Programmable Inrush-current limiter

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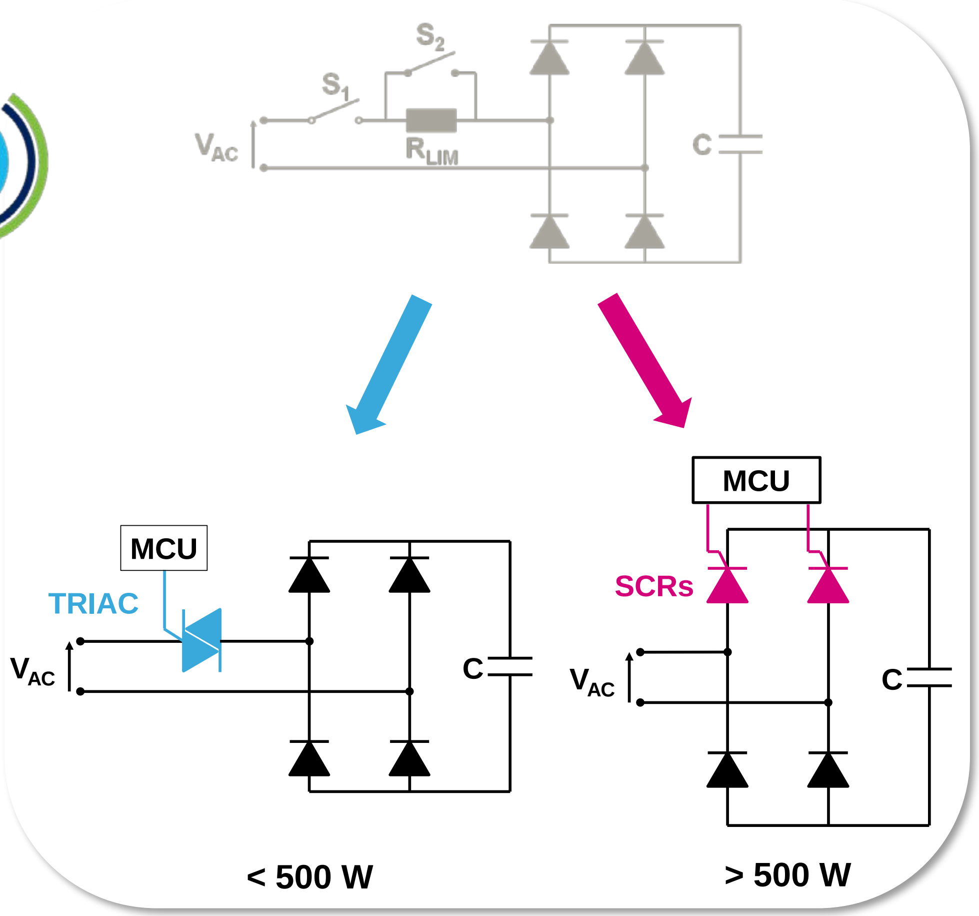
Programmable Inrush Current Limiter



- Simple implementation w/ digital control
- Inrush current limitation
- Programmable soft-start
- High efficiency solution
- Improved reliability
- High power density
- Line-drop recovery

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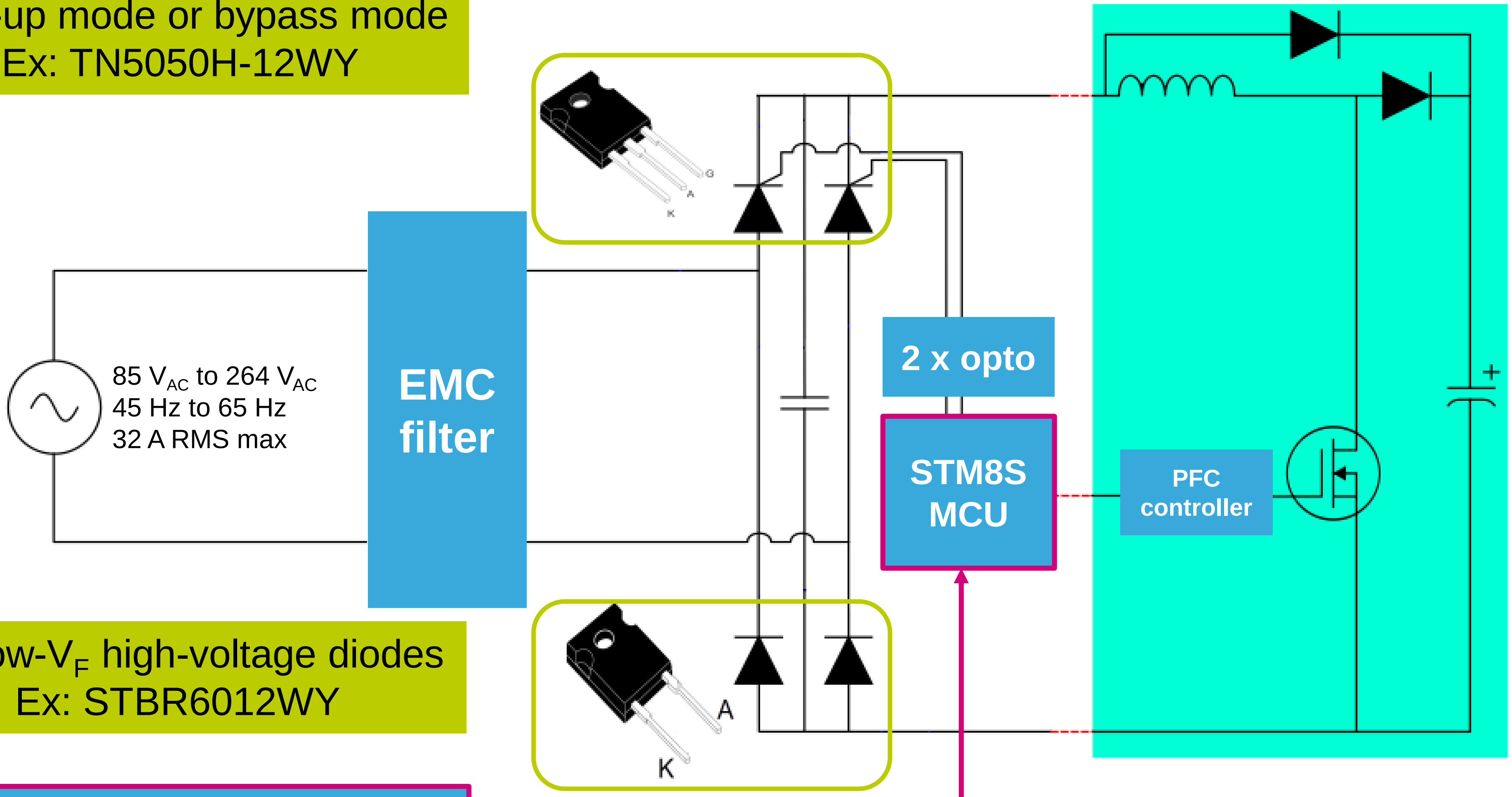
Simple implementation

Mixed-bridge example

2 x SCRs used in progressive start-up mode or bypass mode
Ex: TN5050H-12WY



Compliance with:
EN55015, IEC61000-4-11, IEC61000-3-3
IEC61000-4-5, 4 kV
IEC61000-4-4 EFT burst: 4 kV min
Stand-by losses < 300 mW

2 x low-V_F high-voltage diodes
Ex: STBR6012WY

1 MCU used to drive the SCRs and for the digital-control of the PSU

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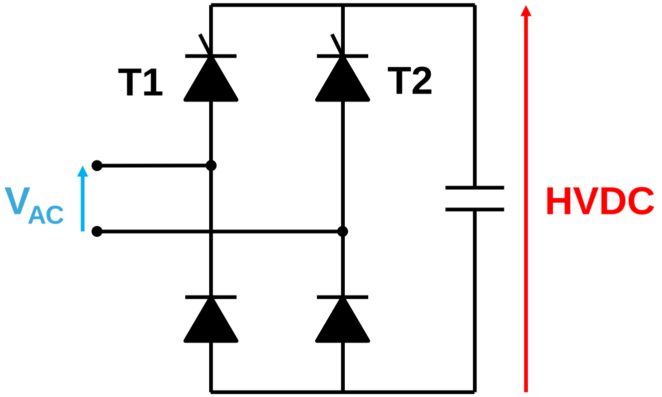
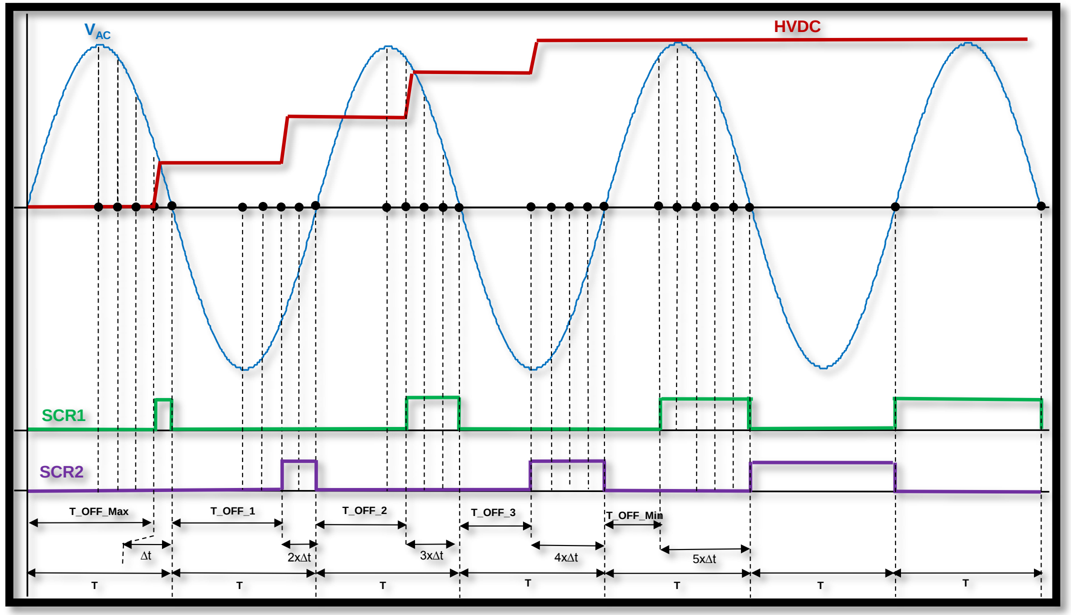
Programmable soft-start

Mixed-bridge example



- Operation :
  - Bulk capacitor charged smoothly thanks to phase angle control of the SCRs
  - T1 and T2 synchronized according to the zero crossing (ZVS) of the AC line



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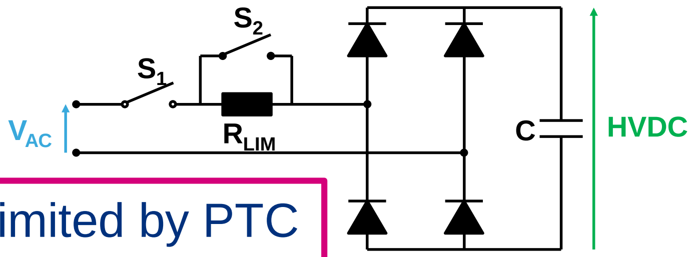
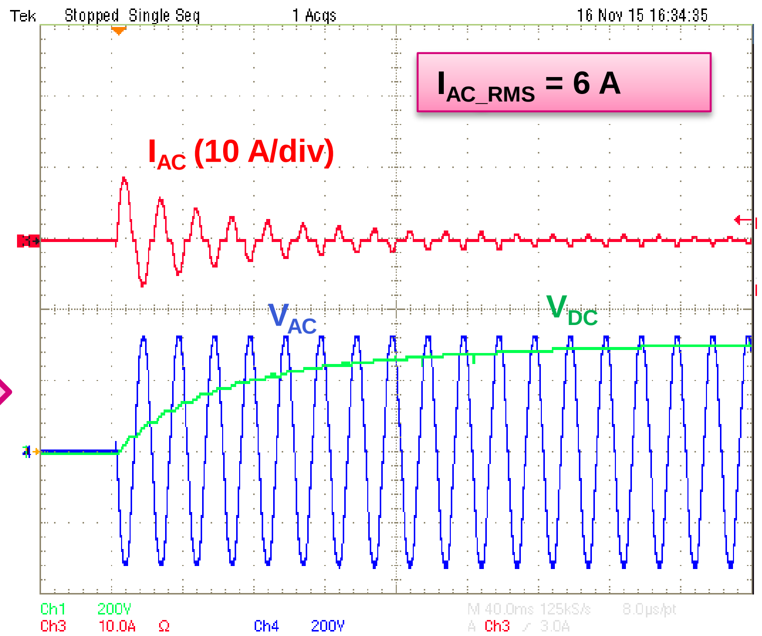
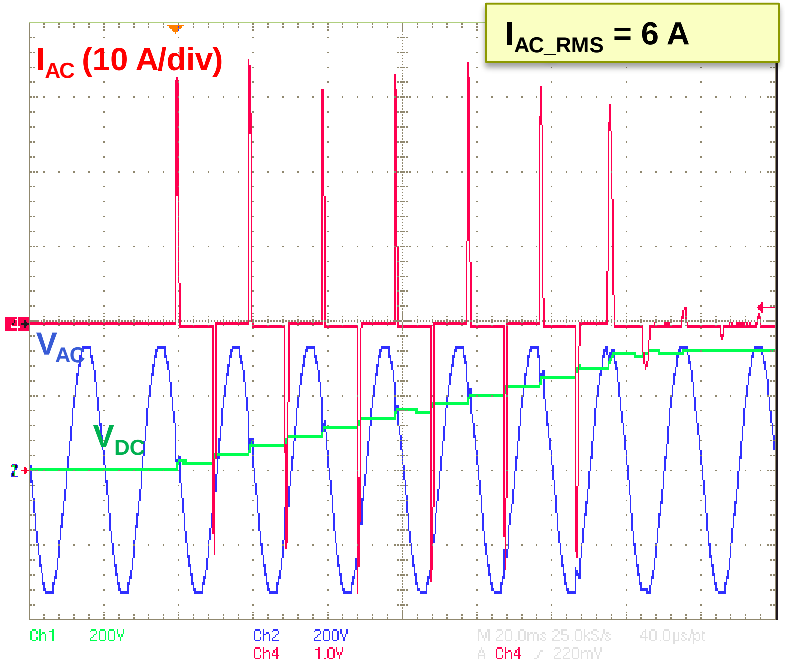
Inrush current limitation

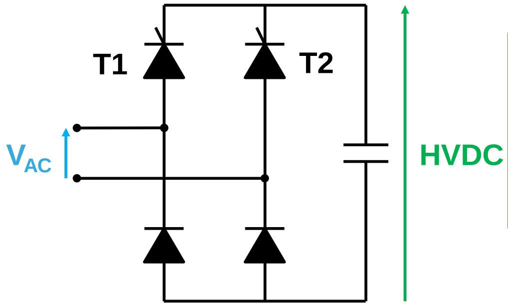
Mixed-bridge example



Inrush current limited by PTC
Charge time = **400 ms**

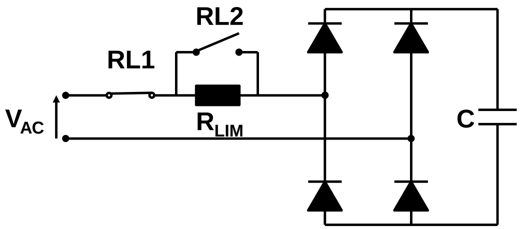
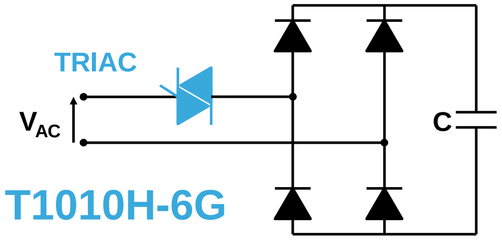




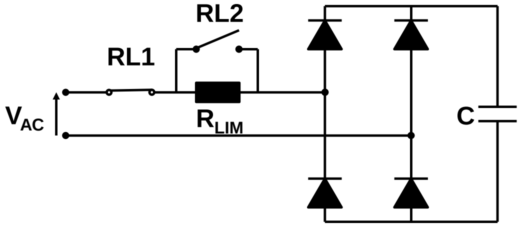
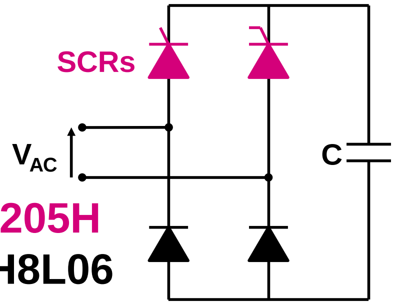


Inrush current limited by SCRs phase control
Charge time = **120 ms** while complying with IEC61000-3-3

Efficient

Analysis / Type	Stand by power losses	On-state power losses 150 W application	On-state power losses 200 W application	Energy consumption – 1 hour (50% stby + 50% on)
	RL1 closed Power losses = coil consumption ➔ **400 mW**	Dissipated power: Coil = 0.4 W (G5 relay) Contact resistance: P = RI²=0.1*(150/230)²= 42.5mW Bridge: P_D = 482 mW **Total dissipated power: 924 mW ➔ 0.62 % of total**	Dissipated power: Coil = 0.4 W (G5 relay) Contact resistance: P = RI²=0.1*(200/230)²= 76 mW Bridge: P_D = 649 mW **Total dissipated power: 1125 mW ➔ 0.56 % of total**	150W application: **0.69 Wh** 200W application: **0.76 Wh**
**T1010H-6G**	gate current still applied ➔ **50 mW**	Triac: P_D = 534 mW Bridge: P_D = 482 mW **Total dissipated power: 1016 mW ➔ 0.67 % of total** **No heatsink required**	Triac: P_D = 701 mW Bridge: P_D = 649 mW **Total dissipated power: 1350 mW ➔ 0.67 % of total** **No heatsink required**	150W application: **0.53 Wh** 200W application: **0.7 Wh**

Efficient

Analysis / Type	Stand by power losses	On-state power losses 500 W application	On-state power losses 1.1 kW Application	Energy consumption - 1 hour (50% stby + 50% on)
	RL1 closed Power losses = coil consumption ➔ **400 mW**	Dissipated power: Coil = 0.4 W (G5 relay) Contact resistance: P = RI²=0.1*(500/230)²= 472mW Bridge: P_D = 1707 mW **Total dissipated power:** **2580 mW ➔ 0.51 % of total**	Dissipated power: Coil = 0.4 W (G5 relay) Contact resistance: P = RI²=0.1*(1100/230)²= 2287 mW DBridge: P_D = 4131 mW **Total dissipated power:** **6818 mW ➔ 0.62 % of total**	500W application: **1.49 Wh** 1100W application: **3.61 Wh**
 **TN1205H** **STTH8L06**	gate current still applied ➔ **25 mW**	Diodes: P_D = 923 mW SCR: P_D = 878 mW **Total dissipated power:** **1801 mW ➔ 0.36 % of total** **No heatsink required**	Diodes: P_D = 2167 mW SCRs: P_D = 2089 mW **Total dissipated power:** **4156 mW ➔ 0.38 % of total** **No heatsink required**	500W application: **0.9 Wh** 1100W application: **2.08 Wh**

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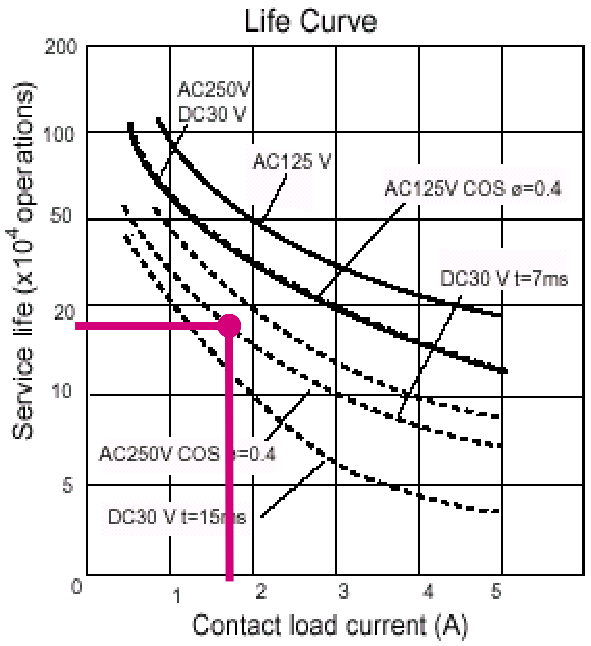
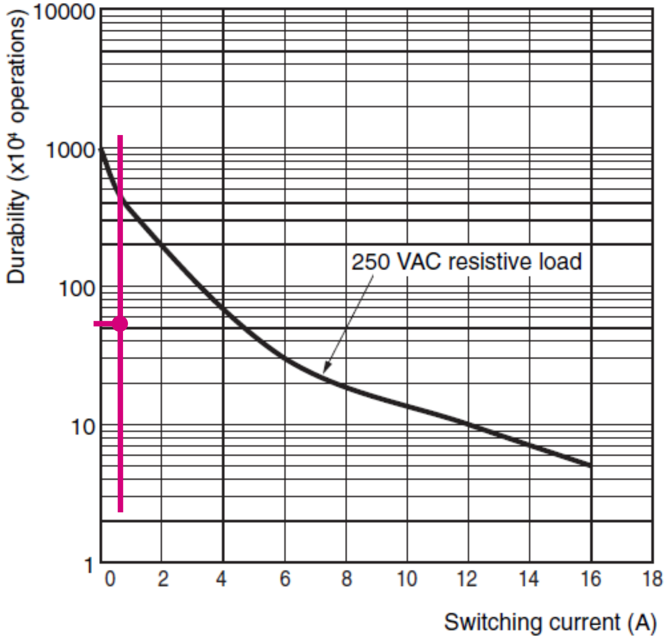
Reliable

5 A Relay



175,000 operations
< 10 Years
5 A relays for 1.8 A load

10 A Relay

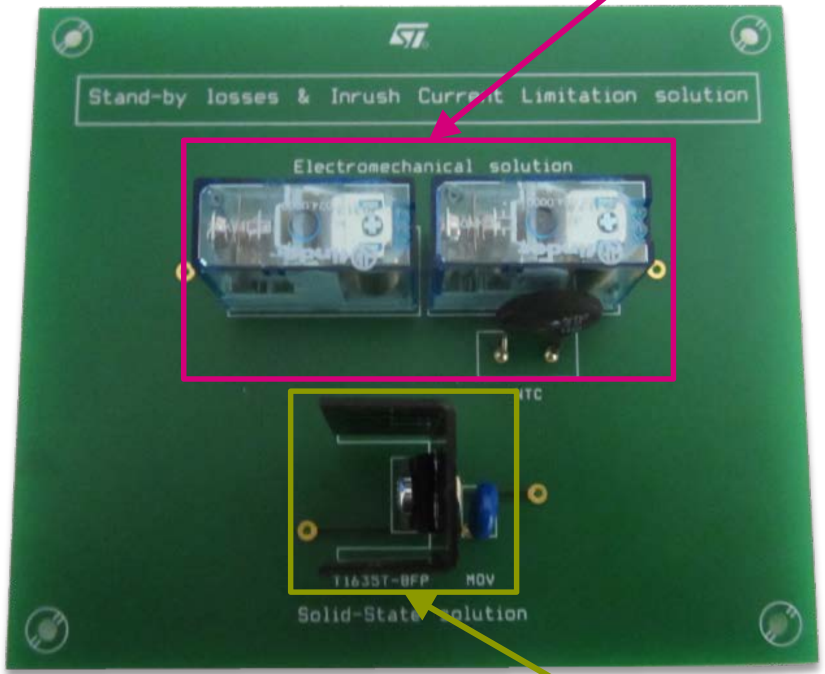


500,000 operations
< 10 Years
10 A relays for 0.5 A load !

SCRs and Triacs being semiconductor switches → No ageing effect

High power density

Relays:
60 mm x 20 mm



Triac + heatsink:
25 mm x 20 mm

Line-drop recovery

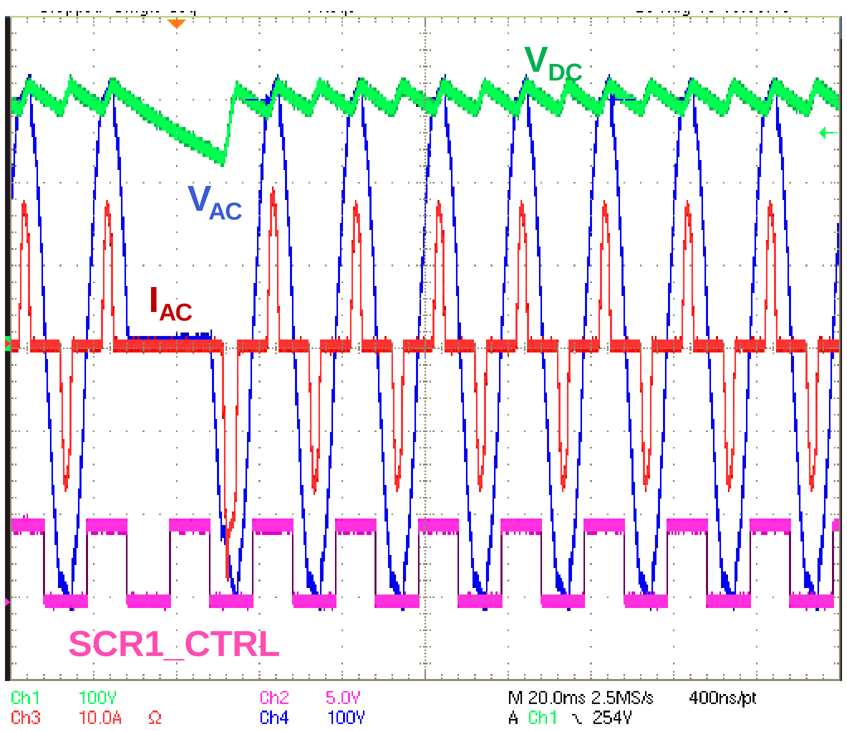
Mixed-bridge example

AC line voltage interrupt lasts less than 30 ms

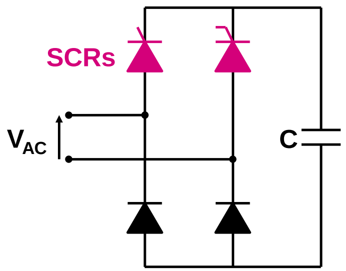
➔ SCRs are kept “ON”, criteria A

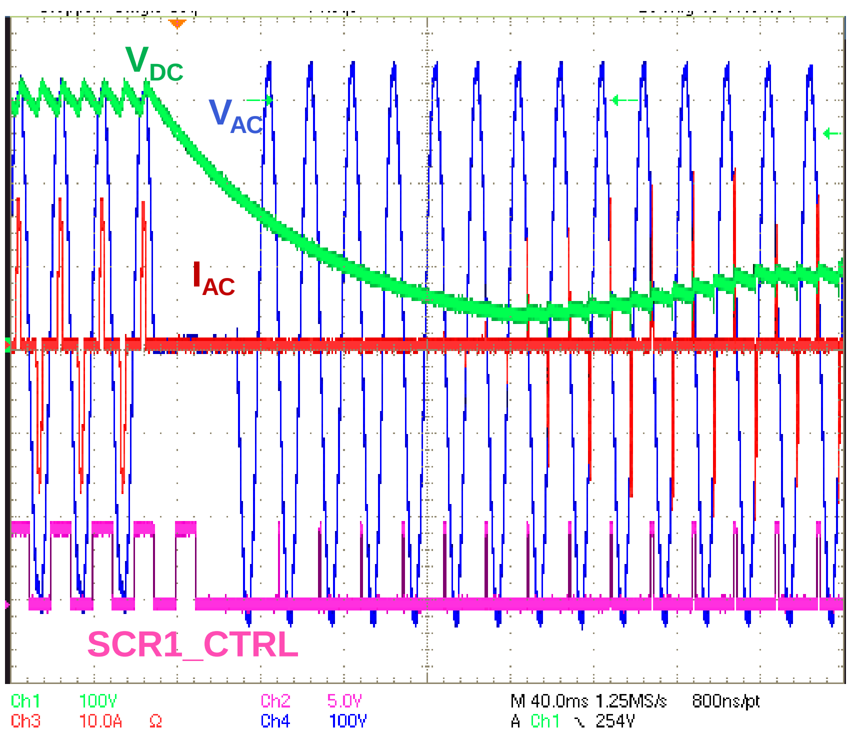
AC line voltage interrupt lasts more than 30 ms

➔ SCRs are controlled back in soft-start when the VAC is reapplied, criteria B



AC line voltage dips with a 0% residual voltage applied during 20 ms – Pout = 1kW





AC line voltage dips with a 0% residual voltage applied during 40 ms – Pout = 1kW