



 **Strukton**  
Rail



# Strukton Rail - Traction drives

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23 juni 2015

Power Quality Monitoring  
Power Conversion  
Power Applications  
Power Research

**VERMOGENS**  
**ELEKTRONICA** 2015

23-06-15 - 1931 Congressentrum Den Bosch

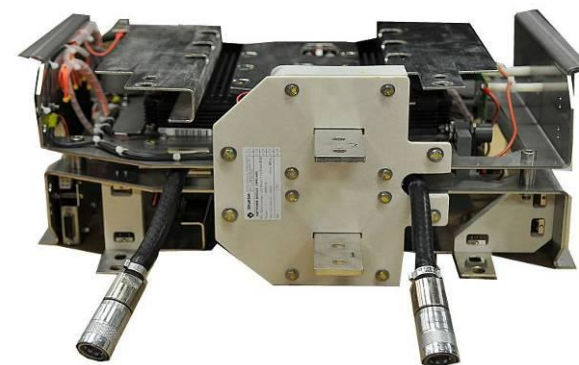
- Standardized IGBT technology, modular construction
- Powerful diagnostics
- Compact & flexible
- Critical components specified to have  $\geq 2$  suppliers where possible
- Air & liquid cooling
- AC-inverter, DC-chopper, Line converter
- Power supply: 600 Vdc - 3 kVdc ; all AC catenary voltages
- Power Range 100 kW – 5 MW



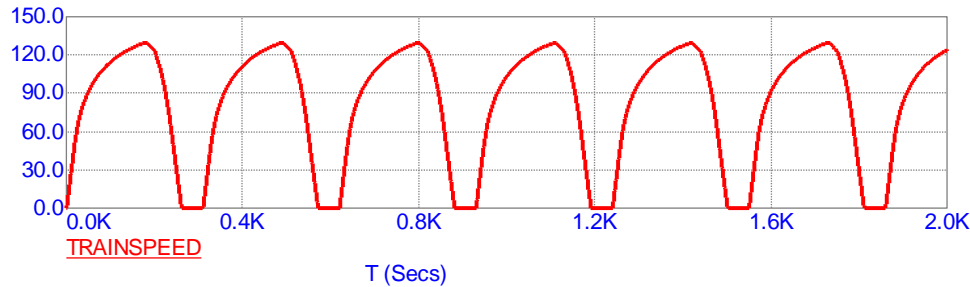
**Natural air-cooled traction module**



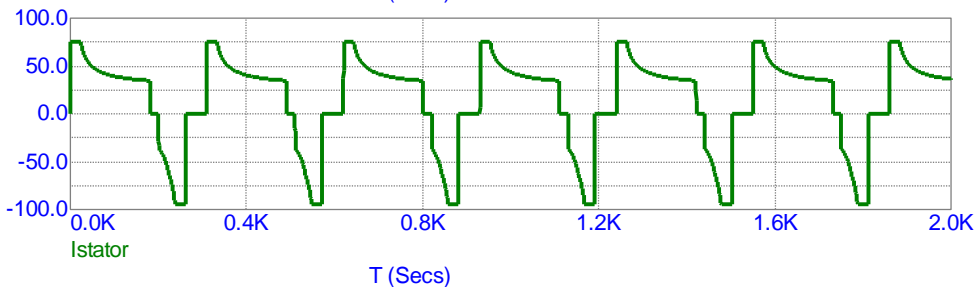
**forced air-cooled traction module**



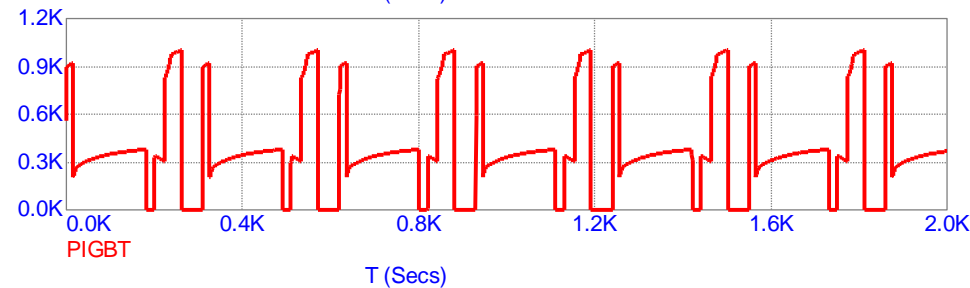
**water cooled traction module**



**Train model =>**  
input: acceleration, cycle time  
output: speed, torque

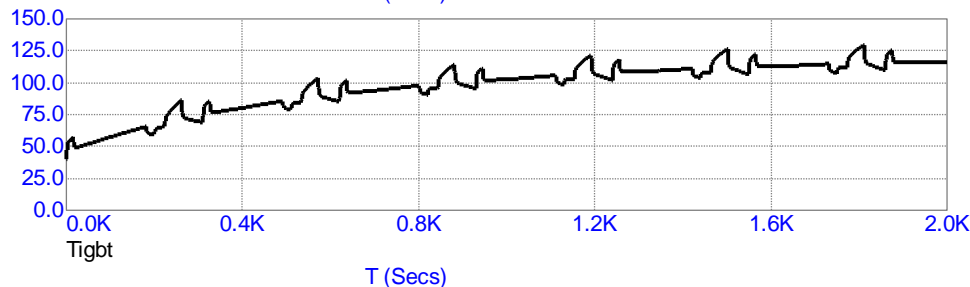


**Motor model =>**  
input: torque  
output: current



**Semiconductor model =>**  
input: current  
output: power loss

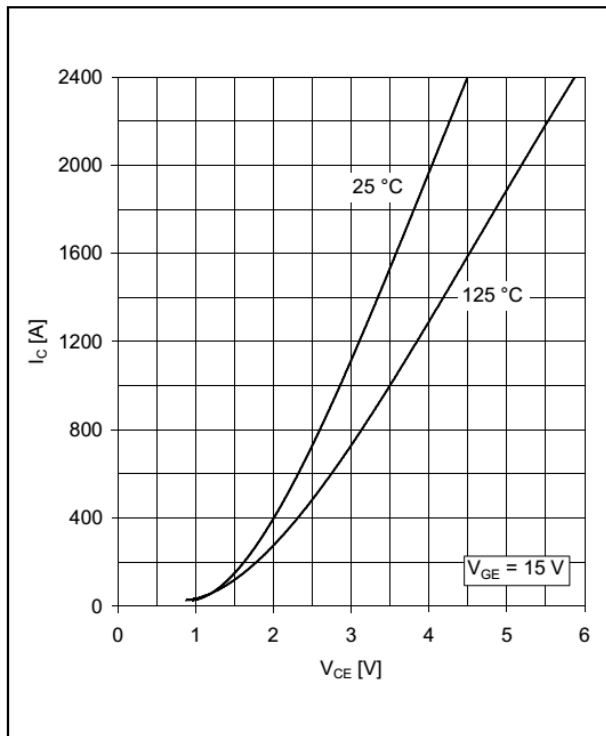
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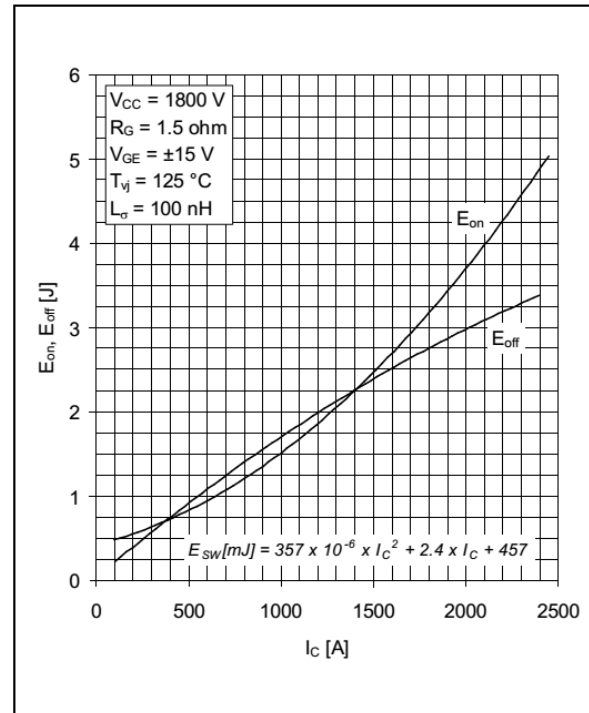
**Heat sink model =>**  
input: power loss  
output: junction temperature

?

## IGBT losses: on state, switching



**Fig. 1** Typical on-state characteristics, chip level

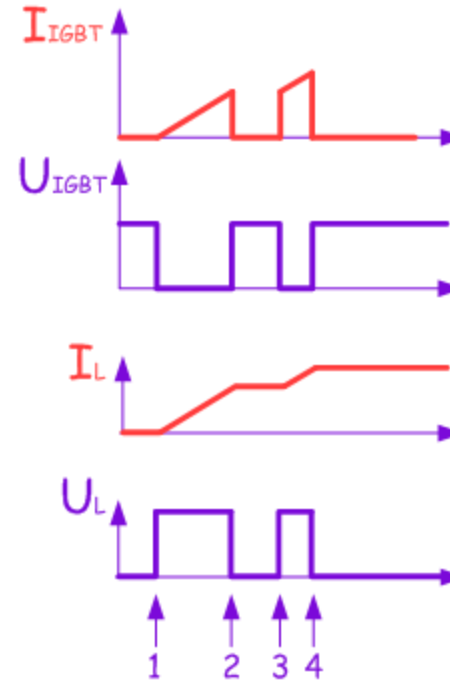
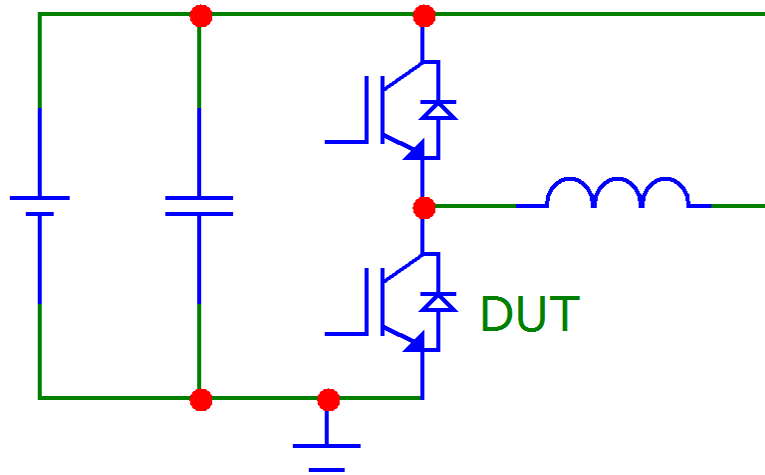


**Fig. 5** Typical switching energies per pulse vs collector current



**Driver conditions differ:  
Tests with own driver required**

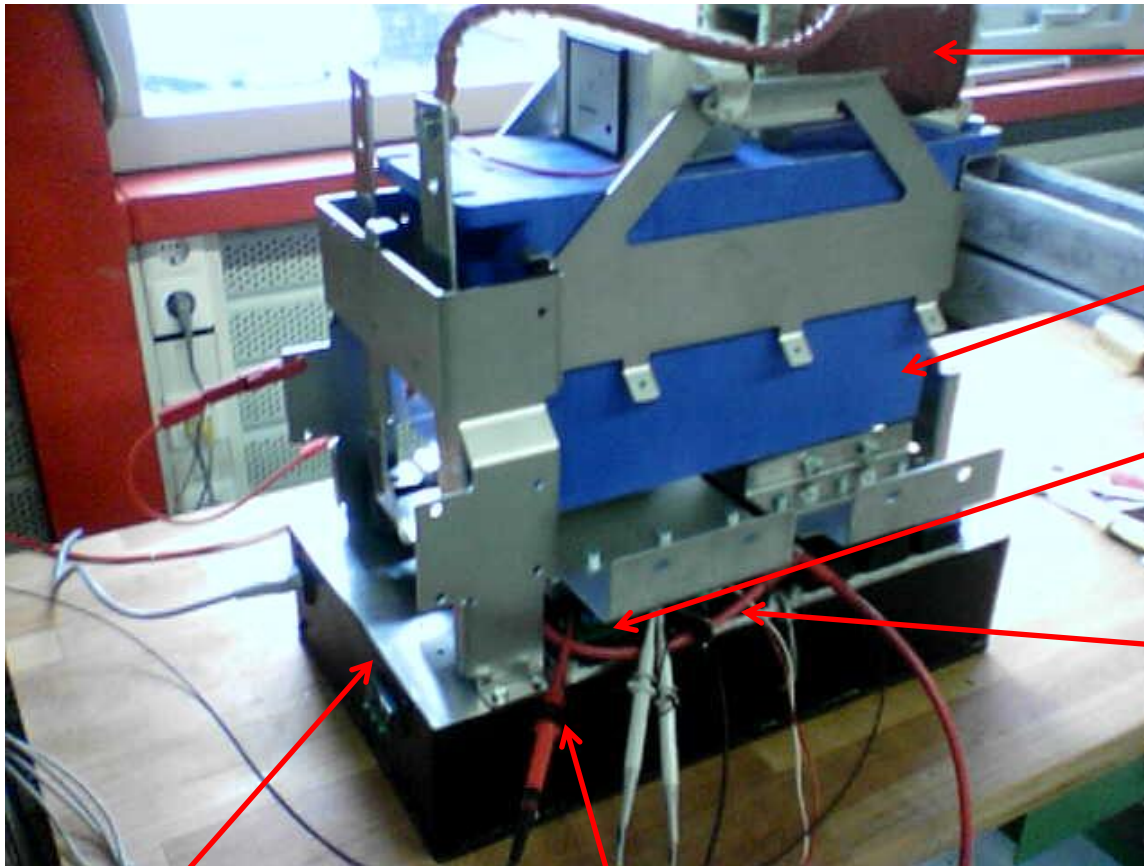
## Test circuit



**2: turn-off**

**3: turn-on**





**Inductor**

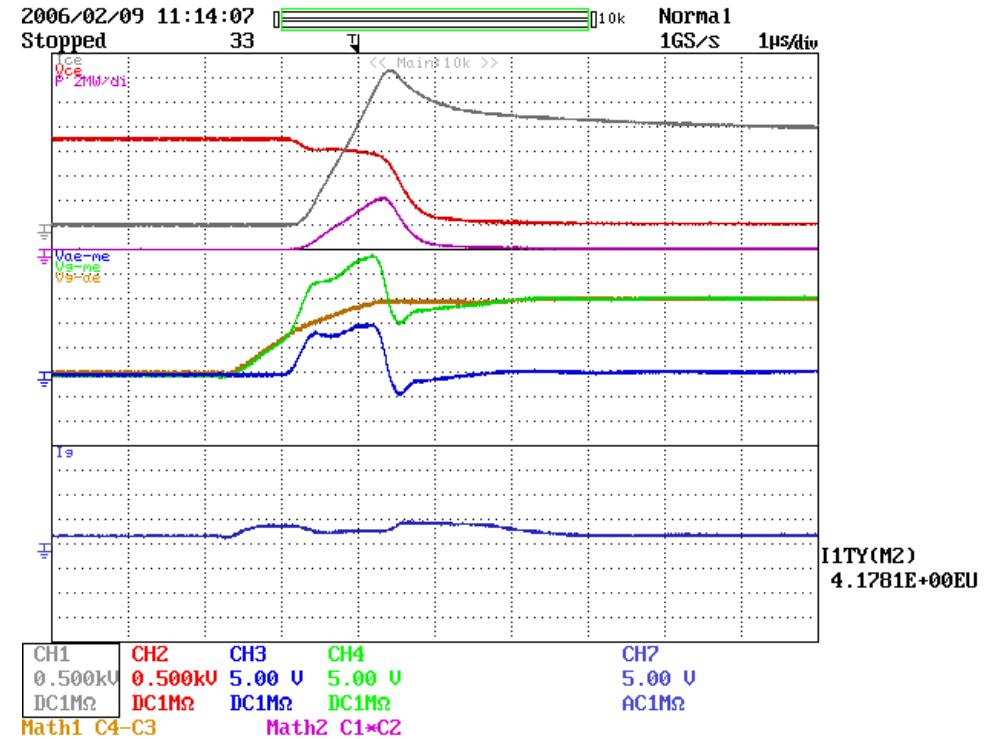
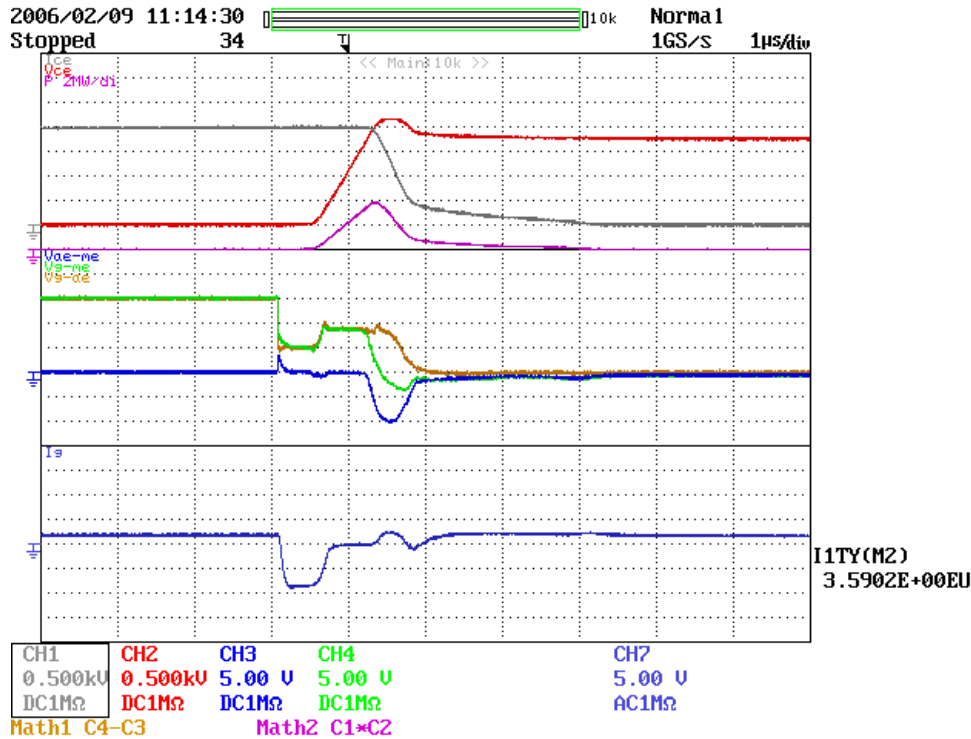
**Capacitor**

**IGBT**

**Rogowski coil**

**Heating plate**

**Voltage probe**



2kA, 1750V @125°C

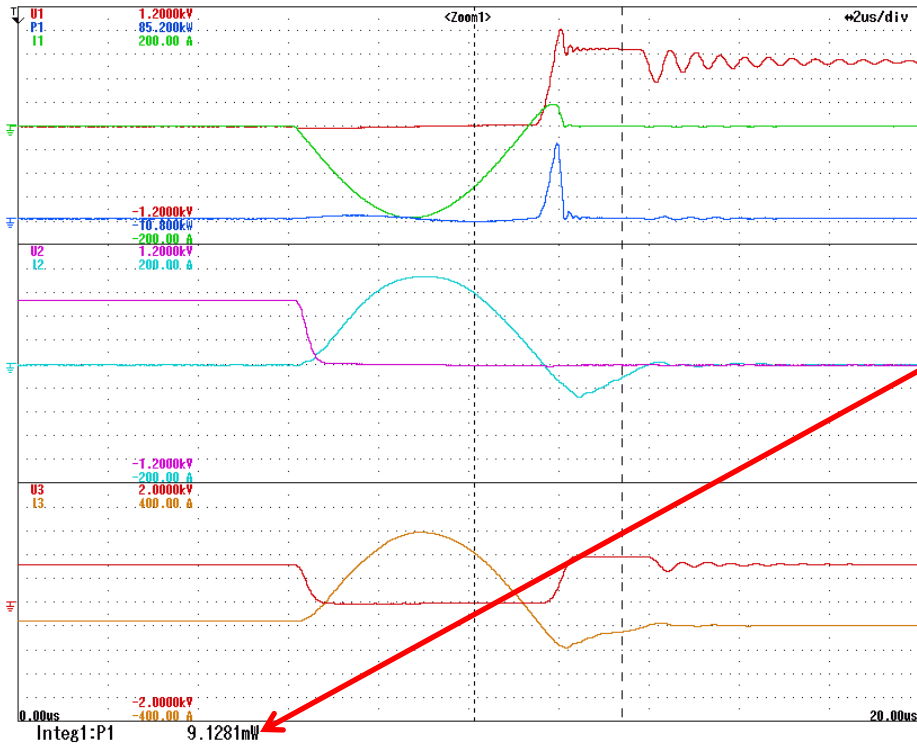
P1 : 600V, E 10V  
Position : -4.00 div

RangeStatus: CH1 CH3 CH5 CH7  
CH2 CH4 CH6 CH8

Scaling : On  
Averaging : Off  
LineFilter : On  
FreqFilter : Off

Zoom1: 1.0k Main: 5.0M

AcqMode : Normal  
50MS/s 10ms/div



- Element 1  
U1 600V  
I1 E 10V  
Scale Sync Src: U4
- Element 2  
U2 600V  
I2 100mA  
Scale Sync Src: U4
- Element 3  
U3 1000V  
I3 200mA  
Scale Sync Src: I2
- Element 4  
U4 15V  
I4 20mA  
Scale Sync Src: U4

Harmonics Status  
PLL: U4 5.0518 kHz

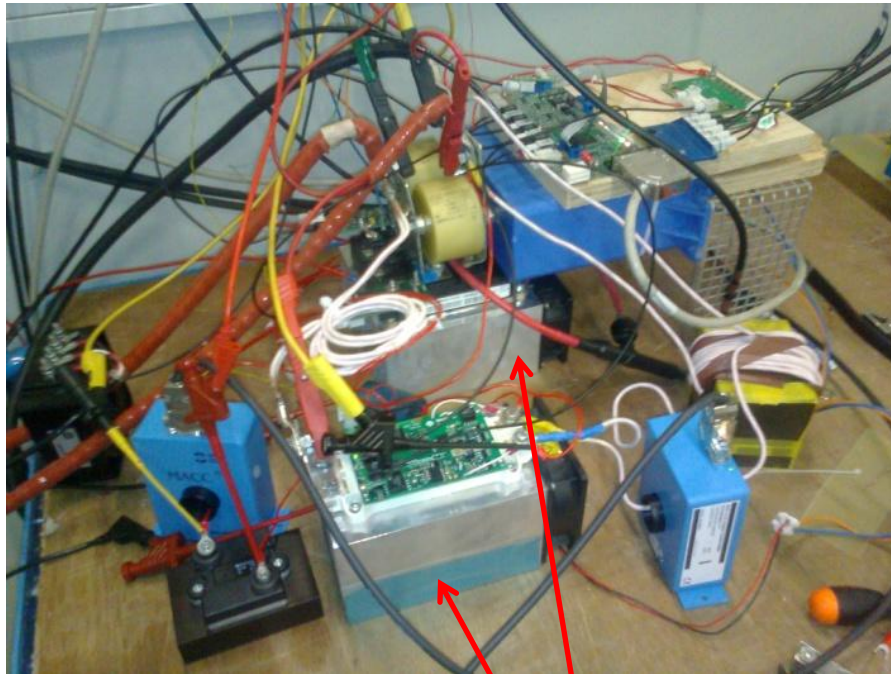
**Very low recovery loss: 9mJ**

Stopped 19 2015/03/25 15:32:01.811617 Edge U4 8.0000 V

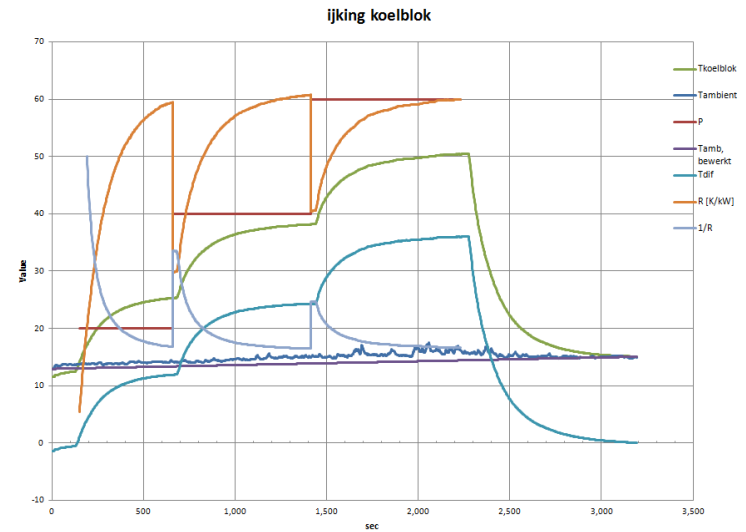
PrintTo 2015/03/25 15:42:48







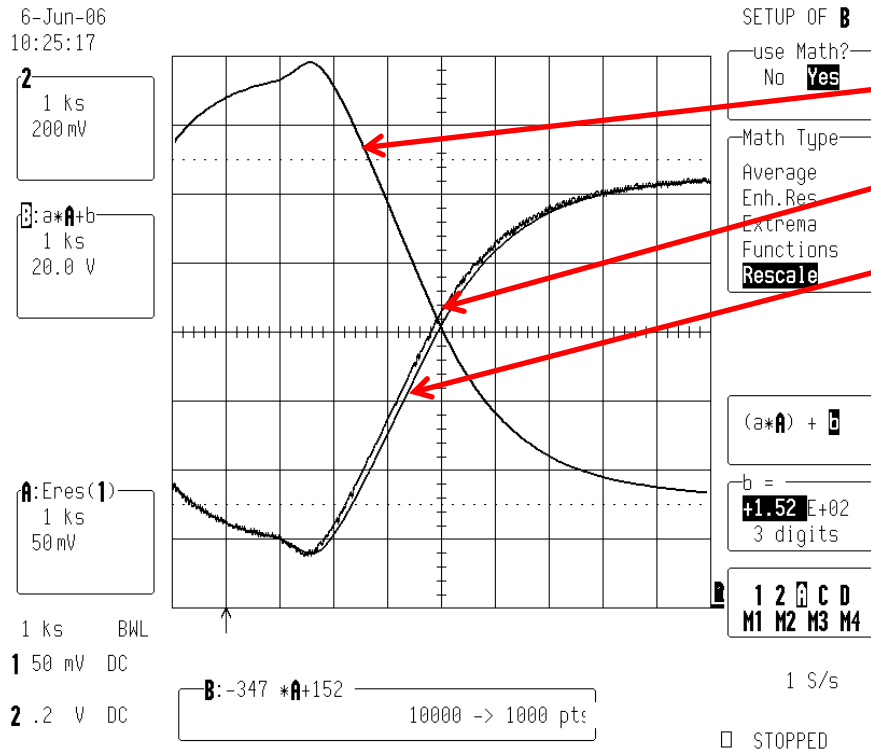
**IGBTs on separate heat sinks**



**Calibrate heat sink: use dc current**

P[W]	200		400		600	
	R [K/kW]	1/R [W/K]	R	1/R	R	1/R
1 min	25,6	39	38,4	26	46,5	21,5
2 min	39	25,7	46	21,6	51	19,6
5 min	54,5	18,3	56	17,8	57	17,5
10min			60	16,6	59,2	16,9

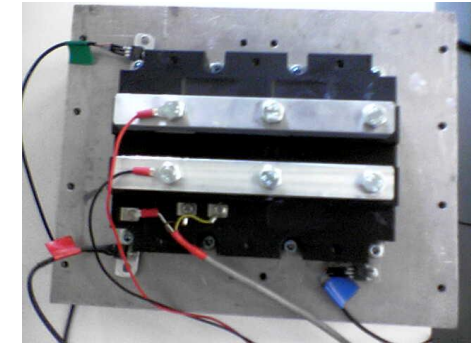
## Calibrating IGBT: on state voltage @ 100mA is temperature dependant



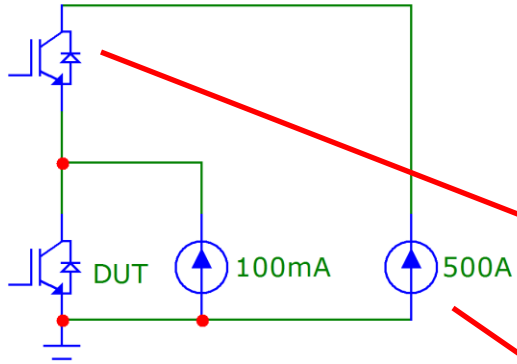
**A: Uce [50mV/div]**

**2: T sensor [20°C/div]**

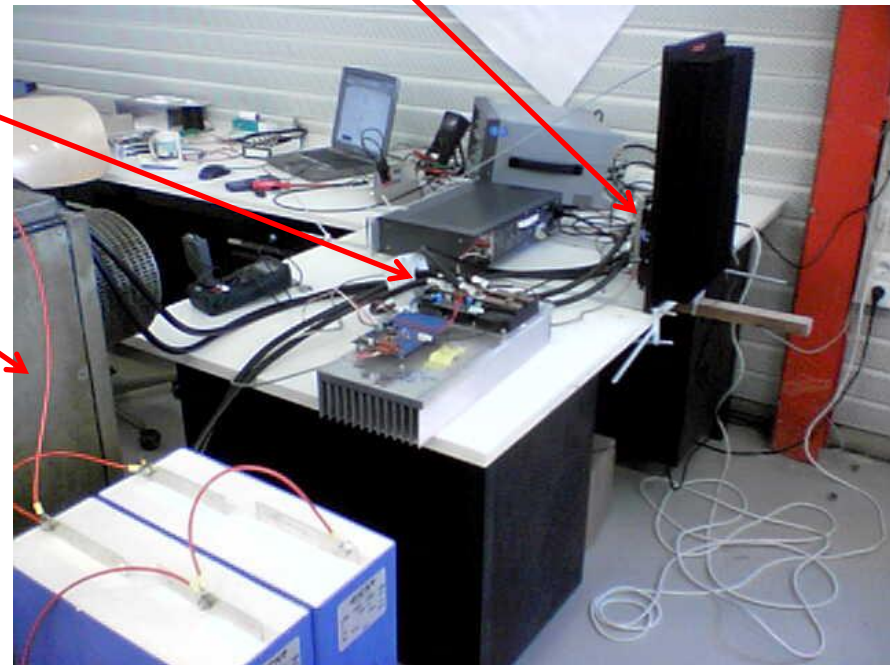
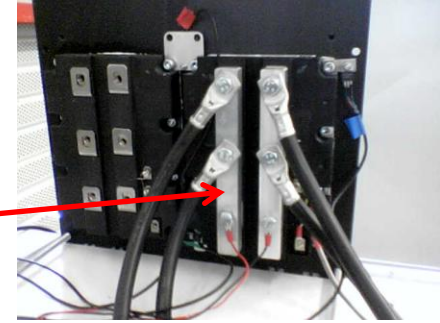
**B: Tjunction [20°C/div]**

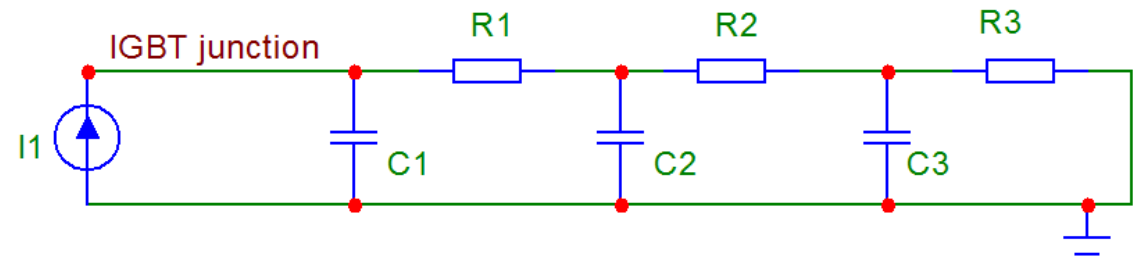
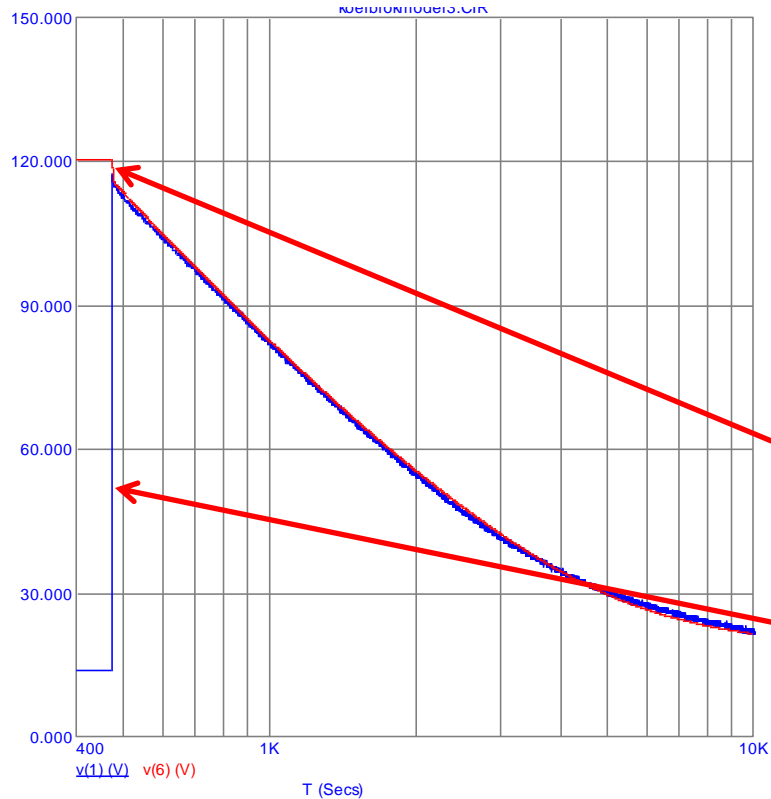


**Climate chamber**



DUT





```
.DEFINE R1 8.5m .DEFINE C1 50
.DEFINE R2 7.5m .DEFINE C2 275
.DEFINE R3 2.5m .DEFINE C3 2500
```

**simulation**

**measurement**



Vragen?

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