</td>
<td>250</td>
<td>-</td>
</tr>
<tr>
<td>L5973AD</td>
<td>HSOP8</td>
<td>2</td>
<td>1.5</td>
<td>4.4V to 36V</td>
<td>0.5V to Vin</td>
<td>500</td>
<td>Inhibit, Vref, Sync</td>
</tr>
<tr>
<td>L5973D</td>
<td>HSOP8</td>
<td>2.5</td>
<td>2</td>
<td>4.4V to 36V</td>
<td>0.5V to Vin</td>
<td>250</td>
<td>Inhibit, Vref, Sync</td>
</tr>
</tbody>
</table>

* all but L5972D

<table>
<thead>
<tr>
<th>SO8 - Rth j-amb 115C/W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rth j-amb 62C/W for L5972D</td>
</tr>
</tbody>
</table>

HSO8 - Rth j-amb 40C/W
DC-DC converters – A597xD for Automotive

More than 2A in small SO8 package with minimum external component count
P-channel PowerMOS: no bootstrap capacitor
Wide input voltage range: 4V up to 36V
High switching frequency: 250kHz /500kHz
Inhibit pin
Embedded protection features
Operates over the -40°C to +125°C temperature range
BURN-IN test for high reliability (B5973D)

<table>
<thead>
<tr>
<th>Device</th>
<th>Package</th>
<th>Ipk (A)</th>
<th>Iout (A)</th>
<th>Vin (V)</th>
<th>Vout (V)</th>
<th>Fsw (kHz)</th>
<th>Toperating</th>
<th>Extra functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>A5970D</td>
<td>SO8</td>
<td>1.5</td>
<td>1</td>
<td>4V to 36V</td>
<td>0.5V to Vin</td>
<td>250</td>
<td>-40°C to +125°C</td>
<td>Inhibit, Vref, Sync</td>
</tr>
<tr>
<td>A5970AD</td>
<td>SO8</td>
<td>1.5</td>
<td>1</td>
<td>4V to 36V</td>
<td>0.5V to Vin</td>
<td>500</td>
<td>-40°C to +125°C</td>
<td>Inhibit, Vref, Sync</td>
</tr>
<tr>
<td>A5972D</td>
<td>SO8</td>
<td>2</td>
<td>1.5</td>
<td>4V to 36V</td>
<td>1.23V to Vin</td>
<td>250</td>
<td>-40°C to +125°C</td>
<td>-</td>
</tr>
<tr>
<td>A5972AD</td>
<td>HSOP8</td>
<td>2</td>
<td>1.5</td>
<td>4V to 36V</td>
<td>0.5V to Vin</td>
<td>500</td>
<td>-40°C to +125°C</td>
<td>Inhibit, Vref, Sync</td>
</tr>
<tr>
<td>A5973D</td>
<td>HSOP8</td>
<td>2.5</td>
<td>2</td>
<td>4V to 36V</td>
<td>0.5V to Vin</td>
<td>250</td>
<td>-40°C to +125°C</td>
<td>Inhibit, Vref, Sync</td>
</tr>
<tr>
<td>B5973D</td>
<td>HSOP8</td>
<td>2.5</td>
<td>2</td>
<td>4V to 36V</td>
<td>0.5V to Vin</td>
<td>250</td>
<td>-40°C to +125°C</td>
<td>Inhibit, Vref, Sync</td>
</tr>
</tbody>
</table>
More than 2A in small QFN3x3-8L package with minimum external component count
P-channel power MOS: no bootstrap capacitor
Wide input voltage range (2.9V up to 18V)
High switching frequency (250KHz, adjustable up to 1MHz) with Synchronization capability
Internal Soft-start
Inhibit pin
Embedded protection features
Suitable for MLCC output filter
Typ $R_{DS(on)} = 140\, \text{mΩ}$

Suggested when $\text{Vin} < 18\, \text{V}$

<table>
<thead>
<tr>
<th>Device</th>
<th>Package</th>
<th>In</th>
<th>Out</th>
<th>Vin (V)</th>
<th>Vout (V)</th>
<th>Fsw (kHz)</th>
<th>Extra Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>L5980</td>
<td>QFN3x3-8L</td>
<td>1</td>
<td>0.7</td>
<td>2.9V to 18V</td>
<td>0.6V to Vin</td>
<td>250</td>
<td>Inh, AdjFsw, Sync</td>
</tr>
<tr>
<td>L5981</td>
<td>QFN3x3-8L</td>
<td>1.5</td>
<td>1</td>
<td>2.9V to 18V</td>
<td>0.6V to Vin</td>
<td>250</td>
<td>Inh, AdjFsw, Sync</td>
</tr>
<tr>
<td>L5983</td>
<td>QFN3x3-8L</td>
<td>2</td>
<td>1.5</td>
<td>2.9V to 18V</td>
<td>0.6V to Vin</td>
<td>250</td>
<td>Inh, AdjFsw, Sync</td>
</tr>
<tr>
<td>L5985</td>
<td>QFN3x3-8L</td>
<td>2.5</td>
<td>2</td>
<td>2.9V to 18V</td>
<td>0.6V to Vin</td>
<td>250</td>
<td>Inh, AdjFsw, Sync</td>
</tr>
</tbody>
</table>

QFN 3x3 8L - $R_{th,j-amb} = 60^\circ\text{C/W}$
L497x Application

Circuit for driving up to 12 LEDs

<table>
<thead>
<tr>
<th>Efficiency</th>
<th>8 LEDs</th>
<th>10 LEDs</th>
<th>12 LEDs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vin=48V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iout=350mA</td>
<td>95%</td>
<td>96%</td>
<td>98%</td>
</tr>
</tbody>
</table>

Application described in AN 1891
L497x Family

- Up to 3.5A available both in DIP and SO packages
- Wide voltage input range (8V up to 55V) and output range (0.5V up to 50V)
- Internal current limit
- Inhibit pin*
- OVP*
- External reference**

* Suggested When Vin > 36V and Iout > 2A

<table>
<thead>
<tr>
<th>Device</th>
<th>Package</th>
<th>Ipk [A]</th>
<th>Iout [A]</th>
<th>Vin (V)</th>
<th>Vout (V)</th>
<th>Fsw [KHz]</th>
<th>Extra functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>L4976</td>
<td>DIP8, SO16W</td>
<td>1.5</td>
<td>1</td>
<td>8V to 55V</td>
<td>0.5 to 50</td>
<td>up to 300</td>
<td>Vref</td>
</tr>
<tr>
<td>L4971</td>
<td>DIP8, SO16W</td>
<td>2</td>
<td>1.5</td>
<td>8V to 55V</td>
<td>3.3 to 50</td>
<td>up to 300</td>
<td>Inhibit</td>
</tr>
<tr>
<td>L4978</td>
<td>DIP8, SO16W</td>
<td>2.5</td>
<td>2</td>
<td>8V to 55V</td>
<td>3.3 to 50</td>
<td>up to 300</td>
<td>Inhibit</td>
</tr>
<tr>
<td>L4973 v.3.3</td>
<td>DIP18, SO20</td>
<td>4</td>
<td>3.5</td>
<td>8V to 55V</td>
<td>0.5 to 50</td>
<td>up to 300</td>
<td>Inhibit, Vref, Sync</td>
</tr>
<tr>
<td>L4973 v.5</td>
<td>DIP18, SO20</td>
<td>4</td>
<td>3.5</td>
<td>8V to 55V</td>
<td>5.1 to 50</td>
<td>up to 300</td>
<td>Inhibit, Vref, Sync</td>
</tr>
</tbody>
</table>

* all but L4976, **L4976 and L4973
Main Characteristics:

- PWM fixed frequency 900KHz. It can be ext synch from 0.4 to 1.2MHz
- Output Current Capability: 3A max over all operating conditions
- Output Voltage: Adjustable from 0.8V feedback voltage
- Ceramic Capacitors and small Inductor
- 3.3V, 5V Fixed Output Voltages under customer request
- Max Operating Input voltage up to 18V
- Soft-Start circuit to reduce inrush current
- Efficiency: up to 90%
- Fast Transient Response
- Available with logic control Electronic Shutdown
- PPAK and DFN Packages
- Evaluation board with voltage output: STEVAL-ISA044V1
  STEVAL-ISA044V2
High Current LED Driver: Controller + PMOS

- **Vin**: 8 – 18V
- **Vout**: 2.5 – 14V
- **Iout**: 1A, 1.5A, 2.8A, only limited by MOSFET and current sense resistors
- PWM and analog dimmable through interface
- High efficiency due to synchronous rectification
- Very compact
- Key components:
  - L6726
  - STS8DNH3LL
- Tools:
  - STEVAL-ILL023V1 coming soon
  - AN in preparation
- Schematic
- Output current with 1 x 2.8A LED
Step-down topology
Signage, Torch, portable lighting

Monolithic Step-down Synchronous Regulator

L6902
L597X
L497X
ST1Sxx

L6925
L6926

Application notes
AN1891
AN1941
High efficiency monolithic step down regulator
Operating input voltage 2V – 5.5V (battery supplied applications)
No external Schottky required – minimized external component count
600kHz switching frequency
Externally synchronizable from 500kHz – 1.4MHz
MSOP8 package
800mA maximum current
Overcurrent protection
L6925 – L6926 Application
Monolithic synchronous converter

L6926D in buck topology supplied by 5V for 1 high brightness LED

<table>
<thead>
<tr>
<th>Vin (V)</th>
<th>5</th>
<th>5.5</th>
<th>5.96</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eff (%)</td>
<td>85</td>
<td>84</td>
<td>84</td>
</tr>
</tbody>
</table>

Application described in [AN 1891](#)
More LED applications in [AN 1941](#)
Step-up topology
Signage, Torch, portable lighting

Power Schottky Diode

Monolithic Step-up Synchronous Regulator

STLD20D
STLD40D

L6920D
L6920DB

Application notes
AN1891
AN1941
L6920
1V START-UP SYNCHRONOUS STEP UP CONVERTER

Features
* 0.6 TO 5.5V OPERATING INPUT VOLTAGE
* 1V START UP INPUT VOLTAGE
* INTERNAL SYNCHRONOUS RECTIFIER
* ZERO SHUT DOWN CURRENT
* 3.3V AND 5V FIXED OR ADJUSTABLE OUTPUT VOLTAGE (2V UP TO 5.2V)
* 120mΩ INTERNAL ACTIVE SWITCH
* LOW BATTERY VOLTAGE DETECTION
* REVERSE BATTERY VOLTAGE PROTECTION

TSSOP8
• achievable 1A output current
• 1 LED can be driven with 700mA output current (Vf = 4.4V)
• 1 LED can be driven with 350mA output current (Vf = 4V)

<table>
<thead>
<tr>
<th>Vin (V)</th>
<th>2</th>
<th>2.5</th>
<th>3</th>
<th>3.5</th>
<th>3.7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eff (%)</td>
<td>88</td>
<td>88</td>
<td>90</td>
<td>86</td>
<td>84</td>
</tr>
</tbody>
</table>

Application described in AN 1891
More LED applications in AN 1941
Main Characteristics:

- Adjustable Output Voltage: from 6V to 12V
- DC-DC Switching Frequency: 1.2MHz or 600Khz
- Output Current: up to 1A
- Internal Synchronous Rectification
- Efficiency up to 90% (Output set to 9V)
- Logic Control Electronic Shutdown
- Output Current CUT-OFF when in shutdown

QFN 4X4MM -8L

Demo board available on request
Step-up topology
Signage, Torch, portable lighting

Power Schottky Diode

Monolithic Step-up Synchronous Regulator

STLD20D
STLD40D

L6920D
L6920DB

Application notes
AN1891
AN1941
• STLD20D drives 4 and STLD40D drives 10 white LEDs from battery voltage supply.
• Constant LED current regulation
• High efficiency over extremely wide range of battery voltage
• LED branch isolation switch (STLD20 only)
• Over voltage and over temperature protection
• Dynamic battery voltage variation compensation.
• Soft start.
• Shut-down mode with dimming control.
• Small packages
STLD20 Application

- White Led supply for LCD backlight
- Mobile phone
- PDA and organizers
- Any handsets powered from 2.8V to 4.2V
- Maximum output voltage **18.5V** (internally limited)
- 5 white LEDs can be driven with 20mA output current (Vf = 3.5V)
White Led supply for LCD backlight
Any handsets powered from 3.3V to 4.8V
PDA and organizers
Mobile phone
Maximum output voltage 37V
10 white LEDs can be driven with 20mA output current (Vf = 3.5V)

Evaluation board: STEVAL-TLL001V1

AN2333
Linear solution with high power dissipation on resistor using **LM217**

**Advantage:**
- Low cost solution
- Easy design
- Less components is used
- Output voltage range: 1.25V to 37V
- Maximum output current 1.5A

**Disadvantage:**
- Efficiency
- Power losses on resistor

\[ R = R_1 + R_2 = \frac{U_{adj}}{I_{led}} \]

\[ U_{adj} = 1.25V \]
1.5A Max constant current LED driver

**Description:**

The STCS1 is a BiCMOS constant current source designed to provide a precise constant current starting from a varying input voltage source. The main target is to replace discrete components solution for driving LEDs in low voltage applications.

**Features:**

- Up to 40V input voltage
- Less than 0.5V voltage overhead
- Output current setting between 1mA and 1.5A; precision ±10%
- PWM Dimming pin up to 50kHz
- Shutdown pin
- LED disconnection diagnostic
- Slope control with external cap for controlling current rise from tens of microseconds to tens of milliseconds allowing reduction of EMI

**Applications:**

- LED constant current supplying for varying input voltages
- Low voltage lighting
- Small appliances LED lighting
- Car LED lights
• LED7706/7 backlight and emergency lighting
LED770x family for LCD Backlight and Emergency Lighting

VIN from 4.5V to 36V

Available soon

2A (switch) up to 85mA for each row up to 1MHz

2A (switch) up to 30mA for each row up to 1MHz

Example of LED load board

VFQFPN 4x4 – 2A

Top view
**LED7706-7 Key Features**

**Boost Section**

- 4.5V To 36V Input Voltage Range
- Internal Power MOSFET
- Internal +5V LDO for device supply
- Up To 36V Output Voltage
- Constant Frequency Peak Current-mode Control
- 200kHz to 1MHz adjustable switching frequency
- External synchronization for Multi-device Application
- Pulse-skip power saving mode at light load
- Programmable Soft-start
- Programmable OVP protection
- Thermal Shutdown
- Suitable for MLCC Output Filter
LED7706-7 Key Features

**Backlight driver Section**

- Six rows with 30mA (85mA)* maximum current capability (Adjustable)
- Up to 60 White LEDs
- Parallelable rows for higher current (LED7707)
- Rows disable option
- Less than 500ns (10µs)* minimum dimming time (1% minimum dimming duty-cycle at 20kHz)
- ±2% current matching between rows
- LED failure (open and short circuit) detection

(* LED7707 only)
EVALED7707

6-rows 85mA LEDs driver with boost regulator for LCD panels backlight

Documentation: AN2810 publishing in progress

- LED7707 (VFQFPN-4x4) driver onboard set for 60mA/channel.
- 4.5V to 32V input voltage range.
- Up to 10 White-LEDs (36V) in series on each channel.
- Selectable switching frequency (660kHz or 825kHz).
- Selectable fault management.
- Onboard test point for each important signal for laboratory evaluation.
- Onboard reset button.
- 8-pins header for external LEDs array connection.
- Fault LED indicator.

Key Product:
- ✔ LED7707 (VFQFPN-4x4)

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

Board Purpose:
Compact solution with high dimming and control performance for driving LEDs in not only 6 strings 85mA each, but even one string at 500mA.

In stock soon
Documentation
Demo/Evaluation boards overview

LED dedicated:

- **STP24DP05** - order code: STEVAL-ILL015V1
- **STP16CP05** - order code: STEVAL-ILL003V2
- **STP08DP05** - order code: STEVAL-ILL002V3/4
- **STP04CM05** - order code: STEVAL-ILL009V5
- **L6902D** - order code: STEVAL-ILL009V3 (LOAD board with LEDs)
- **L6902D** - order code: STEVAL-ILL009V4 (LOAD board with LEDs)
- **L6920** - order code: STEVAL-ILL008V1
- **L5973D** driver for MR-16 - STEVAL-ILL007V1
- **STLD40** - order code: STEVAL-TLL001V1
- **STCF01** - order code: STEVAL-TLL002V1 (coming soon)
- **STCF02** - order code: STEVAL-TLL003V1 (coming soon)
- **LED7706/7** - order code: EVALED7706/7
- **VIPer12A** - order code: STEVAL-ILL005V1
- **New VIPer17** - order code: STEVAL-ILL017V1
- **VIPer22A** - order code: STEVAL-ILL006V1
- **VIPer22A with DALI connector** - STEVAL-ILL001V1
- **Coming soon**: L6562A – order code: STEVAL-ILL013V1
- **Osram Dragon LEDs**: - order code STEVAL-ILL018V1/2/3/4
General purpose boards:

L597x - order code: EVAL5970 or EVAL5973
L6902D - order code: EVAL6902
L497x - order code: EVAL4971 or EVAL4971D or EVAL4973
L6561 - order code: EVAL6561-80
L6562 - order code: EVAL6562-80
L6920 - order code: EVAL6920
Application Notes Overview
dedicated for LEDs

- **DC/DC:**
  - AN 1891 / Application ideas - driving LEDs using L497x, L597x, L692x DC-DC converters families
  - AN 1941 / Low voltage LED driver using L6920D, L4971 and L6902d
  - AN 2129 / Dimmable LED driver using L6902D
  - AN 2333 / White LED power supply for large display backlight using STLD40
  - AN 2243 / Step up converter for camera flash light using STCF01
  - AN 2304 / Designing a Flash LED driver using an STCF02 step-up/down current mode converter
  - AN 2259 / High intensity LED driver using the L5970D/L5973D
  - UM-ILL023 / High current 2.8A LED driver using L6726 in preparation

- **Offline:**
  - AN 1916 / VIPower - Offline constant current LED driver using VIPer12/22A
  - AN 2042 / VIPower: Dimmable driver for high brightness LEDs with VIPer22A
  - AN 1060 / Flyback converters with the L6561 PFC
  - AN 1059 / Design equations of high – power – factor flyback converters based on L6561
  - AN 2067 / Dimmable white LEDs power supply with VIPer53
  - AN 1734 / VIPer12A SINGLE OUTPUT REF. BOARD 85 TO 264 VAC INPUT, 6W OUTPUT
  - AN 1934 / VIPer12A NON ISOLATED FLYBACK CONVERTER REFERENCE BOARD
  - AN 1894 / VIPer12A NON ISOLATED BUCK AND BUCK-BOOST CONVERTER REF. BOARD
  - AN2811 / VIPer17 based 2 W non-insulated Flyback LED driver
  - UM0670 / 80W non-insulated offline LED driver with PFC and DC/DC converter based on L6562A
  - AN2838 / 35W High power insulated flyback LED Driver based on L6562A

- **LED Matrix Display**
  - AN 2141 / STP16CP596 + L5970 + ST7Lite09 LED Array driver reference design
  - AN 2415 / STP08CDC596 + L5970 + LE50 + ST7Lite39 LED error detection demo board
  - AN 2478 / STP08DP05, STP16DP05 Normal mode and error detection features
  - AN 2531 / Generating multicolor light using RGB LEDs with STP04CM596
  - AN2841 / UM0574 / UM0588 / STP24DP05 + STM32F103 Array and Display driver reference design