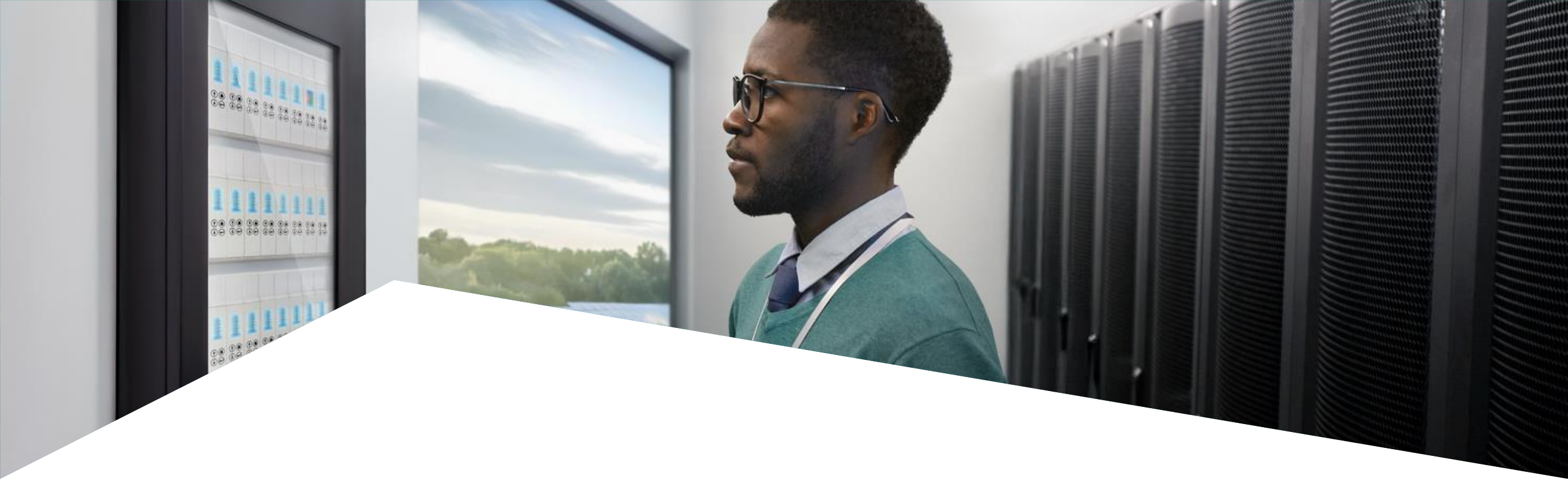


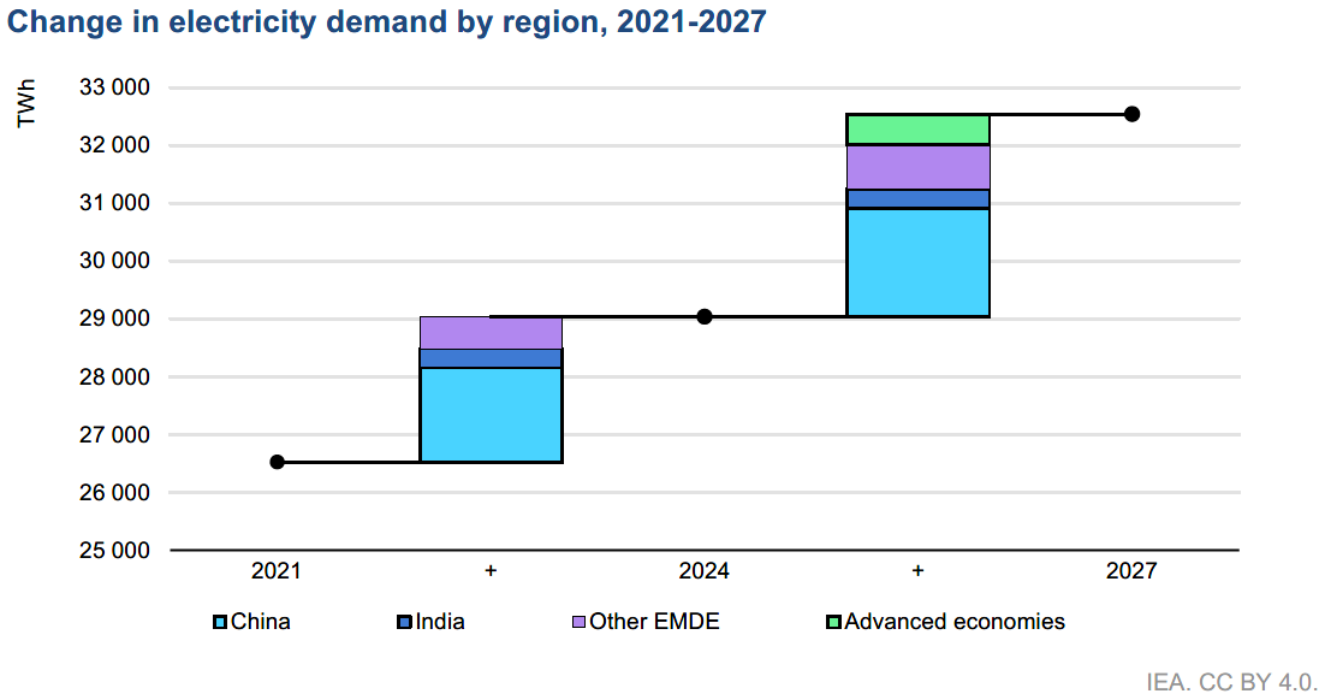
Discrete CoolSiC™ JFET 750 V and 1200 V: The heart of next-generation Solid-State Power Distribution

Baris Yildirim, Giovanbattista Mattiussi

May 2025

public

Electricity demand is surging globally, and power distribution systems must evolve to keep up



Note: EMDE = Emerging market and developing economies.

Source: International Energy Agency (IEA), "Electricity 2025: Analysis and forecast to 2027," Paris: IEA, February 2025. License: CC BY 4.0 (https://www.iea.org/reports/electricity-2025)

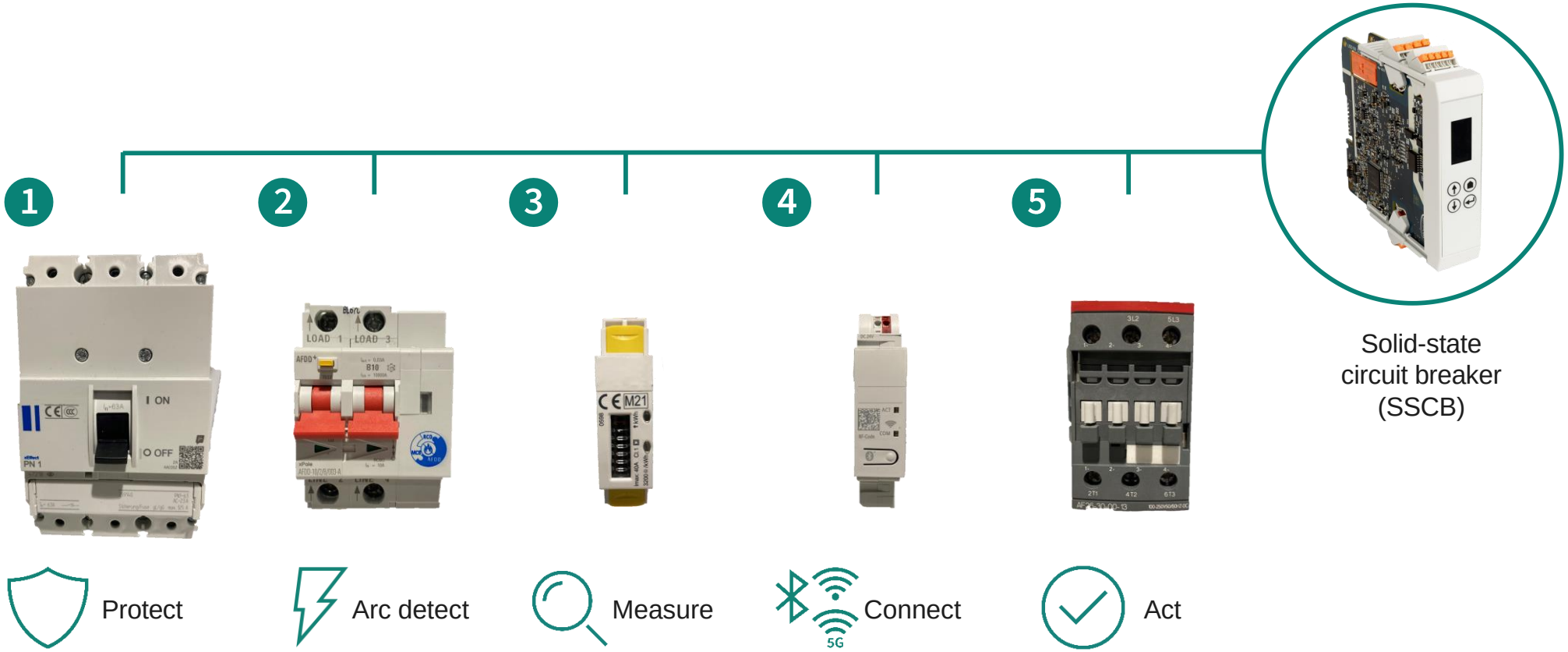
Megatrends

- Electrification of transportation and heating/cooling
- Expansion of data centers and digital technologies
- Electrification of industry and manufacturing

"How do we tackle with this safely and sustainably?"

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Power distribution is going smart with solid-state circuit breakers



Smart circuit breakers (SSCBs) integrate multiple functions into one single device

Encompasses a wide range of components adapted to specific system requirements

Compact, reliable, and cost-effective solid-state solution

Key technology selection criteria for solid-state circuit breakers

System Integration

System in the box
Passive cooling



1

Key power semiconductor challenges:

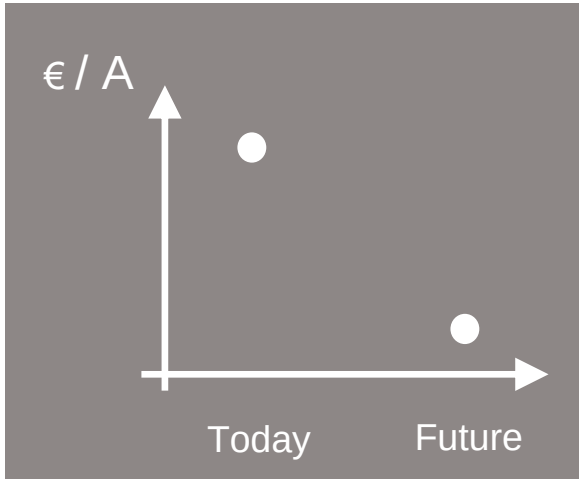
- Very low $R_{DS(on)}$ devices, paralleling
- High thermal utilization (temp cycling)
- Wide range of operating profiles
- Reliable handling of SC conditions
- Continuous operation / long lifetime

2

3

Commercial Viability

OEM feature integration



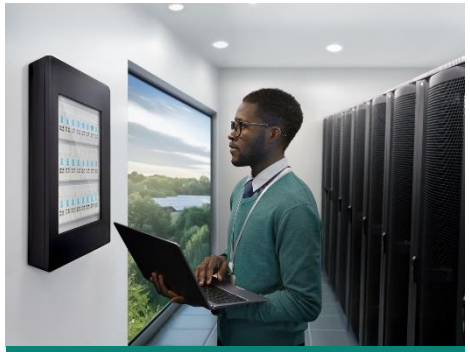
Robustness and Reliability



15 years * 24/7 full load operation
Overload, overcurrent and unclamped inductive switching robustness

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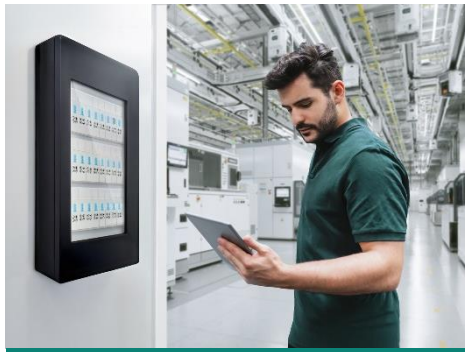
Designing for power distribution requires new thinking



SSCBs, Hotswap



SSCBs, DC Breakers, eFuses



SSCBs, DC Breakers, Motor Soft Starters



Battery Disconnect Unit (BDU), eFuse

CoolSiC™ JFET enabling diverse landscape of applications

- Solid State Relays
- Solid State Circuit Breakers
- Hybrid Circuit Breakers
- Contactors
- Motor soft starters
- Power Distribution Switches
- Surge Protection Devices
- Pre-chargers
- Hot swap
- …

Many different names (and richness of features) but all require some of the **„puzzle pieces“.**

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Silicon Carbide JFET is back and perfectly timed

- **Manufacturing has improved** for SiC in general
- **Package innovation**
- **Solid-state power distribution** market
- **JFETs offer unique features** which are particularly interesting for **power distribution applications**

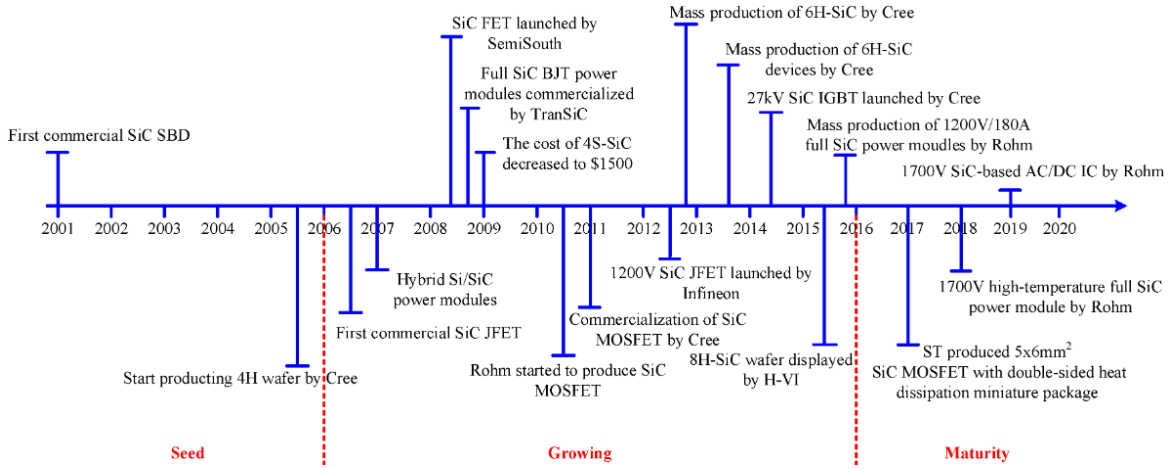


Figure source: Hai Xiao et al., "A Brief Review of SiC Power Device Development," Micromachines, 2019, 10(6), 406. https://doi.org/10.3390/micromachines10060406. Licensed under CC BY 4.0.

Lowest $R_{DS(on)}$ per device

Linear mode stability

Avalanche ruggedness at highest currents





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CoolSiC™ JFET: Built for power distribution

“Conduct”

$R_{DS(on)}$ puzzle piece

“Connect”

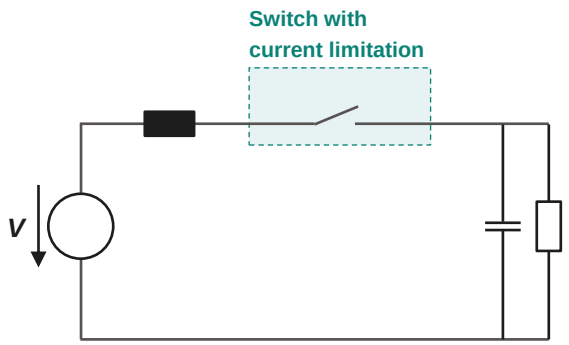
Linear mode piece

“Disconnect”

Avalanche piece

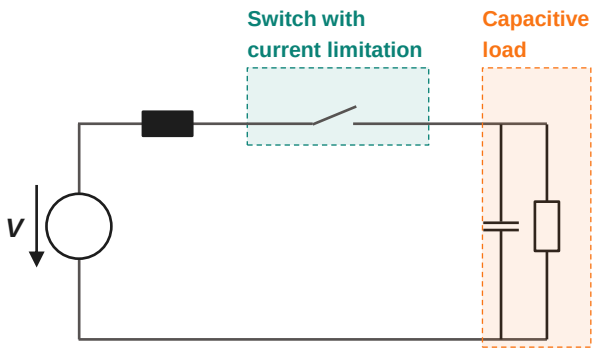
Lowest $R_{DS(on)}$ per device

- The JFETs open and close a circuit.
- No switched-mode power supply



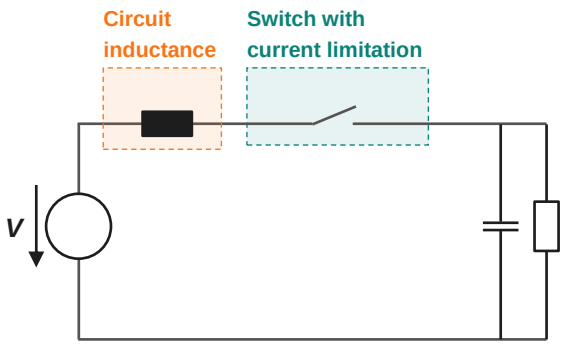
Linear mode stability

- Example: inrush currents when powering a capacitive load with a voltage source
- Linear mode makes a JFET high-ohmic
- The resistance of a JFETs limits inrush



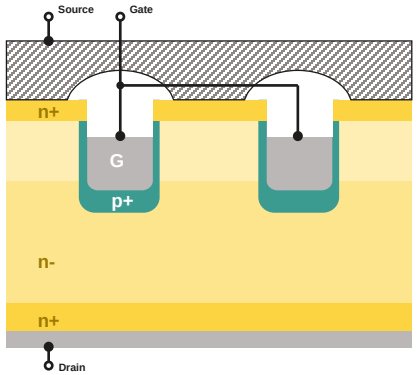
Avalanche ruggedness

- Example: overvoltage when opening a circuit with an inductance
- The inductance will force an overvoltage
- The switch needs to cope with it.

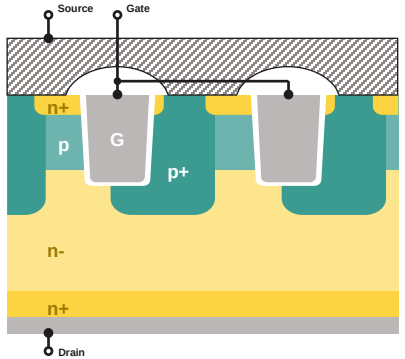


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Technology differentiation – CoolSiC™ JFET vs. MOSFETs



SiC JFETs



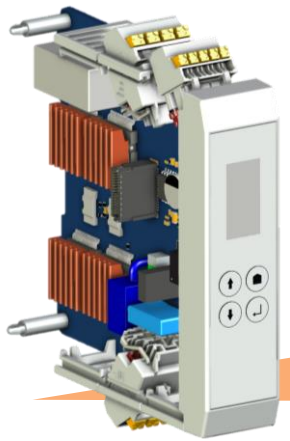
SiC MOSFETs

Construction	Bulk conduction, normally on Non isolated gate Optimized for $R_{DS(on)}$ and avalanche robustness	Channel conduction, normally off Fully isolated gate Optimized for minimum gate feedback
FOMs	Lowest possible $R_{DS(on)}$ per device Higher temperature coefficient	Generally higher $R_{DS(on)}$ per device Lower temperature coefficient
Benefits	Maximum power density Active clamping Linear mode operation	Simplified control Compatibility to legacy circuits

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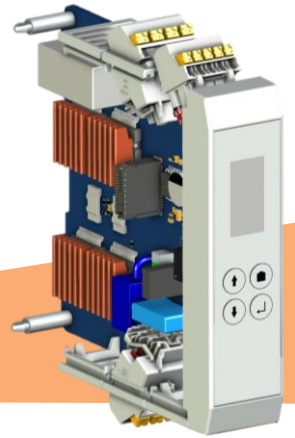
Technology driven miniaturization and CAPEX savings

CoolMOS™



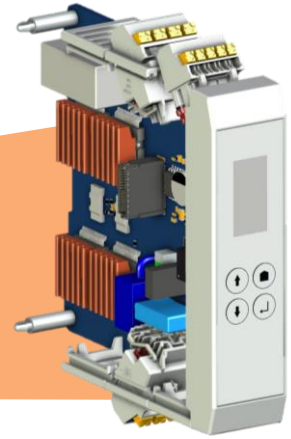
16 A

CoolSiC™ MOSFET



32 A

CoolSiC™ JFET



63 A*

Highest ampacity
Smallest form factor

Pushing application limits, reducing total cost of ownership (TCO)

**SSCB current rating based on 750V QDPAK @1.5mOhm $R_{DS(on)}$*

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Further savings through reducing BOM and failure modes

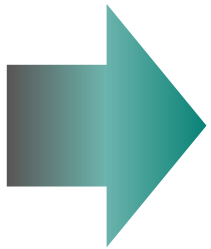
Solid-state power distribution system with MOSFETs

Complex clamping for overvoltage control

- More intricate clamping setup is required, utilizing MOV, TVS, and an RC Snubber combination

Introduces challenges for customers

- This approach adds complexity to clamping, increases BOM costs, and poses challenges to system reliability



Solid-state power distribution system with CoolSiC™ JFETs

Simplified clamping circuitry

- The CoolSiC™ JFET enables a simplified clamping solution is enabled by the JFET which can operate in avalanche mode.

Relieving customer pain points

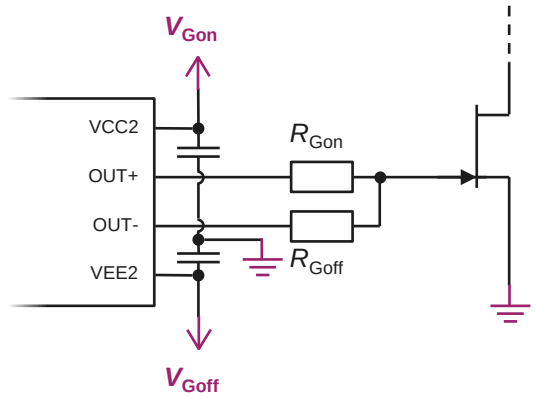
- This solution addresses key customer challenges by simplifying clamping, reducing BOM costs, and enhancing system reliability by reducing failure modes.

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How to design with CoolSiC™ JFET in mind – driving concepts

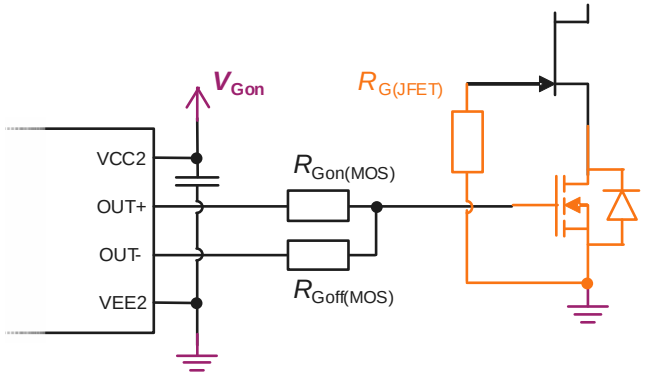
- Pull gate negative to turn-off the JFET since it's normally on.
- Use cascode configuration to behave like a normally off device.
- Note: Driving requires relatively high gate current and need to handle avalanche current on the gate.

Single JFET (normally on)



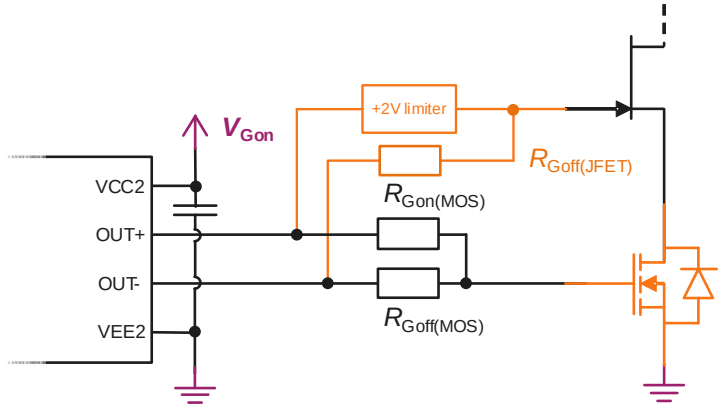
- Normally-on configuration
  (air-gap device to create galvanic isolation)
- Overdrive is possible
  (gate voltages are adjustable)

Classic cascode (normally off)



- Normally-off configuration
  (LV-MOS provides driving voltage for JFET)
- Overdrive not possible
  (gate voltages depend only on LV-MOS)

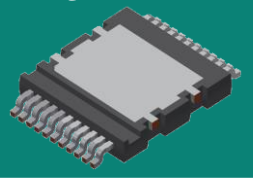
Adapted cascode (normally off)



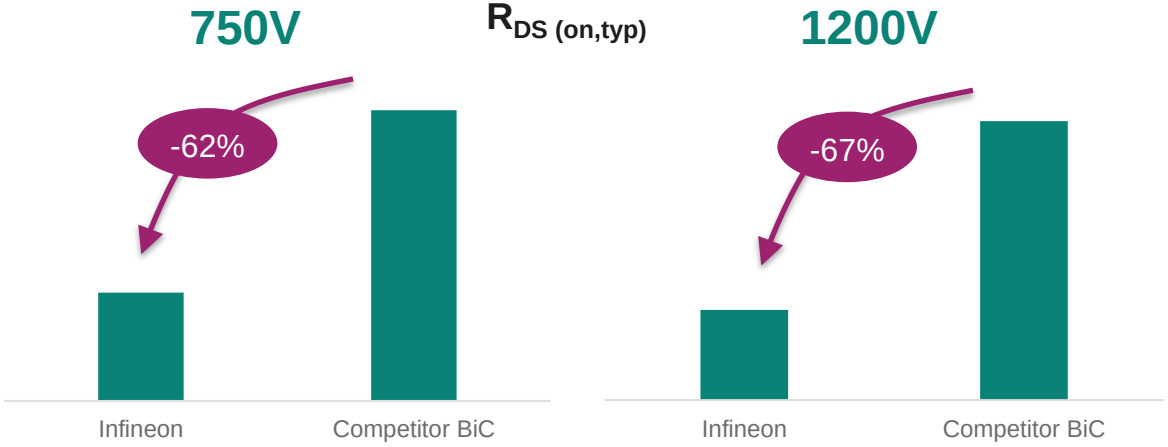
- Normally-off configuration
  (LV-MOS provides driving voltage for JFET)
- Overdrive possible
  (JFET gate voltage adjustable)
- Adapted gate drive cirucuit

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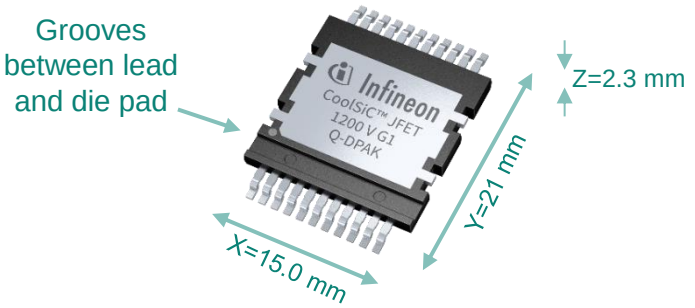
Infineon's new CoolSiC™ JFET 750 V / 1200 V Discrete portfolio

CoolSiC™	$R_{DS\ (on,typ)}$ [mΩ]	Q-DPAK 
750 V	3.9	IJCQ75RM39J1
	2.2	IJCQ75RM22J1
	1.5	**IJCQ75RM15J1** BiC
1200 V	5.8	IJCQ120RM58J1
	4.6	IJCQ120RM46J1
	2.6	IJCQ120RM26J1
	2.3	**IJCQ120RM23J1** BiC

New CoolSiC™ JFET technology achieving **industry-leading lowest $R_{DS(on)}$ per device**







BiC = Best-in-class
Disclaimer: Rdson values and part numbers are subject to finalization

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Summary and key takeaways

- **Solid state power distribution** is emerging as the next frontier and demands a new class of power semiconductors
- **CoolSiC™ JFET** is built for the set of requirements for power distribution:
  - Conduct, connect, disconnect
- **Core features of CoolSiC™ JFET**
  - Lowest $R_{DS(on)}$ per device → compact, cost-efficient scaling
  - Thermal stability in linear mode → safe inrush current control
  - High avalanche ruggedness → shut-down current handling without compromise
- Meet our experts at **Hall 7, Booth 470!**

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