Energy-efficient solutions for offline LED lighting and general illumination
Offline LED lighting/general illumination

ST’s position
- #1 in lighting segment*
- #2 in power management**

ST’s expertise
- System solutions
- Technology integration and innovation
- Excellent technical support

*STMicroelectronics, Datapoint and Darnell – 2008
**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

3 to 10 W
- 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

Offline single-stage buck solution

Offline single-stage buck-boost solution

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

Applications

- Bulb replacement
- Lamp retrofit

AC-DC solutions for LED driving

- Buck
- Buck-boost
- Flyback
Non-isolated eval boards: 3-10W

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

Key features
- Single package approach:
  - integrated
  - robust
  - sophisticated

Main benefits
- Miniaturized form factors
- Easy design
- High power factor > 0.7
- Compliant to energy saving regulations
- No high-voltage electrolytic cap usage
- High reliability (extended MTBF)

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

**Device** | **Part number/family** | **Benefits**
--- | --- | ---
PWM controller | L6562A | • High power factor
Buck and buck-boost MOSFETs | SuperMESH 3* | • High safety margin and ruggedness
 | MDmesh II* (super junction) | • High immunity to dV/dt, low conduction and switching losses
Ultrafast diodes | STTHxx | • Up to 800 V with the best RDS(on) in the market
 | | • Best-in-class in dynamic dV/dt
 | | • Low input capacitance and gate charge, low gate input resistance

**Applications**

- Neon and bulb replacement
- Lamp retrofit

**AC-DC solutions for LED Driving**

- Inverse buck
- Buck-boost

* See MOSFET selection guide in presentation, online, and in energy-efficient solutions for LED lighting brochure
L6562A PWM controller eval boards

Key features
- Buck-boost topology
- Transition mode operation
- High power factor > 0.8
- Open-load protection
- Short-circuit protection

Main benefits
- Simple
- Lower switching losses
- Compliant to energy saving regulations, suitable for residential lighting
- 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

Applications for LED driving

- Bulb replacement
- Lamp retrofit

Flyback solution

Device | Part number/family | Benefits
--- | --- | ---
Primary IC | HVLED805 (controller + MOSFET) | CC/CV primary regulation, QR zero voltage switching operation, 800 V avalanche rugged MOSFET

VIPer Plus (controller + MOSFET) | 800 V avalanche rugged MOSFET, high power factor, Jittering for low EMI, Advanced OVP and OCP

Schottky diodes | STPSxx | Wide product range in Vf/Ir trade off, avalanche ruggedness

CV/CC control | SEA0x | Very low current consumption, wide input voltage range
HVLED805 with primary-side regulation

![Typical Application](image)

**Key features**

| Single package approach
| integrated
| robust
| sophisticated |
| CC/CV primary regulation |
| No optocoupler |
| Zero voltage switching operation and high voltage start-up |

**Main benefits**

| Miniaturized form factors
| Easy design |
| Reduced costs and system complexity
| Very small form factor to fit in LED retrofit applications |
| High reliability (extended MTBF) |
| High efficiency up to 85% |
HVLED805 eval board solutions

**EVALHVLED805**
- 4.2 W solution for 350 mA LED type

**STEVAL-ILL037V1**
- Efficiency > 80%
- 3 W solution for 300 mA LED type

**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

No e-cap solution | Solution with e-cap
VIPerPlus family overview

- **Quasi-resonant**
  - VIPer35*
  - VIPer25
  - VIPer15
- **Non isolated**
  - Buck/buck-boost/flyback
  - VIPer26
  - VIPer16
  - VIPer06*
- **Fixed frequency with jittering**
  - VIPer37
  - VIPer27
  - VIPer17
  - VIPer28
- **Isolated**
  - Flyback
  - Peak power management

- Power (W) w/85-440 VAC
- Supported topologies
- Full production
- *Production 2011
VIPerPlus HPF LED driver eval board

High-voltage converters in high power factor flyback

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

<table>
<thead>
<tr>
<th>Evaluation board</th>
<th>Application note</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EVLVIP27-7WLED *</td>
<td>AN3212</td>
<td>3.5 W to 7 W high power factor offline LED driver based on VIPer devices</td>
</tr>
</tbody>
</table>

* Please contact local sales support to order this board
Isolated applications: from 10 to 75W

### Applications

<table>
<thead>
<tr>
<th>Applications</th>
<th>AC-DC solutions for LED driving</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ Tube lamp and bulb replacement</td>
<td>Flyback</td>
</tr>
<tr>
<td>▪ Architectural and decorative lighting</td>
<td>Flyback</td>
</tr>
<tr>
<td>▪ Street lighting</td>
<td>Flyback</td>
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</tbody>
</table>

### Device Specifications

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

* * See MOSFET selection guide in presentation, online, and in energy-efficient solutions for LED lighting brochure
L6562A

15W Triac dimmable eval board

Key features | Main benefits
---|---
High power factor flyback topology supported > 0.9 | Compliant to energy saving regulations
Control and power section separated | Suitable for high power
Design flexibility | Design flexibility
Triac dimmable | Commonly available dimming option for home fixtures
High output voltage | No limitation to the number of LEDs within a string
Based on low-cost controller and MOSFETs | 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>
Key features | Main benefits
--- | ---
- High efficiency (> 90%), high power factor (> 0.9), flyback topology supported | - Compliant to energy saving regulations
- Control and power section separated | - Suitable for high power
- CC regulator in inverse buck working in fixed off time | - Design flexibility
- Constant ripple current, when input/output voltages change | - No limit to number of LEDs on string
- High output voltage | 

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

* Please contact local sales support to order this board
Non-isolated: 80W and higher eval board

**PFC boost + inverse buck**

<table>
<thead>
<tr>
<th>Applications</th>
<th>AC-DC stage</th>
<th>DC-DC stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Street lighting</td>
<td>PFC boost</td>
<td>Inverse buck</td>
</tr>
</tbody>
</table>

**Key features**

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

**Evaluation board**

<table>
<thead>
<tr>
<th>Evaluation board</th>
<th>Application note</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEVAL-ILL013V1</td>
<td>AN2928 UM0670</td>
<td>80 W offline LED driver with dimming based on L6562A</td>
</tr>
</tbody>
</table>
**Isolated: >70W resonant LED eval boards**

**PFC (L6562AT) + resonant converter (L6599AT) + inverse buck (L6562AT) with MOSFETs***

### Key features
- PFC + resonant controller, with extended temperature range
- No el-cap usage
- Zero voltage switching and symmetrical topology
- Post-regulation with dimming solution
- EN55015 and EN61000-3-2 compliant

### Main benefits
- Suitable for outdoor applications
- High rel (extended MTBF)
- Very high efficiency > 92%
- Dimmable solutions
- Satisfies the relevant lighting regulations

### Evaluation board

<table>
<thead>
<tr>
<th>Evaluation board</th>
<th>Application note</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EVL130W-SL-EU</td>
<td>AN3105</td>
<td>48 V, 130 W LED street lighting SMPS based on L6562AT and L6599AT for European input mains range</td>
</tr>
<tr>
<td>EVL130W-STRLIG</td>
<td>AN3106</td>
<td>48 V, 130 W LED street lighting SMPS based on L6562AT and L6599AT for wide input mains range</td>
</tr>
<tr>
<td>EVL6562A-LED</td>
<td>AN2983 AN2928 for ref</td>
<td>Modified buck converter for LED applications</td>
</tr>
</tbody>
</table>

* See MOSFET selection guide earlier in presentation, online, and in energy-efficient solutions for LED lighting brochure
Isolated LED supply: >75W eval board

L6564: current mode PFC controller

<table>
<thead>
<tr>
<th>Key features</th>
<th>Main benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast bidirectional input voltage feedforward</td>
<td>Fast reaction to</td>
</tr>
<tr>
<td>Protection</td>
<td>- load change</td>
</tr>
<tr>
<td>- for inductor saturation</td>
<td>- input voltage change</td>
</tr>
<tr>
<td>- adjustable overvoltage</td>
<td></td>
</tr>
<tr>
<td>- against feedback loop disconnection</td>
<td>Very robust design</td>
</tr>
<tr>
<td>Low start-up current</td>
<td>High efficiency</td>
</tr>
</tbody>
</table>

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

**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\textsubscript{AC}
- 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

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

<table>
<thead>
<tr>
<th>Evaluation board</th>
<th>Application note</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEVAL-ILL031V1</td>
<td>AN3151</td>
<td>Digital constant-current controller for multi-string LED applications based on STM8S208x</td>
</tr>
</tbody>
</table>
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

Intelligent LED cities – ST solutions

- Lamp driver and controller
  - Power Supply L6562AT L6599AT
  - LED Driving STM8S

- Lamp communication module: wireless network solution
  - STM32W
  - M24LR64-R

- Lamp communication module: wired network solution
  - STM32F
  - ST7540
  - M24LR64-R

District data concentrator

- GPRS Module
- M24128-Bxx
- STM32F
- ST7540
- STM32W
- M24LR64-R

Lightens street lighting energy load

STMicroelectronics
### Power MOSFET overview

<table>
<thead>
<tr>
<th>P/N</th>
<th>BVDss (V)</th>
<th>$R_{DS(on)}$ (max) (Ω)</th>
<th>Package</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST*90N4F3</td>
<td>40</td>
<td>0.0065</td>
<td>DPAK, TO-220, IPAK</td>
<td>STripFET™ III</td>
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<tr>
<td>ST*200N4F3</td>
<td>40</td>
<td>0.004</td>
<td>DPAK, TO-220</td>
<td>STripFET™ III</td>
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<td>ST*270N4F3</td>
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<td>0.0025</td>
<td>DPAK, TO-220</td>
<td>STripFET™ III</td>
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<td>STL70N4LLF5</td>
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<td>PowerFLAT 5x6</td>
<td>STripFET™ V</td>
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<td>STripFET™ V</td>
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<td>STL140N4LLF5</td>
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<td>PowerFLAT 5x6</td>
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<td>ST*3NF06L</td>
<td>60</td>
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<td>SOT-223</td>
<td>STripFET™ II</td>
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<tr>
<td>ST*4NF06L</td>
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<td>ST*28N6F3</td>
<td>80</td>
<td>0.034</td>
<td>PowerFLAT 3.3 x 3.3</td>
<td>STripFET™ III</td>
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<td>ST*4NF100</td>
<td>100</td>
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<td>STripFET™ II</td>
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<td>ST*19NF20</td>
<td>200</td>
<td>0.16</td>
<td>TO-220, TO-220FP, DPAK</td>
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<td>ST*20NF20</td>
<td>200</td>
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<td>STripFET™ II</td>
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<td>ST*16NF25</td>
<td>250</td>
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<td>TO-220, TO-220FP, DPAK</td>
<td>STripFET™ II</td>
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<td>ST*50NF25</td>
<td>250</td>
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<td>TO-220, DPAK</td>
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<tr>
<td>STQ3N45K3-AP</td>
<td>450</td>
<td>3.8</td>
<td>IPAK, SOT-223, TO92</td>
<td>SuperMESH 3™</td>
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<td>ST*8NM50N</td>
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<td>0.79</td>
<td>DPAK, TO-220, TO-220FP</td>
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<td>ST*10NM50N</td>
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<td>ST*11NM50N</td>
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<td>ST*14NM50N</td>
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<td>0.32</td>
<td>DPAK, DPAK</td>
<td>MDmesh™ II</td>
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<td>DPAK, TO-220, TO-220FP</td>
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<td>ST*23NM50N</td>
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<td>0.19</td>
<td>DPAK, TO-247, TO-220FP</td>
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<td>SuperMESH 3™</td>
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<td>ST*6N52K3</td>
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<td>DPAK, TO-220FP</td>
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<td>1.15</td>
<td>DPAK, TO-220FP, TO-220</td>
<td>SuperFREDmesh 3™</td>
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<td>ST*7NM60N</td>
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<td>0.9</td>
<td>DPAK, TO-220, TO-220FP</td>
<td>MDmesh™ II</td>
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<td>ST*9NM60N</td>
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<td>DPAK, TO-220, TO-220FP</td>
<td>MDmesh™ II</td>
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<td>0.55</td>
<td>DPAK, TO-220, TO-220FP</td>
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<td>0.36</td>
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<td>ST*18NM60N</td>
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</table>

**MDmesh II** – ST’s 2nd generation super junction, high-voltage power MOSFET technology

**SuperMESH 3** – Covers high-voltage breakdown class for
- improved avalanche ruggedness
- lower on-resistance
- enhanced dynamic performance
- improved diode reverse recovery characteristics

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STEVAL-ILL027V2

STEVAL-ILL017V1

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STEVAL-ILL016V2

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EVALHVLED805

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Thank you