ALBA Power Supplies Activities

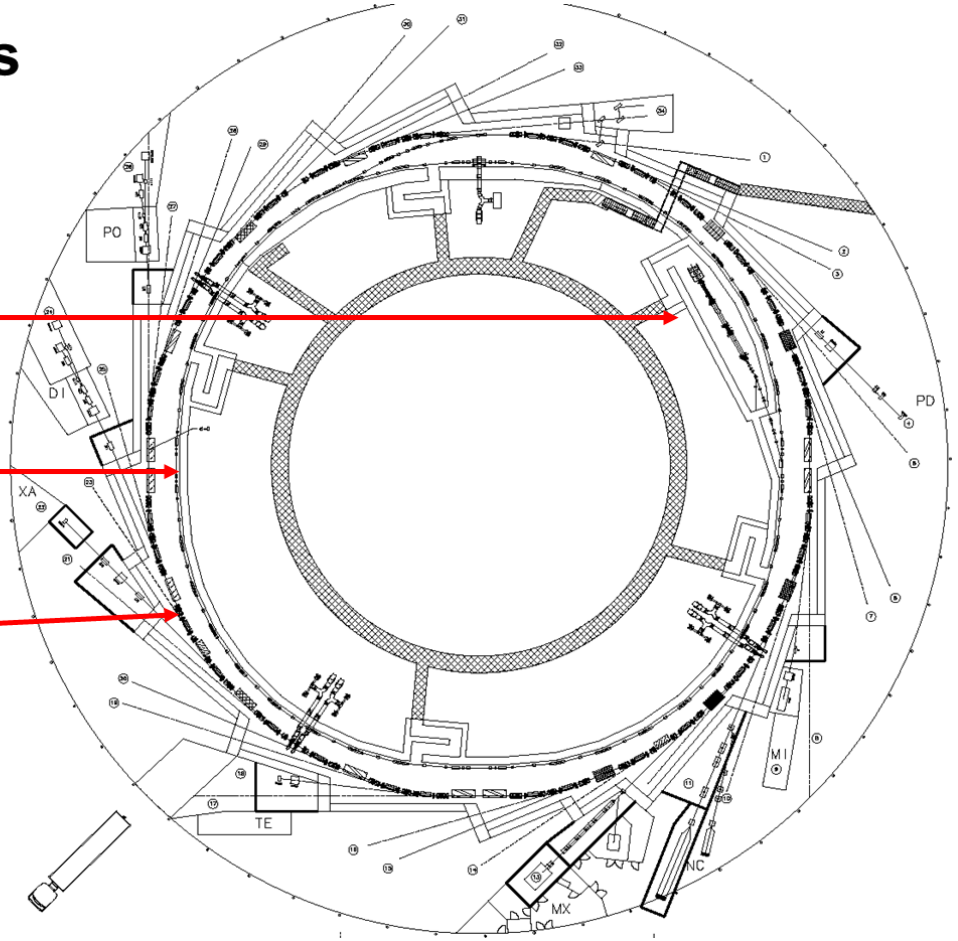
Magnet Power Supply System Overview

ALBA accelerators

LINAC
100 Mev

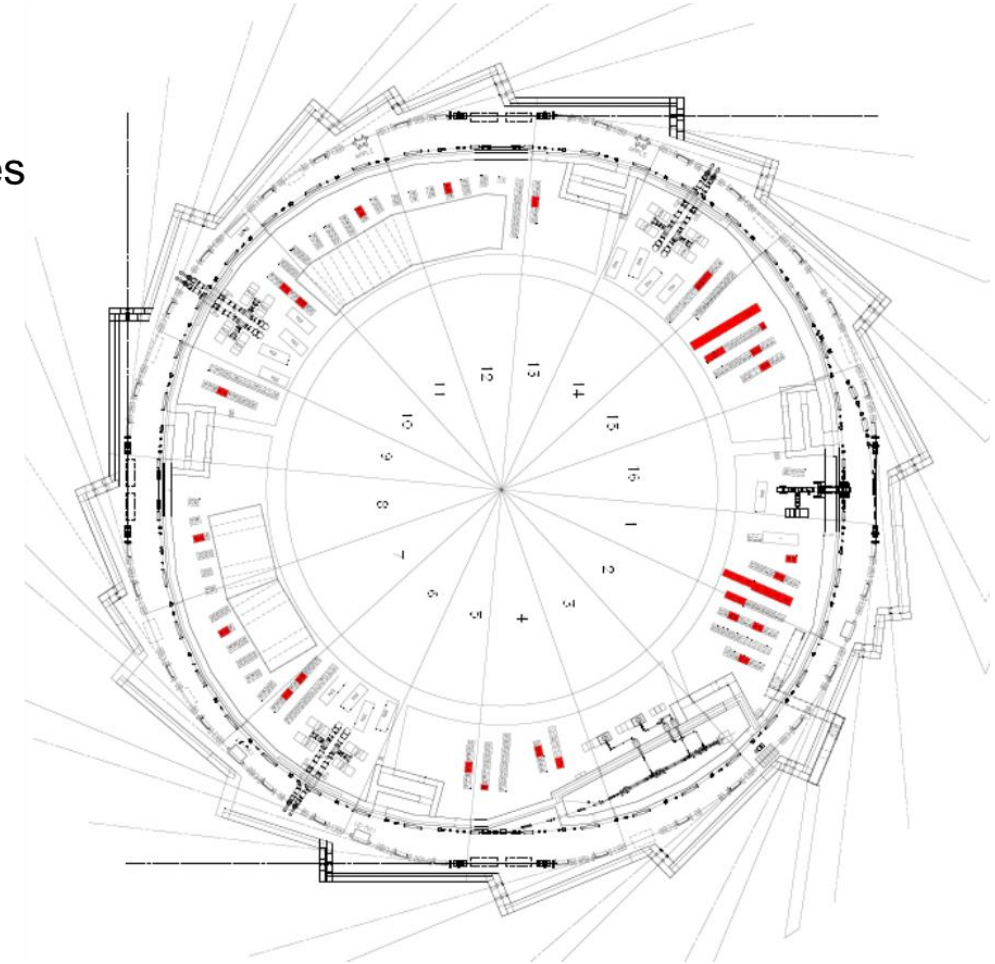
BOOSTER
100 MeV – 3 GeV

STORAGE RING
3 GeV

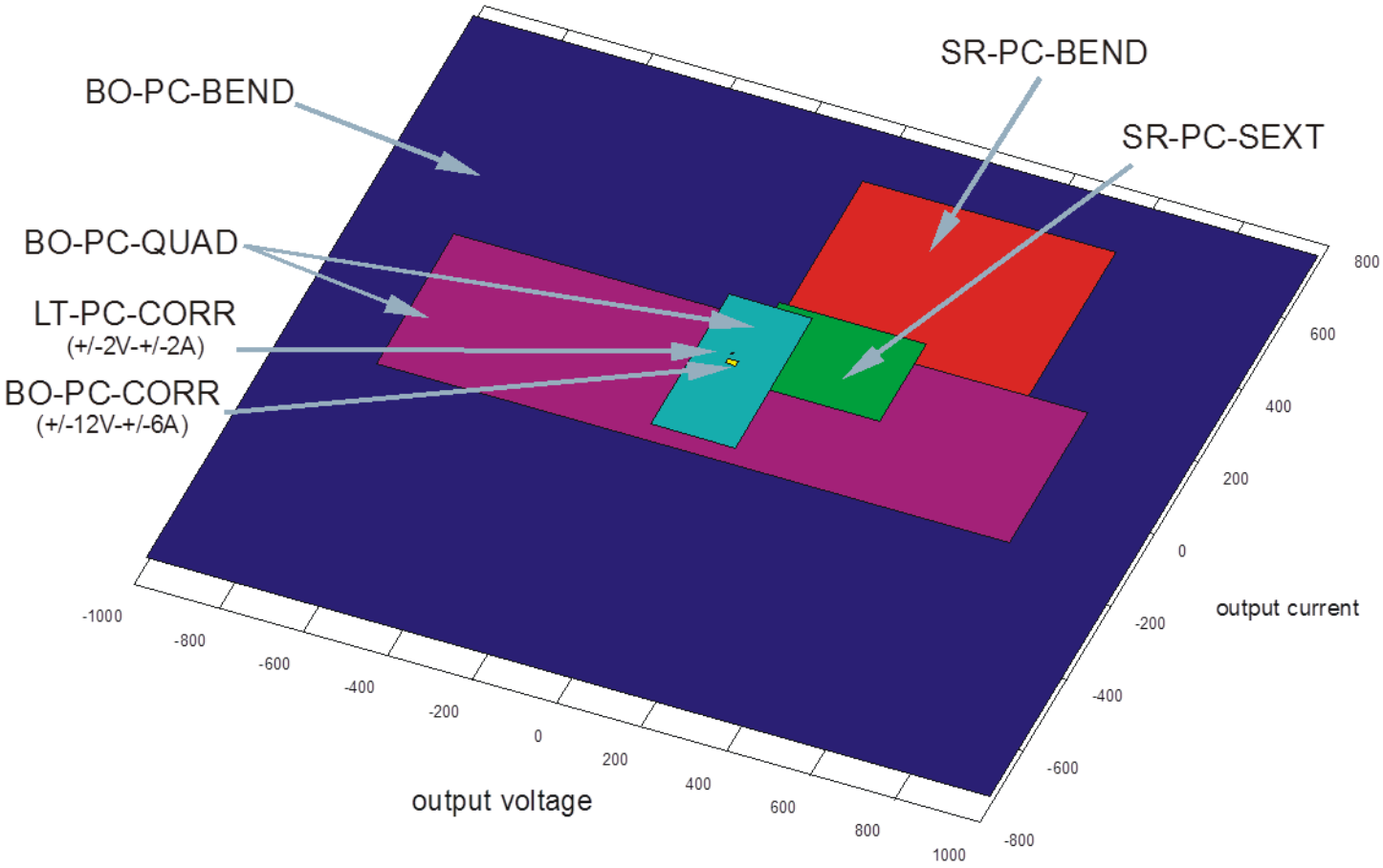


Distribution of Power Supplies in Service Area

Distribution of Power Supplies in the Service Area



Range of Magnet Power Supplies



OVERVIEW OF STORAGE RING POWER SUPPLIES

MAGNET	QUANTITY		Nº PS	SPARE	Current (A)	Voltage (V)	OUTPUT POWER (kW)
DIPOLES	33		1	0	600	750	450
QUADRUPOLES	112	16 (Q200)	88	8	200	15	3
		48 (Q260)					
		24 (Q280)					
		24 (Q500)	24	2	225	25	5,625
SEXTUPOLES	120	4 families x 8 magnets (S150A)	4	1	215	100	21,5
		2 families x 16 magnets (S150B)	2	0	215	190	40,85
		2 families x 24 magnets (S220A)	2	1	215	350	75,25
		1 family x 8 magnets (S220B)	1	0	215	125	26,875
CORRECTORS	208	Horizontal	88	6	±12	±60	200
		Vertical	88	6	±12	±60	200
		Skew	2	0	±5	±60	200

OVERVIEW OF BOOSTER POWER SUPPLIES

MAGNET	QUANTITY		Nº PS	SPARE	Current (Apeak)	Voltage (Vpeak)	OUTPUT ACTIVE POWER (kW)
DIPOLES	40	40 coils	1	0	750	±1000	95
		40 coils	1	0	750	±1000	95
QUADRUPOLES	60	16 (series connection 8+8)	2	0	180	±100	3,5
		8	1	0	180	±200	5,6
		36	1	0	180	±750	24,5
SEXTUPOLES	16 (series connection 8+8)		2	0	±8	±60	0,45
CORRECTORS	72		72	4	±6	±10	0,25

OVERVIEW OF TRANSFER LINES POWER SUPPLIES

LINAC to BOOSTER TL

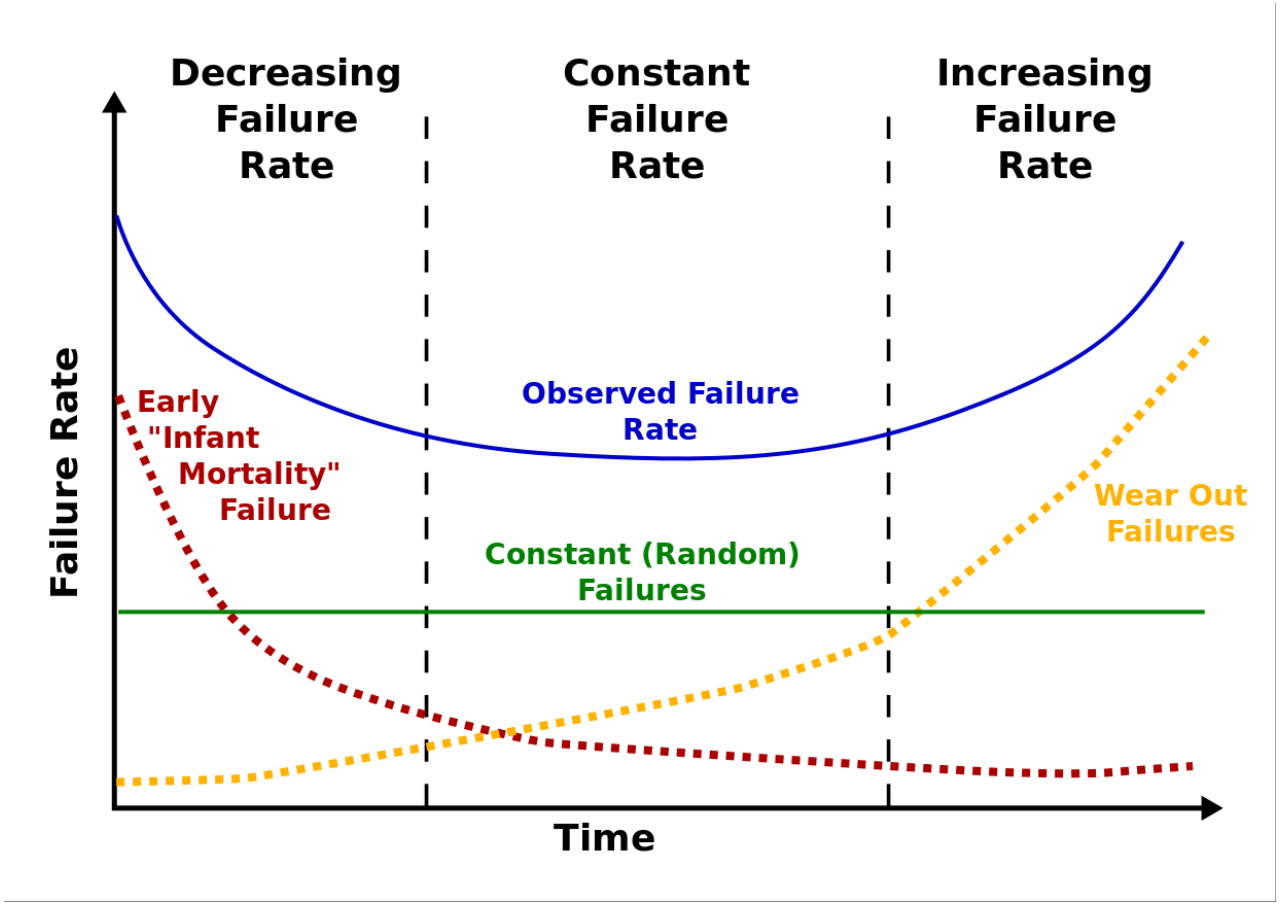
MAGNET	QUANTITY		Nº PS	SPARE	Current (A)	Voltage (V)	OUTPUT POWER (W)
DIPOLES	2	type 1	1	0	180	20	3600
		type 2	1	0	12	12	150
QUADRUPOLES	9		9	1	15	20	300
CORRECTORS	8		8	2	±2	±2	4

BOOSTER to STORAGE RING TL

MAGNET	QUANTITY	Nº PS	SPARE	Current (A)	Voltage (V)	OUTPUT POWER (W)
DIPOLES	2	2	0	180	60	10800
QUADRUPOLES	7	7	1	170	15	2500
CORRECTORS	8	8	2	±6	±10	60

2017 statistics

Scheduled hours	4630 h
No Beam hours Due to PS	10.1 h
Availability	99.78 %
MTBF	578.8 h
MTTR	1.26 h
decay mode due to BO_PS interlocks	28.9 h


Decreasing Failure Rate
Constant Failure Rate
Increasing Failure Rate
Failure Rate
Time
Observed Failure Rate
Early "Infant Mortality" Failure
Constant (Random) Failures
Wear Out Failures

wikipedia

Today's main concern

Booster Dipole Power Supplies:

Two Main Problems

1) very low lifetime of 2Q modules under the stress of top-up operation.

Power and thermal cycling.

2) Large difficulties to make failure diagnostics when the control/regulation boards are involve.

Approach

1) Try to obtain the best of the current design.

    1) Management of module to balance top and botton IGBT
    2) Better IGBT with same packaging
    3) Improve thermal contact (thermal compounds)
    4) DC warm-up

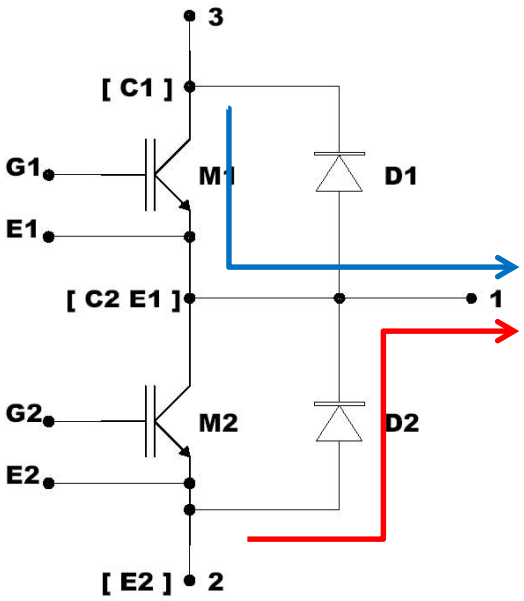
2) Find a permanent solution

    1) New design (Soleil approach)

1) Try to obtain the best of the current design.

    1) Management of modules to balance top and botton IGBT degradation

o



1) Try to obtain the best of the current design.

2) Better IGBT with same packaging

Simulations using Matlab

2.1 FZ600R12KE3

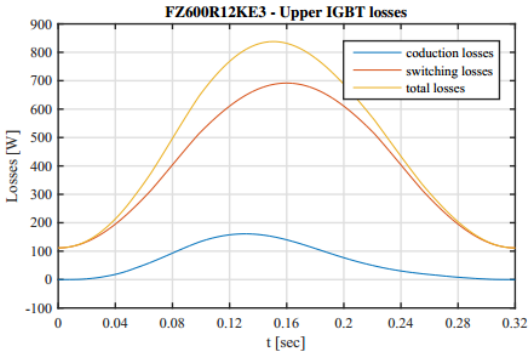
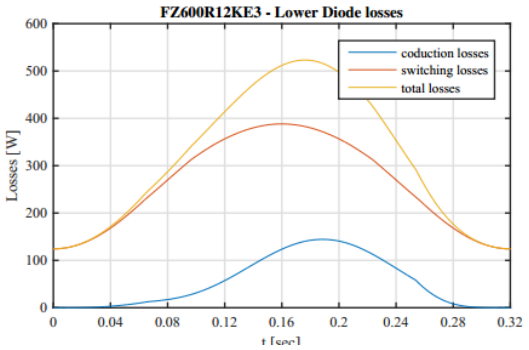


Figure 1: FZ600R12KE3 Upper IGBT losses



2.2 FZ600R12KS4

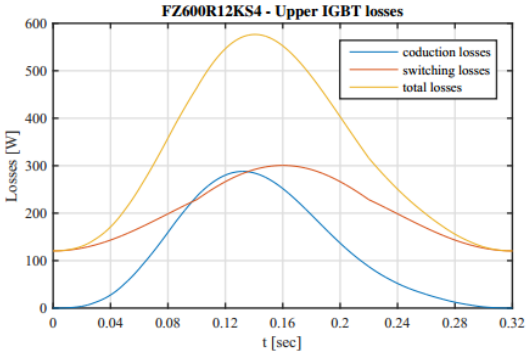
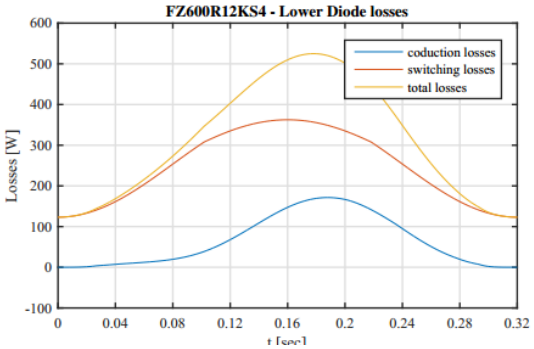


Figure 3: FZ600R12KS4 Upper IGBT losses

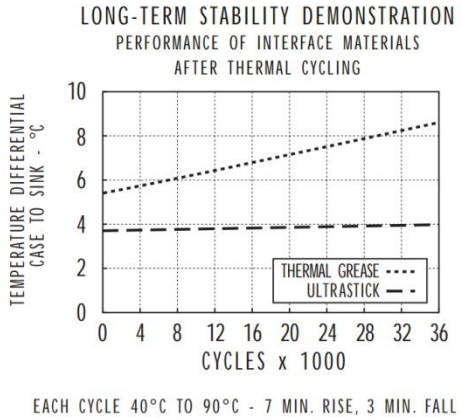


1) Try to obtain the best of the current design.

3) Improve thermal contact (thermal compounds)

Aavid Ultrastick™
Phase-Change
Thermal Interface Compound

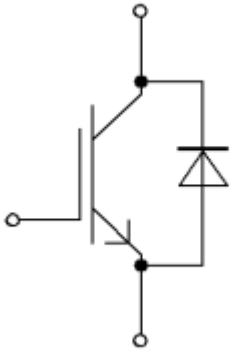
THERMAL PERFORMANCE:



Laird
TECHNOLOGIES
Innovative Technology
for a Connected World

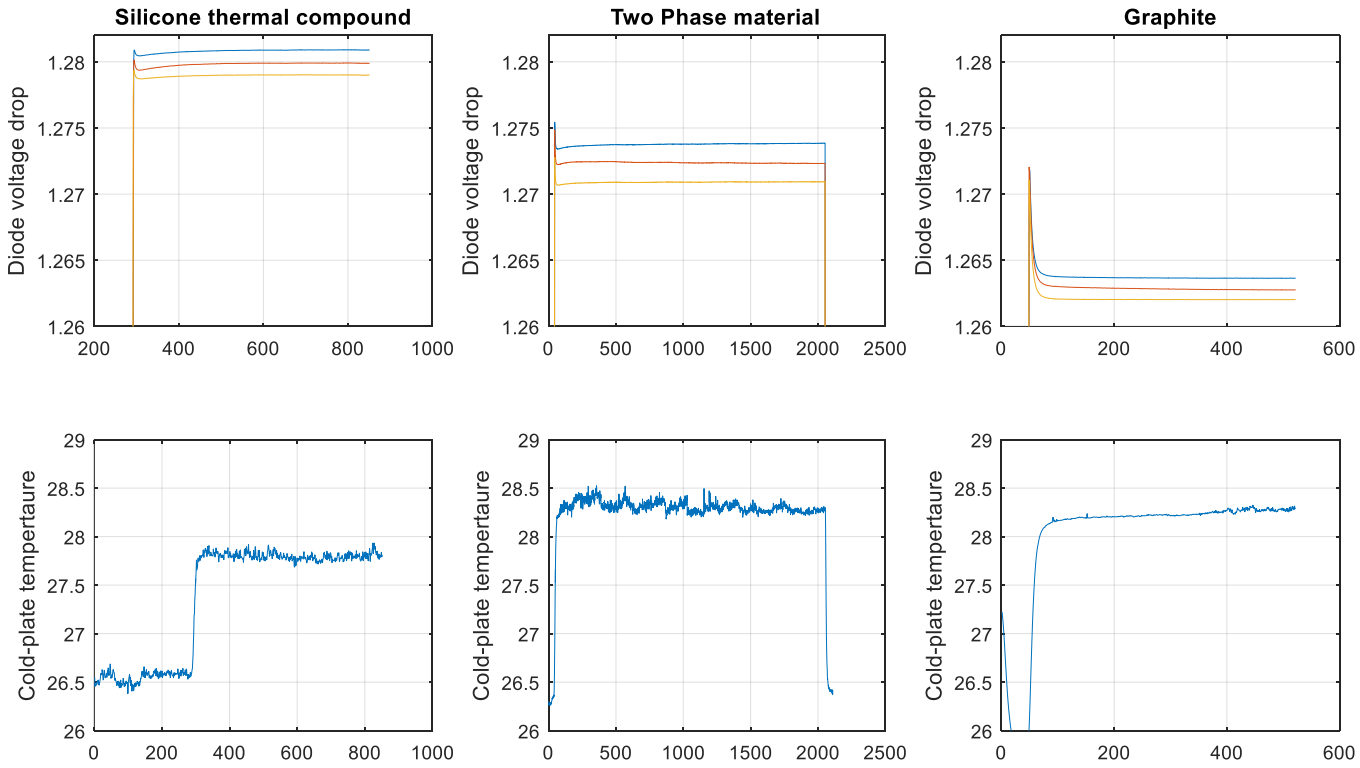
Tgon™ 800 Series
Electrically and Thermally Conductive Interface Pad

Use the diode to measure the temperature

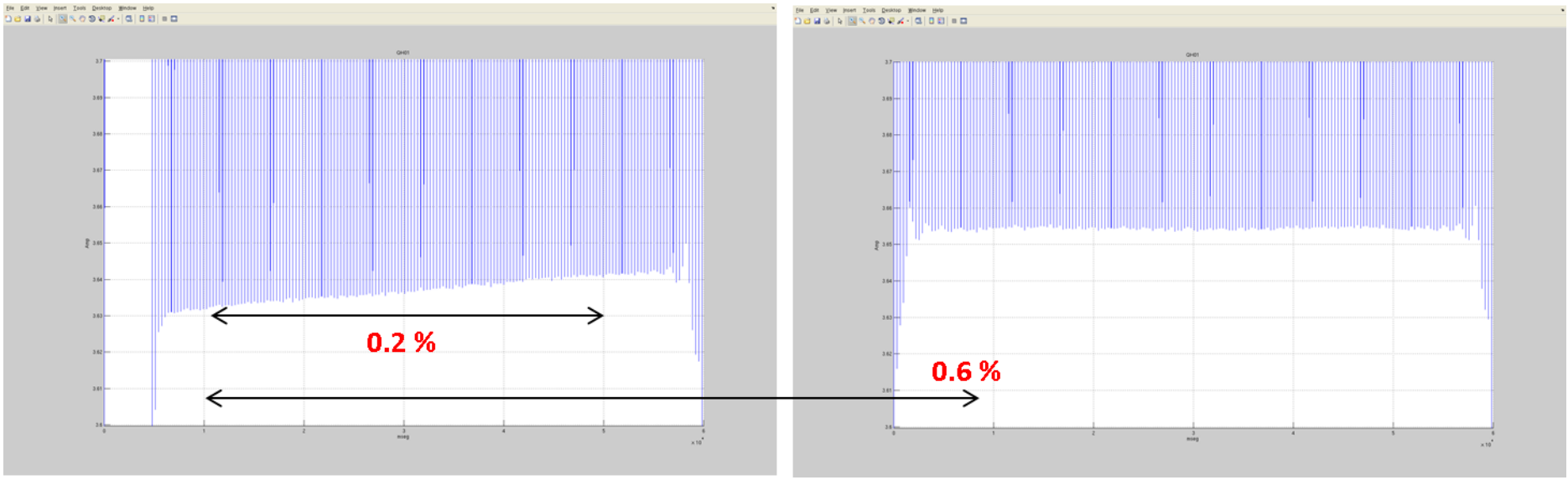


$$dV_D/dT \approx -2.1 \text{ mV/degree.}$$

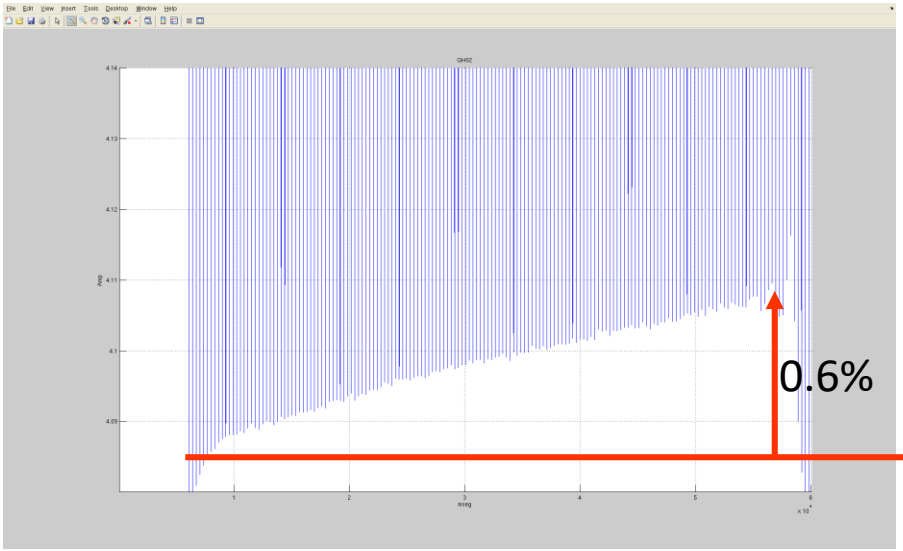
3 IGBT-Diode modules / 3 thermal compounds

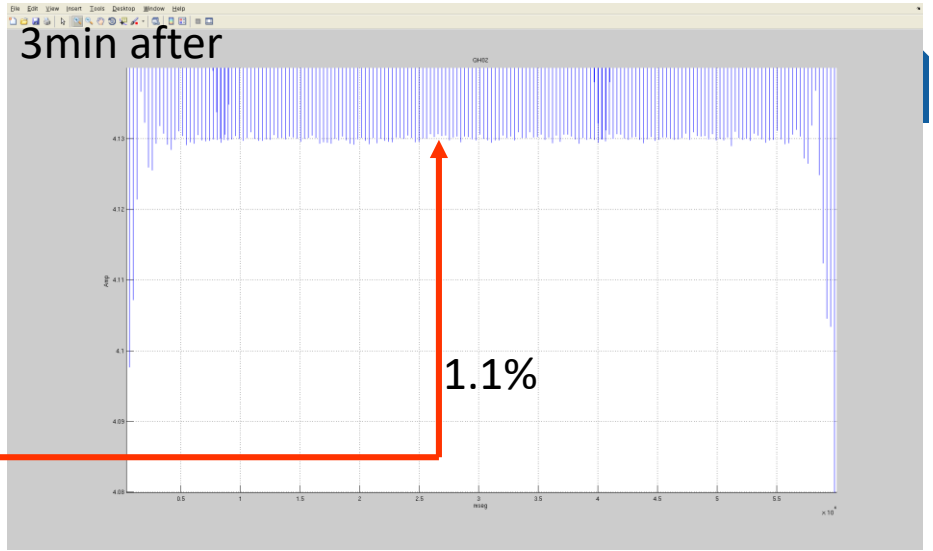


DC Warm-up.



Cause: change in load resistor value.

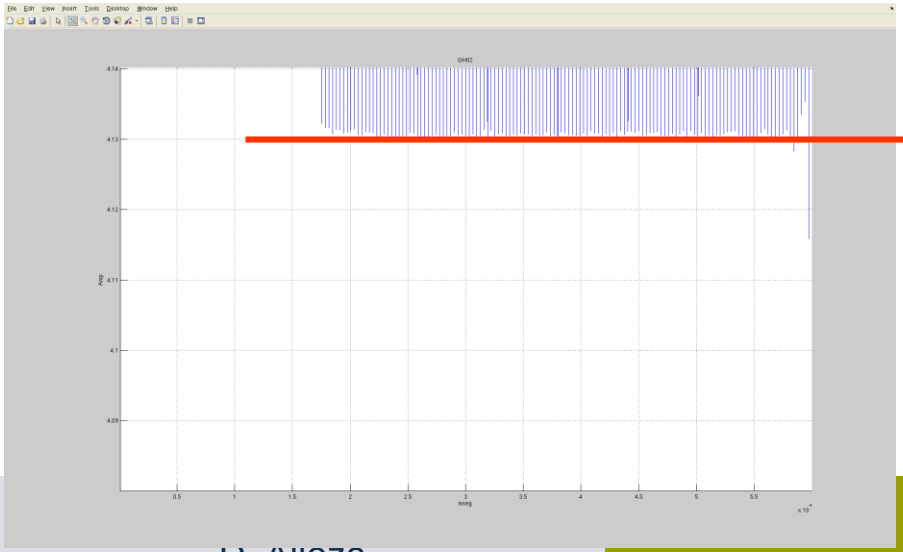




Start from 3.4A

QH02 Waveform from 3.4 A. to 123 A

Start from 77 A. (waveform RMS value)



2. Find a permanent solution

1) New design (Soleil approach)

Product Brief

PrimePACK™ with TRENCHSTOP™ IGBT5 .XT

The dawning of a new era

The tremendous success of PrimePACK™ since its introduction back in 2006 confirms that it's the optimal choice for the majority of high-power inverters. The series production of PrimePACK™ with the latest IGBT and joining technologies – TRENCHSTOP™ IGBT5 .XT – was recently started.

Increased power density

The new PrimePACK™ modules feature IGBT5 – our latest chip generation with a continuous operating temperature that is 25 K higher (T_{vjop} = 175°C). This allows higher power densities in 1200 V and 1700 V applications. The output power of the application can therefore be increased by 25% within the standard PrimePACK™ footprint.

Longer lifetime

PrimePACK™ has been developed with .XT joining technology to fulfill current and future lifetime requirements. This has been realized by sintering IGBT chips and diodes along with improved system soldering and replacing the aluminum bonds with copper bonds. Applications benefit from increased system availability due to a ten times longer lifetime of the PrimePACK™ module.

Design flexibility

System designers enjoy greater flexibility thanks to the integration of IGBT5 and .XT into PrimePACK™. By using the new PrimePACK™ with IGBT5, the output power in the application can either be increased by 25% or the lifetime can be increased tenfold with the same output current. Various tradeoffs between output power and lifetime are feasible. This new design flexibility means that the optimum fit for the majority of systems can be realized.

With years of experience under our belt, a steady stream of innovations and the latest optimized chip generations, we always provide the optimal solution for demanding applications such as wind and solar power, industrial drives traction and commercial vehicles.

Key features

- Static and dynamic losses reduced by up to 20%
- Power cycling capabilities increased by a factor of 10
- Continuous operating temperature of T_{vjop} = 175°C

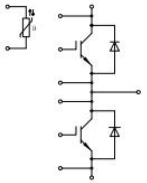
Benefits

- Power density increase of 25% or a 10 times longer lifetime
- Reduced cooling effort for same output power
- Reduction of overall system costs

FF1800R12IE5P

PrimePACK™3+ Modul mit Trench/Feldstopp IGBT5, Emitter Controlled 5 Diode und bereits aufgetragenem Thermal Interface Material

PrimePACK™3+ module with Trench/Fieldstop IGBT5, Emitter Controlled 5 diode and pre-applied Thermal Interface Material



V_{CES} = 1200V

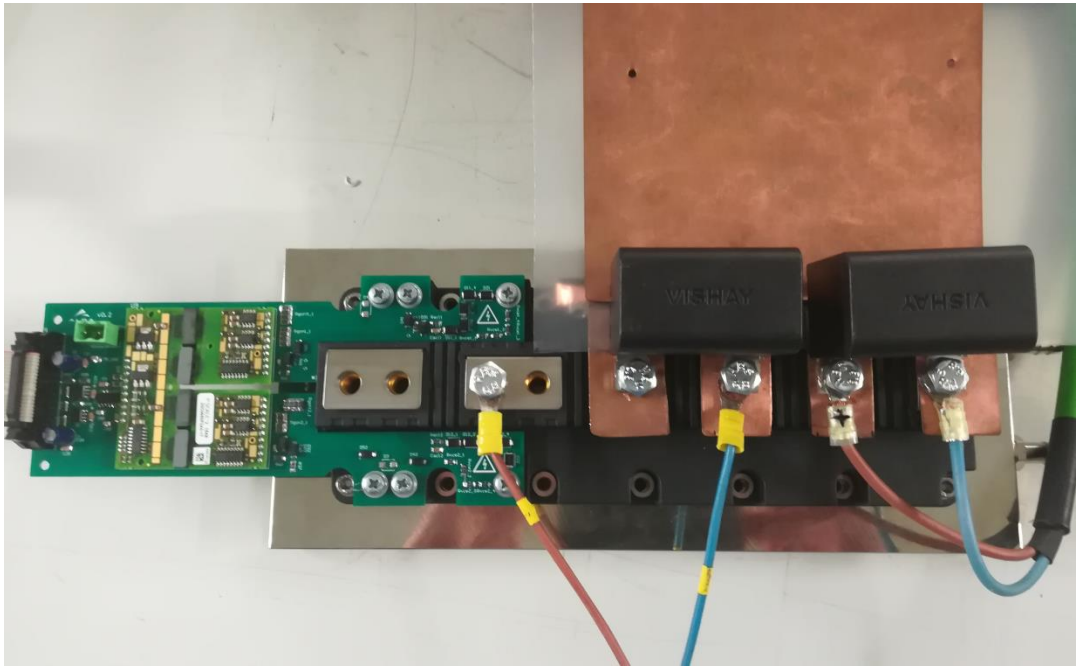
$I_{C\ nom}$ = 1800A / I_{CRM} = 3600A

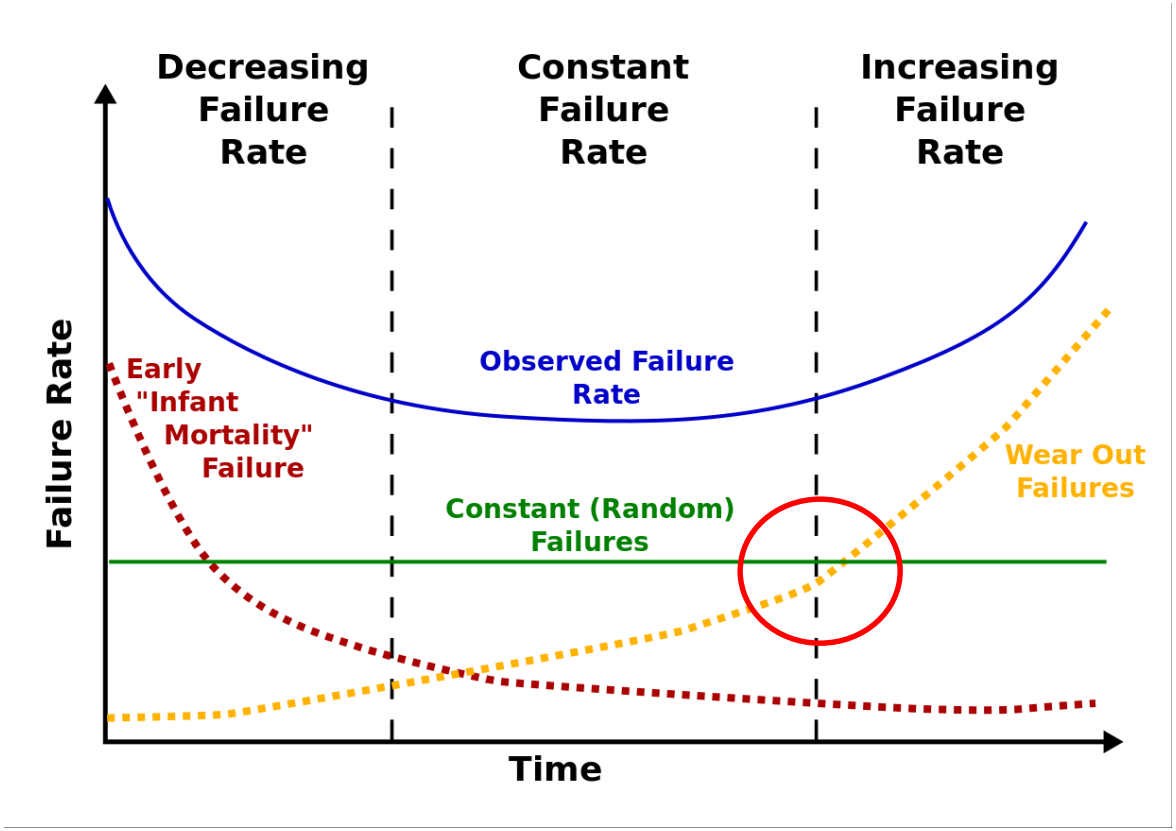
Driver Prototype using commercial driver core

Status: First tests

Designing mechanical parts

(power busbar and supports)

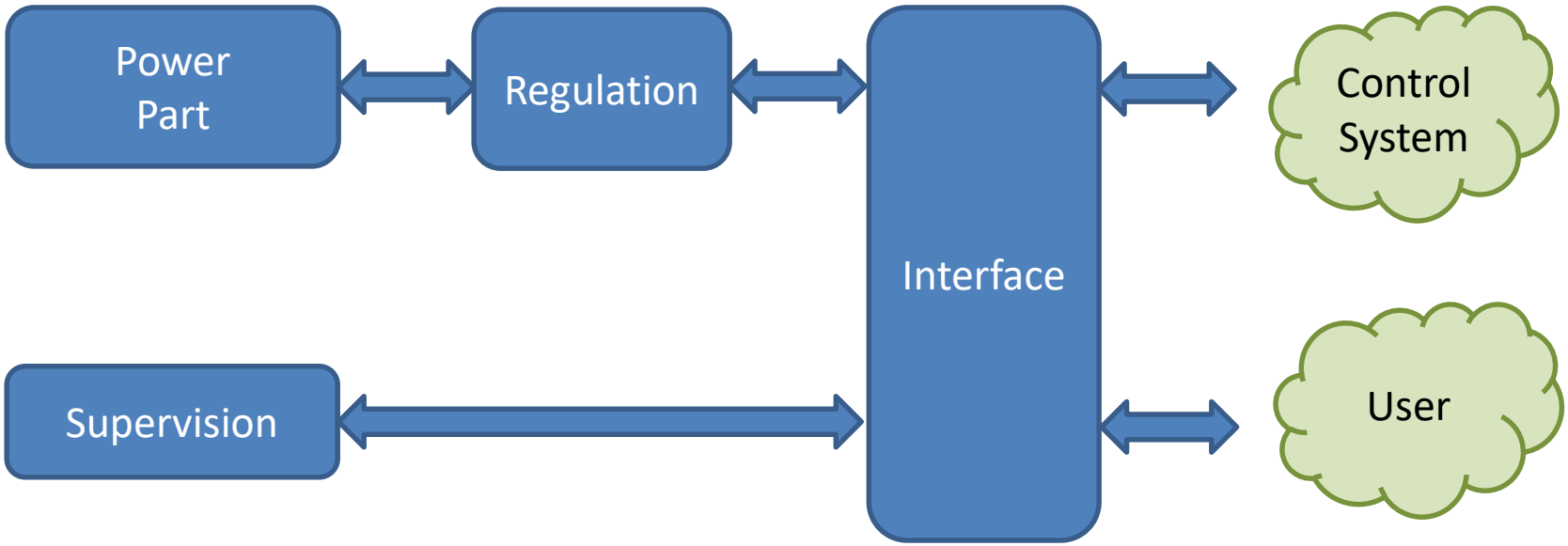




wikipedia

- How to detect this point?
- How to be prepared for this point?

Power Supply Block Diagram



Today's Situation

	Power Part	Regulation	Supervision	Interface
Main SR PS DC 600A 750V	Custom			
Main Booster PS ramping 750A 1000V	Custom			
SR QUAD DC 250A 30V	Custom			
DC Correctors DC 20A 20V	Custom			
Fast Correctors High BW 20A 100V	Custom			

Ideal Situation

	Power Part	Regulation	Supervision	Interface
Main SR PS DC 600A 750V	Custom	Custom	COTS (PLC)	COTS
Main Booster PS ramping 750A 1000V	Custom	Custom	COTS (PLC)	COTS
SR QUAD DC 250A 30V	COTS	Custom	COTS (PLC?)	COTS
DC Correctors DC 20A 20V	COTS	Custom	?	COTS
Fast Correctors High BW 20A 100V	Custom?	Custom	?	Custom?

Thank you

Questions

Suggestions?

Today's Solutions are Tomorrow's Problems

Yesterday's Solutions:

- Transfer the risk of a new design to an external company
- Low Manpower needed, only to follow up the companies
- Low delivery time.

Today's Problems

- Risk of out of business of a manufacturer.
- Companies may change their business.
- The complete know how is in the manufacturer.
- Design errors that appear after long term in operation. Not cover by warranties.

Electronics Section Functions

–Control Hardware (cPCI, DIO cards, NIM...)
–**Accelerator Power Supplies**
–Instrumentation support (ADCs, DACs, Counters, V2F,...)
–Motion control (ICEPAP project)
–Timing System
–Centralized Hardware Documentation Repository (CableDB)
–Hardware installation
–Electronics design projects

Electronics Section

- Composed by
  - 8 electronics engineers
  - 6 electronics technicians

Problem Solving Approaches:

1) First step. More spare modules are needed in order to reduce the risks.

Further steps:

Under evaluation.

refurbish the 2Q modules:

over-dimension IGBT

SiC modules

2) We must have a control/regulation boards with a complete access (documentation, firmware, etc)