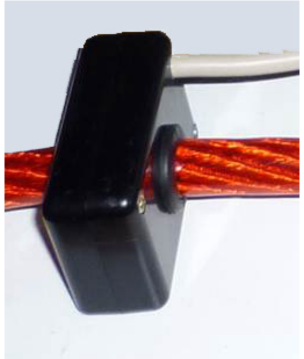
Smart Current Sensing System



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Messtechnik ● Sensorik ● Mechatronische Systeme ● Umweltsimulationstests

Motivation

There are many contact-less electric DC current sensors based on several magnetic technologies.

Most of these sensors provide just an analogue signal output of raw magnetic sensors, which depends on tolerances of many parameters, leaving the calibration and/or fine tuning to be performed by the final application. If accuracies below few % Full Scale are desired, sensor serviceability is not possible due to cumbersome external calibration required. Self-diagnostics of such current sensors does not exist. In addition, the accuracy is influenced by disturbances of external magnetic fields.

The development target was to provide a „low-cost ~ high accuracy" solution, especially for DC currents above 300 A, to support final applications by individually calibrated parameters, full self-diagnostics and fast data transmission. Also, the compensation of the disturbances by external magnetic fields was implemented.

Available technologies for DC current sensing (1):

Resistive

+ **Materials** for shunts are **well developed**:
  - sufficiently high resistance,
  - sufficiently low power dissipation,
  - stable temperature coefficient.

+ Affordable electronics to measure small voltages is available, thus providing **high precision** readings.

- **Galvanic connection** to the current measuring path is **unavoidable**.

- Current carrying **cable has to be cut** to accomodate the shunt.

- **Weight** of the shunt.

- **External protection** against currents above the maximum rated current **must be implemented** in order to avoid sensor destruction or even **fire**.

Available technologies for DC current sensing (2): Contactless

+ There is **no galvanic connection** to the current carrying cable. The sensor can be placed anywhere along the current carrying cable.
+ **Current overload** (i.e. short circuit) will **not damage** the sensor.
+ Current carrying **cable** (or bus bar) **doesn‘t need to be cut**.

- Many parameters are influencing the **accuracy**.
- The available sensors on the market are **not sufficiently calibrated**. Therefore, they can‘t provide accuracy similar to the resistive solution.
- Open loop versions: Sensitive to external magnetic fields.
- Standard closed loop versions: Too complex. Not suitable for high currents due to high power consumption.

Accuracy example of available linear Hall-effect sensor elements

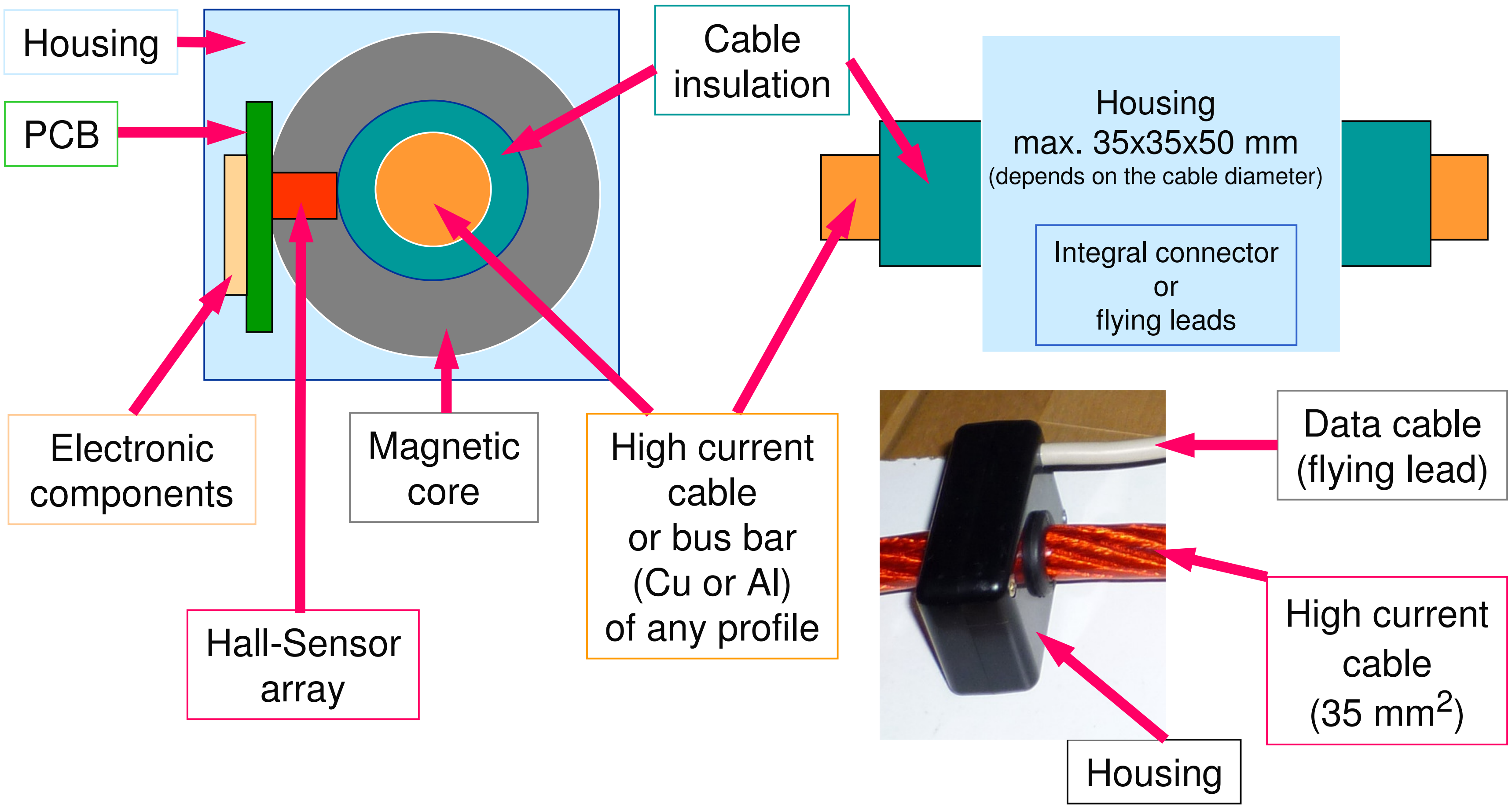
Parameter	Unit	Nominal value	Tolerance ranges of some Hall-sensors		
Magnetic range	G	+/-650	+/-50	+/-75	+/-100
Sensitivity	mV/G	3,125	+/-0,075	+/-0,1	+/-0,125
Offset (output@0G)	V	2,5 V	+/-0,075	+/-0,1	+/-0,125
Temperature error Sensitivity	%/K	0	+/-0,03	+/-0,05	+/-0,06
Temperature error Offset	%/K	0	+/-0,02	+/-0,08	+/-0,05

It is obvious that based even only on these few parameters, the overall **accuracy** to measure magnetic fields **cannot be below few % Full Scale without individual calibration** or special selection. In addition, more parameters are influencing the accuracy of current sensing with such elements.

Main benefits of the SCSS technology

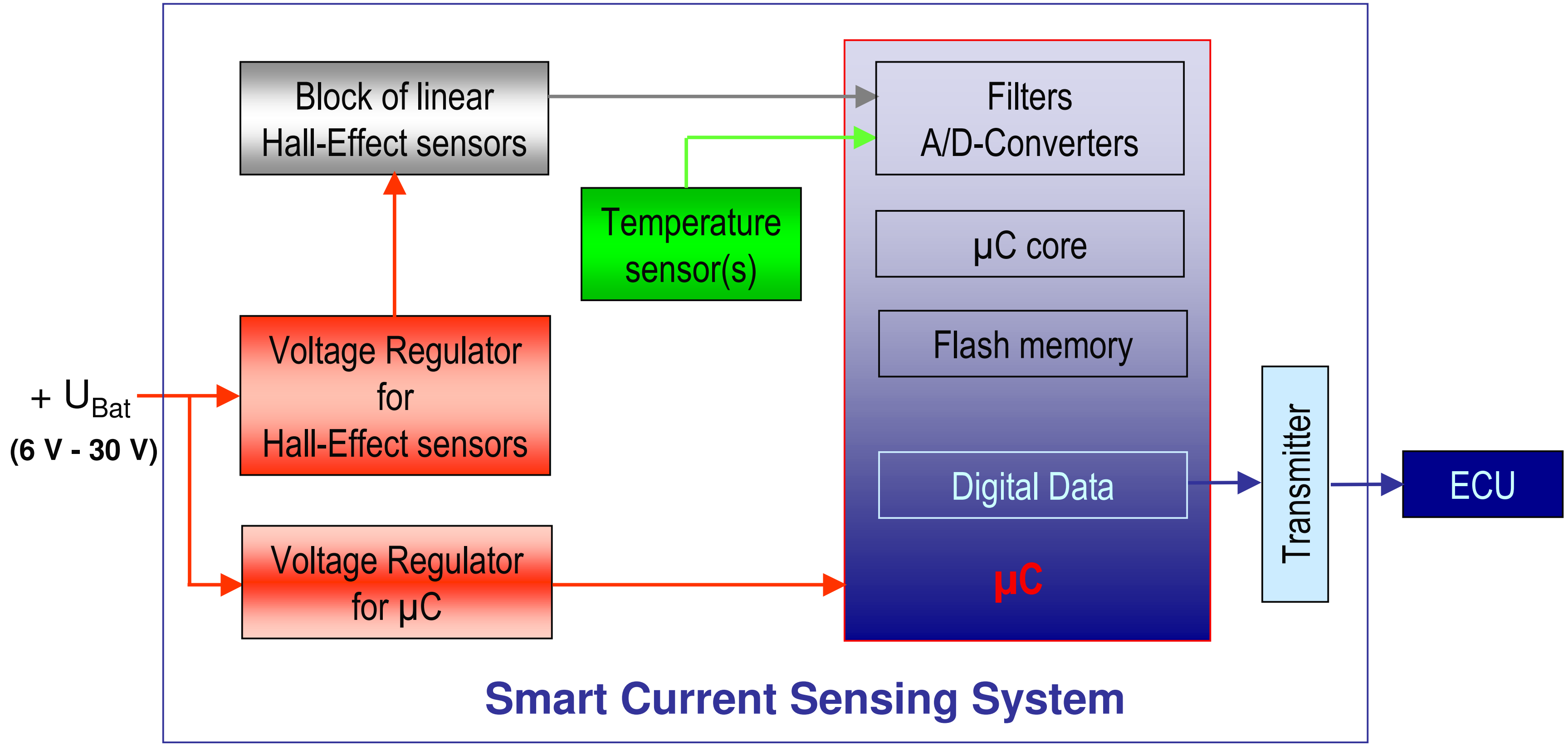
- + Easy mechanical adaptation: SCSS can be mounted on the cable without additional connections or supplied with fixed bus bar; the size of the SCSS depends mainly on the cable or bus bar cross section profile.
- + Low-cost solution due to utilization of available off-shelf linear Hall-effect sensors.
- + Accuracy up to 0.1 % Full Scale over the entire operating temperature range (-40℃ to +125℃).
- + Disturbances created by external magnetic fields are detected and can be compensated.
- + Choice of any digital data interfaces (i.e. SPI, UART, LIN, I2C, CAN, USB, LAN), wireless and optical data transmission.
- + Self-diagnostics, redundand features and multiple current ranges due to multiple sensor elements and implemented local intelligence.
- + Sleep-down modes are available.
- + Possible implementation of simultaneous measurement of other parameters (i.e. battery voltages, cable temperature).
- + Optional extended high temperature range up to +150℃.

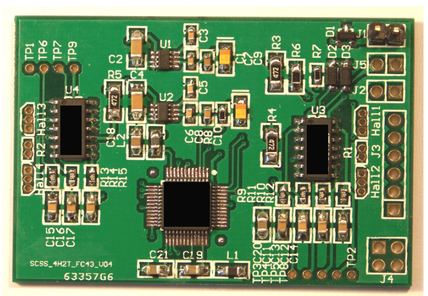
Packaging concept example for max. 100 A DC cont.



Further packaging concepts upon request, especially for bus bars.

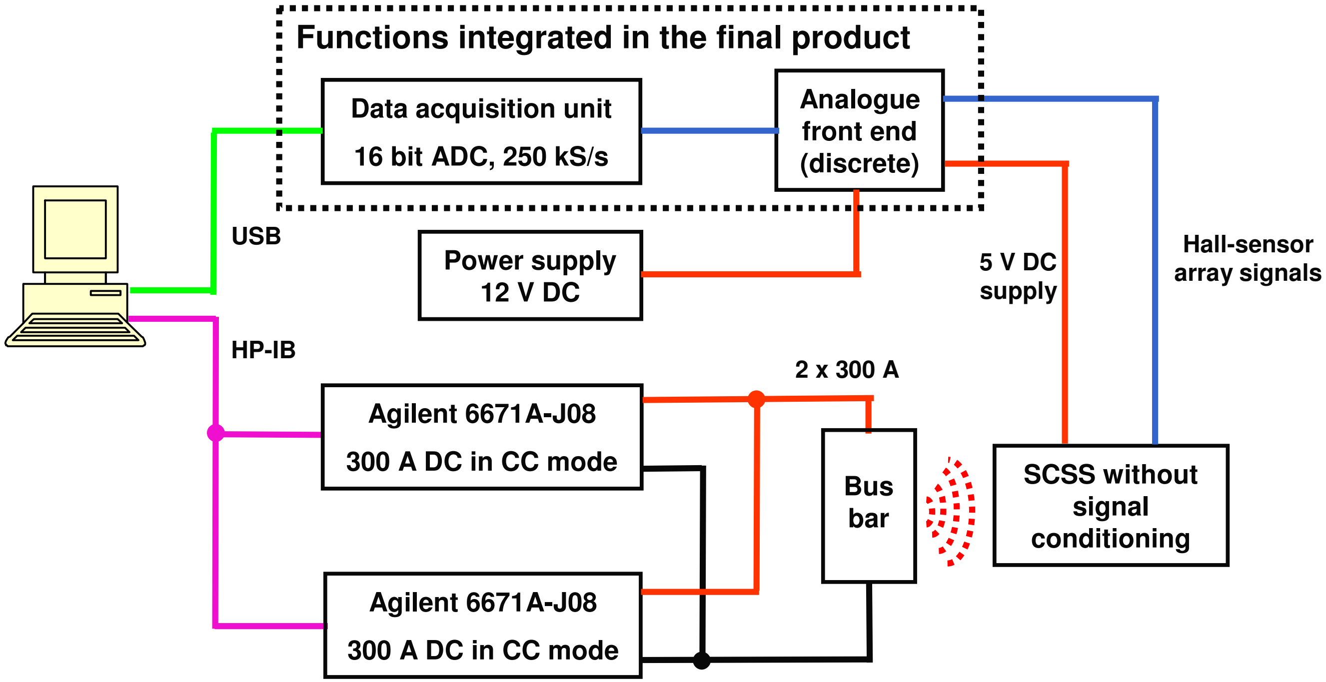
Architecture of the SCSS



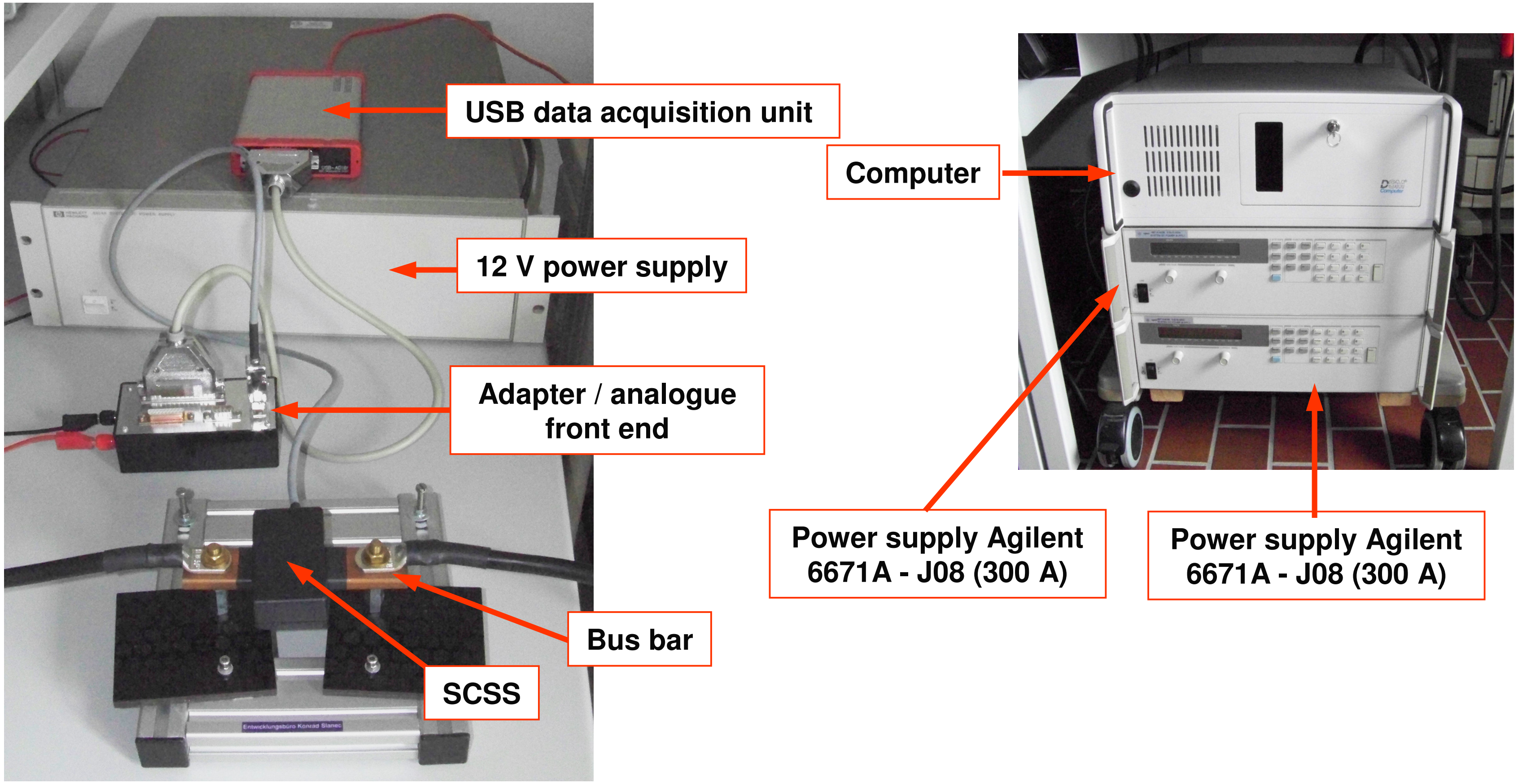


PCB example of a SCSS with SCI, JTAG and SPI interface for DC current sensing up to 800 A with bus bar 10 mm x 30 mm cross section.

Setup example for SCSS parameter and verification tests

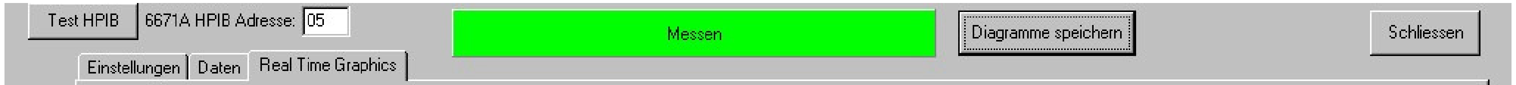


Test equipment example



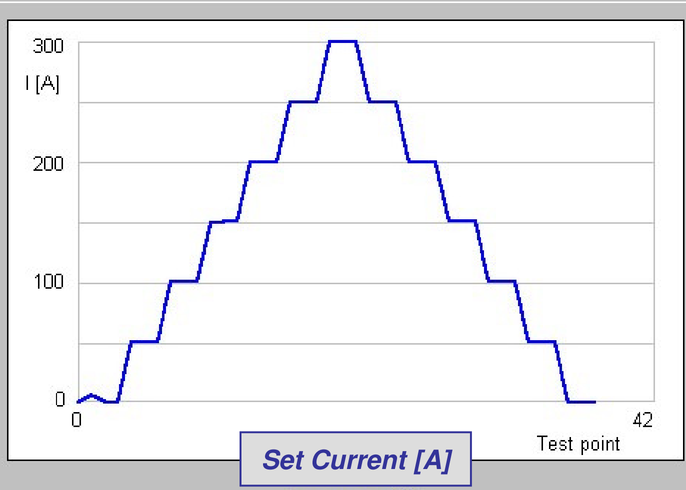
In addition to the standard bench test equipment, computer contolled power supplies (for max. 1.8 kA), data acquision units and temperature chamber are currently available for SCSS tests.

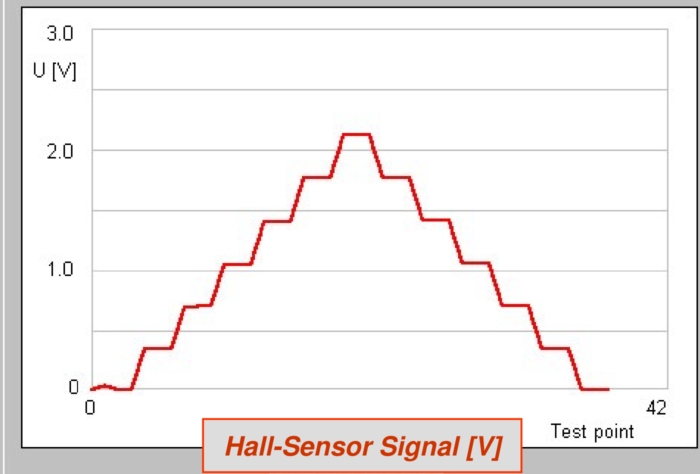
Example: Result without magnetic disturbances

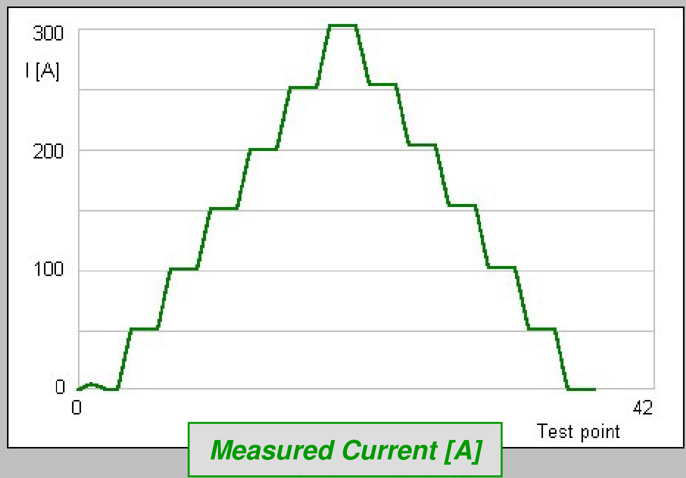


- Measurement at +23 °C,
- Current set via computer in steps of 50 A,
- Temperature compensation due to heat generated by cable was not implemented.

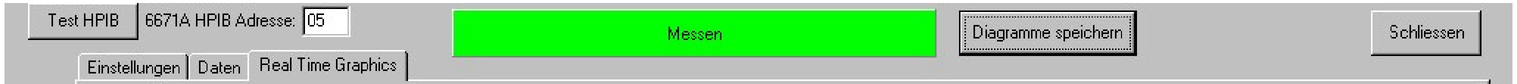
At decreased current after the heat generated at 300 A, the signals deviate from the original value since the temperature influence was not considered.





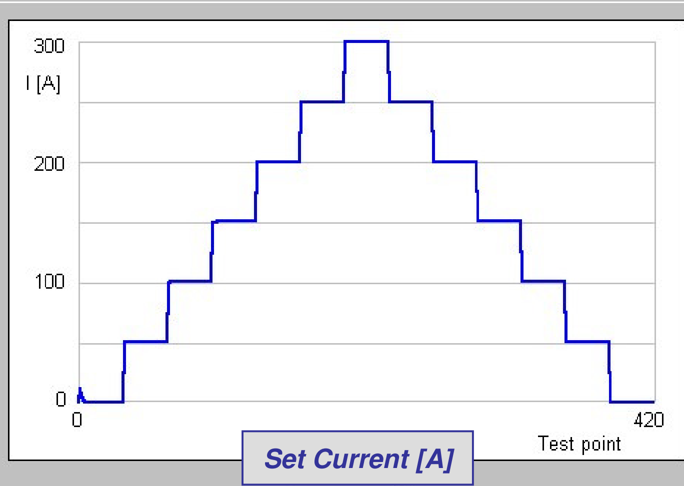


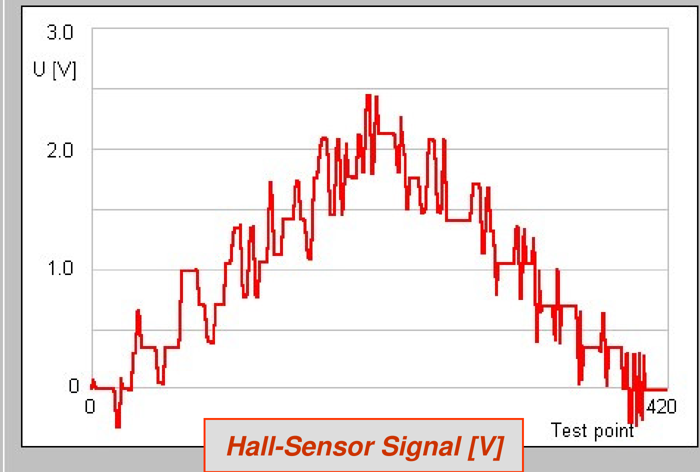
Example: Result under disturbances of ~ +/- 15 mT

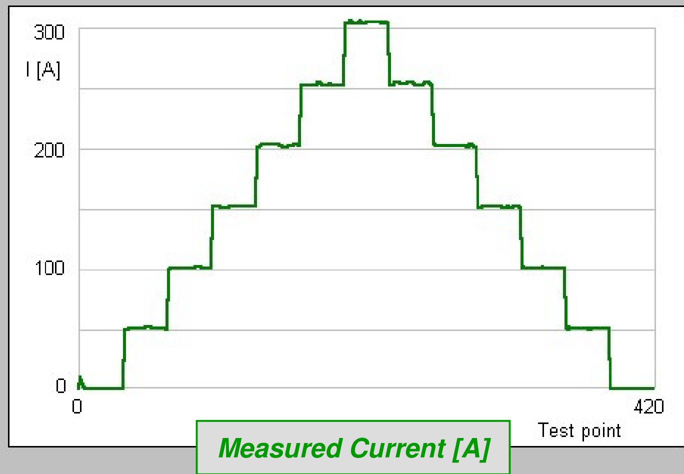


- Measurement at +23℃,
- Current set via computer in steps of 50 A,
- Temperature compensation due to heat generated by cable was not implemented.

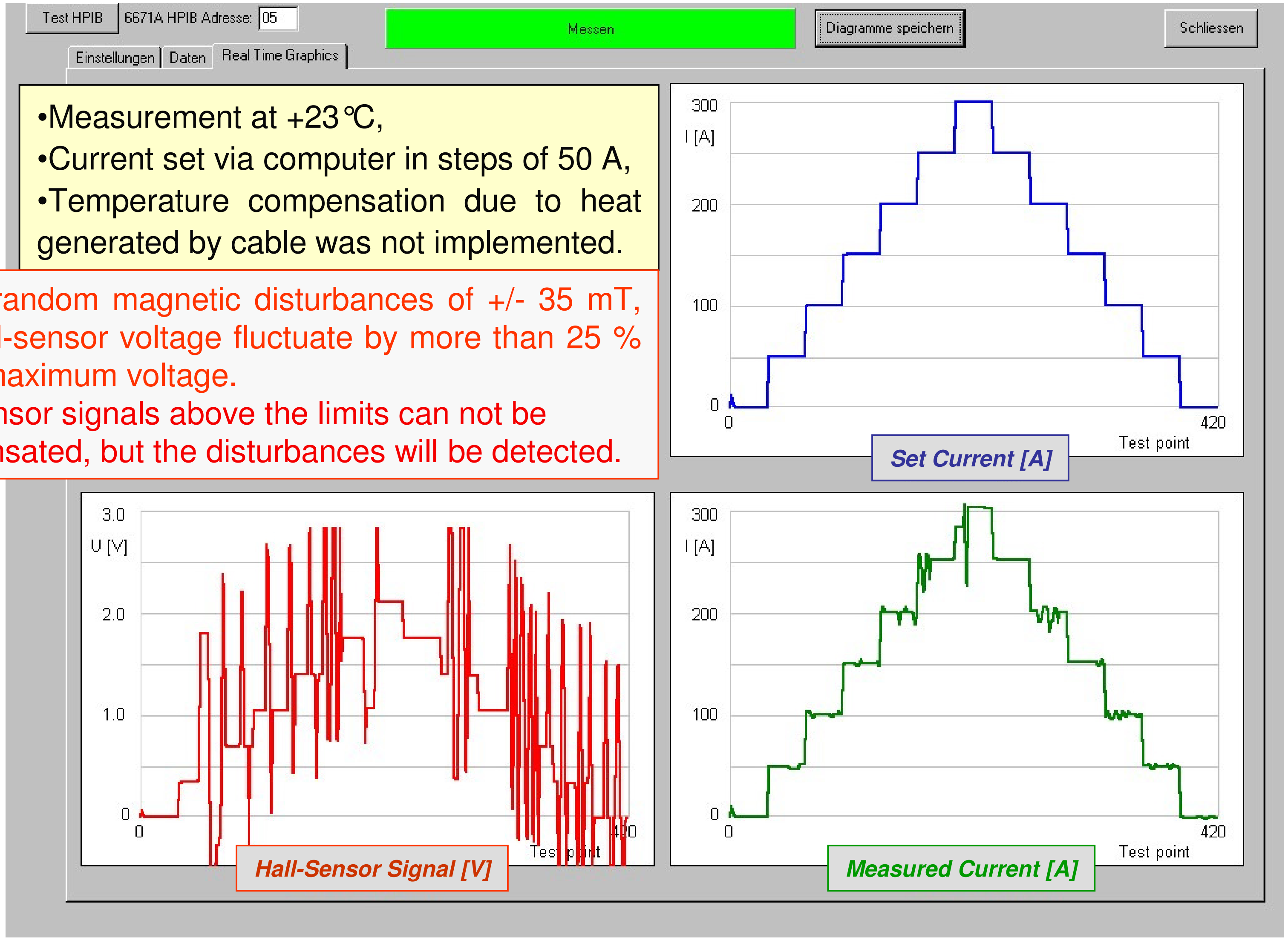
Under random magnetic disturbances of +/- 15 mT, the Hall-sensor voltage fluctuate by ~ 12 % of the maximum voltage.







Example: Result under disturbances of ~ +/- 35 mT



- Measurement at +23 °C,
- Current set via computer in steps of 50 A,
- Temperature compensation due to heat generated by cable was not implemented.

Under random magnetic disturbances of +/- 35 mT, the Hall-sensor voltage fluctuate by more than 25 % of the maximum voltage.
Hall-sensor signals above the limits can not be compensated, but the disturbances will be detected.

Thank you for your attention!

We are looking forward to receive your specification and requirements!