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ABB LinPak: smart design for efficient converters

IWIPP 2019

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ABB LinPak: smart design for efficient converters

Module concept and EM Design

Design and Manufacturing

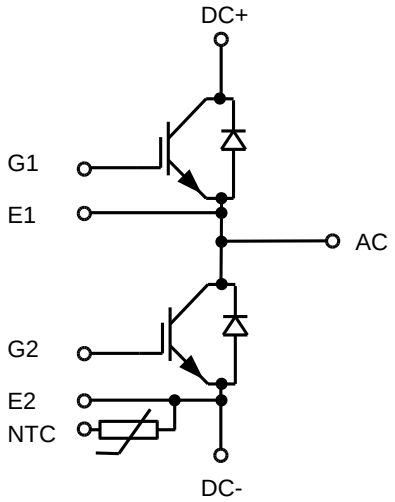
Applications

Outlook

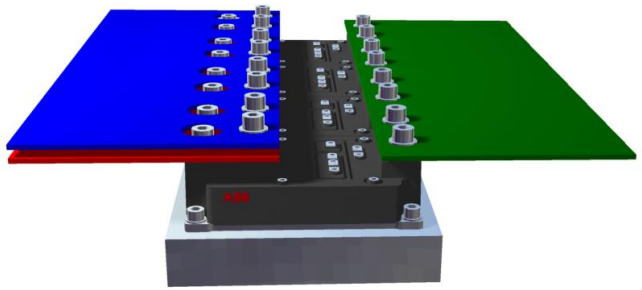
LinPak IGBT modules

Setting the standard for the next generation power module

- **Low inductive**
  module inductance 10 nH,
  ready for fast chip-sets and future SiC solutions
- **Flexible**
  one module for different current ratings,
  easy paralleling with one driver
- **Highest current density**
  compact inverter design
- **Integrated thermistor**
  keep the temperature under control
- **Multiple source**
  Open standard – no license fee for the outline
- **150°C (3.3kV) and 175°C (1.7kV) operation**



1700V, 2 x 1000A
3300V, 2 x 450A

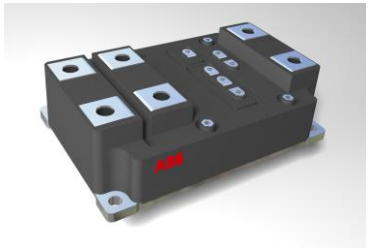


How an idea evolves into a standard

LinPak has a history and drives the future

2010 | 2014 | 2015 | 2016 | 2017

First advanced thoughts and discussions on a phase-leg IGBT module with traction proof high reliability, low inductance and appropriate power connections.



October 2014:
ABB and Hitachi present for the first time a product-concept based on 90 x 140mm^2

PCIM'15:
ABB presents a prototype stack with 4 LinPak modules in parallel. Outline changed to 100x140mm^2 as a result of customer feedbacks.

Autumn 2015:
Final outline and pin-out of the LinPak is frozen.

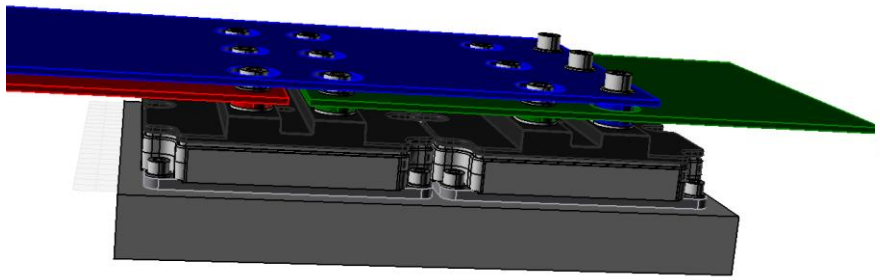
Spring 2017:
LinPak is fully qualified. First bulk order received for traction converters and deliveries of modules has started.

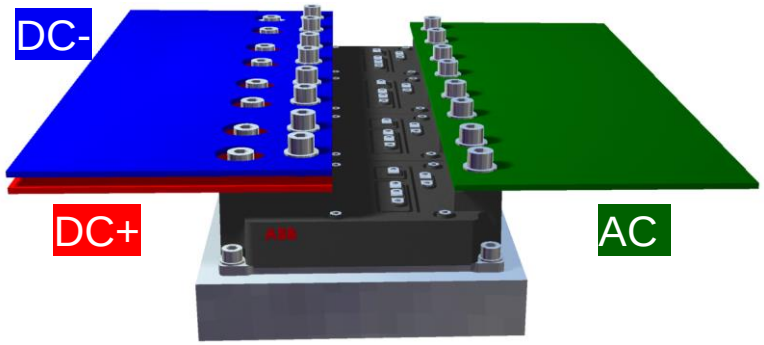
Comparison in the inverter

HiPak versus LinPak

HiPak

LinPak



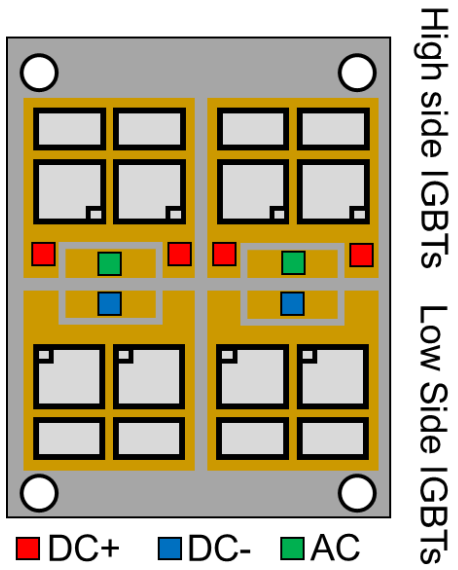


	2 HiPak (1.7 kV / 3600A)	4 LinPak (1.7 kV / 4000A)
Module inductance	16nH (2 x 8nH)	2.5nH (10nH for a single module)
Bus-bar inductance	10nH	1.5nH
Capacitor inductance	1.5nH	1.5nH
Total (module including DC-link)	27.5nH	5.5nH (22nH for a single module)
$L_\sigma \cdot I_C$ (3600A)	99 µVs	19.8µVs
Overvoltage @ t_f = 0.12µs (1700V SPT++)	**825V** ***100%***	**165V** ***20%***

LinPak: Electromagnetic Layout

Coupling Inductance

LinPak internal layout

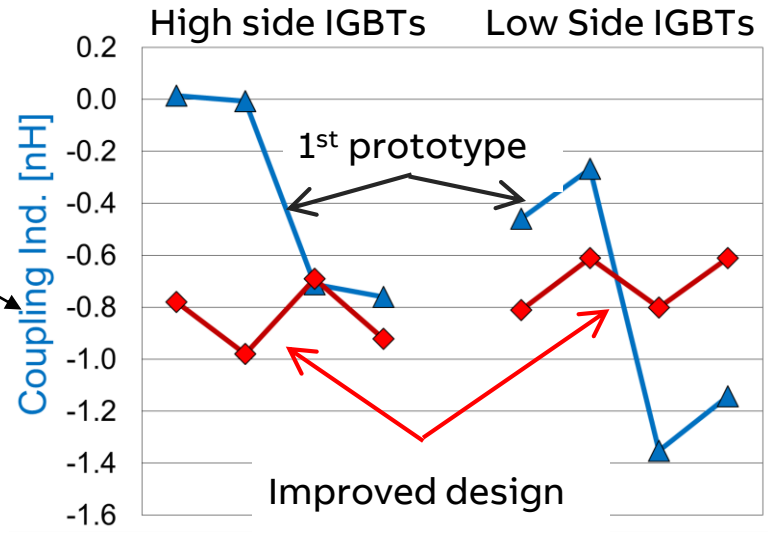


Gate Emitter Coupling

$$V_{GE,x} = V_{GE} + L_x \frac{dI}{dt}$$

VGE,x: Effective gate-emitter-voltage at IGBT x
VGE: Externally applied gate-emitter voltage
Lx: coupling inductance
di/dt: current transition

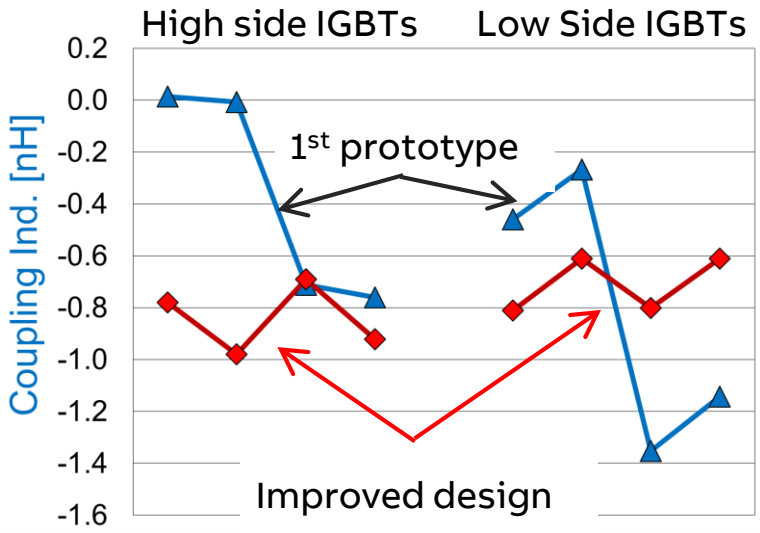
EM improvement in the development



For fast Si chip-sets and SiC devices a balanced gate emitter coupling is crucial

LinPak EM layout

Impact on IGBT turn on behavior



Similar switching speed of bottom and top switch

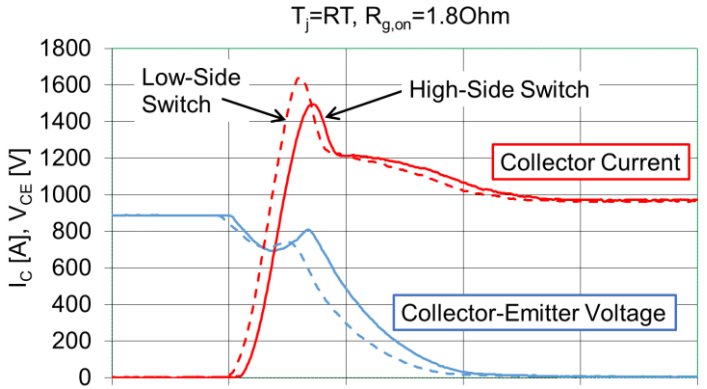
Balanced GE-coupling

– Homogenous current sharing during switching

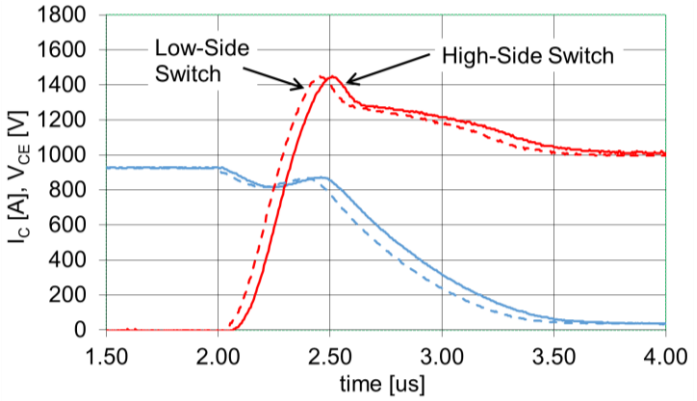
Counter coupling trade-off

– Limit short-circuit oscillations, but still allow fast switching

1st prototype



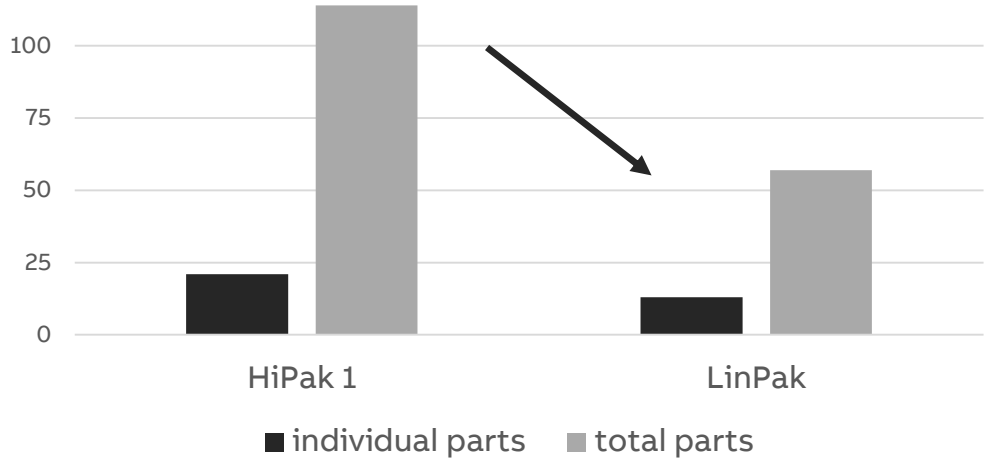
Current design



LinPak Assembly

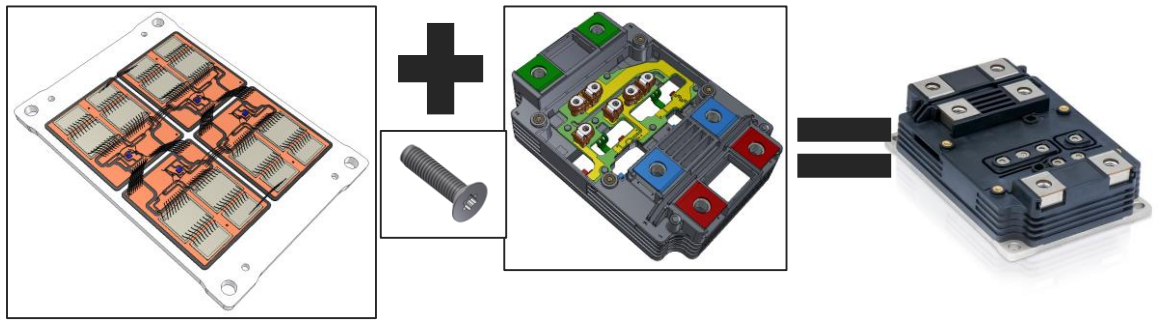
Design for Automation and Manufacturing

HiPak 1 vs. LinPak Components



Housing assembly with integrated terminals, nuts, sealings and gateprint (PCB)

- Reduced number of components for assembly
- Fewer process steps
- Faster production
- Easy for automated manufacturing



LinPak Assembly

Particle free ultra sonic welding

Link to video: https://search-ext.abb.com/library/Download.aspx?DocumentID=9AKK107046A4692&LanguageCode=en&DocumentPartId=&Action=Launch

LinPak IGBT modules

Easy paralleling (e.g. 1700V)

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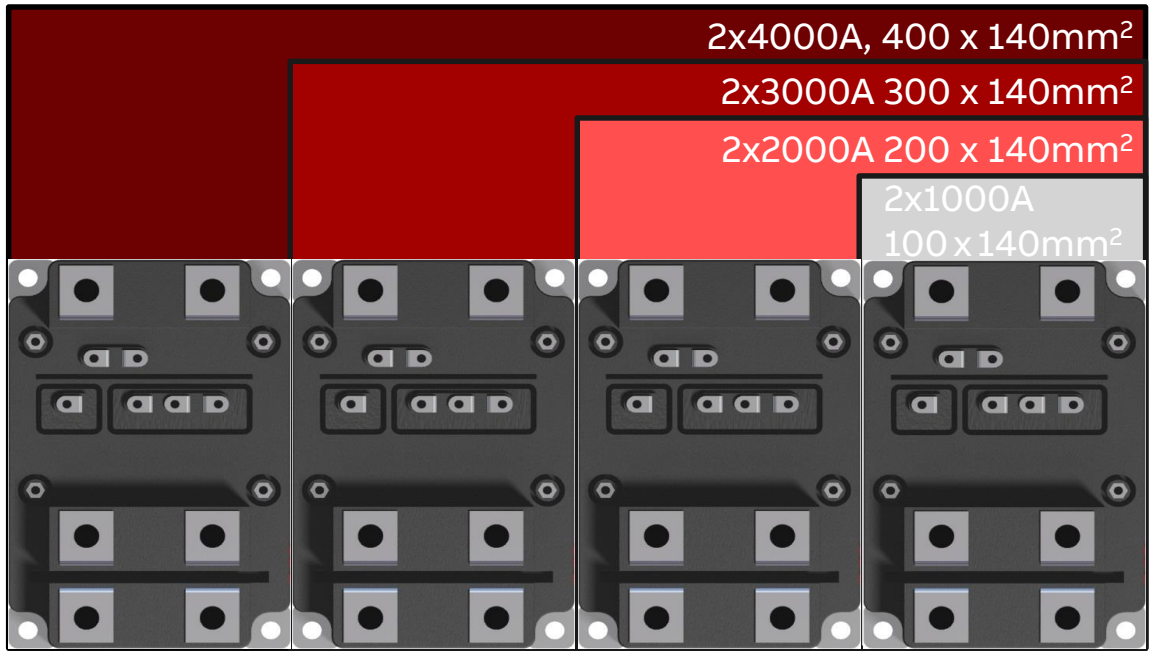
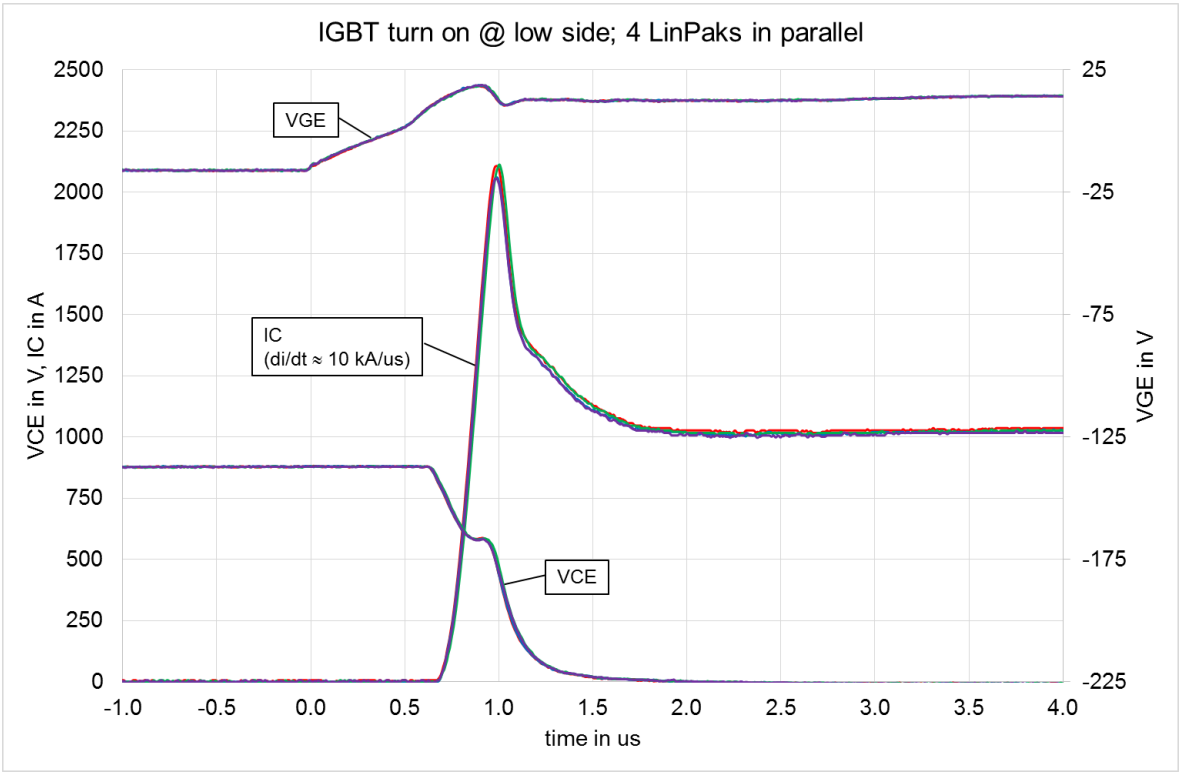


One directional internal current flow from dc to phase

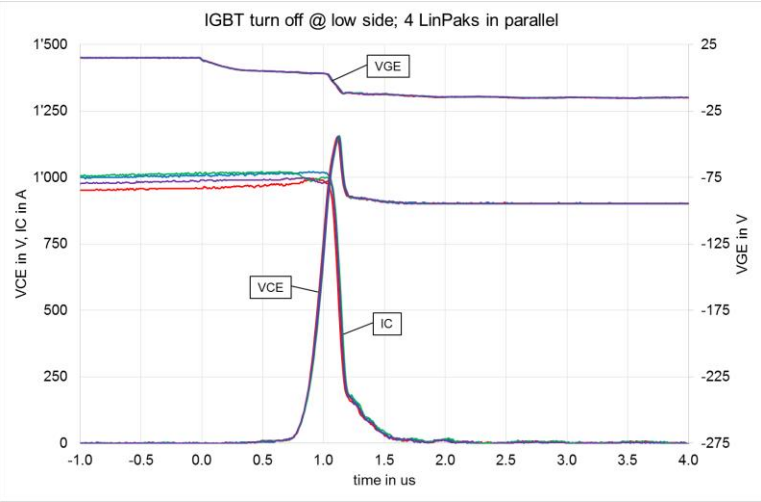
Paralleling with minimal de-rating



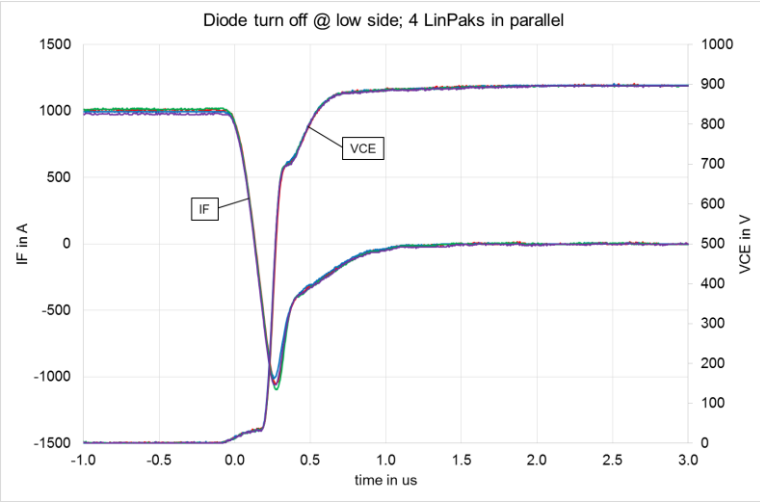
LinPak IGBT modules

Easy paralleling (e.g. 1700V)

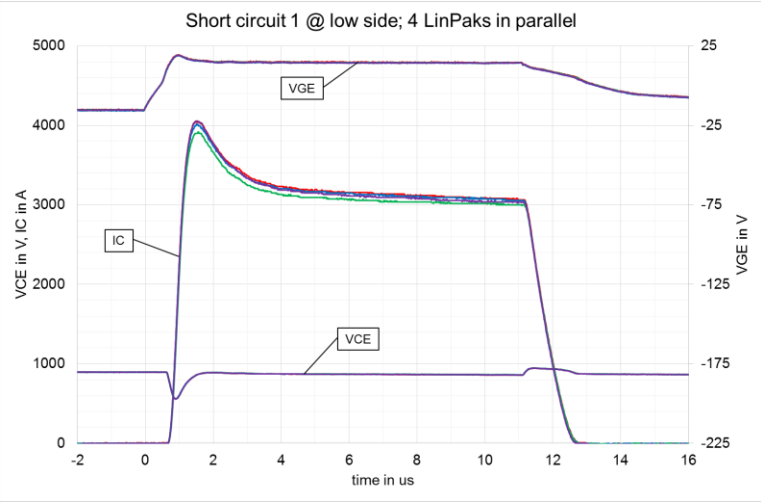
IGBT turn off



Diode turn off



Short circuit 1



Homogenious switching behavior in paralell operation

Traction package for regional trains

Next generation traction converter platform

Country:
CH, DE

Operator:
SOB, SBB, BLS, GoAhead, Abellio

Category:
EMU FLIRT

Scope of supply:
Transformer
Traction converter

Key data:
3000 – 3700 kW per train

Deliveries:
Since 2018

Customer need

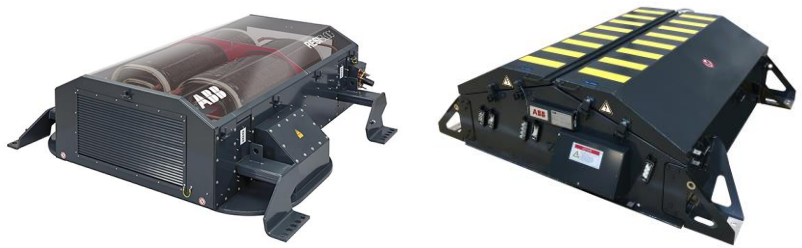
- Highest efficiency
- 100 % roof-mounted traction package
- Higher traction and auxiliary power

ABB solution

- High efficient converter with innovative topology
- Next generation power semiconductors
- Most efficient traction transformer
- New high-performance control system with TRDP (train real time data protocol)
- High power density

Customer benefits

- Up to 25 % improvement of overall traction chain efficiency
- Increase of passenger capacity



SiC - LinPak

Technology drivers

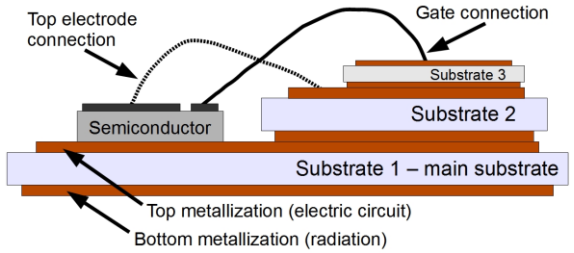
CONFIDENTIAL

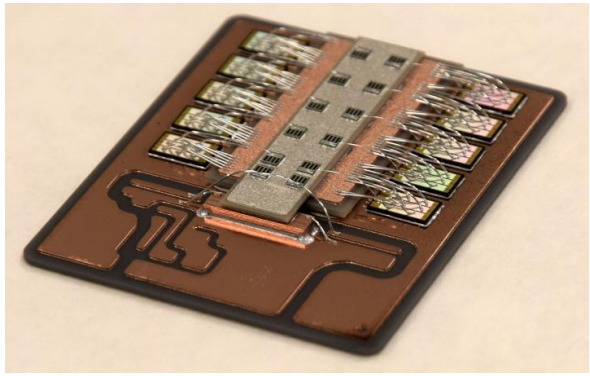
Full-SiC technology drivers built and tested with special substrate for homogenous switching: 1200V, 2 x 500A

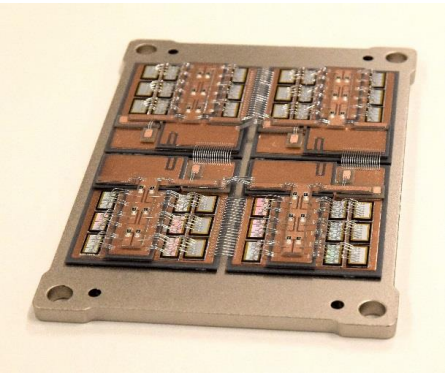
Lowest switching losses and low over-voltage

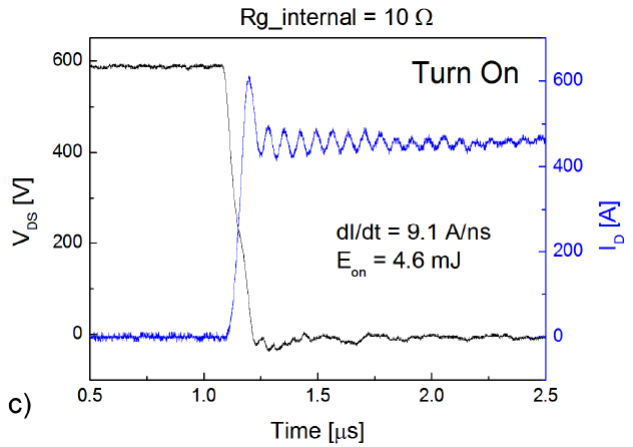
1700V, 2* 1100A available as engineering sample

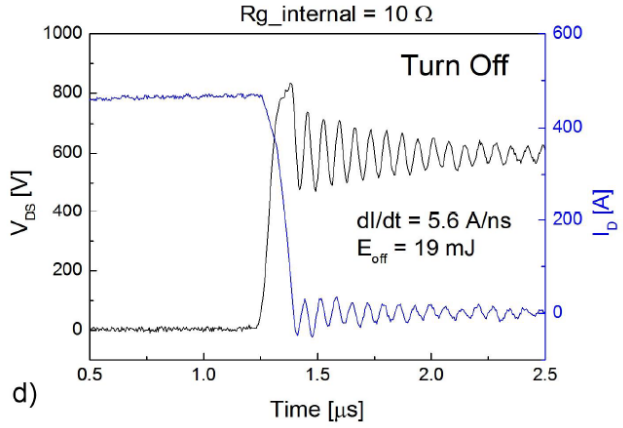
3300V technology drivers in evaluation







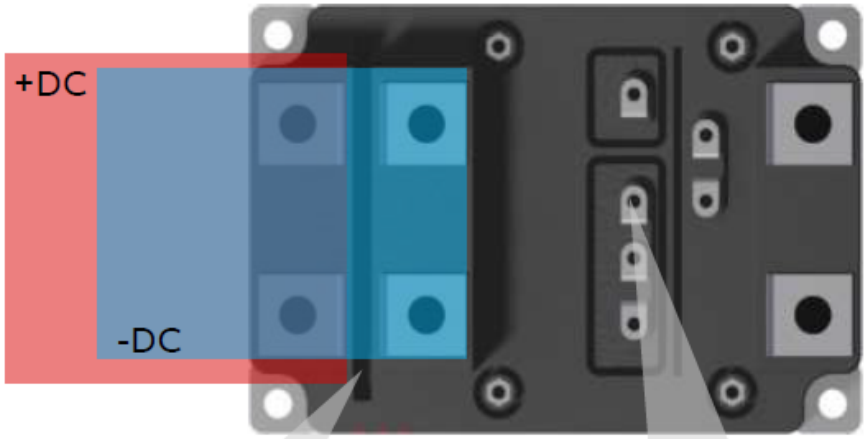




LinPak

Comparison LV to HV package

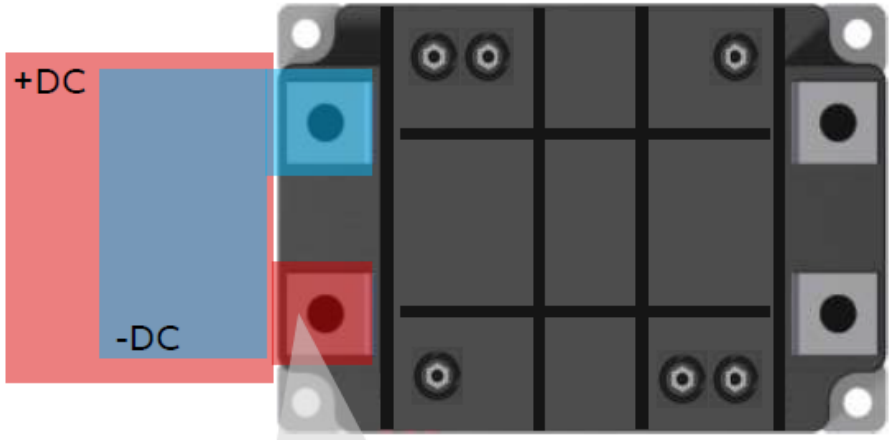
LV LinPak



Low-inductive strip-line
DC- connection

Temperature sensor

HV LinPak



Interrupted strip-line:
increased DC-link inductance
Electro magnetic field emission


ABB