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100W HV (1kVDC) auxiliary power supply: from solar to high power industrial

STMicroelectronics

STMicroelectronics solution for very high-voltage medium-power auxiliary power supplies

Need for
very HV auxiliary power supplies

100W HV (1kVDC)
auxiliary power supply

Key power product families

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Need for very HV auxiliary power supplies

Industrial market requires very HV auxiliary power supplies

Auxiliary power supply to manage several tens of watts

Very high voltage input bus (up to 1kVDC)

Flyback topology with isolated output

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Markets with very high voltage bus

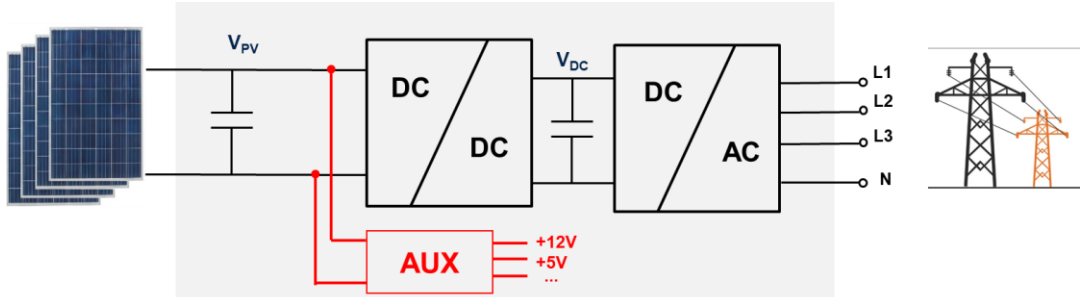
Industrial Drives

On-line UPS

Solar Inverter

Very high voltage auxiliary power supplies in solar inverters & on-line UPS

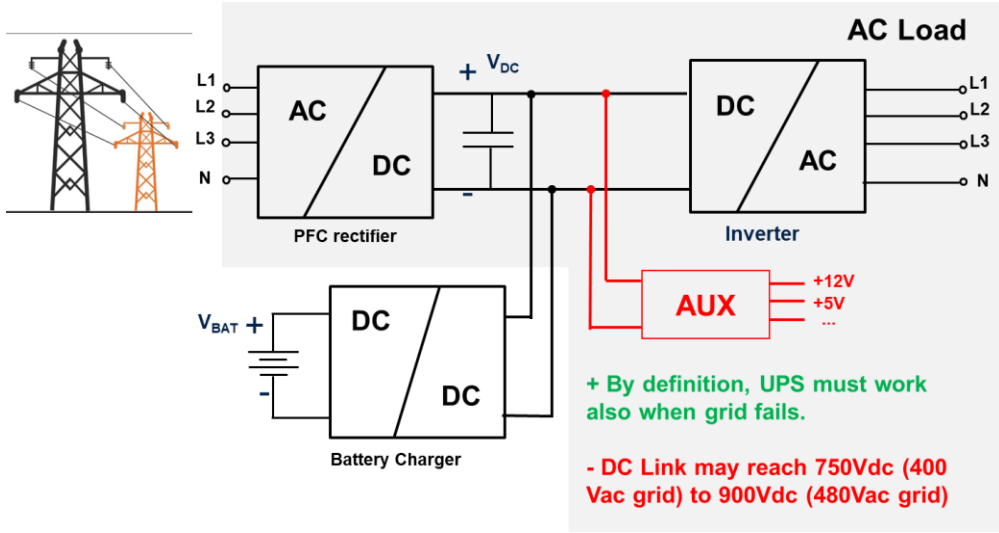
SOLAR INVERTER



+ Zero consumption during night.

+ Safety, in case grid fails, inverter still „alive“ for safe disconnection

ON-LINE UPS



+ By definition, UPS must work also when grid fails.

- DC Link may reach 750Vdc (400 Vac grid) to 900Vdc (480Vac grid)

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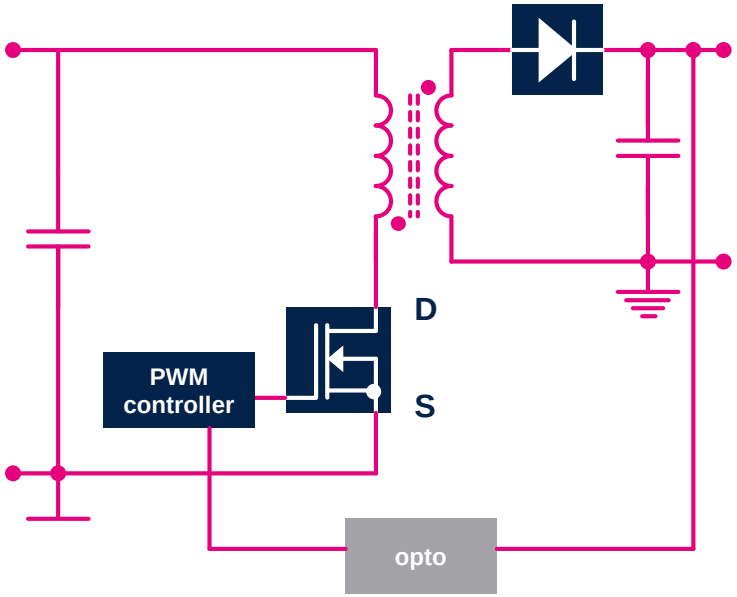
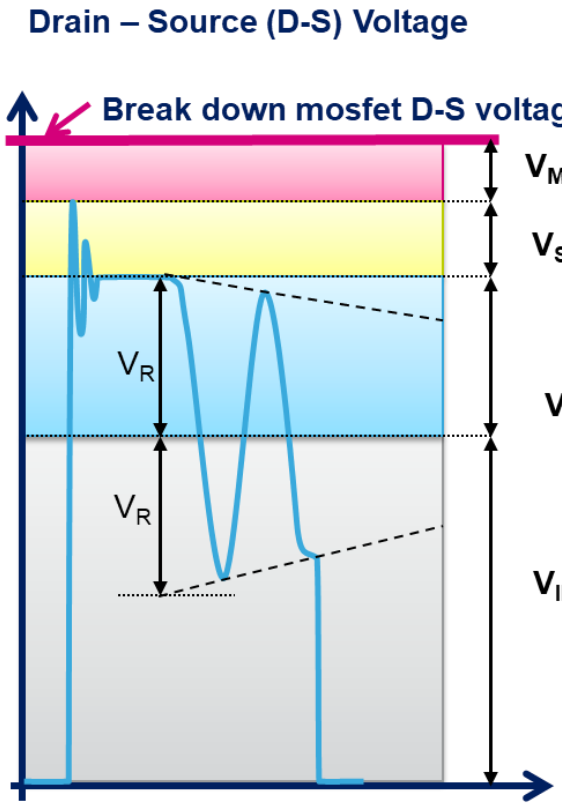
Minimum MOSFET break-down voltage requirement

FLYBACK TOPOLOGY





Margin

V_{Margin} = 10 – 30% $V_{(BR)DSS}$

Leakage inductance spike

Limited by peak calm circuit

V_{SPIKE} = 50 – 200V typically

Reflected Voltage

$$V_R = nV_{OUT} = \frac{D}{(1-D)}V_{IN}$$

V_R = 50 – 200V typically

Input voltage

V_{INmax} = 1000V

V_{INPUT}	$V_{REFLECTED}$	V_{SPIKE}	V_{MARGIN}	V_{DS_MIN}	
1000V	+ 200V	+ 180V	+ 200V	= 1580V	1.7kV

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100W HV (1kVDC) auxiliary power supply with 1700V K5 super-junction MOSFET

Very high voltage, robust, efficient flyback

- 88% peak efficiency
- 1kV HV start-up
- Undervoltage down to 150 VDC / 180 VAC

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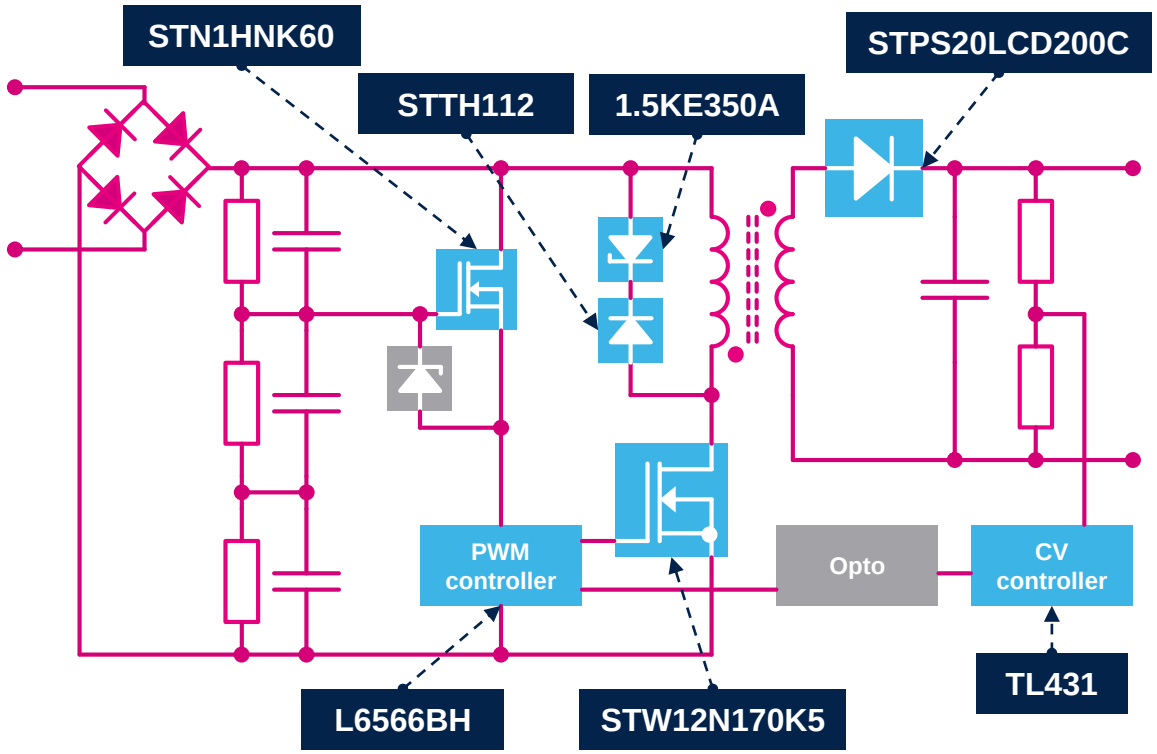
STEVAL-ISA211V1: 100W HV (1kVDC) auxiliary power supply

ST Evaluation Board
STEVAL-ISA211V1
(available October 2020)

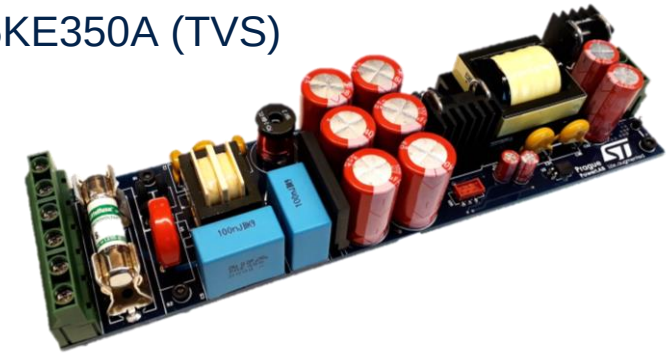
- Wide input voltage range:
  - 230 to 690 VAC
  - 250 to 1000 VDC
- Output 24 V / 100 W
- Short time undervoltage (long time for 50W output) down to 150 VDC / 180 VAC
- Selectable fixed-frequency or quasi-resonant operation
- Embedded 1kV high voltage startup
- Modified soft-start circuit
- Optionable brownout protection
- RoHS compliant

STEVAL-ISA211V1: 100W HV (1kVDC) auxiliary power supply



ST Products

- STW12N170K5 (1700V K5 super-junction MOSFET)
- L6566BH (flyback controller)
- STPS20LCD200C (200V Schottky diode)
- STN1HNK60 (600V planar MOSFET)
- TL431 (voltage reference)
- STTH112 (1200V ultra-fast diode)
- 1.5KE350A (TVS)



Up to 88% efficiency at full load

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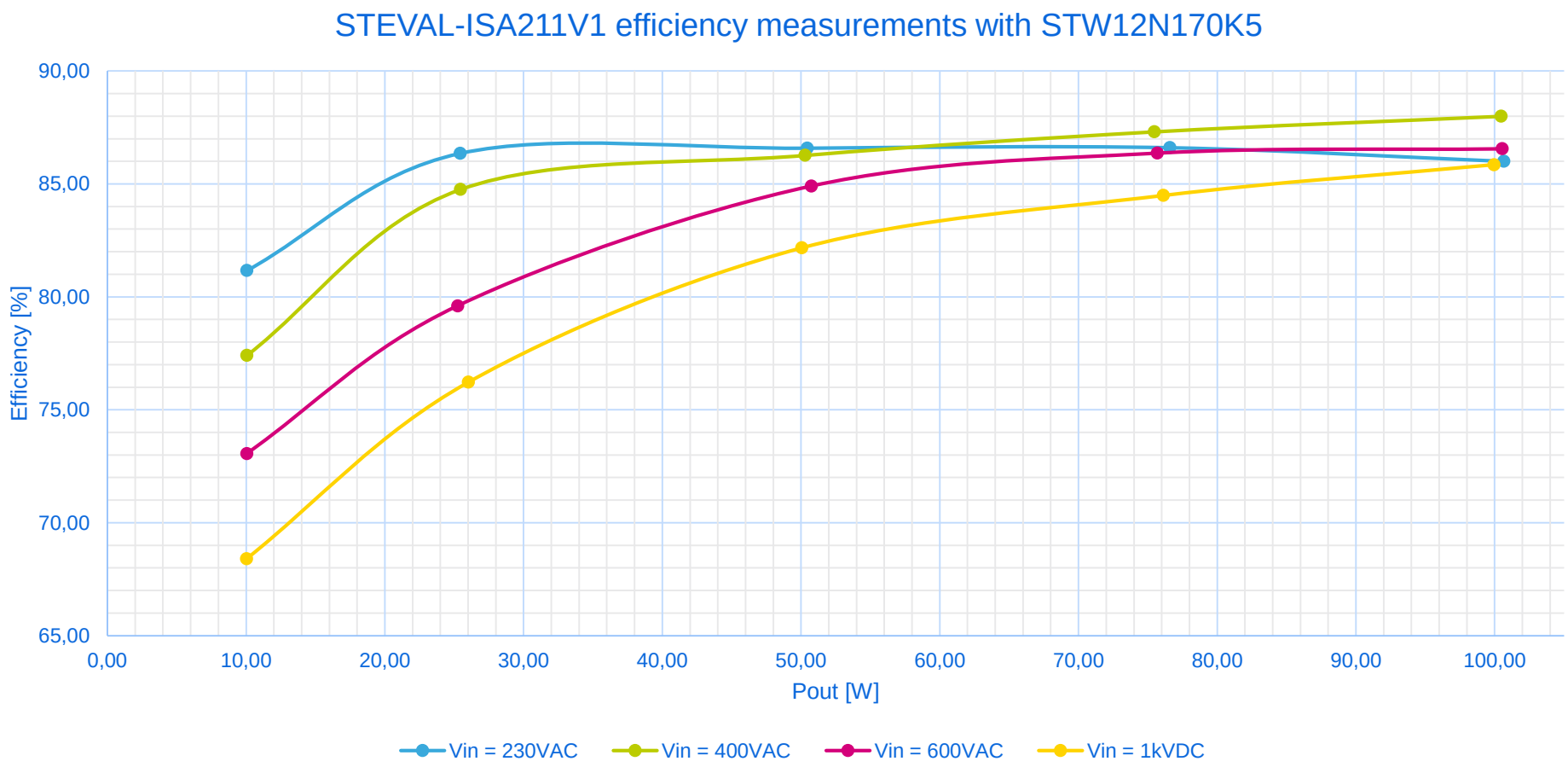
100W HV (1kVDC) auxiliary power supply Efficiency at different input lines



Efficiency at full load > 86% at all input line conditions

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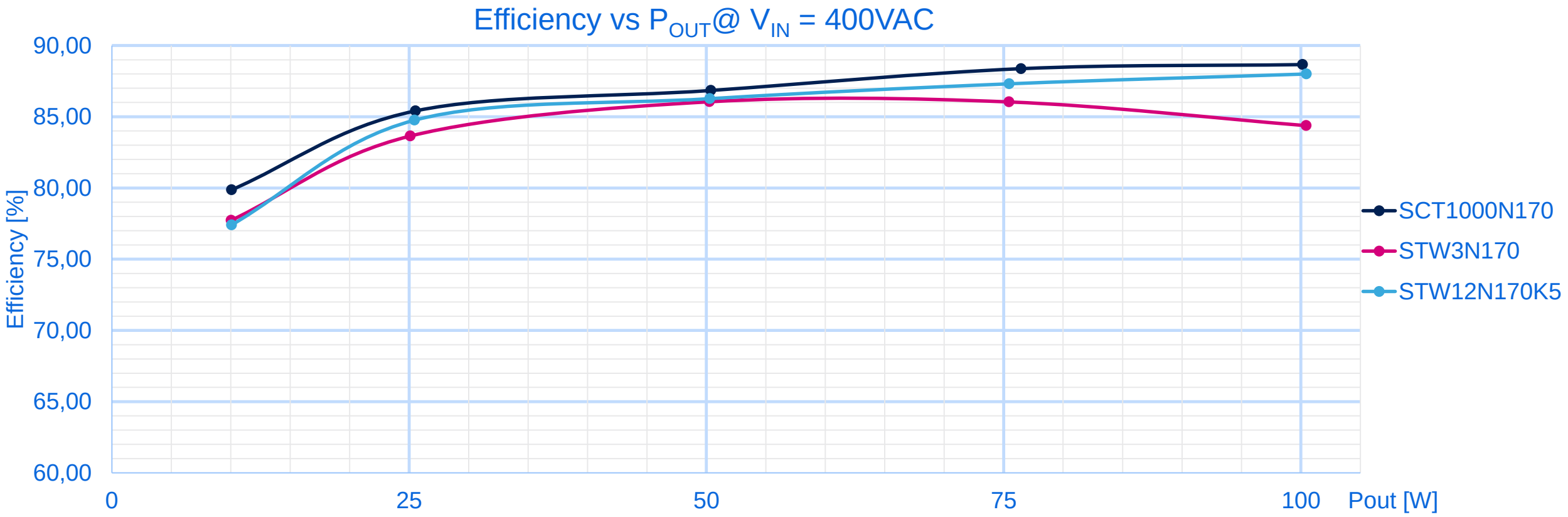
100W HV (1kVDC) auxiliary power supply
Efficiency for different MOSFET technologies



Very high efficiency (88% at full load) also with K5 super-junction MOSFET

SIC MOSFET gives ~ 1% more efficiency

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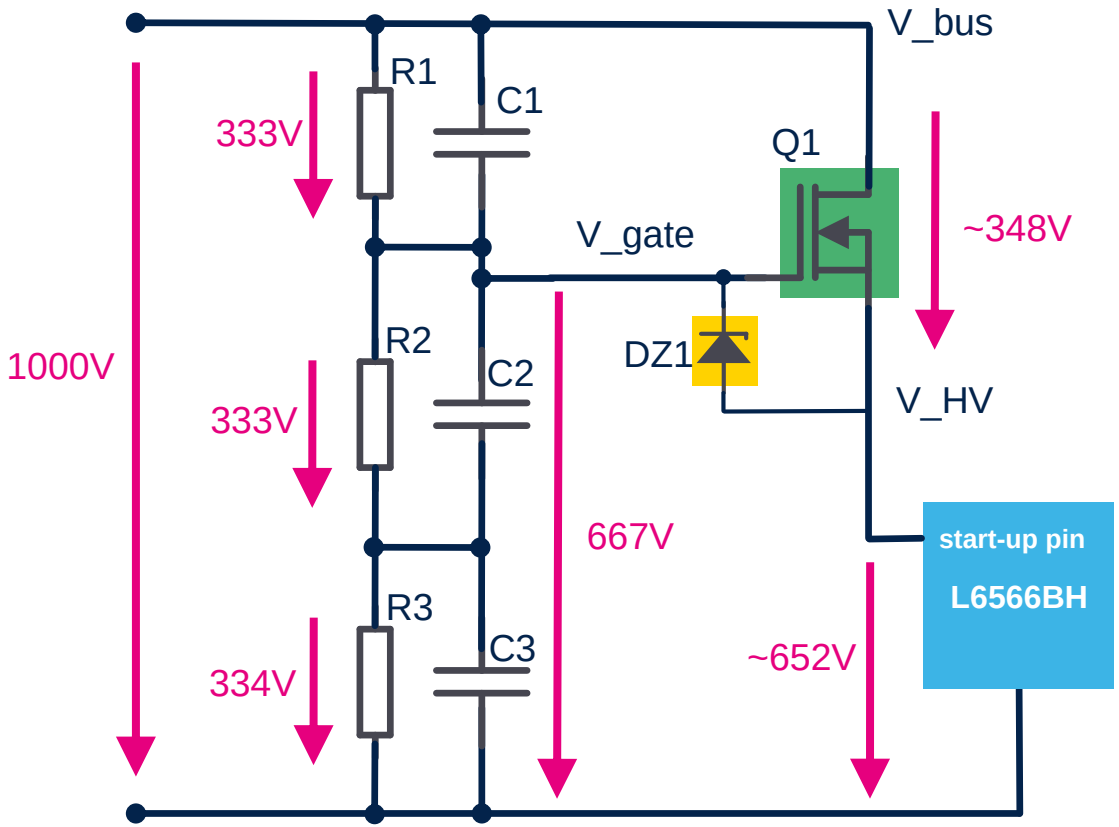
100W HV (1kVDC) auxiliary power supply
HV start-up extension



- R1,2,3: balancing resistors
- C1,2,3: electrolytic capacitors
- Q1: high voltage MOSFET
- DZ1: zener diode

MOSFET Q1 extends the HV start up strength. L6566BH has embedded 840V HV start-up.

The total applicable voltage considering the 20% margin and using STN1HNK60 (600V) is ~1200V.

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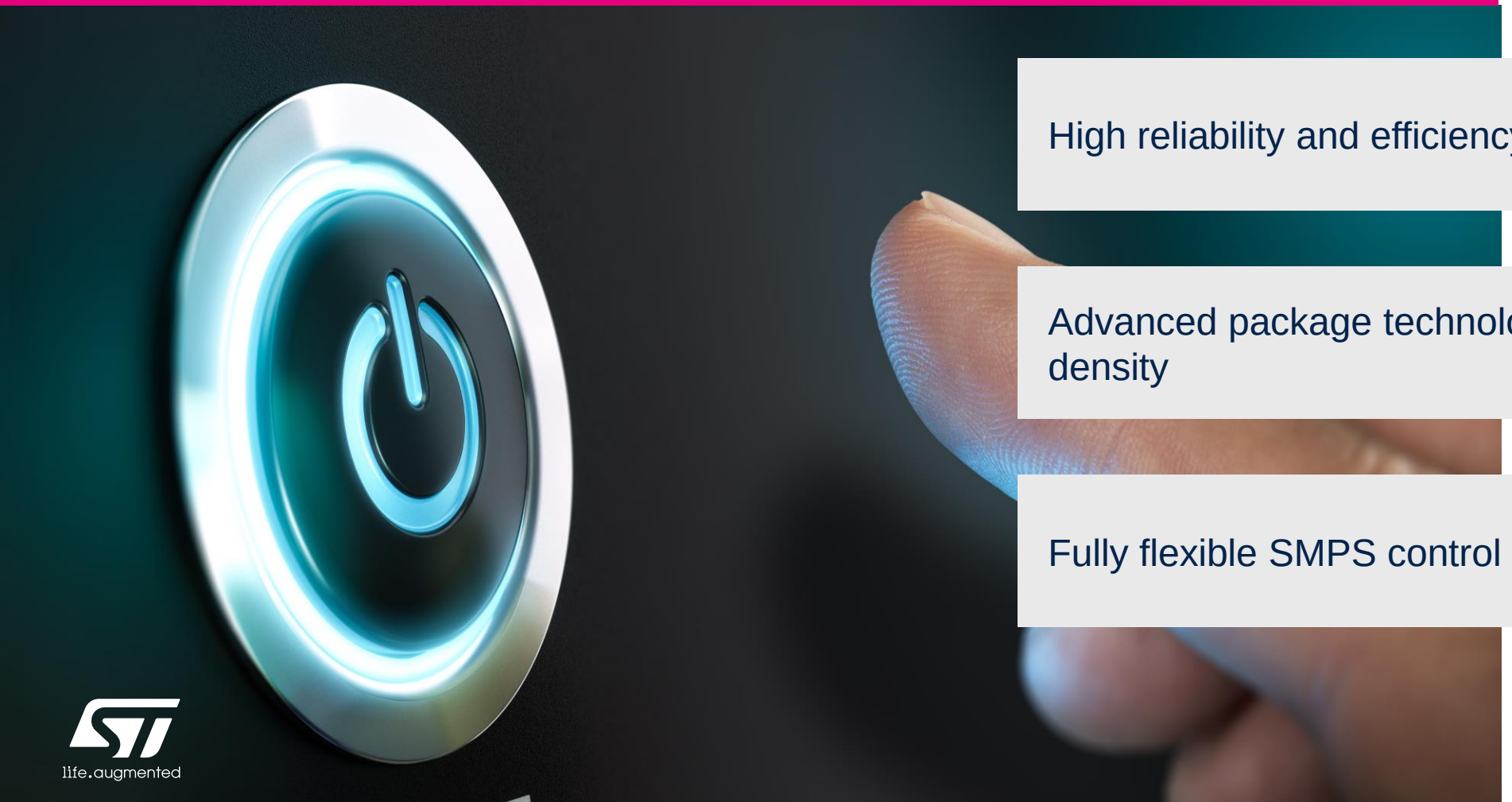
Key power product families

A real boost for robust & efficient SMPS



- High reliability and efficiency
- Advanced package technology to increase power density
- Fully flexible SMPS control

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MDmesh* K5 series
S-J MOSFET family for Flyback and 3-ph PSU

The ONE-STOP-SHOP for VHV MOSFET

- **The most complete** series for Very HV MOSFET (from 800 up to 1700V)
- **Targeted** for Flyback topologies and 3 phase SMPS
- **Best in class $R_{DS(on)}$** for >1000V BVdss range

Higher BVDSS for higher design margin

Industry's **lowest** $R_{DS(on)}$ for higher power and greater efficiency

Lowest Qg for faster and more efficient switching

Low Ciss and Coss for low energy losses

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800V ÷ 1700V MDmesh* K5 series for performance and ruggedness

Datasheet data

Avalanche energy, single pulse	E_{AS}	-	-	43	mJ	I_D=2.2A; V_{DD}=50V
Avalanche energy, repetitive	E_{AR}	-	-	0.36	mJ	I_D=2.2A; V_{DD}=50V
Avalanche current, repetitive	I_{AR}	-	-	2.2	A	-

Best competitor

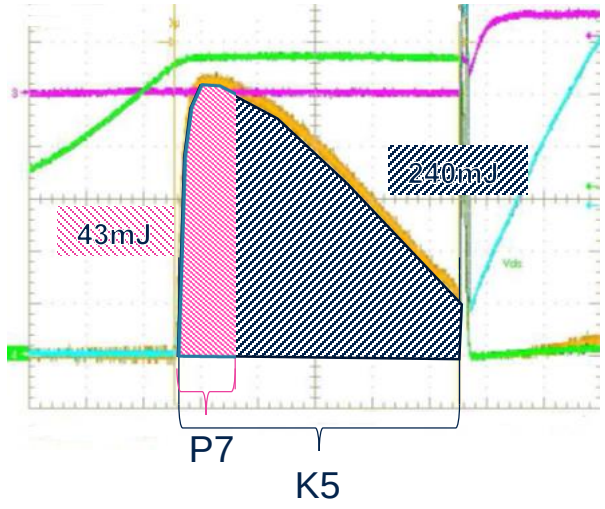
Similar avalanche current (Iar)

Table 4: Avalanche characteristics

Symbol	Parameter	Value	Unit
I_{AR}	Avalanche current, repetitive or not repetitive (pulse width limited by T_{jmax})	2.7	A
E_{AS}	Single pulse avalanche energy (starting T_j = 25 °C, I_D = I_{AR}, V_{DD} = 50 V)	240	mJ

ST

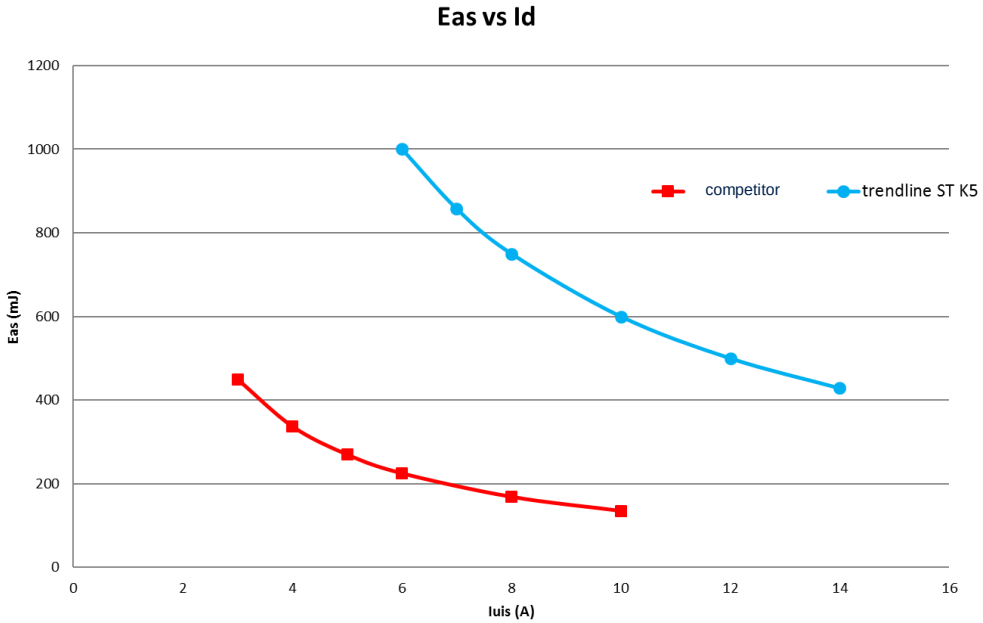
Picture is purely indicative of avalanche phenomenon



Performance

STF14N80K5 vs competitor

UIS test condition: @Vdd=50V; Vgs=10V; Rg=47ohm



NOTE: Destructive test, not an absolute maximum rating

K5 shows avalanche energy dissipation capability is far superior to best in class RDS(on) from competition.

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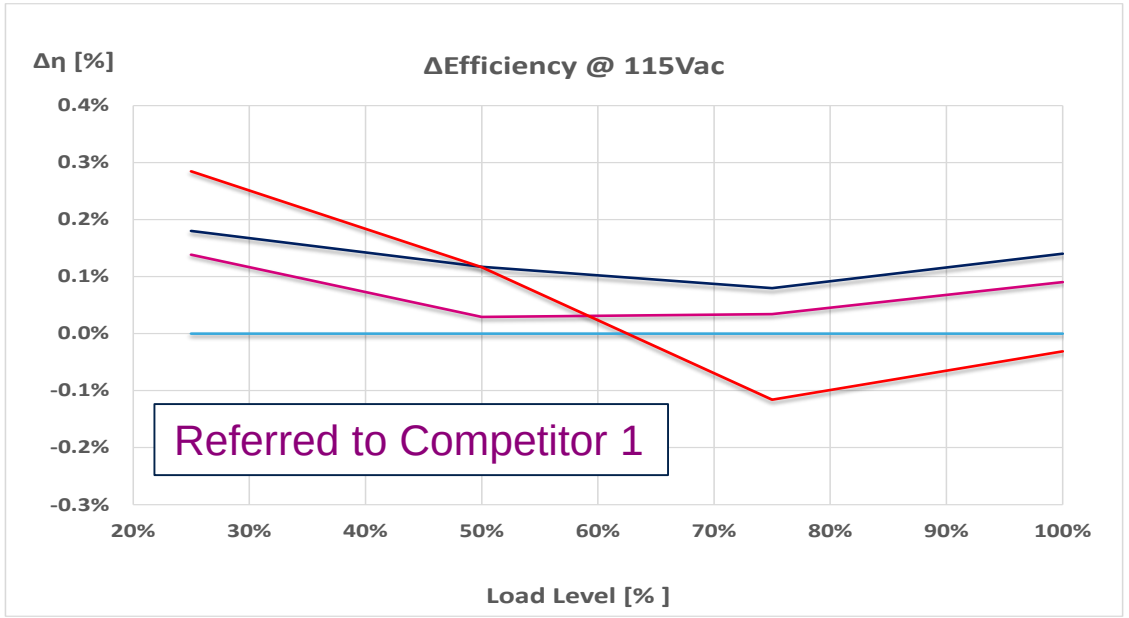
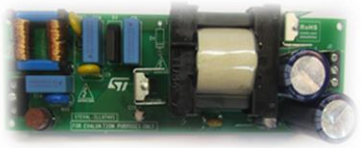
MDmesh* K5 Positioning
Test benchmark with 800V/450 mΩ



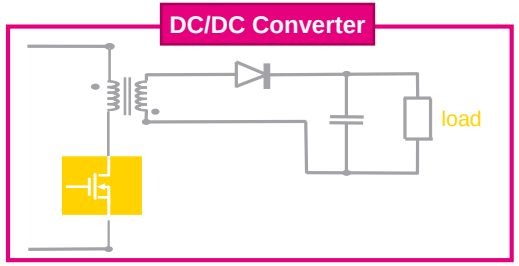
STF14N80K5 | Competitor 2 | Competitor 1 | Competitor 3



STEVAL – ILL074V1

- V_{IN} = 115 Vac
- P_{OUT} = 60 W Flyback
- V_{OUT} = 52 V

tested without heat-sink



	STF14N80K5	Competitor 1	Competitor 2	Competitor 3
BV_{dss} [V]	**800** ID=1mA	**800** VGS=0, ID=0.25mA	**800** VGS=0, ID=0.25mA	**800** VGS=0, ID=1mA
$V_{GS(th)(typ)}$ [V]	**4** VDS=VGS, ID=0.1mA	**3** VDS=VGS, ID=0.68mA	**3** VDS=VGS, ID=0.68mA	**3** VDS=VGS, ID=0.22mA
$R_{DS(on)(max)}$ [mΩ]	**445** VGS=10V, ID=6A	**450** VGS=10V, ID=7.1A	**460** VGS=10V, ID=7.1A	**450** VGS=10V, ID=4.5A

* Datasheet values

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HV MOSFETs
Advanced packaging technologies

SMD

PowerFLAT™

- 3.3x3.3
  - Space Saving vs. SOT223
- 5x5
  - Customized solutions
- 5x6
  - Higher creepage for Very High Voltage
- 8x8 (HV)
  - Space Saving vs. D2PAK
  - Higher efficiency
  - Kelvin pin option avallabile

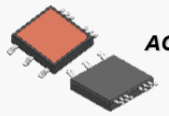
TO-LL

- Compactnes
- Higher power density
- Reliability at high V_{DSS} rating

H2PAK

- Designed for Automotive
- Higher insulation voltage (higher creepage)
- Available for 1200V series
- Available with 7 pins

ACEPAKTM SMIT



In development

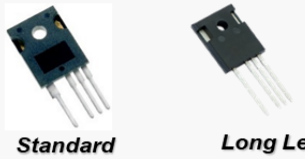
- Top side cooling package
- Dice chips on Direct Bond Copper (DBC) substrate
- 2500Vrms electrical isolation
- Product Plan in Development

SOT223-2

Keys advantages

- Increase Power Density
- Reduce parasitic effects
- Target higher efficiency level

Through Hole (TO247-4)



Kelvin Pin (versus 3L solution)

- Lower Switching losses
- Higher efficiency
- Available in Long Lead option
- Higher insulation voltage (higher creepage)

Our wide range of new packages maximize design flexibility.
The new MOSFET technology increases power density in the smallest packages.

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ST Flyback controllers

	L6565	L6566A/B/BH	HVLED001A/B	STCH03
Mode of Operation	QR	QR or FF (with programmable FSW)	QR	QR
PSR (CV)	NO	NO	YES	NO
Also CC supported	NO	NO	YES (but SSR needed)	YES
Power Factor Correction	NO	NO	YES	NO
Additional frequency modulation for low EMI	NO	YES	NO	YES
HV start-up	NO	YES, 700V or 840V	YES, 800V	YES, 650V
Stand-by	depending on ext. HV start-up	~100mW	~250/150mW	<10mW
OCP	pulse-by-pulse and hiccup	pulse-by-pulse + hiccup with counter + 2nd OCP	pulse-by-pulse + hiccup with counter + 2nd OCP	pulse-by-pulse + hiccup with counter + 2nd OCP
Additional short circuit management	shutdown, autorestart with Vcc	shutdown, autorestart with Vcc or latched	shutdown, autorestart after 2.5s	with output UVP
Voltage feedforward	YES	YES, programmable	NO	YES
Output OVP	NO	YES, autorestart or latched	YES, autorestart	YES, autorestart **or latched**
Input OVP	NO	Could be obtained by DIS PIN	YES	NO
Brown-out Protection	NO	YES, programmable	YES	NO
External Components	~ 10	~ 12	~ 9	~ 8
Package	SO8, DIP8	SO16N	SSO10	SO8
Highlights	**BASIC**	**HIGH FLEXIBILITY, MANY PROTECTIONS**	**PSR, MANY PROTECTIONS**	**LOW STAND-BY, LOW BOM**

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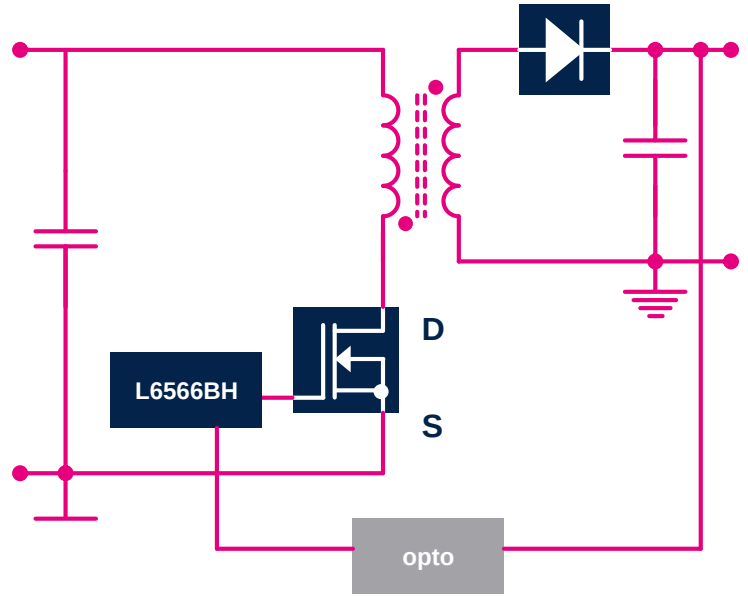
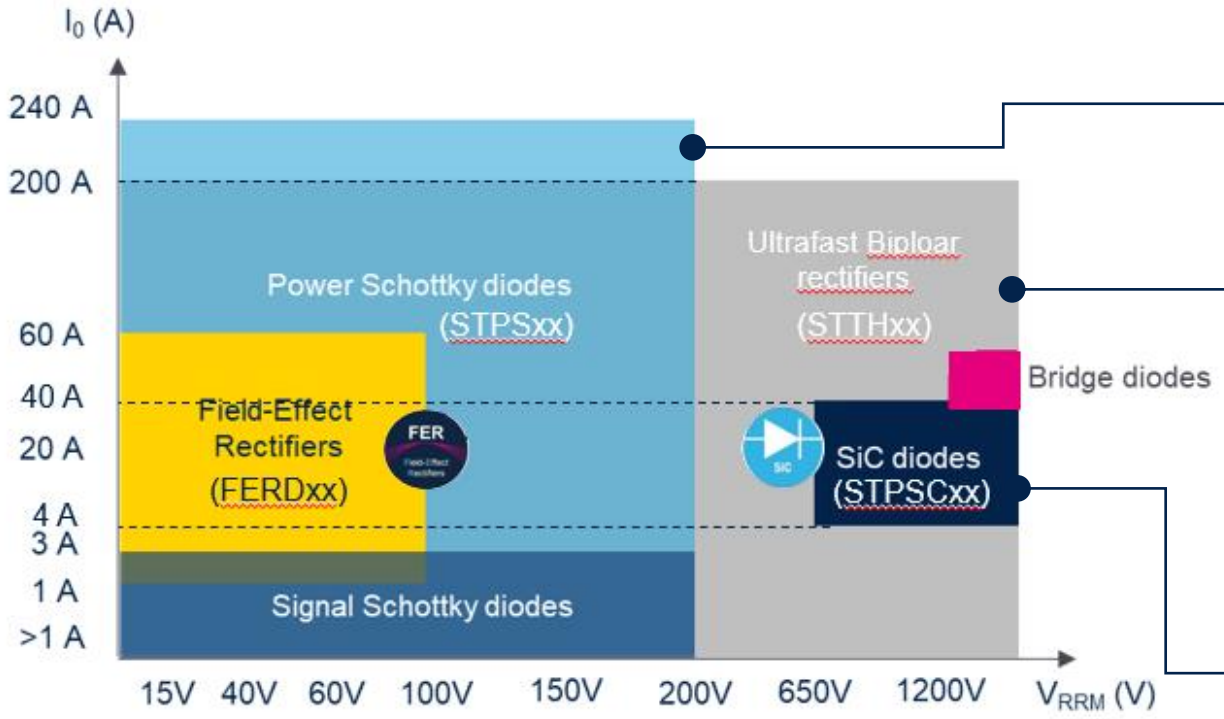
Multi-mode flyback controller

- Selectable multimode operation: fixed frequency or quasi-resonant
- On-board 840 V high voltage startup
- Advanced light load management
- Adaptive UVLO
- Line feedforward for constant power capability vs. mains voltage
- Pulse-by-pulse OCP, shutdown on overload (latched or auto-restart)
- Transformer saturation detection
- Programmable frequency modulation for EMI reduction
- Latched or auto-restart OVP
- Brownout protection



ST Rectifiers

A broad portfolio from Low to High voltage and Silicon Carbide



Low voltage diodes (<200V) – FERD and STPS series :

- Avalanche rated
- 175°C as mainstream
- Low V_F

High Voltage silicon diodes (200V – 1200V):

- Platinium doped for low leakage & high reliability
- 175°C everywhere
- multiple trade-off tailored by application & market

Silicon Carbide diodes (650V – 1200V):

- Wide range of High robustness and low V_F devices
- In mass production since 10 years

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Thank you

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