UNIVERSITÄT BONN

SI LAB
Silizium Labor Bonn

Theresa Goldschmidt

Commissioning and Characterization of PXD Power Supply Calibration

International DEPFET workshop
Munich

16th May 2022

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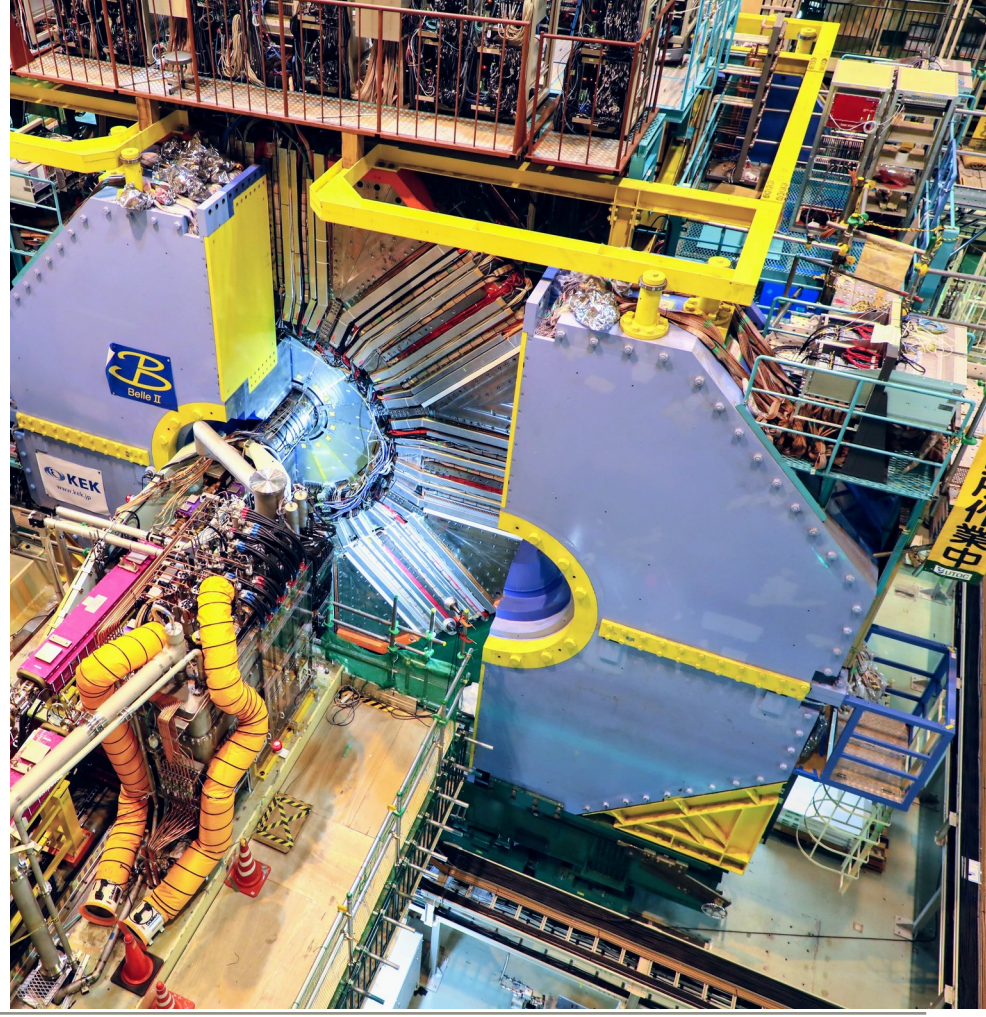
MOTIVATION

Calibration drift and changes through repairs expected

➔ Set-up at KEK needed

- Commission set-up in Bonn
- Study calibration stability and drift



Foto/©: Shota Takahashi, KEK

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THE SET-UP

WORKING PRINCIPLE

FIRST CALIBRATIONS

OUTLOOK

THE BELLE II POWER SUPPLY

- Supplies the PXD module with 24 different voltages
- Remote sensing of each channel

14m long power cables

Monitoring information of node 56

	Set Voltage (mV)	**Set Current (mA)**	ltage at Regulator (m	Voltage at Load (mV)	Current (mA)	Regulator Status Bit
DHP_IO	0	0	-6	-4	-8	LOW
SW_DVDD	0	0	-6	-6	-4	LOW

All channels listed

2 set values

3 monitoring values

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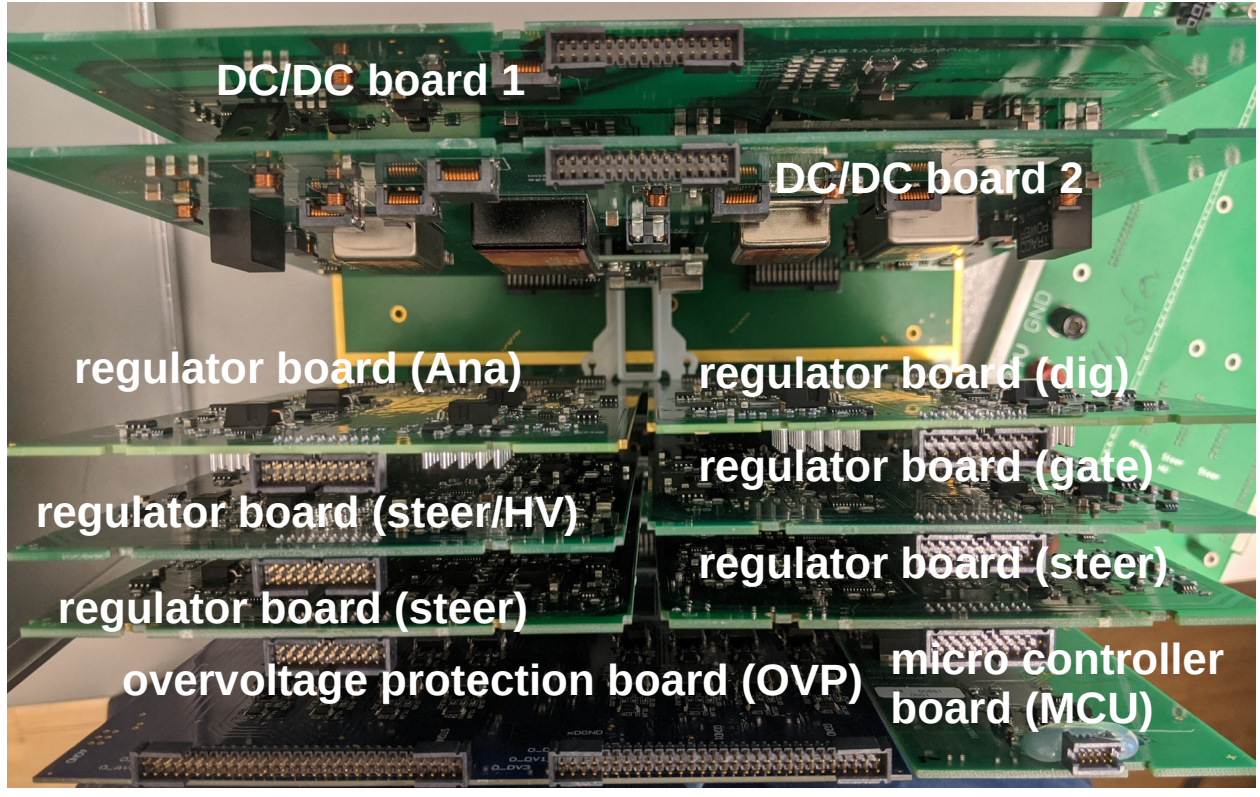
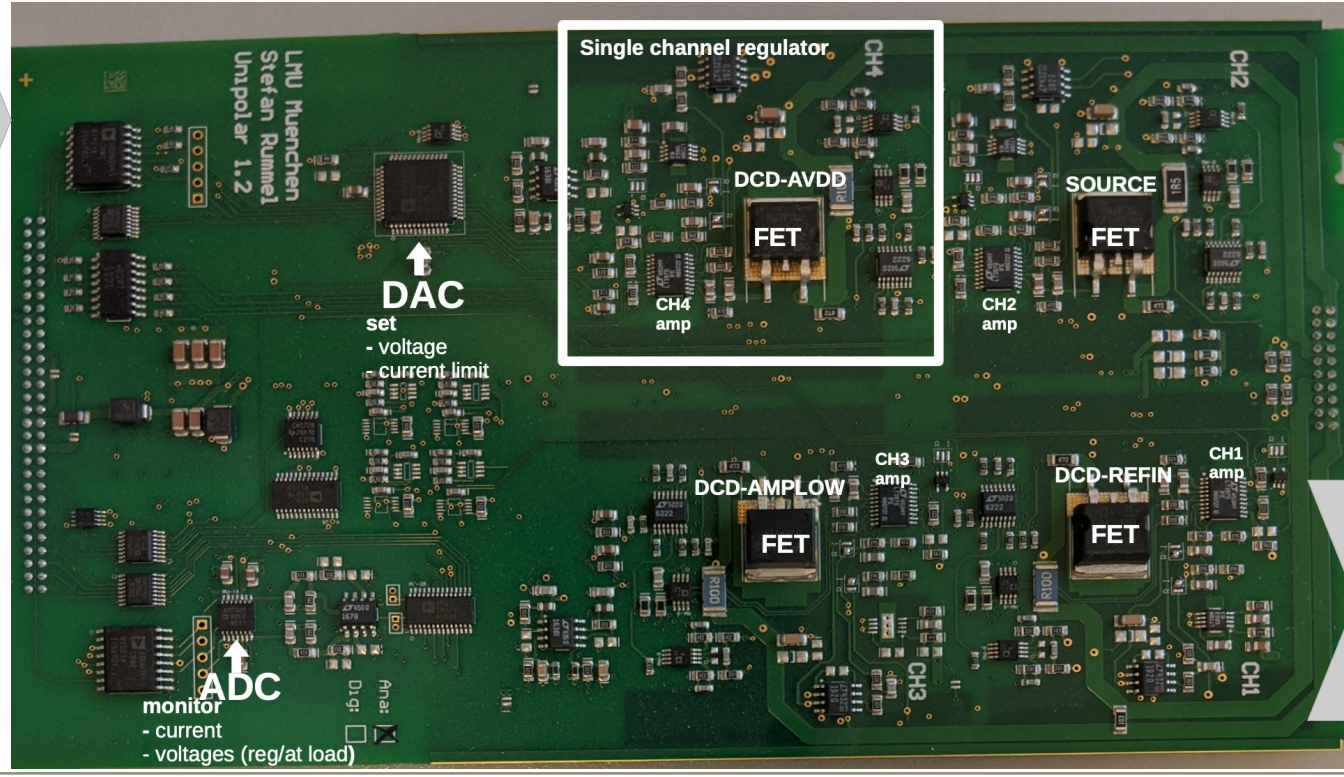
INSIDE THE BELLE II POWER SUPPLY



THE REGULATOR BOARD:
4 CHANNELS ON ONE BOARD

EXAMPLE: ANALOG BOARD

DC power in

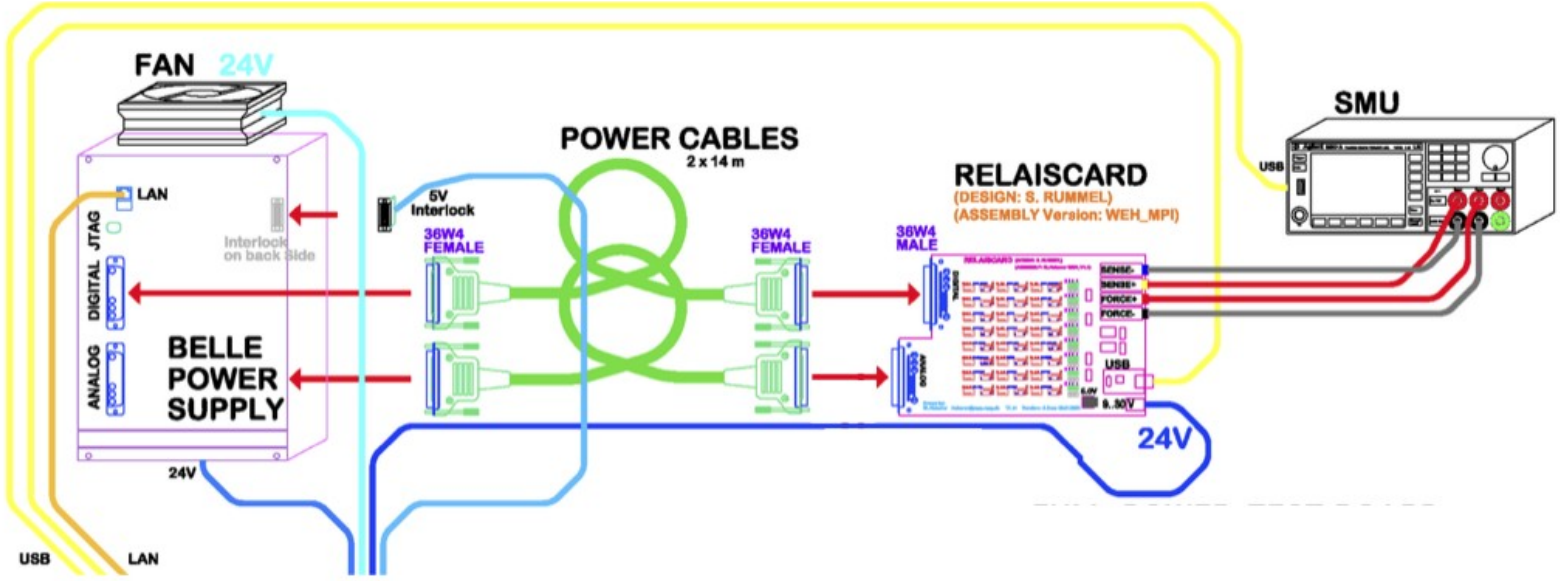


Front PCB - connector

back PCB - connector

4 channel out to PXD

THE DEVICES



Drawn by W. Haberer haberer@mpp.mpg.de

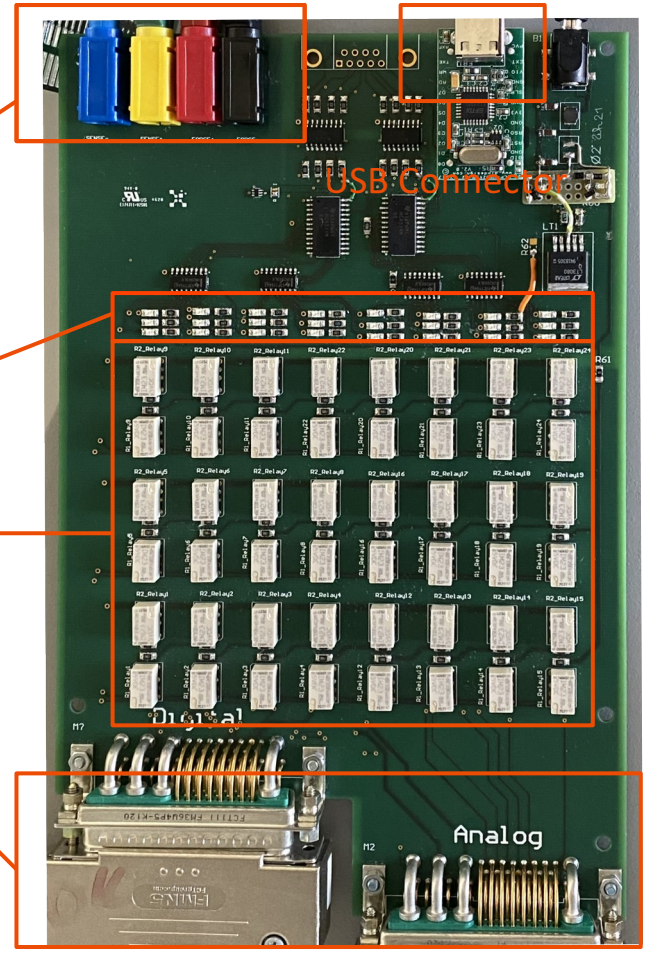
THE RELAISBOARD

Job of relaisboard:

➔Connecting one channel at a time to SMU

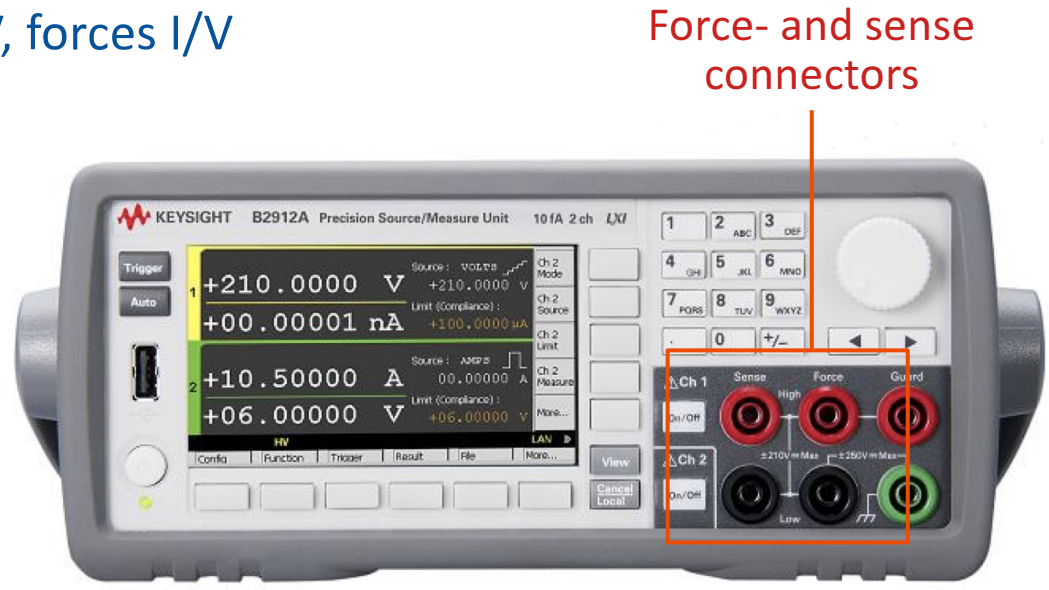
Two Relais for each channel:

➔ Forcelines and senselines



THE SOURCE MEASURE UNIT (SMU)

- “Simulates the PXD” in the calibration process
- **Function of device:** measures I/V, forces I/V
- controlled/read out by PC

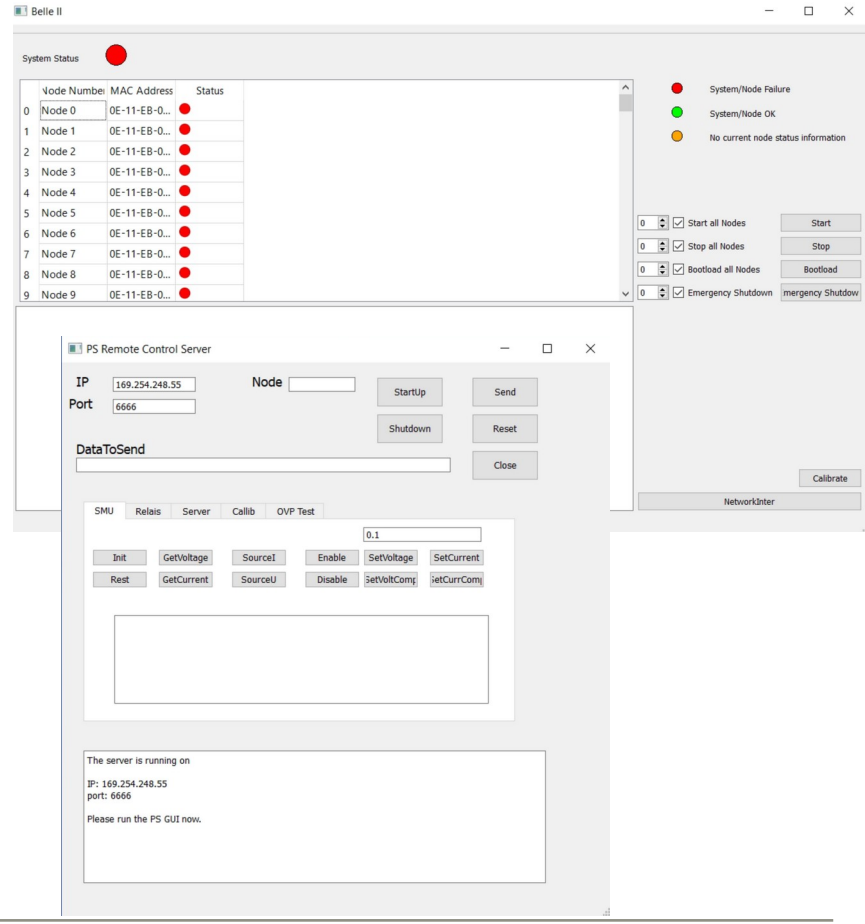


THE SOFTWARE

➔ The software runs on dedicated Windows laptop

- **Remote control and monitoring** of the SMU, the relaisboard and PS
- **What else is it used for:**

➔Has eclipse to flash **old** chromosome (XME)-based version of the firmware



https://stash.desy.de

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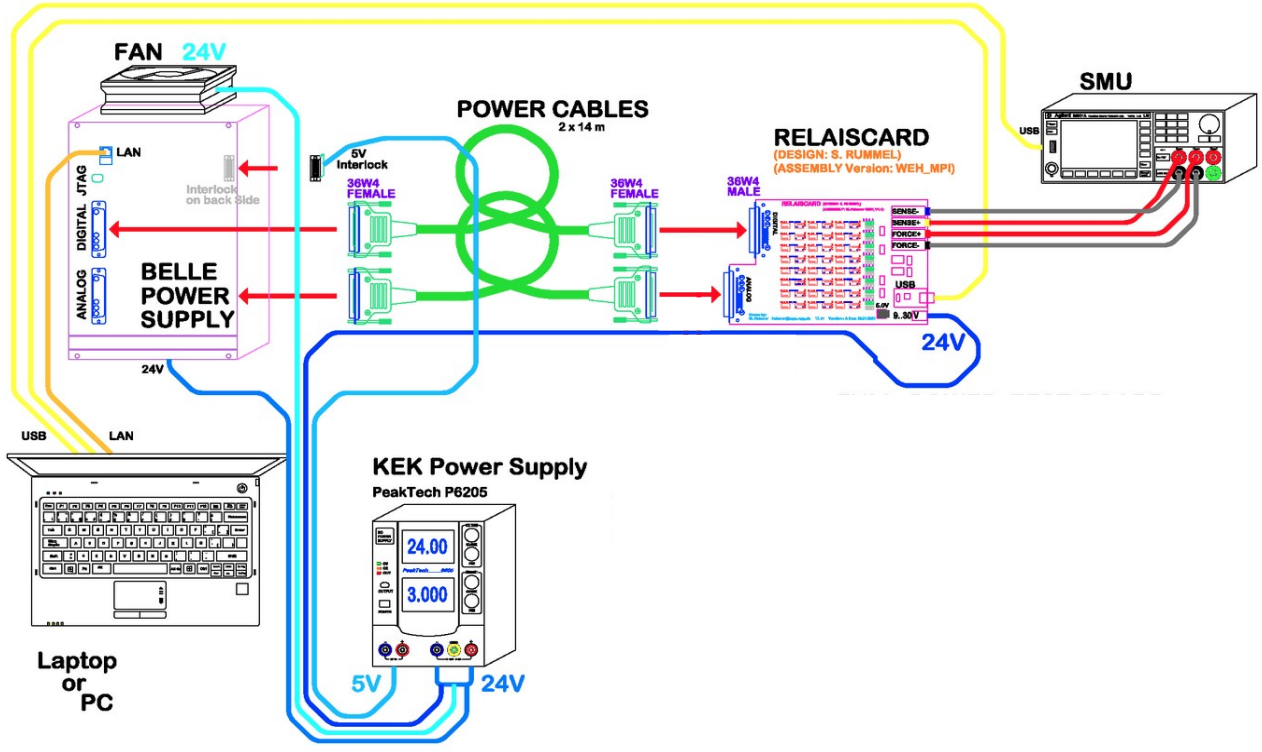
THE SET-UP



Drawn by W. Haberer haberer@mpp.mpg.de

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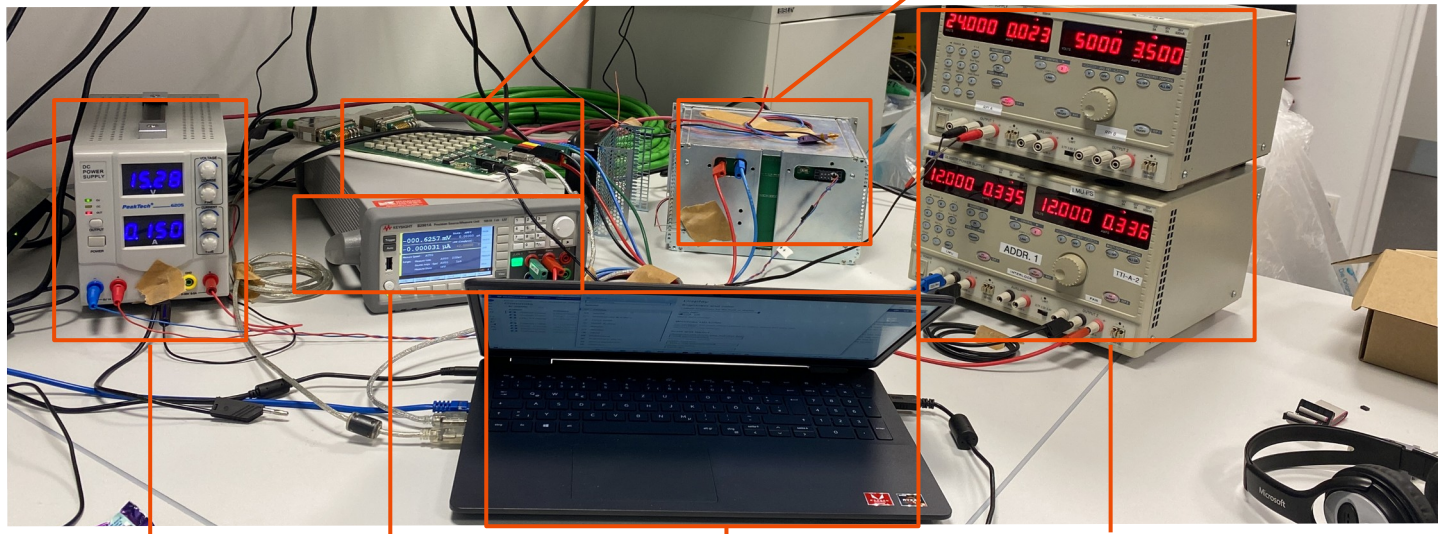
THE SET-UP



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THE SET-UP

THE WORKING PRINCIPLE

FIRST CALIBRATIONS

OUTLOOK

CALIBRATION WORKFLOW

.ini – file

```
[UNI4]
ID=15
RELAIS=17
StartVolt=0
StopVolt=5
MidScale=2.5
Compliance=30
StartCurrent=-0.1
StopCurrent=0.1
StartLimit=0
StopLimit=4
Range=200
```

Control software

Scan voltages/ currents

Select channel

Scan voltages/ currents

PXD PS

Relais card

SMU

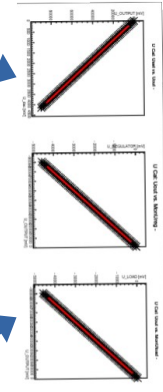
... 24 voltages force + sense

force

sense

Measure voltages/ currents

Measure voltages/ currents



Fitting (root script)

```
[0]
DAC_VOLTAGE_GAIN=10016
DAC_VOLTAGE_OFFSET=211
ADC_U_LOAD_GAIN=4648
ADC_U_LOAD_OFFSET=-791
ADC_U_REGULATOR_GAIN=10006
ADC_U_REGULATOR_OFFSET=-886
ADC_I_MON_GAIN=-9905
ADC_I_MON_OFFSET=-100
DAC_CURRENT_GAIN=-10024
DAC_CURRENT_OFFSET=-1180
```

Calibration constants

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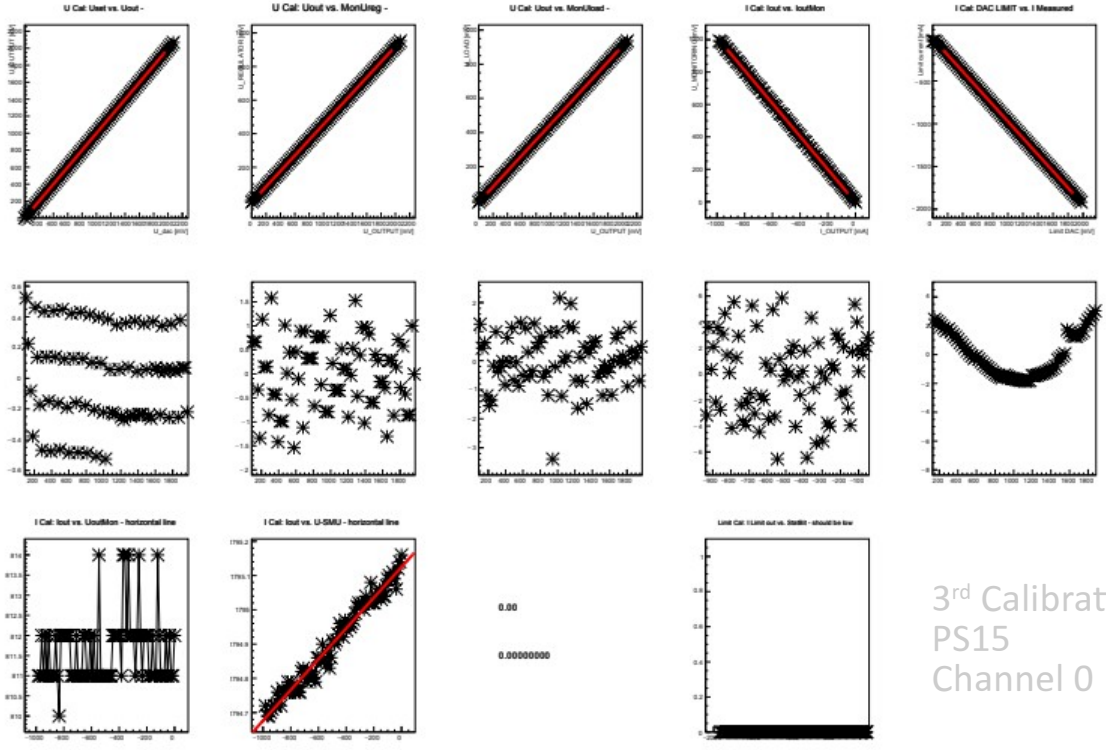
THE SET-UP

THE WORKING PRINCIPLE

FIRST CALIBRATIONS

OUTLOOK

THE CALIBRATION CURVES



The calibration curves

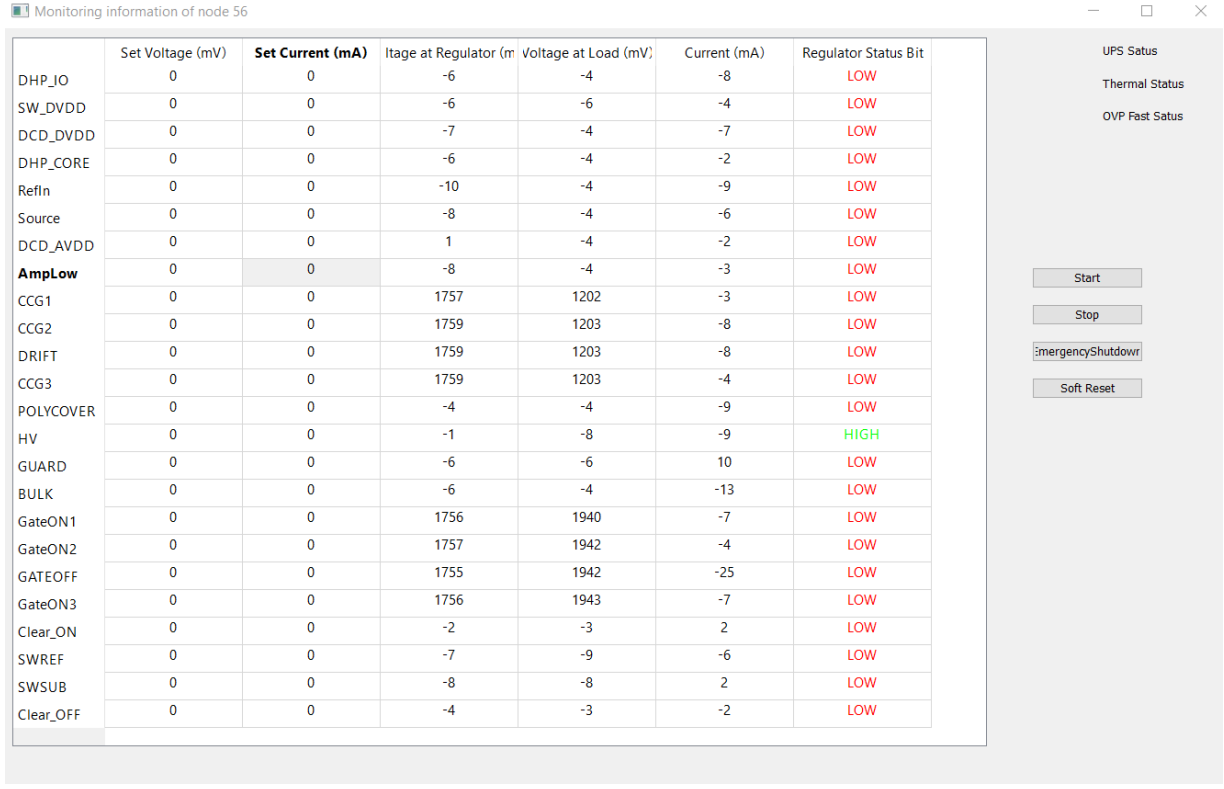
Residual Plots

3rd Calibration
PS15
Channel 0

Further investigation needed

UPLOADING THE CALIBRATION DATA

SCGUI channel monitoring **before** calibration

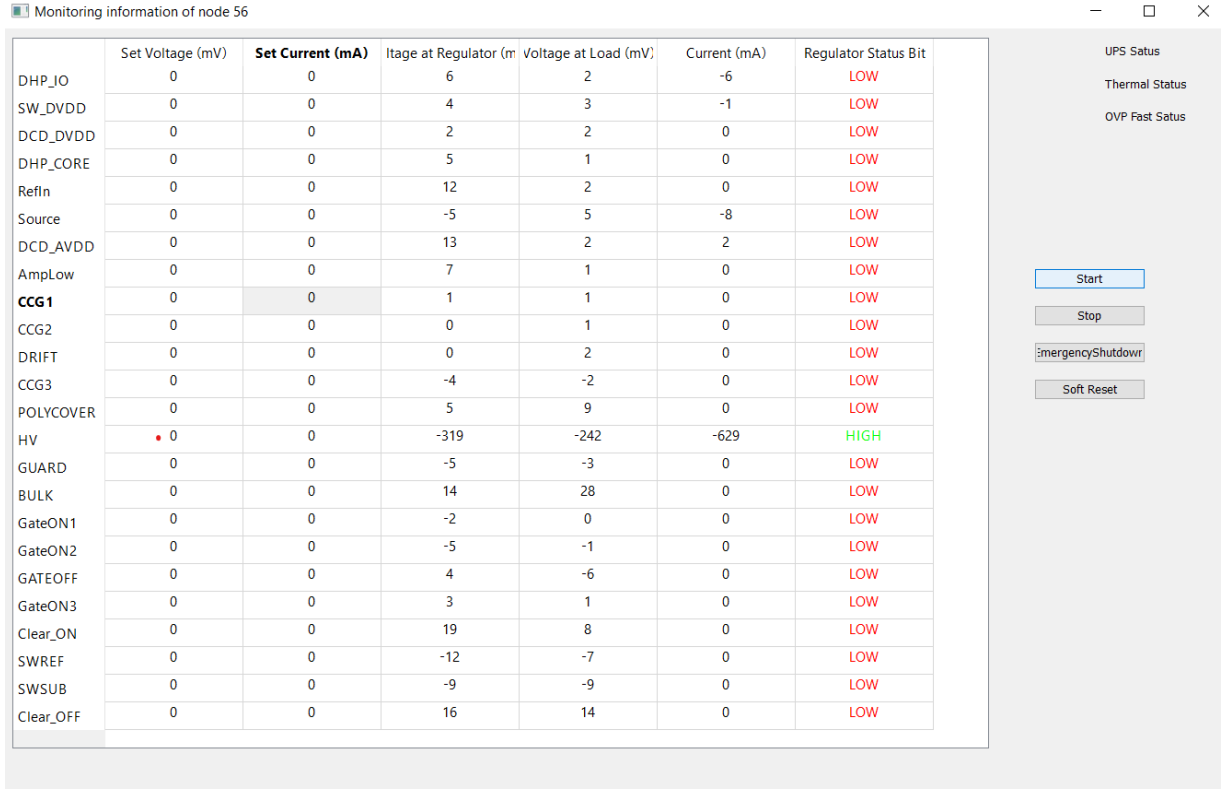


	Set Voltage (mV)	**Set Current (mA)**	ltage at Regulator (m	Voltage at Load (mV)	Current (mA)	Regulator Status Bit
DHP_IO	0	0	-6	-4	-8	LOW
SW_DVDD	0	0	-6	-6	-4	LOW
DCD_DVDD	0	0	-7	-4	-7	LOW
DHP_CORE	0	0	-6	-4	-2	LOW
RefIn	0	0	-10	-4	-9	LOW
Source	0	0	-8	-4	-6	LOW
DCD_AVDD	0	0	1	-4	-2	LOW
AmpLow	0	0	-8	-4	-3	LOW
CCG1	0	0	1757	1202	-3	LOW
CCG2	0	0	1759	1203	-8	LOW
DRIFT	0	0	1759	1203	-8	LOW
CCG3	0	0	1759	1203	-4	LOW
POLYCOVER	0	0	-4	-4	-9	LOW
HV	0	0	-1	-8	-9	HIGH
GUARD	0	0	-6	-6	10	LOW
BULK	0	0	-6	-4	-13	LOW
GateON1	0	0	1756	1940	-7	LOW
GateON2	0	0	1757	1942	-4	LOW
GATEOFF	0	0	1755	1942	-25	LOW
GateON3	0	0	1756	1943	-7	LOW
Clear_ON	0	0	-2	-3	2	LOW
SWREF	0	0	-7	-9	-6	LOW
SWSUB	0	0	-8	-8	2	LOW
Clear_OFF	0	0	-4	-3	-2	LOW

PS 87

UPLOADING THE CALIBRATION DATA

SCGUI channel monitoring **after** calibration

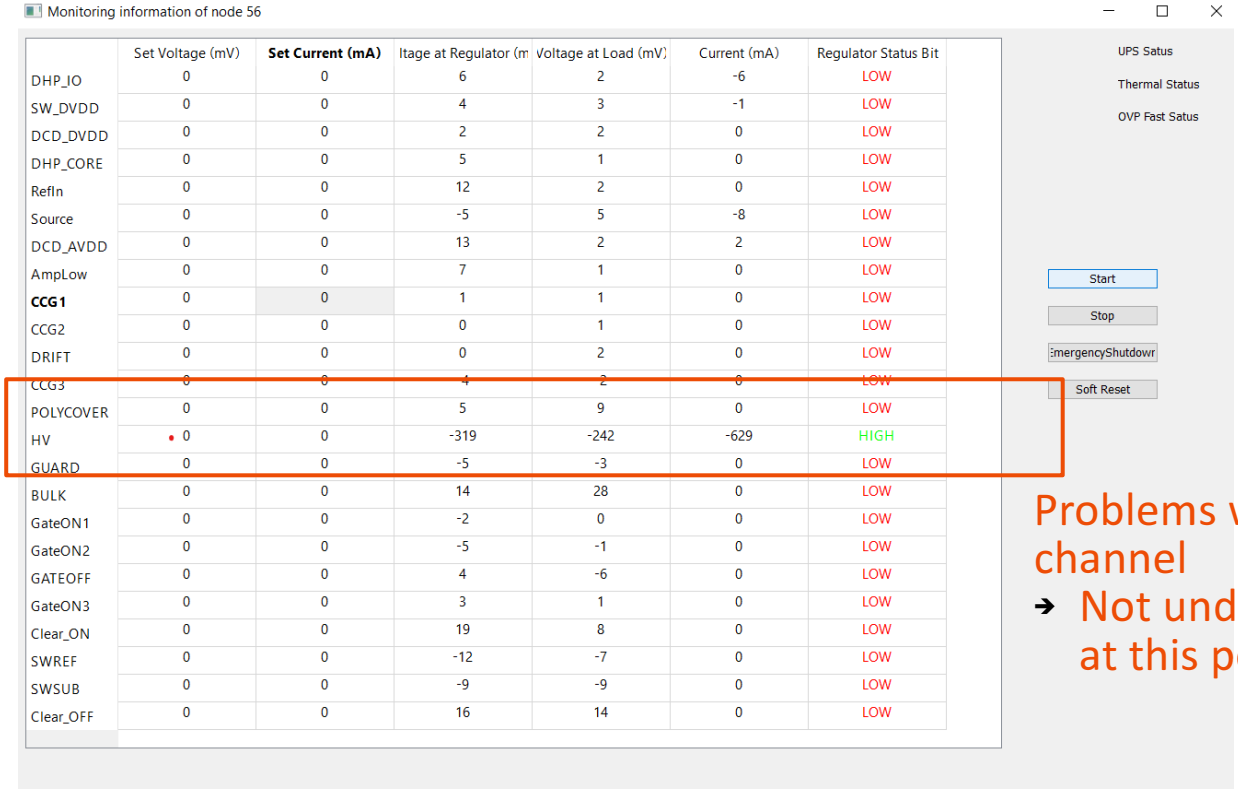


	Set Voltage (mV)	**Set Current (mA)**	Itage at Regulator (m	Voltage at Load (mV)	Current (mA)	Regulator Status Bit
DHP_IO	0	0	6	2	-6	LOW
SW_DVDD	0	0	4	3	-1	LOW
DCD_DVDD	0	0	2	2	0	LOW
DHP_CORE	0	0	5	1	0	LOW
RefIn	0	0	12	2	0	LOW
Source	0	0	-5	5	-8	LOW
DCD_AVDD	0	0	13	2	2	LOW
AmpLow	0	0	7	1	0	LOW
CCG1	0	0	1	1	0	LOW
CCG2	0	0	0	1	0	LOW
DRIFT	0	0	0	2	0	LOW
CCG3	0	0	-4	-2	0	LOW
POLYCOVER	0	0	5	9	0	LOW
HV	0	0	-319	-242	-629	HIGH
GUARD	0	0	-5	-3	0	LOW
BULK	0	0	14	28	0	LOW
GateON1	0	0	-2	0	0	LOW
GateON2	0	0	-5	-1	0	LOW
GATEOFF	0	0	4	-6	0	LOW
GateON3	0	0	3	1	0	LOW
Clear_ON	0	0	19	8	0	LOW
SWREF	0	0	-12	-7	0	LOW
SWSUB	0	0	-9	-9	0	LOW
Clear_OFF	0	0	16	14	0	LOW

PS 87

UPLOADING THE CALIBRATION DATA

SCGUI channel monitoring **after** calibration



	Set Voltage (mV)	**Set Current (mA)**	ltage at Regulator (m	Voltage at Load (mV)	Current (mA)	Regulator Status Bit
DHP_IO	0	0	6	2	-6	LOW
SW_DVDD	0	0	4	3	-1	LOW
DCD_DVDD	0	0	2	2	0	LOW
DHP_CORE	0	0	5	1	0	LOW
RefIn	0	0	12	2	0	LOW
Source	0	0	-5	5	-8	LOW
DCD_AVDD	0	0	13	2	2	LOW
AmpLow	0	0	7	1	0	LOW
CCG1	0	0	1	1	0	LOW
CCG2	0	0	0	1	0	LOW
DRIFT	0	0	0	2	0	LOW
CCG3	0	0	-4	2	0	LOW
POLYCOVER	0	0	5	9	0	LOW
HV	0	0	-319	-242	-629	HIGH
GUARD	0	0	-5	-3	0	LOW
BULK	0	0	14	28	0	LOW
GateON1	0	0	-2	0	0	LOW
GateON2	0	0	-5	-1	0	LOW
GATEOFF	0	0	4	-6	0	LOW
GateON3	0	0	3	1	0	LOW
Clear_ON	0	0	19	8	0	LOW
SWREF	0	0	-12	-7	0	LOW
SWSUB	0	0	-9	-9	0	LOW
Clear_OFF	0	0	16	14	0	LOW

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Problems with HV channel

➔ Not understood at this point

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CHALLENGES FACED SO FAR

Setting up the Software is <u>not</u> trivial:

- PS with old firmware has no static IP

  ➔ Communication via DHCP server

- Installing everything to flash old firmware

  ➔ Programs used very out of date

- Git master branch does not contain correct versions needed for calibration

Confluence

https://confluence.desy.de

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THE SET-UP

THE WORKING PRINCIPLE

FIRST CALIBRATIONS

OUTLOOK

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GOALS FOR MY THESIS

1) Commissioning of **calibration set-up** in Bonn
    - Including working HV channel
2) Generating the calibration constants and plots with **Python**
    - Slope and offset given with plots
3) Automatic **pass/fail** for successful calibration
4) Drift/**stability studies**
5) **Comparison** between different PS units
6) Update and complete **documentation**

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FURTHER OUTLOOK

If there is enough time, we would like to…

… Change from Windows to Linux

… Make it work with the latest firmware

… Simplify the calibration process

… Simplify the Set-Up for calibration

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Thank you !

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GENERATING THE CALIBRATION CONSTANTS

- 80 measuring points set for each channel
- Voltage range and current change set for each channel

```
[0]
DAC_VOLTAGE_GAIN=10016
DAC_VOLTAGE_OFFSET=211
ADC_U_LOAD_GAIN=4648
ADC_U_LOAD_OFFSET=-791
ADC_U_REGULATOR_GAIN=10006
ADC_U_REGULATOR_OFFSET=-886
ADC_I_MON_GAIN=-9905
ADC_I_MON_OFFSET=-100
DAC_CURRENT_GAIN=-10024
DAC_CURRENT_OFFSET=-1180
```

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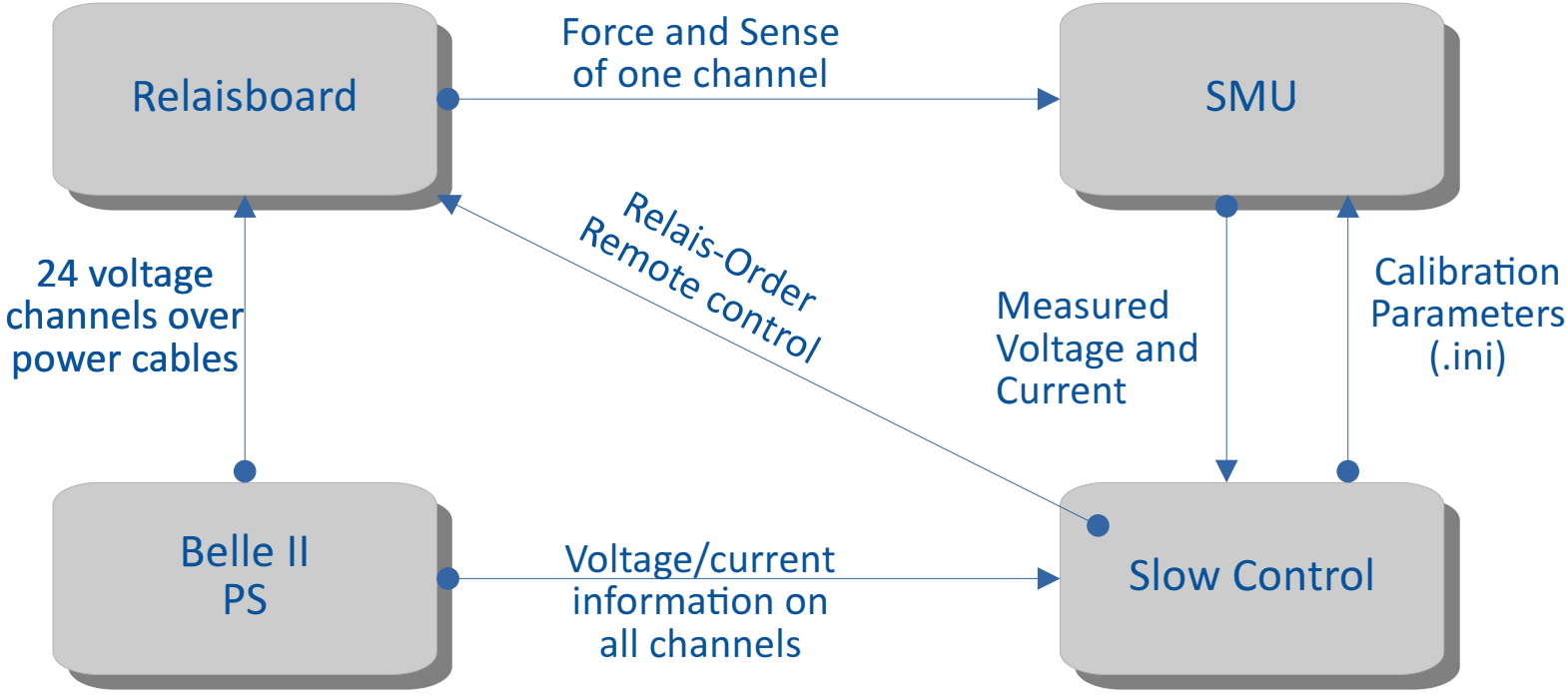
THE SIGNAL-PATH



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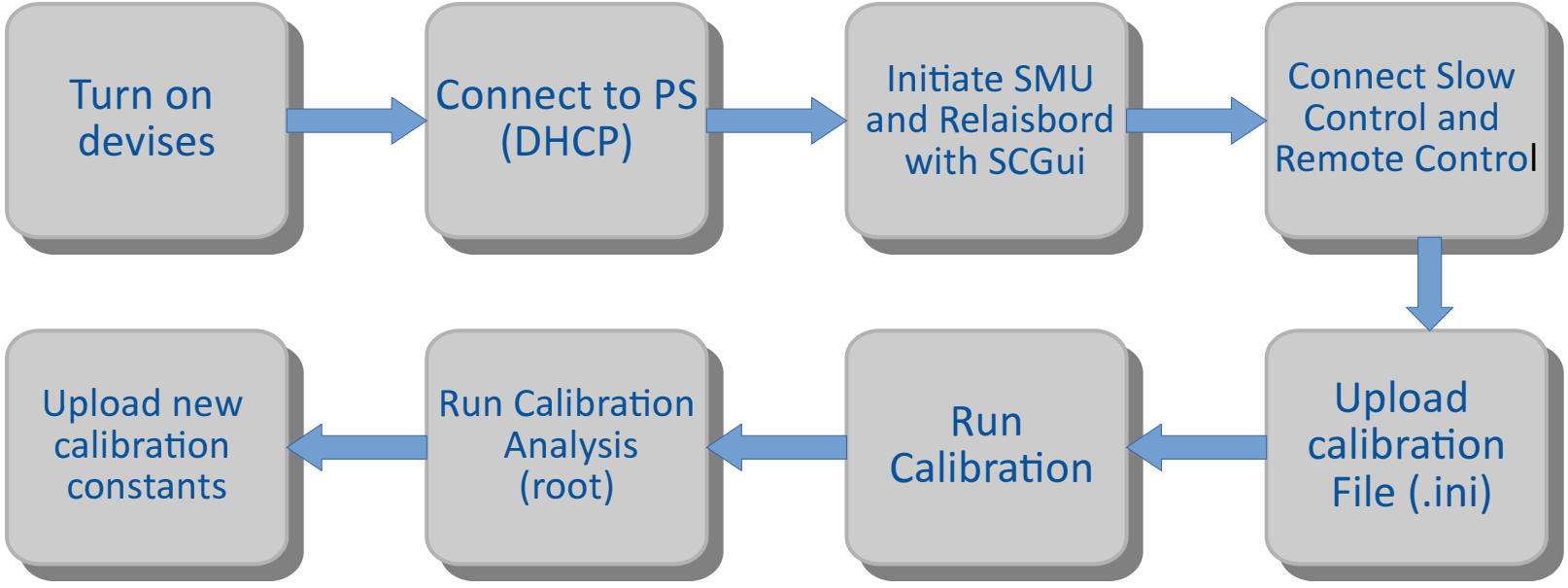
CALIBRATION WORKFLOW



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THE CALIBRATION CONSTANTS

3rd Calibration PS15 Channel 0

```
[0]
DAC_VOLTAGE_GAIN=10016
DAC_VOLTAGE_OFFSET=211
ADC_U_LOAD_GAIN=4648
ADC_U_LOAD_OFFSET=-791
ADC_U_REGULATOR_GAIN=10006
ADC_U_REGULATOR_OFFSET=-886
ADC_I_MON_GAIN=-9905
ADC_I_MON_OFFSET=-100
DAC_CURRENT_GAIN=-10024
DAC_CURRENT_OFFSET=-1180
```

DAC_VOLTAGE_GAIN=10016 DAC_VOLTAGE_OFFSET=211	output voltage (SMU) vs. input voltage
ADC_U_LOAD_GAIN=4648 ADC_U_LOAD_OFFSET=-791	monitored voltage at load vs. measured output voltage
ADC_U_REGULATOR_GAIN=10006 ADC_U_REGULATOR_OFFSET=-886	monitored voltage at regulator vs. measured output voltage
ADC_I_MON_GAIN=-9905 ADC_I_MON_OFFSET=-100	monitored output current vs. measured output current
DAC_CURRENT_GAIN=-10024 DAC_CURRENT_OFFSET=-1180	measured output current vs. set DAC limit

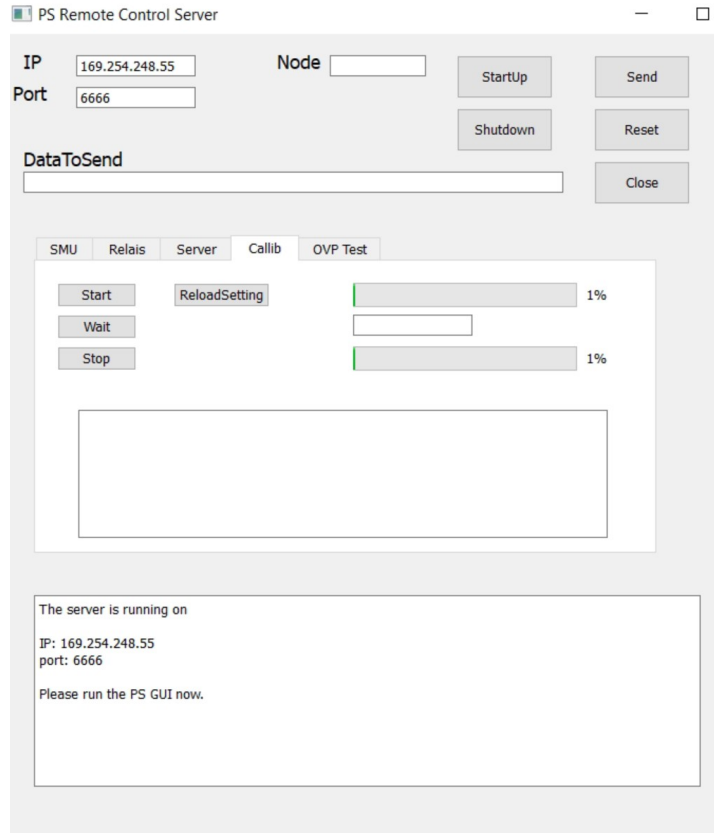
PS-REMOTE CONTROL

- Remote control of SMU
- Initializing of relaisboard
- Uploading information for calibration

  ➔.ini file containing information on each channel

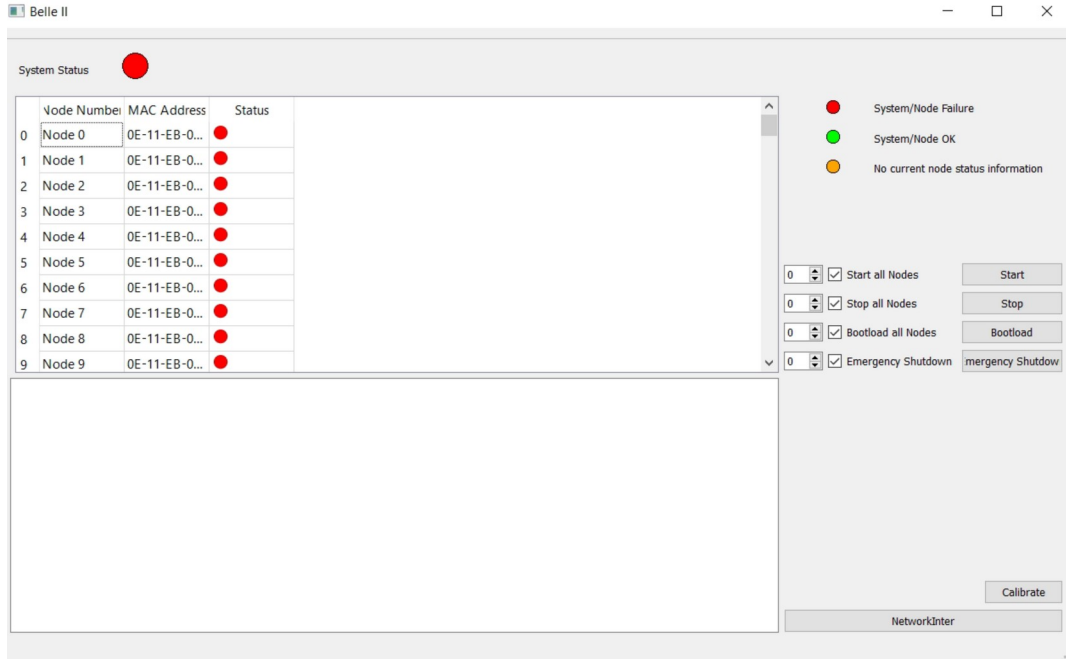
- Monitor progress of calibration

```
[UNI4]
ID=15
RELAIS=17
StartVolt=0
StopVolt=5
MidScale=2.5
Compliance=30
StartCurrent=-0.1
StopCurrent=0.1
StartLimit=0
StopLimit=4
Range=200
```



SLOW CONTROL GUI

- List of the nodes
- Resetting the calibration constants to default
- Monitoring each channel for the DUT
- Uploading new calibration constants

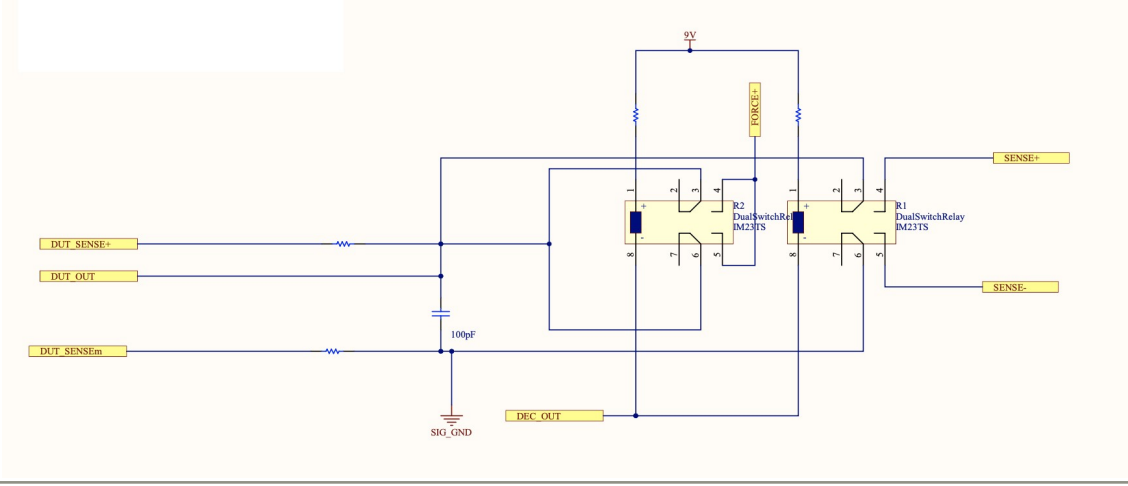


THE DOUBLE RALAIS

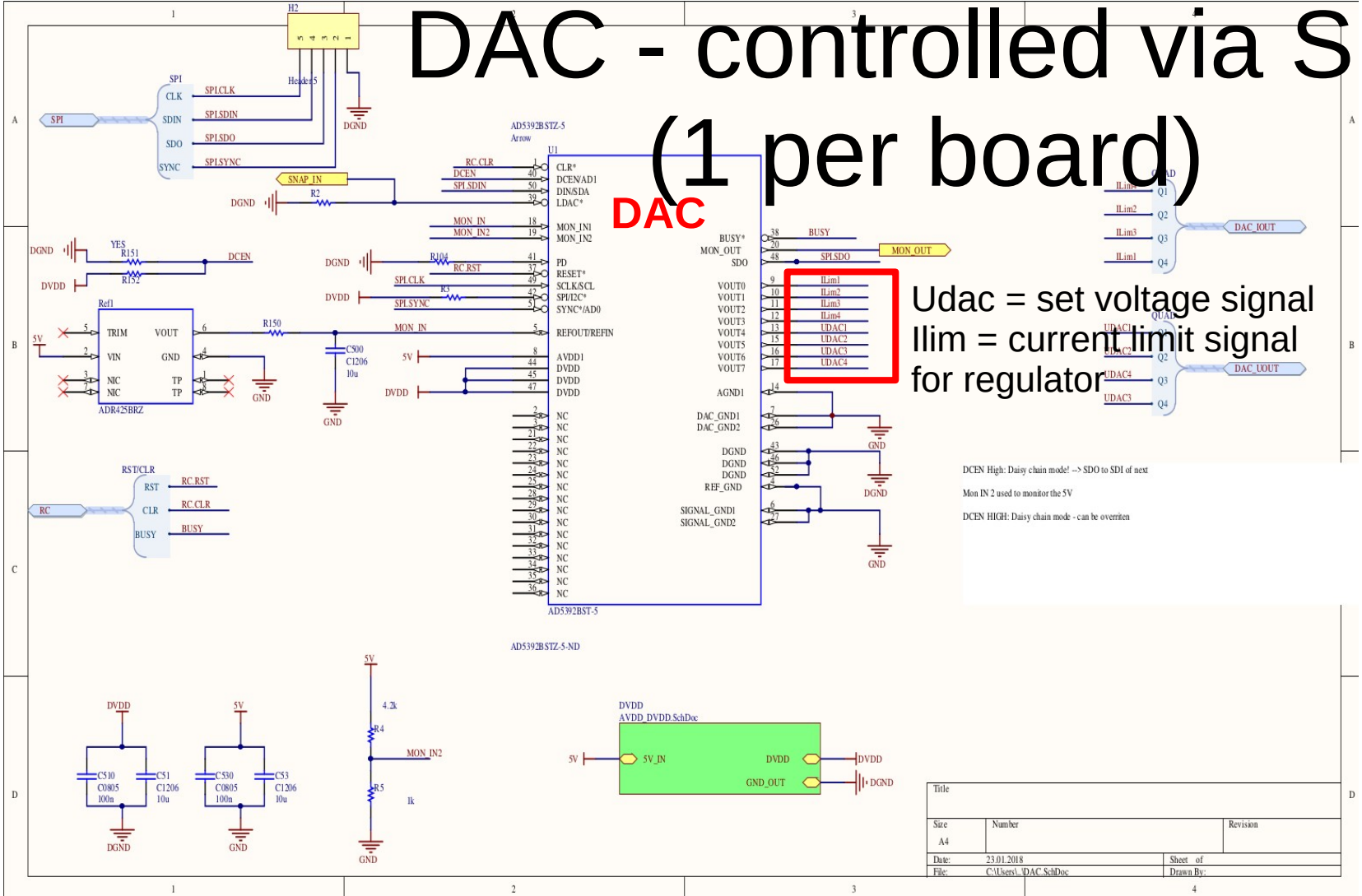
- Calibration of sensing for each channel

  ➔Ensuring correct voltage at DUT

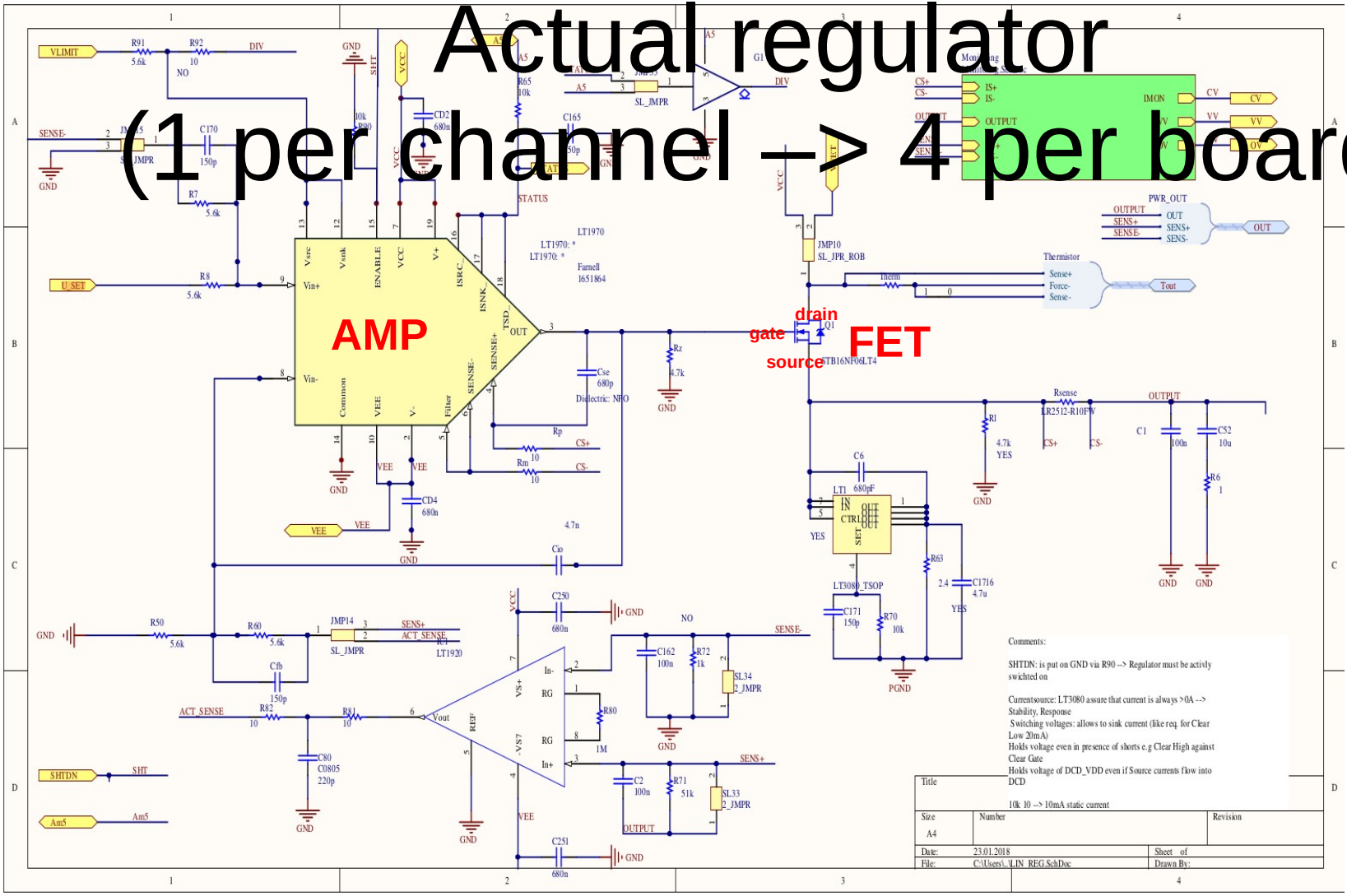
- Double relais to connect force and sense and force to SMU



DAC - controlled via SPI (1 per board)



Actual regulator (1 per channel –> 4 per board)



ADC for all monitoring (1 per card)