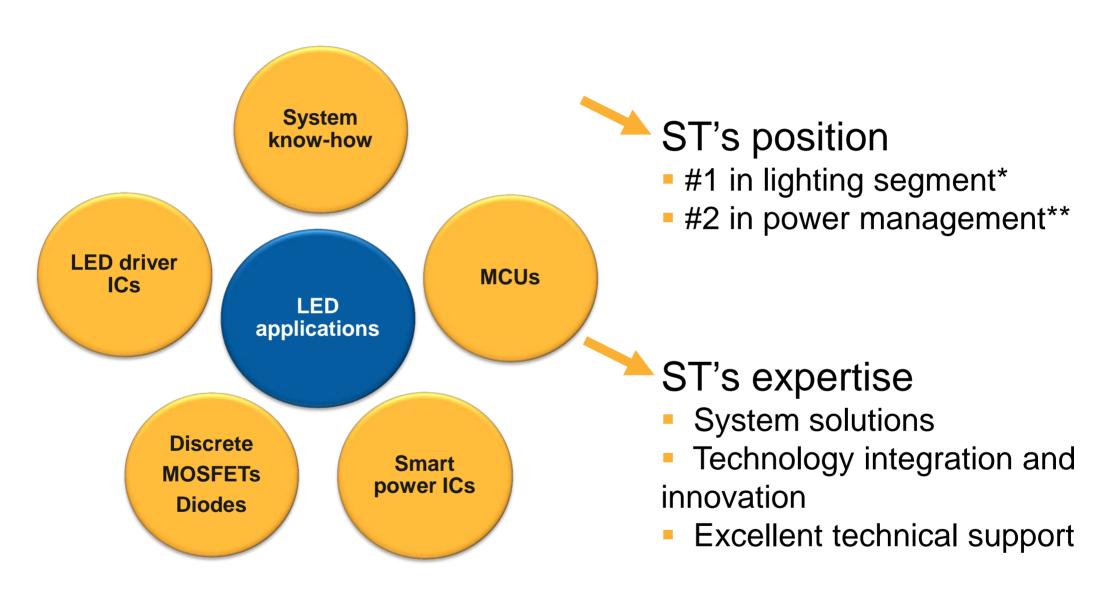
# Energy-efficient solutions for offline LED lighting and general illumination





# Offline LED lighting/general illumination





<sup>\*</sup>STMicroelectronics, Datapoint and Darnell - 2008

<sup>\*\*</sup>iSupply - 2010

### **Contents**



- Energy-efficient solutions for offline LED lighting
  - Offline LED driver solutions
    - Features/benefits
    - System evaluation boards and tools
  - General illumination applications
    - Residential lighting
    - Commercial lighting
    - Architectural and decorative lighting
    - Street lighting and public illumination
    - Emergency lighting
    - Machine vision



## **Driving LEDs using AC-DC solutions**



#### Isolated and non-isolated topologies with high efficiencies and power factor





Single package approach, primary-side or secondary-side CC regulation

- Incandescent replacement
- Decorative bulbs

10 to 50 W



Single-stage AC-DC, single or multiple LED strings Triac dimmable or post regulation w/dimming

- Incandescent and fluorescent replacement
- Architectural and decorative lighting

50 W and above

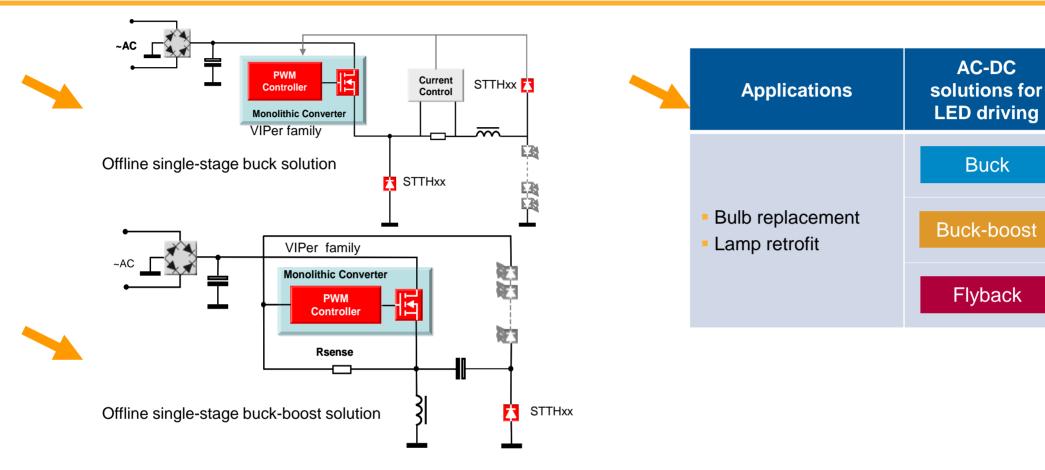


Single-stage or double-stage AC-DC plus analog or digital CC controllers

- Streetlights
- Parking garages
- Warehouse high bays

## Non-isolated applications: up to 10W





Device		Part number/family	Benefits
	Monolithic converter	VIPer family (Integrated controller + MOSFET)	<ul> <li>800 V avalanche rugged MOSFET (VIPerPlus)</li> <li>Jittering for low EMI (VIPerPlus)</li> <li>Advanced OVP and OCP</li> </ul>
	Ultrafast diodes	STTHxx	<ul> <li>Wide selection of electrical parameters and packages</li> </ul>

### Non-isolated eval boards: 3-10W



### VIPer family: High-voltage converters in non-isolated topologies



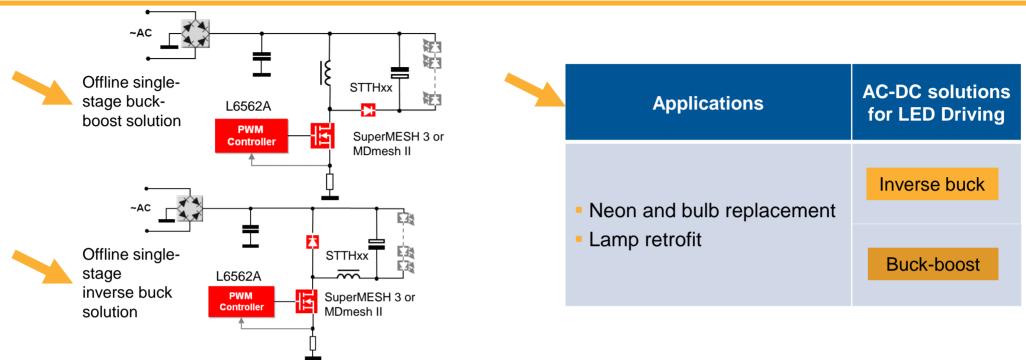


Key features	Main benefits
<ul><li>Single package</li><li>approach:</li><li>integrated</li><li>robust</li><li>sophisticated</li></ul>	<ul><li>Miniaturized form factors</li><li>Easy design</li></ul>
High power factor > 0.7	<ul><li>Compliant to energy saving regulations</li></ul>
<ul> <li>No high-voltage electrolytic cap usage</li> </ul>	<ul><li>High reliability (extended MTBF)</li></ul>

Evaluation board	Application note	Description
STEVAL-ILL026V1	AN2961	3 W non-isolated offline LED driver solution based on VIPER22AS
STEVAL-ILL017V1	AN2811	3.5 W non-isolated flyback constant- current source based on VIPER17

# Non-isolated applications: up to 20W





Dev	ice	Part number/family	Benefits
PWM co	ntroller	L6562A	High power factor
	SuperMESH 3*	<ul> <li>High safety margin and ruggedness</li> <li>High immunity to dV/dt, low conduction and switching losses</li> </ul>	
Buck an boost Mo		MDmesh II* (super junction)	<ul> <li>Up to 800 V with the best RDS(on) in the market</li> <li>Best-in-class in dynamic dV/dt</li> <li>Low input capacitance and gate charge, low gate input resistance</li> </ul>
Ultrafast	diodes	STTHxx	<ul> <li>Wide selection of electrical parameters and packages</li> </ul>

<sup>\*</sup> See MOSFET selection guide in presentation, online, and in energy-efficient solutions for LED lighting brochure

### L6562A PWM controller eval boards







Buck-boost STEVAL-ILL027V2





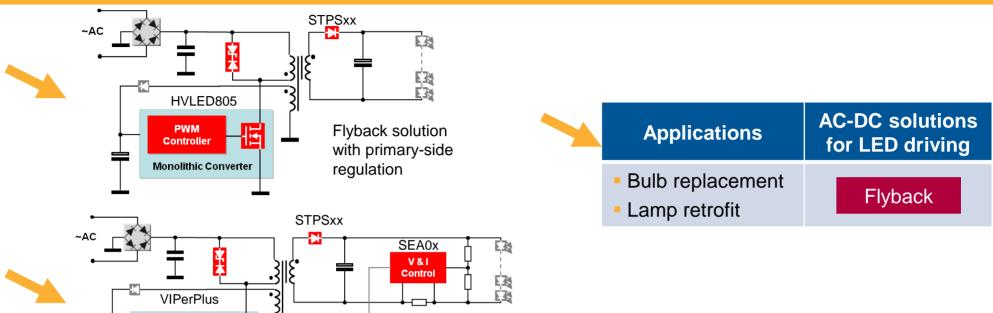
HPF inverse buck STEVAL-ILL034V1

Key features	Main benefits
Buck-boost topology	<ul><li>Simple</li><li>Low cost</li></ul>
<ul><li>Transition mode operation</li></ul>	<ul><li>Lower switching losses</li><li>Spread of EMI spectrum</li></ul>
High power factor > 0.8	<ul> <li>Compliant to energy saving regulations, suitable for residential lighting</li> </ul>
<ul><li>Open-load protection</li><li>Short-circuit protection</li></ul>	Robust

Evaluation board	Application note	Description
STEVAL-ILL027V2	AN3111	18 W single-stage offline LED driver
STEVAL-ILL034V1	AN3256	Low-cost LED driver for an A19 lamp

# Isolated applications: Up to 10W





Flyback solution with secondary-

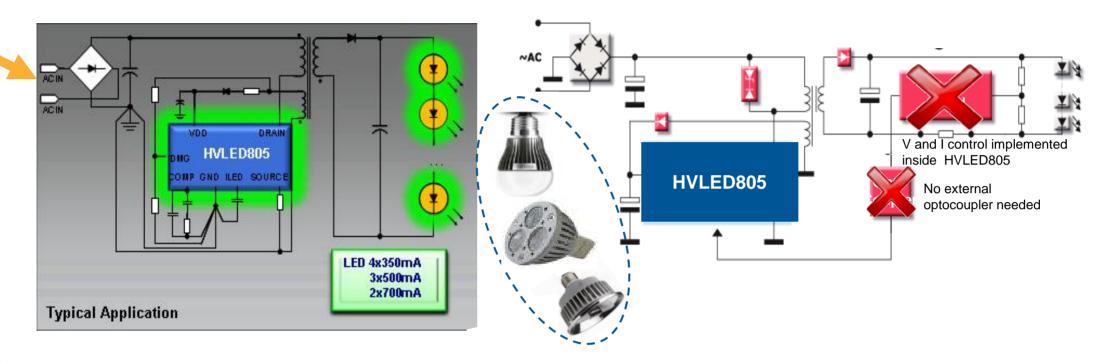
side regulation

	Device	Part number/family	Benefits
	Primary IC Schottky diodes	HVLED805 (controller + MOSFET)	<ul> <li>CC/CV primary regulation</li> <li>QR zero voltage switching operation</li> <li>800 V avalanche rugged MOSFET</li> </ul>
		VIPer Plus (controller + MOSFET)	<ul> <li>800 V avalanche rugged MOSFET, high power factor</li> <li>Jittering for low EMI</li> <li>Advanced OVP and OCP</li> </ul>
		STPSxx	Wide product range in Vf/Ir trade off, avalanche ruggedness
	CV/CC control	SEA0x	Very low current consumption, wide input voltage range

**Monolithic Converter** 

# HVLED805 with primary-side regulation





Key features	Main benefits
<ul> <li>Single package approach</li> <li>integrated</li> <li>robust</li> <li>sophisticated</li> </ul>	<ul><li>Miniaturized form factors</li><li>Easy design</li></ul>
<ul><li>CC/CV primary regulation</li></ul>	<ul> <li>Reduced costs and system complexity</li> <li>Very small form factor to fit in LED retrofit applications</li> </ul>
<ul><li>No optocoupler</li></ul>	High reliability (extended MTBF)
<ul> <li>Zero voltage switching operation and high voltage start-up</li> </ul>	<ul> <li>High efficiency up to 85%</li> </ul>

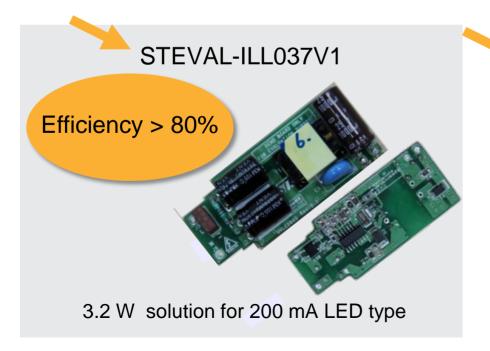
### **STMicroelectronics**

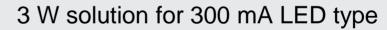
### **HVLED805** eval board solutions

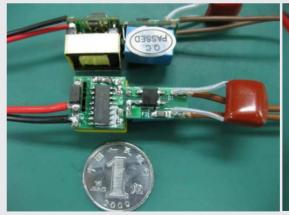


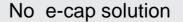


Evaluation board	Application note	Description
EVALHVLED805	Data brief	4.2 W offline LED driver with primary-side regulation
STEVAL- ILL037V1	AN3360	3.2 W LED power supply based on HVLED805







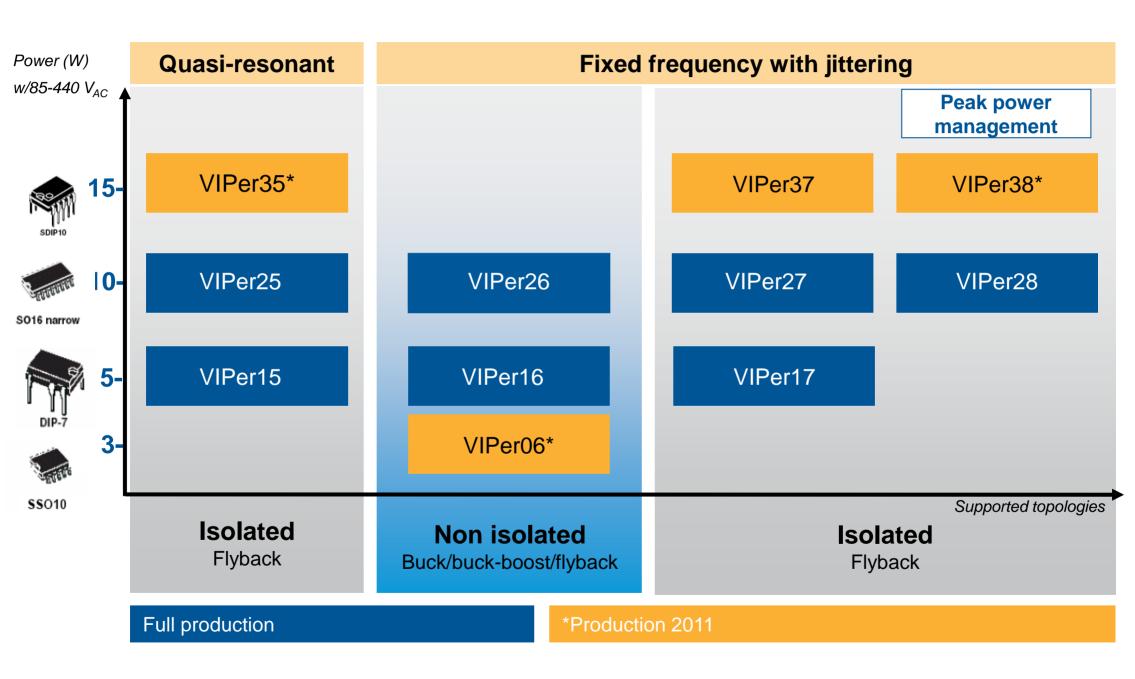




Solution with e-cap

# **VIPerPlus family overview**





### VIPerPlus HPF LED driver eval board

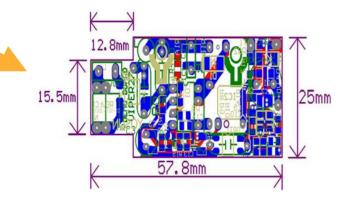


### High-voltage converters in high power factor flyback



EVLVIP27-7WLED \* VIPer27 LED driver module

Key features	Main benefits
<ul> <li>Single package approach</li> <li>integrated</li> <li>robust</li> <li>sophisticated</li> <li>High-frequency operation</li> </ul>	<ul><li>Miniaturized form factors</li><li>Easy design</li></ul>
High power factor > 0.9	<ul> <li>Compliant to energy saving regulations, suitable for commercial lighting</li> </ul>
<ul> <li>No electrolytic output capacitor if current ripple is accepted</li> </ul>	<ul><li>High reliability (extended MTBF)</li></ul>

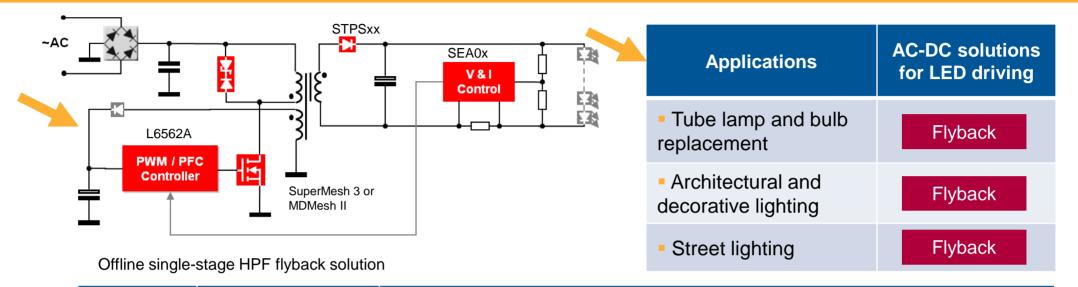


Evaluation board	Application note	Description
EVLVIP27-7WLED *	AN3212	3.5 W to 7 W high power factor offline LED driver based on VIPer devices

<sup>\*</sup> Please contact local sales support to order this board

## Isolated applications: from 10 to 75W





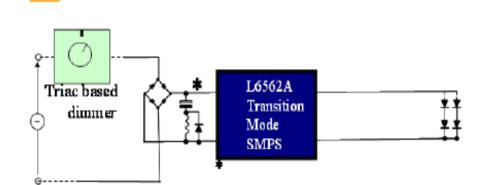
	Device	Part number/family	Benefits
	Primary IC	L6562A / AT (PFC controller)	<ul> <li>High power factor flyback</li> <li>Triac dimmable</li> <li>Extended temperature range (AT version)</li> </ul>
	Elybook	SuperMESH 3*	<ul> <li>High safety margin and ruggedness</li> <li>High immunity to dV/dt, low conduction and switching losses</li> </ul>
ı	Flyback MOSFET	MDmesh II* (super junction)	<ul> <li>Up to 800 V with best R<sub>DS(on)</sub> in the market</li> <li>Best-in-class in dynamic dV/dt</li> <li>Low input capacitance and gate charge, low gate input resistance</li> </ul>
	Schottky diodes	STPSxx	<ul> <li>Wide product range in Vf/Ir trade-off, avalanche ruggedness</li> </ul>
	CV/CC control	SEA0x	<ul> <li>Very low current consumption, wide input voltage range</li> </ul>

<sup>\*</sup> See MOSFET selection guide in presentation, online, and in energy-efficient solutions for LED lighting brochure

### L6562A



### 15W Triac dimmable eval board





STEVAL-ILL016V2

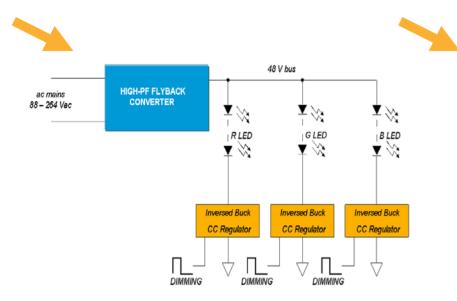
Key features	Main benefits
<ul> <li>High power factor flyback topology supported &gt; 0.9</li> </ul>	<ul> <li>Compliant to energy saving regulations</li> </ul>
<ul> <li>Control and power section separated</li> </ul>	<ul><li>Suitable for high power</li><li>Design flexibility</li></ul>
Triac dimmable	<ul> <li>Commonly available dimming option for home fixtures</li> </ul>
<ul><li>High output voltage</li></ul>	<ul> <li>No limitation to the number of LEDs within a string</li> </ul>
<ul> <li>Based on low-cost controller and MOSFETs</li> </ul>	Cost-effective solution

Evaluation board	Application note	Description
STEVAL- ILL016V2	AN2711	15 W offline Triac dimmable LED driver from 96 to 32 V <sub>AC</sub>

### **L6562A**



### **HPF flyback + inverse buck eval boards**



Key features	Main benefits
<ul> <li>High efficiency (&gt; 90%), high power factor (&gt; 0.9), flyback topology supported</li> </ul>	<ul> <li>Compliant to energy saving regulations</li> </ul>
<ul><li>Control and power section separated</li></ul>	<ul><li>Suitable for high power</li><li>Design flexibility</li></ul>
<ul> <li>CC regulator in inverse buck working in fixed off time</li> </ul>	<ul> <li>Constant ripple current, when input/output voltages change</li> </ul>
<ul><li>High output voltage</li></ul>	<ul> <li>No limit to number of LEDs on string</li> </ul>



STEVAL-ILL019V1

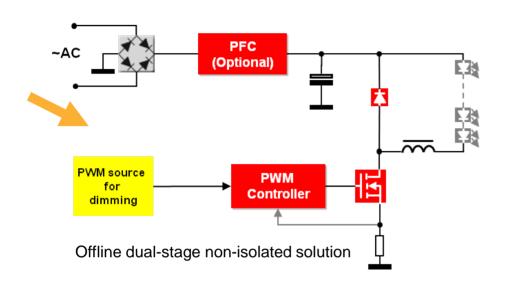
Evaluation Application board note		Description
STEVAL- ILL019V1	UM0926	35 W offline RGGB LED driver with individual channel brightness regulation
EVL6562A- 35WFLB *	AN2838	35 W wide-range HPF flyback converter with L6562A
EVL6562A- LED	AN2928 AN2983	Modified buck converter for LED applications

<sup>\*</sup> Please contact local sales support to order this board

# Non-isolated: 80W and higher eval board



#### PFC boost + inverse buck





Applications AC-DC stag		DC-DC stage
Street lighting	PFC boost	Inverse buck

Key features	Main benefits
LED current setting to 350 mA, 700 mA and 1 A	<ul><li>High flexibility</li></ul>
<ul> <li>High efficiency (~90%), high power factor, very low THD</li> </ul>	<ul><li>High performances</li></ul>
<ul> <li>High output voltage</li> </ul>	<ul> <li>No limitation to the number of LEDs within a string</li> </ul>
<ul> <li>EN55015 and EN61000-3-2 compliant</li> </ul>	<ul> <li>Satisfies the relevant lighting regulations</li> </ul>

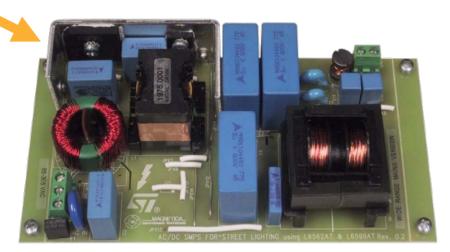
Evaluation board	Application note	Description
STEVAL- ILL013V1	AN2928 UM0670	80 W offline LED driver with dimming based on L6562A

# Isolated: >70W resonant LED eval boards



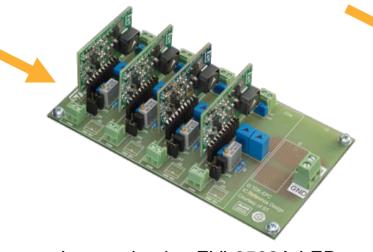
PFC (L6562AT) + resonant converter (L6599AT) + inverse buck (L6562AT)

with MOSFETs\*



PFC + resonant converter

Key features	Main benefits
<ul> <li>PFC + resonant controller, with extended temperature range</li> </ul>	<ul> <li>Suitable for outdoor applications</li> </ul>
No el-cap usage	High rel (extended MTBF)
<ul><li>Zero voltage switching and symmetrical topology</li></ul>	Very high efficiency > 92%
<ul><li>Post-regulation with dimming solution</li></ul>	<ul> <li>Dimmable solutions</li> </ul>
<ul> <li>EN55015 and EN61000-3-2 compliant</li> </ul>	<ul> <li>Satisfies the relevant lighting regulations</li> </ul>



Inverse buck – EVL6562A-LED	Inverse	buck -	– EVL	.6562A-	LED
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Evaluation board	Application note	Description
EVL130W-SL-EU	AN3105	48 V, 130 W LED street lighting SMPS based on L6562AT and L6599AT for European input mains range
EVL130W-STRLIG	AN3106	48 V, 130 W LED street lighting SMPS based on L6562AT and L6599AT for wide input mains range
EVL6562A-LED	AN2983 AN2928 for ref	Modified buck converter for LED applications

<sup>\*</sup> See MOSFET selection guide earlier in presentation, online, and in energy-efficient solutions for LED lighting brochure

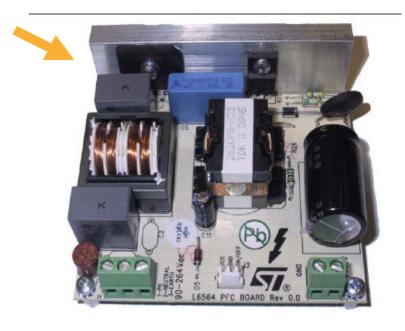
#### **STMicroelectronics**

# Isolated LED supply: >75W eval board



#### L6564: current mode PFC controller

Key features	Main benefits
Fast bidirectional input voltage feedforward	Fast reaction to load change input voltage change
Protection	<ul><li>Very robust design</li></ul>
Low start-up current	<ul><li>High efficiency</li></ul>



Device	Part number/family	Benefits
PFC controller	L6562AT L6563S, L6564	<ul> <li>Flexibility: 8 pins (L6562A) to 10 pins (L6564) up to 14 pins (L6563S) with different levels of protection</li> <li>T version for extended temperature range (-40 to 150 °C)</li> </ul>

Ideal for
PFC preregulator
SMPS for LED luminaries

Evaluation board	Application note	Description	
EVL6564- 100W	AN3022	100 W transition mode PFC preregulator with L6564	

### L6585DE: SMPS eval board for LEDs



#### Front-end one-chip SMPS solution

#### **Description and purpose**

 Highly-efficient and compact power supply for high-brightness LED applications such as street lighting

#### **Key features**

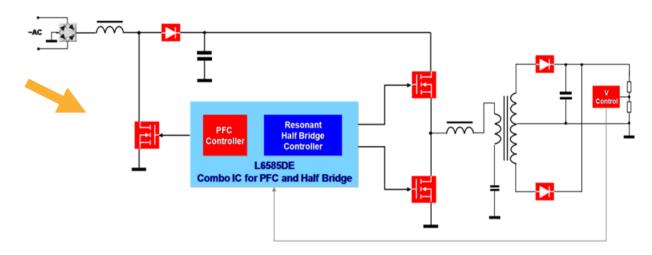
- Input voltage 90 to 264 V<sub>AC</sub>
- Output current: 2 7 A
- Output voltage: 48 V
- No el cap (extended MTBF)
- Efficiency: 91% (115 VAC), 93% (230 VAC)
- System power: 130 W
- OCP, SC protection

#### **Key products**

 L6585DE, STF9NM60N, STF21NM60N, STPS10150C, STTH3L06

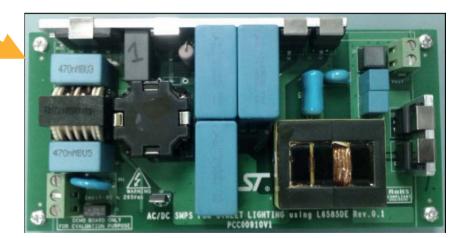
#### **Typical applications**

Street lighting SMPS, adapters (with 19 V, 4.7 A output)



PFC stage + series-resonant half-bridge topology



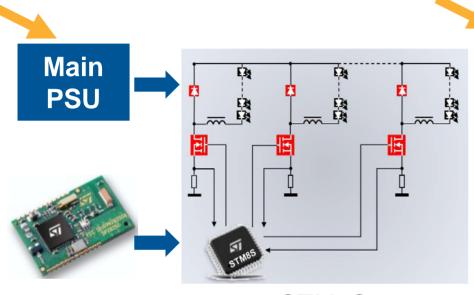


STEVAL-ILL038V1

### Digital current controller eval board



### Multi-string LED driving based on STM8S microcontroller



ZigBee module

STM8S



STEVAL-ILL031V1

	Key features	Main benefits
	<ul> <li>Inverse buck topology in CCM</li> </ul>	<ul> <li>Ground referred circuit, no need for gate drivers</li> <li>Logic level MOSFET driven directly by microcontroller</li> <li>Low-voltage sensing circuit</li> <li>High efficiency up to 98%</li> <li>Works w/o output capacitor</li> </ul>
	<ul> <li>Accurate average- current control</li> </ul>	<ul><li>Long lifetime for LED</li><li>Able to compensate for Vf variation due to thermal issue</li></ul>
	<ul> <li>Global dimming from 2% to 100% at 225 Hz (PWM dimming)</li> </ul>	<ul> <li>No flicker</li> </ul>
	<ul><li>Independent analog dimming</li></ul>	<ul> <li>Suitable for RGBW luminaries</li> </ul>

Evaluation board	Application note	Description
STEVAL- ILL031V1	AN3151	Digital constant-current controller for multi-string LED applications based on STM8S208x

# Solar-LED streetlight controller w/STM32

### 25 W LED lamp driver and 80 W battery charger

#### **Description and purpose**

 Cost-optimized and fully-protected solution to control solar energy storage and to manage LED streetlights

#### **Key features**

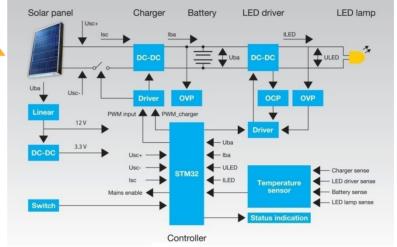
- Maximum power point tracker (MPPT) for more efficient energy use
- Automatic day/night detection
- Automatic battery/mains switchover
- Constant-current control for LED lamps
- Battery charge control with temperature monitoring
- Easy system monitoring via debug
- Full protection function for battery, LED lamp and solar panel

#### **Key products**

 STP40NF10, STP75NF75, STPS20H100, STPS1L60, STPS2045

#### **Typical applications**

LED street lighting, solar LED applications





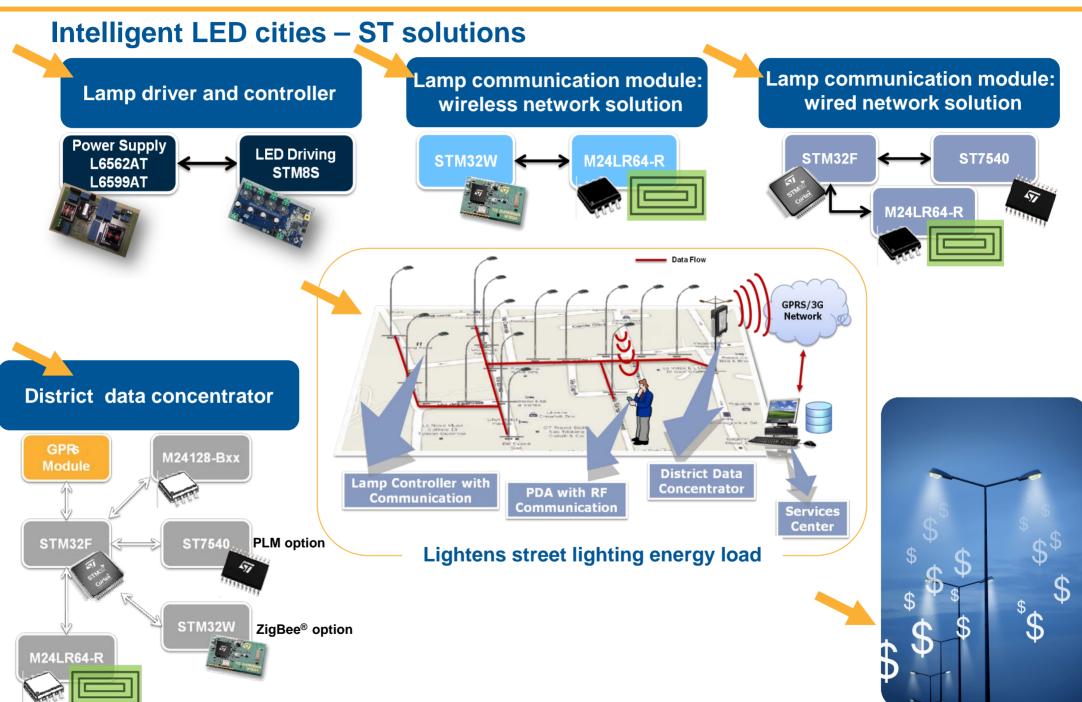




Evaluation board	Application note	Description	
STEVAL- ILL022V1	UM0512	STEVAL-ILL022V1 solar-LED streetlight controller with 25 W LED lamp driver and 80 W battery charger based on the STM32F101Rx	

# **Smart street lighting**





### **Power MOSFET overview**



BVDss	R <sub>DS(on)</sub> (max)	Package	Technology
(V)	(Ω)		
40	0.0065	DPAK, TO-220, IPAK	STripFET™ III
40	0.004	D <sup>2</sup> PAK, TO-220	STripFET™ III
40	0.0025	D <sup>2</sup> PAK, TO-220	STripFET™ III
40	0.0065	PowerFLAT 5x6	STripFET™ V
40	0.005	PowerFLAT 5x6	STripFET™ III
40	0.00275	PowerFLAT 5x6	STripFET™ V
60	0.1	SOT-223	STripFET™ II
60	0.055	SO-8	STripFET™ II
40	0.055	SO-8 DUAL	STripFET™ II
80	0.034	PowerFLAT 3.3 x 3.3	STripFET™ III
100	0.06	SO-8	STripFET™ II
200	0.16	TO-220, TO-220FP, D2PAK	STripFET™ II
200	0.125	TO-220, TO-220FP, DPAK	STripFET™ II
250	0.235	TO-220, TO-220FP, DPAK	STripFET™ II
250	0.069	TO-220, D2PAK	STripFET™ II
450	3.8	IPAK, SOT-223, TO92	SuperMESH 3™
500	0.79	DPAK, TO-220, TO-220FP	MDmesh™ II
500	0.63	DPAK, TO-220, TO-220FP	MDmesh™ II
500	0.47	DPAK, TO-220, TO-220FP	MDmesh™ II
500	0.32	DPAK, D2PAK	MDmesh™ II
500	0.25	TO-220, TO-220FP	MDmesh™ II
500	0.19	D2PAK, TO-247, TO-220/FP	MDmesh™ II
500	0.158	D2PAK, TO-247, TO-220/FP	MDmesh™ II
525	1.5	D²PAK, DPAK, TO-220FP, TO-220, IPAK	SuperMESH 3™
525	1.2	DPAK, TO-220FP	SuperMESH 3™
525	1.15	DPAK, TO-220FP, TO-220	SuperFREDmesh 3™
	(V) 40 40 40 40 40 40 60 60 60 40 80 100 200 250 250 450 500 500 500 500 500 500 525	(max) (V) (Ω) 40 0.0065 40 0.004 40 0.0025 40 0.0055 40 0.00275 60 0.1 60 0.055 40 0.055 80 0.034 100 0.06 200 0.16 200 0.125 250 0.235 250 0.069 450 3.8 500 0.79 500 0.63 500 0.47 500 0.32 500 0.25 500 0.19 500 0.158 525 1.5	(V)         (Ω)           40         0.0065         DPAK, TO-220, IPAK           40         0.004         D²PAK, TO-220           40         0.0025         D²PAK, TO-220           40         0.0065         PowerFLAT 5x6           40         0.005         PowerFLAT 5x6           40         0.00275         PowerFLAT 5x6           60         0.1         SOT-223           60         0.055         SO-8           40         0.055         SO-8 DUAL           80         0.034         PowerFLAT 3.3 x 3.3           100         0.06         SO-8           200         0.16         TO-220, TO-220FP, D2PAK           200         0.16         TO-220, TO-220FP, DPAK           250         0.235         TO-220, TO-220FP, DPAK           250         0.069         TO-220, TO-220FP, DPAK           450         3.8         IPAK, SOT-223, TO92           500         0.79         DPAK, TO-220, TO-220FP           500         0.63         DPAK, TO-220, TO-220FP           500         0.47         DPAK, TO-220, TO-220FP           500         0.19         D2PAK, TO-247, TO-220/FP           500         0.158

P/N	BVDss	R <sub>DS(on)</sub> (max)	Package	Technology
	(V)	(Ω)		
ST*7NM60N	600	0.9	DPAK, TO-220, TO-220FP	MDmesh™ II
ST*9NM60N	600	0.7	DPAK, TO-220, TO-220FP	MDmesh™ II
ST*10NM60N	600	0.55	DPAK, TO-220, TO-220FP	MDmesh™ II
ST*13NM60N	600	0.36	DPAK, TO-220, TO-220F	MDmesh™ II
ST*18NM60N	600	0.285	D2PAK, TO-247, TO-220/FP	MDmesh™ II
ST*22NM60N	600	0.22	D2PAK, TO-247, TO-220/FP	MDmesh™ II
ST*24NM60N	600	0.19	D2PAK, TO-247, TO-220/FP	MDmesh™ II
ST*26NM60N	600	0.165	D2PAK, TO-247, TO-220/FP	MDmesh™ II
ST*2N62K3	620	3.5	DPAK, TO-220, TO-220FP	SuperMESH 3™
ST*3N62K3	620	2.5	D2PAK, DPAK, TO-220FP, TO-220, IPAK	SuperMESH 3™
ST*4N62K3	620	1.95	DPAK, D <sup>2</sup> PAK,TO-220FP, IPAK, TO-220, I <sup>2</sup> PAK	SuperMESH 3™
ST*5N62K3	620	1.6	D <sup>2</sup> PAK, DPAK,TO-220FP, TO-220, IPAK	SuperMESH 3™
ST*6N62K3	620	1.2	IPAK, DPAK, TO-220,TO-220FP	SuperMESH 3™
ST*10N65K3	650	1	TO-220FP	SuperMESH 3™
ST*3NK80Z	800	4.5	TO-220, TO-220FP, DPAK, IPAK	SuperMESH™
ST*5NK80Z	800	2.4	TO-220, TO-220FP	SuperMESH™
ST*7NM80	800	1.05	TO-220, TO-220FP, DPAK, IPAK	MDmesh™ II
ST*11NM80	800	0.4	D2PAK, TO-220, TO-220FP, TO-247	MDmesh™ II
STS3N95K3	925	6.3	TO-220, TO-220FP, DPAK, IPAK	SuperMESH 3™
ST*5N95K3	925	3.5	TO-220, TO-220FP	SuperMESH 3™
ST*7N95K3	925	1.35	TO-220, TO-220FP, DPAK, IPAK	SuperMESH 3™
ST*13N95K3	925	0.85	D2PAK, TO-220, TO-220FP, TO-247	SuperMESH 3™



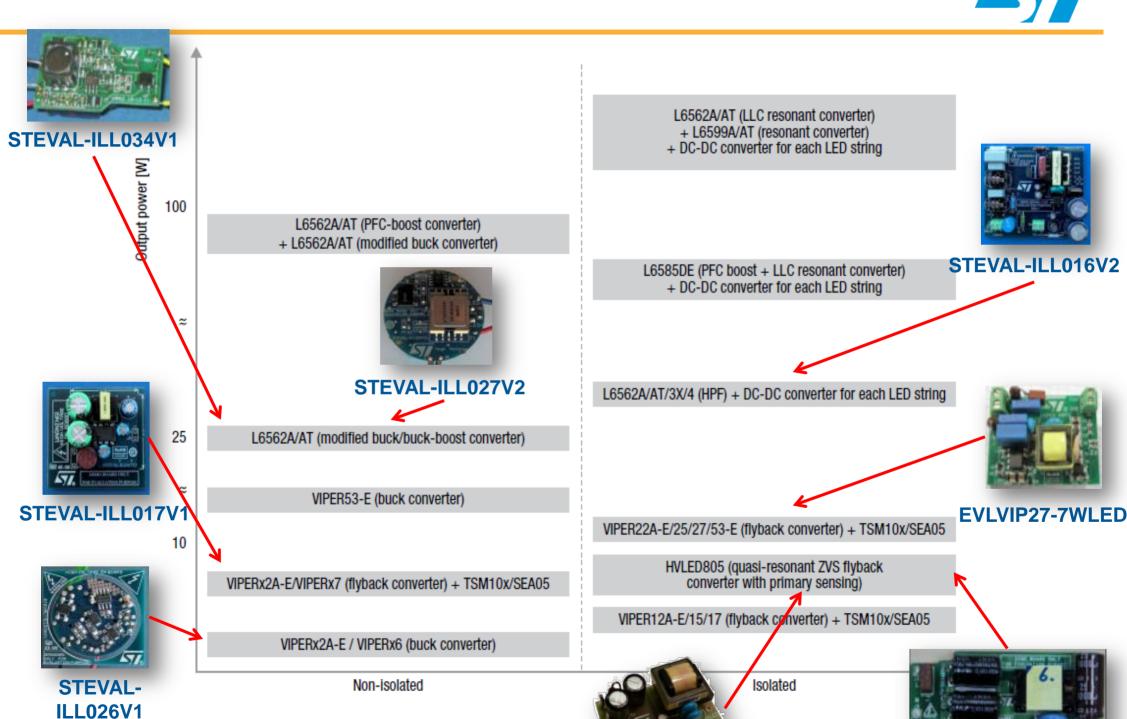
<u>MDmesh II</u> – ST's 2<sup>nd</sup> generation super junction, high-voltage power MOSFET technology <u>SuperMESH 3</u> – Covers high-voltage breakdown class for

- improved avalanche ruggedness
- lower on-resistance
- enhanced dynamic performance
- improved diode reverse recovery characteristics

\* Under development. Available in Q3/2012

### ST Solutions for Off-Line LED Lighting Overview





**EVALHVLED805** 

STEVAL-ILL037V1

### **Energy-efficient solutions on st.com**



### Offline LED lighting and general illumination

### LED lighting brochure

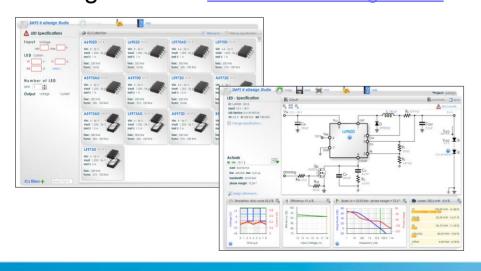


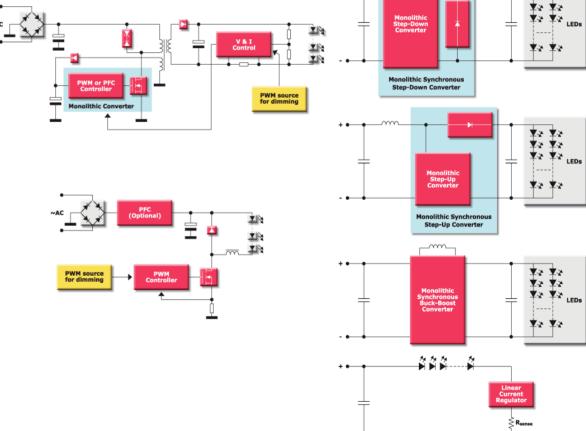
### LED application web pages



STMicroelectronics offers a full range of components and evaluation boards for offline LED driver applications. The most common topologies are presented. The major applications covered are residential, commercial, architectural and street lighting.







### ST products and solutions



For more information, visit:

<u>www.st.com</u> > home > support > tools & resources
<u>www.st.com/LED</u> > off-line LED drivers

Thank you