pcim
ASIA

High voltage gate driver IC technology integrated with DESAT diode

Weidong Chu, Infineon Americas Corp.

23rd PCIM Asia Conference 2024

Agenda

1. IGBT behavior in short circuit condition
2. Five different short circuit conditions of 3 phase inverter
3. Short circuit protection
4. Silicon on insulator (SOI) technology
5. Gate driver integrated with DESAT protection circuitry and DESAT diode
6. Conclusion

IGBT behavior in short circuit condition

- When an IGBT experiences a short-circuit, the collector-emitter voltage V_{CE} rises rapidly, causing the IGBT to exit the saturation region and enter the active region.
- The short-circuit current increases to 3-5 times the rated current in a very short time, and the excessive current can burn out the IGBT device without protection although there is short circuit withstand time (SCWT) of IGBTs.

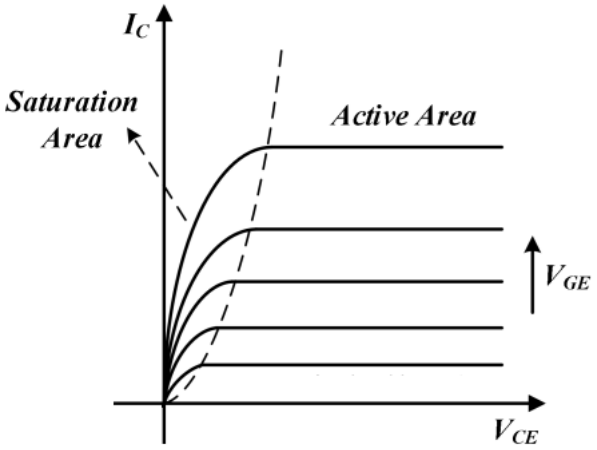


Fig.1. Output characteristic curve of IGBT

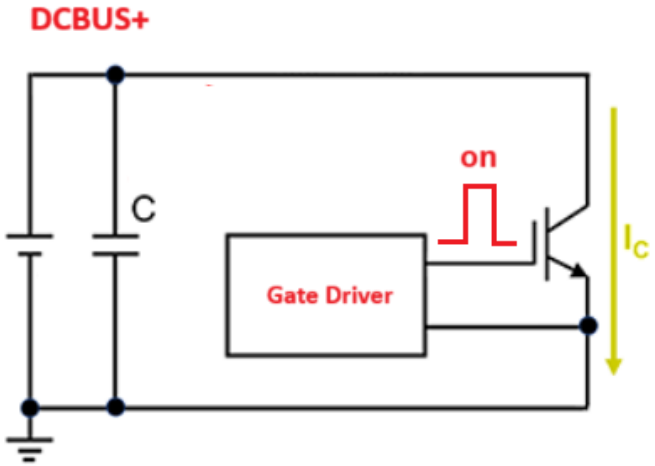


Fig.2. Test circuit

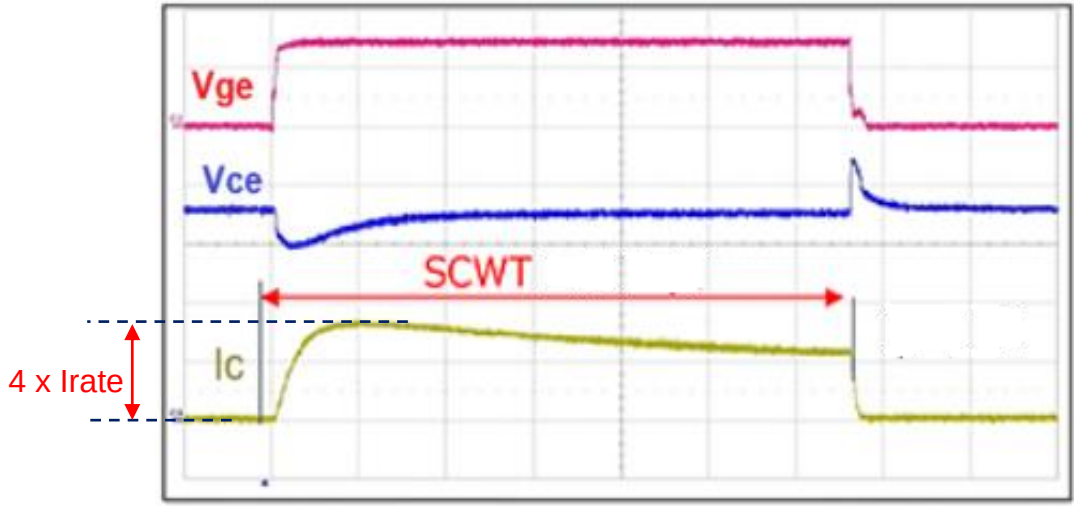
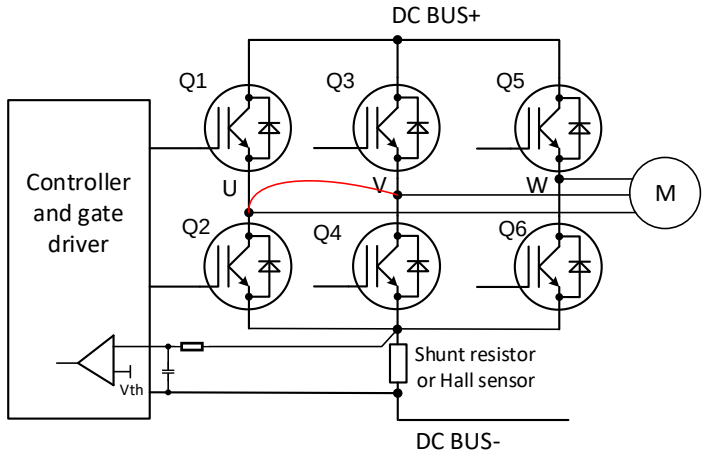
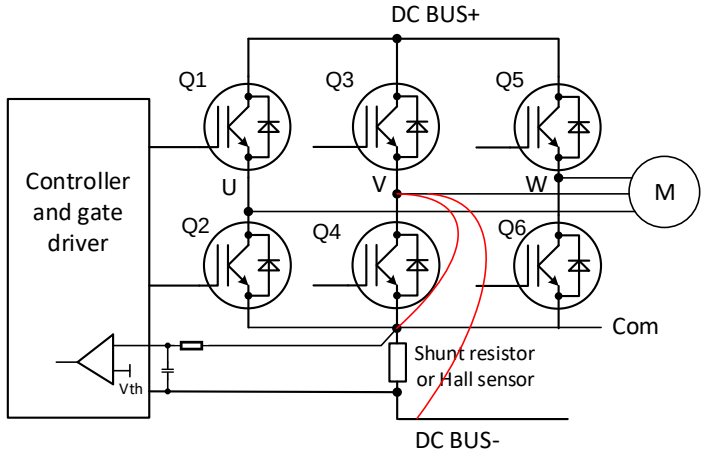


Fig.3. Waveform

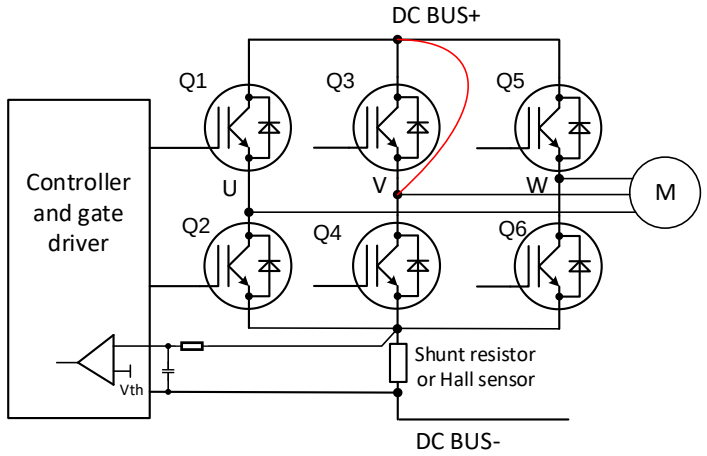
Five different short circuit conditions of 3 phase inverter



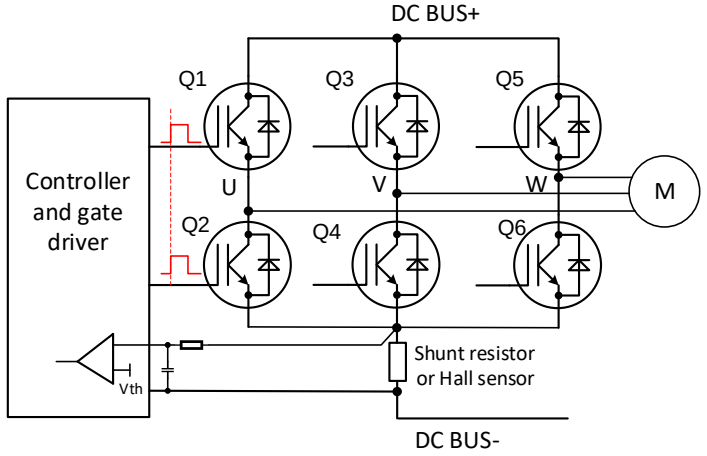
1: Phase to phase short



2/3: Phase to DC BUS- short

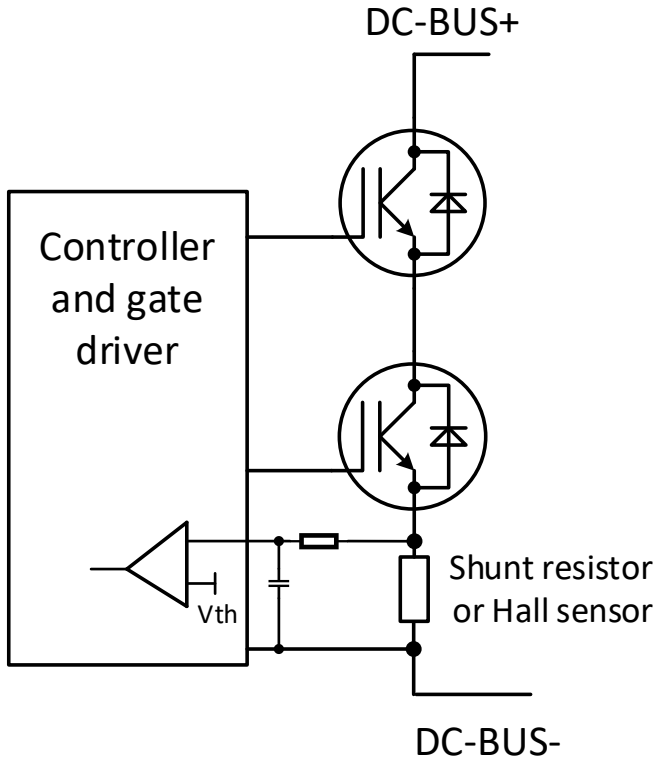


4: Phase to DC BUS+ short



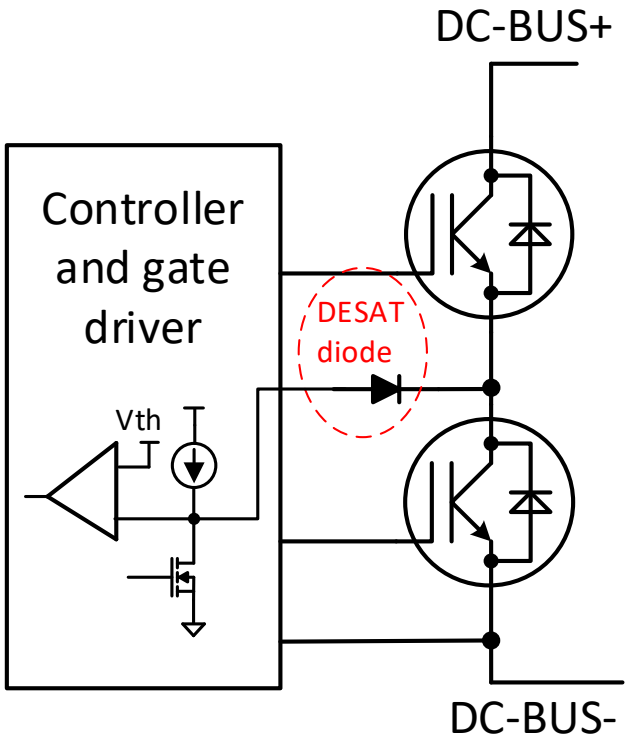
5: Half-bridge short through

Short circuit protection



First:

- Shunt resistor or hall sensor protection
- Cover the protection of above four short-circuit conditions.



Second:

- DESAT protection
- Cover the protection of above five short-circuit conditions.

Silicon on insulator (SOI) technology

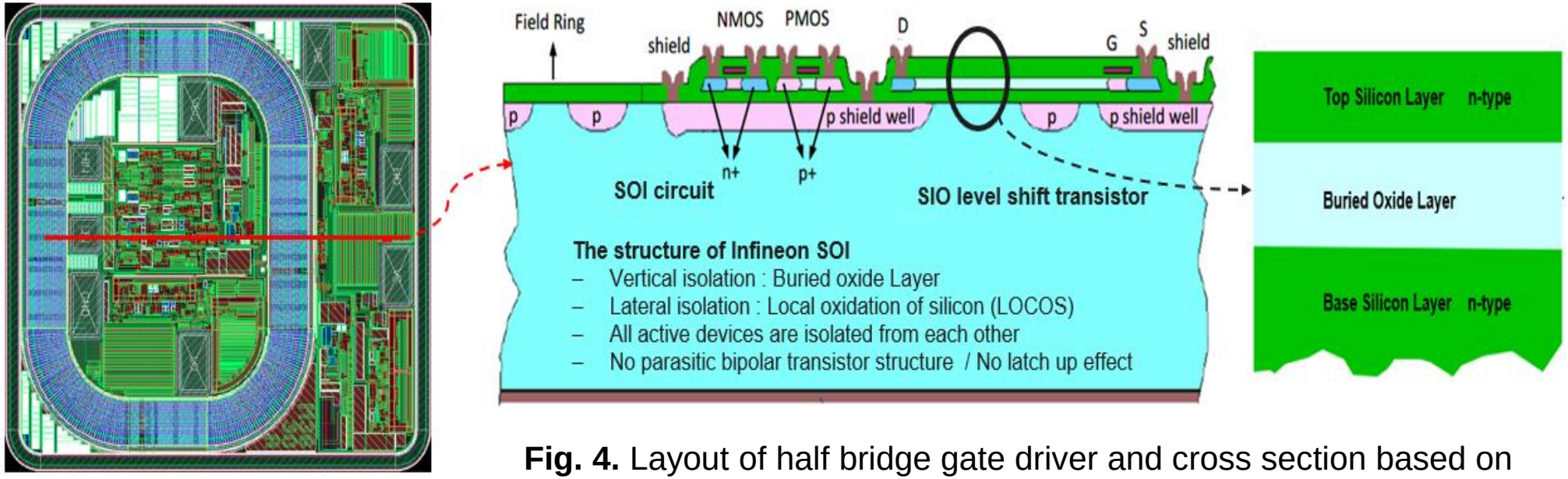
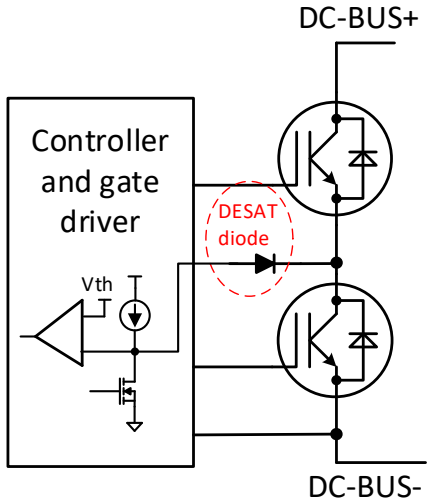


Fig. 4. Layout of half bridge gate driver and cross section based on Infineon's SOI technology

- Vertical isolation: buried oxide layer
- Lateral isolation: local oxidation of silicon (LOCOS)
- All active devices are isolated from each other
- No parasitic bipolar transistor structure
- No latch-up effect

The requirement of the DESAT diode

- A diode with a small current capacity (< 20mA) is sufficient because the forward bias current flowing (The current source within the DESAT protection circuit) is normally less than 1 mA.
- A reverse breakdown voltage is equivalent to the V_{CE} (650 V) breakdown voltage of the IGBT (650 V).
- Small junction capacitance (< 5 pF@650V) is necessary to prevent DESAT malfunction.
- Low reverse recovery time (t_{rr} < 100 ns) and energy to save the switching loss.



Gate driver integrated with DESAT protection circuitry and DESAT diode

- 650 V half-bridge gate driver monolithically integrated with high voltage fast recovery (t_{rr} ≈ 50 ns) DESAT diode + DESAT protection circuitry + Boot strap diode based on Infineon's SOI gate drive technology.

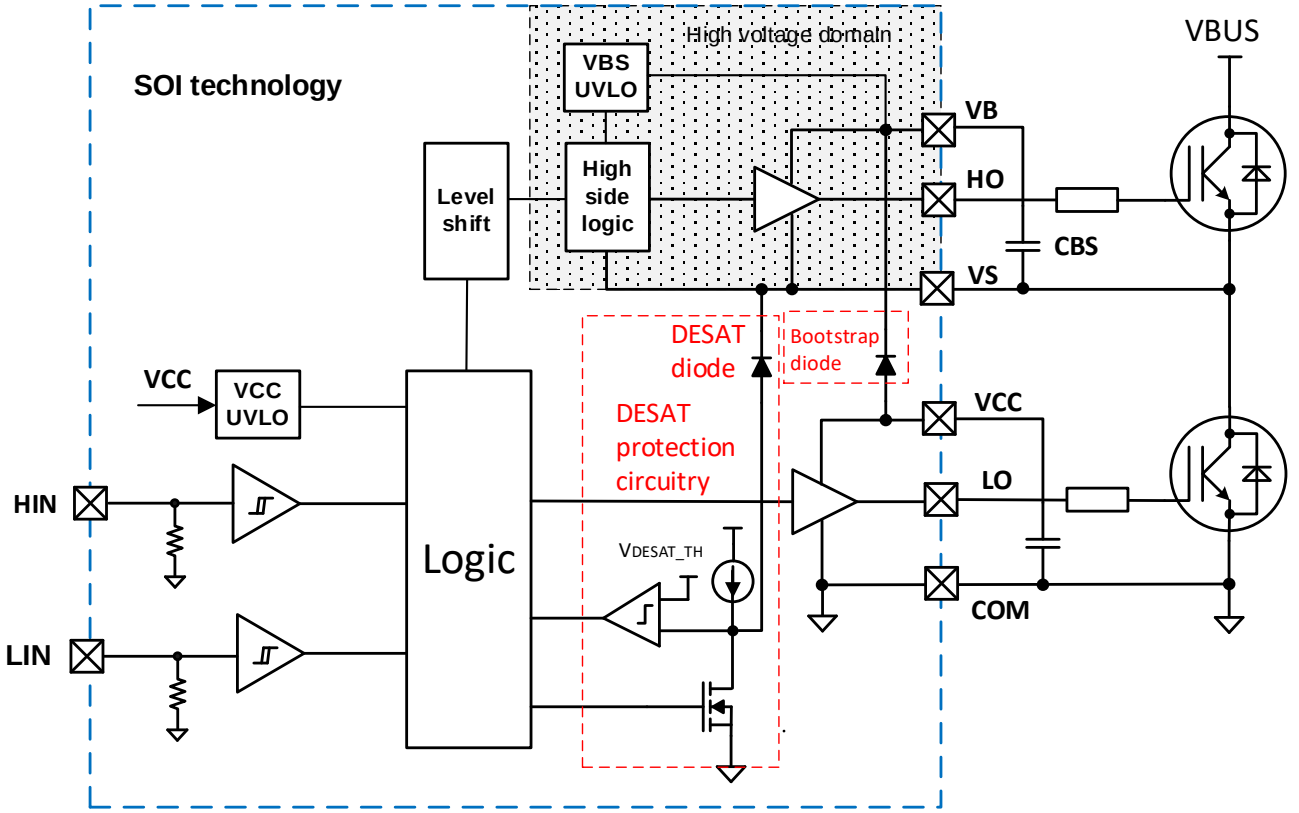
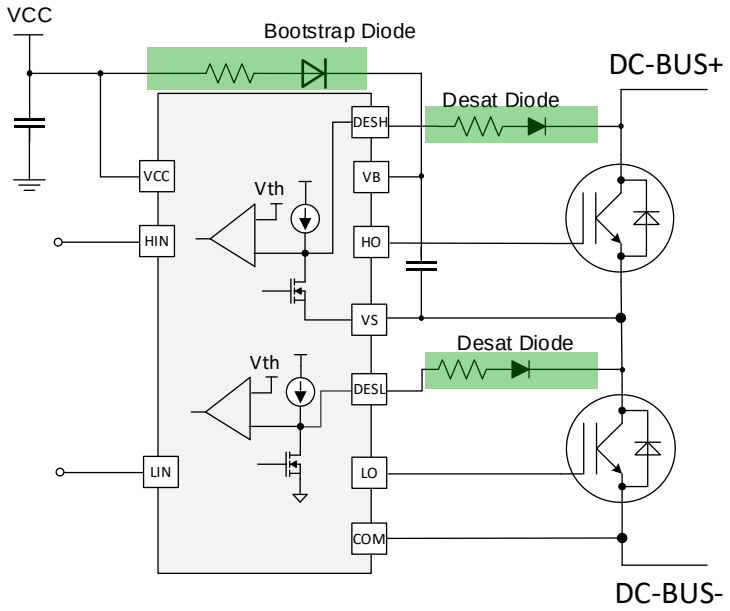
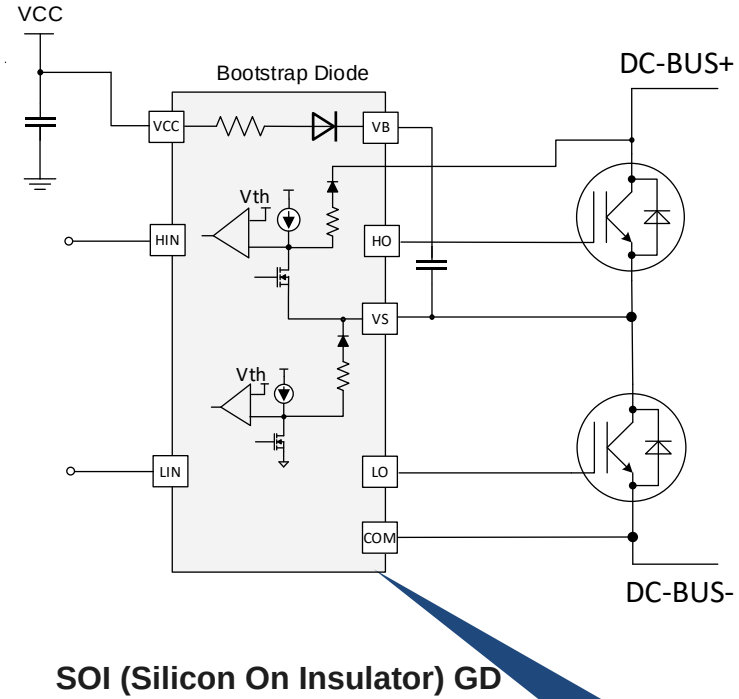


Fig. 5. Block diagram of half bridge gate driver

Components and cost saving



Junction isolation GD



SOI (Silicon On Insulator) GD

- Embed Bootstrap Diode
- Embed DESAT Diode

Save components and Cost down:

- Boot strap Diode: 600V FRD diode ('S', 'V' diode ASP is about $0.03 ~ $0.05 and resistor)
- DESAT Diode: 600V FRD diode ('S', 'V' diode ASP is about $0.03 ~ $0.05 and resistor)
  - → ~ **$0.1** cost saving per Half fridge (2CH)
  - → ~ **$0.3** cost saving for 3 phase inverter

Conclusion

- In a short circuit condition, the current flowing through the inverter increases rapidly and may exceed the maximum current rating of the power devices. This can cause the power devices to overheat and fail, leading to damage of the inverter and potentially causing safety hazards. Short circuit protection is essential in an inverter to prevent equipment damage and ensure the safety of people and equipment. It is a mandatory requirement for many safety standards, and it is crucial to include in the design of any inverter application.
- Shunt resistor or hall sensor can protect the four different short-circuit conditions in inverter applications.
- Desaturation protection can protect the five different short-circuit conditions in inverter applications.
- In the desaturation detection circuit, it needs a high voltage fast recovery diode which increases the PCB size and the cost.
- Infineon offers a high voltage gate driver IC technology - SOI, the technology can integrate the desaturation protection circuit which includes the high voltage fast recovery desaturation detection diode and high voltage fast recovery bootstrap diode monolithically, hence reducing PCB space and total system cost.

Part of your life. Part of tomorrow.

Thank you!