Power converter control, instrumentation, quench detection

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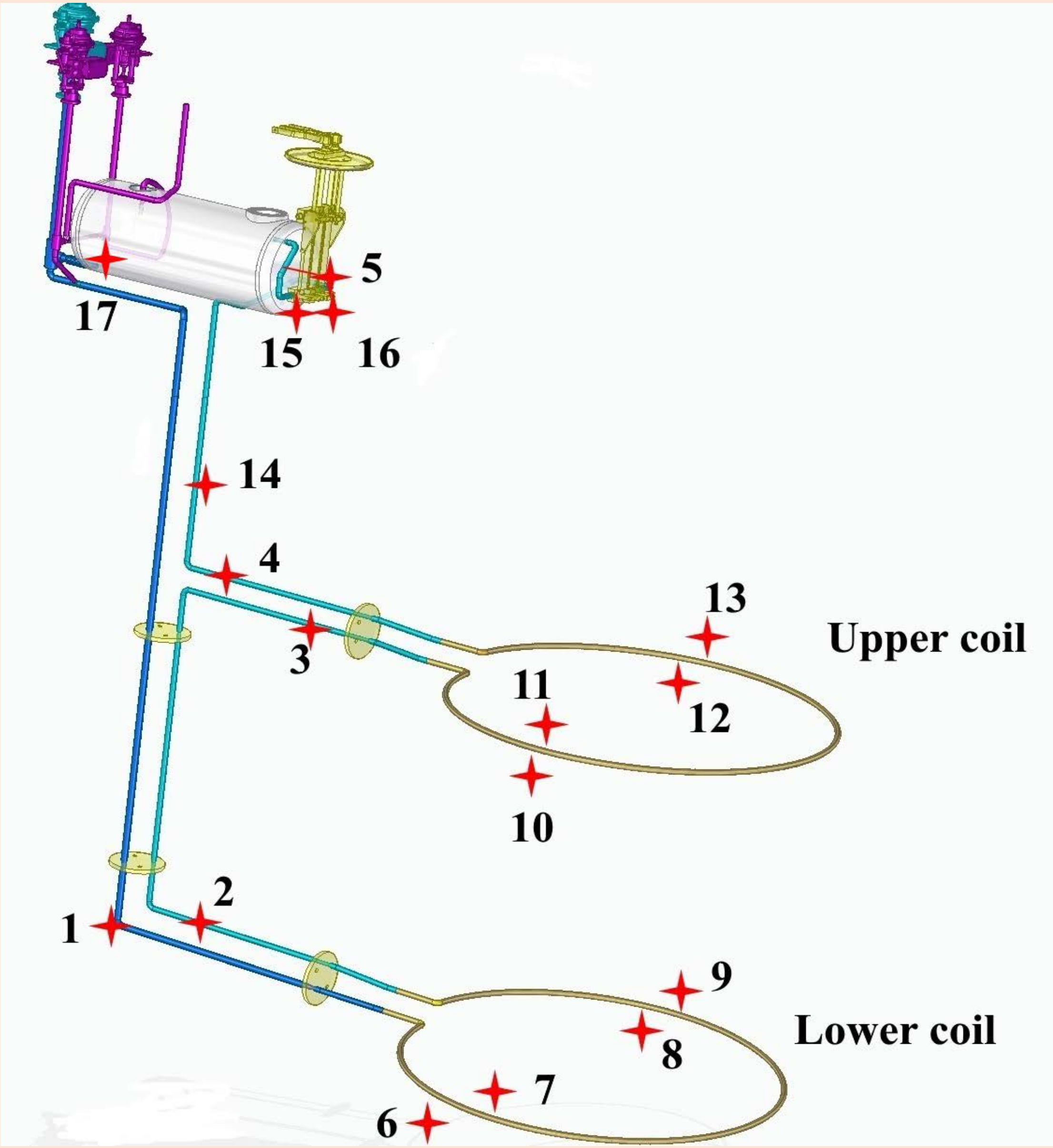
The cryogenic behavior includes

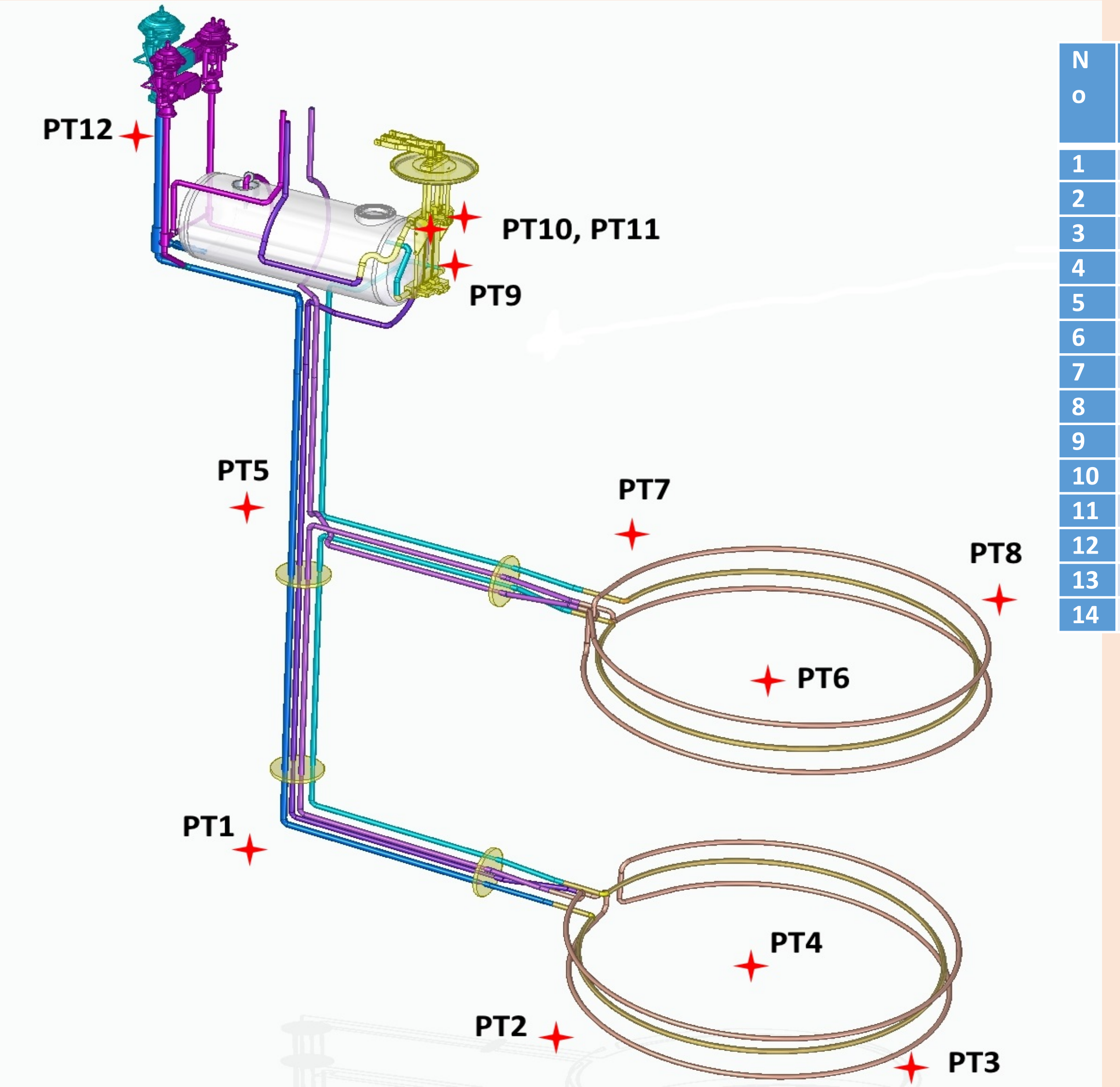
- Temperature sensors placement
- Converter
- Quench detection

Placement of the temperature sensors – 4.5 K surfaces



No	The placement of the sensors	Designation	Serial number, data of calibration (example)
1	On the lowest place of the cooling tube	DT1 +1	D6075405 , 30.10.2018
2	On the outlet of the cooling tube of the lower coil	DT2+1	D6075409
3	On the inlet of the cooling tube of the upper coil	DT3+1	D6075410
4	On the outlet of the cooling tube of the upper coil	DT4+1	D6075411
5	On the outlet of the cooling tube of the current leads	DT5+1	
6	Lower copper plate (opposite the struts) of the lower coil	DT6	
7	Upper copper plate of the lower coil	DT7	
8	Lower copper plate (opposite the struts) of the lower coil	DT8	
9	Upper copper plate of the lower coil	DT9	
10	Lower copper plate of the upper coil	DT10	
11	Upper copper plate (opposite the struts) of the upper coil	DT11	
12	Lower copper plate of the upper coil	DT12	
13	Upper copper plate (opposite the struts) of the upper coil	DT13	
14	On the tube by the heater	DT14+1	
15	On the current lead	DT15	
16	On the current lead	DT16	
17	Bottom of helium vessel	DT17	

Temperature sensors – 55 K surfaces



No	The placement of the sensors	Designation	Serial number, data of calibration (example)
1	On the radiation shield by the cooling tube	PT1	D6075405 , 30.10.2018
2	On the radiation shield by the support first	PT2	D6075409
3	On the radiation shield by the support second	PT3	D6075410
4	On the radiation shield of the lower coil	PT4	D6075411
5	On the radiation shield by the assembling place	PT5	
6	On the radiation shield of the upper coil	PT6	
7	On the radiation shield of the upper coil by the support first	PT7	
8	On the radiation shield of the upper coil by the support second	PT8	
9	On the radiation shield by the current leads	PT9	
10	On the first current lead	PT10	
11	On the second current lead	PT11	
12	On the radiation shield by the control valves	PT12	
13		PT13	
14		PT14	

Control system demands to the cryostat and magnet

1. Temperature sensors DT type:

Total number 17 + 6 = 23

2. Temperature sensors PT type:

Total number 12 + 5 = 17

3. Voltage taps

Total number: 5

Tree on the coils: inlet, middle, outlet. Two on the current leads.

4. Quench detection

For the coils, the threshold is 0.1 V for quench detection and 10 ms for validation.

For the busbars, the threshold is 0.01 V for quench detection and 500 ms for validation.

5. Three control valves electronics

Control system

The CBM magnet control system implements the following functions to provide safe and reliable machine operation:

- Cryostat monitoring;
- Quench detection
- Interlock protection;

The control system includes the interface to the Control Computer hereinafter referred to as IOC (Input/Output Controller), the design of the functionality in the IOC and the development of the user interface. The functionality of the control computer and the interface with the host system will be discussed later.

Hardware components

The control system hardware consists of:

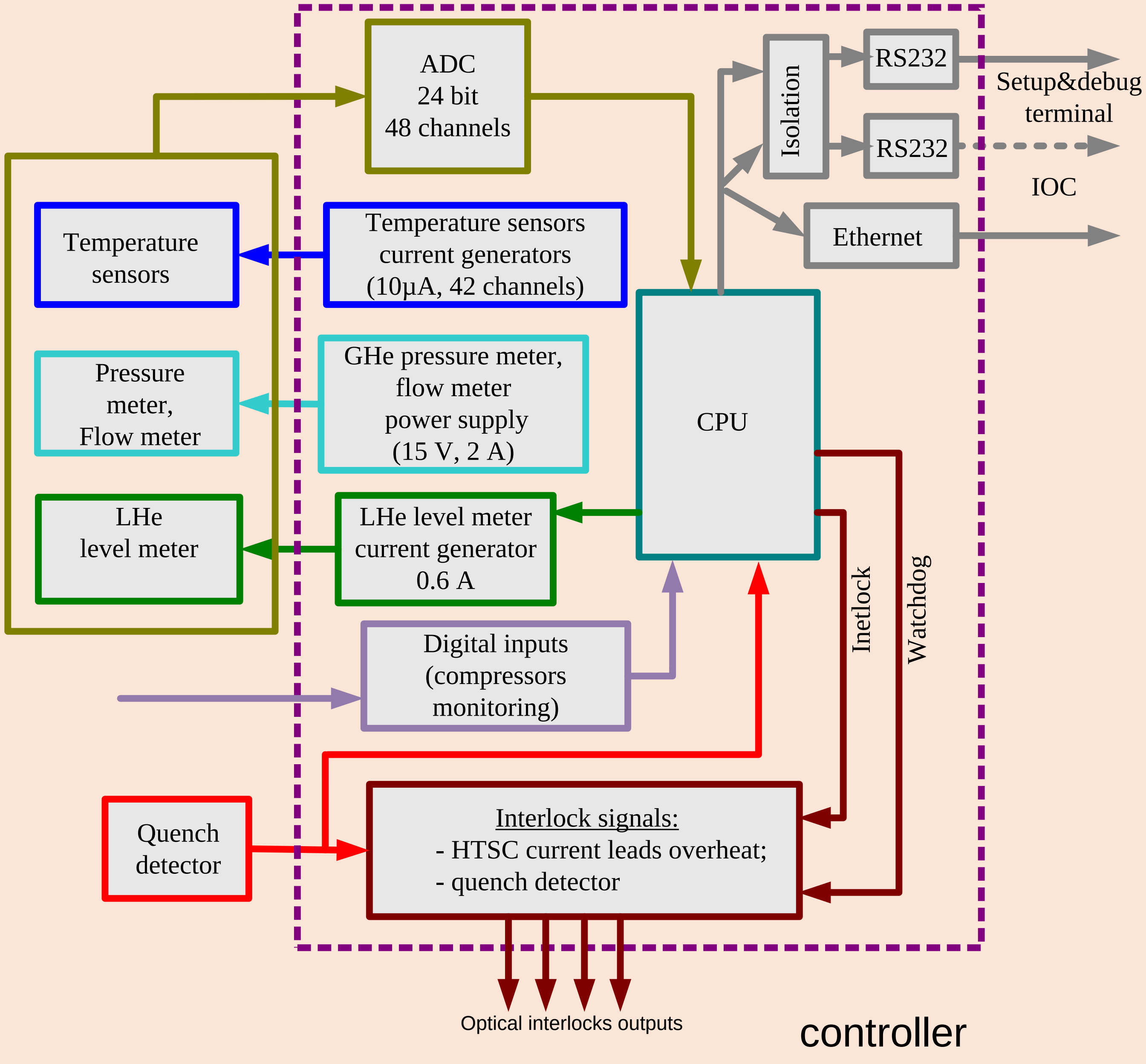
- Superconducting magnet controller (SCMC) – special electronics designed in BINP for SCM control system;
- Cryostat monitoring sensors;
- Vacuum meter (Pfeiffer)

The controller scheme

The special electronics (SCWC) is designed in BINP for data acquisition and interlocking. It contains:

- ADC (24 bits, 48 channels);
- current generators (10μA or 100 μA, 42 channels) for temperature sensors;
- channel of LHe level meter with current generator of 0.3A-0.6A;
- channel for gas helium pressure meter with power supply of 15V;
- interlock logic;
- connectors for all needed sensors and quench detector;
- optical interlock outputs
- 2 RS-232 communication interfaces.
- Ethernet (tcp/ip) interface

The interlock logic is realized as combined hardware/software system. The most important interlock on quench is hardware realized. And the interlocks on current leads overheat are software realized in the SCMC firmware. Also there is a hardware interlock at SCMC faults, on the basis of the watchdog circuit. All interlocks are hardware united and brought out to the back panel of the SCMC to interface with the power supply units, energy extraction module, host controller and other. Also it can be reading by the IOC through RS232 or Ethernet interface. The outline scheme of the SCWC is shown in the Figure.

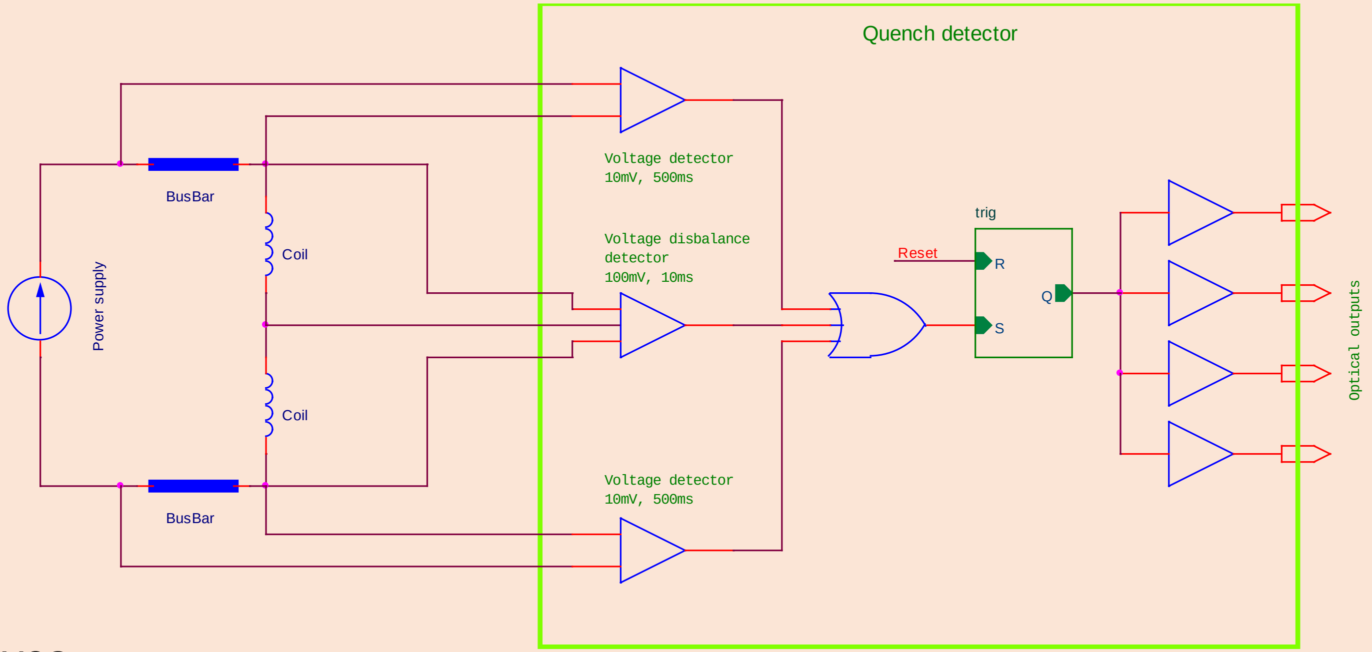


Quench detector interlock

The main interlocks events are:

- Quench;
- HTSC current leads overheat.
- SCMC failure

Additionally, the temperature of the LHe interlock sensor is used as a warning signal. All interlock digital signals are connected to the IOC and brought out to the back panel of the CBM magnet to interface with the power supply units, energy extraction module and host system.



Normal zone appearance in a one of the magnet coils gives rise to voltage unbalance in the magnet electrical circuit. An imbalance of more than 100mV for more than 10ms will be detected as quench. Also, the appearance of a voltage of more than 10mV for more than 500 ms on any of the bus bars will be detected.

Monitoring and Interlocking

Cryostat control & monitoring

To ensure safe and reliable machine operation monitoring of the main cryostat parameters will be provided, namely:

- Temperature of critical locations;
- LHe level;
- GHe pressure in the LHe vessel;
- Insulating vacuum;

LHe level

LHe level sensor is a superconducting wire (Nb-Ti). The resistance of the wire depends on the LHe level.

Interlocking

The main interlocks events are:

- Quench;
- HTSC current leads overheat.
- SCMC failure

Additionally, the temperature of the LHe interlock sensor is used as a warning signal. All interlock digital signals are connected to the IOC and brought out to the back panel of the SCWC to interface with the power supply units, energy extraction module and host system.

Conclusions

- Temperature sensors placement. Is the amount enough or not?
- The demands to the control system is presented
- Typical operation of the control system and the converter is presented. It needs specifications for demands of FAIR electronics for interactions.