ST Power Discrete Solution for SMPS

陳文聰 Alvin Chen
意法半導體
大中華暨南亞區功率元件技術行銷專案經理
High Voltage
Power MOSFET

Planar technology

Super-junction technology

SuperMESH “NK series”

SuperMESH™ K3

MDmesh™ M5

MDmesh™ M6

MDmesh™ M2

MDmesh™ M2 EP

MDmesh™ DM2 with fast diode

MDmesh™ DM2 with fast diode

PowerMESH “N series”

MDmesh™ K5

200V 400V 500V 600V 650V 700V 800V 1000V 1050V 1200V 1500V
SuperJunction MDmesh™
M5, M6, M2, DM2 & K5 Technologies

Products & Applications

- M5: the leading technology for high end hard switch
  
  **Key Features**
  - Industry’s one of the lower $R_{DS(on)}$ in the Market
  - High switching speed
  - 650V Bvdss rated
  
  **Benefit**
  - highest efficiency in the application
  - Smaller form factor of final system
  - Especially targeted for High Power hard switching (PFC, Boost, TTF, Flyback)

- M2 / M2 EP/ M6: best for LLC
  
  **Key Features**
  - Up to 30% lower Qg (equivalent die size)
  - 400 – 700V Bvdss rated
  - Back-to-Back G-S zener protected
  
  **Benefit**
  - Reduced switching losses through optimized (Qg) ($C_{iss}$, $C_{oss}$)
  - Enhanced immunity vs ESD & $V_{gs}$ spikes in the application
  - Especially targeted for HB LLC, TTF, Flyback...
  - M2 EP Tailored for Very High Frequency Converters ($f >$)

- DM2 DM6 Fast Diode: best F/B ZVS
  
  **Key Features**
  - Integrated fast body diode
  - Softer commutation behavior
  - Back-to-Back G-S zener protected
  
  **Benefit**
  - Reduced switching losses through optimized (Qg) ($C_{iss}$, $C_{oss}$)
  - High peak diode $dV/dt$ capabilities
  - Best use in Full Bridge ZVS

- K5: best in class Very High Volt.
  
  **Key Features**
  - Extremely good $R_{DS(on)}$ at very high BVDSS
  - High switching speed
  - From 800 till 1500V BVDSS rated
  - 950 V and 1050 V integrated fast body diode
  
  **Benefit**
  - High efficiency with lower design complexity
  - Especially targeted for flyback LED topologies and high voltage range in the application
MDmesh™ M2 EP Series

Key features
• Extremely low Qg
• Optimized for light load conditions
• Optimized Vth and Rg values for soft switching
• Body diode ruggedness

Key benefits
• Improved efficiency especially in light load condition in PFC and resonant topologies (i.e. LLC)
• Reduced switching losses for wide range of load and input voltage
• Suitable for hard & soft-switching topologies

Up to 20% $E_{off}$ reduction
MDmesh™ M6

- Especially targeted for resonant topologies (LLC) and high-medium PFC
- Optimized Vth (3.25 V min, 4.75 V max, 4V typ) and Rg values for soft switching
- 600V, 650V, 700V BVdss rated
- Low conduction and even more reduced switching losses in soft switching
- Extremely low Qg vs previous series and optimized Capacitances profile for light load conditions;
- Easy to drive

Chargers, Adapters, SilverBox, LED lighting, Server, Telecom, Solar, UPS, LCD TV
MDmesh™ M6
Improves your efficiency

KEY FEATURES

• Up to 35% Eoff reduction
• Up to 35% turn off loss reduction in hard switching converters
• Turn-off energy and curve available at datasheet
MDmesh™ K5

- Extremely good RDS(on) at very high BVdss
- Industry’s best figure of merit (FoM)
- High switching speed 800V-900V-950V-1050V-1200V-1500V BVdss rated
- High efficiency with lower design complexity
- Especially targeted for Flyback LED driver topologies and AUX PSU
- Higher safety margin

LED Driver, LED Lighting, Adapter/Metering, Solar Inverters, Factory automation, Consumer
# LV MOSFET STripFET™ Series

## Application – Topology positioning

<table>
<thead>
<tr>
<th>Voltage Range</th>
<th>Device</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>30V</td>
<td>H6</td>
<td>Load Switch O-ring, Motor drives</td>
</tr>
<tr>
<td></td>
<td>H7</td>
<td>DC-DC &amp; Synchronous Rectification, SMPS / SERVER / TELECOM</td>
</tr>
<tr>
<td></td>
<td>H8</td>
<td>Sine wave inverter, Motor Drives</td>
</tr>
<tr>
<td>40V - 80V</td>
<td>F6</td>
<td>Motor Drives / Sync.R / DC-DC / O-Ring / Primary Switch / Reverse battery protection</td>
</tr>
<tr>
<td>40V - 150V</td>
<td>F7</td>
<td>Sync.R / DC-DC / O-Ring / Primary Switch / BMS</td>
</tr>
<tr>
<td>100V &amp; 150V</td>
<td>F8</td>
<td>ForkLift / Telecom Bricks / Light Electric Vehicles / Solar Inverters / SMPS for Data Center</td>
</tr>
</tbody>
</table>

- **H8/F8**: Under development
# STripFET™ H7 & F7 Series Highlights

<table>
<thead>
<tr>
<th>Features</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely Low Rds(on)</td>
<td>• Low conduction losses</td>
</tr>
<tr>
<td>Optimized body diode (low Qrr) and intrinsic capacitances (Optimal capacitance Crss/Ciss ratio)</td>
<td>• Excellent switching performance (higher efficiency) • No EMI issue</td>
</tr>
<tr>
<td>ST provides several package solutions, including PowerFLAT 5x6 and H2PAK</td>
<td>• A more complete solution provided to the CTMs</td>
</tr>
</tbody>
</table>

## Key Advantages Vs Competition
- Among the best on-resistance in PowerFLAT 5x6
- Excellent intrinsic body-drain recovery charge (Qrr)
- Higher efficiency of final applications

## Key applications
- Server
- Solar
- Energy Management
- Automotive
- Motor Control
- AC/DC & Isolated DC/DC Power Supply

## ST can offer a Very Wide Product Portfolio in the LV arena
- From 12V to 350V
- Trench: F6-F7-H6-H7 (plus Schottky diode on board)

### Key products:
- **STH410N4F7-6AG**: 0.8 mΩ typ on-resistance in a H2PAK package (i.e. for EPS applications)
- **STL220N6F7**: 1.2 mΩ typ on-resistance in a chip scale PowerFLAT 5x6 package
60V STripFET™ “F7” at a Glance

STripFET improvement: 7th vs 6th gen

Features

<table>
<thead>
<tr>
<th>Order code</th>
<th>$V_D$</th>
<th>$R_{D\text{on max}}$</th>
<th>$I_D$</th>
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<tbody>
<tr>
<td>STL220N6F7</td>
<td>60 V</td>
<td>0.0014 Ω</td>
<td>40 A</td>
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</table>

New F7 series

- Lower conduction losses
- Lower switching losses

FoM @10V

-70%
Package
Continuous Packaging Improvement

01
Now You Can!
Extremely Low Profile
Improved Thermal dissipation
Reduced Inductance generation due to internal contacts

02
Improved & Upgraded
Widen solution for Cree-page clearance
UNL Removed Stand-off for Height clearance
Through Hole Low Profile fully molded “4Leads” with Kelvin Source

03
Now You Can!
Power & Customization
Higher operating junctions temperature
Integration & Sensing Functions
## TO-220FP Ultra Narrow Lead Package

### Key Features and Benefits

**Features:**
- Ultra narrow lead for full insertion
- Total height lower than 15.9 mm when fully inserted
- 18% reduction vs TO-220FP when inserted at stand off

**Benefits:**
- Reduced thickness of case adapter
- Compact solution

### Dimension Comparison

![Dimension Comparison Diagram](Image)

**0.9mm (Max.)**

### Ultra Narrow Lead

![Ultra Narrow Lead Image](Image)

- < 15.9 mm
- 18.8 mm

### MOSFET Portfolio

<table>
<thead>
<tr>
<th>BV_{DSS} [V]</th>
<th>R_{DSon} [mΩ]</th>
<th>ID [A]</th>
<th>P/N</th>
<th>Eng. Samples Datasheet</th>
<th>status</th>
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</thead>
<tbody>
<tr>
<td><strong>600</strong></td>
<td></td>
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<td></td>
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<tr>
<td>0.38</td>
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<td></td>
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<tr>
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</table>
Key Features and Benefits

Features:
- Body height lower than 10.85 mm
- 30% reduction vs TO220FP
- Full insertion at stand off
- Step cutting for better creepage
- Missing upper hole

Benefits:
- Reduced thickness of case adapter
- Compact solution
- High insulation
- Avoid the use of screw
- Fixing clip

VHV MOSFET Portfolio

<table>
<thead>
<tr>
<th>Technology</th>
<th>$BV_{DSS}$ [V]</th>
<th>$R_{DSon}$ [Ω]</th>
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HV MOSFET Portfolio

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</table>
Wide Creepage Package

Thermal Behaviors

![Graph showing thermal behaviors](image-url)

+ heatsink

Test Condition

- DC/DC Converter
- Load
- $f_{SW} = 53kHz, 55kHz, 65kHz$
- $I_d = 2.2.5.2.7$
- $V_{in}=200Vdc$
- $V_{out}=17Vdc$

Key Features and Benefits

**Features:**
- No need to use insulation paste (Silant)
- Wider case Dimension vs TO-220FP standard
- Package shared with two other big players in the market

**Benefits:**
- Better throughput for customers in their assembly line
- Cost Saving
- Possibility to assembly more sizes
- Higher Insulation rating

MOSFET Portfolio

<table>
<thead>
<tr>
<th>BV_{DSS} [V]</th>
<th>R_{Dson} [Ω]</th>
<th>ID [A]</th>
<th>P/N</th>
<th>Eng. Samples</th>
<th>Datatsheet</th>
<th>status</th>
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<tbody>
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</tbody>
</table>
### Efficiency comparison

![Efficiency comparison chart](chart.png)

- **Temperature**
- **Efficiency**

Δη=0.34%

### Key Features and Benefits

**TO247-4 Features:**
- Kelvin Source PIN to separate power path from driving signal
- Increased creepage between PINs

**TO247-4 Benefits:**
- Lower losses at both turn-off and turn-on
- Higher efficiency
- Lower working temperature
- Higher insulation standards

### MOSFET portfolio

<table>
<thead>
<tr>
<th>BV_{GSS} [V]</th>
<th>R_{DS(on)} [mΩ]</th>
<th>ID [A]</th>
<th>P/N</th>
<th>Main application</th>
<th>Eng. Samples</th>
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<tbody>
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</table>
PowerFLAT™ New Packages for HV MOSFETs

The smart package solutions for space saving

ST provides a new fantastic trio of Surface Mounting Packages belonging to the new High Voltage PowerFLAT™ Family

- PowerFLAT™ 8x8 HV
- PowerFLAT™ 5x6 HV & VHV
- PowerFLAT™ 3.3x3.3 HV
Brand new finders, to allow an easier and faster recollect of the most important information about any power transistor in ST’s portfolio.
ST Rectifiers Product Range

- **Power Schottky diodes**
- **Ultrafast bipolar rectifiers**
- **Field-effect rectifiers**
- **SiC diodes**

- **Signal Schottky diodes**
## 4 pillars to drive Innovation and Leadership

### Power Schottky Rectifiers
- Planar Power Schottky technology
- Lowest $V_F$ with “L” series
- Optimized $V_F/I_R$ trade-off (H, M series)
- Avalanche specification
- $T_j$ max = 175°C
- From 15 to 200V

### Ultra Fast Rectifiers
- Planar Ultra Fast technology w/ Pt doping
  - Lowest $Q_{RR}$ with “R” series; Tandem Config.
  - Optimized for a large scope of applications (L, R & S EV/MC series)
  - $T_j$ max = 175°C
  - From 200V to 1200V, extension to 1600V

### Very High Efficiency
**FERD technology**
- Power integration
- Flat packages
- Best in class $V_F/I_R$
- “U” & “M” series
- From 45 to 100V

**SiC technology**
- Get the highest efficiency on the market
- Downsize your global system
- From 600 to 1200V

### Environment & Quality
- Lead Free components
- RoHS compliant
- Halogen free resin
- PPAP capable
- AEC-Q101 compliant
Silicon Carbide Diode
Where to Place SiC Diodes?

- Motor drive
- Telecom power
- Industrial Power Supply
- Automotive
- PC power
- Server power
- UPS
- Industrial
- Motor drive

High reliable products with high performances and robustness

Different solutions which can cover a wide range of applications
Introduction to SiC Diode

• ST SiC uses Shottky technology to get the best efficiency possible in the application
  • Schottky SiC ("G1" series)

• Schottky using JBS (Junction-Barrier Schottky) solution ("G2" series)
  • It overcomes the drawback of the positive thermal coefficient of the "G1" series
  • Surge current capability is increased
<table>
<thead>
<tr>
<th>Year</th>
<th>Series</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>«G1» series</td>
<td>Introduction to the market of first ST SiC range.</td>
</tr>
<tr>
<td></td>
<td>«G2» H series</td>
<td>Evolution of the 1° gen.</td>
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<tr>
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<td>Implementation of JBS structure</td>
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<tr>
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<td>Improvement of robustness with higher $I_{FSM}$ vs «blank»</td>
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<tr>
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<td>Improvement of $V_{RRM}$ up to 650V</td>
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<tr>
<td>2012</td>
<td>«G2» C series (TO-220AC)</td>
<td>Best robustness/price value tradeoff</td>
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<tr>
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<td>Suitable for mainstream applications</td>
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<tr>
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<td>Implementation of JBS structure</td>
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<td></td>
<td>Automotive Grade</td>
<td>Improvement of robustness with higher $I_{FSM}$ vs «blank»</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Improvement of $V_{RRM}$ up to 650V</td>
</tr>
<tr>
<td></td>
<td>New blank 650V series</td>
<td>Best in class $V_F$</td>
</tr>
<tr>
<td>2016 H1</td>
<td>«G2» H series</td>
<td>Low forward conduction losses and negligible switching losses</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High efficiency adding value to the power converter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High robustness ensuring high reliability for automotive</td>
</tr>
<tr>
<td>2016 H2</td>
<td>New 1200V SiC</td>
<td>For high power applications and three phase topologies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Complete offer available in H2 2016</td>
</tr>
</tbody>
</table>
IFSM / VF Trade-offs of ST SIC Diode

Multiple trade-offs to address all market needs

- **HIGH EFFICIENCY**
  - New blank

- **High Robustness**
  - (Recommends for continuous mode PFC circuits)

\[ I_{FSM} \quad \text{vs} \quad V_F \]
Field-Effect Rectifiers
Introduction to FERD

Higher Efficiency

Positioning performances / price is in between Schottky and Sync. Rectification

Reliability: Where Schottky has risk of thermal runaway, the FERD makes the difference.

increase Power Integration

The smart solution to reduce space

Smaller package

BOM cost reduction

Provide the best in class \( V_F/I_R \) trade-off not achievable with Schottky
Benefit of FERD Technology

Benefit of FERD diode compared to the PS:

- Ultra low VF technology => for a better efficiency
- Higher current density (A/mm²) => Package size reduction / saving space
- Continuous trade off VF/IR for same die size => for an optimized design
- Lower leakage current ratio typ/max => for a better design
- Lower dependency of IR versus Tj => Lower thermal runaway risk
- Lower $V_F$ value at low temperature => efficiency improved at light load
- Lower $\alpha VF$ => benefit for parallel configuration
## FERD Family Portfolio

<table>
<thead>
<tr>
<th>Voltage</th>
<th>30 A</th>
<th>40 A</th>
<th>60 A</th>
<th>20 A</th>
<th>50 V</th>
<th>60 V</th>
<th>100 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>45V</td>
<td>FERD30M45CT</td>
<td>FERD30M45CG</td>
<td>FERD30M45CR</td>
<td>FERD30U50CFP</td>
<td>FERD30U45CG</td>
<td>FERD40L60CG</td>
<td>FERD20H100SFP</td>
</tr>
<tr>
<td>50V</td>
<td>FERD40M45CT</td>
<td>FERD40M45CG</td>
<td>FERD40U45CG</td>
<td>FERD20H/L60CG</td>
<td>FERD20U60DJF</td>
<td>FERD40L60CG</td>
<td>FERD30SM100ST</td>
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<tr>
<td>60V</td>
<td>FERD60M45CT</td>
<td>FERD60U45CT</td>
<td></td>
<td>FERD20H/L60CG</td>
<td>FERD20U60DJF</td>
<td>FERD40L60CG</td>
<td>FERD30SM100ST</td>
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<tr>
<td>100V</td>
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<td>FERD20H100SFP</td>
<td>FERD40H100SG</td>
<td>FERD30SM100ST</td>
</tr>
</tbody>
</table>

- **Green**: Mass Production
- **Orange**: In development
Rectifiers Presentation

You can download the new app:

ST DIODE FINDER
Thank You

ST stands for life.augmented