

# Smart Battery Switch (SBS) First Steps

Hardware Version 3

ATV SYS SE

Rev 2

25.08.2015



# SBS First Steps

## Product Safety Warnings



- › The Smart Battery Switch (SBS) is only intended to be used as an engineering demonstrator. It is not intended for extensive use or to be re-used in a product or system that is sold to consumers.
- › Battery Clamp is compliant to IEC 60095-2\_Ed.4 (2009)
- › The SBS is intended to be used by electrical engineers who are experts in the field of high current design. If you are not qualified, seek the help of an expert before using the demonstrator.
- › Questions about the SBS should be directed to Infineon Application Engineering.
- › The cable, cable lug, washer and nut used to connect to the bolt mounted onto the SBS demonstrator's circuit board must all be made of high current-capable metals which will not experience a significant temperature rise while conducting the current.
- › The cable lug must be mounted directly to the bolt. (torque 6Nm +-1Nm)
- › Keep the current below 1800A. The time a current may be applied is limited by the temperature rise.
- › Don't exceed 1 Joule of switching energy.
- › Switching to high currents or to high switch off energy may destroy the switch and the test setup and end up in fire.

# SBS First Steps Contents

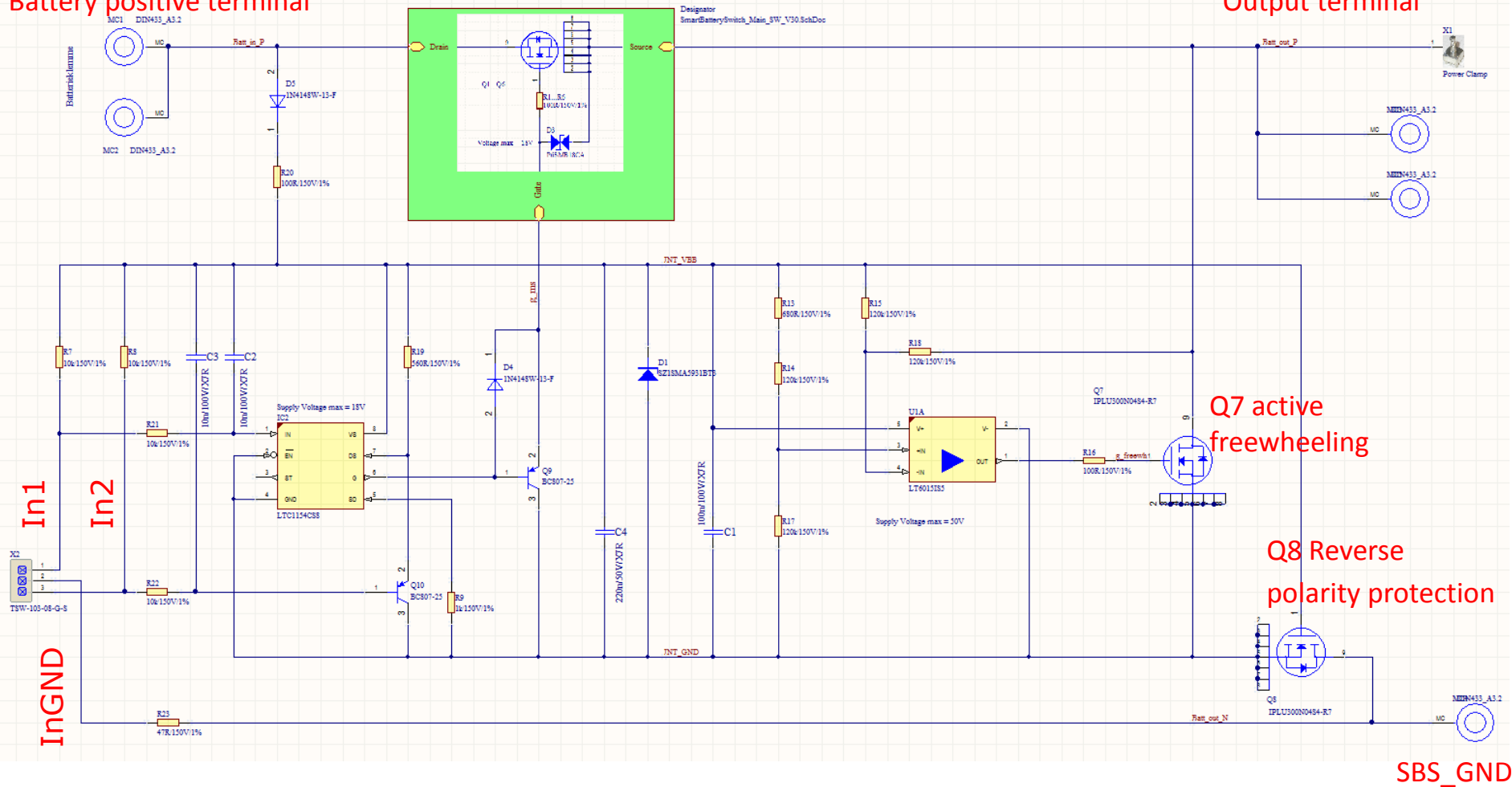
- › Schematic
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# SBS First Steps Schematic

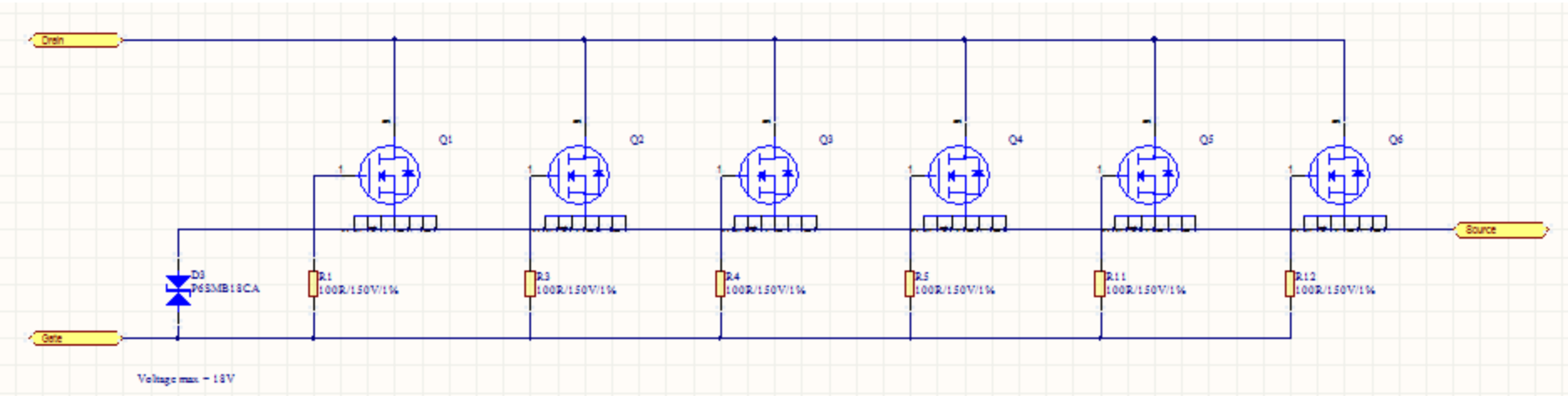
Battery positive terminal

Output terminal



# SBS First Steps Schematic

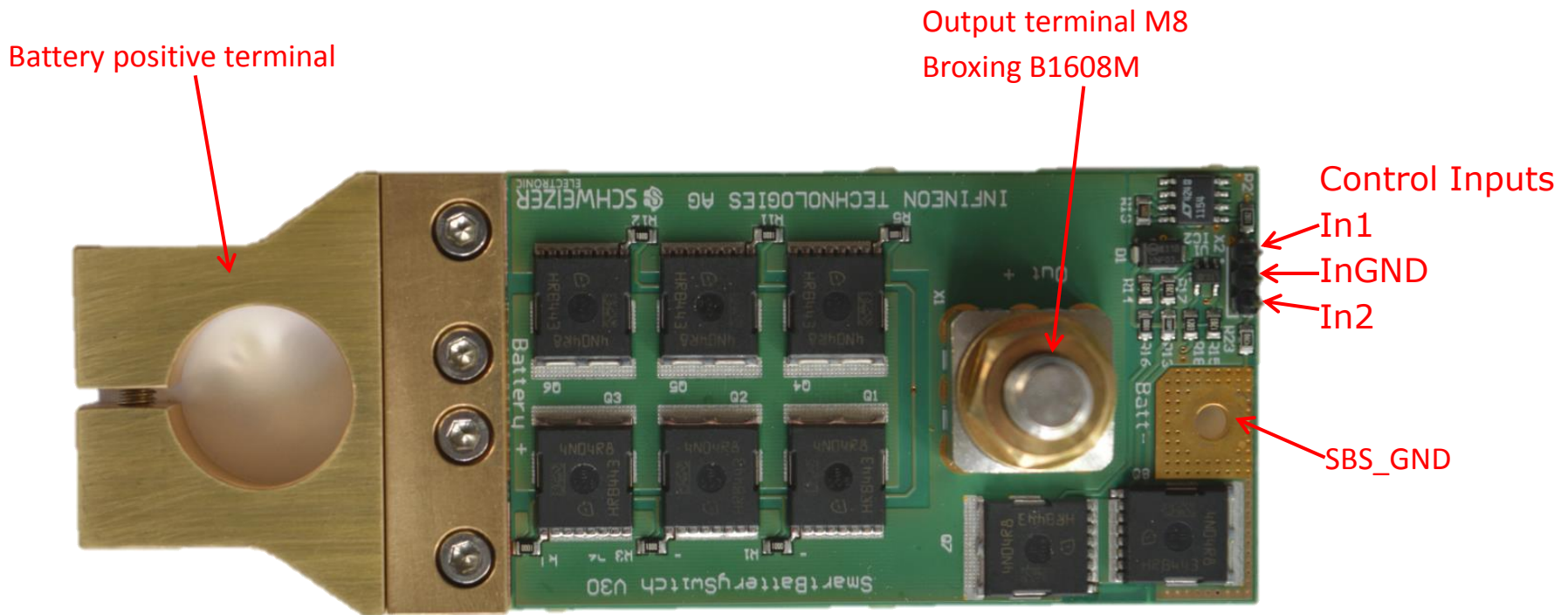
Q1...Q6 parallel connection




D3 Gate protection (18V)

# SBS First Steps


## How to connect the SBS



In1	In2	Switch
NC	NC	on
L	NC	off
NC	L	off (latched)
	NC	reset latched

NC = not connected

L = connected to InGND

 = pull down In2 to InGND and release again

# SBS First Steps

## Test 1: Switch on/off and latch

### Test setup:

$V_{\text{Batt}} = 12\text{V}$  (current limitation 100mA)

$R_L = 1\text{k}$

### Verify the switch on status of the SBS:

In1 and In2 are not connected (NC)

SBS (Q1...Q6) is on

measure  $V_{\text{DS}}$  of Q1...Q6 (check if  $< 2\text{ mV}$ )

measure  $V_{\text{GS}}$  of Q1...Q6 (check if  $> 16\text{ V}$ )

measure the Leakage Current  $I_{\text{GND}}$  (check if between  $400\mu\text{A}$  and  $600\mu\text{A}$ )

### Verify the switch off status of the SBS:

In1 is connected to InGND

SBS (Q1...Q6) is off

measure  $V_{\text{GS}}$  of Q1...Q6 (check if  $< 50\text{ mV}$ )

check if  $V_{\text{DS}}$  of Q1...Q6 is around  $V_{\text{Batt}}$

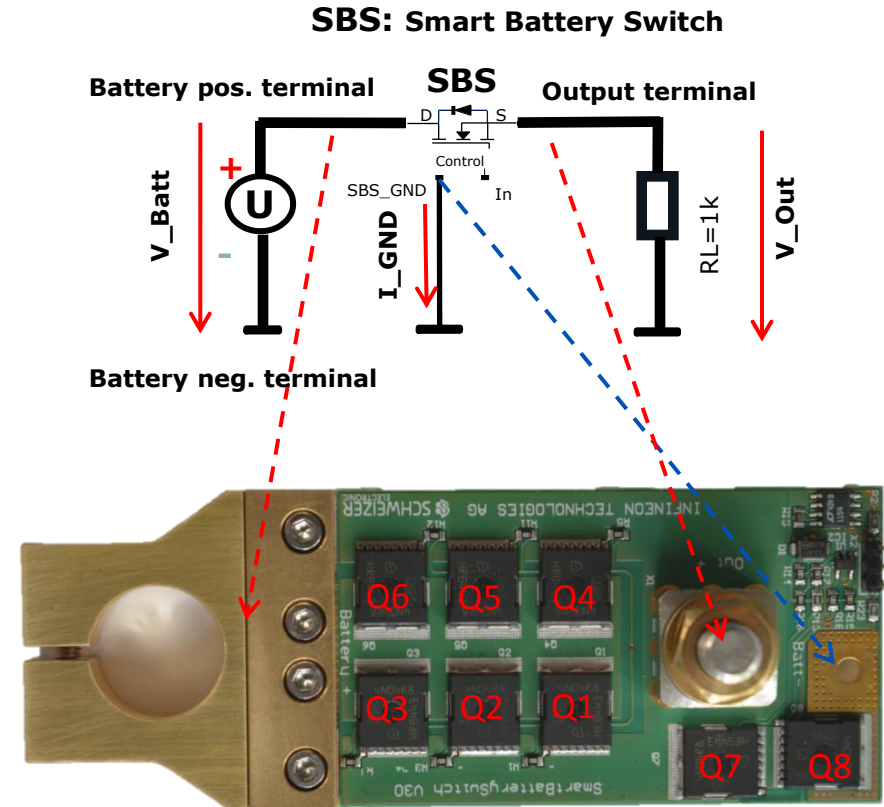
### Verify the latch function of the SBS:

Pull down In2 to InGND and release again

check off status of SBS

To reset the latch pull In2 to InGND and release again

check on status of SBS



# SBS First Steps

## Test 2: Wrong polarity protection

### Test setup:

$V_{\text{Batt}} = 12\text{V}$  (current limitation 100mA)

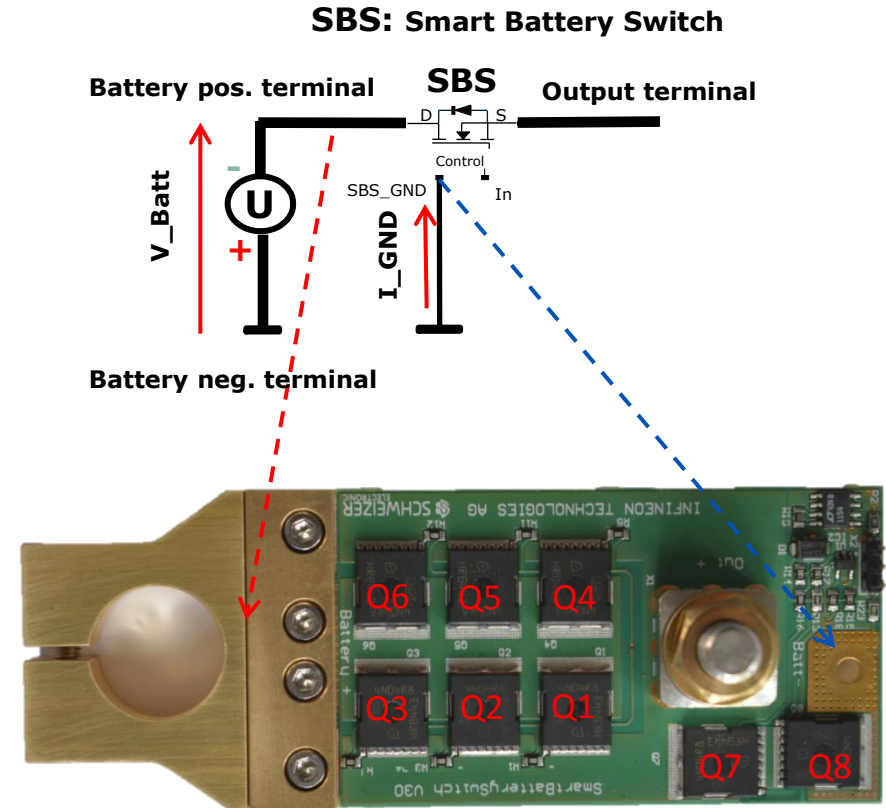
In1 and In2 are not connected

Output terminal is not connected

### Verify the wrong polarity capability:

Q8 is switched off

measure the GND current ( $I_{\text{GND}}$ ) (check if  $< 10\mu\text{A}$ )





# SBS First Steps

## Test 3: Active freewheeling (static)

### Test setup:

$V_{\text{Batt}} = 12\text{V}$  (current limitation 100mA)

$V_{\text{aft}} = 12\text{V}$  (current limitation 100mA)

$R_L = 1\text{k}$

In1 and InGND are linked with a jumper

In2 are not connected

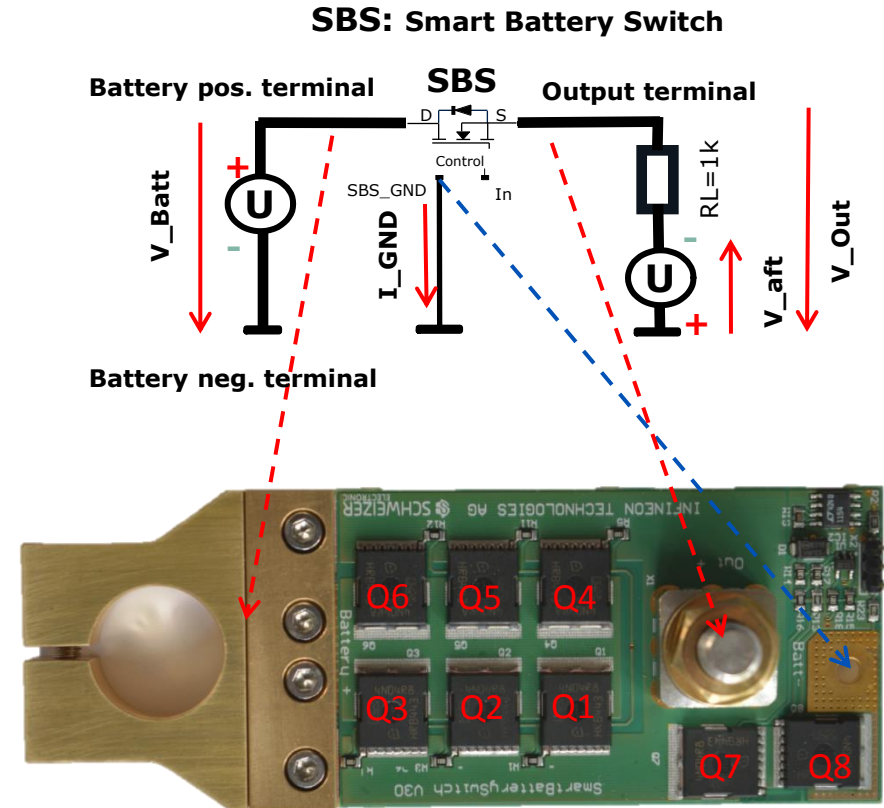
### Verify the active freewheeling capability:

SBS is switched off

Q7 is switched on

measure VGS of Q7 (check if between 3,6 V – 3,95 V)

measure  $V_{\text{Out}}$  (check if  $< 10\text{mV}$ )  $V_{\text{Out}}$  is negative to GND!



# SBS First Steps

## Test 4: Static high current

### Test setup:

$V_{Batt} = 12V$  (current limitation 100mA)

$I_{out} = 250A$  (voltage limitation 2V)

In1 and In2 are not connected

**All the components used in the high-current path should be properly selected.**

Cables 50qmm / no washers between cable shoe and terminal etc.

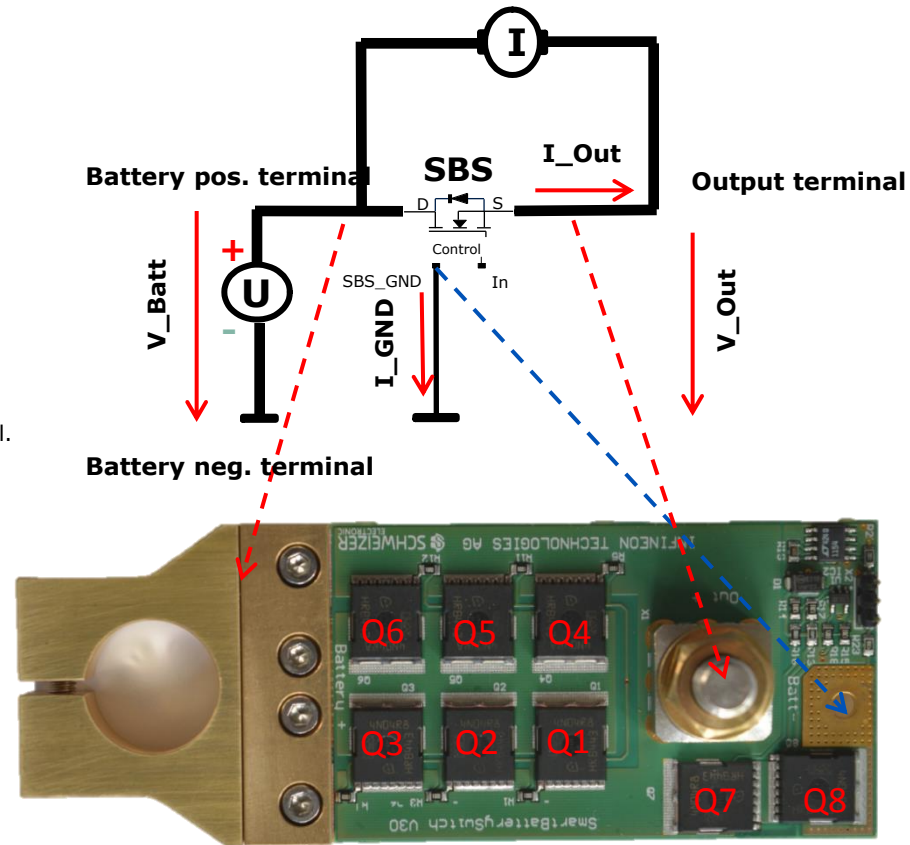
### Verify the high current capability:

SBS is switched on

measure the voltage between the battery positive terminal and the output terminal.  
(check if < 30mV)



### SBS: Smart Battery Switch

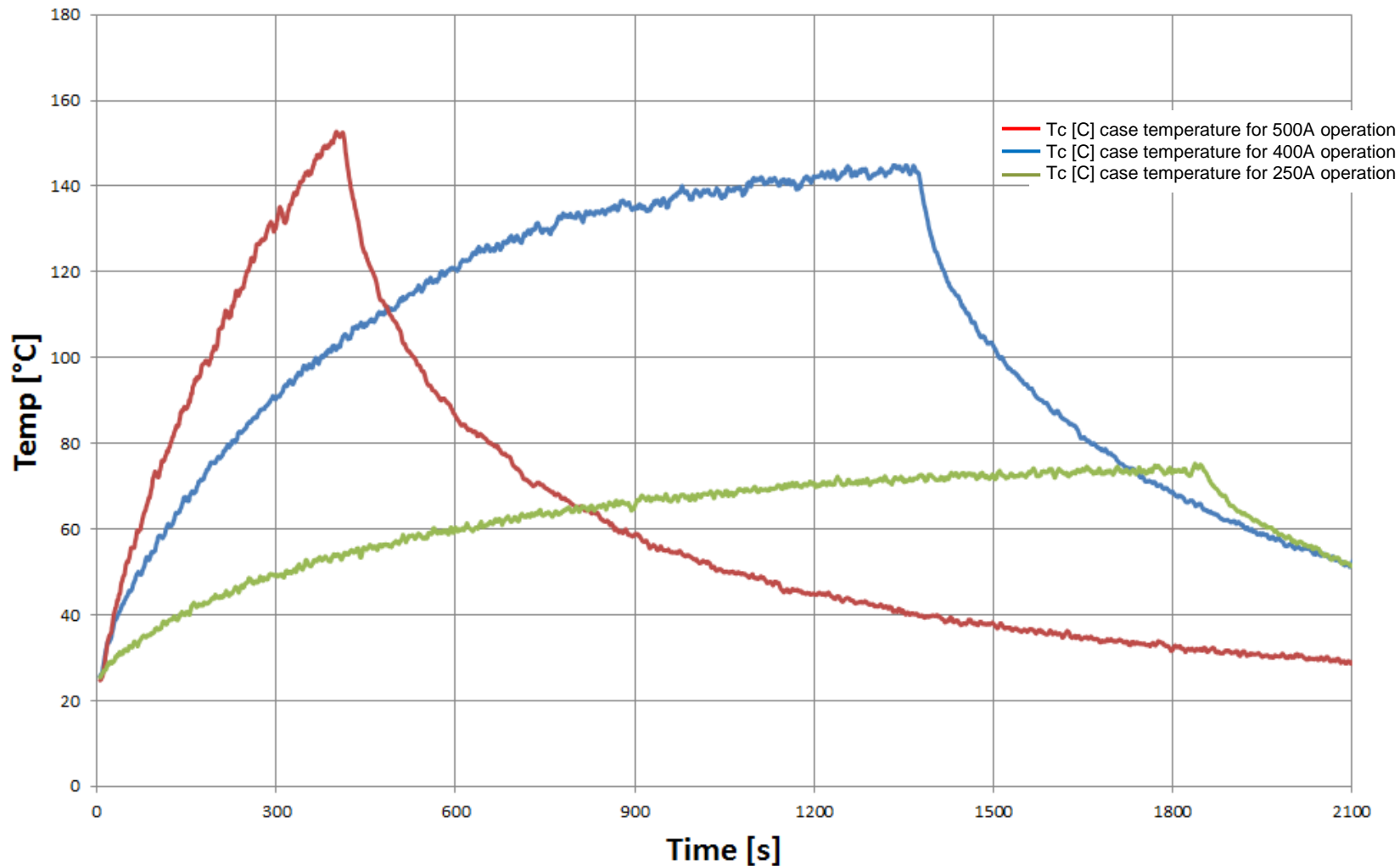


Thermal Image after 10 minutes and 250A of output current

# SBS First Steps

## Test 4: Static high current

Device case temperature variation according to load-current



# SBS First Steps

## Test 5: Switching high current

### Test setup:

V\_Batt = AGM Battery 105Ah charged to 13V

Load = cable 25qmm; length 4.5m windings 3.5; diameter 30cm; 7uH

SC switch = fast potential free switch to simulate a short circuit (controlled by P2)

T1 is with an opt coupler and connected to In2 of the SBS (controlled by P1)

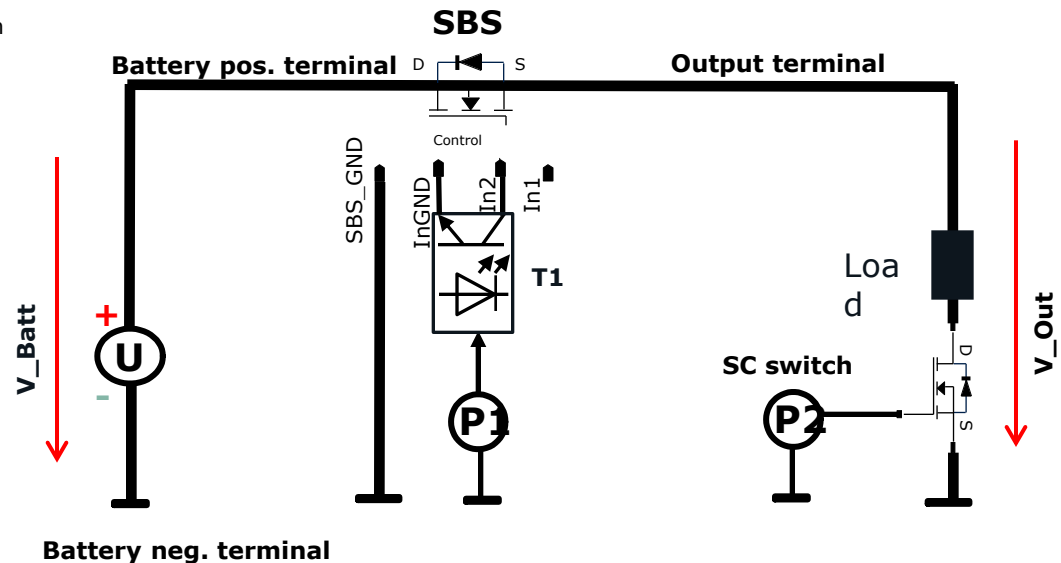
P1/P2 Pulse generator synchronised outputs 1 and 2

To reset the latch of SBS use In1

**All parts inside the high current path should be appropriate for the current!**

### Verify the high current switching capability:

1. Switch on SBS by resetting the latch and wait until the SBS is fully on
2. Apply a load or "short circuit" by switching on the SC switch
3. Wait until you reach the expected current
4. Switch off the SBS by applying low to In2

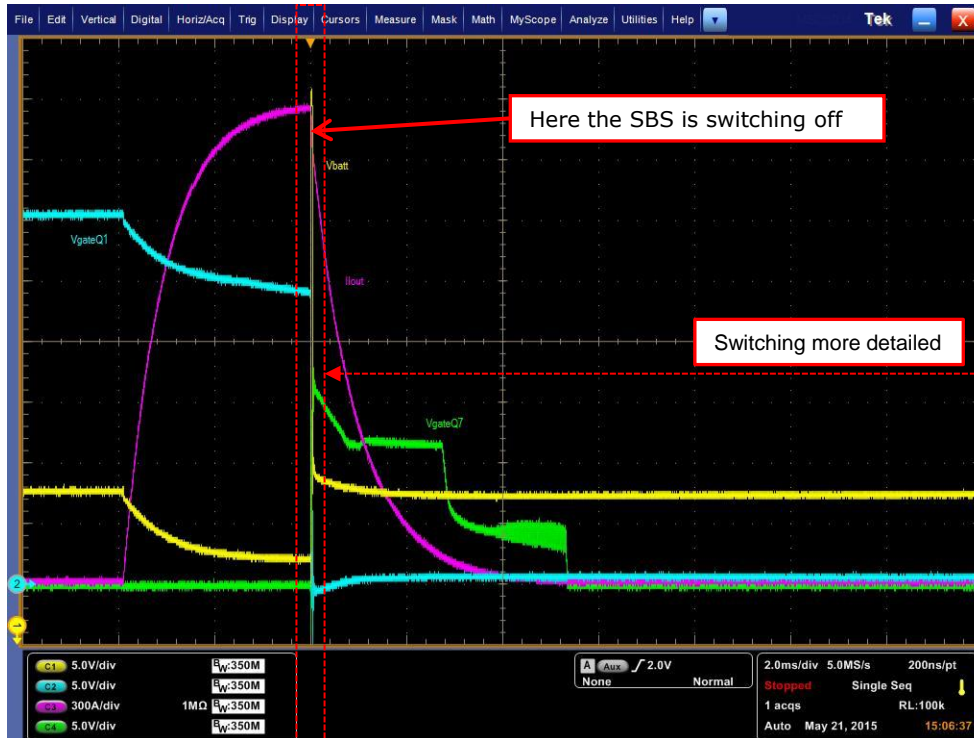


# SBS First Steps

## Test 5: Switching high current

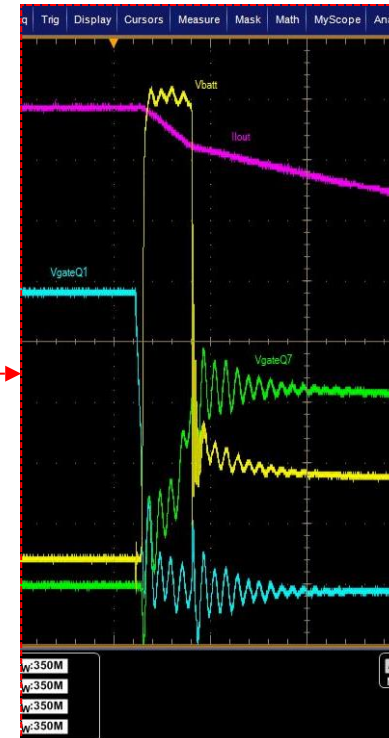
2ms/DIV

Graph1: Overall trend (applying a short circuit and switching off)  
Pink (CH3) is the output current.



50us/DIV

Graph2: Switching more detailed



Ch1: VBatt (GND Pos: -5)  
Ch2: Vgate Q1...Q6 (GND Pos: -4)  
Ch3: Iout (GND Pos: -4)  
Ch4: Vgate Q7 (GND Pos: -4)

GND of the probes are connected to SBS\_GND

# SBS First Steps

## Test 5: Switching high current

10us/DIV Graph3: Switching more detailed with switching power (M2)  
 $PQ1...Q6 = (V_{batt} - V_{out}) * I_{batt}$



This glitch in the Output signal is expected in version 3 and will be resolved in the next version

Ch1: Vbatt (Pos:- 5)  
 CH2: (Pos:- 5)  
 CH3: Iout (Pos: -4)  
 CH4: Vout (Pos: -3)  
 Math2:  $PQ1...Q6 = (Ch1 - Ch4) * Math4$  (Pos: -4)  
 Math4: Ibatt = Ch3 - Ch2 (Pos: -4)

GND of the probes are connected to SBS\_GND

# SBS First Steps

## Test 5: Switching high current

10us/DIV

Graph4: Switching more detailed with the transfer of current and switching energy (M1)



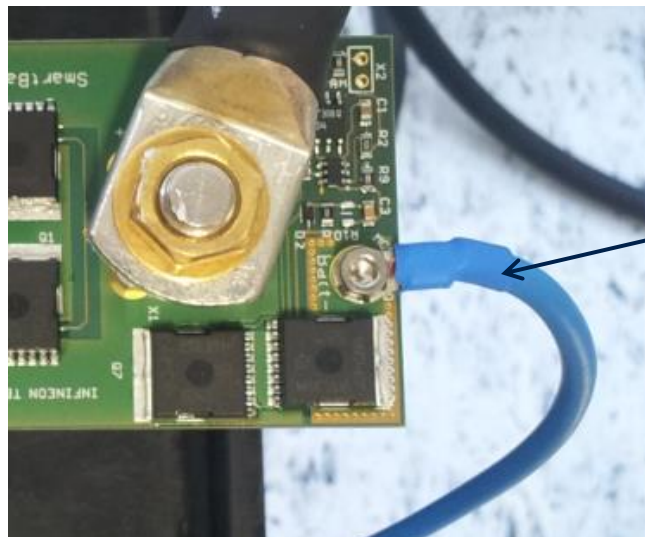
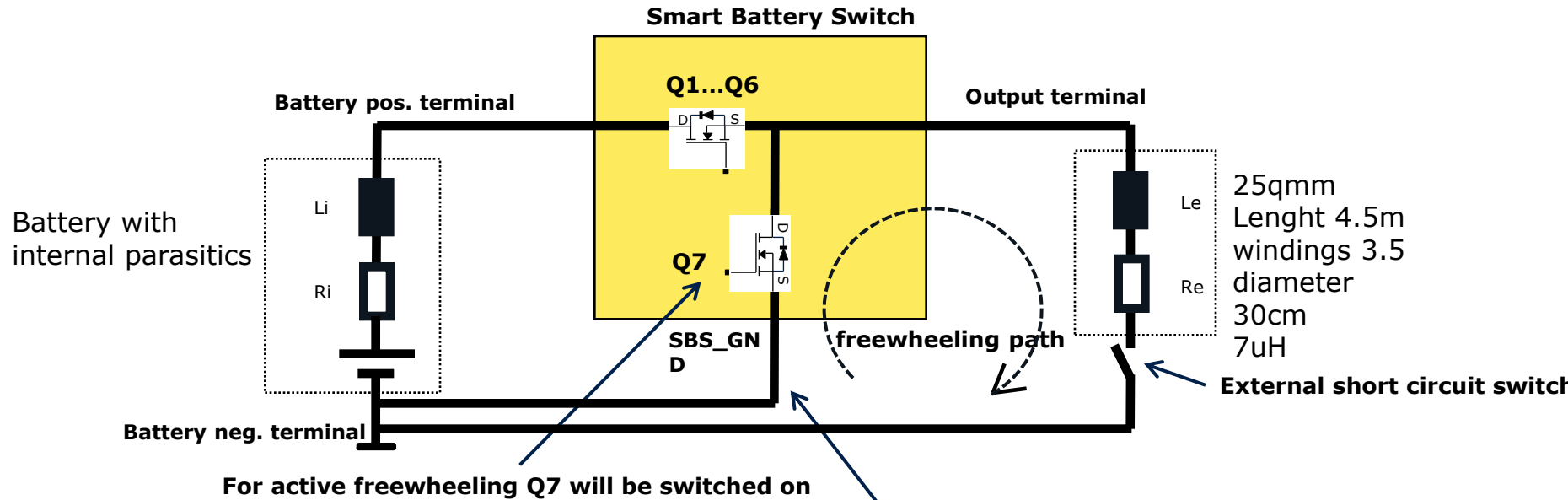
CH1: Vbatt (Pos:- 5)  
 CH2: Ignd (Pos:- 4)  
 CH3: Iout (Pos:- 4)  
 CH4: Vout (Pos:- 3)  
 Math3: E Q1...Q6 INTG(Math2) (Pos:- 1)  
 Math4: Ibatt Ch3-Ch2 (Pos:- 4)

GND of the probes are connected to SBS\_GND



# SBS First Steps

## Active freewheeling



Consider a reasonable ground connection



# SBS First Steps

## Active freewheeling

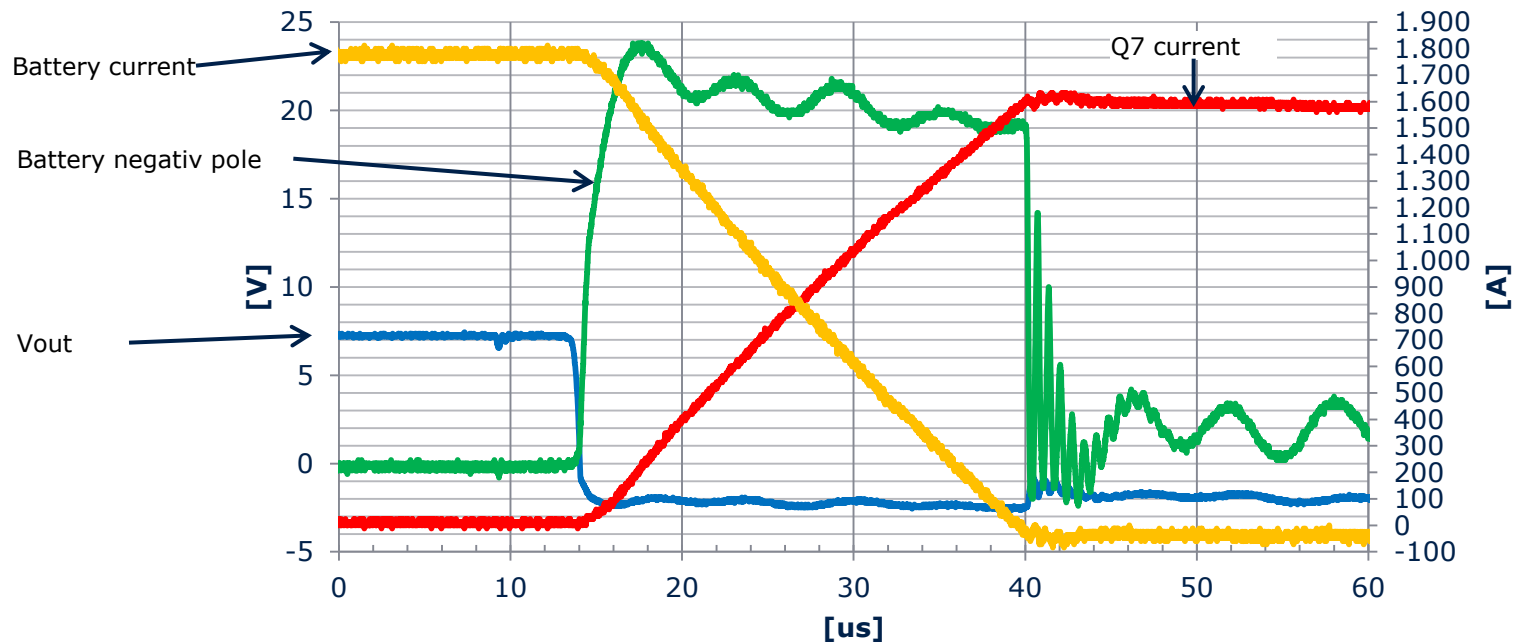
### Setup example:

Same as described in "Switching high current"

1. SBS (Q1...Q6) is switched on
2. Turning on the external switch (SC switch) generates a short circuit on the output terminal: Current is rising
3. At the user defined current switch the SBS (Q1...Q6)  
**Le and Li are now charged!**

4. **Le** is charged and is forcing the output voltage drop until the body diode of Q7 is conductive. Q7 is additionally switched on. The whole current is now flowing through the SBS\_GND and Q7/Q8. Due to the high current the Battery negative pole is rising up.  
(Remark: Negative pole of the battery is the reference point of all other ECU's)
5. **Li** is charged and is rising the input voltage up to the breakdown stage of the Q1..Q6 which will run into avalanche.

All GND's of the Probes are connected to SBS\_GND directly on the SBS



# SBS First Steps

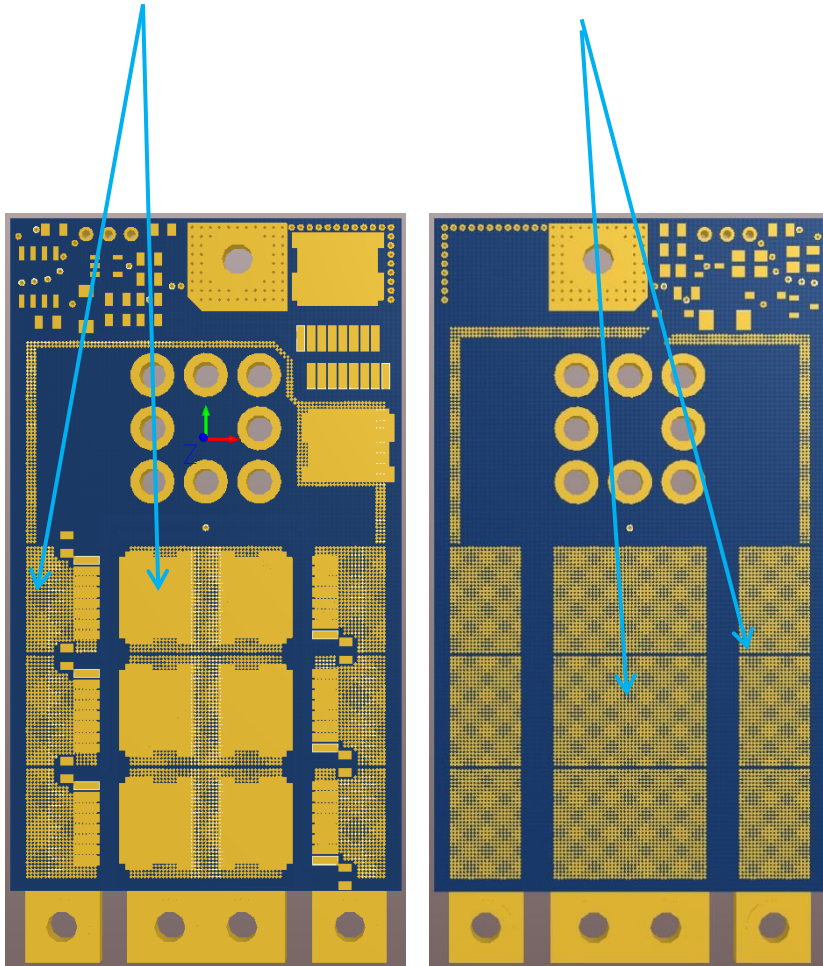
## PCB description

Outer layers 100um

Inlay 2mm

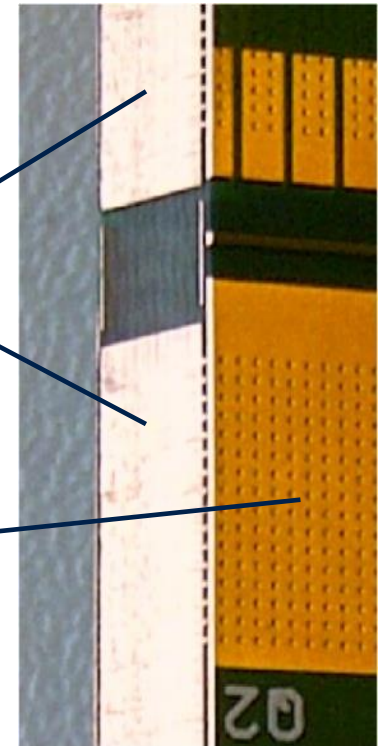
microvias

- cooling area with microvias



2mm Cu-Inlay

thermal-vias



# SBS First Steps

## Version History



### Rev1:

26.05.2015 Initial Version

28.05.2015 Modify Active freewheeling test

02.06.2015 Official Version

### Rev2:

02.06.2015 Add Graphs to chapter 5

29.06.2015 PCB chapter added

02.07.2015 Active freewheeling chapter added

07.07.2015 rework of "Active freewheeling" and "Switching high current chapters"

25.08.2015 rework all pages



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