life.augmented

Totem-pole PFC reference design with SiC technology

STMicroelectronics

STMicroelectronics powers totem pole PFC with SiC MOSFETs, thyristor SCRs and digital control

Bridgeless totem-pole PFC

Inrush current limiter with SCRs in totem-pole PFC

3.6 kW totem pole PFC solution with SCR Inrush current limiter

Key Power Product Families

life.augmented

Bridgeless totem-pole PFC

Supporting Car Electrification and Power Conversion

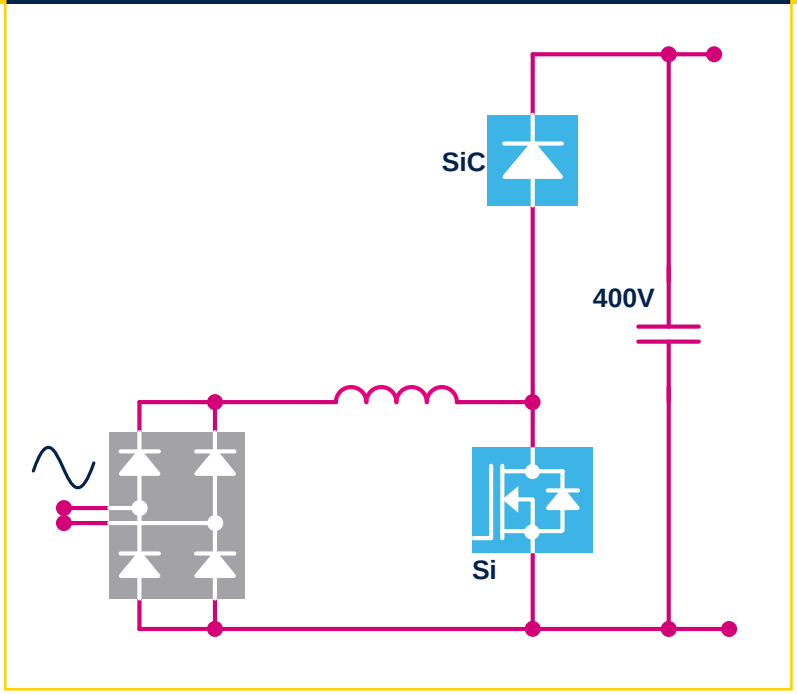
- Increased power density with totem pole boost
- Smart Inrush Current Limitation
- SCR high reliability without moving parts

life.augmented

Basic single phase PFC topologies for CCM

With input bridge rectifier

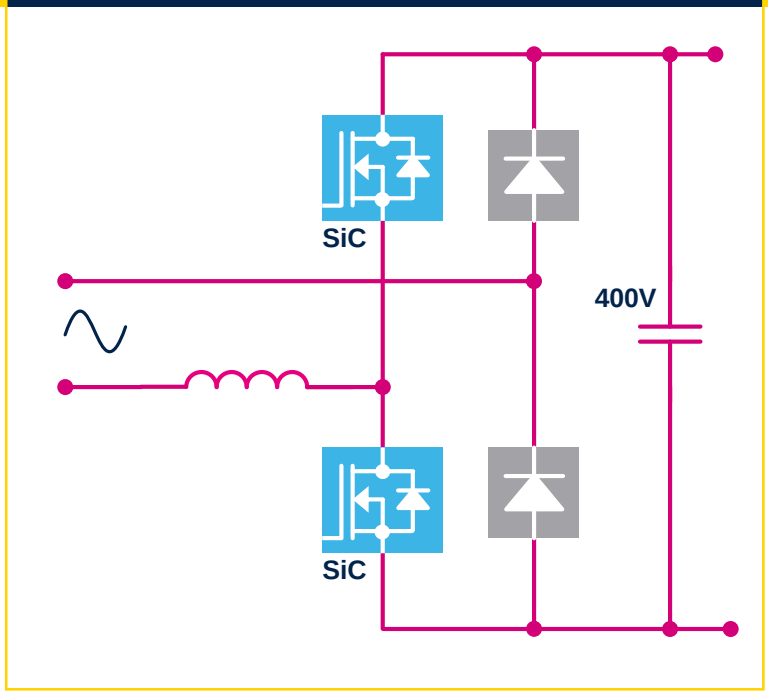
Simple Boost



+ Simple
+ Simple input voltage sensing
- Two diodes in series all the time

Bridgeless

Totem-pole

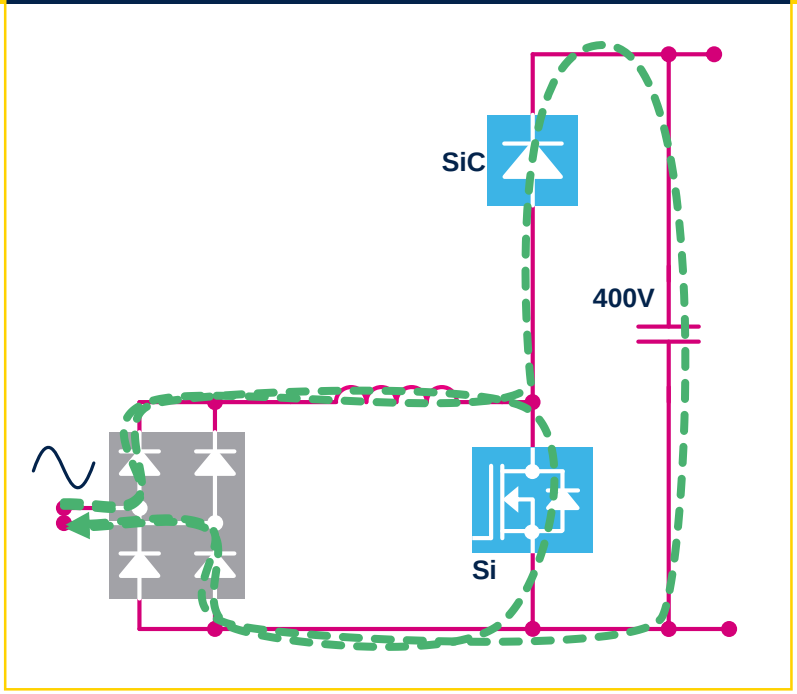


+ Higher efficiency
- Input voltage sensing requires OpAmp
- More complex
- Needs SiC MOSFETs with no Q_{RR} of diode

Basic single phase PFC topologies for CCM

With input bridge rectifier

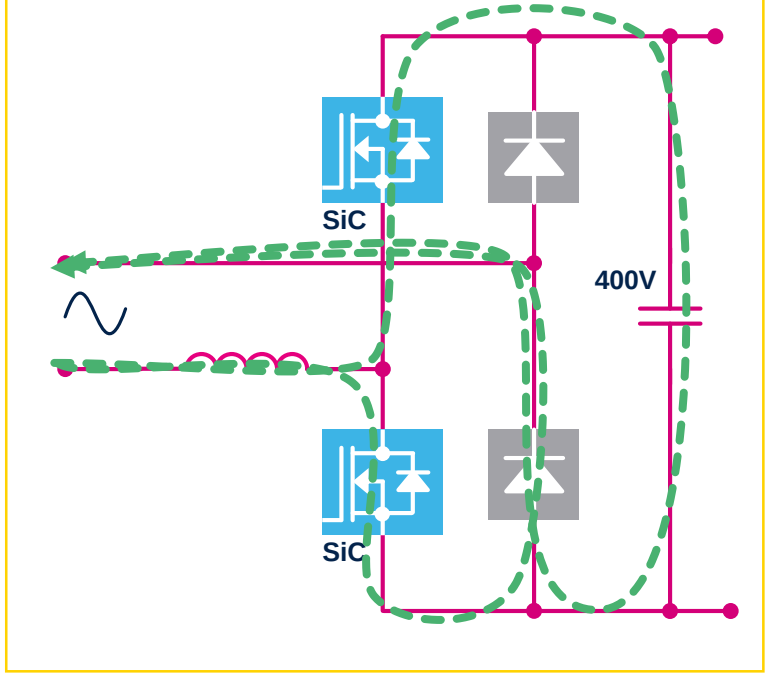
Simple Boost



junctions in series: **3**

Bridgeless

Totem-pole



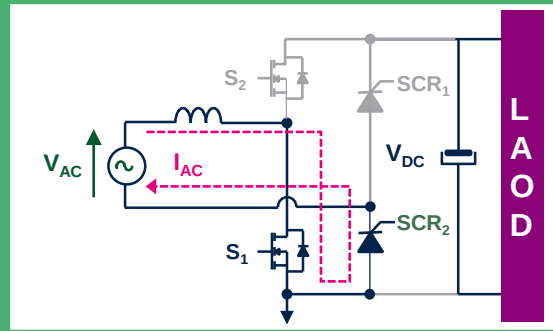
junctions in series: **2**

Totem pole bridgeless PFC working in CCM totem pole PFC operation in steady-state

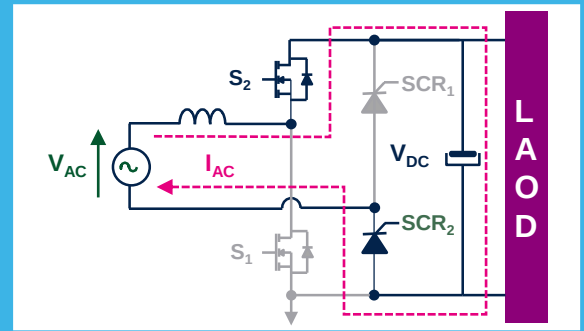
$V_{AC} > 0$

S1 controls PFC choke charging
S2 body diode is used only for discharging choke to the output
S2 can be switched on during t_{off} to reduce voltage drop of the body diode

S1 on, inductor current rising



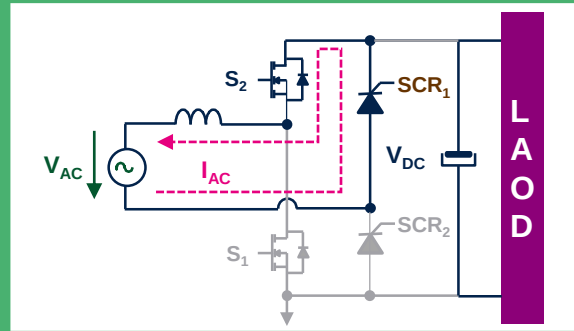
S1 off, inductor current falling



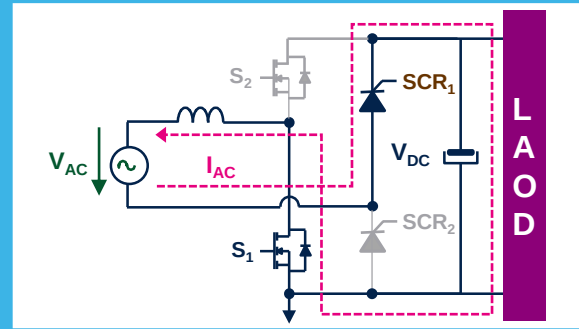
$V_{AC} < 0$

S2 controls PFC choke charging
S1 body diode is used only for discharging choke to the output
S1 can be switched on during t_{off} to reduce voltage drop of the body diode

S2 off, inductor current rising



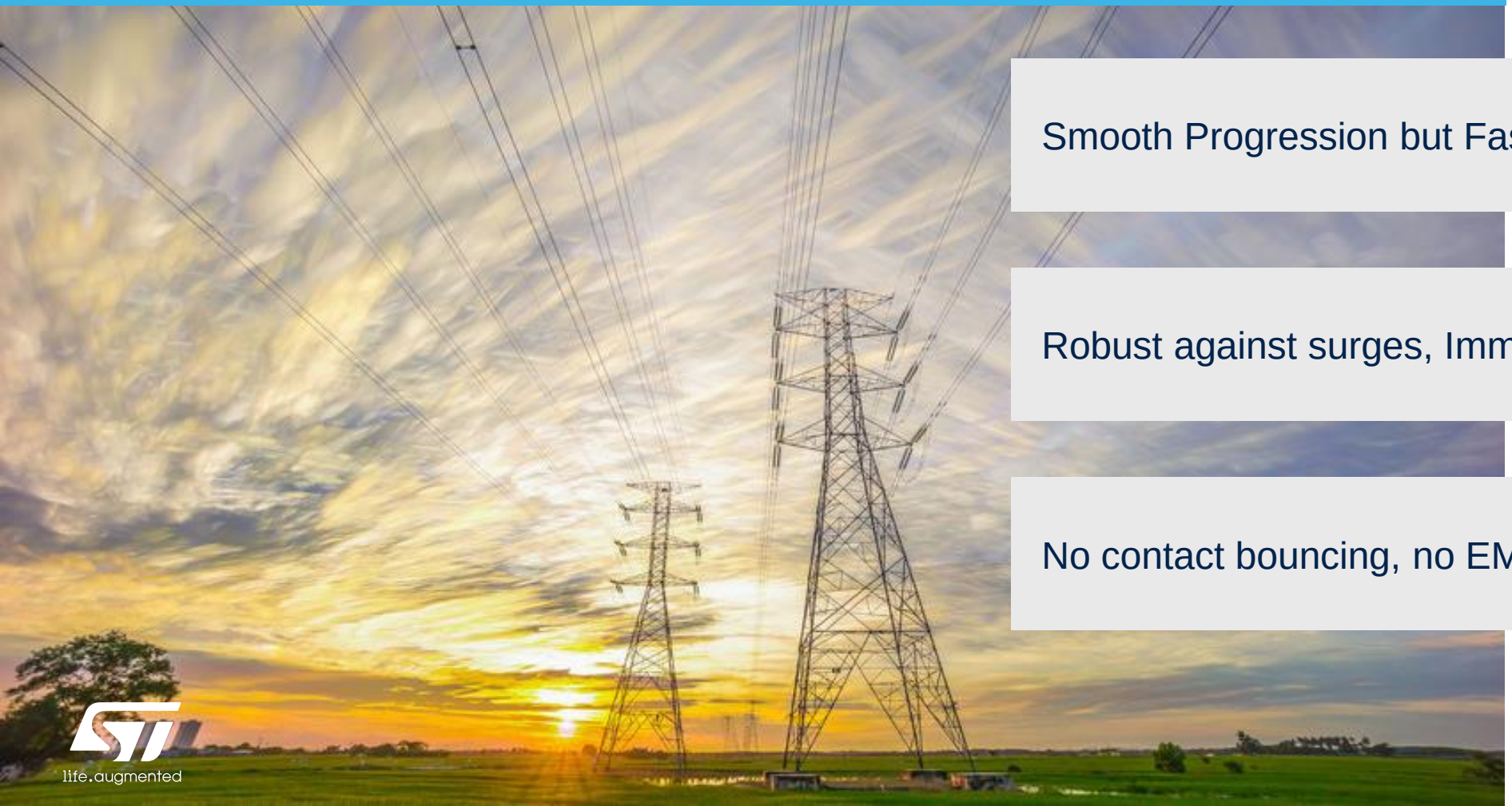
S2 off, inductor current falling



life.augmented

Inrush current limiter with SCRs in totem-pole PFC

Smart and Reliable control of the AC Power Delivery

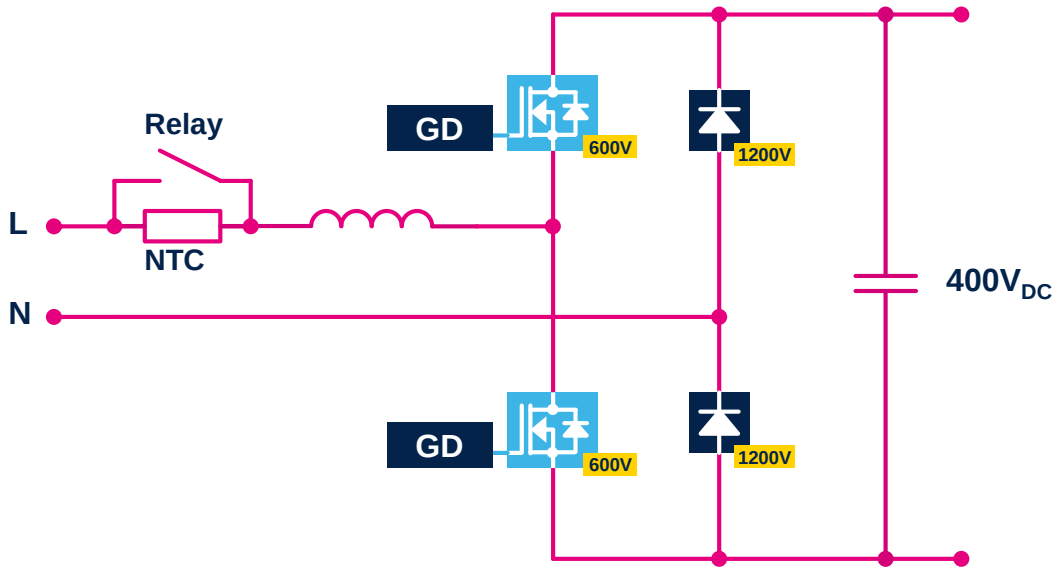


- Smooth Progression but Fast Power Up
- Robust against surges, Immune to electrical transients
- No contact bouncing, no EMI noise

life.augmented

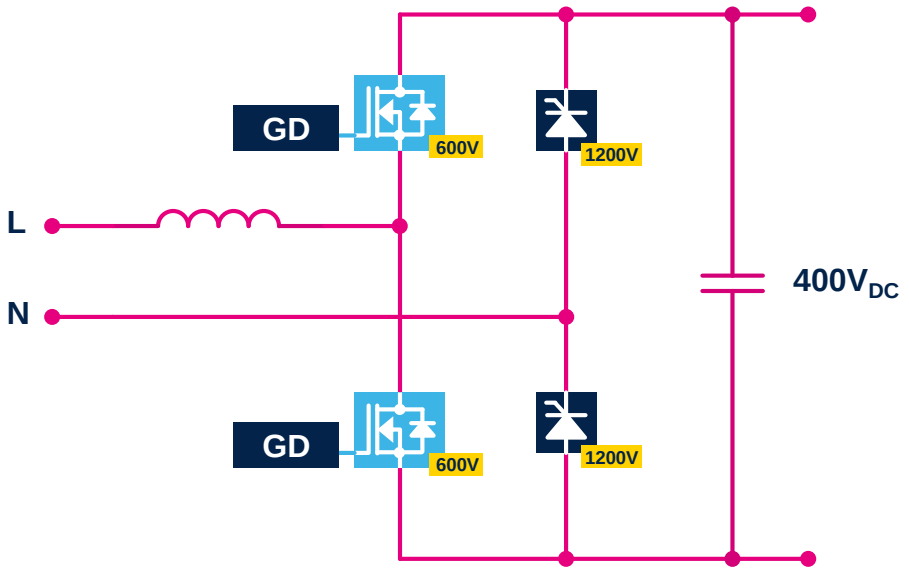
Inrush current limiter with SCRs in totem-pole PFC

ICL with NTC and bypassing relay



- Diodes are used for returning current path
- Resistive element is inserted into current path (NTC or PTC)
- NTC is bypassed after startup by relay to decrease power losses on NTC

ICL with SCRs



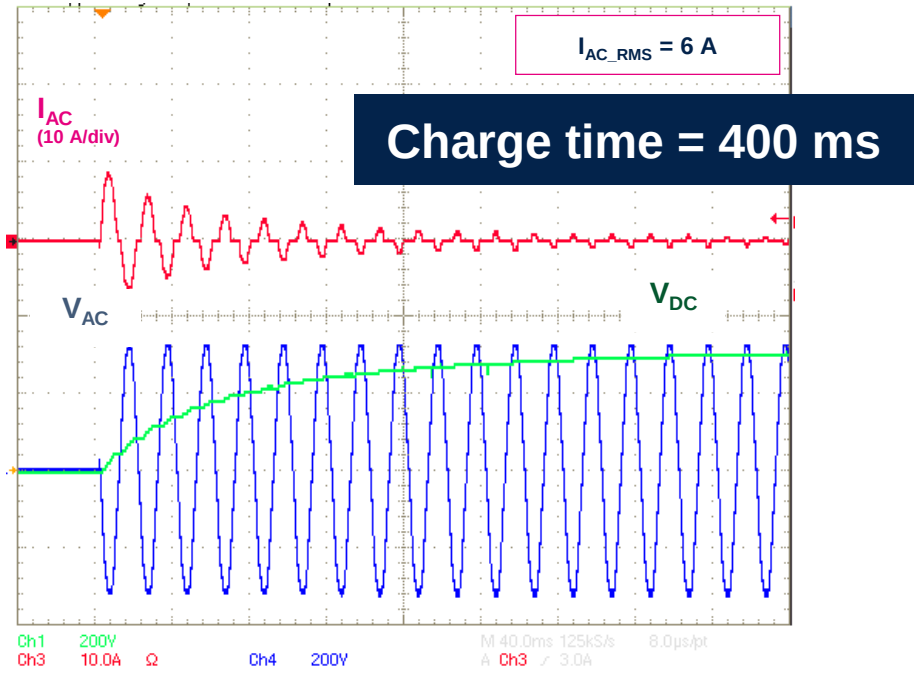
- SCRs are used for returning current path
- When SCR are not being switched, output capacitor is disconnected
- During startup phase, pulses to SCR are being time controlled to slowly charge output capacitor
- This method requires timing → MCU required

life.augmented

Inrush current limiter with SCRs in totem-pole PFC

ICL with NTC and bypassing relay

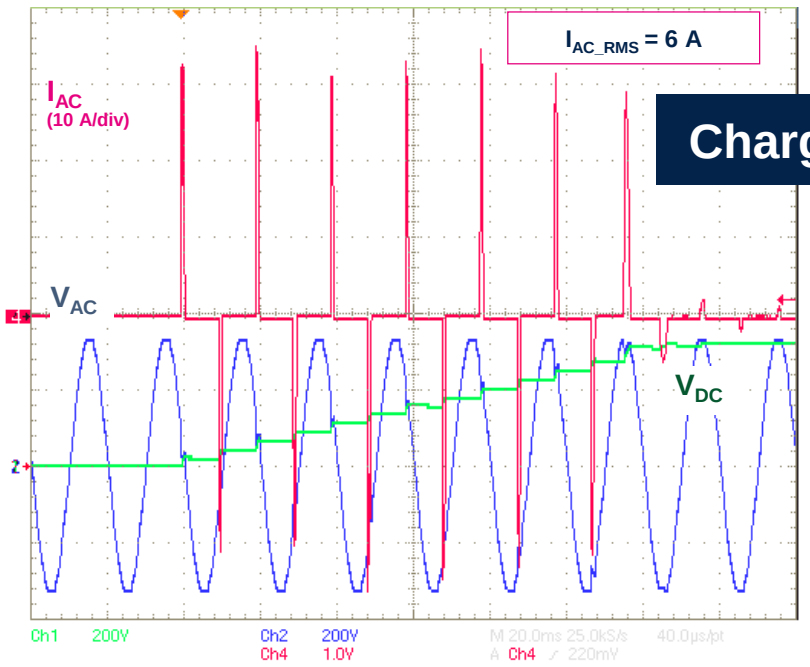
+ Relay can be driven by simple delaying circuit
- Relay causes audible noise when switching
- Relay not usable in systems with vibration
- Relay metal contact aging
- Slower charging time (current drops every cycle):



Charge time = 400 ms

ICL with SCRs

+ No electromechanical bouncing
- Need exact SCR pulse timing
+ Faster startup procedure (constant peak current)

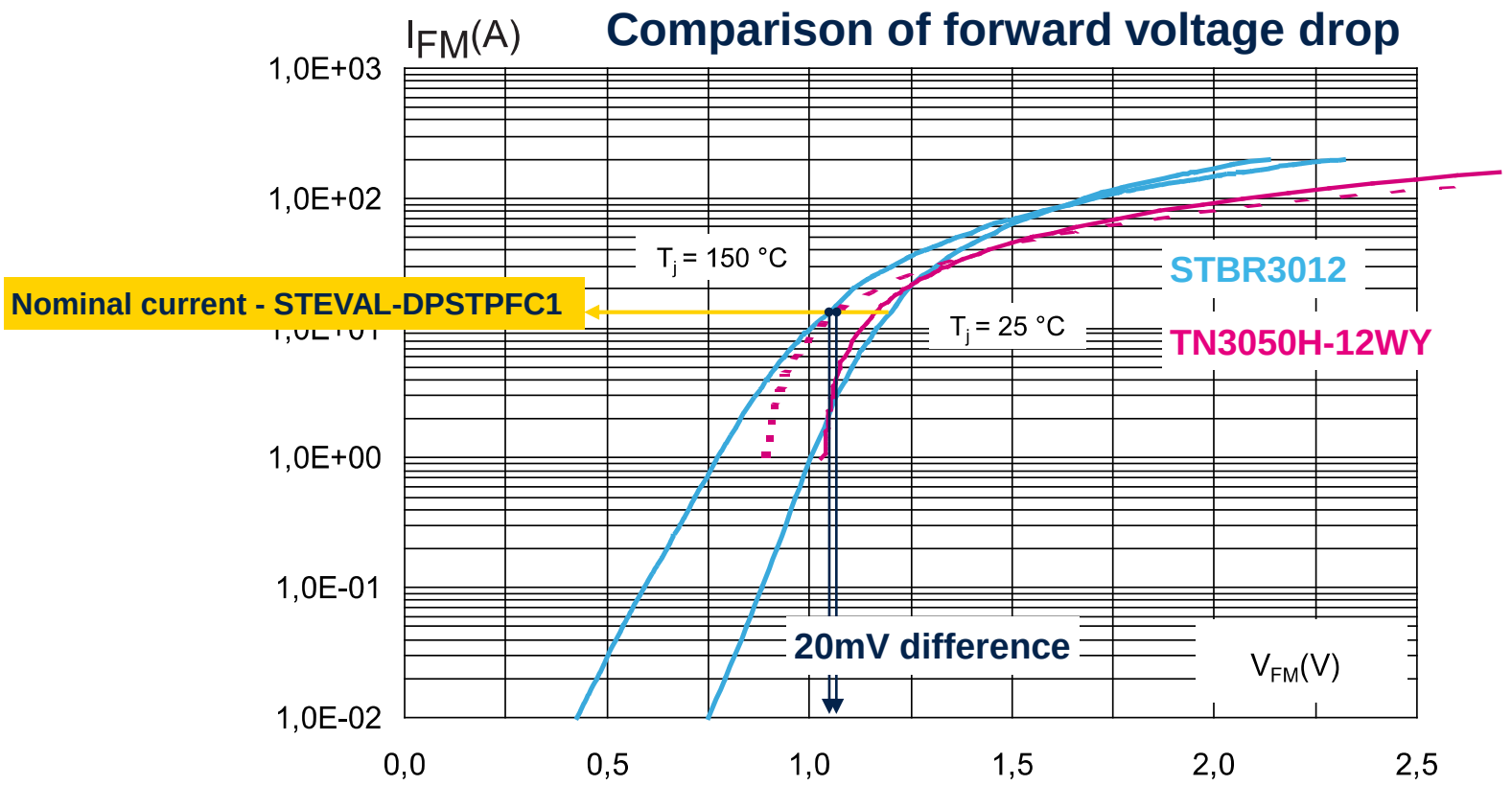


Charge time = 120 ms

life.augmented

Inrush current limiter with SCRs in totem-pole PFC

But a Thyristor has a much higher voltage drop than a diode...
Or does it?



SCR has almost the same voltage drop (at 150°C) compared to bridge rectifier (both 30A/1.2kV)

life.augmented

3.6 kW totem pole PFC solution with SiC MOSFETs, thyristor SCRs and digital control

Innovative topology for D-SMPS, EV charging and motor drives

- 97.5 % peak efficiency
- Peak inrush current tuning
- Very low THD and high power factor

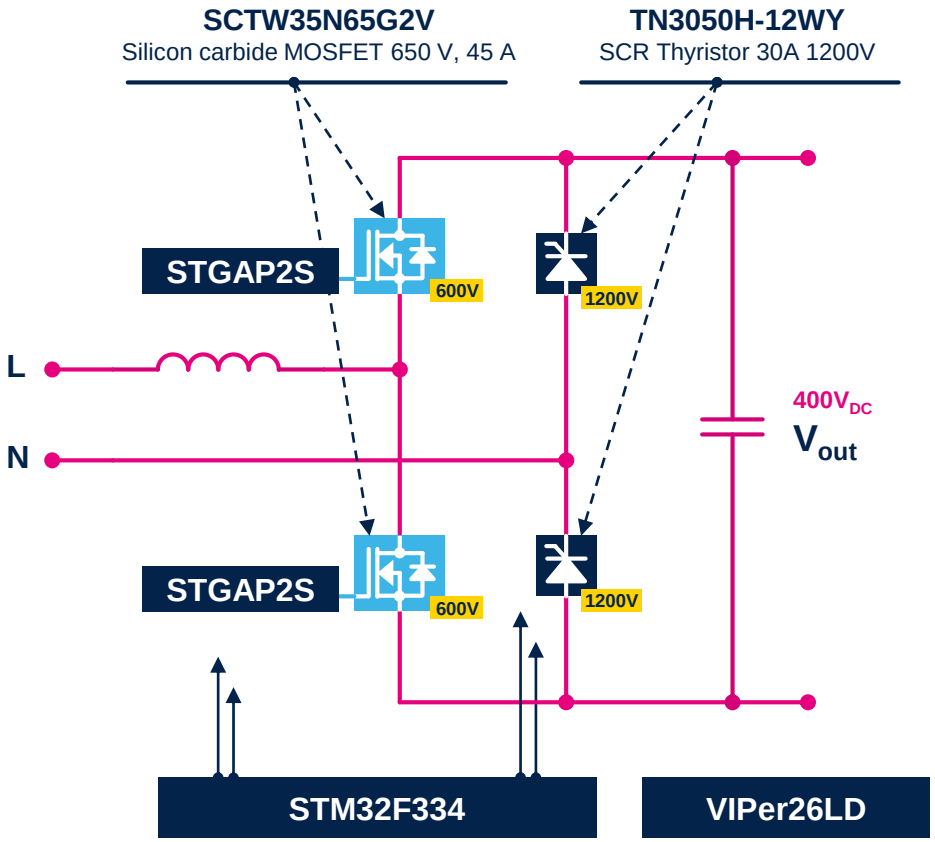
life.augmented

STEVAL-DPSTPFC1
3.6 kW 1-ph totem-pole PFC

- Input AC voltage: **85 V_{AC} up to 264 V_{AC}**
- Input AC frequency: 45 Hz up to 65 Hz
- DC output voltage: **400 V_{DC}**
- Maximum input current: **16 A_{RMS}**
- Ambient temperature: tested from 0 °C up to 45 °C
- Peak Efficiency: **97.7 %** with **4.7%** THD
- Compliant with:
  - EN 55015 and IEC 61000-4-11 and IEC 61000-3-3
  - IEC 61000-4-5 surge: 4 kV
  - IEC 61000-4-4 EFT burst: criteria A @ 4 kV min
- Cooling: forced air cooling with active fan
- Designed for operation with DC / DC converter
- Peak **inrush** current tuning

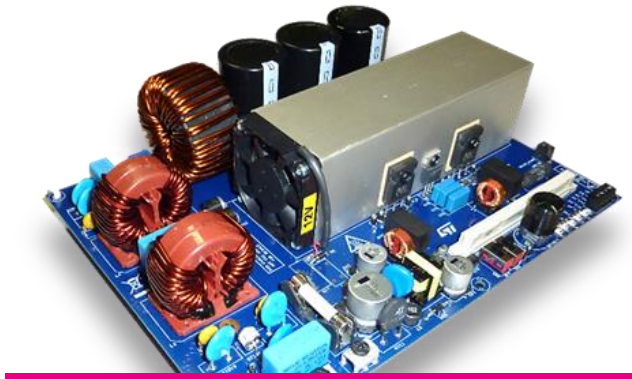
life.augmented

STEVAL-DPSTPFC1
3.6 kW 1-ph totem-pole PFC



Key Products:

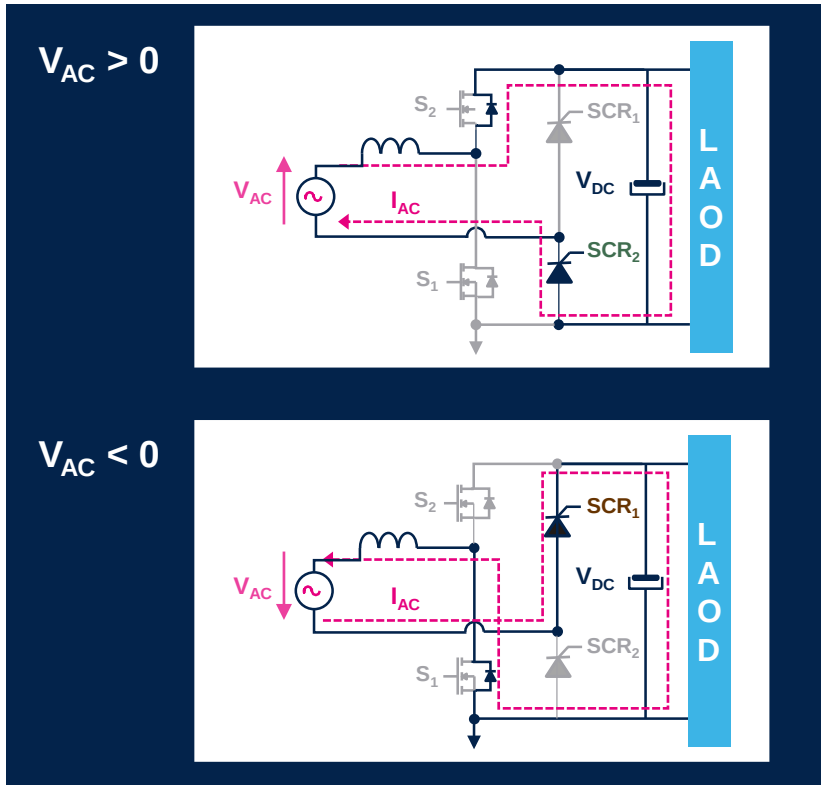
- SCTW35N65G2V (SiC MOSFET)
- TN3050H-12GY (SCR Thyristor)
- STGAP2AS (Galvanic insulated gate driver)
- STM32F334 (32-bit MCU)
- VIPer26LD (converter for aux. PS)

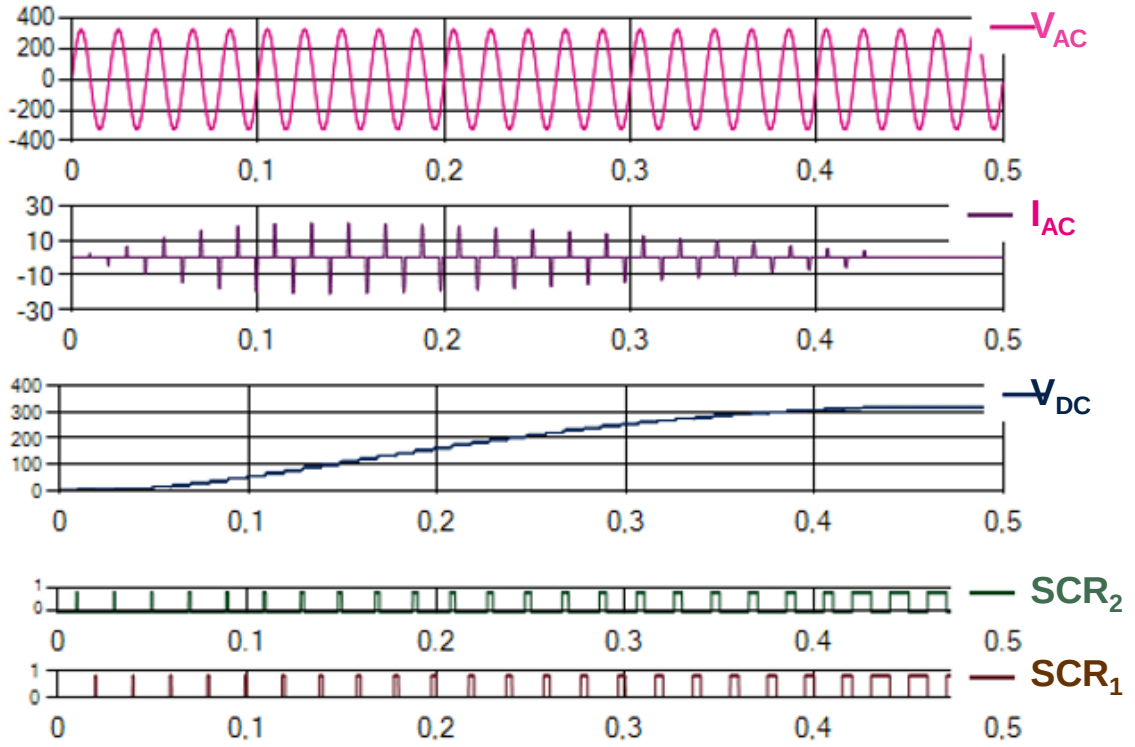


97.5 % efficiency at full load

life.augmented

Digital bridgeless PFC with inrush limiter
STEVAL-DPSTPFC1 – operation during inrush limitation

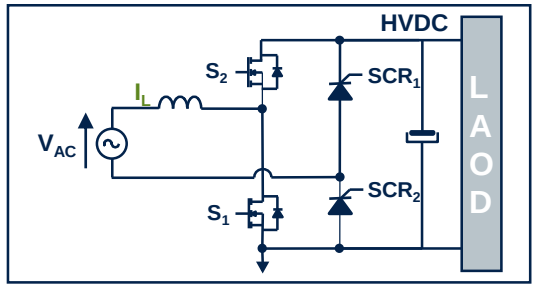


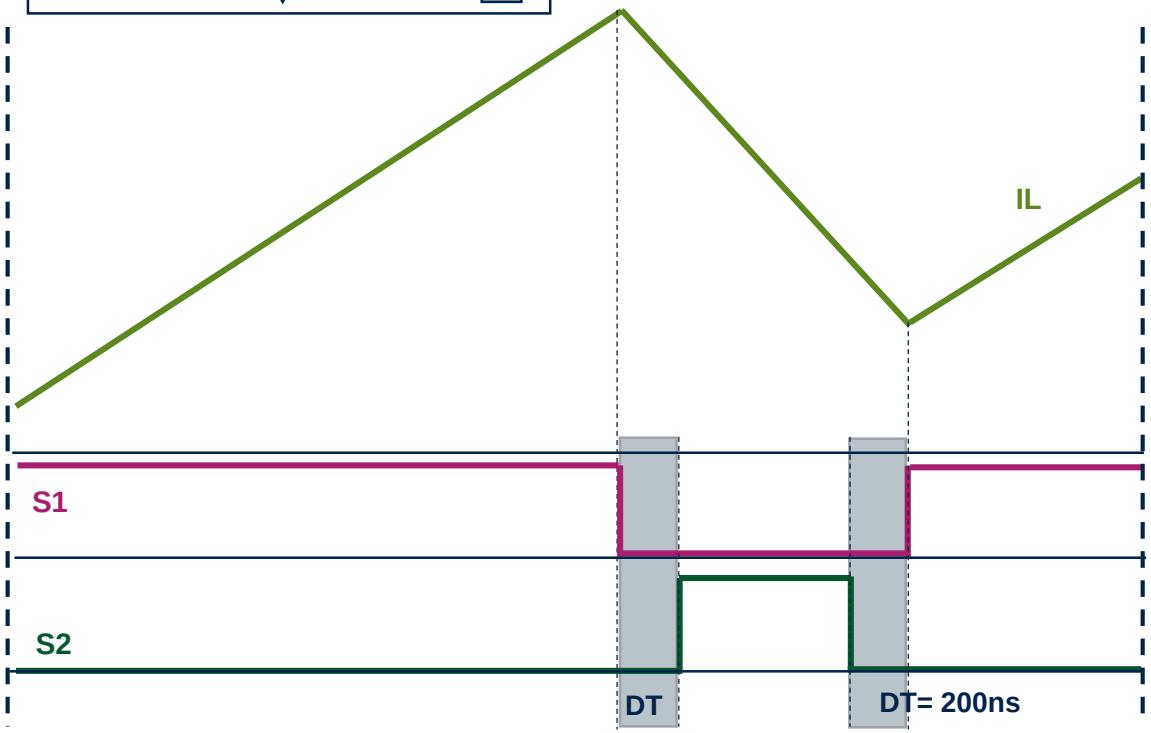


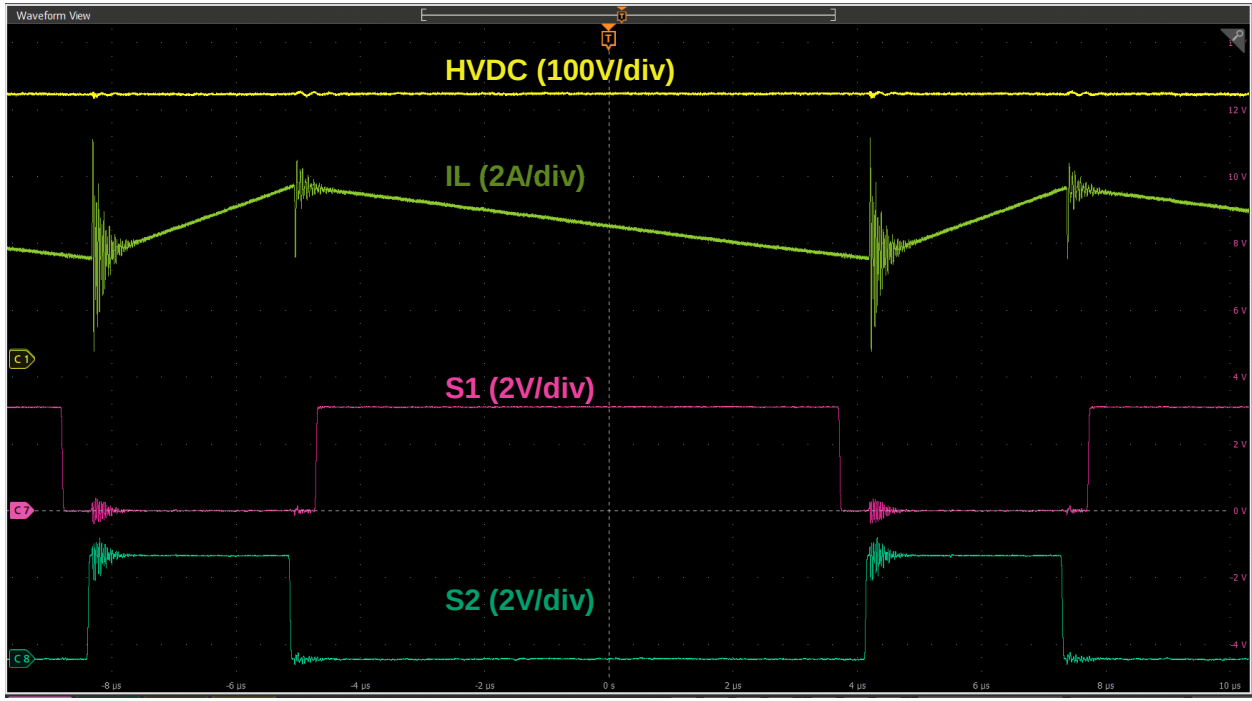
The SCR gate signals limit the AC inrush current by sweeping triggering angle backward from 180° to 0°

life.augmented

Digital bridgeless PFC with inrush limiter STEVAL-DPSTPFC1 – MOSFETs control



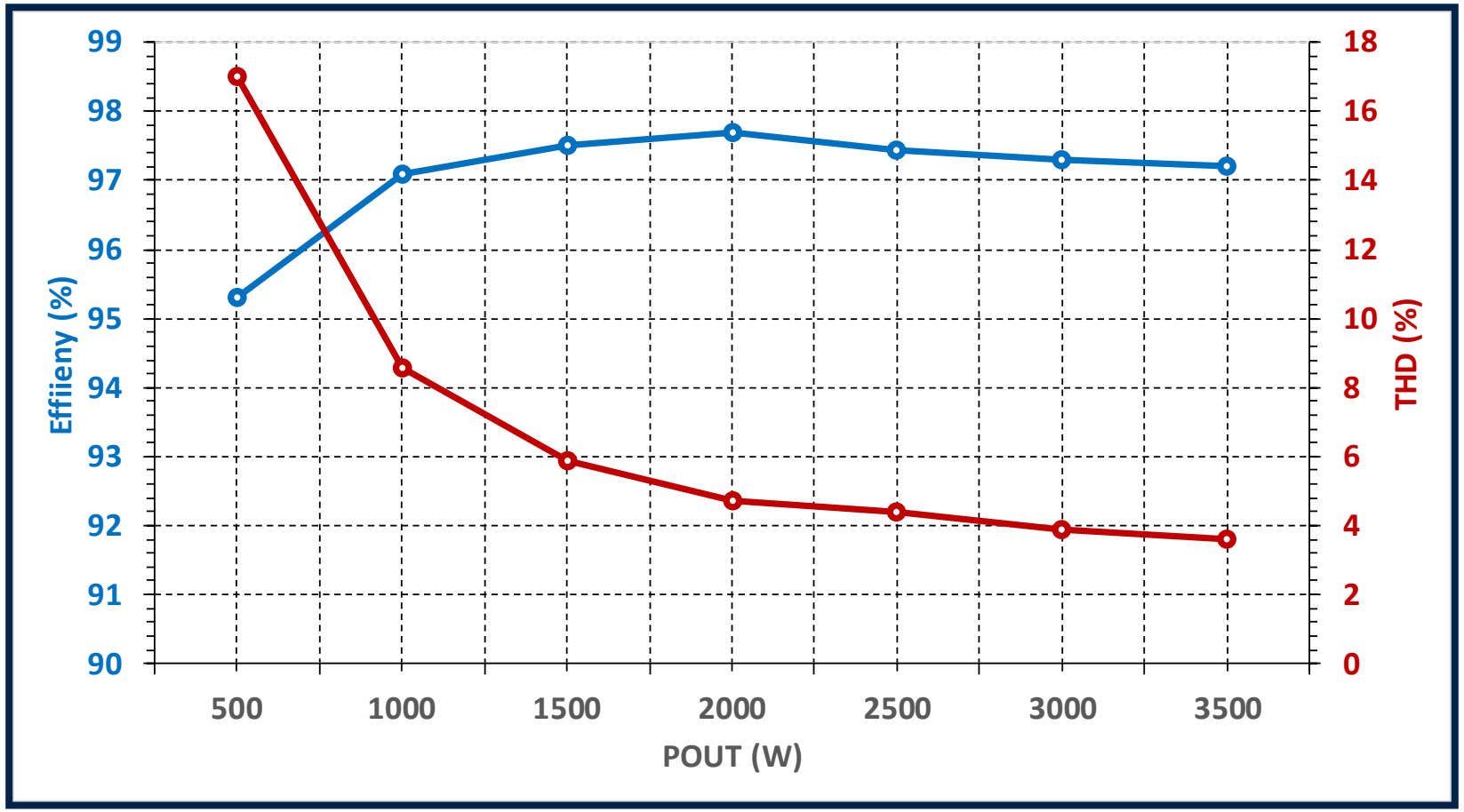




SiC MOSFETs operate in safe synchronous conduction mode to optimize efficiency

life.augmented

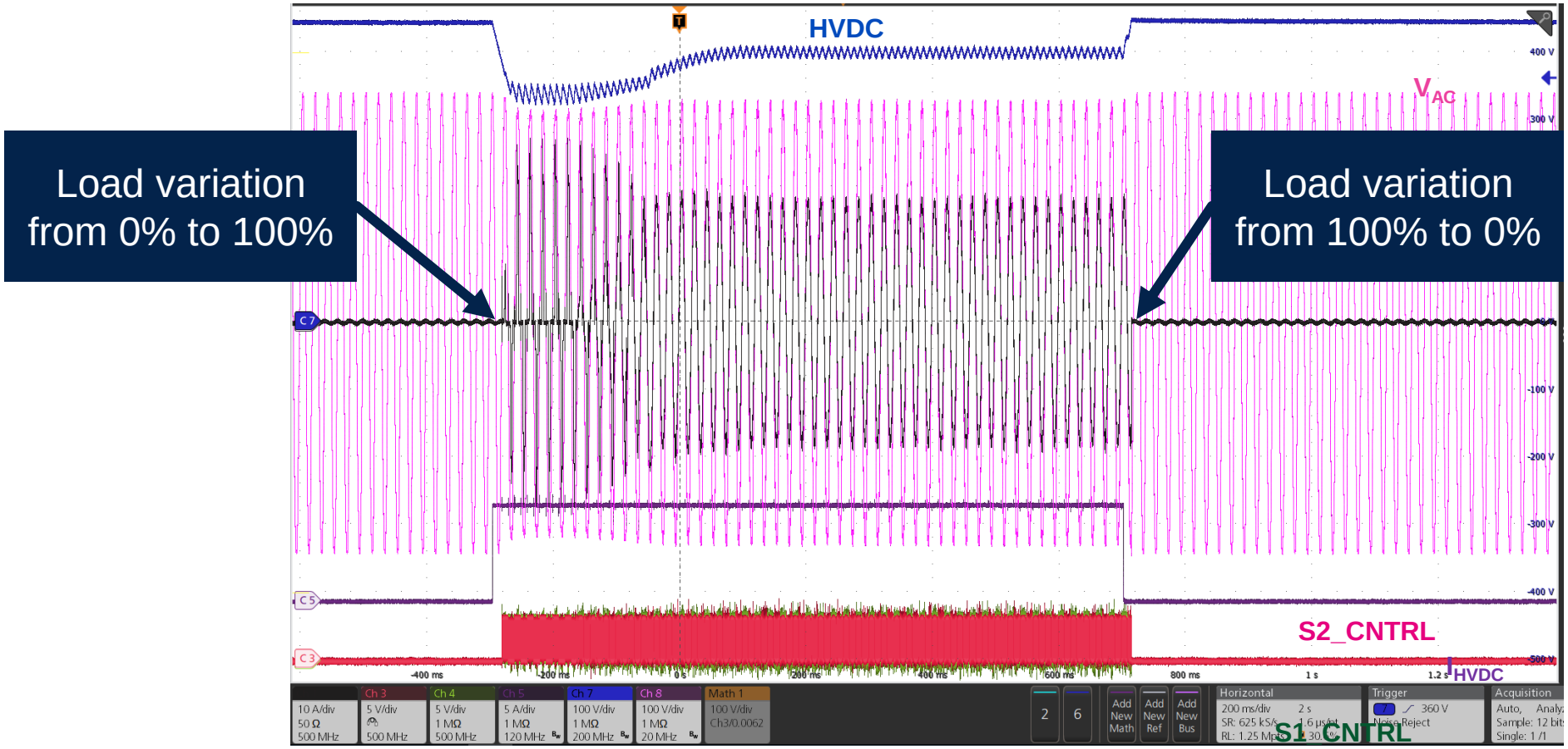
Results: efficiency & THD
V_{AC} = 230 V_{RMS} @ 50 Hz, T_{amb} = 25°C



High Efficiency over complete load range – Very low THD in medium / high load

life.augmented

Results: Load variation
V_{AC} = 230 V_{RMS} @ 50 Hz, P_{OUT} = 3.6 kW (100%)



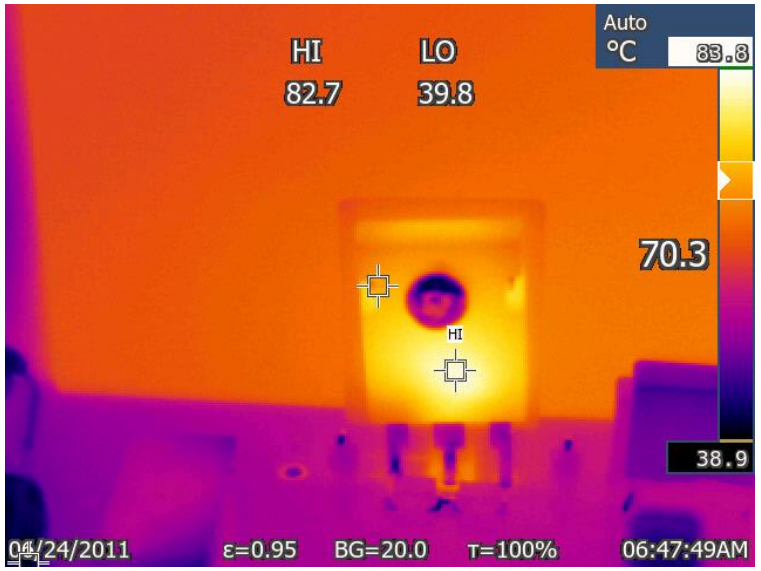
Excellent Transient Load Variation thanks to feed forward digital implementation

life.augmented

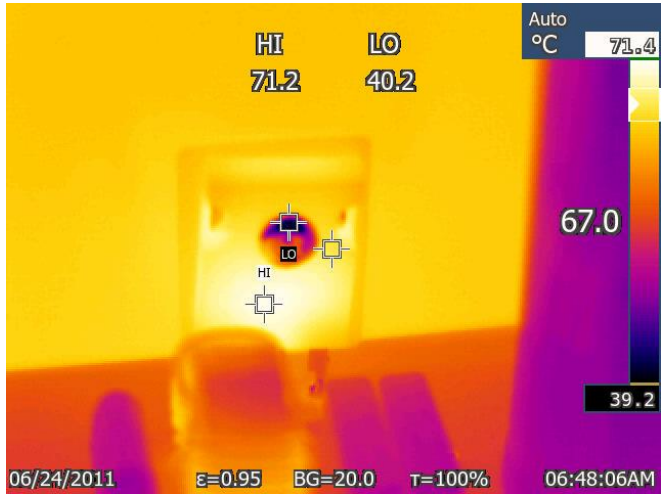
Results: power device temperatures

V_{AC} = 230 V_{RMS} @ 50hz, P_{OUT} = 3.6 kW, t_{amb} = 28 °C, FAN ON

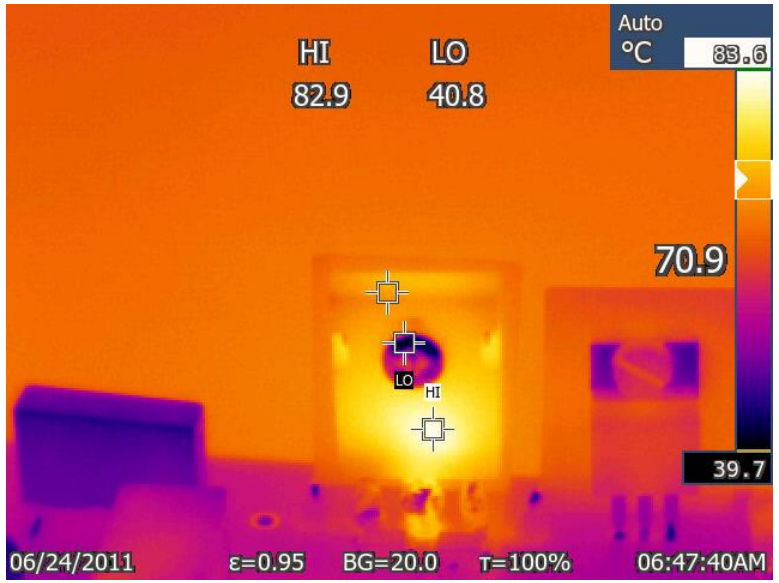
Low side SiC MOSFET



High side SCR



High side SiC MOSFET

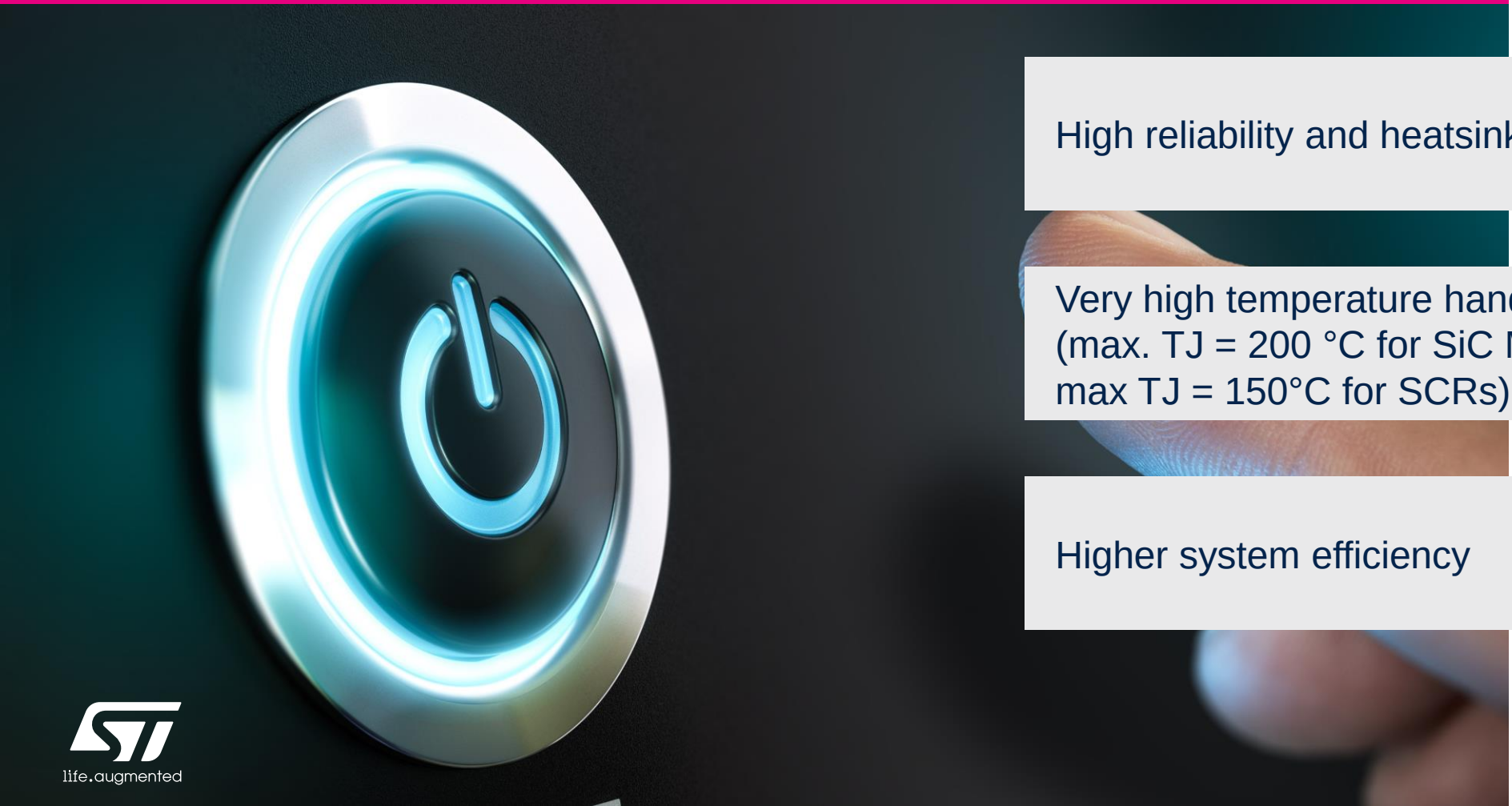


The board is equipped with Over Temperature Protection mounted on the heatsink

life.augmented

Key power product families

A real boost for efficient high power designs



High reliability and heatsink reduction

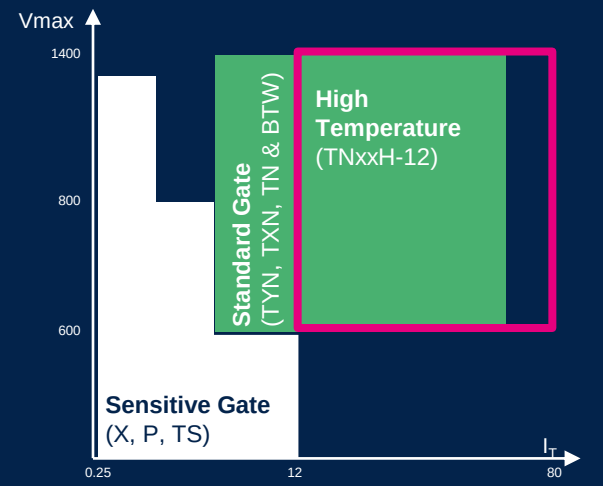
Very high temperature handling capability
(max. TJ = 200 °C for SiC MOSFETs,
max TJ = 150°C for SCRs)

Higher system efficiency

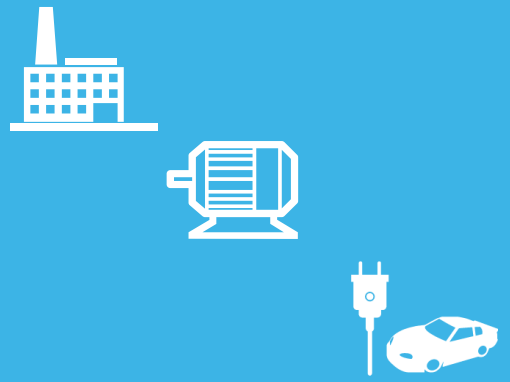
life.augmented

The most innovative SCR thyristor portfolio

Strong & wide SCR range

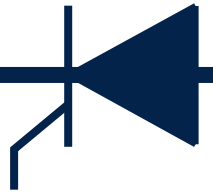


High Temperature Applications



High performance characteristics

V_{DRM} :	600 V to 1200 V
I_{GT} :	5 µA to 50 mA
I_{TRMS} :	12 A to 80 A
T_J :	150°C

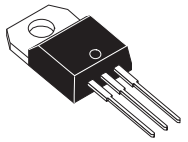


1200V thyristor SCRs range

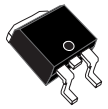
Reliable and compact designs in new AC / DC functions

Commercial Part	Current (A_{RMS})	Surge (A_{10ms})	Trigger (mA)	dV/dt (V/µs)	Package
Industrial Grade 1200 V , 125°C					
TYN1212RG	12	120	15	200	TO-220
TN2540-12G	25	300	40	1500	D^2PAK
TYN1225RG	25	300	40	1500	TO-220
TN4050-12PI	40	400	50	500	TOP3-I
BTW69-1200N	50	700	50	1000	TOP3
TN6050-12PI	60	700	50	1000	TOP3-I
Automotive Grade 1200V , 150°C					
TN3050H-12GY	30	300	50	1000	D^2PAK
TN3050H-12WY	30	300			TO-247
TN5050H-12WL	50	400			TO-247LL
TN6050HP-12WY	80	600			TO-247
TN8050H-12WL	80	720			TO-247LL

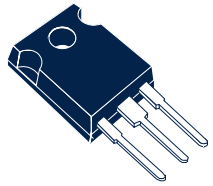
NEW = Light Blue



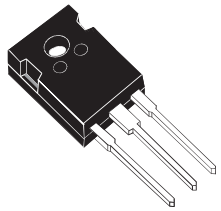
TO-220AB



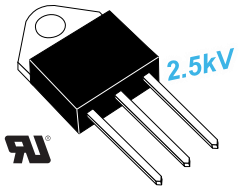
D^2PAK



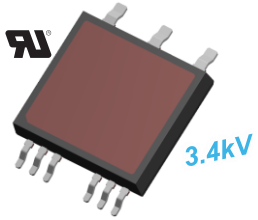
TO-247



TO-247 LL



TOP3 Insulated



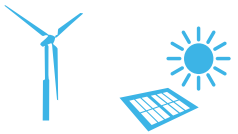
ACEPACK SMIT

Critical Power UPS

HVAC

Smart Energy

Renewable



Charging Stations

IE3 Motor Drives

life.augmented

Gen2 650V SiC MOSFET product range

Part Number	V_{DS} [V]	$R_{DS(on)}$ Typ @ 25 ºC [Ω]	Id [A]	Package			
				HiP247	HiP247-LL	HiP247-4LL	H2PAK-7L
				Tj max= 200°C			*Tj max= 175°C*
650 Gen2 (Vgs=18V) series							
SCTW90N65G2V	650	0.018	119	X			
SCTWA90N65G2V					X		
SCTWA90N65G2V-4						X	
SCTH90N65G2V-7							X
SCTW100N65G2AG		0.020	100	X			
SCTWA100N65G2AG					X		
SCTWA100N65G24AG						X	
SCTH100N65G2-7AG							X
SCTW35N65G2V	650	0.55	45	X			
SCTWA35N65G2V					X		
SCTWA35N65G2V-4						X	
SCTH35N65G2V-7							X
SCTW35N65G2VAG				X			
SCTWA35N65G2VAG					X		
SCTWA35N65G2V4AG						X	
SCTH35N65G2V-7AG							X

Key Features

- Enales new technology platform with outstanding Figure Of Merit
- Excellent system efficiency and reduced cooling requirements
- Very low on-state resistance
- 200ºC maximum junction temperature
- Very fast and robust intrinsic body diode
- Industrial and Automotive Grade qualified

Typical Applications

- Charger Stations and On-Board Chargers
- PFC - SMPS for Industrial, Telecom & Class-D Audio Amplifiers
- Traction inverters in HEV and BEV
- Motor drives
- DC-DC converters

The best $R_{DS(on)}$ vs Q_g trade-off

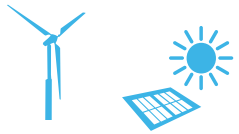
Automotive Grade

life.augmented

Isolated Gate Drivers
STGAP2S & STGAP2D

Different flavors for different needs

Renewable



STGAP2S

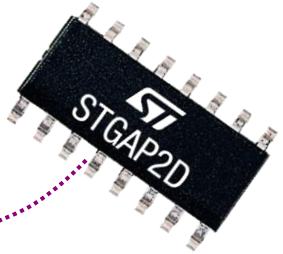
- 1.7 kV Isolation
- 4 A sink and source current
- Single channel
- Active Miller Clamp or G_{ON}/G_{OFF} pins

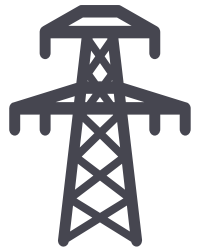
SO8N

STGAP2D

- 1.7 kV Isolation
- 4 A sink and source current
- Dual channel
- Compact layout
- Industrial grade

SO16N



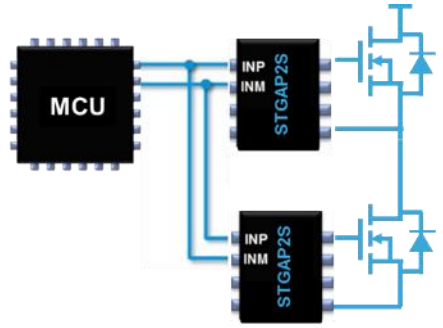


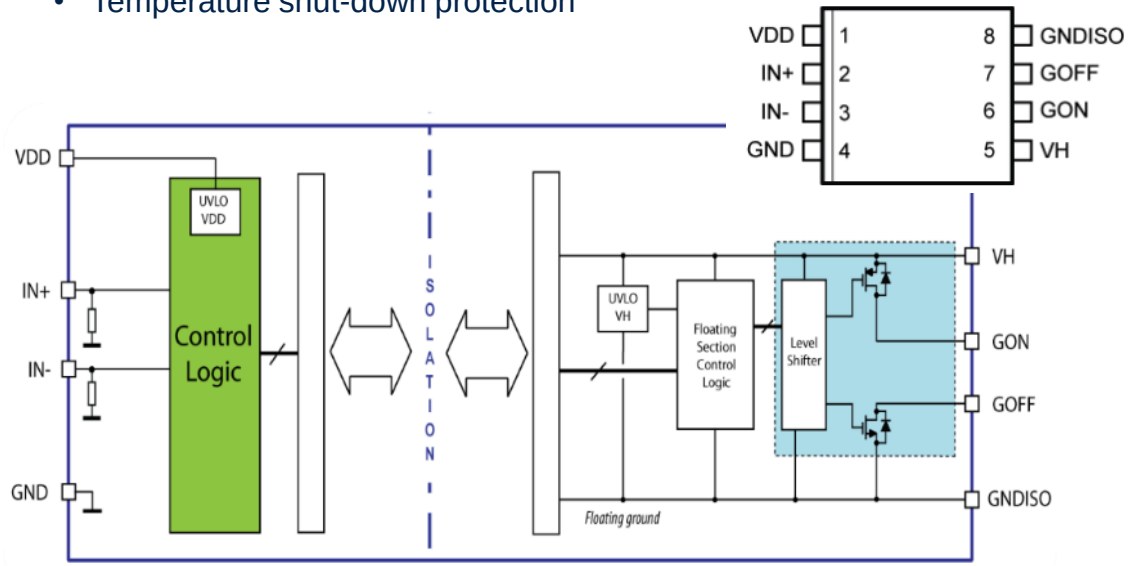
life.augmented

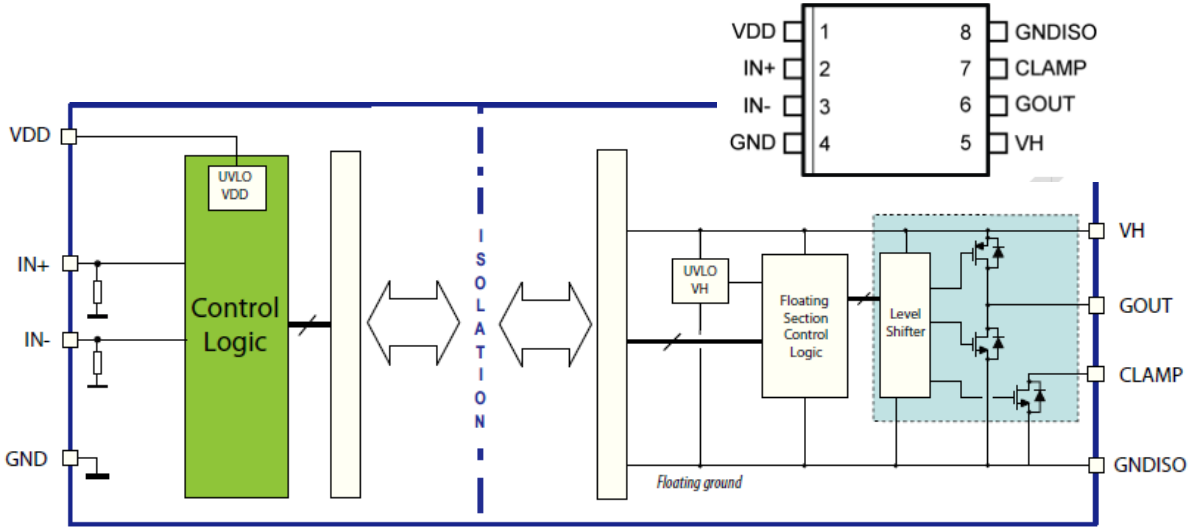
STGAP2S
1700V, 4A isolated gate driver

- 3V3 / 5 V logic inputs (logic thresholds 1/3, 2/3 of VDD)
- **Up to 26 V supply voltage**
- **4 A Sink/Source current capability**
- Short propagation delay: 80 ns
- UVLO Function
- Stand-by function
- 100 V/ns CMTI
- **High voltage rail up to 1700 V**
- Temperature shut-down protection

- Active High & Active Low input pins, for HW interlocking
- **STGAP2SM**: Separated outputs option for easy gate driving adjustment
- **STGAP2SCM**: Miller CLAMP pin option to avoid induced turn-on
- Negative gate drive ability
- SO8 Package







life.augmented

Thank you

life.augmented