

3-level T-type 4-in-1 Module for Active Front End Solution

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Abstract

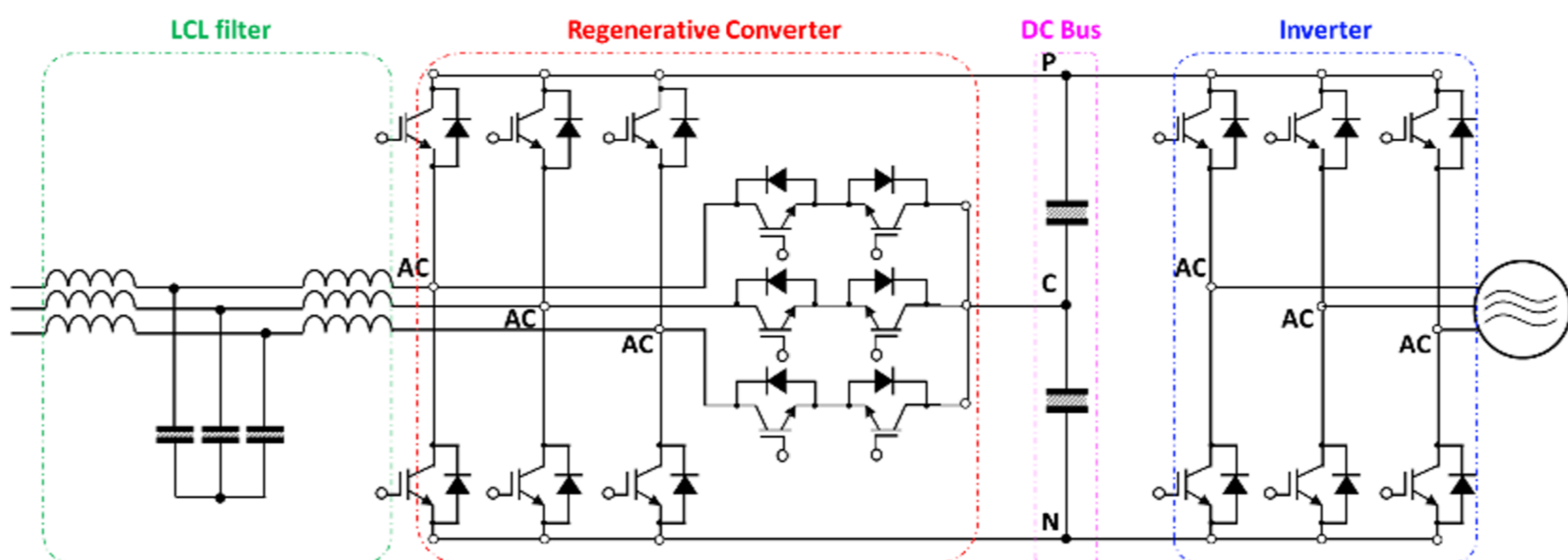
This paper offers new products of 3-level power modules suitable of Active Front End (AFE) for further harmonics mitigation solution. Variable frequency drives, which have long been used in industrial equipment, can create significant harmonics. High levels of harmonics can negatively affect to the industrial equipment longevity and performance. 2-level power solution of Active Front End has been used for mitigating harmonics solution so far. Our new power module are adopted latest chip technology and a unique packaging which is for 3-level T-type configuration in a single package.

1. 3-level T-type solution and proposed power module for Active Front End

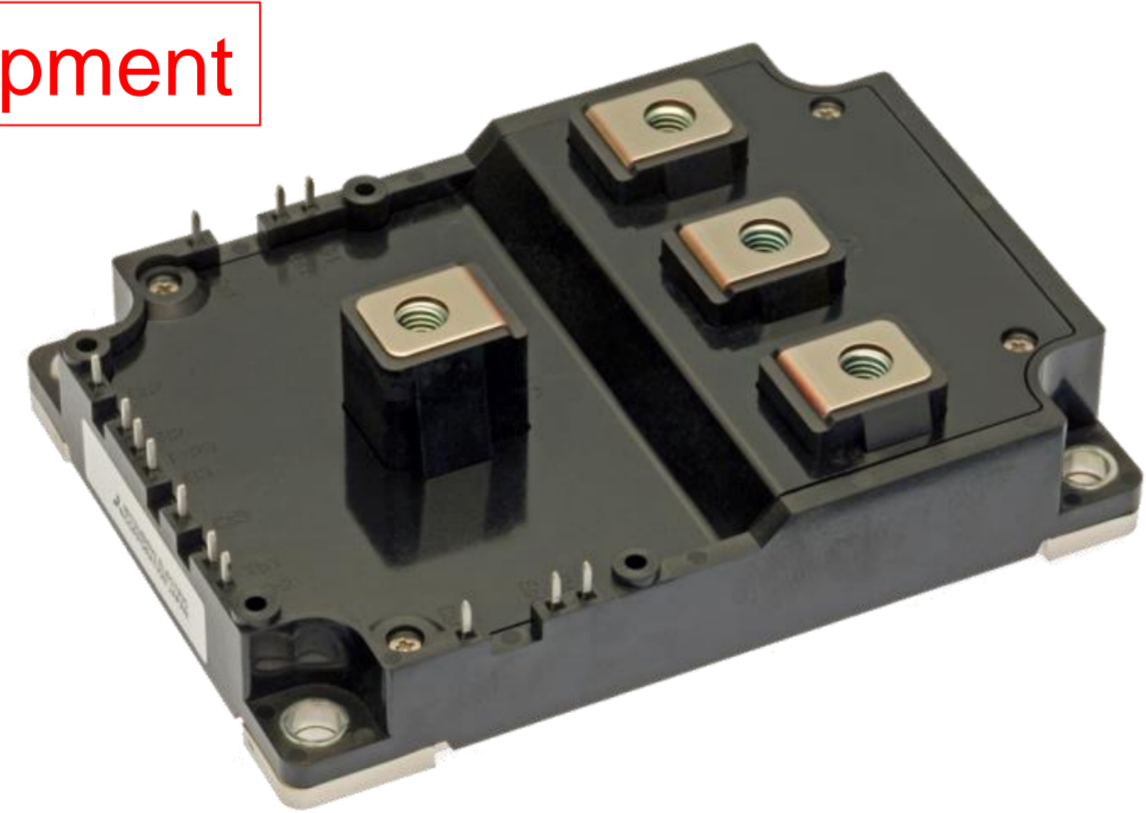
Advantage of 3-level AFE solution compared to 2-level

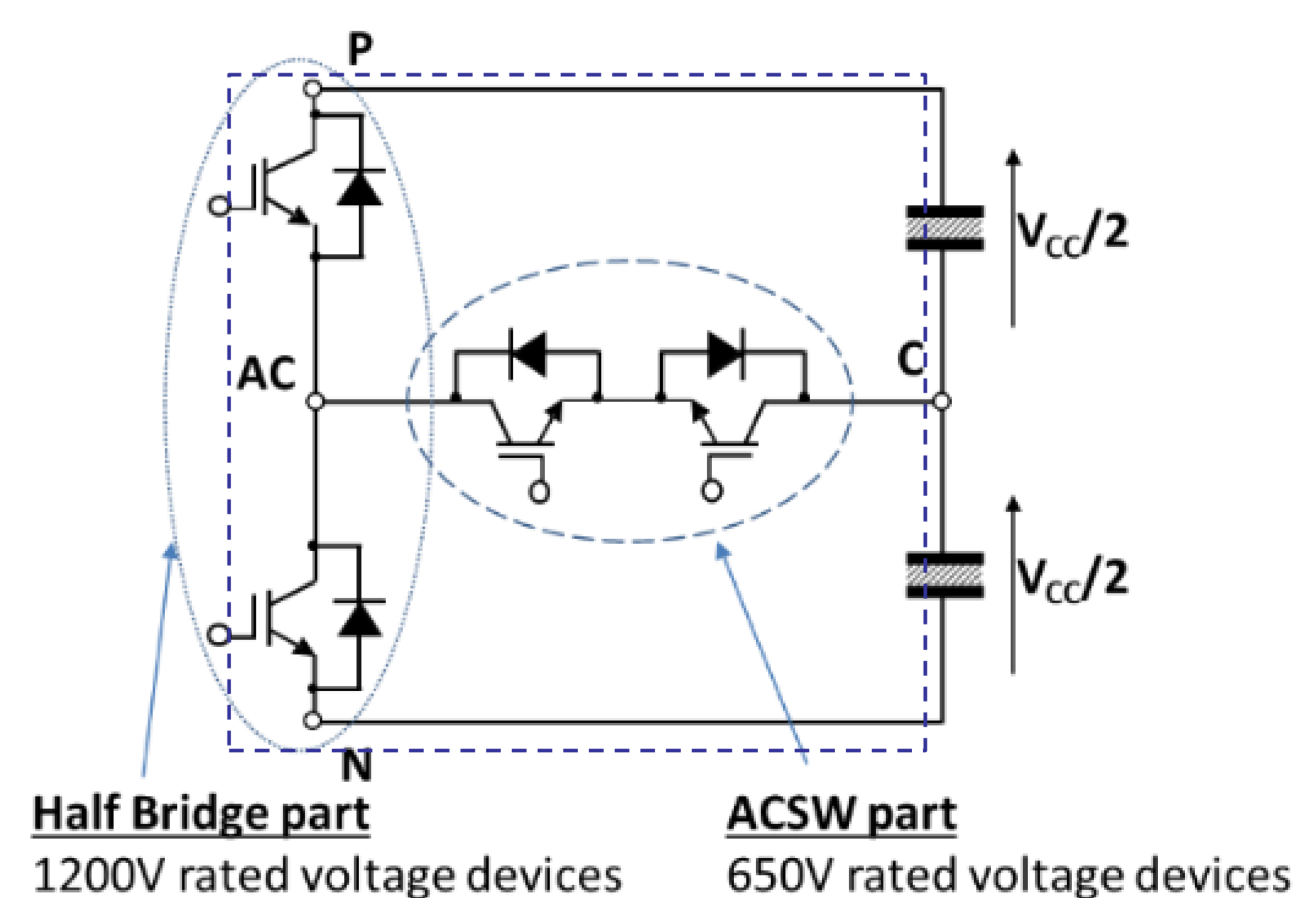
- ✓ Further mitigation of harmonics distortion due to drawing nearly pure sinusoidal current.
- ✓ Increasing of the power density of AFE drive due to lower power consumption.
- ✓ Downsizing of LCL filter due to drawing nearly pure sinusoidal current.

Schematic of Active Front End Drive with 3-level T-type solution



New products of 3-level T-type 4-in-1

Product	Under development 
Size	115mm x 82mm x 32.4mm
Isolation voltage	4kV
Chip generation	7 th gen IGBT, FWD
Voltage rating	1.2kV
Current rating	400A, 200A



7th gen. (generation) chips, very low DC loss, 1200V rated are adopted to HB part and 650V rated are adopted to ACSW part and 3-level T-type into single module

Our new products (under development), optimized for the best performance of 3-level T-type, can realize downsize and simplify the power electronics system.

- ✓ 7th gen. (generation) chips, very low DC loss, 1200V rated are adopted to HB part and 650V rated are adopted to ACSW part and 3-level T-type into single module.
- ✓ Two current lineup of 200A and 400A rated contribute to high efficiency power conversion system, such as 200A rated is for ~75kW inverter, and 400A rated module is for ~160kW inverter. The package designed for easy paralleling realizes high scalability for 160kW above inverter.

2. Advanced package for 3-level T-type solution

Image of internal terminal layout

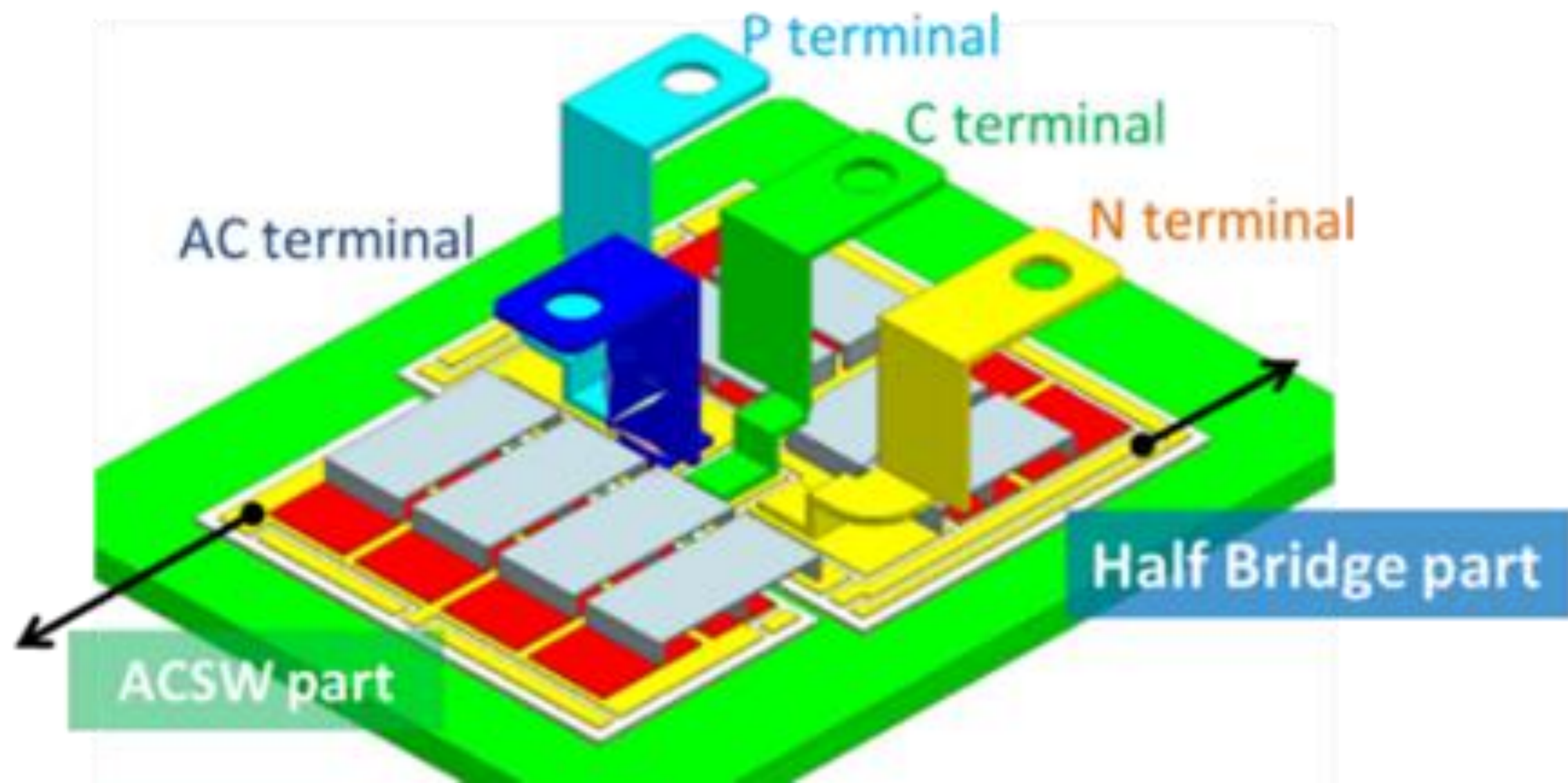
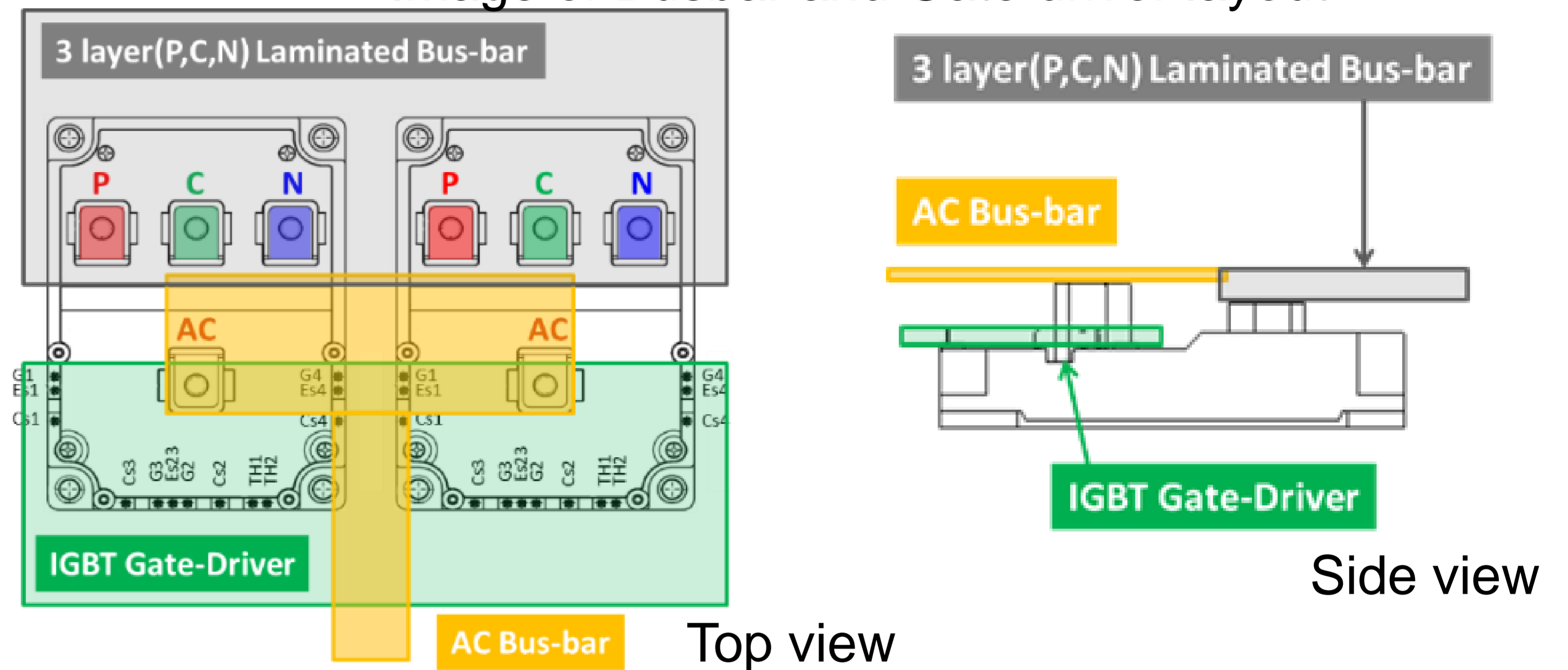


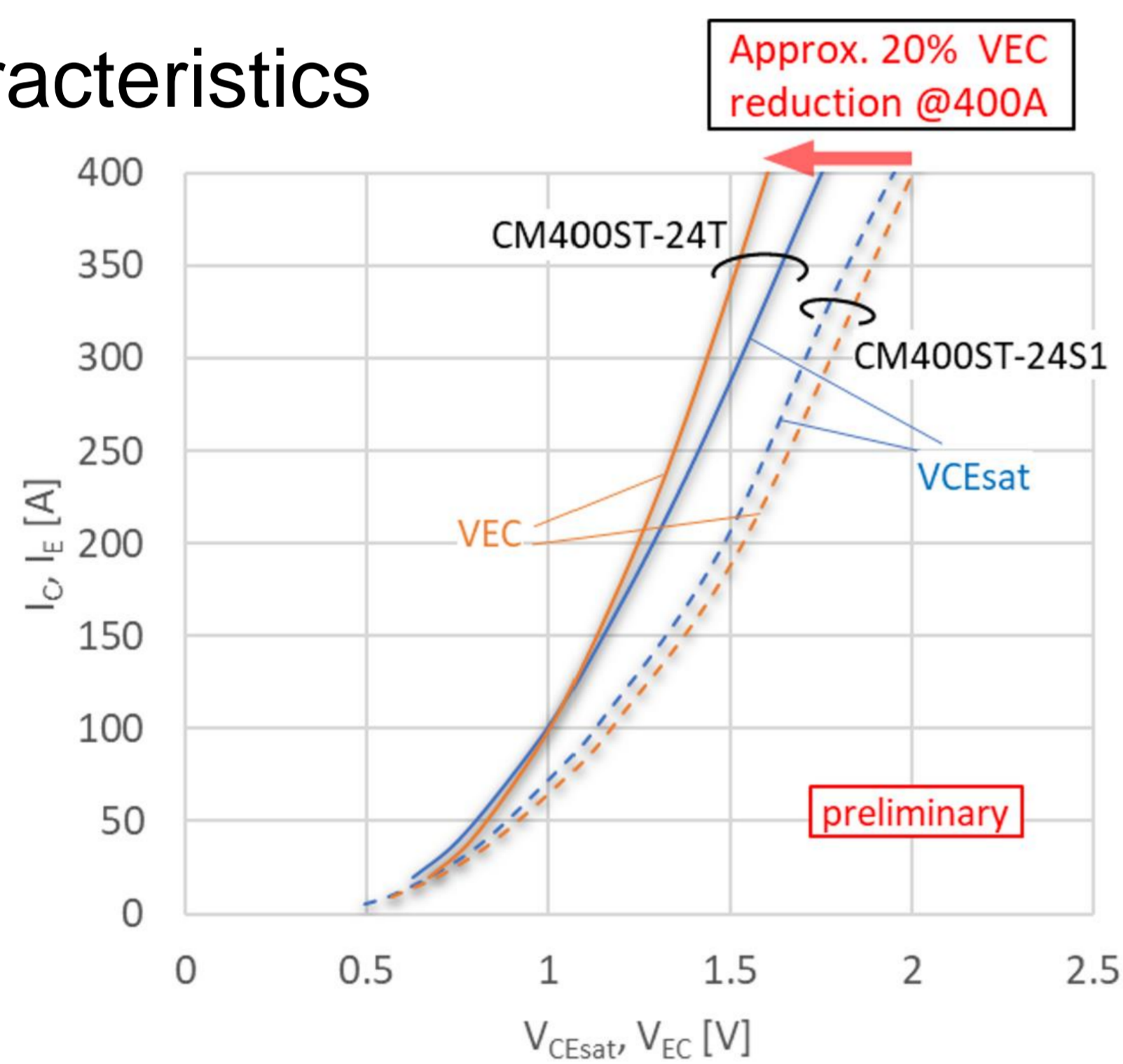
Image of Busbar and Gate driver layout



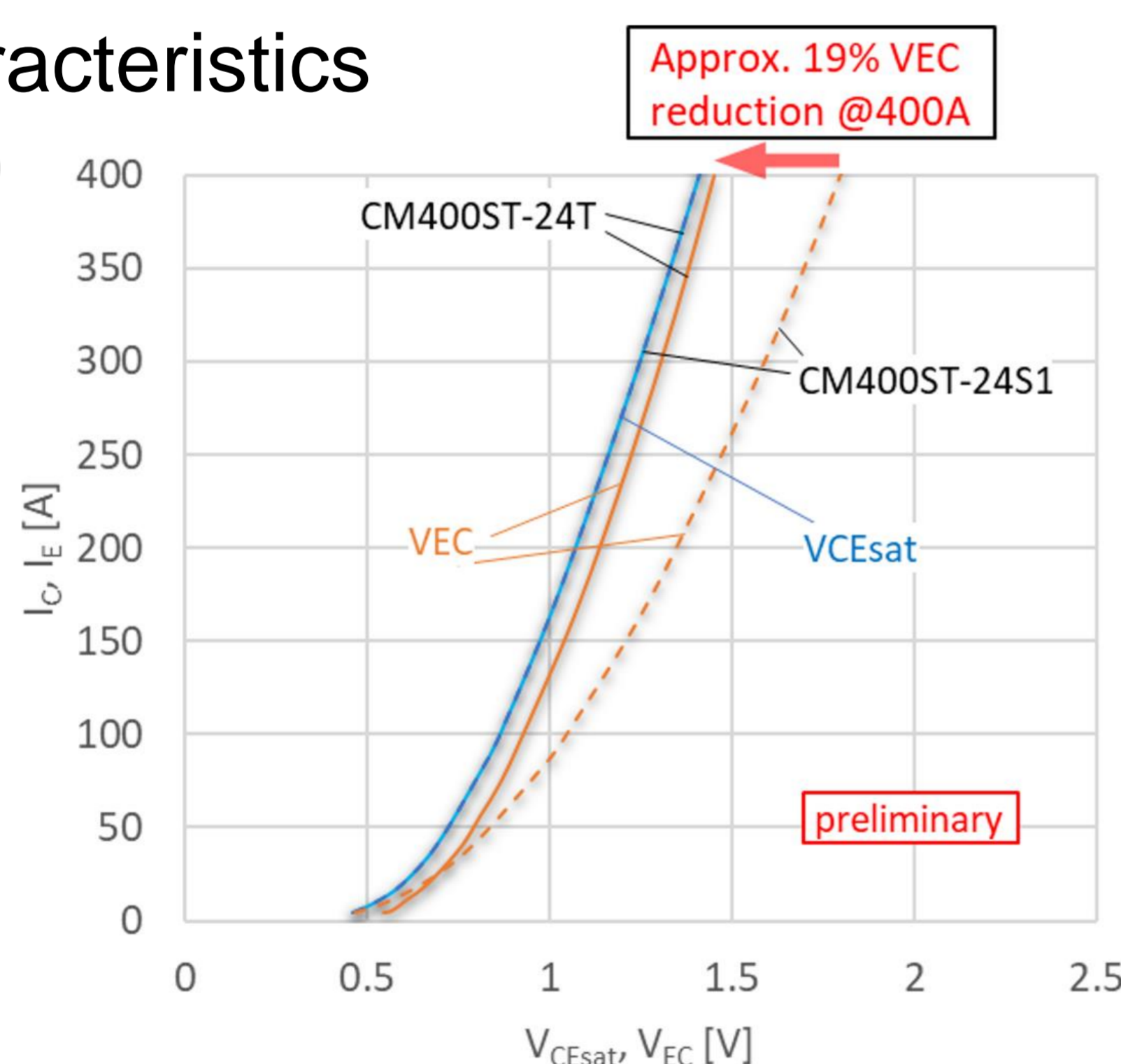
- ✓ The 3-level T-type configuration is combined in a single package. HB part and ACSW part are included in 4-in-1 module. → feasible to the compact design of 3-level power solution.
- ✓ Optimized terminal layout (P, C, N and AC terminal are configured in center of module)
 - The shortest commutation path between chips make the package inductance become lower (Approximately 30nH for PN, PC, CN).
 - The close P, C, N terminals and separated AC terminal allow the clear separation of DC-bus and AC line, as well as low inductance bus design with 3layer (P,C,N) laminated busbar.

3. Power loss simulation

DC characteristics (HB)

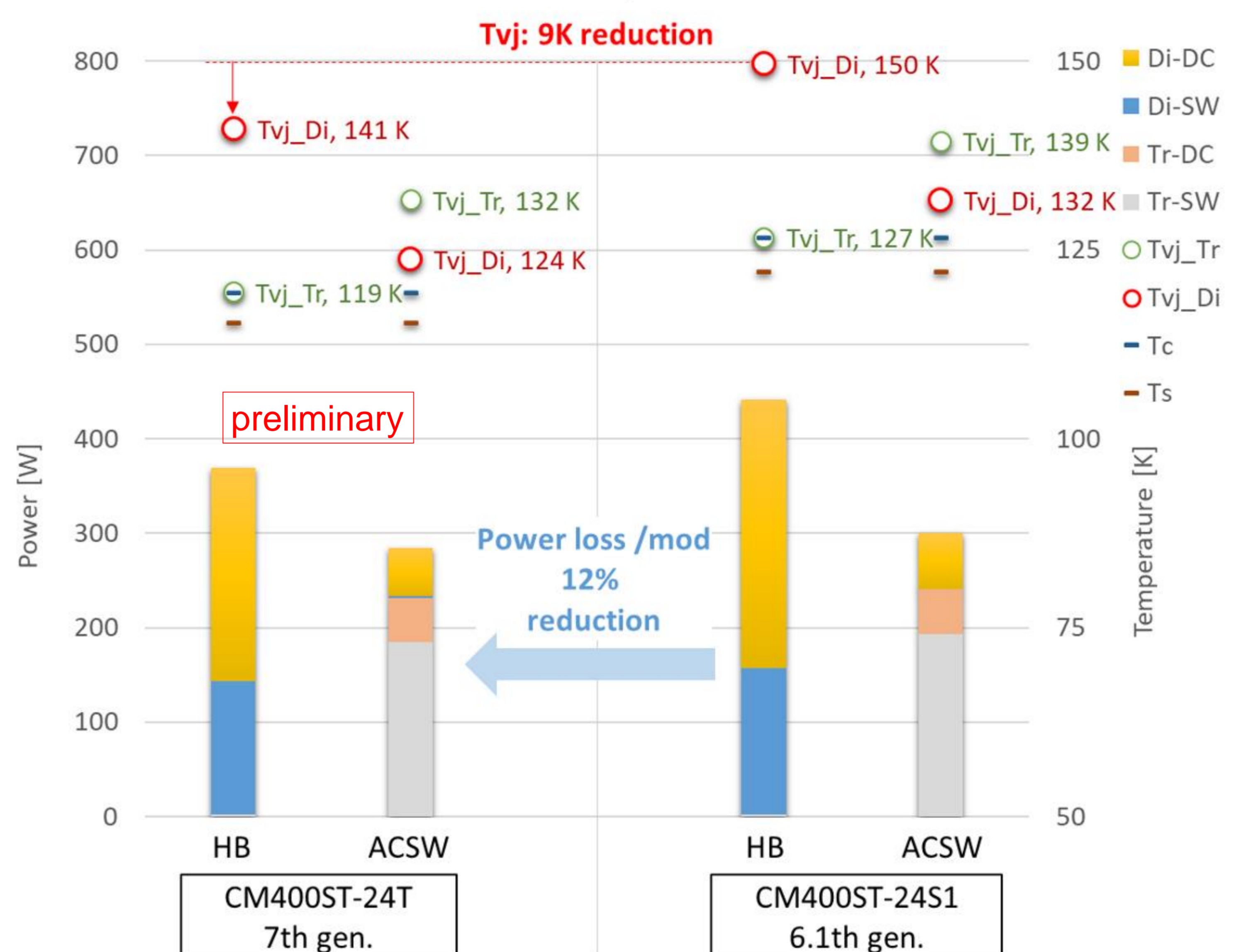


DC characteristics (ACSW)



Simulation condition:

3-level T-type, VCC=566V, IO=233Arms, PF=-0.99, M=1, fc=15kHz, Ta=65°C, Air cooling
(Rth(c-s)=0.0061K/W per mod, Rth(s-a)=0.077K/W per mod)



- ✓ Both VEC characteristics in HB part (1200V rated) and ACSW part (650V rated) part are reduced approximately 20% @400A compared to conventional product.
- ✓ The lower DC characteristics of 7th gen chips allows power loss 12% reduction and Tvj 9K reduction than conventional 3-level 4-in-1 module at rectification mode of AFE.

4. Conclusion

The new products of 3-level power module for AFE have following advantages

- 1) Power loss 12% reduction and Tvj 9K reduction than conventional module at rectification mode of AFE.
- 2) Low inductance 3-level T-type configuration with unique package (Approx. 30nH for PN, PC, CN).
- 3) High scalability, 200A rated module for ~75kW inverter, 400A rated module for ~160kW inverter and ingenious terminal layout allows easy parallel connection for 160kW above inverters.